Forest and Woodland Health

2018 Invasive Plant Treatment Prioritization

Planning Analysis for the Department of Forestry and Fire Management

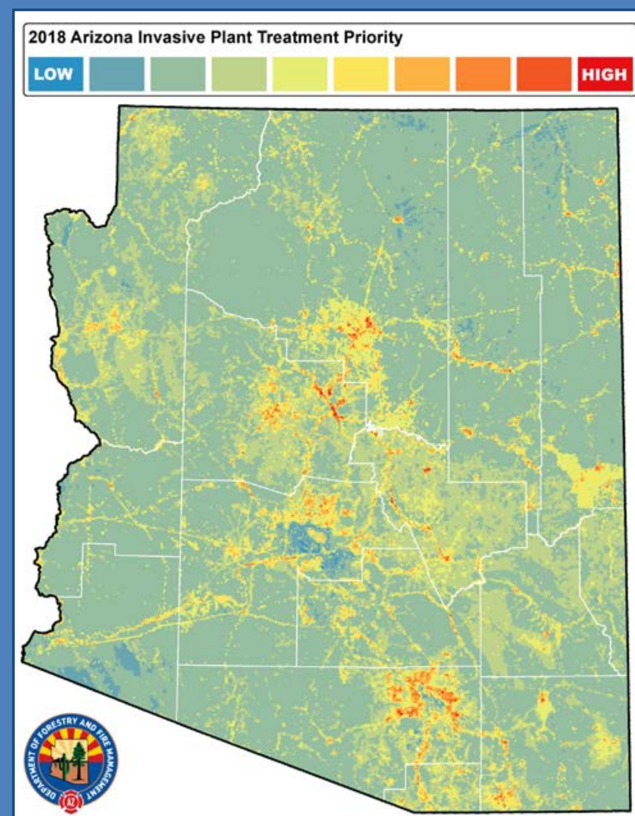


Table of Content

I. Executive Summary 3
II. Introduction 4
A. Intent 4
B. Target Audience 4
C. How to Use and Cite 5
III. Methodology 5
D. Analysis Area 6
E. Wildfire Risk Index 6
F. Riparian Area Index 7
G. Protected Species Index 7
H. Spread Corridors Index 7
I. Invasive Plant Threat Level Index 8
J. Prior Treatments Index 10
K. Wildland Urban Interface (WUI) Index 11
L. Undeveloped Areas Index 11
M. Invasive Plant Treatment Prioritization Index 12
N. Methodology Summary 13
IV. Results 14
O. IPTP Model Evaluation 14
P. 2018 Invasive Plant Treatment Prioritization Products 16
Q. 2018 Invasive Plant Treatment Priority Map 17

Figure 1: Fire Risk Index (blue = low, red = high) with overlaid analysis hexagons for Flagstaff, AZ 6
Figure 2: Riparian, wetland, and modified flood areas plus analysis hexagons near Camp Verde, AZ. 7
Figure 3: From left to right: Flagstaff to Verde River; greater Phoenix area; greater Tucson area. 14

Table 1: DFFM modified 2017 ADA Invasive Plant Threat Level list and species observation datasets. 8
Table 2: PCA of IPTP sub-indices and their predictive strength of full priority range (Master Index 0 to 1). 15
Table 3: PCA of IPTP sub-indices and their predictive strength of high priority areas (Master Index values ≥ 0.5). 15

I. Executive Summary

This report summarizes the intent, methodology, and results of the 2018 Invasive Plant Treatment Prioritization (IPTP) analysis of the Forest and Woodland Health Program (FH) at the Arizona Department of Forestry and Fire Management (DFFM). The purpose of the analysis was to assess the Arizona landscape and identify invasive plant treatment priority areas based on management criteria.

The spatial analysis, based on square mile hexagons, generated eight sub-indices for criteria identified by an expert panel: Fire Risk, Riparian Areas, Protected Species, Spread Corridors, Invasive Plant Threat Level, Prior Treatments, Wildland Urban Interface (WUI), and Undeveloped Areas. The eight sub-indices were combined into one IPTP Master Index. The resulting reports, maps, and GIS data provide compiled information that can be easily used for identifying areas for strategic invasive plants management across Arizona.

The analysis has been welcomed with interest by local, state, and federal land management professionals. Initial feedback pointed out the need to transition from a statewide prioritization to a more local planning tool. For example, a breakdown of species composition and population trends per analysis hexagon would help identify applicable treatment methods. This being the first spatio-quantitative analysis effort of its kind by DFFM, time is needed to tell the effectiveness of the analysis and products. The analysis and products represent a work in progress which is expected to improve as better data becomes available and analysis criteria and methods are improved.

This report is limited at conveying the scale and depth of the analysis results which – for more detailed use – are best explored through print and interactive maps or the GIS data available through the FH Program webpage at https://dffm.az.gov/forestry-community-forestry/forest-health.

II. Introduction

The analysis and results presented in this document were developed by the Forest and Woodland Health Program (FH) at the Arizona Department of Forestry and Fire Management (DFFM). Invasive plants are a major threat across the state of Arizona. They occur across all land ownerships, change the natural fire regime, alter watersheds, out-compete native vegetation and crops, and destroy the natural beauty of the Arizona landscape. The USDA Forest Service (USDA FS) estimated that invasive plants are spreading at about 1.5 million acres per year and impact the U.S. economy at $30 billion dollars annually (https://www.fs.fed.us/foresthealth/management/fhm-invasives-plants.shtml).

DFFM's FH Program is a cooperative forestry program, funded primarily by USDA FS, that provides information, education, technical assistance, and integrated management strategies to prevent and suppress invasive plants, insect and disease infestations, and achieve healthy forest, woodland, and rangeland conditions. The DFFM FH Program assists private landowners, professional foresters, and other stakeholders in their management needs. When dealing with invasive plants, focus is on prevention, control, and eradication. The program supports increasing local capacity to manage encroachment of invasive plants and employs an integrated weed management approach to target and treat invasive plants capable of transforming plant communities. Since 2007, the DFFM FH program has awarded almost $1 million dollars in invasive plant projects with approximately 1.5 times that amount in partner matching contributions.

In 2017, the FH Program identified the need for a rapid spatial assessment of invasive plant species and their management needs in Arizona to identify areas that would benefit from increased invasive plant management efforts. The 2018 Arizona Invasive Plant Treatment Prioritization (IPTP) analysis represents an ongoing, strategic effort to spatially and quantitatively assess existing invasive plants management data and identify treatment priority areas.

A. Intent

The intent of the IPTP analysis is to:

- Rapidly and strategically assess AZ’s invasive plants management data
- Use data to inform DFFM future priorities in FH planning
- Account for existing invasive plant management efforts from local to federal level
- Keep spatial and quantitative analysis simple and transparent
- Generate summaries and geospatial products for internal and public dissemination

The analysis and products will inform future DFFM priorities for program delivery and may be used directly by communities for their management needs.

B. Target Audience

Although the Invasive Plant Treatment Prioritization analysis and resulting products are intended primarily to inform FH program planning, their use by Arizona’s communities and others to improve invasive plant management are encouraged. However, please note that the analysis results are limited and caution should be used when drawing conclusions that exceed the analysis intent and data limitations. See the Method's section on page 5 for a detailed description.

C. How to Use and Cite

Use is granted to public agencies, educational institutions, non-profit organizations and private individuals for non-commercial purposes. For commercial use of the Department of Forestry and Fire Management maps and data see Arizona Revised Statutes 39-121.03. The Department makes no warranties, implied or expressed, with respect to accuracy and use of this data for any specific purpose. Users are required to make their own assessment of the data for any specific use.

Cite this product as:
FH. 2018 Invasive Plant Treatment Prioritization. Phoenix: Arizona Department of Forestry and Fire Management, 2018.

III. Methodology

The IPTP analysis parameters and spatial units were determined by available data and expert opinion. An advisory panel comprised of local, state, and federal natural resource managers and invasive plant experts suggested a number of managerial and environmental measures to be considered in the analysis. The expert panel included professionals from Arizona Department of Agriculture (ADA), Arizona Department of Transportation (ADOT), Arizona Game and Fish Department (AGFD), Arizona State Land Department (ASLD), Arizona-Sonora Desert Museum, Bureau of Land Management (BLM), DFFM, U.S. Fish and Wildlife Service (US FWS), University of Arizona Cooperative Extension, and USDA FS. The initial list of general topics included: fire risk, riparian areas, protected species, spread corridors, Invasive Plant Threat Levels, areas of prior treatments, economic impact, accessibility for treatment, higher risk to introduction (Wildland Urban Interface - WUI), water bodies of high value, undeveloped areas, and sustainability. Existing local, state-, and nation-wide datasets were a good fit for most topics; but, in a few cases, alternate datasets had to be created or found. Economic impact, accessibility for treatments, water bodies of high value, and sustainability parameters were not included because of quantification difficulties, due to limited data availability, and to reduce double counting. We attempted to capture a measure of invasive plants treatment sustainability by supporting areas with active, local weed or invasive plant management groups but were not able to capture it spatially in a representative manner at the time of analysis.

For better cross comparison, the selected dataset's scores were converted into a normalized index with a value range between 0 (“cool”) and 1 (“hot”):

```
normalized index value = (score value – score min) / (score max – score min)
```

All indices have been calculated for a 1 square mile hexagon analysis area. A hexagon GIS layer provided by AGFD ensured a uniform and standardized spatial unit at an appropriate resolution which was unmistakable from land ownership boundaries.

The 8 normalized indices were averaged by adding them together and dividing them by 8 to generate a final score. Besides normalizing all scores between 0 and 1, we did not apply any statistical corrections or preference weights to the 8 sub-indices. See the Methodology Summary section on page 13.

D. Analysis Area

For the Arizona-wide spatial analysis unit, we relied on 1 square mile hexagons that remain unmistakable from land ownership boundaries (e.g. Public Land Survey System's Township, Range, and Section boundaries). We used various methods to summarize source data to a hexagon such as converting data to area-weighted measures, measuring vector line length per hexagon, or counting point observations within hexagons. Although there are minor area-size variations in the hexagons, we treated them as equal-sized. The final score for hexagons wholly covered by lakes were set to null (NO DATA).

E. Wildfire Risk Index

For the Fire Risk index, we used the Arizona Wildfire Risk Portal's (AZWRAP https://arizonawildfirerisk.com/) wildfire Fire Risk Index (FRI) raster data developed as part of the 2012 West Wide Assessment by the Council of Western State Foresters (CWSF). The original 9 FRI classes (1= Very Very Low to 9 = Extreme fire risk) at a 30m by 30m resolution were modified to include the "Not Defined" class with a value of 0 for interior urban areas and areas outside of Arizona (originally NO DATA). Because of the 0-value class, the average FRI value calculated per hexagon will result in underestimates for hexagons crossing Arizona's borders. However, hexagons crossing into urban areas with presumed very low wildfire risk will less likely overestimate the average fire risk. The average FRI score per hexagon was normalized between 0 (low) and 1 (high) IPTP Wildfire Risk index.

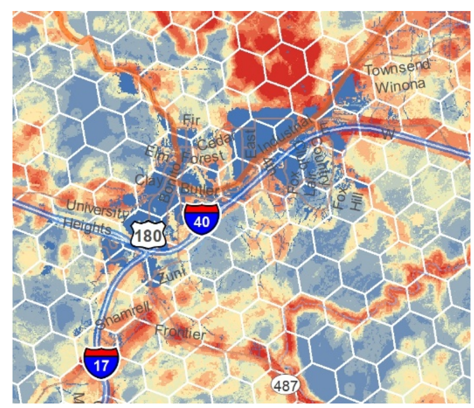


Figure 1: Fire Risk Index (blue = low, red = high) with overlaid analysis hexagons for Flagstaff, AZ

F. Riparian Area Index

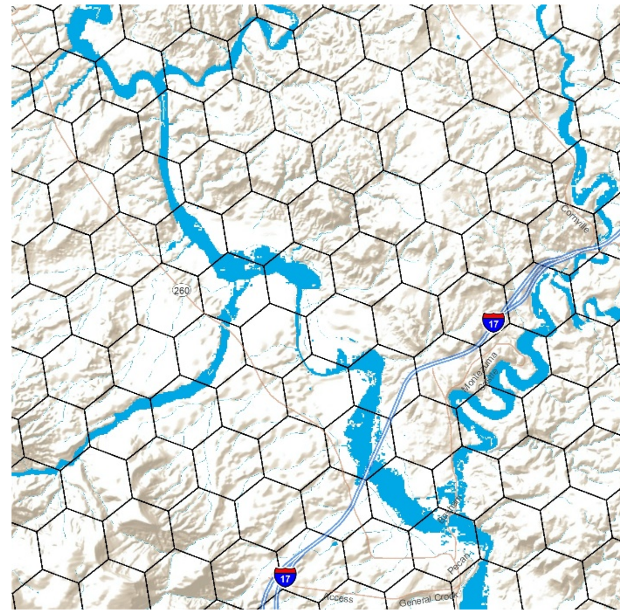


Figure 2: Riparian, wetland, and modified flood areas plus analysis hexagons near Camp Verde, AZ.

Capturing Arizona's diminishing yet ecologically valuable riparian areas was challenging due to definition difficulties in context of invasive plant species management and lack of statewide data. We ended up combining US FWS 2017 Riparian and Wetland polygon data (https://www.fws.gov/wetlands/data/data-download.html) with a modified 2017 Federal Emergency Management Agency (FEMA) Flood Hazard polygon dataset (https://catalog.data.gov/dataset/national-flood-hazard-layer-nfhl). We used FEMA's 1% Annual Chance Flood Hazard zones (flood zone: A, AE, AH, AO, and VE) to identify 100-year flood zones. Because much of the 100-year flood zones cover built-up areas and agricultural land, we used the U.S. Department of Agriculture's (USDA) 2015 Cropland Data Layer (CDL; https://www.nass.usda.gov/Research_and_Science/Cropland/Release/index.php) at 30m by 30m resolution to identify and exclude cropland and built-up areas. For each hexagon, we calculated the acres of the modified and merged riparian areas, wetlands, and flood zones. Hexagons wholly covered by lakes were set to null (NO DATA). The acres were normalized between 0 (low) and 1 (high) Riparian Area index.

> Since the writing of this report, USDA came out with a 2017 CDL product, which will be included in the next iteration of the IPTP analysis.

G. Protected Species Index

To capture areas with sensitive and listed animal and plant species, we used AGFD's Heritage Database Management System data (HDMS; https://www.azgfd.com/Wildlife/HeritageFund/). HDMS' polygon layer summarizes species observations from 1969 to 2017 in one square mile hexagons. For each IPTP hexagon, we calculated the observed species diversity. The species diversity count was normalized between 0 (low) and 1 (high) Protected Species index.

H. Spread Corridors Index

To capture major spread corridors for invasive plants species we combined roads and perennial streams. The 2017 U.S. Census TIGER Roads dataset provided the best state-wide coverage of urban, rural, and two-track roads in Arizona (https://www.census.gov/geo/maps-data/data/tiger-line.html). ASLD's 2006 Stream dataset provided the most consistent perennial streams classification for Arizona (https://land.az.gov/mapping-services/sco/gis-data-sources). At the time of analysis, U. S. Geologic Survey's (USGS) National Hydrography Dataset (NHD) suffered from inconsistent stream classification in Arizona and could not be used. We calculated miles of combined roads and perennial streams per analysis hexagon. The miles of spread corridors were normalized between 0 (low) and 1(high) Spread Corridors index.

I. Invasive Plant Threat Level Index

We revised the ADA (https://agriculture.az.gov/) August 15, 2017, draft Invasive Plant Threat Level (ITL) table to identify invasive plant species of greatest management concern. The modified ITL species list divides species into 3 categories (see Table 1 for a full species listing):

> ***Class A*** *weeds are newcomers to the State of Arizona and still have a limited distribution. Preventing new infestations of these species and eradicating existing infestations is the highest priority.*
> ***Class B*** *weeds are limited to portions of the state. In areas with severe infestations, management should be determined to contain the infestation and stop any further spread.*
> ***Class C*** *weeds are widespread in the state of Arizona. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation.*

We modified and combined the following point- and polygon-based plant species databases to create a more comprehensive Arizona-wide invasive species observations dataset (see Table 1 for species and data source cross listing):

- **2017 iMapInvasive** data of invasive plant species observations provided by AGFD (116,259 point records; https://www.imapinvasives.org/). Among others, includes the 2007 Southwest Exotic Plant Mapping Program (**SWEMP**) data.
- **2018 SEINet** statewide herbarium specimen and field observation data (445,259 usable point records; http://swbiodiversity.org/seinet/).
- **BLM's 2018** Weed Infestation Location data (36,844 polygon records).
- **USDA FS 2018** Invasive Plant Current data (24,320 polygon records).

Table 1: DFFM modified 2017 ADA Invasive Plant Threat Level list and species observation datasets.

Species Code	Scientific Name	Common Name	Invasive Threat Level	iMap Invasives 2017	SEINet 2018	BLM 2018	USDA FS 2018
ACRE3	*Acroptilon repens*	Russian knapweed	B	yes	yes	no	yes
AECY	*Aegilops cylindrica*	Jointed goatgrass	B	yes	yes	yes	yes
AIAL	*Ailanthus altissima*	Tree of heaven	C	yes	no	yes	yes
ALMA12	*Alhagi maurorum (A. pseudalhagi)*	Camelthorn	B	yes	yes	yes	yes
ARDO4	*Arundo donax*	Giant reed	B	yes	yes	yes	yes
ASFI2	*Asphodelus fistulosus*	Onionweed	A	yes	yes	yes	yes

Species Code	Scientific Name	Common Name	Invasive Threat Level	iMap Invasives 2017	SEINet 2018	BLM 2018	USDA FS 2018
BOIS	*Bothriochloa ischaemum*	Yellow bluestem	**B**	no	yes	no	yes
BRNI	*Brassica nigra*	Black mustard	**B**	yes	yes	yes	yes
BRTO	*Brassica tournefortii*	Saharan mustard	**B**	yes	yes	yes	yes
CADR	*Cardaria draba*	Globe-podded hoary cress	**A**	yes	yes	yes	yes
CAAC	*Carduus acanthoides*	Plumeless thistle	**A**	yes	no	yes	no
CANU4	*Carduus nutans*	Musk thistle	**B**	yes	yes	yes	yes
CEEC	*Cenchrus echinatus*	Southern sandbur	**A**	no	yes	no	no
CESP4	*Cenchrus spinifex* (synonym: *C. incertus)*	Field sandbur	**B**	no	yes	no	no
CECA2	*Centaurea calcitrapa*	Purple starthistle	**A**	no	yes	no	no
CEDI3	*Centaurea diffusa*	Diffuse knapweed	**B**	yes	yes	yes	yes
CEME2	*Centaurea melitensis*	Malta starthistle	**B**	yes	yes	yes	yes
CESO3	*Centaurea solstitialis*	Yellow starthistle	**B**	yes	yes	yes	yes
CESTM	*Centaurea stoebe* ssp. *Micranthos (C. maculosa, C biebersteinii)*	Spotted knapweed	**A**	yes	yes	no	yes
CHJU	*Chondrilla juncea*	Rush skeletonweed	**A**	yes	yes	yes	no
CIAR4	*Cirsium arvense*	Canada thistle	**A**	yes	yes	yes	yes
CIVU	*Cirsium vulgare*	Bull thistle	**B**	yes	yes	yes	yes
COAR4	*Convolvulus arvensis*	Field bindweed	**C**	yes	yes	yes	yes
CUME	*Cucumis melo v. Dudaim Naudin*	Dudaim melon	**A**	no	yes	no	no
DRAR7	*Drymaria arenarioides*	Alforbrilla	not included				
EICR	*Eichhornia crassipes*	Floating water hyacinth	**A**	no	no	yes	no
ELAN	*Elaeagnus angustifolia*	Russian olive	**B**	yes	yes	yes	yes
ELRE4	*Elymus repens (Elytrigia repens)*	Quackgrass	**A**	yes	yes	yes	yes
EUES	*Euphorbia esula*	Leafy spurge	**A**	yes	yes	yes	yes
EUSUV	*Euryops subcarnosus*	Sweet resinbush	**A**	yes	yes	no	no
HAGL	*Halogeton glomeratus*	Halogeton	**B**	yes	yes	yes	no
HECI	*Helianthus ciliaris*	Texas blueweed	not included				
HYVE3	*Hydrilla verticillata*	Hydrilla	**A**	no	yes	yes	no
IPCO3	*Ipomoea coccinea*	Scarlet morning glory	**C**	no	yes	no	no
IPHE	*Ipomoea hederacea*	Ivy-leaf morning glory	**C**	yes	yes	yes	yes

Species Code	Scientific Name	Common Name	Invasive Threat Level	iMap Invasives 2017	SEINet 2018	BLM 2018	USDA FS 2018
IPPU2	*Ipomoea purpurea*	Garden or common morning glory	C	yes	yes	no	no
IPTR3	*Ipomoea tricolor*	Grannyvine	C	yes	yes	no	no
IPTR2	*Ipomoea triloba*	Morning glory	C	no	no	no	no
IPLE4	*Ipomoea x leucantha*	No common name	C	no	yes	no	no
ISTI	*Isatis tinctoria*	Dyer's woad	A	no	yes	no	no
BASC5	*Kochia scoparia*	Kochia	C	no	yes	no	no
LIDA, LIDAD	*Linaria dalmatica (L genistifolia v. dalmatica)*	Dalmatian toadflax	B	yes	yes	yes	yes
LYSA2	*Lythrum salicaria*	Purple loosestrife	A	no	no	no	no
MEPO3	*Medicago polymorpha*	Burclover	C	yes	yes	yes	yes
MERE9	*Melinis repens*	Natal grass	B	yes	yes	yes	no
MYAQ2	*Myriophyllum aquaticum*	Parrotfeather	not included				
ONPI	*Oncosiphon piluliferum*	Globe chamomile	B	yes	yes	no	yes
ONAC	*Onopordum acanthium*	Scotch thistle	B	yes	yes	yes	yes
ORRA	*Orobanche ramosa*	Branched broomrape	B	no	no	no	no
PEHA	*Peganum harmala*	African rue	A	no	yes	no	no
PECI, CESE10	*Pennisetum ciliare (Cenchrus setiger)*	Buffelgrass	C	yes	yes	yes	yes
PESE3	*Pennisetum setaceum* (not *P. setaceum v. rubrum)*	Fountain grass	C	yes	yes	no	yes
POOL	*Portulaca oleracea*	Common purslane	C	no	yes	no	no
SAMO5	*Salvinia molesta*	Giant salvinia	A	no	yes	yes	no
SIAR4	*Sinapis arvensis*	Wild mustard	A	yes	yes	yes	yes
SOHA	*Sorghum halepense*	Johnsongrass	C	yes	yes	yes	yes
TARA	*Tamarix ramosissima*	Saltcedar	C	yes	yes	yes	yes
TRTE	*Tribulus terrestris*	Puncturevine	C	yes	yes	yes	yes

Double counted observations were not an issue because we only captured the presence of the highest ranked ITL species per hexagon where A > B > C. For the IPTP ITL score, we assigned a value of 3 to A rank, 2 to B rank, 1 to C rank hexagons and 0 to all other hexagons. The ITL score was then normalized between 0 (low) and 1 (high) Invasive Plant Threat Level index.

J. Prior Treatments Index

The intent is to favorably account for adjacency to future, current, and past invasive plants treatment projects. However, due to difficulties in spatially capturing planned and in-progress treatment projects, we limited the index to treated areas over the last 10 years. In addition to state and federal land managers, we reached out to over 40 invasive plants treatment groups and NGOs via contacts provided by Arizona Natural Resource Conservation Districts (NRCD; https://land.az.gov/natural-resource-conservation-districts), the Southwest Vegetation Management Association (SWVMA; https://www.swvma.org/), and Arizona Cooperative Extension county offices (https://extension.arizona.edu/). We were not able to convert Arizona Department of Transportation's (ADOT) weed treatment reports into a GIS accessible format in a timely manner to include in this round of analysis. The final invasive plants treatment data included point and polygon data from:

- **BLM** – Subset of Treatment Component Location and VTRT polygons
- **DFFM** – Invasive Plants Grants treatment polygons and points
- **Friends of the Verde River** and Verde Watershed Restoration Coalition(VWRC; https://verderiver.org/verde-watershed-restoration-coalition/) – treatment polygons
- **iMapInvasives** (provided by AGFD; https://www.imapinvasives.org/) – includes federal, state, and local treatment data
- **Kachina Village Improvement District** (KVID; https://www.kachinawater.com/) – treatment polygons
- **Prescott Creeks Preservation Association** – treatment polygons
- **Sky Island Alliance** (SIA; https://www.skyislandalliance.org/) – 2 Aravaipa treatments
- **USDA FS** – Arizona Invasive Treatment polygons

We buffered treatment points into circles of equal areas as reported by the treatment record. Points without treatment acres were dropped from the analysis. We merged all treatment polygons and buffered points into one polygon layer, which removed double counting. Next, we calculated treatment acres per IPTP hexagon to establish a ratio of treated and non-treated areas per analysis hexagon. The treated acres score was normalized between 0 (low) and 1 (high) Prior Treatment index.

K. Wildland Urban Interface (WUI) Index

Programmatically, we want to emphasize the WUI as an area of high risk to introduction as well as an area of increased treatment priority. We ran a union operation on University of Wisconsin-Madison SILVIS 2010 WUI dataset (http://silvis.forest.wisc.edu/maps/wui) and the analysis hexagons to calculate the acres of WUI (where WUIFLAG10 = Intermix WUI or Interface WUI) per hexagon. The WUI acres score was normalized between 0 (low) and 1 (high) WUI index.

L. Undeveloped Areas Index

We found it necessary to emphasize undeveloped land – treatment areas – over built-up areas. We assumed that there tends to be a higher information density, especially in the case of species observations, in and near urbanized areas than in more remote areas. In addition, we needed to counter our spread corridor index, which is heavily skewed by extreme road density in urban areas. We used the inverse % imperviousness of National Land Cover Database's (NLCD; https://www.mrlc.gov/nlcd11_data.php) 2011 Percent Developed Imperviousness raster layer at

30m by 30m resolution. After calculating the average % imperviousness per hexagon, we calculated the inverse (average % "undeveloped") and normalized the score between 0 (low) and 1 (high) Undeveloped Areas index.

M. Invasive Plant Treatment Prioritization Index

A Master Score was calculated by averaging all 8 sub-indices per analysis polygon which was then normalized to values ranging from 1 (“hot”) to 0 (“cold”) for the IPTP Master Index.

N. Methodology Summary

Index	Description	Data Source	Calculation
A Fire Risk	2012 AZWRAP Wildfire Risk Index (FRI): (average FRI / sqr. mile)	AZWRAP	$Index = \text{normalized } average\ fire\ risk$
B Riparian Areas	2017 FEMA 100-Year Flood Zone (developed and ag. land excluded with 2015 USDA CDL data), 2017 USFWS Riparian areas, 2017 USFWS Wetlands: (area / sqr. mile)	FEMA, USDA, USFWS	$Index = \text{normalized } "riparian"\ acres$
C Protected Species	1969 to 2017 AGFD HDMS species observations: (diversity count / sqr. mile)	AGFD	$Index = \text{normalized } protected\ species\ diversity$
D Spread Corridors	2017 U.S. Census roads and ASLD perennial rivers: (road and perennial river miles / sqr. mile)	U.S. Census, ASLD	$Index = \text{normalized } road\ \&\ river\ density$
E Invasives Threat Level	~1816 to 2018: USDA-FS, BLM, DFFM, iMapInvasives, and SEINet plant species observations ranked by ADA's 2017 draft Invasive Plant Threat Level list: (highest ranking per sqr. mile; where A=3, B = 2, C = 1)	USDA-FS, BLM, ADA, DFFM, iMapInvasives, SEINet	$Index = \text{normalized } threat\ level\ ranking$
F Prior Treatments	2017-2018 invasive plants treatment areas reported by USDA-FS, BLM, iMapInvasives, DFFM, and various NRCDs and NGOs: (merged treated acres / sqr. mile)	USDA-FS, BLM, iMapInvasives, DFFM, other	$Index = \text{normalized } treated\ acres$
G WUI	2010 SILVIS Wildland Urban Interface classification: (WUI acres / sqr. mile)	SILVIS	$Index = \text{normalized } WUI\ acres$
H Undeveloped Areas	2011 NLCD % Imperviousness: (inverse of average % imperviousness / sqr. mile)	NLCD	$Index = \text{normalized } \%\ undeveloped$
Invasive Plant Treatment Prioritization Index	The **Master Score** is the average of all sub-indices per analysis polygon. The **Master Index** is based on normalizing the Master Score per analysis polygon.		$Score = \frac{(A+B+C+D+E+F+G+H)}{8}$ $Index = \text{normalized } Score$
Spatial Analysis Unit = 1 square mile hexagons			

IV. Results

The simple, expert opinion based, and deterministic IPTP spatial model is not meant to provide an absolute measure but help the ongoing effort of strategically identifying invasive plant treatment priority areas across Arizona. The indices' values range from 0, or "cold," to 1, or "hot" (see Figure 3 and IPPM Map on page 17). Initial feedback indicated the need to transition from a statewide prioritization to a more local planning tool. For example, a breakdown of species composition and population trends per analysis hexagon would help identify applicable treatment methods. This analysis and results represent a work in progress which is expected to change as better data becomes available and analysis criteria and methods improve.

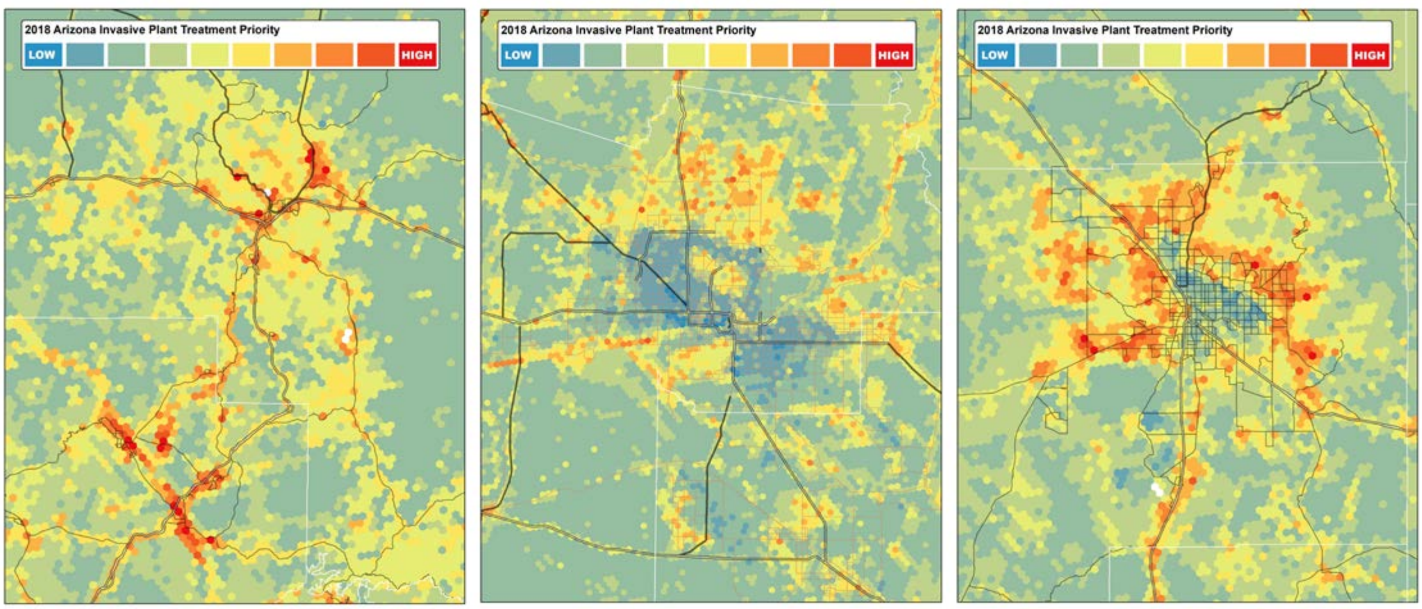


Figure 3: From left to right: Flagstaff to Verde River; greater Phoenix area; greater Tucson area.

O. IPTP Model Evaluation

We applied a Principal Components Analysis (PCA) to IPTP variables (sub-indices) and results (Master Index) using the GeoDA (https://spatial.uchicago.edu/geoda) spatial analysis tool to statically describe which IPTP sub-indices drive the Master Index values. PCA is a statistical procedure often used to help reduce a large set of variables to a smaller one which still contains most of the information in the original set. Notes:

- Variables of lesser statistical importance in determining overall Invasive Plants Treatment Prioritization may still be informative to management decision making.
- Arizona-wide top priority areas are not necessarily more important for management decision making than local high priority areas within communities, watersheds, road and drainage reaches, and ecological regions.

Running a PCA (Singular Value Decomposition method; Kaiser criterion = 3; correlation > 0.5) on all analysis hexagons (Master Index values 0 to 1) resulted in 3 meaningful Principal Components

(PC; see Table 2). The 1st PC shows that **Spread Corridor Index** and **WUI Index** account for the majority of STPP Master Index variability. The 2nd and 3rd PCs show that **Protected Species Index** and **Treated Areas Index** account for IPTP's remaining variability. A 95% threshold criterion of 6 PCs implies that all other Indexes except the Undeveloped Areas Index have some role in describing variability.

Table 2: PCA of IPTP sub-indices and their predictive strength of full priority range (Master Index 0 to 1).

IPTP (0-1) Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Fire Risk Index	0.118	0.471	-0.422	**0.501**	-0.253	-0.116	-0.494	0.118
Riparian Areas Index	0.136	0.162	-0.454	**-0.829**	-0.172	-0.060	-0.168	-0.020
Protected Species Index	0.153	**0.538**	-0.053	-0.010	**0.609**	-0.423	0.366	-0.026
Spread Corridor Index	**0.607**	-0.224	-0.009	0.012	0.030	0.028	0.110	**0.753**
Treated Areas Index	0.146	0.312	**0.612**	-0.119	**-0.579**	-0.390	0.080	0.010
Undeveloped Areas Index	-0.437	0.366	-0.171	0.004	-0.270	0.380	**0.535**	0.378
WUI Index	**0.523**	-0.066	-0.280	0.190	-0.291	0.165	0.481	**-0.513**
Invasives Threat Level Index	0.298	0.421	0.362	-0.108	0.205	**0.693**	-0.241	-0.107
PCA SVD method; Kaiser criterion: 3; 95% threshold criterion: 6; correlation > 0.5								

Running a PCA (Singular Value Decomposition method; Kaiser criterion = 3; correlation > 0.5) on just hexagons with high priority, where Master Index ≥ 0.5, resulted in 3 PCs with different variables (see Table 3). The 1st PC shows that **Spread Corridor Index** and **WUI Index** describe the majority of STPP Master Index variability. The 2nd and 3rd PCs shows that **Invasives Threat Level Index**, **Fire Risk Index**, and **Riparian Areas Index** describe the remainder of STPP Master Index variability. A 95% threshold criterion of 6 PCs implies that all remaining Indexes have some role in describing variability.

Table 3: PCA of IPTP sub-indices and their predictive strength of high priority areas (Master Index values ≥ 0.5).

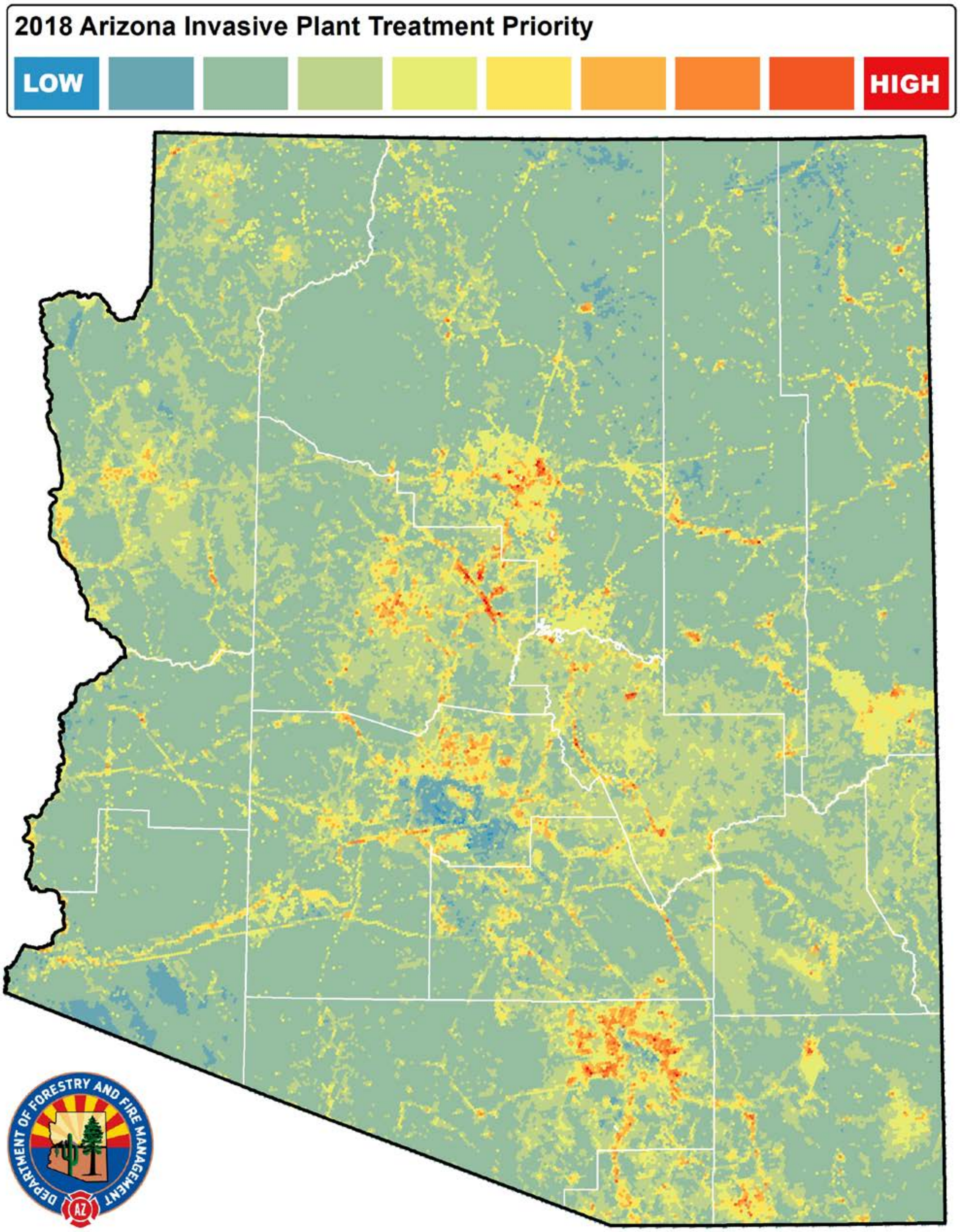
IPTP (≥ 0.5) Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Fire Risk Index	0.072	-0.271	**-0.752**	0.242	0.090	-0.498	0.196	-0.048
Riparian Areas Index	0.151	-0.480	**0.558**	-0.098	0.350	-0.392	0.339	-0.187
Protected Species Index	0.239	0.135	-0.311	**-0.750**	0.471	0.184	0.068	-0.070
Spread Corridor Index	**-0.547**	0.198	0.032	-0.161	0.067	-0.164	0.495	**0.598**
Treated Areas Index	0.103	0.450	0.062	**0.542**	**0.695**	0.070	0.017	0.015
Undeveloped Areas Index	0.476	-0.260	-0.058	0.198	-0.125	**0.538**	**0.503**	0.323
WUI Index	**-0.536**	-0.124	-0.115	0.086	0.065	0.417	0.358	**-0.609**
Invasives Threat Level Index	0.301	**0.594**	0.071	-0.050	-0.374	-0.262	0.465	-0.352
PCA SVD method; Kaiser criterion: 3; 95% threshold criterion: 6; correlation > 0.5								

P. 2018 Invasive Plant Treatment Prioritization Products

The spatial analysis results are available for download on DFFM's FH Project web site at https://dffm.az.gov/2018-invasive-plant-treatment-prioritization. Among the available products are:

- IPTP Report – this planning report
- IPTP Web Map – an interactive online map of the prioritization parameters and results
- IPTP GIS Data – spatial parameter and results data in Esri format

Q. 2018 Invasive Plant Treatment Priority Map



Special thanks for the advice and contributions from:

Arizona Department of Agriculture
Arizona Department of Transportation
Arizona Game and Fish Department
Arizona State Land Department
Arizona's Natural Resource Conservation Districts
Arizona-Sonora Desert Museum
Bureau of Land Management
U.S. Fish and Wildlife Service
University of Arizona Cooperative Extension
USDA Forest Service

Publication information: Arizona Department of Forestry and Fire Management – Forest Health (September 2018).
Prepared by Wolfgang Grunberg, John Richardson, and Cori Dolan.

Major funding provided by the USDA Forest Service.

Disclaimer of Non-endorsement

Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the Department or USDA Forest Service. The views and opinions of individuals expressed herein do not necessarily state or reflect those of the Department or USDA Forest Service, and shall not be used for advertising or product-endorsement purposes.

Geospatial Disclaimer

Property line representations and/or any other type of boundary, linear or point location representations contained within this data or displayed within this product are approximate, and cannot be used for authoritative location purposes. Users should independently research, investigate and verify all information before relying on it or using it in the preparation of legal documents. Legally-defensible property boundaries can only be established by state-registered professional land surveyors. A list of Arizona Registered Land Surveyors is available at btr.az.gov.