Pima County Ecological Monitoring Program's Monitoring Protocol for Tracking Invasive Plant Occurrences

June 2020

PIMA COUNTY
SUSTAINABILITY & CONSERVATION

Prepared by Pima County Office of Sustainability and Conservation Staff:
Amanda D. Webb

Cover photo: Fountain grass (*Pennisetum setaceum*) fills in spaces among native plants in Espiritu Canyon on A7 Ranch in the Santa Catalina Mountains, Pima County, Arizona.

Recommended citation:
Webb, A.D. 2020. Pima County Ecological Monitoring Program's Monitoring Protocol for Tracking Invasive Plant Occurrences. Ecological Monitoring Program, Pima County Multi-species Conservation Plan. Report to the U.S. Fish and Wildlife Service, Tucson, Arizona.

Contents

List of Figures

List of Tables

Executive Summary

Pima County, part of a larger region known for its high biodiversity, harbors many unique species and ecological communities across its iconic landscapes. These natural resources are threatened by invasive, nonnative plants that out-compete native plants, alter ecosystem processes, and degrade wildlife habitat. The Pima County Multi-Species Conservation Plan (MSCP) outlines conservation measures that the County is undertaking to preserve and enhance 44 plant and animal species of conservation concern and their habitats. The MSCP commits Pima County and the Regional Flood Control District (County collectively) to collect monitoring observations on and prepare a database for 15 to 20 of the most important invasive plant species that all appropriate County staff and cooperators should be able to identify during vegetation monitoring occurring in the Preserve network. This protocol provides information on 25 invasive plants that are a priority for monitoring and management across Pima County conservation lands, and lays out a process by which the County will monitor them. Recommendations for prioritizing management actions are also included.

The purpose of this protocol is to create a process by which Pima County can:

1. **Detect the spread of the most harmful invasive plants into new areas;**
2. **Detect new invasions early when they can be controlled more easily;**
3. **Store and share data on invasive plant occurrences across departments in a geodatabase that can be used to inform the development of management plans and the coordination of invasive plant control efforts, where appropriate and feasible.**

To narrow down the long list of invasive plants known to occur in and around Pima County into a short list of the most important species for monitoring and management, we consulted with partners within and external to Pima County departments to get feedback on selected species, and reviewed other available resources including reports, field guides, and other databases. As part of our justification, we focus largely on invasive plants that are the most likely to impact vegetation and ecological processes such that they can lead to an ecosystem type conversion (e.g., buffelgrass increases fine fuel loads and increases fire frequency, which leads to the mortality of native vegetation while perpetuating the spread of buffelgrass, thus changing the ecosystem from desert or thornscrub to a nonnative-dominated grassland). Our assumption is that the conversion of ecosystem types would trigger direct and indirect negative impacts to covered species and their habitats. We also incorporate all 10 focal species of the Sonoran Desert Cooperative Weed Management Area (SDCWMA), a partnership led by the Arizona-Sonora Desert Museum that strives to focus on species that local partners are concerned about the most. Finally, several species included in this protocol are designated as noxious weeds by the state of Arizona.

Pima County's ecological monitoring program (EMP) supports the MSCP by tracking ecological conditions, stewardship effectiveness, and the status of covered species across the County's conservation lands. Under the MSCP, the EMP is required to develop a protocol that addresses

surveillance for the presence of invasive plants. The EMP will accomplish this by: leveraging data collected at long-term plots for soils and vegetation monitoring; collecting invasive plant data opportunistically while carrying out other monitoring protocols, property assessments, and other operations in-the-field; utilizing data collected by other organizations that are freely available online; through regular communications with partners at the local, state, and federal levels.

Although the EMP collects data in support of the MSCP, other Pima County departments, primarily the Pima County Regional Flood Control District (RFCD) and Natural Resources, Parks and Recreation (NRPR), also collect data on invasive plant occurrences. The EMP does not directly implement invasive plant control. In contrast, both RFCD and NRPR have invasive plant management responsibilities with multiple on-going projects across the County lands that they manage. To help facilitate data sharing (i.e., get EMP's observations to NRPR and RFCD so managers can use those data to implement control strategies) EMP is developing a geodatabase where these data can be stored and viewed. Furthermore, the EMP is working with the County's GIS technical team to create an automated script that will make these data available to the relevant managers on a daily basis. These procedures and processes are meant to ensure that County land managers are kept up to date on the most current status of invasive plant occurrence on County lands, particularly as it relates to any emerging threats warranting rapid response.

Our recommendations to managers include developing a strategic management plan for tackling invasive plants. Treating new infestations early is likely to save time and money in the long run. Plans should have clearly defined objectives, but be flexible to allow for improvements when new information becomes available. Partnerships, cross-boundary collaboration, and volunteers will likely continue to be critical elements of success. We recommend maintaining an ad hoc, interdepartmental working group focused on invasive plants to help provide a forum for discussion among staff at OSC, RFCD, and NRPR.

To help County managers develop robust control strategies, we present information about each of the invasive plants highlighted in this report, what ecosystems they are known to invade, what their general status is, as well as particular County conservation lands where they have been observed. We also describe the key resources associated with several covered species, and which invasive plants may pose the most immediate threat to their habitats. Other portions of this protocol which may be of use to managers are a list of operational and logistical considerations for prioritizing treatments, and the identification of existing resources on developing invasive plant management plans and criteria for selecting the highest priority species on which to focus. The bibliography also provides some additional management resources that may be useful.

Acknowledgements

I thank my colleagues in Pima County for their past, current, and future due diligence in their reporting of species of interest on Pima County open space lands. I thank Ian Murray and Julia Fonseca for their valuable input on multiple aspects of this protocol. I thank Jeff Gicklhorn for his significant contributions toward the development of data management strategies, and for producing the maps herein depicting documented locations of buffelgrass and fountain grass on Pima County conservation lands. I thank Jennifer Becker, Carianne Campbell, and Gita Bodner for their thoughtful reviews of this document. I thank Brian Powell, Doug Siegel, and Rachel Loubeau for input on the species included in this protocol, their impacts, and their whereabouts on County conservation lands. Marisa Rice provided sustained input on elements ranging from relevant invasive species to development of digital datasheets and data management. I thank Don Swann for his comments on invasive species in the region that are important for monitoring. I also thank Pima County IT GIS, especially Mike List, Elisabeth Van Der Leeuw, Becky Steinnecker, and Pankaj Jamwal, for their continual efforts to build and improve the ecological monitoring program's geodatabase, as well as for assisting the monitoring program with other GIS-related needs like producing map products and providing assistance with digital data collection best practices and hardware.

Background

Nonnative invasive plants and their detrimental impacts on naturally functioning ecosystems across the landscape are an increasing threat to native plants and wildlife worldwide. They can out-compete native plants, alter ecosystem processes such as fire and nutrient cycling, and affect food web structure. Invasive plant infestations can also bring about economic impacts by affecting recreational experiences, agricultural production, and increasing fire hazards in housing developments, industrial areas and on military bases. Pima County has highlighted management of invasive plants, specifically buffelgrass, as critical to the conservation of the diverse and unique ecological communities of the region. Monitoring is needed to inform management. It is the means by which County staff can detect invasive plants, track their movement over space and time, and assess the threats they pose to valued resources. This document lays out the protocol that Pima County staff will follow as it carries out its commitments for invasive plant monitoring, as described in the Pima County Multi-Species Conservation Plan (MSCP). Furthermore, this protocol provides land managers in Pima County with information intended to help them make effective management decisions given the large scope of the invasive plant problem, the vast area covered by County preserves, and the limited resources available to apply towards this issue.

By implementing the MSCP, Pima County remains in compliance with the Endangered Species Act through its Section 10 Incidental Take Permit issued by the US Fish and Wildlife Service (USFWS) in 2016 (Pima County 2016). The MSCP covers 44 species (covered species) that are federally listed as threatened or endangered, or otherwise recognized as species of conservation concern due to factors such as their limited distribution and risk of rapid decline due to threats like habitat destruction. The MSCP was developed as part of Pima County's broader Sonoran Desert Conservation Plan (SDCP), in which a stated goal is to ensure that the full range of native plants and animals continue to occur on the County's conservation lands. The species covered under the MSCP include amphibians, birds, fish, mammals, reptiles, and plants. For many of these species, invasive plants and their associated impacts are a major threat to their persistence.

Pima County's ecological monitoring program (EMP) is a crucial part of the MSCP because it allows the County to track ecological conditions, the effectiveness of its stewardship, and the status of covered species across County conservation lands. Under the MSCP, the EMP is required to develop a protocol that addresses surveillance for the presence of invasive plants across County conservation lands. Additionally, Pima County's MSCP identifies a set of changed circumstances that could potentially arise and that would impact covered species or their habitats (Table 7.1, Pima County 2016). Several of these changed circumstances are related to the potential impacts caused by invasive plants. Changed circumstances will be discussed in further detail later in this report along with the County's potential responses to these problems.

As stated in Table A-2 of the MSCP, the EMP has committed to developing a database for recording species observations for 15-20 of the most important invasive species that all appropriate County staff and cooperators should be able to identify. These invasive plants are

to be surveyed for in and around all long-term monitoring plots at the same time as vegetation monitoring. Furthermore, the County has committed to assisting local, state, and federal partners in Pima County with mapping and monitoring buffelgrass. This protocol addresses these commitments, but also goes beyond them by: including additional opportunities for collecting field data; utilizing field data collected by other individuals and organizations; providing an assessment of 25 species that are a high priority for management; providing a list of key resources and associated geographic areas that are critical for MSCP covered species and should ideally be protected from invasive plants; and providing a list of operational and logistical considerations to help inform prioritization of management projects. The EMP is providing these additional data, recommendations, and considerations in an effort to assist the County's orchestration of a management response to invasive plants on more than 250,000 acres of conservation lands and other County-owned properties, which is very difficult given limited resources. As conditions change on-the-ground and new information about the impacts of invasive plants on MSCP covered species are discovered, this protocol may, and should be, updated.

Purpose

The purpose of this protocol is to create a process by which Pima County can:

1. **Detect the spread of the most harmful invasive plants into new areas;**
2. **Detect new invasions early when they can be controlled more easily;**
3. **Store and share data on invasive plant occurrences across departments in a geodatabase that can be used to inform the development of management plans and the coordination of invasive plant control efforts, where appropriate and feasible.**

Ecosystems of Pima County

The ecological requirements for the persistence, spread, and harm posed by invasive plants varies from species to species, and are dependent on site-specific conditions. To help guide treatment and monitoring efforts, it is helpful to understand what ecosystems occur in Pima County, and which of them an invasive plant is most likely to impact. The table below summarizes major ecosystems that occur in Pima County (Dimmit 2000). The upland systems are considered biomes, as described by Dimmit (2000). The riparian zone includes many different riparian vegetation communities owing to the great diversity of vegetation types that occur in riparian zones across elevations and latitudes (Dimmit 2000). The upland ecosystems have been stratified by elevation as a proxy for biome-level plant communities to structure vegetation and soils sampling in NPS's long-term monitoring protocol for parks in the Sonoran Desert Network (Hubbard *et al.* 2012), which Pima County has adapted for its own use (Gicklhorn 2020). This design will allow the County to analyze change over time in each upland ecosystem type individually (Figure 1). While these broad delineations are helpful for analyzing vegetation change in the context of other environmental factors (e.g., climate, land use, etc.), the reality on-the-ground is that plant communities are more complex, with transition zones of overlapping vegetation types that do no adhere to strict elevation boundaries. For finer-scale classifications of ecosystem types, see Ecological Site Descriptions produced by the Natural

Resources Conservation Service
(https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/).

Table 1. Ecosystems of Pima County with notes on the elevations at which they are typically found, vegetation characteristics, and natural disturbance regimes.

Ecosystem	Approximate Elevation (ft)	Plant Community Characteristics	Disturbance Regimes
Desert	0 – 2,500	Cacti; annual grasses and forbs; some shrubs (mesquite, acacia, creosote bush) but not dense	Low fire frequency, drought maintains considerable open space around most plants
Thornscrub	2,500 – 3,700	Shares many of the same species found in Desert but with more succulents, more shrubs, and fewer herbaceous species and annuals; agave, yucca, and paloverde more common	Low fire frequency, drought-resistance is high
Semi-desert grassland	3,700 – 4,500	Perennial short- and mid-grasses; annuals; occasional shrubs and trees	High frequency fire is important for maintaining grassland characteristics, drought reduces perennial grass cover, infrequent prolonged freezing can affect mesquite
Interior chaparral	3,700 – 4,500	Dense shrubs including manzanita and shrub live oak	Fires are stand-replacing and occur on average every 125 years (Fryer et al. 2012), drought can exacerbate fire
Madrean evergreen woodland	4,500 – 6,000	Oak, pinyon pine, juniper; perennial grasses	Low severity fires common with stand replacing fires occurring every 65 years on average (Fryer et al. 2012), drought can exacerbate fire
Xeric riparian	0 – 6,000	Some species similar to adjacent uplands but more dense and robust life forms; woody species may include mesquite, desert willow, netleaf and desert hackberry, paloverde, oak, and desert broom	Intermittent flooding; fire regimes influenced by those in adjacent uplands and the plant-scouring action of flooding that may decrease fuel continuity; drought
Mesic riparian	0 – 6,000	Variable; may be herbaceous-dominated (sedges, cattails), woody-dominated (cottonwood, Goodding's willow, mesquite, velvet ash, walnut, netleaf hackberry), or mixed	Seasonal or more frequent inundation with flooding common; fire regimes highly variable depending on vegetation structure and composition, and influenced by fire regimes in adjacent uplands; drought effects are moderated by available water including shallow groundwater where present

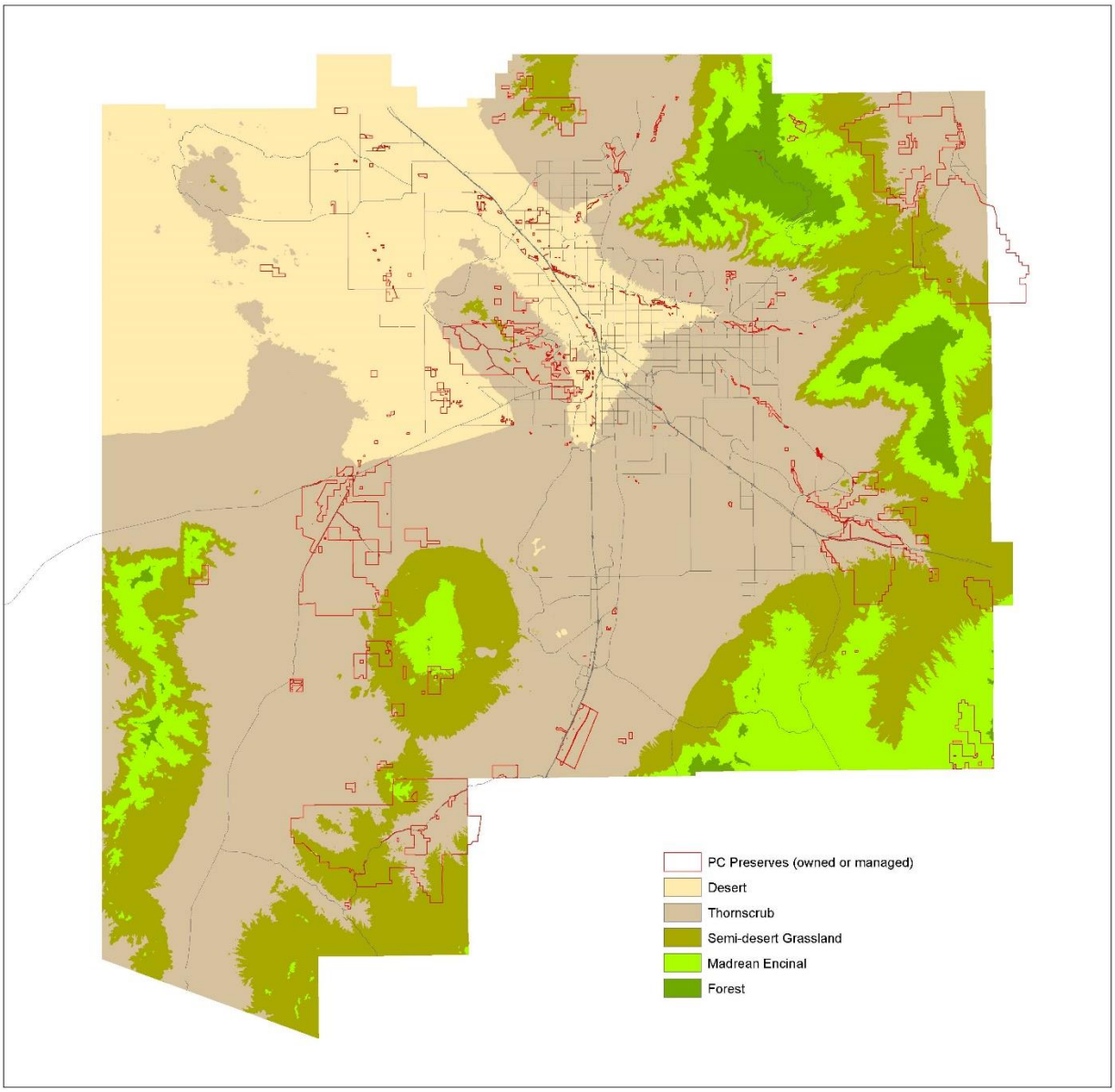


Figure 1. Geography of terrestrial biomes across eastern Pima County. Categorization uses elevation as a proxy for biome, as presented in Hubbard et al. (2012). Corresponding elevations are listed in Table 1. For information on riparian areas in Pima County, see RFCD's Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines (https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Environmental%20Quality/Water/Stormwater/2011_RFCD_RiparianHabitatProtectionMitigationGuidelines.pdf).

Assessment of Current Management Programs and Procedures

While the Conservation Science Division of Pima County's Office of Sustainability and Conservation houses the EMP and is responsible for compliance monitoring under the MSCP, the management of invasive plants on County conservation lands is undertaken by other Pima County departments. The Natural Resources, Parks and Recreation (NRPR) department manages most of the County-owned parks, trails, preserves, rangelands, and grazing leases.

Among many other responsibilities, staff at NRPR coordinate and lead invasive plant removal projects on the lands they oversee, primarily on fee-lands. For example, NRPR is currently developing a long-term strategic plan for invasive plant species management across County open space lands, including a summary of the invasive plant efforts of County open space lands over the last 20 years, creation of an application targeting real-time reporting of invasive species mapping, removal, and monitoring, as well as creation of a functional, accessible, and long-term central database for management and monitoring of invasive species. Additionally, the Pima County Regional Flood Control District (RFCD) engages in invasive plant monitoring and removal projects in their efforts to protect and enhance floodplain function across a sizeable network of floodplains, constructed restoration projects, and open space lands. Projects are generally focused on minimizing flood and fire risk while providing habitat for native species and passive recreational opportunities for people. The District is currently developing a floodplain management plan for unincorporated lands in Pima County. Among many objectives, the plan includes invasive species management.

Due to the complex nature of designing and implementing floodplain projects and limitations on staff resources, RFCD accomplishes much of its restoration project work with professional contractors, but uses NRPR Operations Division staff, contractors, and groups such as the Arizona Conservation Corps and the Pima County Summer Youth Group for land management actions including invasive species removal. Just recently, the RFCD received a large grant from the Arizona Department of Forestry and Fire Management for invasive plant species control on County-managed lands, particularly targeting monitoring and re-treatment of known infestations.

In addition to work organized and done by County field staff, NRPR regularly engages the public in volunteer projects. For example, a stakeholder citizen group called the Sonoran Desert Weedwackers meets three times per month to conduct invasive plant removal in and around the Tucson Mountain Park. NRPR staff provides tools and equipment, education on plant identification and safe removal techniques, and works with the group in-the-field on projects taking place on County property. Pima County collaborates with Tucson Clean and Beautiful to allow volunteer groups access to County-owned lands for invasive species removals, but these groups must demonstrate trained expertise and function relatively autonomously. As with RFCD, NRPR also hires youth corps work groups (i.e., Arizona Conservation Corps) that spend a portion of their time on invasive plant removal.

Despite the opportunities County staff seize to engage in invasive plant removal, staff availability for this is limited as they have multiple responsibilities and a large geographic area with substantial area of remote and rough terrain. Although the County actively seeks funding opportunities that can support invasive plant removal, such as the grant mentioned above, challenges related to limited staff availability and the large scope of the invasive plant problem will most likely remain, making sustained progress slow and difficult. Nonetheless, efforts are being made to improve strategies for managing invasive plants on County lands.

Many agencies, individuals, and organizations in Pima County are struggling with invasive plants, which spread in response to ecological conditions and without regard to jurisdictional or land ownership boundaries. The Southwest Vegetation Management Association (SWVMA) is a statewide organization that focuses on invasive species ecology, inventory, and management. The Sonoran Desert Cooperative Weed Management Area (SDCWMA) is a partnership that responds to the need for better coordination of invasive plant management across the local landscape. Pima County is one of several entities partnering with the SDCWMA.

In addition to on-the-ground removal tactics and monitoring, the County has other tools to help address the threats posed by invasive plants. Since the development of the SDCP, Pima County has implemented a number of policies and plans for protecting native plant communities *in situ* as well as those that address invasive plants. These policies avoid and minimize disturbances, promote use of native species in landscaping, institutionalize processes for monitoring and managing invasive plants, and give the County authority to take action in instances where invasive plants on private land create a public health hazard.

The SDCP policies and plans can be divided into two categories: those that address threats monitoring and response in the County's preserve network, and those that outline procedures for avoidance and minimization of impacts associated with County projects outside of the preserve network (Table 2).

Table 2. Formalized rules and procedures for addressing invasive plants in unincorporated Pima County.

Title	Summary	More Information
Threats monitoring and response inside the preserve network		
Buffelgrass Control: Standard Operation Procedure No. 2009-02	Outlines procedures County staff shall follow to detect, map, and treat buffelgrass.	See Appendix A
Cienega Creek Natural Preserve Management	Currently under revision. Existing plan calls for the development of a cooperative program that includes monitoring for invasive plants and wildlife.	https://webcms.pima.gov/cms/one.aspx?pageId=65706
Floodplain Management Plan	Development of this plan is currently underway. The plan will integrate riparian habitat preservation and restoration into operations designed to protect public safety and prevent flood damage.	https://webcms.pima.gov/cms/One.aspx?portalid=169&pageId=450475

Title	Summary	More Information
Range Management Standards and Guidelines	Describes standards, guidelines, and procedure for how the County will manage ranch properties sustainably and as an important part of MSCP implementation.	https://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=41864
Restoration Plans	RFCD has and continues to develop restoration plans at several sites within and outside of the County's Conservation Lands System.	https://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=57629
Avoidance of disturbance and minimization of impacts associated with County projects outside the preserve network		
Plant Materials Salvage and Selection for Pima County Projects: Administrative Procedure No. 51-3	Establishes a procedure for plant selection and salvage for projects constructed by Pima County to ensure compliance with state and local requirements, and to provide a unified approach for use of native plants. Directs staff to SOP 2009-02 for management and control of invasive plants, including fountain grass and Sahara mustard.	https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Administration/Administrative%20Procedures/51-3%20Plant%20Salvage,%20Selection%20for%20County%20Projects.pdf
Buffelgrass Control: Standard Operation Procedure No. 2009-02	Outlines procedures County staff shall follow to detect, map, and treat buffelgrass.	See Appendix A
Noxious and Invasive Vegetation on DOT Projects: Standard Operation Procedure No. 201-01	Provides a cost effective procedure for removing buffelgrass, fountain grass, and other target invasive plants in areas of the right-of-way for all transportation Capital Improvement Program (CIP) projects regardless of size.	https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Transportation/Standard%20Operating%20Procedures/SOP201-01_Noxious_and_Invasive_Vegetation_on_DOTProjects.pdf
Community Participation and Mitigation: Pima County Zoning Code Chapter 10.56	Requires that all transportation projects include the application of the Environmentally Sensitive Roadway Design Guidelines. Guidelines include a list of invasive plants that are not allowed for use in post-construction revegetation.	https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Transportation/Roadway%20Design/EnvironmentallySensitiveRWY/ESR-WebsiteDocumentGuidelineswith4dmemo.pdf
Native Plant Salvage on DOT	Outlines a procedure by which Pima County DOT will minimize impacts to	https://webcms.pima.gov/UserFiles/Servers/Server_6/Fil

Title	Summary	More Information
Projects: Standard Operation Procedure No. 809-01	existing vegetation and provide opportunities for native plant salvage. Requires the removal and disposal of invasive plants prior to salvage where they will be impacted by salvage activity.	e/Government/Transportation/Standard%20Operating%20Procedures/SOP809-01_NativePlantSalvage_on_DOTProjects.pdf
Private Landscaping Additions to the Right-of-Way: Standard Operating Policy and Procedure No. 670.03	For private landscape additions on public right-of-ways, requires private entities to include in their landscape plans the approximate locations of invasive species, treatment schedule, and treatment type.	Appendix B
Removal of Rubbish, Trash, Weeds, Filth and Debris: Pima County Code, Title 7, Chapter 33; Ordinance No. 2008-117	Identifies buffelgrass as a weed subject to regulation. Allows the County the authority to issue property owners in unincorporated Pima County an Opportunity to Correct, seek a court injunction, or abate the property when buffelgrass poses a significant public safety threat such as fire.	http://www.deq.pima.gov/Regulations/pdf/ORD2008-117BUFFELGRASS.pdf

Invasive species of interest

One commitment that Pima County has under the MSCP is to develop a database for recording observations of 15-20 of the most important invasive species. Below are descriptions of 25 invasive plant species of interest. To help ensure that these species are the most important, we have consulted with partners within and external to Pima County departments in an effort to get feedback on the selected species, as well as reviewed resources readily available online. All invasive plants included in this protocol are nonnative species.

A majority of the species in this protocol are important because they have been documented to lead to ecosystem type conversions by triggering changes in ecosystem processes that mediate habitat for plants, or have characteristics that suggest this is a possibility in the ecosystems they invade. In many cases, this is most evident in the way invasive plants alter fuel structure and fuel loading, accompanied by shifts in fire characteristics (Figure 2); for example, some invasive species increase fire frequency, size, and intensity (Rice et al. 2008; Webb et al. 2019). Fires can expedite the spread of invasive species that is already happening due to climate change and natural resource management. For a few species included in this protocol, although they appear unlikely to result in ecosystem type conversions, there remain concerns about how they alter vegetation structure and overtake native species, which may also have detrimental effects on MSCP covered species.

The invasive species in this protocol overlap with the focal species of the Sonoran Desert Cooperative Weed Management Area (SDCWMA). The SDCWMA is a partnership led by the Arizona-Sonora Desert Museum and made up of several organizations that work on invasive plant issues in Pima County. The partnership's list of focal species was developed in response to feedback from partners regarding what species they work on and are concerned about the most. All ten of the SDCWMA focal species are included in this protocol.

Figure 2. Buffelgrass burning in Marana, Pima County, Arizona.

As another indication of their importance, several invasive plants in the descriptions below are designated as noxious weeds by the state of Arizona due to the hazards they pose to native ecosystems, agriculture, and public health and safety. These plants are identified as Regulated, Restricted, or Prohibited in the state of Arizona, as defined under state administrative codes R3-4-244 and R3-4-245. The full list of Arizona noxious weeds can be found on the Arizona Department of Agriculture website (https://agriculture.az.gov/pestspest-control/agriculture-pests/noxious-weeds). Where applicable, we note the designation of a noxious weed in the table and species descriptions below.

Table 3. Invasive plants highlighted in this protocol are listed in the table below. They are divided into two categories: watchlist species for which intensive management may be avoided if infestations can be addressed early, and high priority species for management that are more established, and in some cases, widespread.

Scientific Name	Common Name	Functional Group	Eco-systems Invaded	Status in Pima Co.	AZ Nox-ious Weed	SDCWMA Focal Species
Watchlist Species: Undetected, uncommon, or newly emerging in Pima County						
Ailanthus altissima	tree-of-heaven	tree or shrub	Mesic riparian	Spreading in urban and riverine areas	Yes	No
Asphodelus fistulosus	onion weed	annual or perennial forb; flowers in winter/spring	Thornscrub; semi-desert grassland; xeric riparian; mesic riparian	Uncommon	Yes; also federally listed	No

Scientific Name	Common Name	Functional Group	Eco-systems Invaded	Status in Pima Co.	AZ Nox-ious Weed	SDCWMA Focal Species
Bothriochloa ischaemum	yellow bluestem	warm season perennial grass	Semi-desert grassland; xeric riparian	Spreading; present in urban Pima County and recently emerging on range lands	Yes	No
Matthiola parviflora	small-flowered stock	annual forb; flowers in winter/spring	Thornscrub, xeric riparian, mesic riparian	New; uncommon; spreading in Tucson metro	No	No
Oncosiphon piluliferum	stinknet	annual forb; flowers in spring	Desert; thornscrub; xeric riparian	New; uncommon; spreading rapidly in metro Tucson, Phoenix and S. CA	Yes	Yes
Vinca major	periwinkle	herbaceous vine; flowers in spring/ summer	Mesic riparian	Uncommon	No	No
Volutaria tubuliflora	volutaria	annual forb; flowers in winter/spring/ summer	Mojave desert	Not yet detected	No	No
High Priority Species for Management: Widespread, common, or established species						
Arundo donax	giant reed	warm season perennial grass	Mesic riparian	Spreading in washes	Yes	Yes
Brassica tournefortii	Sahara mustard	annual forb; flowers winter/spring	Desert; thornscrub; xeric riparian	Spreading	Yes	Yes
Bromus rubens	red brome	cool season annual grass	Desert; thornscrub; chaparral; Madrean woodland; mesic and xeric riparian	Spreading; common in Arizona	No	No
Centaurea melitensis	Malta starthistle	annual or biennial forb; flowers in spring/summer	Desert; thornscrub; mesic riparian; xeric riparian	Spreading	Yes	Yes

Scientific Name	Common Name	Functional Group	Eco-systems Invaded	Status in Pima Co.	AZ Nox-ious Weed	SDCWMA Focal Species
Centaurea solstitialis	yellow starthistle	annual forb; flowers summer/fall/early winter	Thornscrub; semi-desert grassland; chaparral; Madrean woodland	Spreading	Yes	No
Enneapogon cenchroides	soft feather pappusgrass	annual or perennial grass; non-seasonal	Desert; thornscrub; xeric and mesic riparian	Spreading; current distribution appears to be mainly in Pima County	No	No
Eragrostis curvula	weeping lovegrass	warm season perennial grass	Desert; thornscrub; xeric riparian	Widespread within and beyond Pima County	No	No
Eragrostis echinochloidea	African lovegrass	warm season perennial grass	Desert; thornscrub; grassland;	Spreading; current distribution appears to be mainly in Pima and Cochise counties	No	No
Eragrostis lehmanniana	Lehmann lovegrass	warm season perennial grass	Semi-desert grassland; thornscrub; xeric riparian	Widespread within and beyond Pima County	No	Yes
Euryops multifidus	sweet resinbush	subshrub; flowers in winter/spring	Thornscrub; semi-desert grassland	Spreading; present elsewhere in Arizona but not widespread in Pima County	Yes	No
Melinis repens	natal grass	perennial or annual grass; may flower for much of the year; intolerant of hard frosts	Semi-desert grassland; thornscrub	Spreading	Yes	Yes
Pennisetum ciliare	buffelgrass	warm season perennial grass	Desert; thornscrub; xeric riparian	Widespread within and beyond Pima County	Yes	Yes

Scientific Name	Common Name	Functional Group	Eco-systems Invaded	Status in Pima Co.	AZ Nox-ious Weed	SDCWMA Focal Species
Pennisetum setaceum	fountain grass	warm season perennial grass	Desert; thornscrub; xeric riparian; mesic riparian	Widespread within and beyond Pima County	Yes	Yes
Searsia lancea (formerly *Rhus lancea*)	African sumac	tree or shrub	Xeric and mesic riparian	Spreading out from urban and suburban areas	No	No
Setaria adhaerens	bur bristlegrass	warm season annual grass	Mesic and xeric riparian	Spreading; present in far NE Pima County and beyond	No	No
[1]*Sorghum halepense*	Johnsongrass	warm season perennial grass	Mesic riparian; moist ditches	Widespread within and beyond Pima County	Yes	Yes
Tamarisk chinensis; T. ramosissima	Salt cedar	tree or shrub	Mesic riparian; xeric riparian	Common	Yes	Yes

Grasses

Arundo donax (Giant reed)

Giant reed is a perennial grass from Asia and Africa that was introduced as an ornamental plant and planted for erosion control in drainages. In Pima County, giant reed is largely confined to mesic riparian areas. It has been found in a few County-owned areas at Cienega Creek Natural Preserve, and along Agua Verde Creek and Santa Cruz River. Currently, it is not widespread in these areas. There are a few small patches and occasional singular plants along waterways, and in particular there may be dense patches in areas along the middle Santa Cruz River. Along Tanque Verde Creek, however, it is spreading rapidly. It is considered a Class B noxious weed in Arizona, meaning it is still spreading as opposed to being established. Giant reed is a focal species of the SDCWMA.

Giant reed is large and fast-growing, reaching up to 30 feet tall, and has the potential to affect water availability due its very high use of water for transpiration relative to native plants (US Forest Service 2014a). Chemical compounds in giant reed can inhibit growth of other species,

[1] Monitoring will also include *Panicum antidotale* (blue panic grass) which is often mistaken for Johnsongrass due to its visual similarity and occupation of the same mesic niche.

and the decay of dead plant material can impact water quality when it results in the creation of toxic ammonia (US Forest Service 2014a).

While populations appear somewhat constrained in Pima County at this time, in other parts of the southwestern United States, giant reed has displaced native plants in rivers and flood control channels, including woody species, and has spread to form dense monocultures. Were this to occur on County conservation lands, several covered riparian birds that depend on trees and shrubs could be impacted. Giant reed in flood control channels could lead to a build-up of materials, reducing flood capacity and slowing water in floodways, and thus increase flood risk in upstream and adjacent areas. Furthermore, the longer giant reed is in a location, the harder it can be to remove, particularly if it experiences repeated flood events that bury its roots in successive layers of sediment. Pieces of plants that break away can wash downstream and establish new infestations.

The presence of giant reed can increase fuel loads and continuity, thus increasing fire risk in riparian areas. In fact, observations in California suggest that streams dominated by giant reed can act as conduits for fire spread, allowing fires started in uplands to spread across water bodies and continue burning on the other side (Coffman et al. 2010). Fires promote further dominance of giant reed; nutrient levels observed post-fire suggest nutrients increase around burned giant reed plants and not around burned native plants (Coffman et al.2010).

Bothriochloa ischaemum (Yellow bluestem)

Yellow bluestem is a warm season perennial grass native to southern Europe and Asia (Coyne and Bradford 1985). It was in the United States by the early 1900s when there was interest in Old World bluestems as good forage for livestock (Celarier and Harlan 1955). Today, it is a noxious weed in Arizona, categorized as a Class B Weed, meaning that it is known to occur, but of limited distribution in the State and may be a high priority pest for control or mitigation. According to the NRCS Plants Database (https://plants.sc.egov.usda.gov/), current distribution includes the southern United States. In Pima County, it is likely to primarily be an issue in semi-desert grassland, xeric riparian areas, Madrean evergreen woodland, and also potentially thornscrub. It has recently been observed on County-owned and leased lands at Sands Ranch, Davidson Canyon, and King 98 Ranch. As with other invasive grasses in thornscrub habitats, it may contribute to the threat of ecosystem conversion to grassland, and could thus threaten MSCP covered species through the demise of the native plant communities on which they depend. A study in Texas demonstrated that where yellow bluestem dominates, species richness and diversity of perennial herbaceous species are lower than areas where it does not occur (Gabbard and Fowler 2007). This may be due to direct or indirect effects of allelopathic compounds released by yellow bluestem (Greer et al. 2014). Furthermore, yellow bluestem has been found to grow in a wide variety of conditions (Gabbard and Fowler 2007).

Bromus rubens (Red brome)

Red brome is a cool season annual grass (Figure 3) from the Mediterranean region that was introduced as forage. It has been reported in many places across southern Arizona and Pima County, including Cienega Creek Natural Preserve and Tucson Mountain Park. It was highlighted

Figure 3. Red brome can invade a wide range of ecosystem types that occur in Pima County.

as a species of concern for implementing the Sonoran Desert Conservation Plan (Pima County 2002).

Red brome can invade desert, thornscrub, interior chaparral, Madrean evergreen woodland, and riparian areas, both xeric and mesic. It is known to invade overgrazed rangelands and lands that are otherwise disturbed. Germination of red brome requires relatively little rainfall. Like many other on-native invasive grasses, it increases fire risk, which can lead to the demise of fire-sensitive species while increasing dominance of red brome (US Forest Service 2017b).

Enneapogon cenchroides (Soft feather pappusgrass)

Soft feather pappusgrass is native to Africa and southern reaches of mainland Asia (Barkworth et al. 2007). It may grow as an annual or a perennial (Natural Resources Conservation Service n.d.). Information about this species in the United States is scarce, although plant inventory records indicate that soft feather pappusgrass seeds were presented to the US Department of Agriculture in 1942 (US Department of Agriculture 1951). Based on observations recorded in SEINet and iNaturalist (https://www.inaturalist.org/), the primary area of infestation lies in and around Tucson with a few observations to the south and east. Soft feather pappusgrass has also been detected in Organ Pipe National Monument where it has been described a potentially serious invader (Felger et al. 2014), and it is a concern in Saguaro National Park (NPS 2019). In Pima County, staff have observed this species in Tucson Mountain Park, as well as in

widespread floodplain areas and County-managed ranches on the east side of the Santa Catalina Mountains, such as A7 and M Diamond Ranches.

The information available about this species in Arizona suggests that soft feather pappusgrass invades primarily thornscrub and semi-desert grassland, with some potential to occur in xeric riparian situations. This suggests that it is one of multiple invasive grass species that are likely contributing to the loss of native vegetation and conversion to grassland. Therefore, multiple desert and thornscrub species that depend on native plant communities, such as Sonoran desert tortoise, are at risk of losing their habitats. While more information on the distribution of soft feather pappusgrass would be helpful for making an informed assessment of the potential for control, existing information suggests the infestation covers a smaller area of the Southwest than most other invasive grasses in this report, indicating that it may be possible for soft feather pappusgrass to be greatly limited in its spread if there are opportunities for aggressive management.

Eragrostis curvula (Weeping lovegrass)

Weeping lovegrass is a warm season bunchgrass native to Africa. It was planted in the United States for erosion control, and was seeded in Arizona as recently as 1990 (Gucker 2009). The Natural Resources Conservation Service still hosts a plant fact sheet online that describes considerations and benefits of seeding weeping lovegrass (Natural Resources Conservation Service 2002). It is an apomictic plant, meaning it can clone itself through seeds (Carballo et al. 2019). Weeping lovegrass is present in several states. On Pima County conservation lands, it is known to occur on Bar V Ranch and Oracle Ridge. It invades multiple ecosystems, including desert, thornscrub, semi-arid grassland, and xeric riparian areas. Weeping lovegrass in desert, thornscrub, and xeric riparian may contribute to an increase in fine fuel loads caused by invasive grasses, contributing to fire risk and the potential for ecosystem conversion to grass-dominated vegetation types. Loss of desert and thornscrub habitat would likely be detrimental to several covered species that rely on native vegetation structure, such as cactus ferruginous pygmy owls and Sonoran desert tortoise. While eradication of weeping lovegrass may not be possible, controlling it in areas inhabited by MSCP covered species is advisable.

Eragrostis echinochloidea (African lovegrass)

This perennial grass is native to Africa, and was grown in at least one Tucson nursery in the mid-1940s (Reeder and Reeder 1985). It is possible that African lovegrass started out as an urban invader that later spread into surrounding areas that were less developed (Reeder and Reeder 1985). Based on observations available in SEINet (http://swbiodiversity.org/seinet/) at the time this report was written, the distribution within the United States appears limited to Arizona, with the most observations reported within eastern Pima County, several in Santa Cruz and Cochise counties, five in Pinal County, and two in Maricopa County. A few other records exist for Sonora, Mexico. Very little information is readily available online regarding the ecology of African lovegrass.

Pima County staff from NRPR report that African lovegrass is spreading and that it invades multiple ecosystems types including desert, thornscrub, semi-desert grasslands, xeric riparian

areas, and mesic riparian areas. A few African lovegrass observations in SEINet are from elevations above 5,000 feet, suggesting that it may also spread into Interior chaparral and Madrean woodlands. African lovegrass may pose a threat to MSCP covered species, particularly in thornscrub and desert areas where it alters vegetation structure and provides a source of fine fuels for wildfires. More information about the ecology of this species in Arizona would be helpful for informing management.

Eragrostis lehmanniana (Lehmann lovegrass)

Lehmann lovegrass is a perennial bunchgrass that is native to South Africa. It was brought to the southwestern United States in the 1930s and planted for livestock forage and erosion control (Uchytil 1992; US Forest Service 2014b). Lehmann lovegrass was also planted widely for restoration after wildfires and highway construction projects (US Forest Service 2014b). Nowadays, it is widespread in Pima County and other parts of southeastern Arizona where it is a common invader of semi-desert grasslands, thornscrub, and xeric riparian areas.

Impacts of Lehmann lovegrass on MSCP covered species are not well-documented. It may be that negative impacts are more likely in thornscrub than in semi-desert grasslands because of a greater departure from vegetation structures typical of thornscrub and an increase in fine fuel loads that can lead to mortality of native plants such as agaves and saguaros. Regardless, the propensity of Lehmann lovegrass to form dense monocultures may increase the likelihood of fire-related mortality of Pima pineapple cactus (*Coryphantha sheeri* var. *robustipina*) and needle-spined pineapple cactus (*Echinomastus erectocentrus* var. *erectocentrus*), even where they occur in grassland settings. Additionally, a substantial body of work shows that while dense stands of this grass may benefit a small number of grassland bird and rodent species (Litt and Steidl 2016), there is a primarily negative impact on arthropod biomass, heteromyid rodent abundance, and on habitat use of some, but not all, species of grassland sparrows (Litt and Steidl 2011; Andersen et al. 2018; Titulaer et al. 2018; Andersen 2019). Although it may not be possible to eradicate Lehmann lovegrass on a large scale, management actions that ensure native grasses are still part of the invaded grassland community may help minimize negative impacts to native species.

Melinis repens (Natal grass)

Natal grass is native to South Africa that is an annual or perennial depending on conditions. Even though it is listed as a noxious weed in Arizona, there is a limited amount of information readily available on this species. It has been documented as spreading rapidly in Sonora where it has displaced native grasses and may achieve high enough biomass levels to be a fire risk (Van Devender and Reina 2005). Natal grass is a focal species of the SDCWMA, and on their website they describe this as mainly an invader of grasslands, and while also present in thornscrub, it does not grow densely enough to pose a serious fire threat and is not likely to contribute to a vegetation conversion (SDCWMA n.d.). However, because it has shown potential in the region to spread quickly and displace native grasses, in combination with other invasive grasses, it could possibly degrade habitat for MSCP covered species that depend on native grasslands. This

grass is relatively intolerant of harsh frosts, highlighting the fact that warming trends may enhance its ability to spread into areas and elevations where it currently cannot persist.

Pennisetum ciliare (Buffelgrass)

Buffelgrass was imported from Africa and planted for erosion control and forage for cattle by the United States government. A noxious weed, buffelgrass is widespread in Pima County, and occurs on County-controlled properties including Tucson Mountain Park (Figure 4). Buffelgrass is one of ten focal species of the SDCWMA.

This drought-tolerant, perennial grass is a very urgent and serious threat in desert, thornscrub, and xeric riparian ecosystems of Pima County where it crowds out native plants and spreads rapidly. By creating a carpet of fine fuels in vegetation communities where there is usually lots of space around individual plants, buffelgrass increases fire risk, intensity, size, and frequency. This can be a concern in neighborhoods as well as wildlands. Native Sonoran desert plants did not evolve to be fire-adapted, so when a buffelgrass-fueled fire occurs, it leaves in its path widespread mortality of native plants, including saguaros, other cacti, and MSCP covered plants. In addition to direct mortality from fire, because buffelgrass leads to the destruction of native vegetation communities, several species of MSCP-covered wildlife are at risk of losing their habitats and food sources.

It should be noted that, although buffelgrass is not considered a major threat in mesic riparian systems, by increasing fuel loads in adjacent uplands it can increase fire risk in the riparian zone, especially where buffelgrass-invaded uplands abut riparian areas that are infested with other invasive plant species that increase fire risk. Therefore, potential impacts exist to covered species that are riparian-obligates even if they don't use uplands as habitat.

Pima County has an official Standard Operating Procedure (Appendix A) for addressing buffelgrass on County-controlled lands. Current methods for addressing buffelgrass are limited mainly to manual removal and foliar herbicide application at times when it is photosynthetically active (e.g. "green"). Therefore, planning for herbicide treatments generally involves tracking rainfall patterns as buffelgrass greens up when recent rains trigger active growth, which in Pima County is primarily during the summer monsoon season (Wallace et al. 2016).

Pennisetum setaceum (Fountain grass)

Fountain grass is a perennial native to parts of Africa and Asia. It has been widely sold in nurseries and used as an ornamental grass for landscaping. Having escaped from gardens and yards, fountain grass is now widespread in Pima County, designated as a noxious weed in Arizona, and a priority of the SDCWMA. Fountain grass typically grows in xeric riparian areas as well as adjacent uplands. Large numbers have been observed at Pima County preserves such as Tucson Mountain Park, A7 Ranch, Rancho Seco, as well as other areas (Figure 4).

Though fountain grass is commonly observed invading canyons and xeric riparian areas, it can also be found in mesic riparian habitats and in upland desert and thornscrub. This dense bunchgrass spreads rapidly, crowding out native species, including the grasses and forbs that

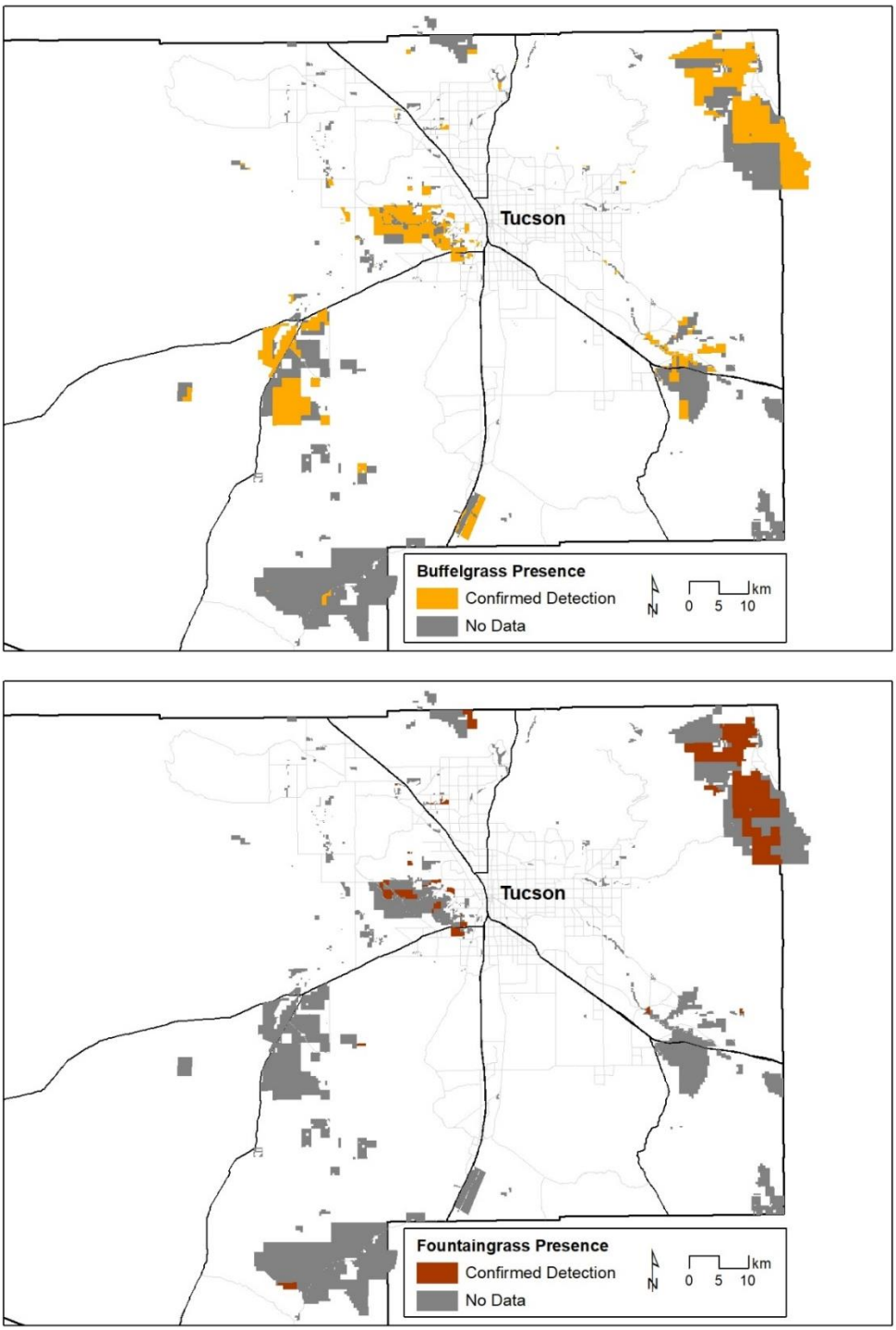


Figure 4. Maps highlighting parcels on Pima County conservation lands where observations of buffelgrass (top) and fountain grass (bottom) presence have been documented. These species likely occur in many areas colored gray, but records were not available in sourced data. The northeastern boundary of Pima County is visible as a black line. Plant data sources include EMP incidental observations, NRPR observations, and EDDMaps data (https://www.eddmaps.org/; accessed 28 February 2020). Note that highlighted parcels do not indicate abundance or severity of infestations. Instead, they are meant to generally indicate how widespread these grasses are on County conservation lands, based on data available to Pima County, and are largely a reflection of where County staff have done ground assessments.

provide forage and other resources for a variety of MSCP covered species. Similar to buffelgrass, fountain grass invasions result in ample fine fuels that increase fire-related mortality of native plants, including cacti (US Forest Service 2017a).

The presence of fountain grass in riparian zones increases the potential for fire to carry in these areas, which can rapidly change vegetation characteristics through mortality of native trees and shrubs. Subsequently, fountain grass can preemptively colonize the open spaces available post-fire. Therefore, several covered species that depend on riparian shrubs and trees could be impacted by fountain grass. Any fire in a mesic riparian zone has the potential to affect covered aquatic species through direct mortality as well as through fire effects on the physical environment, such as impacts to water quality. Fountain grass is not a desirable range species for livestock grazing because mature plants are not very palatable or nutritious (US Forest Service 2017a).

Setaria adhaerens (Bur bristlegrass)

Bur bristlegrass is an annual grass native to parts of Europe and the Middle East (CABI 2020). While present in neighboring regions of the Southwest and Sonora, it is not yet widespread in Pima County where it invades mesic and xeric riparian areas. The seeds of this plant are easily picked up and carried on fabric and animal fur, highlighting the caution that County staff should take when working in known areas of infestation to minimize the possibility of serving as a vector (i.e., thoroughly remove seeds adhering to shoes, socks, and pant legs). There is limited information readily available about this species. Pima County staff have reported that the initial phases of the infestation came on very quickly, and that it has been seen inhabiting both wet and dry locations. Bur bristlegrass is particularly widespread in portions of the lower San Pedro River Valley, but within the Tucson Basin, its current distribution appears to be restricted to certain areas, suggesting that addressing this species in the near term could greatly minimize its spread. A new infestation at the Swan Wetlands restoration project was eradicated with vigilant attention during 2015-2017. If it continues to spread, bur bristlegrass has the potential to impact MSCP covered species that utilize riparian areas such as mesquite bosques.

Sorghum halepense (Johnsongrass)

Johnsongrass is a perennial species from the Mediterranean region (Howard 2004) that was introduced to the eastern United States in the early to mid-1800s (US Department of Agriculture 2015c) and was planted in Arizona as forage for livestock despite the fact that it sometimes produces deadly prussic acid (Anderson et al 1952). It now occurs in nearly every state in the United States. In Arizona, it is listed as a Class C noxious weed, meaning that it is widespread but may be recommended for active control based on risk assessment.

In Pima County, Johnsongrass is usually found in mesic riparian areas, in ditches, and along roadsides. Along Cienega Creek, for example, there are large swathes of Johnsongrass along the riparian corridor in some stretches where it is dense and dominates ground cover. In this way, it could impact MSCP covered species in riparian by altering vegetation structure and composition. Although there is little information available about the effects of Johnsongrass on

fire regimes, like other invasive grasses, it may provide ample fine fuels to increase flammability and fire spread, and could potentially carry flames into the canopy (Webb et al. 2019).

Monitoring will also include *Panicum antidotale* (blue panic grass) which is often mistaken for Johnsongrass due to its visual similarity and occupation of the same mesic niche. Blue panic grass (*Panicum antidotale*) has displaced most of the Johnsongrass in Pantano Wash, and it is now prevalent in the Rillito and elsewhere around Tucson (J. Becker, personal communication, February 14, 2020).

Forbs

Asphodelus fistulosus (Onion weed)

Onion weed is an annual or short-lived forb native to the Mediterranean region (Winston et al. 2014). It may be that onion weed was brought from naturalized populations in Mexico and sold in Texas in the 1980s (APHIS 2008). It is sometimes planted as an ornamental (APHIS 2008). Onion weed is listed as a noxious weed in Arizona and federally in the United States (https://plants.usda.gov/java/noxious). It is reported that plants in Arizona have been found from about 2,000 to 4,500 feet in elevation (APHIS 2008), making onion weed a likely invader of thornscrub, semi-desert grasslands, xeric riparian areas in Pima County. Along Rincon Creek in Saguaro National Park, it is a common invader of mesic riparian areas, often occurring in and right next to water (D. Swann, personal communication, February 25, 2020).

Onion weed is avoided by livestock, which may reinforce its presence, and burning may help facilitate its spread (Winston et al 2014; NatureServe 2019a). Where it forms dense patches, onion weed can crowd out native species and result in changes in vegetation structure (NatureServe 2019a). There is limited information about the ecology of onion weed in Pima County, and so it is difficult to speculate on potential impacts to MSCP covered species. Evidence suggests that in lower elevation desert areas it may be moisture-limited. However, it appears to be currently a relatively uncommon plant on Pima County conservation lands, and addressing any infestations early may minimize future impacts and costs associated with control.

Brassica tournefortii (Sahara mustard)

Sahara mustard is an annual forb native to the Mediterranean region and the Middle East that was likely introduced to the United States in shipments of date palms sent to the Coachella Valley of California in the early 1900s (Barrows and Allen 2007). Since then, Sahara mustard has become a notorious invader in the Sonoran and Mojave deserts. Sahara mustard is listed as a noxious weed in Arizona and is a focal species of the SDCWMA. In Pima County, it invades desert, thornscrub, and xeric riparian ecosystems. While it is not yet widespread on County conservation lands specifically, it has been observed in and around the area of Tucson Mountain Park as well as various low-lying lands that the RFCD manages.

Sahara mustard is notorious for using up available moisture in the early spring and crowding out native plants in the Mojave desert and other regions. Monocultures can form, and when the plants dry up, they become a fire risk that threatens native plants and infrastructure (US

Department of Agriculture 2015b). Because of this, it is a serious threat to MSCP covered species, and its presence on the landscape could facilitate an ecosystem type conversion as native cacti and other food plants for wildlife are destroyed. Research shows that larger plants may produce more seeds than smaller plants. This suggests control efforts that reduce density in an area but do not remove all individuals may actually result in increased seed production when the plants that were not removed grow larger in response to reduced competition (Trader et al. 2006). Mature individuals can produced up to 9,000 seeds (US Department of Agriculture 2015b). Although this species is widespread in some areas of the Sonoran desert, its presence has been limited in Pima County until recently. It is suspected that plentiful monsoon rains help to destroy the seedbank in the Sonoran desert region. Sahara mustard has become an increasingly concerning problem in Avra Valley. Working with partners to minimize its spread on County and neighboring lands could help avert serious impacts to native biota.

Centaurea melitensis (Malta starthistle)

Malta starthistle is an annual forb native to the Mediterranean region. It is listed as a noxious weed in Arizona and is a focal species of the SDCWMA. It is believed to be in the early stages of colonization in Pima County where it invades desert, thornscrub, mesic riparian areas, and xeric riparian areas (Grissom n.d.). Malta starthistle can form dense stands and displaces native vegetation. A large infestation at the Arroyo Chico Park Avenue Basin flood control and mitigation project was eradicated with vigilant attention during 2014-2018.

Malta starthistle poses threats to livestock due to the sharp spines found on seed heads (US Department of Agriculture 2015a). These spines and the prolific production of seeds make it easy for Malta starthistle to spread via vehicles, machinery, people and wildlife, including seeds transported by birds that eat them (USDA 2015). Malta starthistle is a suspected cause of "chewing disease" in horses, a neurological disorder that has no cure (USDA 2015). Therefore, Malta starthistle has the potential to have negative impacts on native vegetation relied upon by MSCP covered species, but also may impact livestock on the County's ranches and leased lands.

Centaurea solstitialis (Yellow starthistle)

Yellow starthistle is a winter annual forb native to Eurasia that was introduced to the United States in the mid-1800s via imported seed that was contaminated (US Department of Agriculture 2014b). It is listed as a noxious weed in Arizona. Yellow starthistle is a potential invader of thornscrub, semi-desert grasslands, chaparral, Madrean woodlands, and mesic riparian areas (US Department of Agriculture 2014b; Zouhar 2002). In Pima County, it may not be as widespread as it is in other parts of Arizona and California, but County staff report recent increases in populations. This highlights the importance of monitoring this species given its impacts on native plant communities and livestock.

Yellow starthistle displaces native species and has been identified as a particularly serious concern for rangelands and grasslands where it can form dense monocultures (Randall et al. 2017). It has a deep taproot that can grow to over 1 meter long (Randall et al. 2017) making it an intense competitor for available moisture. Fire exclusion in grasslands and oak woodlands may help facilitate spread of yellow thistle, and its dominance may alter fuel structures and

therefore impact fire regime characteristics (Zouhar 2002). This raises a red flag about the ability of yellow starthistle to degrade grassland conditions and potentially impact MSCP covered species that occur there. Yellow starthistle can have a number of negative impacts on livestock, and it is toxic to horses (DiTomaso et al. 2006).

Matthiola parviflora (Small-flowered stock)

Small-flowered stock is an annual forb native to the Mediterranean. It was first discovered in the Western Hemisphere at the Desert Laboratory on Tumamoc Hill in 2008 (Horst et al. 2014). In one location where it was found, there were 576 individuals in an area of about 150 meters squared; in 2010, there were 4,018 individuals in the same location (Horst et al. 2014). Small-flowered stock was found in Saguaro National Park in 2015 (Walton 2015). In 2016, it was found on Pima County's Cienega Creek Natural Preserve. This species emerges in the spring in response to winter rains.

Research suggests that Pima County is ideal habitat for small-flowered stock, and that it will probably continue to spread (Horst et al. 2014). Because it is new to the western hemisphere, it is difficult to anticipate impacts of small-flowered stock on MSCP covered species, but a reduction in native plant diversity seems likely based on its rapid spread across the Desert Laboratory. This species has been observed spreading rapidly throughout large parts of the Tucson metro area, and there is evidence that this plant can invade thornscrub, xeric riparian, and mesic riparian ecosystems. However, given its recent introduction, its potential to spread to other ecosystems is unknown, underscoring the importance of monitoring for this species. Early, proactive management of this species before it spreads over large areas would be advisable to minimize adverse impacts and costs associated with control.

Oncosiphon piluliferum (Stinknet)

Stinknet (Figure 5) is an annual herb from South Africa that was introduced to central Arizona as a landscaping plant. Over the last 20 years, it has spread rapidly in Maricopa County, now infesting hundreds of areas and continuing to spread southwards. It was confirmed in the Tucson area in 2015. Stinknet infestations are found on County lands along the Chuck Huckelberry Loop near Prince Road (Appendix E), Three Points, plus there are more isolated occurrences around metro Tucson and Vail. It has the potential to spread extensively at lower elevations. Stinknet was newly added to the list of Arizona noxious weeds in January 2020, and is focal species of the SDCWMA.

Stinknet germinates and grows in response to cool season precipitation. It can form dense mats of ground cover in desert, thornscrub, xeric riparian areas, and disturbed areas such as roadsides and fields. Because of this, it threatens food sources for Sonoran desert tortoise, and could spread to invade habitats where Pima pineapple cactus and needle-spined pineapple cactus are found. When patches of stinknet dry out, they become flammable, and could increase fire risk in native habitats where fires are typically rare events. The smoke from burning stinknet is caustic.

Figure 5. Photos of stinknet when it is young (left) and mature (right).

Fortunately, this emerging threat is on the radar of organizations in Tucson and around Arizona. After witnessing the rapid takeover of this species in Maricopa County, the Arizona Native Plant Society initiated a Tucson-area effort to educate local jurisdictions, landscape contractors, and the community in general about stinknet. This has included numerous training sessions on the identification, ecology, and control of stinknet. Early detection and eradication is important due to the way stinknet can grow in layers, with older plants shielding younger plants from herbicide application.

Vinca major (Periwinkle)

Periwinkle is a perennial, herbaceous vine native to the Mediterranean region. With lovely purple-blue flowers, this semi-evergreen species has been popular as an ornamental groundcover for centuries, and continues to be promoted as such today (Stone 2009). In Arizona, periwinkle invades mesic riparian areas. On Pima County conservation lands, it has been found and treated in the Cienega Creek Natural Preserve. It is not likely to pose a widespread threat, but has the potentially to impact key riparian sites. Periwinkle forms dense mats that cover the ground, excluding other plants that might otherwise sprout and grow, and thus impacting vegetation structure and diversity. Where it grows along streams, it can alter hydrogeological processes (NatureServe 2019b).

Asexual reproduction is very important for this species (Stone 2009). It reproduces largely by rooting stolons, and plant fragments carried away by floods, people, or wildlife may result in plants becoming established in new areas. This capability also makes removing periwinkle very difficult, requiring many repeat visits and the complete removal of plant material. The potential impact of periwinkle on riparian vegetation is a concern for the MSCP covered species that rely on native plants for habitat. Due to the difficultly of removing this species, and its uncommon occurrence on County lands, addressing infestations early may be the most prudent course of action.

Volutaria tubuliflora (Volutaria)

Volutaria is an annual from the Mediterranean region. It appears to be a relatively new invasive plant in the United States, initially discovered in California's Mojave desert in 2011 in the Borrego Springs area. Volutaria, to our knowledge, has not yet been detected in Arizona or

Pima County. However, its rapid spread in southern California has triggered an alarm in the conservation and restoration community there, with practitioners sending information out to neighboring areas (https://anzaborrego.ucnrs.org/wp-content/uploads/2018/02/Volutaria-Threats-and-Management-UCCE-McDonald.pdf). Volutaria is also a growing problem in the Great Basin desert (C. Campbell, personal communication, February 19, 2020).

Volutaria may outcompete native plants (plants can grow quite large, up to 5 feet high), and could be toxic to some livestock. Early detection of this species, should it be discovered in Pima County, could greatly increase the chances of cost-effective control. In southern California, volutaria typically germinates in response to winter rains, but has also been observed germinating after summer rains and in response to irrigation.

Woody plants

Ailanthus altissima (Tree of heaven)

Tree of heaven is a native of China that was first introduced to the United States as an ornamental plant. In the southwestern United States, it invades mesic riparian areas and moist drainages. It is listed as a Class C noxious weed in Arizona, meaning that it is widespread but may be recommended for active control based on the risks it poses. In Pima County, tree of heaven has been documented on the Coronado National Forest on southern, northern, and eastern slopes of the Santa Catalina Mountains (iNaturalist; SEINet) and in the lower reaches of Madera Canyon in the Santa Rita Mountains. It has also been observed in the Santa Rita foothills east of Helvetia (SEINet), and in towns and urban areas. Though most of these locations range in elevation from approximately 4,500 to 5,100 feet, tree of heaven has also been observed at lower elevations in other counties, including along the lower San Pedro River in Pinal County.

Tree of heaven could pose a risk to MSCP covered species that rely on native riparian vegetation. If detected on County conservation lands, treating the infestation early may be the best course of action. Tree of heaven is fast-growing and can develop dense thickets of trees cloned from root sprouts (Fryer 2010; US Department of Agriculture 2014). A single tree can produce up to 300,000 seeds per year, although seeds are short-lived and persist for only one or two years (US Department of Agriculture 2014a). Many plant parts contain allelopathic chemicals, including seeds, which can inhibit growth of native plants (US Department of Agriculture 2014a). Following fire, tree of heaven can regenerate by resprouting or by seed (Fryer 2010).

Euryops multifidus (Sweet resinbush)

Sweet resinbush is a subshrub native to South Africa that was introduced to the southwestern United States for erosion control and range improvement by the United States Soil Conservation Service in 1935 (Pierson and McAuliffe 1995). It invades thornscrub and semi-desert grassland. It is a Class A noxious weed in Arizona, meaning it is a plant not known to exist or of limited distribution in the state and is a high priority for quarantine, control, or mitigation. One well-known and problematic infestation is located on Frye Mesa in Graham County southwest of Safford, Arizona (Pierson and McAulliffe 1995). In Pima County, sweet resinbush

has been observed in the area of Sabino Canyon on the Coronado National Forest on the outskirts of Tucson (Pierson and McAuliffe 1995), and was still being actively managed by the Sabino Stewards at least as recently as the late 2010s (C. Campbell, personal communication, February 14, 2020).

In southern Arizona, sweet resinbush is of particular concern in semi-desert grasslands where it can dominate vegetation (Gornish and Howery 2019). Sweet resinbush has been observed to replace native grasses and native woody species while also increasing exposure of bare soil, leading to higher erosion rates (Pierson and McAulliffe 1995; US Department of Agriculture 2017b). Also, it may be toxic to livestock and wildlife (US Department of Agriculture 2017b).

Searsia lancea (African sumac)

African sumac grows in the form of a shrub or tree and is native to Africa. It is commonly promoted in landscaping within the Sonoran desert because it can grow large enough to provide shade and is a low water use plant. Hardy as it is, it has escaped cultivation and can now be found in washes and canyons throughout Tucson and in the surrounding landscape. Furthermore, it produces copious amounts of allergenic pollen and vigorously sprouts and volunteers where it is not wanted in the landscape, which also highlights that the species is a nuisance. Current records of African sumac in SEINet and iMapInvasives show a similar pattern around Phoenix, with observations seeming to radiate out from the city.

African sumac can displace native woody species that MSCP covered species depend on, such as mesquite, cottonwood, and willows. Therefore, it has the potential to alter how flood waters move through the system, which could trigger additional problems. In fact, it was called out specifically in the MSCP as a species of concern. In 2005, the Arizona Wildlands Invasive Plant Working Group labeled African sumac as a medium threat, meaning that is has substantial impacts on ecosystems, biota, and vegetation structure, and well as medium to high rates of dispersal (AWIPWG 2005). More information about the ecology of African sumac in Arizona would be helpful for informing management.

Tamarix spp. (Salt cedar)

The genus *Tamarix* includes several species, including at least five that are known to occur in the southwestern United States (*T. aphylla*, *T. chinensis*, *T. gallica*, *T. parviflora*, and *T. ramosissima*). However, they are often grouped together in various combinations because there is dispute over their taxonomy, some are very difficult to distinguish from one another, and they are known to hybridize (Gaskin and Schaal 2002; US Department of Agriculture 2017a; Zouhar 2003). For the purposes of this protocol, we focus on *T. chinensis* and *T. ramosissima* and their hybrids because they are most commonly implicated as invasive threats in the region, and we henceforth refer to them as salt cedar.

Salt cedar is a large shrub, native to eastern Europe and Asia, that was introduced to the United States in the mid-1800s (Tellman 1998). It quickly escaped cultivation, and moved into riparian areas, where it spread quickly during the mid-1900s with an increase in dam construction and associated interruption of natural flood regimes (Tellman 1998; Zouhar 2003). Salt cedar now

occurs in riparian areas across much of the western United States. In Pima County, it can be found in mesic and xeric riparian areas, including along Cienega Creek, the Santa Cruz River, and in many ephemeral washes. Salt cedar is listed as noxious weed in Arizona and is a focal species of the SDCWMA.

As drought and water management have altered environmental conditions along southwestern streams, salt cedar has taken advantage of the negative effects of these drivers on native riparian plants. Salt cedar now dominates or co-dominates vegetation in many places. This has led to increased risk of more frequent and more intense fires that lead to widespread mortality of native species while concurrently favoring greater dominance of salt cedar (Webb et al. 2019). Salt cedar can provide nesting opportunities for some birds, such as the southwestern willow flycatcher, an MSCP covered species. However, the overall impact of the replacement of cottonwood-willow riparian woodlands with invasive species is a decline in biodiversity, which could impact MSCP covered species through pathways that impact ecological communities at multiple trophic levels (Webb et al. 2019).

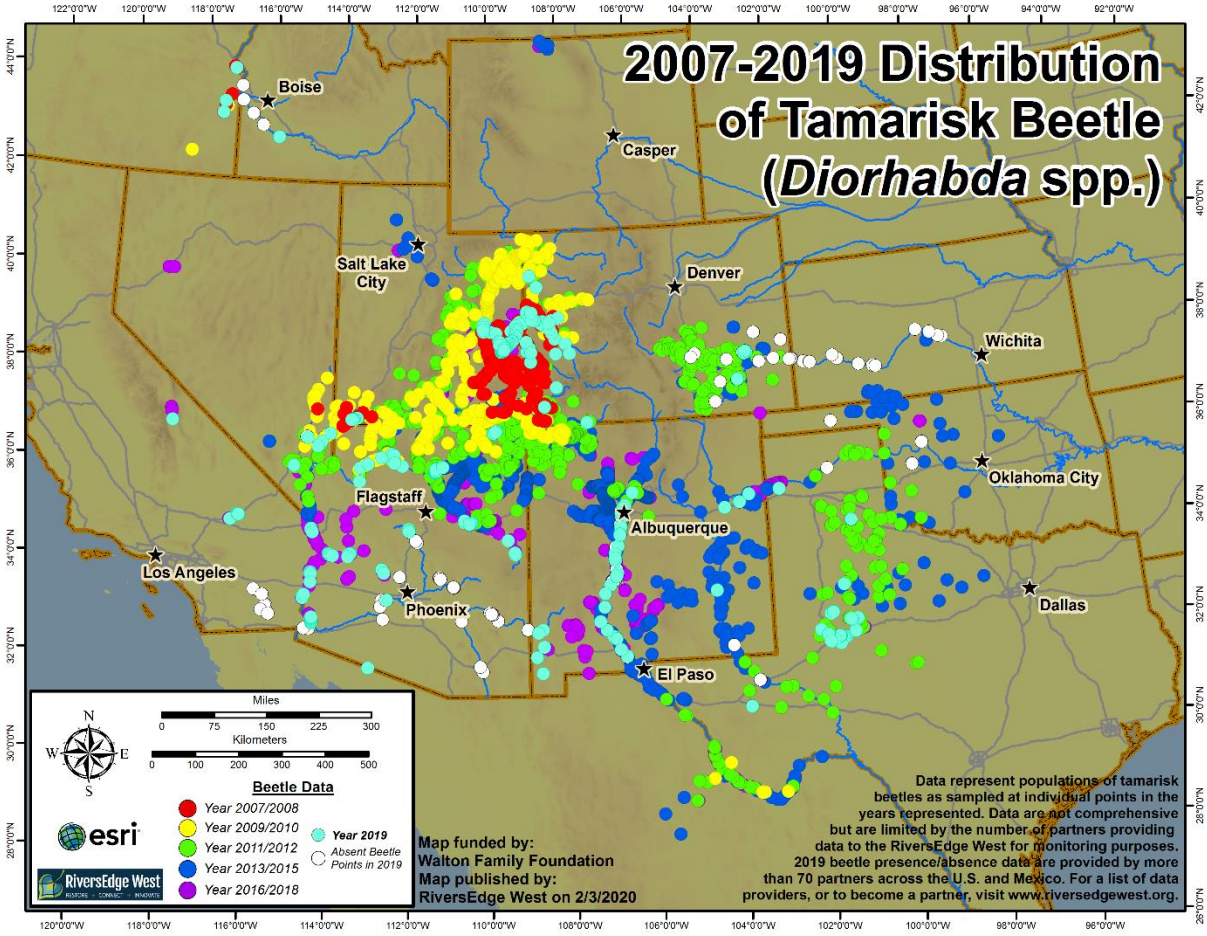


Figure 6. Tamarisk beetles have spread along streams throughout much of the southwestern United States. This map shows them present in the Gila River basin, which includes the Santa Cruz River and Cienega Creek. Map courtesy of Ben Bloodworth, RiversEdge West.

An additional emerging concern in Pima County is the continued expansion of a biological control agent, tamarisk beetles (*Diorhabda* spp), which is reported on annually (Figure 6) through a beetle monitoring program conducted by RiversEdge West (https://riversedgewest.org/events/tamarisk-beetle-maps). Tamarisk beetles are introduced insects that are native to the same regions as salt cedar. When the beetles feed on salt cedar, fire risk may be temporarily elevated while dead leaves persist on branches (Drus et al. 2012). Then, after the salt cedar is dead, there may be concerns about what plants will move into the new open space. A case is to made for preemptively removing and replacing salt cedar with native species in stages prior to the arrival of tamarisk beetles to minimize the effects of habitat loss for nesting birds when the beetle arrives (Coulson et al. 2016). Where salt cedar is affected by beetle herbivory, active management may be needed to ensure desirable species fill in the new available space instead of other invasive species. On the Upper Gila River, the Gila Watershed Partnership has been engaged in a multi-year restoration project in anticipation of the arrival of tamarisk beetles to mitigate the impacts of herbivory on southwestern willow flycatchers and other riparian species (https://arcg.is/1zuarL).

Methods

We (Pima County EMP) will monitor invasive plants by leveraging existing plot-based vegetation monitoring efforts as well as collection of incidental observations during staff time in the field spent on a variety of other monitoring protocols. We will collect data using a digital data form (Appendix C) using ArcGIS Collector that includes quantitative and qualitative fields that were developed in consultation with multiple departments within Pima County that are involved with detection and management of invasive plants.

To help guide data collection efforts by County staff, cooperators, partners, and volunteers, we have developed a subset of invasive plant species (provided in the previous section) that occur or could spread into the area and are considered high priority for monitoring and detection. This is intended to focus data collection on the species that pose the highest risk to MSCP covered species and their habitats. However, Pima County has a more extensive list of invasive plant species that are also included on the digital data form and that will also be tracked opportunistically. This list was borrowed from a compilation by the Arizona Wildlands Invasive Plant Working Group (Appendix D; https://www.swvma.org/wp-content/uploads/Invasive-Non-Native-Plants-that-Threaten-Wildlands-in-Arizona.pdf).

Field Survey Methodologies

Uplands vegetation and soil monitoring

As part of the monitoring requirements committed to under the MSCP, we will leverage existing upland vegetation and soils monitoring plots as part of the invasive plant monitoring protocol. These are long-term, geo-referenced plots (20 m by 50 m) that are monitored using a rotating panel design that ensures each plot is monitored once in each 5-year term for a total of 6 times through the 30-year span of the County's Section 10 permit (Gicklhorn 2020; Hubbard et al. 2012). Pima County has committed to establishing a minimum of 100 plots (Gicklhorn 2020).

Sampling locations are designed to capture conditions in all of the upland biomes that occur on Pima County lands (see Table 1).

Surveyors of upland vegetation plots are trained field technicians skilled in plant identification (Figure 7). Field monitoring data is collected via a digital database operating on a ruggedized field tablet or computer (Panasonic Toughbook). The EMP receives an annual download of certified field monitoring data for storage in the County's OnBase data management system. At the end of each field season, field staff provide summaries that highlight, among other things, occurrences of new plant species. These observations will be input directly into the database by EMP staff using Collector on a desktop computer. EMP staff will quality check the data, which will then be post-processed by the database manager.

Figure 7. Field staff from the National Park Service and Tucson Audubon Society monitor uplands vegetation on Pima County's Six Bar Ranch.

The data collected can be used to analyze changes in plant community structure and species diversity over time, including the presence and relative abundances of some invasive plant species. Though not an explicit goal of this particular monitoring element, these efforts are also capable of contributing to the ability to detect new invasive plant populations (in those areas where plots are established). For more details about the County's upland vegetation and soils monitoring protocol, see Gicklhorn (2020).

Incidental observations made during other operations

In addition to monitoring efforts described above, EMP staff will collect incidental observations of high priority invasive plants during field operations, including while implementing monitoring protocols for other species or threats, and conducting general property inventories and assessments. Observations will be collected via a digital database operating on a ruggedized field tablet or computer (Panasonic Toughbook). In the office, EMP staff will sync data collected on the tablet with the Incidental Observations geodatabase. Afterwards, staff will quality check the data, which will then be post-processed by the database manager.

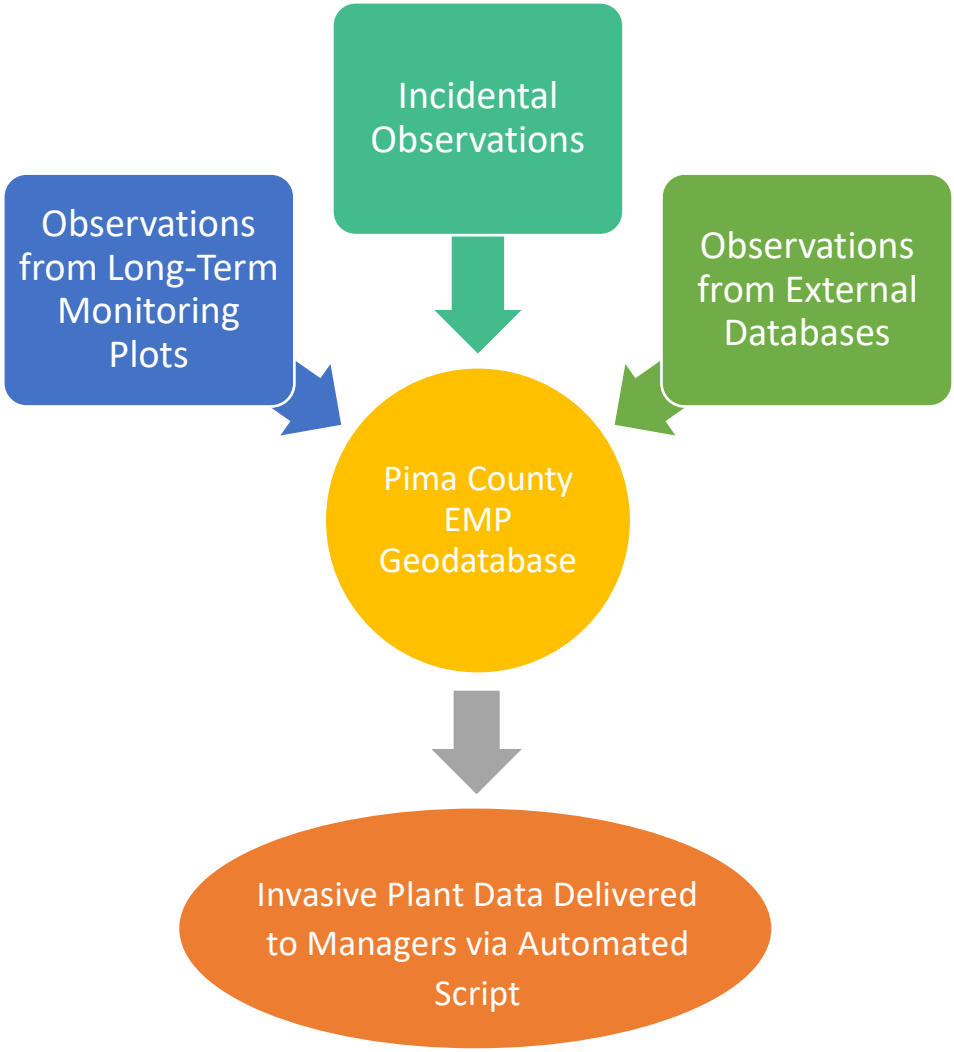


Figure 8. Conceptual diagram summarizing sources of invasive plant data, and how data will be stored and shared.

Utilization of external databases

County staff will utilize four external databases that may contain observations of interest to the County that have been recorded by other organizations or individuals:

- SEINet (http://swbiodiversity.org/seinet/index.php), which serves as a gateway to access herbariums specimens and other collections with a focus on Arizona and New Mexico;
- iMapInvasives (https://www.imapinvasives.org/), which is maintained by Arizona Game and Fish Department as part of its Heritage Data Management System;
- Early Detection and Distribution Mapping System (EDDMaps; https://www.eddmaps.org/), which was developed by The University of Georgia's Center for Invasive Species and Ecosystem Health;
- Nonindigenous Aquatic Species (NAS; https://nas.er.usgs.gov/), a repository for spatially referenced biogeographic accounts of introduced aquatic species.

On iMapInvasives, EDDMaps, and NAS, EMP staff will set up monthly alerts to receive emails about high priority species detected within a specified geography. County staff will follow up on reports to confirm species identification and presence, as needed. When confirming reports, staff will collect data on the field tablet and include it in the Incidental Observations database, following the quality check and post-processing process described above. Other data collected externally, if credible, will be input directly into the database using Collector on a desktop computer.

Data sharing for management of Pima County mitigation lands

There is a need for the data collected using the methods described above to be compiled and made available for use by other Pima County departments (Figure 8), including NRPR, RFCD, and DOT. The EMP is currently devising a process by which invasive plant data collected and stored in the Incidental Observation database can be shared with other Pima County departments to support their control efforts. While still in development, the goal is to create a system that automatically makes invasive plant data, along with other data, available to managers on a daily basis. If there is a new invasive plant observation that is a concern because of the potential for rapid spread, such as with stinknet, EMP staff will communicate with other departments about the observation by email within one week of the date observed to ensure managers are aware of the observation.

The data collected in this effort will also be of value for management planning in general, such as in the development of site-specific management plans. The data will be available for Pima County staff to view and use in their own analyses, allowing for a data-informed approach to incorporating management of invasive plants into management planning across landscapes. Furthermore, the EMP staff who have collected and compiled the data will themselves be valuable participants in management planning as stewards of this information.

Communication with external partners and keeping up to date on current threats

Informal communication and networking with local, state, and federal agency partners is also a valuable means to keep abreast of notable observations of invasive plants that could potentially impact County lands. Pima County EMP staff regularly communicate with various external partners who may have work or research activities on or near County conservation lands, including biologists with Arizona Game and Fish Department, USFWS and BLM biologists, staff from various non-profit organizations (i.e., Sonoran Institute and The Nature Conservancy), and researchers from the University of Arizona. Staff also work with the local SDCWMA and the statewide SWVMA, which are additional venues for information-sharing. Regular communications with all of these entities are another means by which EMP staff may become aware of, and follow up on if needed, observations of invasive plants on County lands. Conversely, these are also opportunities for EMP staff to share notable observations with other agencies and organizations who may have a role in addressing threats and impacts of invasive plants. These interactions will be important for determining if and when new species should be added to this protocol.

Training

Many Pima County staff in departments that manage lands currently receive training on invasive plant identification and removal. As relevant, EMP staff will participate in trainings on invasive plant identification and ecology. For example, more than 50 members of the staff at Pima County, including EMP staff, attended a stinknet awareness session orchestrated by the Arizona Native Plant Society and Pima County Native Plant Nursery in early 2020. Other relevant educational opportunities may arise with the SWVMA and SDCWMA.

Recommendations for the Prioritization of Invasive Plant Management

The best defense against invasive plants is often maintaining an intact community of native plant species and the ecological processes that provide their habitats. Preventing or quickly eradicating new infestations of invasive plants is likely to be the most cost-effective form of control in many situations, especially for long-term ecosystem management (McCrea and DiSalvo 2001). Monitoring and early detection are key to prevention and the development of a rapid response. The monitoring outlined in this protocol will help support early detection and management, but in some areas of County lands, additional scouting or monitoring may be needed both for early detection and for developing robust control strategies. Partnerships, cross-boundary coordination, and volunteers can help support these efforts.

Best management practices for developing invasive plant strategies begin with having short- and long-term objectives that are clearly defined (Flint et al. 2003; Federal Integrated Pest Management Coordinating Committee 2018; McCrea and DiSalvo 2001; US Fish and Wildlife Service 2006). Management should be implemented based on the best available science and technologies, and plans should be flexible to allow improvements based on new information (Flint et al. 2003). Control treatments and other management actions should be supported with monitoring protocols designed to track the effectiveness of management. To help foster the sharing of knowledge and coordination of efforts, we recommend that Pima County create an ad hoc, interdepartmental working group (NRPR, RFCD, and OSC) to provide a forum for discussion. Such discussions would also help determine when updates of this monitoring protocol are needed to account for newly emerging risks from invasive species and to better integrate operations across Pima County departments.

Changed circumstances that would affect species or lands covered by the MSCP and that are realistic and can be planned for must be assessed to meet USFWS requirements for all habitat conservation plans. Potential changed circumstances are listed in Table 7.1 of the MSCP (Pima County 2016), some of which are related to the introduction of invasive plants, their effects on biotic communities, and climate change (which influences invasive plants). The invasive plants database may help aid discovery of changed circumstances. For example, if new non-native plants are identified on County lands, this information could be used to help determine if a new species has become commercially available for landscaping. In this scenario, if it was confirmed that a new species of landscaping plant was being sold in the region, EMP would report the occurrence(s) to senior officials in OSC. These officials would then coordinate with the County's

Development Services Department to update lists of species that are not allowed to be used in County construction and right-of-way projects.

Another aspect of developing a robust invasive plant strategy is identifying areas that are high priorities for management and monitoring. Below is a list of key resources (Table 4) that support MSCP covered species, and where management of the invasive species highlighted in

Table 4. Associations of covered species and invasive plants in the habitats where they occur. This table is not intended to be comprehensive, but to highlight invasive plants that may pose the most immediate threats to key resources used by some MSCP covered species, and therefore might warrant a high level of consideration for active management.

Covered Species	Key Resources	Geography	Invasive Plants
Talussnails	Talus slopes and rocky outcrops	Occur at multiple elevations but of most concern in thornscrub due to buffelgrass	Buffelgrass Fountain grass
Sonoran desert tortoise	Rocky slopes and washes	Thornscrub	Buffelgrass Fountain grass Red brome Stinknet Sahara mustard
Pima pineapple cactus	Areas of known occurrences	Thornscrub and semi-desert grasslands in the Altar Valley and on County conservation lands in the Santa Cruz Valley and Bar V Ranch	Lehmann lovegrass Buffelgrass Weeping lovegrass African lovegrass
Cactus ferruginous pygmy-owl	Large saguaros and mature xeric riparian vegetation (mesquite, palo verde, ironwood)	Thornscrub and semi-desert grasslands; Altar Valley	Buffelgrass Sahara mustard Weeping lovegrass
Aquatic and riparian species (frogs, fish, birds, reptiles)	Water quantity, quality, and hydrological regimes; mesic riparian vegetation structure	Streams, springs, and cienegas	Buffelgrass Fountain grass Giant reed Johnsongrass African sumac Salt cedar Stinknet
Nectar feeding bats	Saguaros plus Palmer's and Parry's agave	Thornscrub and semi-desert grasslands	Lehmann lovegrass Buffelgrass Fountain grass Stinknet Natal grass

this protocol may be required to maintain and promote habitat availability and quality. Priority areas for treatments should also include areas important for wildlife species' movements and maintaining ecosystem function. In addition to the geographically specific areas listed below, high priority areas for treatment include those driven by partnerships where the combined efforts of multiple entities can have a significant impact and where partnerships can be leveraged to bring in more resources for control efforts. County conservation lands in the San Pedro Valley may require additional assessment beyond what is provided here. Vector control should be assessed and considered to help maintain efficacy of control operations. For vector control, treatment may be needed in areas of any biological value where movement of people, wildlife, wind, or water could serve as vectors to spread invasive plants into a highly valued area.

In addition to biological values, there are several operational and logistical considerations that should be taken into account when prioritizing sites and species for management. They include (listed in no particular order):

A. What is the management status of the land in question? Fee lands should be prioritized over leased lands, which the County does not have full management discretion over. Management ability will vary by location.

B. Are there newly emerging invasive plant species, or new infestations of known species, where concerted action could stop a damaging and costly invasion later?

C. Does the invasive plant species represent a measurable risk to a federally listed covered species or secondarily, any MSCP covered species? Includes risk to key or necessary habitat components.

D. Does the invasive plant represent a measurable risk to adjacent property or development, public health and safety, recreational and aesthetic values, or educational opportunities?

E. What are logistical considerations in terms of ease of access?

F. Is there a nexus with County ranch operations? Are invasive plants making ranch operations more difficult or expensive?

G. What is the restoration potential of the site?

H. Are there areas of high biological value that are mostly pristine where some amount of effort could help prevent encroachment of invasive plants?

I. Where can we build on existing work and collaborative partnerships to control invasive plants?
    a. Building on existing work where there has already been a significant investment in management and/or where progress has already been made (both internally

and regionally) could be a consideration, as well as the synergy of coordinated efforts by multiple organizations in the geographic area

b. Leveraging outside funding opportunities

J. Are there seeps, springs, or high value riparian areas that are at risk from invasive plants?

K. What is the cost-benefit analysis of action versus no action? Is doing nothing now likely to be more expensive or otherwise unacceptable in the long-term?

L. Where an infestation crosses jurisdictional or private property boundaries, will most or all affected parties work to control the invasive species of interest to achieve effective management?

In this protocol, we have provided input on which species are high priorities for management, what biological values may be at risk (Figure 9), and where they are located geographically. However, we recognize that developing a robust invasive plant management strategy for Pima County, which we recommend undertaking, is a larger endeavor that goes beyond what we have covered here. There are multiple organizations that have produced guidance to help aid the development of invasive plant management plans and set priorities. We list several such documents below, and include a couple of examples of invasive plant management plans from other parts of Arizona. Also, we encourage utilization of the bibliography in this protocol as a resource for managers to easily access information about appropriate control methods, and the ecology and management of individual invasive plant species.

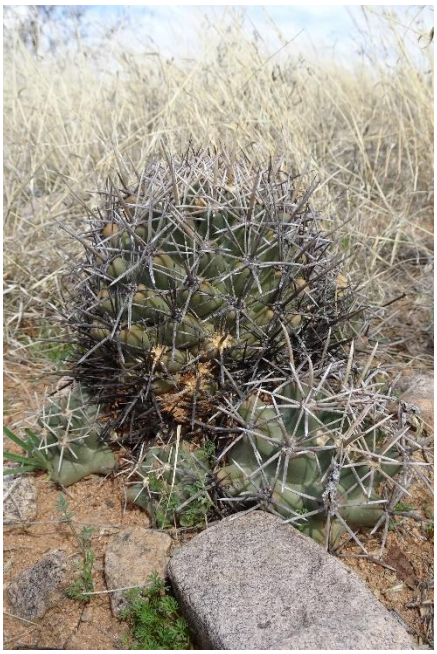


Figure 9. The range of the Pima pineapple cactus is small, occurring mainly in Pima County, as well as Santa Cruz County and in northern areas of Sonora, Mexico.

Guides for developing invasive plant management strategies:

- Invasive Plant Management Planning: Technical Considerations (Dingman et al. 2018) https://irma.nps.gov/Datastore/DownloadFile/612495
- Land Manager's Guide to Developing an Invasive Plant Management Plan (US Fish and Wildlife Service and California Invasive Plant Council 2018) https://bugwoodcloud.org/mura/mipn/assets/File/USFS/2019%20Invasive%20Plant%20Mgmt%20Planning_BMP_USFWS.pdf
- Guidance for Invasive Species Management in the Southwestern Region (USDA Forest Service 2014) https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3801891.pdf

- An Invasive Species Assessment Protocol (Morse et al. 2004) https://www.natureserve.org/sites/default/files/invasive_species_assessment_protocol.pdf
- Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands (California Exotic Pest Plant Council and Southwest Vegetation Management Association 2003) https://www.cal-ipc.org/docs/ip/inventory/pdf/Criteria.pdf
- 2018 Invasive Plant Treatment Prioritization (Grunberg et al. 2018) https://dffm.az.gov/2018-invasive-plant-treatment-prioritization

Example plans from other organizations:

- Navajo Nation Integrated Weed Management Plan (Fred Phillips Consulting n.d.) https://www.bia.gov/sites/bia.gov/files/assets/public/pdf/idc2-060709.pdf
- Verde River Cooperative Invasive Plant Management Plan (Fred Phillips Consulting 2011) https://verderiver.org/wp-content/uploads/2017/12/verde-river-cooperative-invasive-plant-management-plan.pdf

Works Cited

Anderson, D.; Hamilton, L.P.; Reynolds, H.G.; Humphrey, R.R. 1953. Reseeding desert grassland ranges in southern Arizona. Bulletin 249. Agricultural Experiment Station, University of Arizona, Tucson, Arizona.

APHIS. 2008. Eradication program for onionweed in Arizona. Environmental Assessment, March 2008. Animal and Plant Health Inspection Service, US Department of Agriculture. Phoenix, Arizona. file:///C:/Users/u148704/Downloads/feddocs_799.pdf [Accessed January 16, 2020]. Final Report. University of California, Riverside. Riverside, California.

AWIPWG. 2005. Invasive non-native plants that threat wildlands in Arizona. A categorized list developed by the Arizona Wildlands Invasive Plant Working Group. https://www.swvma.org/wp-content/uploads/Invasive-Non-Native-Plants-that-Threaten-Wildlands-in-Arizona.pdf [Accessed January 17, 2020].

Barkworth, M.E.; Anderton, L.K.; Capels, K.M.; Long, S.; Piep, M.B. (eds). 2007. Manual of Grasses for North America. University Press of Colorado. 640 pp.

Barrows, C.W.; Allen, M.F. 2007. 2005-2006 Coachella Valley MSHCP monitoring framework priorities: Impacts of exotic weed species including Saharan mustard (*Brassica tournefortii*). Available at: https://escholarship.org/uc/item/3gr6974t [Accessed January 16, 2020].

CABI. 2020. *Setaria verticillata* (bristly foxtail) [updated by Parker, C.]. In: Invasive Species Compendium. CAB International, Wallingford, United Kingdom. www.cabi.org/isc [Accessed January 16, 2020].

Carballo J.; Santos, B.A.C.M.; Zappacosta, D.; Garbus, I; Selva, J.P. et al. A high-quality genome of *Eragrostis curvula* grass provides insights into Poaceae evolution and supports new strategies to enhance forage quality. Scientific Reports 9, 10250 (2019). doi:10.1038/s41598-019-46610-0.

Celarier, R.P.; Harlan, J.R. 1955. Studies on Old World bluestems. Agricultural Experiment Station, Oklahoma A & M College, Stillwater, Oklahoma.

Coulson, R.N.; Trace, J.L.; Drus, G.; Giermakowski, T.; Tcharkerian, M.T.; Johnson, M. 2016. Fire-smart southwestern riparian landscape management and restoration of native biodiversity in view of species of concern and the impacts of tamarisk beetles. Final Report, Bureau of Reclamation project, R14AC00083. 251 p. https://www.sciencebase.gov/catalog/item/548a27d6e4b0becfd8cebc35 [Accessed January 22, 2020].

Coyne, P.I.; Bradford, J.A. 1985. Some growth characteristics of four Old World bluestems. Journal of Range Management 38(1):27-33. Technical Bulletin No. T-58.

Dimmitt, M. A. 2000. Biomes and communities of the Sonoran Desert region. Pages 3–18 in S. J. Phillips and P. W. Comus, eds., A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, Arizona.

Dingman, S.; Abella, S.R.; Frey, M.; Budde, P.; Hogan, T. 2018. Invasive plant management planning: Technical considerations. Natural Resource Report NPS/NRSS/BRD/NRR-2018/1820. National Park Service, Fort Collins, Colorado.

DiTomaso, J.M.; Kyser, G.B.; Pitcairn, M.J. 2006. Yellow starthistle management guide. Cal-IPC Publication 2006-03. California Invasive Plant Council. Berkeley, California. 78 pp. https://www.cal-ipc.org/docs/ip/management/pdf/YSTMgmtweb.pdf [Accessed January 24, 2020].

Drus, G.M.; Dudley, T.L.; Brooks, M.L.; Matchett, J.R. 2012. The effect of leaf beetle herbivory on the fire behaviour of tamarisk (Tamarix ramosissima Lebed.). International Journal of Wildland Fire. 22: 446–458. https://doi.org/10.1071/WF10089.

Falk, D.A. 2017. Restoration ecology, resilience, and the axes of change. Annals of the Missouri Botanical Garden. 102(2): 201–216.

Federal Integrated Pest Management Coordinating Committee. 2018. A national road map for integrated pest management. Revised September 21, 2018. US Department of Agriculture. https://www.ars.usda.gov/ARSUserFiles/OPMP/IPM%20Road%20Map%20FINAL.pdf [Accessed November 5, 2019].

Felger, R.S.; Rutman, S.; Malusa, J. 2014. Ajo Peak to Tinajas Altas: A flora of southwestern Arizona. Part 6. Poaceae – grass family. Phytoneuron 2014-35:1-139. http://www.phytoneuron.net/2014Phytoneuron/35PhytoN-SWArizFlora6Poaceae.pdf [Accessed January 15, 2020].

Flint, M.L., S. Daar, R. Molinar. 2003. Establishing integrated pest management policies and programs: A guide for public agencies. Publication 8093. University of California, Division of Agriculture and Natural Resources, Oakland, California. https://anrcatalog.ucanr.edu/pdf/8093.pdf [Accessed November 5, 2019].

Fred Phillips Consulting. n.d. Navajo Nation integrated weed management plan. Report prepared for: US Department of the Interior, Bureau of Indian Affairs, Navajo Region. https://www.bia.gov/sites/bia.gov/files/assets/public/pdf/idc2-060709.pdf [Accessed February 25, 2020].

Fred Phillips Consulting. 2011. Verde River cooperative invasive plant management plan. Report prepared for: Friends of the Verde River Greenway. Cottonwood, Arizona. https://verderiver.org/wp-content/uploads/2017/12/verde-river-cooperative-invasive-plant-management-plan.pdf [Accessed February 25, 2020].

Fryer, J.L. 2010. *Ailanthus altissima*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences

Laboratory. https://www.fs.fed.us/database/feis/plants/tree/ailalt/all.html [Accessed February 27, 2020].

Fryer, J.L.; Luensmann, P.S. (compilers) 2012. Fire regimes of the conterminous United States. IN: Fire Effects Information System. Fire Sciences Laboratory, Rocky Mountain Research Station, Forest Service, US Department of Agriculture. https://www.fs.fed.us/database/feis/fire_regime_table/PNVG_fire_regime_table.html#Southwest [Accessed January 27, 2020)].

Gabbard, B.L.; Fowler, N.L. 2006. Wide ecological amplitude of a diversity-reducing invasive grass. Biological Invasions 9(2007):149-160.

Gaskin, J.F.; Schaal, B.A. 2002. Hybrid *Tamarix* widespread in US invasion and undetected in native Asian range. PNAS 99(17):11256-11259.

Gicklhorn, J.M. 2020. Uplands Vegetation and Soils Monitoring Protocol. Ecological Monitoring Program, Pima County Multi-species Conservation Plan. Report to the U.S. Fish and Wildlife Service, Tucson, AZ.

Gornish, E.S.; Howery, L.D. 2019. Non-native, invasive plants of Arizona. Az1482. Cooperative Extension, University of Arizona. Tucson, Arizona. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1482-2019.pdf [Accessed January 21, 2020].

Greer, M.J.; Wilson, G.W.T.; Hickman, K.R.; Wilson, S.M. 2014. Experimental evidence that invasive grasses use allelophathic biochemical as a potential mechanism for invasion: chemical warfare in nature. Plant and Soil 385(1/2):165-179.

Grissom, P. n.d. Malta Star Thistle (*Centaurea melitensis*). Sonoran Desert Cooperative Weed Management Area [Website]. https://sdcwma.org/species/maltastarthistle.php [Accessed January 16, 2020].

Grunberg, W.; Richardson, J.; Dolan, C. 2018. 2018 Invasive plant treatment prioritization. Arizona Department of Forestry and Fire Management – Forest Health. https://dffm.az.gov/sites/default/files/media/2018_AZ_IPTP_Report_DFFM.pdf [Accessed February 25, 2020].

Gucker, C.L. 2009. *Eragrostis curvula*. In: Fire Effects Information System, [Online]. Fire Science Laboratory, Rocky Mountain Research Station, Forest Service, US Department of Agriculture. https://www.fs.fed.us/database/feis/plants/graminoid/eracur/all.html [Accessed January 15, 2020].

Horst, J.L.; Kimball, S.; Becerra, J.X.; Noge, K.; Venable, D.L. 2014. Documenting the early stages of invasion of *Matthiola parviflora* and predicting its spread in North America. The Southwestern Naturalist 59(1):47-55.

Howard, J.L. 2004. *Sorghum halepense*. In: Fire Effects Information System, [Online]. Fire Sciences Laboratory, Rocky Mountain Research Station, Forest Service, US Department of Agriculture. https://www.fs.fed.us/database/feis/plants/graminoid/sorhal/all.html [Accessed January 15, 2020].

Hubbard, J. A., C. L. McIntyre, S. E. Studd, T. Nauman, D. Angell, K. Beaupré, B. Vance, and M. K. Connor. 2012. Terrestrial vegetation and soils monitoring protocol and standard operating procedures: Sonoran Desert and Chihuahuan Desert networks, version 1.1. Natural Resource Report NPS/SODN/NRR—2012/509. National Park Service, Fort Collins, Colorado. https://irma.nps.gov/DataStore/DownloadFile/447961

McCrea, J., C.L.J. DiSalvo. 2001. Integrated pest management: What is it? What has it done for the National Park System? In: Harmon, D. (ed) Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and Public Lands. The George Wright Society, Hancock, Michigan.

Morse, L.E.; Randall, J.M.; Benton, N.; Hiebert, R.; Lu, S. 2004. An invasive species assessment protocol: Evaluating plants for their impact on biodiversity. Version 1. NatureServe, Arlington, Virginia.

Murray, I.W., & J.M. Gicklhorn. 2019. Aquatic Invasive Species Monitoring Protocol. Ecological Monitoring Program, Pima County Multi-species Conservation Plan. Report to the U.S. Fish and Wildlife Service, Tucson, AZ.

National Park Service. 2019. What's an invasive plant? Saguaro National Park. Website. https://www.nps.gov/sagu/learn/nature/what-s-an-invasive-plant.htm [Accessed January 15, 2020].

Natural Resources Conservation Service. n.d. *Enneapogon cenchroides* (Licht.) Roem. & Schult. ex C.E. Hubbard soft feather pappusgrass. Plants Database [Online]. Natural Resources Conservation Service, US Department of Agriculture. https://plants.usda.gov/core/profile?symbol=ENCE [Accessed January 15, 2020].

Natural Resources Conservation Service. 2012. Weeping lovegrass *Eragrostis curvula* (Schrad.) Nees. Plant Fact Sheet. US Department of Agricultural. https://plants.usda.gov/factsheet/pdf/fs_ercu2.pdf [Accessed January 15, 2020].

NatureServe. 2019a. *Asphodelus fistulosus* – L. In: NatureServe Explorer [Online]. http://explorer.natureserve.org/servlet/NatureServe?searchName=Asphodelus%20fistulosus [Accessed January 16, 2020].

NatureServe. 2019b. *Vinca major* – L. In: NatureServe Explorer [Online]. http://explorer.natureserve.org/servlet/NatureServe?searchName=vinca+major [Accessed January 16, 2020].

Northam, F.; Backer, D.; Hall, J. 2005. Development of a categorized list of invasive non-native plants that threaten wildlands in Arizona: Individual plant assessments by species. Final

report to the Arizona Wildland Invasive Plant Working Group, Volume 2 *Hordeum murinum* to *Vinca major*. Department of Defense Legacy Resource Management Program, project number 04-1703. https://www.denix.osd.mil/nr/otherconservationtopics/invasivespecies/manuals/development-of-a-categorized-list-of-invasive-non-native-plants-that-threaten-wildlands-in-arizona-individual-plant-assessments-by-species-vol-2-hordeum-murinum-to-vinca-major/ [Accessed December 9, 2019].

Pierson, E.A.; McAuliffe, J.R. 1995. Characteristics and consequences of invasion by sweet resin bush into the arid southwestern United States. In: DeBano, L.F.; Gottfried, G.J.; Hamre, R.H.; Edminster, C.B. (technical coordinators) Biodiversity and Management of the Madrean Archipelago: The Sky Islands of Southwestern United States and Northwestern Mexico. Proceedings. September 19-23, 1994, Tucson, Arizona. General Technical Report RM-GTR-264. Rocky Mountain Research Station, US Forest Service, Department of Agriculture. Fort Collins, Colorado.

Reeder, J.R.; Redder, C.G. 1985. Notes on Arizona grasses. Desert Plants 7(1):22-23. The University of Arizona. Tucson, AZ. https://repository.arizona.edu/handle/10150/554184 [Accessed January 13, 2020].

Pima County. 2002. An invasive species management program for Pima County. Sonoran Desert Conservation Plan. Tucson, AZ.

Pima County. 2016. Multi-species Conservation Plan for Pima County, Arizona: Final. Submitted to the Arizona Ecological Services office of the US Fish and Wildlife Service, Tucson, Arizona.

Randall, C.B.; Winston, R.L.; Jette, C.; Pitcairn, M.J., DiTomaso, J.M. 2017. Biology and biological control of yellow starthistle. Fourth Edition. FHTET-2017-08. Forest Health Technology Enterprise Team, Forest Service, US Department of Agriculture. Morgantown, West Virginia. https://www.fs.fed.us/foresthealth/technology/pdfs/FHTET-2016-08_Biocontrol_Yellow_Starthistle.pdf [Accessed January 17, 2020]

Rice, P.M.; McPherson, G.R.; Rew, L.J. 2008. Chapter 8: Fire and nonnative invasive plants in the Interior West bioregion. IN: Zouhar, K.; Smith, J.K.; Sutherland, S.; Brooks, M.L. Wildland fire in ecosystems: fire and nonnative invasive plants. General Technical Report. RMRS-GTR-42-vol 6. Rocky Mountain Research Station, Forest Service, US Department of Agriculture. Ogden, Utah.

SDCWMA n.d. Natalgrass (*Melinis repens*). Sonoran Desert Cooperative Weed Management Area. https://sdcwma.org/species/rosenatal.php [Accessed January 15, 2020].

Stone, K.R. 2009. *Vinca major, V. minor*. In: Fire Effects Information System [Online]. Fire Sciences Laboratory, Rocky Mountain Research Station, US Forest Service, Department of Agriculture. https://www.fs.fed.us/database/feis/plants/vine/vinspp/all.html [Accessed January 16, 2020].

Tellman, B. 1998. Stowaways and invited guests: How some exotic plant species reached the American Southwest. In: Tellman, B.; Finch, D.M.; Edminster, C.; Hamre, R. (eds). The Future of Arid Grasslands: Identifying Issues, Seeking Solutions. October 9-13, 1996, Tucson, Arizona. Proceedings. RMRS-P-3. Rocky Mountain Research Station, Forest Service, US Department of Agriculture. Fort Collins, Colorado.

Trader, M.R.; Brooks, M.L.; Draper, J.V. 2006. Seed production by non-native *Brassica tournefortii* (Sahara mustard) along desert roadsides. Madroño 52(4):313-320.

Uchytil, R.J. 1992. *Eragrostis lehmanniana*. In: Fire Effects Information System [Online]. Fire Sciences Laboratory, Rocky Mountain Research Station, US Forest Service, Department of Agriculture. https://www.fs.fed.us/database/feis/plants/graminoid/eraleh/all.html [Accessed January 15, 2020].

USDA Forest Service. 2014. Guidance for invasive species management in the Southwestern Region. US Department of Agriculture, Forest Service, Southwest. Region. TP-R3-16-26. Albuquerque, New Mexico.

US Department of Agriculture. 1951. Plant Inventory No. 150. US Department of Agriculture, Washington D.C. https://books.google.com/books?id=uey3Yngwve4C&pg=RA22-PA94&lpg=RA22-PA94&dq=Enneapogon+cenchroides+usda&source=bl&ots=Y9jy4eh-Zv&sig=ACfU3U2Gb8Mb_A_KD9ulqBrnbz__FvApEg&hl=en&sa=X&ved=2ahUKEwjEyrDgxIbnAhXIv54KHQuHB6wQ6AEwEXoECAkQAQ#v=onepage&q=Enneapogon%20cenchroides%20usda&f=false [Accessed January 15, 2020].

US Department of Agriculture. 2015a. Field guide for managing Malta starthistle in the Southwest. TR-R3-16-01. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410119.pdf [Accessed January 16, 2020].

US Department of Agriculture. 2015b. Field guide for managing Sahara mustard in the Southwest. TR-R3-16-32. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3828962.pdf [Accessed January 16, 2020].

US Department of Agriculture. 2017a. Field guide for managing saltcedar in the Southwest. TP-R3-16-02. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563045.pdf [Accessed January 22, 2020].

US Department of Agriculture. 2017b. Field guide for managing sweet resinbush in the Southwest. TP-R3-16-30. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico.

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563047.pdf [Accessed January 21, 2020].

US Department of Agriculture. 2014a. Field guide for managing Tree-of-heaven in the Southwest. TR-R3-16-09. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410131.pdf [Accessed February 27, 2020].

US Department of Agriculture. 2014b. Field guide for managing yellow starthistle in the Southwest. TP-R3-16-07. Southwestern Region, Forest Service, US Department of Agriculture. Albuquerque, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410133.pdf [Accessed January 17, 2020].

US Department of Agriculture. 2015c. Weed risk assessment for *Sorghum halepense* (L.) Pers. (Poaceae) – Johnsongrass. Version 1, August 12, 2015. Animal and Plant Health Inspection Service. US Department of Agriculture, Raleigh, North Carolina.

US Fish and Wildlife Service. 2006. Integrate pest management: reducing risks to pollinators from pest management activities. US Fish and Wildlife Service, Division of Environmental Quality, Arlington, Virginia. https://www.fws.gov/pollinators/pdfs/IPMpol.pdf [Accessed November 5, 2019].

US Fish and Wildlife Service and California Invasive Plant Council. 2018. Land manager's guide to developing an invasive plant management plan. Cal-IPC Publication 2018-01. National Wildlife Refuge System, Pacific Southwest Region, Inventory and Monitoring Initiative, Sacramento, CA. California Invasive Plant Council, Berkeley, CA.

US Forest Service. 2014a. Field guide for managing giant reed in the Southwest. TP-R3-16-11. US Forest Service, Southwest Region, Department of Agriculture. https://slco.org/uploadedFiles/depot/publicWorks/fWeed/stelprdb5410114.pdf [Accessed December 11, 2019].

US Forest Service. 2014b. Field guide for managing Lehmann and weeping lovegrasses in the Southwest. TP-R3-16-21. US Forest Service, Southwestern Region, Department of Agriculture. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410118.pdf [Accessed January 15, 2020].

US Forest Service. 2017a. Field guide for managing fountain grass in the Southwest. TP-R3-16-27. US Forest Service, Southwest Region, Department of Agriculture. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563027.pdf [Accessed December 10, 2019].

US Forest Service. 2017b. Field guide for managing red brome in the Southwest. TP-R3-16-19. US Forest Service, Southwest Region, Department of Agriculture.

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563040.pdf [Accessed December 17, 2019].

Van Devender, T.R.; Reina, A.L. 2005. The forgotten flora of la frontera. In: Gottfried, G.J.; Gebow, B.S.; Eskew, L.G.; Edminister, C.B. (compilers)Connecting Mountain Islands and Desert Seas: Biodiversity and Management of the Madrean Archipelago II. 5th Conference on Research and Resource Management in the Southwestern Deserts, May 11-15, 2004, Tucson, Arizona. Proceedings RMRS-P-36. Rocky Mountain Research Station, US Forest Service, Department of Agriculture. Fort Collin, Colorado. Pages 158-161.

Wallace, C.S.A.; Walker, J.J.; Skirvin, S.M.; Patrick-Birdwell, C.; Weltzin, J.F.; Raichle, H. 2016. Mapping presence and predicting phenological status of invasive buffelgrass in southern Arizona using MODIS, climate and citizen science observation data. Remote Sensing, 8(7), 524. https://doi.org/10.3390/rs8070524.

Walton, E. 2015. 99 species of annual wildflowers identified during Wildflower Bioblitz. News report. Tucson News Now. https://www.kold.com/story/28772722/99-species-of-annual-wildflowers-identified-during-wildflower-bioblitz/ [Accessed January 16, 2020].

Warner, P.J.; Bossard, C.C.; Brooks, M.L.; DiTomaso, J.M.; Hall, J.A.; Howald, A.M.; Johnson, D.W.; Randall, J.M.; Roye, C.L.; Ryan, M.M.; Stanton, A.E. 2003. Criteria for categorizing invasive non-native plants that threaten wildlands. California Exotic Pest Plant Council and Southwest Vegetation Management Association.

Winston, R.; DesCamp, W.; Andreas, J.; Randall, C.B.; Milan, J.; Schwarzländer. 2014. New invaders of the Southwest. FHTET-2014-13. Forest Health Technology Enterprise Team, US Department of Agriculture. https://www.fs.fed.us/foresthealth/technology/pdfs/FHTET-2014-13_SW_New_Invaders.pdf [Accessed January 16, 2020].

Webb, A.D.; Falk, D.A.; Finch, D.M. 2019. Fire ecology and management in lowland riparian ecosystems of the southwestern United States and northern Mexico. General Technical Report RMRS-GTR-401. Rocky Mountain Research Station, Forest Service, US Department of Agriculture. Fort Collins, Colorado.

Zouhar, K. 2002. *Centaurea solstitialis*. In: Fire Effects Information System [Online]. Fire Sciences Laboratory, Rocky Mountain Research Station, US Forest Service, Department of Agriculture. https://www.fs.fed.us/database/feis/plants/forb/censol/all.html [Accessed January 17, 2020].

Zouhar, K. 2003. *Tamarix* spp. In: Fire Effects Information System [Online]. Fire Sciences Laboratory, Rocky Mountain Research Station, US Forest Service, Department of Agriculture. https://www.fs.fed.us/database/feis/plants/tree/tamspp/all.html [Accessed January 22, 2020].

Appendix A: Pima County's Buffelgrass Control Procedure

Pima County
Public Works Departments
Standard Operating Procedures

PUBLIC WORKS
pima county

Subject: **Buffelgrass Control**	**SOP No.: 2009-02**
Approved By: _____ **John M. Bernal, Deputy County Administrator**	**Effective Date: November 10, 2009**

A. STATEMENT OF PURPOSE

The vision of the Pima County public works departments for buffelgrass is to preserve our communities and our natural resources and to be recognized as the regional leader of a comprehensive and aggressive program to coordinate, manage, control the spread of, and where possible, to eliminate, buffelgrass on Pima County rights-of-way and county owned property.

Buffelgrass (*Pennisetum ciliare)* is a fire-prone non-native perennial grass that grows in dense stands, crowds out native plants and can fuel frequent and devastating fires in both natural open space and established neighborhoods. It is predicted that without a concerted and sustained effort to control further spread and eliminate buffelgrass where possible, the Sonoran Desert will be modified, thus losing native desert environments and creating increased exposure to potentially deadly urban fires.

These standard operating procedures are agreed upon by the involved Pima County departments to optimize the opportunity for application of identified human and financial resources in the most cost-effective manner. The commonly desired approach to buffelgrass identification, eradication, and monitoring described herein is not a commitment of specific departmental resources but provides a guide for departmental actions when apply any such resources.

B. DEFINITIONS

1. **Buffelgrass**: *Pennisetum ciliare* a shrubby bunch grass 1.5 feet tall, and 1 to 3 feet wide.
2. **Treatment**:
    a. Chemical Herbicide: Glyphosate herbicides in a 2 percent solution. Aquatic areas require further regulator compliance, and may require a different product; and
    b. Manual: Pulling or digging out the whole plant.
3. **Proper disposal**: Bagged grass is to be delivered to a Municipal Solid Waste Landfill. When this is not feasible due to remote conditions the material can be mounded and held in place with rock to adequately minimize seed dispersal.
4. **Monitoring**: Surveillance and documentation of conditions and efforts at identified locations.

C. PROCEDURE

This Standard Operating Procedure (SOP) ensures the goal of the Pima County public works departments to develop and support an aggressive program to control the spread of buffelgrass.

All public works departments will develop and implement a program to address buffelgrass on rights-of-way and properties under their control. The lead department for this collective effort will be Natural Resources Parks and Recreation Department (NRPR). NRPR will be responsible for training of public works departments' key staff in the identification and control options for buffelgrass. The trained key staff within each department will be responsible for training their own respective agency staff. NRPR staff will advise and assist with training any public works department when requested. The Public Works Geographic Information Services Office will be the lead for the development of uniform Geographic Information System standards for capturing the mapped buffelgrass data. Each public works department will maintain information regarding control efforts/options and time commitments and will make such information available as part of the buffelgrass interagency working group and Pima County Invasive Species Working Group.

D. DETECTION, MAPPING AND TREATMENT

Properties under a public works department control should be surveyed for the presence of buffelgrass. Areas found to have a presence of buffelgrass should be subject to increased inspections and assessments regarding proper management options. It is easier and more effective to aggressively address the initial appearance of buffelgrass than to wait until it establishes a firm presence.

Treated sites should be resurveyed to evaluate effectiveness of control efforts or expansion of the infestation following the primary growing season. Staff should be trained to distinguish dormant (yellowish) from active (green) buffelgrass so inspections can be done year round. Maps of surviving buffelgrass and survey forms should be generated for the following season use.

The Public Works Geographic Information Services Office shall maintain a common GIS database for public works. Where possible, Pima County MapGuide ortho photos of the property should be utilized to record the location of buffelgrass. Standard survey forms should be filled out for each property or portion of a property surveyed and treated. Copies of the maps and survey forms shall be entered into the GIS buffelgrass database by each department on a monthly basis or as warranted by inspection findings.

E. TREATMENT AND CONTROL TECHNIQUES

Buffelgrass is a persistent perennial grass that has a long-lived seed bed. Current work indicates the seed bed can survive for at least 3-5 years following control efforts. There are two primary methods of control, herbicide application and/or manual pulling. The growth period for buffelgrass depends on rainfall or the availability of supplemental water. The primary regional growth period corresponds to the summer/monsoon rains and can be as little as a 2-6 week window, typically starting after mid-July. A spring time growth period may happen in February or March. Efforts to control buffelgrass should be planned well ahead and put into action as the growth period becomes evident.

1. **Chemical control:**
    - Buffelgrass must be green and actively growing for herbicides to be effective.
    - Try to spray before the buffelgrass develops seed heads or just as they are forming seed heads.
    - Herbicides will be most effective when at least 50% of the buffelgrass plant is green material.
    - The current herbicide recommended for use is a 2% solution of glyphosate. As the dry portions of the plant reach closer to 50%, then a higher concentration may be more effective but do not exceed more than a 5% solution. If the spray

treatment is in an area where revegetation isn't anticipated or desired, a pre-emergent can be added to the glyphosate mixture.

- Follow all label directions for the herbicide(s), include use of foaming agent in large spray tanks and a dye marker in mix to more effectively target spray on all buffelgrass present and away from non-target plant species.
- Take precautions to not spray non-target species of native plants. Use a pre-emergent additive only where the native seed bank will not be hampered from recolonizing the treated area.
- All spray units used by county staff should be operated under immediate supervision of a licensed sprayer and according to state law.
- Volunteers should not be allowed to use spray equipment on county lands unless specifically allowed by written agency procedures and state law.
- When spraying plants, put enough chemical on plants to coat all leaves but not enough to run off.
- Do not spray in rain, threat of rain or excessively windy conditions.
- Buffelgrass killed by herbicides can be removed or left to decompose in place.
- Chemical control sprays can be applied by hand, vehicle mounted units or other approved methods.

2. **Manual control:**
    - Mowing is not an effective control method by itself. It can be used in some cases just before the active growing season when followed by application of herbicide.
    - Mowing can sometimes stimulate buffelgrass to put out more green growth in the growing season and be more susceptible to herbicide applications, but don't mow if mowing will potentially spread seed to adjacent non-infested areas
    - The whole buffelgrass plant, including root rhizomes, must be removed for manual efforts to be effective; any portion of the root ball left behind can re-sprout.
    - Generally, buffelgrass has a defined and readily extractable root ball. Smaller buffelgrass plants in moist soil can be pulled by hand. For larger plants and in dryer soils utilize a digging bar or long-handled pick hammer to go in under the root ball at an angle and pop it out; utilizing the digging tool is more effective if two person teams work together.
    - Once grass with a root ball is removed from the ground, it should be put into large plastic bags with tie closures before removing from site for disposal in a landfill, whenever feasible. In remote areas, piling up the removed grass and rocking it in place to prevent seed dispersal is acceptable but will require additional/more frequent monitoring. Do not shake or disturb seed-heads, to minimize broadcasting of seed.
    - Buffelgrass cannot be used for mulch. Buffelgrass composting is highly discouraged, and would require intensive monitoring efforts in receiving areas.
    - If large areas of buffelgrass are detected that require manual control efforts beyond capabilities of an agency, NRPR can be contacted to assist with coordination of volunteer control projects.
    - Use of volunteers to control buffelgrass should be conducted in a way to ensure compliance of volunteers with the Public Works SOP, county risk management requirements, any applicable agency volunteer program procedures and state law.

F. MONITORING

All treated roadsides or treated patches of buffelgrass infestation should be monitored for new growth for at least 3 consecutive years. If new growth is detected, continue treatment efforts. Once no presence of buffelgrass is detected for three years, maintain a monitoring schedule of one site visit during the growing season every 3 to 5 years thereafter

Apply the same procedures initially used for surveying and mapping for routine monitoring of treated areas. Monitoring is best done during the active growth period.

Monitoring reports should be retained by each Department to track efforts and effectiveness of control strategies. A cost and time estimate by property or program should be developed at the end of every treatment period or fiscal year by responsible agency. A copy of all records will be submitted to ITD for a central database.

Appendix B: Private Landscaping Additions to the Right-of-Way

PIMA COUNTY
TRANSPORTATION

STANDARD OPERATING
POLICY AND PROCEDURE

Subject:	Number:	Page:	Effective Date:
Private Landscaping Additions to the Right-of-Way	670.03	1 of 6	09/26/19

Approval: Ana M. Olivares, P.E., Director

PURPOSE:

To establish standards and requirements for the design, installation, and maintenance of private landscaping placed within public right-of-way by any person, entity, corporation, company, subdivision, or organization.

BACKGROUND:

Landscape additions must meet standards of public safety, environmental and economic sustainability, and fit aesthetically within the context of the surrounding area. This procedure outlines requirements for landscape additions that fulfill one or more of the following goals:

- Increasing shade and vegetative cover
- Creating and improving neighborhood identity at subdivision entries and along roadsides
- Providing stabilization and erosion control
- Increasing visual interest and creating "sense of place" in roadside and median areas devoid of vegetation
- Taking advantage of excess roadway stormwater runoff by creating water harvesting areas, and
- Fulfilling mitigation requirements of Title 18.72, the Native Plant Preservation Ordinance (NPPO) and Title 16.30, Riparian Habitat Protection.

DEFINITIONS:

Landscape is defined as all vegetation (both naturally occurring native and introduced vegetation), irrigation, and hardscape elements, such as decorative paving, benches, rocks, boulders, and decorative walls. It includes native grasses and other understory native plants, in addition to the plants on the Arizona Department of Agriculture's Protected Native Plants List *(1)*.

PROCEDURE:

1. Landscape additions not required by the NPPO shall be identified on a planting plan and submitted as part of the Right-of-Way Use Permit. The plan shall adhere to Section 3 of this procedure, be drawn to scale and include the following:

    - Bar scale and north arrow
    - Location Map
    - Right-of-way line
    - Pavement, including existing curbs and paths
    - Utility locations-overhead and underground
    - Topography – existing and proposed
    - Structures in vicinity – i.e. walls, utility boxes, building, signs
    - Street names
    - Limits of disturbance used in constructing project
    - Sight visibility triangles
    - Drainage structures- i.e. curb inlets, drainage basins, culverts, etc.
    - Existing vegetation in and adjacent to the project area
    - Existing washes
    - Proposed plant types, including scientific name, container size, and quantities
    - Lighting
    - Existing Regional Flood Control District (RFCD) riparian areas (if applicable)
    - Method of irrigation (if applicable)

2. Landscape additions that are required by the NPPO shall be shown on the project's landscape plans submitted with the Tentative Plat or Development/Site Construction Plan. A separate landscape plan for the right-of-way is not required. All proposed landscaping shall adhere to Section 3 of this procedure.

    - Landscape plans shall be reviewed by Development Services Department (DSD) staff assigned to review NPPO submittals and/or by RFCD staff assigned to review riparian habitat disturbance. Landscape mitigation shall be designed to be compatible with adjacent landscape bufferyard plantings.
    - Landscape mitigation plans shall indicate watering methods that will insure long-term survival of plants. If an automatic irrigation system is used, an irrigation plan shall be submitted along with the landscape plan. Cacti generally do not require automatic

irrigation systems, while irrigation systems are typically recommended for tree plantings. See Section 3 (II) for irrigation requirements.

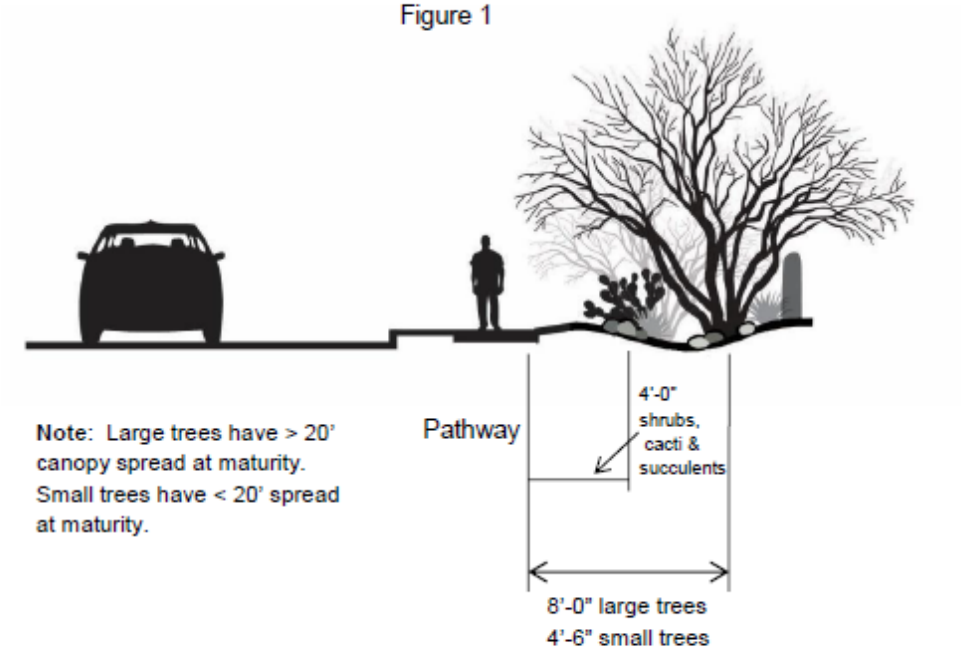
3. Landscape Guidelines

I. All proposed landscape plantings shall follow these requirements:

- Required setbacks

Plant Type	Requirement
Large Tree (Greater than 20' canopy spread at maturity)	8'-0" minimum from edge of shoulder or pedestrian path
Small Tree/Large Shrub	4'-6" minimum from edge of shoulder or pedestrian path
Small Shrubs/Cacti/Accents	4'-0" minimum from pedestrian path, face of curb, or edge of paving

Figure 1



Note: Large trees have > 20' canopy spread at maturity. Small trees have < 20' spread at maturity.

- Plant selections:

  a. Native plants observed growing in the immediate site vicinity or found historically within the project area should be used.
  b. When a wider selection of plants is desired, plants shall be selected from the Low Water Use Drought Tolerant Plant List *(2)*.
  c. Plants not meeting the recommended setback distances require more frequent pruning and maintenance.
  d. Consideration should be given to placing appropriate shrubs and small trees within clear zone limits. No individual part of the plant shall be larger than 4" in diameter at mature size. Trees and shrubs that are twiggy in character with multiple branches are appropriate. Many desert trees could be classified as large shrubs and can be used in the clear zone.
  e. Trees shall be selected that are multi-trunk or low branching and do not require staking. This form is typical of native desert trees. Planting structurally stable trees that do not require staking is preferred. If staking is used, it shall comply with American Nursery Association standards.

II. Invasive Non-Native Species: If invasive non-native species are present, the landscape plan will show the approximate locations of the invasive, state the schedule for, and type of treatment.

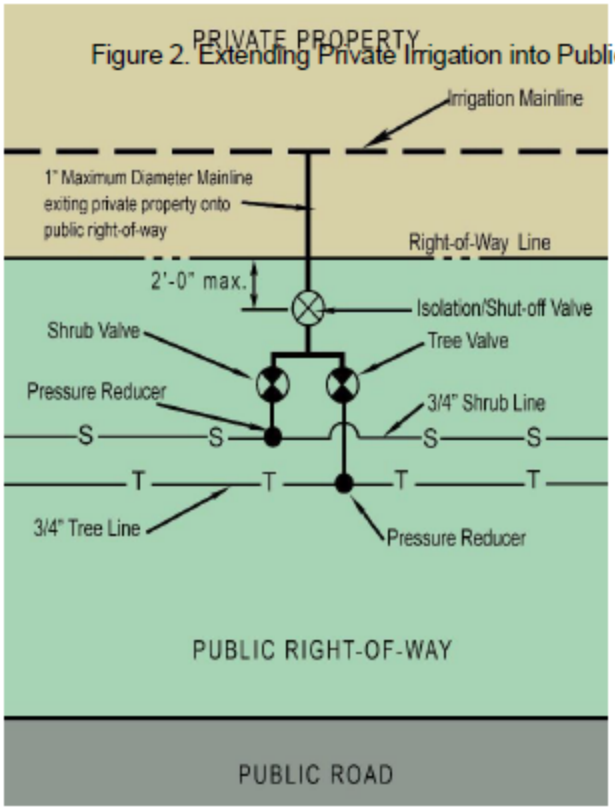
III. Irrigation: The method of watering new plantings is to be identified in the planting or landscape plan. Proposed plantings of cacti and succulents may not require supplemental irrigation depending on what time of year they are planted. Natural rainfall may be supplemented with drip irrigation system when necessary. Irrigation methods may include one or a combination of the following:

- If the landscaping in the right-of-way requires only minimal irrigation, emitter lines may be extended from the adjacent private property's irrigation system into the right-of-way and shall meet the specification for emitters under 808-2.13 of the Pima Association of Governments (PAG) Standard Specification for Public Improvements or unless approved otherwise by the County.
- If a more extensive irrigation system is required, an irrigation system either within the right-of-way with its own dedicated water meter and shut-off or outside of the right-of-way on private property in conformance with Figure 2

may be used. In either case, approval from Pima County Department of Transportation (PCDOT) is required.

- Landscape irrigation system installed within the right-of-way shall adhere to the latest requirements specified in the PAG Standard Specification for Public Improvements.
- Stormwater and rainwater harvesting may be incorporated in order to take advantage of natural stormwater runoff and rainfall. Basins shall be shown on the landscape plan. Maximum depth of basins = 1 foot with a minimum of 3 inches of freeboard. Guidance on stormwater harvesting basins can be found at Low Impact Design and Green Infrastructure Guidance Manual (3).
- Truck, hand, or other manual watering methods may be used.

Figure 2. Extending Private Irrigation into Public Right-of-way



- Irrigation plans for the development shall be provided with the submittal.
- All irrigation piping within the right-of-way shall be PVC Schedule 40.
- The portion of the irrigation system extending into the right-of-way shall be accessible to PCDOT in accordance with the diagram at left.
- An isolation valve shall be installed within the right-of-way to enable the system to be shut off by PCDOT when necessary.

IV. Maintenance:

- The person, entity, corporation, company, subdivision, or organization installing plantings in the right-of-way is responsible for the first year of landscape establishment. PCDOT shall assume landscape maintenance responsibility after one year for all landscape enhancements that have been approved under this Standard Operating Policy and Procedure. Privately installed plantings that mature to establish growth outside of the right-of-way on private property may be trimmed or removed by PCDOT.
- All landscape additions in which plants non-native to the Tucson region are selected or that are planted closer than recommended distances shall be maintained in perpetuity by the applicant.
- Maintenance activities performed within the right-of-way by the applicant are to be identified in a License Agreement with the County.

V. Disclaimer:

It shall be recognized as a condition of the license agreement that PCDOT may remove or trim plants in the County right-of-way at any time for road or shoulder widening or any purpose deemed necessary for the health, safety, and welfare of the public.

REFERENCES

1. Arizona Administrative Code, *Appendix A. Protected Native Plants by Category*, Title 3. Agriculture, Chapter 3. Department of Agriculture-Environmental Services Division, Article 1. Arizona Native Plants, pages 44 – 51, March 31, 2016.

2. Arizona Department of Water Resources, *Low Water Use Drought Tolerant Plant List*, Tucson Active Management Area, March 2007. 400 W. Congress, Suite 518, Tucson, Arizona, 85701.

3. Pima County/City of Tucson, *Low Impact Development and Green Infrastructure Guidance* Manual, March 2015.

Appendix C: Digital data form fields

Property Name

Survey Date

Time

Observer

Class (select one)

- Cultural
- Herb
- Bird
- Plant
- Invertebrate
- Mammal
- Fish
- **Invasive Plant**
- Invasive Animal
- Infrastructure
- Threat
- Other

Type (select one)

- Invasive plant species names appear in this field when Invasive Plant is selected for Class. For a list of species, see Appendix D.

Sub-type (select one)

- Isolated
- Localized
- Extensive
- Overrunning

Number

File Upload (select one)

- Yes
- No
- NA

Notes

Attachments

Appendix D: Invasive plants included in Pima County's digital data form

Excerpted from Appendix of the Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines entitled, "Appendix E: List of noxious & invasive plant species & best management practices."

Pima County Regional Flood Control District. 2011. Regulated riparian habitat mitigation standards and implementation guidelines. Supplement to Title 16 Chapter 16.30 of the Watercourse and Riparian Habitat Protection and Mitigation Requirements Ordinance No. 2010 FC5, November 2011.

Arizona Wildlands Invasive Plant Working Group: Invasive Species Plant List

The following list was developed by the Arizona Wildlands Invasive Plant Working Group and adopted by the Arizona Invasive Species Advisory Council under EO 2007-07. The list was created to address invasive, non-native plant species that pose an ecological threat to wildlands in Arizona, and is divided into three categories, indicating the severity of ecological impacts on plant communities by invasive species. Plant species listed shall be controlled within disturbed and mitigated area(s) to prevent the spread into surrounding areas.

The entire document can be viewed at:

http://www.swvma.org/InvasiveNon-NativePlantsThatThreatenWildlandsInArizona.pdf

Hard copies of this document are available at our customer service counter, located at 97 E. Congress Street, 3rd floor.

Native Plant Species with Weedy Growth Habits

In certain areas, in particular, floodplains, specific native plant species can become invasive. While native species that are invasive in nature tend to be few, they can still affect the success of a mitigation area. For example, Palmer's Amaranth, an annual that germinates during the summer months, tends to form monotypic stands, competing with other native species for water and nutrients. Native weedy species should monitored and thinned as necessary to ensure success of the mitigation area.

Arizona Wildlands Invasive Plant Working Group: Invasive Species Plant List (continued)

Scientific Name	Common Name
High	
Acroptilon repens	Russian knapweed
Arundo donax	Giant reed
Bromus rubens	Red brome
Bromus tectorum	Cheatgrass
Centaurea solstitialis	Yellow starthistle
Eichhornia crassipes	Water hyacinth
Elaeagnus angustifolia	Russian olive
Eragrostis lehmanniana	Lehmann lovegrass
Euphorbia esula	Leafy spurge
Euryops multifidus	Sweet resinbush
Lepidum latifolium	Perennial pepperweed
Myriophyllum aquaticum	Parrot's feather
Myriophyllum spicatum	Eurasian watermilfoil
Pennisetum ciliare	Buffelgrass
Pennisetum setaceum	Fountain grass
Salvina molesta	Giant salvinia
Tamarix chinensis	Fivestamen tamarisk
Tamarix parviflora	Smallflower tamarisk
Tamarix ramosissima	Saltcedar
Medium	
Alhagi maurorum	Camelthorn
Avena fatua	Wild oat
Brassica tournefortii	Sahara mustard
Bromus diandrus	Ripgut brome
Bromus inermis	Smooth brome
Cardaria chalapensis	Lenspod whitetop
Cardaria draba	Whitetop
Cardaria pubescens	Hairy whitetop
Carduus nutans	Musk thistle
Centaurea biebersteinii	Spotted knapweed
Centaurea diffusa	Diffuse knapweed
Centaurea melitensis	Malta starthistle
Chondrilla juncea	Rush skeletonweed
Cirsium arvense	Canada thistle
Conium maculatum	Poison hemlock
Convolvulus arvensis	Field bindweed

List of Noxious & Invasive Plant Species

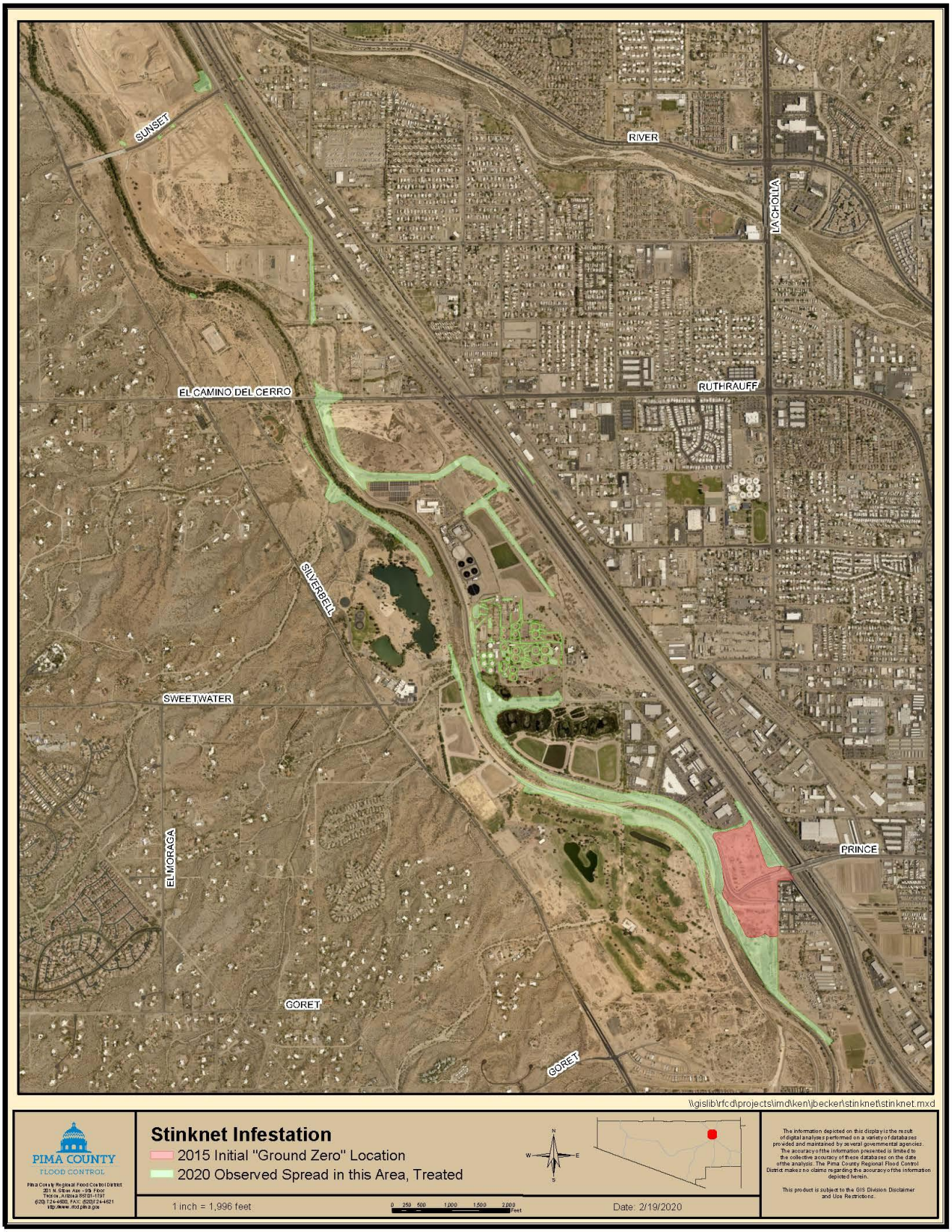
** *Oncosiphon piluliferum* (Stinknet) is a High Severity threat that has emerged since the development of this list.

Arizona Wildlands Invasive Plant Working Group: Invasive Species Plant List (continued)

Scientific Name	Common Name
Cortaderia selloana	Pampas grass
Cynodon dactylon	Bermudagrass
Erodium cicutarium	Redstem filaree
Hordeum murinum	Mouse barley
Linaria dalmatica	Dalmatian toadflax
Linaria vulgaris	Yellow toadflax
Lolium perenne	Perennial ryegrass
Melilotus alba	White sweetclover
Melilotus officinalis	Yellow sweetclover
Mesembryanthemum nodiflorum	Slenderleaf iceplant
Rhus lancea	African sumac
Rubus armeniacus	Himalayan blackberry
Rubus discolor	Himalayan blackberry
Saccharum ravennae	Ravennagrass
Salsola collina	Slender Russian thistle
Salsola paulsenii	Barbwire Russian thistle
Salsola tragus	Prickly Russian thistle
Schismus arabicus	Arabian schismus
Schismus barbatus	Common Mediterranean grass
Sonchus asper	Spiny sowthistle
Sonchus oleraceus	Annual sowthistle
Sorghum halepense	Johnsongrass
Ulmus pumila	Siberian elm
Vinca major	Bigleaf periwinkle
Low	
Aegilops cylindrica	Jointed goatgrass
Asphodelus fistulosus	Onionweed
Cirsium vulgare	Bull thistle
Cynoglossum officinale	Houndstongue
Echinochloa crus-galli	Barnyardgrass
Elymus repens	Quackgrass
Eragrostis curvula	Weeping lovegrass
Leucanthemum vulgare	Oxeye daisy
Mesembryanthemum crystallinum	Common iceplant
Onopordum acanthium	Scotch thistle
Panicum antidotale	Blue panicum
Tamarix aphylla	Athel tamarisk

Appendix E: Map of Initial Stinknet Infestation and Spread in Pima County

This map from Pima County Regional Flood Control District shows the initial infestation and spread of stinknet along the Chuck Huckleberry Loop and surrounding areas in northwestern Tucson.


SUNSET
RIVER
LA CHOLLA
EL CAMINO DEL CERRO
RUTHRAUFF
SILVERBELL
SWEETWATER
EL MORAGA
PRINCE
GORET
GORET
\\gislib\rfcd\projects\imd\ken\jbecker\stinknet\stinknet.mxd
PIMA COUNTY
FLOOD CONTROL
Pima County Regional Flood Control District
201 N. Stone Ave - 9th Floor
Tucson, Arizona 85701-1207
(520) 724-4600, FAX: (520) 724-4621
http://www.rfcd.pima.gov
Stinknet Infestation
2015 Initial "Ground Zero" Location
2020 Observed Spread in this Area, Treated
N
W
E
S
1 inch = 1,996 feet
0 250 500 1,000 1,500 2,000
Feet
Date: 2/19/2020
The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Regional Flood Control District makes no claims regarding the accuracy of the information depicted herein.
This product is subject to the GIS Division Disclaimer and Use Restrictions.