Resolution Copper Project
Noxious Weed and Invasive Species Management Plan on National Forest System Lands

Prepared for:

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May 2019

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1. Introduction

This *Noxious Weed and Invasive Species Management Plan* (Plan) was created to minimize, reduce, or eliminate the potential for introduction, establishment, spread and impact of invasive species in habitats affected by activities associated with the construction, operation, and closure of the Resolution Copper Project (the Project) on National Forest System (NFS) lands. Hereafter, this document uses the term "invasive species" to refer to exotic invasive plant and animal species. Treatment options include mechanical, chemical, or biological controls and seeding desired species. Noxious weeds, invasive species, or other undesirable species will be monitored and treated according to management objectives.

1.1. Plan Objectives

Section 6 of Resolution's *General Plan of Operations* (GPO; Resolution 2016) summarizes the plans associated with all aspects of revegetation, reclamation, and closure of the Resolution Project, including noxious and invasive plant management (Resolution 2016, Section 6.13).

The purpose of this Noxious Weed and Invasive Species Management Plan, in alignment with the U.S. Forest Service (USFS) National Strategic Framework for Invasive Species Management (USFS 2013), is to achieve the following on NFS lands impacted by the Project:

- Prevent the introduction of invasive species;
- Detect invasive species on and around Project areas on NFS lands;
- Eradicate (if possible), control, or manage priority invasive species to minimize spread and adverse effects;
- Restore and rehabilitate areas impacted by invasive species or associated management activities; and
- Communicate with agencies and organizations.

1.2. Plan Description

The remainder of this Plan includes the following sections:

- **Section 2**: Background
- **Section 3**: Prevention
- **Section 4**: Detection
- **Section 5**: Control and Management
- **Section 6**: Restoration and Rehabilitation
- **Section 7**: References

2. Background

The term “invasive” is an aggressive characteristic of a plant or animal that invades and tends to spread prolifically and undesirably. A species is considered to be invasive if it meets two criteria: 1) it is non-native to the ecosystem, and 2) its introduction causes, or is likely to cause, economic or environmental harm or harm to human health (Executive Order 13112) .Invasive species which produce undesirable effects (e.g., decreases species diversity, outcompetes native species, is poisonous to livestock, changes fire frequency or intensity) will be controlled. Infestations of invasive species would be treated as soon as they are identified, or as soon as conditions are appropriate for treatment (USFS 2013).

Invasive animal species include invertebrates and aquatic species; a list of invasive animal species is provided in **Appendix A**. These animals may consume resources more quickly than natives, spread disease, or even directly consume native species. The greater impact from invasive species is on threatened and endangered species. For example, the threatened Chiricahua leopard frog (CLF) is susceptible to American bullfrogs, northern crayfish, tiger salamanders, and other aquatic invasive species. Invasive animals may be identified, monitored, and removed (USFS 2013).

Federal agencies are directed to prevent introduction of noxious and invasive species (Federal Noxious Weed Act 1974 and 1990), and to follow an Invasive Species Management Plan (Executive Order 13112, USFS 2013). Invasive species are detrimental and destructive to native biodiversity, and difficult to control or eradicate, and the USFS has issued management guidelines for these species (USFS 1998). Those species listed by the TNF are called "invasive species" (USFS 2014a). In this report, the term "noxious weeds" is used for TNF invasive species. The Federal noxious weeds list is provided as **Appendix B**, and the TNF weed seed list and invasive species list is provided as **Appendix C**. The presence of any noxious weeds or invasive species would trigger treatment (USFS 2013).

3. Prevention

The most effective and environmentally sound way to manage invasive species is to prevent their introduction and establishment. Invasive species may be introduced through a variety of methods. Invasive species may be introduced to a site inadvertently through reclamation materials or by soil and/or other materials attached to vehicles/equipment, etc. Invasive insects, like tiger mosquitoes, may be brought to the site via winds or may disperse on their own. Drainages also provide a path for invasive species. Seeds may be washed downstream during storm events and be deposited on disturbed ground.

As appropriate, Resolution will implement the following standard practices for the prevention of invasive species introduction on Project areas located on National Forest System lands :

- Certified weed-free seed and hay will be used for reclamation and compliance activities, including wattles and organic materials used for erosion control.

- Invasive ornamental plants will not be used for landscaping or reclamation.
- All heavy equipment will be cleaned prior to entering National Forest System lands and being used on the Project.

Applicant committed environmental protection measures which specifically include components of invasive species control on NFS lands:

- Reseeding activity will use exclusively certified seed and other materials of seed certified to be free of weeds listed on the TNF Weed Seed List (**Appendix C**);
- TNF approval will be obtained prior to initiating any noxious weed control program on federal land;
- Noxious weed control will be limited to chemicals and procedures approved by TNF on National Forest System lands; and
- Monitoring reports summarizing reseeding success will be periodically submitted to the USFS (Resolution 2016, Section 4.9).

4. Detection

An assessment will be conducted to locate invasive species occurring on NFS lands prior to ground-disturbing activities. The assessment will provide baseline information on existing invasive species. The goal of monitoring is to detect and eliminate invasive species within project areas on NFS lands prior to ground-disturbing activities.

To the extent practicable, concurrent reclamation of construction footprints will occur as soon as possible to prevent the introduction of non-native species.

Newly reclaimed areas will be monitored for weeds and invasive plants for the first five years after reclamation. Infestations of invasive species would be treated as soon as they are identified, or as soon as weather conditions are appropriate for treatment.

There have been many invasive species identified across the United States. However, it is difficult to survey for a myriad of species, and it is unlikely that all species will have the potential to occur within Resolution disturbance footprint on NFS lands. A list of potential invasive species that have the potential to occur on Resolution disturbance footprint on NFS lands was compiled from the *Environmental Assessment for Integrated Treatment of Noxious or Invasive Plants* (USFS 2012), and *Forest Service Manual (FSM) Tonto National Forest 2000 National Forest Resource Management Chapter 2080 Noxious Weed Management* (USFS 2009) . If other invasive species are determined by the USFS to be problematic in the future, they will be added to the list of species of concern. **Table 1** provides a list of invasive species detected on Tonto National Forest within the Resolution Baseline Activities area.

Table 1. Invasive Species Observed within Resolution Baseline Activities Area on Tonto National Forest

Noxious Weed Species	Access Route Sites (n = 157)	Baseline Activities Sites (n= 141)	Percent of Total Sample Sites (n=298) (where species were observed)
Brome (*Bromus* sp.)	155	138	96.3
Asian mustard (*Brassica tournefortii)*	34	25	19.8
Non-native annual grass (*Schismus* sp.)	34	16	16.8
Thistle (*Cirsium* sp.)	15	11	8.7
Lehmann's lovegrass (*Eragrostis lehmanniana)*	5	0	1.7
Buffelgrass (*Pennisetum ciliare)*	3	2	1.7
Fountain grass (*Pennisetum setaceum)*	0	1	0.3
Saltcedar (*Tamarix* sp.)	1	0	0.3

(WestLand 2014)

5. Control and Management

Once an invasive species is identified, a plan of action will be created and best management practices will be implemented for its control. Risk factors for invasions depend on the species' biology, introduction pathways, and effects on the ecosystem. These factors will be used to develop effective control tools.

If multiple, non-native species occur within the planned footprint of activities on NFS lands, each non-native species will be prioritized based on the risk it poses to the native species and the vulnerability of the affected ecosystem. Treatment priorities would be coordinated with the TNF. Follow-up monitoring will determine the effectiveness of the treatment and whether additional follow-up treatment would be required (USFS 2013).

There are many methods available to manage invasive species, including mechanical/physical and chemical methods. For example, it may be necessary to mechanically cut down an invasive tree, and then apply an herbicide to the remaining stump to completely eradicate it. **Table 2** provides a list of herbicides and adjuvants acceptable for use on the Tonto National Forest. Approval from the USFS would be obtained prior to initiating any weed control program on federal land.

Table 2. Typical and Maximum Application Rates for Herbicides and Carriers (in pounds active ingredient per acre)

Herbicide/ Carrier	Rangeland	Forestland	Facilities	Right-of- Way	Recreation/ Administration	Riparian
Aminopyralid	0.078 to 0.11	0.078 to 0.11	0.078 to 0.11	0.078 to 0.11	0.078 to 0.11	0
Chlorsulfuron[1]	0.75 to 3	0.75 to 3	0.75 to 3	0.75 to 3	0.75 to 3	0.75 to 3
Clopyralid	0.25 to 0.5	0.25 to 0.5	0.25 to 0.5	0.25 to 0.5	0.25 to 0.5	0.25 to 0.5
Dicamba	2 to 4	2 to 4	2 to 8	2 to 4	2 to 4	2 to 4
Glyphosate	1 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Imazapyr	1 to 1.5	1 to 1.5	1 to 1.5	1 to 1.5	1 to 1.5	1 to 1.5
Metsulfuron methyl	0.5 to .75	0.5 to 1.8	0.5 to 1.8	0.5 to 1.8	0.5 to 1.8	0.5 to 1.8
Picloram	1 to 2	1 to 2	2 to 3	2 to 3	1 to 2	1 to 2
Sethoxydim	4.3 to 7.2	4.3 to 7.2	4.3 to 7.2	4.3 to 7.2	4.3 to 7.2	4.3 to 7.2
Sulfometuron methyl	2 to 9	2 to 6	2 to 9	2 to 9	2 to 9	2 to 9
Triclopyr	1.5 to 2	3 to 6	4 to 9	4 to 9	1.5 to 2	4 to 8
Imazapic	.03 to .06	.03 to .06	.03 to .06	.03 to .06	.03 to .06	0
CARRIERS						
Mineral Oil	2 to 4	4 to 8	2 to 8	2 to 14	2 to 4	2 to 4
Vegetable Oil	2 quarts	2 quarts	2 quarts	2 quarts	2 quarts	2 quarts
Methylated Seed Oil	1 to 2 pints	1 to 2 pints	1 to 2 pints	1 to 2 pints	1 to 2 pints	1 to 2 pints

(USFS 2012)

[1] This application rate is provided in ounces of active ingredient per acre.

Biological characteristics and mechanisms used by the invasive species may also be identified to help determine effective treatment options. For example, when and how an invasive species reproduces will be considered for treatments. Plants may be manually removed or treated with herbicide prior to the development of flowers/seed to prevent the need for bagging seed.

Monitoring will be conducted on treated areas as needed to determine if follow-up treatments are required. Personnel handling herbicides follow the proper use of pesticides per USFS Region 3 guidelines (USFS 2014b).

Individual plants/weeds will be pulled by hand, clipped, or treated with herbicides. Seeding native, resistant species will direct recovery. Mechanical treatments can treat significant infestations over large areas but are limited by slope inclination and soil characteristics. If aquatic invasive species are found, they will be removed (USFS 2013).

During or immediately following treatment, data will be collected regarding the general area of the treatment application and the invasive species targeted.

6. Restoration and Rehabilitation

Following treatment, the area will be re-evaluated to determine if treatment was successful. The timing of the follow-up visit will be on an as-needed basis. For example, if only a few individual invasive plants/weeds were identified and pulled, monitoring may not be necessary until the next growing season or scheduled monitoring event. Follow-up inspections will record the date, location, and findings, i.e., the present or absence of invasive species.

7. References

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WestLand Resources, Inc. 2014. Noxious Weed Survey of the Baseline Activities Area. *Prepared for Resolution Copper Mining*. Tucson, Arizona: WestLand Resources, Inc. May 2014. 59 pp.

APPENDIX A

Invasive Animals List

APPPENDIX A - INVASIVE ANIMALS LIST (USDA 2019)

https://www.invasivespeciesinfo.gov/terrestrial-invasives

Terrestrial Invertebrates		**Terrestrial Vertebrates**	**Aquatic Fish and Vertebrates**	**Aquatic Invertebrates**
Africanized honeybee	Hemlock woolly adelgid	Brown tree snake	Alewife	Asian clam
Asian citrus psyllid	Khapra beetle	Burmese python	Asian swamp eel	Asian shore crab
Asian gypsy moth	Kudzu bug	European starling	Bighead carp	Channeled apple snail
Asian long-horned beetle	Light brown apple moth	Wild boar	Black carp	Chinese mitten crab
Asian longhorned tick	Mediterranean fruit fly		Bullfrog	Clubbed tunicate
Asian tiger mosquito	Mexican fruit fly		Cane toad	Colonial sea squirt
Brown marmorated stink bug	Nun moth		Eurasian ruffe	European green crab
Cactus moth	Old world bollworm		Flathead catfish	Golden mussel
Chilli thrips	Oriental fruit fly		Grass carp	Killer shrimp
Citrus longhorned beetle	Pink bollworm		Lionfish	New Zealand mud snail
Coconut rhinoceros beetle	Pink hibiscus mealybug		Nile perch	Quagga mussel
Common pine shoot beetle	Red imported fire ant		Northern snakehead	Rusty crayfish Northern crayfish (from AGFD top 10)
Emerald ash borer	Russian wheat aphid		Nutria	Spiny water flea
European cherry fruit fly	Screwworm		Round goby	Veined rapa whelk
European grapevine moth	Siberian moth		Sea lamprey	White spotted jellyfish
European gypsy moth	Silverleaf whitefly		Silver carp	Zebra mussel
European spruce bark beetle	Sirex woodwasp			
False codling moth	Soybean cyst nematode			
Formosan subterranean termite	Spotted lanternfly			
Giant African snail	Tropical bont tick			
Glassy-winged sharpshooter				

APPENDIX B

Federal Noxious Weed List

APPENDIX B - FEDERAL NOXIOUS WEED LIST (USDA 2006)
(as of December 10, 2010)

Last updated March 21, 2017 (synonymy added and one spelling correction)
http://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/weedlist.pdf

Aquatic

Latin Name	Author(s)	Common Name(s)
Azolla pinnata	R. Brown	Mosquito fern, water velvet
Caulerpa taxifolia (Mediterranean strain)	(Vahl) C. Agardh	Killer algae
Eichhornia azurea	(Swartz) Kunth	Anchored water hyacinth, rooted water hyacinth
Hydrilla verticillata	(L.) Royle	Hydrilla
Hygrophila polysperma	T. Anderson	Miramar weed
Ipomoea aquatica	Forsskal	Water-spinach, swamp morning glory
Lagarosiphon major	(Ridley) Moss	African elodea
Limnophila sessiliflora	(Vahl) Blume	Ambulia
Melaleuca quinquenervia	(Cavanilles) S.T. Blake	Broadleaf paper bark tree
Monochoria hastata	(Linnaeus) Solms-Laubach	Arrowleaf false pickerelweed
Monochoria vaginalis	(N.L. Burm.) K. Presl	Heartshape false pickerelweed
Ottelia alismoides	(L.) Pers.	Duck lettuce
Sagittaria sagittifolia	Linnaeus	Arrowhead
Salvinia auriculata	Aublet	Giant salvinia
Salvinia biloba	Raddi	Giant salvinia
Salvinia herzogii	de la Sota	Giant salvinia
Salvinia molesta	D.S. Mitchell	Giant salvinia
Solanum tampicense	Dunal	Wetland nightshade
Sparganium erectum	Linnaeus	Exotic bur-reed

Parasitic

Latin Name	Author(s)	Common Name(s)
Aeginetia spp.	Linnaeus	Varies by species
Alectra spp.	Thunb.	Varies by species
Cuscuta spp.(except for natives)	Linnaeus	Dodders
Orobanche spp. (except for natives)	Linnaeus	Broomrapes
Striga spp.	Lour.	Witchweeds

Terrestrial

Latin Name	Author(s)	Common Name(s)
Acacia nilotica *= Vachellia nilotica*	(L.) Willd. ex Delile (L.) P.J.H. Hurter & Mabb.	Prickly acacia (updated 3/21/2017)
Ageratina adenophora	(Sprengel) King & Robinson	Crofton weed
Ageratina riparia	(Regel) King & H. Rob.	Mistflower, spreading snakeroot
Alternanthera sessilis	(L.) R. Brown ex de Candolle	Sessile joyweed
Arctotheca calendula	(L.) Levyns	Capeweed
Asphodelus fistulosus	Linnaeus	Onionweed (corrected 3/21/2107)
Avena sterilis	Durieu	Animated oat, wild oat
Carthamus oxyacantha	M. Bieberstein	Wild safflower
Chrysopogon aciculatus	(Retzius) Trinius	Pilipiliula
Commelina benghalensis	Linnaeus	Benghal dayflower
Crupina vulgaris	Cassini	Common crupina
Digitaria scalarum	(Schweinfurth) Chiovenda	African couchgrass, fingergrass
Digitaria velutina	(Forsskal) Palisot de Beauvois	Velvet fingergrass, annual couchgrass
Drymaria arenariodes	Humboldt & Bonpland ex J.A. Schultes	Lightning weed
Emex australis *= Rumex hypogaeus*	Steinheil T. M. Schust. & Reveal	Three-corned jack (updated 3/21/2017)
Emex spinosa *= Rumex spinosus*	Campdera L.	Devil's thorn (updated 3/21/2017)
Euphorbia terracina	Linnaeus	False caper, Geraldton carnation weed
Galega officinalis	Linnaeus	Goatsrue
Heracleum mantegazzianum	Sommier & Levier	Giant hogweed
Imperata brasiliensis	Trinius	Brazilian satintail
Imperata cylindrica	(L.) Raeuschel	Cogongrass
Inula britannica	Linnaeus	British yellowhead
Ischaemum rugosum	Salisbury	Murainograss
Leptochloa chinensis	(Linnaeus) Nees	Asian sprangletop
Lycium ferocissimum	Miers	African boxthorn
Lygodium flexuosum	(L.) Sw.	Maidenhair creeper
Lygodium microphyllum	(Cav.) R. Br.	Old world climbing fern
Melastoma malabathricum	Linnaeus	Malabar melastome
Mikania cordata	(Burman f.) B. L. Robinson	Mile-a-minute
Mikania micrantha	Kunth	Bittervine
Mimosa invisa Now: *M. diplotricha*	Martius C. Wright	Giant sensitive plant (Updated July 2016)
Mimosa pigra	Linnaeus	Catclaw mimosa
Moraea collina	Thunberg	Cape tulip
Moraea flaccida	(Sweet) Steudel	One leaf cape tulip
Moraea miniata	Andrews	Two leaf cape tulip
Moraea ochroleuca	(Salisbury) Drapiez	Apricot tulip
Moraea pallida	(Baker) Goldblatt	Yellow tulip

Nassella trichotoma	Nees) Hackel ex Arechavaleta	Serrated tussock
Onopordum acaulon	Linnaeus	Stemless thistle
Onopordum illyricum	Linnaeus	Illyricum thistle
Opuntia aurantiaca	Lindley	Jointed prickly pear
Oryza longistaminata	A. Chevalier & Roehrich	Red rice
Oryza punctata	Kotschy ex Steudel	Red rice
Oryza rufipogon	Griffith	Red rice
Paspalum scrobiculatum	Linnaeus	Kodo-millet
Pennisetum clandestinum *= Cenchrus clandestinus*	Hochstetter ex Chiovenda Hochst. ex Chiov.	Kikuyugrass (updated 3/21/2017)
Pennisetum macrourum *= Cenchrus caudatus*	Trinius (Schrad.) Kuntze	African feathergrass (updated 3/21/2017)
Pennisetum pedicellatum *= Cenchrus pedicellatus*	Trinius (Trin.) Morrone	Kyasumagrass (updated 3/21/2017)
Pennisetum polystachion *= Cenchrus polystachios subsp. polystachios*	(Linnaeus) Schultes (L.) Morrone	Missiongrass, thin napiergrass (updated 3/21/2017)
Prosopis alpataco	R. A. Philippi	Mesquite
Prosopis argentina	Burkart	Mesquite
Prosopis articulata	S. Watson	Velvet mesquite
Prosopis burkartii	Munoz	Mesquite
Prosopis caldenia	Burkart	Calden
Prosopis calingastana	Burkart	Cusqui
Prosopis campestris	Griseback	Mesquite
Prosopis castellanosii	Burkart	Mesquite
Prosopis denudans	Bentham	Mesquite
Prosopis elata	Burkart	Mesquite
Prosopis farcta	(Banks & Solander) J.F. Macbride	Syrian mesquite
Prosopis ferox	Grisebach	Mesquite
Prosopis fiebrigii	Harms	Mesquite
Prosopis hassleri	Harms	Mesquite
Prosopis humilis	Gillies ex Hooker & Arnott	Algaroba
Prosopis kuntzei	Harms	Mesquite
Prosopis pallida	(Humboldt & Bonpland ex Willdenow) Kunth	Kiawe, algarroba
Prosopis palmeri	S. Watson	Mesquite
Prosopis reptans	Bentham	Tornillo
Prosopis rojasiana	Burkart	Mesquite
Prosopis ruizlealii	Burkart	Mesquite
Prosopis ruscifolia	Grisebach	Mesquite
Prosopis sericantha	Gillies ex Hooker & Arnott	Mesquite
Prosopis strombulifera	(Lamarck) Bentham	Argentine screwbean
Prosopis torquata	(Cavanilles ex Lagasca y Segura) de Candolle	Mesquite
Rottboellia cochinchinensis	(Lour.) W. Clayton	Itchgrass

Rubus fruticosis	Linnaeus	Wild blackberry
Rubus moluccanus	Linnaeus	Wild raspberry
Saccharum spontaneum	Linnaeus	Wild sugarcane
Sagittaria sagittifolia	Linnaeus	Arrowhead
Salsola vermiculata	Linnaeus	Wormleaf salsola
Senecio inaequidens	DC	South African ragwort
Senecio madagascariensis	Poir.	Fireweed
Setaria pumila ssp. pallidefusca (Now: subsp. subtesselata)	(Schumach.) B. K. Simon (Büse) B.K. Simon	Cattail grass (Updated 9/30/2014)
Solanum torvum	Swartz	Turkeyberry
Solanum viarum	Dunal	Tropical soda apple
Spermacoce alata	Aublet	Winged false buttonweed
Tridax procumbens	Linnaeus	Coat buttons
Urochloa panicoides	Beauvois	Liverseed grass

APPENDIX C

Tonto National Forest Weed Seed List
and Invasive Species List with Descriptions

Tonto National Forest Weed Seed List

Updated June 2013

This list is to be provided to seed testing laboratories, for noxious weed testing in addition to species listed in the Fifty-State Weed Seed List*:

Bromus catharticus	Rescuegrass
Bromus diandrus	Ripgut brome
Bromus japonicus	Japanese brome
Bromus rubens	Red brome
Ceratocephala testiculata	Curveseed butterwort
Eragrostis curvula	Weeping lovegrass
Eragrostis lehmanniana	Lehmann's lovegrass
Melilotus officinalis	Yellow sweetclover
Oncosiphon piluliferum	Globe chamomile
Pennisetum ciliare	Buffelgrass

This list may be modified if these species are added to the Arizona State Noxious Weed Seed List, or if new invasive species are suspected as contaminants.

*The Fifty-State Weed Seed List may be found at the website:
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRD3317318

List of Invasive Species for the Tonto National Forest

Latin name	Common name	AZ Dept. of Agriculture Weed List*	APHIS Weed List	On neighboring states' weed lists?	Tonto category**	AZ-WIPWG class ***
Acroptilon repens	Russian knapweed	P, Res.		CA, CO, NM, NV,UT	A	H
Aegilops cylindrica	Jointed goatgrass	P, Res.		CA, CO, NM	B	L
Ailanthus altissima	Tree of heaven				C	
Alhagi maurorum	Camelthorn	P, Res.		CA, CO, NM, NV,	A	M
Arundo donax	Giant reed				B	H
Asphodelus fistulosus	Onionweed		x	NM	A	L
Avena fatua	Wild oats			CO	C	M
Brassica nigra	Black mustard				B	
Brassica tournefortii	Asian mustard				C	M
Bromus catharticus	Rescuegrass				C	
Bromus diandrus	Ripgut brome				C	M
Bromus japonicus	Japanese brome				C	
Bromus rubens	Red brome				C	H
Bromus tectorum	Downy brome			CO	C	H
Cardaria draba	Globe-podded hoary cress	P, Res.		CA, CO, NM, NV UT	A	M
Cardaria pubescens	Hairy white-top	P		CA	A	M
Carduus acanthoides	Plumeless thistle	P		CA, CO	A	
Carduus nutans	Musk thistle			CA, CO, NM, NV, UT	A	M
Cenchrus echinatus	Southern sandbur	P, Reg.		CA	A	
Cenchrus spinifex	Field sandbur	P, Reg.		CA	A	
Centaurea biebersteinii	Spotted knapweed	P, Res.		CA, CO, NM, NV, UT	A	M
Centaurea diffusa	Diffuse knapweed	P, Res.		CA, CO, NM, NV, UT	B	M
Centaurea melitensis	Malta starthistle			NM, NV	C	M
Centaurea solstitialis	Yellow starthistle	P, Res.		CA, CO, NM, NV, UT	C	H
Chondrilla juncea	Rush skeletonweed	P		CA, CO, NV	A	M
Chorispora tenella	Blue mustard			CA, CO	A	

Latin name	Common name	AZ Dept. of Agriculture Weed List*	APHIS Weed List	On neighboring states' weed lists?	Tonto category**	AZ-WIPWG class ***
Cirsium arvense	Canada thistle	P		CA, CO, NM, NV, UT	A	M
Cirsium vulgare	Bull thistle			CO, NM	C	
Convolvulus arvensis	Field bindweed	P, Reg.		CA, CO, NM, UT	C	M
Dimorphotheca cuneata	White bietou				A	
Dipsacus fullonum	Common teasel			CO, NM	B	
Eleagnus angustifolia	Russian olive			CO, NM	A	H
Elymus repens	Quackgrass	P, Res.		CA, CO, UT	B	L
Eragrostis curvula	Weeping lovegrass				C	L, □
Eragrostis Lehmanniana	Lehmann's lovegrass				C	H
Euphorbia esula	Leafy spurge	P		CA, CO, NM, NV, UT	A	H
Euryops subcarnosus	Sweet resinbush				A	H □
Isatis tinctoria	Dyer's woad	P		CA, CO, NM, NV, UT	A	
Kochia scoparia	Kochia			CO	A	
Leucanthemum vulgare	Oxeye daisy			CO	A	L
Linaria dalmatica	Dalmatian toadflax	P, Res.		CA, CO, NM, NV	A	M □
Linaria vulgaris	Yellow toadflax			CO, NM, NV	A	M
Lythrum salicaria	Purple loosestrife	P		CA, CO, NM, NV, UT	A	
Melilotus officinalis	Yellow sweetclover				C	M
Nerium oleander	Oleander				B	
Oncosiphon piluliferum	Globe chamomile				B	
Onopordum acanthium	Scotch thistle	P, Res.		CA, CO, NM, NV, UT	B	L
Peganum harmala	African rue	P		CA, CO, NM, NV	A	
Pennisetum ciliare	Buffelgrass	P, Reg.			C	H □
Pennisetum setaceum	Fountain grass				C	H □
Pentzia incana	Karoo bush				A	
Polygonum cuspidatum	Japanese knotweed			CA	A	
Potentilla recta	Sulfur cinquefoil			CO, NV	A	

Latin name	Common name	AZ Dept. of Agriculture Weed List*	APHIS Weed List	On neighboring states' weed lists?	Tonto category**	AZ-WIPWG class ***
Pyracantha sp.	Pyracantha				B	
Rhus lancea	African sumac				B	M
Salsola kali & S. tragus	Russian thistle			CA, CO	C	
Salvia aethiopis	Mediterranean sage			CA, CO, NV	A	
Schismus arabicus	Arabian schismus				C	M
Schismus barbatus	Mediterranean grass				C	M
Sinapis arvensis	Wild mustard			CO	B	
Tamarix chinensis	Five-stamen tamarisk			NM	C	H □
Tamarix parviflora	Smallflower tamarisk			CO, NM, NV	C	H □
Tamarix ramosissima	Saltcedar			CO, NM, NV	C	H □
Ulmus pumila	Siberian elm			NM	A	M
Vinca major	Periwinkle				B	M

Definitions: *Arizona State Dept. of Agriculture Weed List: P= Prohibited. These weeds are prohibited from entry into the state.
Reg. = Regulated. These weeds **MAY** be controlled or quarantined if found within the state, to prevent further infestation.
Res. = Restricted. These weeds **SHALL** be controlled or quarantined if found within the state.
****Tonto Weed List: Class A weeds** are of limited distribution in Arizona, or unrecorded in the state. They pose a serious threat. Management goal is eradication. **Class B weeds** are of limited distribution in Arizona, common in some places in the state. Management goal is to contain their spread, decrease population size, then eliminate. **Class C weeds** have spread beyond our capability to eradicate them. Management goal is to contain spread to present size, then decrease the population if possible.
*****AZ-WIPWG = Arizona Wildland Invasive Plant Working Group rating. (SWEPIC 2005) H = High.** These species have severe ecological impacts on ecosystems; invasiveness attributes are conducive to moderate to high rates of dispersal and establishment; species are usually widely distributed. **M = Medium.** These species have substantial and apparent ecological impacts on ecosystems; invasiveness attributes are conducive to moderate to high rates of dispersal, often enhanced by disturbance; ecological amplitude and distribution range from limited to widespread. **L = Low.** These species have minor yet detectable ecological impacts; invasiveness attributes result in low to moderate rates of invasion; ecological amplitude and distribution are generally limited, but the species can be problematic locally.
□ = Additional designation for some species whose current ecological amplitude and distribution are limited. Species are capable of invading unexploited natural communities, based on initial, localized observations or behavior in similar ecosystems/communities elsewhere.

Russian knapweed
Acroptilon repens (L.) DC.

Russian knapweed is a perennial shrub, forming dense colonies by adventitious shoots from widely spreading black roots. Above-ground parts die back each winter; perennial roots send up new shoots in the spring. These roots can penetrate the ground to a depth of over 8 feet and can cover up to 12 square yards in two growing seasons. Stems are erect, openly branched, 18-26" tall. Pink to lavender flowers bloom from June to September (Whitson 2002). It produces seeds sparingly, approximately 50 to 500 per shoot. Seeds are viable for two to three years in soil. Its primary method of reproduction is from vegetative propagation, with seed of secondary importance.

Russian knapweed reduces competition from other plants by allelopathy (production of biochemicals that inhibit the growth of other plants) (Beck 2004). It also produces a neurotoxin that induces symptoms in horses identical to those of yellow starthistle when ingested (Knight 2003). There is no effective treatment for either yellow star thistle or Russian knapweed poisoning because the affected areas in the brain undergo necrosis and do not regenerate.

Russian knapweed is a native to southern Ukraine, southeast Russia, Iran, Kazakhstan and Mongolia; probably introduced into North America about 1898. It is now widely established throughout the west. It is a fairly common weed in the northern half of Arizona, and is also being documented in the southeastern part of the state (USDI 2005). There are infestations along the Upper Verde River upstream from the Tonto. On the Tonto, very small populations have been documented in the vicinity of Gordon Canyon on Highway 260 (Horsley 2005), and at Shumway Millsite on the Payson Ranger District south of Payson (Fenner 2005).

Jointed goatgrass
Aegilops cylindrica Host

Jointed goatgrass is a winter annual grass, 15-30" tall with one to many erect stems or tillers. The flower spike contains 2-12 spikelets, each with 1-3 viable seeds. Flowering and seed production occur May to July. Viability of seeds in the soil is 3-5 years; seeds retain 75% of their viability after passing through a ruminant's digestive tract (CDFA 2005).

Jointed goatgrass is native to southern Europe, but is now established in most winter wheat growing areas of North America. It was introduced from Turkey in the late 1800s (Colorado WMA 2002). It is normally spread as a seed contaminant (Whitson 2002).

Jointed goatgrass normally grows as a crop weed in parts of the U.S. where winter wheat is produced. CRISIS Weed Map and Data Server (2005), which compiles invasive plant records from California, Arizona, Nevada, New Mexico, Utah, Colorado, and parts of Idaho, Oregon, Wyoming and Texas, shows no occurrences of jointed goatgrass in the west. Populations along Highway 87 from Payson to Strawberry, and in the Young area may be fairly recent, or at least have not been documented in any database to date.

Tree of heaven
Ailanthus altissima (P. Mill.) Swingle

Ailanthus is a fast growing deciduous tree, a prolific seed producer, a persistent stump and root sprouter and an aggressive competitor with respect to the surrounding vegetation. It grows up to 90 feet tall. (USDA FS Feb. 2004) It occurs primarily in disturbed areas, though it may invade undisturbed habitats such as riparian areas. Seeds ripen in large crowded clusters from September to October and may persist on the tree through the following winter (Little 1974, Hu 1979). An individual tree can produce 325,000 seeds per year which are easily wind-dispersed (Bory and Clair-Maczulajtys 1980). Seeds are also dispersed by birds and water. Seeds are relatively short-lived (less than 3 years), and vegetative proliferation through root sprouting is by far the most common method of reproduction (Roye 2003).

In the Americas, *Ailanthus* occurs from Canada to Argentina (Hoshovsky 1988). The species was apparently introduced into America by two different routes. It was first introduced to America from China by way of England, by a Philadelphia gardener in 1784 (Hu 1979). Because of its rapid growth and ability to grow in unfavorable conditions with little care, it became a common stock in eastern nurseries by 1840. The second route was through Chinese miners. During the days of the California gold rush, many Chinese miners brought *Ailanthus* seeds with them as they settled in California, probably because of its medicinal and cultural importance to them.

The production of toxic chemicals by *Ailanthus* may also explain the success of this plant. An aqueous extract of ailanthus leaves has been shown to be toxic to 35 species of gymnosperms and 10 species of angiosperms (Mergen 1959). This may be important in limiting natural succession in *Ailanthus* stands.

A recent clinical observation recorded in the Annals of Internal Medicine documents a case of myocarditis that was traced to the patient having worked as a tree surgeon on a team responsible for clearing heavy infestations of tree of heaven. Symptoms included abdominal pain, chest pressure that radiated to both arms, and shortness of breath. The patient reported that all of his coworkers also exhibited these same symptoms. Among its many uses in folk medicine, sap of the tree of heaven is thought to be a cardiac depressant and has been used to slow heart rate (Bisognano et al 2005).

In Arizona, this tree is mostly associated with mining towns. It has been documented around Cottonwood, Camp Verde, and Jerome. There are recent records (1999 and 2002) from Santa Cruz and Pima counties on the Coronado National Forest (CRISIS 2005). On the Tonto, it has been documented on the Verde River near Childs, in the towns of Superior and Globe and on National Forest lands nearby. In the spring of 2005, a few pole-sized plants were documented near the confluence of Pinal Creek and the Salt River (Fenner 2005). Seed were probably carried down the creek from the town of Globe, where the tree grows in abundance. It has also been documented growing in the town of Payson near the Forest boundary.

Camelthorn
Alhagi maurorum Medik.

Camelthorn, a spiny, intricately branched perennial shrub, grows to a height of 1-1/2 to 4 feet. The greenish stems have slender spines 1/4 to 1-3/4 inches long. Single leaves are wedge-shaped and alternate. Flowers are small, pea-like, pinkish purple to maroon, occurring on short spine-tipped branches on the upper portion of the plant. The entire plant dies back to the ground every winter and resprouts from its extensive root system the following spring. It can grow through pavement, and the thorns can flatten car tires. Where it grows near highways, it causes extensive cracking in the asphalt, and constant road repairs are necessary (Horsley 2004).

Camelthorn, a member of the Pea family, was introduced from Asia and grows well on dry or moist sites. It spreads rapidly along streams and canals. (Colo. WMA 2005)

It is considered one of the most difficult noxious weeds to eradicate, due to its extensive root system. It is an aggressive perennial that sends thick rhizomes out 12 meters or more from the parent plant. Seeds may be viable for years, although reproduction is mostly vegetative; seedlings are rarely found (DiTomaso 2003). Although the plant is very thorny, it is apparently also very palatable. Passage through ruminants' digestive tracts serves to scarify the extremely hard seed coats, thus increasing germinability (CDFA 2005).

In Arizona, camelthorn has been documented growing between 100 and 5000 feet in elevation (ADOT 2005). It has established heavy infestations in the northeastern part of the state. It grows along ditches and canals in the vicinity of Painted Rock Dam, southwest of Phoenix, and has recently been found in fields on the west side of Phoenix near Loop 101 near an alfalfa field (Northam 2005). Arizona Department of Transportation has been applying herbicides to an infestation in Chandler for some years. They have also worked for several years on a small infestation along Highway 60 a few miles north of Globe (Horsley 2005). Other camelthorn infestations farther north along Highway 60, north of the Salt River, are also very close to the Tonto; there could easily be camelthorn growing along the Upper Salt River that have spread from these infestations. Surveys of the Upper Salt during the spring of 2005 did not find camelthorn from Cibecue Canyon to the take-out point above the Diversion Dam. The first seven miles below the Highway 60 bridge were not surveyed (Fenner 2005).

Giant reed
Arundo donax L.

Giant reed, also known as wild cane, is a tall, perennial grass that can grow to over 20 feet in height. Its fleshy, creeping rootstocks form compact masses from which tough, fibrous roots emerge that penetrate deeply into the soil. Leaves are elongate, 1-2 inches wide and a foot long. The flowers are borne in 2-foot long, dense, plume-like panicles during August and September.

Reproduction of giant reed is primarily vegetative, through rhizomes which root and sprout readily. Little is known about the importance of sexual reproduction in giant reed, or about its seed viability, dormancy, germination, and seedling establishment (Benton et al 2005). It does not produce viable seeds even in most areas where it appears to be well-adapted (Perdue 1958).

Giant reed becomes established in moist places such as ditches, streams, and riverbanks, growing best in well drained soils where abundant moisture is available. It tolerates a wide variety of conditions, including high salinity, and can flourish in many soil types from heavy clays to loose sands.

Giant reed is widely dispersed into all of the subtropical and warm temperate areas of the world, mostly through intentional human introductions. It was probably first introduced into the United States at Los Angeles, California in the early 1800's. Today, giant reed is widely planted throughout the warmer areas of the United States as an ornamental and in the Southwest, where it is used along ditches for erosion control (Benton et al 2005).

Arundo chokes stream channels, crowds out native plants, interferes with flood control, and increases fire potential. The long, fibrous, interconnecting root mats of giant reed form a framework for debris dams behind bridges, culverts, and other structures that leads to damage. It ignites easily and can create intense fires. It can float miles downstream where root and stem fragments may take root and initiate new infestations. Due to its rapid growth rate and vegetative reproduction, it is able to quickly invade new areas and form pure stands at the expense of other species. Once established, giant reed has the ability to out-compete and completely suppress native vegetation (Hoshovsky 1986).

This species has been planted in many rural communities throughout the state. It grows near the headwaters of the Verde River at Dead Horse State Park, near the Irving Power Plant on Fossil Creek, and is common in the towns of Camp Verde, Globe and Superior. It can be difficult to distinguish from common reed (*Phragmites australis*), which grows on every continent except Antarctica, and is probably the most widespread flowering plant in the world (Tucker 1990). Because *Phragmites* has invaded and formed near-monotypic stands in some North American wetlands only in recent decades there has been some debate as to whether it is indigenous to this continent or not. Convincing evidence that it grew in the western U.S. long before European contact is now available. Identifiable Phragmites remains dating from 600 to 900 A.D. and constituting parts of a twined mat and other woven objects were found during archaeological investigations of Anasazi sites in southwestern Colorado (Breternitz et al. 1986). Other reports document preserved *Phragmites* remains in the southwestern U.S. dating back 40,000 years. (Saltonstall 2005).

Phragmites grows along the Verde River, and has increased in density during the recent drought (Fenner 2003). There is a low probability of Arundo invading habitat along the Verde River, since *Phragmites* is gainfully occupying the same niche. However, with the presence of *Arundo* on the Upper Verde upstream of the Tonto, if a large riverflow were to scour the river channel and floodplains, they could be opened up to invasion by *Arundo*.

Onionweed
Asphodelus fistulosus L.

Onionweed is an herbaceous perennial in the lily family (Liliaceae). It grows to about a foot tall and almost as wide. Clusters of long, tapering, round, hollow leaves very much resemble chives

or scallions. Leaves sprout after winter rains, with flowers appearing in spring. Plants die to the ground during dry seasons. Fruits are 1/8-inch round capsules.

Onionweed might be confused with some native onions (*Allium* spp.). *Allium macropetalum* (desert onion) is a much shorter plant with leaves rarely more than four inches tall. Taller native onions grow in different habitats than onionweed. Onionweed is known to grow in very dry sites where native onions would not grow.

Onionweed is an aggressive invasive species. Introduced as an ornamental, it easily escapes cultivation into surrounding unirrigated land. It seeds prolifically (2-13,000 seeds per plant annually) and can establish large populations quickly (Fox 2004). Seeds remain viable in the soil for many years. Onionweed is unpalatable to cattle and apparently to most wildlife, so it is very persistent once established. To date it tends to invade disturbed ground, so it is unclear whether it will be a threat to natural communities.

This plant is native to southern Europe, Mediterranean Africa, and Western Asia. In the United States onionweed occurs in California (in several coastal southern counties), Arizona, New Mexico, and Texas. Onionweed is also known to be in Mexico. Plants introduced into the United States in the 1980s may be the progenitors of the Arizona population. They were offered for sale in Alpine, Texas and Phoenix, Arizona as early as 1984. Some of the original US plants were collected from a naturalized population near Saltillo, Coahuila, Mexico, where the species was documented in 1930 (Arizona-Sonora Desert Museum 2005).

Some nurseries offer onionweed as an ornamental even though it is a prohibited noxious weed in many states as well as a federally listed noxious weed. Plants have been found in Arizona from about 2000 feet elevation to at least 4500 feet (Arizona-Sonora Desert Museum 2005). Arizona infestations are primarily in the southeastern corner of the state, in areas above the desert that receive moderate winter rainfall. A few small infestations have been found in Tucson. An infestation was discovered in Ajo in 1989 by an Arizona Department of Agriculture employee, who eradicated it by hand pulling all of the plants. In 1994, it was discovered in a demonstration plot at a botanical garden in Tucson. That infestation was also eradicated by hand removal. It has been discovered in several sites in Tucson and southeastern Arizona, including the Audubon Research Ranch, plant nurseries, and residential yards. The most recently identified infestations are near Tombstone, Arizona along Highway 80 (Northam 2005), and in Sedona (Moser 2005).

A well-established population in suburban Tucson was reduced to only two plants after the severe drought of 2002. Germination and plant establishment seem to be enhanced by fire, as observed after fires burned over an infestation near Elgin in 2002 and 2003. (Northam 2005) Onionweed has not been documented on the Tonto.

Wild oats
Avena fatua L.

Wild oats is a cool season annual grass that originated in the Mediterranean area, and has naturalized throughout the world everywhere cereal grains are grown. Besides being an

agricultural weed, it has become a common weed of roadsides and undisturbed wildlands in the western U.S. It was well established in California by the late 1700's.

It is a tall grass, growing up to 4 feet tall, but usually 2 -3 feet tall. Fields of wild oats can produce up to 10,000 seeds per square meter (Brusati 2004). Seeds can survive 4-7 years, but 99% of seeds germinate before 4 years. Seedbank half-life is estimated to be 6 months (Kirby & Moerkerk 2000).

It has been used in Arizona to revegetate disturbed areas near highways, and has spread into low-elevation vegetation types from juniper grassland to the Sonoran desert. It is found along most highways on the Tonto. It dries out by late spring, providing a source of dry standing fuel to carry desert fires from the highway into adjacent uplands.

Black mustard
Brassica nigra (L.) Koch

Black mustard is an annual cool-season forb that grows 2 – 8 feet tall. Stems are erect, with some dense hairs on lower portions, and upper stems usually smooth. Leaves vary from 2-10 inches long, and 1-6 inches wide. Leaves are stalked and deeply lobed. Flowers are larger and brighter yellow than those of Asian mustard. This species can be easily differentiated from wild and Asian mustard in that its seed pods are closely appressed to the stem at maturity (Whitson 2003). Mustard seed can remain viable in the soil for over 5 years.

This plant has been reported to have an allelopathic substance in its leaves (Munir et al 2002). While it tends to grow in clumps that crowd out native plants, it has been considered to have a low invasive potential by other states in the west.

Black mustard was introduced to the U.S. from the Mediterranean area, possibly as a seed grain contaminant. It now grows in nearly every state (Ewing 1999). It is increasing in abundance in Arizona. On the Tonto it has been identified growing along Highway 188 through Tonto Basin, and in revegetation sites along Highway 87. It was apparently also a contaminant in seed used for revegetation of safety zones created during suppression of the Willow Fire in 2004; inspections in 2005 found black mustard plants in nearly every safety zone that was seeded.

Asian mustard
Brassica tournefortii Gouan

This cool-season annual forb germinates in the late fall to winter, and grows very rapidly, seeding out as early as February of the following year. One mature plant can produce as many as 9,000 seeds. Seed longevity is unknown, but based upon observations of other Brassica species, is probably several years (Sanders & Minnich undated).

Asian mustard replaces other native and invasive species by growing in high densities, using soil nutrients and moisture before other plants. It often causes native annuals to die early in the spring, due to lack of available soil moisture (Brooks 2003). It may have an adverse effect to desert tortoise by reducing biomass of native annual forbs and grasses that have palatable leaves

and stems close to the ground at the time of year when tortoises are coming out of their dormant period and foraging for food (Jennings 1993).

Asian mustard is native to the deserts of North Africa, the Middle East, and Mediterranean lands of southern Europe. It was probably introduced to this country with date palms brought from the Middle East in the early 20th century to Coachella Valley. It experienced a population explosion during above-normal winter/spring precipitation years of 1977 to 1983 (Sanders & Minnich 2005).

Asian mustard may have been classified as a "B" species prior to the winter/spring of 2004-2005. Higher than normal precipitation following years of drought that had removed ground cover at lower elevations, resulted in the recent population explosion of Asian mustard. After the last wet winter/spring, Asian mustard has quickly proliferated to occupy roadside and field disturbed areas from southern Arizona to Kingman and the Arizona Strip, into western New Mexico and the deserts of eastern California. It had been present in low numbers before 2004, but seemed to take advantage of abundant cool season precipitation to extend its range dramatically. Mature plants break off and tumble, scattering seed from pods. Asian mustard plants have now moved from the right-of-way along Highway 87 to distances of a quarter mile or more into undisturbed desert, where tumbling plants have hung up under mesquite, palo verde and catclaw, or along minor drainages (Fenner 2005b). A Plant Assessment Form for this species, completed by the California Exotic Pest Plant Council reports that it has spread rapidly from the Sonoran Desert to the Mojave Desert during the 1980's and 1990's (Brooks 2003).

It is now widespread through the Tonto, from Cave Creek Road, to the lower Salt River, Highway 60, Highway 87 to Sunflower, Highway 188 (mostly near new construction at the south end) and roads and drainages through the Mesa, Globe, and Tonto Basin Ranger Districts. New infestations are beginning to appear on the southern boundary of the Cave Creek Ranger District.

This species appears to progress in waves, after extremely wet years. It may not be a dominant weed next year, but its seed is now in the soil on many acres of National Forest, waiting for another wet winter.

In addition to replacing native annual species, Asian mustard matures very early in the spring, leaving a thoroughly dried, often large quantity of biomass along roadsides that can easily carry fire into the desert. Its spreading panicle and growth habit of leafless stems with a rosette of large leaves at the base may prevent it from carrying fire on its own, unless it is growing on a steep slope. But presence of dried annual grasses can serve to carry the fire, which is fueled by Asian mustard, for long distances.

Red brome, rescuegrass, downy brome, Japanese brome, ripgut brome
Bromus rubens L., *B. catharticus* Vahl., *B. tectorum* L., *B. japonicus* Thunb., *B. diandrus* Roth

Red brome is native to Europe. It was introduced to the U.S. in the 1800's. By 1870 it had overtaken California's overgrazed rangelands. Its range in the west is similar to that of downy brome (cheatgrass), except downy brome grows at higher elevations as it is better able to withstand frost (Newman 1992). Temperatures below freezing kill red brome. Downy brome is

native to Eurasia and the Mediterranean area. It was brought to this country and had extensively invaded the Great Basin and other parts of the west by the late 1800's (Carpenter and Murray 1999). Japanese brome was brought into the U.S. from Europe. It was intentionally planted in some areas in the Midwest, for rangeland improvement. Unlike other bromes, it is not adapted to survive frequent fires, but prefers a layer of litter for maximum germination (Grace et al 2001). Rescuegrass was introduced to the U.S. from South America. It is cultivated as winter forage in southern states. It is an annual or short-lived perennial cool-season grower. Originating in the Mediterranean area, ripgut brome was first reported in the San Francisco area by Watson (1880). It became widely established throughout California before the end of the 19th century (Parish 1920).

These cool-season annual grasses are all classified as C species on the Tonto National Forest. This means they are so abundant and widespread that eradication is not a realistic goal. They are included in this analysis for treatment so that they can be removed from strategic sites. Brome grasses created a continuous fuel source that carried desert fires to engulf unprecedented acreages in the summer of 2005. Seven years of drought, followed by an exceptionally wet winter and spring created a landscape where native perennials had died and been replaced by lush annual growth for a few months during the spring months. When early lightning struck in the desert, it ignited the continuous groundcover of red brome that carried fast-moving fires that could not be contained for weeks (Fenner 2005b). The Cave Creek Complex Fire, second largest fire in the state, and the largest ever to burn in the desert, was fueled by red brome. Nearly 250,000 acres burned – 20% of which were classified Sonoran desert scrub. A significant part of the cactus/succulent component of the vegetation was killed. Deserts did not evolve to withstand fire – their normal community structure is widely spaced plants with cryptogamic soils between the plants.

Downy and Japanese bromes grow at higher elevations. The fire hazard they create is not as significant an effect to the vegetation types in which they grow, which are typically adapted to fire frequencies of 5-7 years. However, they move into forests and rangelands where grazing or other disturbance has reduced the competitiveness of native grasses, and replace them, changing perennial grasslands to annual grasslands. In a dense stand, the extensive, fibrous root system can extract all the available moisture from the upper soil profile, so there is none available for slower growing native species.

Downy brome, or cheatgrass seedlings germinate with fall precipitation. Roots can grow throughout most of the winter at soil temperatures as low as 37°F, and can reach a maximum depth of 3 to 4 feet as plants mature. Under ideal conditions, a dense infestation of downy brome can produce over 500 pounds of seed per acre (1 pound of seed contains approximately 250,000 seeds). Dry matter production of downy brome on rangeland sites can vary from less than 100 lb/acre on the poorest sites to more than 2000 lb/acre on the better sites. The brome is of little forage value because it dries quickly, leaving dried awns that can create serious sores in mouths of livestock.

Rescuegrass grows from 140 to 7000 feet elevation. It is reported to compete with and displace native plants, especially on riparian sites (Marshall et al. 2000).

Ripgut brome grows early, creating a continuous fine fuel as do other bromes, but does not tend to grow in monotypic stands as other bromes do. It is a prolific seed producer (over 1000 seeds/square foot), but seeds have a short soil viability (under 3 years). Infestations typically start in disturbed areas, but can move into openings in wildlands. Florets have sharp awns and can wedge into clothing, fur, and machinery. It can also spread as a contaminant in grain seed (Kyser 2004). Ripgut brome plants germinate, grow and produce seeds during the winter, spring and early summer. By the end of the summer most seeds germinate with the opening rains. Seed production can range from 600 to over 3000 per plant.

Bromus species are contaminants of grain and wool, damage animal hides and host a range of serious cereal diseases. In pastures the seeds penetrate eyes, mouths and feet of grazing animals (Cooper & Moerkerk 2000).

Rescuegrass has been identified growing in Yavapai County at Montezuma Castle National Monument, not far from the Tonto's western boundary (Guertin 2001). It probably grows on the Tonto as well. Both ripgut brome and rescuegrass grow in the Tucson Mountains in southern Arizona (Rondeau et al 2000). Ripgut brome has been identified growing on these National Monuments that neighbor the Tonto: Tuzigoot, Montezuma Castle, and Tonto National Monuments (Guertin 2001), and at the Hassayampa River Preserve (Drezner et al. 2001). It has also been identified on the Verde where Highway 260 crosses, near the town of Strawberry, in the area of the Willow Fire of 2004 west of Rye, and at Sycamore Creek along the Beeline Highway (Northam 2005). It grows in riparian areas from below 2000' up to about 5000' on the Tonto (Northam 2005).

Globe-podded hoary cress, hairy white-top
Cardaria draba (L.) Desv., *C. pubescens* (C.A.Meg) Jarmolenko

Whitetop is a deep-rooted perennial in the mustard family, native to Russia. It was first brought to the U.S. in the late 1800's. It often grows up to 2 feet tall, with roots going 12 to 30 feet deep. It can produce 50 shoots in a square yard. With no competition, one plant can spread to cover an area 12 feet in diameter in its first year. It reproduces by seed and by root segments. An extensive root system is established early in the life of a seedling – a 25-day old plant can have a taproot 10 inches deep, with 5-6 lateral roots with vegetative buds. One plant can produce up to 4800 seeds at maturity. The seeds are relatively short-lived, retaining viability for only up to 3 years in the soil (CNAP 2000)

This plant is found on alkaline, disturbed soils and is highly competitive once it becomes established (Whitson 2002).

Hoary cress may be at least mildly toxic to livestock. The plant contains glucosinolates, which are sulfur-containing compounds that can form toxic compounds in the digestive tracts of animals. These compounds are generally present at low levels, which are normally tolerated by livestock and wildlife. While hoary cress has some forage value, managers should use caution when allowing animals to graze hoary cress-infested rangelands (McInnis et al 1993).

Populations have been recorded in Prescott, Camp Verde, Flagstaff, and Cottonwood, and on the upper Verde River near Perkinsville (USDA FS Feb 2004, Northam 2005). It has been

documented on the Tonto, growing on the Pleasant Valley Ranger District (USDI 2005, Northam 2005).

Plumeless thistle
Carduus acanthoides L.

Members of the genus Carduus are native to Europe and Asia. Plumeless thistle is an erect 4-5 foot tall purple-flowered biennial. Leaves are pinnately-lobed and slightly hairy, extending down the stem to form spiny wings. Flowering is induced by a cold period, thus it may not be adapted to invading lower elevations on the Tonto. First flower heads produce up to 1500 seeds, with later flower heads producing only about 25. 99 percent of seeds fall within 150 feet of the adult plant, and are viable for a short time. A study of plumeless thistle suggested that viable seeds of this species rarely persist in the soil seedbank due to decomposition and seed predation by insects, mammals, and birds (CDFA 2005). Competition by perennial grasses suppresses growth of this thistle.

This species has not been documented on the Tonto. The closest population to the Tonto is at the Petrified Forest National Park

Musk thistle
Carduus nutans L.

Musk thistle is an aggressive, biennial herb with showy red-purple flowers and spiny stems and leaves. Mature plants range in height from 1½ to 6 feet tall, and have multi-branched stems. Leaves are dark green, coarsely lobed, with a smooth waxy surface and a yellowish to white spine at the tip. The large disk-shaped flower heads, containing hundreds of tiny individual flowers, are 1½ to 3½ inches in length and occur at the tips of stems. Flower heads will droop to a 90-degree angle from the stem when mature, hence its alternate name, nodding thistle. The number of seedheads per plant is site-dependent and ranges from about 24 to 56 on favorable sites and 1 to 18 on less favorable sites. Flowers emerge in early May to August and seed dissemination occurs approximately one month after the flowers form. A single flower head may produce 1,200 seeds and a single plant up to 120,000 seeds, which may be wind blown for miles. Seed may remain viable in the soil for over ten years, making it a difficult plant to control.

It is unpalatable to wildlife or livestock, and establishes easily in areas opened up by disturbance, such as fire or overgrazed rangelands (Remaley 2005). In pinyon-juniper communities, cheatgrass and musk thistle (among other invasive plants) tend to establish and dominate, replacing native grasses and forbs, following fires (Zouhar 2002). When musk thistle plants bolt, older rosette leaves begin to decompose, releasing allelopathic chemicals into the surrounding soil (Duncan 2005).

Musk thistle is a native of eastern Europe, and was introduced to the eastern U.S. in the mid-1800's (Duncan 2005). It is now found in nearly every state, from sea level to 8000 feet elevation. Musk thistle is very common in the four-corners area (USDI 2005), and has been documented at several locations on the Coconino and Kaibab National Forests in northern Arizona (USDA FS Feb 2004). The species has not been documented on the Tonto.

Southern & Field sandbur
Cenchrus echinatus L., *C. spinifex* Cav.

Southern sandbur, although a native grass, is on the Arizona prohibited and regulated weed lists. Both species are summer annuals that aggressively colonize open disturbed sites such as roadsides and ditch banks. They compete poorly with dense vegetation and rarely become established where there is a good ground cover of native species (CDFA 2005).

Spikelets are enclosed by fused spiny bracts that form a bur. Burs disperse by clinging to skin and fur of animals, shoes and clothing of humans, vehicles, and by floating on water. Seed from upper spikelets normally germinate within one year; those from lower spikelets may remain dormant for up to 5 years. One plant can produce up to 1000 seeds (USDI 2005).

Bur spines are stiff and can injure the mouths of grazing animals.

Sandbur grows along the right-of-way of Highway 60 east of the Tonto National Forest, on the Fort Apache Reservation. It has also been identified on the Tonto, on the right-of-way of Highway 188 a few miles north of Globe.

Spotted knapweed
Centaurea biebersteinii DC.

Spotted knapweed is a biennial or short-lived perennial. Its name is derived from the spots formed by black margins on the flower bract tips. Spotted knapweed typically forms a basal rosette of leaves in its first year and flowers in subsequent years. Rosette leaves are approximately 8 inches long by 2 inches wide, borne on short stalks, and deeply lobed once or twice on both sides of the center vein, with lobes oblong and wider toward the tip. The taproot is stout and deep. Flowers are purple to pink, rarely white, with 25 to 35 flowers per head. Plants bloom from June to October, and flower heads usually remain on the plant (Carpinelli 2005).

It is native to Central Europe, east to central Russia, Caucasia, and western Siberia. Spotted knapweed was introduced to North America from Eurasia as a contaminant in alfalfa and possibly clover seed, and through discarded soil used as ship ballast. It was first recorded in Victoria, British Columbia in 1883 and spread further in domestic alfalfa seeds and hay before it was recognized as a serious problem. Today it is widely distributed in Canada and nearly every state in the U.S.

Spotted knapweed plants in North America generally live 3 to 7 years but can live up to nine years or longer. Plants can sprout from buds on the root crown. Reproduction is by seed only, and plants are capable of producing 500 - 4,000 seeds per square foot per year. About 90% of the seeds are viable at the time of dispersal, and they can remain viable in the soil for 5-8 years. Most seeds are dispersed near the parent plant but can be transported by people, wildlife, livestock, vehicles, and in soil, crop seed, and contaminated hay. Gravel pits, soil stockpiles, powerlines, grain elevators, railroad and equipment yards are important seed distribution points.

This species infests meadows, forests, and lower elevation rangelands, where it out-competes native plant species. It is capable of invading well-managed rangeland. Forage production for livestock and wildlife is decreased, erosion is increased, and stream sedimentation is increased (Carpinelli 2005). Spotted knapweed impacts native vegetation through a combination of resource competition and allelopathy (Ridenour and Callaway 2001).

Repin, a compound that is neurotoxic, damages the brains of horses that graze this species (TNC 2005). It is not toxic to sheep, goats, or cattle.

A report by an employee of the Idaho Panhandle National Forest in 1997 raised the question of carcinogenicity of spotted knapweed sap. One day was spent pulling this plant bare-handed; after several months aggressive tumors developed that required amputation of two fingers. This case was followed up with the doctor at the University of Washington, who believed there is a compound in knapweed that causes cancer. This compound may also exist in diffuse knapweed (TNC 2005).

In Arizona, there are infestations along Highways 89A and 179 in Sedona, on Northern Arizona University campus, along Lake Mary Road, and in the vicinity of Prescott (USDA FS Feb. 2004). It also occurs north of the Grand Canyon in the Arizona Strip, and not far north of the Tonto above the Mogollon Rim (CRISIS 2005). There is an unconfirmed report of spotted knapweed growing on the Pleasant Valley Ranger District.

Diffuse knapweed
Centaurea diffusa Lam.

The origin of diffuse knapweed is the Mediterranean region of Europe. It was probably introduced to North America as a contaminant in alfalfa seed from Asia Minor or in hybrid alfalfa seed from Germany (Maddox 1979). It is one of the dominant rangeland weeds in North America, infesting over 3 million acres of rangeland in the western United States, with the area infested increasing at a rate of 18 percent a year (Zimmerman 1997). It often invades disturbed areas, but is able to compete easily in well-managed rangelands (Duncan 2005).

Diffuse knapweed is a many-branched annual or short-lived simple perennial ranging in height from 1 to 2 feet at maturity. Basal leaves are finely divided; stem leaves are entire and smaller than basal leaves. It flowers from June through September with a white to purple flower. Characteristic floral bracts are yellowish green with a light brown, comblike margin. These bracts are tipped with a definite slender spine (EC Bar Ranch, undated).

Spotted and diffuse knapweed seeds exhibit three germination patterns: non-dormant seeds that germinate with or without light exposure, dormant seeds that germinate in response to red light, and dormant seeds that are not light sensitive. All germination types occur on each plant. Seeds often disperse when stems break off near the ground and tumble along with wind.

Diffuse knapweed contains an allelopathic chemical that can suppress growth of other species and allow diffuse knapweed to grow in monotypic stands (Watson and Renney 1974). It is

unpalatable to livestock, and its spines can cause injury to grazing animals. It also causes increased soil erosion and reductions in wildlife populations (Roche and Roche 1988).

On the Tonto, this species has been documented growing at the Pleasant Valley airport, the Pleasant Valley Ranger Station, along Cherry Creek, and along Highway 288 at Board Tree Saddle south of Young. There are many small infestations on the Pleasant Valley Ranger District. Diffuse knapweed is common on private lands in Young.

Malta starthistle
Centaurea melitensis L.

Malta starthistle was introduced to the southwestern U.S. from Europe as a seed contaminant. It is very similar to yellow starthistle in appearance, and is often mistaken for it. Like yellow starthistle, leaves extend down the stems, giving the stem a winged appearance. A major difference between the two starthistles is length of spines on the flower bracts: those of yellow starthistle are usually approximately an inch in length, while Malta starthistle spines are normally less than 1/2 inch long. Unlike yellow starthistle also, Malta starthistle seeds appear to have longer longevity in the soil: Malta starthistle seed lives for over 3 years in the soil, making it potentially more difficult to eradicate.

Malta starthistle has been implicated in case reports of chewing disease of horses. Ingestion of significant quantities can cause "chewing disease" which is characterized by fatigue, lowered head, an uncontrolled rapid twitching of the lower lip, tongue-flicking, involuntary chewing movements, and an unnatural open position of the mouth. Poisoning occurs after a horse has ingested 60 to 160% of its body weight over a two month period (Panter 1990, 1991). Toxicity effects are cumulative and irreversible. In most cases, poisoning occurs where horses had little or no other palatable feed available to them (Schalau 2005, UNCE undated).

Malta starthistle is rapidly expanding its range in Arizona. In 1972, it was already reported in Apache, Yavapai, Maricopa, Pinal, Graham, Pima and Cochise counties, but was not so serious as to be declared a noxious weed (Parker 1972). It is becoming very common in urban settings in central Arizona, is now found in the far eastern portion of the state, south of Duncan, and in the Tucson area. This plant is also very widespread and spreading rapidly at low elevations on the Tonto. To date, it has been documented below 3000 feet elevation, with a few exceptions. It grows densely along Highway 188 from Highway 87 through Punkin Center to Roosevelt Lake. It has spread to the east side of Roosevelt Lake to the A-Cross Road, west to Camp Reno, and many other sites in Tonto Basin. Patches can be found along Highway 60 from Apache Junction to Florence, to Oak Flat east of Superior. In the spring of 2005 it was pulled from a small site at the Cave Creek Ranger Station horse pasture and at Bartlett Lake. It has spread from the Horseshoe Recreation Area to endangered Arizona cliffrose habitat near Lime Creek. Other mapped locations on the Cave Creek Ranger District include Cartwright Basin and along Forest Road 41. Forest Road 41 is a major access point to the Forest's west side from the northwest Phoenix metro area. Malta starthistle was recently identified growing in abundance on state land west of the Forest's boundary on FR41,on the west end of FR 41 on the Tonto, and in the private landowner's pastures and corrals in that same area. It is common throughout the entire Phoenix metropolitan area, up to Cave Creek and Carefree. The farthest north and highest elevation site

on the Tonto is at Shumway Millsite (4780 feet), where it grows next to yellow starthistle (Fenner 2005b). It has also been documented near Young, Arizona (USDI 2005).

Yellow starthistle
Centaurea solstitialis L.

Yellow starthistle originated from southern Europe, and first entered the United States shortly after the 1849 gold rush. It was imported as a contaminant in alfalfa hay. At that time, the only place California imported alfalfa from was Chile. It had been spread to Chile in the 1600's from Spain. By 1958, it infested over a million acres in California. Today, there are an estimated 16 million acres of yellow starthistle in California, and a couple of additional million acres in other western states. It has spread to 23 of the 48 contiguous states, as far east as New York (DiTomaso 2001).

Yellow starthistle is a winter annual that is a member of the knapweed complex in the sunflower family. It grows about 2-3 feet tall and has yellow flowers. Leaves extend down the edges of the stems, giving the stems a winged appearance. Inflorescences have bracts with stiff, sharp spines that are about an inch long. A single starthistle plant has the potential to produce up to 150,000 seeds. Germination occurs either in the fall or spring; the young plant has a rosette growth form. As plants mature, a flower stalk elongates from the center of the rosette.

Although some studies show that some seeds can remain viable for up to 10 years (Callihan et al 1993), studies done in California under natural conditions demonstrated that 95% of the seeds had either germinated or were damaged after only 2-3 years in the soil (Joley et al 1992)

This plant has the ability to invade rangelands, pastures, croplands, and roadsides throughout the west, especially those with deep, loamy soils. The competitive success of yellow starthistle is directly related to its ability for rapid growth and capture of water, nutrients, light, and space. This species displaces native plant communities, reduces plant diversity, and accelerates soil erosion and surface runoff. It can form solid stands that drastically reduce forage production for livestock and wildlife. Its ability to deplete soil moisture has been compared to a loss of 15 to 25% of annual precipitation (Jetter et al. 2003).

Yellow starthistle is poisonous to horses, causing the same nervous disorder that Malta starthistle causes. Livestock can be injured eating even small amounts of yellow starthistle if forced to feed on the spiny portions of the plant. Animals and humans normally avoid heavily infested sites due to the spiny nature of the mature plants.

Human activities are the primary mechanisms for the long distance movement of yellow starthistle seed. Seed is transported in large amounts by road maintenance equipment and on the undercarriage of vehicles. The movement of contaminated hay and uncertified seed are also important long distance transportation mechanisms. Once at a new location, seed is transported in lesser amounts and over short to medium distances by animals and humans.

A 1972 publication entitled "An Illustrated Guide to Arizona Weeds" states that yellow starthistle was unknown in Arizona (Parker 1972). Since that time, it has become well

established in central Arizona, with thousands of acres of dense infestations in the communities of Flagstaff, Camp Verde, Payson, Star Valley, and Young.

On the Tonto National Forest, this plant currently grows mainly on the higher elevation Districts – Payson and Pleasant Valley. Infestations have also been documented in Tonto Basin at elevations below 3000 feet.

Rush skeletonweed
Chondrilla juncea L.

Rush skeletonweed is native to Europe, northern Africa and central Asia. It was first introduced to eastern North America through contaminated seed, animal bedding or fodder, in 1872. It was first detected on the west coast in 1938. Today it infests an estimated 8.4 million acres in the United States. It invades Ponderosa pine, chaparral, pinyon-juniper, and mountain grassland habitats.

Rush skeletonweed is a perennial or biennial herbaceous plant, growing to 16-60 inches tall. Plants exist as basal rosettes until flowering. The leaves, stem and roots exude a milky sap when cut. The plant grows a long slender taproot that can extend over 6 feet into the soil, reaching into fissures in bedrock. Lateral roots may produce buds and rosettes. Rush skeletonweed exhibits obligate apomyxis (reproducing without pollination), so that populations are normally not genetically diverse. Infestations can be dense, with 2-6 rosettes per square foot measured on dry sites in the western U.S. While a single plant can produce 10,000 to 20,000 seeds in a season, drought severely limits seed production and viability of seeds. Some experiments have demonstrated seed to be viable under certain optimum conditions for up to 5 years; however, most seeds exhibit no dormancy and generally survive for less than 6 to 18 months in the field. Seeds are adapted to both wind dispersal and dispersal through attachment to moving objects.

This species has not been documented on the Tonto. The only documented population in Arizona is at Grand Canyon National Park (CRISIS 2005). This identification of this population may still need to be verified.

Blue mustard
Chorispora tenella (Pall.) DC.

Blue mustard is a native of Russia and southwest Asia (Whitson 2002). It was introduced to the U.S. in 1929, in contaminated grain seed. It infests winter annual crop fields, roadsides, and disturbed rangeland.

It is a leafy annual, 6 – 18 inches tall, with purple flowers. Stems and leaves are covered with gland-tipped hairs. Flowers, which occur in early spring are showy pale purple to bluish purple. Viable seed can be produced as soon as 10 days after flowering begins.

While this plant has not been documented growing on the Tonto, it is not far. In the spring of 2005 a dense patch of it several acres in size was observed along Highway 69 between Cordes

Junction and Prescott. CRISIS regional maps show it as growing in Prescott and also north of Holbrook (CRISIS 2005).

Canada thistle
Cirsium arvense (L.) Scop.

Canada thistle was first introduced to the U.S. in the early 1600's. By 1954, it was declared a noxious weed in 43 states. It has long been recognized as an agricultural weed. Only recently has it become a problem in wildlands.

It is an herbaceous perennial with an erect stem and creeping rootstock. It produces an abundance of bristly-plumed seed that are wind-dispersed. Most of these germinated within a year, but some many remain dormant in the soil for over 20 years (CDFA 2001, Thunhorst & Swearingen 2005a). The taproot sends out lateral roots as deep as three feet underground, which produce above-ground shoots. It can regenerate from root fragments less than an inch in length (Thunhorst & Swearingen 2005a).

Several varieties of Canada thistle have been identified, which differ in their leaf form, growth, photoperiodism and susceptibility to herbicides (Hodgson 1970).

Canada thistle is found in the northeast part of Arizona. It is very common in northern New Mexico. One site has been documented on the Tonto, near the OW Ranch, west of Canyon Creek, on the Pleasant Valley Ranger District. It has been treated by digging plants and roots out in 2004 and 2005, and the infestation is expanding.

Bull thistle
Cirsium vulgare (Savi) Tenore

Bull thistle was brought to this country from Europe and Asia, as a seed contaminant. Bull thistle is a biennial growing 2 to 5 feet tall. It has a short, fleshy taproot. Stems are very pubescent and have dark purple veins. The first year's leaves form a rosette. Second-year leaves are double-toothed ending in a spine; are wavy; have prickles on the surface; and are pubescent on the underside. Stem leaves are similar to rosette leaves, but they are smaller and have longer spines. The tapering pointed ends of the leaves give this thistle its other common name, spear thistle. Flower heads, made up of dark purple flowers, are 1.5 to 2.0 inches wide. Bracts surrounding the receptacle are narrow and spine-tipped (EC Bar Ranch, undated).

Bull thistle has been mapped in northeastern Arizona, northwestern New Mexico, and is common from Flagstaff south to the Mogollon Rim (CRISIS 2005). Bull thistle is probably the least aggressive non-native thistle in the state. It typically appears as a few scattered individuals plants or populations, primarily at higher, moister sites. These individuals proliferate by shedding seed that mostly lands near the parent plant, but can also be wind- or air-borne. It does not compete well with native vegetation where the existing vegetation forms a good ground cover. Small infestations spread opportunistically, taking advantage of scouring floods, periodic heavy grazing, fires, and other soil disturbances that leave openings for seeds to land and germinate.

Seed that is located on or near the soil surface has a very short life; however, seed that is buried at least 6 inches may have over 50% viability after 3 years (Zouhar 2002). This induced dormancy at this depth could account for bull thistle infestations emerging after disturbance in previously uninfested sites. Bull thistle has evolved a system to encourage seed burial. Seeds have a nutrient-rich "peg" called an elaiosome. This external part of the seed induces ants to transport the seed to their underground nests, in order to feed on the elaiosome. After this part is eaten, the seed is discarded in another part of the underground ant nest. When the site becomes disturbed so that the seed is exposed to light, the induced dormant period is broken and a new infestation is started. Bull thistle plants in dry Canadian grasslands are often associated with ant nests (Zouhar 2002).

A major infestation began in Canyon Creek in the wake of the Rodeo-Chediski Fire of 2002. The infestation extends from the headwaters of Canyon Creek below the Mogollon Rim to the Fort Apache Reservation. It grows along Canyon Creek and also on forested slopes. Small infestations have been reported in various sites on the Payson Ranger District, many associated with burn piles.

Field bindweed
Convolvulus arvensis L.

Field bindweed originated in Eurasia but has spread across the world to become a cosmopolitan species growing between 60^{o}N and 45^{o}S latitudes. It was introduced to the eastern U.S. in the 1700's and spread westward rapidly with construction of the railroads. It was established in the western U.S. by the early 1900's (Weaver & Riley 1982).

It is a persistent, perennial vine of the morning-glory family, which spreads rhizomatously and by seed. An extensive root system makes total eradication nearly impossible. Lateral root growth in one year has been measured to average 15 feet. Lateral roots are generally within the top foot of soil, but 1/3 of the total root system grows below 2 feet. Field bindweed also produces extremely persistent seed. In one experiment with 55-year-old seed, 65% were found to be still viable (Brown & Porter 1942). Seed can remain viable in the stomachs of migrating birds for up to 6 days, dispersing it over a distance of many miles (Lyons 1998).

Relatively little is known of the impact of this plant on natural areas. Its extensive root system can deplete the top foot of soil of water to below wilting point for most species. It can choke out native grasses and forbs, especially in riparian areas.

Foliage contains alkaloids that can cause intestinal problems in horses grazing on heavily infested pastures (CDFA 2005).

This plant has mainly been found on roads, near fields and other disturbed areas within the Tonto National Forest, on the Payson and Pleasant Valley Ranger Districts.

White bietou
Dimorphotheca cuneata (Thunb.) Less.

This plant is a perennial half-shrub, native to South Africa, but can be easily purchased in seed form from anywhere in the world. There are no records regarding this plant as an invasive species in the U.S. A related species, *D. sinuata*, is documented as occurring in California as an invasive plant (San Diego Natural History Museum, undated). This species is an annual, commonly called an African daisy.

The Tonto has one population of this plant that has spread from an ornamental planting approximately 20 years ago on private lands south of the Globe Ranger Station. This plant currently occupies 40 acres of the National Forest. This half-shrub, with extremely attractive large white flowers is widespread in yards and canyons between Six Shooter Canyon and National Forest lands to the west.

Common teasel
Dipsacus fullonum L.

Teasel is a European plant introduced to the U.S. in the 1700's (WDNR 2004). It is commonly used, and spread, in dried flower arrangements. It is also sold by nurseries as a flowering plant.

It grows as a short-lived perennial or biennial. It spends one or more years as a rosette before sending up a flower stalk. Teasel's unique inflorescence makes the plant readily identifiable when flowers or seedheads are present. Tiny purple flowers in an ovoid inflorescence are each subtended by a long spiny bract. Infestations occur in sunny riparian areas.

Teasel produces an abundance of seeds. A single teasel plant can produce over 2,000 seeds; up to 30-80% of the seeds may germinate. Seeds may remain viable for at least 2 years. Seeds typically don't disperse far; most seedlings will be located near the parent plant. Streamflow in riparian areas can carry them some distance from the original infestation, however.

There are only a few known isolated populations of teasel in northern Arizona. One patch is at Watson Woods on Granite Creek in the Prescott area (USDA FS Feb 2004). CRISIS maps show another infestation elsewhere in Yavapai County. Teasel has been documented on the Tonto at Shumway Millsite, south of Payson, on the Payson Ranger District. Employees at Payson Ranger District have reported seeing it in the vicinity of Sharp Creek Campground. These infestations are all associated with riparian areas.

Russian olive
Eleagnus angustifolia L.

Russian olive is a fast-growing tree, reaching a height of 10 – 25 feet at maturity (Whitson 2002). Trunks and branches are covered with 1 to 2 inch thorns. Leaves are narrow, 2-3 inches long. Clusters of yellow flowers bloom in early summer; fruit resembles small reddish-brown olives. Birds and small animals eat the fruits, which aids in dispersal of the seeds. Its large seeds remain viable for up to 3 years and are capable of germinating over a broad range of

conditions (Shafroth et al. 1995). Also, seeds germinate anytime from fall to spring, giving Russian olive a competitive advantage over native riparian trees. Russian olive also spreads vegetatively (Tu 2003).

It was introduced from Europe in the early 1800's as a desirable ornamental shade tree. It is now invasive in 17 western states. It is especially invasive in riparian woodlands, taking advantage of scouring events to replace cottonwood and willow trees (Tu 2003). It has nitrogen-fixing roots, which enable it to grow on bare mineral substrates and dominate riparian vegetation where overstory cottonwoods have died. Bird species richness is higher in native riparian vegetation than where Russian olive dominates (Muzika & Swearingen 2005a).

It can survive drought conditions, so is adapted to ephemeral riparian drainages that are common on the Tonto. Dense thickets of Russian olive increase the occurrence of catastrophic wildfires in riparian areas, due to their heavy fuel-loading (Caplan 2002).

Russian olive has been found in the northeast quadrant of Arizona (CRISIS 2005), and also in Prescott Valley, Chino, Camp Verde, and east of Flagstaff (USDA FS Feb 2004). It has not been documented on the Tonto.

Quackgrass
Elymus repens (L.) Gould

Quackgrass is a cool-season, exotic, perennial, rhizomatous graminoid. Its stems are erect growing to 1 to 3 feet in height. Rhizomes can grow 23 inches or more from the main shoot before sending out stems (Fernald 1950). Quackgrass propagates mainly by rhizomes but also reproduces by seed. Seed production, however, is reported to be as low as 25 viable seeds per plant per season. The seeds can remain viable for 1 to 6 years. Viability can be maintained even after passing through the digestive tract of most farm animals (Reidy & Swanton 2001).

Quackgrass is native to Europe and Western Asia. It has been reported growing in every state of the United States (Batcher 2002).

Quackgrass produces chemicals that inhibit nearby plant growth. As a cool-season grower, it can usurp water and soil nutrients through the soil profile, thus suppressing growth of later, warm-season grasses.

To date, this is an uncommon weed in Arizona. It has only been documented near Flagstaff, and in the Grand Canyon National Park. It has been found on one site on the Tonto National Forest, on the Pleasant Valley Ranger District.

Weeping and Lehmann's lovegrass
Eragrostis curvula & E. Lehmanniana

Although there is a native lovegrass species (*E. intermedia*), these 2 species of *Eragrostis* are introduced from South Africa.

These plants were introduced as part of range restoration/soil conservation programs in the southwest, and thousands of acres were planted with them in the 1930's (Moser & Crisp 2003). In the mid to late 1900's, these species were commonly included in seed mixes used after fires, highway construction/reconstruction, and other ground-disturbing activities, such as powerline road construction. Lehmann's lovegrass has thrived the best at elevations from 3000 to 4500 feet; weeping lovegrass grows in Arizona from 4900 to 6500 feet. They were planted with forage value in mind, however, they are not as palatable as native perennial grasses, and tend to out-compete them. Although they are classified as warm-season growers, they produce more green herbage in the winter and early spring than native grasses. This active growth during a time when native warm-season grasses are still dormant is key to their dominance in a grassland community years after planting (Moser & Crisp 2003, Uchytil 1992, Walsh 1994).

When native grassland and pastures seeded to Lehmann's and weeping lovegrass were compared, the two site types differed consistently in that the planted exotics grew in monospecific stands and native grasses did not. Total native herbaceous canopy, species richness, shrub density and shrub canopy were significantly reduced on plots seeded to the lovegrasses. Small birds that nest in grasslands will use Lehmann's lovegrass, but nest more frequently in native grassland if it is available. (Uchytil 1992)

Lehmann's lovegrass reseeds itself quickly after disturbance, and tends to replace native grasses where it has been planted. It has replaced Arizona cottontop, threeawn grasses, and grama grasses over much of the Santa Rita Experimental Range in Arizona (Cable 1971). Weeping lovegrass produces up to 1000 seeds per seedhead, but rate of spread by seeds is very slow, and this plant does not actively colonize adjacent nonplanted sites. Weeping lovegrass should not be planted after wildfires for restoration if management objectives are to maintain native plant communities. Although weeping lovegrass is not particularly invasive, once it is planted, it remains in place for a very long time (Walsh 1994).

Desert shrublands that have been invaded by Lehmann's lovegrass experience much more intense burning during wildfires. Most native desert plants and cryptogams are not adapted to intense and frequent fires; species composition changes over time in sites that have been invaded by this and other exotic perennial grasses such as buffelgrass.

Lehmann's lovegrass seeds are initially dormant, requiring 6 to 9 months of afterripening. They need some type of dry heat to scarify their seedcoat and increase water uptake by the seed to be able to germinate. Shading inhibits germination, as the seeds also require exposure to red light to germinate (Uchytil 1992). Weeping lovegrass exhibits facultative apomyxis; that is, seeds do not have to be fertilized to grow into new plants. Weeping lovegrass seedlings must have dependable moisture after they germinate. Less than 20% of newly germinated seedlings survived one day of dessication, and none survived 3 days of dessication (Uchytil 1992).

On the Tonto, these grasses have been extensively seeded along highways, powerline corridors, and even aerially seeded after fires. In 1951, weeping lovegrass was aerially seeded in the Pinal Mountains after a wildfire (Walsh 1994).

Leafy spurge
Euphorbia esula L.

Leafy spurge was transported to the U.S. possibly as a seed impurity in the early 1800s. First recorded from Massachusetts in 1827, leafy spurge spread quickly and now occurs across much of the northern U.S., with the most extensive infestations reported in Montana, North Dakota, Nebraska, South Dakota, and Wyoming (Thunhorst & Swearingen 2005b). In 1996 there were 2.5 million acres infested with leafy spurge in the U.S. and Canada (Biesboer 1996).

Leafy spurge is an erect, branching, perennial herb 2 to 3½ feet tall, with smooth stems and showy yellow flower bracts. Stems frequently occur in clusters from a vertical root that can extend many feet underground. Stems and leaves have a white milky sap that is a skin irritant. The leaves are small, oval to lance-shaped, somewhat frosted and slightly wavy along the margin. The flowers of leafy spurge are very small and are borne in greenish-yellow structures surrounded by yellow bracts.

Leafy spurge reproduces by seeds that have a high germination rate and may remain viable in the soil for at least seven years. Its seed capsules open explosively, dispersing seed up to 15 feet from the parent plant and may be carried further by water and wildlife. 99% of seeds germinate within two years (Biesboer 1996). Most seeds germinate in the spring, but germination and establishment does occur throughout the growing season. Leafy spurge also spreads vegetatively at a rate of several feet per year. The root system can reach 15 or more feet into the ground, and may have numerous buds.

The milky sap produced by leafy spurge will cause a severe skin rash in humans. This weed is also poisonous to most livestock, with the exception of sheep, which can be used to control it. If horses are permitted to walk in areas with leafy spurge, the sap will cause severe blistering and hair loss on their feet (Nova Scotia Department of Agriculture and Fisheries 2003). It is reported to cause severe irritation of the mouth and digestive tract in cattle, which may result in death (Whitson 2002).

When leafy spurge infests pastures, herbage production can be reduced by as much as 75% (Lym & Messersmith 1985). Cattle will avoid grazing an area with as little as 10% cover of leafy spurge (Hein & Miller 1992).

Extracts from the roots of leafy spurge are leached into the soil wherever the weed grows. These extracts inhibit the germination and growth of other plants in the surrounding area (Nova Scotia Department of Agriculture and Fisheries 2003)

Leafy spurge is an aggressive invader and, once present, can completely overtake large areas of open land. Because of its persistent nature and ability to regenerate from small pieces of root, leafy spurge is extremely difficult to eradicate (Thurhorst & Swearingen 2005b).

The Environmental Impact Statement for treatment of invasive plants on the three northern Forests in Arizona cites one infestation on the Coconino National Forest and two on the Kaibab National Forest (USDA FS Feb 2004). This plant has not been documented on the Tonto.

Sweet resinbush
Euryops subcarnosus DC. ssp. *vulgaris* B. Nord

Sweet resinbush is a perennial shrub, growing up to 3 feet in height, native to South Africa. It was collected by SCS Regional Director F.J. Crider in 1934 for introduction to the southwest to control high erosion that was occurring during the 1930's (Pierson & McAuliffe 1995). A 1928 publication, The Flowering Plants of South Africa claimed sweet resinbush to have good forage value, especially for sheep, to be drought-resistant, and to propagate easily. Two out of three claims were correct. Recent research has shown that most species of Euryops contain noxious chemicals so that they are not only unpalatable, but toxic to wildlife and livestock (Schalau 2001).

Resinbush was planted in many locations throughout the southwest by Civilian Conservation Corps crews doing erosion control projects. Also seeds and young plants were made available by SCS to anyone who would plant them (Pierson & McAuliffe 1995).

The largest population today in Arizona (3000 acres) is on Fry Mesa south of Safford (Schalau 2001). In 1998 it was discovered growing on the Santa Rita Experimental Range in southern Arizona (Howery et al 2003).

Small (less than 1 acre in size) patches of sweet resinbush, remnants of CCC erosion-control plantings, have been mapped south of the Globe Ranger Station, in the same area as the *Dimorphotheca* population. One infestation of about 3 acres remains in Tonto Basin west of Highway 188; the largest population on the Tonto is approximately 30 acres on the north side of Highway 60, north of the Miami cemetery. It also grows east of the cemetery on slopes and two miles down Bloody Tanks Wash toward Miami. All of these populations are associated with CCC civil works projects of the 1930's. Many of the checkdams constructed by the CCC are still functioning, including some very impressive ones in Bloody Tanks Wash west of Globe/Miami.

Invasion by sweet resinbush has produced dramatic changes in much of the semi-arid grasslands and shrublands where it was planted. It creates monocultures, excluding normally prevalent half-shrubs like *Calliandra*, shrubby buckwheat, and even snakeweed. Elimination of grasses leads to a dramatic increase in exposure of bare soil, and increased soil erosion (Pierson & McAuliffe 1995). In a sweet resinbush site in Marijilda Canyon, the bare soil created by the dominance of this species resulted in soil that moved more easily. Exposed roots and soil pedestals around bases of the few remaining native grasses were evident in the zone just ahead of resinbush dominance. A sharp demarcation zone at the front of the resinbush infestation was not due to allelopathy, but to extremely efficient uptake of water by the resinbush, leaving none for the native plants (Pierson & McAuliffe 1995).

Little is known of seed dormancy patterns, production, or longevity in the soil. Most seed falls underneath the parent plant and germinates there. Seed is also transported by adhering to fur or clothing, or by floating in streams or ephemeral washes.

Dyer's woad
Isatis tinctoria L.

Dyer's Woad was introduced into North America from Europe late in the 17th century. It was cultivated as a source of blue dye (Callihan and Miller 1999). It is a perennial or biennial herb in the mustard family.

It reproduces by seed, with most seeds falling near the parent plant. An average of 383 one-seeded pods are produced per plant (CDFA 2005). These pods do not open, and contain water-soluble inhibitors that prevent seeds from germinating until thorough leaching occurs. Seed longevity has not been studied.

Dyers woad invades both disturbed and undisturbed areas, and seems to prefer open dry rocky soils. It also invades stands of other invasive plants, such as cheatgrass. It reduces forage availability by suppressing growth of grasses, and it is low in palatability to grazing animals. It is frequently spread through contaminated hay, as it grows as a weed in alfalfa fields. It is also moved about on contaminated equipment.

This species has not been documented on the Tonto, and there are no documented records for this species in either the CRISIS or SWEMP databases. It is known mainly in the intermountain west and northwest U.S.

Kochia
Kochia scoparia (L.) Schrad.

Kochia is an annual forb brought to North America from Europe. It is now common across the northern U.S, and is working its way southward. In Arizona there are many documented observations in the northeast quadrant of the state. It was observed on the Fort Apache Reservation north of the Salt River during a weed survey of the river in the spring of 2005 (Fenner 2005).

It has a thick taproot, from which it breaks off when the plant is mature. It disperses seeds by tumbling like Russian thistle. One plant typically produces nearly 15,000 seeds (WSNWCB 2005). Seeds on the soil surface typically survive 1-2 years, but buried seeds may remain viable for over 3 years (Zorner et al 1984).

It withstands drought well, becoming a dominant plant in the Midwest during the dust bowl years. It is documented to possess allelopathic properties that affect even its own seedlings (Wali 1999).

Kochia scoparia causes hepatotoxicity with photosensitization, renal disease and polioencephalomalacia to livestock. Another species of kochia, *K. prostrata*, is sold as a forage crop for livestock. *K. prostrata* is a drought-tolerant perennial sub-shrub. Both species have been used for livestock forage (kochiaseed.com 2003).

Oxeye daisy
Leucanthemum vulgare Lam.

Oxeye daisy is a perennial forb in the sunflower family that has naturalized from Europe into all 50 states (USDA NRCS 2004). Spread is assisted by seed companies who sell seed packets even in states where the plant is listed as a noxious weed (WSNWCB 2000). It also spreads vegetatively by rhizomes (Alvarez undated)

Ox-eye daisy is able to produce seed its first summer of growth. It is a prolific seed producer when it is growing in moist soil. Most ox-eye daisy seed remain viable for 20 years in the soil, and remain viable after passing through the digestive tracts of animals (Alvarez undated).

Oxeye daisy has a white flower with a yellow center, and grows to a height of 30 inches. It often invades overgrazed or otherwise disturbed ground. It can tolerate drought and frost, but prefers moist, unshaded sites.

In areas of heavy infestations, there is more bare soil than adjacent native meadows, which increases the potential for soil erosion (Olson & Wallander 1999). Plants are resistant to grazing, and since cattle normally avoid eating oxeye daisy, pastures with this species tend to deteriorate in range capacity through time (WSNWCB 2000).

It has not been documented on the northern three National Forests in Arizona, but does grow in Flagstaff and Kachina Village south of Flagstaff (USDA FS Feb 2004). It was recently identified growing inside an elk exclosure along Canyon Creek, on the Pleasant Valley Ranger District (Fenner 2005). The exclosure fence was recently constructed by the Arizona Game & Fish Department to control overgrazing by elk in this popular fishing area.

Dalmatian toadflax, Yellow toadflax
Linaria dalmatica (L.) P. Mill., *Linaria vulgaris* P. Mill.

Both toadflaxes are native to the Mediterranean region. Dalmatian toadflax was introduced to the west coast of the U.S. in 1874 for use as an ornamental. Yellow toadflax was brought to New England from its native south-central Eurasia in the late 1600's as an ornamental and medicinal plant. Today it is still sold as "butter and eggs," "Jacob's Ladder," or "wild snapdragon." Seed of Dalmatian toadflax is also sold by garden catalogs and nurseries.

Dalmatian toadflax is a creeping perennial herb that grows up to three feet tall. It has grayish-green alternate leaves that clasp the stem. Flowers are yellow and very similar to snapdragon flowers. This plant reproduces by root sprouts and an enormous number of seeds. While it is attractive and not thorny, it does tend to take over wildlands, replacing other species of more value to wildlife, livestock, and erosion control. A single Dalmatian toadflax plant can produce up to 500,000 seeds in one growing season (Robocker 1970). Seed of both toadflaxes can remain viable in the soil for over 10 years. Dalmatian toadflax patches can totally disappear, only to reestablish after several years, from either buried seeds or vegetative buds on the roots (Robocker 1974).

Yellow toadflax is also a perennial forb with a woody base. Leave are narrower than those of Dalmatian toadflax. Flowers are borne in axils of upper leaves, as in Dalmatian toadflax; however, flowers of yellow toadflax have a longer spur.

Both toadflaxes have adapted through centuries of grazing in Europe, to survive highly disturbed habitats. They will move from small sites of natural disturbance into pristine rangeland. Once it invades native rangeland, it is very difficult to stop its spread. Toadflaxes commonly displace existing plant communities and associated animal life. Consequent loss of forage adversely impacts livestock and wildlife. Where it replaces sod-forming or bunch grasses, erosion increases.

Yellow toadflax has been reported to be toxic to cattle, but this is rare, since cattle normally avoid it (Lajeunesse 1999).

Dalmatian toadflax is very common around Flagstaff. It is widespread in Ponderosa pine forests on the Kaibab, Coconino, and Prescott National Forests (USDA FS Feb 2004). On the Tonto, it grows at the Payson Ranger District Hot Shot Base, and along Highway 87 between Payson and Rye (Fenner 2005b). Arizona Department of Transportation treated the infestation on Highway 87 with herbicides for several years, until recently. It was nearly eradicated, but is now returning. In 2003, a small infestation was discovered growing on a low rocky terrace above the Verde River, one mile downstream from Childs, on the Cave Creek Ranger District. It appeared to be associated with a trespass road into the Mazatzal Wilderness. This is the lowest elevation where Dalmatian toadflax has been documented in Arizona (Northam 2004). Yellow toadflax has not been documented on the Tonto.

Purple loosestrife
Lythrum salicaria L.

Purple loosestrife is native to Eurasia and was first reported from the northeastern coast of North America in 1814 (Stuckey 1980).

Lythrum salicaria is a stout, erect perennial herb with a strongly developed taproot. The plant ranges in height from 1 ½ to 8 feet (Bender 2001, Whitson 2002). The inflorescence is spike-like, 4 – 16 inches long. Petals are usually magenta, but white or light pink flowers are also common (Bender 2001). It is usually associated with riparian areas. The semi-woody aerial shoots die in the fall but persist for one to two years making stands of purple loosestrife very dense. New shoots arise the following spring from buds at the top of the rootstocks (Bender 2001).

The seeds are small, weighing 0.06 mg each. Dispersal is mainly by wind, but seeds can also be transported on the feet of waterfowl or other wetland animals. Red-winged blackbirds have been observed eating the seeds. Humans carry seeds inadvertently on clothing and shoes. The seeds and cotyledon stage seedlings are buoyant and can be dispersed by water currents. The seed bank potential is enhanced by the high viability of the seeds. After two years in a lake, 80% of seed viability was retained (Bender 2001). Purple loosestrife seed germinates in such high densities

that it out-competes native seedlings. It tends to build up biomass from year to year, enabling it to move into open water.

Purple loosestrife is considered an important weed of wetlands in most of North America. Reservoirs with widely fluctuating water levels provide excellent habitat for it (Rawinski & Malecki 1984).

The only known populations of purple loosestrife in Arizona are on the Apache-Sitgreaves National Forest (Crisp 2000).

Yellow sweetclover
Melilotus officinalis (L.) Lam.

Melilotus species are native to the Mediterranean area through central Europe to Tibet. They were reported in North America as early as 1664 and have been extensively used by agriculturalists as forage crops, soil builders (they are in the legume family, that fix nitrogen in the soil), and as a nectar source for honey bees. The sweetclovers have spread from cultivation and thrive in waste places and roadsides throughout the U.S. and Canada (Eckardt 1987). Yellow sweetclover can act as a winter annual or a biennial (Whitson 2002).

Rainwater runoff and stream flow are probably the most important means of seed dispersal, although wind can blow seeds several feet. Newly mature seeds will be soft, but as they dehydrate they become temporarily "hard" or impermeable, and can remain viable in this state for many years. Hard sweetclover seeds can remain viable in the soil for over 20 years (Eckardt 1987). Other sources state seeds could remain viable in the soil up to 50 years (USGS undated). Each plant can produce 14,000 to 350,000 seeds. Yellow sweetclover does not reproduce vegetatively.

Yellow sweetclover has a bitter taste, making it less palatable to cattle than other legumes. It is more palatable in early spring and summer, becoming woody in late summer and fall (Sullivan 1992).

This plant is fairly widespread through Arizona – it has been documented at the Grand Canyon, and in Cochise, Pinal, Maricopa, Apache, and Yavapai counties (AZWIP-WG undated). On the Tonto, it has been used in seed mixes, and has lingered on in wetter sites. It is very common in the riparian zone along the Verde River, on the Cave Creek Ranger District.

Oleander
Nerium oleander L.

This is a very commonly used landscaping plant in the Phoenix urban area. There are two sites where it has naturalized on the Tonto National Forest. Several clumps of it have attained great height, growing in Arnett and Telegraph Canyons, near Boyce Thompson Arboretum (Grove 2004). Another large individual plant was found growing in Camp Creek, on the Cave Creek Ranger District, apparently naturalized from a nearby recreational residence (Loomis 2006, Nelson 2006).

Oleander has not been considered to have invasive potential until fairly recently. A Red Alert was issued by the California Invasive Species Council for this plant in 2000. It had been found along the Sacramento floodplain near Redding, and riparian zones in southern California (Tu and Randall 2000).

This year, in Arizona, the Arizona Daily Star included oleander in a list of ornamental plants that were becoming invasive in Saguaro National Park (McKernan 2005).

Oleander is native to the Mediterranean region, where it grows in ephemeral washes. Its pods contain seeds that have plumes of hairs for wind dispersal.

All parts of the plant are extremely poisonous, containing 10 different cardiac glycosides. These compounds induce cardiac arrhythmia and eventual death. The lethal dose of green oleander leaves for cattle and horses is 0.005% of the animal's body weight. Inhalation of smoke from a burning oleander also can cause poisoning (Skurka 2005).

Globe chamomile
Oncosiphon piluliferum (L. f.) Källersjö

This plant is a close relative of *Pentzia incana*, another introduction from South Africa. It is an annual plant, which has escaped cultivation in the U.S. and also in western Australia. In 2005 it began to be observed at several different places in Arizona, possibly naturalized from plantings. To date, it has been documented growing in abundance along 5 miles of I-17 north of Phoenix, spreading up to ¾ mile into the desert on both sides of the interstate (Fenner 2005b, Northam 2005). Isolated patches of globe chamomile have also recently been identified near Skunk Tank Ridge south of Cave Creek on the Cave Creek Ranger District, at the Cave Creek Ranger Station, at the Sonora Desert National Monument, at Pinal City near Superior, along Highway 84 west of Casa Grande, at the Extension Service demonstration garden on east Broadway in Phoenix, on a disturbed site four miles east of I-17 on Carefree Highway, and growing in cultivation at the Desert Botanical Garden and Boyce Thompson Arboretum (Trask 2004, Northam 2005).

Scotch thistle
Onopordum acanthium L.

Scotch thistle is native to Europe and Asia. It was introduced to the eastern U.S. in the late 1800's; today it can be found in most western states. It prefers moist sites, and has the potential to invade riparian areas. It also has been documented to replace native bunchgrasses and sod-forming grasses (Beck 1999).

It is normally a biennial, but can also grow as an annual or a short-lived perennial plant (Young and Evans 1969). This is a large thistle, growing to a height of up to 8 feet, with basal leaves 2 feet long. Leaves are spiny and covered with fine dense hairs on both sides. Flowers are 1-2 inches in diameter, pale purple to red, and flat-topped. Below the flower are spiny bracts (Beck 1999). Up to 90% of seeds are dormant when mature. A water-soluble germination inhibitor in the seeds ensures the plant will grow in moist sites, and prolongs the seeds' life in the soil. Most

seeds germinate near the parent plant, although transport by human activities and animals does occur.

This plant can create a tall, dense, spiny obstruction to human and animal movements.

Scotch thistle is common in the Four Corners area, the Arizona strip, and along the interstate system around Flagstaff. There is one known population on the Prescott National Forest (USDI USGS 2005, USDA FS Feb. 2004). In 2004, the first infestation of this plant was documented on the Tonto, growing in Strawberry at the Highway 87 bridge.

African rue
Peganum harmala L.

African rue is a many-branched perennial that has an aggressive, woody root system. Height rarely exceeds 1 to 1.5 feet. Stems are fleshy. When crunched, the stems have a bitter, acrid taste and a disagreeable odor. Leaves are alternate, smooth, and divided into linear segments. Flowers consisting of five white petals are borne singly in leaf axils along the stems.

African rue's origin is North Africa. The first reported infestation in the United States was near Deming, New Mexico, in the 1920s (EC Bar Ranch, undated). It was brought in by a farmer who wanted a new plant that would yield a red dye for wool yarn (Davison & Wargo 2001).

African rue is poisonous to cattle, sheep, horses, and humans. Other species may be vulnerable as well. The seeds, fruit and young leaves are the most poisonous plant parts. Rue is an extremely unpalatable plant and livestock consume it only when starving or under a severe mineral deficiency. The early symptoms of poisoning include weakness in the hind legs, listlessness, salivation, and anorexia. In humans, the alkaloids present in the plant cause hallucinations and severe vomiting (Davison & Wargo 2001).

The Arizona Department of Transportation recently confirmed a small infestation of African rue growing in Pima County along I-10 near the town of Vail. It also occurs in northwestern and southwestern New Mexico (EC Bar Ranch, undated). This species has not been documented on the Tonto.

Buffelgrass
Pennisetum ciliare (L.) Link

Buffelgrass is native to arid regions of Africa, Asia and the Middle East. It was introduced to Texas as early as 1917, but the most common variety in this country was brought to San Antonio, Texas, California, Arizona and New Mexico from Kenya by the Soil Conservation Service in the 1940's. In Tucson, it was studied at the place now known as the Natural Resource Conservation Service – Tucson Plant Materials Center. It was planted from the 1970's through the 1980's at sites around Tucson, including the Santa Rita Experimental Range, where it still grows (Yetman & Burquez 1994).

It has a sprawling growth habit, with stems that can grow to four feet long, and a mass of tough roots that can penetrate the ground to 4 feet deep (Douglas King Co. 1999).

Buffelgrass is adapted to survive frequent fire. It will burn while still green, and forms new sprouts immediately after the fire has died. This perennial grass crowds out other desert vegetation, or grows in areas that are normally occupied only by ephemeral spring or fall vegetation. It provides a continuous fuel that carries fire into the Sonoran desert, which is not adapted to frequent fire.

Extensive buffelgrass invasions with their consequent frequent fire, have converted desert scrub communities into non-native grassland in Mexico (Burquez et al. 2002).

This perennial cool-season grass is common in Phoenix. It is spreading onto the Tonto along Highways 60 and 87, Pima Road in Scottsdale, Cave Creek Road, and other roads.

Fountain grass
Pennisetum setaceum (Forsk.) Chiov.

Originally native to Africa and the Middle East, fountain grass has been introduced to many parts of the world as an ornamental grass (Benton 2005). It is popular in many countries as an ornamental plant – it has dispersed into wildlands across Arizona, California, Florida, Hawaii, Fiji, South Africa and Australia thanks to sales in nurseries (Lovich undated).

Fountain grass is an attractive perennial grass with a densely clumped growth form and erect stems that grow 2 to 3 feet high. The small flowers of fountain grass are grouped in pink or purple, bristly, upright inflorescences 6-15 inches long. Fruits are small, dry achenes with long bristles. Seed are wind-dispersed, and remain viable in the soil for 7 years or longer. Its seeds may be dispersed greater distances by water, vehicles, livestock and humans (Cal IPC 2005). The long-lived seeds of fountain grass make its control extremely difficult. Fountain grass is apomictic, which means it can reproduce by either fertilized or unfertilized seeds (Simpson & Bashaw 1969).

Fountain grass is a highly aggressive, fire-adapted colonizer that readily out-competes native plants and rapidly reestablishes after burning. Fountain grass raises fuel loads, which increases the intensity and spread of a fire, and results in severe damage to native desert species including all species of cactus.

Fountain grass has been documented on the Tonto on all desert Districts. It grows profusely along Highway 60 between Superior and the mountain tunnel east of town. It also grows along Highway 87, along the road to Bartlett and Horseshoe Reservoirs, and in the Salt River Recreation Area. It is commonly used for landscaping, and is an escaped ornamental throughout the greater Phoenix area.

Karoo bush
Pentzia incana (Thunb.) Kuntze

Pentzia incana was first introduced from South Africa to Arizona by the Soil Conservation Service working with the Civilian Conservation Corps, in the 1930's. It was selected for its drought tolerance, and intended to prevent soil erosion, which was rampant during the drought of the 1930's. Karoo bush was planted as late as 1946 in plant trials at the Santa Rita Experimental Range in southeastern Arizona (Munda & Pater 2003).

It is a small shrub in the sunflower family. Its yellow ball-like flowers appear during the winter. It has not exhibited a great deal of invasiveness in the one site it has been documented on the Tonto, north of Oak Flat Campground on the Globe Ranger District. Soils in the site it inhabits have been severely disturbed. This site is associated with checkdams constructed by CCC crews in the 1930's.

Pentzia is advertised on some landscaping websites as a desirable plant; The State Department of Water Resources recommends it as a low water-use plant (Arizona Dept. of Water Resources 2004), as does the University of Arizona's Office of Arid Land Studies.

Japanese knotweed
Polygonum cuspidatum Sieb. & Zucc.

Japanese knotweed is an herbaceous perennial that can grow to over 10 feet in height. Stems of Japanese knotweed are smooth, stout and swollen at joints where the leaf meets the stem. Leaves are about 6 inches long by 3 to 4 inches wide, broadly oval to somewhat triangular and pointed at the tip. Small greenish-white flowers bloom in the summer. Small winged fruits contain triangular, shiny, 1/10 inch-long seeds.

Japanese knotweed spreads quickly to form dense thickets that exclude native vegetation and greatly alter natural ecosystems. It poses a significant threat to riparian areas, where it is able to rapidly colonize after scouring floods. Once established, populations are extremely persistent. Japanese knotweed spreads primarily by vegetative means. It may also be transported by water, and the tiny seeds may be wind-dispersed. It naturalizes easily from gardens; discarded cuttings are common routes of dispersal from urban areas.

This invasive species can tolerate a variety of adverse conditions including full shade, high temperatures, high salinity, and drought. It is found near water sources, such as along streams and rivers, in low-lying areas, waste places, utility rights-of-way, and around old homesites. It can quickly become an invasive pest in natural areas after escaping from cultivated gardens.

Japanese knotweed was probably introduced to the U.S. in the late 1800's. Also known as crimson beauty, Mexican bamboo, Japanese fleece flower, or Reynoutria, it was first introduced as an ornamental and has also been used for erosion control and for landscape screening. It is now found throughout the eastern U.S., in several western states, and Alaska.

This plant was recently discovered for sale at a nursery in Star Valley, east of Payson (Brock 2004).

Sulfur cinquefoil
Potentilla recta L.

Sulfur cinquefoil is a perennial shrub of the Rose family, native to Eurasia and North Africa. It grows to a height of 1 – 1 ½ feet, with 1 to 8 unbranching stems. The entire plant is covered with shiny erect hairs. A single plant can live up to 30 years. The plant has a single taproot, and may have several spreading branch roots. Flowers are pale yellow with petals up to 1 inch in length.

It can grow in biomes that range from coniferous forests to pinyon-juniper to grassland. It is a very competitive plant – it has been reported to replace spotted knapweed in Montana (Rice 1991). It is a prolific seed producer, averaging up to 5600 seeds per plant. Seeds are wind-dispersed, but typically falling within a foot of the parent plant. Long-distance dispersal can use several vectors, as seeds become easily attached to anything passing by. Research indicates seed may remain viable in the soil for more than 4 years (Endress & Parks 2004).

Sulfur cinquefoil is an aggressive invader, causing a decrease in biodiversity of native plant communities, and altering natural successional processes. *Potentilla* recta has been known to hybridize with other species of the same genus under natural conditions, thus causing reduced reproductive success of native *Potentilla* species (Endress & Parks 2004).

In northern Arizona, it has been documented along the Rio de Flag and on the Lake Mary Road on the Coconino National Forest. It has not been found on the Tonto National Forest.

Pyracantha
Pyracantha M. Roemer

Pyracantha is a commonly used landscaping shrub in the rose family that has small, shiny green leaves, spiny stems, and small clusters of white flowers in the spring that mature to red berries. It was introduced from China as an ornamental plant. Seeds spread by either water or bird distribution.

It is uncommon for this plant to be invasive in the southwest. There is one site that has been identified on the Tonto, where plants probably originated from nearby ornamental plantings, along Camp Creek at the recreational residences. It was removed by the Cave Creek Complex Fire in July 2005; further observations will be made to assess whether it can return after being burned.

African sumac
Rhus lancea L.

This species is recommended as a low water use plant for landscaping by the Arizona Department of Water Resources website (ADWR 2004). It has been used extensively in

landscaping throughout the Phoenix metropolitan area, and is beginning to naturalize in areas with slightly higher runoff or greater moisture conditions than the surrounding desert. It may pose a threat to native trees in riparian ecosystems in the Sonoran Desert.

It has not been documented on the Tonto at the time of this writing.

Russian thistle
Salsola kali L., *Salsola tragus* L.

Russian thistle was brought to the U.S. from Russia in flax seed about 100 years ago. It has spread rapidly. It is an annual bushy plant, growing to from ½ foot to 6 feet in height. At maturity, the stem breaks off at ground level, giving the plant its most common name, tumbleweed. Seeds are dispersed as the plant tumbles across miles of desert. One plant may produce thousands of seeds, which remain viable for years.

Russian thistle is a restricted noxious weed in Arizona. It is a common invader of disturbed areas, especially along roadsides. In Arizona it has not been observed moving into undisturbed areas. Nitrates produced during periods of rapid growth may be toxic to wildlife and livestock.

It is found on the Tonto on recently disturbed soils along roads and highways, and at mining and millsites. Experienced natural resource managers at the Arizona Department of Transportation state they have not seen this plant spread beyond the immediate area of disturbance, where it phases out under competition when native perennial grasses and other native plants recover (Horsley 2004).

Mediterranean sage
Salvia aethiopis L.

Mediterranean sage is an erect, coarse biennial or short-lived perennial, with a stout taproot. The squarish stem, opposite leaves and bilabiate flowers are typical of the mint family. When crushed, a sage-like odor is emitted.

This species is native to Mediterranean North Africa. In Nevada it invades rangelands and pastures, but spread to undisturbed areas has been limited.

Mediterranean sage reproduces by seed. Each plant can produce 50 to 100,000 seeds. Each flower produces four smooth, egg-shaped seeds. Seeds mature by late August, but they are not usually dispersed until September or October, when consistent moisture is available for germination. Mediterranean sage acts like a tumbleweed to disperse the seeds. The flowering stem has an abscission line 4-6 inches above the ground. The stem becomes brittle and light, and breaks off at this line. These stalks roll with the wind, often ending up in fence lines, or creek bottoms. When seeds get wet and imbibe water, they produce a mucilaginous cover within 5 minutes to protect them from desiccation (WSNWCB 1999).

Mediterranean grass
Schismus arabicus Nees, *S. barbatus* (L.) Thell.

Mediterranean grass is an annual short grass, native to southern Europe, northern Africa and the Near East (Jackson 1985). It was in Arizona before the 1900's, and is now particularly abundant where grazing, off-road vehicle use, or construction of linear corridors has reduced vegetative cover. Mediterranean grass out-competes the native annual grass, six-weeks fescue, and tends to replace it through time (Brooks undated).

Schismus germinates in early winter, normally 2 weeks after receiving 0.4 inches of precipitation. It typically matures in March, but can produce seed in as little as two weeks. *Schismus* can also germinate after summer rains and can survive for up to four months with no additional rains (Gutterman & Evenari 1994).

It generally occupies the space between shrubs in desert communities, and its extensive shallow root system monopolizes precipitation to the exclusion of native annual grasses. Dead stems of *Schismus* remain standing for long after the plant dies, serving to carry fire across inter-shrub spaces in normally sparse deserts of Arizona and California.

Wild mustard
Sinapis arvensis L.
Wild mustard is a winter annual forb, with bright yellow, four-petalled flowers in small clusters sitting on thick stalks. The stems are branched near the top and have upper leaves that are toothed and lower leaves with deep lobes, both hairy underneath. Mature plants are 0.3 - 1 m tall. Wild mustard is spread by seed. Each plant produces 2,000 - 3,500 seeds that may remain viable in the soil for several years. It is commonly a crop weed. It reduces crop yields, lowers crop value, and can reduce livestock forage production on pastures. Wild mustard is native to Eurasia.

There are a few small infestations of this mustard growing along Highway 188, from Punkin Center to Roosevelt, on private lands. It is very common on the Agua Fria National Monument, west of Cave Creek Ranger District's Perry Mesa tobosa grassland. The combination of drought, fires, and grazing may have allowed the infestation on the Monument to increase in recent years (Fenner 2005b).

Salt cedar
Tamarix parviflora DC., *Tamarix chinensis* Lour., *T. ramosissima* Ledeb.

"There is probably not another genus of plants as well known as the tamarisks in which the species are so poorly understood or separated on more obscure characters" (McClintock 1951). Each species has a distinct distribution in Eurasia, but they may have hybridized in the southwestern United States (Smith et al 1997). Most salt cedars, or tamarisks, are deciduous shrubs or small trees growing to 12 -15 feet in height and forming dense thickets. Salt cedars are characterized by slender branches and gray-green foliage. The bark of young branches is smooth and reddish-brown. As the plants age, the bark becomes brownish-purple, ridged and furrowed. Leaves are scale-like, about 1/16 inch long and overlap each other along the stem. They are often

encrusted with salt secretions. From March to September, large numbers of pink to white flowers appear in dense masses on 2-inch long spikes at branch tips. Salt cedar spreads vegetatively, by adventitious roots or submerged stems, and sexually. Each flower can produce thousands of tiny (1/25-inch diameter) seeds that are contained in a small capsule usually capped with a tuft of hair that aids in wind dispersal. Seeds can also be dispersed by water. Seedlings require extended periods of soil saturation for establishment. The fragile seeds remain viable for at most 45 days under ideal conditions. (Stevens 1990).

Salt cedar is found in many riparian areas throughout the West. It was introduced in the early 1800's as an ornamental and for erosion control.

Salt cedars are fire-adapted species and have long tap roots that allow them to intercept deep water tables and interfere with natural aquatic systems. They can also increase the risk of fire in riparian ecosystems through deposition of flammable fuels (Brooks & Minnich in press).

Salt cedar disrupts the structure and stability of native plant communities and degrades native wildlife habitat by out-competing and replacing native plant species, monopolizing limited moisture, and increasing the frequency, intensity and effect of fires. The foliage of tamarisk can add salt deposits to the soil, inhibiting growth of other species (Egan et al. 1993, Brotherson & Field 1987). Although it provides some shelter, the foliage and flowers of salt cedar provide little food value for native wildlife species that depend on nutrient-rich native plant resources (Muzika & Swearingen 2005b, Brooks & Minnich, In press).

Salt cedar is able to use salty water. It does this by absorbing the salts through cell membranes. It avoids the toxic effects by using special glands to excrete the salts and by dropping salt-filled leaves. The leaves dropped each fall accumulate to a considerable depth under the canopy. Through this process, salt cedar acts as a salt pump concentrating salts from deep in the ground onto the soil surface. Over time, salts in the mulch layer kill existing plants and prevent others, especially desirable riparian species, from becoming established. As a result, the ground under a salt cedar or within a salt cedar thicket is void of plants except, on occasion, another salt tolerant species (Johnson et al 2002).

The federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*) is known to nest in salt cedar thickets. There has been concern that control of salt cedar would present a threat to recovery of this subspecies of flycatcher. In fact, this endangered flycatcher prefers to feed and breed in riparian woodlands dominated by native plants such as willow, baccharis, and arrowweed. Where salt cedar is removed by control treatments, recovery by these native plants would be expected to fill this void (Lovich and de Gouvenain 1998). In addition, flycatcher nests would be subject to much greater risk of fire in salt cedar dominated riparian areas than in riparian areas dominated by native vegetation.

On the Tonto, salt cedar grows sparsely in many small drainages and along the Verde River and its tributaries. It grows densely along much of the Salt River both above and below the chain of lakes. Salt and Verde River reservoirs have created habitat for salt cedar at inflows into the reservoirs, where there are deep silt deposits and water levels fluctuate too much for native riparian trees such as cottonwood and willow to survive (Fenner 2005b).

Siberian elm
Ulmus pumila L.

Siberian elm is a fast-growing tree in the elm family (Ulmaceae) distinguished by small toothed leaves about 1-2½ in long and half as wide, and pointed at the tip. Mature trees reach a height of 50-70 feet, with a round crown of slender, spreading branches. The bark is rough, gray or brown, and shallowly furrowed at maturity. Flowering occurs in the springtime, either before or with bud break for leaves. After flowering, a single seed forms in the center of each smooth, flattened, circular, ½ inch wide fruit. The seeds are easily windborne to distant areas and germination rate is high (Wieseler 2005)

Preferred habitat is dry to mesic open areas and streambanks at high elevations. Once a tree has become established, thickets of seedlings form underneath it and in disturbed sites in the vicinity. Fast growing seedlings easily overtake native vegetation, especially shade-intolerant species. This often leads to invasion by additional weedy species. (Wieseler 2005).

This tree was introduced to the U.S. in the 1860's for its cold and drought-hardiness (Wieseler 2005). It is fairly common in northern Arizona, often planted as a shade tree. There are currently isolated infestations on the Coconino National Forest east of Flagstaff, and in the Verde River/Lynx Lake/Thumb Butte areas of the Prescott National Forest (USDA FS Feb. 2004). There are no documented populations of this plant on the Tonto National Forest.

Periwinkle
Vinca major L.

Vinca is a spreading perennial vine, introduced from southern Europe and northern Africa as an ornamental groundcover and medicinal herb. It spreads vegetatively and is not known to reproduce sexually (Bean & Russo 1986). Plants spread by sprawling stems that root at the nodes. It grows best in moist shady environments.

In the U.S., *Vinca*'s range extends from California throughout the southern states.

Water can spread broken stem fragments along riparian areas, where it can easily sprout and spread rapidly. Once established, it forms a dense groundcover that prevents growth and establishment of other plant species (Drewitz 2005). In Ramsey Canyon in southern Arizona, *Vinca* has suppressed natural erosional processes in the creek, promoting deepening and scouring of the creek bed and altering local hydrology and vegetation (McKnight 1993).

Vinca naturalizes from gardens on private lands within or adjacent to the National Forest. Grantham homestead on Highway 288 is one example.