ARIZONA

INVASIVE SPECIES MANAGEMENT PLAN

2008

Arizona Invasive Species Advisory Council

Guiding Arizona to a non-invasive state of mind.

Arizona Invasive Species Management Plan

Prepared by the
Arizona Invasive Species Advisory Council
June 30, 2008

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Executive Summary

INTRODUCTION

The Arizona Invasive Species Advisory Council (AISAC) was initially created in 2005 by the Governor's Executive Order to develop a coordinated, multi-stakeholder approach for addressing invasive species issues in Arizona. In June 2006, recommendations to the Governor included that the AISAC be permanently established and a comprehensive invasive species management plan be developed.

The Governor's Executive Order in 2007 directed the AISAC to develop an invasive species management plan by June 30, 2008. This plan is based upon the framework recommended in the initial AISAC report and focused on five strategic concepts: Leadership and Coordination, Research and Information Management, Anticipation and Outreach, Control and Management, and Funding. In developing the plan, fifteen objectives and sixty-three recommendations were established to address invasive species needs in Arizona. Highlights of those recommended objectives and actions are as follows.

LEADERSHIP & COORDINATION

- Identify lead coordination to facilitate the needs identified in the plan;
- Retain the vision of a coordinated, multi-stakeholder approach;
- Implement effective communication and coordination among state and federal agencies and stakeholders as well as with interstate, international and tribal entities; and
- Develop the Arizona Center for Invasive Species as a web-based network.

RESEARCH & INFORMATION MANAGEMENT

- Prioritize and coordinate invasive species research efforts among state and federal agencies, universities, private landowners and neighboring states;
- Coordinate research efforts for data collection, storage, and use; and
- Develop and employ an Arizona invasive species website as a clearinghouse for the public and resource managers where they can contribute and access information.

ANTICIPATION & OUTREACH

- Emphasize education, outreach and awareness across all audiences in support of the focal areas of this plan; and
- Expand and enhance statewide detection capabilities for effective, timely, and coordinated response to new invasive species threats.

CONTROL & MANAGEMENT

- Identify and promote effective strategies for control and management of individual invasive species, and restoring impacted resources;
- Develop rapid assessment processes to improve the ability to respond to a critical invasive species threat in a timely manner;
- Develop and employ flexible yet consistent general best management practices to minimize the potential for unwanted introduction or spread of invasive species; and
- Support subsequent restoration efforts of affected resources.

FUNDING

- Sustain the necessary infrastructure to support invasive species activities for the long-term functions of the plan;
- Identify creative funding solutions for the immediate future. Pursue future adequate and stable state funding resources to sustain the long term goals of the plan; and
- Identify, cultivate, and pursue specific federal and private funding opportunities to assist Arizona in meeting the invasive species challenge.

RECURRING THEMES

The issues associated with invasive species are not expected to diminish or go away. These recommendations represent a comprehensive long-range vision based on ecological timelines, but with an eye to the incremental, achievable successes that cumulatively will shift the direction of invasive species management and shape the outcomes. Implementing this strategy will require a proactive approach. The AISAC believes the cost of doing nothing far outweighs the costs associated with the proactive recommendations identified in the management plan.

In developing the plan, specific themes appeared consistently across the strategic concepts and, as such, need to be emphasized. These repeating themes include needs to:

- Cooperate, coordinate, and increase the effectiveness of communication among agencies and stakeholders to implement comprehensive invasive species management;
- Implement the Memorandum Of Understanding and recruit additional stakeholders to ensure cooperation and collaboration;
- Create the Center for Invasive Species as a web-based network that would be the gateway for information collection, sharing, and distribution to aid the public, agencies and organizations in Arizona in addressing invasive species management needs;
- Seek to establish a rapid response fund and develop a strategy to assess the economic feasibility of creating a sustainable emergency response resource to address the long term issues associated with response to critical invasive species detections;
- Emphasize education and outreach as integral components to effectively accomplish goals identified in each strategic concept;
- Facilitate amending applicable state grant programs so that eligibility criteria would include addressing invasive species issues. Publicize grant opportunities that can potentially fund or enhance efforts for the strategic concepts;
- Pursue, cultivate, and secure creative funding solutions from public and private sources. Raise the awareness of state, federal, and community decision makers for sustained commitment to manage invasive species threats, complementary to and not in lieu of other priority initiatives and program needs.

The AISAC also recognizes that invasive species issues and needs are inter-related with other state movements including forest health, wildlife connectivity, smart growth, rural development, energy development, and climate change. Threats and impacts of invasive species can be identified and associated across all of these issues. Communication and cooperation among the AISAC and other Governor's advisory councils is important to a comprehensive understanding and management of invasive species.

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Introduction

THE PROBLEM

People have always traveled and traded, exploring new places, transporting and exchanging goods. In our modern society, transport, trade and travel have become global in nature, massive in volume, rapid in pace and more essential than ever before as a pillar of our civilization. Travelers come to the United States from around the world. We engage in international trade, importing "non-native" plants and animals and their products to be used for food, building materials, ornamental plants, livestock, pets, and numerous other purposes. But along with the increase in trade and travel has come a growing threat of invasive species, those that are already here and those that may arrive in the future.

A non-native plant, animal, or other organism is one that has been moved from its natural habitat to a new environment. Simply because the non-native species has moved to a new location does not make it an invasive species. Most of our food crops and livestock are not native to the United States and are beneficial to our welfare. An invasive species is a non-native whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Many invasive plant species, for example, can rapidly eradicate native plants when introduced into new habitats where they have not evolved as part of a functionally organized community and where their natural enemies are not present to keep them in check. In doing so, these "invaders" threaten the integrity of native ecosystems that have evolved over many thousands of years.

In the past, before people understood the importance of maintaining natural systems, some invasive introductions were intentional. Nowadays, most introductions are accidental, the result of carelessness or ignorance. In some cases, however, invasive species spread naturally as their populations grow, from state to state, country to country, for these invaders respect no borders.

BEN WILDER

An invasive species is a non-native plant, animal or other organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Many invasive species can rapidly displace native species when introduced into new habitats where they have not evolved as part of a functionally organized community and where their natural enemies are not present to keep them in check.

Whether we know it or not, invasive species affect each of us and their threats and impacts are a growing concern in Arizona. They are already having

Along with other non-native grasses such as red brome and fountain grass, African buffelgrass has fueled a serious increase in desert fires. Buffelgrass is a fast spreading invasive grass that is common in open areas and along trails and washes throughout the Sonoran Desert. Lightning strikes and human-caused fires ignite this additional fuel load, burning off native vegetation and stimulating the spread of even more invasive grasses. These grasses create hot, fast-moving fires that are a particular threat to slow-growing native plants such as saguaro cactus and palo verde, as well as to native wildlife.

The key to minimizing fire risk is a sound public policy that conserves native plant communities, adopts an invasive species response plan prior to their arrival, and controls the spread of those already present.

PATTI FENNER, USDA/FS

a negative effect on the state's economy, natural environment, and human and animal health. Their presence has caused, among many harmful effects, the loss of wildlife habitat, decreased agricultural productivity, degraded watersheds, and increased fire danger, as well as the introduction of human and agricultural diseases. The state has applied funding and energy to combat the threats and impacts of invasive species, but not in a cohesive, comprehensive approach. Arizona does not currently have a unified strategy to prevent an invasive species introduction or avert a threat. Key stakeholders have not yet established the depth of coordination and cooperation required to address management and control issues if or when an invasive species arrives. Responsible management calls for a alignment of priorities and development of a proactive approach to prevent, control and manage invasive species. This plan has been prepared to meet those objectives.

IMPACTS

The impacts of invasive species in Arizona are many and varied, and to a certain extent as yet unknown. Invasive plants can have detrimental effects on native ecosystems, outcompeting native plants for space, light, water and nutrients. Their impacts strike at many levels, from individual organisms up to landscapes, some of which are becoming irreversibly altered. Many of Arizona's unique environments and delicate life forms could succumb to the introduction of invasive species. These concerns are not ill-conceived notions since they have happened in the past and if left unchecked would most certainly happen again.

Many invasive organisms can, and have, caused serious harm to Arizona's agriculture, outdoor recreation, and tourism industries resulting in economic loss. The total economic impact has not been quantified; however, Arizona spent $730,000 dollars between 2006 and 2007 on an effort to combat just one invasive species, the glassy-winged sharpshooter, an insect invader threatening southern Arizona's wine industry. Those expenditures could rise if response measures diminish. Concern over the quagga mussel, a recently introduced invader in Arizona waterways, has produced an ongoing multi-agency effort to identify impacts and strategies for its control and management. Impacts to water delivery,

ecosystem functioning, and recreation are anticipated.

The prevalence of invasive grasses presents a major fire risk, impinging on the ability of land managers and response agencies to plan for, manage, and contain fires. Where invasive grasses are well established, fuel-loads, particularly around human dwellings in rural communities, make fire-fighting extremely difficult. Loss of property and life may result where large fires, fueled by non-native plants, burn hotter and over a larger area. Local communities will face increasing fire response costs, and may be unable to protect the public without significant assistance from state or federal governments.

Invasive plants, pathogens and parasites cut crop yields and sicken livestock. Invasive aquatic plants, which can clog waterways and irrigation canals, host mosquitoes that may carry infectious pathogens. Humans can be directly affected by disease transmission, as well as by invasive ants that cause painful stings, invasive plant pollen that increases the severity of respiratory allergies, and epidemics such as West Nile virus which is an invasive and sometimes deadly pathogen of humans and animals.

BIODIVERSITY

Ecological biodiversity is threatened by invasive species such as water hyacinth, quagga mussels, cactus moths, hydrilla, nutria, snakehead fish, West Nile virus, and the sudden oak death pathogen, all of which may prey upon, displace or otherwise harm native species. Some invasive species affect both aquatic and terrestrial habitats having negative impacts on ecosystem processes, transporting disease, or causing illnesses in animals and humans. For these reasons, invasive species constitute a critical concern for Arizona and its natural resources.

"The prevalence of invasive grasses presents a major fire risk, impinging on the ability of land managers and response agencies to plan for, manage, and contain fires."

AGRICULTURE

Some non-native insects can have devastating effects on the yield of agricultural and horticultural commodities, and can increase industry production costs through pesticide applications for eradication or control. Commonly called "plant pests," these insects reduce product quality and could reduce demand for Arizona products. Two factors contribute to the mounting threat of invasion by plant pests.

- International trade transports many foreign pests to the United States, and often, subsequently, to Arizona, with products that come from other countries. These pests present a significant threat to Arizona agriculture, and to public well-being and associated quality of life. The risk of introducing plant pests or diseases increases with the growth in global commerce.
- Phoenix is among the nation's 10 largest metropolitan areas and population numbers are rising at an amazing rate, an attribute that has fueled a significant upsurge in the importation and distribution of plants, many of which originate in parts of the country already infested with destructive non-native pests, such as the Asian citrus psyllid that vectors citrus greening, a serious threat to residential and commercial citrus trees.

TOURISM AND RECREATION

Arizona's tourism marketing campaigns make the most of the state's natural beauty by featuring saguaro-studded hillsides and panoramic Grand Canyon vistas. On the other hand, catastrophic brush and forest fires and mandatory fire evacuations generate negative publicity that dims Arizona's

reputation as a tourist destination. As fires fueled by invasive plants become more frequent, loss of tourism could result. Summer fire closures of popular recreation areas, particularly in the Chiricahuas, the Mogollon Rim, and the Santa Catalinas, have become commonplace in recent years. As fire danger increases with the growing presence of invasive plants, the public will be increasingly excluded from recreation opportunities on public lands. Closures harm the quality of life for Arizona residents and impact tourism-based revenues for local communities and Arizona as a whole.

HOW ARE THEY GETTING HERE?

Arizona is an epicenter of travel and tourism and a hub for product distribution, which creates ample opportunity for an invasive species to find its way into the state's urban and rural areas. Many kinds of invasive organisms have used a multitude of introduction methods to gain a foothold in Arizona's environment. They have hitchhiked on commercial transport, with tourists and travelers, in packing materials, on livestock, in tire treads, and on boats. They have slipped in concealed in bags of seed and grain and hidden in the blood of birds and other animals. They have been introduced intentionally for management purposes or to meet a social demand for new or different species for pets or hobbies, for landscaping, for crops, food, recreation, education, pest control. The list goes on. Each of these pathways for introduction must be taken into account when developing a comprehensive strategy for combating invasive species.

Many intentional introductions occurred when horticulturists or farmers imported plants from other countries to solve agricultural problems such as the need for rigorous and hardy pasture grasses (e.g., African buffelgrass, reed canary grass) or for use as ornamental plants (e.g., fountain grasses, Russian

Crayfish are an example of an invasive species that was intentionally introduced to use as bait and vegetation control. Our native aquatic plants and animals have no natural defenses against crayfish, who themselves are voracious predators that eat almost anything, from insects and fish to frogs, small snakes and even young turtles. With abundant food and no natural predators, crayfish populations skyrocket. After eliminating the animal food base, they turn to plants, shredding and ripping them from the stream bottom. Before long, vibrant aquatic communities have become muddy and lifeless—except for crayfish, which then turn to cannibalism. Big crayfish eat little ones, and because they are well fed, they produce lots of offspring, more food for themselves and other crayfish. Thus, once crayfish have colonized an aquatic habitat, the result is typically negative for other aquatic species with little hope for recovery, without help.

PATTI FENNER, USDA/FS

olive). Crayfish and bullfrogs were brought in for bait, sport, and food. Many of the fish pursued by anglers in our state were intentionally introduced over the past century and provide significant value to people and the economy. But careful risk-based decisions must be made about any new species introductions, and even introduced species that represent choices of the past must be managed carefully because plant and animal interactions can be negative outside of the areas these additions were intended to serve.

THE GOVERNOR'S APPROACH: EXECUTIVE ORDER 2007-07

Invasive species populations span geographic and jurisdictional boundaries; thus, addressing invasive species issues must be coordinated across boundaries. In 2005, Governor Napolitano established the Arizona Invasive Species Advisory Council (AISAC) by Executive Order 2005-09 and charged it with developing a coordinated, multi-stakeholder approach to dealing with invasive species issues and drafting recommendations for invasive species management. In June 2006, the AISAC submitted to the Governor a report of their findings and recommended actions. Among the AISAC's recommendations were the establishment of the AISAC as a permanent body and the development of a comprehensive statewide invasive species management plan. Executive Order 2007-07, issued in January 2007, reconvened the AISAC as a permanent body under the joint leadership of the Arizona Game and Fish Department and the Arizona Department of Agriculture. The Order directed the AISAC to develop an invasive species management plan by June 30, 2008, based on the framework recommended in the initial AISAC report and centered around five focal strategic concepts:

- Leadership and Coordination
- Research and Information Management
- Anticipation and Outreach
- Control and Management
- Funding

As directed by the Order, the plan should also provide guidance and identify expertise for the recommendations identified in the initial report. The plan presented here has been prepared to fulfill those directives.

"Some invasive species affect both aquatic and terrestrial habitats, having negative impacts on ecosystem processes, transporting disease, or causing illnesses in animals and humans."

INVASIVE SPECIES DEFINITION

The AISAC's consensus definition of invasive species for Arizona is as follows:

"A species that is (1) non-native to the ecosystem under consideration and, (2) whose introduction causes or is likely to cause economic or environmental harm, or harm to human health."

The AISAC recognizes that this definition is open to interpretation, and it is not intended to be a regulatory designation. It is intended to provide counsel and guidance to state agencies and subdivisions of the state, the public, and our partners. The AISAC recognizes that not all non-native species are invasive and that some native species can act in an invasive manner.

PLAN DEVELOPMENT PROCESS

The current AISAC held its first meeting on July 19, 2007, and identified the need to coordinate with as many state, federal, and local organizations, stakeholders and interested parties as possible, with the goal of developing a network of subject matter experts and advisors, and creating a pathway for communication and coordination on invasive species issues.

The AISAC began preparation of the invasive species management plan by designating co-leads to represent the Arizona Game and Fish Department and the Arizona Department of Agriculture and convening work groups to focus on the strategic concepts identified in Executive Order 2007-07. The AISAC directed the work groups to develop objectives consistent with each concept and propose actions for meeting the objectives.

Each work group would work on one of the first four concepts and contribute to the process for addressing the fifth concept, funding. To allow greater AISAC involvement and participation on the work groups, the concepts were addressed two at a time. The first two groups, Leadership and Coordination, and Research and Information Management, were tasked with developing recommendations by October 2007. At that time, two additional work groups were formed, Anticipation and Outreach, and Control and Management. These work groups were tasked with developing recommendations by January 2008. AISAC meetings were held monthly; work group and task group meetings were held on an as needed basis, two to three times a month on average. Work groups provided progress reports at monthly AISAC meetings and sought direction on key issues. Close contact was maintained with the Governor's office throughout. Status reports were delivered and feedback and guidance sought.

"Invasive plants can have detrimental effects on native ecosystems, outcompeting native plants for space, light, water and nutrients."

As presented in the plan, each strategic concept is put forward with the objectives and recommended actions that describe what is to be accomplished over the life of the plan. Measurements of effectiveness are identified for the actions to track progress toward accomplishment. Some actions can be accomplished easily and quickly; others are broader and focus on long term approaches that address ecological time scales. The accomplishment of specific objectives and actions depends upon agency budgets, and in some cases, legal or regulatory authorities.

Following the development of draft recommendations, the co-leads addressed and resolved areas of overlap and inconsistency found in the recommendations developed by the work groups. All four work groups met to perform an evaluation of the recommendations and categorize them into areas of focus, from those that could be accomplished quickly to those that would require long term efforts. The AISAC reviewed and accepted the draft recommendations and provided guidance to develop the plan's ancillary components.

Some recommended actions were identified as potential early successes. Task groups were formed to address those recommendations and initiate the process toward accomplishment. Examples include the development of an information management task force led by the Arizona Government Information Technology Agency, and Council development of a memorandum of understanding among key state agencies and cooperators (the Executive Committee identified in Executive Order 2007-07).

At their March 2008 meeting, the AISAC voted to make the Draft Arizona Invasive Species Management Plan available for public review and comment. The draft was placed on the Governor's Web site From March 14 to April 7, and public meetings were held during the last two weeks of March in six Arizona cities, Yuma, Tucson, Phoenix, Kingman/Bullhead City, Flagstaff,

Many of Arizona's unique environments and delicate life forms could succumb to the introduction of invasive species.

and Pinetop/Show Low. The public meeting format included formal presentations as well as opportunities to interact with the public and solicit comment. Public input was evaluated, and changes were made to the plan to reflect that input.

During the planning process, AISAC members and other participants dedicated both time and travel expenses to the plan's development. Totals for these were calculated for each participant using information from the tracking documents of AISAC and work group meetings. Participants were asked to review their totals and to supply similar information on other planning-related activities. These figures show that participants contributed over 4,000 hours and over $9,000 in overall expenses to the development of the Arizona Invasive Species Management Plan.

In May the final version of the plan was presented for AISAC approval for a June 30, 2008, submission to the Governor.

THE PLAN

The plan has seven sections. The first is an introduction describing the problem and the Governor and the AISAC's approach to solving the problem. The second section points out the known concerns regarding invasive species and the urgency that is needed to deal with them. Section two includes a selection of case studies of individual species to educate readers and drive home the seriousness of the problem. It also includes some notable successes in responding to invasive species issues. Section three is an overview of regulatory authorities. Section four is the meat of the plan, presenting the objectives and recommendations that address the five strategic concepts identified in Executive Order 2007-07. The fifth section describes the program implementation and evaluation processes. The sixth section is a bibliography and the seventh section contains the appendices.

Invasive Species in Arizona

BIOGEOGRAPHY OF ARIZONA

Arizona contains approximately 73 million acres of land characterized by a highly varied topography, geology, and climate. Elevations range from about 75 feet above sea level near Yuma up to about 12,640 feet in the San Francisco Peaks near Flagstaff. Generally, elevation increases from west to east and from south to north. Arizona has three distinct geographic regions, the high plateau in the north, a mountainous zone extending roughly from the southeast corner of the state to the northwest, and low deserts in the south. Precipitation ranges from less than 3 inches per year at desert locations to more than 30 inches at higher elevations in the north. Most precipitation is generated by summer thunderstorms and gentler winter rains and snowfall carrying moisture from the Pacific Ocean. Winter rain or snow is more dominant in northern portions of the state, while summer rain dominates in the south. Arizona's temperature range is extreme. In Phoenix, for example, at an elevation of 1,083, the average July high is 105 degrees; the average low is 81. In Flagstaff, elevation 6,903, the average July high is 81 degrees; the low is 50. In January, the average high and low in Phoenix are 65 and 41 degrees; the Flagstaff averages are 42 and 15.

Arizona's great diversity in elevations, climate, landforms and soil types creates many kinds of environments, from the dry, sparsely vegetated deserts of the south to the grasslands and woodlands at mid-elevations, to the cold, moist montane and alpine forests at higher elevations. In the mountainous region, isolated mountain ranges known as "sky islands" rise steeply from the desert floor producing rapid environmental changes over very short distances.

Arizona's aquatic systems and associated riparian areas play a major role in maintaining a rich biodiversity, and provide migratory birds, pollinating insects and bats with vital travel corridors. The Colorado River flows west through the Grand Canyon and then south to form the state's western boundary. The Gila, Salt, and Verde rivers drain the north-central portion of the state and carry water to reservoirs that support cities and agriculture in central and southern Arizona. Many smaller creeks and tributaries have perennial or intermittent flows, and along with springs, ciénegas

Cactus wren

GEORGE ANDREJKO, AGFD

The complexity of Arizona's landscape gives rise to a wide variety of habitats that support diverse wildlife communities. Arizona ranks third in the nation for the number of native bird species, second for reptiles, fifth for mammals, and eighth for overall vertebrate animal diversity.

Table 1. Land ownership in 2007 in Arizona.

CATEGORY	ACRES	TOTAL PERCENT*
Federal Total		41.9
Bureau of Land Management	12,179,711	16.70
Forest Service	11,162,005	15.30
Military	2,754,755	3.78
National Parks	2,581,987	3.54
Bureau of Reclamation	158,464	0.22
U.S. Fish and Wildlife Service	1,715,784	2.35
State Total		13.0
State Parks	8,527	0.01
Local or State Parks	114,919	0.16
Arizona State Land Department	9,287,494	12.73
Arizona Game and Fish Department	36,399	0.05
Tribal	20,107,743	27.57
Other	788	0.00
Private	12,816,413	17.57
County Land	14,577	0.02

*Percentages based on Arizona State Land Department GIS data

(marshes), and stock tanks supply valuable aquatic and riparian habitat and water for wildlife use. The complexity of Arizona's landscape gives rise to a large variety of habitats that support diverse wildlife communities. Arizona ranks third in the nation for the number of native bird species, second for reptiles, fifth for mammals, and eighth for overall vertebrate animal diversity (Stein et al. 2000). Wildlife that reside in or regularly migrate through Arizona include 32 species of amphibians, 297 species of birds (not including accidental and casual migrants), 72 species of fish, 164 species of mammals, 145 species of reptiles, and more than 20,000 species of macro-invertebrates. Each of these species has associated habitat needs—shelter from the elements and predators, food and water, and materials and locations for nesting or raising young.

The U.S. Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Department of Defense manage the largest portion (42%) of lands in Arizona. Most of these federal lands are unlikely to be subdivided and developed for commercial or residential uses (Table 1). Most Forest Service and Bureau of Land Management lands allow multiple-use activities associated with recreational and economic pursuits. Federal agencies work under a variety of laws and policies that mandate conservation of wildlife.

Tribal governments manage 28 percent of the land in Arizona (Figure 1). Each tribe is a sovereign nation, not subject to state jurisdictions.

The Arizona State Land Department manages 13 percent of the land. Under state law, these State Trust lands are managed, leased, sold, and traded to provide revenue to support education in Arizona. The lands are primarily leased for commercial purposes or occasionally sold for private development.

Private lands comprise 18 percent of Arizona's total area with concentrations near river corridors, watersheds, and other locations that also have important resources for wildlife. Because aquatic and riparian habitats are critical to much of Arizona's wildlife, private landowners must play a large role in preventing the introduction and spread of invasive species.

The rate of population growth in Arizona is among the highest in the nation. From 2000 to 2007, the population grew 24 percent from 5.1 million people to 6.3 million (U.S. Census Bureau 2007). In particular, the desert urban centers of Phoenix and Tucson are growing rapidly, but development

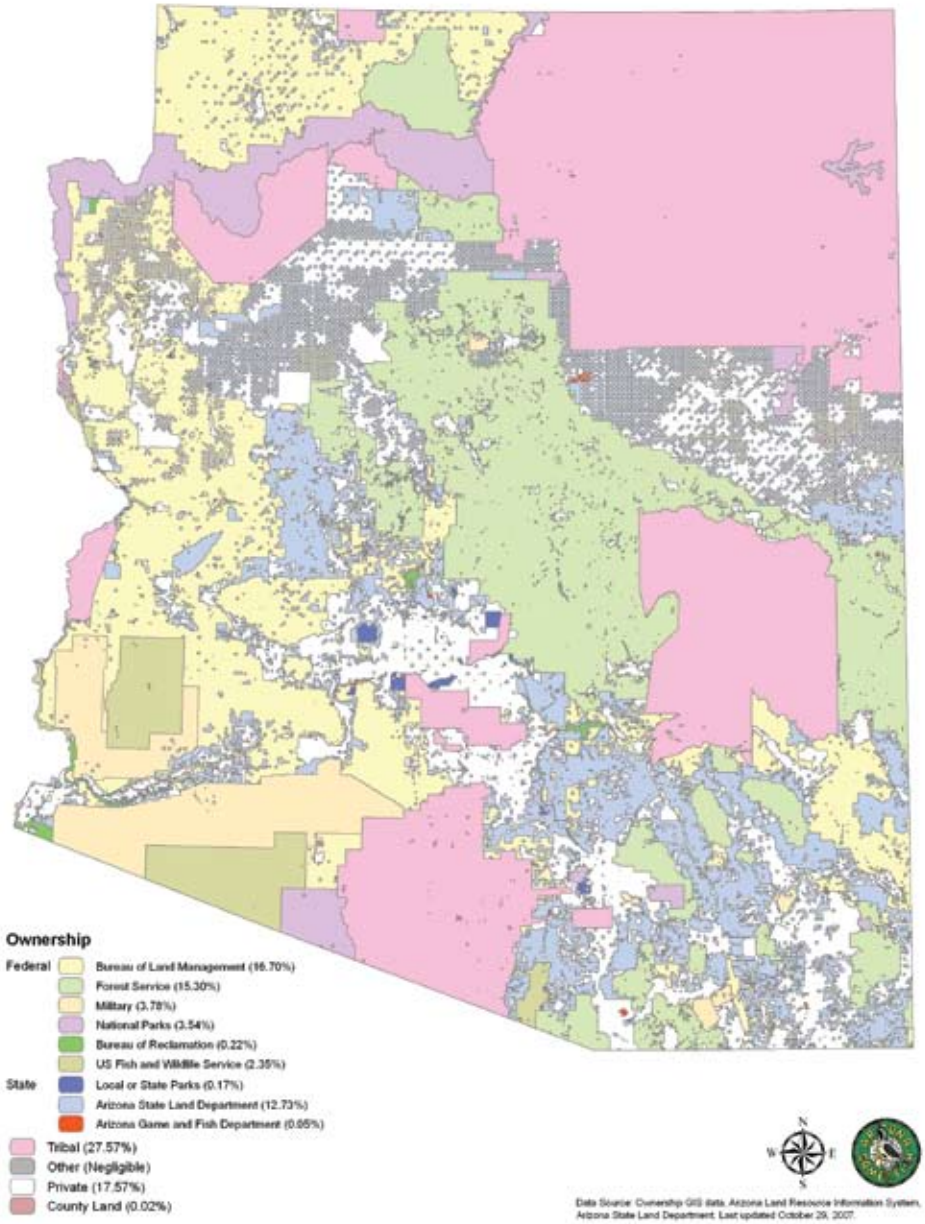


Figure 1. Arizona Land ownership percentages as determined from the Arizona Land Resource Information, Arizona State Land Department, 2007.

is also occurring in rural areas throughout the state. Increases in human population correlate directly with invasive species introduction and spread.

The state's rapid population growth, favorable climate and large amounts of public land and open space produce ever-increasing outdoor recreational pressures. Creative and proactive management is required to reduce stress to wildlife and natural habitats while ensuring quality outdoor recreation opportunities for people.

Arizona's natural ecosystems have been affected by numerous land management actions and human activities throughout the state's history. By the early 20th century, mining, ranching and agriculture had become vital components of Arizona's economy. With the establishment of national forests, parks, and monuments by the federal government, tourism boomed. Over time, regulated hunting and fishing overshadowed subsistence harvesting of wildlife. Other outdoor recreational pursuits increased as well, especially after World War II, when Arizona's population growth accelerated.

Many current invasive species concerns are related to the legacy of early use and stewardship of Arizona's landscapes. Invasive species impacts are growing at a rapid rate and their scale covers enormous areas.

KNOWN PROBLEMS AND CONCERNS

Many ecologists have acknowledged the problems caused by invasion of non-native species into communities or ecosystems and the associated negative effects on global patterns of biodiversity (Stohlgren and others 1999). Once established, invasive species have the ability to displace native plant and animal species (including threatened and endangered species), disrupt nutrient and fire cycles, and alter a community's character by

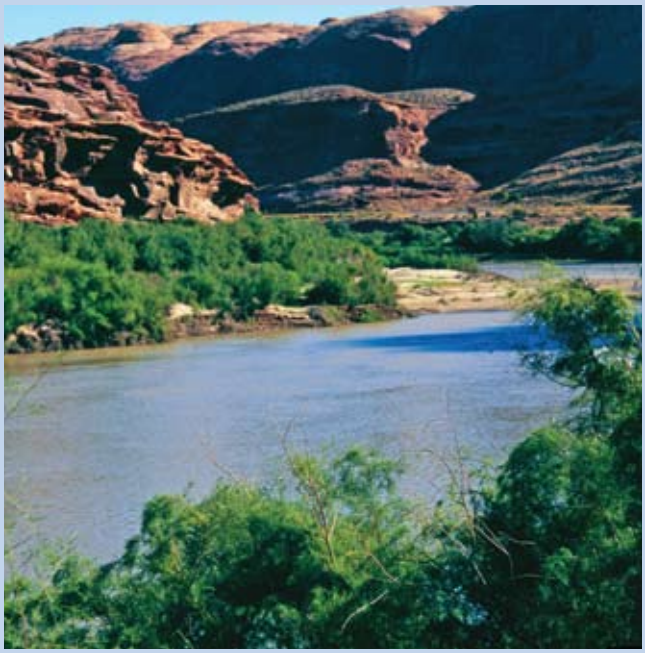
enhancing additional invasions (Cox 1999, DeLoach and others 2000, Zavaleta and others 2001, Osborn and others 2002). By 1998, non-native invaders were implicated in the decline of 42 percent of species listed under the federal Endangered Species Act (Center for Wildlife Law 1999). Presidential Executive Order 13112 (Federal Register 1999) established the National Invasive Species Council in 1999 to provide national leadership in addressing invasive species problems.

In Arizona invasive species concerns are twofold: how to deal with those that are already established here, and how to prevent new invasions. For species that are already here, concerns about their invasiveness and spread across Arizona's ecosystems are forefront. Much time and effort will be required to stop their spread and develop strategies to control if not eliminate them. In cases where the problem is expected to persist, resource managers must enter into the realm of long-term control and management; often a costly and resource consumptive undertaking which must go hand in hand with outreach and education. When a new invasive species reaches North America, there is always a chance that it could make its way to Arizona. Several such species are threatening the state's borders right now, and land and resource managers must keep constant vigil (Table 2). Anticipating and preventing their invasion requires strategic planning that, again, must include outreach and education. To minimize impacts to the environment and economy, prevention is the most desired approach, and long-term planning must be the top priority.

CONTROL AND MANAGEMENT CHALLENGES

Invasive species have a variety of negative impacts on the state's biodiversity, and can affect native species through competition, predation, introduction of disease and parasites, hybridization, and other factors (Tellman 2002). Once present, an invader can change community and ecosystem functions and structure, and in many cases, can present significant management challenges. Solutions are not always clear cut; land and resource managers must often

Extensive areas of lowland riparian habitats in Arizona and elsewhere in the Southwest have been modified or altered due to the highly invasive saltcedar from Asia. Some bird species, including the federally endangered southwestern willow flycatcher, have adapted to using saltcedar in addition to native willows and cottonwoods for nesting and cover; however, many other birds have not adapted to saltcedar, and their populations and range have declined with its spread. Saltcedar increases soil salinity which inhibits the establishment of cottonwood and willow seedlings. Some invaded drainages have been altered so severely that without special treatments, they will no longer support cottonwoods and willows even after successful saltcedar removal. Therefore, any plan that addresses saltcedar removal should include alternatives that lead to the establishment of native riparian habitat.



STEVE DEWEY, UTAH STATE UNIV.

STEVE DEWEY, USU

Saltcedar often form dense monotypic stands sometimes more than 3 meters high, frequently excluding most other native riparian vegetation

Table 2. Current invasive species threats and their status in Arizona.

PLANT/ANIMAL/DISEASE AGENT	STATUS	COMMENTS
Asian Influenza	P	Vectored by invasive mosquitoes
Asian Long-horned Beetle	P	
Buffelgrass	CM	An extensive control and management program currently underway in Pima County
Bullfrogs	CM	
Cactus Moth	P	Current trapping program
Cheatgrass	CM	
Chronic Wasting Disease	P	
Chytridiomycosis	CM	
Citrus Pests	P	Occasional interceptions requiring small scale rapid response.
Collared Dove	CM	Listed as a game bird with AGFD
Cow Birds	CM	
Crayfish	CM	Current control measures implemented.
Dengue Fever	P	Vectored by invasive mosquitoes
European Starling	CM	
Fruit Flies	P	Current trapping program
Giant Salvinia	CM	Biological control measures implemented in Yuma County.
Gizzard Shad	CM	
Glassy-winged sharpshooter	P/RR	Current eradication program exists in Sierra Vista
Hydrilla	P/RR	Past infested sites under monitoring

This list, while not exhaustive, demonstrates the wide range of species and their current status: Prevention (P); Rapid Response (RR); Control and Management (CM).

make critical decisions when dealing with invasive species control and management. The case of saltcedar and the southwestern willow flycatcher is an example. During the past century, extensive areas of native lowland riparian habitats in Arizona and elsewhere in the Southwest have been lost due to human-caused hydrological changes and have subsequently been replaced with several highly invasive plant species, particularly saltcedar *(Tamarix* spp.). Saltcedar invasions follow some form of disturbance, generally one that alters drainage flows, such as groundwater depletion, dam construction or other types of water diversions. In these altered drainages, saltcedar often forms dense monotypic stands sometimes more than 3 meters high.

The saltcedar is fire adapted, and repeated burns encourage denser and thicker growth while at the same time reducing or eliminating the more fire-sensitive native species such as cottonwoods and willows. With hydrological change in many of Arizona's drainages, soil salinity has also increased which reduces the establishment of willow and cottonwood seedlings, often simultaneously promoting establishment of saltcedar. While some bird species, including the federally endangered southwestern willow flycatcher *(Empidonax traillii extimus)*, have locally taken advantage of saltcedar stands for nesting and cover, many others have not, and their populations and range have declined as saltcedar has replaced their native riparian woodlands.

Because of the extensive loss

Table 2 continued.

PLANT/ANIMAL/DISEASE AGENT	STATUS	COMMENTS
Imported Nursery Stock Pests	P/RR	This is an extensive list of known pests that continually changes.
Inland Silverside	CM	
Japanese Beetle	P	Current trapping program
Light Brown Apple Moth	P	Current trapping program
Mosquitoes (various species)	P / CM	Vectors of diseases and pathogens
New Zealand Mud Snail	CM	
Quagga Mussel	CM	Containment measures implemented
Rabies	CM	Requires control and management of vectors
Red Brome	CM	
Red Imported Fire Ants (RIFA)	P/RR	Periodically RIFA are detected on commercial vehicles bound for Arizona.
Red Palm Mite	P	
Saharan Mustard	CM	
Saltcedar	CM	Various control measures in selected areas of the state.
Silver Carp	P	
Snakehead	P	
Non-native Tiger Salamander	CM	
Viral Hemorrhagic Septicemia (VHS)	P	Vectored by invasive mosquitoes
West Nile Virus	RR/CM	Rapid Response required following outbreaks
Whirling Disease	P / RR	
Zebra Mussel	P	

GEORGE ANDREJKO, AGFD

The southwestern willow flycatcher has adapted to using saltcedar for nesting and cover, but many other birds have not, which appears to be contributing to their decline.

of native riparian habitats and subsequent decline of many birds and other wildlife that depend on them, efforts have increased to reduce or remove saltcedar from southwestern drainages. There is concern, however, that these actions might further threaten populations of riparian bird species that successfully nest in saltcedar, such as the southwestern willow flycatcher. This scenario creates quite a challenge for land managers. The hydrology and salinity of some invaded drainages have been altered so severely that without special treatments, they will no longer support native cottonwoods and willows even after successful saltcedar removal. By effectively eliminating any tall, dense riparian vegetation, the result may be the ultimate decline of species such as the southwestern willow flycatcher. Therefore, plans that address saltcedar removal need to include alternatives that lead to the establishment of native riparian habitat.

INVASIVE PLANTS

Among the most harmful invasive plants in southern Arizona are African buffelgrass *(Pennisetum ciliare)*, red brome *(Bromus rubens)* and Saharan mustard *(Brassica tournefortii)*. They tend to grow in high densities and carry wildfires in desert habitats, resulting in wholesale changes in vegetative communities (McAuliffe 1995, Esque and Schwalbe 2002). The Arizona-

Sonora Desert Museum refers to Saharan mustard as "the worst invasive plant in the Sonoran Desert," primarily because of its competitive effects on other plants and its ability to carry fire. Structural differences that occur in desert habitats have unknown effects on reptiles, birds and small mammals, and the Arizona Game and Fish Department is initiating monitoring programs to examine some of those effects on desert lizards. Various websites, including the Invaders page at the Arizona-Sonora Desert Museum site (http://www.desertmuseum.org/invaders/), provide extensive information about these plants.

Invasive riparian and aquatic plants are also having a negative impact on biodiversity. Saltcedar *(Tamarix* spp.), which has invaded many river banks in southern Arizona, alters riparian communities, including bird, mammal and fish diversity (Kennedy and others 2005). Giant salvinia *(Salvinia molesta)* described as the world's worst aquatic weed, alters aquatic ecosystems. As the mature plants weave themselves into thick, floating mats, they block oxygen and light from the water. Native macrophytes (aquatic plants) and microscopic algae that form the base of the food chain die, the animals that feed on this plant life die, and so on up the food chain. This plant has become a problem on the lower Colorado River.

The Southwest Exotic Plant Information Clearinghouse, a cooperative effort among the U.S. Geological Survey, the National Park Service and Northern Arizona University, has organized comprehensive information on non-native plant species in the Southwest on one Web location (http://www.usgs.nau.edu/SWEPIC/index.asp).

"Increases in human population correlate directly with invasive species introduction and spread."

INVASIVE ANIMALS

Non-native aquatic species have considerable effects on all aquatic fauna in Arizona's aquatic habitats. Invasive aquatic species include bullfrogs, crayfish, and non-native fishes (Rosen and Schwalbe 1995, Fernandez and Rosen 1996, Rosen and Schwalbe 1997, Kiesecker and others 2001, Light 2003). Fernandez and Rosen (1996) documented wholesale alteration of a stream community in the White Mountains of Arizona. In terrestrial habitats near urban areas, landfills, recreational areas, and other areas modified by human activities, starlings, cowbirds, and ravens may displace native bird species (Kristan and Boarman 2002). Non-native bees are also replacing native pollinators and potentially impacting vegetative communities (Schaffer and others 1983).

One of the most recent invasive species to make its way to Arizona is the quagga mussel, cousin to the well known zebra mussel that took over the Great Lakes with infestations spreading throughout the Midwest. The quagga mussel *(Dreissena bugensis)* is a very successful and disruptive invader. It can survive and reproduce in a wide range of habitats and environmental conditions, producing 40,000 eggs per breeding cycle with multiple cycles every year. It has microscopic veligers (larvae) that can pass through filters and strainers and remain suspended in the water column for up to four weeks. It has a tendency to aggregate and form massive colonies, attaching to both hard and soft substrates. And it filters large amounts of water (up to one liter/individual/day).

A quagga invasion alters the aquatic environment in ways that have direct impacts on wildlife and water uses. By consuming significant amounts of phytoplankton they can disrupt the ecological balance of entire bodies of water and eventually impact and alter both our native and sport fisheries. There is also mounting evidence that they filter

and concentrate Type E botulism and other toxins from the water, and pass them up to higher trophic levels eventually affecting fish-eating birds.

Quagga attach themselves to hard surfaces with byssal threads, creating an environment that accelerates pitting and corrosion. As a result, lake and river structures such as bridges, docks and navigational equipment require more frequent cleaning, maintenance, and replacement due to the corrosion and the increased weight of the mussel aggregation. Water intake structures that supply water for municipal and agricultural uses are at risk from increased hydraulic roughness and clogging. Besides directly plugging these intake structures, quagga can also restrict cooling water for pumps, engines and power plants.

Quagga mussels are native to the Dnieper River drainage in eastern Europe. They arrived in the United States by ballast water discharged into the Great Lakes in 1989. They were first discovered in Arizona in Lake Mead on January 6, 2007. How they entered Lake Mead is unknown, but most likely they were transported on the hull of a recreational boat.

Quagga are currently found in Lake Mead, Lake Mohave, Lake Havasu, the Colorado River below Lake Havasu, the Central Arizona Project canal (CAP) and Lake Pleasant. The hydrologic connections with these infected waters will allow the quagga to expand its range into the lower Colorado River and Mexico.

The CAP takes water from Lake Pleasant and delivers it to Salt River Project (SRP) canals; this water is then delivered for municipal, agricultural and industrial use in central Arizona and to many public and private urban lakes in the Phoenix

Quagga mussels, which were discovered in Lake Mead in 2007, have spread to lakes Mohave and Havasu, the Colorado River below Lake Havasu, the Central Arizona Project canal and Lake Pleasant. They produce 40,000 eggs per breeding cycle with multiple cycles each year. Adults form massive colonies that can damage bridges, docks and other structures and clog intake pipes. They consume significant amounts of phytoplankton disrupting the ecological balance of entire water bodies. There is also evidence that they filter and concentrate botulism and other toxins from the water and pass them up to higher levels eventually affecting fish-eating birds.

Coordination and planning are critical in developing statewide and watershed level strategies to address the quagga mussel issue in Arizona. Infected waters must be isolated and the quagga contained. A cooperative effort among recreational water users, commercial ventures, government agencies and organizations can achieve this goal.

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BRIAN MCGREW, ADA

Quagga mussels infest new waters by hitching rides on watercraft. The microscopic larvae are transported in bilges, live wells, bait buckets or any other equipment that holds water.

metropolitan area. The lakes that are supplied by SRP canals, along with Saguaro, Canyon and Apache lakes on the Salt River, should be protected from quagga invasion by golden alga *(Prymnesium parvum)*, another invasive species that produces a toxin that kills aquatic organisms.

Arizona's high elevation, small watershed lakes typically do not have the amount of calcium the quagga requires for shell formation, and so the mussel is unlikely to become established at nuisance levels there. The lower elevation, higher risk lakes are Alamo, Bartlett and Roosevelt.

The primary method of their overland dispersal is through human-related activities. Adult quagga have the ability to attach to hard surfaces and survive out of water, which allows them to infest new waters by hitching rides on watercraft. The microscopic larvae can be transported to new waters in bilges, live wells, bait buckets or any other equipment that holds water.

Little can be done to stop the downstream spread of quagga from infected waters, but these waters can be isolated and the quagga contained through a cooperative partnership between recreational water users, commercial ventures and government agencies and organizations.

Organizational coordination and planning are crucial in developing statewide and watershed level strategies to address the quagga issue in Arizona. The participating organizations that are currently working on these strategies are the Arizona Game and Fish Department, Maricopa County Parks and Recreation, U.S. Forest Service, Central Arizona Project, Bureau of Reclamation, Salt River Project, U.S. Fish and Wildlife Service, 100th Meridian Initiative and others. Their work is critical in providing effective direction and resources to encourage voluntary public assistance in restricting the spread of quagga mussels. Educational outreach, enforcement and monitoring are key components to successful quagga management in Arizona.

DISEASES, PATHOGENS, AND PARASITES

Invasive animal or insect species may lead to the introduction or the emergence of certain infectious diseases. Experts believe that the introduction of plague into the United States in the early 1900s occurred at ports via infected rats and rat fleas aboard ships from Asia. Outbreaks in rats and subsequent human epidemics followed. *Aedes albopictus* (Asian tiger mosquito) and *Aedes aegypti* are invasive mosquito species that are competent vectors for two diseases which are not considered endemic to Arizona: dengue and yellow fever. *Aedes aegypti* was found in Arizona in the 1930s and 1940s, but then disappeared from the state. It was reintroduced in the early 1990s and has since

become established in several counties. The Asian tiger mosquito is an invasive species that was first identified in Texas in 1985 and has since spread to 25 states. It has been introduced twice into Arizona since 2000. Control measures were implemented at the local level to monitor and eradicate this mosquito threat. If the Asian tiger mosquito becomes established here, the combined presence of both Aedes mosquito species would increase the risk of dengue and yellow fever becoming endemic to Arizona.

Around the world, recent emergence of infectious diseases such West Nile virus, HIV, hantavirus, avian influenza, Lyme disease, and bovine spongiform encephalopathy ("mad cow disease") started in animal species but spread to humans, either as direct zoonoses or through vector transmission. The spread of these diseases illuminated the links between animal health and human health. Just as clearly, most of these diseases illustrate the large-scale disease threats that face wildlife populations even when they do not immediately spread to humans. All of the diseases listed above became outbreaks in association with human alteration of ecosystems.

Native frog populations have been decimated by the introduction of the fungal disease, chytridiomycosis, whose ultimate origin still remains unknown. Introduced species such as bullfrogs, African clawed frogs and non-native tiger salamanders (introduced for the bait trade) may harbor chytridiomycosis, yet they experience few symptoms of the disease (see for example, Bradley and others 2002).

Whirling disease in trout *(Oncorhynchus* spp.*)* has led to adoption in Arizona of a "no tolerance" policy that bans the stocking or importation of fish infected with whirling disease, although the potential for accidental introduction still exists.

BAIT-BUCKET DUMPING AND ILLEGAL STOCKING

Non-native invasive species that have been released both legally and illegally have harmed aquatic systems and riparian species in Arizona. Crayfish and other baitfish were introduced via recreational fishing activities and now compromise the persistence of many aquatic-obligate species (Fernandez and Rosen 1996). Release of non-native tiger salamanders for use in the bait trade threatens native populations.

FERAL ANIMALS

Escaped or abandoned domesticated pets, farm stock, and equines are severely impacting wildlife and wildlife habitats.

GEORGE ANDREJKO, AGFD

Non-native tiger salamanders, which were introduced for the bait trade, may harbor chytridiomycosis, a fungal disease that has decimated native frog populations.

Horses, burros, goats, domestic sheep, and hogs may overgraze or trample native plant species, thus increasing erosion, compacting soil through frequent trail usage, and polluting aquatic systems through waste accumulation. Feral cats are responsible for the deaths of thousands of birds in the United States each year (audubon.org/local/cn/98march/cats.html). The growing wildland-urban interface exposes wildlife to domestic and feral animals that are potentially infected with diseases such as West Nile virus, rabies, hantavirus, pasturella pneumonia, and sylvatic plague and may contribute to the spread of these diseases.

HYBRIDIZATION

Hybridization threatens the genetic integrity of native species, particularly those inhabiting

aquatic ecosystems, such as Apache trout and Gila trout, through interbreeding with non-native related species (Carmichael and others 1993). Hybridization with non-native tiger salamanders, often imported for use in the bait trade, has been identified as a threat to endangered Sonoran tiger salamanders (Collins and others 1988).

Additional examples of the challenges associated with invasive organisms in Arizona are presented in case Studies of Species-Specific Issues and Management Challenges, page 19.

THREAT ASSESSMENT OF KNOWN PATHWAYS OF ENTRY AND SPREAD

In order to focus on prevention, known pathways of entry and spread must be evaluated regularly. The National Invasive Species Council Pathways Task Team developed an outline identifying the pathways by which invasive species are introduced. The outline is detailed and comprehensive, and can serve as a valuable tool for evaluating and prioritizing potential risks, but resources are limited. Prevention requires constant vigil at check stations, extensive outreach campaigns to inform and educate, and substantial coordination among agencies and other key stakeholders. Therefore, we must think broadly to prioritize pathways by risk, but act with precision and efficiency to guard against introductions that have the strongest potential to harm Arizona's environment, economy and people.

STOP AQUATIC HITCHHIKERS!™

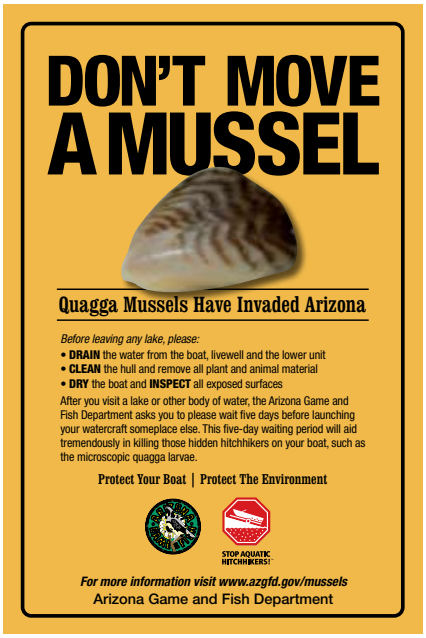
One ongoing effort that focuses on a known pathway is the national "Stop Aquatic Hitchhikers" campaign, which calls on boaters and anglers to help contain the spread of new species to lakes and streams, and to stop the transfer of species between water bodies. The hitchhiker message advises boaters that they could be giving a ride to an unwanted guest hanging onto their boat or trailer and explains what they should do before transporting their boat or other equipment to another lake. Arizona is taking every opportunity to promote this national education campaign.

Signs posted at public and private boat launching ramps lay out three steps that watercraft operators should perform.

- Inspect and remove visible mud, plants, fish and animals before transporting equipment.
- Eliminate water from equipment. Empty bilges, live wells, and pumping equipment that might retain small volumes of water where microscopic animals can survive.
- Do not release plants, fish, or animals into a water body. It is acceptable to empty water, bilge, and plant fragments on land that does not drain directly into a water body.

Introduced waterweeds, such as Eurasian water milfoil, hydrilla, and giant salvinia, have already established in some Arizona lakes and streams. Aquatic plants can reproduce by fragmentation, which means an effective way to prevent their spread is to check thoroughly for and remove any fragments from equipment. The larval stage of the quagga mussel, golden algae, and the spiny water flea are introduced microscopic animals that boats have transported. They can be stopped by taking care to empty water from and dry equipment before using it at another site. Desiccation is an effective method to prevent the spread of these organisms.

Additional steps can be taken to disinfect. Wash equipment with hot water (above 104 degrees) to kill quagga mussel larvae. Full strength vinegar is an equipment-



safe treatment for live wells and bilges to eliminate microscopic hitchhikers that can survive in wet areas.

Invasive species can cause subtle or dramatic changes to the ecology of aquatic environments and affect how we recreate and enjoy them. The campaign emphasizes that it is everyone's responsibility to spread the word and take appropriate actions that will prevent aquatic hitchhikers from going along for a ride.

CASE STUDIES OF SPECIES SPECIFIC ISSUES AND MANAGEMENT CHALLENGES

In some cases, little is known about the biology and impacts of invasiveness organisms. The following case studies offer a sample of what we do know, including the issues and challenges that invasive species present.

BUFFELGRASS AND OTHER SONORAN DESERT ECO-REGION ADAPTED INVASIVE GRASSES

Historically, fires in the Sonoran Desert eco-region occurred once every 350–400 years (Schussman 2006). Now, desert wildlands fires along Arizona's freeways and borders of urban communities are a common occurrence in central and southern Arizona each summer. The increase in fire is fueled by the growing presence of non-native grasses, including buffelgrass, red brome, and fountain grass *(Pennisetum setaceum)*, which have spread quickly along transportation corridors and into the desert from adjacent urban areas (AWIPWG 2005). One of the most pervasive of these grasses, buffelgrass, was historically introduced as livestock feed, and is now commonly found in open areas and along trails and washes throughout the Sonoran Desert (Esque 2006). Human activities such as grazing and new construction near desert areas (Zouhar [in press]), as well as Arizona's warm temperatures, bi-modal rain pattern and summer winds, carry seeds over long distances and promote the establishment (Esque 2006), particularly in heavy monsoon years (Tellman 2002). Lightning strikes and human caused fires can quickly ignite this additional invasive grass fuel load, in areas that historically did not have a naturally occurring fire cycle (Esque 2006), in turn stimulating growth of even more invasive grasses (Tellman 2002).

Buffelgrass and other invasive grasses have the potential to create a severe ecological impact on native species and alter Arizona's desert landscapes as we now know them (AWIPWG 2005). For example, hot, fast moving fires in the Sonoran Desert are a particular threat to slow-growing native plants such as the saguaro cactus *(Carnegiea gigantea)*, prickly pear and cholla *(Opuntia* spp.), and palo verdes *(Parkinsonia* spp.*)*, as well as to native wildlife like the desert tortoise *(Gopherus agassizii)* (Esque 2006). Wildland fires in the Sonoran Desert also pose significant challenge to local communities, governments and agencies, particularly those planning for and managing areas around metropolitan Phoenix and Tucson. Planning for and managing invasive species prior to their arrival, and controlling the spread of those already present (including by developing sound public policies and conserving native plant communities) are the keys to minimizing fire risk in the Sonoran Desert, particularly in areas where excluding the public is impractical and undesirable.

CHEATGRASS IN THE APACHE HIGHLANDS AND COLORADO PLATEAU ECO-REGIONS

In Arizona's semi-arid and montane grasslands, and pinyon-juniper woodlands along the Colorado Plateau, fires have become more frequent, limiting the ability of native plants to recover on their own. Human activities, such as increased urbanization and agricultural use, along with climate change, introduce and facilitate establishment of non-native plants in a given area (Keeley 2003, Erickson 2007), which in turn impacts Arizona's native plant communities.

Historically in Arizona, fire occurred in the pinyon-juniper forests every 60–400 years, in montane grasslands every 2–22 years (Schussman 2006), and in the sagebrush-grasslands every 60–100 years (Randall 1999). In recent decades, fire frequency has increased in some grassland areas, due, in part, to the invasion of non-native plants (Randall 1999), including cheatgrass *(Bromus tectorum)*, Lehmann lovegrass, weeping lovegrass, and Boer lovegrass *(Eragrostis sp.)*, Johnsongrass *(Sorghum halepense)*, and Russian thistle *(Salsola kali)* (Zouhar [in press]). The proliferation of non-native plants into a native grassland will quickly change the local fire cycle, increasing fire frequency from historical levels, to 3–5 year frequencies (Randall 1999). Arizona's pinyon-juniper forests are also highly susceptible to invasion by non-native plants due to their slow seedling recruitment and sparse understory cover (Freiderici 2003), making these forests more susceptible to frequent fires.

Cheatgrass is a well-studied example of a non-native annual grass that out-competes native vegetation in both Arizona's semi-arid grasslands and mature pinyon-juniper woodlands (Erickson 2007; Zouhar [in press]). Cheatgrass thrives

FOREST & KIM STARR, USGS

In recent decades, Arizona's semi-arid and montane grasslands and pinyon-juniper woodlands along the Colorado Plateau have become much more susceptible to frequent fires, in large part due to the invasion of cheatgrass and other non-native grasses. Cheatgrass is a well-studied example of a non-native annual grass that out-competes native vegetation and contributes to the increase in local fire cycles, in some cases increasing fire frequency from historical levels of every 2–22 years, to today's level of 3–5 years. Managing for and responding to fire in an established 3–5 year fire regime is extremely difficult, if not impossible, for Arizona's rural communities, without state or federal assistance. If such a regime were to establish over a wide swath of Arizona's highlands, costs would skyrocket and fire response could become a serious problem. A proactive effort to reestablish native grassland plant communities may be one component of an effective strategy to control invasive plants, because such efforts can prevent an initial invasion.

in disturbed areas after fire (Freiderici 2003, Keeley 2003) including mature forests that historically had little threat from invasives (Keeley 2003). Cheatgrass puts down extensive roots after the winter rains, drawing water and soil nutrients away from native vegetation, and dries out by midsummer (Freiderici 2003). Seeds are easily spread by wind, runoff, animal and human vectors (Freiderici 2003), particularly along transportation corridors. Dry cheatgrass and lightning strikes from summer monsoon rains can be a deadly combination for slower-growing native perennials in Arizona's grasslands and sage brush ecosystems (Randall 1999), as well as to slow-growing and sparely vegetated pinyon-juniper forests (Erickson 2007). A 3–5 year fire cycle makes it impossible for native vegetation to recover, further increasing the prevalence of cheatgrass in the ecosystem (Randall 1999; Erickson 2007).

In addition to loss of native plant communities, managing for and responding to fire in an established 3–5 year fire regime is extremely difficult, if not impossible for Arizona's rural communities, requiring routine state or federal assistance. If a wide-spread 3–5 year fire regime were to establish over a wide swath of Arizona's grasslands, costs would be significant, and fire response would be difficult or impossible in some years.

JOHN M. RANDALL, TNC

Cheatgrass out-competes native vegetation in semi-arid grasslands and mature pinyon-juniper woodlands. It dries out by mid-summer, a ready fuel for lightning strikes during summer storms. Resulting fires are deadly for slower-growing native perennials.

A proactive effort to re-establish native grassland plant communities may be one component of an effective strategy to control invasive plants, because such efforts can prevent non-native plants from invading initially (Zouhar [in press]). For example, studies show that locations where native grasses were present prior to fire were more resistant to invasion by cheatgrass than heavily grazed lands (Zouhar [in press]), suggesting the benefit of restoring grazed areas with native grasses as a preventive measure in managing fire regimes. Accordingly, the most cost-effective strategy to address invasive species problems in Arizona's grasslands and forests is to plan for and manage invasive species, and control the spread of those already present, as well as conserve open spaces for native plant communities.

LEHMANN LOVEGRASS

Lehmann lovegrass *(Eragrostis lehmanniana)* is a perennial warm season grass that was obtained in East Africa by the U.S. Soil Conservation Service in 1932 and subsequently released in 1934 for erosion control and forage (Crider 1945). From 1940 to 1980 it was established by seeding on more than 172,000 acres, and by 1992 had spread to an additional 185,000 acres where it had not been seeded (Halvorson and Guertin 2003). It has proven to be well adapted to the semiarid ranges of the Southwest (Gould 1951), and recently it has become

Lehmann lovegrass

JOHN M. RANDALL, TNC

widespread in northern Sonora, Mexico, and the semi-desert shrub and desert grassland regions of south-central and southeast Arizona (Chambers and Hawkins 2002) and is a common weed in Tucson (Felger 1990).

In recent years, there has been a convincing association between the increasing occurrence of Lehmann lovegrass and a decreasing species richness, alteration of ecosystem processes, modification of community composition, and changes in fire regimes in southern Arizona grasslands (Bock et al. 1986, Anable et al. 1992, Geiger et al. 2003).

Land managers have mixed emotions regarding Lehmann lovegrass because it is an invasive alien species and not considered palatable to livestock (Bock et al. 1986, Kincaid et al. 1959, Voigt et al. 1986), yet it establishes easily on disturbed areas and provides excellent soil cover. Ranchers are faced with incorporating it into grazing management schedules, while at the same time preserve managers are concerned with invasions into native grasslands. While hot fires will kill Lehmann lovegrass plants, new stands will reestablish from seed, and cooler fires have little effect. In addition, where native perennial grasses are killed by fire, Lehmann lovegrass seedlings quickly establish and persist in the area (Ruyle 1988). It becomes obvious that fire alone is insufficient in controlling Lehmann lovegrass, but it could serve as a tool in a control strategy (Brock unpublished). Its advance is retarded somewhat but not prevented by competition from established stands of native grasses, and it establishes quickly in areas where native grasses have been depleted due to the establishment of even a few mesquite trees (Kincaid et al. 1959).

RED BROME

Red brome *(Bromus rubens)* is a weedy annual grass that originated in the Mediterranean. Presently common throughout much of the western United States after having been established in California by 1848, it is seasonably abundant and widespread in the Sonoran (Philips and Comus 2000) and Mojave (Beatley 1966) Deserts. Alien annual grasses such as red brome can have prolific production in years of average to above average precipitation, and together with the alien perennial buffelgrass *(Pennisetum ciliare)* they produce a substantial increase in the fine fuels in the Arizona Upland subdivision of the Sonoran Desert. These invasive grasses have increased the occurrence of wildfires in recent decades, having been relatively uncommon prior to the late 1970s, but which are now expected after

RICHARD OLD, XID SERVICES, INC.

Red brome has been recognized as a principal fuel in the 2005 Cave Creek Complex (Arizona) and Hackberry Complex (California) fires.

Red brome, a weedy annual grass that originated in the Mediterranean, was established in California by 1848. Now common throughout much of the western United States, it is seasonably abundant and widespread in the Sonoran and Mojave deserts. It grows prolifically in years of average to above average precipitation and produces a substantial increase in fine fuel. Wildfires, relatively uncommon prior to the late 1970s, are now expected after winters of above average precipitation. Red brome has a survival advantage over native winter annual species because its moisture and temperature requirements are less exacting for germination, and it has a higher rate of survival after the growing season. It also competes with native desert species for resources such as water, nitrogen and phosphorus.

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single or successive winters of above average precipitation (Esque et al. 2004). Red brome has been recognized as a principle fuel in the recent Cave Creek Complex (Arizona, 2005) and Hackberry Complex (California, 2005) fires.

The requirements of red brome during the growing season match those of native winter annuals. However, it has less exacting moisture and temperature requirements for germination, and along with its consistently higher rate of survival after the growing season it has a survival advantage over native winter annual species (Beatley 1966). In addition to the promotion of wildfires and earlier germination, Red brome also affects native desert species by competing for limiting resources such as water, nitrogen (Brooks 2000) and phosphorus (Yoder and Nowak 2000).

Red brome is especially abundant on overgrazed rangelands where the native perennial grass cover has deteriorated. It is of some forage value, especially for sheep, but has an extremely short period of palatability and is largely ungrazed after the seed heads mature (Burgess 1995, Gould 1951, Humphrey 1956). Thus, it has a negative economic as well as ecological impact.

MALTA STARTHISTLE

Malta starthistle *(Centaurea melitensis)*, also known as tocalote, is a native annual or biennial of Southern Europe where it grows in dry places and disturbed ground. It was introduced to North America in the late 18th century, and is now a pest in most western states, where it grows in a variety of open spaces including disturbed sites, grasslands, rangelands, and woodlands generally below 3,900 feet, often in dense, impenetrable stands, rapidly displacing diverse native vegetation and creating a monoculture, or pure stand. When this occurs, range forage value

is lost as it is of low palatability (Parker 1972, Donaldson and Rafferty 2002, Chambers and Hawkins 2002). A common weed in the Tucson area since 1901, it is suspected to have been introduced to the Southwest in the late 19th century as a contaminant in grain seed.

A successful competitor for space, Malta starthistle displaces both native and agricultural species, threatening the integrity of agricultural and natural ecosystems throughout the world. It is primarily dispersed by livestock, roadside disturbances, contaminated crop seed, disturbances associated with urban development, and especially through vehicular travel (Chambers and Hawkins 2002). Many such invasive plant species are not dominant in their native habitats, but can rapidly eradicate species when introduced in new habitats where they have not evolved as a functionally organized community and where their natural enemies are not present to keep them in check (Callaway and Aschehoug 2000). Malta starthistle is a good example of how an invasive plant species succeeds in dominating new habitats primarily by altering the below surface soil microbiology (Francis and Read 1994, Marler et al. 1999, Callaway et al. 2003).

Little research has been done on the control of Malta starthistle.

AGFD

A recent arrival, Eurasian collared doves are spreading quickly throughout Arizona, and given the history of other introduced bird species, they probably will compete with other doves for food and nest sites.

Traditional mechanical methods, including pulling, grazing, mowing, burning, and cultivation can be used over a period of several years to deplete seed banks and manage infestations. Chemical methods are also effective, but chemicals with no soil residual activity will not prevent seeds in the soil from sprouting. Biological controls hold some amount of promise, and recent research completed in 2001 suggests that a rust that is specific to Malta starthistle may be effective if applied early and heavily, although further research needs to be conducted to confirm these earlier findings (Woods et al. 2001, Donaldson and Rafferty 2002).

EURASIAN COLLARED DOVE

The Eurasian collared dove *(Streptopelia decaocto)* is a medium-sized dove native to Europe and adjacent countries southeast to India. They were first imported to the new world in the Bahamas in the 1970s and 1980s where they escaped to the wild and spread. Eurasian collared-doves first appeared in Florida sometime in the early 1980s and they have since spread to most of the continental United States arriving in Arizona in 2000.

Eurasian collared-doves are aggressive and very prolific doves and successfully compete with smaller mourning and white-winged doves at bird feeders. Given the history of introduced bird species, they probably will compete for food and nest sites with other dove species. They are becoming very common in agricultural habitats and in and around small town and cities throughout Arizona and at all

elevations. If their numbers continue to increase, they may cause damage to small grain crops. Eurasian collared-doves are spreading quickly into rural and semi-urban habitats in Arizona and are here to stay.

In 2007, hunting regulations allowed unlimited bag limits with a year-long open season on these birds. The hunting season will not affect their spread or abundance but the increase in hunting opportunity is at least one benefit from this introduced bird.

EUROPEAN STARLING

European starlings *(Sturnus vulgaris)* were introduced to Central Park in New York City in the 1890s as a tribute to William Shakespeare. These robust, aggressive, adaptable birds have since spread throughout the North American continent arriving in Arizona in the 1940s. Starlings nest in cavities, which they must find since they are incapable of excavating nesting cavities on their own. European starlings will loiter by a nest occupied by another bird, and when that bird leaves, destroy any existing eggs or young and defend the cavity against its previous occupant. As such, they are successful nest competitors and will drive native birds out including woodpeckers, bluebirds, and cavity nesting flycatchers. During the non-breeding season,

GEORGE ANDREJKO, AGFD

they form large flocks and can have substantial local impacts on many native bird species. In large numbers they can also damage agricultural crops and lawn reseeding efforts.

Like many exotic birds, starlings are most abundant around areas disturbed by humans such as agricultural areas and cities. As Arizona becomes increasingly urbanized, starling numbers are likely to increase. Hunting seasons allow for unlimited take of starlings year round although this does little in impacting population numbers.

BULLFROGS

Their bellowing "jug-o-rum" mating call is a sound so familiar to many of us, that we logically assume that to hear it in Arizona is perfectly natural. It is not. Like many invasive species, bullfrogs have become so common that we might forget that they do not belong here. They are native to the central and eastern United States, though they have been introduced widely throughout the western states and elsewhere in the world, primarily for food.

Bullfrogs are incredible eating machines, capable of consuming anything they can cram into their considerable mouths. They have a highly variable diet, which includes vegetation, earthworms, leeches, insects, centipedes, millipedes, spiders, scorpions, crayfish, snails, numerous species of larval and metamorphosed amphibians, fish, small alligators, turtles, lizards, numerous species of snakes [seven genera; including

GEORGE ANDREJKO, AGFD

In their native habitat, bullfrog populations are controlled by predators such as alligators and large snakes. In Arizona they have few predators and even their tadpoles are not palatable to most fish.

six species of gartersnakes, two species of rattlesnakes, and Sonoran gophersnakes *(Pituophis catenifer affinis)*], small mammals (e.g., chipmunks, cotton rats, shrews, mice, and voles), numerous species of birds, bats, muskrats, and even juvenile mink (Bury and Whelan 1984; Clarkson and DeVos 1986; Holm and Lowe 1995; Carpenter et al. 2002; King

et al. 2002; Hovey and Bergen 2003; Casper and Hendricks 2005; Combs et al. 2005; Wilcox 2005). They are a primary factor in the precipitous decline of native leopard frogs and the Mexican and narrow-headed gartersnakes, largely through direct predation on those animals and their prey species.

To make matters worse, bullfrogs often harbor a fungal disease that is typically fatal to many species of Arizona frogs. The disease has also been implicated in frighteningly rapid declines of amphibians worldwide, including several of our native leopard frogs and their relatives. Unfortunately, bullfrogs do not appear to be susceptible to the disease, and instead can serve as reservoirs, passing it on to native amphibians. Thus, even when bullfrog numbers are low and their activities are not a direct threat, bullfrogs can indirectly cause the demise of our native frogs.

CRAYFISH

There are no native crayfish in Arizona. Although this might seem surprising to many, especially as widespread and common as crayfish have become in our state, the statement itself is a warning about the impacts crayfish might have on Arizona's aquatic communities. In fact, many native Arizona species are in imminent danger of being eliminated from vast areas, because crayfish have occupied their habitats. The ability of crayfish to move considerable distances and/or remain entombed in the soil after a water body dries, makes them considerably more difficult to eradicate from areas after they have become established.

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Although crayfish are widespread in Arizona, they are not native to the state and have no natural predators. Many native species are in danger of being eliminated from vast areas, because crayfish have occupied their habitats.

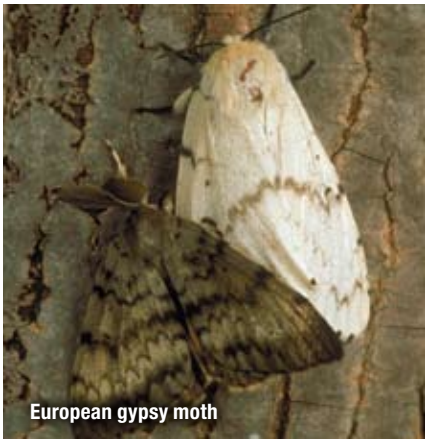
Our native aquatic plants and animals have no natural defenses against crayfish, who themselves are voracious predators that eat—well, almost anything. When crayfish move into a stream, pond or marsh, they prey upon the easy food items, usually insects, snails and other invertebrates. With abundant food and no natural predators, crayfish populations typically sky rocket. Soon, their invertebrate foods are gone. Undeterred, the crayfish moves on to larger prey, including tadpoles, fish, frogs, and gartersnakes. Large crayfish will even consume young turtles. Soon, the crayfish has completely eliminated its animal food base, so it turns to plants, shredding and ripping them from the stream bottom. Before long, vibrant, complex aquatic communities have become muddy and lifeless—except for crayfish.

At this point, one might expect the crayfish population to crash in response to overcrowding and lack of food. But, the tragic reality is that at this point they turn to cannibalism. The big crayfish eat the little crayfish, and because they are well fed, they produce lots of offspring, more food for themselves and other crayfish. Thus, once crayfish colonize an aquatic habitat, the result is reduced productivity for everything but the crayfish, with little hope for recovery, without help.

EUROPEAN GYPSY MOTH

Introduced in Massachusetts in 1869, the European gypsy moth (*Lymantria dispar* L.) is one of the most destructive defoliators of hard and softwood trees. Gypsy moth caterpillars feed on the leaves of more than 500 species of trees and shrubs. The European gypsy moth has been established for more than a century in the northeast United States and neighboring parts of Canada.

Multiple federal agencies, state


European gypsy moth

USDA/APHIS

agencies and universities have embarked on a project called "Slow the Spread." This project's goal is to slow the natural spread of the gypsy moth by using integrated pest management (IPM) strategies. The project defines the extent of the gypsy moth infestation and limits its artificial spread beyond the infested area through quarantine and an active regulatory program. This program, an extremely effective Animal and Plant Health Inspection Service, U.S. Forest Service, and state partnership, prevents the establishment of gypsy moth in areas of the United States not contiguous to currently regulated infested areas. Surveys in Arizona detected European gypsy moth in the past but no established populations were ever found.

SIREX WOOD WASP

An invasive pest of pine trees recently entered the United States with the potential to cause significant mortality to pine trees across the country. Sirex wood wasp, *Sirex noctilio*, a major pest of pine, attacks healthy trees and in the Southern Hemisphere produced 80 percent pine mortality. This wasp has recently been found in New York, Pennsylvania, Michigan, Vermont, and Ontario, Canada. It could spread to all pine habitats in the United States. Sirex kills pines through the injection of toxic mucus and a symbiotic wood fungus at the same time that it

Sirex wood wasp

DAVID R. LANCE, USDA/APHIS

lays its eggs. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, with the cooperation of the U.S. Forest Service and state governments, developed a response to slow the spread of this wasp. Survey, regulatory actions, and a treatment program using biological control measures are employed to find the leading edge of the infestation, prevent artificial movement, and limit damage. Early detection traps are in place in Arizona allowing for a rapid response if this pest is discovered.

ASIAN TIGER MOSQUITO

The Asian tiger mosquito *(Aedes albopictus)* is an invasive species that was first identified in Texas

Asian tiger mosquito

SUSAN ELLIS

in 1985 and has since spread to 25 states. This aggressive biter is a competent vector for diseases such as dengue, West Nile virus, St. Louis encephalitis, and others. It breeds in backyard containers (e.g., buckets, pots, coolers, etc.) and car tires. Its eggs have been spread into new areas by people moving backyard containers, by businesses transporting new or used tires, and via the plant trade (e.g., lucky bamboo). Asian tiger mosquitoes have been introduced twice into Arizona since 2000 via non-native plants purchased over the Internet (banana plants from Florida and volcano plants from a Texas distributor). In both cases, intensive surveillance and control measures were implemented at the local level to monitor and eradicate this mosquito threat. Future introductions are likely.

ASIAN CITRUS PSYLLID/CITRUS GREENING

Citrus greening poses a serious potential threat to both Arizona's residential and commercial citrus;

DAVID HALL, USDA/ARS

it causes infected trees to yellow, decline, and possibly die within a few years. This disease infects most citrus species, hybrids, and cultivars. Infected trees produce fruit that does not ripen properly, is misshapen and bitter in taste. The Asian citrus psyllid is the vector of citrus greening.

LIGHT-BROWN APPLE MOTH

A non-native moth that was recently discovered in California; the larva feeds on a variety of

DAVID WILLIAMS

plants important to Arizona, including alfalfa, apple, *Brassica spp*., grape, citrus, eucalyptus, pyracantha, and privet.

PECAN WEEVIL

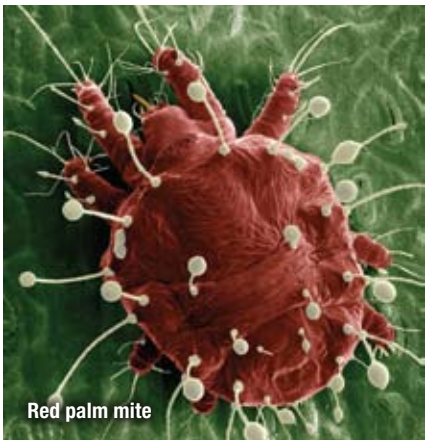
Attacks the pecan nut, causing serious crop loss. The larvae

CLEMSON UNIVERSITY/USDA

(grubs) develop inside nuts and destroy the entire kernel by their feeding process. The nearest infestation of pecan weevil is in New Mexico.

RED PALM MITE

A pest of several important ornamental and fruit producing palm species; host plants include areca, date, and queen palms. It causes serious leaf damage,



ERIC ERBE, CHRIS POOLEY USDA/ARS

ruining the ornamental value of palms. The pest appeared in Puerto Rico in 2006, and researchers expect it to establish in Florida. Wind currents and the movement of infested nursery stock easily distribute this mite.

USDA APHIS PPQ

ASIAN LONGHORNED BEETLE

This unwanted pest is a threat to urban landscapes. The larval or grub life stage kills young and mature trees by tunneling within the trunk and branches, disrupting sap flow and weakening or killing the tree.

JAPANESE BEETLE

The Japanese beetle defoliates ornamental plants and destroys turf roots resulting in decline or

DAVID CAPPAERT, MICH. STATE UNIV.

death. It threatens the quality of golf courses, parks, and lawns, and export potential of Arizona's green industry. Three of Arizona's neighboring states (Colorado, Utah, and New Mexico) are battling infestations of Japanese beetle.

CACTUS MOTH

The Cactus moth *(Cactoblastis*

cactorum) is a significant threat to prickly pear cactus in Arizona. This pest attacks all species of prickly pear cacti *(Opuntia*

Cactus moth

PEGGY GREB, USDA/ARS

spp.) in North America and can completely destroy a cactus plant. Larvae burrow into the pad to feed, and then move to other pads before pupation.

CASE STUDIES HIGHLIGHTING CHALLENGES AND SUCCESSES

Some challenges may seem particularly daunting, but there are also successes to report. The case studies presented below describe some challenges we have barely begun to tackle and some examples of people working together to meet a challenge.

RED IMPORTED FIRE ANT

Since 1988 The Arizona Department of Agriculture has successfully kept a highly

Red imported fire ant

SCOTT BAUER, USDA/ARS

invasive pest, the red imported fire ant, from invading Arizona's agriculture, recreation, and residential communities by aggressively monitoring and surveying high risk pathways and initiating rapid response measures when necessary. This pest has caused severe impacts to the economy and ecology from North Carolina to Texas and in parts of New Mexico and California. Much of Arizona could feel irreparable impacts if this species of ant were to establish a foothold in the state, including the nursery industry facing greater restrictions to conduct business, farmers seeing crop loss, livestock loss affecting ranchers, impacts to some species of threatened or endangered animals, human health concerns over potential allergic reactions to painful stings, and home owners facing added pest control costs to eliminate this threat from their property. Arizona will continue to take a proactive stance on the exclusion of this pest from the state and protecting its natural resources and economy.

FRUIT FLY

In particular, many foreign nations are concerned about the fruit fly complex. Fruit flies, much like a wormy apple, cause citrus fruit to be cosmetically unacceptable to consumers and increase spoilage in commercial storage.

The Arizona Department of Agriculture Fruit Fly Detection Program, supported in part through a United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) grant, involves monitoring nearly 2,870 traps placed statewide and currently meets or exceeds the National Exotic Fruit Fly Trapping protocol. To date, the department's efforts have achieved the result that no fruit flies of concern have been detected in the state.

Fruit fly

JACK DYKINGA, USDA/ARS

Each year Survey and Detection program leaders evaluate fruit fly detection endeavors, with an eye for efficiency, using the most current accepted techniques in the industry. In FY 2007, department inspectors continued to use all internationally accepted lures and trapping arrays and techniques for a highly efficient detection strategy for all fruit fly species of concern. Add to this an ongoing training process for fruit fly trapping personnel and a focused quality control system, and the result is that Arizona citrus, both commercial and residential, is assured of appropriate protection from a debilitating infestation of these destructive pests.

NUT PEST MONITORING

The nut industry, including pecans, pistachios, and walnuts, is a fast growing agricultural industry within Arizona. Production acreage continues to grow annually, with more than 2,000 acres of new production expected in southeastern Arizona in the coming year. Several devastating pests exist within the nut producing states surrounding Arizona, but Arizona still enjoys a pest free status with regard to them. The Arizona Department of Agriculture has developed and implemented a detection strategy to monitor for the introduction of several of these pests, including the hickory shuckworm, the pecan nut casebearer, the pecan weevil and the walnut husk fly. Trapping key groves and inspecting cleaning facilities are two key components in the strategy.

Hand in hand with producers and industry representatives, the department is leading this proactive endeavor to keep Arizona-produced nuts free from pests of export significance, making Arizona-produced nuts a commodity that is desired by many in this important export market.

BUFFELGRASS STRATEGIC PLAN WORKING GROUP: A MODEL PROGRAM FOR SUCCESSFUL AND COORDINATED MULTI-JURISDICTIONAL MANAGEMENT

The Buffelgrass Working Group is a formalized group including representatives of jurisdictions, agencies and organizations who have contributed financially to regional buffelgrass control efforts through the Cooperative Ecosystem Study Unit (CESU). Among the partner members of the Working Group are leadership skills and technical expertise that is tasked to build and strengthen cooperative buffelgrass invasive species management efforts.

UNKNOWN

Buffelgrass *(Pennisetum ciliare)* is a shrubby perennial bunchgrass 10–150 cm. tall. The leaf blades are bluish-green in color, 3–30 cm. long, with soft hairs on the upper surface. The inflorescence is generally cylindrical in outline, 2–14 cm. long, and can be purple, gray or yellowish (straw-colored) when fresh. The spikelets are solitary or clustered, and are surrounded by numerous bristles, which are burs without hardened spines.

It is a non-native invasive grass that threatens to alter the native Sonoran Desert vegetation that is essential to the region's ecological integrity, identity and tourist industry. Buffelgrass has introduced a new fire risk into an ecosystem that is not fire adapted. It grows in dense stands, crowds out native plants, and fuels unprecedented and devastating fires. Competition for water can weaken and kill desert plants including larger trees and cacti, while dense roots and ground shading prevent germination of native seeds. Its resistance to fire, drought, and grazing makes it very persistent and dominant over native species by forming dense monocultures and displacing native species. Buffelgrass alone can kill or exclude most native plants by these processes, but buffelgrass-fueled wildfires hasten the process. Buffelgrass is considered a particularly serious threat to the saguaro cactus, the iconic plant of the Sonoran Desert Eco-region.

Native desert sites like the Arizona-Sonora Desert Museum, Saguaro National Park, Sabino Canyon, Catalina State Park, and Tucson Mountain Park attract tourists from around the world and are frequently visited by local residents. According to the Metropolitan Tucson Convention and Visitors Bureau (based on studies conducted by the University of Arizona) 3.5 million visitors pump $2 billion a year into Tucson's economy, including $20 million in tax revenues for Tucson and Pima County. Tourism

accounts for nearly 40,000 jobs and about 12 percent of total wages in Pima County. Alteration and/or conversion of the Sonoran Desert native vegetation to a buffelgrass dominated grassland system increases the risk of fire not only to natural viewscapes but also to the thousands of homes that currently interface with these wildlands.

Treatment of buffelgrass infestations requires follow-up treatment in subsequent years. Therefore it is important to recognize that projected costs for treating an infestation address treatment only once. Control costs vary by control method (spraying vs. pulling), buffelgrass density, slope of terrain, and distance from road (or water source for chemical mixing). The total cost of treating a particular infestation over 2–3 years should be calculated based on the type of treatment used.

Some estimates for roadside treatment average from about $40 per acre for spray treatment using a large truck with spray booms to about $97 per acre for hand wand spray applications. Away from roadsides, costs can increase substantially. For example, in 2007, large treated areas on Tumamoc Hill costs ranged from $188 / acre to $850 / acre, with an average cost of about $418 / acre. Costs varied by distance from road (water source), slope, whether the area was treated previously, and buffelgrass density (which is also affected by previous treatments). Labor costs were estimated at an average of around $18.50 / hour. Variable materials costs were about $88 per acre.

SONORAN DESERT WEEDWACKERS

Formed in 2000, the Sonoran Desert Weedwackers work only on Pima County properties and primarily within Tucson Mountain Park to remove buffelgrass *(Pennisetum ciliare)* and fountain grass *(P. setaceum)*. They use a two-pronged strategy to defend

BEN WILDER

the park against invasive grasses: reconnaissance and eradication. Reconnaissance is conducted at least once per month. A team of 2–4 people hike throughout the park, eliminating small isolated populations, mapping larger infestations using GPS coordinates and monitoring areas where invasive grasses have been removed. Routes to the patches are recorded; size of patches, area and approximate number of plants are noted. Another volunteer records the data collected by the reconnaissance group in a database maintained by the Arizona-Sonora Desert Museum. It is estimated that approximately 4,000–5,000 acres have been cleared and revisited; another 4,000–5,000 acres have been mapped with areas tagged for future eradication; and a total of 15,000 of 27,000 acres in the park have been surveyed. Following reconnaissance, treatment areas are identified for manual removal and volunteers are directed to the highest priority areas. As of December 2007, 7,300 volunteer hours have been logged and an estimated 73 tons of invasive grasses have been manually removed.

KUDZU

Arizona's first reported population of kudzu *(Pueraria montana* [Lour.] Merr.) was discovered in Cochise County during late September 2006. In October, plant samples collected from that unusual, sprawling, densely leaved, woody vine, plus photos were enough evidence for a University of Arizona Cooperative Extension Weed Biologist, and a plant taxonomist at Arizona State University – Polytechnic to make the initial vegetative diagnosis. DNA sequence analysis of leaf samples at the ASU School of Life Sciences, matched published kudzu DNA sequences.

Kudzu attracts attention from Arizona plant scientists and land managers because this foreign vine has demonstrated its ability to dominate and smother both land and vegetation. Mature pine trees, roadsides, telephone poles and landscape plantings in southeastern states have been buried under kudzu's invasive growth.

Because of kudzu's reputation as a biotic invader, Arizona Department of Agriculture personnel initiated an eradication process when identification was completed. This control measure is based on a new herbicide from Dow AgroSciences called Milestone VM.™ Dow's range and pasture vegetation specialist for Arizona provided weed management expertise for eradication treatments that began in November 2006.

Milestone was applied to the kudzu at a rate of 7 ounces per acre. This application was repeated in March and June 2007. Visual estimates in August 2007 indicated more than 97 percent of kudzu biomass died as a result of those three treatments.

Even though the kudzu infestation appears to be controlled, treatments are planned for 2008 to complete eradication and will continue until new shoots cease to emerge; then occasional monitoring is needed to insure none of the underground root reserves survive and clone new kudzu plants.

GIANT SALVINIA

Giant salvinia *(Salvinia molesta)* was discovered in 1999 in the Imperial and Cibola National Wildlife Refuges on the lower Colorado River. It soon spread from Blythe, California, downriver throughout the entire lower Colorado River and into Mexico. Giant salvinia, described as

Giant salvinia

TROY EVANS

"The World's Worst Aquatic Weed," can greatly alter aquatic ecosystems. As the mature plants weave themselves into a thick, floating mat, oxygen and light are blocked from the water. Native macrophytes and microscopic algae that form the base of the food chain may die off. The animals that feed on this plant life may die, too, and so on up the food chain.

The Lower Colorado Giant Salvinia Task Force was established to control this invasive weed. Task force members include multiple federal agencies, state agencies from California and Arizona, irrigation districts and university researchers. This cooperative effort utilized mechanical, chemical, and biological control methods. Giant salvinia populations peaked in 2004, task force control efforts led to today's lower densities. The success of the task force led giant salvinia control program spurred an expansion to include a larger portion of the Colorado River and all aquatic species. The task force is now known as the Colorado River Invasive Aquatic Species Task Force.

PROMOTING NATIVE PLANT USAGE

Many development areas both residential and commercial, in our state, tend to landscape their project with non-native plant material that places added pressure on the environment in many ways. Excessive water use, unnatural vistas and unwanted spread of problem plants are just a few. Some communities are dealing with this issue by requiring contractors to salvage native plants and providing approved plant lists for contractors to abide by. At the same time many Home Owners Association (HOA's) have even more stringent restrictions. Unfortunately there often is a communication gap

Bottle palm tree

ADA

between, or a lack of education of, the contractors, architects, maintenance people and the inspectors or ordinance builders. This breakdown results in landscapes incompatible with our native landscape.

INTERNET COMMERCE

Internet commerce has opened a pathway infesting lakes, streams and wetlands with foreign plants transported thousands of miles from their natural habitats. A Google search using "water garden plants," "pond plants" or "aquarium plants" reveals numerous non-native aquatic plants available for purchase. For example, even though water hyacinth is designated as an Arizona noxious weed, several out-of-state vendors sell this ecologically and economically dangerous plant.

An innocent purchase plus a few days for delivery can move potential infestations of Water hyacinth *(Eichhornia crassipes)* into Arizona's urban backyard pest refuges. Careless disposal of excessive hyacinth vegetative growth in nearby waters establishes a new infestation in an Arizona lake, stream, wetland or canal.

Other non-native aquatic plants for sale on the Internet include parrots feather *(Myriophyllum aquaticum)* and water spangles *(Salvinia minima)* (a close relative of giant salvinia). If these aquatic weeds are introduced into natural waters, they can harm native plant communities and animal populations by blocking sunlight, reducing dissolved oxygen concentrations, altering water flow, providing habitat for non-indigenous diseases, changing water pH and disrupting natural temperature regimes.

Since Arizona does not control business practices in other states or countries, this Internet conduit of pest organisms is another reason for policy makers, regulatory staff, land managers and an informed public to diligently fund, support and maintain survey operations that facilitate early detection of new invasive species infestations.

PET TRADE

There are unregulated aspects of the pet trade that promote the irresponsible purchase of non-native animals. These purchases can lead to problems such as in 2003 when cases of monkey pox, which is not endemic in the United States, were reported in owners of prairie dogs and veterinary clinic staff. Monkey pox was introduced to the United States through the pet trade when imported rodents were housed with prairie dogs, both being sold as pets.

Internet sales, backyard and basement operations (which often are connected to the Internet or newspaper sales), hobbyist shows, flea markets, etc. are the primary sources of this unregulated trade. Internet sales in particular are a problem, creating a situation in which the consumer does not have an option to investigate the health and disposition of an animal before it enters their home, which may lead to the irresponsible release of an unwanted animal.

Research shows that educated consumers are less likely to purposely harm the environment or support segments of the pet trade that do, but the fragmented nature of the trade makes it difficult to effectively communicate a consistent message to end consumers. Regarding impacts on the environment, economics, and human health from the unregulated trade, ownership, and accidental or intentional release of pets, data are unavailable.

INVASIVE PLANTS AND WILDLANDS FIRES

The pervasiveness of invasive species in Arizona, and non-native grasses in particular, has the potential to permanently disrupt historic fire regimes and impact the state's economy. Failure to adequately manage the invasive species-fire relationship could result in severe consequences.

Increased property loss and public safety risk. As invasive plants become more dominant in the Arizona landscape, they become difficult, if not impossible, to eliminate. The prevalence of invasive grasses represents a major fire risk, impacting the ability of land managers and response agencies to plan for, manage, and contain fires. Where non-native plants are well established, fuel-loads, particularly around human dwellings in rural communities, make fire-fighting extremely difficult. Loss of property and life may result where large fires, fueled by non-native plants, burn hotter and over a larger area. Local communities will face increasing fire response costs, and may be unable to protect the public without significant assistance from state or federal governments.

Increased insurance costs/ inability to obtain insurance. As fires become increasingly severe and frequent due to the presence of invasive grasses, landowners and local governments will see insurance costs rise. In some cases property owners and land managers will be unable to obtain fire insurance at all. Inability to obtain affordable fire insurance coverage has the potential to harm local economies, particularly in Arizona's rural communities.

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The Arizona-Sonora Desert Museum refers to Saharan mustard as "the worst invasive plant in the Sonoran Desert," primarily because of its competitive effects on other plants and its ability to carry fire.

Loss of Arizona's unique landscapes and native species. The loss of Arizona's iconic native species, such as the saguaro cactus and palo verde, is tied to the presence of invasive species. Invasive grasses are common along transportation corridors, and these same places are typically the first to ignite by human-caused fires. Invasive plant-fueled wildland fires have the potential to wipe out large swaths of mature saguaro forests, particularly along popular sight-seeing routes.

Loss of tourist revenue. Arizona's national and international marketing campaigns capture the powerful draw of the state's natural beauty by featuring saguaro-studded hillsides and panoramic Grand Canyon vistas. However, invasive grass-fueled fires in the Sonoran Desert, catastrophic forest fires in the high country, and mandatory fire evacuations of Grand Canyon National Monument, all generate the type of negative publicity that dims Arizona's reputation as a tourist destination. As invasive plant-fueled fires become more frequent, loss of tourism is a likely result.

Loss of recreational opportunities due to closures. Summer fire closures of popular recreation areas, particularly in the Chiricahuas, the Mogollon Rim, and the Santa Catalinas, have become commonplace in recent years. As fire danger increases with the presence of more invasive plants, the public will be increasingly excluded from recreation opportunities on public lands. Closures harm the quality of life for Arizona residents and impact tourism-based revenues for local communities and Arizona as a whole.

Relationship Between Fire and Invasive Species

Studies show a correlation between the widespread presence of invasive grasses and increases in the frequency and severity of wildland fires (Brooks 2001).

An abundance of fast-growing invasive grasses in a native plant community causes fire to spread faster, over a larger area, and burn hotter (Zouhar [in press]). The presence of invasive grasses also promotes favorable fire conditions in areas where fires were historically rare (Brooks 2001).

Invasives also out-compete native plants, potentially reducing the their range and decreasing overall eco-regional plant diversity (Brooks 2001). Fire stimulates the growth of certain invasive species and provides an opportunity for non-natives to further establish their presence in the landscape—making effective control more costly and increasingly difficult over time (Brooks 2001). After a fire, invasive plants can take advantage of canopy openings, changes in soil nutrients, disruption and exposure of soils, and reduction of local plant cover, outcompeting native vegetation, particularly those natives that are slow to recover from fire (Erickson 2007; Tu 2002; DiTomaso 2006).

Prescribed burns to control invasive plants and reduce fuel load may be effective (Erickson 2007), but land managers must balance the benefit of prescribed burns over the short term, with the risk that prescribed fire can also promote colonization by non-native species (DiTomaso 2006). Firefighting activities may also promote non-native colonization, where equipment, vehicles, and workers unknowingly carry in and spread weed seeds over hose-lines, walking and staging areas, and fire-breaks (Erickson 2007).

Invasive Plant Risk and Effective Fire Planning and Management

Each of Arizona's eco-regions poses a different invasive species challenge for land managers and planners (Marshall et al. 2006). To protect both public safety and the long-term health of native species, land managers need to understand the relationship between fire and non-native plants (DiTomaso 2006), and the non-natives that could invade, given their community's climate, rainfall, topography, native plants, and urban growth patterns.

Management of Invasives and Fire

Zouhar [in press], citing Brooks et al. (2004) breaks fire-invasive species management into four phases:

Phase I: Invasive is not yet present in region of interest, but poised to invade. Recommend establishment of priority ranking based on potential to affect fire regime, and prioritized for exclusion.

Phase II: Invasive is present but not causing significant ecological effects. Recommend evaluation for potential to cause significant fuel load increases and ecological changes, and prioritized for exclusion.

Phase III: Invasive has significant ecological effects other than on fire regime. Recommend priority ranking based on fire regime change potential, and restoration of pre-invasion plant community.

Phase IV: Fire regime is altered and an invasive plant/fire regime has established. Elimination of non-native species may be impossible. Recommend reduction of fuel loads by frequent, low-intensity prescribed fires, and creation of "replacement

DAVE POWELL, USDA/FS

communities" of native plant species that are more fire tolerant than originally occurring species and can co-exist with invasive plants.

Invasive species management will depend on the phase of invasive plant presence in a local area, as well as on natural disturbance regimes and local conditions. Managers should consider the entirety of the relationship between invasive plants and fire regime in their community (Zouhar [in press]). A combined early detection and early implementation response to address a non-native plant invasion, based on sound public policy, is far more cost-effective than the alternative—responding to increasing frequency and severity of wildfires, and attempting to eradicate well-established invasive plants following wildfires (Tu 2002; Erickson 2007, Zouhar [in press]).

Partnerships between communities and agencies, in combination with conservation of open lands (both for conservation of native species and as fire buffers from urban development) are critical to an effective invasive species fire management strategy. As private land in Arizona is developed and fragmented, large tracts of public land, particularly federal lands managed by the U.S. Fish and Wildlife Service, the Department of Defense, the U.S. Forest Service, the National Park Service, and the Bureau of Land Management, as well as Tribal lands, will become increasingly important to Arizona's native plant communities (Marshall 2006), particularly lands adjacent to human development. Accordingly, managing fire regimes and controlling the spread of invasive plants will increasingly depend on interagency cooperation with a priority on conserving native lands and wildlife, for the protection of native species and the urban and rural communities near those important lands.

Overall, land managers must balance the costs of a proactive approach to invasive species management (e.g., costs associated with planning for potential invaders, containing non-native plants already established, protecting native plant-rich open spaces around urban areas as a buffer from fire, and/or reestablishing native plant communities in fire-prone areas) against the costs of a reactive approach to dealing with invasive species (e.g., costs of responding to frequent fires, protecting public safety, compensating for lost property, subsidizing local economies when fire strikes, and bearing the costs of increased insurance premiums).

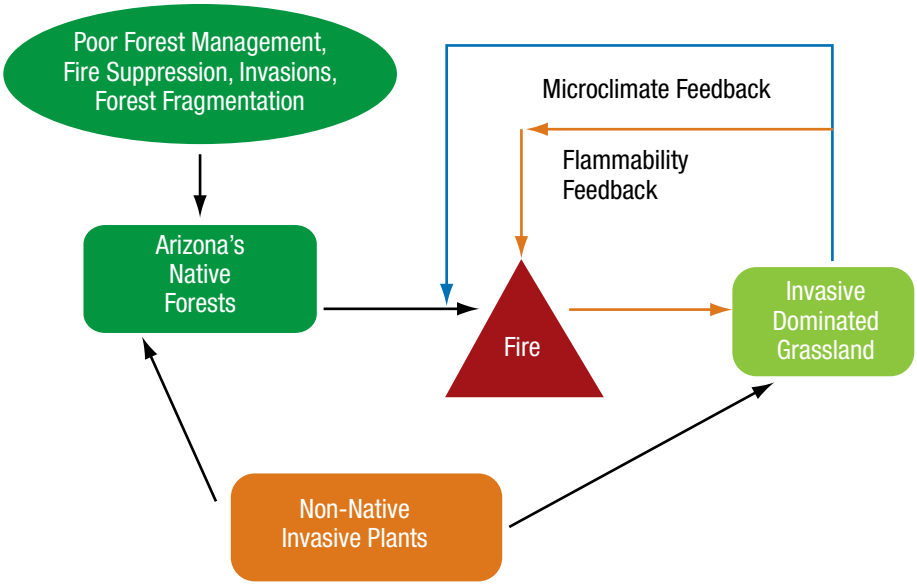


Figure 2. A conceptual model illustrating the rapid change from forest to fire-prone invasive species-dominated grassland once fire initially burns a forest and ignition sources persist. Inadequately managed timber harvesting, agricultural clearing, and fragmentation as a result of urban development are the forcing functions that initiate the change. Non-native grasses enter the process as a result of the initial opening of the forest canopy, but their spread and predominance are the result of the feedback that produces drier, more flammable conditions. Although the process could operate in both directions, i.e., a transition back to forests caused by a long fire-free period, it is predominately one-way. (Adapted from Myers 2006, Cochrane 2001)

Legal Authorities and Programs

STATE AGENCIES

The state agencies listed below are those that have some degree of legal authority regarding invasive species. The federal agencies noted in Part B and the other partners included in Part C are presented not as an exhaustive list, but rather to highlight examples of stakeholders with legal authority and/or program emphasis targeted at invasive species.

ARIZONA DEPARTMENT OF AGRICULTURE

The Arizona Department of Agriculture (ADA) is responsible for administering state laws relating to plant pests and diseases, and to the protection of the livestock and poultry industries from disease (A.R.S. §§ 3-201.01 & 3-1203). Plant pests consist of all noxious weeds, insects, mites, spiders, nematodes and other animal or plant organisms likely to be injurious to plants (A.R.S. § 3-201(7)). Arizona law authorizes the ADA to quarantine, treat, eradicate, destroy or prevent entry into the state of crop pests and diseases and to establish quarantines for or destroy livestock and poultry to prevent the spread of disease among animals. A.R.S. §§ 3-201.01 & 3-1205. The ADA also operates border inspection stations that aid in preventing invasive species from entering the state (A.R.S. §§ 3-107(B), 3-209 & 3-223).

ARIZONA GAME AND FISH DEPARTMENT

The Arizona Game and Fish Department (AGFD), under the direction of the Arizona Game and Fish Commission, is responsible for administering state laws relating to wildlife (A.R.S. § 17-201). Wildlife, including native, migratory and invasive species, is property of the state for regulatory and management purposes. (A.R.S. § 17-102). Arizona law requires the Game and Fish Commission to establish, and the AGFD to implement, policies, programs and administrative rules to manage and protect wildlife. (A.R.S. § 17-231(A)). This authority mandates that the Game and Fish Commission and the AGFD take action to protect wildlife from harm caused by invasive species.

Specific state statutes relating to invasive species regulation include A.R.S. § 17-250 (regulating wildlife movement in the event of a disease outbreak), A.R.S. § 17-317 (regulating white amur, an invasive fish species), and A.R.S. § 17-318 (requiring inspection of all cloven-hoofed wildlife introduced into Arizona).

ARIZONA DEPARTMENT OF HEALTH SERVICES

The Arizona Department of Health Services (ADHS) is responsible for administering public health protection programs related to community water supplies, general sanitation, vector control, food

and drugs, and epidemiology and disease control programs (A.R.S. § 36-104).

The ADHS has authority to coordinate all matters pertaining to the state's response to a public health emergency called by the governor due to the occurrence or

imminent threat of an epidemic or pandemic disease (A.R.S. § 36-787). In the case of a serious threat to public health and welfare, the ADHS director may define and prescribe emergency measures for detecting, reporting, preventing and controlling communicable or infectious diseases or conditions. (A.R.S. § 36-136).

A.R.S. § 36-782 pertains to issuance of an enhanced surveillance advisory by the governor to survey for an illness, health condition or clinical syndrome caused by epidemic or pandemic disease or a highly fatal and highly infectious agent. A.R.S. §36-783 pertains to reporting any case of animal illness or death due to the disease or other health condition designated in the enhanced surveillance advisory.

A.R.S. §36-601 declares public nuisances dangerous to the public health, including rodents and insects that are capable of carrying and transmitting disease-causing organisms; feral honeybees; ectoparasites such as bedbugs, lice, mites and others in any place where sleeping accommodations are offered to the public; and the pollution or contamination of any domestic waters. This statute gives authority to the ADHS director to serve a cease and desist order on any person maintaining a nuisance or engaging in any practice contrary to state health laws.

ARIZONA STATE LAND DEPARTMENT

Arizona Revised Statutes Title 37 sets forth the duties and responsibilities of the Arizona State Land Department as it currently manages approximately 9.2 million acres of State Trust Lands. The Land Commissioner has the authority to lease Trust lands for grazing, agriculture, home sites, commercial and other purposes. A.R.S. § 37-132 gives the Commissioner the implied authority to develop and amend lease and permit terms and conditions. In addition, Arizona Administrative Code R12-5-509 states that the Commissioner may prescribe such provisions, covenants, conditions and restrictions as deemed necessary to fulfill the terms of the lease and/or permit. The requirement to develop weed management plans and control / eradicate invasive and noxious species on State Trust Lands has in recent years been added to lease contracts and permits as special stipulations when applicable.

Title 37, Article 2, of the Arizona Revised Statutes authorizes the State Land Department to establish a Division of Natural Resources. Thirty two Natural Resource Conservation Districts (NRCDs) have been established throughout Arizona with specific powers and authorities delegated by the Commissioner. Among other natural resource related concerns, NRCDs are empowered to conduct surveys, investigate, and sponsor research related to the eradication of noxious and invasive species (A.R.S. §,37-1054). NRCDs may cooperate and enter into agreements with landowners, an operator, or any agency or subdivision of state or federal government to carry out natural resource related programs including eradication of noxious and invasive species (A.R.S. §,37-1054 A.3). In addition to the 32 NRCDs organized under Article 2, 11 Tribal Natural Resource

Conservation Districts have been organized in Arizona under federal law.

The Arizona State Land Department has the authority and ability to play an important role in the implementation of the Arizona Invasive Species Strategic Plan on state and private lands.

ARIZONA STATE PARKS BOARD

Arizona Revised Statute § 41-511 establishes a State Parks Board to select, acquire, preserve, establish and maintain areas of natural features, scenic beauty, historical and scientific interest, and zoos and botanical gardens, for the education, pleasure, recreation, and health of the people, and for such other purposes as may be prescribed by law.

The statute provides no regulatory position for the Parks Board for properties other than those maintained, operated, managed, acquired, and developed by the Parks Board. The statute provides regulatory guidance for the Parks Board to preserve, protect, and enhance natural resources that are interspersed across a checkerboard land ownership that includes state, federal, tribal and private land, and land owned by municipal governments and other entities. The statute also provides for the State Parks Board to enter into agreements with the United States, other state or local governmental units, private societies or persons for the development and protection of state parks, monuments and trails.

ARIZONA GOVERNMENT INFORMATION TECHNOLOGY AGENCY

The Arizona Government Information Technology Agency (GITA) is responsible for developing, implementing and maintaining a coordinated statewide plan for information technology and serves as the statewide coordinator for information technology resources. In addition, GITA may provide to budget units information technology consulting services as it deems necessary (A.R.S. § 41-3507).

ARIZONA DEPARTMENT OF TRANSPORTATION

The Arizona Department of Transportation (ADOT) is the state agency responsible for providing an integrated and balanced state transportation system (See A.R.S. § 28-331). Exclusive control and jurisdiction over state highways, state routes, state-owned airports, and all state-owned transportation systems or modes are vested in the ADOT (See A.R.S. § 28-332[A]). Arizona law requires the ADOT to maintain and operate the state public transportation system. According to Arizona law, the ADOT has administrative jurisdiction of transportation safety programs, and likewise must implement them in accordance with applicable law (See A.R.S. § 28-332[B]). This authority allows the ADOT to take appropriate action according to applicable governing law to preserve and protect the state transportation system from harm caused by invasive species.

FEDERAL AGENCIES AND TRIBES

USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE

The basic mission of the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) is

to protect the health and value of American agriculture and natural resources. APHIS provides leadership in ensuring the health and care of animals and plants. The agency improves agricultural productivity and competitiveness

and contributes to the national economy and public health.

The Plant Protection Act (PPA, 7 U.S.C. 7701 et seq.) authorizes USDA to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism, noxious weed, article or means of conveyance if the Secretary of Agriculture determines that the prohibition or restriction is necessary to prevent the introduction into the United States of a plant pest or noxious weed.

The Federal Seed Act (FSA, 7 U.S.C. 1581 et seq.) requires accurate labeling and purity standards for seed, in commerce, and prohibits the importation and movement of adulterated or misbranded seeds. The FSA works in conjunction with the Federal Noxious Weed Act to authorize USDA to regulate the importation and movement of field crop, pasture and forage, or vegetable seed that may contain noxious weed seeds.

The Public Health Security and Bioterrorism Response Act of 2002 (P.L. 107-188) — Title II, Sections 211-231, provides for the regulation of certain biological agents and toxins by the Department of Health and Human Services and the Department of Agriculture. The act requires that entities such as private, state, and federal research laboratories, universities, and vaccine companies, that possess, use, or transfer biological agents or toxins deemed a threat to public

health and safety or to animal or plant health or products register these agents with the appropriate federal department. The act requires interagency coordination regarding biological agents and toxins that present a threat to both public health and safety and animal health.

The Animal Health Protection Act (AHPA) (7 U.S.C. 8301 et seq.) authorizes APHIS to prohibit or restrict the importation, entry, exportation, and interstate movement of any animal, means of conveyance, or other article if the prohibition or restriction is necessary to prevent a disease or pest of livestock from being introduced into, or disseminated within or from, the United States. The AHPA authorizes additional actions in extraordinary emergencies. It also provides for inspections, seizures, quarantines and disposal, as well as measures to detect, control, and eradicate diseases and pests of livestock, and for a veterinary accreditation program.

USDA FOREST SERVICE

The mission of the Forest Service is to "sustain the health, diversity and productivity of the Nation's forests and grasslands to meet the needs of present and future generations." To work toward this mission, the Forest Service has identified six strategic goals. Among them, Goal 2, is "Reduce the impacts from invasive species." The Forest Service focuses on strategies associated with management of invasive pest species and is increasing its focus on invasive aquatic species management.

Invasive species on National Forest System lands are regulated under a variety of statutes administered by other federal agencies, including the Lacey Act, the Plant Protection Act, the Animal Damage Control Act, the Federal Seed Act, the Nonindigenous Aquatic Nuisance Prevention and Control Act, and the Alien Species

Prevention and Enforcement Act. The Forest Service works cooperatively with other federal agencies to implement these authorities on National Forest lands.

Authorities under which the Forest Service operates that relate to invasive species and noxious weed management are listed below.

Federal Noxious Weed Act of 1974 requires federal land management agencies to develop and establish a management program for control of undesirable plants that are classified under state or federal law as undesirable, noxious, harmful, injurious, or poisonous, and to cooperate with other agencies and implement cooperative agreements for integrated weed management.

1990 Farm Bill (Food, Agriculture, Conservation & Trade Act) directs the Forest Service to develop and coordinate management programs for the control of undesirable plants on all federal lands in cooperation with state and county governments.

Executive Order #13112 on Invasive Species, Feb 3, 1999, establishes the National Invasive Species Council, which provides national leadership. The Order directs that invasive species will be controlled on all federal lands.

Departmental Regulation 9500-10 sets the policy for management and coordination among agencies in the Department of Agriculture and other executive agencies, organizations, and other individuals; establishes IPM (integrated pest management) as the preferred approach to noxious weed prevention, control and eradication.

FS Regulations at 36CFR 222.8 obligates the Forest Service to work cooperatively to identify weed problems and develop control measures.

FS Regulations at 36 CFR 261.50(a) and 261.58(t) directs the Forest Service to issue orders restricting transport of feed, hay, straw, or mulch not certified weed free in states having weed-free legislation.

FSH 6309.12 Sec 42 & 42.1 requires the Forest Service to make every effort to ensure all seed, feed, hay, straw used on National Forest lands is free of noxious weed seeds.

FSM 2080 and FSM 2082.1, the Noxious Weed Management Direction and the direction regarding MOUs and Cooperative Agreements about noxious weeds.

FSM 2150, individual Forests in the Southwestern Region have the authority to use herbicides that have been evaluated under the NEPA process. The Regional Forester retains authority to approve use of herbicides in designated wilderness areas, wilderness study areas, or designated or candidate research areas.

DEPARTMENT OF THE INTERIOR

The Lacey Act (18 U.S.C. 42), administered by the U.S. Fish and Wildlife Service, prohibits importation into the United States or any U.S. territory or possession and shipment between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, and any possession of the United States of certain categories of animal species determined to be "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States."

The "other" Lacey Act, a separate provision also known as the Lacey

Act (16 U.S.C. 3371 et seq.), also has implications for regulating introductions of invasive species. This law, administered by the Secretaries of the Interior, Commerce, and Agriculture, generally makes it unlawful for any person to import, export, transport, sell, receive, acquire, or purchase (or attempt to commit any such act) in interstate or foreign commerce any fish, wildlife, or plant taken, possessed, transported, or sold in violation of any federal, tribal, state, or foreign law. Thus, while the statute does not substantively grant authority to regulate the importation, transportation, exportation, or possession of any species, violation of another federal, state, tribal, or foreign law governing these activities would become a violation of federal law and subject to particular civil and criminal penalties.

The Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA, 16 U.S.C. 4701 et seq.) also has potential to affect the introduction and dispersal of invasive species. Focused primarily on the spread of nonindigenous species through ballast water releases, it create a task force co-chaired by the Director of the U.S. Fish and Wildlife Service and the Undersecretary of Commerce for Oceans and Atmosphere to develop and implement a program to prevent the introduction and dispersal of aquatic nuisance species.

All land-management agencies within the Department of the Interior have the authority to manage the resources on their lands, including taking action to protect those resources from the impacts of invasive species. Authorizing statutes that provide the primary land management authority for Interior agencies include the National Park Service's Organic Act (16 U.S.C. 1 et seq.), the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd), and the Federal Land Policy and Management Act (43 U.S.C. 1701 et seq.).

The Endangered Species Act (ESA, 16 U.S.C. 1531 et seq.) is jointly administered by the Secretaries of Interior and Commerce. It contains provisions regulating import and export of listed species. Other provisions of the ESA, however, relating to how invasive species may negatively affect a listed species are probably more significant and can provide powerful management tools. Section 7 of the ESA requires any federal agency to insure that any action authorized, funded, or carried out by the agency not jeopardize the continued existence of any endangered or threatened species or adversely modify any critical habitat of such species (16 U.S.C. 1536(a)(2)).

BUREAU OF LAND MANAGEMENT

The Federal Land Policy and Management Act of 1976 directs the BLM to manage public lands "in a manner that will protect the quality of scientific, scenic, historic, ecological, environmental, air and atmospheric, water resources and archeological values" and to develop resource management plans consistent with those of state and local governments to the extent that BLM programs also comply with federal laws and regulations.

The Taylor Grazing Act of 1934 introduced federal protection and management of public lands by regulating grazing on public lands. The Oregon and California Grant Lands Act of 1937 provides for the management of the revested Oregon and California and reconveyed Coos Bay Wagon Road grant lands for permanent forest production under the principle of sustained yield and for leasing of lands for grazing.

Carlson-Foley Act of 1968 and the Plant Protection Act of 2000 (Public Law 106-224 includes

management of undesirable plants on federal lands) authorize the BLM to manage noxious weeds and to coordinate with other federal and state agencies in activities to eradicate, suppress, control, prevent, or retard the spread of any noxious weeds on federal lands.

The Federal Noxious Weed Act of 1974 established and funded an undesirable plant management program, implemented

cooperative agreements with state agencies, and established integrated management systems to control undesirable plant species.

The Noxious Weed Control Act of 2004 established a program to provide assistance through states to eligible weed management entities to control or eradicate harmful, nonnative weeds on public and private lands.

The Public Rangelands Improvement Act of 1978 requires the BLM to manage, maintain, and improve the condition of the public rangelands so that they become as productive as feasible.

The BLM must comply with numerous federal laws that govern activities on public lands. The Wilderness Act of 1974 provides management directions to protect wilderness values and guides activities and permitted uses within these areas.

The Safe Drinking Water Act is designed to protect the quality of public drinking water and its sources.

The Clean Water Act regulates discharges into waters of the United States, including wetlands. As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Based on a recent (2006) ruling by the Environmental Protection Agency (EPA), an NPDES permit is not required for applications of herbicides directly to water in order to control aquatic vegetation, or for application of herbicides that are present over or near water, where a portion of the herbicide will unavoidably be deposited to the water in order to target the pest vegetation. The ruling does not apply to terrestrial herbicide applications that drift over and into waters of the United States; issues related to these applications are under review by the EPA.

The EPA regulates pesticides under two major federal statutes. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) establishes procedures for the registration, classification, and regulation of all pesticides. Before any pesticide may be sold legally, the EPA must register it. The EPA may classify a pesticide for general use if it determines that the pesticide is not likely to cause unreasonable adverse effects to applicators, or the environment, or for restricted use if the pesticide must be applied by a certified applicator and in accordance with other restrictions. All applicators that apply them on public lands (i.e., certified applicators or those directly supervised by a certified applicator) must comply with the application rates, uses, and handling instructions on the herbicide label, and where more restrictive, the rates, uses, and handling instructions developed by the BLM.

Under the Federal Food, Drug, and Cosmetic Act, the EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food. The Food Quality Protection Act of 1996 changed the way the EPA sets residue limits (tolerances) for pesticides on foods under the Federal Food, Drug, and Cosmetic Act, and the way the EPA reviews and approves pesticides under FIFRA. Specifically, the act mandated a single, health-based standard for all pesticides in all foods;

provided special protections for infants and children; expedited approval of safer pesticides; created incentives for the development and maintenance of effective crop protection tools for American farmers; and required periodic reevaluation of pesticide registrations and tolerances to ensure that the scientific data supporting pesticide registrations will remain up to date in the future.

The Resource Conservation and Recovery Act regulates the disposal of toxic wastes, including the disposal of unused herbicides, and provides authority for toxic waste cleanup actions when there is a known operator. The Comprehensive Environmental Response, Compensation and Liability Act regulates how to clean up spills of hazardous materials and when to notify agencies in case of spills.

Several laws pertain to the protection of plants and animals and their habitats. The Migratory Bird Treaty Act of 1918, as amended, makes it unlawful to directly, or indirectly, harm migratory birds. If the U.S. Fish and Wildlife Service determines that migratory birds could be harmed by BLM vegetation treatment actions, the two agencies would develop a site-specific assessment and mitigation to prevent harm to these birds.

The Endangered Species Act of 1973, as amended, provides for conserving endangered and threatened species of plants and animals. It also requires that federal agencies use their authorities to carry out programs to conserve threatened and endangered species and consult with the U.S. Fish and Wildlife Service and NMFS to ensure that any actions that they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or result in the adverse modification or destruction of its critical habitat.

The Bald and Golden Eagle Protection Act, originally passed in 1940 to protect bald eagles, was amended in 1962 to protect golden eagles as well, by prohibiting the take of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16 U.S.C 668(a); 50 CFR 22). "Take" includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb (16 U.S.C. 668c; 50 CFR 22.3).

Executive Order 13186, signed on January 10, 2001, directs each federal agency taking actions that are likely to have a measurable effect on migratory bird populations to develop and implement a memorandum of understanding with the U.S. Fish and Wildlife Service that shall promote the conservation of migratory bird populations.

The purpose of Executive Order 13112, signed on February 3, 1999, is to prevent the introduction of invasive species and provide for their control, as well as to minimize the economic, ecological, and human health impacts that invasive species cause.

BUREAU OF INDIAN AFFAIRS AND TRIBAL TRUST LANDS

Authorities for Bureau of Indian Affairs

Federal Fire Prevention and Control Act of October 29, 1974 (88 Stat. 1535; 15 U.S.C. 2201).

United States Department of Agriculture and the Department of Interior Cooperative Agreement, March 28, 1983, authorize the Forest Service to provide funding and technical assistance to the Bureau of Indian Affairs (BIA) for Forest Pest Management.

Public Law 101-512, 1988, the USDI Bureau of Indian Affairs launched a national noxious weed management programs on Indian trust lands.

Presidential Documents Executive Order 13112 of February 3, 1999, Invasive Species, Code of Federal Register Vol. 64, No. 25, authorizes

federal agencies to facilitate and coordinate public education and the preparation of Invasive Species Management Plan.

25 CFR Section 170.7, the BIA has the authority to enter into agreements for the construction and maintenance of certain Indian reservation roads and bridges, especially where road projects serve non-Indian land as well as Indian land (Right-of-way vegetation management is a maintenance function).

Carlson-Foley Act (PL 90-583), requires the control of noxious plants on land under the control or jurisdiction of the federal government.

Southwest Strategy Initiative for the Arizona Wildland Invasive Plant Working Group, 2003.

Noxious Weed Control and Eradication Act, Public Law (P.L.) 108-412, Oct. 30, 2004.

Memorandum of Understanding (MOU) between the Department of the Interior, Bureau of Indian Affairs and U.S. Department of Agriculture, Animal and Plant Health Inspection Service, for the control of grasshoppers and Mormon crickets on BIA and tribally managed lands, 2004.

Salt cedar and Russian olive Control Demonstration Act, Public Law (P.L.) 109-320, Oct. 11, 2006.

Memorandum of Understanding among Department of the Interior, Bureau of Indian Affairs, U.S. Department of Agriculture, Natural Resources Conservation Service, and USDA Farm Service Agency, December 6, 2006. This MOU describes the common objectives for managing and conserving natural resources on Indian lands. It includes programs and treatments for invasive species management.

AUTHORITIES FOR TRIBES

1968-Indian Civil Rights Act, allowed Bill of Rights in Indian Country.

Indian Self-Determination and Education Assistance Act (PL 93-638) of 1975, as amended, allows the use of contracts where tribes assume responsibility for administration of programs.

National Indian Forest Resources Management Act (P. L. 101-630 November 28, 1990).

Tribal Self-Governance Act of 1994 (P.L. 103-413).

San Juan Watershed Woody-Invasive Initiative, May 2006. This partnership includes four states and four native tribes to facilitate coordination among partners across political boundaries. (Includes BIA Navajo Region).

On a project by project basis, tribes support invasive species management with resolutions.

PROGRAMS

The BIA Forestry Pest Management Program was authorized in 1983. It assures that preventive measures are taken to reduce the hazard of insect or disease damage and includes a variety of forest management activities. The funding comes from the US Forest Service but requires the cooperation of the tribe and various levels of BIA to administer the program and funding. There are directives in the BIA Forestry Manual which apply to all federal agencies participating in the management and protection of Indian forest lands. The appropriate federal official must insure that program standards are met.

The BIA Noxious Weed program for rangelands, riparian areas and road right-of ways was initiated in Dec. 1988 in response to Congressional directives for improved management on Indian lands. A task force and 10-year management plan were developed and put into the BIA Range and Agriculture Handbook. The Acting Deputy Commissioner of Indian Affairs issued an Interim Policy in 1991 for the Noxious Weed Control Program. This directed the emphasis to on-the-ground accomplishments and the funds issued to be used directly for weed control. Funding was approximately $2 million prior to 2007 when it was cut in half.

The bulk of the funds are relayed to Tribes by contracts or directly through self-governance. Some funds are used for biological control research with free workshops and insects provided to Tribes. Program standards and oversight are provided by 12 Regional Noxious Weed coordinators.

OTHER PARTNERS

ARIZONA-SONORA DESERT MUSEUM

The "Invaders Program" is one of the major program areas within the Arizona-Sonora Desert Museum's Center for Sonoran Desert Studies. The Mission of the Invaders Program is to raise awareness about the negative impacts of invasive plants and animals, and to inspire and prepare people to assist in tackling this problem through research, early detection, monitoring, mapping, on-the-ground control treatments, and community outreach.

The Desert Museum is one of many public agencies and private organizations working to confront the problem of deleterious invasive species. The Desert Museum's research staff has been identifying the scope and spread of invasives in southern Arizona and Sonora. Its conservation team and volunteer "citizen scientists" are using hand-held computers and GPS units to map the spread of buffelgrass throughout much of the Southwest. We are monitoring for the threat of invasives not yet in Arizona, such as the cactus moth and Argentine fire ant. The Desert Museum is also facilitating collaborations among local, state and national entities involved in invasive species monitoring and management. The Museum has also trained many other museums, zoos and public aquaria around the U.S. to help them establish programs modeled after the Invaders of the Sonoran Desert Region program.

The Invaders Program was initiated in 2005 to tackle the rise of biological invasions by harmful exotic species of plants and animals, with an emphasis on seven species of interest. Since then, the program has expanded to include a broad range of invasive species within the Sonoran Desert, hands-on research, and education to community members. Our goals are to identify the impacts of invasives in our region, map the spread of these invasives, collaborate with eradication projects, and educate others about the implications to the Sonoran Desert. Together, we are making a difference!

SOUTHWEST VEGETATION MANAGEMENT ASSOCIATION

Southwest Vegetation Management Association is organized exclusively for educational and scientific purposes, for the transaction of any or all lawful business for which nonprofit associations may be organized under the laws of the State of Arizona, as they may be amended from time to time. The character of affairs of the Association is to bring together and provide a forum for public and private land managers, agricultural producers, industry experts, governmental regulatory agencies, educational institutions, suppliers of vegetation management related products and services, and public interest groups to exchange ideas, knowledge, and information in order to educate, promote diversity, protect habitat, and maintain the health of the ecosystems within Arizona. Our goal is to foster cooperation between agencies, public interest groups and landowners and managers by addressing common management goals and concerns.

THE NATURE CONSERVANCY

The Nature Conservancy's Invasive Species Initiative identifies two goals that guide the organization's work, internationally, nationally, and in Arizona:

1. Preventing new invasions, in combination with reducing the spread of invasives through development of timely international, federal, state, and local policies, building public awareness, and working with the private sector to recognize and assess risk posed by invasive species; and
2. Building the capacity and funding for international, federal, state, and local programs to assess, prevent, rapidly detect, and control priority invasive species threats to conservation targets.

TNC seeks to provide science-based information to governments and policymakers, with a focus on preventing and controlling the most damaging invaders. TNC seeks to partner with a wide range of stakeholders, including industry, agency, and conservation groups, who share motivation to reduce the harmful environmental and economic costs associated with the spread of invasive species, and to advocate for increased funding and development of strong policy solutions to address the growing invasive species problems in Arizona.

UNIVERSITY OF ARIZONA

The University of Arizona is a premier, student-centered research institution. Established in 1885, the first university in the Arizona Territory and the state's only land-grant institution, the university embraces its three-fold mission of excellence in teaching, research, and public service. As the university's primary land-grant component, the College of Agriculture and Life Sciences (CALS) administers a variety of programs and engages in cooperative efforts with federal, state and county governments and agencies. There are three broad divisions in CALS: teaching, research, and outreach. The teaching area, coordinated by the Office of Academic Programs, includes formal on-campus instruction and informal off-campus instruction. The 12 departments and schools within CALS offer 32 undergraduate and graduate majors covering Agricultural and Biological Sciences, Environmental Sciences, Family and Consumer Sciences and Natural Resources.

Research is conducted across all academic units within CALS and at nine off-campus research and demonstration centers located strategically throughout the state. Research highlights the state's priorities, with consideration for regional, national, and international needs. The research area of CALS is coordinated by the Arizona Agricultural Experiment Station, a component of the Agricultural Experiment Station System established in 1887 to conduct and promote research at land-grant institutions nationwide. The station supports research that underlies academic as well as outreach/extension programs.

The outreach/extension area of the college is coordinated by Arizona Cooperative Extension. Outreach makes informal education opportunities available throughout the state, bringing research-based information into communities to help people improve their lives. Extension is part of a national network of scientists and educators who help people solve problems and put knowledge to use. There are 24 offices in the 15 counties plus five offices on tribal lands.

Management Objectives

LEADERSHIP AND COORDINATION

State regulatory authority for wildlife and plants rests with the Arizona Game and Fish Department and the Arizona Department of Agriculture; however, many other government agencies as well as private businesses, nongovernmental organizations, and the public have a stake in invasive species issues. Applying a cohesive, statewide approach to invasive species management requires leadership and coordination across all stakeholders. This plan builds upon the AISAC's initial vision of a coordinated, multi-stakeholder approach by tapping into key stakeholders and creating a network for coordination, partnership and joint action.

OBJECTIVE 1: AISAC STRUCTURE AND FUNCTION

Executive Order 2007-07 (Appendix A) established the AISAC as a permanent body to advise the Governor on planning and implementing an invasive species policy for Arizona. The AISAC consists of 21 Governor-appointed members who serve without compensation and at the pleasure of the Governor. The Governor may appoint additional members as deemed necessary.

The AISAC's Executive Committee consists of the directors (or their designees) of the following state agencies:

Arizona Game and Fish Department
Arizona Department of Agriculture
Arizona Department of Transportation
Arizona Department of Water Resources
Arizona State Land Department
Arizona State Parks
Arizona Department of Health Services
An Arizona University
Office of the Governor

The AISAC also includes representation from the following entities:

Native American community
Agricultural interests
Conservation community
Forest health management interests
Ranching industry
Nursery and landscape industry
Pet industry
Cooperative Weed Management Areas, invasive species councils, or vegetation management associations
Federal agencies with an interest in invasive species
Academic community and University Cooperative Extension
Other members as deemed appropriate by the Governor

The AISAC functions under the joint leadership of the Arizona Game and Fish Department and the Arizona Department of Agriculture. Although voting authority is limited to members, the AISAC serves as a communication forum for all stakeholders. All interested parties are invited to attend AISAC meetings and work group sessions to provide input and participate in an extended network for information sharing on invasive species issues.

Appointed members may, with the Governor's permission, send designees to serve on the AISAC, provided that the member has delegated the designee with full authority to vote and otherwise act on the member's behalf.

The Governor's Executive Order identified the AISAC's basic structure and function. The following recommendations are intended to further clarify how the AISAC will function in the future.

Recommendation/Action Planned

1. An appointed member who is no longer able to serve as a representative of the entity for which he/she was originally appointed will notify co-chairs who will inform the Office of the Governor. The Governor will name a successor to fill the seat.

2. Encourage members representing state agencies to build working partnerships with members from nongovernmental organizations to foster communication and strengthen networking between members. Incorporate this "buddy" concept into the job duties of the state agency liaisons (see Recommendation 7).

3. Convene AISAC meetings no less than quarterly and more frequently if needed.

4. Retain planning work groups for the life of the plan. Establish an open membership policy with a permanent invitation to members, stakeholders or interested parties who wish to participate in work group sessions. Conduct two-year bench mark performance reviews of work group charter goals and objectives. Conduct a five-year overall plan assessment and update as deemed necessary.

5. Appoint and convene additional work groups on an "as needed" basis to address specific invasive species issues or concerns. Hold work group meetings outside of AISAC meetings and report findings and recommendations to the AISAC. The AISAC may vote to accept, reject or modify proposed recommendations. Work group leadership will be designated by the AISAC.

6. Hold AISAC and work group meetings in the spirit of and subject to Arizona's Open Meeting Law.

OBJECTIVE 2: ROLE OF STATE AGENCIES

To create a more comprehensive state-led approach, state agencies are encouraged to assess their ability to commit resources and/or support in the form of funding and staff positions associated with on-the-ground efforts to address invasive species issues.

The Arizona Game and Fish Department and the Arizona Department of Agriculture have existing staff with the authority to manage invasive species, but these agencies may need additional resources and/or positions to fully implement plan recommendations. Other state agencies, including the Arizona State Land Department, Arizona State Parks, the Arizona Department of Water Resources and the Arizona Department of Transportation, are encouraged to maintain or establish a dedicated liaison position that could organize proactive programs within their agencies and coordinate with other agencies and stakeholders.

In order for the plan to be effective statewide, federal agencies (which comprise approximately 42 percent of the land base in Arizona) will need to be involved. Their commitment of resources and support is necessary to address this immense problem. The work that is planned and carried out by federal agencies should be communicated to the proposed Center for Invasive Species. Coordination and cooperation between state and federal agencies is encouraged.

Arizona has no framework in place to encourage cross-jurisdictional coordination on invasive species. The state would benefit from enhanced

information-sharing within and among agencies, organizations and stakeholders involved in invasive species management. The state agencies with the majority of regulatory authority (wildlife and plants), the Arizona Game and Fish Department and the Arizona Department of Agriculture, could work together to provide statewide leadership and establish a framework for coordination. The University of Arizona, which has operating priorities that are relevant to invasive species issues, may provide support in lead coordination. If an invasive species is determined to be a public health threat by the Arizona Department of Health Services, that agency would provide leadership and coordination for the public health aspect of the specific invasive species.

PEGGY GREB, USDA/ARS

The glassy-winged sharpshooter could constitute a significant economic threat to southern Arizona's wine industry due to transmission Pierce's Disease, which has caused economic losses in California.

Rapid response to unexpected events, such as the occurrence of glassy-winged sharpshooter, quagga mussels, or human health related issues (e.g., an invasive mosquito species that transmits disease to humans), requires readily available funding to stop or limit outbreaks and spread. Obtaining this funding through grants is not practical because granting processes typically have set time cycles, are regulatory, and are not flexible. Agencies generally must reallocate funding from existing programs to address unexpected events. Creation of a rapid response fund that would be available for consultation, training, mobilization and on-the-ground control efforts is essential. Such a fund should be reserved for emergency response only. It should not be used for long-term control or eradication. Therefore, criteria would need to be established for rapid response fund eligibility.

In 2005, the Arizona Department of Agriculture determined that the glassy-winged sharpshooter constituted a significant economic threat to the wine industry in southern Arizona due to previous economic losses in California from Pierce's Disease transmission by the same vector. In support of the Director's Administrative Order 06-05, the Governor released $200,000 in emergency funding and subsequently an additional $530,000 for monitoring and control of this invasive insect.

The Arizona Game and Fish Department has not requested the Governor to release emergency funding, but in recent years two major invasive species incidents relating to the detection and control of quagga mussels and giant salvinia resulted in reallocation of more than $1 million collectively to address rapid response and management.

The director of the Arizona Department of Health Services can request Health Crisis funds from the Governor to respond to a public health emergency or crisis. These funds may not always be available for such an incident as they may be dedicated to other public health emergencies within a year. The Arizona Department of Health Services has not declared an emergency due to an invasive

animal or plant species, but has declared an emergency for an invasive disease, West Nile virus.

Recommendation/Action Planned

7. Identify and enlist, in the form of memorandums of understanding or intergovernmental agreements, any state, federal, and stakeholder contributions and commitments needed to implement the actions identified in this management plan. Signatories will identify a liaison to serve as a primary point of contact.

8. Establish coordinator positions in the Arizona Game and Fish Department, the Arizona Department of Agriculture, and the University of Arizona with individual responsibilities for advancing a statewide invasive species network under the AISAC's guidance. Coordinators will share responsibilities for administrative oversight, information management, public outreach, and statewide coordination among stakeholders.

9. Seek legislative appropriations to sustain a minimum invasive species rapid response fund to hold a suggested amount of $1 million with expenditures accountable to the Governor's office. Evaluate the potential for support from other funding sources, which may include fines for violations of invasive species regulations, sales of natural products, and grants. Ensure that the rapid response fund is dedicated for use on invasive species issues and separate from the Governor's emergency fund.

10. Seek to broaden competitive grant programs to include projects that address invasive species issues. Ensure that applicant eligibility criteria include demonstrated accountability. Ensure that grant opportunities are not broadened to the extent that they dilute the original intent.

OBJECTIVE 3: INTERSTATE, INTERNATIONAL AND TRIBAL COOPERATION

Other states and countries are developing strategies to counter invasive species. As such, Arizona should maintain consistent working relationships with neighboring states and Mexico regarding invasive species issues. Broader interaction is essential for anticipation, prevention, and response.

Close partnership with federal agencies and sovereign tribes will be necessary in order for this plan to be effective statewide. Federal science and agriculture expertise from several agencies will be essential to support the implementation of this plan. Tribal partners will be needed to help develop coordinated detection, management, and response strategies. Coordination and cooperation between state, tribal and federal agencies is encouraged.

Recommendation / Action Planned

11. Develop a database and/or directory of key state, regional, tribal, national and international points of contact within the network of agencies, organizations, and individuals involved with invasive species. Include subject matter experts, key administrative personnel, researchers, land managers, and taxonomic experts. Identify key personnel by position so that turnover in agencies and organizations will not affect coordination.

12. Encourage involvement in regional forums and promote involvement in regional and broader partnerships. Identify local, state, regional, and international conferences, symposiums, and forums, and sponsor or co-sponsor events that pertain to invasive species.

BEN WILDER

A buffelgrass infestation on Tumamoc Hill near Tucson

OBJECTIVE 4: APPROACHES FOR ORGANIZING INVASIVE SPECIES EFFORTS

A review of the actions and tools needed to adequately address invasive species management in Arizona identified gaps in five primary areas:

- Statewide cross-jurisdictional leadership and coordination
- Outreach and education
- Information management and sharing
- Control and management
- Funding

The concept of an Arizona Center for Invasive Species was introduced in the 2006 report to the Governor as one approach to addressing gaps in invasive species management and to serve as a central point of coordination and leadership. The concept was not clearly defined and could range from a self-supporting, brick-and-mortar operation to a virtual network of invasive species experts and managers. During the development of this plan, several approaches were identified and evaluated for their effectiveness in addressing gaps in invasive species management and in their ability to serve as a central point of coordination and leadership.

Many agencies, organizations and stakeholders have internal processes and procedures for addressing invasive species issues; however, a more comprehensive framework is needed to promote cross-jurisdictional cooperation and information sharing. The Arizona Center for Invasive Species, operating in conjunction with the AISAC, could provide leadership and coordination statewide and enhance efforts in communication, education and outreach, and information management.

Most Arizonans are unaware of the magnitude of the threat that invasive species pose to the economy, the environment, and to human health. As well as simply

informing the public about invasive species issues, there is a need to influence public attitudes and behaviors. Centralized invasive species coordination would increase the availability and improve the consistency and quality of invasive species information, education and outreach.

A central point for collection and dissemination of accurate and complete data, maps and other technical information would ensure their availability when needed to make effective control and management decisions. The center could serve as a clearinghouse and repository of information on prevention, detection, control and eradication of invasive species. It could also function as a tool to assist with species identification and data collection protocols to assure a consistent approach in invasive species management.

A challenge exists in identifying adequate long-term and sustainable funding for the center. State agencies have increasing demands on resources that must be addressed with limited or shrinking budgets. Start-up grants could provide short-term support but should not be considered as a long-term funding alternative. Financial support might be accessed through such means as cooperative agreements, memorandums of understanding, endowment funds, sales tax/user tax, and project grants.

Whatever form the center ultimately takes, several key components are required for any of the alternatives to be effective.

- A coordinator to provide cross-jurisdictional coordination and leadership
- Tools to be uniformly deployed and distributed
- Database creation and management
- Website development and management
- A coordinated approach to public outreach

Four alternatives were explored keeping the above key components in mind.

ALTERNATIVE A: NETWORK APPROACH (FIGURE 3)

The center would consist of a distributed invasive species network whereby responsibilities, functions and/or commitment of available resources are assumed by agreement of existing entities including agencies, organizations and stakeholders. An interagency memorandum of understanding would be created to identify shared goals, term of agreement, and responsibilities of individual state agencies in meeting the goals and objectives of the agreement. Nongovernmental stakeholders and tribes would have the opportunity to participate as signatories. The AISAC would identify priorities and provide cross-jurisdictional coordination and guidance.

Coordinator positions in the state agencies with primary statutory authority (Arizona Game and Fish Department and Arizona Department of Agriculture) would have individual responsibilities to advance a statewide invasive species network under the AISAC's guidance and establish a framework for central coordination. The inclusion of a third coordinator from an agency, institute, or organization that has relevant functions could be incorporated to aid in the lead coordination functions. The coordinators would have shared responsibilities for administrative oversight, information management, public outreach and education, and statewide coordination among stakeholders. As an interim measure, these responsibilities could be assigned to an individual within an agency or university willing to accept them. The coordinators would also be responsible for monitoring progress of deliverables, working closely with AISAC work groups, and reporting to the AISAC quarterly. All other signatories would identify liaisons to serve as central points of contact within the network.

Signatories agreeing to take on tasks would report periodically to the AISAC. Individual signatories would assume funding of primary responsibilities. Additional funding could be generated through cooperative and intergovernmental agreements, memorandums of understanding, endowments,

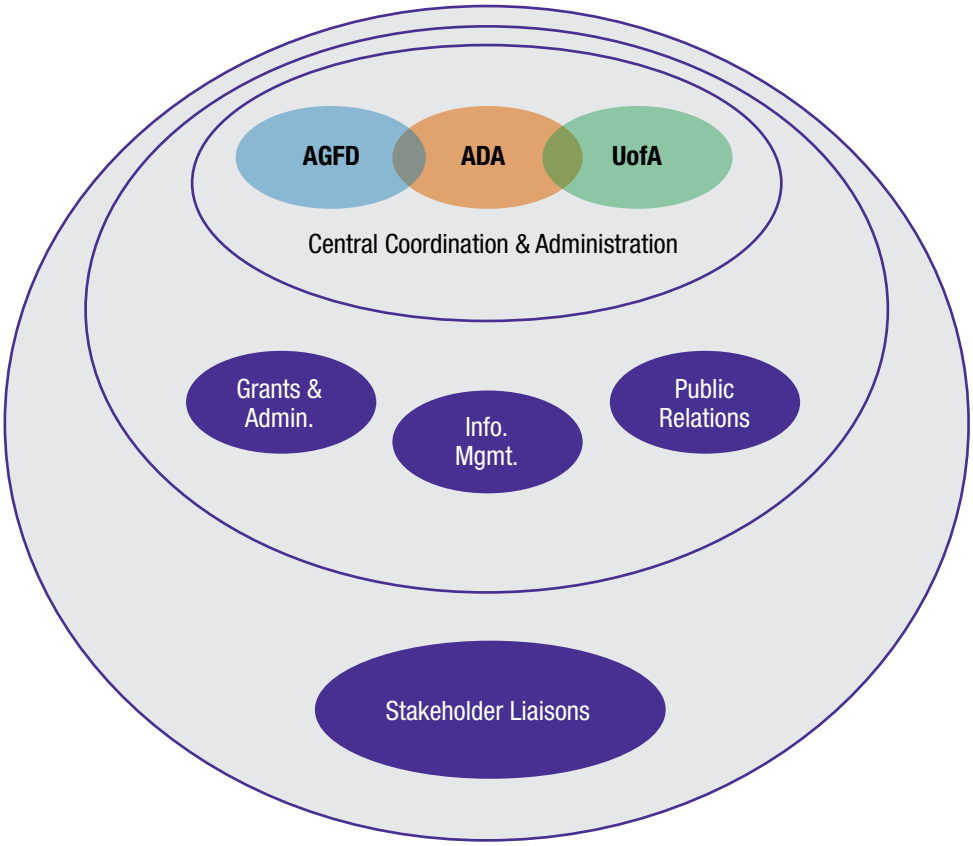


Figure 3. Proposed framework for the network approach to an Arizona Center for Invasive Species

and grants. Database development and management should reside in either the university or cooperative extension system; however, every agency would have information reporting responsibilities and appropriate coordination would be necessary. The Arizona Water Institute and the Forest Health Council are examples of organizations with a similar structure.

Primary Center Functions

- Administration: Central point of coordination/leadership (Arizona Game and Fish Department, Arizona Department of Agriculture, University of Arizona)
- Grants Administration
- Information Management: Web design and management; database/GIS implementation and management
- Public Relations: Education and outreach coordination
- Stakeholder Liaison Coordination and Communication

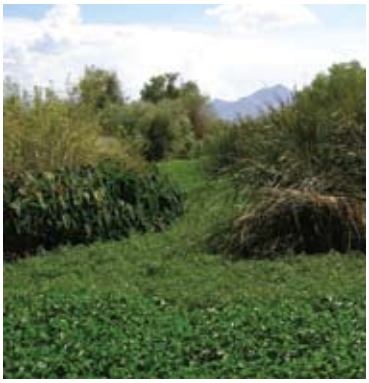
ALTERNATIVE B: AGENCY APPROACH

Under this approach, the center would be housed on its own, separate from any agency or organization. The AISAC, which is composed of state, federal and local governments, universities, nongovernmental organizations, and other key stakeholders, would provide the framework for invasive species management. A close working relationship would be developed among AISAC members and academic and research communities through memorandums of understanding and cooperative agreements. The AISAC would provide administrative oversight and appoint an unaffiliated executive director to oversee staff and daily functions and report directly to the Governor's office. The AISAC would identify research needs and make grant award decisions. Operation and staffing would be funded through general fund appropriation, intergovernmental agreements, endowments, grants, and source-generated revenues.

ALTERNATIVE C: PUBLIC, COMMUNITY AND ACADEMIC APPROACH

This approach would be a neutral and nonregulatory body composed of members from the public, as well as the academic and other interested communities. The center would have no AISAC affiliation and only limited ties to state and federal agencies and nongovernmental organizations. The nature of participation would be very broad, and areas of focus would be chosen and directed by the center's membership. The center would coordinate with the academic community, special interest groups, and other interested parties to recommend research needs and priorities. Funding would be self-generated with support from grants, endowments, charitable donations, and membership dues. No guaranteed public money would be affiliated with this approach.

Examples of organizations with a similar structure include the Western Association of Fisheries and Wildlife Agencies (501c.4), the Arizona Association of Conservation Districts (501c.3b), Southwest Vegetation Management (501c.3b), and Weed Management Areas.



ADA

An infestation of several non-native invasive plants in the Salt River near Phoenix.

ALTERNATIVE D: ACADEMIC/UNIVERSITY APPROACH

The center would be affiliated with Arizona universities which would provide coordination and communication among government agencies, organizations and interested parties in relation to nonregulatory invasive species issues. The center's operation would incorporate opportunities for temporary state agency staff assignments and would be funded through existing university funding, cooperative and intergovernmental agreements, memorandums of understanding, endowments and grants.

The alternative strategies were evaluated using the following criteria:

- Highest value for the cost. A cost/benefit approach was taken to identify which alternative would provide the most benefit in addressing statewide invasive species issues for the least cost.
- Least funding risk. The alternative with the most stable long-term funding is the most desirable.
- Lowest risk due to political change. The alternatives were assessed according to their susceptibility to shifts in political priorities.
- Highest leadership and coordination potential. The need for cross-jurisdictional leadership and coordination will be paramount in adequately and appropriately addressing invasive species issues.
- Highest success at addressing invasive species issues.
- Highest voter accountability.

Each alternative was ranked from 1 to 4 for each criterion with 4 being most desirable outcome, and 1 being the least desirable outcome (Table 3). The alternative with the highest total score was considered to be most suitable alternative.

Recommendation / Action Planned

13. Adopt Alternative A, the Network Approach, as the recommended concept for the Center for Invasive Species to address needs in coordination, collaboration, resources and outreach; to identify and prioritize needs in research; and to increase public awareness and motivation to support invasive species priorities.

Table 3. Ranking of alternative approaches for an Arizona Center for Invasive Species.

Criteria	Alternative			
	A	B	C	D
Highest value for the cost	4	1	2	3
Least funding risk	4	2	1	3
Least political risk	3	1	4	2
Highest leadership and coordination potential	2	4	1	3
Highest success at addressing invasive species issues	2	3	1	4
Highest voter accountability	3	4	1	2
Total	18	15	10	17

OBJECTIVE 5: STAKEHOLDER COORDINATION

The AISAC will continue to identify stakeholders and interested parties and solicit participation at AISAC meetings. No formal process has been developed to ensure that communities work with agencies in a standardized way, which has resulted in uncoordinated and oftentimes overlapping control efforts. In 2005, AISAC surveyed government agencies and nongovernmental organizations to estimate spending on invasive species. Information provided by nine independent groups estimated their total spending on control, outreach, and education from 2003 to 2005 at $1.5 million. Identifying areas of overlap and providing a coordinated approach could generate cost savings and allow redirection of those dollars to address other invasive species issues. Enhanced coordination would reduce sporadic and incomplete control efforts, minimize overlap, identify gaps and provide a more comprehensive and effective approach to invasive species control.

Recommendation / Action Planned

14. Formalize a standard management protocol for use by volunteer groups and state and federal agencies with oversight responsibilities.

15. Align and coordinate statewide jurisdictions to eliminate overlap and gaps in existing authorities and responsibilities.

16. Encourage county and municipal government involvement in the development of a statewide invasive species control plan, and consider increasing the Arizona Invasive Species Advisory Council membership to include a city/town representative.

MEASURES OF EFFECTIVENESS

The management plan will be reviewed on a two-year cycle. At that time, the

Leadership and Coordination work group will review the Leadership and Coordination objectives and action plan to evaluate progress on accomplishing the following measures of effectiveness:

- A review of all recommendations (actions planned) is conducted every two years for progress and completion as per AISAC priority. Addition of components may be identified and incorporated per AISAC direction.
- A web-based directory has been produced and is being used. Track number of hard copies requested and distributed, frequency of directory updates.
- Activity is occurring at local, state and regional conferences and forums. Track attendance, participation and sponsorship.
- The process to establish the Invasive Species Rapid Response Fund has been initiated.
- Funding and other resources are being used effectively. Review annual expenditures and accomplishments.
- AISAC members, experts, advisors and participating stakeholders are providing interagency contributions and in-kind service. Monitor and report on amount.
- Web-based and other outreach mechanisms are effective. Monitor use and conduct online surveys to evaluate success in achieving change/ expected outcomes.

The Buffelgrass Strategic Plan Working Group is a formalized association that includes representatives of jurisdictions, agencies and organizations that have contributed financially to regional buffelgrass control efforts through the Cooperative Ecosystem Study Unit. The group's goal is to build and strengthen cooperative buffelgrass management efforts.

The group has compiled cost estimates for treating buffelgrass infestations, which range from about $40 per acre for spray treatment of roadsides using a large truck with spray booms to about $97 per acre for hand wand-spray applications. Costs increase substantially away from roadsides. For example, in 2007, costs for treating large areas on Tumamoc Hill ranged from $188/acre to $850/acre, with an average cost of about $418/acre. Labor costs were estimated at an average of around $18.50/hour. Variable materials costs were about $88 per acre. These cost estimates are for just one treatment, and follow-up treatments are generally required in subsequent years.

BEN WILDER

- An invasive species memorandum of understanding that identifies responsibilities, coordinated efforts, and opportunities for coordination and management has been prepared and signed by state agencies, federal agencies and stakeholders.
- Cost savings are resulting from coordination and redirection of funds among groups that support invasive species actions. Calculate savings, identify overlap and redirect dollars to address other invasive species issues with the goal of increasing effectiveness and providing cost savings.

RESEARCH AND INFORMATION MANAGEMENT

A plan to manage invasive species must address research, which in turn strengthens every aspect of the plan, from outreach and prevention to control and restoration. Progress in dealing with invasive species is propelled by research; however, challenges to research continue to grow as new invasive species come to light. Prioritization and coordination of research efforts among state and federal agencies, universities, private landowners and neighboring states is essential to ensuring a rapid, integrated response to invasive species threats that respect no boundaries.

Malta starthistle is a native of southern Europe introduced to North America in the late 18th century. Now a pest in most western states, it is a good example of how an invasive plant succeeds in dominating new habitats primarily by altering the below surface soil microbiology. Little research has been done on its control. Traditional mechanical methods, including pulling, grazing, mowing, burning, and cultivation can deplete seed banks and manage infestations when used over a period of several years. Chemical methods are also effective, but chemicals with no soil residual activity will not prevent seeds from sprouting. Biological controls hold some amount of promise, and recent research completed in 2001 suggests that a rust specific to Malta starthistle may be effective if applied early and heavily, although further research is required to confirm these findings.

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OBJECTIVE 6: COORDINATION OF RESEARCH EFFORTS

Research on invasive species in Arizona is largely uncoordinated and driven by the interests of individual scientists or the mandates of various agencies. It would be highly beneficial to coordinate and monitor research to the maximum extent possible. A contact database with a directory of invasive species experts would be a valuable aid in coordinating research efforts and encouraging communication on invasive species issues. The database could be created and updated by distributing a feedback form to identify subject matter experts, scientists, and resource managers who can respond quickly to matters of research and information management and provide leadership and coordination skills.

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Malta starthistle often grows in dense, impenetrable stands, rapidly displacing native vegetation and creating a monoculture, or pure stand. Range forage value is lost when this occurs, as the plant is of low palatability.

Preventing or limiting an invasive species introduction generally depends on rapid response. Experts, resource managers and other key stakeholders need to be contacted and convened quickly to assess any potential threat and coordinate on expanding detection efforts and/or accelerating prevention and response measures. The contact database would support a timely response.

Improved coordination would allow the rapid assessment of an invasive species organism. It would also encourage research across all disciplines to address areas of need such as prevention and early detection capabilities, reporting and monitoring systems, and control and management strategies.

Coordination of research efforts could be improved by surveying invasive species experts and stakeholders to identify and assess invasive species threats, including species that are already present in Arizona and those that may soon arrive. Survey results would guide statewide research efforts. This information should be collated and incorporated into a comprehensive database.

Conducting a review of past and present invasive species research would greatly benefit coordination efforts and guide future research. It would help researchers stay informed and promote information sharing among interested parties. Additional benefits would be realized from a recurring review of both research and threats to identify and prioritize current and potential research needs. A prioritized list of research needs could guide the direction of future research and funding and assist agencies and organizations in setting priorities and gaining project approval.

An appropriate venue for such an exercise would be a workshop setting. Participation should be large enough to have sufficient representative expertise, but small enough to be able to make decisions. Participants should include representation from the following entities:

State Agencies
Arizona Department of Agriculture
Arizona Department of Commerce
Arizona Department of Environmental Quality
Arizona Department of Health Services
Arizona Department of Homeland Security
Arizona Department of Transportation
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona State Land Department
Arizona State Parks

Federal Agencies
Animal and Plant Health Inspection Service
Bureau of Indian Affairs
Bureau of Land Management
Bureau of Reclamation
Centers for Disease Control and Prevention
Fish and Wildlife Service
Forest Service
Geological Survey
National Park Service
National Plant Diagnostic Network

Local Government
Cities
Counties

Academic
Arizona State University
University of Arizona
Northern Arizona University

Tribes
Intertribal Council

Private and Nongovernmental
Arizona Association of Conservation Districts
Arizona Public Service
Arboretum and botanical gardens
Arizona-Sonora Desert Museum
Arizona Weed Management Areas
Audubon Society
Native Plant Society
Riparian Council
Salt River Project
Sierra Club
Sonoran Institute
Southwest Gas
Southwest Vegetation Management Association
The Nature Conservancy

All the material used in the review and prioritization process, as well as the workshop outcomes, should be collated and stored in a comprehensive database. Having all this information at hand would promote communication and information sharing and allow frequent review of research progress and results. It would also help managers conduct science-based risk assessments, assist in the rapid evaluation of an invasive organism's potential to impact agriculture, wildlife, human health and the environment, support timely actions to limit or eradicate invasive organisms, and provide restoration strategies and outcomes.

Recommendation / Action Planned

17. Identify invasive species experts including public and private scientists and resource managers and create and maintain a database of contact information. Survey the experts every two years to identify current invasive species threats, and compile associated information in an accessible comprehensive database (Recommendation 22).

18. Conduct an initial systematic review of past and present invasive species research efforts and invasive species threats in order to identify gaps in research. Create a prioritized list of current and potential invasive

species research needs to guide future research and funding. Following the initial review, organize and conduct a regularly scheduled workshop (recommended for every two years) to review the list of invasive species threats and current research efforts, and create a new prioritized list of research needs. Catalog all research data, reports, and results in an accessible comprehensive database (Recommendation 22).

19. Encourage research across all disciplines to address areas of need. Conduct research to develop, improve, and maintain early detection capabilities, and reporting and monitoring systems. Develop and improve control and management strategies. Catalog all research data, reports, and results in an accessible comprehensive database (Recommendation 22).

20. Use the database of contact information (Recommendation 17) and information compiled in Recommendation 18 to arrange and conduct rapid assessments of individual invasive species issues as they arise and as needed. Convene experts, scientists, and resource managers to assess potential threats and impacts on biological, environmental, ecological, economic, and human health using the prioritization criteria described in Appendix B. Catalog all research data, reports, and results in an accessible comprehensive database (Recommendation 22).

H. D. CATLING

Symptoms of citrus greening disease on a sweet orange tree

OBJECTIVE 7: COORDINATED INFORMATION MANAGEMENT SHARING SYSTEM

A coordinated, up-to-date information management system is a critical component of state-level invasive species planning. Information management is a universal issue that affects multiple aspects of such plans. Several state and federal agencies, nongovernmental organizations, and institutions of higher learning have already developed databases and information-management systems. Examples include:

Heritage Data Management System (HDMS), managed by Arizona Game and Fish Department, identifies and tracks plants and animals of concern or those with special status at the federal, tribal, or state level.

Southwest Exotic Plant Information Clearinghouse (SWEPIC) and **Southwest Exotic Plant Mapping Program** (SWEMP), both managed by U.S. Geological Survey, regional invasive plant databases available online http://invasivespecies.nbii.gov/projects/swemp/swemp.html

Crayfish Occurrences, managed by Arizona Game and Fish Department.

National Agricultural Pest Information System, regulated plants, insects,

diseases, and bio-control agents with occurrences recorded mostly at the county level (some global positioning system-derived locality information, presence-absence data, management status, and survey information).

Forest Service databases, forest insect and diseases: http://www.fs.fed.us/foresthealth/programs/invasive_species_mgmt.shtml; http://www.invasive.org/insects.cfm; http://www.invasive.org/diseases.cfm.

Arizona Department of Agriculture Invasive Plant Database (nonpublic).

Arizona Department of Transportation, invasive plant treatment database providing occurrence information to SWEMP.

Natural Resources Conservation Service, plant material databases containing introductions, investigations, etc.

Southwest Environmental Information Network (SEINet), Arizona herbaria specimen database available online at: http://seinet.asu.edu/collections.

PLANTS database, available online at http://plants.usda.gov.

INVADERS database, invasive species of the Pacific Northwest available online at http://invader.dbs.umt.edu/.

Arizona FIREMAP (Fuels, Information, Restoration, Education Mapping and Assessment Program), a project being developed by the State Forester's Office and the State Cartographer's Office that includes a number of tools to help track, plan, and prioritize fuel treatment and other forest activities throughout Arizona, available online at: http://azfiremap.org/azfiremap/.

Arizona Plant Diagnostics Network (AZPDN): http://cals.arizona.edu/azpdn/

Regional Plant Diagnostics Network (WPDN): https://www.wpdn.org/index.php

National Plant Diagnostics Network (NPDN): http://www.npdn.org/DesktopDefault.aspx

Arizona Crop Information Site (ACIS): http://cals.arizona.edu/crops/

Creation of one central location for data collection, collation, analysis and dissemination would minimize current barriers to providing comprehensive, statewide management strategies. Such a system should be compatible with existing systems, interoperable and sharable, and have minimum data standards that are defined and consistent. Resulting products and data should be available to agencies, universities, regional planners and any other potential users.

Recommendation / Action Planned

21. Create a task force to: 1) review database and mapping systems and recommend one that will meet the needs identified in this management plan; 2) evaluate existing information management systems potentially adaptable to meet or supplement Arizona information needs (e.g., SWEPIC, SWEMP, HDMS, etc.).

22. Implement the invasive species database and mapping system identified by the task force (Recommendation 21). Identify the appropriate organization/stakeholder(s) to dedicate to database management and maintenance and website design and maintenance (funding reallocated within existing budgets for responsible parties).

23. Create and maintain an invasive species website. Maintenance will be overseen by the lead entity identified in Recommendation 22.

CHRIS EVANS, RIVER TO RIVER CWMA

Introduced waterweeds, such as hydrilla, have already established in some Arizona lakes and streams.

OBJECTIVE 8: COORDINATED INFORMATION EXCHANGE, ROLE FOR A CENTER FOR INVASIVE SPECIES

Data and information collection efforts are ongoing, but transfer of this information among agencies, organizations, universities and other parties is limited. Coordinated information and data transfer is needed to assure effective, data-driven, statewide research and management decisions; a Center for Invasive Species would facilitate this need.

Recommendation / Action Planned

24. Make data easily accessible, easily and routinely updated, and available via a web interface (in coordination with Recommendations 22 and 23).

25. Maintain links on the Invasive Species website to other sites, such as the APHIS Pest Alert website, to promote coordination and information sharing with other organizations (in coordination with Recommendations 23 and 24).

26. Create, maintain and publish an online library on the Invasive Species website (in coordination with Recommendations 23 and 24).

27. Identify information management gaps in the occurrence, assessment, inventory, and monitoring of invasive species information.

MEASURES OF EFFECTIVENESS

- A directory of subject matter experts has been created and is being kept current through web-based input. Measure breadth of coverage by the number of inputs made and the extent of taxa. Measure accuracy by the number of messages that bounce back when sent to the e-mail list.

- Invasive species databases have been identified and linked into an informational database or list for reference by interested parties. Log the number of databases linked and the number of times the informational database or list is accessed.
- The list of subject matter experts has been invited to establish the Arizona Invasive Species Research Review Committee. Note the number of experts actively involved and coverage of subject matter. Validate and verify the research prioritization and review process.
- A prioritized list of current and potential invasive species research needs has been completed. Reviews of the list are conducted every two years. Track the number of times the list is used.
- A workshop is conducted every two years to review research efforts and threats and prioritize research needs in conjunction with the meeting of the Arizona Invasive Species Research Review Committee. Track reporting occurrence following the research workshop (target = 100%).
- A research results database has been established. Track number of times the database is accessed.
- A survey has been developed for experts, scientists and managers to submit a species to be reviewed and prioritized for research. Track the number of times a prioritization of research needs is conducted.
- Research is being conducted to address areas of need such as early detection capabilities, reporting and monitoring systems, and control and management strategies. Track number and progress of research projects during biennial workshop review.
- A task force of database and mapping experts has been assembled. The task force has evaluated existing information systems and developed a recommendation for a database and mapping system. The recommended database and mapping system has been implemented.
- An Arizona Invasive Species website has been created. Track the number of hits on the site.

ANTICIPATION AND OUTREACH

Few Arizonans understand or are even aware of the issues associated with invasive species, yet knowledge and cooperation must be the foundation of any effort to address these issues. Arizona needs a robust outreach program to promote widespread awareness, understanding, and support. The program should have a broad, consistent message for the general public to encourage behavioral changes and build support for actions to combat invasive species.

The program should also have more specific messages aimed at specific concerns to assist authorities responsible for acting on invasive species issues, as well as landowners and managers who must make management decisions, and policymakers who control funding, legal authorities and agency accountability.

An outreach program must also anticipate pathways of invasive species introduction and convey information to key audiences who can take preventive action. Once a species has been introduced and becomes widespread, controlling it can require significant time and sustained expenditures. Prevention is the first line of defense and the most cost-effective measure to protect against invasive species introduction.

OBJECTIVE 9: EDUCATION, KNOWLEDGE AND AWARENESS OF INVASIVE SPECIES

Many groups of people are in a position to impact an invasive species introduction. Many of these same groups are well situated to help in detecting and reporting occurrences and spreads. Reaching these varied audiences

Import and transport of crayfish within Arizona (except in portions of Yuma and La Paz counties) is restricted to help reduce their spread into sensitive habitats. However, many schools rely on live crayfish as a central component of a fourth grade science module. The Arizona Game and Fish Department is working with school districts on a pilot program to keep crayfish in the classroom. The program requires a "Responsible Use Plan for Live Animals in the Classroom" and a department Wildlife Holding Permit to ensure that teachers and district science coordinators do not allow live crayfish or other classroom specimens to be released into the wild or given away to students or other unauthorized stewards. Eight school districts have enrolled so far.

A classroom lesson plan called "The Trouble with Crayfish" was jointly developed by the department and science teachers to highlight the impact that crayfish have on Arizona's native wildlife and habitats. The lesson plan is available on the department's website: http://www.azgfd.gov/i_e/ee/lessons/crayfish/crayfish.shtml.

JEFF SORENSEN, AGFD

Crayfish have overrun this springhead at Three Forks in the White Mountains. It was once habitat for the federally threatened Chiricahua leopard frog and the candidate Three Forks springsnail. Notice the lack of aquatic vegetation.

and engaging their support requires a variety of information and education strategies.

KEY AUDIENCES

Five key audiences have the potential to play a role at varying levels of prevention, detection, regulation, education, control, and management. These audiences may be targeted to increase awareness of invasive species issues.

- **Government:** City, county, state and federal agencies, chambers of commerce, roadside rest stops, ports of entry, airports, tribes, schools K-16 (teachers and students)
- **Retail and Industry:** Garden centers, sporting goods retailers and rentals, equipment rentals, pet store owners, horticulturalists, landscape industry, growers (nurseries), resort and tourism industries, bus and rail lines, car rental agencies, trade associations, marinas, moving companies, developers, pesticide/herbicide applicators
- **Private:** Ranchers, farmers, homeowners associations, home owners, gardeners
- **Nongovernmental Organizations:** Youth organizations (4H, Future Farmers of America), scouting groups, conservation groups, professional societies, equestrian associations, veterinarians association
- **Recreationists:** Boaters, anglers, hunters, hiking/camping clubs, birdwatchers, off-highway vehicle operators

Areas for Outreach Focus

Many outreach campaigns and associated materials have already been designed

The national public awareness and partnership campaign, "Stop Aquatic Hitchhikers," calls on recreational water users to help contain the spread of new species to lakes and streams, and to stop the transfer of species between water bodies. The U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration launched the campaign to reach out to federal and state agencies, organizations and businesses to help spread the message by using a distinct, easily identifiable "brand," and a strong call to action. The campaign uses signs, handouts, and other communication tools, including news releases and a Web site, ProtectYourWaters.net.

In addition to raising the awareness of recreationists, the campaign is also designed to unite the conservation community to speak with one voice about this complex issue and to demonstrate the critical role that outreach, education, communications and marketing plays in dealing with challenging resource management issues.

STOP AQUATIC HITCHHIKERS!™

Prevent the transport of nuisance species.
Clean all recreational equipment.
www.ProtectYourWaters.net

to address a variety of invasive species issues. These issues fall into six primary categories: General, Insects, Aquatic Species, Terrestrial Species, Weeds, Disease and Vectors. A table presented in Appendix C (Existing Campaigns/ Messages) contains information about these campaigns grouped by species/ issue addressed, author/sponsor, message, deployment method, and website address.

AGFD

A Game and Fish officer checks a watercraft for quagga mussels.

POSITIVE COMMUNICATION TOOLS

An outreach program should employ a variety of communication tools selected within the limits of available funding to most efficiently and effectively reach the targeted audience. The following list presents a broad array of the many options available.

- **Print Media:** Brochures, flyers, mail stuffers (licenses, utility bills, etc.), posters, newspaper, and chamber of commerce informational packets
- **Web Media:** Websites and links, PowerPoint presentations, pod casts, distance learning (online curriculum)
- **Television:** Public service announcements (PSAs), TV programming (e.g., Arizona Wildlife Views), local talk shows
- **Radio:** PSAs, local talk shows
- **Signage:** Billboards, strategically placed interpretive displays (display booths for classes and events), roadside message boards, car wraps, buses (city, school), airports and transportation corridor display boards
- **Promotional Items:** Refrigerator magnets, buttons, tape measures, key chains, pens, coffee cups, calendars, bumper stickers, t-shirts, hats, CD ROMs, temporary tattoos
- **Educational Programs:** Clinics, presentations, education curriculum, CD ROMs
- **Other:** Speakers bureau, arena/stadium Jumbotrons, movie theater screen advertisements

PROCESS OWNERS

The following listing (Table 4) identifies agencies and organizations that are suitable process owners for creating and distributing invasive species information tools. Agencies with regulatory authorities would likely take the lead role in efforts to increase awareness. For example, if quagga mussels are discovered on a boat hull in a body of water in Arizona, the Arizona Game and Fish Department would be the suitable process owner to take the lead coordination role in informing partners and the public.

Table 4. Process owners for creating and distributing invasive species information tools.

State
Arizona Department of Agriculture
Arizona Game and Fish Department
Arizona Department of Emergency Management
Arizona Department of Health Services
Arizona Department of Transportation
Arizona Office of Tourism
Arizona State Parks
Arizona Department of Water Resources
Arizona Department of Commerce
Arizona State Land Department
Arizona Office of Homeland Security
State Universities

Federal
U.S. Fish and Wildlife Service
Bureau of Land Management
National Park Service
USDA Forest Service
USDA - APHIS
Department of Homeland Security

Local
Conservation Districts
County and Municipal Governments
Cooperative Extension (Universities)

Nongovernmental Organizations
The Nature Conservancy
Arizona Audubon Society
Museums
Arizona Association of Conservation Districts
Trust for Public Lands
Center for Biological Diversity
Native Plant Society
Southwest Vegetation Management Association
Arizona Weed Management Areas
Other

Tribes
Intertribal Council

UNIFIED OUTREACH AND ADVANCE DETECTION PLAN

The charts presented below outline a proposal for a unified outreach and advance detection plan. The proposal incorporates a two-step approach. Step One is an outreach plan to identify threats, promote prevention, and facilitate early detection and reporting. Step Two is a strategy for a rapid response operation following an initial detection.

Step One: Outreach Plan

The Outreach Plan Process flow chart illustrates a course of action the process owner may follow when conducting outreach on invasive species issues. It describes the steps for effective communication using various media outlets. The media outlets and outreach strategies are summarized in the Invasive Species Outreach Plan Process (Figure 4) and should be selected and implemented based on the issues at hand. The planning process includes interaction with and approval from AISAC stakeholders and partners for continuous support and teamwork, and measuring the effectiveness of the outreach strategies to aid in improving future efforts.

The Outreach Plan Template (Appendix F) can be used for proactive promotional purposes (i.e., promoting the new website), rapid response or issue-based public information. The template outlines a number of outreach strategies, most if not all of which can be accomplished with minimal funds. If significant funding is obtained, billboard, radio and television announcements may also be considered.

To evaluate the success of an outreach campaign, the knowledge, attitudes and behaviors of your target audience should be assessed before the campaign begins and then monitored for change as it progresses. Baseline information does not exist for invasive species issues in Arizona, but it could be collected by adding invasive species questions to the Arizona Game and Fish Department's biennial "Trends" survey, a telephone survey of 1,500 randomly selected Arizona residents age 18 years and older. Questions could focus on invasive species awareness, knowledge of existing campaigns, and preferred methods/sources of receiving information. Measuring success will require monitoring to measure long-term trends.

Step Two: Rapid Response Following Initial Detection

A rapid response operation is made up of five actions: detection and reporting, identification and vouchering, rapid assessment, planning, and rapid response. The Rapid Response Process (Figure 5) provides an overview of these actions as they should occur. This process is a simplified example demonstrating key steps in rapid response and in no way is intended to preclude the adoption of more structured decision-making tools.

In addition to this, a Rapid Response Fund needs to be considered to help supplement, not supplant, existing program funds that would be used in the response process.

Sirex wood wasp, a major pest of pine producing 80 percent pine mortality in the Southern Hemisphere, has recently been found in New York, Pennsylvania, Michigan, Vermont, and Ontario, Canada. It could spread to all pine habitats in the United States. Surveys, regulatory actions, and a treatment program using biological control measures are employed to find the leading edge of the infestation, prevent artificial movement, and limit damage. Early detection traps are in place in Arizona allowing for a rapid response if this pest is discovered.

DAVID R. LANCE, USDA/APHIS

Outreach Plan Process

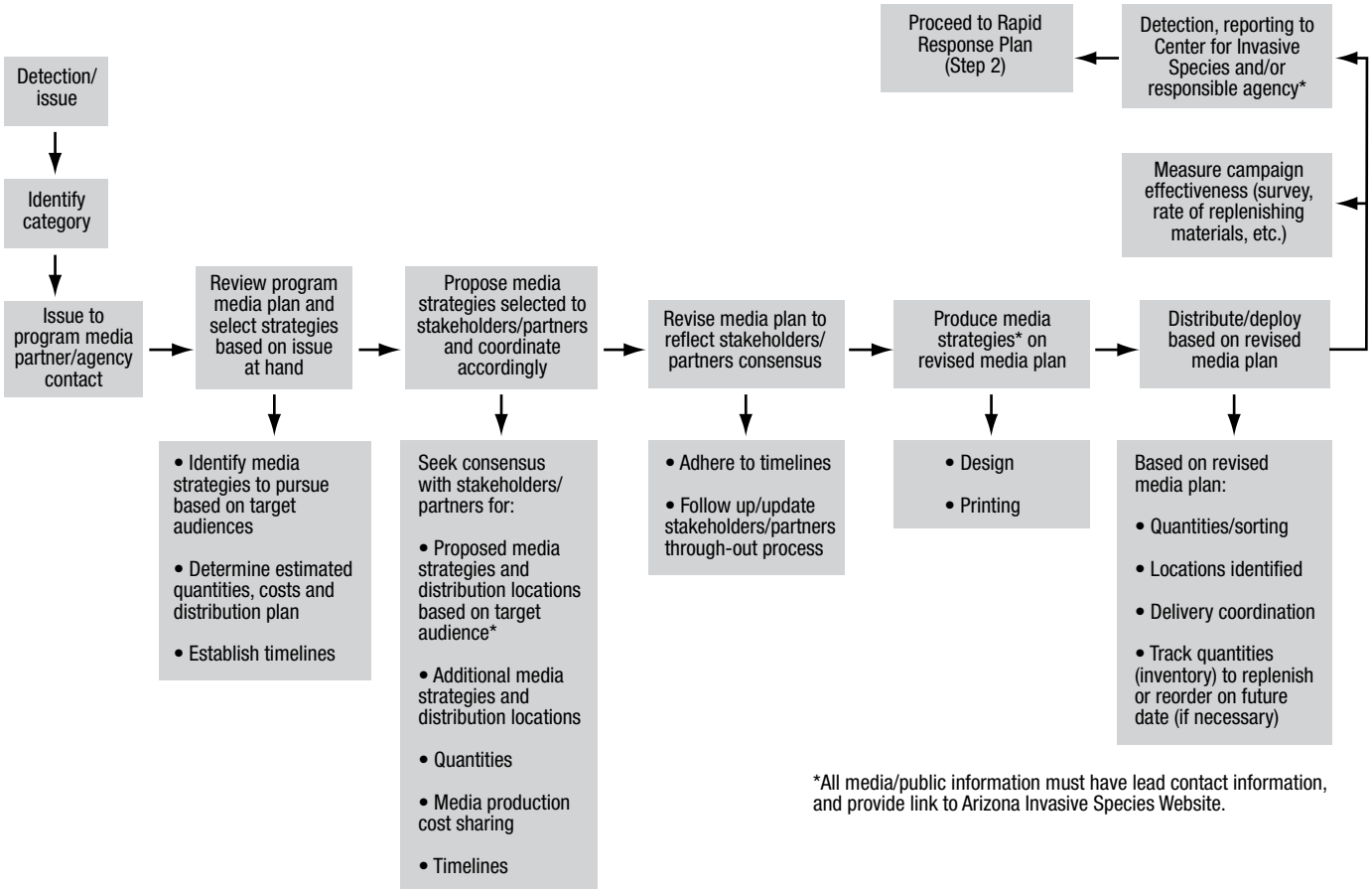


Figure 4. Outreach plan process for invasive species campaign development and deployment.

Detection and Reporting

When a suspected invasive species has been detected and reported by a state or federal agency or nongovernmental organization, it must be submitted for identification using approved protocols.

Identification and Vouchering

A state and/or federally accredited laboratory must verify any suspect samples before regulatory action can be pursued. For nonregulated invasive species, nongovernmental organizations may take action with support from relevant agencies.

Rapid Assessment

After verification is made, steps must be taken to assess potential ecological and economic impacts according to established protocol. A delimiting survey must be conducted to define the extent of the problem. Pathways and mobility of the threat must be identified to determine the likelihood of spread (Refer to Pathways Outline, Appendix D). A cost/threat analysis must be conducted

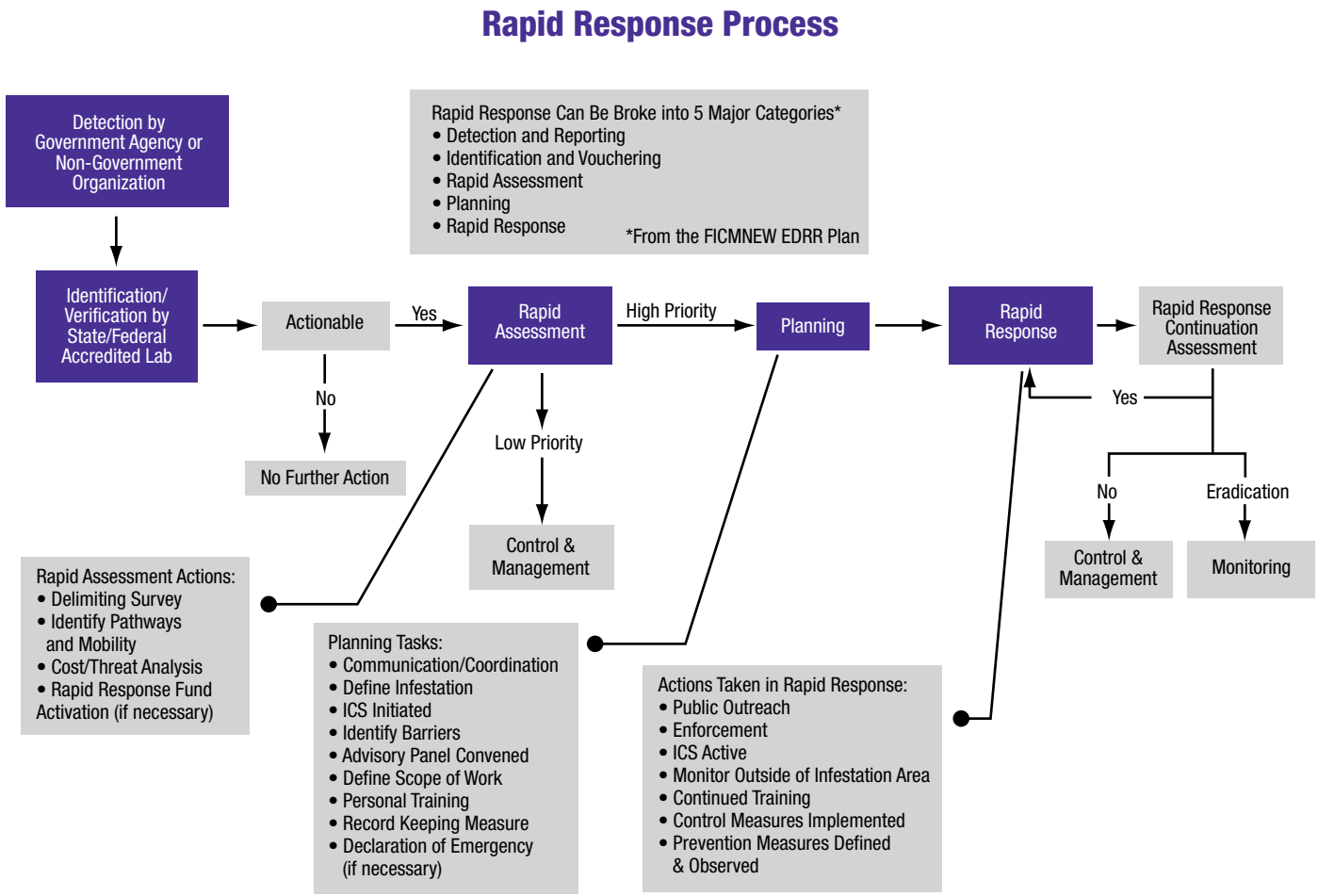


Figure 5. Rapid response process following initial detection and reporting of an invasive species occurrence. Darker boxes represent the five major categories of rapid response.

to weigh the needed actions versus the potential impact. If funding support is needed, the proposed rapid response fund should be used. If the situation does not warrant continued rapid response actions, pest management measures may be implemented.

Planning

- When a Rapid Response action has been deemed necessary, a series of planning steps must be carried out.
- Initiate communication and coordination with appropriate key stakeholders, landowners, and authorities.
- If applicable, delineate the quarantine area where regulatory authority measures are being implemented.
- For a nonregulated species, delineate the extent of infestation.
- Initiate Incident Command Systems (ICS) for effective leadership and coordination; state and federal agencies observe the Federal Emergency

Management Agency's ICS 100 and 200 training program modules at a minimum (see page 85 for information on program).

- Identify potential barriers due to land ownership and possible restrictions on control measures; take action to remove barriers or identify alternate means of control.
- Consult an advisory panel of experts to determine the most effective means of control given the situation and Best Management Practices to ensure containment.
- Outline the scope of work describing the manner in which control measures will be conducted and providing an overview of their effectiveness.
- Conduct training for personnel who will be involved in rapid response measures.
- Establish and follow adequate record-keeping procedures.
- If priorities deem it necessary, take steps to activate an Emergency Declaration from the Governor's office.

Rapid Response

Once Rapid Response actions are initiated, the following processes should be active.

- Conduct public outreach to ensure cooperation of all participating agencies and organizations with local authorities, businesses, and residents.

Arizona's first reported population of kudzu was discovered in Cochise County in late September 2006. Collected samples plus photos were enough evidence for a U of A weed biologist and an ASU plant taxonomist to make the initial vegetative diagnosis. DNA sequence analysis of leaf samples at the ASU School of Life Sciences matched published kudzu DNA sequences.

The Arizona Department of Agriculture initiated an eradication process using Milestone VM,™ a new herbicide from Dow AgroSciences. A Dow specialist supplied weed management expertise for eradication treatments that began in November 2006. Milestone was applied to the kudzu at a rate of 7 ounces per acre and repeated in March and June 2007. Visual estimates in August 2007 indicated that more than 97 percent of kudzu biomass died as a result of those three treatments.

Even though the kudzu infestation appears to be controlled, treatments are planned for 2008 to complete eradication and will continue until new shoots cease to emerge; then occasional monitoring is needed to ensure none of the underground root reserves survive and clone new kudzu plants.

KERRY BRITTON, USDA/FS

- Enforce any quarantine measures previously defined and any regulatory mandates to eliminate possible human-caused spread.
- Continue ICS efforts for leadership and coordination.
- Implement monitoring of key, high-risk areas outside the infestation area to ensure containment.
- Continue training of personnel on rapid response measures and ICS.
- Implement control measures to eliminate the threat.
- Review rapid response actions on a continual basis to assess their feasibility and viability. Continue them if needed.
- If the threat is eradicated, initiate a monitoring program.
- If ecological and economic parameters determine rapid response is ineffective and unfeasible, implement control measures.
- Identify and adhere to prevention measures.

KERRY BRITTON, USDA/FS

The woody, densely leaved kudzu vine grows rapidly, smothering both land and vegetation. In southeastern states, mature pine trees, roadsides, landscape plantings, even telephone poles have been buried under kudzu's invasive growth.

CONTROL AND MANAGEMENT

If constant evaluation has deemed the rapid response measures unfeasible, and the invasive species has not been eradicated, control and management measures will be initiated.

Funding needs to be available to support a prompt and appropriate response to invasive species introductions. Timely access to funding must be assured because rapid procurement and distribution of resources is often critical to a successful response effort. An invasive species rapid response fund needs to be considered as a means to supplement, not supplant, existing program funds that would be used in the response process.

Recommendation / Action Planned

28. Conduct a survey of Arizona residents to determine baseline knowledge of invasive species issues and campaigns, and conduct follow-up surveys to identify effectiveness of those campaigns, and related behavioral changes. Survey questions can be revised annually to identify effectiveness of specific campaigns. Refer to Appendix E for draft survey questions.

29. Conduct web-based surveys to evaluate the effectiveness of specific campaigns. Share survey results with stakeholders and other interested parties.

30. Employ or incorporate positive communication tools in the development of outreach campaigns, and make materials available to stakeholders and

interested parties (in coordination with recommendations 22–26, which refer to information sharing on the web).

31. Develop an Arizona Invasive Species logo/brand/icon and make materials available to stakeholders and interested parties.

32. Develop a general invasive species campaign (e.g., Arizona's 10 most wanted) using positive communication tools and various deployment methods, including curriculum development. Make materials available to stakeholders and interested parties.

33. Implement the outreach plan and advance detection system (Objective 9) for informing the public and key audiences of the risks of invasive species. Provide reporting mechanisms that include the Center for Invasive Species website (Recommendation 23).

OBJECTIVE 10: PATHWAYS FOR INVASIVE SPECIES

Prevention is generally the most effective line of defense against the damages and risks associated with invasive species. The most effective prevention strategy is to identify the pathways by which introduction and spread occur and take action to close them off. Arizona-specific guidelines to identify and understand

Internet commerce has opened a new and problematic pathway for foreign plants transported thousands of miles from their natural habitats to infest Arizona's lakes, streams and wetlands. A Google search using "pond plants" or "aquarium plants" reveals numerous ecologically and economically dangerous non-native aquatic plants available for purchase. A simple purchase by an uninformed Arizonan can easily move a water hyacinth or other non-native plant infestation into a backyard pond or aquarium. Then, careless disposal into nearby waters of excessive vegetative growth establishes an infestation in a local lake, stream, wetland or canal.

Eurasian watermilfoil

ROBERT L. JOHNSON, CORNELL UNIV.

Water hyacinth

TED CENTER, USDA/ARS

Since there is only limited control of Internet commerce, this conduit for introducing pest organisms is another reason for policy-makers, regulators, land managers and an informed public to fund, support and maintain survey operations to detect new invasive species infestations before they spread.

these pathways would improve control and management efforts and enhance outreach efforts to expand detection capabilities.

PATHWAYS

The National Invasive Species Council (NISC) Pathways Task Team developed an outline identifying the pathways by which invasive species are introduced. With some minor modifications specific to Arizona, the outline can be adopted as a tool to help to guide outreach, management and research efforts. This tool could be used in current efforts to identify threats. The modified Pathways Outline is attached in Appendix D.

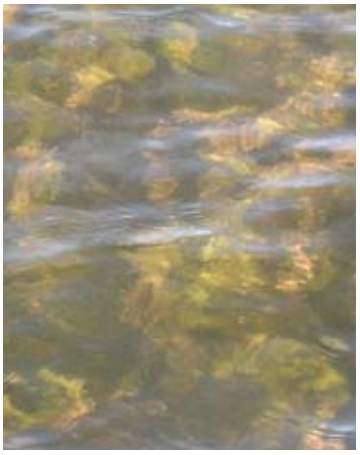
The NISC Pathways document identified the need to collect data to use in ranking pathway risks. The task team developed the "Significance Criteria Questionnaire" as a tool for collecting consistent data to use in determining the priority of an invasive species pathway (Invasive Species Advisory Committee, 2003). Adoption of the questionnaire as well as the pathways report will provide a mechanism for ongoing data collection and analysis. Frequent review of pathways will help focus research, control and management in those areas of high priority, and identify new pathways and/or shifts in the priority of existing pathways.

BEST MANAGEMENT PRACTICES

Arizona agencies and partnering organizations are committed to ending the introduction and spread of invasive species by adopting responsible management processes. Some agencies have already developed or adopted "Best Management Practices" for various invasive species and related issues. Best Management Practices (BMPs) are defined as the most satisfactory (under specific program legislative requirements) set of methods for exerting control over a regulated process or result. While each invasive species may require specific strategies, some general BMPs could be adopted by all stakeholders to help avoid the unintentional movement of plants and animals. Appendix C lists invasive species campaigns that include BMPs for the control of these species. Some issue-specific examples are listed below.

Preventing the Movement of Invasive Aquatic Species

- Don't transport water, plants or animals from one lake to another: drain bilge waters; wash boats and equipment.
- Inspect boat, trailer, and boating equipment (anchors, centerboards, rollers, axles), and remove any plants and animals that are visible before leaving any water body.
- Drain water from the motor, live well, bilge, and transom wells while on land before leaving any water body.



CHRIS EVANS, RIVER TO RIVER CWMA

Introduced waterweeds, such as Eurasian water milfoil, can reproduce by fragmentation. An effective way to prevent their spread is to check thoroughly for and remove any plant fragments from boats and equipment.

- Dispose of unwanted bait in the trash. Never release live bait into a water body, or release aquatic animals from one water body into another.
- Wash then dry your boat, tackle, downriggers, trailer, and other boating equipment to kill harmful species that were not visible at the boat launch. This can be done on your way home or once you have returned home. Some invasive aquatic species can survive more than two weeks out of water, so it is important to rinse your boat and equipment that normally gets wet with hot (at least 40° C or 104° F) tap water; or spray your boat and trailer with high-pressure water; or dry your boat and equipment for at least five days before transporting to another water body.
- Learn what these organisms look like (at least those you can see). If you suspect a new infestation of an invasive plant or animal, report it to your natural resource agency.
- Consult your natural resource agency for recommendations and permits before you try to control or eradicate an invasive "pest." Remember, invasive pests thrive on disturbance. Do-it-yourself control treatments often make matters worse and can harm native species.
- Do not release or put plants, fish or animals into a body of water unless they came out of that body of water.
- Aquarium and Aquatic Pets: If your family gets tired of its aquarium or aquatic pets, do not release anything from the aquarium (water, plants, fish or animals) into or near a body of water or storm drain. Explain to your children how you could be hurting all of the streams and lakes around the country and killing other fish and animals that already live in the water.

Monitoring and Preventing the Spread of Chronic Wasting Disease (CWD)

- Prohibit the importation of live deer and elk into Arizona, and restrict the movement of deer and elk within the state. Captive deer and elk are subject to marking and reporting requirements. Advise hunters of precautions to take when bringing harvested deer or elk into Arizona from other states.
- Extensive surveillance programs that monitor CWD distribution and prevalence have been instituted nationwide.
- In CWD-positive and -exposed facilities for farmed and captive cervids, the preferred management approach is state quarantine followed by whole herd depopulation and appropriate carcass disposal. Federal support, including financial compensation, is usually available for these activities.
- In some cases, double fencing around captive populations is recommended to prevent direct contact between captive and wild animals. A management

option currently utilized by several wildlife agencies is to reduce the density of wild cervids in infected areas in an effort to slow the transmission of the disease. This is primarily being done by increasing the number of hunting licenses issued to hunters.

- Additionally, some states selectively cull animals suspected to have been directly exposed to the disease.
- Many state agencies have banned the importation of live deer and elk into their states, and some also have halted intrastate movement of deer and elk. A number of states have banned supplemental feeding and baiting, which artificially congregates animals and enhances disease transmission.
- Several states also have implemented regulations that allow only boned meat, quarters (without spinal column or head) or processed meat from deer or elk to be exported or imported from certain areas containing CWD.

Asian tiger mosquito

SUSAN ELLIS

Prevention and Control of West Nile Virus

Prevention and control of West Nile virus and other arboviral diseases are most effectively accomplished through integrated vector management programs. These programs should include surveillance for West Nile virus activity in mosquito vectors, birds, horses, other animals, and humans, and implementation of appropriate mosquito control measures to reduce mosquito populations when necessary. Additionally, when virus activity is detected in an area, residents should be alerted and advised to increase measures to reduce contact with mosquitoes. Details about effective prevention and control of West Nile virus can be found in the Centers for Disease Control's, "Guidelines for Surveillance, Prevention, and Control."

Hazard Analysis and Critical Control Point (HACCP) Planning

Hazard Analysis and Critical Control Point planning is widely know by its acronym, HACCP (pronounced "hassip"). HACCP planning can be used as a pathway management tool to identify risks and focus procedures on preventing the spread of invasive species through natural resource pathways. Natural resource work could unintentionally spread nontarget (potentially invasive) species to new habitats. These nontargets could hitchhike on field or farm equipment, or be included in shipments of species moved into or out of a refugium or relocated to restore range. Species monitoring, collections, natural resource surveys, and fish stockings are also potential pathways.

On a larger scale, shipping and importation have provided pathways by which nonindigenous species have arrived in the United States. For example, it is widely accepted that zebra mussels *(Dreissena polymorpha)* were introduced to the Great Lakes through international shipping traffic and ballast water discharge.

Shippers did not intentionally move zebra mussels, but the ballast water they used to safely cross the ocean happened to contain zebra mussels. Once a ship enters a port, the ballast water is discharged and cargo loaded. Unfortunately many nontarget species can survive transoceanic trips in ballast water.

In a similar way, the horticultural industry has provided pathways by which numerous plants, or hitchhikers on plants, have been imported into the United States. Some of our worst insect invaders, such as the Formosan subterranean termite (*Coptotermes formosanus,* Shiraki), arrived in packing and crating materials. These invasive species now cause major problems in agricultural, rangeland, riparian, and other areas.

HACCP planning has become an industry standard ensuring food purity by removing hazards at critical control points throughout production rather than by more costly end-point testing. The key to understanding natural-resource-modified HACCP is to view nontarget species of plants, animals, diseases, pathogens, and parasites as hitchhikers or hazards throughout the planning process. The target is whatever is being moved from place to place. It could be a plant, animal, piece of equipment, sampling gear, or even a person.

Applying HACCP planning to natural resource work is a new concept. Without appropriate planning, the work that takes natural resource specialists and their equipment to various habitats could create pathways for species spread. HACCP planning identifies high-risk activities and focuses attention on those actions needed to close open pathways. Plans documenting risks, as well as methods used to remove nontarget species, give managers the opportunity to weigh the

MATT CHMIEL, AGFD

Gizzard shad may have been accidentally introduced to a lake in New Mexico with a shipment of largemouth bass from a hatchery in Texas. How they reached the Colorado drainage is unknown. One single adult gizzard shad was collected from Lake Powell in 2000 near the San Juan River inflow. By 2007 these highly invasive fish occupied the entire lake, and in a 2006 netting sample they accounted for almost as much fish biomass as striped bass. Gizzard shad grow quickly and attain a much larger size than threadfin, previously the only shad in Lake Powell. By 2005, some adults had reached 18 inches in length and weighed 2 pounds. The rapid growth means that largemouth and smallmouth bass are able to eat them for only a short time each spring; then shad and young bass may actually compete for the same limited planktonic food.

In a system the size of the Colorado River and its reservoirs, there are no control mechanisms for gizzard shad. The system is open and has a direct pathway to Lake Pleasant. Our only management tools are current laws against transportation of live fish and restrictions and regulations put on the bait fish industry.

risks for species spread against the benefits of natural resource actions. For some pathways, the risks outweigh resource benefits until better procedures are identified. HACCP planning provides a systematic method to make decisions and develop procedures that can be shared with other stakeholders to reduce risks of species spread through pathways with similar characteristics.

MATT CHMIEL, AGFD

Gizzard shad can cause major problems with a sport fishery. Survival of newly hatched bluegill and largemouth bass is poor because of competition with shad. Bluegill growth suffers, which leads to a decrease in bluegill over 6 inches long. As a result of fewer bass, carp increase in abundance as does their contribution to sport fishery problems.

Recommendation / Action Planned

34. Adopt the 2003 NISC Invasive Species Pathways Report with minor revisions to make it Arizona specific.

35. Conduct a species-specific analysis of identified pathways to focus outreach and advance detection efforts. Adopt use of the "Significance Criteria Questionnaire" for reporting an invasive species pathway and assessing its priority. Ensure the pathway is represented in the pathways outline. (This effort may be held concurrently with the research prioritization identified in Recommendation 18)

36. Compile and share general Best Management Practices for preventing movement of invasive species into and within Arizona in accordance with Recommendation 51.

OBJECTIVE 11: POTENTIAL GAPS IN ANTICIPATION AND PREVENTION

Arizona agencies keep lists of invasive species; however, there is no single list that is cross jurisdictional covering all Arizona invasive species. Current lists are often defined by statutory authority. If an undesirable species is not on a list, a gap exists and action may not occur when it is needed. In general, central coordination of invasive species related efforts is needed in order to identify such gaps. The "Network" approach (Recommendation 13) will satisfy this need and will also provide a centralized location to maintain AISAC-approved lists of species of concern.

An inventory of invasive species housed on the invasive species website (Recommendation 23) would make it possible for interested parties to go to a central location to find species-specific information about invasive species in or threatening Arizona. Another helpful addition to the website in the area of outreach would be a list of alternative species that can be used safely instead of regulated species. When informing the public about a regulated species or a species of concern, proposing a prudent alternative would make it more likely that people would change their behavior and take action toward the purchase or use of "friendly" species (this works for pets as well as plants).

Many residential and commercial developers are still landscaping their projects with non-native plants that place added pressure on the environment in many ways. Some communities are dealing with this issue by providing approved plant lists for contractors to abide by and requiring contractors to salvage native plants. Unfortunately, a communication gap or a lack of education still exists among some contractors, architects, maintenance people and the inspectors or ordinance builders. This breakdown results in developments that are incompatible with our native landscape.

BRIAN MCGREW, ADA

The species could be grouped into the following categories:

- Regulated Species (state and federal)
- Species of Concern (not regulated, but identified as a potential risk): can be identified by research priorities (Recommendation 18), Wildlands list, National Invasive Species Council website, etc.
- Good Alternative Species: Native Plant Society and Bureau of Land Management lists of invasive species and suitable alternatives, etc. (Lists of good alternative species may need to be prepared for some insects and animals.)

These categories would need to be updated regularly, and links would need to be provided to appropriate websites that house pertinent and reliable information. A center for invasive species (Recommendation 13) could maintain and update the list and also serve as a clearinghouse and a central point of access for collecting and making available outreach and education information and materials identified in Recommendations 30–32.

One approach to identifying and addressing gaps in knowledge is to promote cross-jurisdictional training. A successful example of this sort of training is the Arizona Game and Fish Department Watercraft School, which accepts officers from any Arizona state, county or municipal agency and prepares them for the rigors of watercraft enforcement on our state's waterways. The school has been extremely successful and is used as a model for training efforts throughout the country.

Cross-jurisdictional training would expand detection and reporting capabilities. Agencies with statutory authority would be able to increase their capacity

to assess the magnitude of threats and administer appropriate and timely responses. To meet detection training needs, stakeholders with regulatory authority and/or expertise could publicize training opportunities and invite other agencies and partners. To expand detection efforts (agency inspections are largely focused on commercial pathways) and enlist the help of the public, self-inspection/survey processes could be promoted (e.g., self-certification).

As recommended under Objective 10, identified pathways need to be revisited on a regular basis to identify gaps, new pathways, and high threat areas.

Recommendation / Action Planned

37. Provide links to existing lists that identify regulated species; create an AISAC-approved list of species of concern and a list of prudent alternative species for use on the website. Update website links as needed.

38. Expand Arizona's early detection network by announcing interagency training opportunities provided by stakeholders with regulatory authority and/or expertise and invite other agencies to attend.

39. Expand detection efforts by developing self-inspection processes that incorporate Best Management Practices (Recommendation 36). Include an easy reporting process, facilitated by the Arizona Center for Invasive Species website (in coordination with Recommendation 33).

MEASURES OF EFFECTIVENESS

The management plan will be reviewed on a two-year cycle. At that time, the Anticipation and Outreach work group will review objectives, recommendations and action plan to evaluate progress on accomplishing the following measures of effectiveness:

- Invasive species questions have been added to the Arizona Game and Fish Department's biennial "Trends" survey. Track long-term survey results to determine if general and issue-specific campaigns are effectively raising levels of knowledge and hence expanding detection capabilities.
- Process owners have increased use of logo/brand/icon.
- Public recognition of logo/brand/icon is growing.
- The public is using the invasive species website and other mechanisms (Recommendation 33) for reporting invasive species detections (this measure indicates effectiveness of campaigns and of the website as a mechanism for reporting). Track number of reports.
- Process owners have published best management practices and more than one process owner have implemented the practices.

The Arizona Game and Fish Department Watercraft School is an excellent model for multi-agency cooperation. It accepts watercraft enforcement officers from any Arizona state, county or municipal agency, introduces them to the basics of watercraft enforcement and prepares them for the rigors of watercraft enforcement on our state's waterways. Seasoned watercraft officers also benefit from the school as an opportunity to further refine skills already acquired in the field.

SACCO, AGFD

The school operates under a multi-agency approach, not only by offering training opportunities to other agencies, but also by incorporating other agency personnel as trainers and evaluators. This approach creates a forum for sharing ideas among participants and closes the gap between agencies in regard to interpreting regulations and implementing law enforcement techniques. As the participating agencies share costs, the multi-agency approach also yields fiscal benefits, reducing barriers for participants since there is no cost for the training other than travel and per diem. The school has had great success with this system of operation, and it is used as a model for training efforts throughout the country.

- New interagency training opportunities are being successfully publicized. Track number of interagency participants.

CONTROL AND MANAGEMENT

The goals of control and management are to mitigate the undesired impacts of invasive species on agricultural productivity, biodiversity, public health, economies, infrastructure, tourism, recreation, and wildfire. When invasive species have become permanently established, the most effective action may be to prevent their spread or lessen their impact through control and management measures, but a number of factors pose challenges to using these measures, including complex and interspersed land ownership, multiple jurisdictional authorities, and diverse policies and cultures. Perhaps the greatest challenge is the significant and sustained cost associated with control and management, which points to the importance of prevention as the first and most cost-effective defense.

Long-term success in prevention will reduce the rate of introduction and establishment and the damage that additional invasive species could cause by entering the state. Success will require public investments in prevention tools, resources, and infrastructure, but the returns will be great in the protection of human health, agriculture and natural resources.

To conduct rapid response actions, invasive populations must first be found.

They are often found by chance, but they can also be detected through targeted invasive species surveys and monitoring of specific areas. These early detection efforts require resources, planning, and coordination. After specimens have been detected and identified, the boundaries of the infestation must be determined. Monitoring, taxonomic verification and species surveys provide data needed to construct accurate distribution maps. These maps and other ecological and biological information are critical to planning and response actions. Still, for much of Arizona, monitoring, mapping, and taxonomic resources and capabilities are lacking.

GEORGE ANDREJKO, AGFD

The AGFD Watercraft School incorporates the teaching of best management practices during its 60 hours of continuing education and proficiency training.

"Rapid Assessment" encompasses all of the actions required to determine an appropriate response. A rapid assessment identifies the invasive species, the extent of infestation, and interdiction options. It sets the timing and overall strategy and provides reliable information for the public. Advanced planning that anticipates invasions and takes into account trans-jurisdictional issues can greatly expedite efforts.

"Rapid Response" is a systematic effort to eradicate, contain, or control a potentially invasive species while the infestation is still localized. It may address new introductions or satellite infestations of previously established species. Timeliness is a critical element. Resources must be mobilized and management actions must be applied before the infestation becomes established. Many rapid response efforts are led by state or local officials working with private landowners. Invasions can rapidly overwhelm these local resources. To improve the odds for success, a rapid response operation should have prior authorizations and preset arrangements to share resources across jurisdictional boundaries, form strategic partnerships, and have ready access to plans, funds and technical resources.

OBJECTIVE 12: SUPPORT FOR RAPID ASSESSMENT AND RESPONSE

Even the best prevention efforts cannot stop all invasive species. Early detection, rapid assessment and rapid response comprise a critical second defense against them. This second defense increases the likelihood that localized invasive populations will be found, contained and eradicated before they become established; range expansion will be slowed, and the need for extensive and costly long-term control efforts will be reduced.

The Federal Emergency Management Agency (FEMA) provides an accredited training module that certifies agency personnel in the area of emergency operations through its Incident Command System training. Most agencies that may have a role in emergency planning, response, and recovery can

benefit from the ICS 100 and 200 training program modules for coordination, communication, and organization.

The Arizona Division of Emergency Management (ADEM) may have the ability to include invasive species issues as part of the State Emergency Response and Recovery Plan and the associated Emergency Support Functions (ESF), which may allow resources to be used in authorized emergency incidents. ADEM may also facilitate training opportunities for the ICS training modules to agencies that are seeking certification.

Use of the State Emergency Response and Recovery Plan following detection of a new invasive species will require improved coordination and identification of triggers by which emergency response funds are released. Impact categories should be identified and used in coordination with the threat assessment/ research needs prioritization process identified in Recommendation 18.

For early detection, Arizona's first line of defense is in its inspection stations at the various ports of entry. State and federal monitoring programs have also been designed to detect a new invasive species. Efforts to monitor for potential invasive species by local government agencies and nongovernmental organizations occur as well. Following detection of a new invasive species, existing detection programs and approaches should be evaluated and adapted to improve effectiveness in detection and increase efficiency in reporting and

Camelthorn *(Alhagi maurorum)*, a native to the Middle East, southeastern Russia, and northern Africa, was introduced to the United States about 1900 as wrapping material for date palm offshoots and in alfalfa seed. It is locally abundant in the Southwest, especially along the Little Colorado River in northeastern Arizona, and is found in scattered stands throughout Arizona. Although grazed lightly by domestic livestock, it competes with native vegetation and is difficult to control.

STEVE DEWEY, UTAH STATE UNIVERSITY

In 1999 camelthorn was found in a ponderosa pine-Gambel oak forest in north-central Arizona. The plants, which had been introduced in construction material, were growing on roadway right-of-ways. Forty stands were found containing 4,468 plant crowns ranging up to 1 meter in height. The detection triggered a rapid response action. Pulling, fire and mechanical treatments result in numerous resprouts, and there are no known biological control agents. Selective, systemic herbicides were applied beginning midsummer 2000 and have been applied annually to re-emerging crowns. Mortality in 2001 averaged 84 percent; by 2007 crown mortality had increased to an average of 99 percent, with little damage to native species.

coordinating an assessment. The Pathways outline should also be reviewed and amended to include additional pathways and related information (Recommendation 35).

JOHN M. RANDALL, TNC

Camelthorn is a semi-woody perennial with highly branched glabrous stems, small leaves, and 2 cm spines. It flowers in midsummer, produces three to five seeds per fruit, and vegetatively reproduces from rootstalks. The underground stems are known to penetrate asphalt and buildings to produce new plants.

Recommendation / Action Planned

40. In coordination with Recommendation 20, develop and adopt impact categories for assessing the need to mobilize rapid response. Include impacts to the ecology, economy, human health, domestic plants and animal health; geographic scope; invasive potential; and management difficulty as it pertains to Arizona. Assign authorization to trigger an incident command and/or rapid response to agencies with regulatory authority.

41. To address the need for a statewide rapid response plan, amend the Arizona Department of Emergency Management's Emergency Support Functions (ESF), found within the State Emergency Response and Recovery Plan, to capture invasive species rapid response functions that may be used by an incident command structure. Make agencies, organizations, and stakeholders aware of ADEM's ESF as the base model for rapid response. Provide lists of regulated species to ADEM and provide updates as needed.

42. Employ the Federal Emergency Management Agency's Incident Command Systems 100 and 200 training program modules, at a minimum, to certify appropriate agency personnel. Identify appropriate agency personnel who would benefit from Incident Command training. Address early detection and rapid response needs as an incident command process for use when appropriately triggered.

43. Develop a mechanism to evaluate the effectiveness of rapid response activities and make adjustments as necessary.

OBJECTIVE 13: UNIFORM PREVENTION, ERADICATION, CONTROL AND MANAGEMENT PROCESSES

Government personnel working at the various points of entry to Arizona (borders, airports, etc.) may benefit from expanded training opportunities to reinforce the first line of defense in prevention and early detection. State agencies are encouraged to support training and inter-agency coordination by providing training opportunities, certification, cross-training and job descriptions to expand the detection network.

Eradication and control and management processes are not codified into a useable system. A statewide invasive species plan requires the development of a comprehensive approach and streamlined procedures across state agencies to carry out control and management activities as rapidly as possible. Groups with

the sole intent of helping to control the spread of invasive species are in the early stages of organizing. County governments have informal associations, a number of "weedwacker" groups have been established that tend to be species oriented (e.g., buffelgrass, saltcedar), and Arizona Weed Management Areas (WMA's) and weed SWAT teams are at various stages of development. Identifying areas of overlap and providing a coordinated approach could generate cost savings and allow redirection of dollars to address other invasive species issues. Enhanced coordination would reduce sporadic and incomplete control efforts, minimize overlap, identify gaps and provide a more comprehensive and effective approach to invasive species control.

With the needs of procurement in mind, the possible areas identified for streamlining are acquisition of chemicals, mapping, and equipment; contracting with biological and engineering consulting services, groundskeeping services, and licensed applicators; and arranging for travel and lodging. Cooperation among all agencies, organizations and stakeholders is encouraged for efficiency and success in facing invasive species threats.

Recommendation / Action Planned

44. Construct procurement contracts for use by multiple state agencies to eliminate delays and restrictions that could hinder invasive species control and management efforts.

45. Make available through the state purchasing office a link that provides a comprehensive directory of contracts and contractors with services and goods related to invasive species control, management, and restoration, including chemicals, groundskeeping, mapping, equipment, biological and engineering consulting services, licensed applicators, travel and lodging.

46. Support development of training and continuing education opportunities to certify government personnel who are involved in invasive species early detection, control and management actions. Update database of contact information (Recommendation 17).

47. Review relevant state position descriptions and questionnaires to ensure that required knowledge, skills, abilities and job duties cover expertise needs adequately and that appropriate training will be provided. Create no or low-cost training opportunities.

48. Establish procedures and funding access to assure rapid response to limit or eliminate an invasive organism. Convene experts, scientists, and resource managers to evaluate the various methods for managing populations of key invasive species, and ascertain the best method. Evaluate biological, chemical, and mechanical control methods and social behavioral

approaches to limit or eliminate an invasive species, and recommend the most appropriate methods. Evaluate impacts of control measures on the environment and nontarget species and modify measures accordingly. Calculate the cost to implement control or eradication strategies. Ensure that the contact database (Recommendation 17) includes information on qualified personnel with certifications that have relevance to invasive species control and management. Catalog all research data, reports, and results in the comprehensive database (Recommendation 22).

49. Identify specific responsibilities and strategies for effective resource sharing in invasive species control and management. Execute agreements between and among state and federal agencies specifying responsibilities and providing a mechanism whereby monies, materials, or matching funds can be transferred. Execute partnership agreements between government agencies and nongovernmental organizations and/or private entities to specify responsibilities and convey monies, materials, and services.

50. Utilize a coordinated effort of volunteer public participation programs for invasive species control and management. Track volunteer participation and level of awareness. (Appendix G).

51. Develop, share and seek to implement Best Management Practices for control and management of invasive species and restoration practices. (In accordance with Recommendation 36).

52. Make use of conferences for gathering and distribution of information pertaining to control and management of invasive species and restoration practices. (In support of Recommendation 12)

SONORAN DESERT WEEDWACKERS

Formed in 2000, the Sonoran Desert Weedwackers work only on Pima County properties and primarily within Tucson Mountain Park to remove buffelgrass *(Pennisetum ciliare)* and fountain grass *(P. setaceum).* They conduct reconnaissance at least once per month to identify areas for manual removal. A team of 2–4 people hike the park, eliminating small isolated populations, mapping larger infestations using GPS coordinates and monitoring areas where invasive grasses have been removed. Information collected by the reconnaissance team is stored in a database maintained by the Arizona-Sonora Desert Museum. The weedwackers have cleared and revisited approximately 4,000–5,000 acres; mapped another 4,000–5,000 acres with areas tagged for future eradication; and surveyed a total of 15,000 of the park's 27,000 acres. As of December 2007, 7,300 volunteer hours have been logged and an estimated 73 tons of invasive grasses have been manually removed.

53. Regularly review and compile a control and management outcomes report. Submit the report to the Governor's office for AISAC review, and publish it in the central database (Recommendations 18 and 26).

OBJECTIVE 14: RESOURCES FOR ENHANCING AND/OR ESTABLISHING RESTORATION EFFORTS

Habitats and ecological processes can suffer cumulative impacts from the direct and indirect effects of invasive species. Ecological relationships that have evolved over evolutionary timescales can be at risk. Invasive species can cause disturbances that have multiple effects throughout an ecosystem, and they may be exacerbated by human alterations of the environment. These disturbances are not always easily healed. Thus, restoration treatments are an integral part of control and management efforts. They help guard against future re-infestations and the potential for further harm.

Restoration is based on a combination of general principles and site-specific considerations. Resource managers need to be able to assess an ecosystem's desired future condition and its restoration potential so they can act strategically in both the eradication and restoration process. To do this, they need access to information on the best strategies and tools to assist them in restoration efforts and on the best materials for competing with and keeping out invasive species. Also of value would be information on available resources that could be used in support of restoration efforts. Devising a plan to meet these needs would likely result in lower control costs, increased effectiveness, and improved chances for ecosystem restoration success.

Recommendation / Action Planned

54. Provide guidance, technical assistance and access to information on restoring and rehabilitating high-value ecosystems and key ecological processes to meet desired future conditions with long-term effectiveness. Include resource information and restoration effectiveness in proposed database (Refer to Recommendations 17, 20 and 22).

55. Identify and publicize potential resources to support restoration efforts following a regulated invasive species control action (i.e., insurance, federal recovery plan, ADEM's recovery plan, etc.; in accordance with Recommendations 22–26).

56. Convene and conduct an initial systematic review of past and current major rehabilitation and restoration efforts and identify successes. In line with Recommendations 18 and 22, catalog all data, results and reports in an accessible comprehensive database.

MEASURES OF EFFECTIVENESS

The management plan will be reviewed on a two-year cycle. At that time, the Control and Management work group will review Control and Management objectives, recommendations and action plan to evaluate progress on accomplishing the following measures of effectiveness:

- Impact categories have been developed and adopted for assessing the need to mobilize rapid response team.
- ADEM plan incorporates invasive species rapid response functions.
- A list of regulated species is provided to ADEM and is reviewed for current accuracy.
- State agencies are utilizing the available training program, ICS 100 and 200, to certify that relevant agency personnel are competent in the functions of incident command.
- A mechanism to evaluate effectiveness of rapid response activities has been developed.
- State purchasing office provides a link to comprehensive directory of contracts and contractors with services and goods related to invasive species.
- Training, certification, and continuing education are provided for appropriate agency personnel; agency personnel attendance monitored.
- Relevant state agency position descriptions and questionnaires are reviewed and revised to incorporate skills and expertise for invasive species control and management.
- A directory of volunteer public participation programs has been created and is being kept current through web-based input.
- Activity is occurring at local, state and regional conferences and forums. Track attendance, participation and sponsorship.
- A systematic review has been completed of past and current major rehabilitation and restoration efforts. Measure success of restoration approaches, and fiscal spending on restoration efforts.
- A procedure has been established for managers, experts, and scientists to submit control, management, and restoration progress and outcome reports. Reports have been submitted to invasive species database.

IGNACIO BAEZ, USDA/ARS

Cactus moth larvae can completely destroy a cactus plant.

FUNDING

Funding is an integral component of a comprehensive plan to address invasive species issues in Arizona. Investment in program development now, will reduce future costs for control and abatement as well as other costs that all sectors of Arizona's economy may have to bear. Stable funding sources are required to implement a consistent, long-term approach to prevention and management and sustain the necessary infrastructure to support invasive species related activities. Funding must also be recurring, flexible and accountable. However, given the state's current budget deficit, AISAC agrees that dedicated funding via legislative appropriation is not a feasible option and that other creative solutions must be identified for the immediate future, with hopes that the economic situation will improve and options for securing funding can be reviewed at that time. Current economic challenges have not swayed AISAC's resolve to develop a comprehensive statewide management plan that will guide efforts to prevent and/or control invasive species introductions.

OBJECTIVE 15: IDENTIFY INVASIVE SPECIES FUNDING OPPORTUNITIES

AISAC believes that most of the plan's objectives can be addressed by employing the strategies listed below and discussed in the subsequent paragraphs.

- Use Existing Agency and Partner Infrastructures and Resources
- Arizona Center for Invasive Species
- Begin Development of a Rapid Response Fund
- Seek Federal Funding
- Seek to Amend Existing External Grant Opportunities to Include Invasive Species in Criteria
- Explore Other Creative Funding Solutions
- Future State Funding Opportunities

USE EXISTING AGENCY AND PARTNER INFRASTRUCTURES AND RESOURCES

Many prevention, control, and management actions can be addressed with Arizona's existing infrastructure, resources, knowledge and expertise. The key is to improve communication, coordination and resource sharing among stakeholders. Their continued interest and support are essential to pulling together resources and addressing the challenge successfully.

Because state agencies are committed to this endeavor, much of the funding will

be in-kind and will result in reallocation of existing funds. This fact indicates how strongly Arizona's land and resource managers feel about reducing and eliminating the impacts of invasive species on the environment, economy and human health. They acknowledge that any commitment to address these issues must continue in perpetuity, just as the development and growth of economies, which is intimately linked with invasive species issues, will continue.

Some state resources are dedicated by statutory mandates to the battle against a number of invasive pests; however, most of the state funds, resources, and authorities that support the functions identified in this plan will be redirected from existing commitments. AGFD and ADA, with their substantial regulatory authority over wildlife and plants, recognize the significance and permanence of the invasive species threat. In response, both agencies have moved forward to develop or enhance internal invasive species programs and, with the University of Arizona, provide leadership for the Center for Invasive Species.

A memorandum of understanding (Recommendation 7) is the primary mechanism identified for promoting communication, coordination and sharing of resources among state, federal, tribal, private and nongovernmental agencies and organizations. This instrument will serve as an umbrella agreement from which future contracts, agreements and understandings can stem. Future agreements can be specific between two or more cooperators regarding transfer of funds, equipment, personnel, information or other resources or responsibilities that cooperators are willing to assume.

Giant salvinia was discovered in 1999 in the Imperial and Cibola National Wildlife Refuges on the lower Colorado River. It soon spread from Blythe, California, downriver throughout the entire lower Colorado River and into Mexico. The Lower Colorado Giant Salvinia Task Force was established to control this invasive weed. Task force members include multiple federal agencies, state agencies from California and Arizona, irrigation districts and university researchers. Giant salvinia populations peaked in 2004, but task force control efforts using mechanical, chemical, and biological means led to today's lower densities. The control program's success spurred expansion to include a larger portion of the Colorado River and all aquatic species. The group is now known as the Colorado River Invasive Aquatic Species Task Force.

ADA

Because funding is at a premium, spending must be targeted where the most impact can be achieved. As such, prevention must always be the first line of defense.

Stakeholders can implement many of the recommendations in this plan at little or no cost. Examples include such activities as enhanced interagency and inter-partner communications, streamlining existing processes, and the networking established by the AISAC.

Because database and website maintenance require dedicated technical staff, data management will constitute the largest funding requirement for plan implementation. Several funding strategies have been proposed to meet this requirement, although appropriate process owners have not yet been identified. Partnering with GITA (Government Information Technology Agency) has eliminated or substantially reduced traditional costs associated with developing a data management system. This is because GITA has contractual web management agreements in place that can be extended to database selection, development, and maintenance. Additional funding will be required for a database manager, a web manager, and possibly system infrastructure, although one or more state agencies may already have a suitable infrastructure that may be employed.

Existing grant opportunities could support some of the associated information management costs; however, grant durations are generally short term (1–3 years). Secure, long-term funding is needed to ensure continuity and integrity in information collection, management and accessibility. AISAC has discussed the possibility of cost sharing among agencies and stakeholders to fund technical positions. Fund transfers would be arranged through funding agreements.

ARIZONA CENTER FOR INVASIVE SPECIES

One of the Governor's priorities is promoting efficiency among state agencies. The proposed concept for the Arizona Center for Invasive Species (Recommendation 13) supports this focus, as the center will be implemented with existing resources and personnel from state agencies, Arizona universities, and other stakeholders. The network concept for the center supports the Governor's desire for efficiency because it provides a framework to connect experts and managers across agencies and organizations but requires little administrative staffing and support.

The agencies with primary regulatory authorities (AGFD and ADA) in coordination with the U of A, which has connectivity with the academic and private communities, have each committed to providing coordination and

leadership (Recommendation 8). Other primary cooperators, as identified in the invasive species memorandum of understanding, have also committed to various responsibilities associated with the Center.

USDA/APHIS

Highly competitive jointed goatgrass infests rangelands and grain fields.

Even though funding requirements would be reduced by employing a network approach, there are still areas where additional funding sources would enhance and improve upon the base structure. Reliable, sustainable alternative funding sources would make prevention and control efforts much more effective. External grant opportunities could potentially provide additional resources to support staffing; develop and implement tools for outreach, education and information; collect and manage data; distribute information; and conduct control and restoration efforts.

BEGIN DEVELOPMENT OF RAPID RESPONSE FUND (RECOMMENDATION 9)

AISAC feels strongly that prevention is the most cost effective approach to meeting and addressing invasive species threats. Prevention strategies can be implemented with relatively little cost and time, and are more cost effective than control and management. An important component of prevention is the ability to rapidly respond to initial detection occurrences with the intent of eliminating the invasive species from Arizona.

The key to prevention is changing behaviors and practices, and developing an effective detection and response plan. The creation and availability of a rapid response fund will put Arizona in a proactive position, able to respond to critical invasive species issues in a timely manner, and acquire, assemble and distribute resources to mobilize a rapid response strike team. Failure to eradicate new invaders at the earliest stages may result in significant long-term costs to control or manage the new invasive species.

Legislative action will be required to establish a rapid response fund. As conceived, the fund will be dedicated solely to invasive species rapid response. Until a framework is developed that will allow the Center to administer the funds, AGFD and ADA will retain oversight and administer release of funds on a case by case basis. The fund will be replenished annually through appropriations or from alternative sources of state generated funds; potential sources may include user or impact fees. Alternative funding sources for establishing the fund should also be identified.

The current budget shortfall does not support the creation of a rapid response fund, but steps can be initiated that are conducive to the development of a fund during the scope of this plan.

GRANTING OPPORTUNITIES (RECOMMENDATION 10)

Given current state government budget constraints, it is not feasible to create a grant program supported by legislative appropriations to assist invasive species projects/efforts. However, existing grant programs should be reviewed and their administrators contacted in regard to amending their "Request for Proposal" language to include funding criteria for invasive species projects (Recommendation 10). Many grant sources focus on specific invasive species, but there may be other less obvious opportunities. Integrated pest management (IPM), Heritage Fund, and National Research Initiative (NRI) are examples of granting programs with funding opportunities that may align with invasive species needs.

Applicants might be more successful in obtaining external grants if they 1) had access to a list of granting opportunities that corresponds to their area of expertise, and 2) were provided guidance or assistance in completing grant proposals. Providing "grant facilitators" to assist applicants in applying for suitable granting opportunities would increase the likelihood of existing grants being awarded to invasive species related projects.

As mentioned above, grants can also be sought on behalf of the Arizona Center for Invasive Species to assist with obtaining resources for staffing; developing and implementing tools for outreach, education and information; data collection and management; information distribution; and control and restoration efforts.

Recommendation / Action Planned

57. Assign a grant coordinator who will assist applicants in obtaining external grants, and pursue opportunities for broadening the scope of existing grants. Grant coordination functions may be undertaken by one of the three invasive species coordinators identified in Recommendation 8 and 10.

58. Create, publicize and maintain a list and calendar of granting opportunities relative to invasive species; categorize the list and make it available for review on the Invasive Species website in coordination with recommendations 23–25.

59. Consult the list of research needs and the evaluation of information gaps (Recommendations 18 and 27) to provide direction for project proposals and grant applications. Support the development of relevant, issue-specific impact assessments to assist in securing additional funding sources to meet invasive species needs.

SEEK FEDERAL FUNDING

Several federal funding avenues exist through which to obtain sole or matching funding for invasive species needs (see Appendix B for detailed list). Some examples include Federal Interagency Committee for Management of Noxious and Exotic Weeds (FICMNEW) grants, Pulling Together Initiative (National Fish and Wildlife Foundation), and agency funding and grants from the U.S. Department of Agriculture, U.S. Department of Interior, Environmental Protection Agency, and U.S. Army Corps of Engineers.

RICHARD OLD, XID SERVICES, INC.

Back mustard is highly invasive in natural systems and is also a concern in agricultural situations.

The federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, amended by the National Invasive Species Act of 1996, calls for the development of state and regional management plans to control aquatic nuisance species (ANS). Following approval of an Arizona ANS plan by the national ANS Task Force, matching funds could be made available. The Arizona ANS plan is in its final stages of development and should soon be available for submission for national approval.

A challenge in Arizona is in addressing invasive species issues on private lands, which comprise approximately 18 percent of Arizona. Some federal funding sources, such as the Federal Farm Bill, provide opportunities for cooperation between agencies and private landowners whereby agencies can assist in carrying out programs on private lands through cost-sharing programs. Farm Bill eligibility criteria also include development of a statewide invasive species management plan in order to apply for grant funding.

Recommendation / Action Planned

60. Identify and pursue specific federal funding opportunities. Convene a work group to track, review and comment on new legislation and pursue (identify, write and submit) AISAC-approved federal funding opportunities.

61. Complete and submit an Arizona ANS plan for approval by the national ANS Task Force.

CREATIVE SOLUTIONS TO FUNDING

Outside of state and federal funding, other potential opportunities may exist and should be explored, in particular those stakeholders that are directly impacted by invasive species (user or impact fees). The list of granting and other possible funding opportunities is compiled here as a starting point for developing a publishable list that should be maintained and updated on the invasive species website:

Stakeholder Groups: Rocky Mountain Elk Foundation, Desert Big Horn Sheep Society, Trout Unlimited, Ducks Unlimited, National Wild Turkey Federation,

Arizona State Association of Four Wheel Drive Clubs

Land Use Groups: Water Conservation Districts, Arizona Cattle Growers, Arizona Transit Association (trucks, rail passengers, etc.), National and/or Arizona Mining Association, Arizona Rock Products Industry

Agribusiness Related: Agriculture chemical suppliers, Arizona Cotton Research and Protection Council, Arizona Crop Improvement Association, Arizona Contractors Association, local irrigation districts

Utilities: Salt River Project, Arizona Public Service, Tucson Electric Power

Conservation and Sustainable Ecosystem Foundations/Special Interest Groups: The Nature Conservancy, the Wilderness Society, National Audubon Society, American Rivers Society, Kellogg Foundation, Arizona Association of Conservation Districts, Environmental Grant Making Foundations, Center for Biological Diversity

Private/Local Stakeholders: towns, counties, home owner associations, developers and other stakeholders that are directly impacted by invasive species. Such entities may be willing to fund projects at the local level, or enforce user impact fees or taxes.

Business/Corporate: Wal-Mart, Cabela's, Bass Pro Shops, Sportsman's Warehouse, PetSmart, PETCO, R.E.I.

Recommendation / Action Planned

62. Survey identified user groups to assess interest in and feasibility of securing funding to support invasive species related needs.

FUTURE STATE FUNDING OPPORTUNITIES

State agencies have committed time and resources to establish a foundation for addressing invasive species issues. To improve and build upon that foundation will require future commitments. The invasive species threat will doubtless continue to grow, but existing state budgets may not be able to continue to meet the challenge. As progress is made in achieving the recommendations proposed in this plan, AISAC will be looking to the future and preparing for opportunities to seek legislative appropriation that will further the success of AISAC's objectives.

Recommendation / Action Planned

63. Seek legislative appropriation to fund Arizona's invasive species prevention and control program.

Program Implementation and Evaluation

Following their development and approval by the AISAC, the plan's recommendations were reviewed and ranked into areas of focus based on four criteria. AISAC members and work group participants discussed and evaluated each recommendation using the four criteria and assigned a value for each criterion to each recommendation (Table 5).

Table 5. Scoring Criteria Used to Evaluate Arizona Invasive Species Management Plan recommendations

Criteria				
Score	**Time to complete / implement***	**Needed to ensure success at addressing invasive species issues****	**Cost to implement**	**Feasibility**
3	1 year or less	Critical need	Low cost (no cost or absorbed in existing budget)	Easy
2	1 – 5 years	Moderate need	Would require multiple partners and resource sharing	Moderate
1	> 5 years	Non-essential need	Not covered by "in kind"	Difficult

* Ongoing recommendations were assigned initiation dates by each work group.
**Tie back to ecology, economics, human health.

During development of the evaluation process, participants discussed the following issues:

- **Criteria Suitability.** Participants discussed whether the criteria are sufficient and reasonable, if any were irrelevant or need to be amended, or if additional criteria needed to be added. Four criteria were employed, and it was determined that they were reasonable and sufficient to evaluate the recommendations. Any additional criteria would make the process cumbersome.
- **Criteria Weighting.** The AISAC decided that the four criteria should be weighted equally, because the process is an exercise to identify the order, timeline, and approach for completing the recommendations, and feasibility is influenced by availability of resources and compounding factors such as order of operations. Scores are relative and the actual numbers should not be taken literally. Recommendations were reviewed post-evaluation to ensure that the outcomes made sense.

- **Defining Categories.** The AISAC looked at definitions for the categories that recommendations would fall into based on assigned scores. They discussed the concept of "areas of focus" versus "priority" (high/medium/low) and agreed that all recommendations are important in addressing invasive species issues, but that the evaluation is really an assessment of which recommendations would bring early successes versus those that are ongoing and comprised of many steps that will generate change along the way and ultimately result in large scale successes (up to 100 years out). Areas of focus were categorized as immediate successes, short term successes, and long term successes (10+ years).

AREAS OF FOCUS

Political and budget agendas, which must respond to the concerns of the time, generally determine the priorities and funding of programs and projects, but the issues associated with invasive species are not expected to diminish or go away. The approach to invasive species management must have a long term focus, even to 100 years out, long past the five-year horizon of this plan. Therefore, the recommendations identified here represent a comprehensive long range vision based on ecological timelines, but with an eye to the small, achievable successes that cumulatively will shift the direction of invasive species management and shape the ultimate outcome. Putting this strategy into action will require a proactive approach. The AISAC believes that the cost of doing nothing far outweighs the costs associated with the proactive recommendations identified in the management plan.

The recommendations were grouped into "Areas of Focus" to aid in assessing the most efficient use of available resources. Recommendations that are easily accomplished and highly feasible are in the "Immediate Success" area of focus. Recommendations that are feasible and moderately easy to carry out are in the "Short-term" area of focus for actions that may require more time, but can be accomplished during the horizon of this plan. Recommendations in the "Long Term" area of focus are less feasible, more difficult to complete, and have a timeline of 10+ years or longer. These recommendations generally have broad application, require multiple steps and funding beyond that which state agencies and partners are currently able to support, may require government or legislative commitment, and have outcomes focused on ecological results and timescales (i.e., long term results). The outcome of the evaluation process is not a rank of importance, because the AISAC deems all the recommendations important, but rather an order of focus and accomplishment. Areas of focus are identified alongside each recommendation in the Implementation Matrix (Table 6).

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
Leadership & Coordination	1	Vacancies replaced at the discretion of the Governor. Appointments to be announced prior to the next quarterly council meeting.	x				quarterly	Office of the Governor and AISAC	
	2	Council may appoint state staff to assist NGO with organizational input and information transfer.		x		Refer to Recom-mendation #7	as needed	AISAC	
	3	Council meetings will be held no less than quarterly or on an as needed basis.	x				quarterly or as needed	AISAC	
	4	Initial Work Groups exist for the life of the AISC Strategic Plan. Work Group goals and objectives will receive a performance review every two years and Strategic Plan will be up dated every 5 years as needed.	x				ongoing	AISAC	
	5	Council may appoint additional Work Groups as needed.	x				as needed	AISAC	
	6	Comply with existing and future Open Meeting Laws and regula-tions	x				ongoing	AISAC	
	7	Identify and enlist State and Federal Agencies and Stakeholder commitments and contributions in the form of memorandums of understanding or inter-governmental agreements (MOUs or IGAs) to fulfill the functions identified in this management plan. Upon sign-ing the MOU, each stakeholder may identify a liaison that will be a central point of contact.	x				July 08; ongoing	Council; AGFD, ADA, U of A	
	8	Establish coordinator positions to be staffed by Arizona Game and Fish Department, Arizona Department of Agriculture and the Uni-versity of Arizona; each with individual functional responsibilities to further a statewide invasive species network under the guidance of the Council.	x			In Kind	following approval of In-vasive Species Management Plan	AGFD, AZDA, U of A	
	9	Identify and initiate the process for seeking legislative appropria-tions to sustain a minimum Invasive species Rapid Response Fund with a suggested of 1M dollars with accountability of expenditures to the Governor's Office.			x	1M	assess feasi-bility in 2010	Office of the Governor, State Legislature; State Coordinators; Federal Partners	

Table 6. Arizona Invasive Species Management Plan Implementation Matrix.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	10	Broaden the scope of existing grant programs available to communities, agencies, NGO's, and local volunteer groups and organizations demonstrating minimum fiduciary requirements required by the State of Arizona. Targeted goal of $1M.		x			Jul-09	Federal, State, and local agencies and NGO's with existing grant funding	
	11	Develop a database and/or directory of key points of contact within other state, federal, and international agencies, tribes, and other organizations outside the State of Arizona (see Recommendation 24).	x			$15K of in kind and reallocation of funds	Dec-08	State agencies, Universities, Cooperative Extension	
	12	Encourage involvement in regional forums and promote involvement in regional and broader partnerships. Identify local, state, regional, and international conferences, symposiums, and forums, and sponsor or co-sponsor events that pertain to invasive species.	x			$30K per year	ongoing	All organizations that are part of the current network.	
	13	Adopt Alternative A, the Network Approach, as the recommended concept for a Center for Invasive species to address information, education, coordination, collaboration, resources and outreach needs; identify and establish priorities (research needs, coordination needs); motivate the public and increase awareness; and influence public to support invasive species priorities via social marketing.	x			In Kind	following approval of Invasive Species Management Plan	Office of the Governor and the AISAC	
	14	Formalize a standard protocol that details communication and cooperation strategies between local volunteer groups and local, state and federal agencies with oversight responsibilities.		x			Jul-09	State and Federal agencies with direct oversight responsibilities	
	15	Align and coordinate statewide jurisdictions to eliminate overlap and gaps in existing authorities and responsibilities.		x			on going	All agencies with enforcement authority.	
	16	Increase involvement of county and municipal governments in the implementation of the statewide invasive species management plan. Consider adding local government representation on AISAC.		x			on going	AISAC	
Research & Information Management	17	Identify invasive species subject matter experts including public and private scientists and resource managers; create and maintain a database of contact information, survey the experts every 2 years to identify current invasive species threats, and compile the information along with subject matter expert contact information in an accessible comprehensive database (see Recommendation 22).	x			in kind	6 months following approval of Invasive Species Management Plan	AISAC Research & Information Management work group	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	18	Conduct an initial review, followed by a regularly scheduled workshop (every 2 years recommended), of identified invasive species threats, and create a prioritized list of current a potential invasive species research needs. Catalogue all research data, reports, results for invasive species in an accessible comprehensive database.		x		cost recovery*; grants; private funding sources	ongoing	AISAC; invasive species coordinators	
	19	Conduct research to enhance early detection and monitoring capabilities.			x	unknown	ongoing		
	20	Be able to convene experts, scientists and resource managers to conduct rapid assessment of invasive species and their potential impacts. Catalogue all research data, reports, results for invasive species in an accessible comprehensive database (Recommendation 23).		x		unknown	ongoing	Center for Invasive Species / invasive s pecies coordinators	
	21	Create a task force of database and mapping experts to review existing information management systems and make recommendations to meet Arizona's invasive species database and mapping system needs.	x			in kind	Dec-08	AZGITA; NIC; AISAC	
	22	Implement the invasive species database and mapping system identified by the Task Force (Recommendation 21). Identify the appropriate stakeholder(s) dedicated to: 1) database management and maintenance, and 2) web page design and maintenance (funding reallocated within existing budgets for responsible parties).		x		responsibilities may be absorbed within existing operating budgets of the agency or agencies	Jul-09	Dependent upon outcome of Recommendation 33	
	23	Create and maintain Arizona Invasive Species Web site to be overseen by a dedicated web manager.	x			operating costs TBD	create Dec-08; ongoing maintenance	Dependent upon outcome of Recommendation 33	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	24	Make data easily accessible, easily and routinely updated, and available via a web interface (in coordination with Recommendation 22 & 23).		x		operating costs TBD	ongoing	Dependent upon outcome of Recommendation 17	
	25	Maintain links to other invasive species related websites (in coordination with Recommendations 23 & 24).	x				ongoing	Web manager	
	26	Provide an online library (in coordination with Recommendations 23 & 24).		x			ongoing	Web manager	
	27	Review and analyze existing information to identify gaps.		x			annual	Invasive Species Coordinators	
Anticipation & Outreach	28	Conduct a survey of Arizona residents to determine baseline knowledge and awareness of invasive species issues and campaigns. conduct follow-up surveys to identify effectiveness of those campaigns, and related changes in behavior. Survey questions can be changed bi-annually or on an as needed basis to identify effectiveness of specific campaigns.	x			in kind	Initial: March 2008; then bi-annual;	Bi-annual Survey: AGFD (included in AGFD trend survey);	
	29	Outside of the Arizona Game and Fish Department's bi-annual "Trends" survey, additional surveys could be included in web-based releases to identify if a specific campaign is having the desired effect. Survey results will be shared with stakeholders and interested parties.		x		in kind	as needed	any lead agency with a campaign	
	30	Employ positive communication tools in campaign development as identified in Objective 9 of the management plan and make materials available to stakeholders and interested parties (in coordination with Recommendations 22 - 26) .			x		ongoing	any lead agency with a campaign	
	31	Develop Arizona Invasive Species logo/brand/icon and make materials available to stakeholders and interested parties.	x			unknown	60 days following approval of Arizona Invasive Species Management Plan	AGFD; Anticipation and Outreach work group	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	32	Develop a general invasive species campaign (e.g. Arizona's 10 most unwanted) that would include positive communication tools, curriculum development, and various deployment methods and make materials available to stakeholders and interested parties.		x		in kind	6 months following approval of Arizona Invasive Species Management Plan	AGFD and partners	
	33	Implement the advance detection system and outreach plan outlined (Objective 9) for informing the public, local, state and federal agencies of the risks of invasive species. Provide reporting mechanisms that include the Center for Invasive Species Website (Recommendation 23).		x		in kind	ongoing	Suitable process owners and partners	
	34	Adopt the 2003 NISC Invasive Species Pathways Report with minor revisions to make it Arizona specific.	x				upon permission from NISC	Council	
	35	Conduct a species-specific analysis of identified pathways to focus outreach and advance detection efforts. Adopt use of the Significance Criteria Questionnaire (Appendix E) for reporting invasive species pathways and determining priority of that pathway (and ensure the pathway is represented in the pathways outline). This task may be held concurrently with Recommendation 18.			x	in kind; external grant opportunity	within 1 year following approval of management plan, updated on continuous basis	MOU menu of responsibilities	
	36	Compile and share general best management practices for preventing movement of invasive species into and within the state of Arizona in accordance with Recommendation 51.		x			ongoing	Coordinators; stakeholders	
	37	Provide links to existing lists that identify regulated species, create a Council-approved list of species of concern, and identify prudent alternative species on the Web page. Update web page links as needed and provide lists to cooperators (Recommendation 23)	x				Within 90 days of development of Arizona invasive species web site	web manager (manage lists); Coordinators (develop list); Council (approve list)	
	38	Stakeholders with regulatory authority and/or expertise will advertise and provide training opportunities to other agencies to expand Arizona's early detection network.		x		in kind	ongoing	Suitable process owners and partners	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	39	Develop self inspection processes that incorporate best management practices to increase the network of first line detection.* Include an easy reporting process, facilitated via Network for Invasive Species.			x		ongoing	Suitable process owners and partners	
Control & Management	40	Develop and adopt Arizona specific impact categories that will be used to mobilize rapid response.		x		In Kind	FY 08-09	Council work group	
	41	Amend ADEM's Emergency Support Functions Plan to include invasive species rapid response. State Agencies with regulatory authorities will provide lists of regulated species to ADEM and provide updates as needed.		x		In Kind	FY 08-09	Invasive Species Coordinators and ADEM, AGFD, ADA	
	42	Identify appropriate agency personnel who would benefit from incident command training. Employ the Federal Emergency Management Agency ICS-100 & 200 training program to provide incident command certification for appropriate agency personnel.		x		In Kind	FY 08-09; ongoing	Agencies with response capabilities	
	43	Develop a mechanism to evaluate effectiveness of rapid response activities and make adjustments as necessary.	x			In Kind	FY 08-09; ongoing	Process Owners	
	44	Construct procurement contracts to allow other government agencies to utilize them		x		In Kind	FY 08-09	Lead State Agencies	
	45	Through the State Purchasing Office provide a link to a comprehensive directory of contracts and contractors related to invasive species control, management, and restoration.		x		In Kind	FY 08-09	Invasive Species Coordinators and the State Purchasing Office (SPIRIT)	
	46	Support development of training opportunities to provide credentials for certified personnel and ensure to update contact information in the database of subject matter experts (Recommendation 17).		x		In Kind	ongoing	Agencies with training capabilities (i.e. ADA, Universities, Structural Pest Control Comm., etc.)	
	47	State Agencies should review relevant PDQ's to make certain that appropriate training will be provided and ensure that job descriptions adequately cover expertise needs.		x		In Kind	FY 08-09	Agencies with IS positions; In accordance with agencies mission; In cooperation with Universities	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
	48	Be able to convene experts, scientists, resource managers, and qualified personnel with applicable certifications to conduct rapid mobilization and response to invasive species and their potential impacts. Catalogue all research data, reports, results for invasive species in an accessible comprehensive database (Recommendation 24).		x		unknown	ongoing	Center for Invasive Species / invasive species coordinators	
	49	Identify the kinds of standing agreements that need to be executed to provide a mechanism for resource sharing and a willingness to cooperate among agencies and stakeholders	x			In Kind	Aug-08	Council & Council work groups	
	50	Utilize public participation programs for invasive species control and management practices and to raise awareness (Appendix H)	x			In Kind	FY 08-09; ongoing	Agency liaisons (recommendation 7)	
	51	Develop, share and seek to implement Best Management Practices (BMPs) for control and management of invasive species and restoration practices in accordance with Recommendation 36.		x		In Kind	FY 08-09; ongoing	Agencies and organizations with responsibilities in invasive species control and management	
	52	Utilize conferences for information distribution and information gathering as it pertains to control and management of invasive species and restoration practices. (In support of recommendation 12)	x			In Kind	FY 08-09; ongoing	Office of the Governor, ADA, & AGFD	
	53	Regularly review and publish outcomes of invasive species control and management efforts to the central data base developed and maintained by the Network for Invasive Species. (Refer to recommendation 18 & 26).		x		In Kind	ongoing	Council	
	54	Provide guidance, including but not limited to technical assistance and access to information for restoration and rehabilitation (Refer to Recommendations 18 & 26).		x		In Kind	ongoing	Agencies and Stakeholders; Center for Invasive Species	
	55	Identify and publicize potential resources (e.g. funding opportunities) for restoration efforts following a regulated invasive species control action.	x			In Kind	ongoing	Center for Invasive Species	
	56	Convene and conduct an initial systematic review of past and present major rehabilitation and restoration efforts on invasive species (in accordance with recommendations 18).		x		In Kind	within horizon of management plan	Agencies and stakeholder with reporting capabilities	

Table 6. continued.

Strategic Concept		Recommendation	Area of Focus			Cost	Time Frame	Lead Entity	Status
			Immediate Success	Short Term	Long Term				
Funding	57	Assign a grant coordinator who will assist applicants in obtaining external grants, and pursue opportunities for broadening the scope of existing grants. Grant coordination functions may be undertaken by one of the three invasive species coordinators identified in Recommendation 8 and 10.		x		In Kind	following approval of Invasive Species Management Plan	Center for Invasive Species	
	58	Create, publicize and maintain a list and calendar of granting opportunities relative to invasive species; categorize this list and make it available for review on the Invasive Species Web site in coordination with recommendations 23–25.		x		In Kind	60 days following deployment of invasive species web site	Grant coordinator	
	59	Consult the list of research needs and the evaluation of information gaps (Recommendations 18 and 27) to provide direction for project proposals and grant applications. Seek to support the development of relevant issue specific impact assessments in support of securing additional funding sources to meet invasive species needs.		x			ongoing	AISAC Universities; Agencies	
	60	Identify and pursue specific federal funding opportunities. Convene a work group to track, review and comment on new legislation and pursue (identify, write and submit) AISAC-approved federal funding opportunities.		x			ongoing	AISAC	
	61	Complete and submit an Arizona ANS plan for approval by the national ANS Task Force.	x				8-Dec	AGFD	
	62	Survey identified user groups to assess interest and feasibility of securing funding to support invasive species related needs.	x						
	63	Identify the steps needed to seek legislative appropriation.		x			within horizon of management plan	AISAC	

EVALUATION OUTCOMES

In general, how the recommendations fell out after the scoring process was consistent across the strategic concepts, and there was relative consensus among AISAC members regarding the placement of the recommendations among the areas of focus. See the Implementation Matrix in Table 6 for each recommendation's area of focus and timeline for completion.

Recommendations that are big picture in nature were harder to rate because they often require many steps and long term planning and funding, yet they generally fell into the long term area of focus, and they were evident across all five strategic concepts. In many cases, several recommendations require multiple steps that need to be accomplished before others can be initiated, and as such, they become long term approaches. Such recommendations are, however, clearly of critical importance in addressing invasive species issues. For example, establishing a rapid response fund of $1 million is a critical component for an aggressive approach to managing invasive species, but many separate steps will be required to reach that goal. Government and political commitments will be required as will a legislative appropriation, and it will all depend on educating policy and decision makers of the repercussions of doing nothing to address the threat of invasive species.

"The AISAC does not envision this management plan to be a static document, and the members fully expect the areas of focus will change over time as needs change and recommendations are achieved."

Regarding other evaluation outcomes, Recommendation 19, which identifies research as a critical component, ranked low compared to other Research and Information Management related recommendations. Yet research is critical to long term success and sustainability because it provides information and leading edge tools needed to effectively combat invasive species issues. Research also provides an avenue for evaluation of approaches and adaptive management.

Recommendation 27, which calls for review and identification of gaps in knowledge, also ranked relatively low; however, it is an essential component in long term planning. Without identifying information gaps and needs, approaches will continue to be overlapping, uncoordinated, and patchy. The AISAC recognizes the importance of research without being able to directly identify funding to support such efforts because they are often driven by current needs and funding availability.

As identified by the Anticipation and Outreach work group, many campaigns are focused on a variety of specific invasive species issues; however, there is no general campaign that focuses on the issue of invasive species. Also, compilation and implementation of best management practices, as well as

promoting interagency training, requires cultural barriers to be broken down and acceptance of different approaches and ideas.

Finally, long term tools such as restoration following control treatments are recognized as critical, but they do not provide immediate results. They often drop to the bottom of the list when evaluating "feasible and attainable" accomplishments because they require long term planning and dedication of funding. Such approaches are, however, the foundation for achieving long term success.

The AISAC does not envision this management plan to be a static document, and the members fully expect the areas of focus will change over time as needs change and recommendations are achieved.

COMMON THEMES ACROSS STRATEGIC CONCEPTS

During the evaluation and ranking of areas of focus, certain themes appeared consistently across the strategic concepts and as such, need to be emphasized.

- Cooperation and Coordination – Increased communication is needed across agencies and stakeholders to implement comprehensive invasive species management.
- Coordination can be facilitated through regular workshops where information can be exchanged, threats can be assessed and ranked, and research, control, management and restoration needs identified.
- Information and data need to be collected every step along the way, and need to be compiled in a central accessible database, and used to make comprehensive, responsible assessments and decisions.
- Given current budget constraints, agencies and stakeholders recognize the need and critical importance of funding invasive species issues; however, this occurs at the expense of other initiatives because legislative appropriation is not a feasible solution.

The AISAC also recognizes the importance of tying invasive species issues and needs to other state movements including forest health, connectivity, smart growth, energy development, and climate change. Threats and impacts of invasive species can be identified across all of these issues, and cooperation and discussion among the AISAC and other Governor advisory councils is important to seeking comprehensive understanding and management of invasive species issues.

Bibliography

Anable, M. E., M. P. McClaran, and **G. B. Ruyle.** 1992. Spread of introduced Lehmann lovegrass Eragrostis lehmanniana Nees. in southern Arizona, USA. *Biological Conservation* 61:181–188.

Arizona Wildlands Invasive Plant Working Group (AWIPWG). 2005. *Invasive non-native plants that threaten wildlands in Arizona.* Available at http://www.swvma.org.

Beatley, J. C. 1966. Ecological status of introduced brome grasses *(Bromus spp.)* in desert vegetation of southern Nevada. *Ecology* 47 (4): 548–554.

Betancourt, J. L. 1990. Late Quaternary biogeography of the Colorado Plateau. In *Packrat middens: the last 40,000 years of biotic change,* eds., J. L. Betancourt, T. R. V. Devender, and P. S. Martin, 259–293. University of Arizona Press, Tucson.

Bock, C. E., J. H. Bock, K. L. Jepson, and **J. C. Ortega.** 1986. Ecological effects of planting African lovegrasses in Arizona. *National Geographic Research* 2 (4): 456–463.

Bradley, G. A., P. C. Rosen, M. J. Sredl, T. R. Jones and **J. E. Longcore.** 2002. Chytridiomycosis in native Arizona frogs. *Journal of Wildlife Diseases* 38:206–212.

Brock, J. H. (unpublished) Restoration of plant communities invaded by *Eragrostis* spp. and *Cenchrus ciliaris.*

Brooks, M. L. 2000. Competition between alien annual grasses and native annual plants in the Mojave Desert. *American Midland Naturalist* 144:92–108.

Brooks, M. L., and **D. A. Pyke.** 2001. Invasive plants and fire in the deserts of North America. In *Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species,* eds. K. E. M. Galley and T. P. Woods, 1–14. Fire Conference 2000, The 1st National Congress on Fire Ecology, Prevention and Management. Misc. Pub. No. 11, Tall Timbers Research Sta., Tallahassee, Fla.

Brown, D. E., ed. 1994. *Biotic Communities: Southwestern United States and Northwestern Mexico.* University of Utah Press, Salt Lake City. Originally published 1982 as Desert Plants 4 (1–4).

Burgess, T. L. 1995. Desert grassland, mixed shrub savanna, shrub steppe, or semidesert scrub? *In The Desert Grassland,* eds. M. P. McClaran and T. R. Van Devender, 31–67. University of Arizona Press, Tucson.

Callaway, R. M. and **E. T. Aschehoug.** 2000. Invasive plants versus their new and old neighbors: a mechanism for exotic invasion. *Science* 290:521–523.

Callaway, R. M., B. E. Mahall, C. Wicks, J. Pankey and **C. Zabinski.** 2003. Soil fungi and the effects of an invasive forb on grasses: neighbor identity matters. *Ecology* 84 (1): 129–135.

Carmichael, G. J., J. N. Hanson, M. E. Schmidt and **D. C. Morizot.** 1993. *Introgression among Apache, cutthroat and rainbow trout in Arizona.* Transactions of the American Fisheries Society 122:121–130.

Center for Wildlife Law, Defenders of Wildlife, and Environmental Law Institute. 1999. *New Mexico's natural heritage: a handbook of law and policy.* Albuquerque.

Chambers, N. and **T. O. Hawkins.** 2002. *Invasive plants of the Sonoran Desert.* Sonoran Institute, Tucson.

Clinton, W. J. 1999. Executive Order 13112 of Feb. 3, 1999. Invasive species. *Federal Register* 64 (25): 6183–6186.

Cochrane, M. A. 2001. Synergistic interactions between habitat fragmentation and fire in tropical forests. *Conservation Biology* 15:1515–1521.

Collins, J. P., T. R. Jones, and **H. A. Berna.** 1988. Conserving genetically distinctive populations: the case of the Huachuca tiger salamander *(Ambystoma tigrinum stebbinsi)*. In *Management of amphibians, reptiles, and small mammals in North America,* eds. R. C. Szaro, K. C. Severson and D. R. Patton, 45–53. USDA Forest Service GTR-RM-166, Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Cox, G. W. 1999. *Alien species in North America and Hawaii: impacts on natural ecosystems.* Island Press, Washington, D.C.

Cox, J. R., M. H. Martin-R, F. A. Ibarra-F, J. H. Fourie, N. F. G. Rethman, and **D. G. Wilcox.** 1988. The influence of climate and soils on the distribution of four African grasses. *Journal of Range Management* 41 (2): 127–139.

Crider, F. J. 1945. *Three introduced Lovegrasses for soil conservation.* U.S. Department of Agriculture Circular No. 730.

DeLoach, C. J., R. I. Carruthers, J. E. Lovich, T. L. Dudley, and **S. D. Smith.** 2000. Ecological interactions in the biological control of saltcedar (*Tamarix* spp.) in the United States: toward a new understanding. In *Proceedings of the X International Symposium on Biological Control of Weeds,* July 1999, ed. N. R. Spencer. Montana State University, Bozeman.

DiTomaso, J. M. and **D. W. Johnson,** eds. 2006. *The use of fire as a tool for controlling invasive plants.* Ca-IPC Publication 2006-01. California Invasive Plant Council, Berkeley.

Donaldson, S. and **D. Rafferty.** 2002. *Identification and management of Malta starthistle (Centaurea melitensis* L.). Fact Sheet 02-86. University of Nevada Cooperative Extension, Reno.

Erickson, H. E. and **R. White,** eds. 2007. *Invasive plant species and the joint fire science program.* Gen. Tech. Rep. PNW-GTR-707. USDA Forest Service Pacific Northwest Research Station, Portland, Ore.

Esque, T. C. and **C. R. Schwalbe.** 2002. Alien annual grasses and their relationships to fire and biotic change in Sonoran Desertscrub. In *Invasive exotic species in the Sonoran Desert region,* ed. B. Tellman, 165–194. University of Arizona Press and Arizona-Sonora Desert Museum, Tucson.

Esque, T. C. and **C. Schwalbe.** 2006. *Nonnative grass invasions and fire in the Sonoran Desert,* U.S. Geological Survey Western Ecological Research Center, Las Vegas Field Station, Henderson. Available at: http://www.werc.usgs.gov/invasivespecies/sonorangrassfire.html.

Esque, T. C., C. R. Schwalbe, D. F. Haines, and **W. L. Halvorson.** 2004. Saguaros under siege: invasive species and fire. *Desert Plants* 20 (1): 49–55.

Felger, R. S. 1990. *Non-native plants of Organ Pipe Cactus National Monument, Arizona.* Tech. Rep. 31, Cooperative National Park Resources Studies Unit, University of Arizona, Tucson.

Fernandez, P. J. and **P. C. Rosen.** 1996. Effects of the introduced crayfish *Orconectes virilis* on native aquatic herpetofauna in Arizona. Report to Arizona Game and Fish Department Heritage Program, Phoenix.

Francis, R. and **D. J. Read.** 1994. The contributions of mycorrhizal fungi to the determination of plant community structure. *Plant and Soil* 159:11–25.

Friederici, P. ed. 2003. *Ecological restoration of southwestern ponderosa pine forests.* Island Press, Washington, D.C.

Geiger, E., T. Mau-Crimmins and **H. Schussman.** 2003. *Spread of nonnative grass across southern Arizona: multiple data sources to monitor change.* USDA Forest Service Proceedings RMRS-P-30.

Gould, F. W. 1951. **Grasses of the southwestern United States.** University of Arizona Press, Tucson.

Humphrey, R. R. 1956. *Arizona range grasses: their description, forage value and management.* University of Arizona Press, Tucson.

Invasive Species Advisory Committee, Pathways Task Team. 2003. *Invasive Species Pathways Team Final Report.* U.S. Department of Agriculture, National Invasive Species Information Center. Available at http://www.invasivespeciesinfo.gov/toolkit/pathways.shtml.

Keeley, J. E. 2003. *Impact of fire and grazing on plant diversity and invasion in Sierran forests.* USGS Western Ecological Research Center, Sequoia and Kings Canyon Field Station, Three Rivers, Calif. Available at http://www.werc.usgs.gov.

Kennedy, T. A., J. C. Finley and **S. E. Hobbie.** 2005. Eradication of invasive *Tamarix ramosissima* along a desert stream increases native fish density. *Ecological Applications* 15:2072–2083.

Kiesecker, J. M., A. R. Blaustein and **C. L. Miller.** 2001. Potential mechanisms underlying the displacement of native red-legged frogs by introduced bullfrogs. Ecology 82:1964–1970.

Kincaid, D. R., G. A. Holt, P. D. Dalton and **J. S. Tixier.** 1959. The spread of Lehmann lovegrass as affected by mesquite and native perennial grasses. *Ecology* 140 (4): 738–742.

Kristan, W. B. and **W. I. Boarman.** 2002. Spatial pattern of risk of common raven predation on desert tortoises. *Ecology* 84 (9): 2432–2443.

Light, T. 2003. Success and failure in a lotic crayfish invasion: the roles of hydrologic variability and habitat alteration. *Freshwater Biology* 48:1886–1897.

Marler, M. J., C. A. Zabinski and **R. M. Callaway.** 1999. Mycorrhizae indirectly enhance competitive effects of an invasive forb on a native bunchgrass. *Ecology* 80 (4): 1180–1186.

Marshall, J. T. 1957. Birds of Pine-Oak Woodland in Southern Arizona and Adjacent Mexico. Cooper Ornithological Society, Berkeley, California. Pacific Coast Avifauna. 125 pp.

Marshall, R., M. List and C. Enquist. 2006. *Ecoregional-based conservation assessments of the southwestern United States and northwestern Mexico.* The Nature Conservancy: Tucson. Available at www.azconservation.org.

McAuliffe, J. R. 1995. The aftermath of wildfire in the Sonoran Desert. *Sonoran Quarterly* 49:4–8.

Myers, R. L. 2006. *Living with fire: sustaining ecosystems and livelihoods through integrated fire management.* The Nature Conservancy-Global Fire Initiative, Tallahassee, Fla.

Osborn, S., V. Wright, B. Walker, A. Cilimburg and **A. Perkins.** 2002. Linking wilderness research and management. In *Understanding and managing invasive plants in wilderness and other natural areas: an annotated reading list,* series ed. Vita Wright. U.S. Forest Service Gen. Tech. Rep. RMRS-GTR-79-Vol. 4. Rocky Mountain Research Station, Fort Collins, Colo.

Parker, K. F. 1972. *An illustrated guide to Arizona weeds.* University of Arizona Press, Tucson.

Philips, S. J. and **P. W. Comus,** eds. 2000. *A natural history of the Sonoran Desert.* Arizona-Sonoran Desert Museum Press, Tucson.

Randall, J. and **R. Robison,** eds. 1999. *Elemental Stewardship Abstract, Bromus tectorum L., Cheatgrass.* The Nature Conservancy-Wildland Weed Management Program, 124 Robbins Hall, University of California, Davis.

Rosen, P. C. and **C. R. Schwalbe.** 1995. Bullfrogs: introduced predators in southwestern wetlands. In *Our living resources: a report on the distribution, abundance, and health of U.S. plants, animals, and ecosystems,* eds. Laroe, E. T., G. S. Farris, C. E. Puckett, P. D. Doran and M. J. Mac, 452–454. U.S. Dept. of Interior, National Biological Service, Washington, D.C.

Rosen, P. C. and **C. R. Schwalbe.** 1997. *Bullfrog impacts on sensitive wetland herpetofauna, and herpetology of the San Bernardino National Wildlife Refuge.* Final Report to Arizona Game and Fish Department Heritage Program, and U.S. Fish and Wildlife Service.

Ruyle, G. R., B. A. Roundy and **J. R. Fox**. 1988. Effects of burning on germinability of Lehmann lovegrass. *Journal of Range Management* 41 (5): 404–406.

Schaffer, W. M., D. W. Zeh, S. L. Buchmann, S. Kleinhaus, M. V. Schaffer and **J. Antrim.** 1983. Competition for nectar between introduced honeybees and native North American bees and ants. *Ecology* 64:564–577.

Schussman, H., C. Enquist and **M. List.** 2006. *Historic fire intervals for Arizona and New Mexico: a regional perspective for southwestern land managers.* The Nature Conservancy, Tucson. Available at www.azconservation.org.

Sheridan, T. E. 1995. *Arizona: A History.* University of Arizona Press, Tucson.

Stein, B. A., L. S. Kutner and **J. S. Adams,** eds. 2000. *Precious heritage: the status of biodiversity in the United States.* Oxford University Press.

Stohlgren, T. J., D. Brinkley, G. W. Chong, M. A. Kalkhan, L. D. Schell, K. A. Bull, Y. Otsuki, G. Newman, M. Bashkin and **Y. Son.** 1999. Exotic plant species invade hot spots of native plant diversity. *Ecological Monographs* 69:25–46.

Tellman, B. ed. 2002. *Invasive exotic species in the Sonoran Desert region.* University of Arizona Press, Tucson.

Tu, M., J. Randall, R. Klinger and **G. Babb.** 2002 (unpublished). Fire and invasive species: considering the impacts of fire control techniques and prescribed fire on invasive plants, pre- and post-burn. The Nature Conservancy, Wildland Invasive Species Team, Portland, Ore.

U.S. Census Bureau, Population Estimates, 2007.

Voigt, P. W., L. I. Croy and **F. P. Horn.** 1986. Forage quality of winterhardy lovegrasses. *Journal of Range Management* 39 (3): 276–280 (May 1986).

Woods, D. M., V. Popescu and **M. J. Pitcairn.** 2001. Puccinia centaurea, a naturally occurring pathogen of tocalote. In *Biological control program annual summary,* 2001, ed. Dale M. Woods, 2002. California Department of Food and Agriculture, Plant Health and Pest Prevention Services, Sacramento.

Yoder, C. K. and **R. S. Nowak.** 2000. Phosphorus acquisition by Bromus madritensis ssp. rubens from soil interspaces shared with Mojave Desert shrubs. *Functional Ecology* 14:685–692.

Zavaleta, E. S., R. J. Hobbs and **H. A. Mooney.** 2001. Viewing invasive species removal in a whole ecosystem context. *Trends in Ecology and Evolution* 16:454–459.

Zouhar, K., J. L. Smith, J. Kapler, S. Sutherland and **M. L. Brooks,** eds. *Wildland fire in ecosystems: fire and non-native invasive plants* (in press). Gen. Tech. Rep. RMRS-GTR-42 vol. 6. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. Available at http://www.fs.fed.us/fmi/products/Zouhar_et_al_2007.html.

Appendix A

Executive Order

EXECUTIVE ORDER 2007-07

Re-Establishing The Arizona Invasive Species Advisory Council

WHEREAS, Arizona's land, water, and other resources face severe impacts from harmful, unwanted, invasive plant and animal species that are increasing yearly in number and area in Arizona and throughout the Southwest, including, for example, the recent discovery of quagga mussels in Lake Mead; and

WHEREAS, these impacts include ecological damage to Arizona's natural environments, economy and human health such as: (1) decreasing land productivity; (2) impairing water quality and reducing water yield; (3) increasing instances of livestock poisoning; (4) degrading fish and wildlife habitat; (5) impairing forest and rangeland health by altering natural or desired fire regimes; (6) creating disease vectors; (7) increasing allergens; (8) increasing erosion and watershed degradation; (9) altering landscapes that affect visual aesthetics; and (10) destroying agricultural crops, wetlands, waterways, and recreational areas; and

WHEREAS, prevention, early detection, rapid response, and eradication are the most effective and least costly strategies to combat new biological invaders before they expand beyond control; and

WHEREAS, implementation of the above strategies requires leadership by the State of Arizona and coordination with federal, tribal, international, and local partners and other stakeholders; and

WHEREAS, pursuant to Executive Order 2005-09, the Arizona Invasive Species Advisory Council ("AISAC") identified invasive species as an immediate threat to the State and that Council's report has put Arizona in a position to take a lead nationally in invasive species management;

NOW, THEREFORE, I, Janet Napolitano, Governor of the State of Arizona, by virtue of the authority vested in me by the Constitution and laws of this State, do hereby order as follows:

1. The consensus definition of invasive species developed by the AISAC pursuant to Executive Order 2005-09 is hereby adopted as an advisory, non-regulatory definition for Arizona's Executive Branch agencies. Pursuant to that definition, an invasive species is defined as: "A species that is (1) non-native to the ecosystem under consideration and, (2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health."

2. The AISAC is hereby re-established, and shall serve as a new, permanent Advisory Council that shall be chaired under the joint leadership of the Arizona Game and Fish Department and Arizona Department of Agriculture. It shall consist initially of twenty-one (21) members to advise the State regarding planning and implementation of invasive species policy for Arizona

3. Members of the AISAC shall be appointed by, and serve without compensation at the pleasure of, the Governor. The Governor may appoint additional members as deemed necessary.

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4. Members of the Governor's AISAC may, with the Governor's permission, send designees to serve on the council; provided, however, that such designees shall have been delegated by the member with full authority to vote and otherwise act on behalf of the member.

5. AISAC shall include the Directors (or their designees) of the following State agencies and these entities shall be considered the AISAC Executive Committee:

   - Arizona Game and Fish Department
   - Arizona Department of Agriculture
   - Arizona Department of Transportation
   - Arizona Department of Water Resources
   - Arizona State Land Department
   - Arizona State Parks
   - Arizona Department of Health Services
   - University in Arizona
   - Office of the Governor

6. AISAC shall also include representation from each of the following entities:

   - Native American community
   - Agricultural interests
   - Conservation community
   - Forest health management interests
   - Ranching industry
   - Nursery and landscape industry
   - Pet industry
   - Cooperative Weed Management Areas, invasive species councils, or vegetation management associations
   - Federal agencies with an interest in invasive species
   - Academic community and University Cooperative Extension
   - Other members as deemed appropriate by the Governor

7. AISAC shall develop a comprehensive statewide invasive species management plan for Arizona based upon the framework recommended in the report, "Arizona's Invasive Species Situation: unwanted plants and animals – June, 2006" ("Report"). As recommended in the Report, the framework shall center around five focal strategic concepts:

   - Leadership and Coordination
   - Research and Information Management
   - Anticipation and Outreach
   - Control and Management
   - Funding

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This comprehensive statewide invasive species management plan should also provide guidance and identify expertise for the recommendations outlined in the Report.

8. The Arizona Invasive Species Advisory Council shall submit this comprehensive statewide invasive species management plan for review and evaluation to the Governor by June 30, 2008.

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Arizona.

GOVERNOR

DONE at the Capitol in Phoenix on this 24th day of January in the Year Two Thousand and Seven and of the Independence of the United States of America the Two Hundred and Thirty-First.

ATTEST:

SECRETARY OF STATE

Appendix B

Process for Establishing Research Priorities for Invasive Species

Each species will be rated on a 10-point scale in each of four categories: Negative Ecological Impacts, Negative Economic Impacts, Negative Impacts to Human Health, and Research Need.

Negative Ecological Impacts: This category includes wild/feral distribution of the invasive; ability to spread; number of other species negatively impacted; level of impact to other species; negative impacts to air, water, and soil quality; and increase in fire occurrence or severity.

SCORE	JUSTIFICATION
1	No impact known or expected
2	Minor impacts to a highly localized area and unlikely to spread
3	Major impacts to <5 highly localized areas and unlikely to spread
4	Major impacts to at least 1 native species in 1 biome and unlikely to spread
5	Major impacts to at least 1 native species in 1 biome and likely to spread
6	Major impacts to at least 1 native species across multiple biomes and unlikely to spread
7	Major impacts to at least 1 native species across multiple biomes and likely to spread
8	Significant impacts to rare, threatened, or endangered native species existent or likely
9	Full ecosystem impacts (e.g., negative impacts to multiple species) within 1 biome existent or likely
10	Full ecosystem impacts (e.g., negative impacts to multiple species) across multiple biomes existent or likely

Negative Economic Impacts: This category includes direct and indirect impacts to livestock, crops, transportation, resource extraction (e.g., mining or logging), and commerce as well as cost of prevention, control, and eradication and likelihood of spread.

SCORE	JUSTIFICATION
1	No impact known or expected
2	Minor localized impacts with low cost to prevent, control, and/or eradicate
3	Minor localized impacts with high cost to prevent, control, and/or eradicate but unlikely to spread
4	Minor localized impacts with high cost to prevent, control, and/or eradicate and likely to spread
5	Major localized impact with low cost to prevent, control, and/or eradicate
6	Major localized impact with high cost to prevent, control, and/or eradicate but unlikely to spread
7	Major localized impact with high cost to prevent, control, and/or eradicate and likely to spread
8	Minor widespread impacts with high cost to prevent, control, and/or eradicate and likely to spread
9	Major widespread impacts to at least 1 economic category with low cost of prevention, control, and/or eradication
10	Major widespread impacts to at least 1 economic category with high cost of prevention, control, and/or eradication

Negative Impacts to Human Health: This category includes direct negative impacts to human health through disease, injury, infection, and disease transmission. Human health impact duration (acute vs. chronic), level of impairment, contagiousness (including vector availability), and likelihood of fatality affect the score in this category. Indirect affects on human health (e.g., increase in fire occurrence, dust, etc.) are included in the Negative Ecological Impacts category.

SCORE	JUSTIFICATION
1	No impact known or expected
2	Rare (<5%), acute impact with little to no subsequent health impairment
3	Minor acute impact (5-50%) or effect unknown but expected to be acute
4	Common, minor acute impact (≥50%) or fatal if ingested
5	Major acute impact (<50%)
6	Common, major acute impact (≥50%)
7	Chronic impacts (≥1%) or effect unknown but expected to be chronic
8	Fatal (<5%) with low rate of contagiousness (e.g., requires direct contact with infected fluids)
9	Highly contagious (e.g., air- or water-borne or common vector) and fatal (<5%) or fatal (≥5%) with low rate of contagiousness or uncommon vector (e.g., requires direct contact with infected fluids)
10	Highly contagious (e.g., air- or water-borne or common vector) and fatal (≥5%)

Research need: This category includes extent of existing knowledge applicable to the Southwest in five main categories: general natural history that applies to management; prevention; monitoring/identification; impact evaluation; and control/eradication/restoration. The amount of existing knowledge as well as pertinence to Southwest biomes is considered.

SCORE	JUSTIFICATION
1	No needs identified
2	Minor deficit in no more than 1 category
3	Minor deficits in 2 categories
4	Minor deficits in 3 categories
5	Minor deficits in 4 categories
6	Major deficit in no more than 1 category
7	Major deficits in 2 categories
8	Major deficits in 3 categories
9	Little previous research (major deficits in 4 categories)
10	Little to no previous research (major deficits in all 5 categories)

Red Flagging: Individual species may be red flagged due to concerns about spread to particular geographic areas or highly significant impacts in one of the three impact categories (economic, ecological, or human health). Red flagging may cause a particular type of research on a species in a particular geographic area to become a priority regardless of the species score.

Appendix C

Granting / Funding Opportunities

Funding programs identified below were active granting entities at the time Arizona's Invasive Species Plan was published. Keep in mind, however, that changes may occur in agency and non-governmental organization, proposal submission dates, budgets and priorities. Likewise, website URLs do not remain constant; therefore if the link does not work, search the web by program name.

Biology of Weedy and Invasive Species Agroecosystems - National Research Initiative, Cooperative State Research, Education and Extension Service - USDA

http://www.csrees.usda.gov/fo/weedyinvasivespeciesnri.cfm

The goal of the program is to provide ecological and economically rational strategies for management, control, or elimination of weedy or invasive species.

Cooperative Forest Stewardship Program, U.S. Forest Service - USDA

http://www.fs.fed.us/spf/coop/programs/loa/fsp.shtml

Provides funds for invasive plants/weeds (including weed management activities), plant pathogens/diseases, and insects on state and private forested land. Eligible entities include cooperative weed management areas, states, privately owned forest lands and nonprofit organizations.

Environmental Quality Incentives Program, Natural Resources Conservation Service - USDA

http://www.nrcs.usda.gov/PROGRAMS/EQIP/

The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land.

Forest Service Pesticide Impact Assessment Program, U.S. Forest Service - USDA

http://www.fs.fed.us/foresthealth/pesticide/fspiap/

The mission of FS-PIAP is to support studies that develop use and effects data for priority forestry pesticides. FS-PIAP studies generate data and findings in support of continued registration by the U.S. Environmental Protection Agency of forestry uses for pesticides.

Invasive Species – Funding Opportunities, Cooperative State Research, Education

http://www.csrees.usda.gov/invasivespecies.cfm

CSREES is actively engaged in the battle against invasive species through leadership in the implementation of the National Invasive Species Management Plan and funding from Section 406 Pest Management Programs and others in the National Research Initiative (NRI) Program.

Invasive Species Research, Technical Assistance, Prevention and Control, U.S. Department of Agriculture Funding Programs Summary (Jan07; PDF 112 KB)

http://www.invasivespeciesinfo.gov/toolkit/grants.shtml#fed

This workbook contains basic information on USDA programs that could be used to fund invasive species related projects. The list should be a helpful place to start a search for resources for invasive species activities but by no means represents the complete universe of potential invasive species funding opportunities.

Legacy Resource Management Program, U.S. Department of Defense

http://www.dodlegacy.org/Legacy/intro/guidelines.aspx

Invasive species also can adversely affect military readiness and create fire and safety hazards. We will invest in habitat enhancement, particularly through control of exotic pests and promotion of natural species to minimize disturbance of natural landscapes and increase vegetative cover, thereby controlling a growing threat to environmental security and improving training conditions. We will also invest in efforts to institutionalize Early Detection and Rapid Response methods within DoD.

National Science Foundation Program Areas That May Accept Invasive Species Proposals: (1) Dynamics of Coupled Natural and Human Systems, (2) Ecological Biology and (3) Long Term Research in Environmental Biology, U.S. National Science Foundation

http://transcoder.usablenet.com/tt/www.nsf.gov/funding/

The National Science Foundation funds research and education in most fields of science and engineering. It does this through grants, and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the United States. The Foundation accounts for about one-fourth of federal support to academic institutions for basic research.

Natural Resource Assistance Grants, U.S. Fish and Wildlife Service - U.S. Department of Interior

http://www.fws.gov/grants/

The Fish and Wildlife Service administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals.

North American Wetlands Conservation Act, U.S. Fish and Wildlife Service - U.S. Department of Interior

http://www.fws.gov/grants/

The North American Wetlands Conservation Act (NAWCA) of 1989 provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.

Organismal and Population Biology of Arthropods and Nematodes, Cooperative State Research, Education and Extension Service - USDA

http://www.csrees.usda.gov/fo/arthropodnematodeorganismalbiologynri.cfm

Our ability to respond to and recover from pests and diseases that threaten our food supply has recently assumed paramount importance. Fundamental knowledge is needed to form the basis of novel management strategies for pests, which will lead to better utilization of beneficial species.

Pesticide Environmental Stewardship Program, Environmental Protection Agency

http://www.epa.gov/oppbppd1/pesp/grants.htm

These grants support pollution prevention projects that are important to and complement ongoing efforts in the EPA regional offices. Invasive species control research that reduces pesticide use qualifies for this program.

Program of Research on the Economics of Invasive Species Management, Economic Research Service - USDA

http://www.ers.usda.gov/Briefing/InvasiveSpecies/preism.htm

PREISM focuses on economic issues related to exotic pests of crop, forest, and range land (such as insects, weeds, and disease-causing pathogens), and foreign livestock, poultry, and zoonotic diseases (transmittable between animals and humans); also exotic pests and foreign diseases affecting public lands, ecosystems, and urban systems.

Pulling Together Initiative, National Fish and Wildlife Foundation

http://www.nfwf.org/AM/Template.cfm?Section=Grants

The Pulling Together Initiative (PTI) provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships. These partnerships engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy.

Regional Geographic Initiatives, Environmental Protection Agency

http://www.epa.gov/regional/rgi.htm

Provides up to four years of seed money for projects that address a high health or ecosystem risk (such as those associated with aquatic invasive species) and have significant potential for risk reduction.

Wetlands Reserve Program, Natural Resources Conservation Service, USDA

http://www.nrcs.usda.gov/Programs/WRP/

The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help landowners with their wetland restoration efforts. The NRCS goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program.

Wildlife Habitat Incentives Program, Natural Resources Conservation Service, USDA

http://www.nrcs.usda.gov/programs/whip/

Through WHIP, the USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant (landowner) generally last from 5 to 10 years from the date the agreement is signed.

Appendix D

Existing Campaign / Messages

ISSUE	SPONSOR	DEPLOY*	CATCH PHRASE OF MESSAGE	WEBSITE
AQUATIC				
Misc Aquatic	Invasive Species Pilot Program	C	Americas Most Wanted	
Misc Aquatic	Arizona Game and Fish Department		Attention Boaters Don't Pick Up Hitchhikers!	www.azgfd.gov
Misc Aquatic	Arizona Game and Fish Department	BG	Stop the Spread of Aquatic Pests!	www.azgfd.gov
Misc Aquatic	Arizona Game and Fish Department	BEM	Stop the spread of aquatic pests!	www.azgfd.gov
Misc Aquatic	Arizona Game and Fish Department	BEM	Don't Pick Up Hitchhikers!	www.azgfd.gov
Misc Aquatic	100th Meridian Initiative	CO	Help stop the spread of Aquatic Nuisance Species	www.100thmeridian.org
Misc Aquatic	USDA Forest Service (cooperative)	D	Invaders Among Us	
Misc Aquatic	Arizona Game and Fish Department	PO	Attention Boaters, Don't Pick Up Hitchhikers	www.azgfd.gov
Misc Aquatic	US Fish and Wildlife Service	S	Stop Aquatic Hitchhikers	www.ProtectYourWaters.net
Misc Aquatic	US Fish and Wildlife Service	S	Stop Aquatic Hitchhikers!	www.protectyourwaters.net
Misc Aquatic	Arizona Game and Fish Department	WE		www.azgfd.gov/
Misc Aquatic	Onterio Federation of Anglers and Hunters	WE	Invading Species Awareness Program	www.invadingspecies.com
Misc Mussels	Arizona Game and Fish Department	N	Invasive Mussels found at CAP	www.azgfd.gov
Misc Mussels	Arizona Game and Fish Department	N	Invasive mussels now confirmed at Lake Havasu as w	www.azgfd.gov
Misc Mussels	Arizona Game and Fish Department	N	Dreaded invader has arrived at Lake Mead	www.azgfd.gov
Quagga		F	Alert: Quagga mussels infest these waters!	
Quagga	Arizona Game and Fish Department	O		www.azgfd.gov
Zebra Mussel	National Park Service	F	Prevent the Spread of Zebra Mussels!	
Zebra Mussel	100th Meridian Initiative	P	Zap the Zebra	www.100thmeridian.org
Zebra Mussel	USDA Animal and Plant Health Inspection Service	W	Not All Alien Invaders Are From Outer Space	
DISEASE				
Misc Disease	Texas Department of Health	P	Zoonoses	
Phytophthora Ramorum	USDA Animal and Plant Health Inspection Service	P	Stopping the spread	

ISSUE	SPONSOR	DEPLOY*	CATCH PHRASE OF MESSAGE	WEBSITE
DISEASE (continued)				
Chronic Wasting Disease	Wyoming Game and Fish Department	P	What Chronic Wasting Disease Means to You	http://gf.state.wy.us
Avian Influenza	California Department of Fish and Game	P	Avian Influenza: What every hunter should know	www.dfg.ca.gov/avianflu
Avian Influenza	USDA	P	A Consumer Guide to Avian Influenza	www.usda.gov/birdflu
Avian Influenza	National Restaurant Association	P	Our Business Cares about Your Safety: Avian Influenza	www.restaurant.org/ai
Smallpox	Hawaii State Department of Health	P	Caution Smallpox Biohazard	www.hawaii.gov/doh
Plague	Hawaii State Department of Health	P	Caution Plague Biohazard	www.hawaii.gov/doh
Brucellosis	Virginia Tech	P	Brucellosis: A Disease of Humans and Animals	
Whirling Disease	Montana Water Center	W	Whirling Disease Initiative	http://whirlngdisease.montana.edu/initiative/
Chronic Wasting Disease	The Wildlife Management Institute	PDF	Questions and Answers on CWD for Hunters	www.cwd-info.org
Avian Influenza	Michigan Department of Agriculture	P	Avian Influenza: Michigan's Preparation and Respon	www.michigan.gov/flu
Brucellosis	Hawaii State Department of Health	P	Caution Brucellosis Biohazard	www.hawaii.gov/doh
Avian Influenza	USDA	P	Protecting the United States	www.usda.gov/birdflu
General Invasive Species				
General Invasive Species	Biosecurity New Zealand	MA	The enemy within -- environmental weeds	www.biosecurity.govt.nz
Ideas * 50's 60's slogans campaigns			Keep America Clean and Beautiful (slogans)	
Misc Weeds	USDA National Agricultural Library	WE	National Invasive Species Information Center	www.invasivespeciesinfo.gov
Misc Weeds	National Audubon Society	WE		www.audubon.org
Ideas * * * Reducing Mosquitoes			SWAT or SWARM (Acronyms)	
INSECTS				
Japanese Beetle	USDA Animal and Plant Health Inspection Service	W		http://www.aphis.usda.gov/plant_health
Grasshopper	USDA Animal and Plant Health Inspection Service	B	Grasshopper Integrated Pest Management (1991)	
Educational Resources	USDA National Agricultural Library	WE	Educational Resources	www.invasivespeciesinfo.gov/animals/education.shtm
False Codling Moth	USDA Animal and Plant Health Inspection Service	PC	Seeing Spots?	http://www.csrees.usda.gov
Exotic Fruit Flies	Arizona Department of Agriculture	DO	Say "No" to Exotic Fruit Flies in Arizona	
Brown Citrus Aphid	Arizona Department of Agriculture	W	Pest Alert	
Boll Weevils	USDA Animal and Plant Health Inspection Service	P	Deliver Us From Weevil	
Asian Longhorned Beetle	Local Department of Agriculture office	MI	Save Trees! Report the Asian Longhorned Beetle	www.aphis.usda.gov

ISSUE	SPONSOR	DEPLOY*	CATCH PHRASE OF MESSAGE	WEBSITE
INSECTS (continued)				
Philippine downy mildew of corn	USDA Animal and Plant Health Inspection Service	PC	Seeing Spots?	http://www.csrees.usda.gov
Red Palm Mite	USDA Animal and Plant Health Inspection Service	P	Look Out for the Red Palm Mite	http://www.aphis.usda.gov/plant_health
Siberian Silkworm	USDA Animal and Plant Health Inspection Service	PC	Seeing Spots?	http://www.csrees.usda.gov
British root-knot nematode	USDA Animal and Plant Health Inspection Service	PC	Seeing Spots?	http://www.csrees.usda.gov
Giant African Snail	USDA Animal and Plant Health Inspection Service	W		http://www.aphis.usda.gov/lpa/issues/ga_snail/
Cactus Moth	USDA Animal and Plant Health Inspection Service	PDF	Pest Alert	http://www.aphis.usda.gov/ppq/ep/emerging_pests/
Asian Citrus Psyllid	USDA Animal and Plant Health Inspection Service	PDF	Significant Pest Bulletin	
Misc Insects	NY State Department of Environmental Conservation	WE	Don't Move Firewood-You could be killing our trees	http://www.dec.ny.gov/animals/28722.html
Red Palm Mite	USDA Animal and Plant Health Inspection Service	PDF	Pest Alert	http://www.aphis.usda.gov/plant_health/
Light Brown Apple Moth	USDA Animal and Plant Health Inspection Service	PDF	Significant Pest Bulletin	
Japanese Beetle	USDA Animal and Plant Health Inspection Service	MI	Beware of the Japanese Beetle	http://www.aphis.usda.gov/ppq/ispm/jb
VECTORS AND DISEASE				
West Nile Virus	California Department of Health Services	P	What your should know to protect yourself and family	www.westnileca.gov
Glassy-Winged Sharpshooter	University of California Agriculture & Natural Res	PO	WANTED	
West Nile Virus	Michigan Department of Community Health	P	What is West Nile Virus	www.michigan.gov/westnilevirus
West Nile Virus	Nevada District Health Department	P	Answers to Common Questions	www.co.washoe.nv.us/health/ehs
West Nile Virus	Indiana State Department of Health	P	What you can do to Protect your Family, Animals	
West Nile Virus	Town of Queen Creek	P	West Nile Virus Mosquito Control	www.azdhs.gov/phs/oids/westnile/
West Nile Virus	Delaware Department of Natural Resources and Env.	PDF	Mosquitoes and West Nile virus in Delaware	
West Nile Virus	Department of Health and Human Services	P	Fight the Bite!	www.cdc.gov/westnile
West Nile Virus	Pima County Health Department	P	Fight the Bite!	www.westnileaz.com
West Nile Virus	American Veterinary Medical Association	L	What you should know about West Nile Virus	www.avma.org
WEEDS				
Misc Weeds	BLM /FWS /NPS /USDA /NAWMA /WSSA Weedcenter (coop)	PO	National Invasive Weed Awareness Week	www.nawma.org/niwaw_index.htm
Giant Salvinia	Arizona Game and Fish Department	F	Have You Seen This Plant?	www.azgfd.gov
Leafy Spurge	USDA-ARS Team Leafy Spurge Area-Wide IPM Program	B	Biological Control of Leafy Spurge	www.team.ars.usda.gov

ISSUE	SPONSOR	DEPLOY*	CATCH PHRASE OF MESSAGE	WEBSITE
WEEDS (continued)				
Buffelgrass	Pima County Parks and Rec. (coalition)	P	Wanted Buffelgrass Dead and Gone	www.buffelgrass.org
Tropical Soda Apple	USDA	W	Don't Spread Tropical Soda Apple	
Misc Weeds	USDA	D	Dangerous Travelers, Controlling Invasive Plants..	
Misc Arizona Weeds	Arizona Wildlands Invasive Plant Working Group	B	Invasive Non-Native Plants that Threaten Wildlands	www.swvma.org
Misc Weeds	Nevada Bureau of Land Management (coalition)	P	Invasive Weeds, You can help stop their spread!	www.invaders.nv.blm.gov
Karnal Bunt	USDA	MI	Help Corral Karnal Bunt	www.aphis.usda.gov
Misc Weeds	Federal Highway Administration	WE	Invasive Species - FHWA Roadside	www.fhwa.dot.gov/vegmgt/invasive.htm
Misc Weeds	Weedbusters New Zealand	WE	Weedbusters	www.weedbusters.org.nz/
Misc Weeds	Australian Government Department of the Environment	WE	Be Smart With Seed	www.environment.gov.au/land/publications
Misc Weeds	USDA Forest Service	WE	Non-Native Invasive Species NNIS	www.fs.fed.us/invasivespecies
Misc Weeds	Rocky Mountain Elk Foundation	A	… campaign against weeds in western Montana	Rocky Mountain Elk Foundation, Bugle, Nov/Dec 07
Misc Weeds	Ohio Invasive Plants Council (coalition)	WE		www.oipc.info
Misc Weeds	National Park Service	WE	Weeds Gone Wild	www.nps.gov/plants/alien
Misc Weeds	New Mexico State University (coalition)	WE	Dirty Dozen Invaders of the Southwest	www.invasiveweeds.com/dirty/welcome.html
Misc Weeds	National Park Service	WE	Safeguarding Native Plants and Animals	www.nature.nps.gov/biology/invasivespecies/
Misc Weeds	USDA National Agricultural Library	WE	National Invasive Species Information Center	www.invasivespeciesinfo.gov/plants/main.shtml
Misc Weeds	USDA Natural Resources Conservation Service	WE	Invasive and Noxious Weeds	http://plants,usda.gov/java/noxious
Misc Weeds	Weedinvasion.org	WE	Alien Invasion Plants on the Move	www.weedinvasion.org/weeds/weed_home.php
Misc Weeds	Montana statewide noxious weed and education campaign	WE	Pulling Together Against Noxious Weeds	www.weedawareness.org/factsheet3.html
Misc Weeds	National Park Service (cooperative)	WE	Aliens in your neighborhood!	www.nps.gov/invspcurr/alienhome.htm

DEPLOYMENT KEY	
A	Article
B	Booklet
BEM	Boating Education Manual
BG	Boaters Guide
CO	Conference
D	DVD
DO	Door Hanger
DP	DVD / PSA
F	Flyer
L	Leaflet
M	Magazine Issue 69, Aug 06
MI	Miscellaneous Promo Item
N	News Release
OU	Outreach Outline
P	Pamphlet
PC	Postcard
PDF	PDF
PO	Poster
S	Sticker
W	Watchcard
WE	Web page/site

Appendix E

Pathway Outline

As modified from the "Invasive Species Pathways Report," Pathway Task Team, National Invasive Species Council, 2003. This outline lists and groups the pathways of introduction for invasive species. The pathways identified fall into three categories:

1) Transportation Related: All pathways related to the transportation of people and goods and the vehicles themselves. This category includes military travel. Subcategories include: modes of transportation, items used in the shipping process, travel/tourism/relocation, and mail/Internet/overnight shipping companies.

2) "Living" Industry: All pathways associated with living plants and animals or their by-products. Subcategories within this broad category include food pathways (market ready, for immediate consumption), nonfood animal pathways (transporting animals for other reasons), and the plant trade (aquatic and terrestrial).

3) Miscellaneous: Pathways that did not fit under the other two categories. Subcategories include other aquatic pathways, ecosystem disturbance, other nonliving animal- and plant-related pathways and natural spread of established populations of invasive species.

Note: For the "Organisms Transported" entry in the outline, the organisms have been listed with the following letter codes to avoid repetition. Some organisms may have been missed and some of the organism categories may be lumped together.

Key to Organisms Transported

ai = aquatic invertebrates (and larval stages)
adp = animal disease pathogens and parasites
ap = aquatic plants
av = aquatic vertebrates (and larval stages)
di = dinoflagellates
dp = disease pathogens
gm = gypsy moth
hfo = hull fouling organisms
in = insects and similar invertebrates
inv = other invertebrates (not insects)
mbv = microbes, bacteria, and viruses
pdp = plant disease pathogens
ph = phytoplankton
ps = plants and seeds
si = snails and other invertebrates
tv = terrestrial invertebrates (insects and other arthropods)
v = vertebrates

Pathways Outline

I. TRANSPORTATION-RELATED PATHWAYS, INCLUDING MILITARY TRAVEL

A. Modes of Transportation (i.e., things doing the transporting)

1. Air Transportation
   a) Examples: planes, helicopters, etc. (e.g., stowaways in wheel wells, cargo holds, and anywhere else)
      (1) Organisms Transported: v (snakes and others), in, inv, ps, pdp
2. Water/Aquatic Transportation, including all methods of moving through the water
   a) Examples: recreational boats and other craft, semi-submersible dry-docks, can be large or small; includes industrial, tourism, recreational, law enforcement, and Coast Guard crafts
   b) Subpathways
      (1) Ballast water and sediments and other things that hold water: sea chests, engines, etc.
         (a) Organisms Transported: ai, ap, mbv, di, ph
      (2) Hull/Surface fouling
         (a) Organisms Transported: hfo, other aquatic organisms when talking about slow moving platforms
      (3) Stowaways in holds, cabins, etc.
         (a) Organisms Transported: v, inv, ps, pdp
      (4) Superstructures/structures above the water line
         (a) Organisms Transported: inv (gypsy moths), others?
      (5) Dredge spoil material
         (a) Organisms Transported: ai, av, ap, adp, pdp
3. Land/Terrestrial Transportation, including all methods of moving across the ground
   a) Subpathways
      (1) Cars, trucks, buses, ATVs, etc.
      (2) Construction equipment and firefighting equipment
      (3) Trains, light rails
      (4) Hikers, hunters, anglers, horses, pets
   b) Organisms Transported: ps, gm, si, in, v, adp, pdp

B. Items Used in Shipping Process

1. Containers - both exterior and interior
   a) Organisms Transported: ps, gm, si, in, v, dp,
2. Packing Materials
   a) Subpathways
      (1) Wood packing materials: wood pallets, wood crates,

(a) Organisms Transported: ps, in, pdp, si

(2) Seaweed

(a) Organisms Transported: ai, av, adp, pdp

(3) Other plant materials

(a) Organisms Transported: ps, psp, in, si, v, adp

(4) Sand/earth - sometimes used in archaeological shipments

(a) Organisms Transported: in, inv, ps

C. Tourism/Travel/Relocation

1. Examples: travel for recreation, business or for relocation
2. Subpathways
   a) Travelers themselves (includes humans as vectors for disease)
   b) On baggage and gear - "carry on" and checked items
   c) Transported pets/plants and animals transported for entertainment, including pets that are transported when one moves or travels, and animals transported for horse shows, sporting events, circuses, rodeos, plant or garden shows, etc.
   d) Travel consumables (food in RVs, etc.)
3. Organisms Transported: ps, insect, sim inverts, dp

D. Mail/Internet/Overnight Shipping Companies

1. Organisms Transported: ps, pdp, in, si, ai, av

II. LIVING INDUSTRY PATHWAYS

A. Food Pathways

1. Live Seafood (market ready - imported into and/or throughout the U.S. for immediate consumption)
   a) Subpathways
      (1) Food organism "in trade," intentionally released (authorized or unauthorized) or escaped
      (2) Hitchhikers[1]
         (a) On or in live seafood (includes parasites and pathogens)
         (b) In water, food, packing material, substrate (live rock?)
   b) Organisms Transported: ai, ap, av, di, ph, adp, pdp, la
2. Other Live Food Animals (imported alive into and/or throughout the U.S.)
   a) Examples: livestock, game birds
   b) Subpathways

[1]Note: In all places where the term hitchhiker is used, it includes plants, animals, invertebrates, parasites, diseases, and pathogens.

(1) Food organism "in trade," intentionally released (authorized or unauthorized) or escaped
(2) Hitchhikers
(a) On or in live animals (includes parasites and pathogens)
(b) In water, food, growing medium, nesting or bedding
c) Organisms Transported: adp, in, mbv, tv, v

3. Plants and Plant Parts as Food (imported into and/or throughout the U.S.)
a) Examples: fruits, vegetables, nuts, roots, seeds, edible flowers, etc.
b) Subpathways
(1) Plant "in trade," intentionally released (authorized or unauthorized) or escaped
(2) Hitchhikers
(a) On or in food organism (includes parasites and pathogens)
(b) In water, food, growing medium, nesting or bedding
c) Organisms Transported: ps, pdp, in, inv, v (frogs on plants, etc.)

B. Non-Food Animal Pathways

1. Aquaculture (includes the sites where organisms are raised, the raising of the organisms, and their movement, unless classified as live seafood; if an organism usually classified as live seafood is being transported for reproduction purposes or other reasons, it falls under aquaculture)
a) Examples: fish, shellfish, shrimp and other invertebrates
b) Subpathways
(1) Aquacultured organism "in trade," intentionally released (authorized or unauthorized) or escaped
(2) Hitchhikers
(a) On or in cultured organism (includes parasites and pathogens)
(b) In water, food, growing medium, nesting or bedding
c) Organisms Transported: when including larval stages of animals, almost any aquatic plant or animal is possible, with the exception of marine mammals

2. Pet/Aquarium Trade, including the organisms and their facilities
a) Examples: dogs, cats, birds, herptiles, exotic mammals, fish, other aquarium stock, invertebrates (tarantulas, scorpions, etc.)
b) Subpathways
(1) Pet organism "in trade," intentionally released (authorized or unauthorized) or escaped
(2) Hitchhikers

(a) On or with pet organism (includes parasites and pathogens)
(b) In water, food, growing medium, nesting or bedding, aquarium substrates

c) Organisms Transported: almost anything is possible

3. Bait Industry
   a) Examples: anything used as bait for fishing, etc.
   b) Subpathways
      (1) Bait organisms "in trade," intentionally released (authorized or unauthorized) or escaped
      (2) Hitchhikers
         (a) On or with bait (includes parasites and pathogens)
         (b) In water, food, growing medium, nesting or bedding
   c) Organisms Transported: ai, ap, av, di, ph, adp, pdp, la
4. Non-Pet Animals
   a) Examples: importation of animals for non-food livestock (hunt clubs, breeding, racing, work animals), research, harvesting fur/wool/hair, entertainment and their sites of deliberate introduction (zoos, public aquaria, ranches, rodeos, lab facilities, etc.)
   b) Subpathways
      (1) Non-pet organism "in trade," intentionally released (authorized or unauthorized) or escaped
      (2) Hitchhikers
         (a) On or with non-pet animal (incl. parasites and pathogens)
         (b) In water, food, growing medium, nesting or bedding
   c) Organisms Transported: adp, in, mbv, tv, v

C. Plant Trade (aquatic and terrestrial)

1. Examples: importation of plants and sites of deliberate introductions (botanical gardens, nurseries, landscaping facilities, research facilities, public and private plantings, and aquariums/water gardening facilities when talking about aquatics, etc.)
   a) Whole plants and nurseries/landscaping/garden facilities
   b) Plant parts
      (1) Seeds and the seed trade
      (2) Below ground plant parts
         (a) Bulbs, culms, roots, tubers, etc.
      (3) Above ground plant parts
         (a) Cuttings, budwood
      (4) Aquatic plant propagules
2. Subpathways

a) Plant organisms "in trade," intentionally released (authorized or unauthorized) or escaped
b) Hitchhikers
(1) On or with plant or plant part (includes parasites and pathogens)
(2) In water, growing medium, or packing material
3. Organisms Transported: ps, pdp, in, si, v, ai, av, adp

III. OTHER MISCELLANEOUS PATHWAYS

A. Other Aquatic Pathways
1. Subpathways
a) Interconnected waterways
(1) Examples: Colorado and Salt River Reservoir systems
b) Interbasin transfers
(1) Examples: SRP canals, CAP canals, etc.
2. Organisms Transported: ai, av, ap, adp, pdp

B. Other Animal and Plant Related Pathways
1. Minimally Processed Animal Products
a) Examples: hides, trophies, feathers
b) Organisms Transported: adp, in, inv
2. Minimally Processed Plant Products
a) Examples: logs, firewood, chips, mulch, straw, baskets, sod, potting soils, etc.
b) Organisms Transported: in, inv, ps, pdp, si, v
3. Meat Processing Waste
a) Organisms Transported: adp

C. Ecosystem Disturbance
1. Short-term Disturbances that Facilitate Introduction
a) Examples: habitat creation, restoration, enhancement; forestry; post fire treatments (BAER – Burned Area Emergency Response)
b) Organisms Transported: ps, pdp, in, inv, v
2. Long-term Disturbances that Facilitate Introduction
a) Examples: highway, railroad, and utility rights of way; land clearing, development, damming, stream channelization, logging
b) Organisms Transported: ps, pdp, in, inv, v

D. Natural Spread of Established Populations of Invasive Species
1. Examples: natural migration, movement and spread of established populations, ocean currents, wind patterns, unusual weather events, spread by migratory waterfowl, etc.
2. Organisms Transported: this category contains all established invasive species

Appendix F

Survey Questions to Gauge Public Awareness

Potential survey questions to be included in the 2008 Arizona Game and Fish Department "Trends" Survey (dependent on professional survey vendor reviews and pre-test results)

1) Have you ever heard of the term "Invasive Species"?

❑ Yes
❑ No
❑ I don't remember

a. Asked of respondents who answered "Yes." **Can you name at least one invasive species found in Arizona?**

Read to the respondent: **"Invasive species can be plants, animals, insects, fungi (pronounced Fun-ji), viruses, or micro-organisms that are not native to the local environment and have the potential to cause environmental damage or pose risks to human health."**

2) How would you categorize your knowledge: Would you say you know a great deal, a moderate amount, a little, or nothing about invasive species in Arizona?

❑ A great deal
❑ A moderate amount
❑ A little
❑ Nothing

3) Do you recall ever being exposed to any informational material about invasive species in Arizona? This may include sources such as books, magazines, newspaper articles, informational brochures, websites, television/ radio shows, etc.

❑ Yes
❑ No
❑ I don't remember

a. Asked of respondents who answered "Yes." **What type of information source do you recall seeing about invasive species in Arizona?**

b. Do you recall which invasive species the information pertained to?

4) If you were asked to do some research about invasive species in Arizona, what source(s) of information would you be likely to use?

5) In your opinion, what level of emphasis should be placed on addressing invasive species in Arizona?

❑ Much more emphasis
❑ More emphasis
❑ Same amount of emphasis
❑ Less emphasis
❑ Much less emphasis

Appendix G

Outreach Plan Template

The columns can be filled out for the strategies applicable to a particular issue and used as a checklist or for decision-making. The strategies listed are not prioritized.

STRATEGY	QUANTITY	ESTIMATED COST	LOCATIONS	METHOD OF DELIVERY
On-sight signage • Lakes • Rivers • Park kiosks • Roadsides • Other				
Invasive Species website development; post all media related collateral on website; video-streaming if footage exists; pictures, etc. • Online newsletter or program information to its own listserv, other existing newsletters, bulletins, or informational brochures • Link on AISAC Center portal page • Links on stakeholder / partners websites including bordering states such as CA, NV, UT, NM				
Informational leaflets (in place of brochures); front and back • Use as inserts for registrations and citations, or other existing mail-outs for licenses or permits, etc. • Customer service take-ones at partnering facilities, cooperative retailers and partnering license dealers; other organizations for distribution at their events or meetings				
Article about the program and current issues (interview stakeholders / partners as well) • Use as public service announcements in periodicals, newsprint tabloids; include radio and television news stations • News releases (cover story with reporters) to print, radio and television media • Post on AISAC Center website				
News releases • About program and how it's evolving • Issue-based as necessary (proactive and rapid response) • Send to television, radio and print media				

STRATEGY	QUANTITY	ESTIMATED COST	LOCATIONS	METHOD OF DELIVERY
Posters to keep the issue in the forefront at partnering facilities, cooperative retailers and partnering license dealers and offices, other organizations for their meeting facilities • Message focus on website for more information and most grave issue (such as quagga or golden algae, etc.) • Artwork or photo of invasive species				
When due, reprint license or permit forms to promote program or include new Invasive Species website address				
Create customer service telephonic recording to promote website or convey important invasive species messages when customers are placed on hold				
Keep employees informed about program via e-mails or intranet (stay consistent; well-informed employees are the voice of the agency/organization)				
Program booth presence at applicable events such as the Outdoor Expo, boat shows, Tri-state area events, local related conferences, etc.; staff booth with employees or representatives who know the program				
TV Story for PBS channel 8 or cable networks that partnering agencies participate in • Create 10-minute script • Coordinate with audio/visual staff • Plan thoroughly with plenty of time before production				

Appendix H

Invasive Species Volunteer-Public Participation Program Overview

1. What is an Invasive Species Volunteer-Public Participation Program (ISVPPP)?

A group of local stakeholders working to promote common practices in invasive species management strategies for the conservation of Arizona's unique ecosystems. Stakeholders include concerned citizens or anyone interested in or concerned with invasive species management.

2. Status of Volunteer Working Groups in Arizona

There are multiple initiatives throughout Arizona working to address invasive species issues in the state. Unlike other western states that have laws establishing countywide Weed Control Districts, Arizona Weed Management Areas (WMAs) are local partnerships that are not funded with tax dollars, are not governing entities or legislative bodies, are not tax districts, or enforcement agencies and are not regulated under any state agency (Report to the Governor, 2006, pg. 19).

Invasive species management organizations are at the early stages of organization. County governments have informal associations, and various individual weedwacker groups exist that tend to be species oriented (e.g., buffelgrass, saltcedar).

3. Benefits to Members of a Public Participation Program

Joining an ISVPPP brings benefits to the participants, including an opportunity to:

- Participate in and assist in conservation of Arizona's unique ecosystems
- Promote and participate in a community-based program
- Participate in meaningful science, leading to cross-jurisdictional common best management practices
- Create new public outreach opportunities and raise social awareness
- Perform meaningful and exciting projects that combine science, education, and habitat conservation and restoration

4. Elements and Activities of a Public Participation Program

Participants in ISVPPP will include dedicated volunteers with a range of skills, including leaders who will coordinate activities, collate and report results, and recruit and retain volunteers.

- ISVPPP groups will (take the lead) (assist) in invasive species inventory and monitoring programs by assessing threats, mapping, implementing eradication programs, and training recruits.

In addition, ISVPPP groups will operate in the following areas:

- Public Policy and Advocacy
- Education and Outreach
- Fundraising (Individuals, Foundations, Agencies, Corporations)

ISVPPP activities may include:

- Inventory
- Monitoring
- Habitat management, restoration, enhancement
- Education and outreach about planning invasive species volunteer public participation program activities (communications with local landowners, presentations to community, creation of invasive species materials)

5. Public Participation Program Process: How would you start an Invasive Species Volunteer Public Participation Program?

WMAs provide a working model for other programs. The following steps provide a general approach for developing ISVPPPs:

- Find out where volunteer opportunities exist and can have a meaningful impact; list of volunteer contacts/expert information will be available on the Arizona invasive species website (Objective 4 Recommendation 13, pg. 10).
- In cooperation with land/resource manager, select a site where you would like to volunteer.
- Identify one or more species or issues of personal interest.
- Identify an individual (yourself or someone who you can invite to join your group) to act as the main coordinator and contact with the land management agency (ies).
- Work with the land/resource manager's invasive species coordinator to get permission to adopt a site, to identify any permits that may be required, and to identify objectives, timelines and outcomes to achieve management goals.

- Work with the land/resource manager's invasive species coordinator to develop a site-specific program of activities.
- Work with existing WMAs and other stakeholders who hold a stake today and in the future of the site.
- Recruit, educate, train and keep volunteers motivated.
- Record, monitor and report activities and information.

6. Web Resources

- Utilize web to search for ISVPPP examples and opportunities (e.g., www.invasive species.gov).
- Matching volunteers with land/resource manager needs and volunteer coordinators.
- Arizona Invasive Species Web Site will serve as a place for ISVPPPs to post contact information.

7. Partnerships

- Financial
- Create networks among ISVPPPs
- Land/Resource managers encourage networking among volunteers

Appendix I

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Appendix J

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Arizona Invasive Species Advisory Council

Guiding Arizona to a non-invasive state of mind.