APPENDICES

Appendix A – Sonoran Desert Management Questions

Organization of Appendix A

The following sources and results are provided for each management question: a conceptual model and/or a Process Model and a description of the analytical process (including source data) for each management question and results in the form of maps and other supporting graphics. Access to a data portal to examine the results in greater detail is available at the BLM website: https://gbp-blm-egis.hub.arcgis.com
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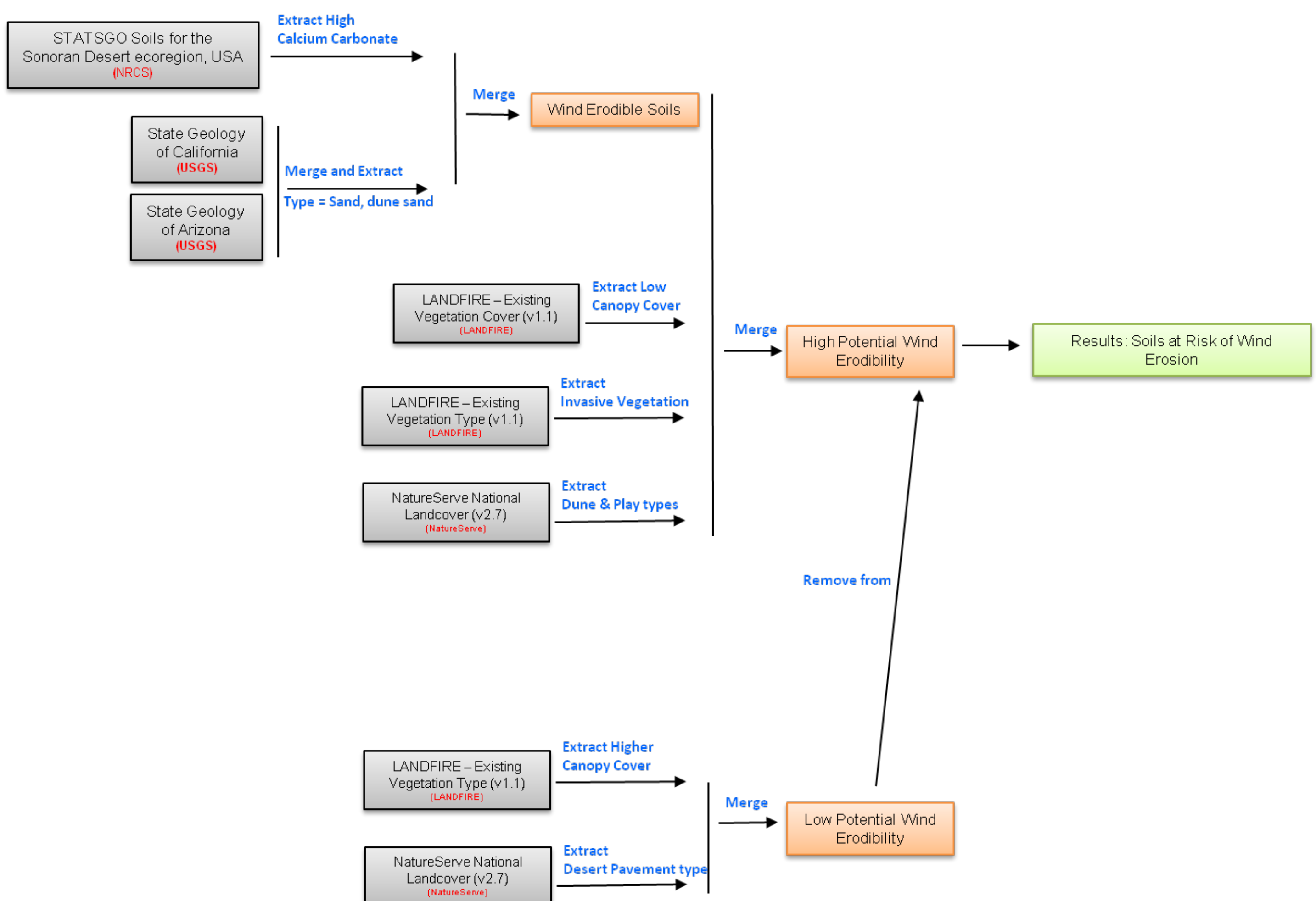
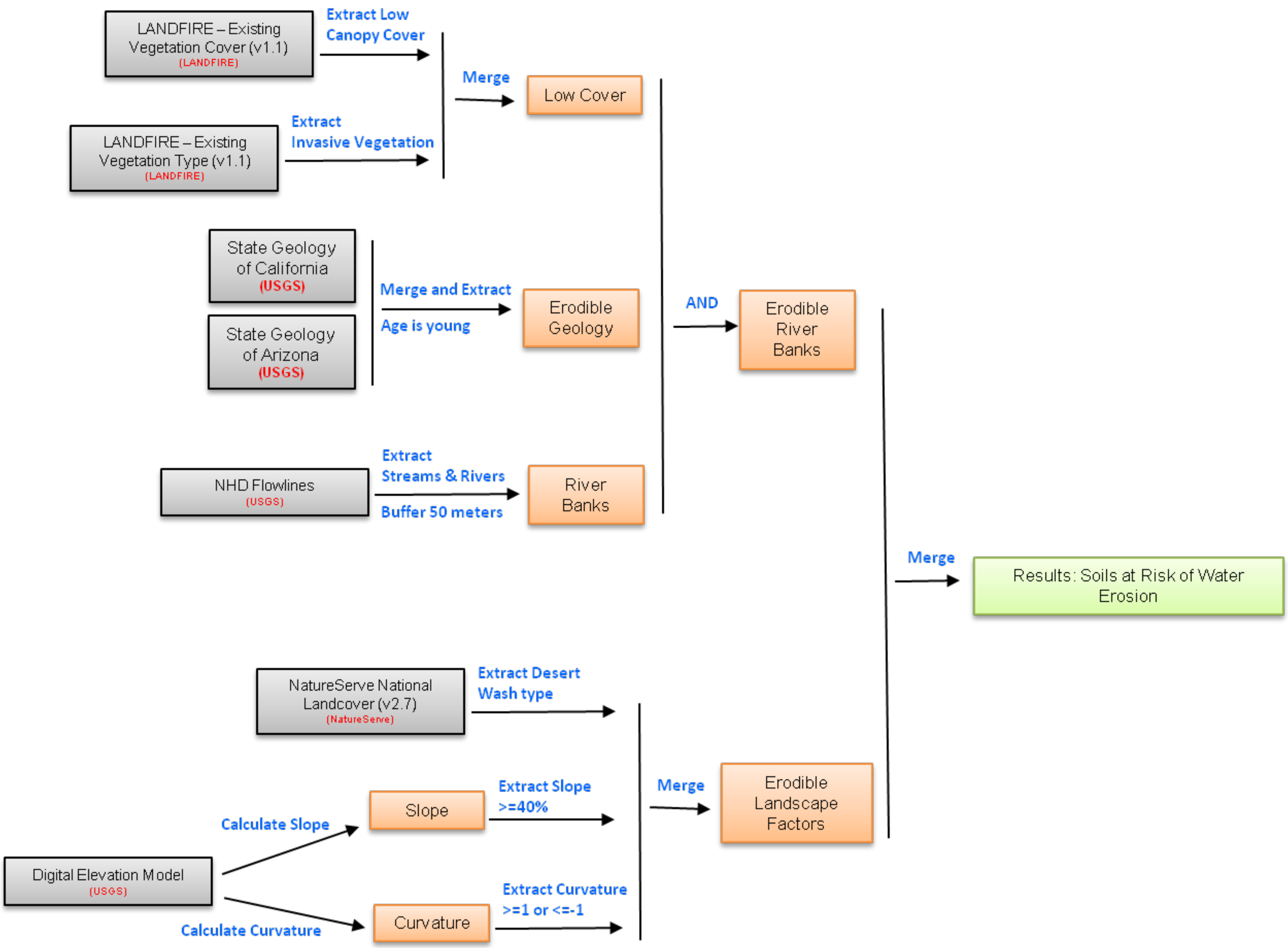
A. Soils, Biological Crust, and Forage Management

MQ A1. Where are soils susceptible to wind and water erosion?

Process Model: Wind Erosion

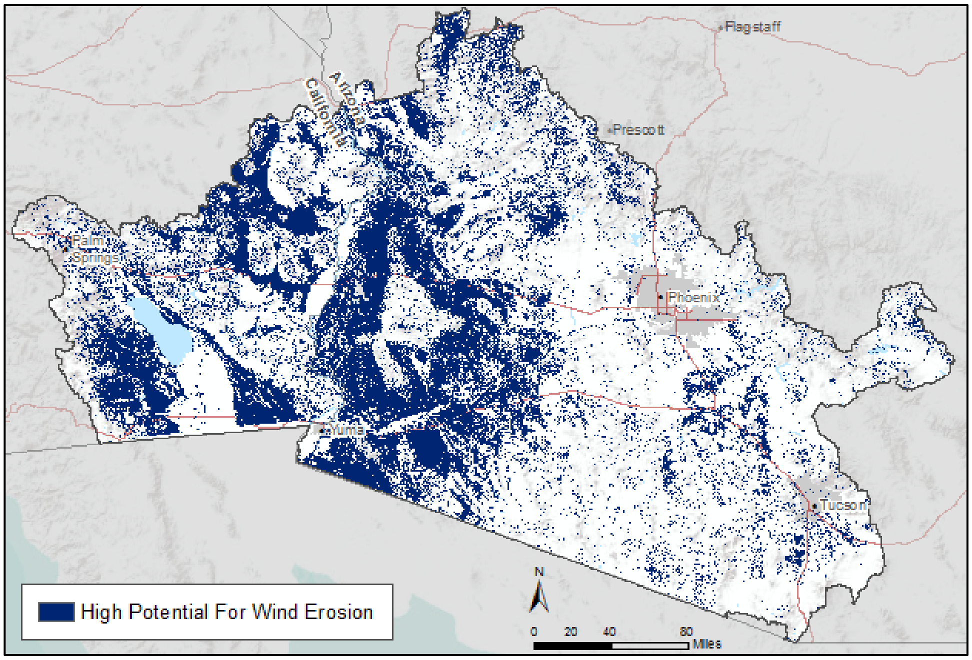


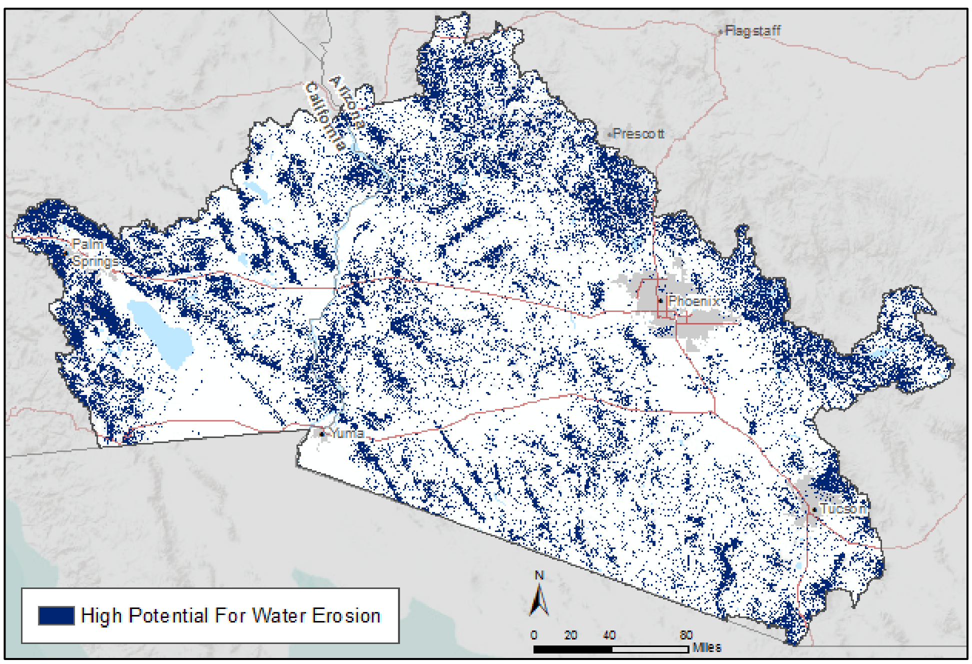
Process Model: Water Erosion



Results for Soils Susceptible to Wind and Water Erosion

MQ A1. Where are soils susceptible to wind and water erosion?

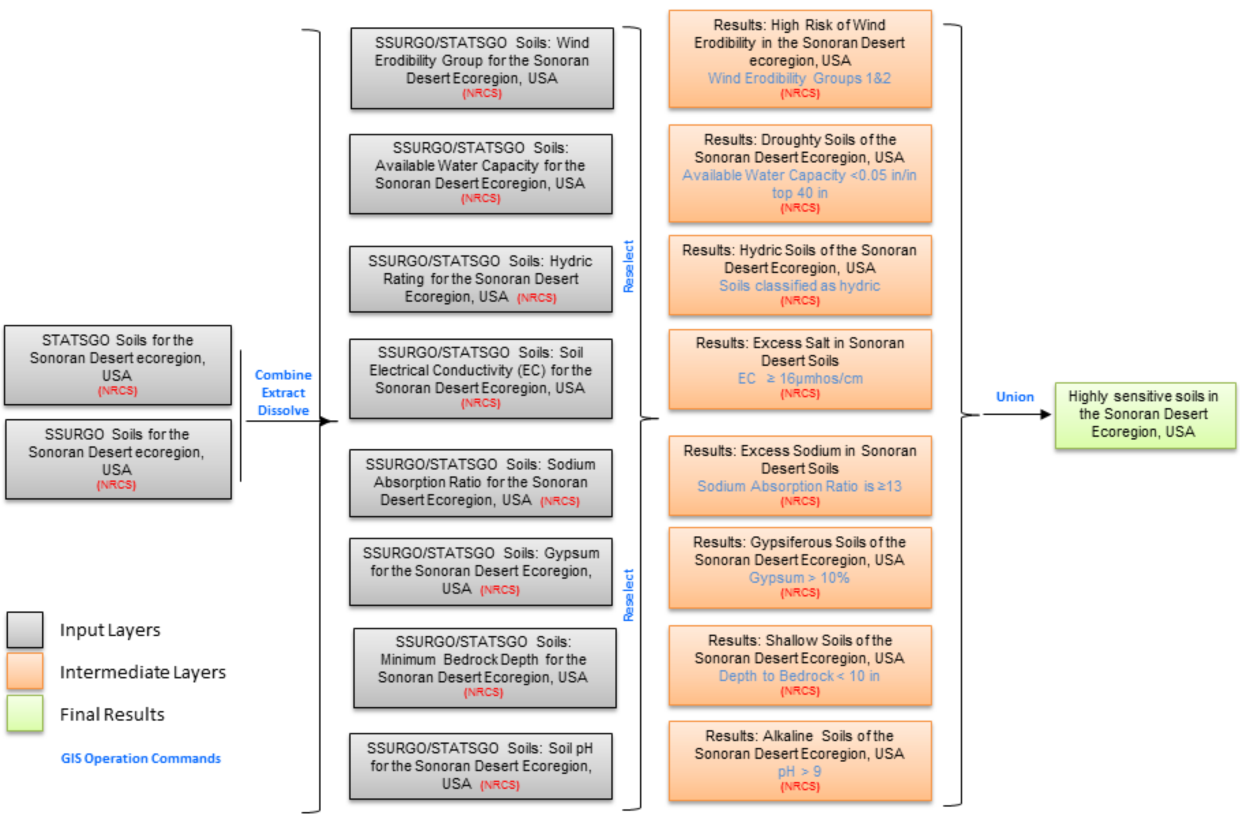




A. Soils, Biological Crust, and Forage Management

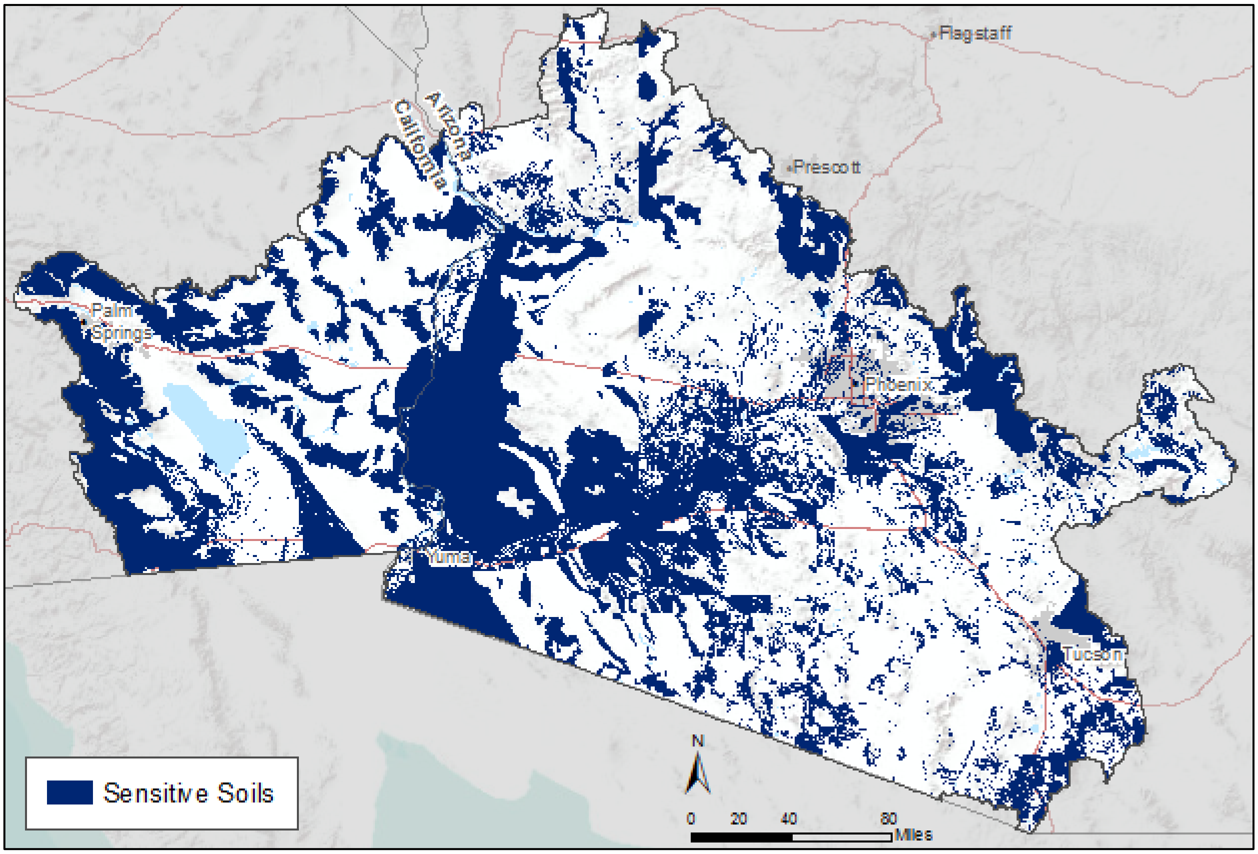
MQ A2. Where are sensitive soils (including saline, sodic, gypsiferous, shallow, low water holding capacity)?

Process Model



Results for Sensitive Soils All Types

MQ A2. Where are sensitive soils (including saline, sodic, gypsiferous, shallow, low water holding capacity)?



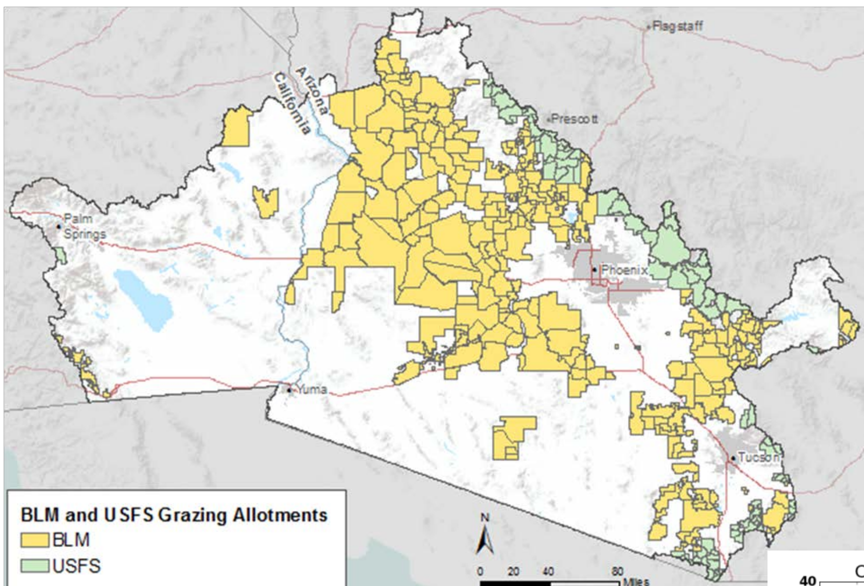
Note: Any individual soil type may be viewed individually as source data on date portal.

A. Soils, Biological Crust, and Forage Management
MQ A3. Which HMAs and allotments may experience significant effects from change agents including climate change?

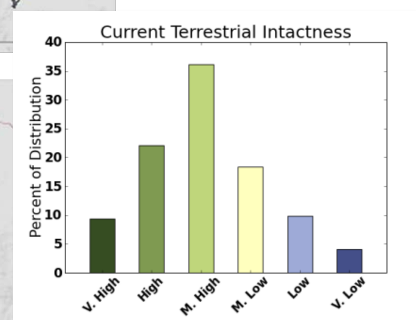
Process Description

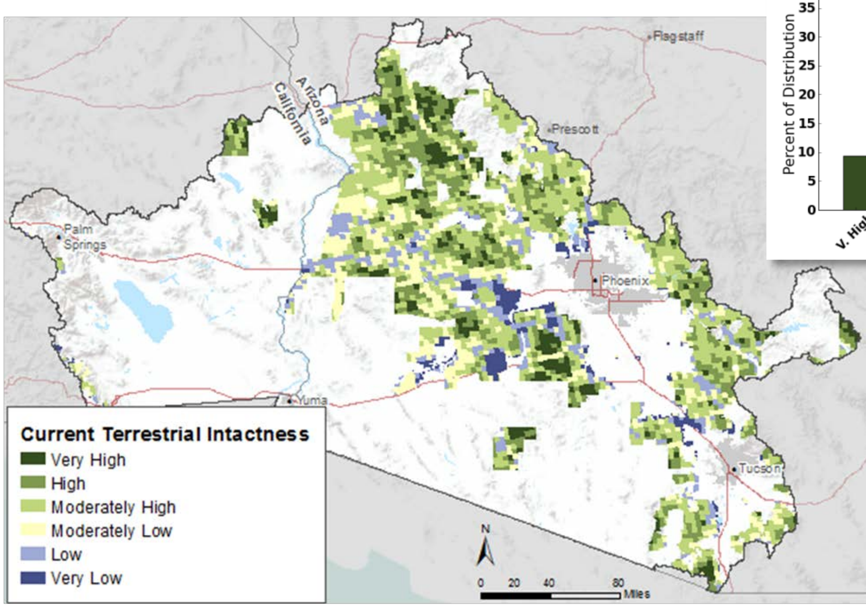
Grazing allotments and Wild Horse and Burro Herd Management Areas were intersected with the combined results of current and near-term terrestrial intactness and long-term potential for climate change and energy development (see Appendix E for logic models).

Results



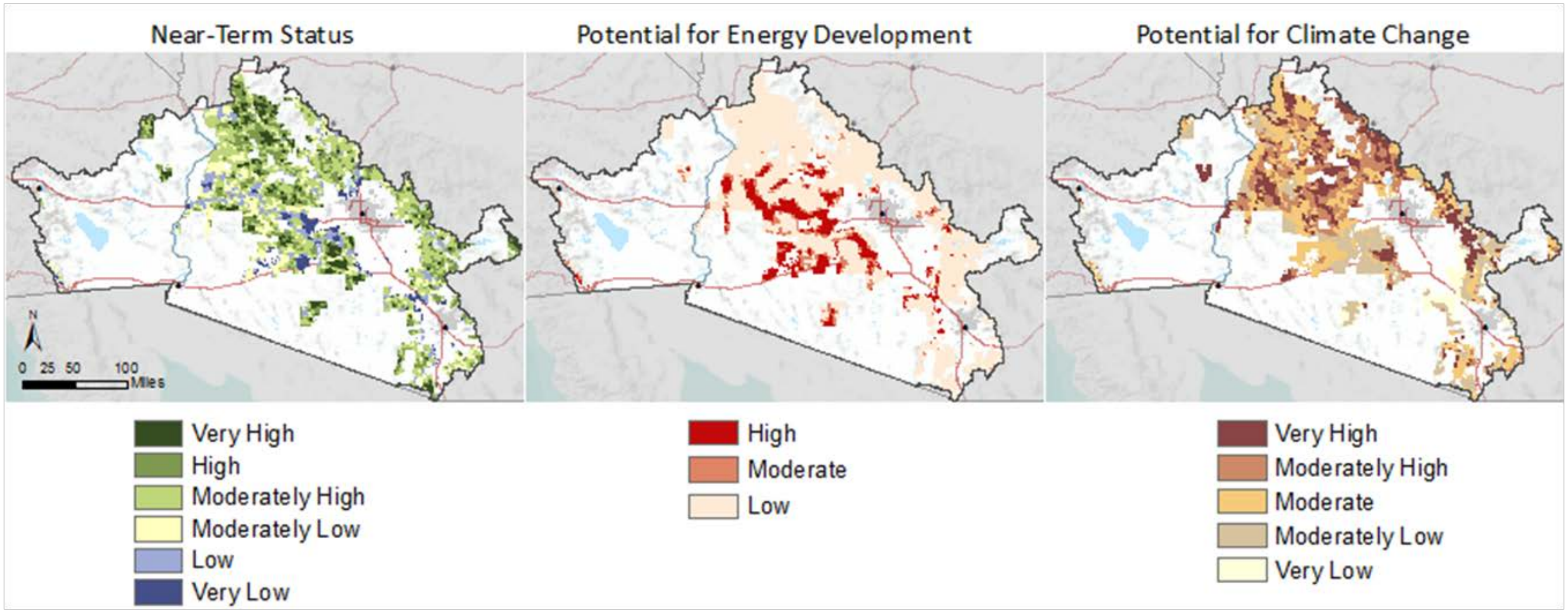
Allotments

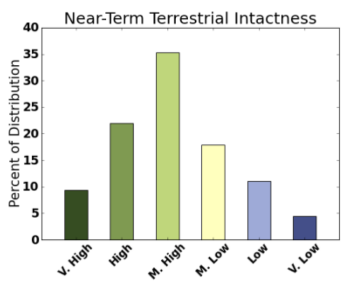


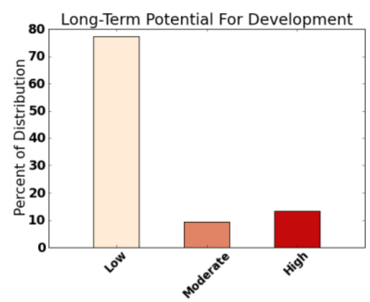


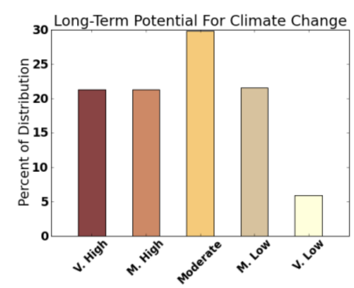
Status/Current Terrestrial Intactness

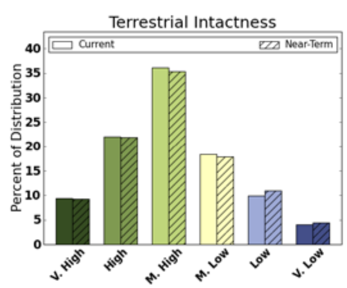
MQ A3. Which grazing allotments may experience significant effects from change agents including climate change?









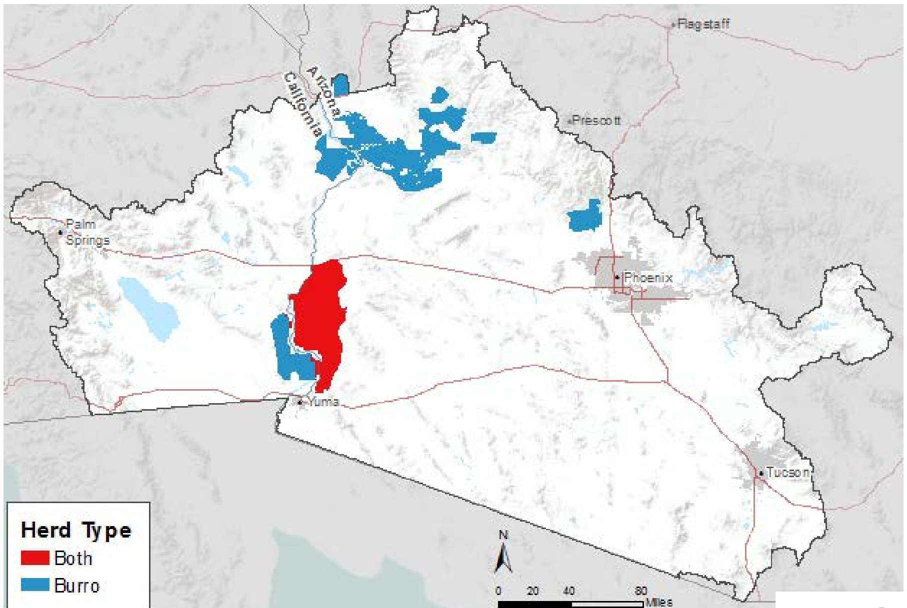


Current & Near-term Intactness

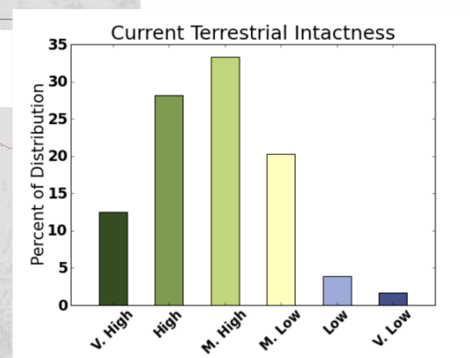
Current (solid color) and Near-term (cross-hatched) Intactness

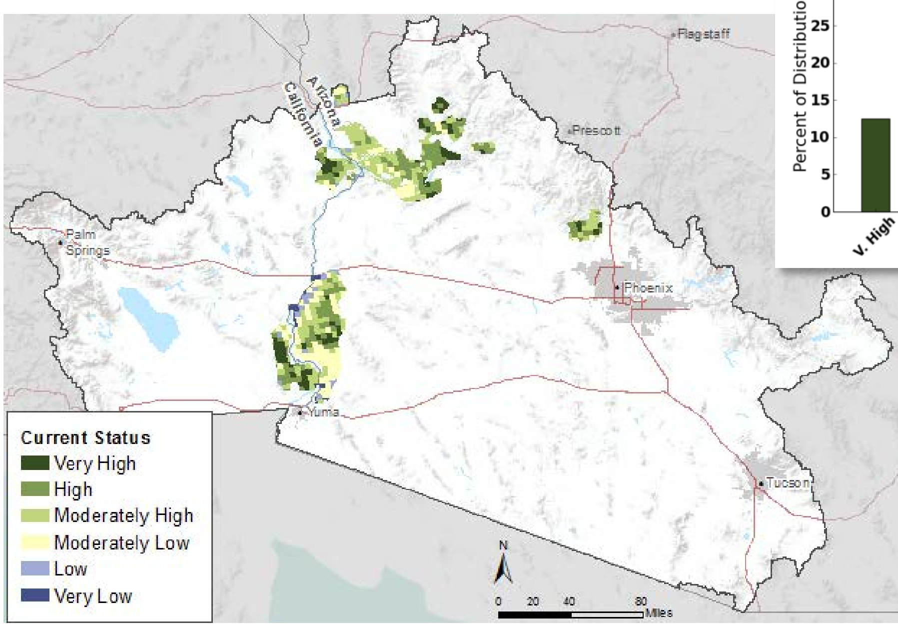
MQ A3. Which Wild Horse and Burro Herd Management Areas may experience significant effects from change agents including climate change?

Current Distribution and Status of Herd Management Areas (HMAs)



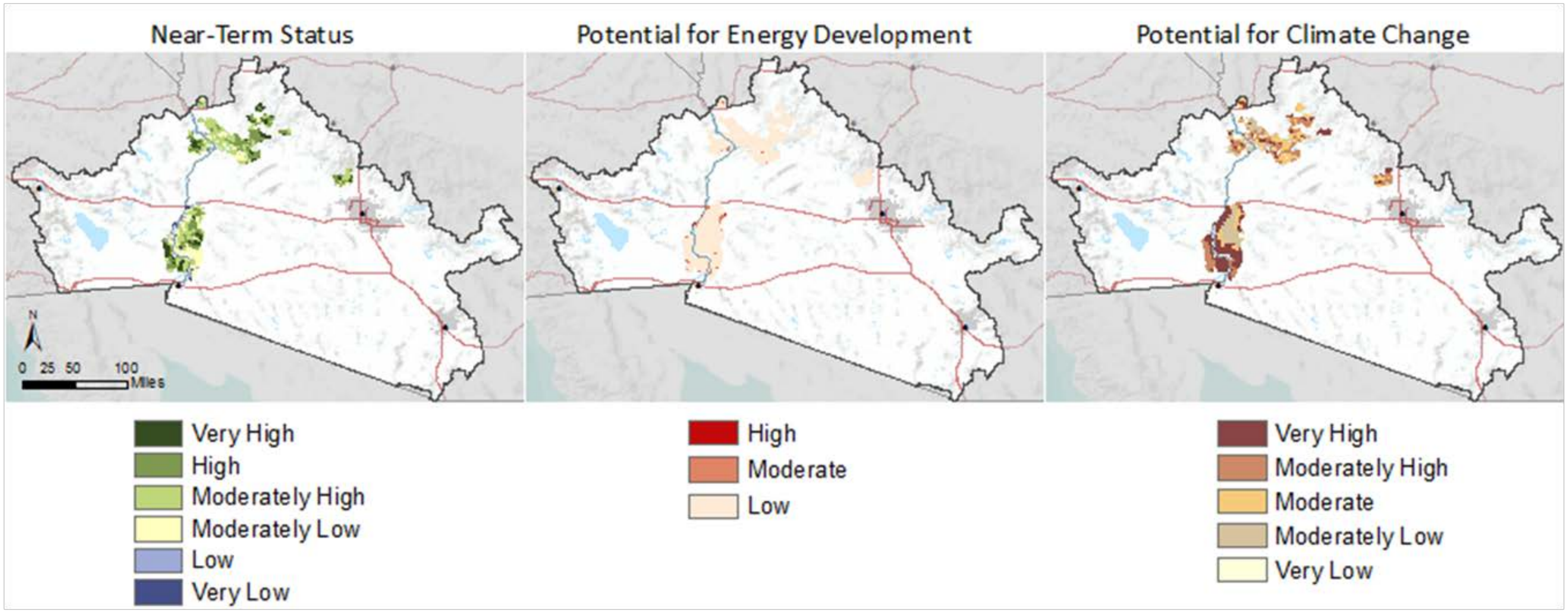
Herd Management Areas

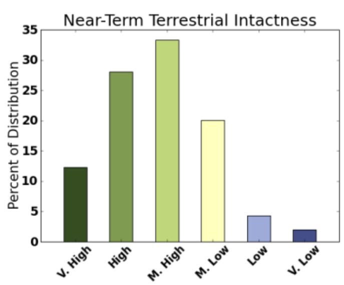


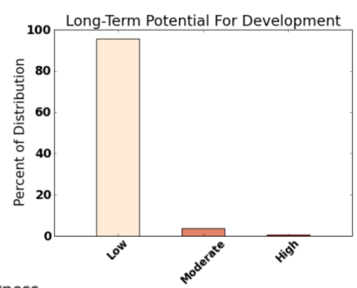


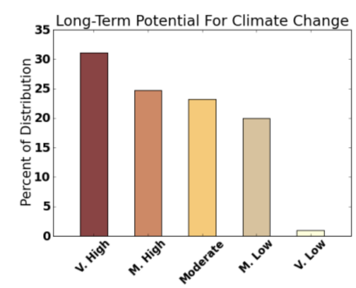
Status/Current Terrestrial Intactness

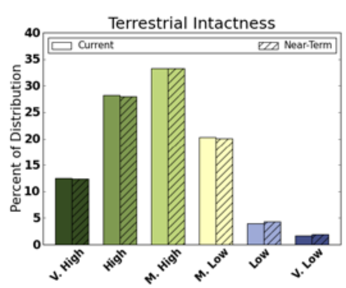
MQ A3. Which Wild Horse and Burro Herd Management Areas may experience significant effects from change agents including climate change?











Herd Management Areas
Current & Near-term Intactness

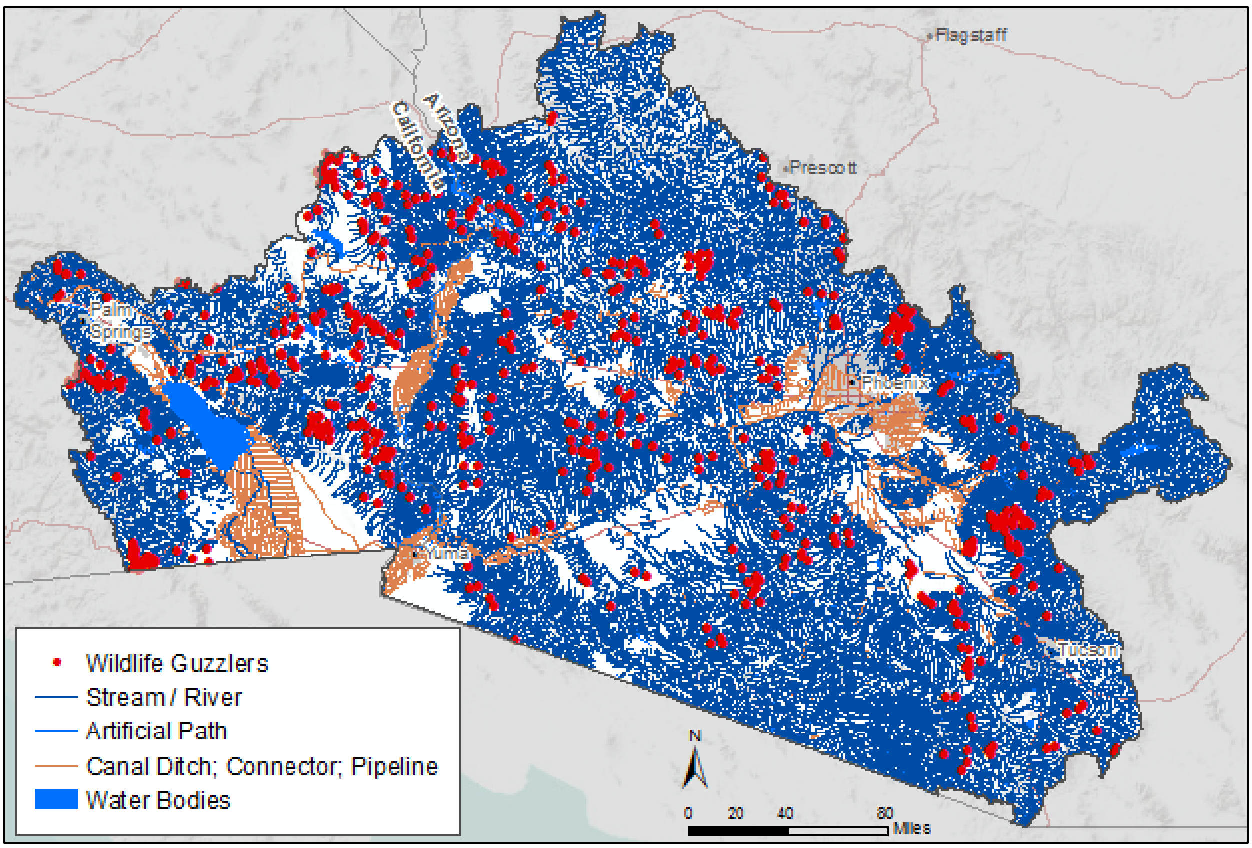
Current (solid color) and Near-term (cross-hatched) Intactness

B. Surface and Groundwater
MQ B1. Where are lotic and lentic surface waterbodies and livestock and wildlife watering tanks and artificial water bodies?

Process Model or Description

Features from National Hydrography Dataset (USGS) Flowlines and Water Bodies datasets extracted. **Flowlines represent ephemeral, intermittent, and perennial stream channels.**

Results

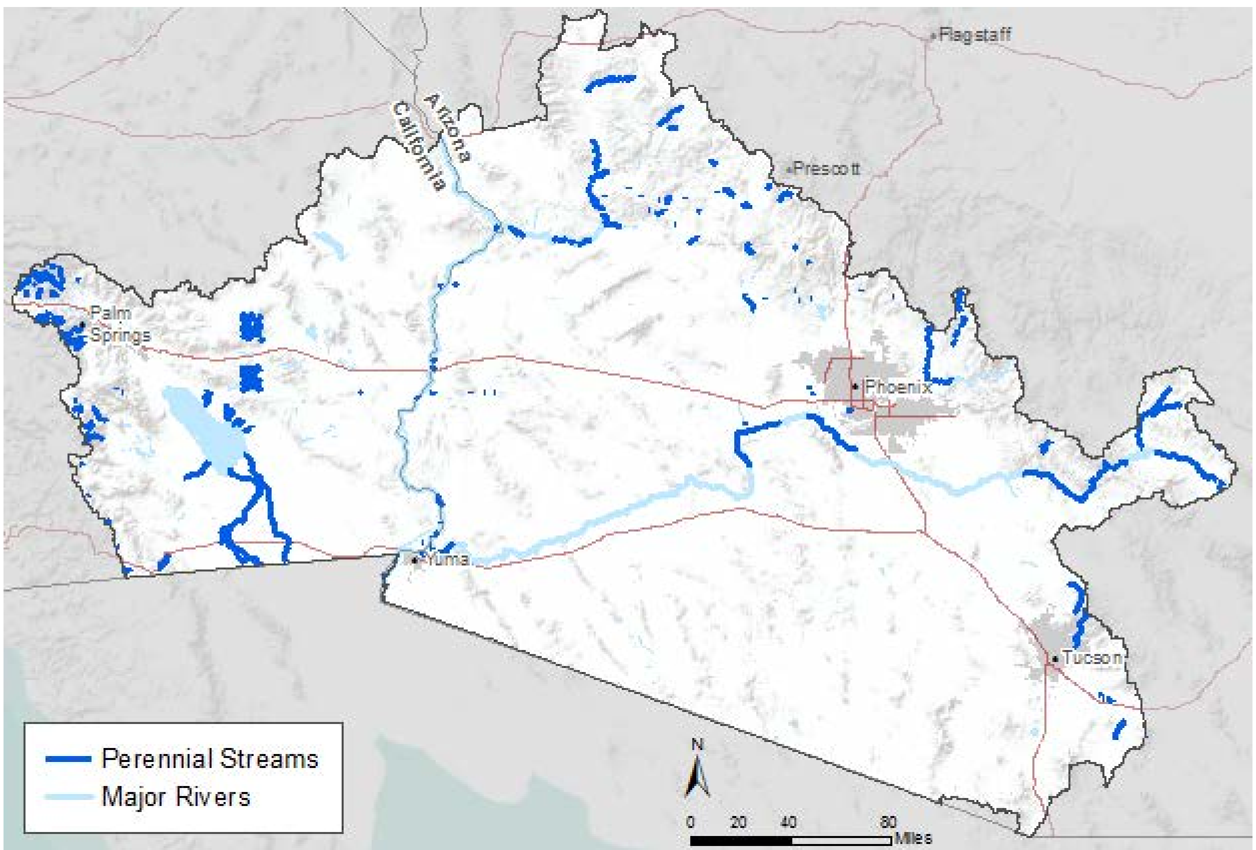


B. Surface and Groundwater
MQ B2. Where are perennial streams and stream reaches?

Process Model or Description

Features marked as perennial streams from National Hydrography Dataset (USGS) Flowlines. (Note: some features that may in fact be perennial were not marked as such, because of other labels, e.g., Artificial Path)

Results

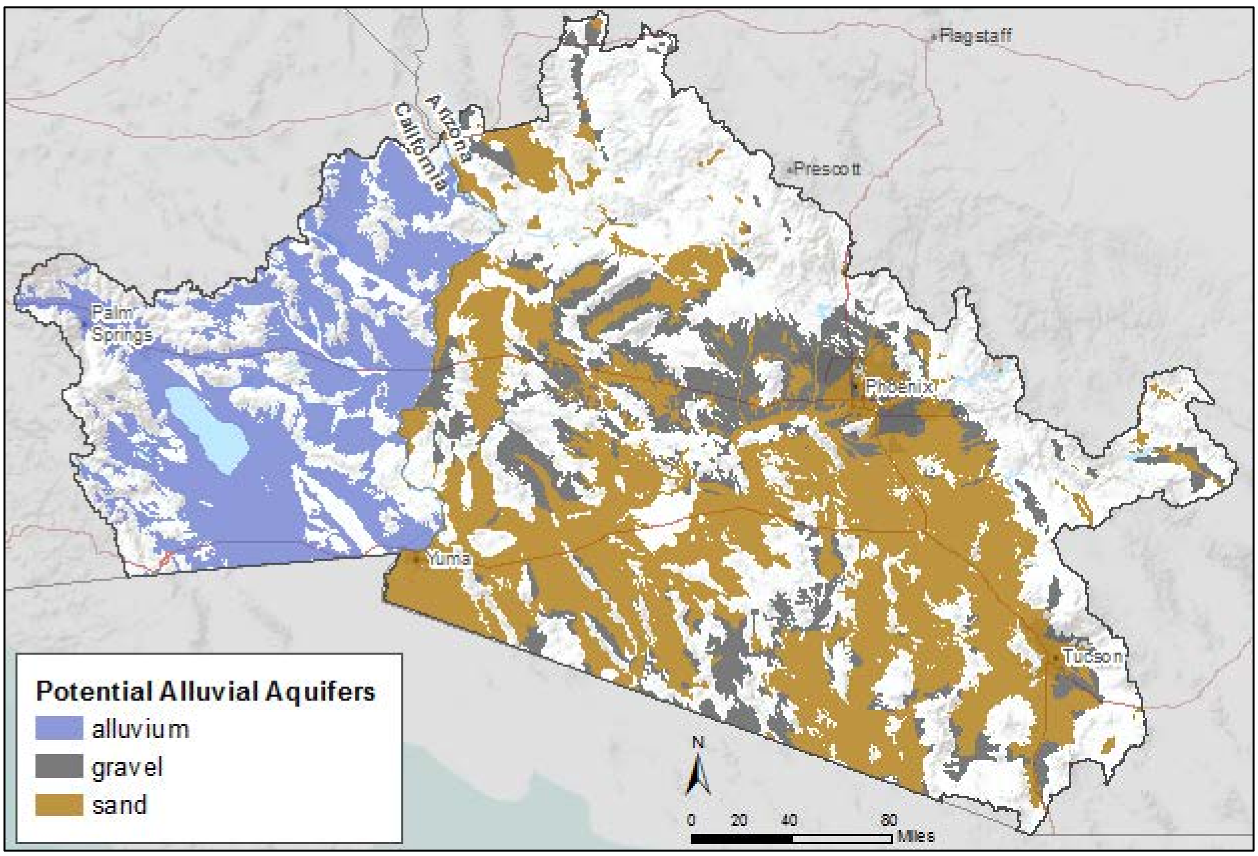


B. Surface and Groundwater
MQ B3. Where are the alluvial aquifers and their recharge areas (if known)?

Process Model or Description

Selected alluvium, sand, and gravel types from composite state geology dataset

Results

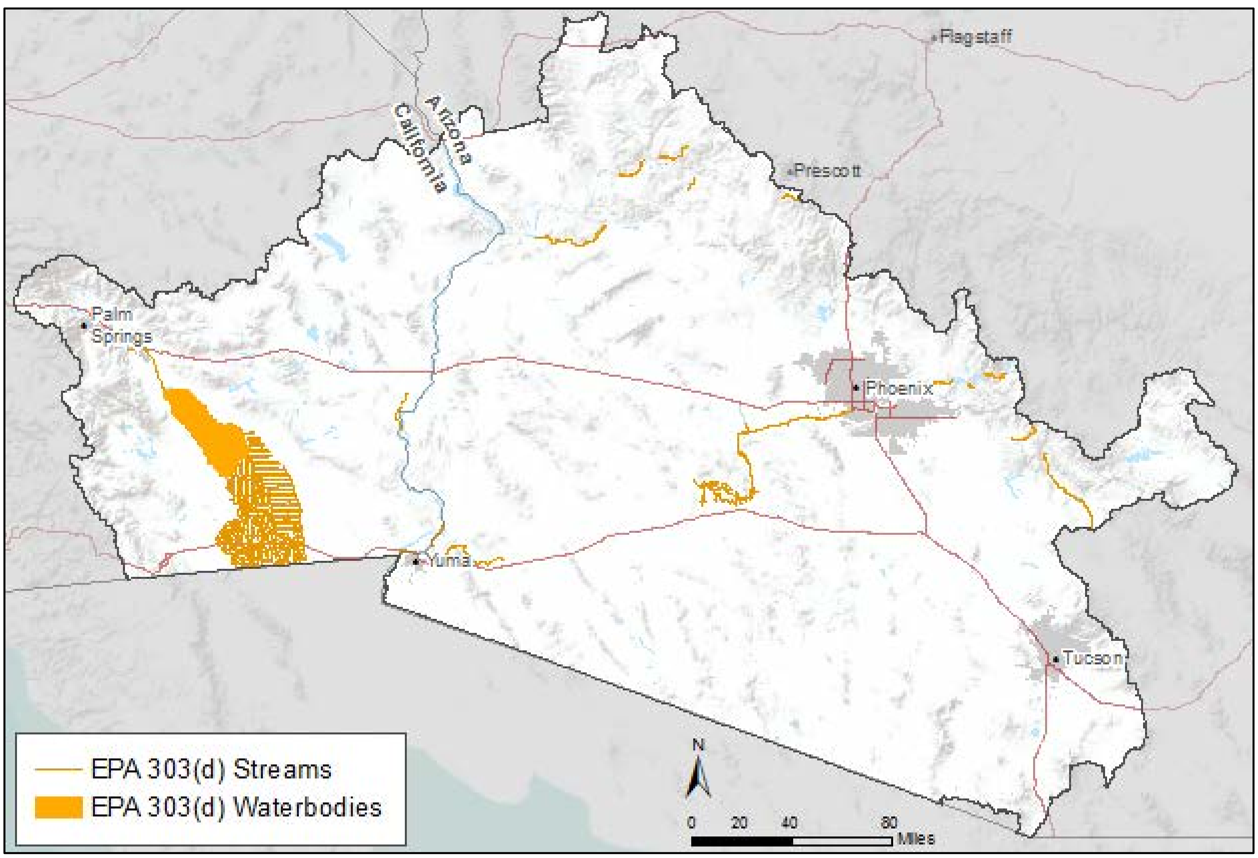


B. Surface and Groundwater
MQ B4. Where are the aquatic systems listed in 303(d) with degraded water quality or low macroinvertebrate diversity?

Process Model or Description

Features were identified in Environmental Protection Agency (EPA) 303(d) datasets. Explanation of 303(d) below from EPA website http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/overview.cfm:
The term "303(d) list" refers to the list of impaired and threatened waters (stream and river segments, lakes) that the Clean Water Act requires all states to submit for EPA approval every two years on even-numbered years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for development of Total Maximum Daily Loads (TMDLs) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors. States then provide a long-term plan for completing TMDLs within 8 to 13 years from first listing.

Results for Aquatic Systems listed in Section 303(d)

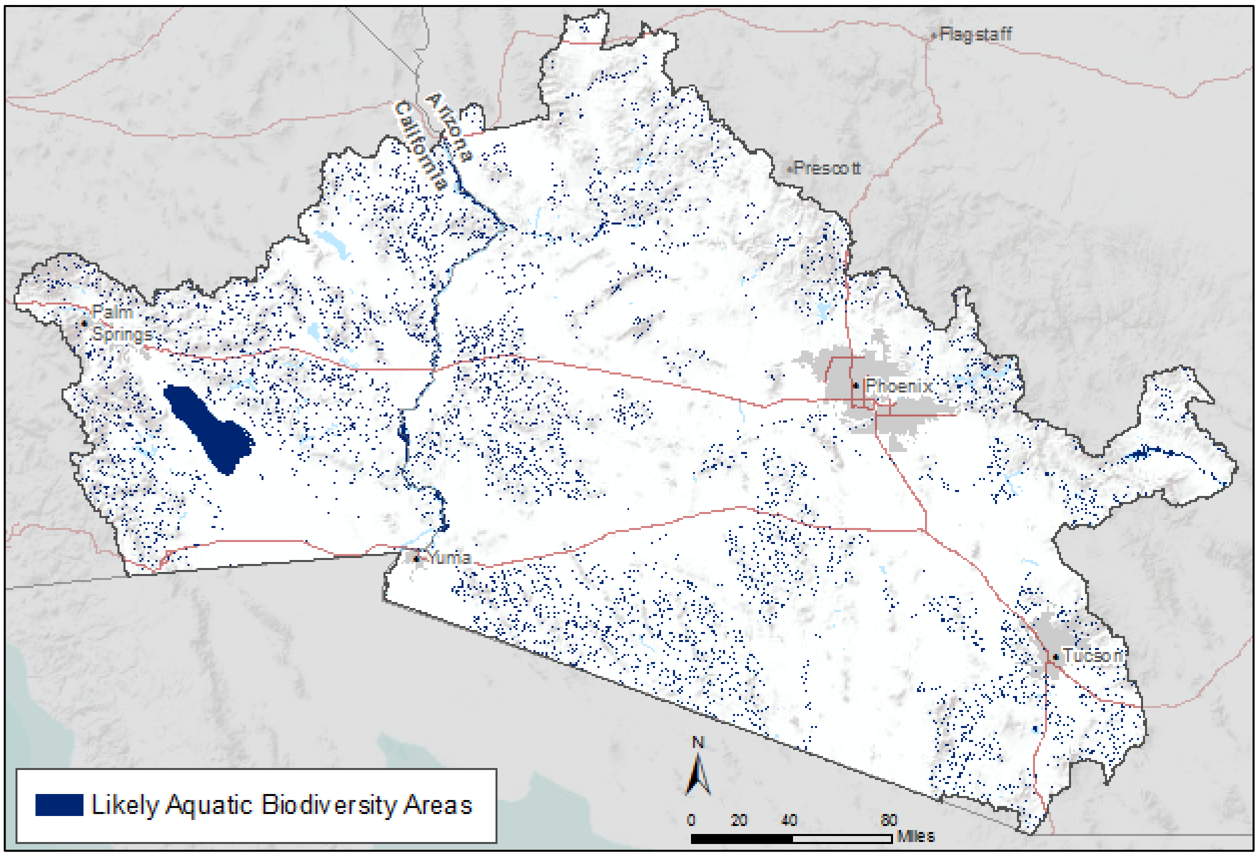


B. Surface and Groundwater
MQ B6. What is the location/distribution of these aquatic biodiversity sites?

Process Model or Description

40 meter buffers were selected around NHD flowlines, wetlands, and deep water habitats (USFWS) that fell within Nature Conservancy (TNC) Conservation Portfolio areas or Special Designations.

Results



B. Surface and Groundwater
MQ B7. What are seasonal discharge maxima and minima for the Colorado River and major tributaries at gaging stations?

Process Model or Description

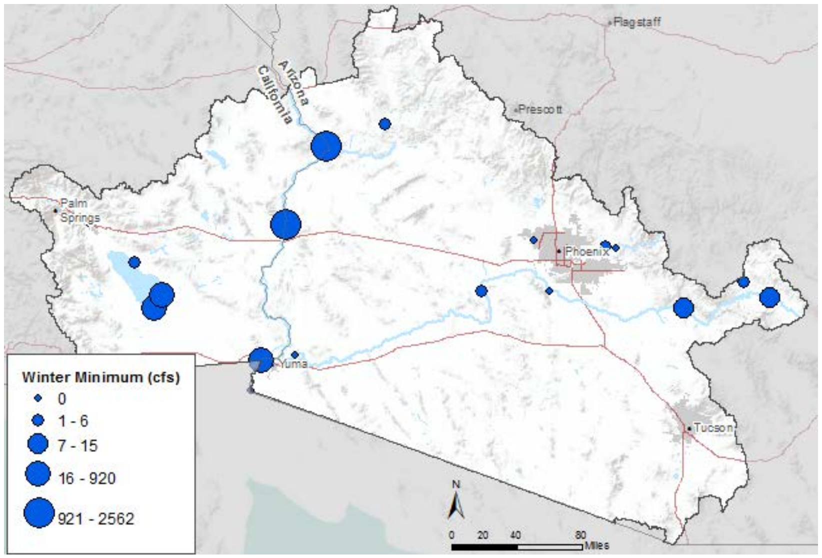
For each gaging station, daily summary statistics were obtained from USGS for the period of record of the station up to 9/30/2010. Daily statistics were partitioned into seasons and minimums and maximums calculated for each season.

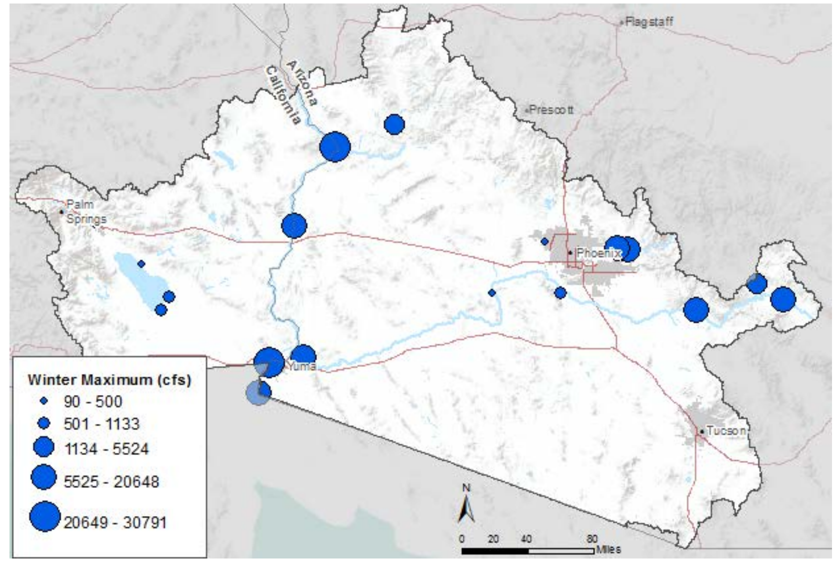
Average seasonal maxima and minima for gaging stations on the lower Colorado River and major tributaries recording 12–100 years of records from various gaging stations through 9-30-2010 (Source: http://waterdata.usgs.gov/nwis). Figures in cubic feet/second rounded to the nearest cfs.

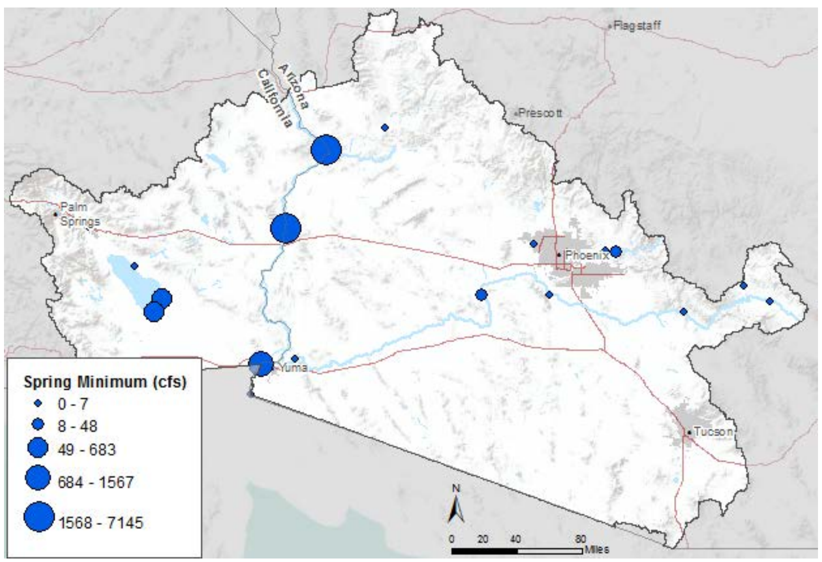
Gaging Station Location	SPMN	SPMX	SUMN	SUMX	FMN	FMX	WMN	WMX
COLORADO RIVER PARKER DAM, AZ-CA	7145	29691	7243	38777	2440	33405	2502	30791
WHITEWATER RIVER AT INDIO CA	0	4	0	53	0	28	0	500
COLORADO RIVER PALO VERDE DAM, AZ	6149	17167	5763	13332	2978	13119	2562	18403
SALT CREEK NEAR MECCA	2	21	1	50	1	53	3	90
ALAMO RIVER NEAR NILAND CA	683	1290	599	1274	540	1201	389	1133
NEW RIVER NEAR WESTMORLAND CA	469	918	416	1049	414	973	392	932
AGUA FRIA RIVER AT EL MIRAGE, AZ	0	43	0	19	0	15	0	101
VERDE RIVER NEAR SCOTTSDALE, AZ	0	3950	16	1883	6	2473	6	17144
SALT RIVER STEWART MT DAM, AZ	48	7707	147	2638	1	4672	0	19554
GILA BEND CANAL AT GILLESPIE DAM, AZ.	36	170	23	130	1	105	2	171
SANTA CRUZ RIVER NEAR LAVEEN, AZ.	0	56	0	843	0	1081	0	1017
COLORADO RIVER AT NIB	1567	19814	1644	30509	662	28100	920	24144
GILA RIVER NEAR DOME, AZ.	0	13257	0	3344	0	6667	0	15691
SAN CARLOS RIVER NEAR PERIDOT, AZ.	0	477	0	747	0	1276	2	4655
GILA RIVER AT KELVIN, AZ.	7	3034	3	5540	1	5405	14	16062
GILA RIVER AT CALVA, AZ.	1	3039	0	3101	0	9044	15	13905
COLORADO RIVER NEAR SAN LUIS, AZ.	0	15359	0	25060	0	24945	0	20648

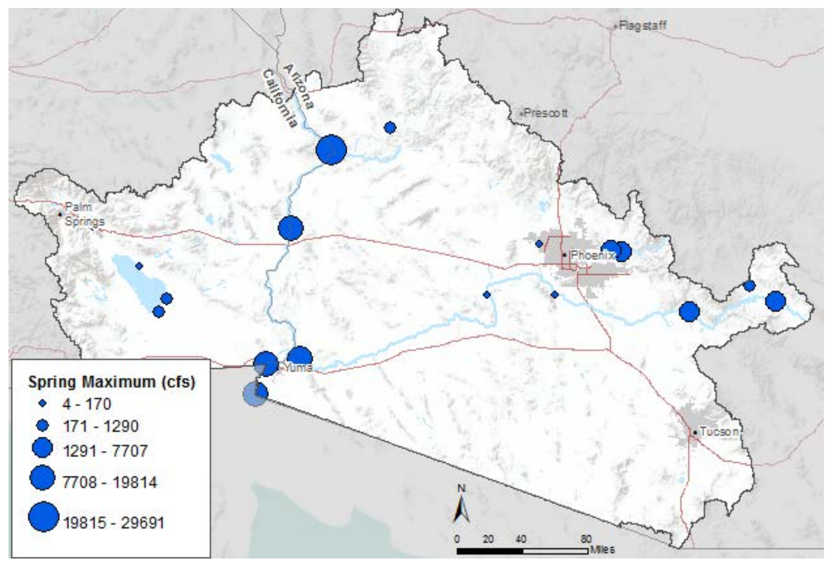
SPMN=spring minimum; SPMX=spring maximum; SUMN=summer minimum; SUMX=summer maximum; FMN=fall minimum; FMX=fall maximum; WMN=winter minimum; WMX=winter maximum.

Results for Seasonal Max/Min at Various Gaging Stations on the Lower Colorado River and Tributaries

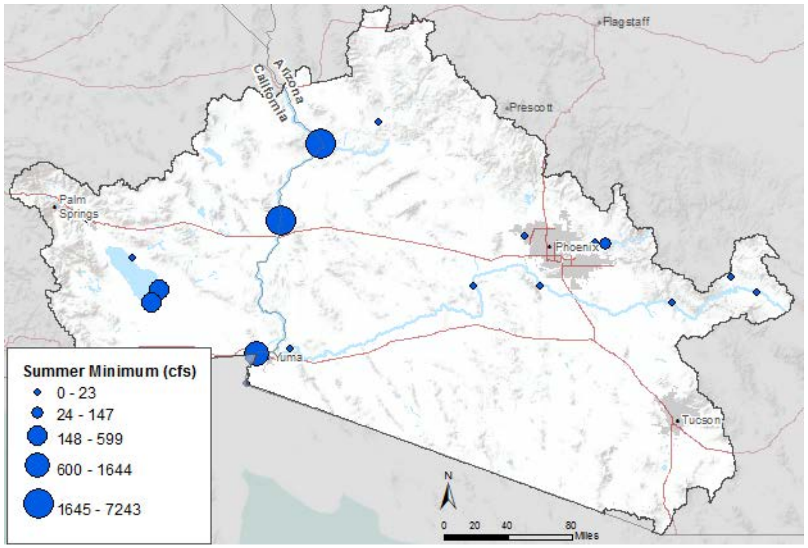


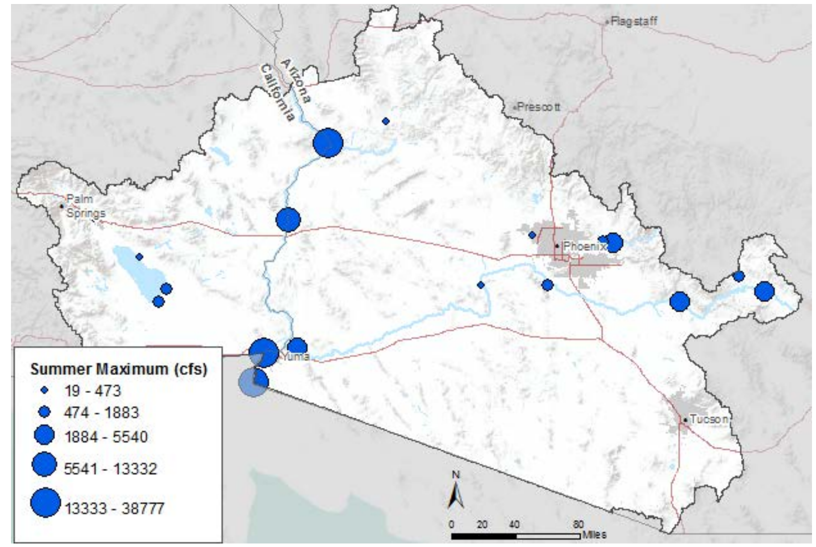


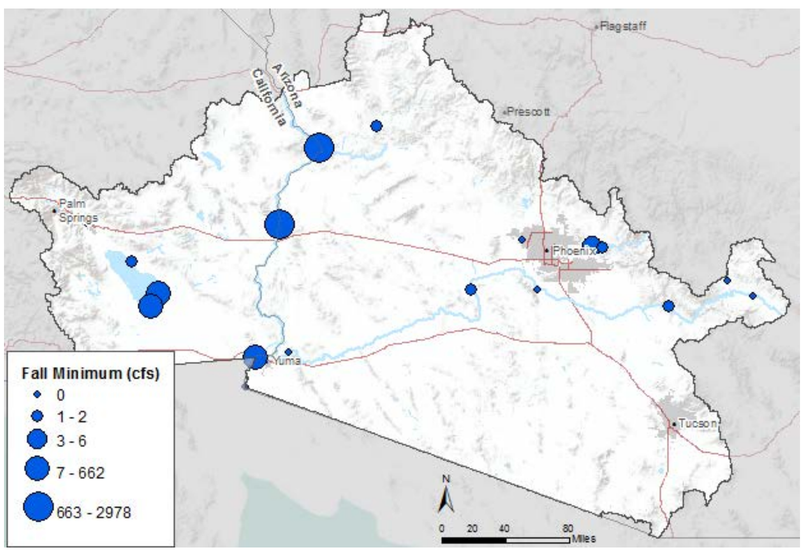


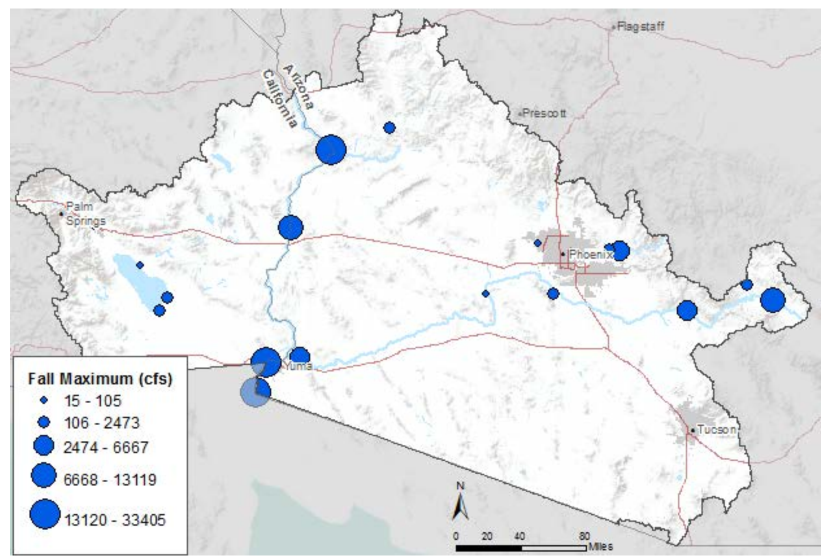


Results for Seasonal Max/Min at Various Gaging Stations on the Lower Colorado River and Tributaries









C. Ecological Systems Conservation Elements Management Questions
Sonoran Paloverde-Mixed Cacti Desert Scrub – go to Appendix B
MQ C1. Where is existing Sonoran Palo Verde-Mixed Cacti Desert Shrubland and what is its status?
MQ C2. Where are vegetative communities vulnerable to change agents in the future?
MQ C3. What change agents have affected existing vegetative communities?
Sonoran-Mojave Creosotebush-White Bursage Desert Scrub - go to Appendix B
MQ C1. Where is existing Sonoran-Mojave Creosotebush-White Bursage Desert Scrub and what is its status?
MQ C2. Where are vegetative communities vulnerable to change agents in the future?
MQ C3. What change agents have affected existing vegetative communities?
Riparian Vegetation - go to Appendix B
MQ C1. Where is existing Riparian Vegetation and what is its status?
MQ C2. Where are vegetative communities vulnerable to change agents in the future?
MQ C3. What change agents have affected existing vegetative communities?

D. Species Conservation Elements–Management Questions
MQ D1. What is the most current distribution and status of available occupied habitat (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?
MQ D6. What aquatic and terrestrial species CEs and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?
Go to Appendix C for details on the wildlife species conservation elements listed below:
Bell's Vireo
Desert Bighorn Sheep
Desert Tortoise (*Gopherus agassizii*)
Desert Tortoise (*G. morafkai*)
Golden Eagle
Le Conte's Thrasher
Lowland Leopard Frog
Lucy's Warbler
Mountain Lion
Mule Deer
SW Willow Flycatcher

D. Species Conservation Elements
MQ D4. Where are potential areas to restore connectivity?

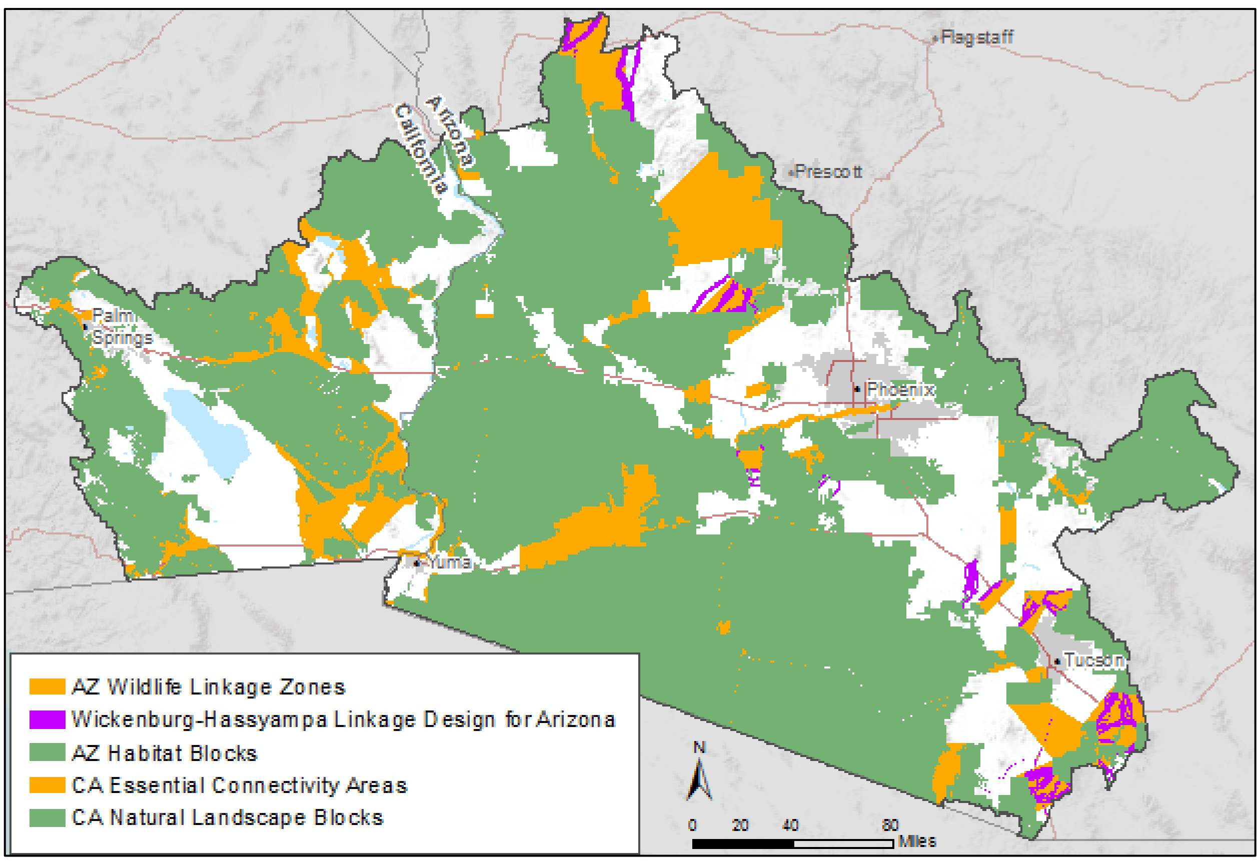
Process Description

Data were compiled from CA essential connectivity analysis (see Spencer et al. 2010), and Arizona wildlife linkages and blocks (AZDOT 2006). See text Section 4.2.2.

AZDOT (Arizona Department of Transportation). 2006. Arizona's Wildlife Linkages Assessment. Arizona Department of Transportation and Arizona Game and Fish Department. Phoenix, Arizona

Spencer, W.D., P. Beier, K. Penrod, K. Winters, C. Paulman, H. Rustigian-Romsos, J. Strittholt, M. Parisi, and A. Pettler. 2010. California essential habitat connectivity project: A strategy for conserving a connected California. Prepared for the California Department of Transportation, California Fish and Game, and Federal Highway Administration. http://www.dfg.ca.gov/habcon/connectivity/.

Results



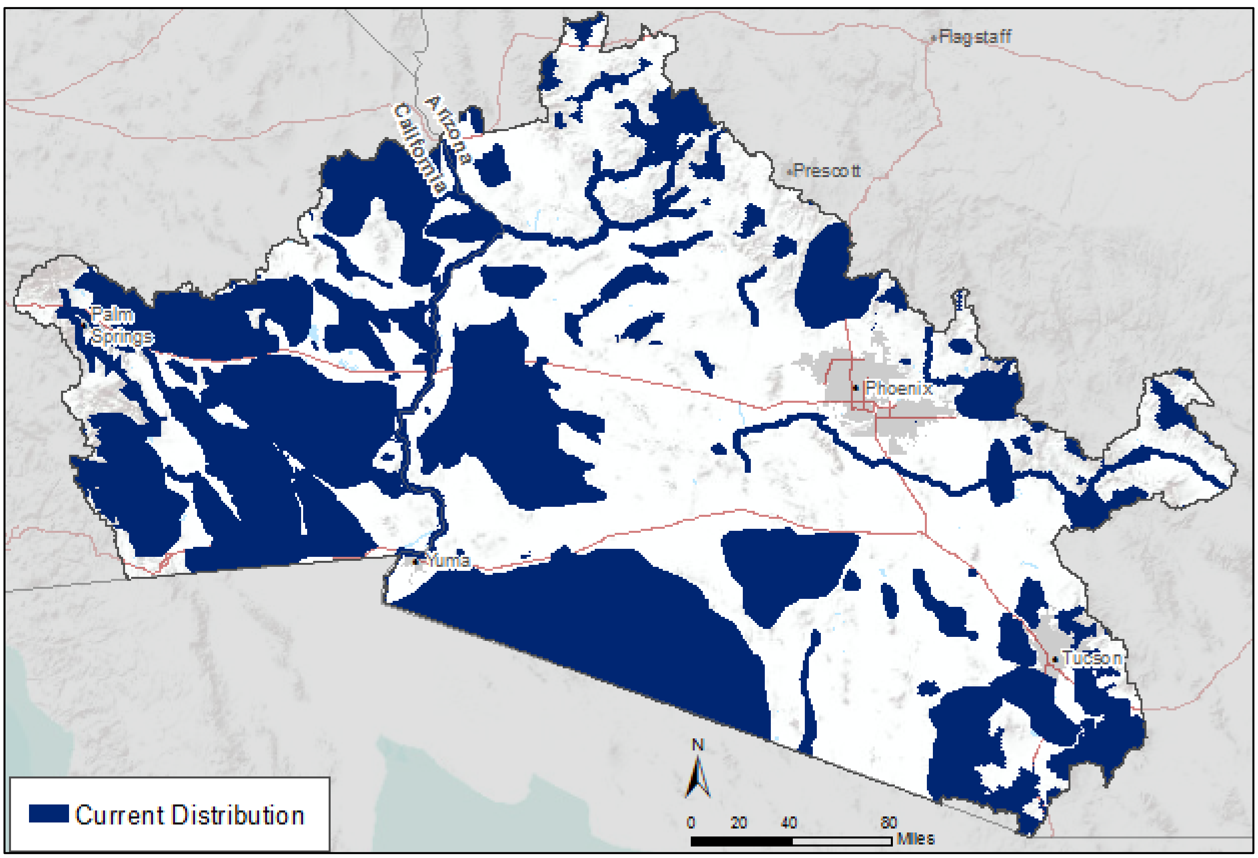
D. Species Conservation Elements
MQ D5. What is the location/distribution of terrestrial biodiversity sites and designated sites?

Process Description

Terrestrial Biodiversity Sites are defined by TNC Terrestrial Conservation Portfolio areas plus Special Designations: combined CBI Protected Areas Database GAP 1 & 2, roadless areas (USFS), and conservation easements (NCED) with recent versions of wilderness areas and areas of critical environmental concern (BLM). Map also shows national historic and scenic trails, and wild and scenic rivers.

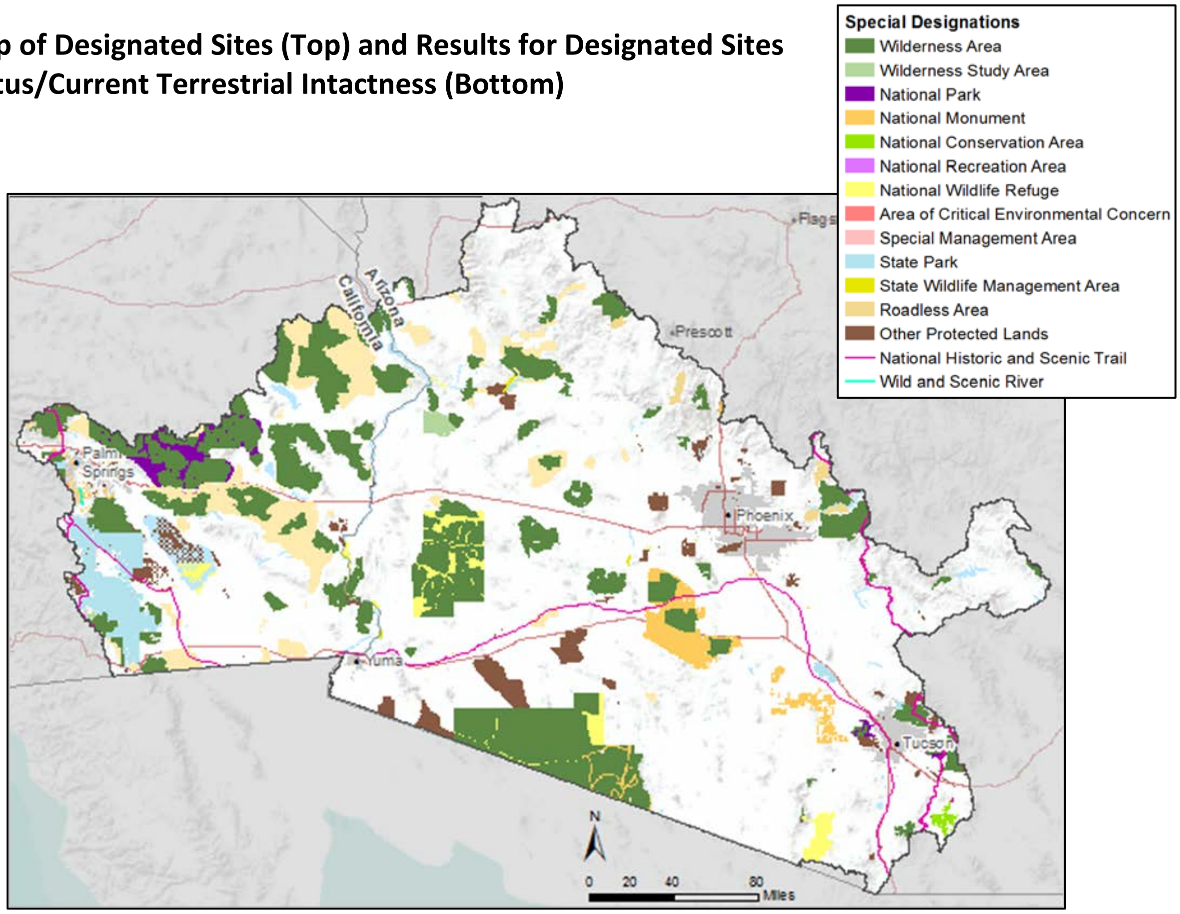
Results

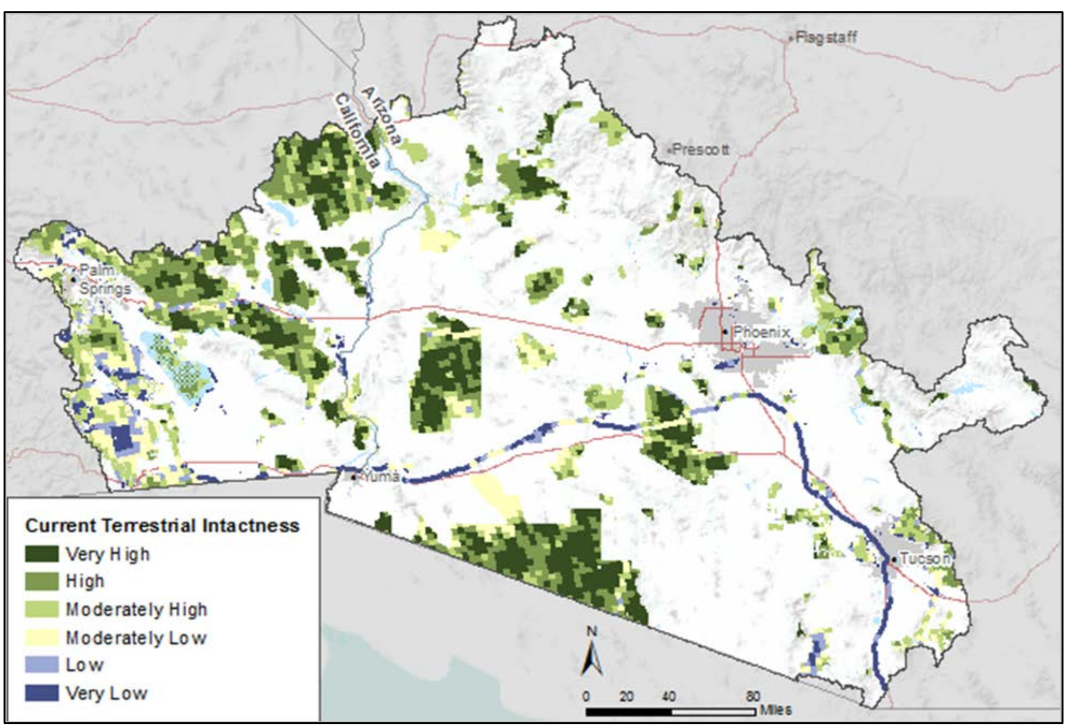
MQ D5. What is the location/distribution of terrestrial biodiversity sites?



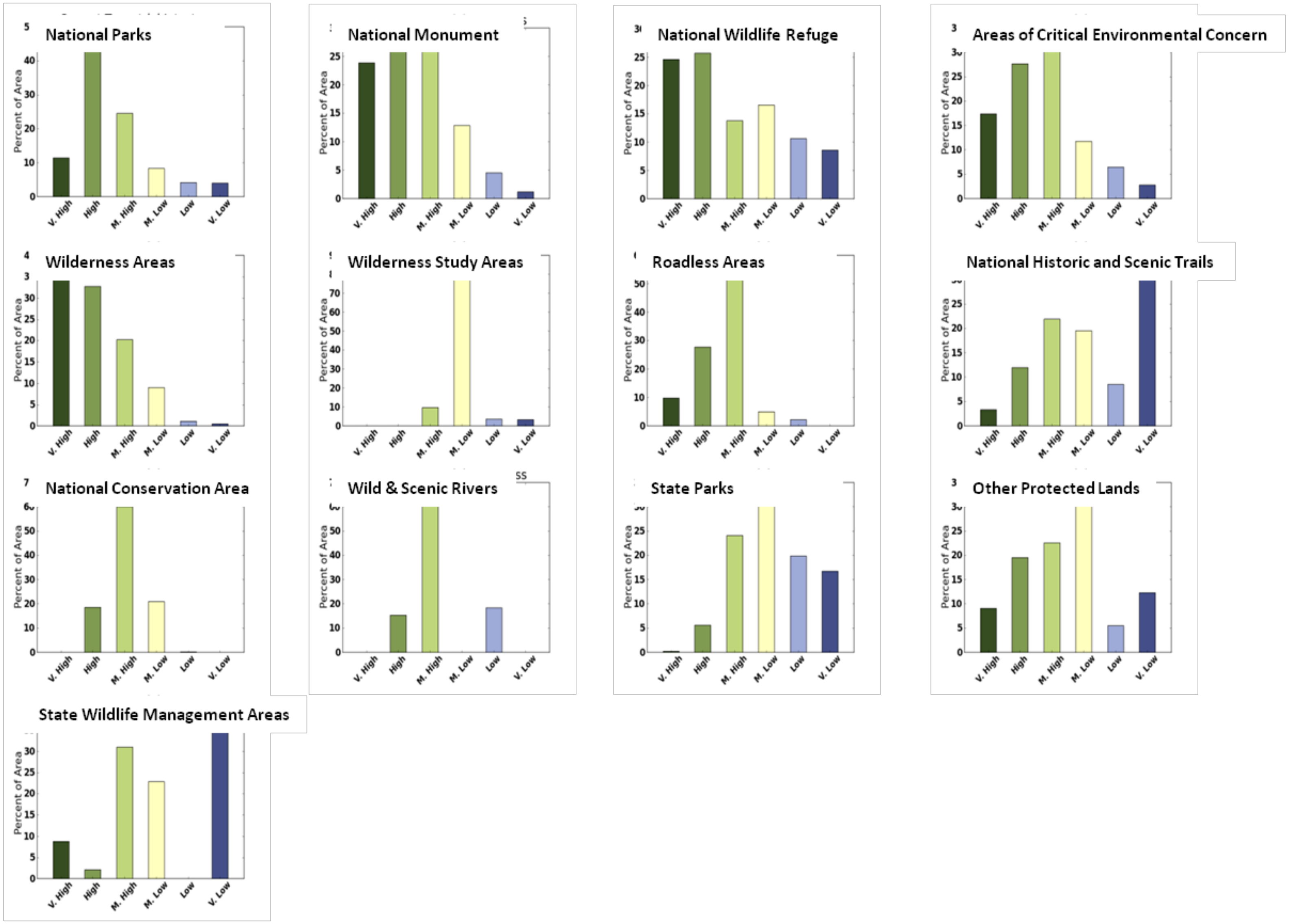
MQ D5. What is the location/distribution of designated sites?

Map of Designated Sites (Top) and Results for Designated Sites Status/Current Terrestrial Intactness (Bottom)





Histograms represent 6 classes of Current Terrestrial Intactness for each category of designated sites.



MQ D5. What is the location/distribution of designated sites?

Table 4-7. Total area (acres) of each status category for all designated protected lands in the Sonoran Desert Ecoregion.

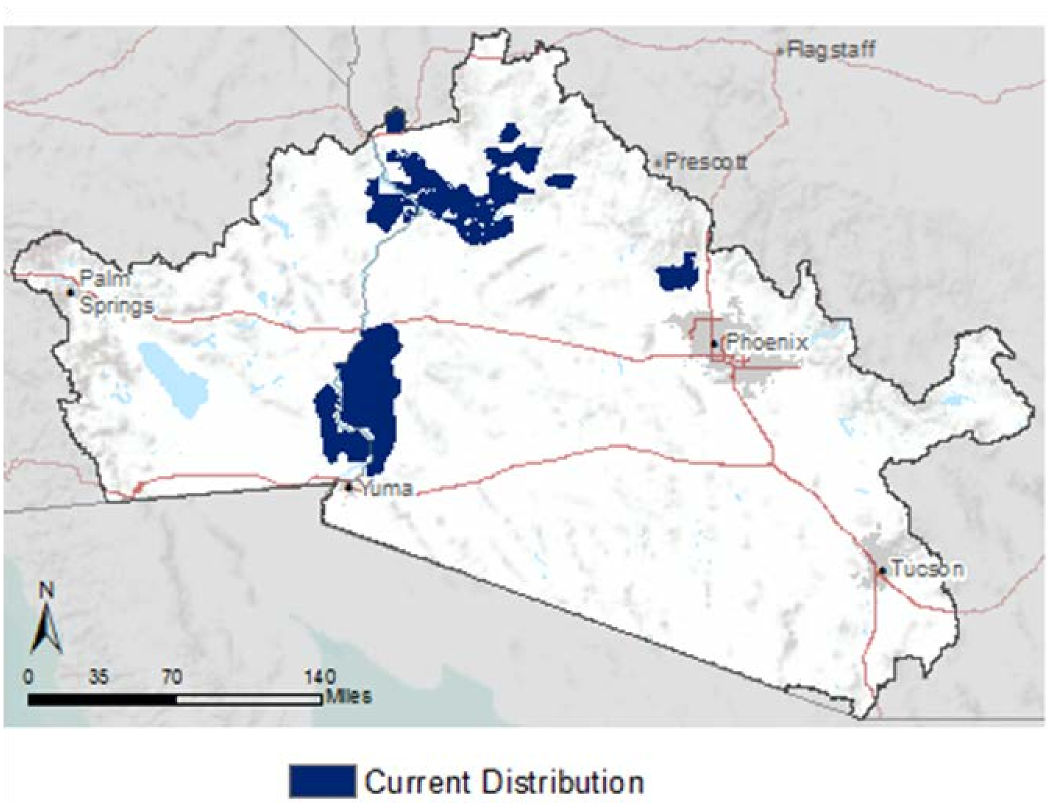
Designation Category	Very High	High	Moderately High	Moderately Low	Low	Very Low	Total Area (acres)
Wilderness Area	1,812,561	1,632,927	1,011,143	451,464	55,862	21,933	4,985,890
Wilderness Study Area	0	0	6,620	55,984	2,525	2,272	67,401
National Park	19,819	83,040	42,873	14,441	7,178	6,979	174,330
National Monument	127,785	148,652	158,627	68,922	24,265	6,305	534,556
National Conservation Area	0	6,779	21,819	7,638	95	0	36,331
National Wildlife Refuge	91,295	95,602	51,145	61,499	39,637	31,834	371,012
Area of Critical Conservation Concern	257,951	409,293	503,740	174,291	95,838	41,669	1,482,782
State Park	1,151	35,434	152,845	212,951	126,418	105,968	634,767
State Wildlife Management Area	1,202	288	4,250	3,126	4	4,819	13,689
Roadless Area	11,564	32,957	65,350	5,908	2,526	0	118,305
Other Protected Lands	71,122	153,511	177,174	243,082	43,660	97,114	785,663
Totals	2,394,450	2,598,483	2,195,586	1,299,306	398,008	318,893	9,204,726
Designation Category	**Very High**	**High**	**Moderately High**	**Moderately Low**	**Low**	**Very Low**	**Total Area (miles)**
National Historic and Scenic Trail	28	97	179	160	69	282	815
Wild and Scenic River	0	1	6	0	2	0	9
Totals	28	98	185	160	71	282	824

D. Species Conservation Elements
MQ D7. Where are HMAs located?

Process Description

Data on BLM Wild Horse and Burro Herd Management Areas (HMAs) obtained from BLM.

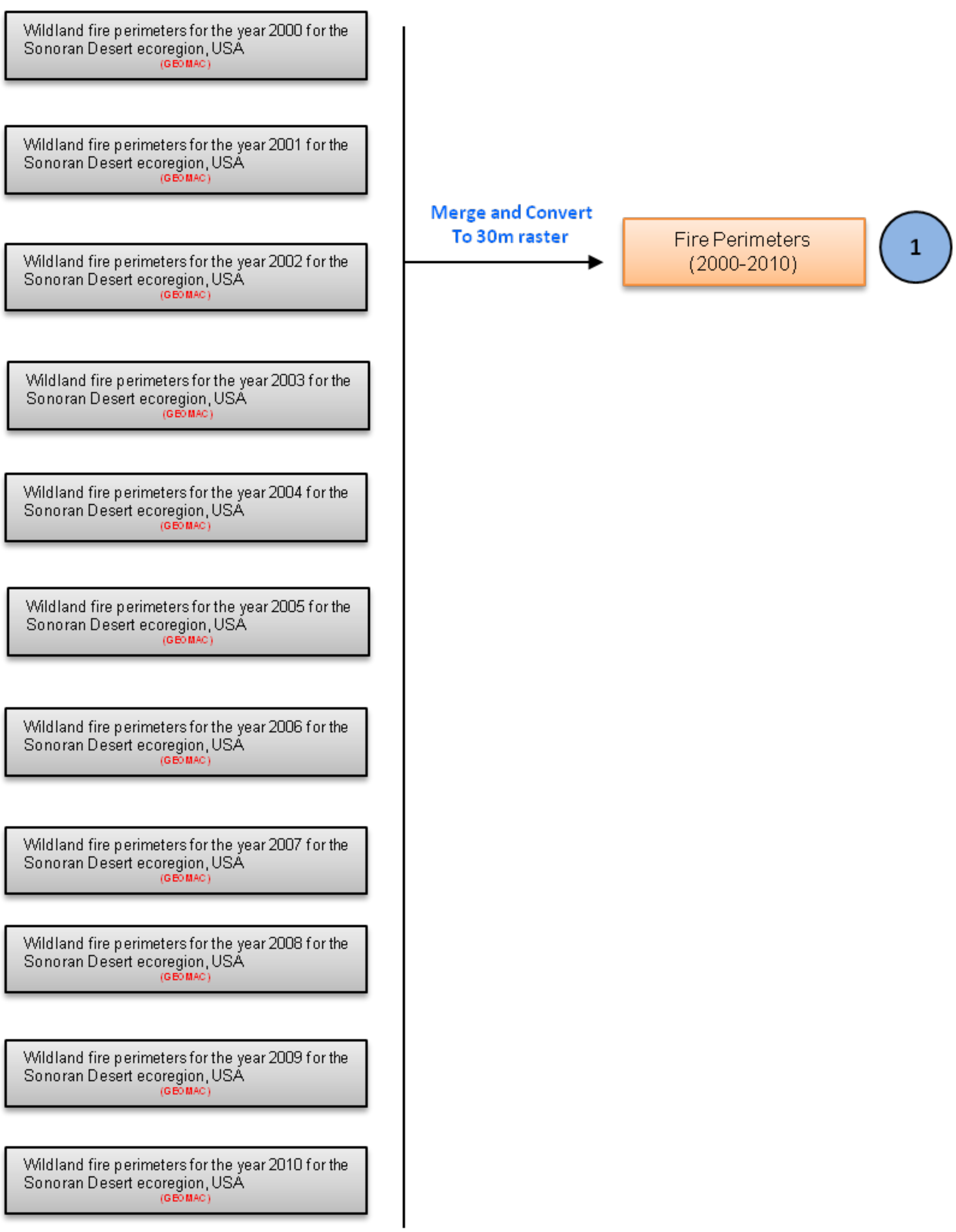
Results for Wild Horse and Burro Herd Management Areas

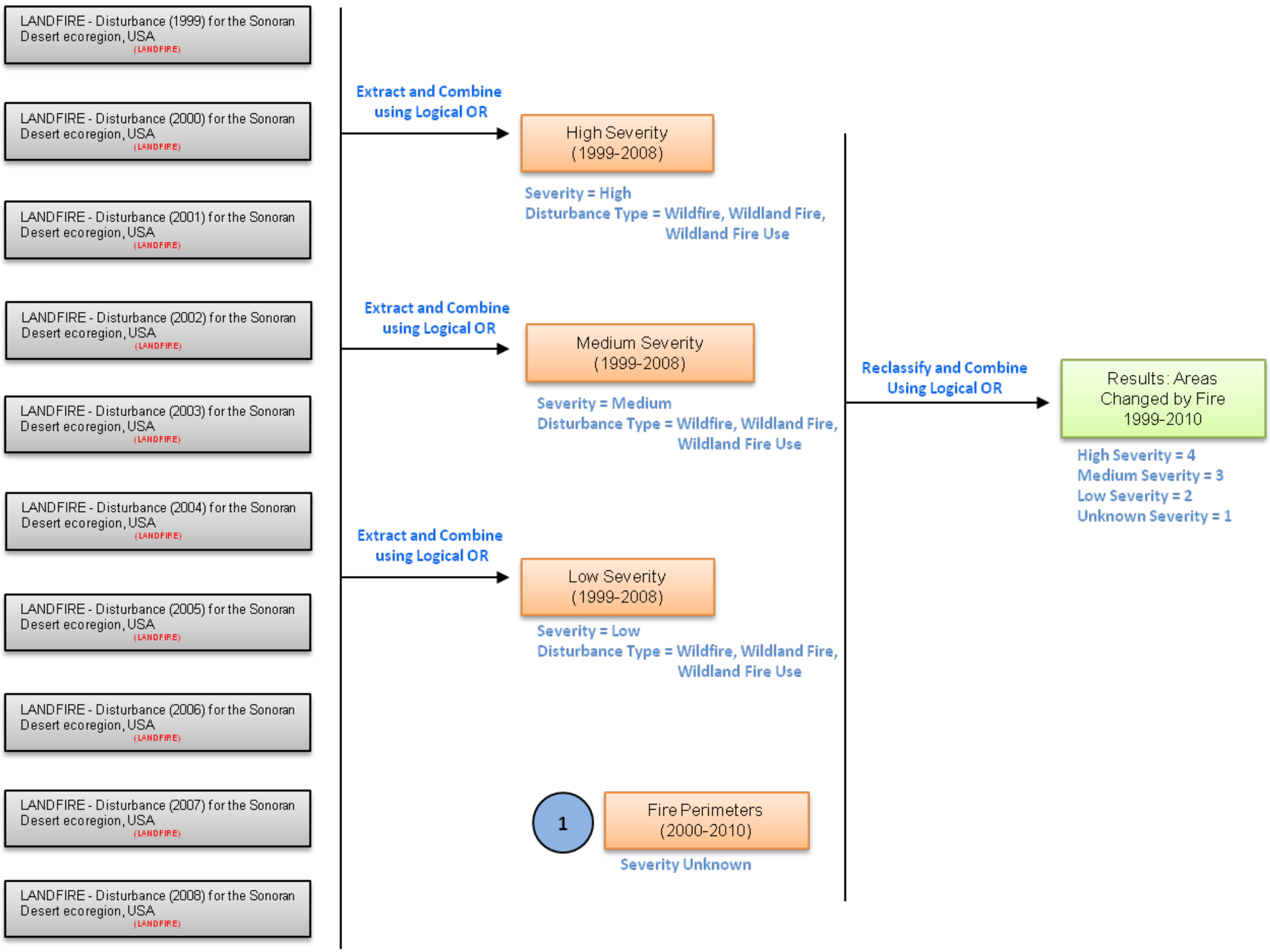


E. Wildfire
MQ E1. Where are areas that have been changed by wildfire between 1999 and 2009?

Process Model or Description

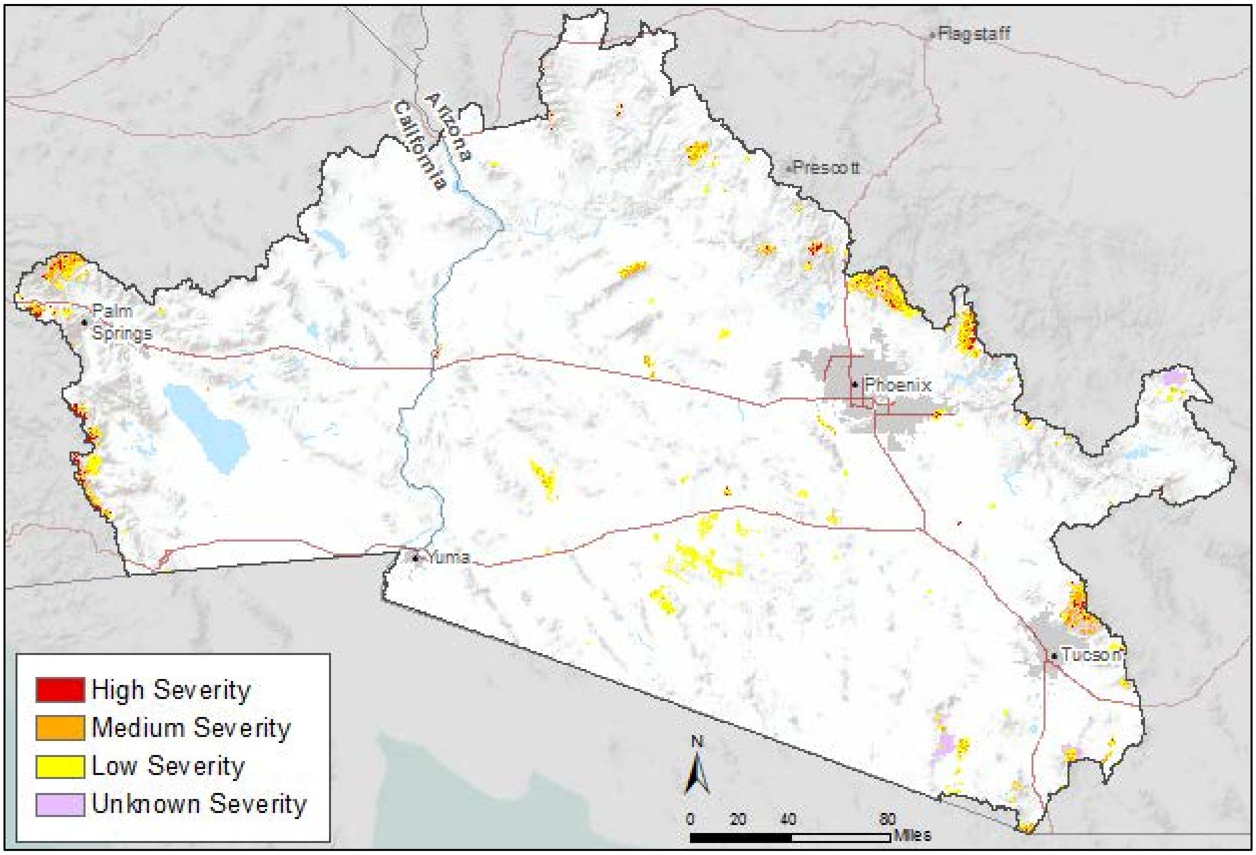
Merged fire perimeters from USGS for 2000–2010 with fire severity data obtained from LANDFIRE Disturbance datasets (1999–2008).




LANDFIRE - Disturbance (1999) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2000) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2001) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2002) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2003) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2004) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2005) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2006) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2007) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
LANDFIRE - Disturbance (2008) for the Sonoran Desert ecoregion, USA
(LANDFIRE)
Extract and Combine using Logical OR
High Severity (1999-2008)
Severity = High
Disturbance Type = Wildfire, Wildland Fire, Wildland Fire Use
Extract and Combine using Logical OR
Medium Severity (1999-2008)
Severity = Medium
Disturbance Type = Wildfire, Wildland Fire, Wildland Fire Use
Extract and Combine using Logical OR
Low Severity (1999-2008)
Severity = Low
Disturbance Type = Wildfire, Wildland Fire, Wildland Fire Use
1
Fire Perimeters (2000-2010)
Severity Unknown
Reclassify and Combine Using Logical OR
Results: Areas Changed by Fire 1999-2010
High Severity = 4
Medium Severity = 3
Low Severity = 2
Unknown Severity = 1

Results

MQ E1. Where are areas that have been changed by wildfire between 1999 and 2009?

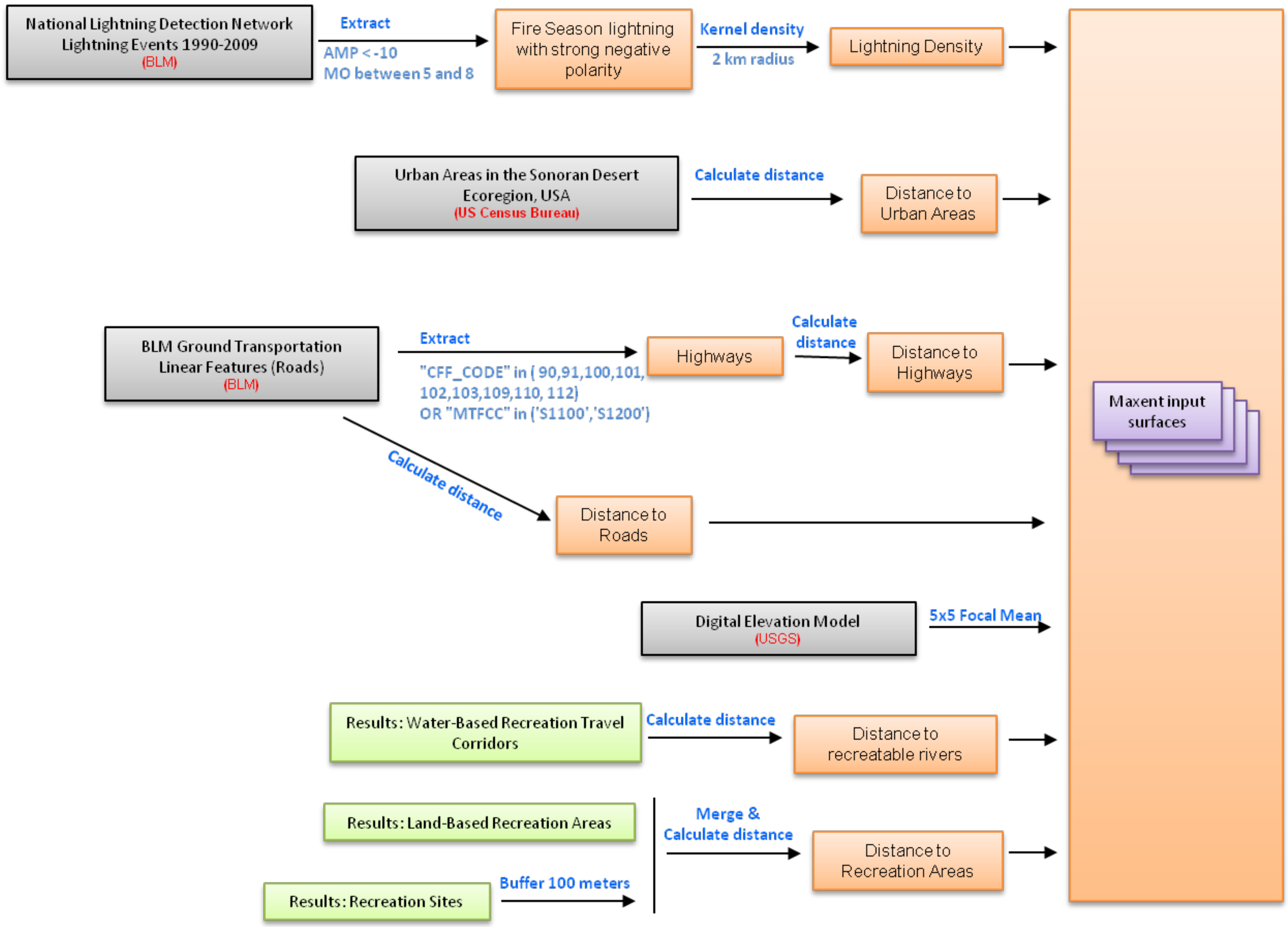


E. Wildfire
MQ E2. Where are areas with potential to change from wildfire?

Process Model or Description

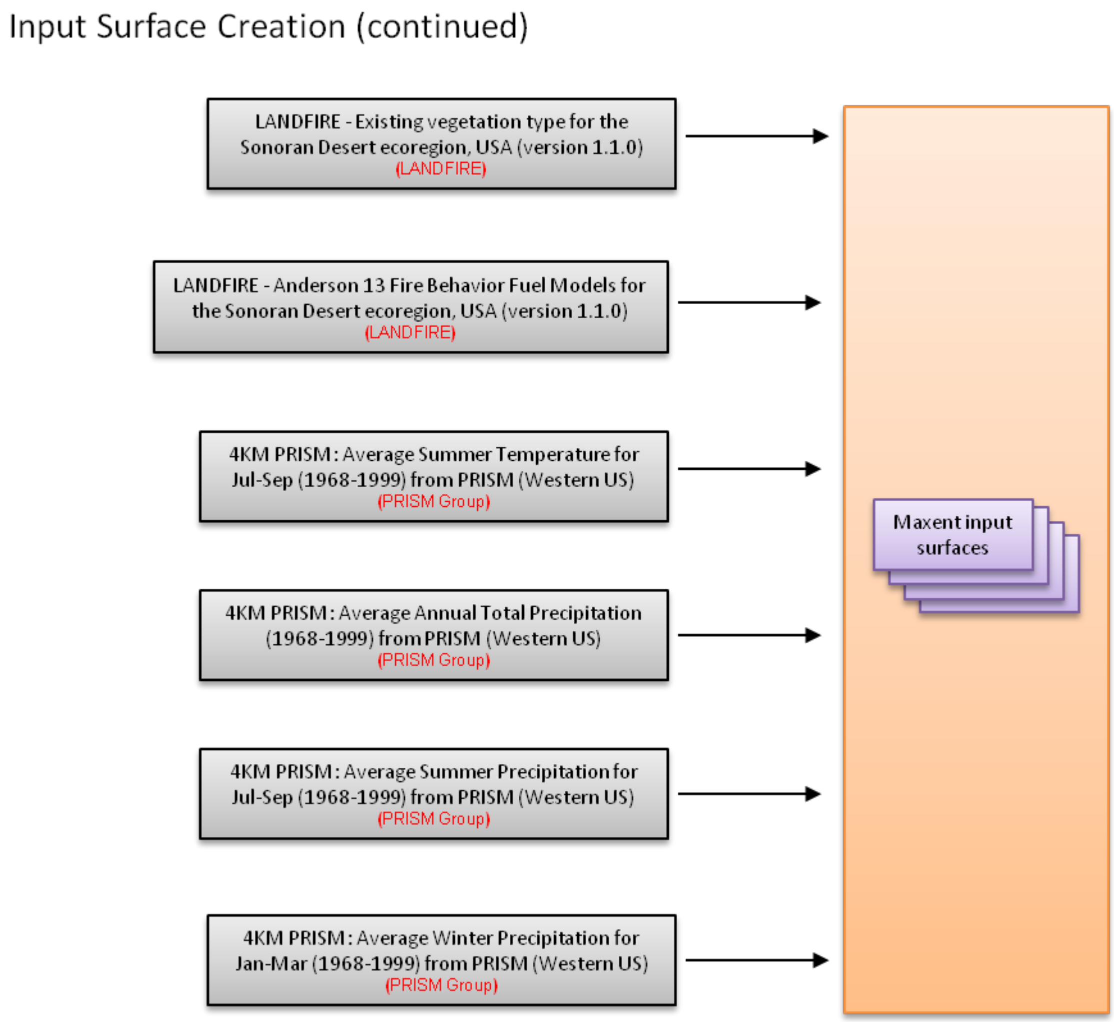
See process model for development of MaxEnt model based on current climate (PRISM) and landscape factors. Projected near-term (2015–2030) and long-term (2045–2060) results using this same model with near-term and long-term climate parameters obtained from RegCM3 regional climate model based on ECHAM5 boundary conditions. Other landscape factors were not changed for future projections. Calculated difference between near-term and long-term areas of high potential for fire occurrence compared to current areas of high potential.

Input Surface Creation



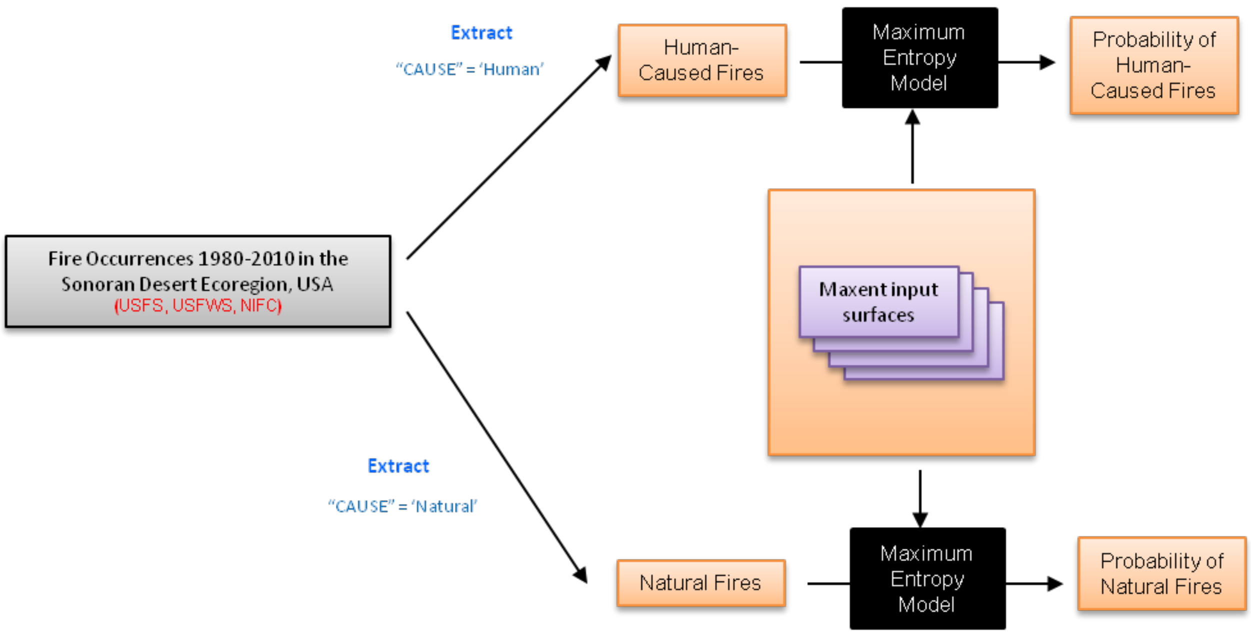
MQ E2. Where are areas with potential to change from wildfire?

Process Model Part 2

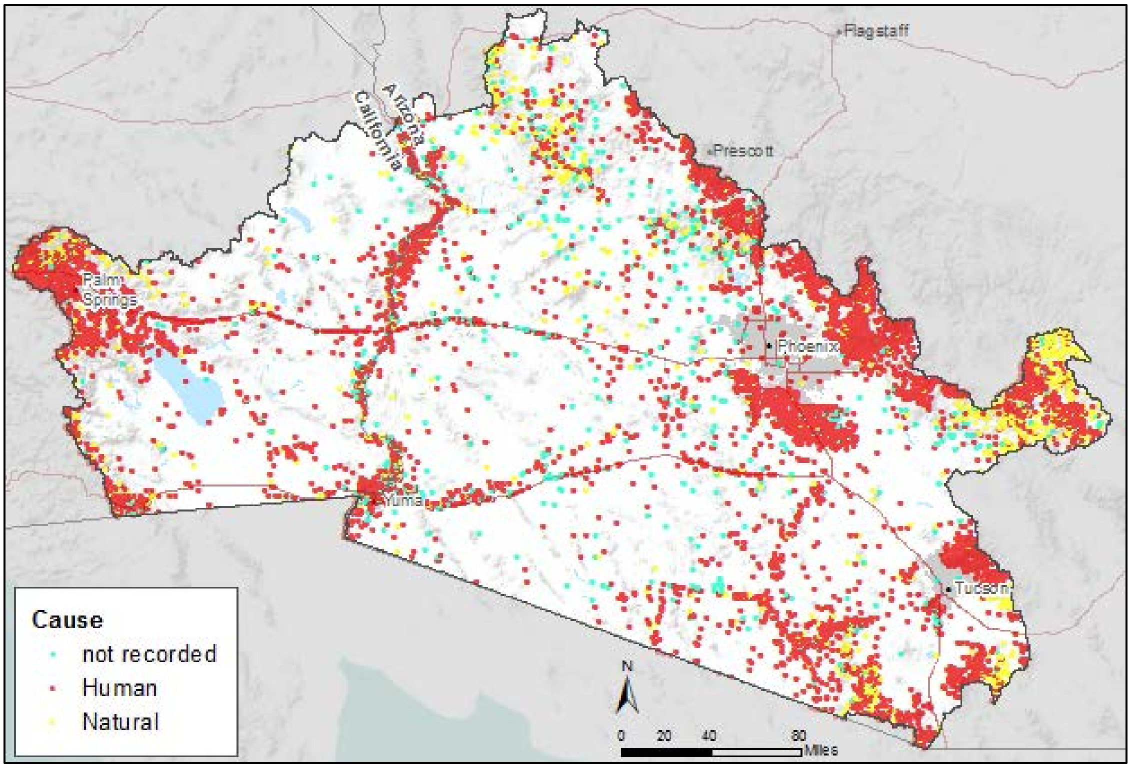


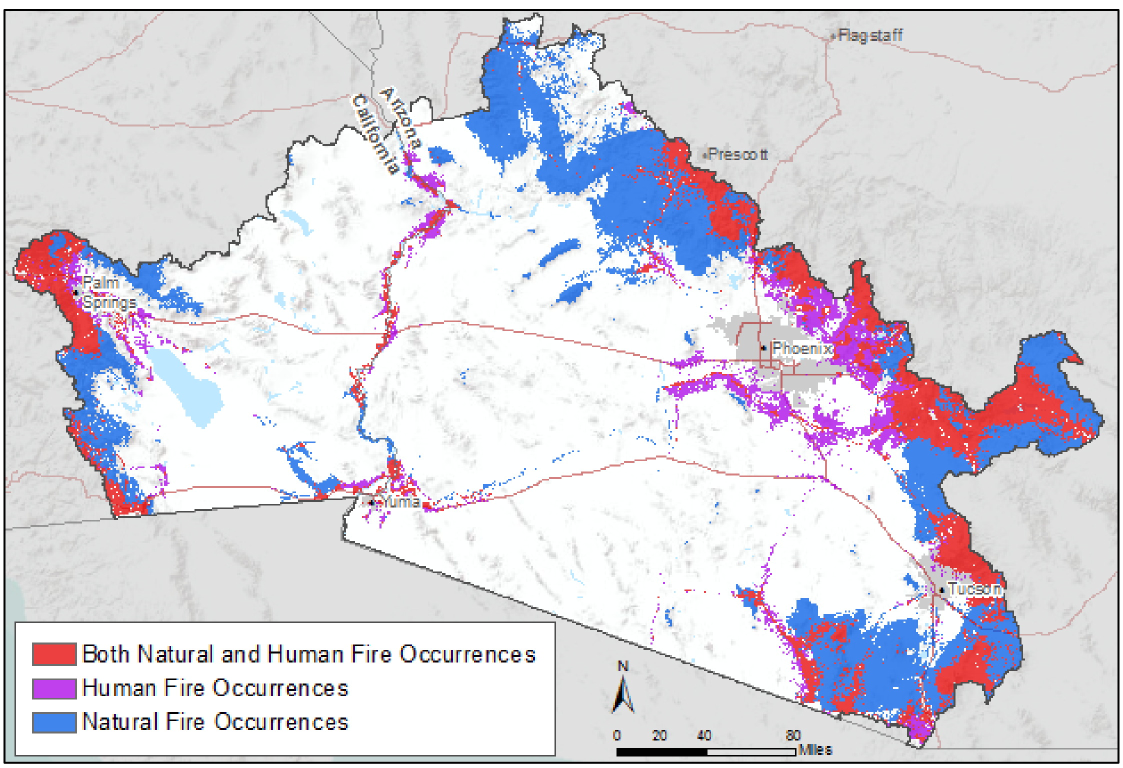
MQ E2. Where are areas with potential to change from wildfire?

Process Model Part 3



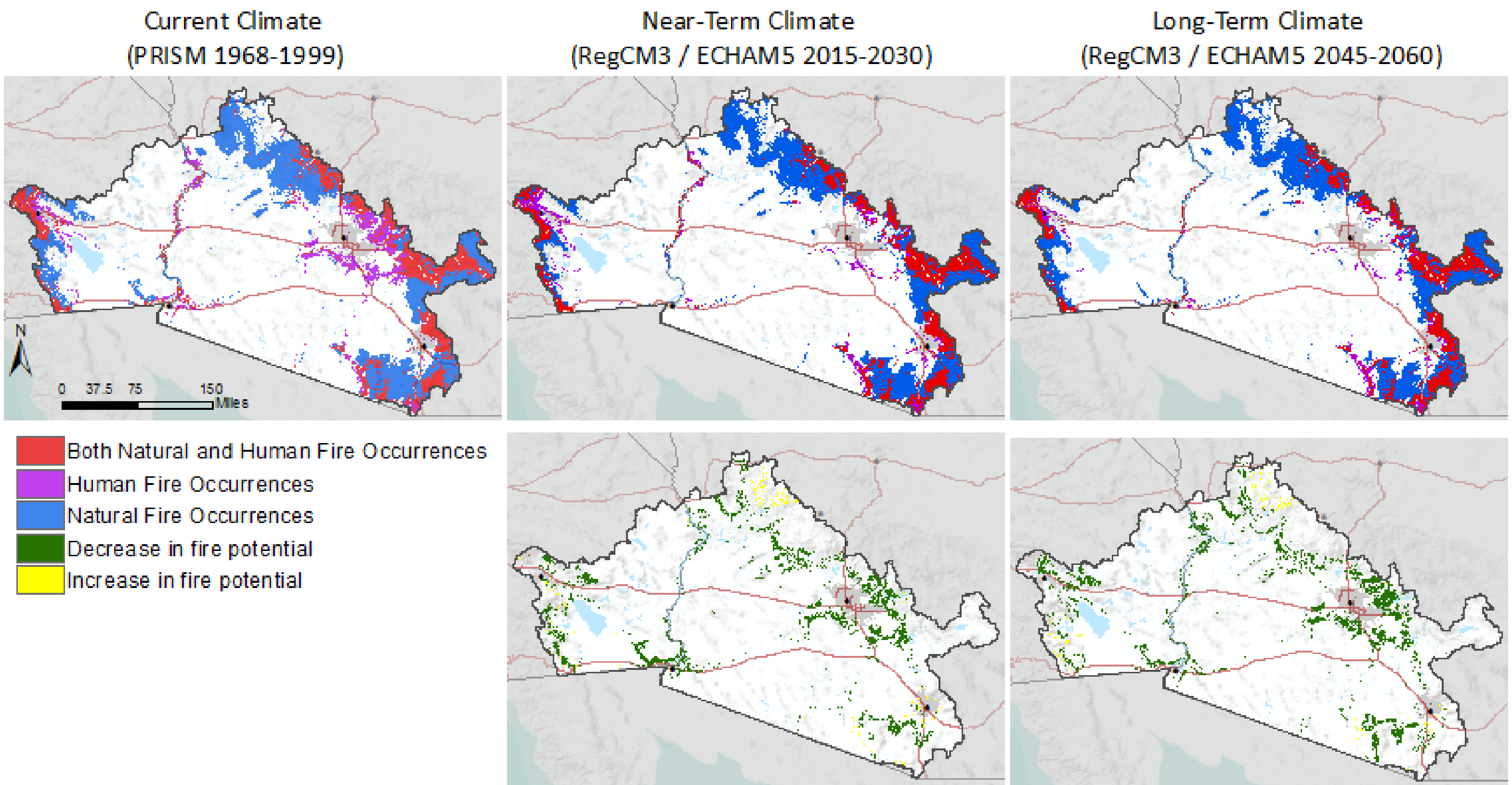
Results for Areas with Potential to Change from Wildfire





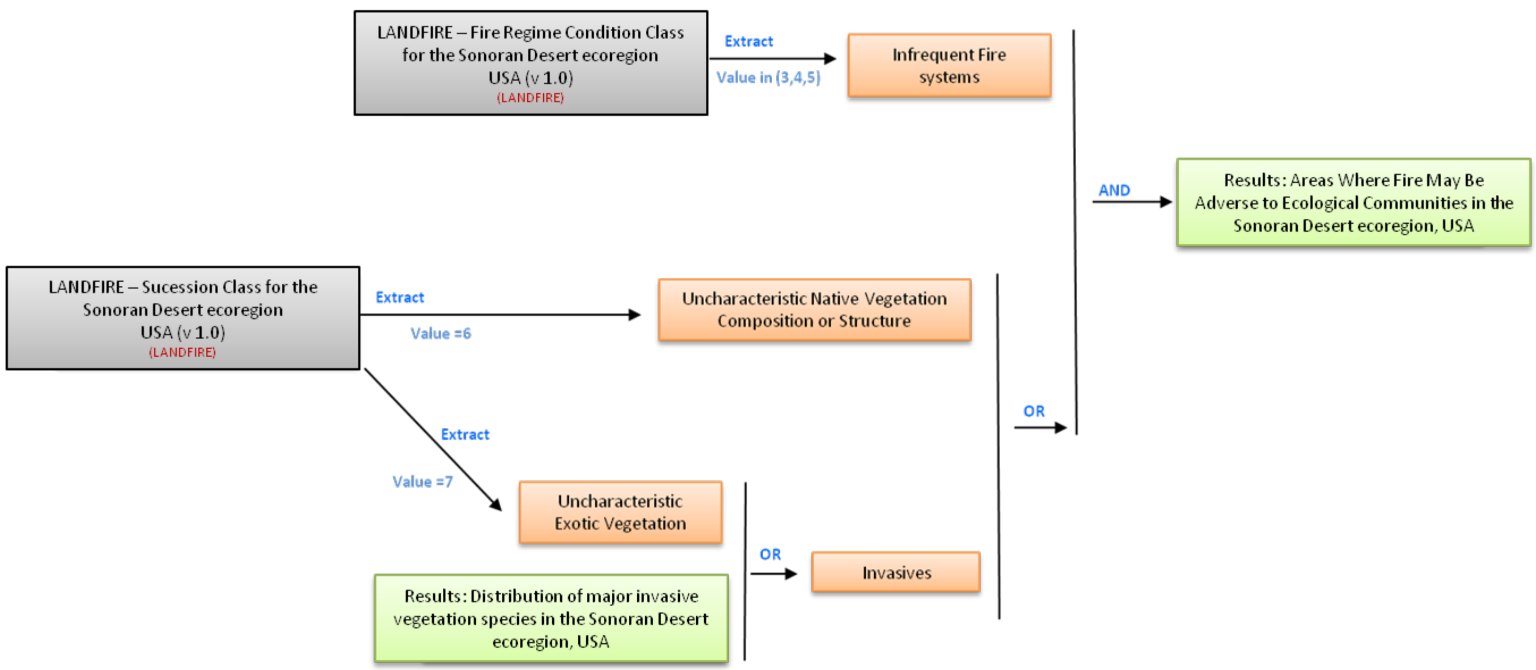
MQ E2. Where are areas with potential to change from wildfire?

Projected near-term (2015–2030) and long-term (2045–2060) results using this same model with near-term and long-term climate parameters obtained from RegCM3 regional climate model based on ECHAM5 boundary conditions.



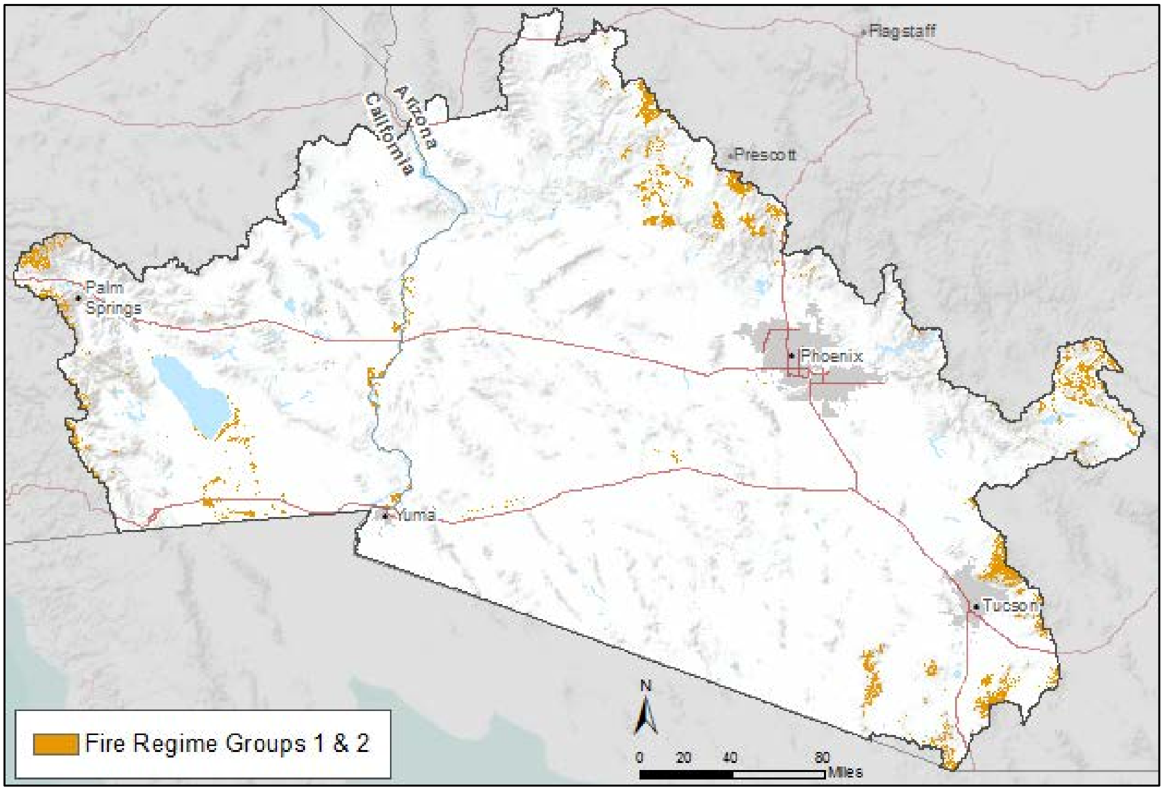
E. Wildfire
MQ E3. Where are fire-adapted communities?

Process Model or Description



MQ E3. Where are fire-adapted communities?

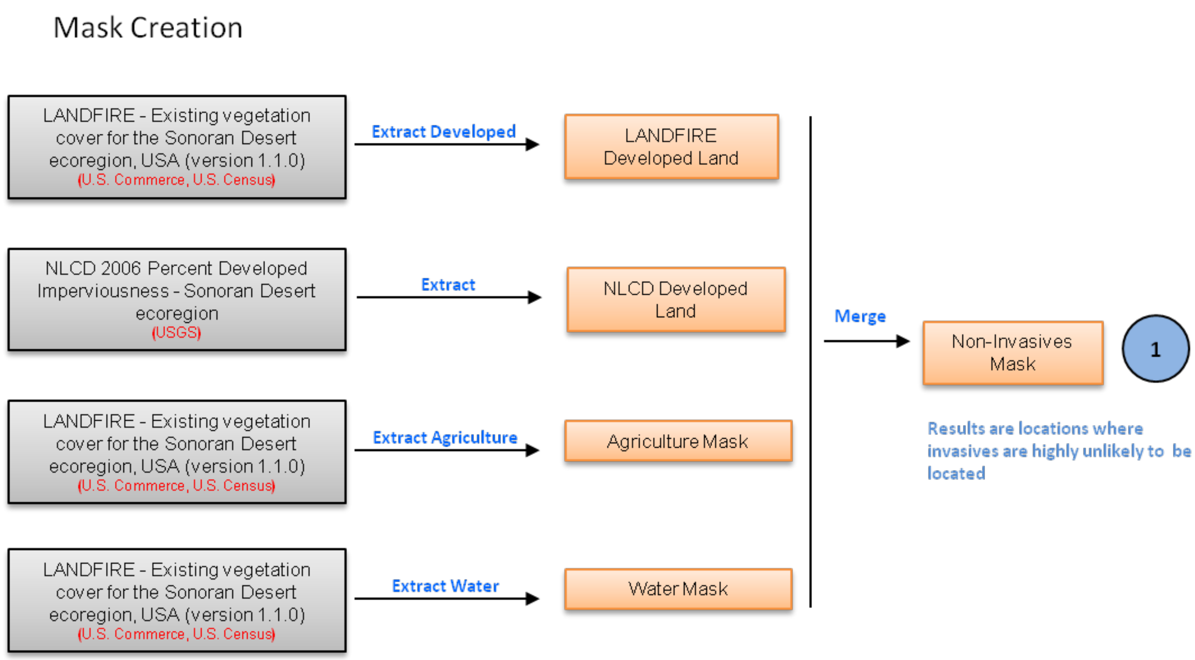
Results

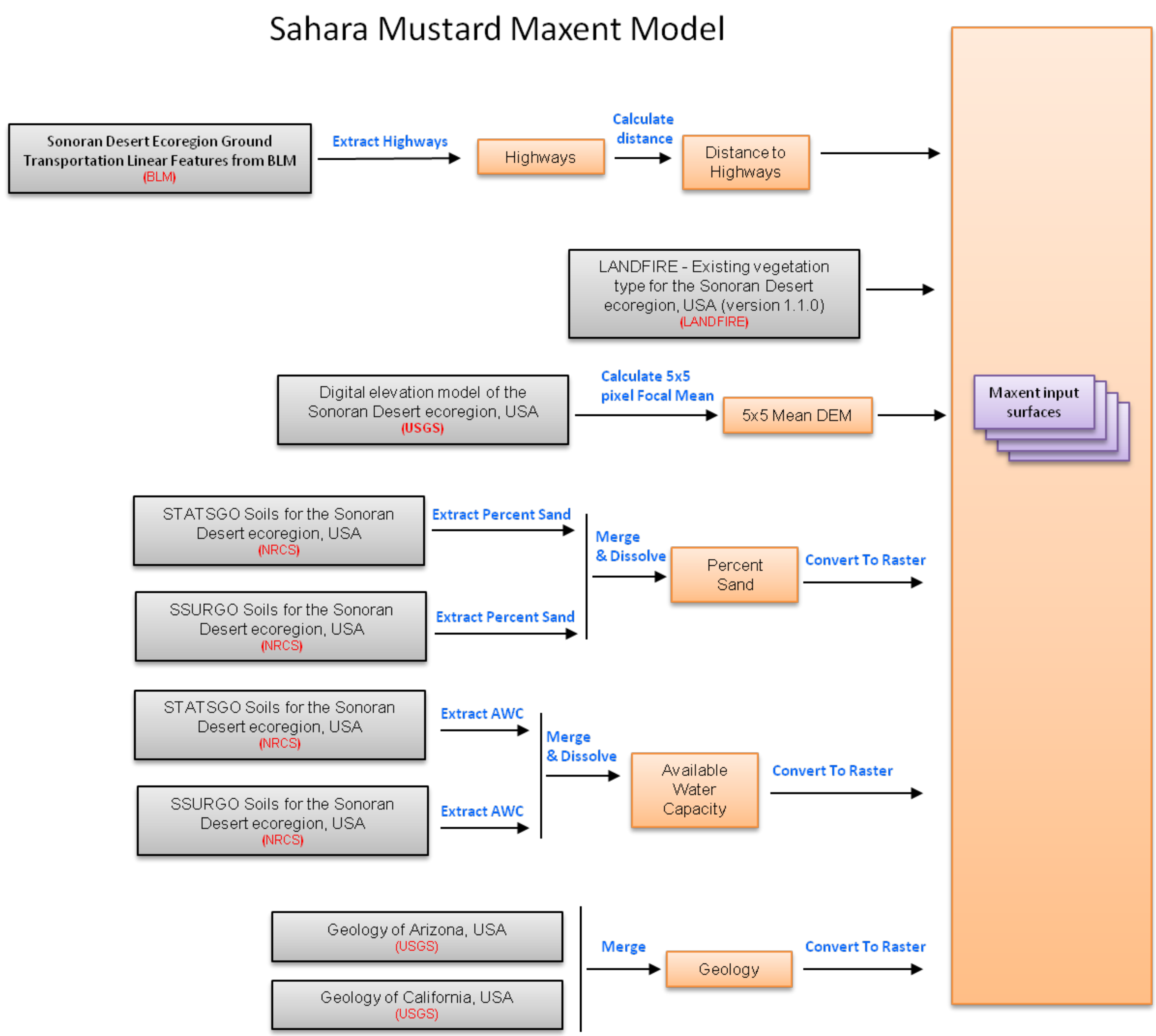


F. Invasive Species
MQ F1. Where are areas dominated by tamarisk, invasive grasses, and Sahara mustard, and where are quagga, zebra mussel, and Asiatic clam present?

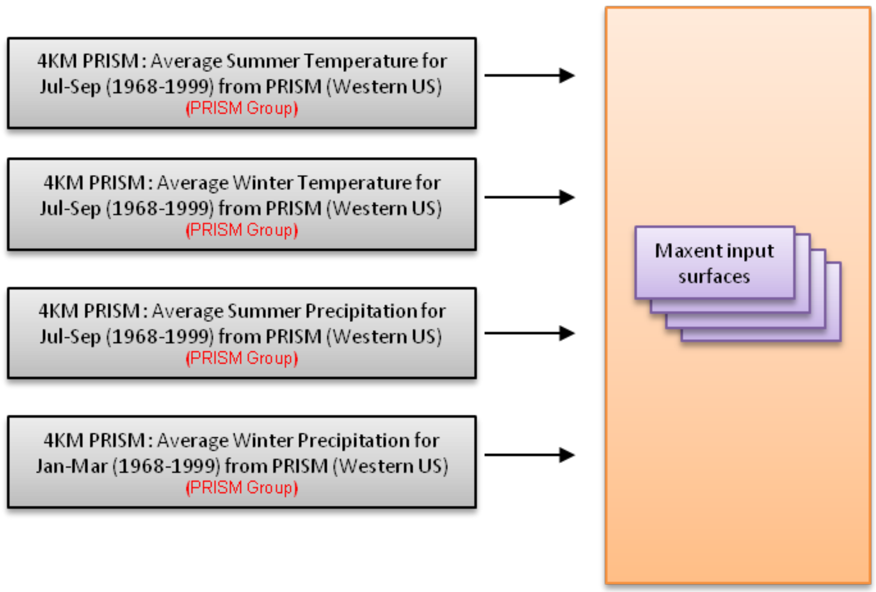
Process Model or Description

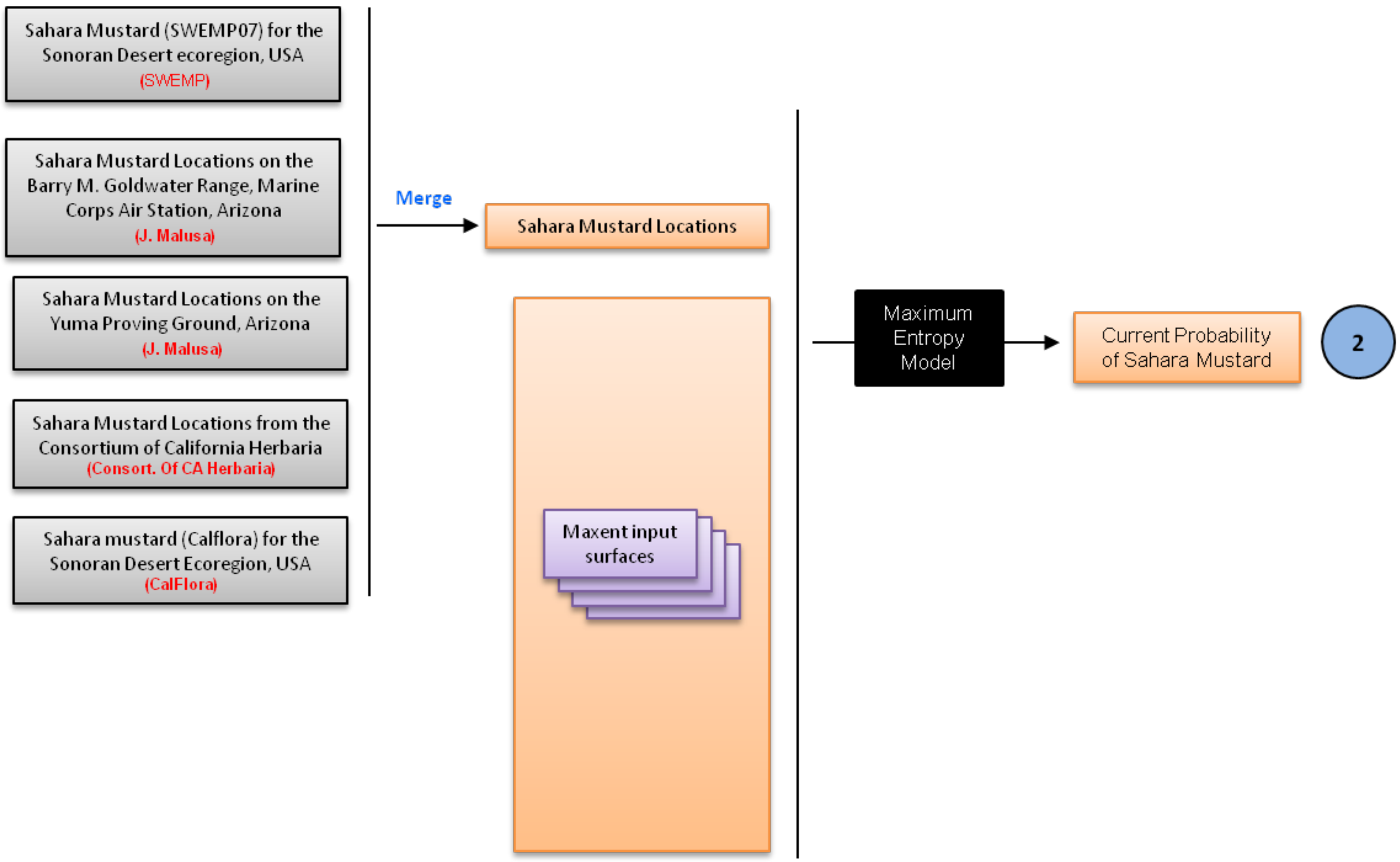
See process model for vegetation invasives. Aquatic invasives are simply selected from the USGS Nonindigenous Aquatic Species database (http://nas.er.usgs.gov/)

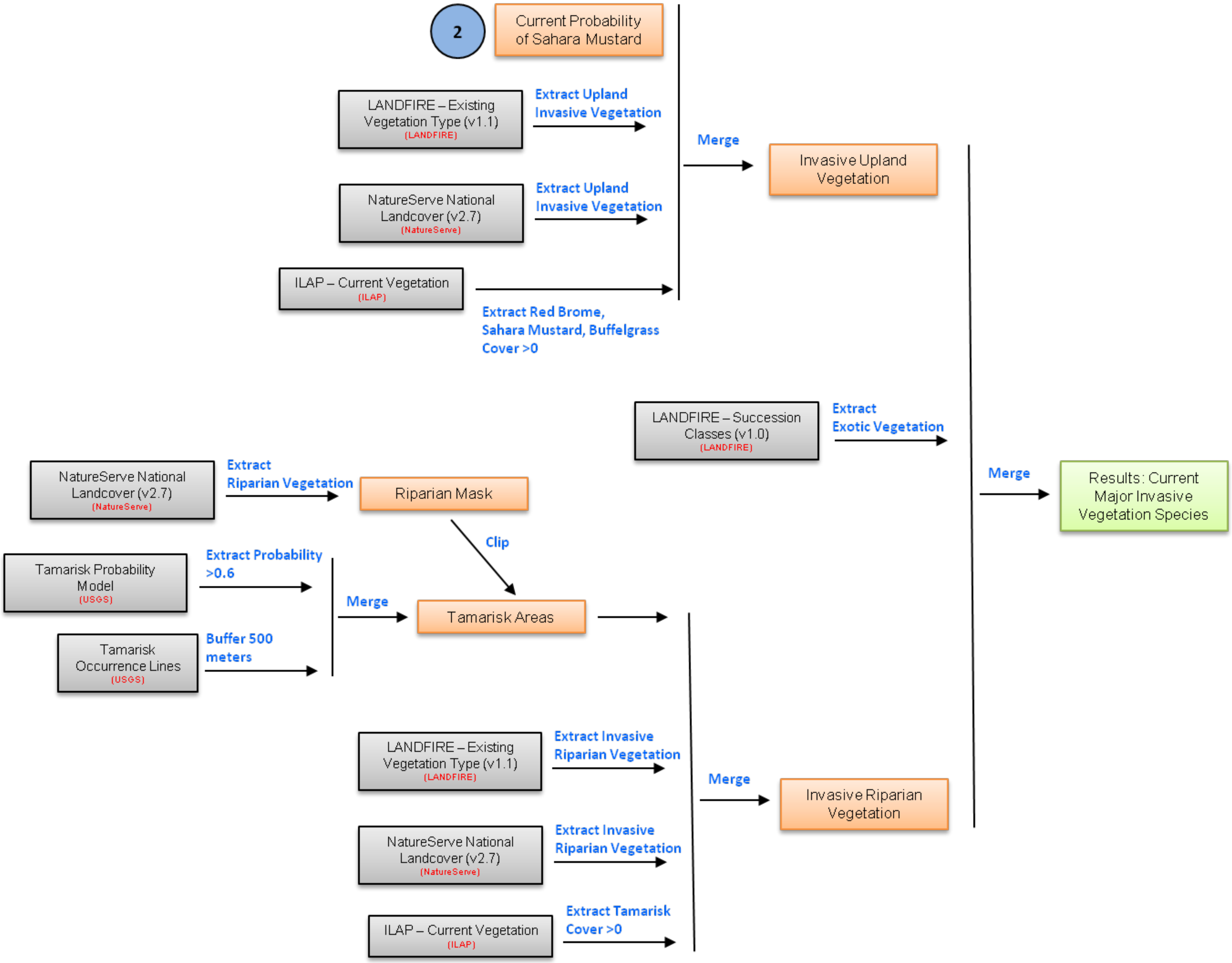



Sahara Mustard Maxent Model
Sonoran Desert Ecoregion Ground Transportation Linear Features from BLM
(BLM)
Extract Highways
Highways
Calculate distance
Distance to Highways
LANDFIRE - Existing vegetation type for the Sonoran Desert ecoregion, USA (version 1.1.0)
(LANDFIRE)
Digital elevation model of the Sonoran Desert ecoregion, USA
(USGS)
Calculate 5x5 pixel Focal Mean
5x5 Mean DEM
Maxent input surfaces
STATSGO Soils for the Sonoran Desert ecoregion, USA
(NRCS)
Extract Percent Sand
SSURGO Soils for the Sonoran Desert ecoregion, USA
(NRCS)
Extract Percent Sand
Merge & Dissolve
Percent Sand
Convert To Raster
STATSGO Soils for the Sonoran Desert ecoregion, USA
(NRCS)
Extract AWC
SSURGO Soils for the Sonoran Desert ecoregion, USA
(NRCS)
Extract AWC
Merge & Dissolve
Available Water Capacity
Convert To Raster
Geology of Arizona, USA
(USGS)
Geology of California, USA
(USGS)
Merge
Geology
Convert To Raster

Sahara Mustard Maxent Model – Current Climate

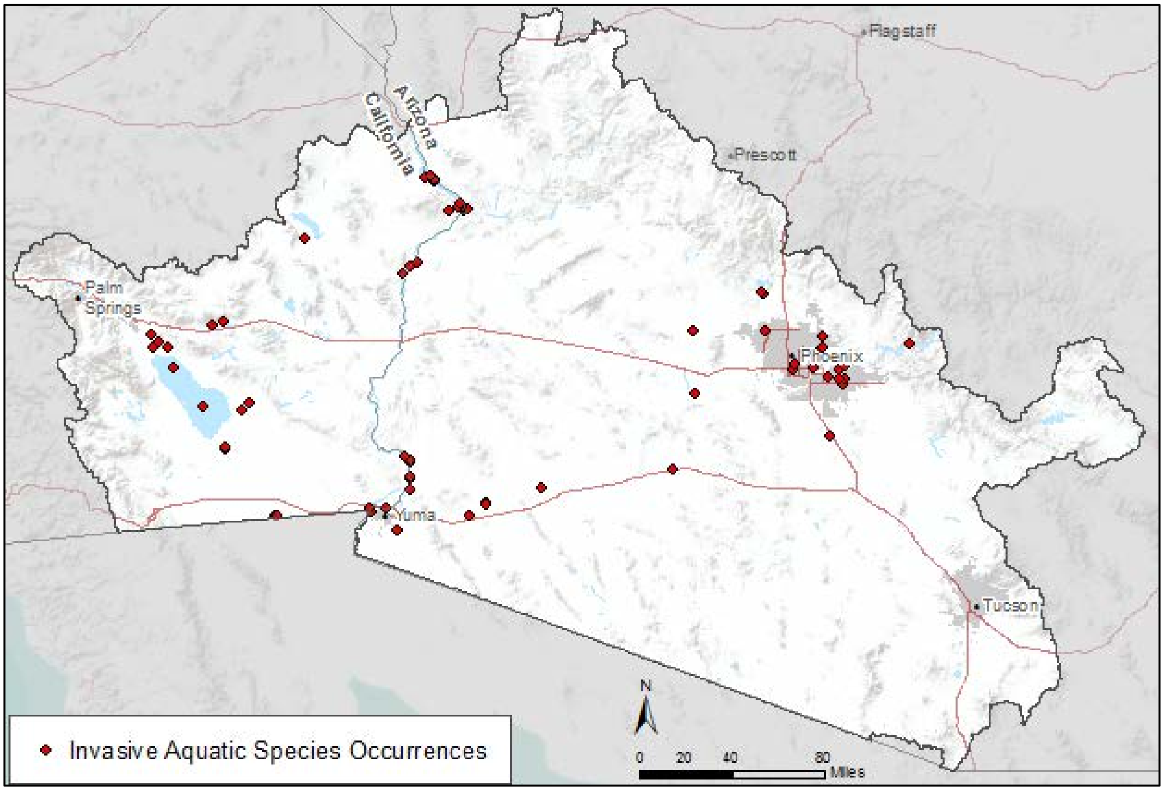


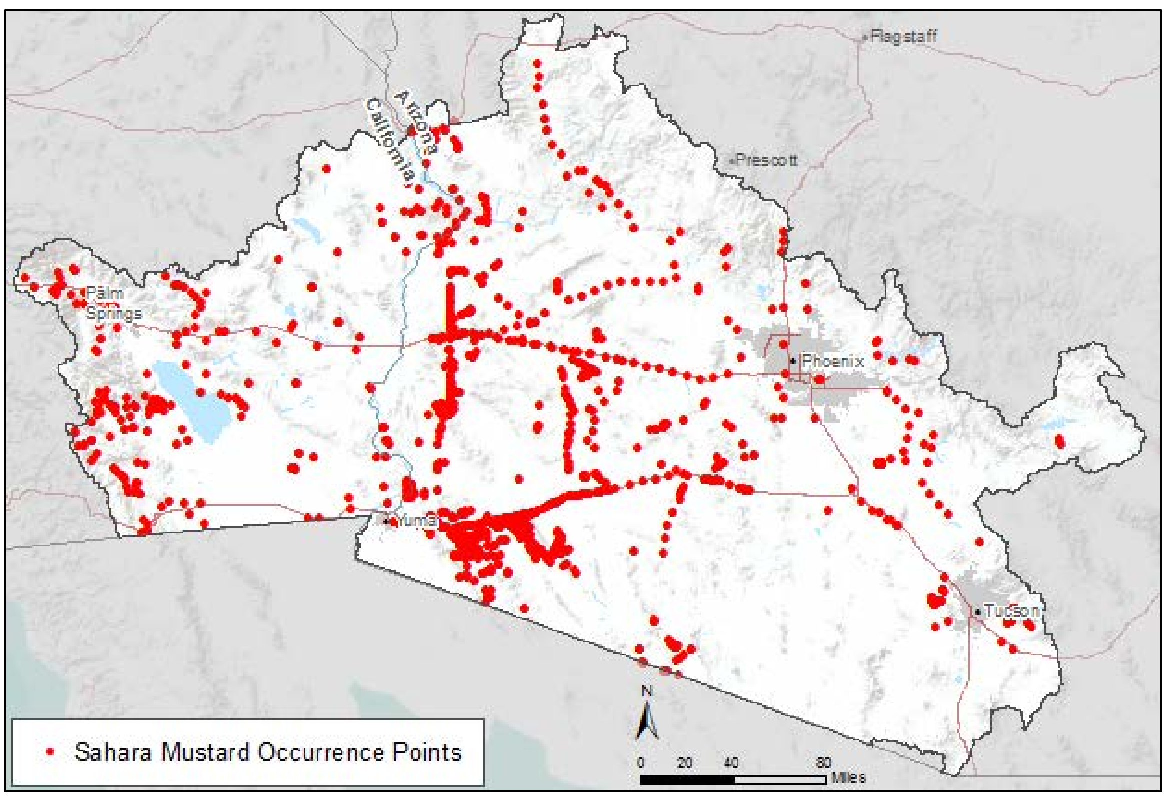

Sahara Mustard (SWEMP07) for the Sonoran Desert ecoregion, USA
(SWEMP)
Sahara Mustard Locations on the Barry M. Goldwater Range, Marine Corps Air Station, Arizona
(J. Malusa)
Sahara Mustard Locations on the Yuma Proving Ground, Arizona
(J. Malusa)
Sahara Mustard Locations from the Consortium of California Herbaria
(Consort. Of CA Herbaria)
Sahara mustard (Calflora) for the Sonoran Desert Ecoregion, USA
(CalFlora)
Merge
Sahara Mustard Locations
Maxent input surfaces
Maximum Entropy Model
Current Probability of Sahara Mustard
2

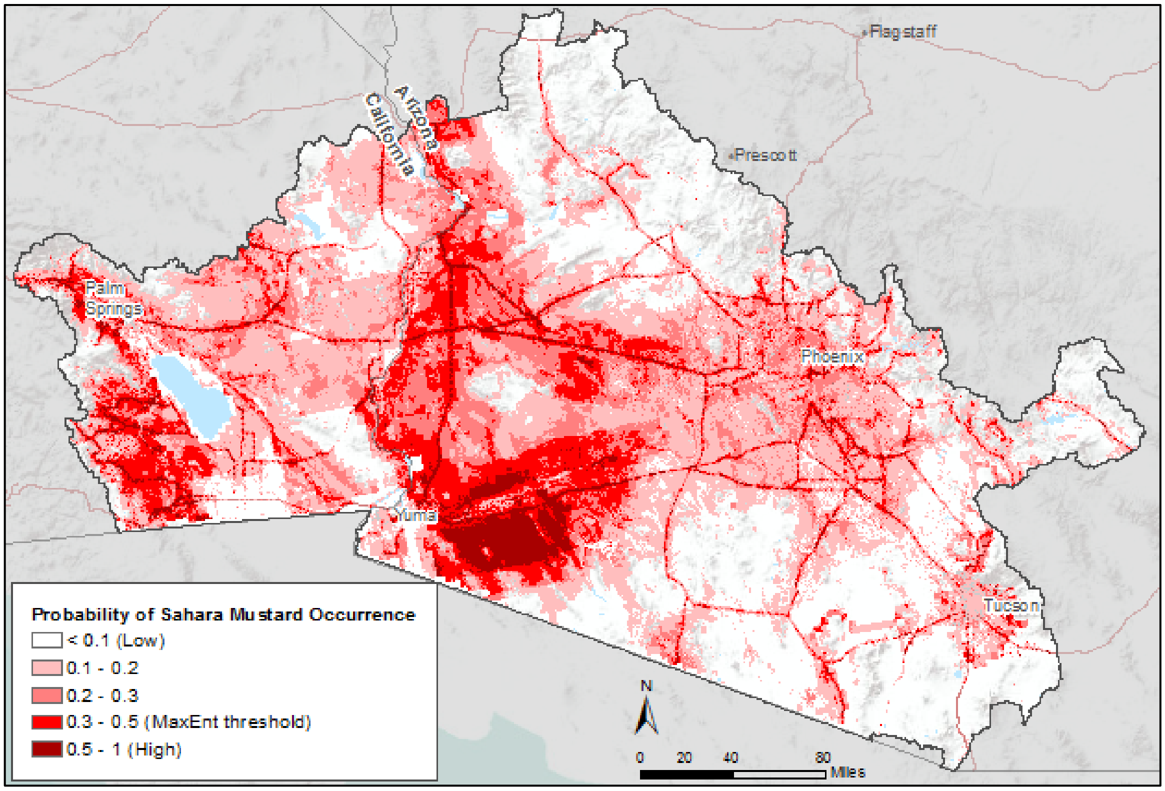


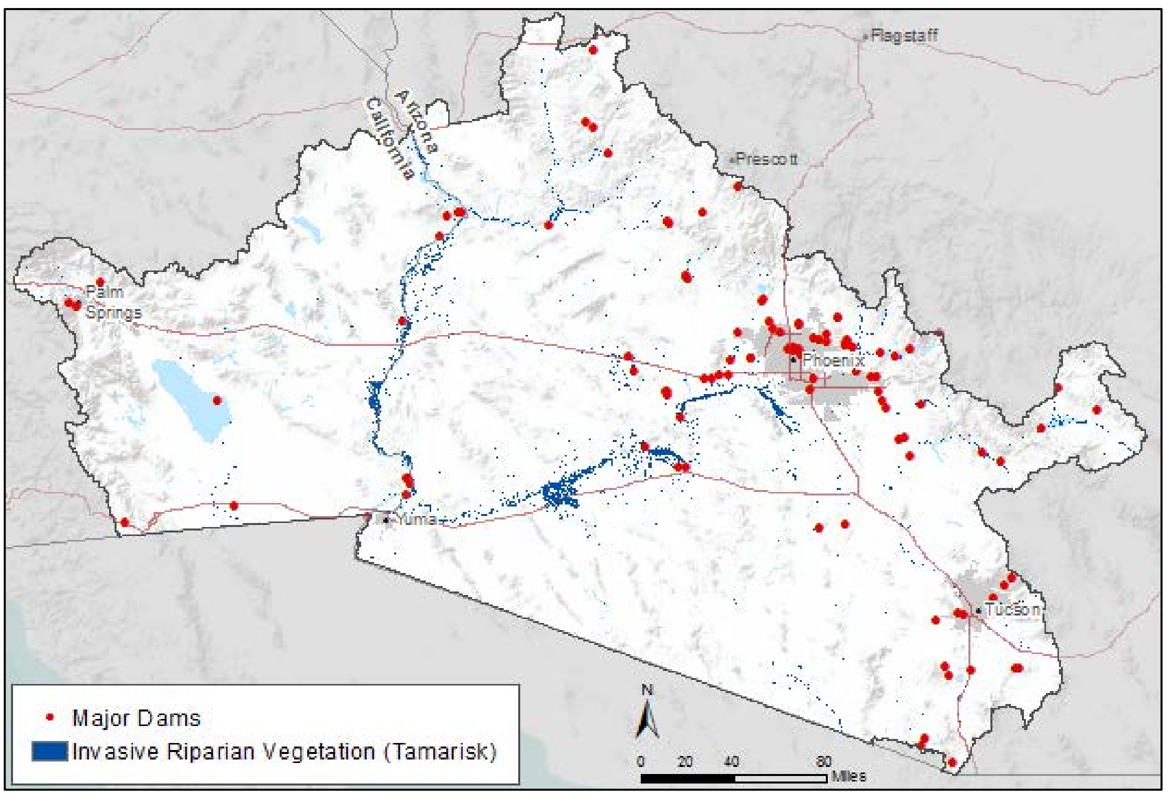
2
Current Probability of Sahara Mustard
LANDFIRE – Existing Vegetation Type (v1.1)
(LANDFIRE)
Extract Upland Invasive Vegetation
NatureServe National Landcover (v2.7)
(NatureServe)
Extract Upland Invasive Vegetation
ILAP – Current Vegetation
(ILAP)
Extract Red Brome, Sahara Mustard, Buffelgrass Cover >0
Merge
Invasive Upland Vegetation
LANDFIRE – Succession Classes (v1.0)
(LANDFIRE)
Extract Exotic Vegetation
Merge
Results: Current Major Invasive Vegetation Species
NatureServe National Landcover (v2.7)
(NatureServe)
Extract Riparian Vegetation
Riparian Mask
Clip
Tamarisk Probability Model
(USGS)
Extract Probability >0.6
Tamarisk Occurrence Lines
(USGS)
Buffer 500 meters
Merge
Tamarisk Areas
LANDFIRE – Existing Vegetation Type (v1.1)
(LANDFIRE)
Extract Invasive Riparian Vegetation
NatureServe National Landcover (v2.7)
(NatureServe)
Extract Invasive Riparian Vegetation
ILAP – Current Vegetation
(ILAP)
Extract Tamarisk Cover >0
Merge
Invasive Riparian Vegetation

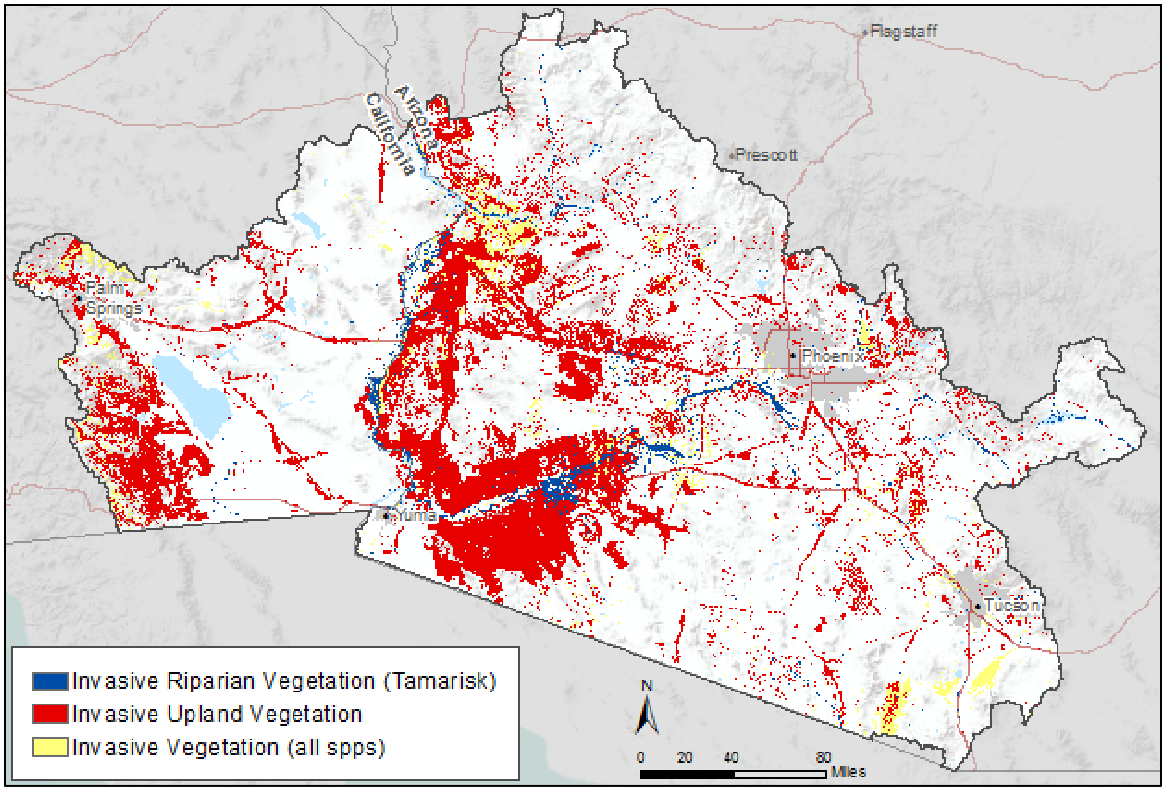
Results for Aquatic, Upland, and Riparian Invasive Species






Flagstaff
Prescott
Arizona
California
Palm Springs
Phoenix
Yuma
Tucson
Probability of Sahara Mustard Occurrence
< 0.1 (Low)
0.1 - 0.2
0.2 - 0.3
0.3 - 0.5 (MaxEnt threshold)
0.5 - 1 (High)
N
0 20 40 80
Miles


Flagstaff
Prescott
Arizona
California
Palm Springs
Phoenix
Yuma
Tucson
Major Dams
Invasive Riparian Vegetation (Tamarisk)
N
0 20 40 80
Miles



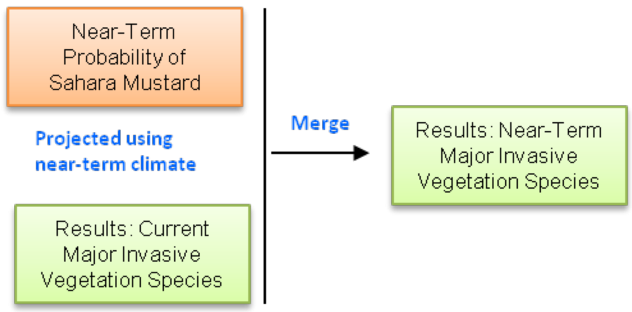
Flagstaff
Arizona
California
Prescott
Palm Springs
Phoenix
Yuma
Tucson
Invasive Riparian Vegetation (Tamarisk)
Invasive Upland Vegetation
Invasive Vegetation (all spps)
N
0 20 40 80
Miles

F. Invasive Species

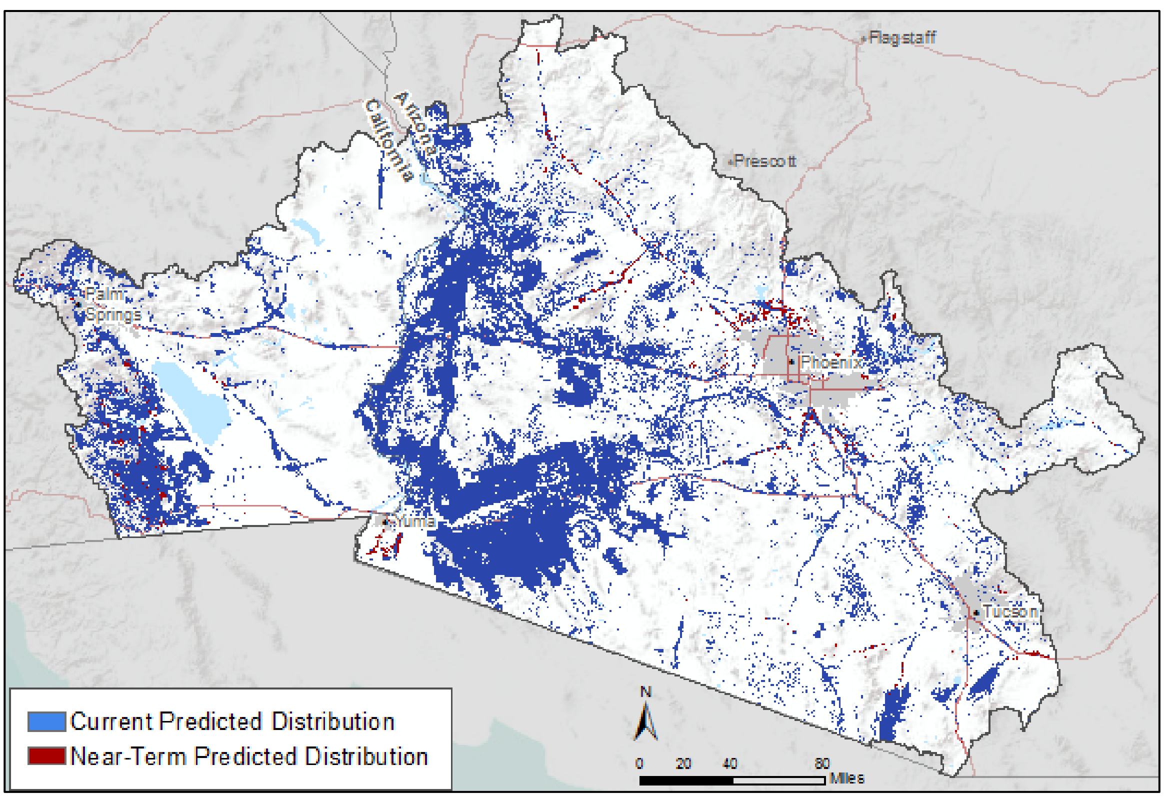
MQ F2. Where are areas of potential future encroachment from this invasive species?

Process Model or Description

Process model for vegetation (below) is an extension of Process Model for MQ F1. MQF2 was not done for aquatic invasives due to insufficient future projection data.



Results for Current and Near-Term Distribution of Invasive Species



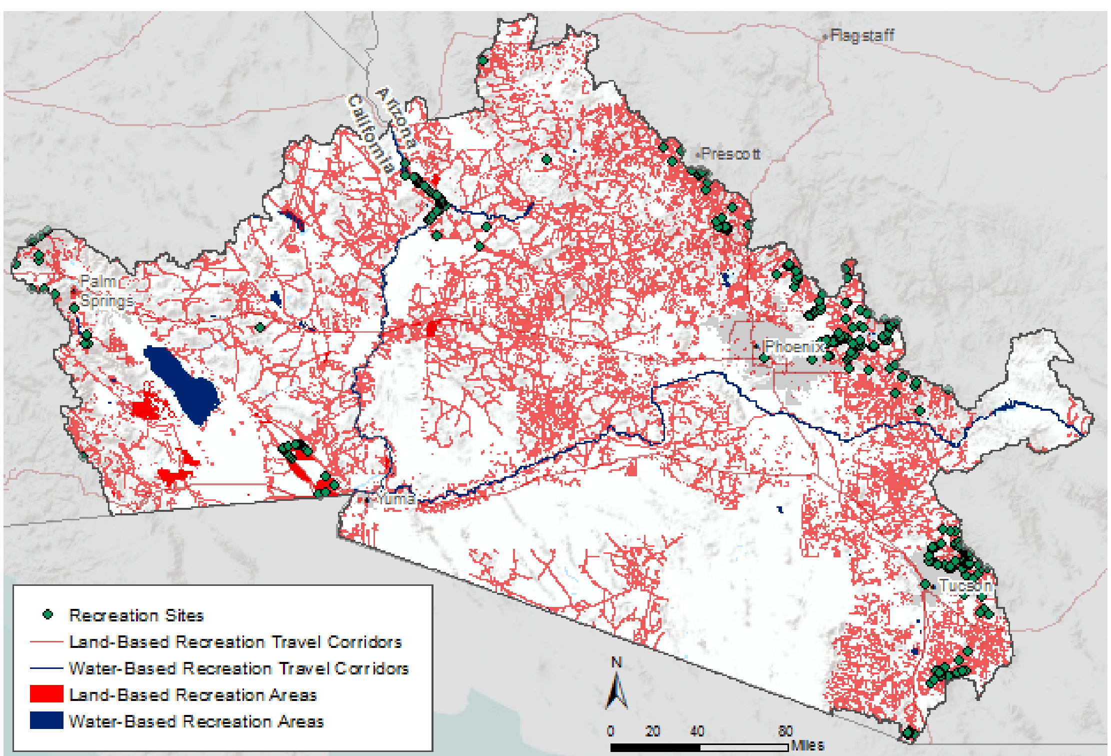
G. Future Development
MQ G1. Where are areas of planned development? – **go to Appendix E**
MQ G2. Where are areas of planned development, including renewable energy and where are potential conflicts with conservation elements? – **go to Appendix E**
MQ G3. Where are areas of potential development (e.g., under lease), including renewable energy sites and transmission corridors and where are potential conflicts with CEs? – **go to Appendix E**

H. Resource Use
MQ H1. Where are high-use recreation sites, developments, roads, infrastructure or areas of intensive recreation use located (including boating)?

Process Model or Description

Recreation sites were compiled from USFS and BLM data. We compiled land-based recreation areas (open OHV areas) from BLM and water-based recreation areas by selecting larger water bodies from NHD (>1 square kilometer). Land-based travel corridors were extracted from BLM ground transportation linear features dataset within federal and state lands in Conservation Biology Institute protected areas database (excluding DOD lands). Water-based travel corridors were compiled by selecting rivers from NHD flowlines that were listed on BLM rivers website.

Results for High-Use Recreation

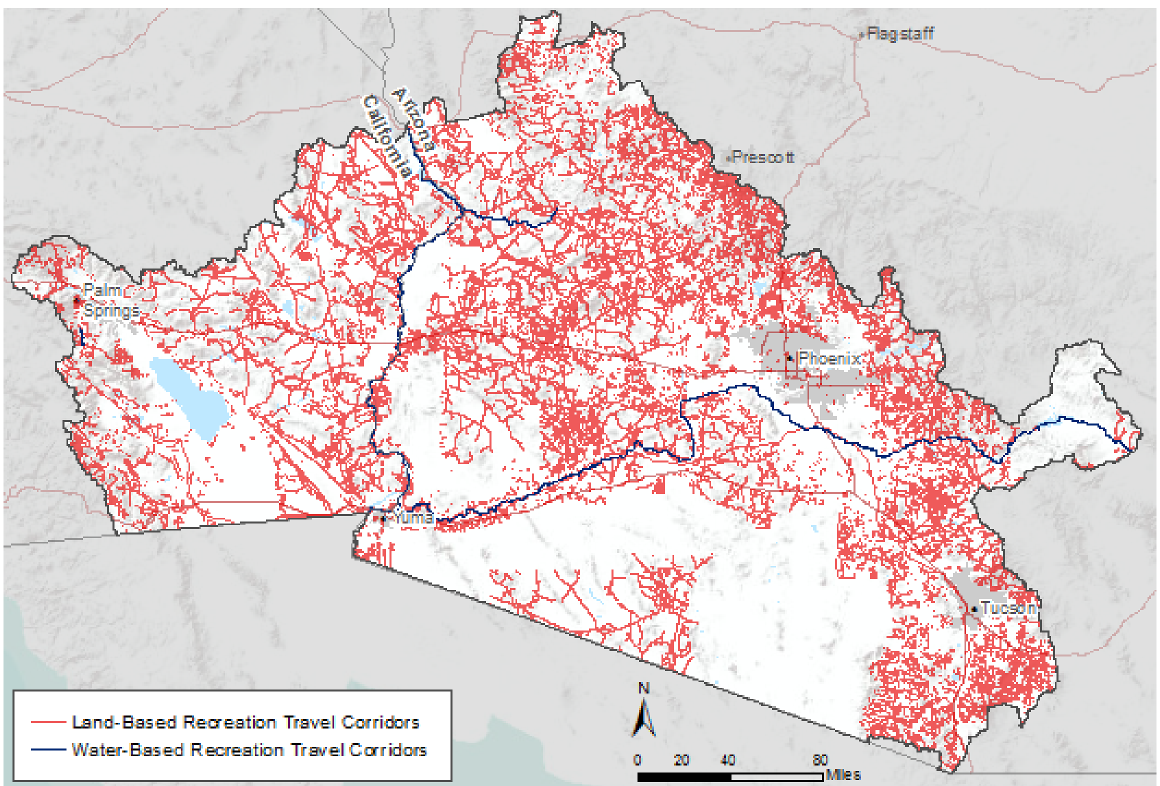


H. Resource Use
MQ H2. Where are areas of concentrated recreation travel (OHV and other travel) located?

Process Model or Description

Land-based travel corridors were compiled from BLM ground transportation linear features dataset within federal and state lands in Conservation Biology Institute protected areas database (excluding DOD lands). Water-based travel corridors were extracted by selecting rivers from NHD flowlines that were listed on BLM rivers website.

Results for Areas of Concentrated Recreation Travel

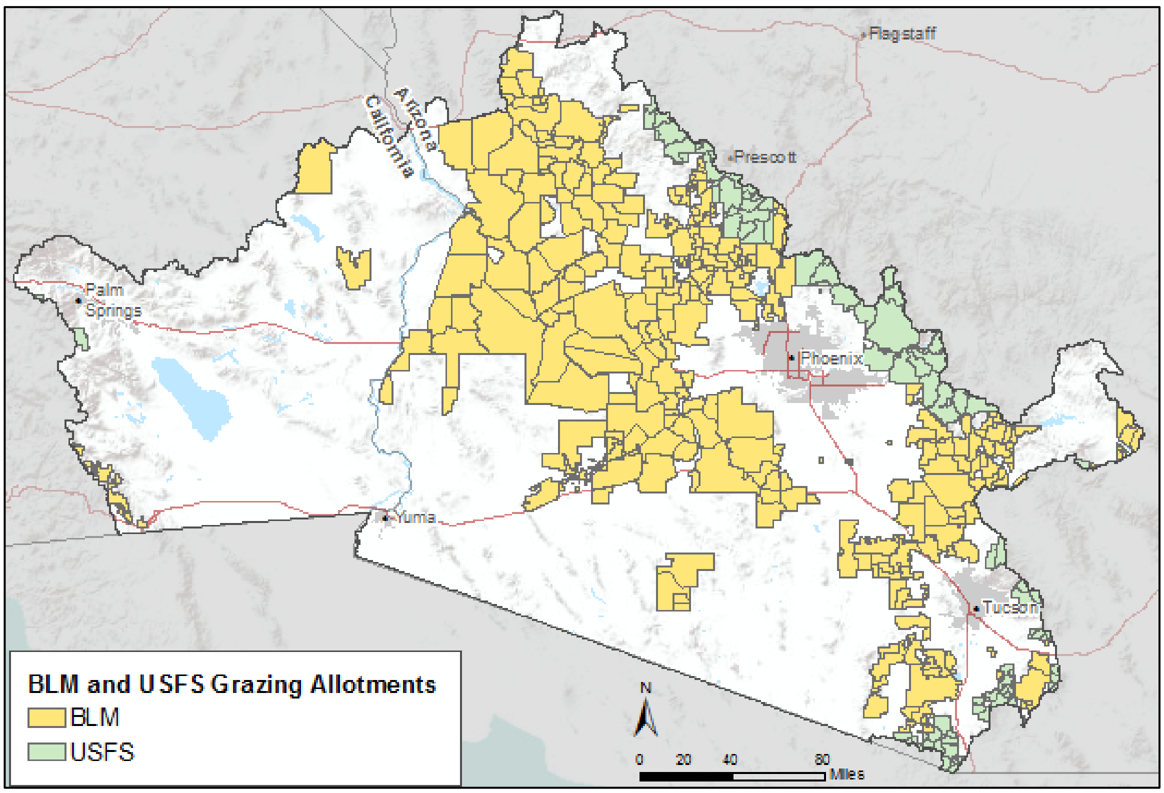


H. Resource Use
MQ H4. Where are allotments and type of allotment?

Process Model or Description

Grazing allotments were compiled from USFS and BLM datasets.

Results for Location of Grazing Allotments

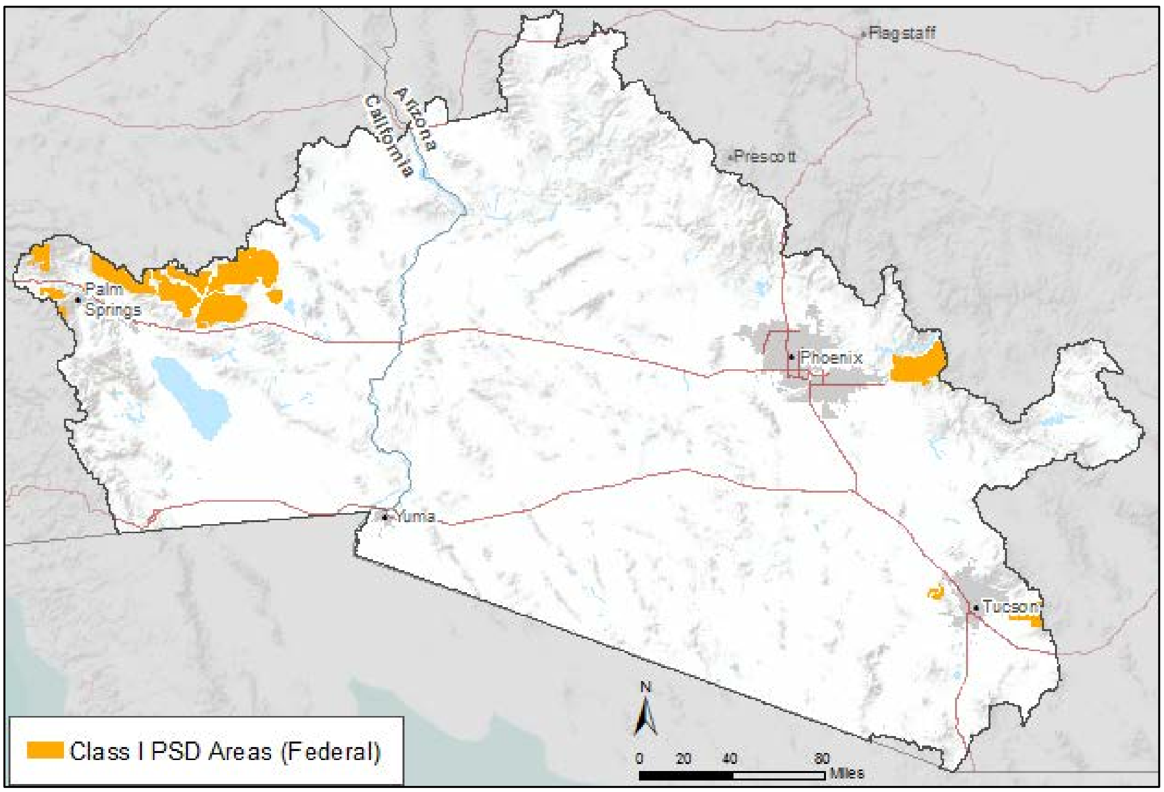


I. Air Quality
MQ I3. Where are the Class I PSD areas?

Process Model or Description

Federal Class I PSD areas selected from CBI protected areas database using authoritative list of areas (all national parks and some wilderness areas) from EPA.

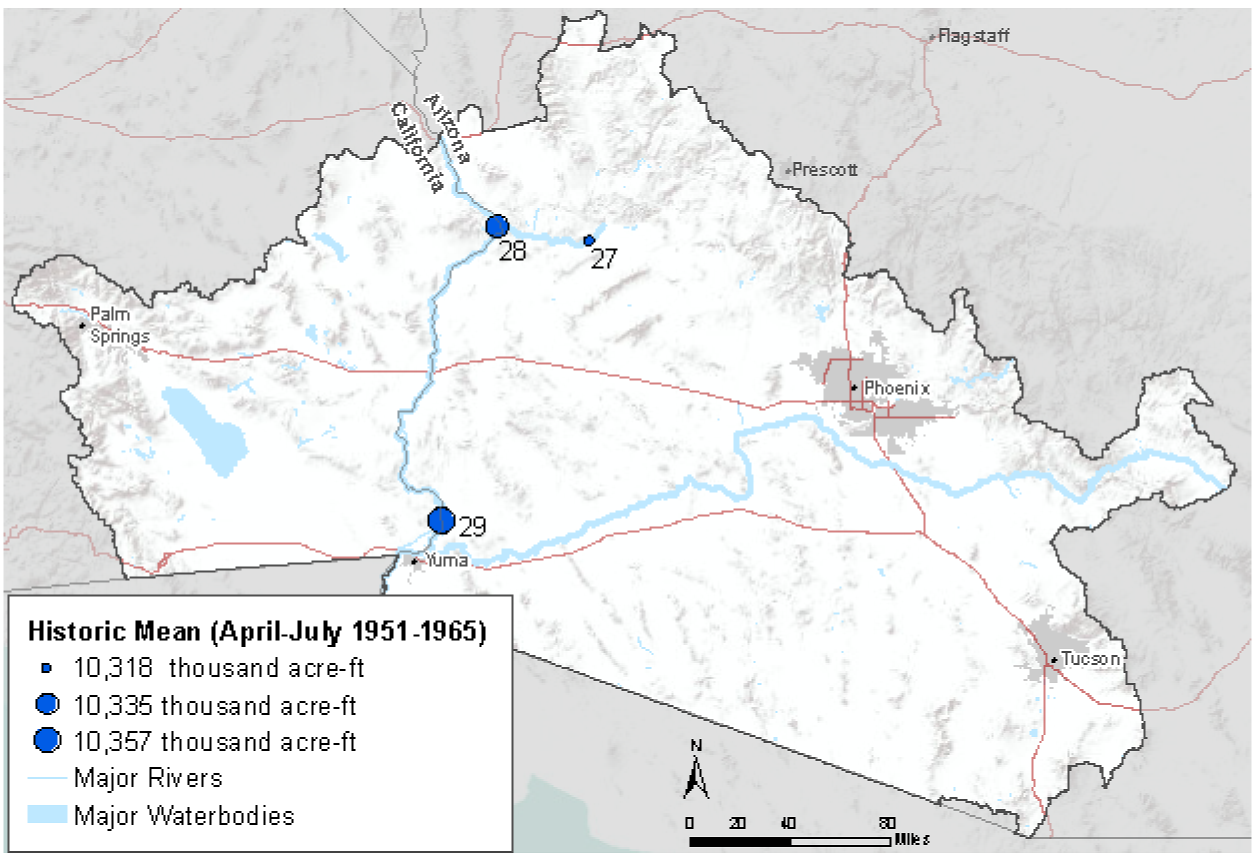
Results for Class I PSD Air Quality Areas



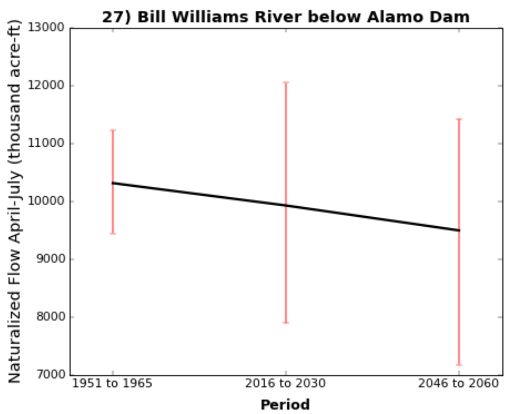
J. Climate Change
MQ J1. Where/how will the distribution of dominant native and invasive plant species be vulnerable to or have potential to change from climate change in 2060? – **see MQ C2 for each plant community**
MQ J3. Where are areas of species conservation elements distribute change between 2010 and 2060? – **see MQ D6 for each species**
MQ J4. Where are aquatic/riparian areas with potential to change from climate change? – **see MQ C2 for riparian vegetation and results below for future discharge**

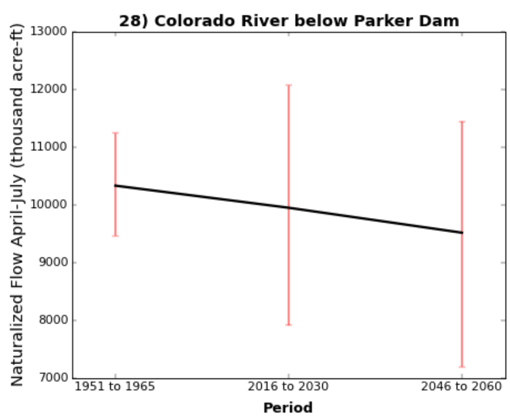
Results for Aquatic Areas with Potential to Change from Climate Change

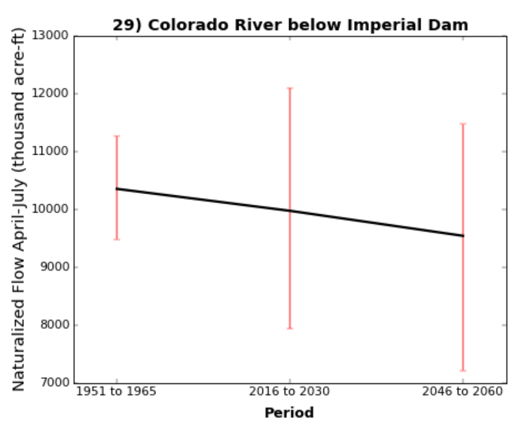
Map below: Historic stream flow data (April–July 1951–1065) from 12 gaging stations on the Colorado River and major tributaries in the Colorado Plateau.



Graphs show alteration in flow at 3 gaging stations pictured above from historical period (1951) through current period and projected to mid-21st century (2060, Bureau of Reclamation data, BOR 2012). Graph numbers correspond to gaging station locations on previous map.







BOR (Bureau of Reclamation). 2012. Colorado River Basin water supply and demand study. Technical report B: Water Supply Assessment. Prepared by Colorado River Basin Water Supply and Demand Study Team, U.S. Bureau of Reclamation.

Appendix B – Ecological Systems Conservation Elements

Organization of Appendix B

The following sources and results are provided for each Ecological System (vegetation community) conservation element: a Conceptual Model, a description of the analytical process (including source data) and/or a Process Model for each management question, and results in the form of maps and other supporting graphics. Access to a data portal to examine the results in greater detail is available at the BLM website https://gbp-blm-egis.hub.arcgis.com

Ecological Systems Conceptual Models

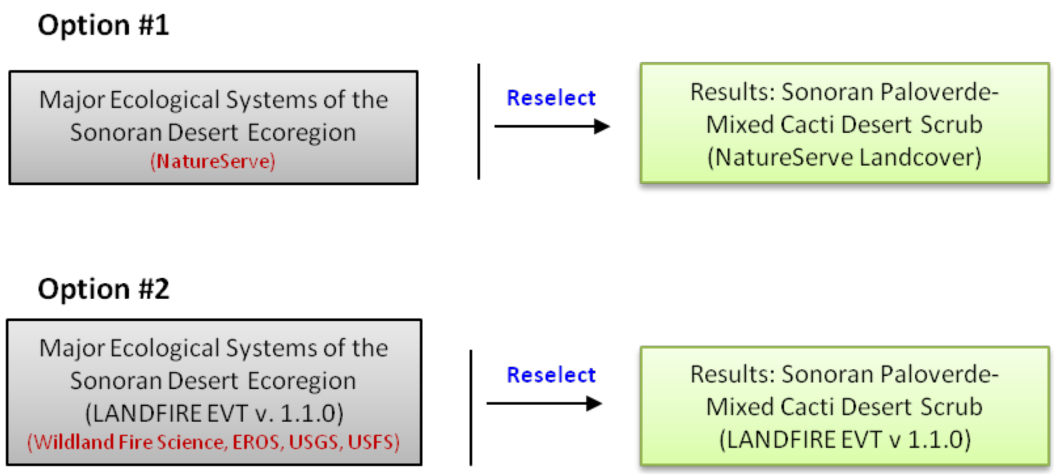
Conceptual models used in the Sonoran Desert REA organize and articulate the relationship between the various change agents and natural drivers for a particular conservation element. Not all of the relationships identified lend themselves well to measurement or monitoring but they are still important to include as it aides in our general understanding of complex interactions.

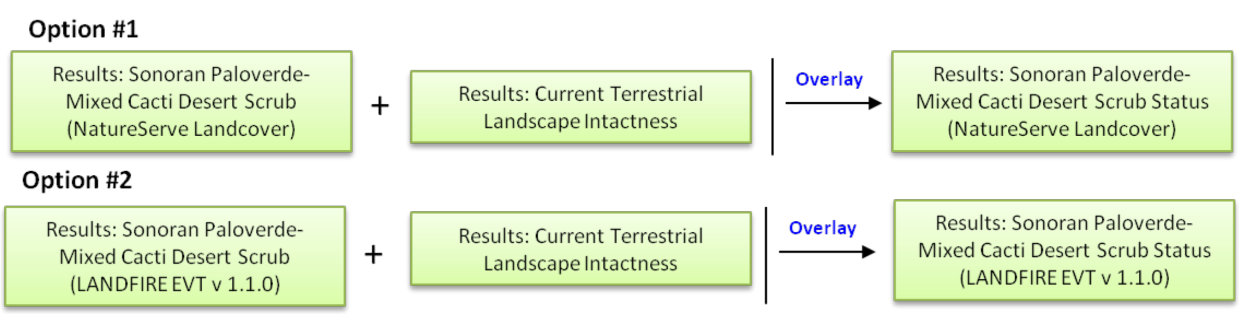
All ecological systems conceptual models include a series of change agents (depicted with yellow boxes) and natural drivers (cyan boxes). Specifics regarding some of the factors are presented in blue text. Within each ecological system, one or more dominant species are included in the model. Arrows represent relationships between the various change agents and natural drivers with the community overall and, where appropriate, with the dominant species more directly. More specific information is provided by the orange text. Thicknesses of the arrows **DO NOT** represent degree of importance. Rather, bold lines represent those factors that are tracked or modeled to varying degrees of certainty throughout the REA analysis.

Fire regime is influenced by a complex interaction of factors: fuel load and condition, grazing, invasive species, and fire frequency (both natural—a function of climate—and human-caused—a function of development). Fire suppression is another influencing factor on the fire regime. Climate change and development affects the entire complex and all of its components. Natural ecological systems are shaped by a natural fire regime and altered by a different regime. Native ecosystems can also be directly affected by invasive species and grazing. No natural system is fixed in time or space, and it is the individual species that respond to environmental change rather than the community.

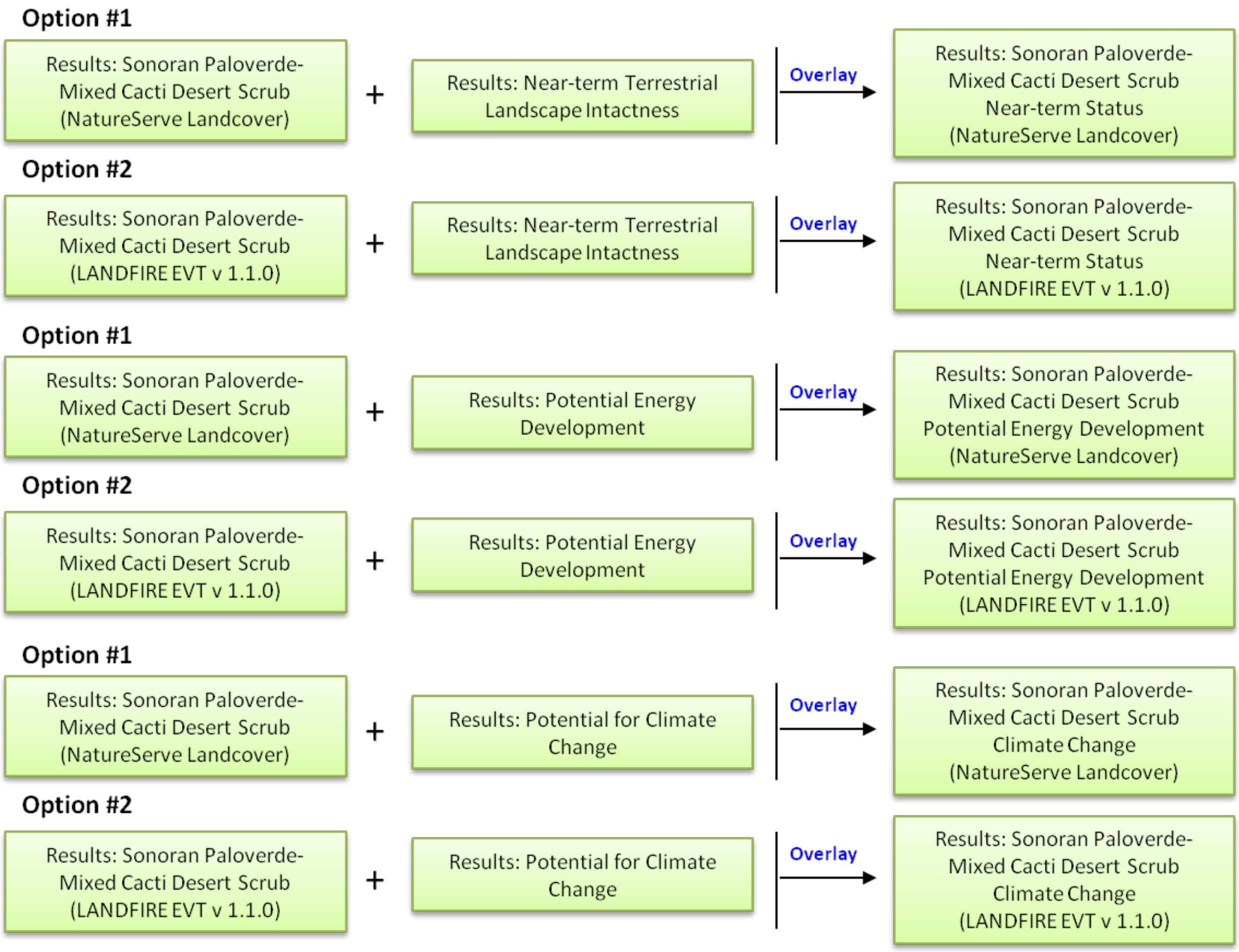
Process Models

MQ C1. Where are existing vegetation communities of interest present and what is their current status?

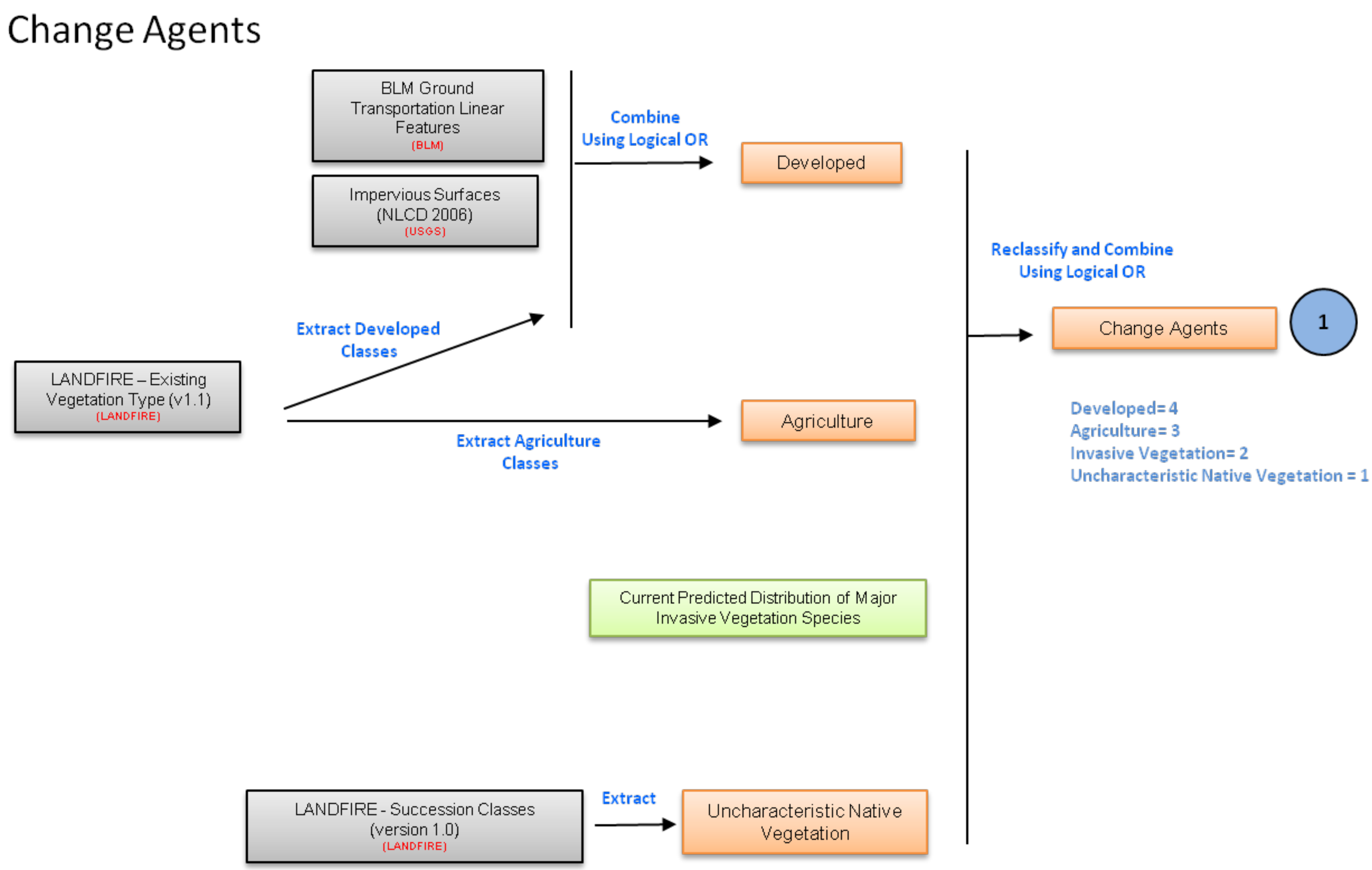




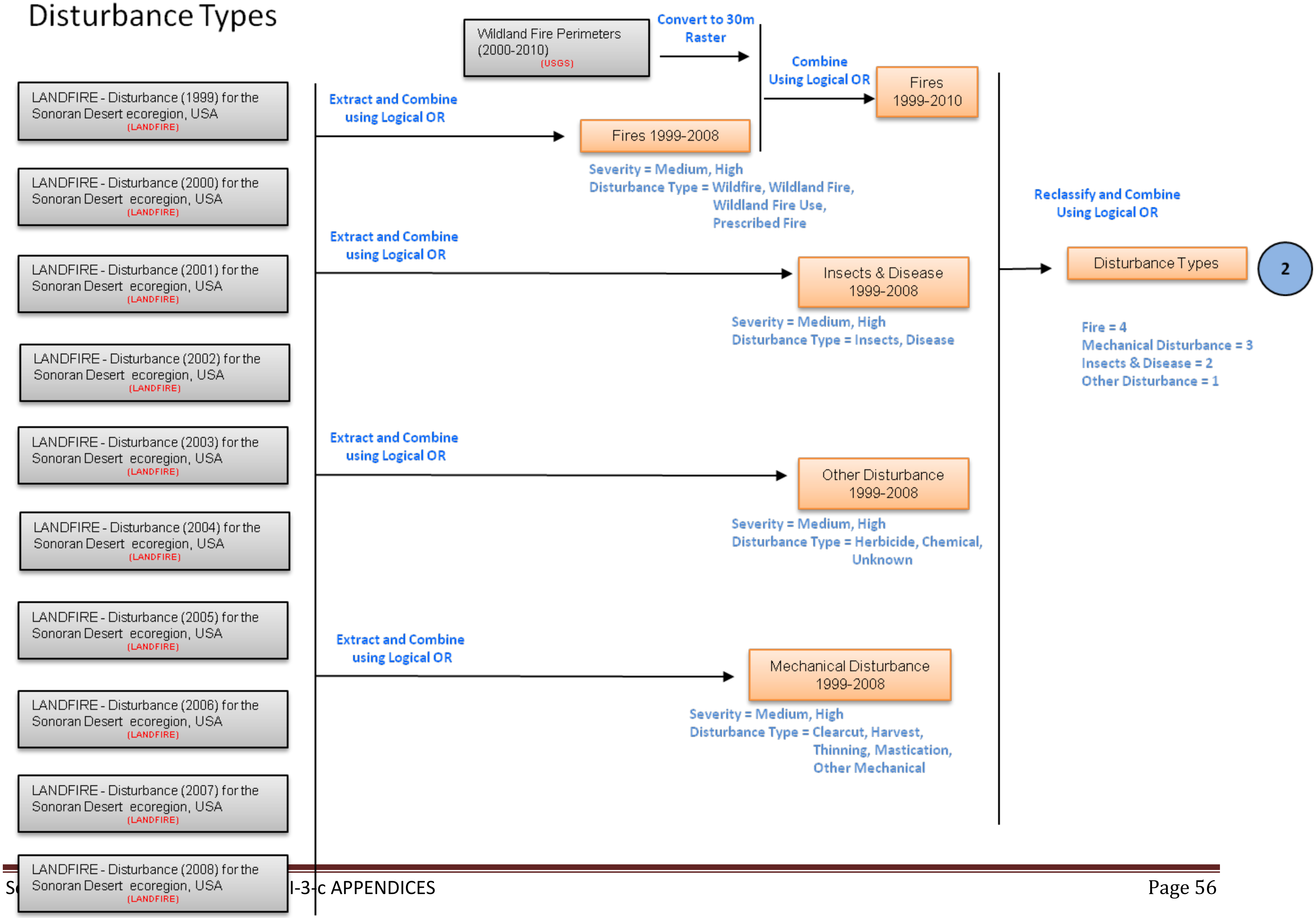
MQ C2. Where are vegetative communities likeliest to be vulnerable to change agents in the future?

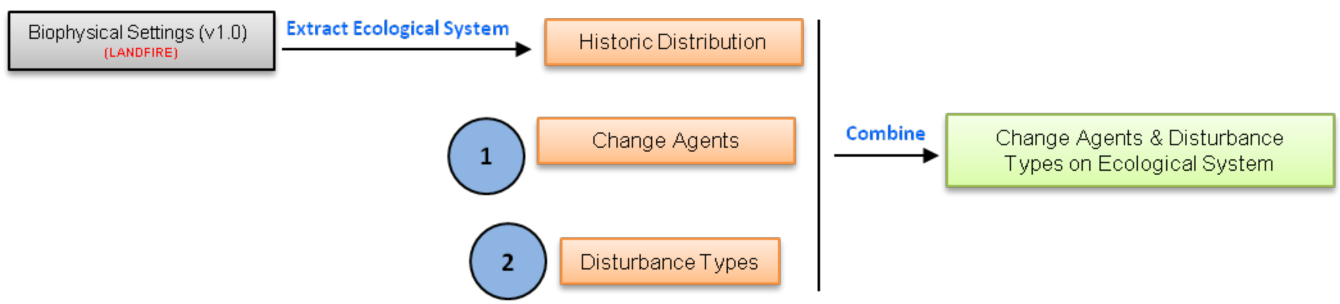


MQC3. What change agents have affected existing vegetative communities?



Disturbance Types




Biophysical Settings (v1.0)
(LANDFIRE)
Extract Ecological System
Historic Distribution
1
Change Agents
2
Disturbance Types
Combine
Change Agents & Disturbance Types on Ecological System

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, erosion, soil characteristics, precipitation, temperature, windthrow, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Sonoran Paloverde-Mixed Cacti Desert Scrub is a matrix community of the Sonoran Desert comprised of a few to many different plant species controlled by soil moisture and local geomorphic conditions (Brown 1982). This ecological system is characterized by the dominant overstory plant, saguaro cactus (*Carnegiea gigantia*), but other canopy species are present. Bursage (*Ambrosia deltoidea*) is the dominant understory species and often serve as a nurse plant for the dominant overstory plants (McAuliffe 1988). Extended periods of drought and extreme cold events limit this ecological system.

Historically, fire was not part of the natural disturbance regime and native plant species have not evolved fire-adapted strategies. With the influx of non-native invasive grasses as the result of disturbance (including widespread livestock grazing), more frequent fire has become more commonplace across the landscape. Windthrow is a significant mortality source for saguaro as is illegal removal of the species for ornamental planting.

Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Removal, Fires, and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs are also used to predict where the current Sonoran Paloverde-Mixed Cacti Desert Scrub may be under significant climate stress.

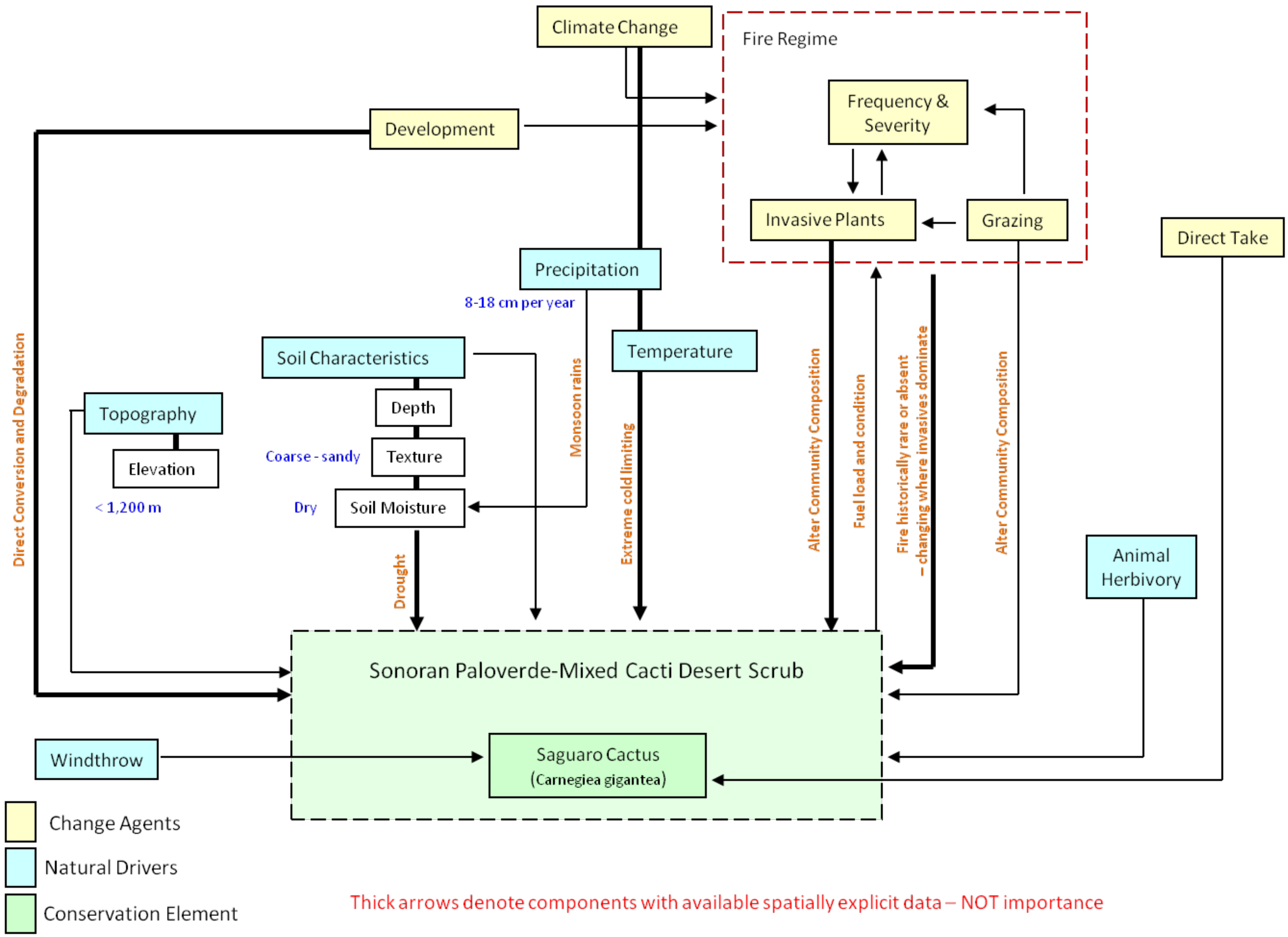
References Cited

Brown, D.E. (ed.). 1982. Biotic communities of the American Southwest. *United States and Mexico Desert Plants* 4(1-4):1–342.

LANDFIRE Biophysical Setting Model. September 2007.

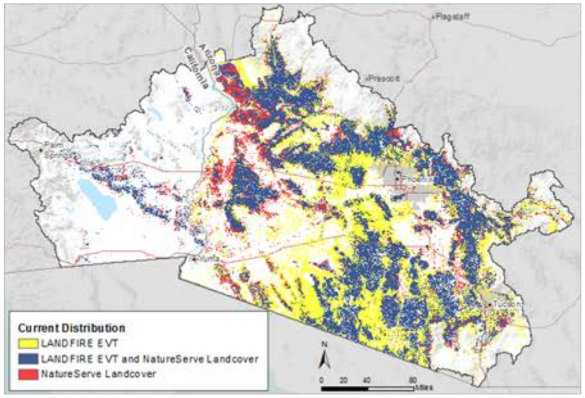
McAuliffe, J.R. 1988. Markovian dynamics of simple and complex desert plant communities. *American Naturalist* 131:459–490.

NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, Virginia.


Climate Change
Fire Regime
Frequency & Severity
Development
Invasive Plants
Grazing
Direct Take
Precipitation
8-18 cm per year
Soil Characteristics
Temperature
Monsoon rains
Extreme cold limiting
Alter Community Composition
Fuel load and condition
Fire historically rare or absent – changing where invasives dominate
Alter Community Composition
Direct Conversion and Degradation
Topography
Elevation
< 1,200 m
Depth
Coarse - sandy
Texture
Dry
Soil Moisture
Drought
Animal Herbivory
Sonoran Paloverde-Mixed Cacti Desert Scrub
Windthrow
Saguaro Cactus
(Carnegiea gigantea)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Sonoran Paloverde-Mixed Cacti Desert Scrub and what is its status?

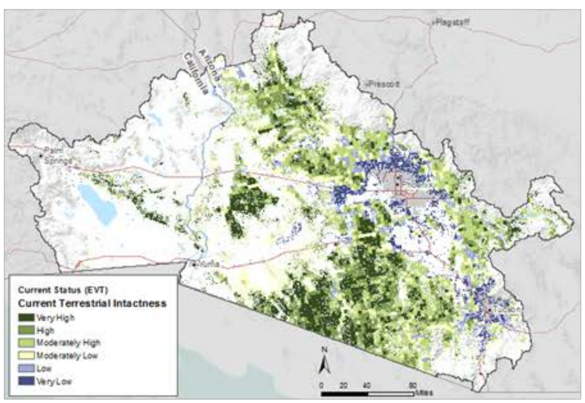


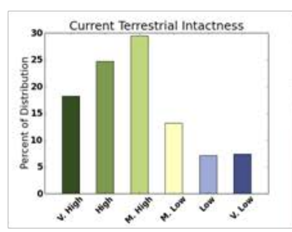
Distribution of Sonoran Paloverde-Mixed Cacti Desert Scrub LANDFIRE (yellow), NatureServe (red), and both (blue).

Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Sonoran Paloverde-Mixed Cacti Desert Scrub	5,332,340	1,796,793	7,373,363	50.84

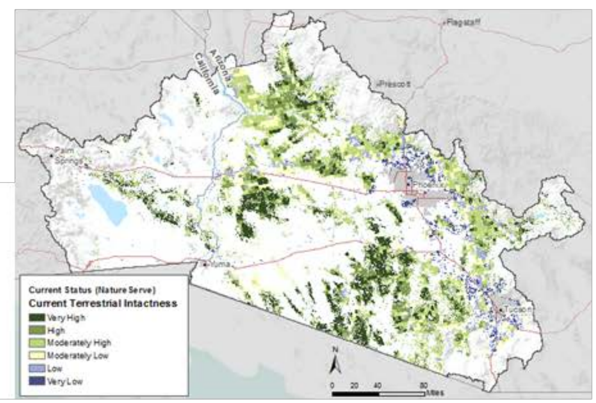
Status

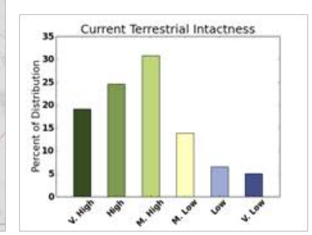
LANDFIRE





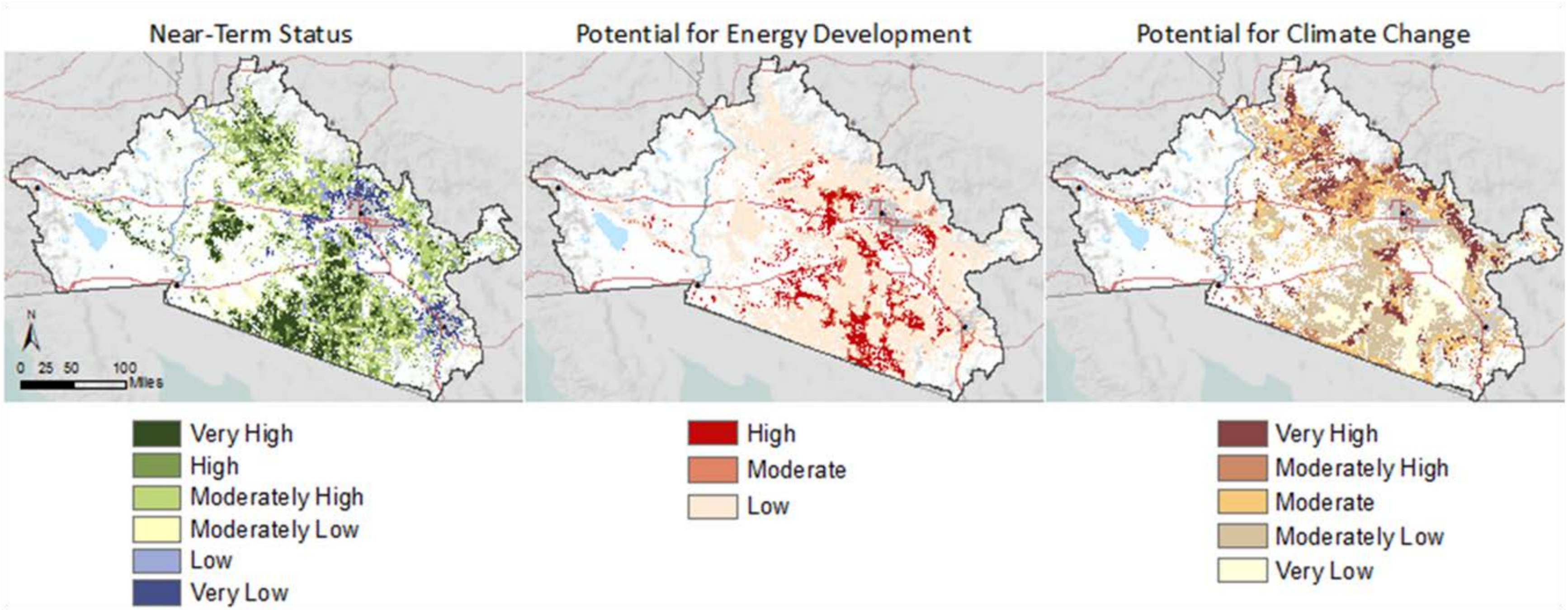
NatureServe

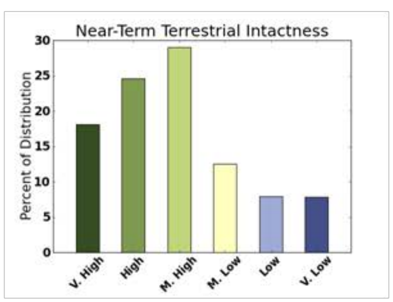


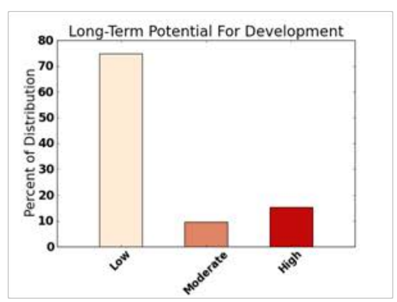


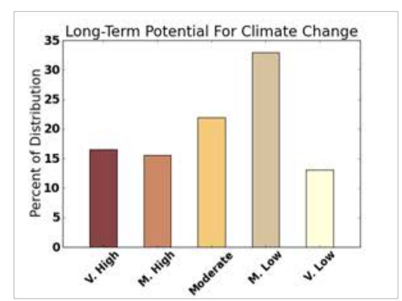
MQ C2. Where is Sonoran Paloverde-Mixed Cacti Desert Scrub vulnerable to change agents in the future?

LANDFIRE



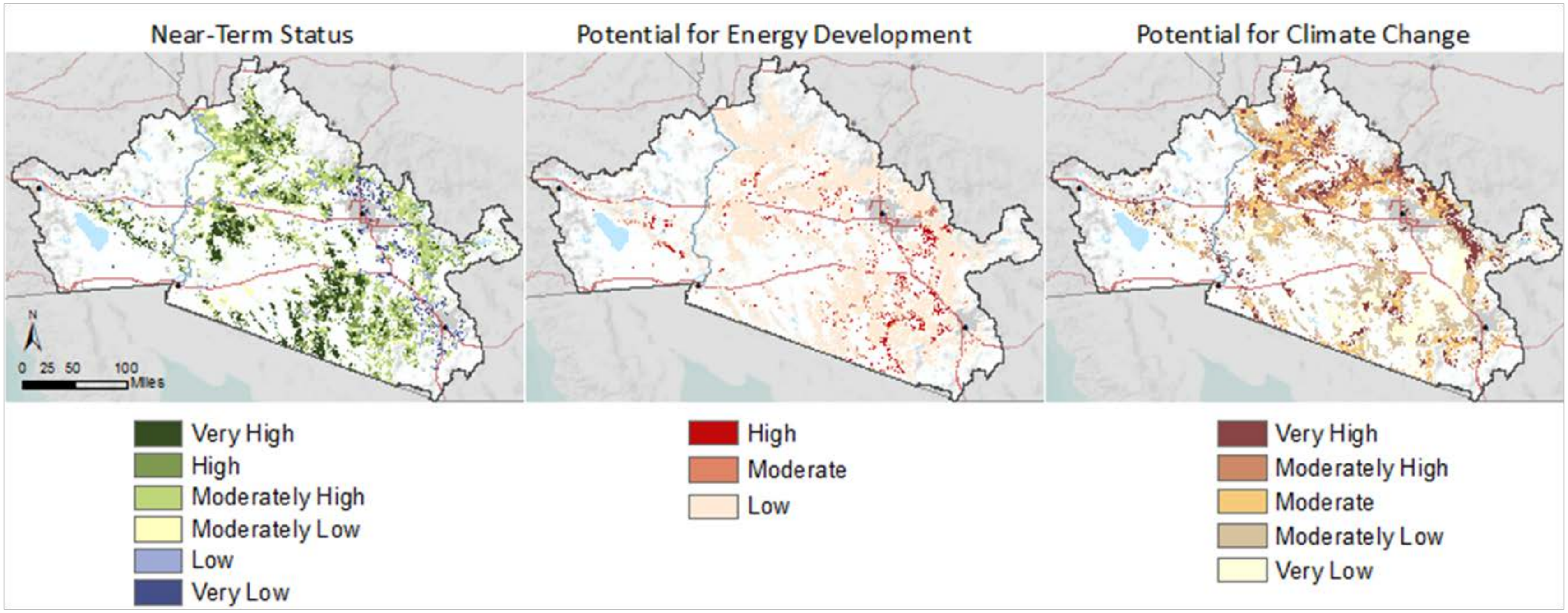


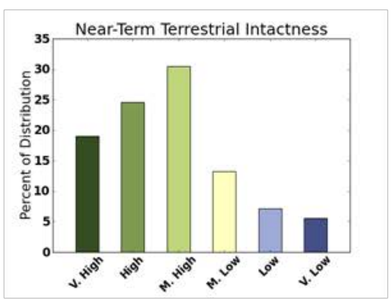


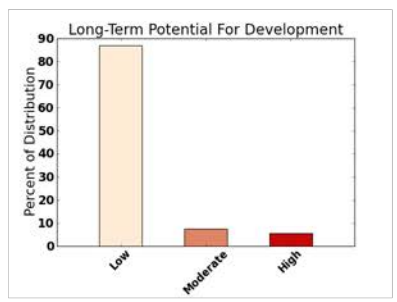


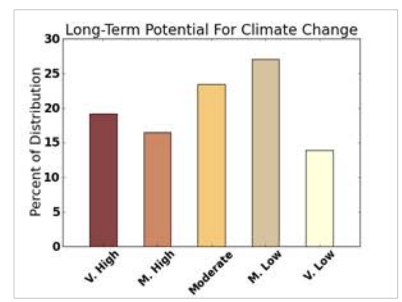
MQ C2. Where is Sonoran Paloverde-Mixed Cacti Desert Scrub vulnerable to change agents in the future?

NatureServe

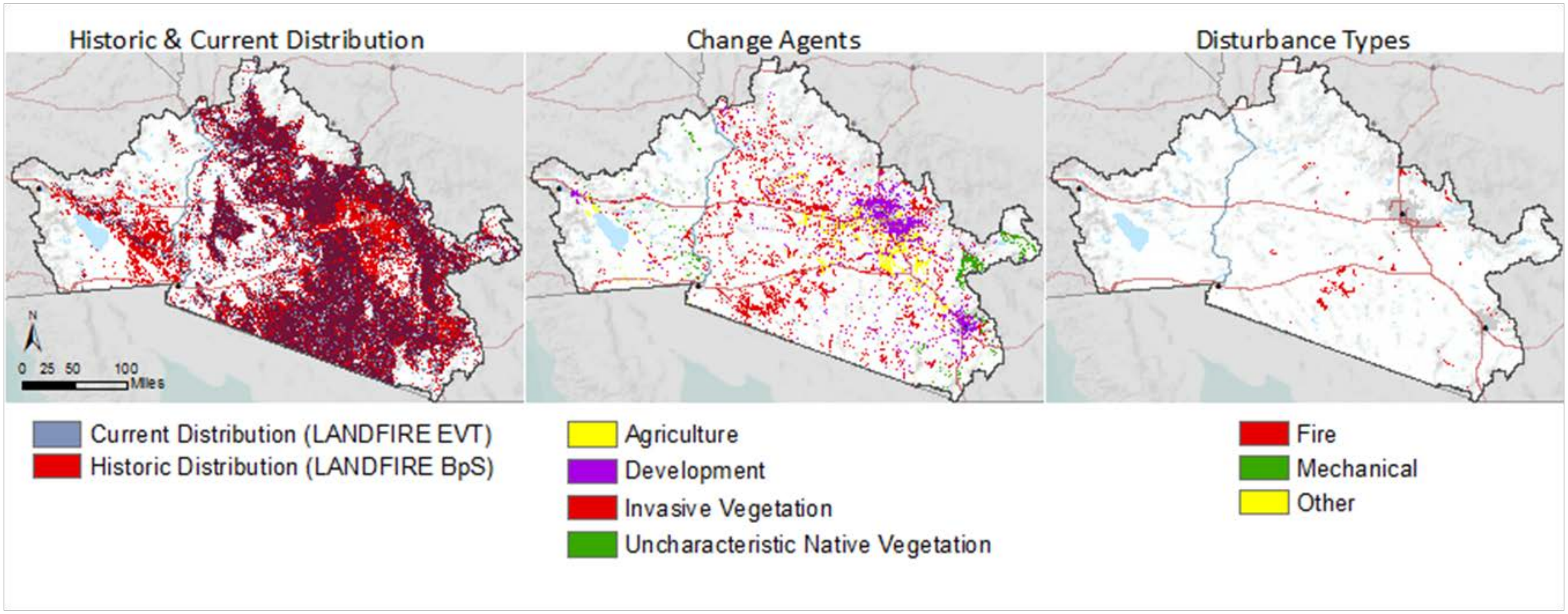








MQC3. What change agents have affected Sonoran Paloverde-Mixed Cacti Desert Scrub?



Historic Change Agents (change from modeled reference condition [LANDFIRE BpS dataset]

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
15,730,037	1,255,201	672,008	2,345,345	429,066	4,701,620	29.89%

Recent Disturbance (1999–2008)

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
15,730,037	212,197	0	18	212,215	1.35%

Conceptual Model

There are five primary natural drivers (cyan boxes) for this ecological system including topography, erosion, soil characteristics, precipitation, temperature, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

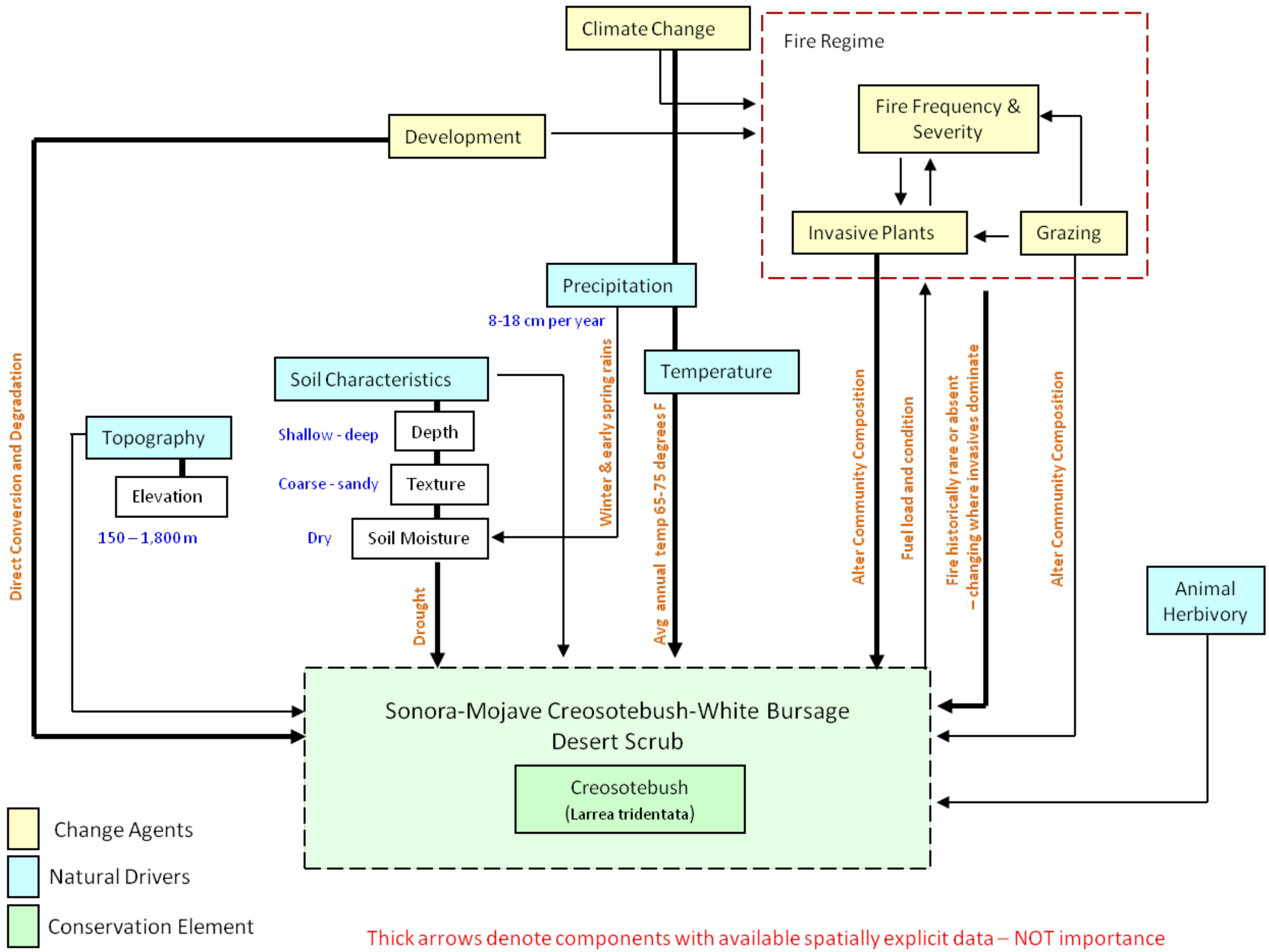
Sonoran-Mojave Creosotebush-White Bursage Desert Scrub is a matrix community dominated by the very long-lived creosotebush (*Larrea tridentata*). Other constituents of the community are determined by local soil moisture and landform. Livestock grazing has had a major impact on the ecosystem and invasive grasses dominate in some areas altering the fire regime completely. Historically, this ecological system rarely if ever burned. Species like creosotebush are intolerant of fire and the system recovers very slowly after a burn.

Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover). Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs are also used to predict where the current Sonoran-Mojave Creosotebush-White Bursage Desert Scrub may be under significant climate stress.

References

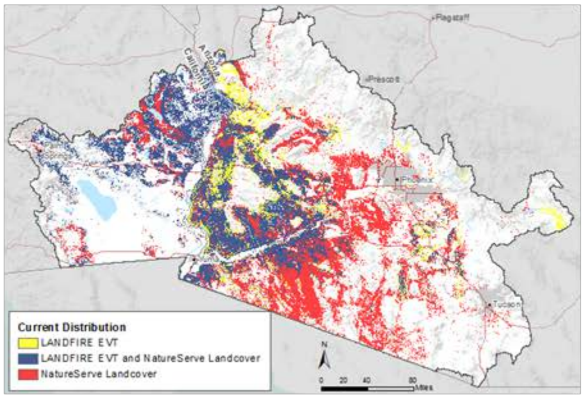
LANDFIRE Biophysical Setting Model. September 2007.

NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, VA.


Climate Change
Fire Regime
Fire Frequency & Severity
Development
Invasive Plants
Grazing
Precipitation
8-18 cm per year
Soil Characteristics
Temperature
Topography
Shallow - deep
Depth
Elevation
Coarse - sandy
Texture
150 – 1,800 m
Dry
Soil Moisture
Direct Conversion and Degradation
Winter & early spring rains
Avg annual temp 65-75 degrees F
Alter Community Composition
Fuel load and condition
Fire historically rare or absent – changing where invasives dominate
Alter Community Composition
Drought
Animal Herbivory
Sonora-Mojave Creosotebush-White Bursage Desert Scrub
Creosotebush (Larrea tridentata)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Sonoran-Mojave Creosotebush-White Bursage Desert Scrub and what is its status?

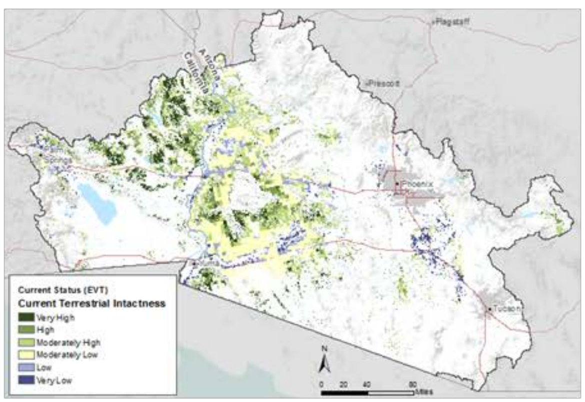


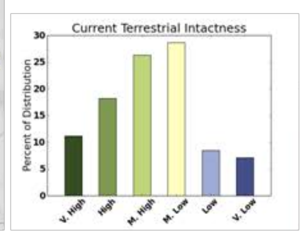
Distribution of Sonoran-Mojave Creosotebush-White Bursage Desert Scrub LANDFIRE (yellow), NatureServe (red), and both (blue).

Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	5,361,364	1,417,474	4,823,357	41.6

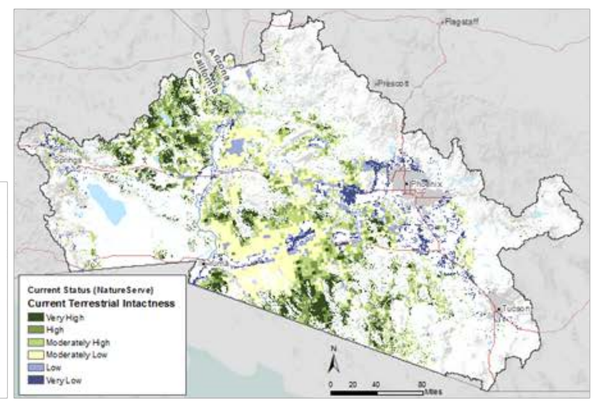
Status

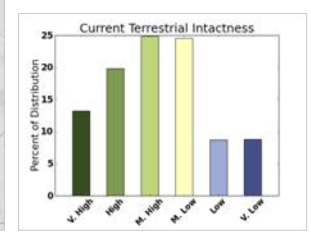
LANDFIRE





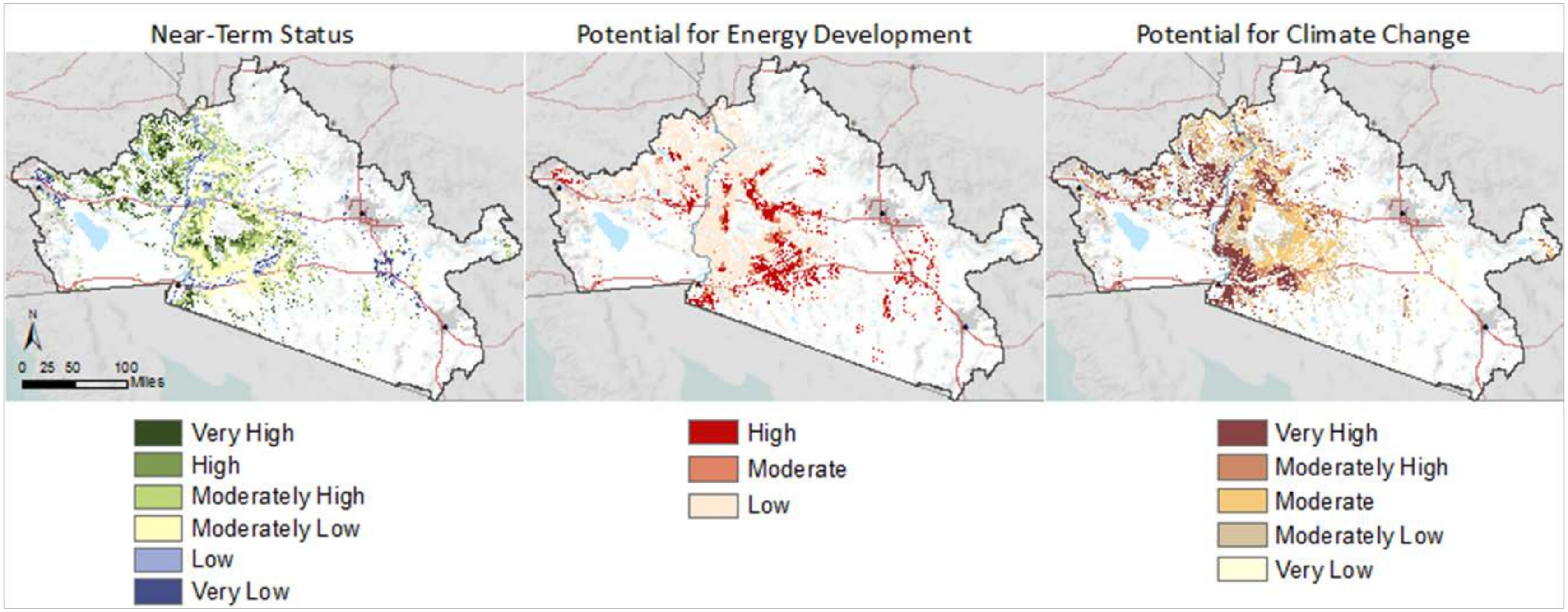
NatureServe

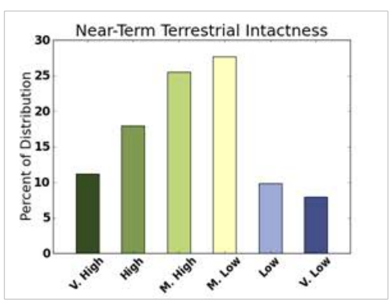


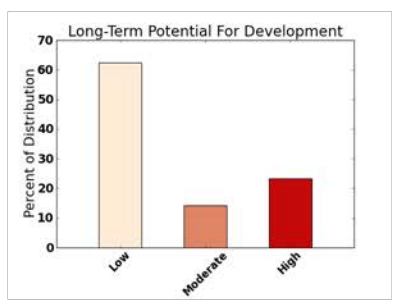


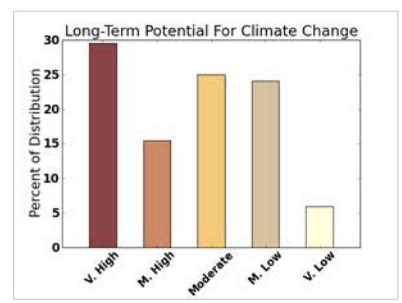
MQ C2. Where is Sonoran-Mojave Creosotebush-White Bursage Desert Scrub vulnerable to change agents in the future?

LANDFIRE



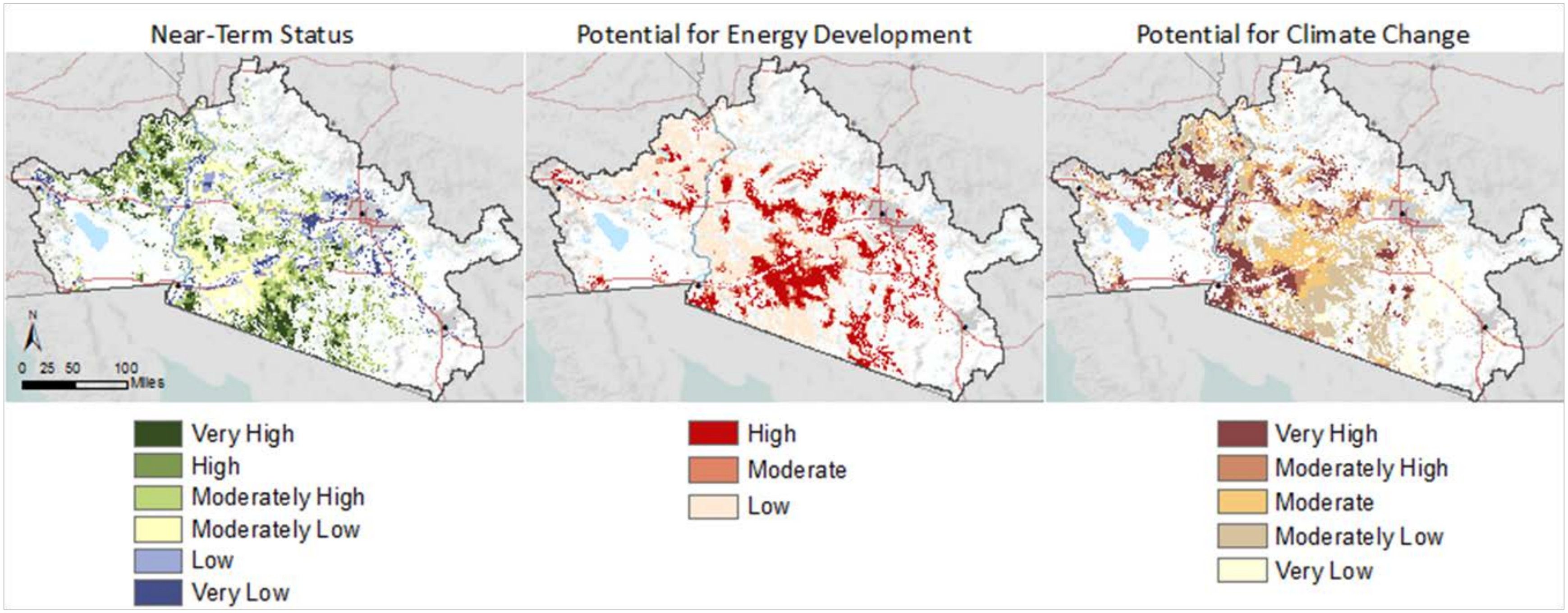


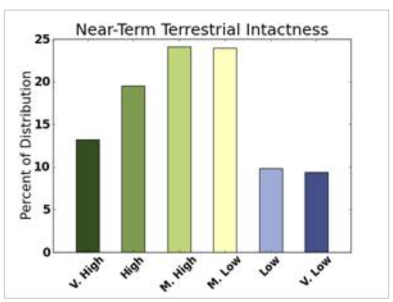


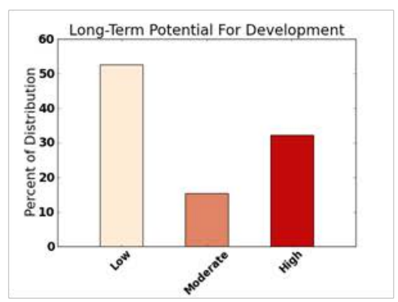


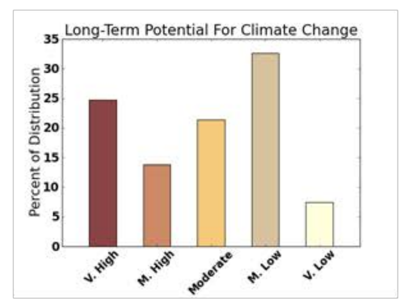
MQ C2. Where is Sonoran-Mojave Creosotebush-White Bursage Desert Scrub vulnerable to change agents in the future?

NatureServe

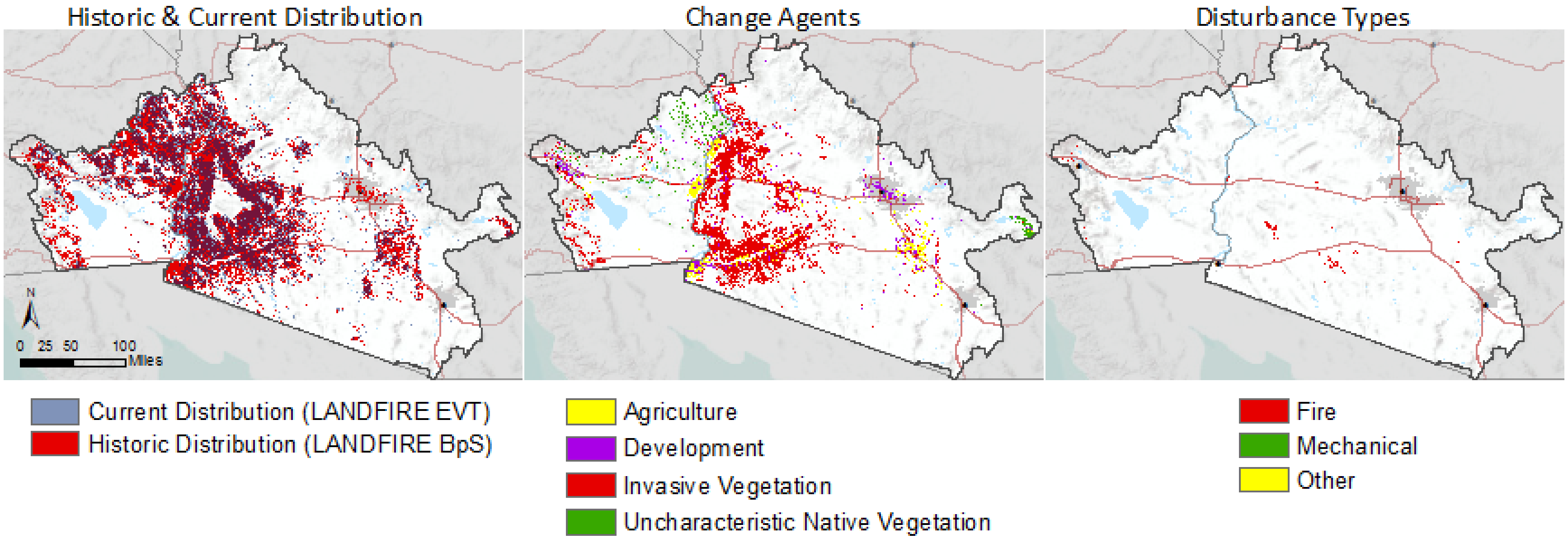








MQC3. What change agents have affected Sonoran-Mojave Creosotebush-White Bursage Desert Scrub?



Historic Change Agents (change from modeled reference condition [LANDFIRE BpS dataset]

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
7,857,699	429,263	432,831	2,909,387	273,834	4,045,315	51.48%

Recent Disturbance (1999–2008)

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
7,857,699	85,434	0	80	85,514	1.09%

Riparian Vegetation

Conceptual Model

Riparian ecological systems have undergone significant physical and biological changes throughout the ecoregion due to numerous factors, including: conversion to other uses; changes in the natural flow regimes and suppression of fluvial processes (Stromberg 2001, Stromberg et al. 2007); livestock grazing (Armour et al. 1994); and invasive species dominance, such as tamarisk (Horton 1977, Friedman et al. 2005, Merritt and Poff 2010).

There are six primary natural drivers highlighted in the conceptual diagram: groundwater, channel geomorphology and soils, precipitation, temperature, stream hydrology, and animal herbivory. Together these shape the composition, structure, and function of riparian ecosystems.

The yellow boxes in the diagram, which denote the major change agents, impact these drivers in a number of ways. Some development directly converts riparian vegetation to other land uses, especially irrigated agricultural lands in this arid or semi-arid region. Development also affects riparian ecosystems in other ways including drawdown of groundwater lowering the water table, water use and contamination of surface water, and diversion from dams and various water management practices.

The climate regime (precipitation and temperature) regulates the water quantity and delivery to the system. In this ecoregion, moisture tends to be seasonal and flashy, and any significant departure from this pattern can degrade riparian ecosystems.

Fire regime is influenced by a complex interaction of factors—fuel load and condition, grazing, invasive species, and fire frequency (natural, a function of climate, and human-caused, a function of development). In the case of riparian vegetation, the fuel load and condition of surrounding vegetation is as much or more of a factor than the condition of the riparian vegetation itself, which is obviously wetter than surrounding conditions. Fire suppression is another influencing factor on the fire regime. Riparian vegetation is affected by fire in two ways. There is the outright burning of the vegetation and, more broadly, there are changes in water retention and runoff over the larger burn area outside the riparian zone resulting in alterations in the amount of water and sediment that reaches the riparian zone.

Livestock grazing has damaged approximately 80% of stream and riparian ecosystems in the western US (Belsky et al. 1999). Grazing alters streamside morphology, increases sedimentation, degrades riparian vegetation through trampling and consumption and causes nutrient loading to the system. Invasive plants such as tamarisk often successfully out-compete native species such as willows, because of its reproductive capacity and its tolerance to drought and flooding events (Stevens and Waring 1985, Glenn et al. 1998, Stromberg et al. 2007).

Mapping riparian systems is difficult to do using satellite remote sensing. The narrow linear nature of the community makes it difficult to delineate with high levels of accuracy. The most recent landcover edited by NatureServe was used for the REA assessment to assess current distribution. There was ample data for development, fire, tamarisk, and dams and diversions to assess current and future condition and to address the management questions related to this topic. An aquatic intactness model was also developed to describe the upland impacts to aquatic environments more accurately: the aquatic intactness model can be overlaid against the existing riparian habitat data throughout the ecoregion.

References Cited

Armour, C., Duff, D. and Elmore, W. 1994. The effects of livestock grazing on western riparian and stream ecosystems. Fisheries 19(9): 9–12.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. *Journal of Soil and Water Conservation* 54:419–431.

Friedman, J.M., G.T. Auble, P.B. Shafroth, M.L. Scott, M.F. Merigliano, M.D. Freehling, and E.R. Griffin. 2005. Dominance of non-native riparian trees in western USA. *Biological Invasions* 7:747–751.

Glenn, E., R. Tanner, S. Mendez, T. Kehret, D. Moore, J. Garcia, and C. Valdes. 1998. Growth rates, salt tolerance, and water use characteristics of native and invasive riparian plants from the delta of the Colorado River, Mexico. *Journal of Arid Environments* 40:281–294.

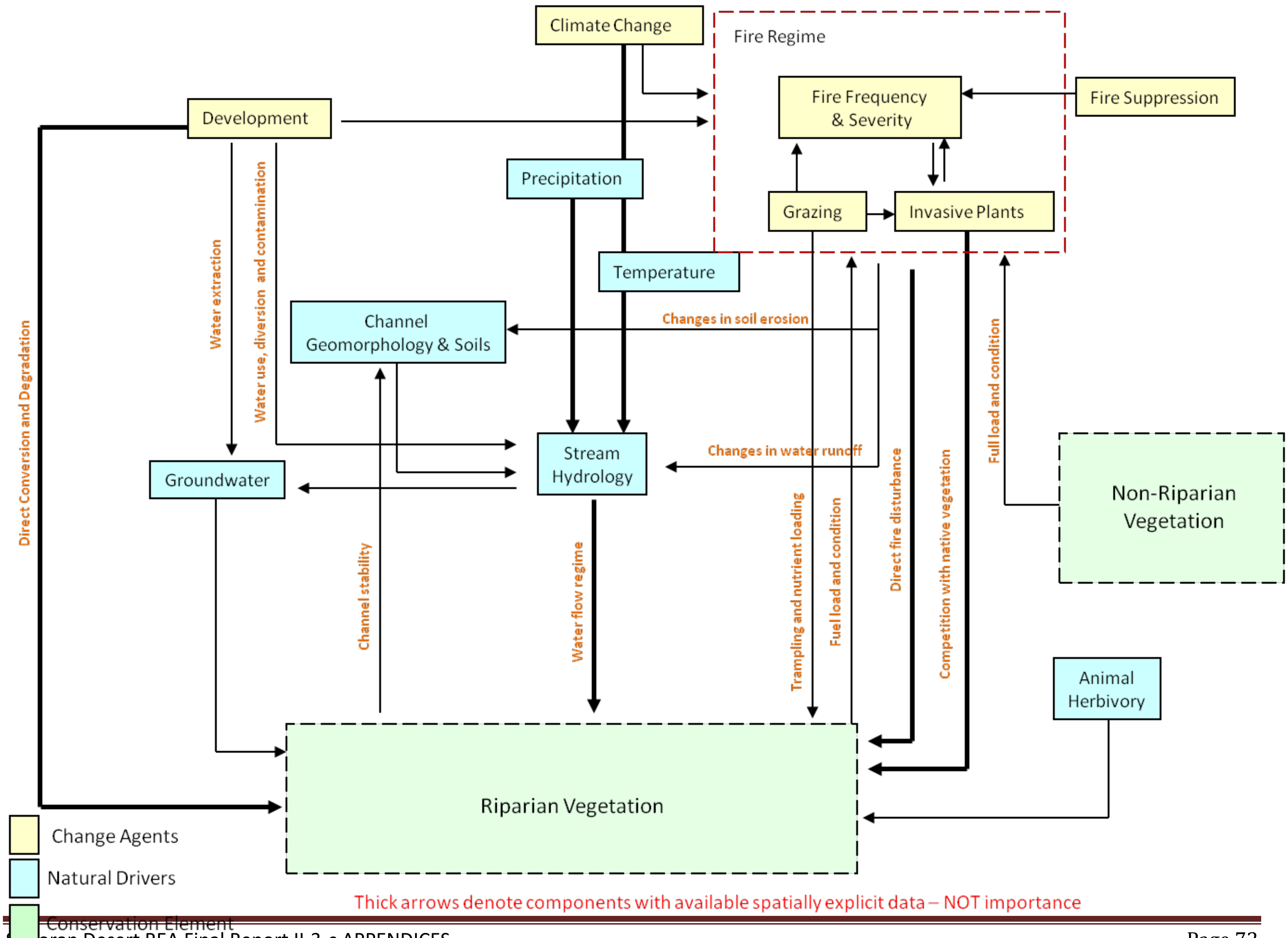
Horton, J.S. 1977. The development and perpetuation of the permanent tamarisk type in the phreatophyte zone of the southwest. *Pp. 124-127 In: Importance, preservation and management of riparian habitat: A symposium*. General Technical Report RM-43. U.S. Forest Service, Washington, D.C.

Merrit, D.M., and N.L. Poff. 2010. Shifting dominance of riparian *Populus* and *Tamarix* along gradients of flow alteration in western North American rivers. *Ecological Applications* 20(1):135–152.

Stromberg, J.C. 2001. Restoration of riparian vegetation in the southwestern United States: importance of flow regimes and fluvial dynamism. *Journal of Arid Environments* 49:17–34.

Stromberg, J.C., V.B. Beauchamp, M.D. Dixon, S.J. Lite, and C. Paradzick. 2007. Importance of low-flow and high-flow characteristics to restoration of riparian vegetation along rivers in arid south-western United States. *Freshwater Biology* 52:651–679.

Stevens, L.E., and G.W. Waring. 1985. The effects of prolonged flooding on the riparian plant community in Grand Canyon. Pages 81–86 *in* Johnson, R.R., C.D. Ziebell, D.R. Patten, P.F. Ffolliot, and R.H. Hamre (eds.), Riparian ecosystems and their management: Reconciling conflicting uses. General Technical Report RM-120. U.S. Forest Service, Tucson, Arizona. 523 pp.


Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Development
Precipitation
Grazing
Invasive Plants
Temperature
Channel Geomorphology & Soils
Changes in soil erosion
Water extraction
Water use, diversion and contamination
Direct Conversion and Degradation
Groundwater
Stream Hydrology
Changes in water runoff
Full load and condition
Non-Riparian Vegetation
Channel stability
Water flow regime
Trampling and nutrient loading
Fuel load and condition
Direct fire disturbance
Competition with native vegetation
Animal Herbivory
Riparian Vegetation
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

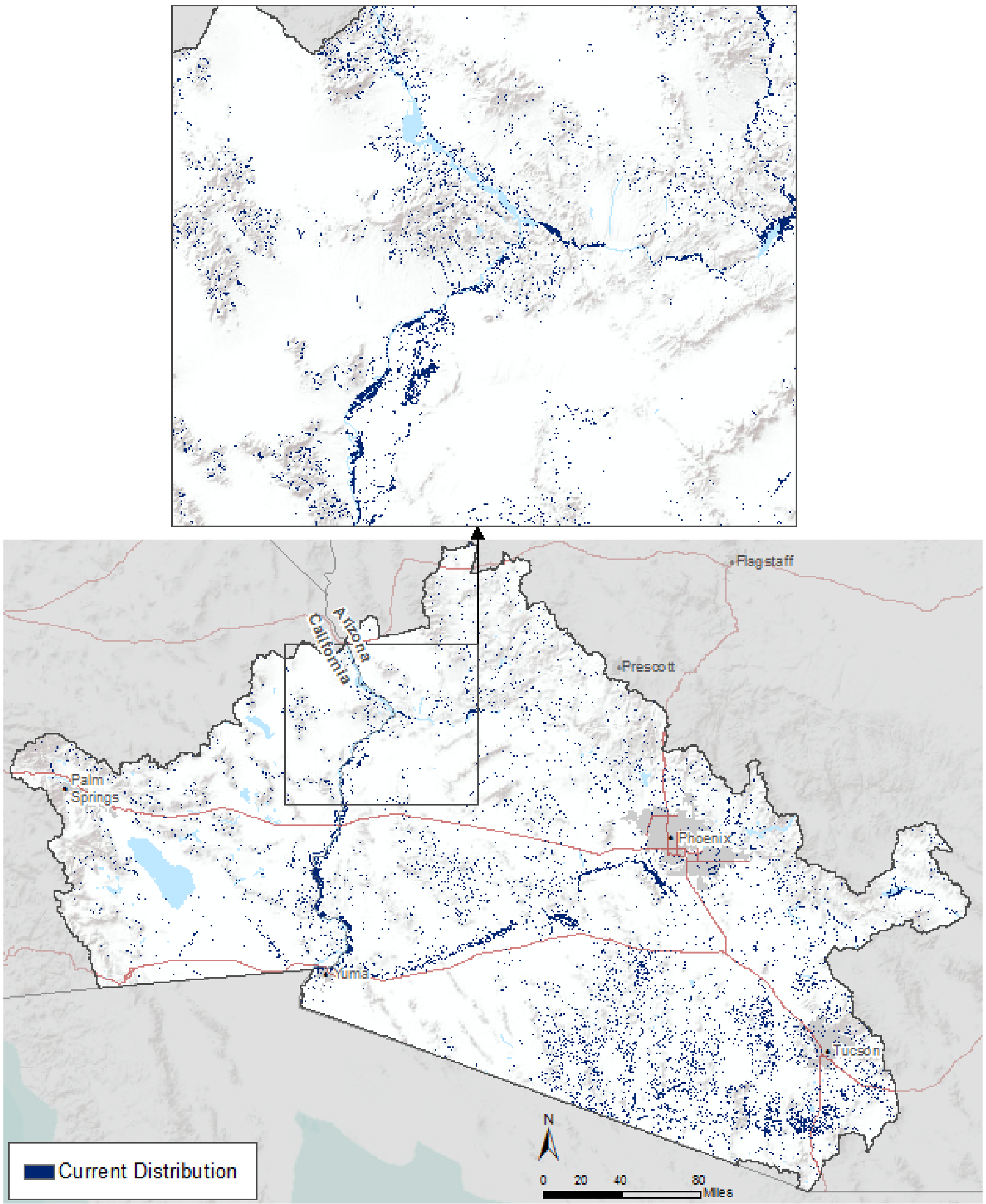
Results

MQ C1. Where is existing Riparian Vegetation and what is its status?

Access to a data portal to examine the results in greater detail is available at the BLM website: https://gbp-blm-egis.hub.arcgis.com.

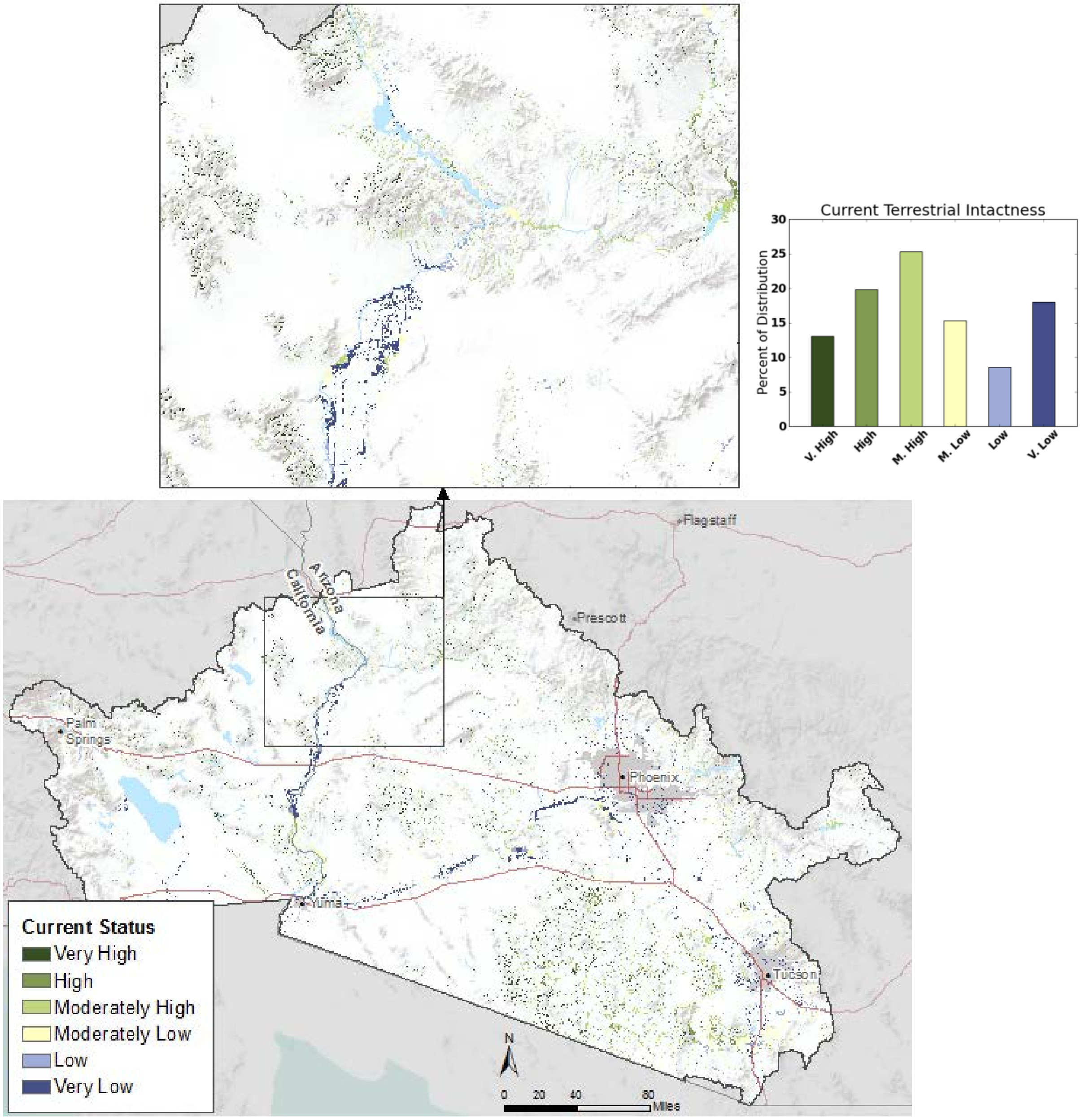
NatureServe data only

Distribution



MQ C1. Where is existing Riparian Vegetation and what is its status?

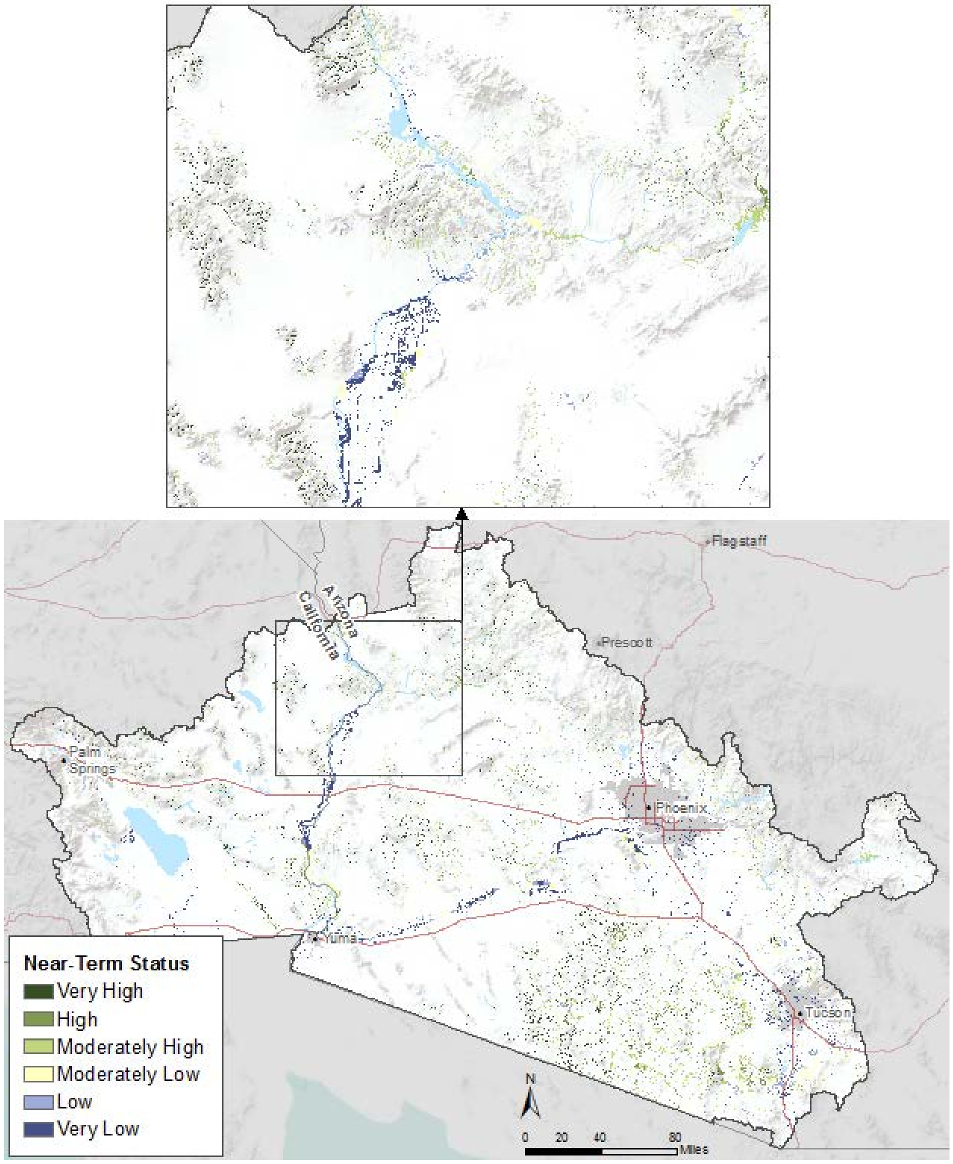
Status

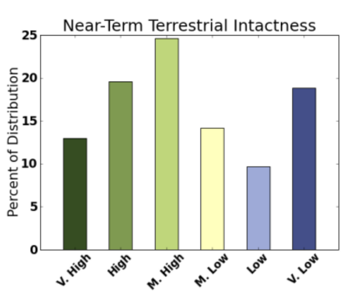


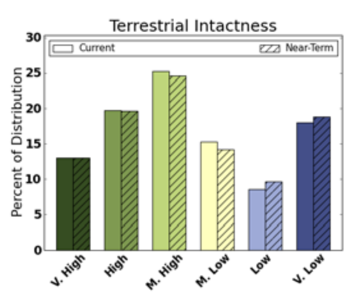
MQ C2. Where is Riparian Vegetation likeliest to be vulnerable to change agents in the future?

NatureServe data only

Near-term Future Terrestrial Intactness



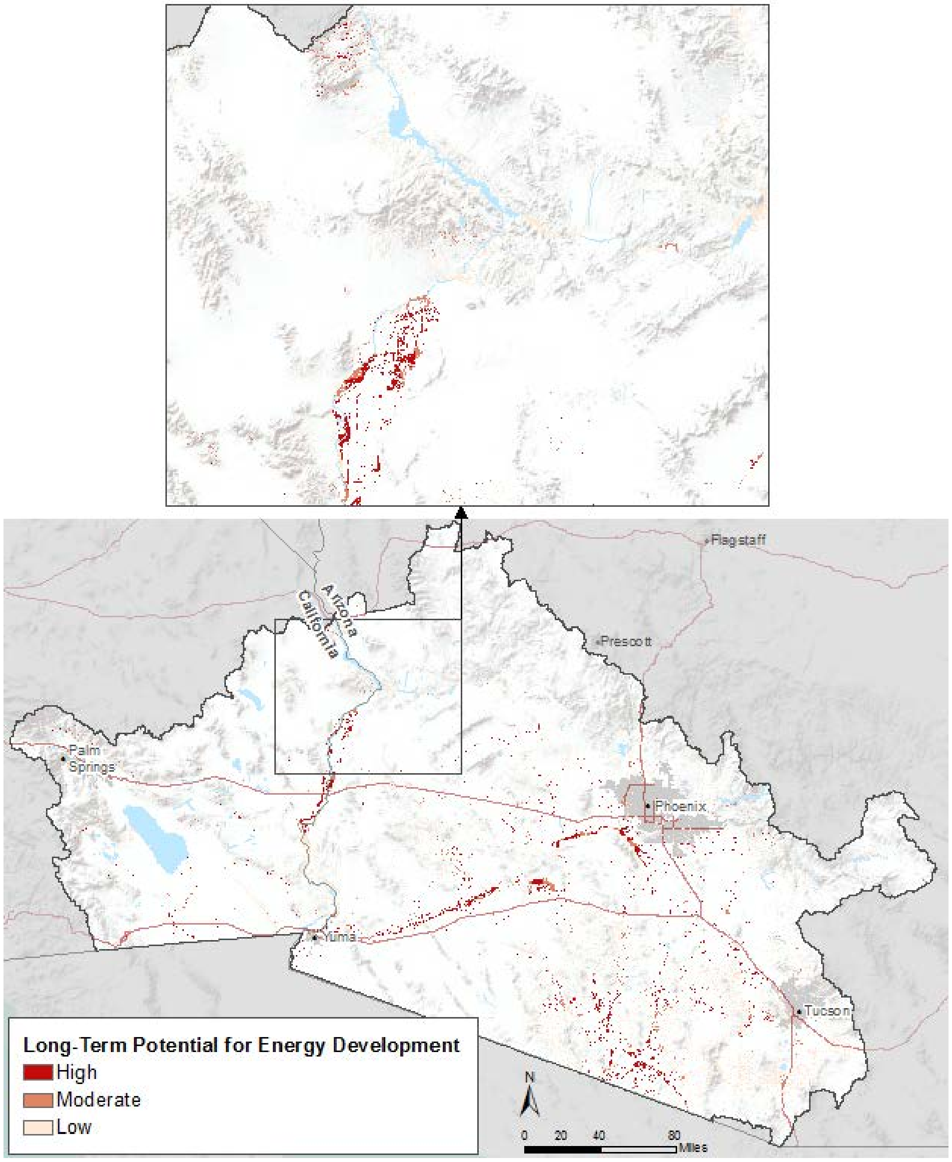


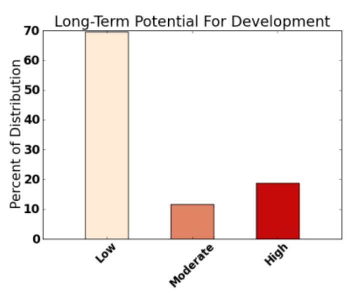


Current (solid bars) compared with near-term future (2025, hatched bars) terrestrial intactness

MQ C2. Where is Riparian Vegetation likeliest to be vulnerable to change agents in the future?

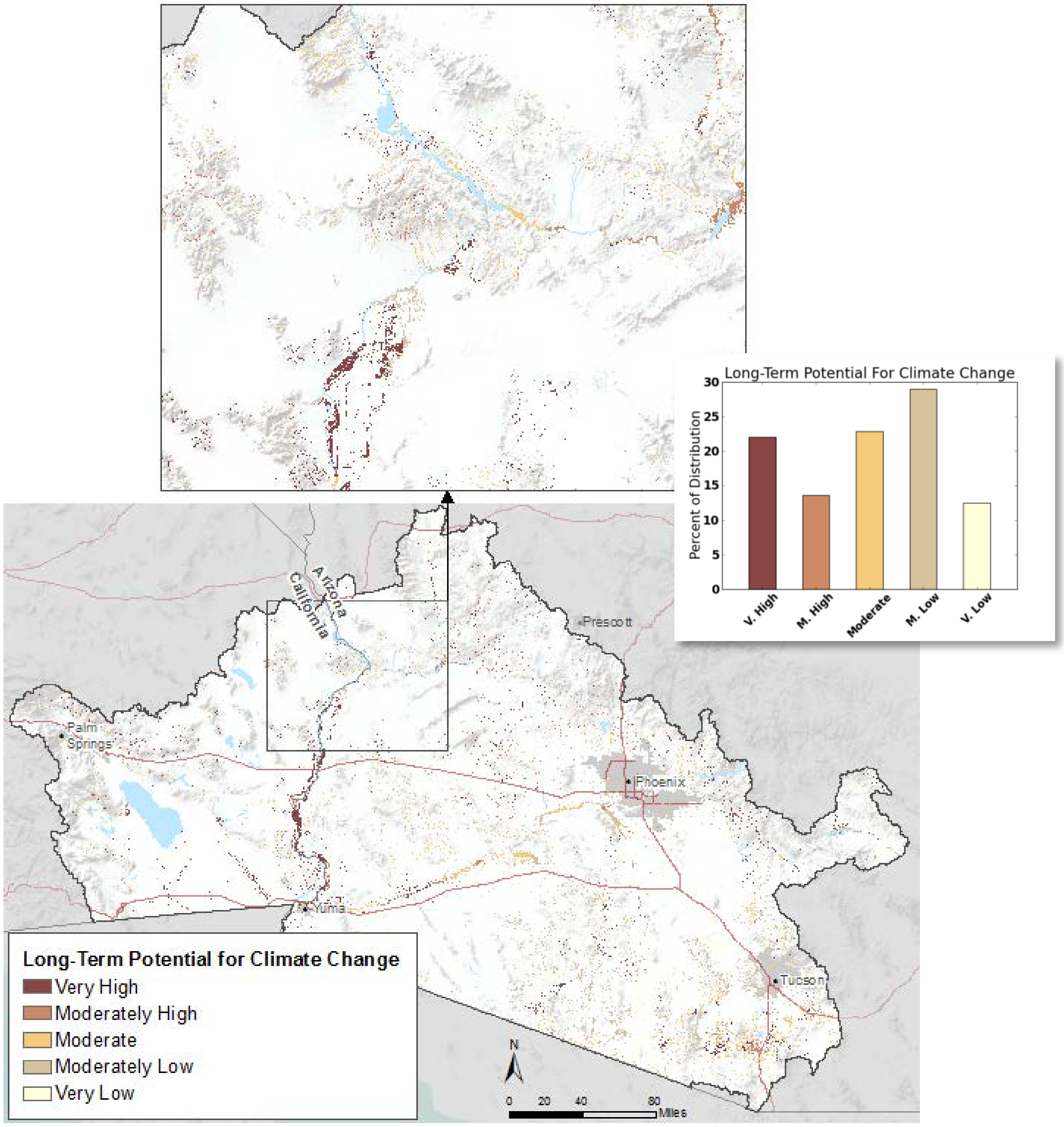
Maximum Long-Term Energy Development





MQ C2. Where is Riparian Vegetation likeliest to be vulnerable to change agents in the future?

Potential for Climate Change (2060)



Note: The management question, MQ C3. What change agents have affected Riparian Vegetation?, was not addressed because LANDFIRE BpS data (modeled vegetation reference condition) does not exist for this vegetation type.

Appendix C – Species Conservation Elements

Organization of Appendix C

For each conservation element, we provide some background information, a conceptual model, description of the analytical process (including source data) and/or a Process Model for each management question, and results in the form of maps and other supporting graphics. Access to a data portal to examine the results in greater detail is available at: https://gbp-blm-egis.hub.arcgis.com.

Species Conceptual Models

Conceptual models attempt to organize and articulate the relationship between the various change agents and natural drivers for each conservation element. Not all of the relationships identified lend themselves well to measurement or monitoring, but they are still important to include, as they add to our general understanding of complex interactions.

All conceptual models include a series of change agents (depicted with yellow boxes) and natural drivers (cyan boxes). Specifics regarding some of the factors are presented in blue text. Arrows represent relationships between the various change agents and natural drivers on the community overall and, where appropriate, on the dominant species more directly. More specific information is provided by the orange text. Thicknesses of the arrows **DO NOT** represent degree of importance. Rather, bold lines represent those factors that are tracked or modeled to varying degrees of certainty throughout the REA analysis.

Species Process Models

Two basic management questions were addressed for each species conservation element. The first question pertained to current distribution and status. The second question referred to potential impact on the species from near-term (2025) future change, impact from potential energy development, and long-term potential-for-change (2060) from climate change. The basic method for each species was similar, but, for current distribution, input data varied in source and quality. Source data for each is provided in the introduction for each species. Current status was determined by overlaying current distribution against terrestrial landscape intactness (Chapter 4) for terrestrial species.

For potential future condition, current distribution was evaluated in a similar fashion against potential energy development (Chapter 5, Section 5.2), near-term (2025) terrestrial landscape intactness (Chapter 5, Section 5.3), and climate change model results (Chapter 5, Section 5.4).

Bell's Vireo (*Vireo bellii and Vireo bellii pusillus*)

Bell's vireo is represented in the Sonoran REA as two distinct subspecies, Arizona Bell's vireo (*Vireo bellii arizonae*) and least Bell's vireo (*Vireo belli pusillus*). In the Sonoran Desert ecoregion, Arizona Bell's vireo occurs east of the Colorado River in southern Arizona, and in California it is confined to the west bank and floodplain of the lower Colorado River. Least Bell's vireo occurs on the western edge of the ecoregion in California, in riparian areas of streams draining the lower slopes of the San Jacinto and Santa Rosa mountains (Patten 1998). Subspecies *arizonae* is state-listed as endangered in California (not listed in Arizona), and *pusillus* is both state and federally listed as endangered in California. Least Bell's vireo experienced a steady decline in California throughout the mid- to late- 20th century. The species was extirpated from the San Joaquin and Sacramento valleys by the mid-1950s (Goldwasser 1978). North American Breeding Bird Survey trend results are not reliable for least Bell's vireo because of its low numbers; but results for Arizona Bell's vireo have higher confidence and indicate a 2.0 % yearly percentage decline in Bell's vireo abundances in Arizona from 1966–2009 (Sauer et al. 2011).

Bell's vireo inhabits early successional riparian thickets. Depending on location, the dominant vegetation may be cottonwood (*Populus fremontii*), willow (*Salix* spp.), mesquite (*Prosopis* spp.), elderberry (*Sambucus* spp.), or seep willow (*Baccharis salicifolius*). Although many report that Arizona Bell's vireo will use invasive tamarisk (*Tamarix* spp.) for nesting (Brown and Trosset 1989, Patten 1998, GBBO 2010, CEC 2011), Averill-Murray and Corman (2005) state that "few" Bell's vireos were found in tamarisk thickets during 7 years of canvassing for the Arizona Breeding Bird Atlas. In Arizona, besides moist riparian areas, vireos inhabit drier mesquite bosques and desert washes containing blue paloverde (*Parkinsonia floridium*), ironwood (*Olneya tesota*), and netleaf hackberry (*Celtis reticulata*, Averill-Murray and Corman 2005). Dense, low shrubby habitat structure, independent of vegetation type, is important to the vireo because it nests and forages for insects close to the ground (0.6–3 m, Goldwasser 1978). Loss of riparian (and xeroriparian) shrub cover is a major threat to the continued productivity of both vireo subspecies; riparian habitat loss has occurred and continues due to agricultural practices, livestock grazing, stream channelization, flood control projects, conversion of riparian habitat to parks and golf courses, water diversion, and lowering of groundwater levels from groundwater pumping (Patten 1998, USFWS 2006, GBBO 2010).

However, depletion of riparian habitat is not the only disturbance affecting the survival of Bell's vireo. In a survey of 21 streams in 7 southern California counties, Goldwasser (1978) found that just 19% of potential nesting habitat was occupied and suggested that other factors, such as nest predation and brood parasitism by brown-headed cowbird (*Molothrus ater*)—accounting for 27% and 46%, respectively, of the nest failures recorded in the study—were responsible for the species' precipitate decline. Although cowbirds are not as numerous in the range of Arizona Bell's vireo (Clark 1988, Patten 1998), they still have a negative impact on the species, as they do on other common cowbird hosts, yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), and willow flycatcher (*Empidonax traillii*). During the Arizona Breeding Bird Atlas survey, Bell's vireo was recorded as the top cowbird host (Averill-Murray and Corman 2005).

Bell's vireo readily responds to habitat restoration as well as to brown-headed cowbird control efforts. Goldwasser (1978) noted that male birds sang in newly-established riparian habitat (< 8 years old), suggesting that the birds might respond fairly quickly to riparian vegetation restoration efforts. Recently, multiple county and state agencies collaborated in the Santa Ana River basin to remove giant reed (*Arundo donax*), which had formed a riparian monoculture along streams and rivers. Following giant reed removal, nesting vireo pairs in the basin increased from only 19 in 1986 to 413 in 2004 (IWAC 2006). Other riparian restoration and cowbird removal efforts in San Diego County on the Santa Margarita River and in Riverside County in the Prado Basin also resulted in significant increases in breeding least Bell's vireo populations (Patten 1998). Overall, in southern California, there has been a 10 fold increase in Least Bell's vireo abundance since listing in 1986; the US Fish and Wildlife Service (2006) determined that the successes resulted from a combination of riparian restoration and cowbird control that may need to continue into the foreseeable future to sustain the species. However, the success of the least Bell's vireo recovery effort in California indicates that similar efforts in the lower Colorado River basin may help to reverse the decline of Arizona Bell's vireo. As an example from a recent study, riparian shrub density increased and Arizona Bell's vireo abundance increased from 0.91 to 2.69 detections/km four years after cattle were removed from a section of the San Pedro River in Arizona (Krueper et al. 2003).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	riparian vegetation	No shrub cover			Dense shrub understory up to 3 m [10 ft] high; tree overstory either relatively open or absent	Averill-Murray et al. 1999
habitat degradation	water diversion - distance to water				< 1,000 m [0.6 mi] from water; standing water is an important habitat element	Kus et al. 2010
parasitism	cowbird abundance	increased parasitism with decreased density of understory vegetation			parasitism decreases with increased density of understory vegetation	Kus et al. 2010

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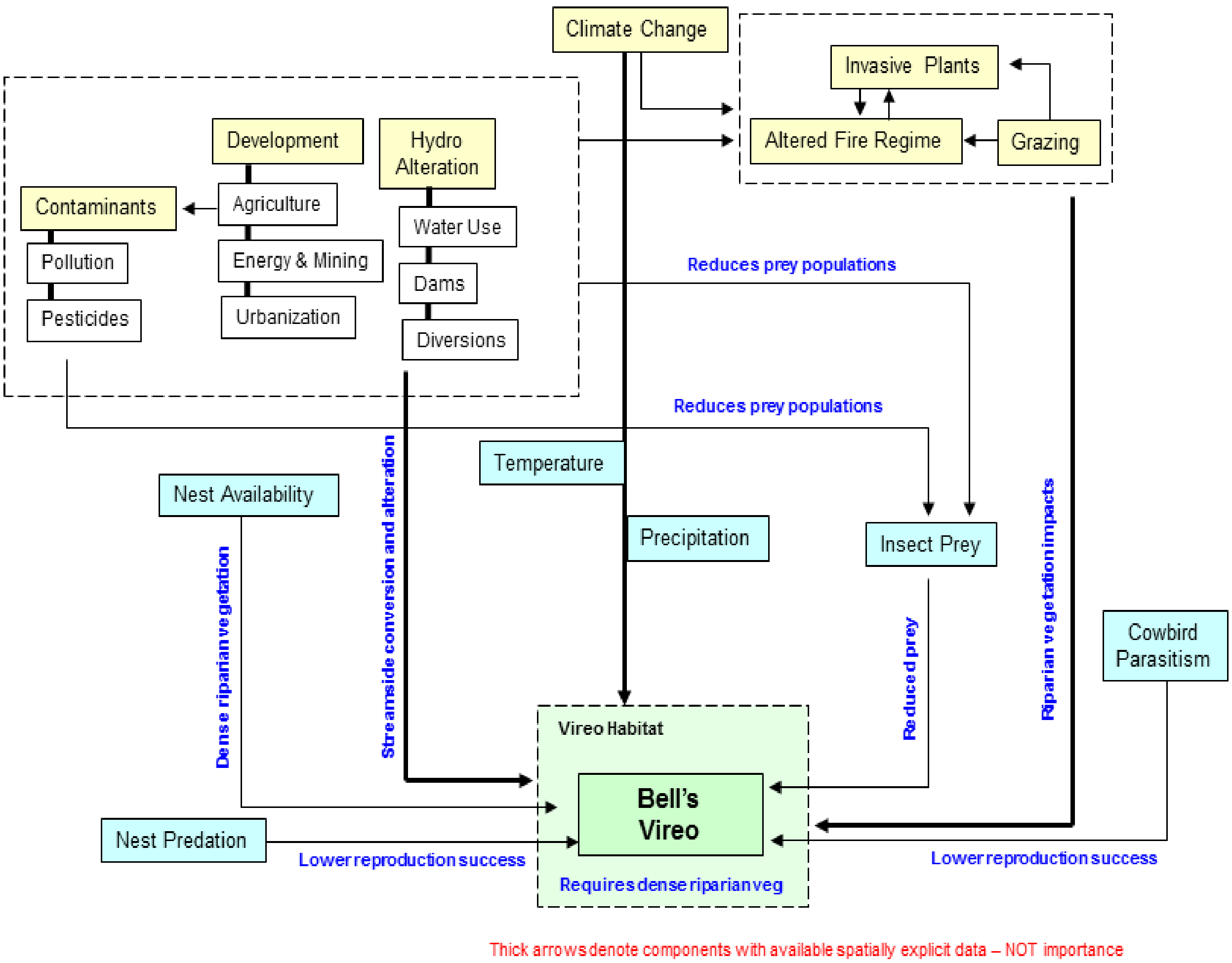
Bell's Vireo Conceptual Model



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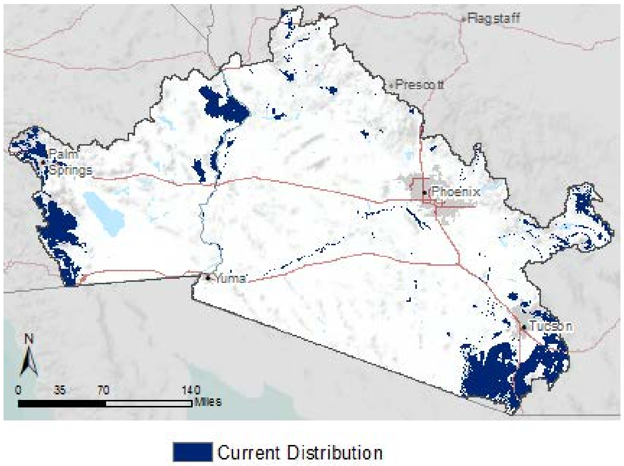
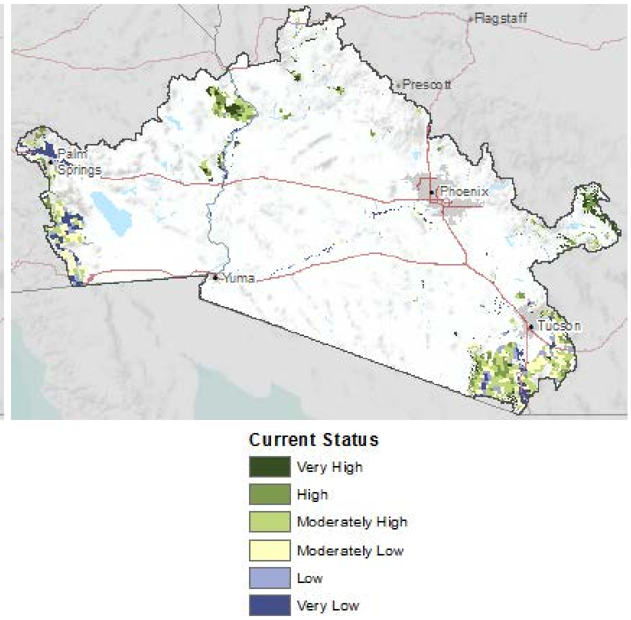
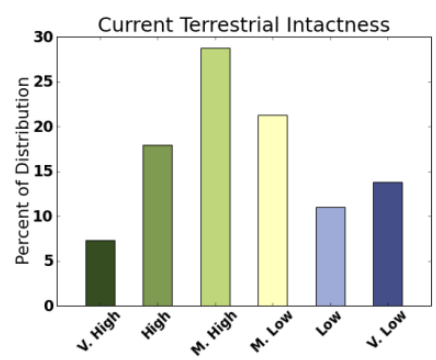




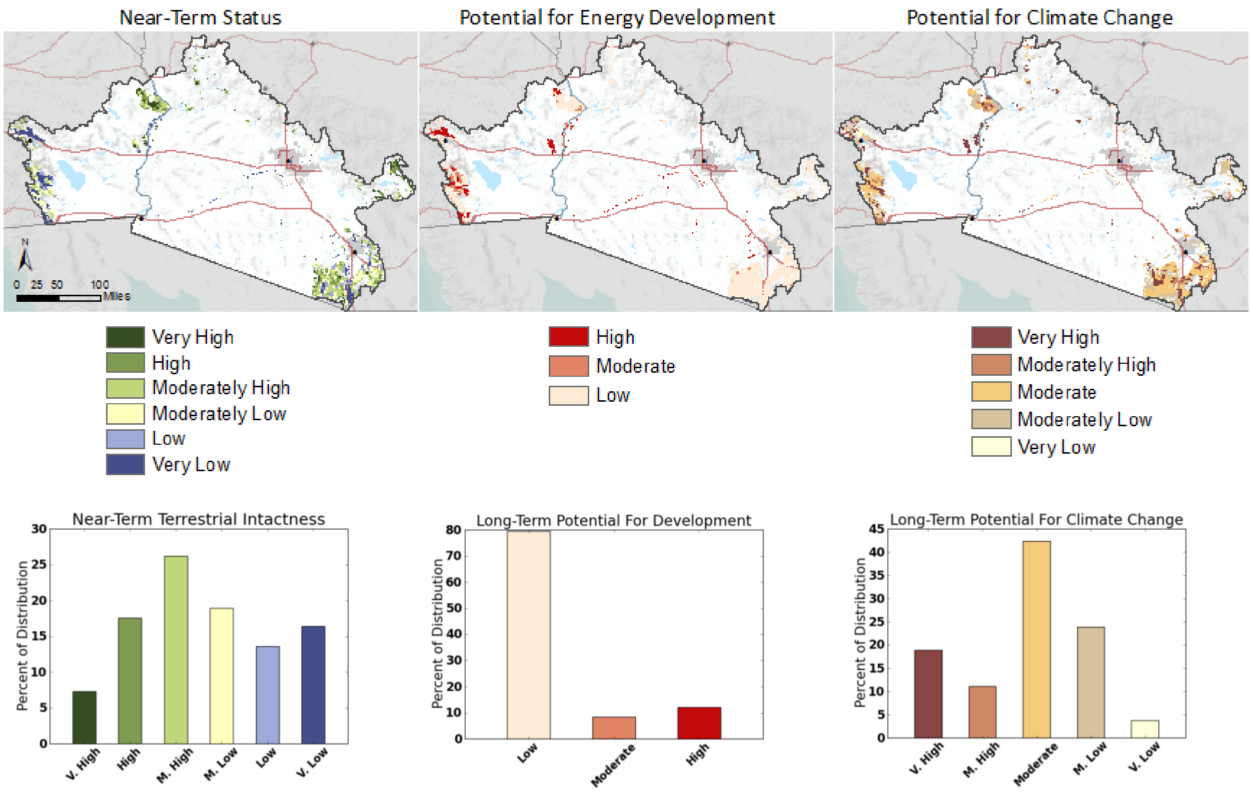
Data Sources:

Arizona GAP and California GAP

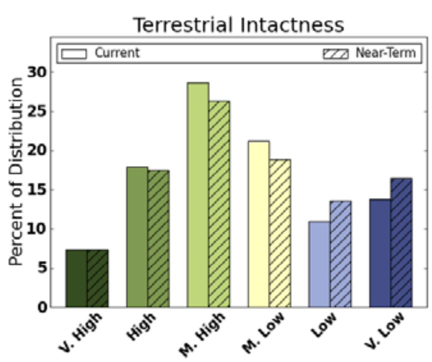


MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Bell's Vireo Potential for Change



Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Desert Bighorn Sheep – *Ovis canadensis nelsoni*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
habitat	cover & terrain	forest/thick brush; lack of precipitous escape terrain			visually open with steep, rocky slopes	Sierra Nevada Bighorn Sheep Foundation; Beecham et al 2007
Disease	Proximity to domestic livestock				a minimum of 13.5 km between sheep & domestic livestock	Beecham et al, 2007; Singer et al, 2001
Habitat	Habitat fragmentation	Increased human disturbance			Little to no human disturbance	Beecham et al, 2007; King and Workman 1985
Climate	effect on vegetation	higher temperatures - decreased precipitation			normal to higher levels of rainfall	Beecham et al, 2007

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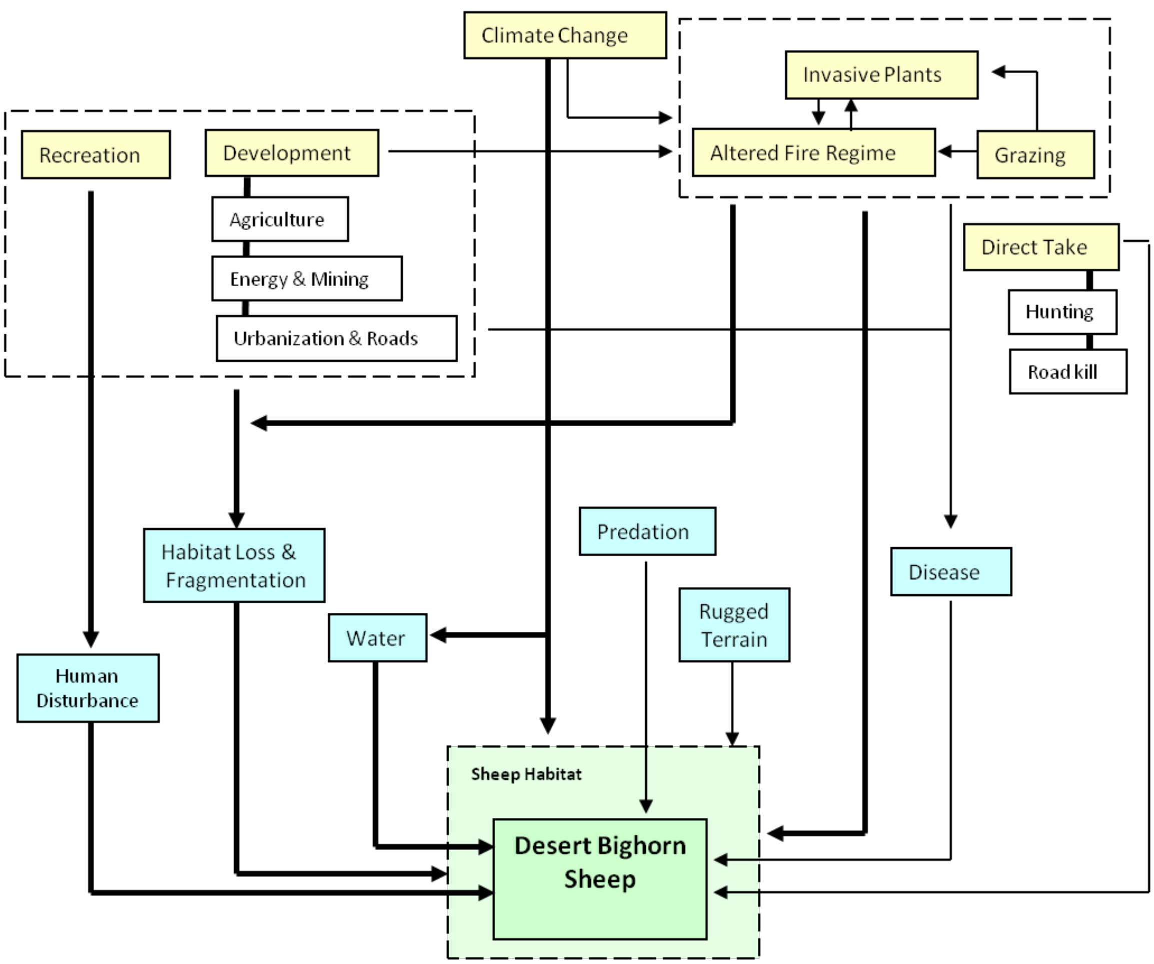
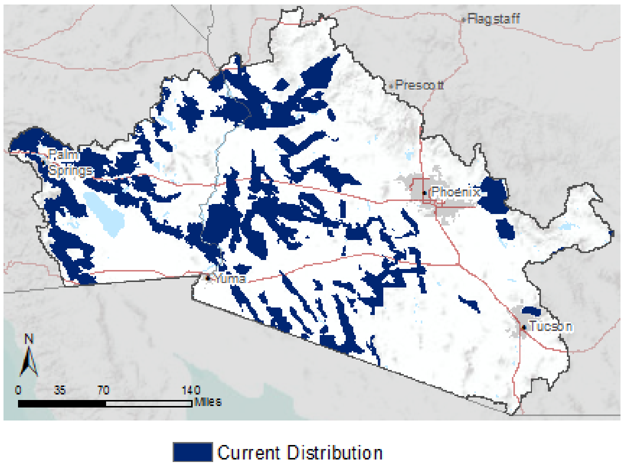
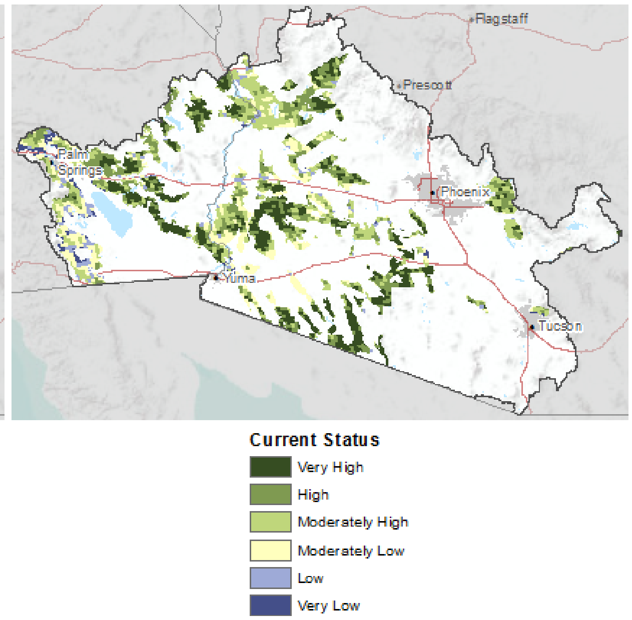
Desert Bighorn Sheep Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

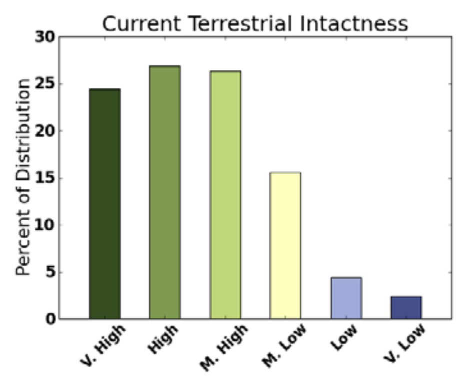
MQ D1. What's the current distribution and status of desert bighorn sheep (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





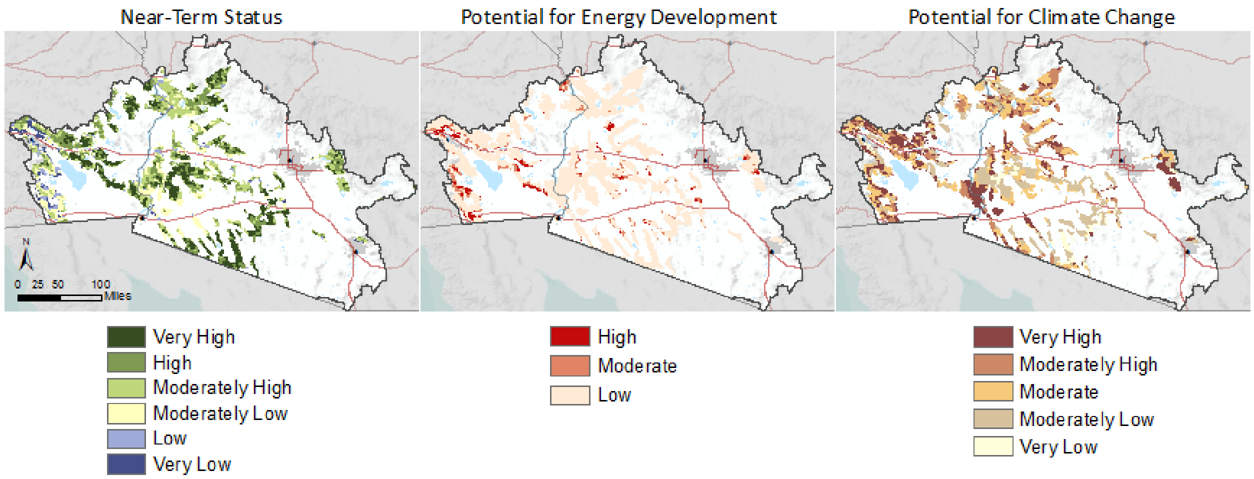
Data Sources:

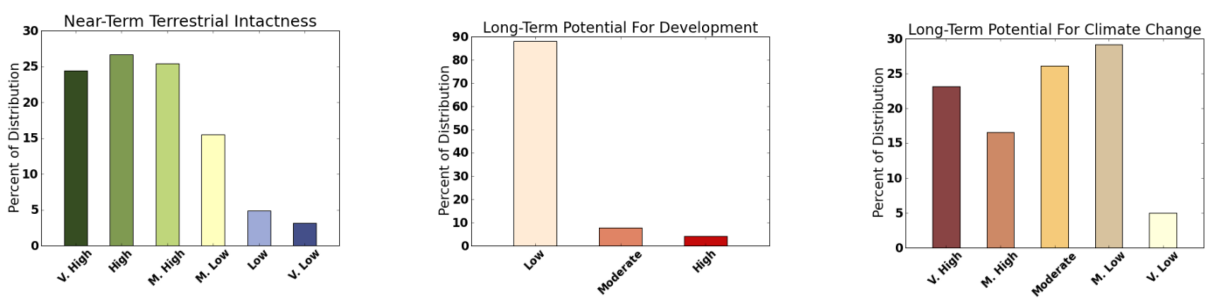
USFWS Critical Habitat, BLM Wildlife Movement Corridors, California and Arizona Wildlife Agencies (compiled by USFS)



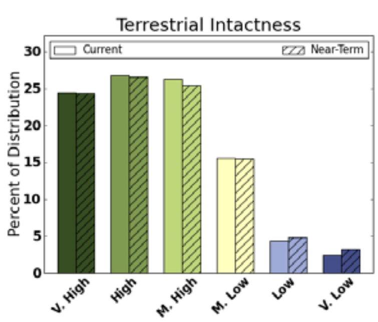
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Desert Bighorn Sheep Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mojave Desert tortoise (*Gopherus agassizii*)

For full detailed account of both desert tortoise species see Desert Tortoise Case Study Insert.

The desert tortoise was selected as a core conservation element for the Sonoran Desert REA because it is an iconic species of the region that reflects inter-regional variability in climate, landform, and vegetation. The tortoise is a good indicator of desert condition because it is widely distributed across the ecoregion and, at the same time, sensitive and vulnerable to multiple disturbance factors. The desert tortoise inhabits desert environments in the Mojave and Sonoran deserts in southern California, southern Nevada, Arizona, southwestern Utah, and northwestern Mexico. Once recognized as a single species (*Gopherus agassizii*) with two recognized populations, it has recently been split into two species (Averill-Murray 2011). The Mojave desert tortoise occurs north and west of the Colorado River and retains the Latin name *Gopherus agassizii*. It was listed as threatened in 1990 and, 22 years after listing, the species is still declining, particularly in the western portion of its range in California (Brussard et al. 1994, Tracy et al. 2004, USFWS 2008, 2011). The Sonoran population is now called *Gopherus morafkai*, distinguished from *G. agassizii* by its physical features, different habitat, life history traits, and DNA evidence (Murphy et al. 2011). The Sonoran desert tortoise occurs east and south of the Colorado River, from Arizona into Mexico. REA results produced maps for current status and future condition for the two desert tortoise species.

The Mojave desert tortoise occurs mainly in creosote bush (*Larrea tridentata*) flats, but it is also found in salt desert scrub and on sloping terrain on alluvial fans or foothills. It forages mostly on annual plants produced by winter rains. The yearly life cycle of the Mojave desert tortoise is heavily influenced by the annual precipitation pattern in the western Sonoran (and Mojave) Desert—precipitation that mainly falls in the winter and early spring with little or no summer precipitation (Van Devender 2002, Dickinson et al. 2002). As a result, most Mojave tortoise activity takes place in the spring when winter annuals and spring grasses are readily available (Nagy and Medica 1986, Brussard et al. 1994). Mojave tortoise hatchlings may overwinter in their nest and may not eat fresh forage until the following winter or spring. In years of low winter rainfall, Mojave tortoises may feed on introduced annual grasses in the absence or scarcity of winter annuals (Esque 1994), and while it is known that a diet of invasive grasses will keep tortoises alive, it is unknown if over time such a diet will keep them fit (Esque et al. 2002).

The species faces the prospect of annual summer drought; in the hot summer months and through the winter, the tortoises spend many months of inactivity in burrows in estivation or hibernation without eating or drinking. Mojave tortoises actively dig their own burrows in the friable soils of the western Sonoran Desert's basins and alluvial fans; they have the opportunity to alter the depth and extent of burrows to provide optimal thermal refuge and proper nest temperatures. Mojave desert tortoises typically burrow under shrubs in coarse sandy or loamy soils; they will also burrow under rocks, layers of caliche (as in the photo below), or even cement slabs in disturbed areas (Andersen et al. 2000, Lovich and Daniels 2000). Tortoises use multiple burrow sites that may vary in aspect throughout the year; burrows are often located under shrubs for shade, thermal cover, and protection from predation (eggs and juveniles, Lovich and Daniels 2000).

Because the species is at the northern limit of the overall range of desert tortoise species and because of their dietary restraints and restricted access to water, the Mojave desert tortoise may be more vulnerable to mortality from drought, loss of condition, and other stressors than the Sonoran desert tortoise (Peterson 1996, Oftedal 2002). The harsher conditions of the western Sonoran Desert ecoregion are reflected in the demographic characteristics of Mojave tortoises: individuals mature earlier reproductively and have a shorter life span than the Sonoran tortoises (Curtin et al. 2009). Curtin et al. (2009) admit that relatively fast growth and early reproduction in a harsh environment may be counterintuitive, but that such a life history strategy may have a selection advantage in populations with high juvenile mortality and shorter overall life span.

Although similar threats and disturbances affect both tortoise species, there are differences related to their varying life histories and habitats (Curtin et al. 2009). For example, as a lowland tortoise, Mojave tortoise inhabits more developable flatlands and basins in fast-developing areas of California's Sonoran Desert; as a result, it is more directly threatened by displacement from urban, agricultural, and energy development than the Sonoran tortoise that frequents the rocky slopes of the Arizona Upland (Hunter et al. 2003, also see development section below). The fragmentation of habitat through rural housing and energy development affect tortoise populations not just through direct alteration of habitat but also through providing infrastructure and amenities that benefit predators of juvenile tortoises (Doak et al. 1994, Boarman 2003). Residential development, roads, and landfills favor tortoise predators such as ravens, coyotes, and feral and domestic dogs. For example, during a 25-year period in the late 20th century, some Mojave and California Sonoran raven (*Corvus corax*) populations in recently developed areas increased by 450-1000% (Boarman 2003). Piles of tortoise shells (incriminating evidence) have been found under raven nests (Boarman 2003). In contrast, Boarman and Coe (2002) found that raven densities were low in the roadless portions of Joshua Tree National Park.

Desert tortoises in the Mojave Desert suffer more than Sonoran desert tortoises from the upper respiratory tract disease (URTD) mycoplasmosis. Losses from this disease were one of the reasons for listing the Mojave species as threatened under the Endangered Species Act in 1990 (Van Devender 2002, USFWS 2008). For the Mojave tortoise, the frequency and intensity of URTD may be influenced by the effects of other disturbances. Habitat degradation, drought stress, food shortages, and crowding may all affect the onset and severity of URTD infections (Tracy et al. 2004)

Declines in Mojave desert tortoise continue even though tortoise management areas have been established and some of the major disturbances in those areas have been excluded. Prospects for recovery of Mojave desert tortoise are bleak if threats to both adult and juvenile segments of the population are not reduced. Doak et al. (1994) found that the rate of desert tortoise population growth was most sensitive to the survival of large adult females, and they proposed that improving survival of adult females could reverse population declines. Tracy et al. (2004) observed that the threats to desert tortoise are interactive and synergistic, and that recovery management required attention to factors affecting other age classes as well, such as the increase in predation on juvenile tortoises.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	size	<200 sq mi	200-500 sq mi	500-1,000 sq mi	>1,000 sq mi	Brussard et al. (1994)
predation	common ravens	abundant	fairly common	rare	absent	Brussard et al. (1994)
habitat degradation	exotic ephemerals	abundant, ineradicable	fairly common and widespread	scarce and patchy	none	Brussard et al. (1994)

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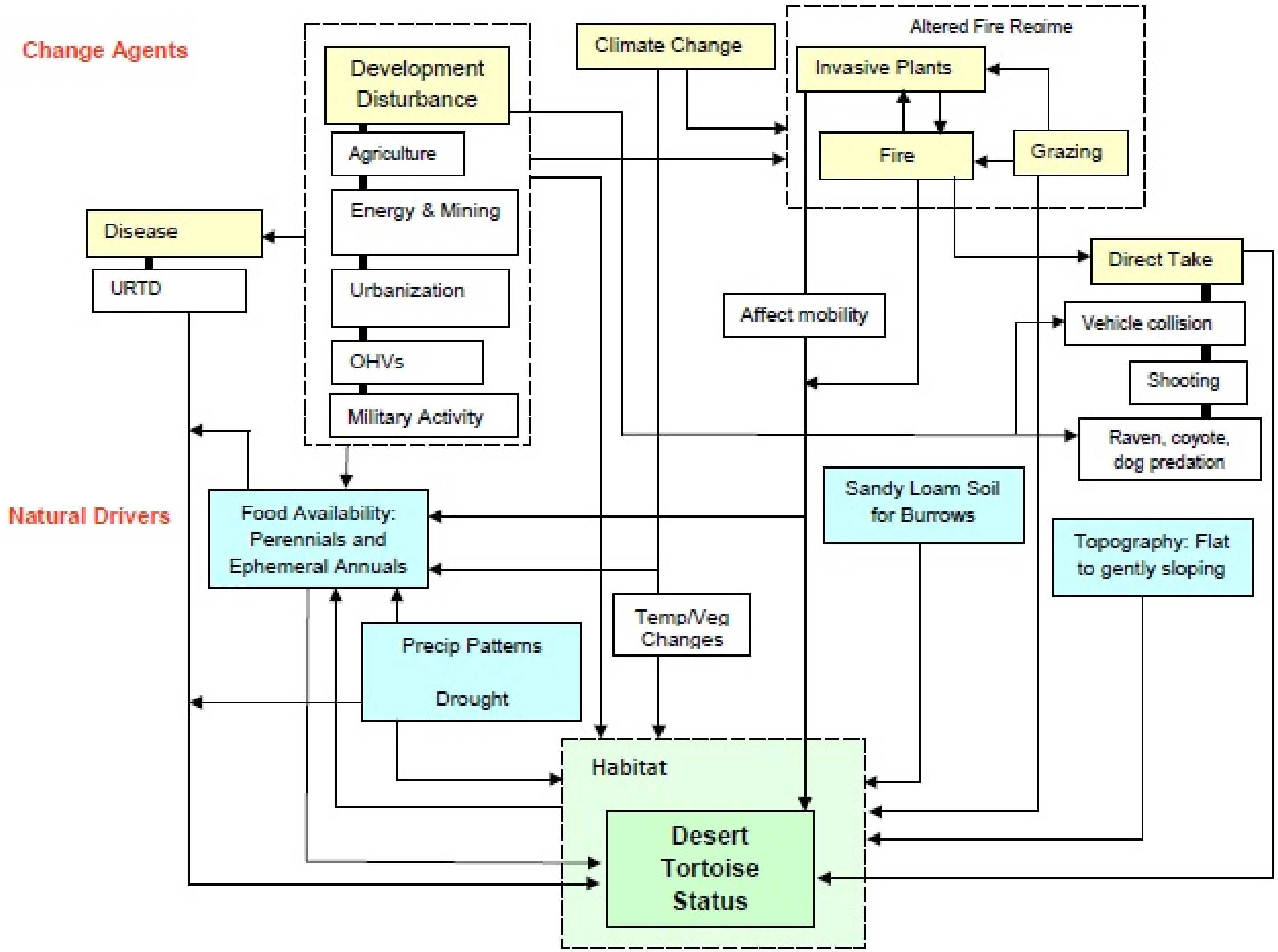
Photo: Mojave tortoise in its burrow. S. Schwarzbach, U.S. Geological Survey

Mojave Desert Tortoise Conceptual Model



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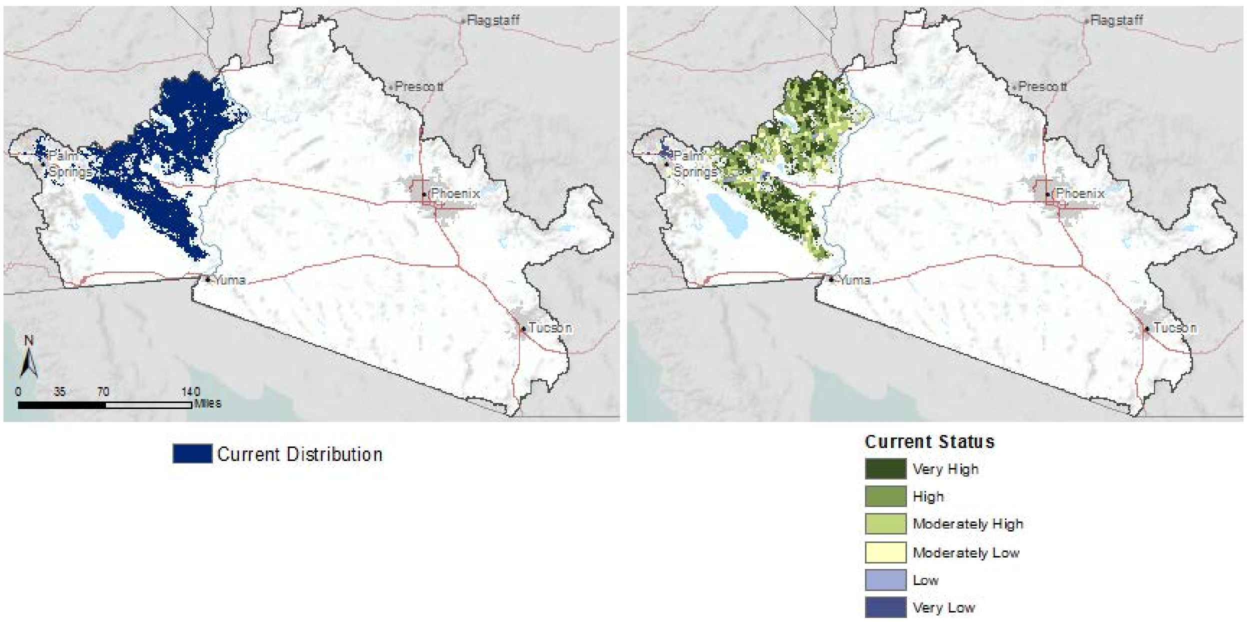
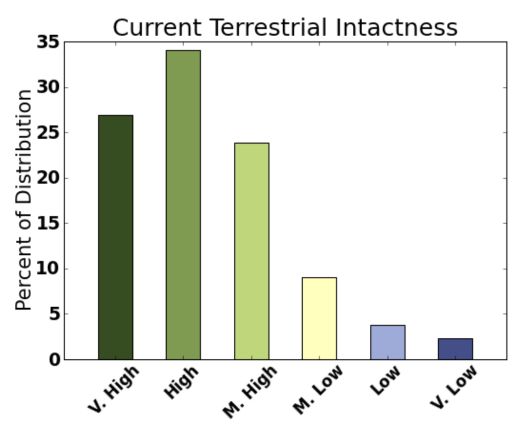


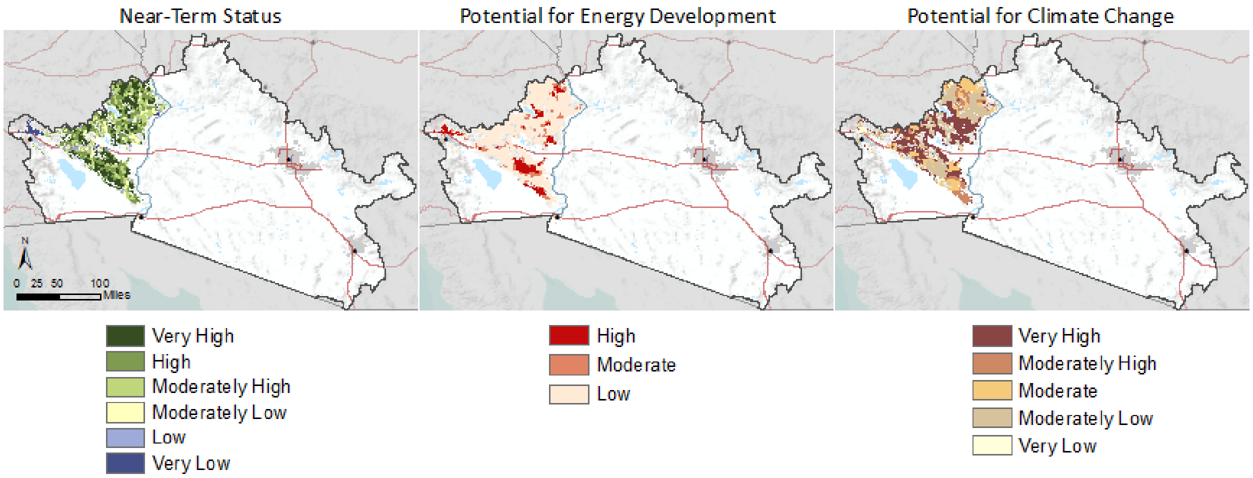
Data Sources:

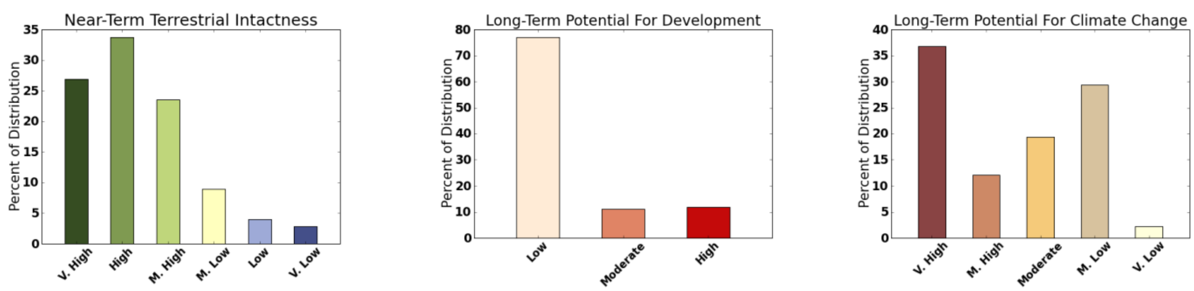
Probability model from Nussear et al. 2009 (clipped to remove areas w/ of Salton Sea and ag/urban in LANDFIRE)



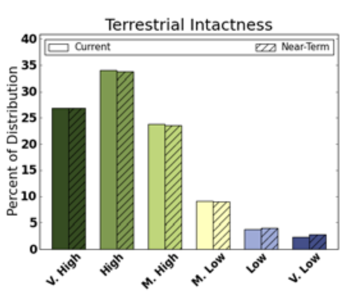
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mojave Desert Tortoise Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Sonoran Desert tortoise (*Gopherus morafkai*)

Sonoran desert tortoises live on the rocky slopes and bajadas of Arizona east of the Colorado River in the Arizona Uplands and northwestern Mexico. There is a wide range in tortoise densities across the Sonoran Desert depending on habitat conditions and food availability; Sonoran tortoise populations may range from 15–100 adults/mi^2 (Averill-Murray et al. 2002). Home range sizes also vary, but a typical female tortoise home range in Arizona is 10 ha; males' territories may be larger, overlapping the range of several females (Van Devender 2002, Averill-Murray et al. 2002). The species does occur on occasion and in low densities in the valleys (USFWS 2010), but the frequency of dispersal of young or adults between mountain ranges is unknown. It appears that the Sonoran desert tortoise, with its patchy distribution, may have fewer opportunities for maintenance of genetic diversity and dispersal than the Mojave tortoise, which has greater continuity among populations across the broad basins of the Colorado Desert (disregarding fragmentation and human disturbance factors, Van Devender 2002, Hagerty et al. 2011).

Sonoran desert tortoises construct burrows under shrubs and rocks or in caliche caves; the tortoise may expand existing crevices under rocks, but the rocky soil does not permit the extent of burrowing that occurs in the more friable soils of the Colorado Desert. Desert washes are important to this species as they provide exposed banks with variable aspects, exposed caliche caves for locating burrows, and xeroriparian vegetation for thermal cover (Riedle et al. 2008). Unlike the Mojave tortoise that estivates in its burrow during the summer drought, the Sonoran tortoise is active in the summer during the monsoon season when fresh forage is available. Eggs usually hatch at the end of the summer rainy season, meaning that hatchlings have more access than Mojave tortoise hatchlings to fresh forage in most years (Averill-Murray et al. 2002). Besides summer annual forbs, the Sonoran tortoise feeds on warm season grasses such as big galleta (*Pleuraphis rigida*), bush muhly (*Muhlenbergia porteri*), and threeawns (*Aristida* spp.). These grasses become sparser to the west where the summer monsoon rains dwindle; as a result, Sonoran tortoises living on the drier mountain ranges closer to the Colorado River subsist on alternate food sources more similar to those available to Mojave tortoises (Van Devender 2002).

The eggs and young of both species of tortoise are subject to heavy predation by a range of mammal and bird species as well as other reptiles (e.g., Gila monsters). With their soft shells, the young are rather defenseless, and they also must spend a greater proportion of their time foraging, exposing them to predation (Morafka 1994). Raven predation, however, may not be as high for tortoises in Arizona as it is in California; the increases in raven populations subsidized by development have not (yet) occurred to the same extent. Bird predation on tortoises in general may be less in much of tortoise habitat in Arizona because of the greater cover provided by denser upland vegetation (USFWS 2010).

The greatest human-induced threats to Sonoran desert tortoise are urban and exurban development, associated road building and highway upgrading, and the increasing demands of a larger population on outdoor recreation. Throughout the 1990s the urban fringe in Phoenix advanced outward at the pace of ½ mile per year (Rex 2005). Population projections for the Phoenix areas for the next 5 decades envision a 1–1.5 million increase per decade (assuming sufficient water availability, Rex 2005). Although urban development in lowland areas may not directly convert tortoise habitat on slopes and bajadas, it puts human influence and activities in closer proximity to tortoise habitat, increasing overall access, recreation use, harassment, and pet predation. Even if valley dispersal among populations is not common, it may be important to genetic diversity; barriers from development between mountain ranges create closed populations that, if degraded or damaged, will not have the ability to recover through recruitment from other populations (USFWS 2010). In 2010 the US Fish and Wildlife Service found that listing the Sonoran population of the desert tortoise was warranted, but that listing was precluded by higher priority actions (USFWS 2010). As a result, the Sonoran population of the desert tortoise was added to the candidate species list, where its status will be reconsidered annually.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	size	<200 sq mi	200-500 sq mi	500-1,000 sq mi	>1,000 sq mi	Brussard et al. (1994)
habitat degradation	exotic ephemerals	abundant, ineradicable	fairly common and widespread	scarce and patchy	none	Brussard et al. (1994)

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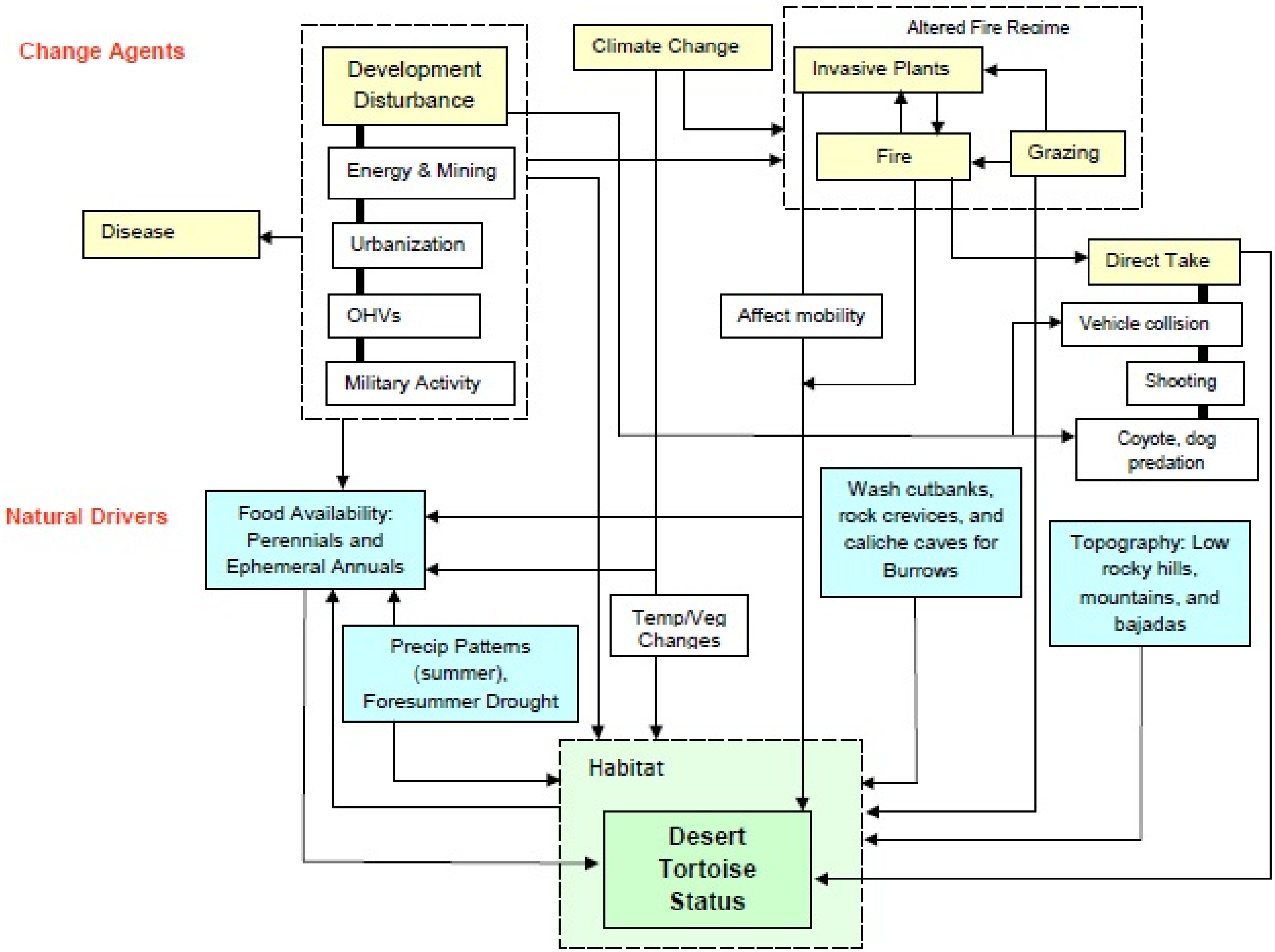
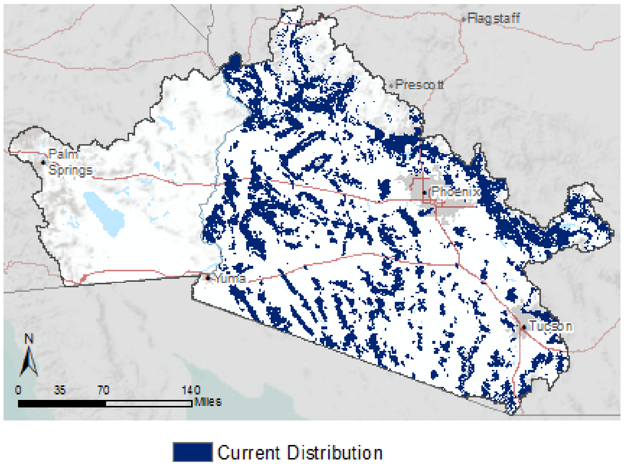
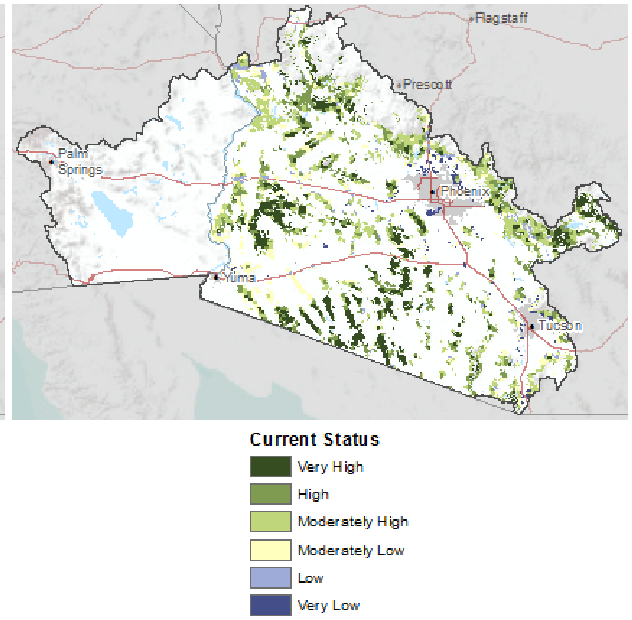
Sonoran Desert Tortoise Conceptual Model

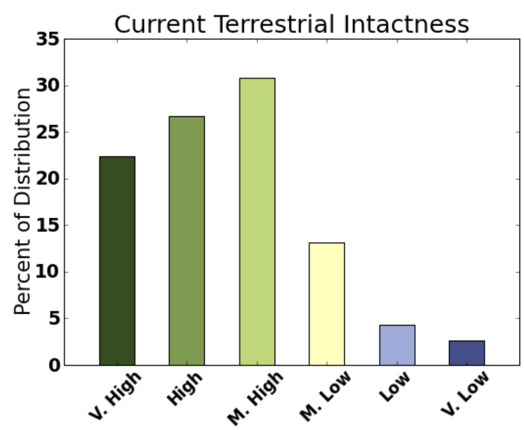


MQ D1. What's the current distribution and status of Sonoran desert tortoise (G, morafkai, and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?



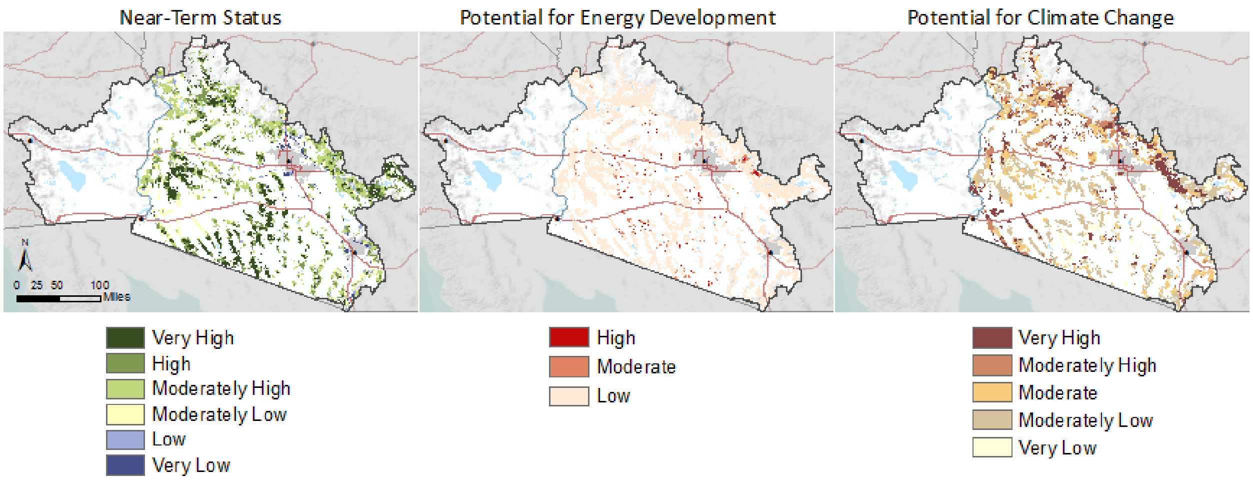


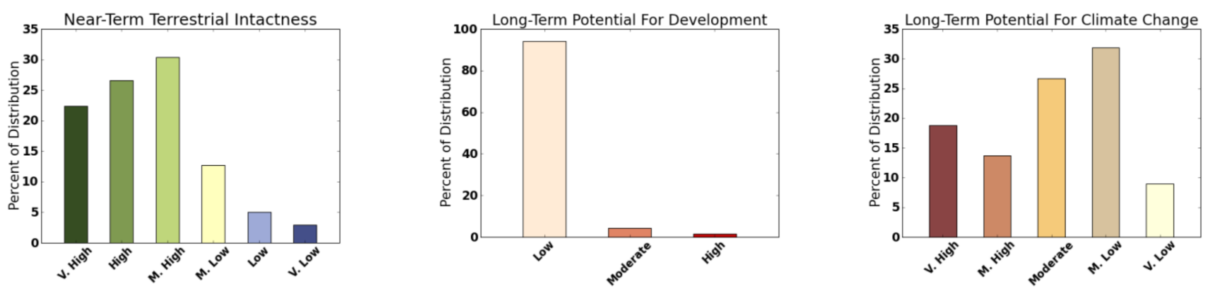
Data Sources:
Arizona GAP (clipped to remove ag/urban in LANDFIRE)



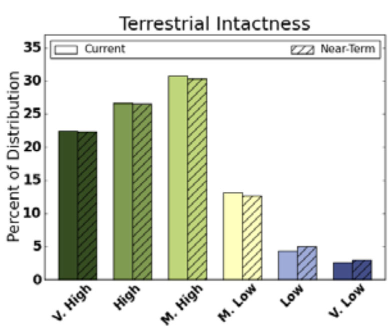
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Sonoran Desert Tortoise Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Golden Eagle – *Aquila chrysaetos*

Golden eagles hunt over open spaces in western North America, often in the vicinity of cliffs and ridges where the birds prefer to nest (Kochert et al. 2002). The eagles feed primarily on small to medium-sized mammals, principally hares and rabbits (Olendorff 1976). In a sample of prey remains from 9 nests in central Arizona, Eakle and Grubb (1986) found that black-tailed jackrabbit (*Lepus californicus*) was the dominant prey item followed by ground squirrel (*Spermophilus* spp.); bird prey included other raptors such as red-tailed hawk and great-horned owl. Stahlecker et al. (2009), in their survey of 191 nests in the Four Corners region of the southwestern U.S., confirmed the preference for jackrabbit and noted that ravens were the most common avian prey.

Golden eagles usually nest on cliffs, although in more developed areas they will also utilize human-made structures such as windmills, electrical transmission towers, and nesting platforms (Kochert et al. 2002). Golden eagles are typically short- to medium-distance partial migrants with individuals from northern breeding areas migrating longer distances. Eastern golden eagles nesting in northern Quebec have been tracked to wintering grounds as far south as West Virginia and the Georgia border and Alaskan eagles have been detected as far south as Kansas (Brodeur et al. 1996). Eagles in more moderate climates migrate shorter distances or remain as winter residents. Canvassers for the Arizona Breeding Bird Atlas found golden eagles sparsely distributed in the Sonoran Desert; 15% of all golden eagles detected over the 7 year survey were recorded in Sonoran desert scrub (Driscoll 2005). As with other desert inhabitants, golden eagles breeding success in the Sonoran Desert depends on a combination of favorable weather and prey availability.

Although eagles and their nests have been protected since 1962 by the Bald and Golden Eagle Protection Act, long-term surveys indicate population declines in portions of the western U.S. (Kochert and Steenhof 2002). Eagles are vulnerable to environmental change, especially from human development and changes to habitat. Breeding Bird Survey trend results show a 0.4% yearly percentage increase between 1966 and 2009 for the Mojave and Sonoran deserts and a 1.1% yearly percentage decline for Arizona for the same time period. However, these trend results carry substantial caveats since they reflect the detection difficulties and small sample size of a wide-ranging species with low abundance (Sauer et al. 2011).

The major reasons for the decline of golden eagles are direct take and habitat destruction through development. Humans cause over 70% of recorded deaths, either directly or indirectly, through collisions with vehicles, power lines, and wind turbines, electrocution on power poles, poisoning, and shooting (Franson et al. 1995). Although they are protected under the Bald and Golden Eagle Protection Act, golden eagles are sometimes illegally shot when suspected of killing livestock.

Habitat destruction due to land development has led to large-scale population declines in some areas (Kochert and Steenhof 2002). Alteration of open shrubland or grassland habitat through development or conversion to agriculture has a negative effect on eagle populations because it reduces prey populations. Eagles are often the victims of secondary poisoning when they consume prey that have been killed or sickened by pesticides, herbicides, or rodenticides (Franson et al. 1995). Eagles may also survive with elevated blood-lead levels from consuming prey that are contaminated with lead or from directly ingesting lead shot (Pattee et al. 1990, Kramer and Redig 1997). Wildfires affect golden eagles in the sagebrush community in the western U.S. through the loss of shrub habitat and resident prey. Kochert et al. (1999) found that golden eagles in sagebrush areas in Idaho avoided previously burned areas and that eagle fledging success declined with an increasing extent of burned area in the vicinity of the nest. It is unknown how burned-over areas will affect golden eagles in the Sonoran Desert as wildfire, once rare in desert scrub, becomes more common with the expansion of invasive annuals.

Infrastructure such as power lines and wind turbines are also responsible for eagle mortality. In the Altamont Pass Wind Resource Area in west-central California, Smallwood and Thelander (2008) estimated 67golden eagle fatalities per year due to wind turbines; sub-adults and floaters appeared to be affected disproportionately (Hunt 2002). Golden eagle fatalities were correlated with turbine height, location, and topography with the majority of deaths associated with shorter turbines (e.g. Type 13), end of row and second from the end turbines, and favored aerial pathways through dips and notches in topography (Curry and Kerlinger 1998, Hunt 2002). Although it has been reported that fatalities are much lower from newer wind farms with more recent turbine designs, there is no clear relationship between pre-construction risk assessment planning and reduced mortality (Lynn and Auberle 2009). While, on one hand, Smallwood and Karas (2009) estimated that newer turbines at Altamont could reduce mean annual fatality rates by 54% for raptors (while more than doubling annual wind-energy generation), eagle deaths tallied at a new (2 year old) wind farm north of Los Angeles, showed an annual death rate per turbine to be three times higher than at the older Altamont facility (Sahagan 2011). Potential risk assessments conducted prior to permitting wind facilities evaluate topography, weather patterns, and vegetation type, the presence of flyways and migration corridors, the numbers of birds potentially flying in the risk zones near the rotors, the possible presence of species of concern, the distance to important nesting areas and roost sites for birds and bats, and the potential for prey species such as ground squirrels to inhabit the site (Lynn and Auberle 2009).

Golden eagles populations are sustained by the conservation of large areas of intact desert habitat. Eagle home ranges are large, but they vary considerably in size depending on region, prey availability, and season from a few thousand to tens of thousands of hectares. Eagle management is inseparable from management of prey populations and their habitat, and shrub patch size is an important element; in sagebrush communities to the north, a management rule of thumb is to avoid fragmentation of shrub habitats below the mean patch size of 5000 ha shown to support healthy jackrabbit populations (Marzluff et al. 1997). If they do not already exist, establishing similar guidelines for golden eagle prey species' habitat patches in the Sonoran Desert may be a useful research objective to accompany eagle monitoring.

In the Sonoran Desert, golden eagles benefit from established protected areas, such as the Kofa and Cabeza Prieta National Wildlife Refuges, National Parks and Wilderness areas, and some military lands such as Barry M. Goldwater Air Force Range. In southeastern California, the Desert Renewable Energy Conservation Plan reports that the golden eagle has 72% of its predicted breeding habitat and 48% of its predicted foraging habitat already within protected areas (CEC 2011). With the advent of additional energy development in potential solar and wind areas of the Sonoran Desert, planning for golden eagles should include protecting nest sites and minimizing activity in eagle nesting areas (CEC 2011), eagle-sensitive turbine selection and placing (Curry and Kerlinger 1998, Hunt 2002, Smallwood and Thelander 2007), and raptor-safe electrical transmission lines and poles with widely spaced conductors, perch guards, or perches installed above the conductors (BLM 2005).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat loss or degradation	urban development	present	--	minimal	absent	Kochert and Steenhof (2002)
habitat degradation	livestock grazing and agriculture	existing or planned	--	--	absent	Beecham and Kochert (1975)
habitat degradation	fire	>40,000 ha of shrublands burned	--	burned territory; adjacent vacant unburned	unburned territories	Kochert et al. (1999)
habitat degradation	mining and energy development	present	--	--	absent	Phillips and Beske (1982)
habitat	vegetation	disturbed areas, grasslands, agriculture			shrubland/open grassland	Marzluff et al. (1997), Peterson (1988)
habitat/nest sites	topography	--	--	--	cliffs within 7 km of shruband	Menkens and Anderson (1987), Cooperrider et al. (1986)
mortality	infrastructure (roads, power lines, wind turbines	--	--	--	infrastructure absent	Franson et al. (1995)
Illness mortality	poisoning from pesticides and other toxins	high levels of contaminants	--	--	low/no contaminants	Franson et al. (1995), Harmata and Restani (1995), Kramer and Redig (1997), Pattee et al. (1990)
habitat loss or degradation	urban development	present	--	minimal	absent	Kochert and Steenhof (2002)

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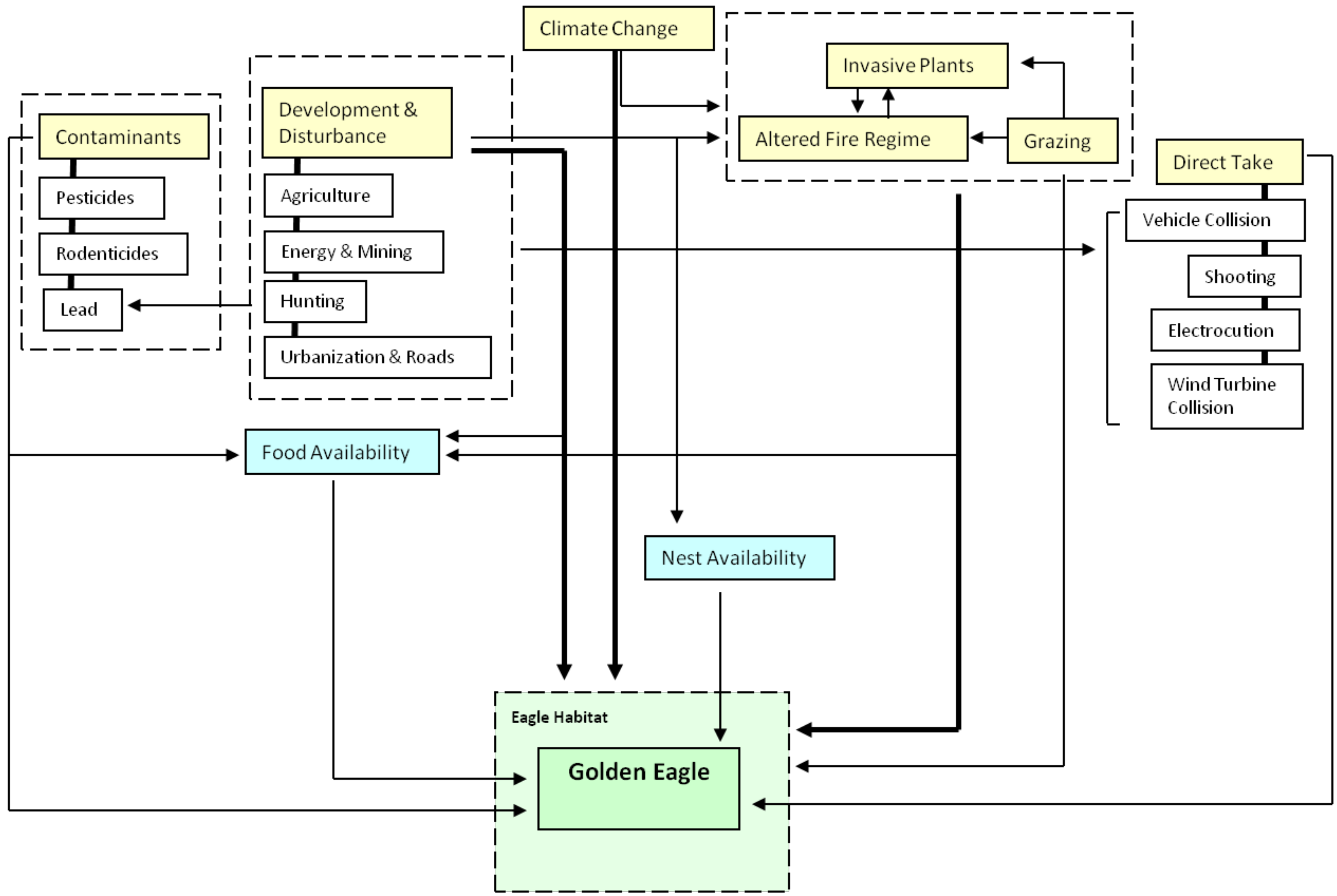
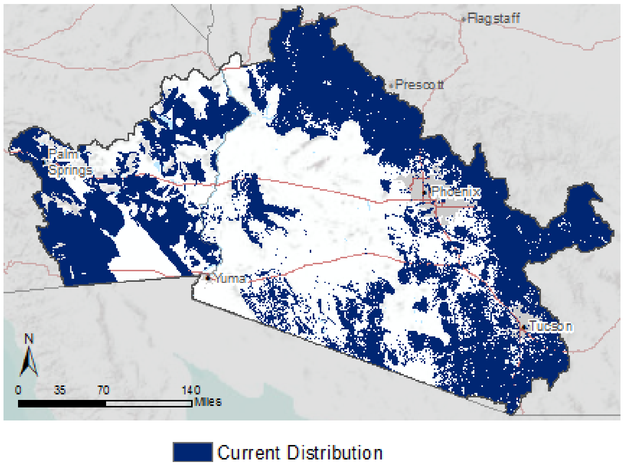
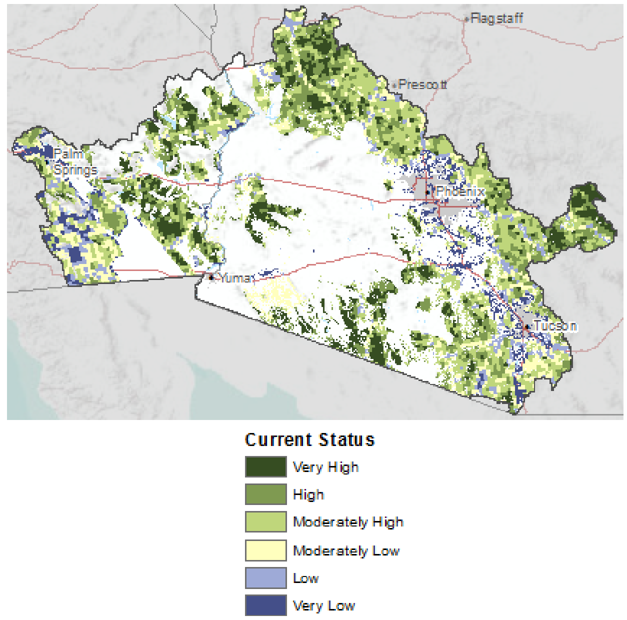
Golden Eagle Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

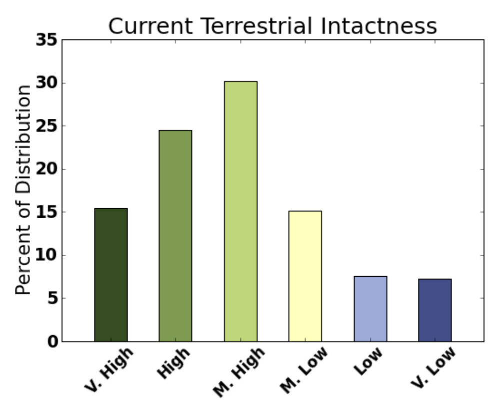
MQ D1. What's the current distribution and status of golden eagle (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





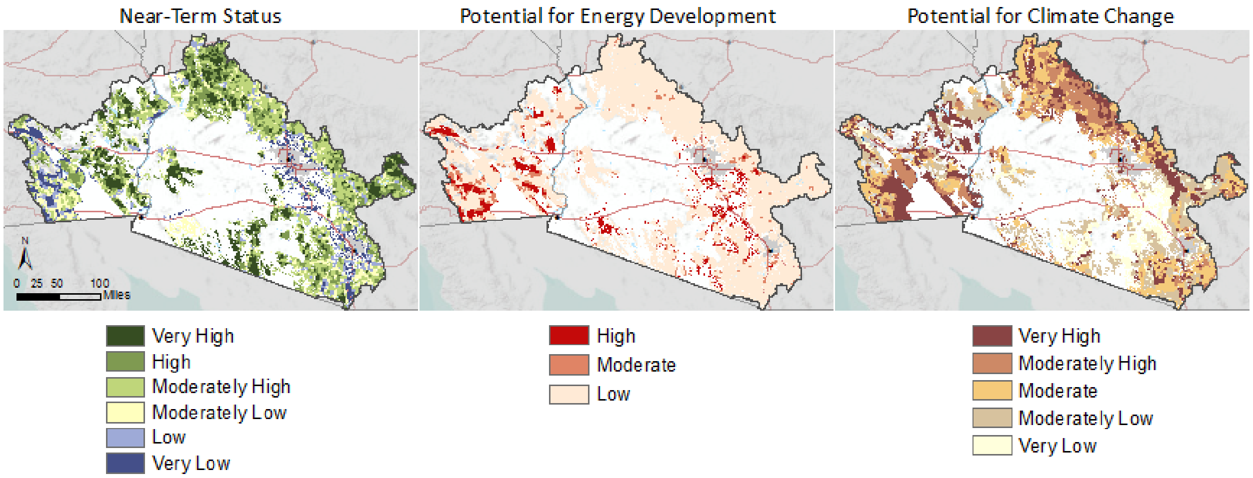
Data Sources:

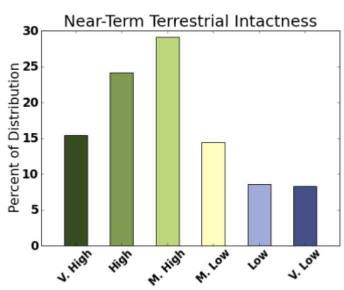
California GAP and Arizona Game and Fish Department

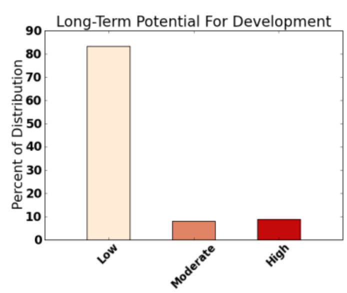


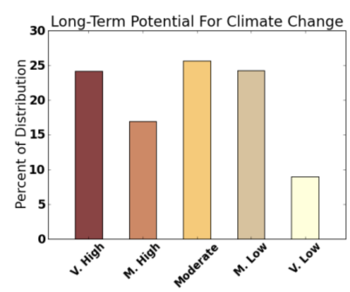
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Golden Eagle Potential for Change

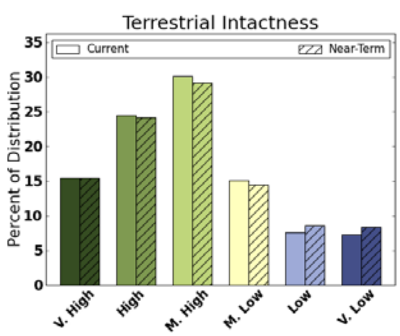








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Le Conte's Thrasher (*Toxostoma lecontei*)

Le Conte's thrasher *(Toxostoma lecontei)* is on the Audubon Society's Watch List as a species that is at risk because of its low abundance (historic and present) and relative lack of mobility. Even in optimal habitat, densities may be as low as five pairs or fewer per square mile (National Audubon Society 2011). Breeding Bird Survey trend estimate data for the Sonoran Desert ecoregion shows a 3.2 % per year decline for the period 1966–2009 and a 2.6% per year decline for the period 1999–2009 (n=detections on 47 BBS routes, Sauer et al. 2011). Habitat loss has resulted in local extirpations in the Coachella and Imperial valleys of California (Weigand and Fitton 2008). The thrasher population in the Gila River valley in Arizona is also in danger of extirpation due to agriculture and expanding urban and exurban sprawl (Corman 2005). Thrashers previously reported in the Avra Valley in northern Pima County, Arizona, have not been detected since the 1980s (Corman 2005).

The species is a year-round resident in the Colorado Desert that covers the sparsely vegetated, lower-elevation portions of the Sonoran Desert ecoregion in southeastern California and southwestern Arizona. Le Conte's thrashers frequent somewhat rolling, well-drained areas for foraging (the toeslopes of bajadas or alluvial fans), avoiding the more poorly drained valley floors (playas) that may be flooded in winter or highly alkaline in the dry season (Shuford and Gardali 2008). Optimal foraging areas have a mixture of bare ground and scattered litter. The thrashers forage on the ground by digging and probing in the soil, flipping bits of debris with their stout curved bills to search for insects beneath. They also glean other prey from vegetation or pursue insects and lizards on the ground (Weigand and Fitton 2008, National Audubon Society 2011). Le Conte's thrashers hide their nest low to the ground in the thick vegetation of thorny bushes or small trees such as saltbush (*Atriplex* sp.), mesquite (*Prosopis* sp.), desert-thorn (*Lycium* sp.), lotebush (*Ziziphus obtusifolia*), blue palo verde (*Parkinsonia floridium*), ironwood (*Olneya tesota*), Joshua trees (*Yucca brevifolia*), cholla cacti (recorded only in California, *Cylindropuntia* sp.), and ocotillo (in Arizona, *Fouquieria splendens*, Corman 2005, Weigand and Fitton 2008, CalPIF 2009). These favored nesting shrubs and small trees occur in basins and washes in the creosotebush (*Larrea tridentata*)-white bursage (*Ambrosia dumosa*) vegetation community class common to the alkaline basins and lowlands of the Sonoran Desert. As with other desert species, during periods of drought, Le Conte thrasher nesting may fail or be deferred, while, in better years, there may be multiple broods.

The increasing incidence of fire in the desert shrub habitats of the Sonoran Desert poses a serious threat to Le Conte's thrasher. Many desert shrub species do not sprout readily and are slow to reestablish. Burned areas may be replaced by invasive annual plants that burn more frequently. Following fire, thrashers may be displaced from the burned area for decades because they lose nesting shrubs and, if annuals establish post-burn, they also lose the bare ground and surface litter that they require for foraging (Shuford and Gardali 2008). Grazing also has been implicated in the gradual conversion of shrublands to non-native annual grasses and forbs. Saltbush shrub habitat may be managed for grazing to avoid negatively affecting Le Conte's thrasher by avoiding stocking in drought years and by limiting grazing to early season use to preclude browsing on shrubs later in the season (Shuford and Gardali 2008).

The long-term sustainability of Le Conte's thrasher depends on unfragmented expanses of desert shrubland and connectivity between patches, since the species is relatively sedentary and does not disperse widely. Le Conte's thrashers apparently will not inhabit fragments of shrub habitat within areas undergoing development due to increased disturbance and lack of connectivity (Weigand and Fitton 2008). Since they nest close to the ground, thrashers experience increased nest predation by wild and domestic predators in fragmented areas. Concentrating development-related disturbances in the thrasher's range will help to limit fragmentation (Weigand and Fitton 2008). For example, siting a solar energy field in former agricultural land or near existing infrastructure is preferable to carving it out of remote, intact desert shrubland. Thrashers are also vulnerable to disturbance and death from OHV activity in basins and desert washes. Limiting OHV use to designated routes would conserve thrasher habitat. Le Conte's thrasher benefits from refuges that are created to protect other inhabitants of the Sonoran Desert; intact breeding populations of Le Conte's thrashers occur within the Desert Tortoise Research Natural Area in California and Cabeza Prieta National Wildlife Refuge and the Barry M. Goldwater Range in Arizona (National Audubon Society 2011, Corman 2005).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat degradation	invasive grasses				revegetation at disturbed sites of desert thorn (*Lycium*) and saltbush (*Atriplex*) species;	Weigand and Fitton (2008)
habitat	Habitat fragmentation -	>10 km distance between habitat fragments			maximum of 2 km distance between habitat fragments	Weigand and Fitton (2008)

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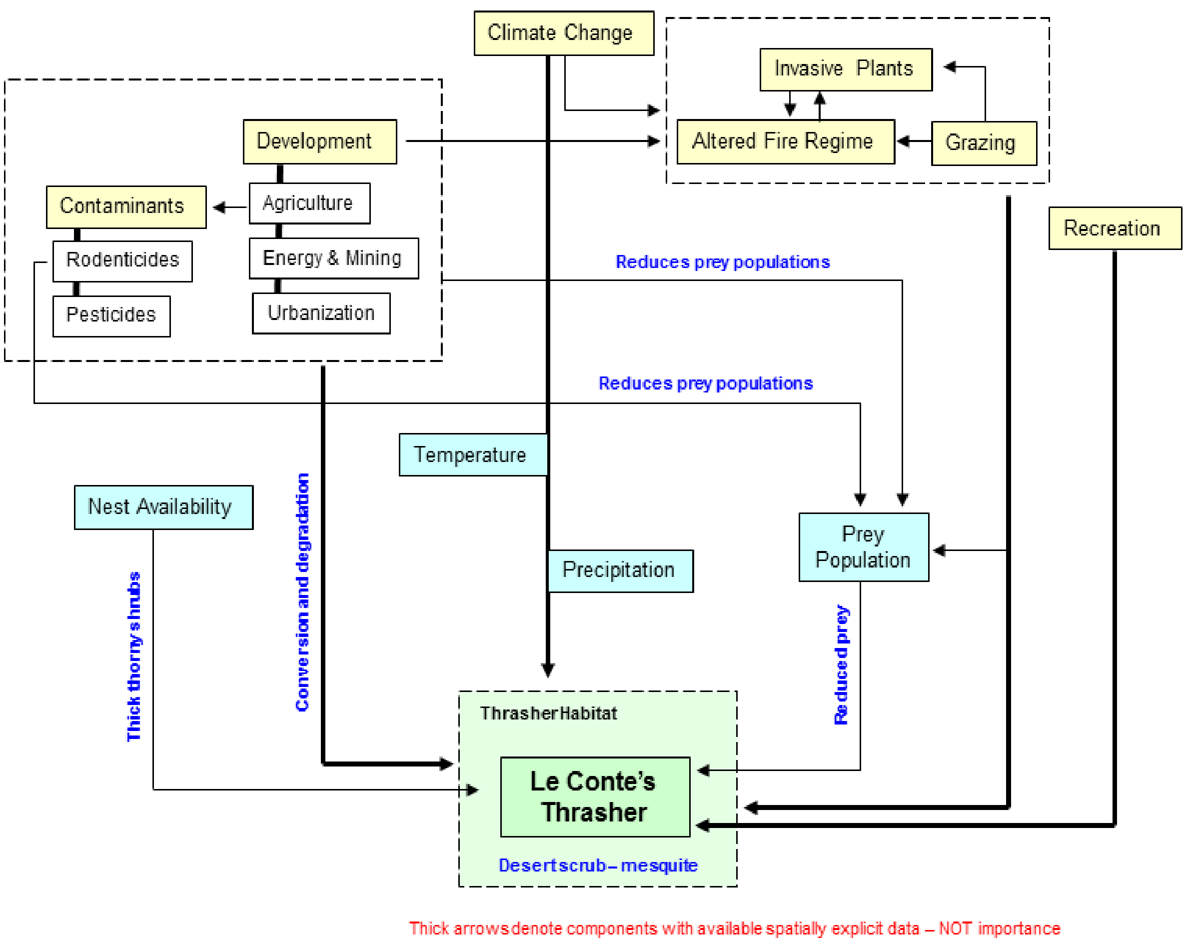
Le Conte's Thrasher Conceptual Model



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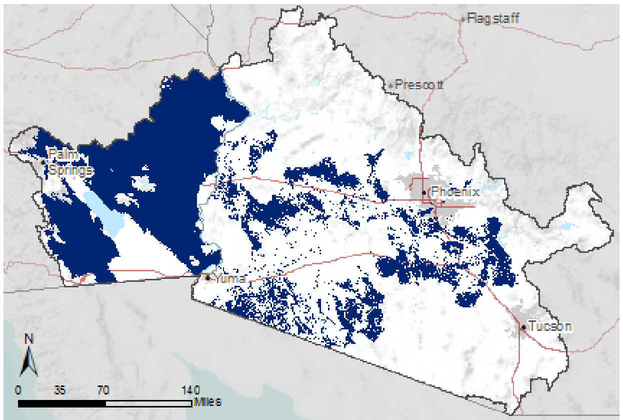
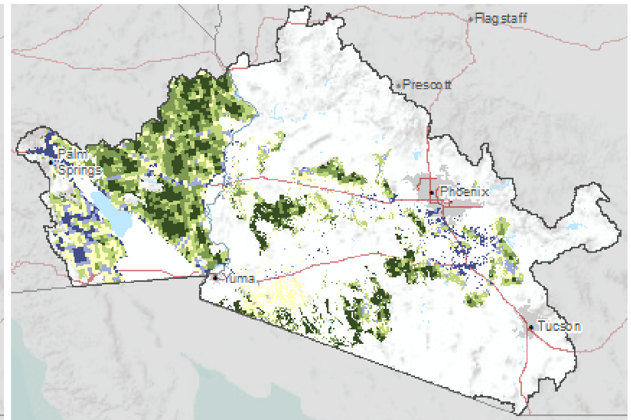


Current Distribution

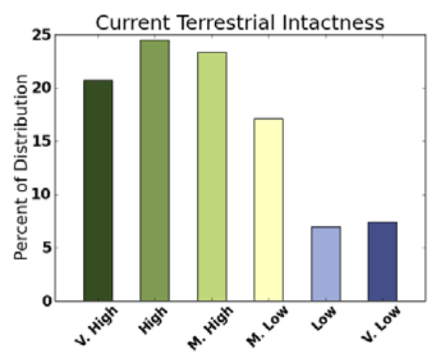


Current Status

- Very High
- High
- Moderately High
- Moderately Low
- Low
- Very Low

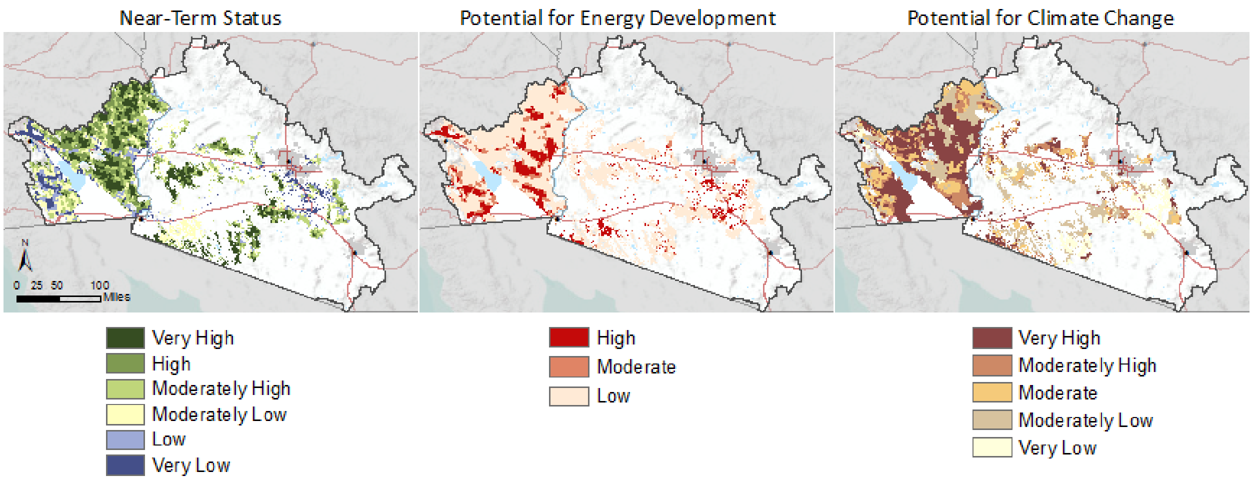
Data Sources:

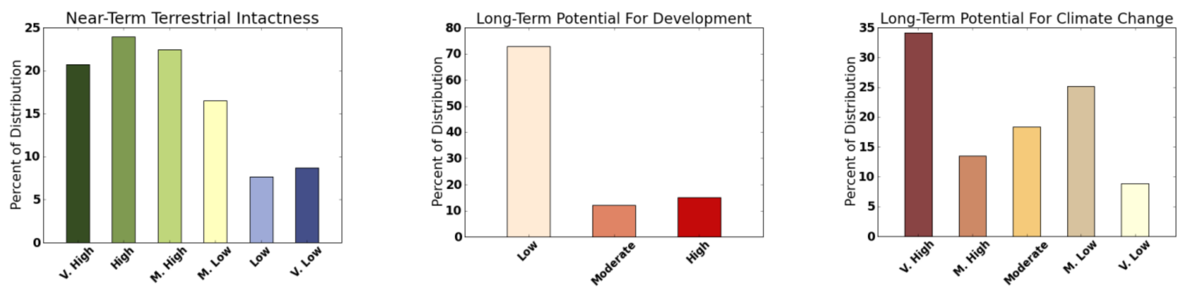
California GAP and Arizona Game and Fish Department



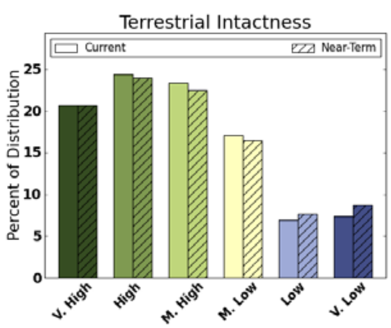
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Le Conte's Thrasher Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Lowland Leopard Frog (*Lithobates yavapaiensis)*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	elevation	>8,200 ft	6,400 - 8,200 ft	-	<6,400 ft	AZGFD (2006)
predation	American bullfrog	present	-	-	absent	Jennings (1994)
habitat	water development	present			absent	Center for Biological Diversity & S. Utah Wilderness Alliance- Petition to list

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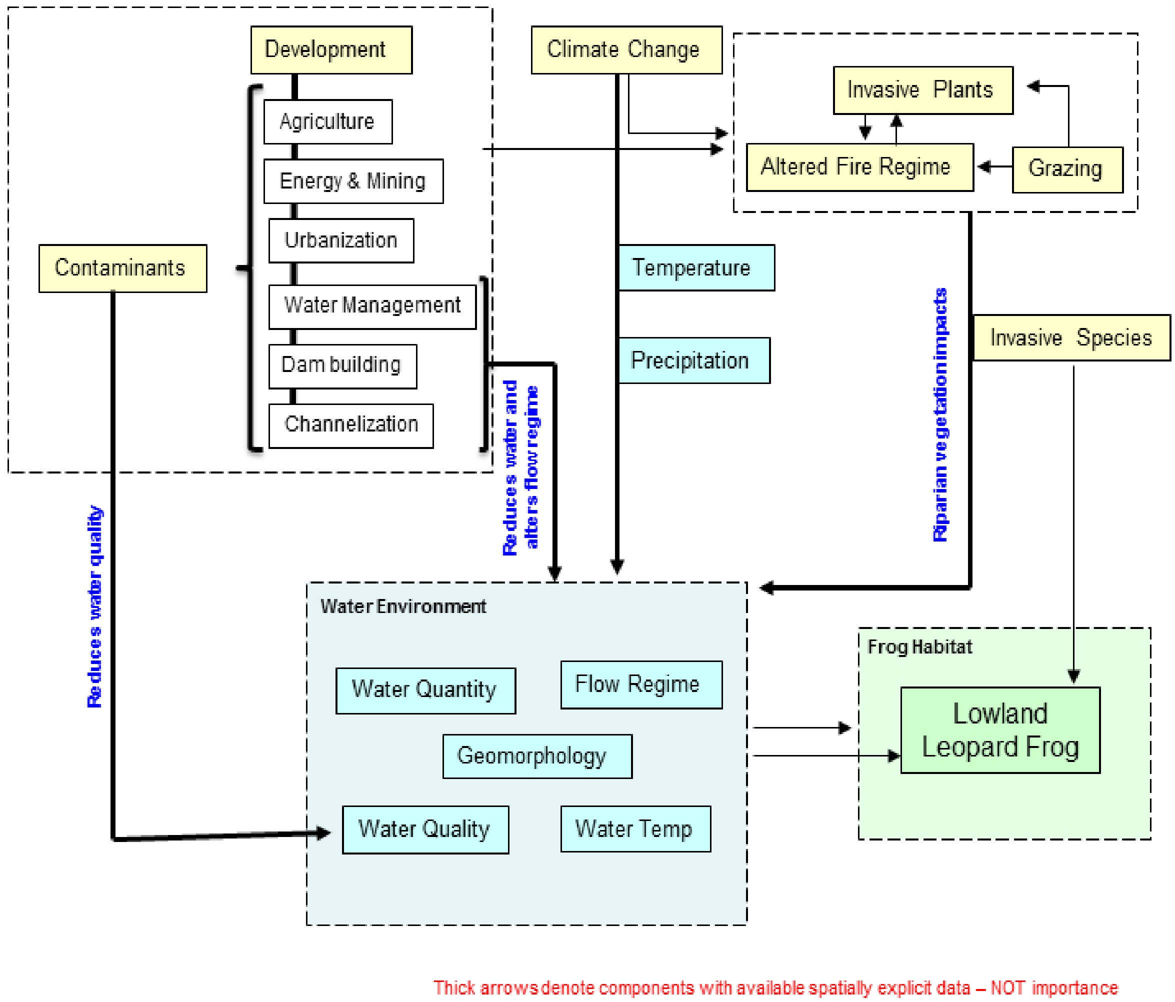
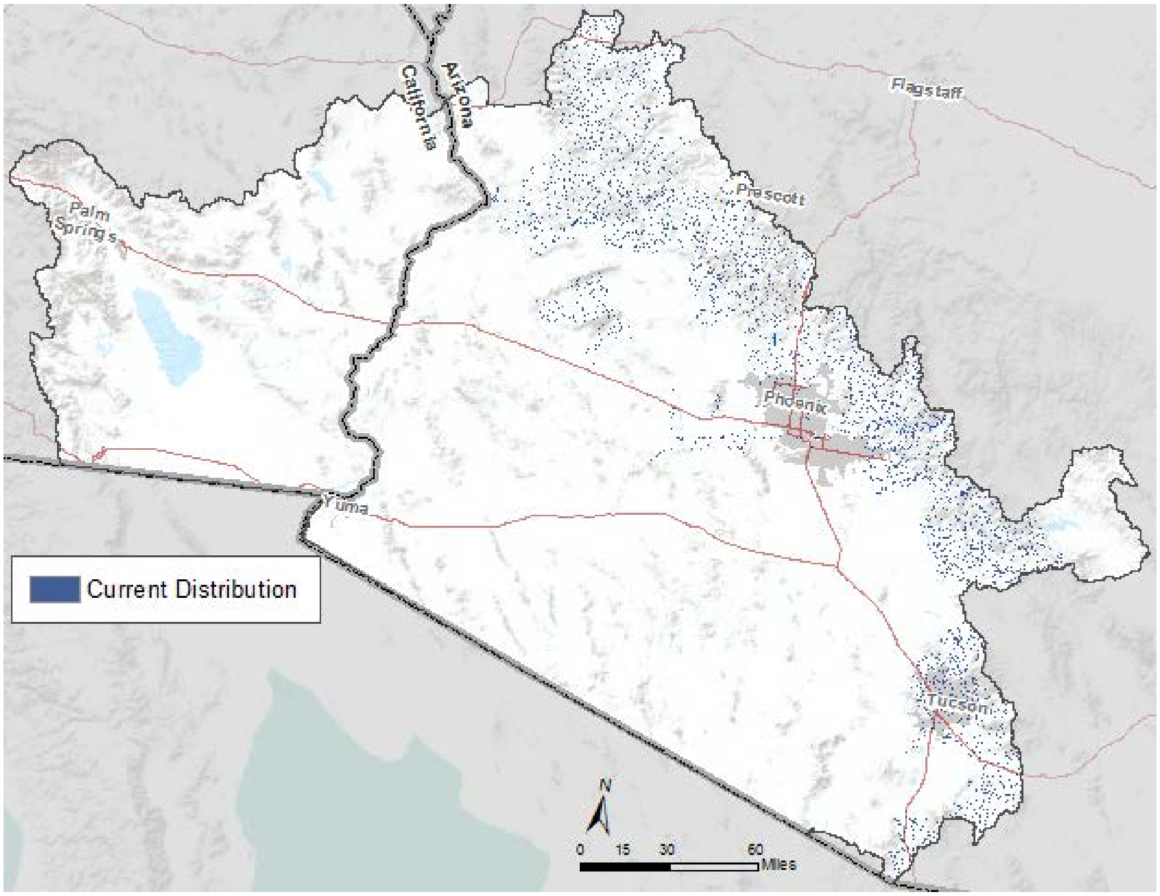
Center for Biological Diversity and Southern Utah Wilderness Alliance http://www.biologicaldiversity.org/species/amphibians/relict_leopard_frog/pdfs/petition.pdf.

Jennings, M.R., and M.P. Hayes. 1994. Decline of native ranid frogs in the desert southwest. Pages 183–211 *in* P.R. Brown and J.W. Wright (eds.), Herpetology of the North American deserts. Southwestern Herpetologists' Society, Special Publication No. 5.

Lowland Leopard Frog Conceptual Model

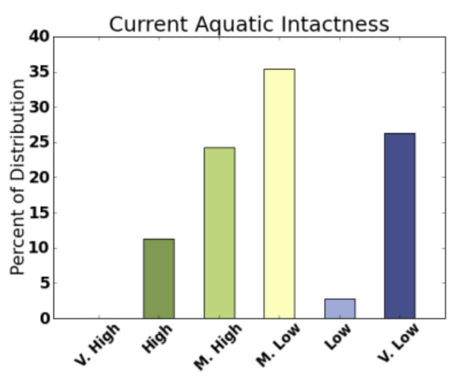


MQ D1. What's the current distribution and status of lowland leopard frog (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?



Data Sources:

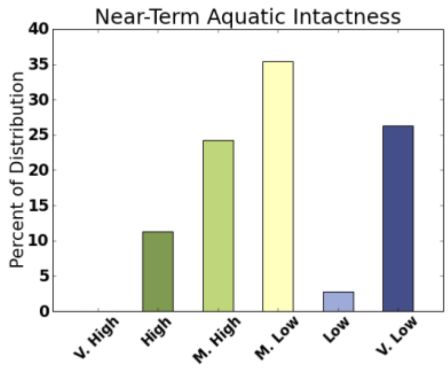
SW ReGAP clipped to watersheds containing post-1980 element occurrence data from Arizona Natural Heritage Program

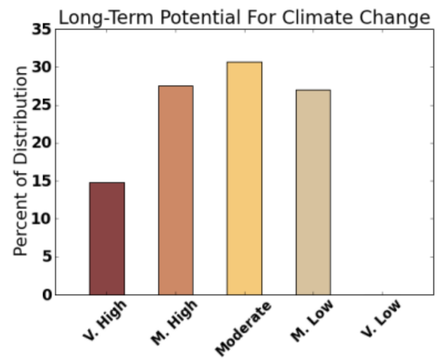


Lowland Leopard Frog Status

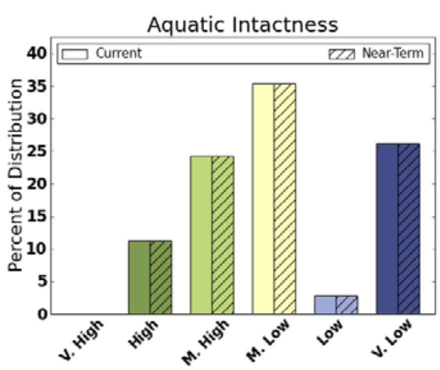
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Lowland Leopard Frog Potential for Change



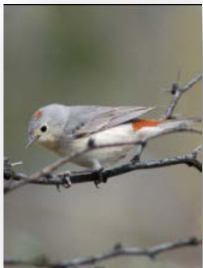


Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Lucy's Warbler (*Oreothlypis luciae*)



The sustainability of Lucy's warbler populations is directly linked to the availability of functioning riparian woodland. The warbler is considered a species of special concern in California, where it was once considered common early in the 20th century (Garrett 2008). In the Sonoran Desert ecoregion in California, Lucy's warbler is confined to the west bank and tributary washes of the lower Colorado River in addition to a remnant population in Anza-Borrego State Park (Garrett 2008). Although most of the honey mesquite (*Prosopis glandulosa*) bosques along the Colorado River were cleared during the 1990s, pockets of remaining habitat may be found near Fort Mojave and between Blythe, California and Yuma, Arizona (National Audubon Society 2011). Lucy's warbler is somewhat more common in riparian areas of southern Arizona. Breeding Bird Survey (BBS) trend estimate data for the Sonoran Desert-Mojave Desert combined ecoregion shows a 1.3 % per year increase for the period 1966–2009 and a 2.7% per year increase for the period 1999–2009 (n=detections on 32 BBS routes, Sauer et al. 2011). However, these trend results carry the caveat of small sample size of a species occurring in a habitat not well-represented in the BBS (Sauer et al. 2011).

Lucy's warbler is an insect gleaner that is dependent for foraging on a diverse riparian structure with both a tree canopy and shrubby understory. In optimal riparian habitat in southwestern New Mexico, breeding territory densities of Lucy's warbler have been estimated as high as 1.7 to 3.3 territories per ha (Stoleson et al. 2000). The species is a cavity nester that requires trees of adequate diameter for nesting (McCreedy 2011). It will also use hollow limbs, loose bark, crevices in cliffs or stream banks, abandoned cliff swallow nests, or suspended flood debris (Corman 2005). Although brown-headed cowbirds will parasitize Lucy's warbler nests, the impacts are not as great as they are for Bell's vireo, perhaps because cavity nesting offers a deterrent to cowbird egg laying (Corman 2005, Garrett 2008). The species' preferred habitats vary regionally: in California and along the lower Colorado River, Lucy's warbler frequents mesquite (*Prosopis* spp.) bosques; elsewhere in Arizona and southwestern New Mexico, it may nest in cottonwood-willow (*Populus fremontii-Salix gooddingii*) or sycamore-ash (*Platanus-Faxinus* spp.) associations (Stoleson et al. 2000, Garrett 2008, CalPIF 2009). Where mesquite bosques have been degraded or eliminated along the lower Colorado River, Lucy's warbler nests have been found in drier tributary washes in blue palo verde (*Parkinsonia floridium*), foothills palo verde (*Parkinsonia microphylla*) and ironwood (*Olneya tesota*) trees (average diameter at ground level 55.6 cm [22 in], McCreedy 2011). Lucy's warbler has also adapted to nesting in tamarisk (*Tamarix* spp.), and the species has increased in abundance in the tamarisk thickets of the Grand Canyon (Yard et al. 2004). Yard et al. (2004) found that a non-native leafhopper (*Opsius stactagolus,* occurring only on tamarisk) composed 49% of the warbler's diet at these Grand Canyon sites. The adaptability of Lucy's warbler to exploit alternative nesting trees and food resources suggests that the species will respond readily to restoration management in riparian areas across the ecoregion.

The loss of riparian and desert wash habitats is a major threat to Lucy's warbler populations. Lucy's warbler is not found in urban, suburban, or agricultural areas (Rosenberg at al. 1987, Corman 2005, Garrett 2008). Agricultural and urban development has eliminated Lucy's warbler from its historic nesting habitats in the Imperial and Coachella valleys in California (Garrett 2008). McCreedy (2011) noted that the depletion of xeric woodland (e.g., mesquite and palo verde) to just 7% of wash corridor surface area at study sites in western Arizona represented an ecological bottleneck for woodland nesting species. Riparian habitats are continually reduced by cumulative disturbances such as direct habitat destruction through clearing, flood control projects, damming, channelization, agricultural conversion, grazing, invasion of exotic annuals, OHV activity, urbanization, groundwater pumping, and more recently in the Sonoran Desert, fire. Flow regulation, groundwater pumping, and concurrent salt buildup threaten areas with existing native riparian and xeroriparian vegetation. Depth to groundwater is a limiting factor that affects the distribution of native plant species within the riparian zone (Lite and Stromberg 2005, Shafroth et al. 2010). Cottonwood trees lose their vigor if groundwater levels fall below 3 m (10 ft.), and even deep-rooted mesquite will decline if groundwater levels drop to 12 m (40 ft.). Groundwater withdrawals for human use put native species at risk and promote the spread of invasives such as tamarisk and invasive annual grasses (Stromberg et al. 2007, Garrett 2008).

Fire is increasing in frequency in riparian areas of the southwestern U.S. for a number of reasons: a lack of flood flows in regulated river systems with a subsequent buildup of litter and woody debris, increased human ignitions, an increase in fire-adapted invasive species, combined with typical or climate-change-induced drought cycles (Ellis 2001). In a study of the lower Colorado River, Busch (1995) found that wildfire could be expected to burn over 20% of the riparian vegetation along the lower Colorado River each decade. Xeroriparian species growing in desert washes are not fire-adapted and they re-populate very slowly following fire (Esque and Schwalbe 2002). McCreedy (2011) identified fire as the greatest threat to the persistence of riparian and xeroriparian species and recommended protection of native mesquite and palo verde woodlands to reduce annual invasives and minimize fire danger.

The adaptability of Lucy's warbler to various nest substrates and alternate food sources suggests that the species will respond readily to restoration efforts. Management in riparian areas and desert washes that provides for mature native trees and understory shrubs will benefit the warbler and other riparian and xeroriparian woodland species. Opportunities exist on public lands in the lower Colorado River valley to enhance existing mesquite bosques and restore lost riparian cottonwood and willow in areas of adequate available groundwater (McCreedy 2011, National Audubon Society 2011). Both grazing and OHV use interfere with tree and shrub regeneration and also promote the invasion of invasive species. Management actions such as the removal of feral burros, limiting grazing or removing livestock, and re-routing OHV trails away from desert washes can reverse the trend of woodland decline (Garrett 2008, McCreedy 2011). For example, the removal of cattle from the San Pedro National Conservation Area (NCA) in Arizona resulted in a rapid recovery of riparian and associated mesquite and with it the return of several bird species of concern. Four years after cattle were removed from the NCA, understory vegetation recovered and Lucy's warbler abundance increased from 13.8–20.81 detections/km (Kreuper et al. 2003). Other bird species responded as well: insectivores, granivores and omnivores all increased significantly, with insectivores showing the strongest response. For restoration efforts that require vegetation clearing to reduce the presence of invasives, Yard et al. (2004) warned that managers should consider the availability of alternate habitats for species such as Lucy's warbler that use tamarisk for nesting before proceeding with broad-scale tamarisk clearing projects.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	Loss & degradation of riparian mesquite habitat	extensive development			no development	Otahal, C.D., 2006, Johnson et al., 1997
interspecific interactions	brood parasitism	prevalent			not present	Otahal, C.D., 2006; Johnson et al., 1997
habitat	Overgrazing of mesquite scrub	present			not present	Otahal, C.D., 2006; Johnson et al., 1997

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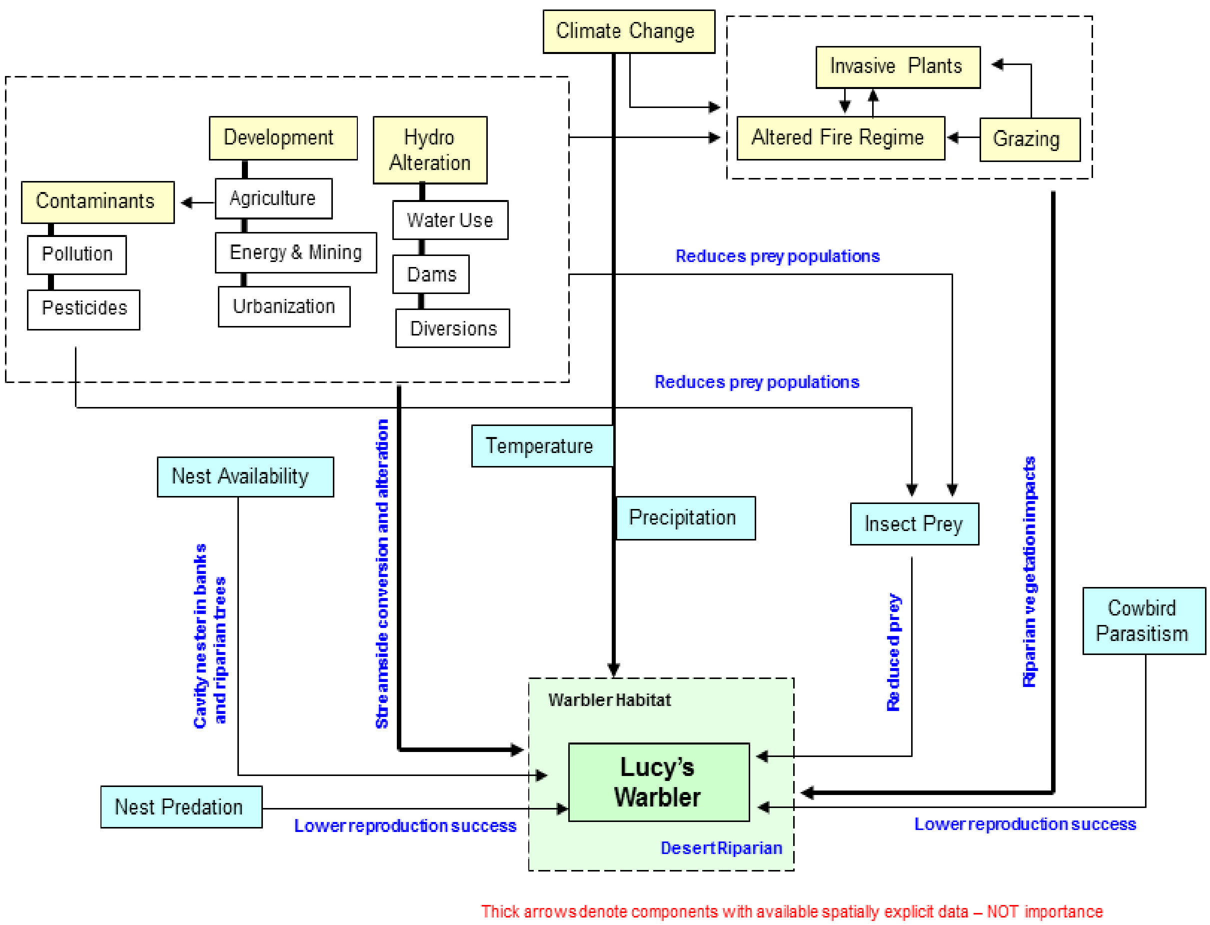
Lucy's Warbler Conceptual Model



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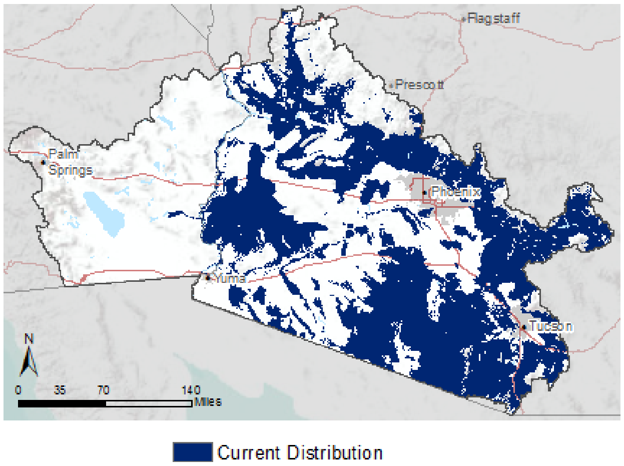
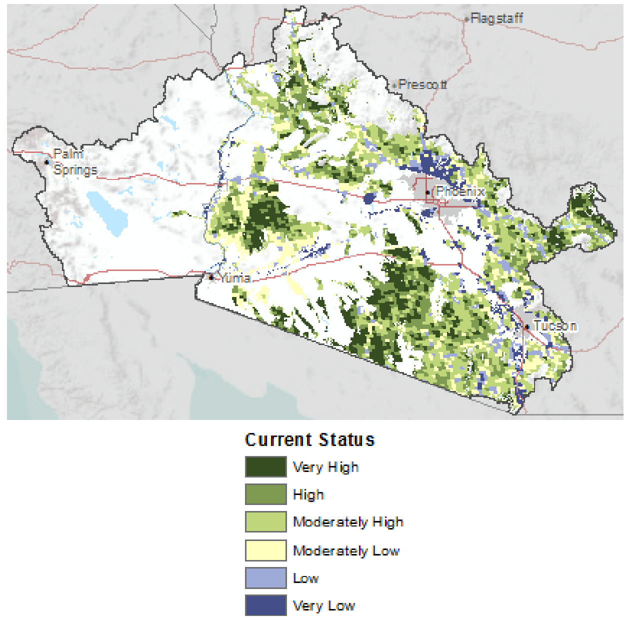
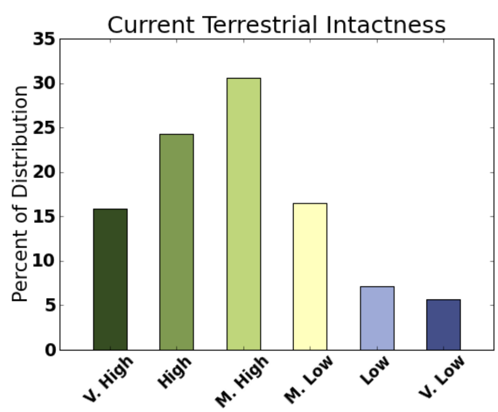




Data Sources:
Arizona GAP and California Wildlife Habitat Relations



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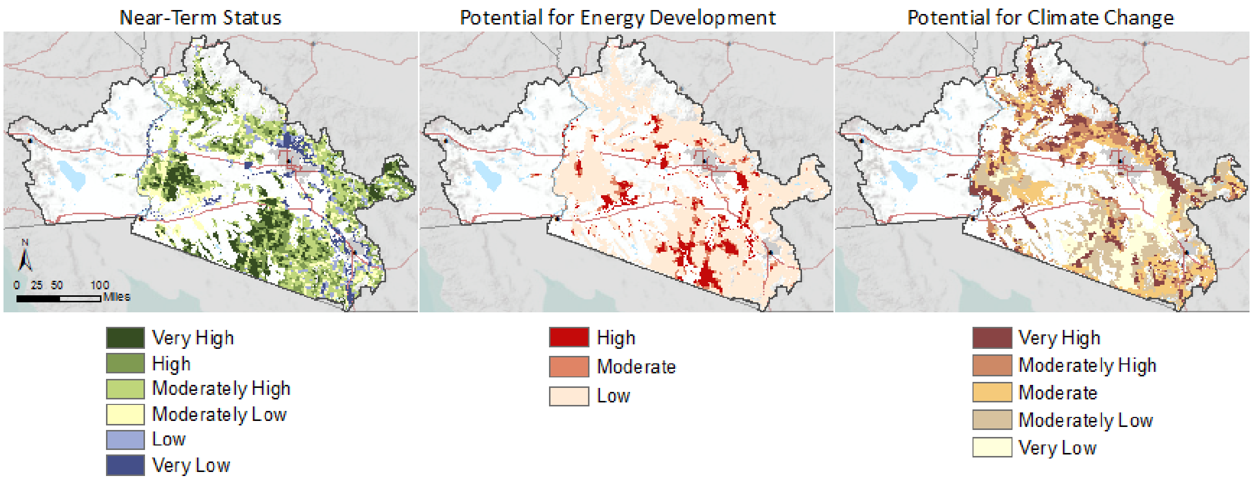
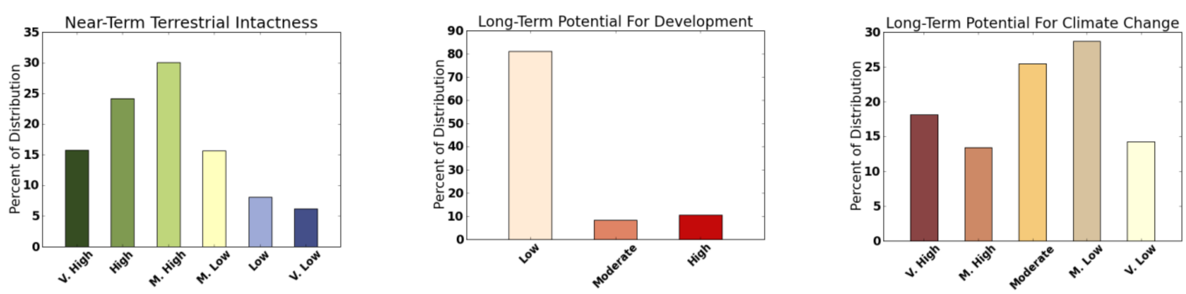
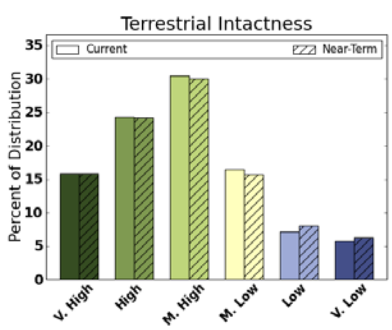
Lucy's Warbler Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mountain Lion – *Puma concolor*

Mountain lions are habitat generalists and have adapted to a wide range of environmental conditions (Weaver et al. 1996). The three main components defining high quality mountain lion habitat is abundance of prey species (e.g., mule deer, elk, and bighorn sheep), steep, rugged terrain, and vegetative cover to allow for the successful stalking of prey (Hornocker 1970, Koehler and Hornocker 1991). Mountain lions can inhabit all elevations but prefer open mixed hardwood and coniferous forest vegetation zones below timberline. Terrain ruggedness is a better predictor than vegetation cover in some landscapes such as the Sonoran Desert, and the species is fairly widespread throughout the ecoregion. However, availability of abundant prey (especially in winter) is the most important factor in supporting a strong lion population. Mountain lions are solitary predators, highly territorial, and display a wide variability in home range sizes (males 25->500 sq mi and females 8->400 sq mi). Territory size, which often shifts seasonally, is determined by a number of ecological and allometric factors including abundance of prey – higher prey densities often result in smaller home ranges (Grigione et al. 2002). Hemker et al. (1984) reported some of the largest known home range sizes for mountain lions in southern Utah with males occupying up to 513 sq mi and females up to 426 sq mi. A typical mountain lion population consists of resident males and females in occupied territories, transient males and females moving across the landscape looking to establish their own territories, and dependent kittens of resident females (Lynch 1989).

At the ecoregion level, mountain lions require fairly large home ranges with ample food and cover (provided by vegetation cover and/or rugged terrain). They also require the ability to disperse widely in search of prey and new territories as this is important component of their life history. Mountain lions can tolerate significant human disturbance (Weaver et al. 1996); however, they do avoid developed and semi-developed areas unless dispersing to new territories, which is normally conducted at night when under more stressful circumstances (Beier 1995). The most important threat to mountain lions in the ecoregion is overall habitat degradation due to residential development, recreational development, and road building. For example, Van Dyke et al. (1986) reported road densities > 0.6 km/sq km as poor for mountain lion due to avoidance behavior and direct mortality through increased conflict with humans.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
prey	ungulate density	low	medium	high	very high	Julander and Jeffrey (1964)
habitat degradation	road density	.6 km/sq km	0.4	0.2	0	Van Dyke et al. (1986)
habitat	cover & terrain	very dense or open cover	-	-	rugged terrain with mixed cover	Riley (1998)
habitat degradation	human development	Highly developed	moderate developed	low developed	no development	Van Dyke et al. (1986)

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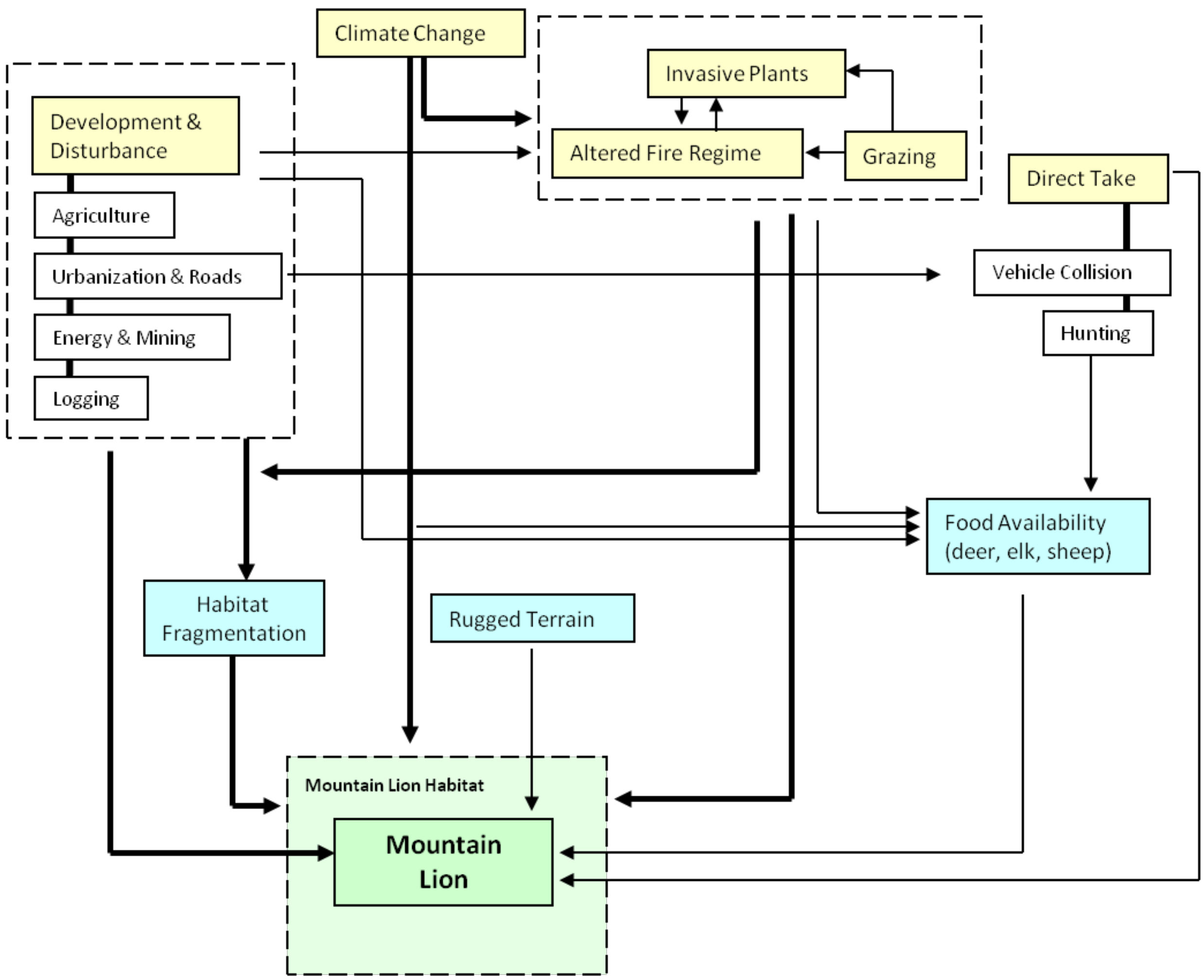
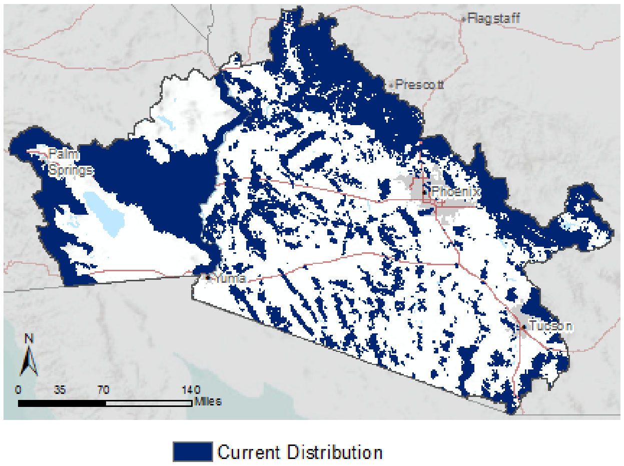
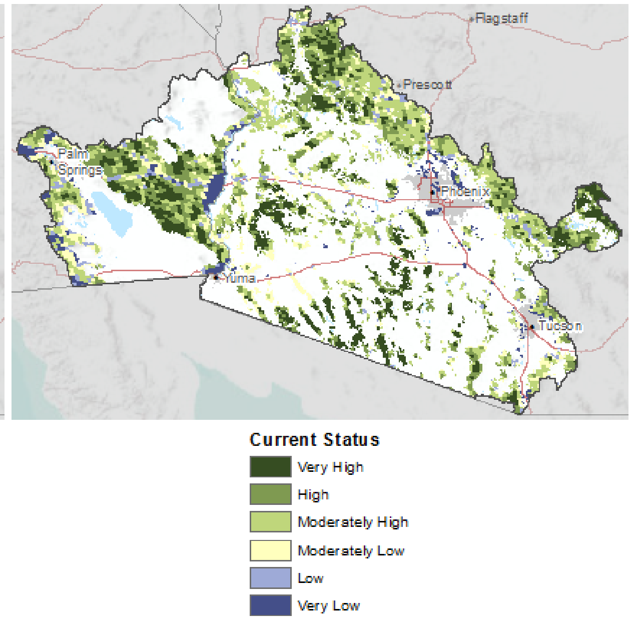
Mountain Lion Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

MQ D1. What's the current distribution and status of mountain lion (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





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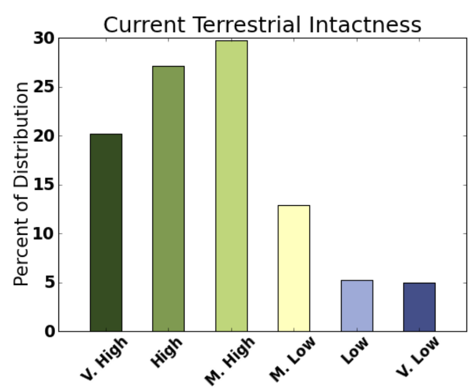
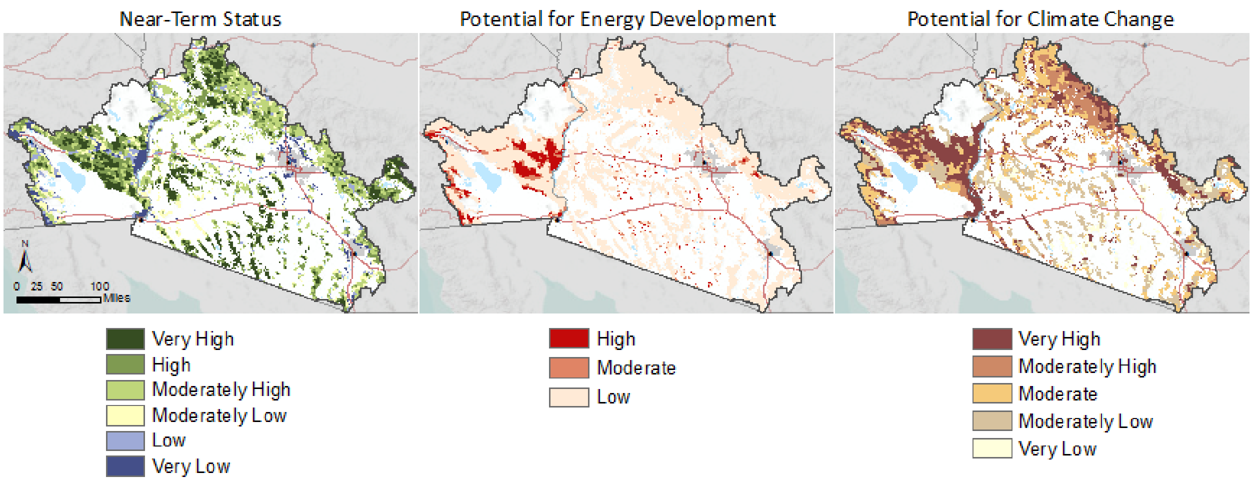
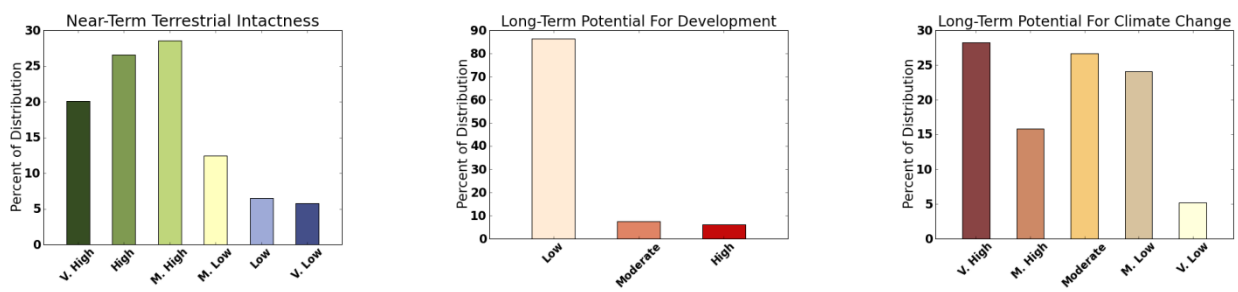
Arizona GAP and California GAP



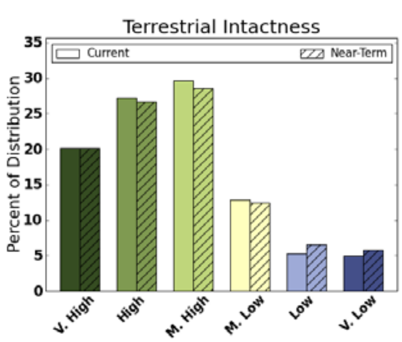
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mountain Lion Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mule Deer – *Odocoileus hemionus*

Mule deer have the ability to occupy a diverse set of habitats but are most commonly associated with sagebrush communities (Mule Deer Working Group 2003; Theodore Roosevelt Conservation Partnership 2011). Shrub communities are important to mule deer for food and shelter, and the connection of such seasonal habitats is critical to the survival of mule deer populations (Theodore Roosevelt Conservation Partnership 2011). Like most deer, mule deer are browsers and rely on a diverse range of plants for their nutrition. In late spring to early fall, mule deer eat mostly forbs and grasses, while in late fall they eat the leaves and stems of brush species, and in winter to early spring they must survive on just twigs and branches (Theodore Roosevelt Conservation Partnership 2011). So, while mule deer forage on a wide variety of plant species, they also have very specific seasonal foraging requirements, and variety and high nutritional content across seasons is imperative to the survival of populations (Watkins et al. 2007). Ideally, mule deer consume around 3 quarts of water per day for every 100 lbs of body weight (Wallmo 1978 and Wallmo 1981). Mountain lions are the top predators in the ecoregion.

Despite their adaptability, mule deer populations have been decreasing in numbers since the latter third of the 20th century. In Utah, the 2007 post-hunting season population was estimated to be 302,000 deer well below the long-term management objective of 426,000 individuals (Utah Division of Wildlife Resources, Statewide Management Plan for Mule Deer 2008). There are a myriad of stressors on mule deer, but the most significant threats involve how their habitat is changing and disappearing (Theodore Roosevelt Conservation Partnership 2011). The vegetative species composition has been modified extensively with the invasion of non-native plants such as cheatgrass (Watkins et al. 2007). Cheatgrass out-competes most native plant species in a moisture-limited environment and changes the site-specific fire ecology, resulting in a loss of important shrub communities (Watkins et al. 2007). Plant species composition has also changed due to excessive livestock foraging, successional changes caused by fire suppression, and the disturbance and conversion of habitat (Watkins *et* al. 2007). In addition to the change in plant species composition, active fire suppression has changed the vegetation structure to result in the accumulation of unnaturally high fuel loads that can lead to massive fires (Watkins et al. 2007; Mule Deer Working Group 2011). Other factors that contribute to the decline of mule deer populations include habitat fragmentation due to gas, mineral, and oil exploration and increased competition with elk when habitat is poor or limited (Mule Deer Working Group 2011). Numerous diseases impact mule deer but two viral hemorrhagic diseases - epizootic hemorrhagic disease (EHD) and bluetongue (BTV) - are recognized as the most devastating. In recent years, chronic wasting disease and tuberculosis are emerging (Mule Deer Working Group 2003).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat degradation	distance from oil wells	<2.7 km	-	-	>3.7 km	Sawyer et al. (2006)
habitat degradation	distance from roads	>200m	-	-	>500 m	
habitat	loss, fragmentation, drought, fire, low quality					http://www.ndow.org/wild/animals/facts/mule_deer.shtm
habitat	vegetation/food preference as associated with fire suppression	Large, hot fires			small, cool, frequent fires (early successional plants)	Mule Deer Working Group - Western Assoc. of Fish & Wildlife agencies, 2003
habitat	variety of vegetation	homgenous			mosaic of early successional habitat (food) & tree-dominated habitats (cover)	Mule Deer Working Group - Western Assoc. of Fish & Wildlife agencies, 2003

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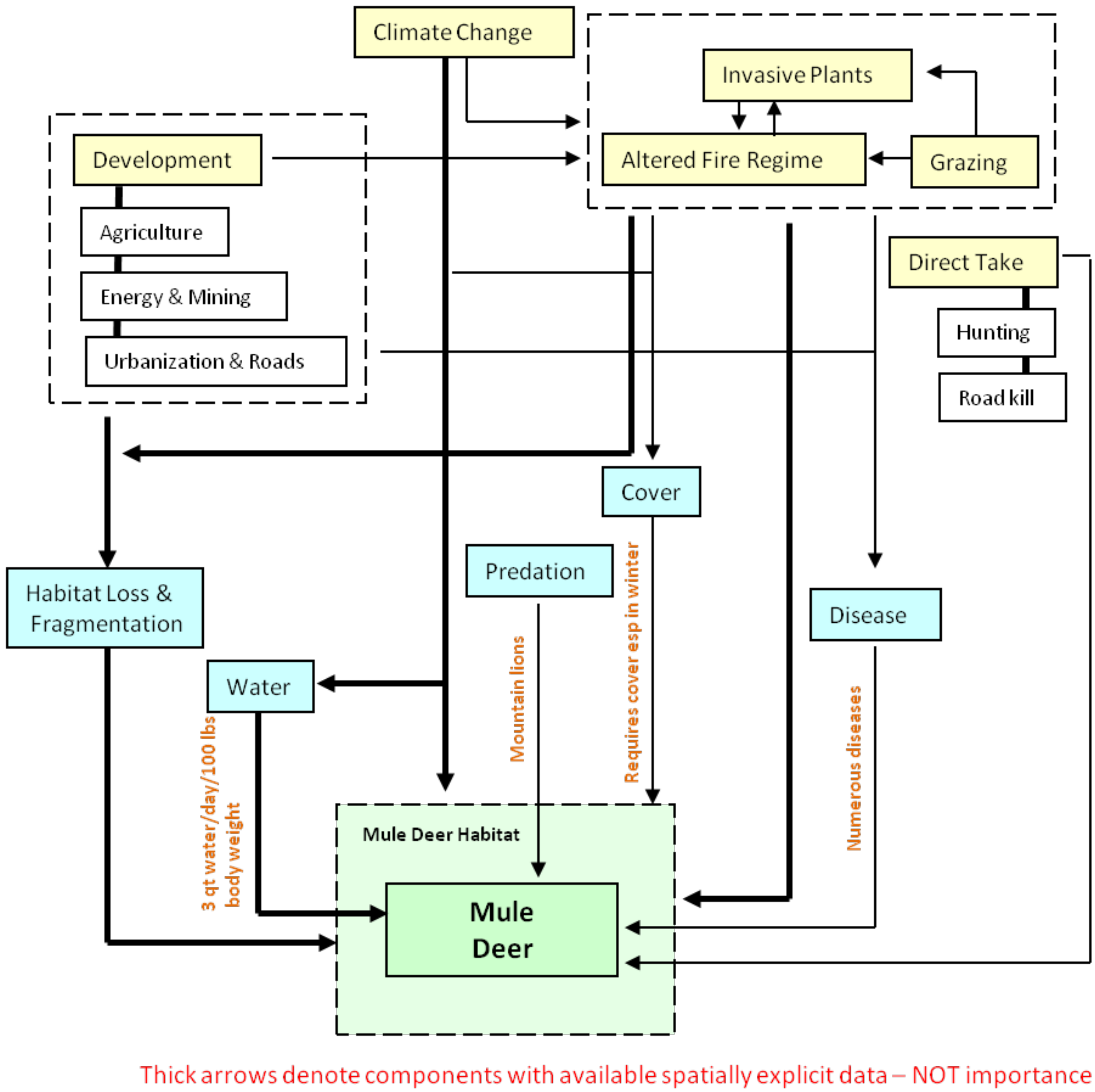
Mule Deer Conceptual Model



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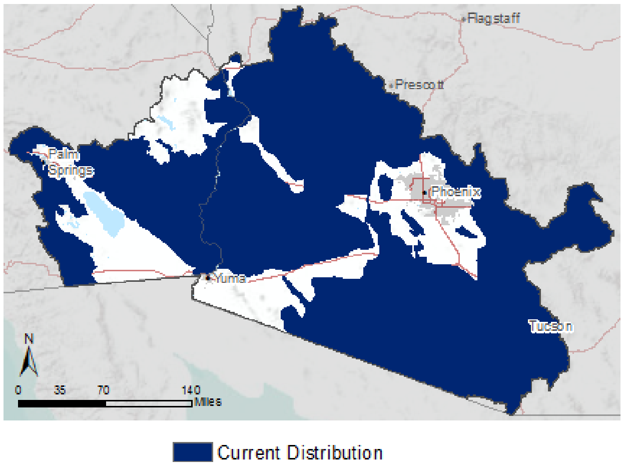
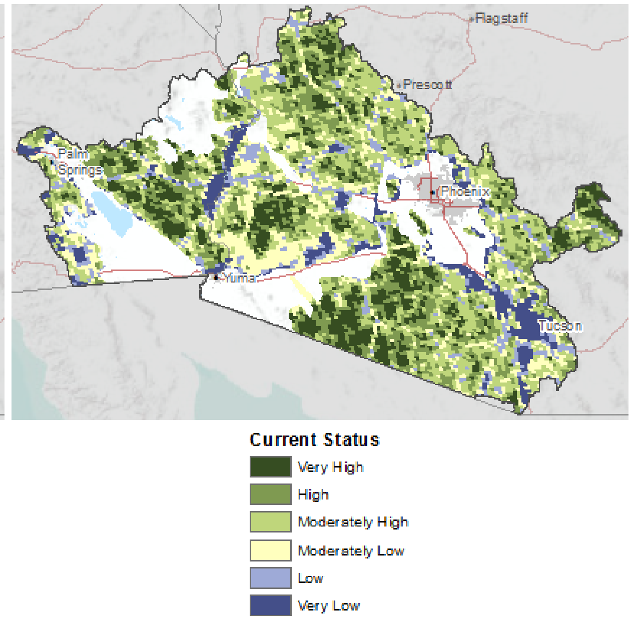
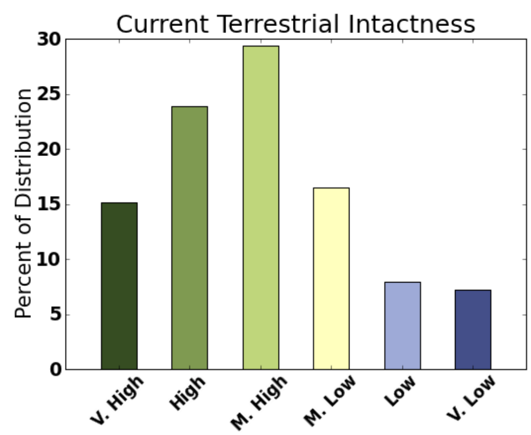




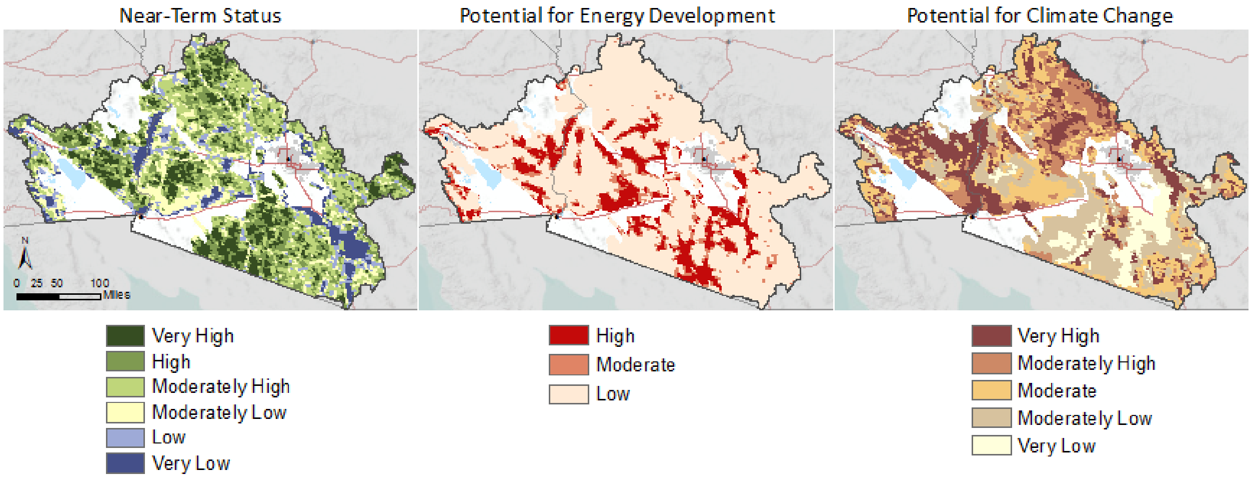
Data Sources:

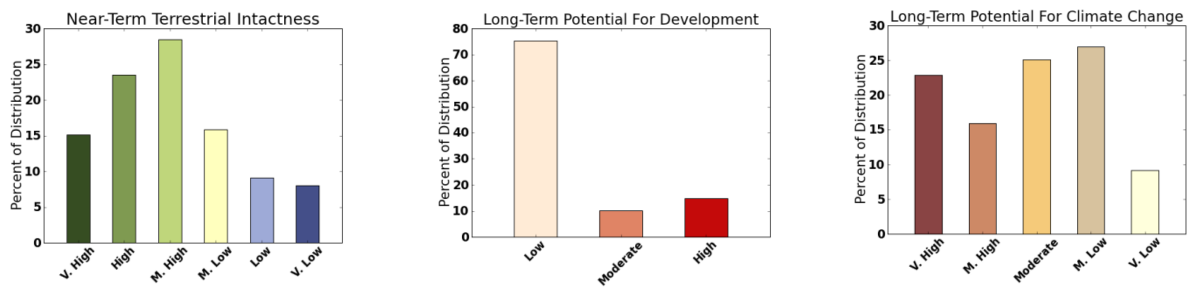
Arizona Game and Fish Department, California Wildlife Habitat
Relations, Mule Deer Habitat of North America



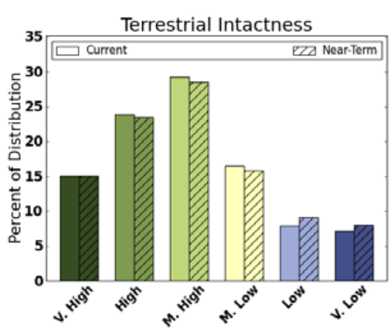
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mule Deer Potential for Change





Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

The southwestern willow flycatcher was state listed as endangered by California in 1990 and the subspecies *extimus* was federally listed as endangered in 1995 (USFWS 2002). Range-wide, flycatcher experts estimate the species overall population at 1300 to 2000 individuals (McCarthey 2005, Sogge et al. 2005). Once common in riparian willow thickets, the flycatcher is now found in the California Sonoran Desert only along San Felipe Creek on the far western edge of the ecoregion; it is also recorded as a probable breeder at several sites on the west bank of the lower Colorado River. In Arizona, breeding territories for the flycatcher are more often recorded on Colorado River tributaries, rather than along the river's mainstem where suitable habitat is limited. However, mainstem Colorado River riparian habitats are critically important to and more heavily used by migrating flycatchers in the spring and fall (USFWS 2011). The largest concentrations of breeding territories (> 500) occur in Arizona on the Gila and lower San Pedro rivers and along the Salt River and Tonto Creek inflows to Roosevelt Lake (USFWS 2011). The Arizona Game and Fish Department manages another important flycatcher breeding habitat (30 territories) at Alamo Lake State Wildlife Area, La Paz County, Arizona.

Southwestern willow flycatchers are most often found near low gradient streams with broad floodplains and riparian thickets of the proper density. Thickets of tree saplings and shrubs, such as Goodding willow (*Salix gooddingii*), mesquite (*Prosopis* spp.), seepwillow (*Baccharis salicifolia)*, arrowweed (*Tessaria sericea*), tamarisk (*Tamarix* spp.), and blackberry (*Rubus* spp.) may be overtopped by a canopy of mature cottonwood (*Populus fremontii,* USFWS 2002). Most willow flycatchers occur below 1219 m (4000 ft.); a smaller segment of the population nests at higher elevations above 2438 m (8000 ft.) in Geyer willow (*Salix geyeriana,* McCarthey 2005). The southwestern willow flycatcher has adapted to life in the dynamic riparian zone where nesting habitat is in constant flux (USFWS 2011). In a study at Roosevelt Lake, Arizona, Cardinal and Paxton (2005) found that, even when mature native riparian vegetation was available, it was not used by radio-tagged nesting flycatchers, because of its rarity (1% of total). Instead, the birds used mixed mature (a mix of native and non-native vegetation at least 5 years old, 28% of available habitat) for nesting and woodland of all ages for foraging. Canvassers for the Arizona Breeding Bird Atlas found that 54% of 59 atlas records for the flycatcher were recorded in native vegetation or native vegetation mixed with tamarisk and 29% of survey detections originated in tamarisk or tamarisk-dominated riparian growth (McCarthey 2005). Tamarisk has similar structural characteristics to native riparian shrubs and woodland. At Roosevelt Lake, flycatchers choose tamarisk nesting habitat even when native patches are still available (Sogge et al. 2005). Researchers there also observed flycatchers moving into younger riparian growth that filled flood-scoured areas or receding lake margins (Hatten and Paradzick 2003). Although Drost et al. (2001) found a significant difference in diet among flycatchers in native vs. tamarisk habitats, Sogge et al. (2005) could find no differences in physiological condition, nesting success, or survivorship among flycatchers nesting in either vegetation type. Yard et al. (2004) found that tamarisk patches provided an alternative food source, a non-native leafhopper (*Opsius stactagolus*), that occurs only on tamarisk, which is readily utilized by insectivorous birds.

A major threat to the sustainability of southwestern willow flycatcher populations is the management of water resources in the arid southwestern (Marshall and Stoleson 2000, USFWS 2002). During the 20th century, urban and agricultural developments created increasing demands for water use, resulting in the damming and manipulation of most of the region's streams and rivers. Flow alterations below dams, groundwater pumping, and reductions in flooding and the scouring of stream channels all contribute to losses of native riparian vegetation (for more details see flow regime overview in Invasive Species, Tamarisk, Section XX). For example, the flow regime of the lower Colorado River has been so altered that it meets none of the requirements for native plant regeneration: perennial or near-perennial flow, periodic spring floods, sediment delivery, salinity levels < 4g/l NaCl, and shallow depth to groundwater for seedling and sapling survival (Stromberg et al. 1996, Glenn et al. 1998). As a result, the Lower Colorado Management Unit for flycatcher critical habitat, where the species was once common, has just 13% of known southwestern willow flycatcher breeding territories (USFWS 2005) because of the loss of suitable flycatcher habitat.

Loss of connectivity between suitable riparian habitats negatively affects flycatcher recovery. As appropriate habitats become more rare and fragmented, dispersing flycatchers lose opportunities for colonization and recruitment. Although most known populations of southwestern willow flycatchers are concentrated in localized groups of breeding territories, non-nesting, pre-nesting, and post-nesting males use larger territories than nesting birds, and they move between nesting territories and even between drainages (Cardinal and Paxton 2005, USFWS 2011).

Fire is increasing in frequency in riparian areas of the southwestern U.S. for a number of reasons: increased human ignitions, the spread of fire-adapted invasive species, a buildup of litter and woody debris from a lack of flooding, and lowered water tables, in addition to typical or climate-change induced drought cycles (Busch 1995, Busch and Smith 1995, Ellis 2001). Increased fire risk in tamarisk-dominated riparian areas is also one of the greatest threats to willow flycatcher breeding sites (USFWS 2002). Marshall and Stoleson (2000) noted the loss of several southwestern willow flycatcher breeding sites due to fire in the mid- to late-1990s in riparian areas along the San Pedro and Gila rivers in Arizona. Presumably these habitats are lost to nesting flycatchers until suitable riparian vegetation (of at least 5 years of age) has re-established.

Livestock grazing and the incidence of associated brown-headed cowbirds both negatively affect the success of southwestern willow flycatchers. The effects of livestock grazing on riparian areas, both historically and currently, have been well-documented (Marshall and Stoleson [2000] provide a thorough literature review). Over time, a regime of livestock grazing in riparian areas during the late spring and summer can eliminate the regeneration of cottonwood and willow saplings and shift the abundance of plant species from wetland obligate species to more upland species or to invasives such as tamarisk (Ohmart 1996, Dobkin et al. 1998). Removal of livestock from the upper San Pedro River National Conservation Area (managed by BLM) in the late 1980s allowed the regeneration of riparian understory species and resulted in the subsequent confirmation of southwestern willow flycatcher as a breeding species there within a decade of the elimination of grazing (McCarthey et al. 1998).

Brown-headed cowbirds occur in association with grazed systems and row crop agriculture, and their parasitism of southwestern willow flycatcher nests contributes to flycatcher decline and limits flycatcher recovery (Whitfield and Sogge 1999, USFWS 2002, Brodhead et al. 2007). In a study conducted on the Kern River in California, Uyehara et al. (2000) found that cowbird parasitism explained 44% of the variation in flycatcher population growth rates. Cowbirds parasitize flycatcher nests at various rates depending on region of occurrence, surrounding land use, and the configuration of nesting habitat (Whitfield and Sogge 1999, Uyehara et al. 2000). Small, isolated willow flycatcher populations in smaller habitat patches suffer much higher rates of nest parasitism. Whitfield and Sogge (1999), using pooled data from the Kern River in California, the Grand Canyon, and other sites in Arizona, found that the majority of parasitized nests fail and that flycatcher fledging rate in parasitized nests was significantly lower than in un-parasitized nests, 11% vs. 47% respectively. In heavily parasitized areas, cowbird trapping can be an effective means to increase the flycatcher's reproductive success. Uyehara et al. (2000) noted that a restoring a self-sustaining flycatcher population may be possible at their Kern River, California study site if parasitism levels are maintained below 8.4% with the help of continued cowbird control.

The Southwestern Willow Flycatcher Recovery Plan (USFWS 2002), critical habitat designation documents (USFWS 2005, 2011), and Chapter 10 in Finch and Stoleson (2000) all give thorough overviews of management options for restoring flycatcher populations rangewide. In managing for flycatcher habitat, it is of primary importance to manage for or select a stream length with a flow regime and groundwater level that supports riparian woodland and shrubland. Existing riparian habitats can be classified and ranked into potential, suitable, or occupied habitats for willow flycatcher (Finch et al. 2000). Potential habitats lack essential flycatcher habitat elements and may require more restoration cost and effort; suitable unoccupied habitats may only require minimal management effort in the form of recreation or grazing restrictions to eventually attract nesting flycatchers. Because willow flycatcher dispersal is more common within drainages than among drainages (Cardinal and Paxton 2005), management effort directed toward enhancing or restoring new flycatcher habitat may have the best chance for success if it is focused on areas within the dispersal distance of existing nesting populations (about 15 km, USFWS 2002) to increase the chance of colonization or to connect isolated populations. Management options recommend the exclusion of livestock in flycatcher-occupied sites (or in *potential* sites adjacent to or near occupied sites), but dormant season grazing may be allowed if high-quality shrub cover can be maintained (Finch et al. 2000). Since flycatchers use tamarisk for nesting, tamarisk control and clearing should be done on a site-by-site basis after monitoring for southwestern willow flycatcher presence. A more gradual or patch replacement of tamarisk (in patches not exceeding 25% of the total such as might occur with scouring floods), may ensure that sufficient riparian woodland remains available for nesting (Finch et al. 2000). Cowbird trapping may be considered if monitoring reveals that nest parasitism exceeds about 8–10% (Uyehara et al. 2000, Finch et al. 2000).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
habitat	proximity to surface water	>100 m	50-100 m	25-50 m	0-25 m	Sogge and Marshall (2000)
connectivity	distance between occupied sites	>30 km	15-30 km	2-15 km	<2 km	Finch et al. (2002)
habitat degradation	recreation	present in high intensity	present in moderate intensity	present in low intensity	absent	Marshall and Stoleson (2000)

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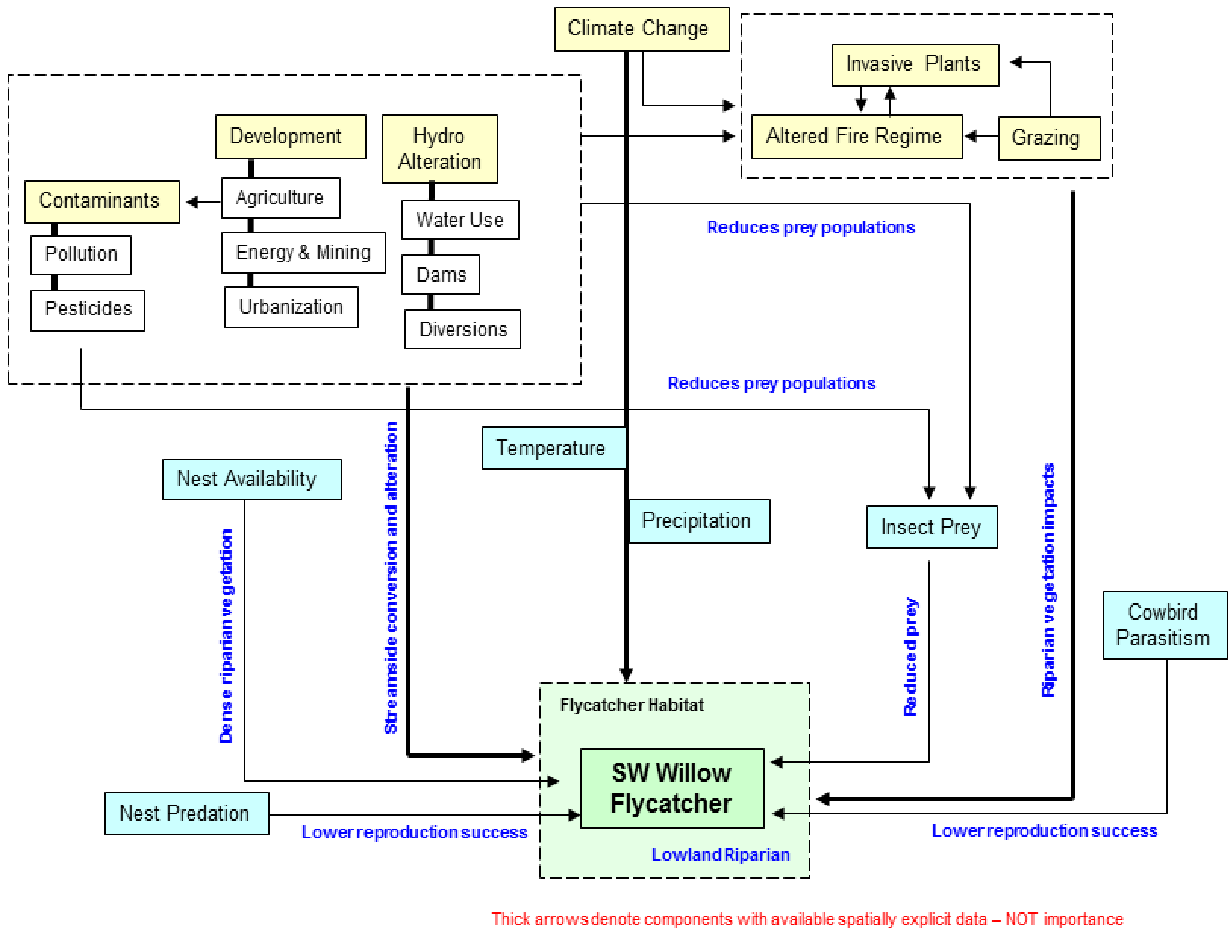
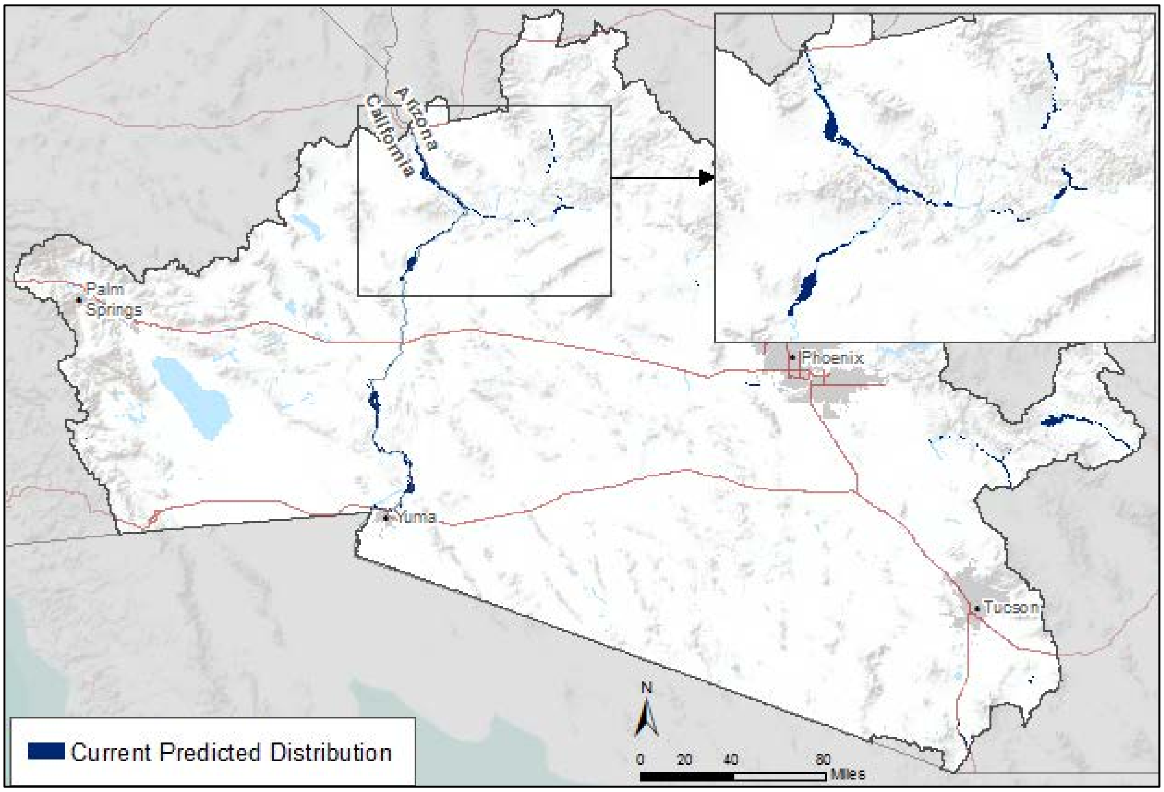
Southwestern Willow Flycatcher Conceptual Model



Access to a data portal to examine the results in greater detail is available at:
https://gbp-blm-egis.hub.arcgis.com.

MQ D1. What's the current distribution and status of southwestern willow flycatcher (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?

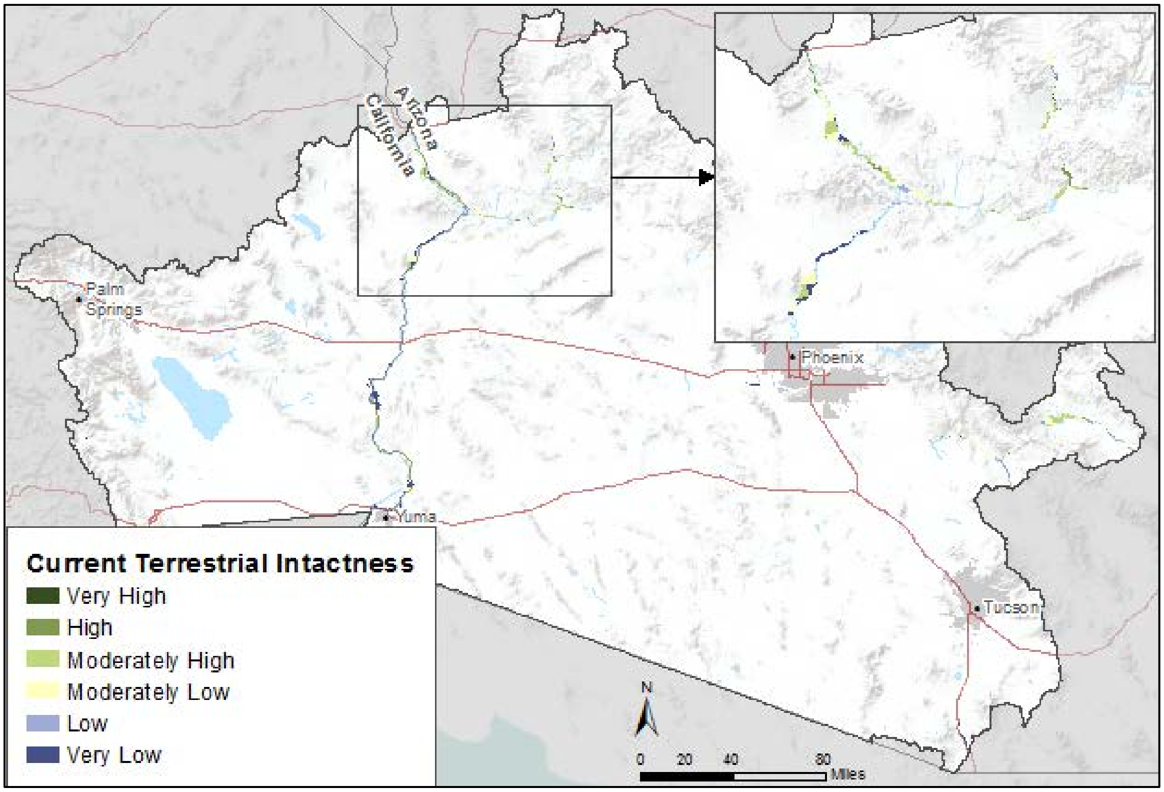
Current Distribution

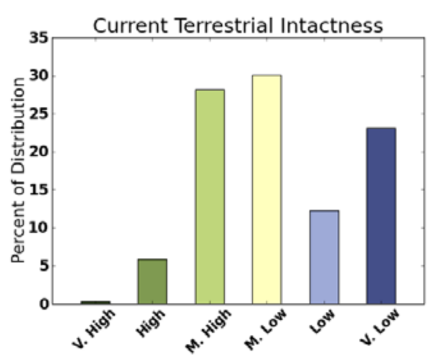


Data Source:

USFWS Critical Habitat

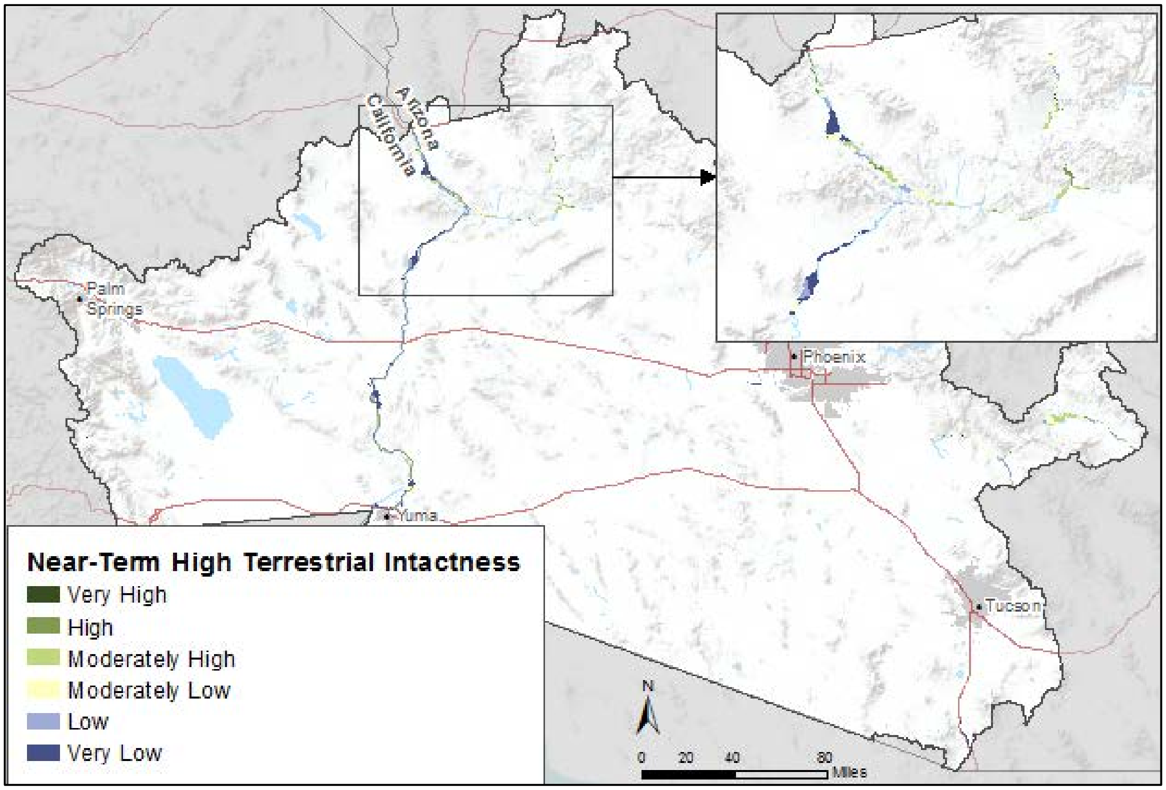
Southwestern Willow Flycatcher Status

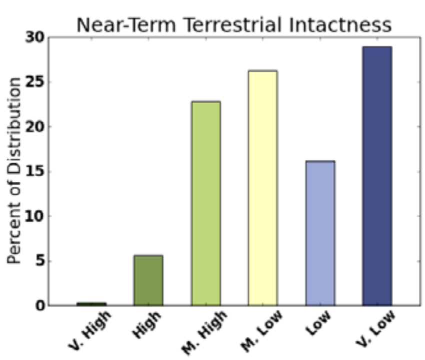


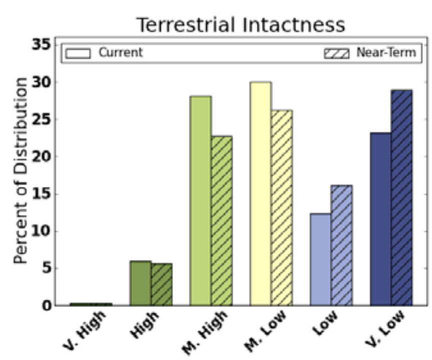


MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

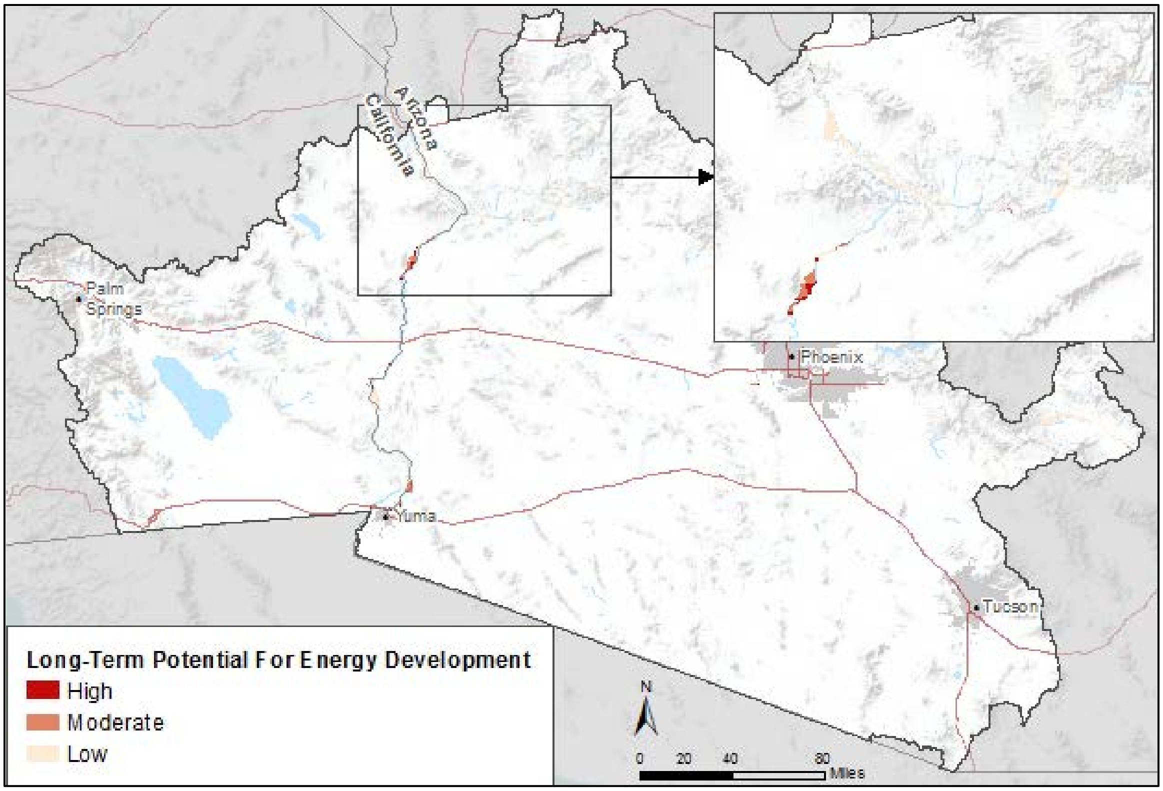
Southwestern Willow Flycatcher Potential for Change: Near-Term (2025) Development

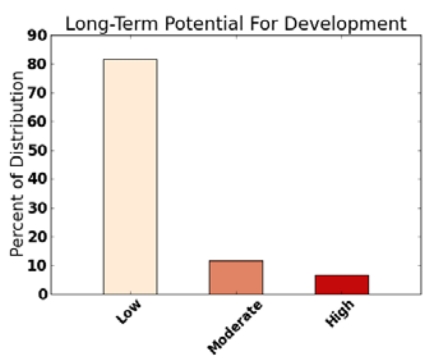




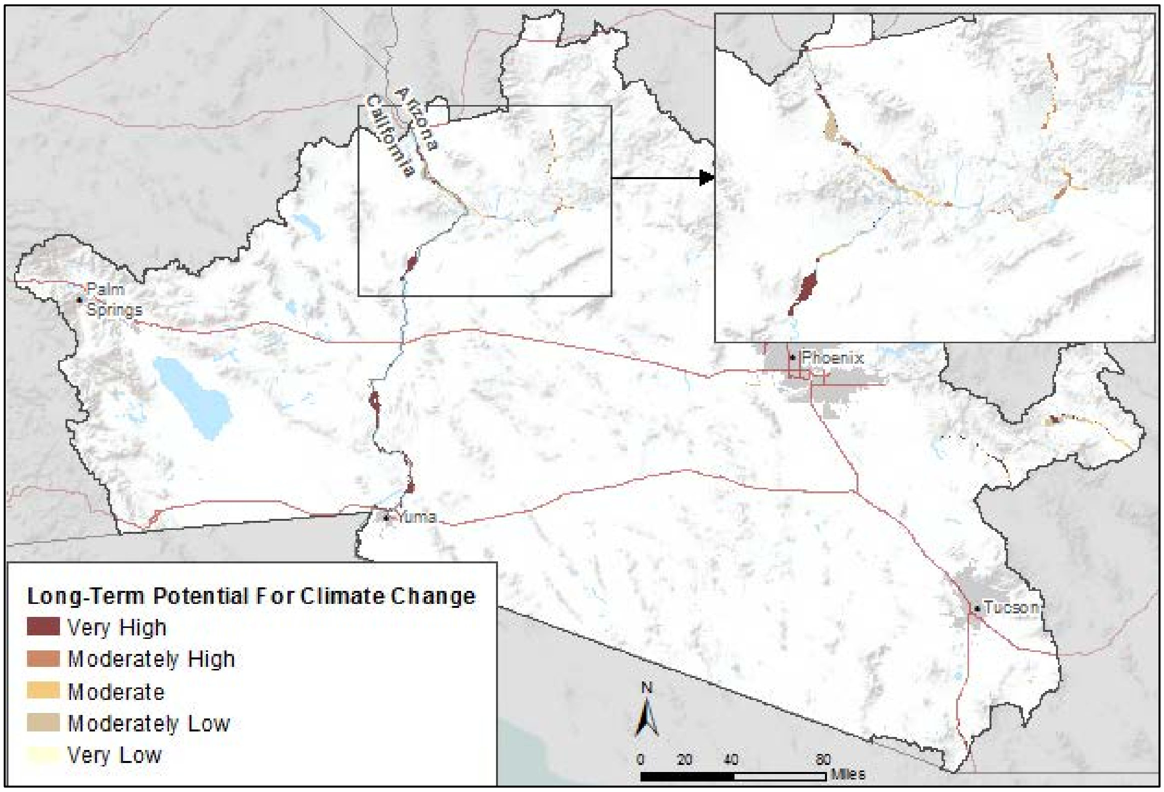


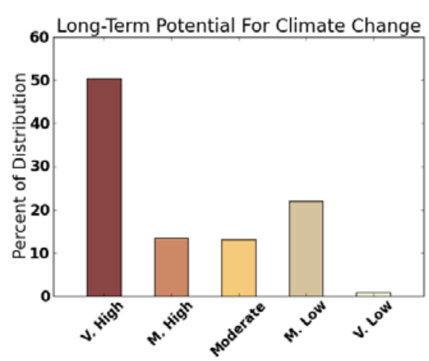
Southwestern Willow Flycatcher Potential for Change: Maximum (Long Term) Energy Development





Southwestern Willow Flycatcher Potential for Change: Potential for Climate Change

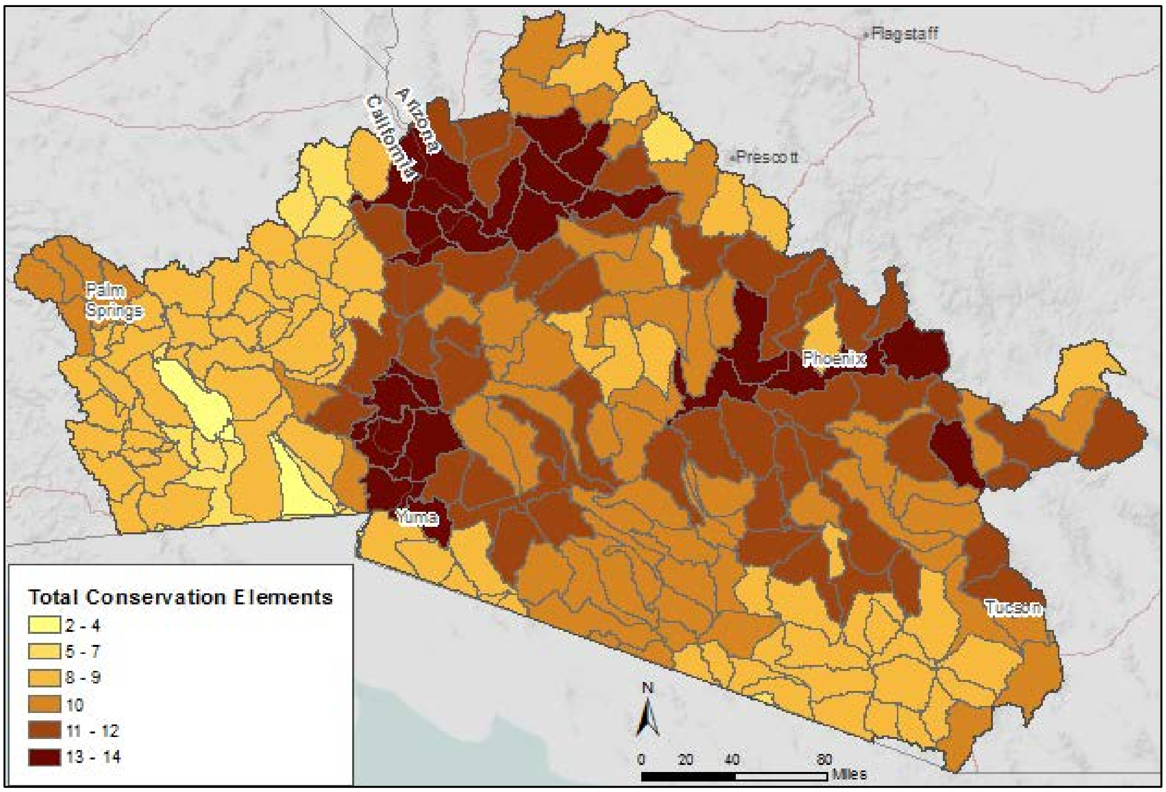




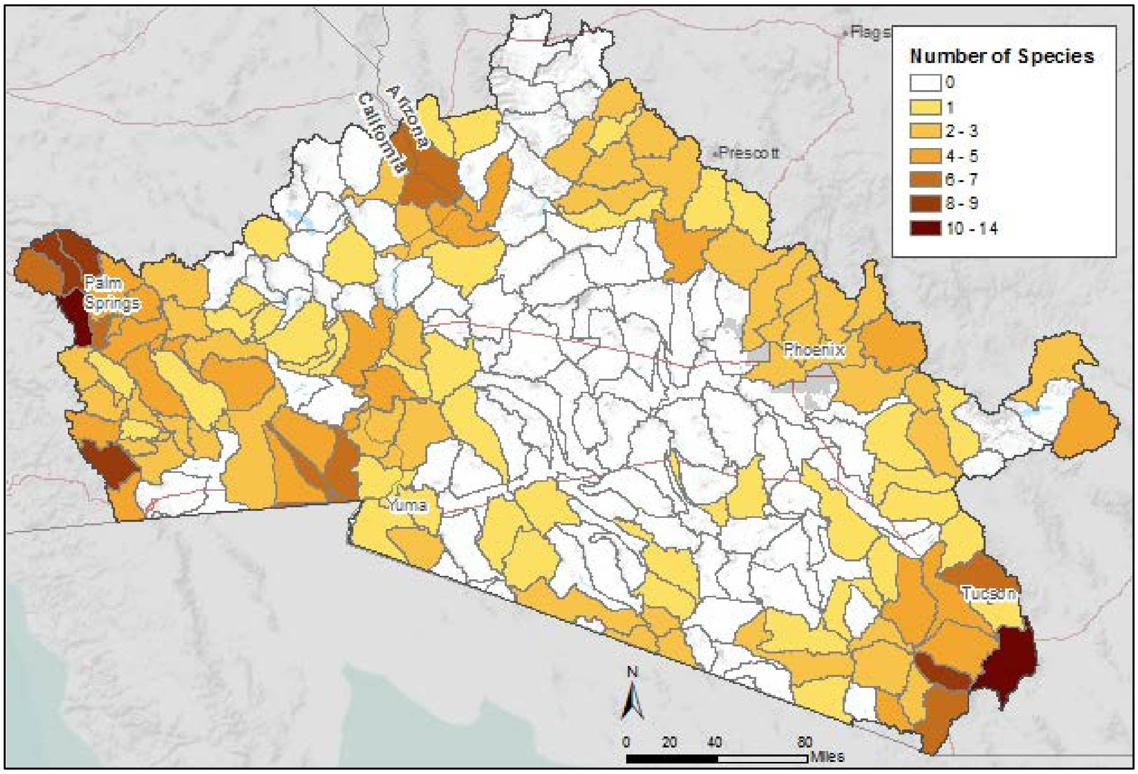
NatureServe Element Occurrence Data

BLM acquired species element occurrence data NatureServe Natural Heritage data enumerated by HUC for the REA. From the data, which was organized by 5th level HUC, four different map-based products were generated, including (1) number of all species, (2) number of globally critically imperiled and imperiled species (G1 and G2 species), (3) number of globally critically imperiled, imperiled, and vulnerable species (G1-G3 species), and (4) number of USFWS listed threatened and endangered species.

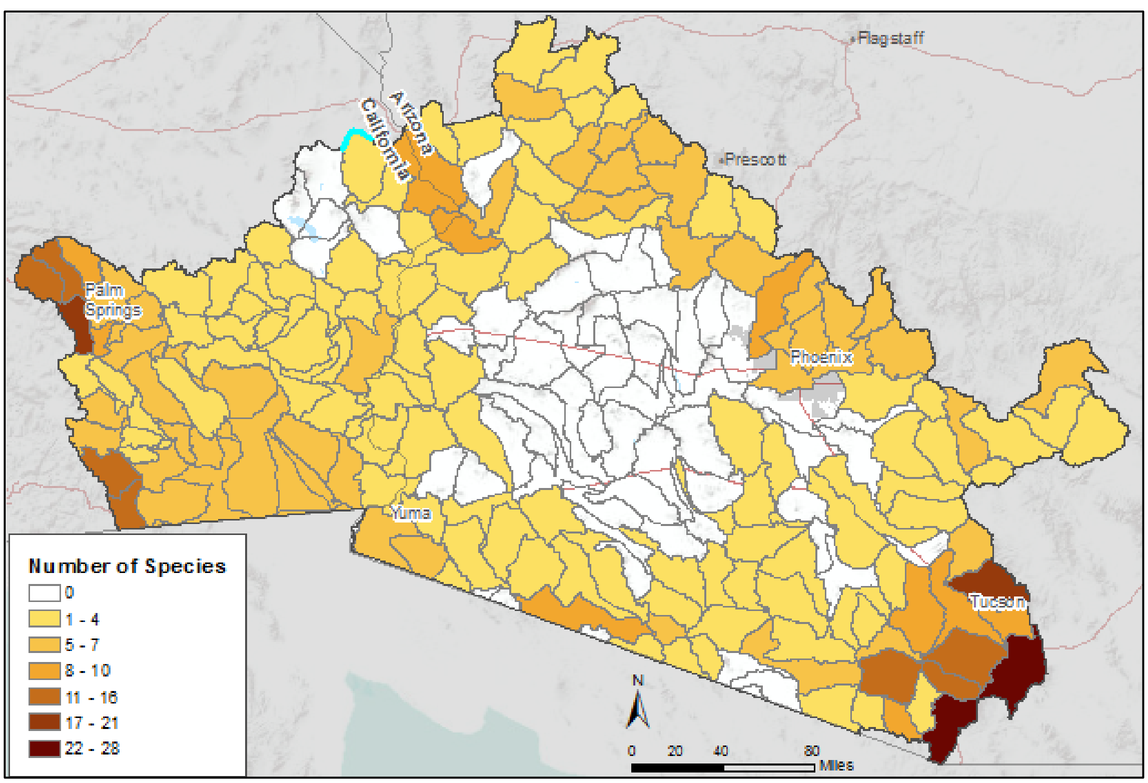
Number of All Species



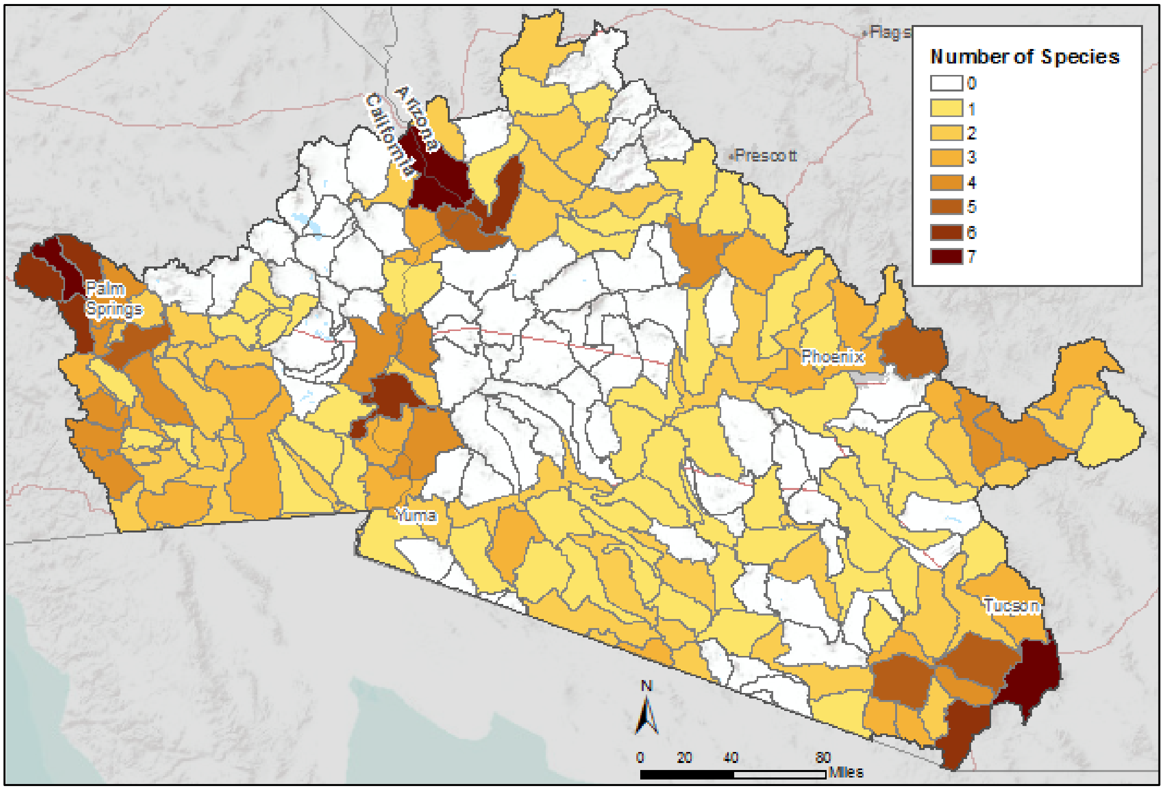
Number of G1 and G2 Species



Number of G1–G3 Species



Number of USFWS Listed Species



Appendix D – Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	References
Bell's Vireo (*Vireo bellii and Vireo bellii pusillus*)						
habitat	riparian vegetation	No shrub cover			Dense shrub understory up to 3 m [10 ft] high; tree overstory either relatively open or absent	Averill-Murray et al. (1999)
habitat degradation	water diversion - distance to water				< 1,000 m [0.6 mi] from water; standing water is an important habitat element	Kus et al. (2010)
parasitism	cowbird abundance	increased parasitism with decreased density of understory vegetation			parasitism decreases with increased density of understory vegetation	Kus et al. (2010)
Desert Bighorn Sheep (*Ovis canadensis nelsoni*)						
Disease	Proximity to domestic livestock				a minimum of 13.5 km between sheep & domestic livestock	Beecham et al. (2007), Singer et al. (2001)
Habitat	Habitat fragmentation	Increased human disturbance			Little to no human disturbance	Beecham et al. (2007), King and Workman (1985)
Climate	effect on vegetation	higher temps - decreased precip			normal to higher levels of rainfall	Beecham et al. (2007)

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	References
Desert tortoise (*Gopherus agassizii*)						
habitat	size	<200 sq mi	200-500 sq mi	500-1,000 sq mi	>1,000 sq mi	Brussard et al. (1994)
predation	common ravens	abundant	fairly common	rare	absent	Brussard et al. (1994)
habitat degradation	exotic ephemerals	abundant, ineradicable	fairly common and widespread	scarce and patchy	none	Brussard et al. (1994)
Desert tortoise (*Gopherus morafkai*)						
habitat	size	<200 sq mi	200-500 sq mi	500-1,000 sq mi	>1,000 sq mi	Brussard et al. (1994)
predation	common ravens	abundant	fairly common	rare	absent	Brussard et al. (1994)
habitat degradation	exotic ephemerals	abundant, ineradicable	fairly common and widespread	scarce and patchy	none	Brussard et al. (1994)
Golden Eagle (*Aquila chrysaetos*)						
habitat loss or degradation	urban development	present	--	minimal	absent	Kochert et al. (2002)
habitat degradation	livestock grazing and agriculture	existing or planned	--	--	absent	Beecham and Kochert (1975)
habitat degradation	fire	>40,000 ha of shrublands burned	--	burned territory; adjacent vacant unburned	unburned territories	Kochert et al. (1999)
habitat degradation	mining and energy development	present	--	--	absent	Phillips and Beske (1982)
habitat	vegetation	disturbed areas, grasslands, agriculture			shrubland/open grassland	Marzluff et al. (1997), Peterson (1988)
habitat/nest sites	topography	--	--	--	cliffs within 7 km of shruband	Menkens and Anderson (1987), McGrady et al. (2002), Cooperrider et al. (1986)

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	References
mortality	infrastructure (roads, power lines, wind turbines	--	--	--	infrastructure absent	Franson et al. (1995)
Illness mortality	poisoning from pesticides and other toxins	high levels of contaminants	--	--	low/no contaminants	Franson et al. (1995), Harmata and Restani (1995), Kramer and Redig (1997), Pattee et al. (1990)
habitat loss or degradation	urban development	present	--	minimal	absent	Kochert et al. (2002)
Le Conte's Thrasher (*Toxostoma lecontei*)						
habitat degradation	invasive grasses				revegetation at disturbed sites of desert thorn (*Lycium*) and saltbush (*Atriplex*) species;	Weigand and Fitton (2008)
habitat	Habitat fragmentation -	>10 km distance between habitat fragments			maximum of 2 km distance between habitat fragments	Weigand and Fitton (2008)
Lowland Leopard Frog (*Lithobates yavapaiensis*)						
habitat	elevation	>8,200 ft	6,400 - 8,200 ft	-	<6,400 ft	AZGFD (2006)
predation	American bullfrog	present	-	-	absent	Jennings and Hayes (1994)
habitat	water development	present			absent	Center for Biological Diversity & S. Utah Wilderness Alliance-Petition to list

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	References
Lucy's Warbler (*Oreothlypis luciae*)						
habitat	Loss & degradation of riparian mesquite habitat	extensive development			no development	Otahal 2006, Johnson et al. 1997
interspecific interactions	brood parasitism	prevalent			not present	Otahal 2006, Johnson et al. 1997
habitat	Overgrazing of mesquite scrub	present			not present	Otahal 2006, Johnson et al. 1997
Mountain Lion (*Puma concolor*)						
prey	ungulate density	low	medium	high	very high	Julander and Jeffrey (1964)
habitat degradation	road density	.6 km/sq km	0.4	0.2	0	Van Dyke et al. (1986)
habitat	cover & terrain	very dense or open cover	-	-	rugged terrain with mixed cover	Riley (1998)
habitat degradation	human development	Highly developed	moderate developed	low developed	no development	Van Dyke et al. (1986)
Mule Deer (*Odocoileus hemionus*)						
habitat degradation	distance from oil wells	<2.7 km	-	-	>3.7 km	Sawyer et al. (2006)
habitat degradation	distance from roads	>200m	-	-	>500 m	
habitat	loss, fragmentation, drought, fire, low quality					http://www.ndow.org/wild/animals/facts/mule_deer.shtm
habitat	vegetation/food preference as associated with fire suppression	Large, hot fires			small, cool, frequent fires (early successional plants)	WAFWA Mule Deer Working Group - Western Assoc. of Fish & Wildlife agencies, 2003

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	References
Southwest Willow Flycatcher (*Empidonax traillii extimus*)						
habitat	proximity to surface water	>100 m	50-100 m	25-50 m	0-25 m	Sogge and Marshall (2000)
connectivity	distance between occupied sites	>30 km	15-30 km	2-15 km	<2 km	Finch et al. (2002)
habitat degradation	recreation	present in high intensity	present in moderate intensity	present in low intensity	absent	Marshall and Stoleson (2000)

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Photo: Nurse tree. Arizona-Sonora Desert Museum

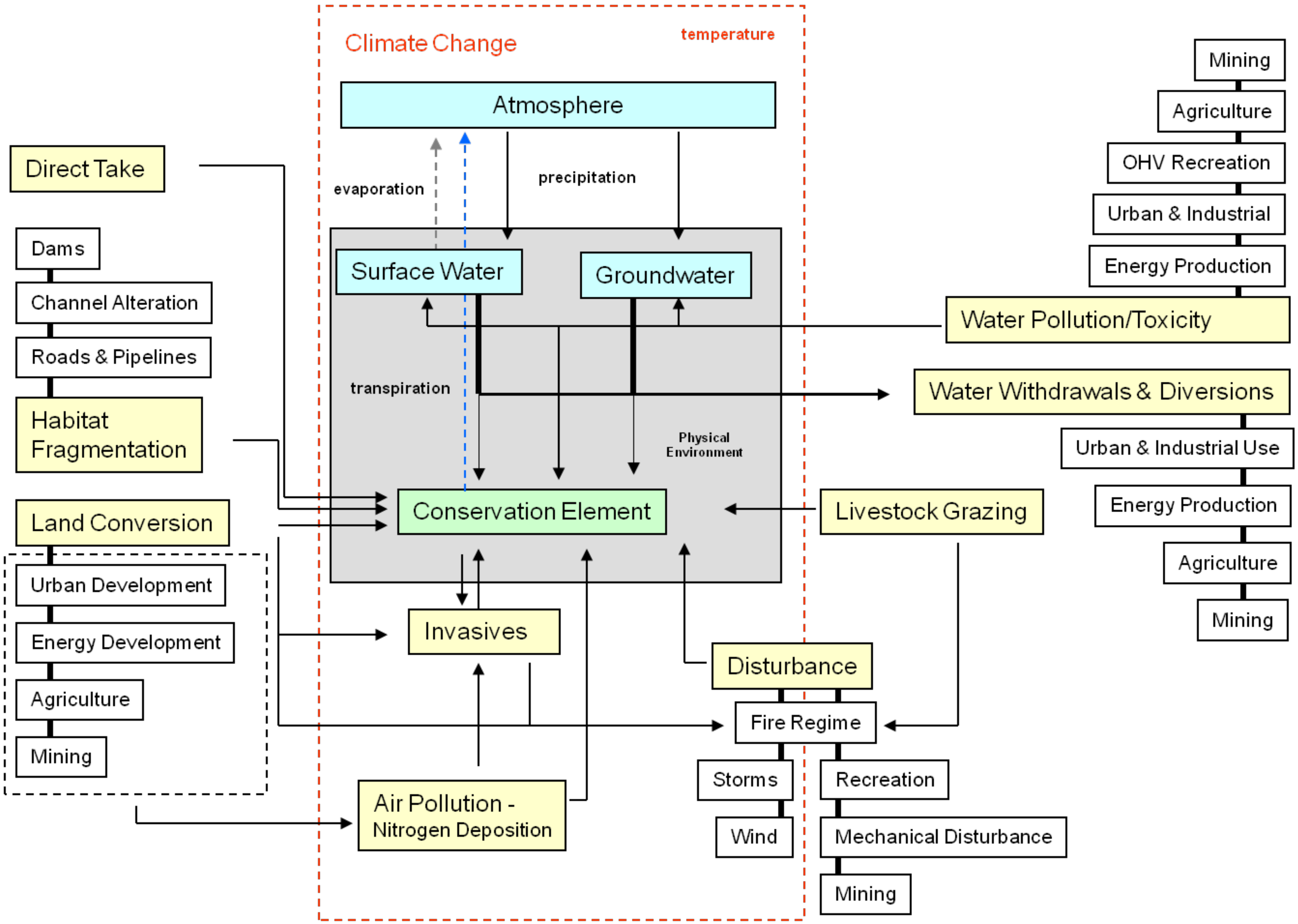
Appendix E – Logic Models

Organization of Appendix E

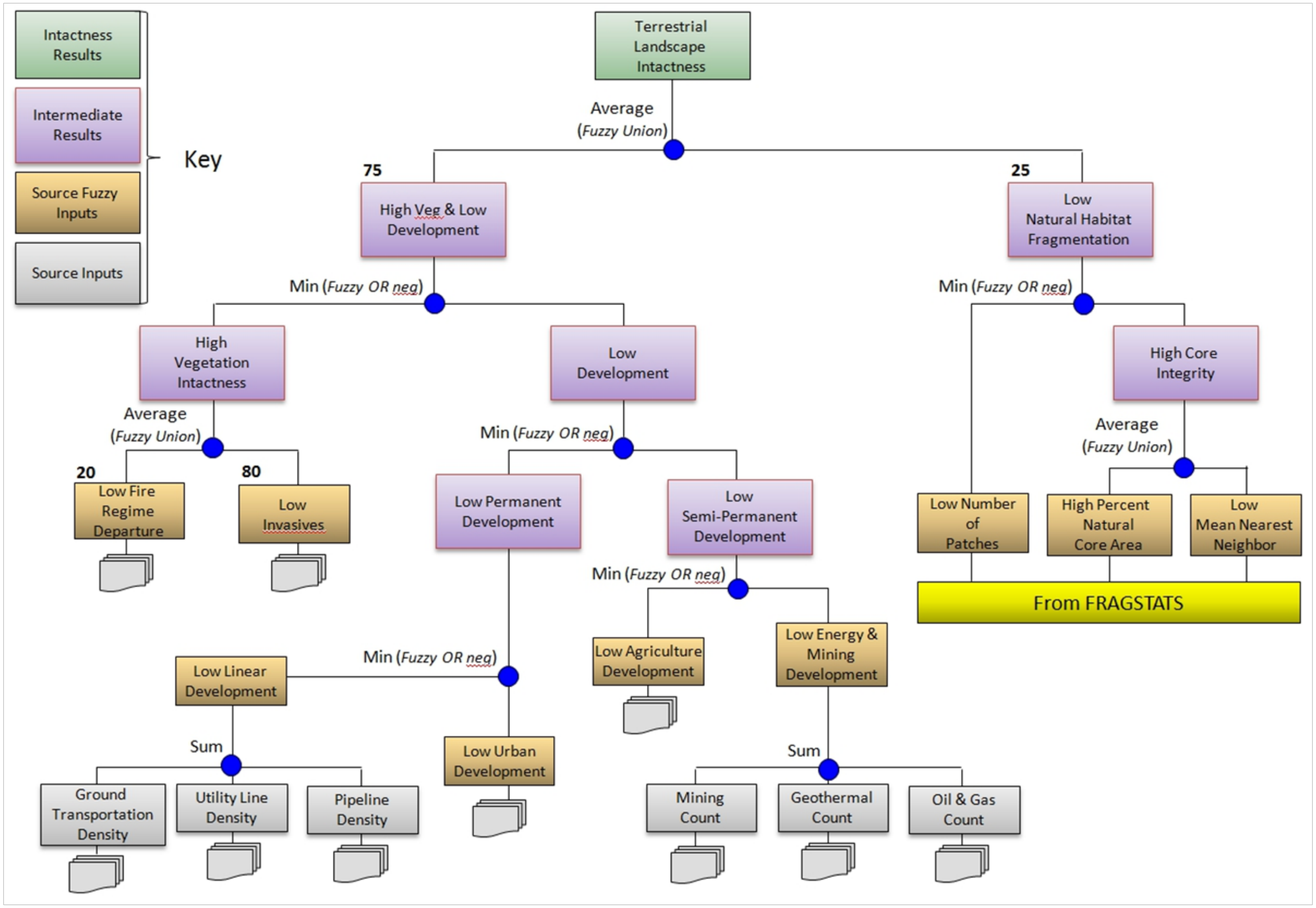
For the Sonoran Desert REA, six issues questions relied on development of more complicated fuzzy logic modeling, including current terrestrial landscape intactness, current aquatic intactness, near-term future (2025) terrestrial landscape intactness, near-term future (2025) aquatic intactness, current development, near-term future (2025) development, maximum (long term) potential energy development, and potential climate change impacts (2060) on conservation elements. All of these models were used to address multiple management questions and they cover different aspects of change agents operating on the landscape. The relationship of the factors modeled above can be viewed as part of a larger, generalized conceptual diagram regarding change agents (conceptual model next page).

For each of the eight models, the logic model is presented first, followed by a table of data sources, an assessment of data quality and overall confidence in the model, and threshold tables. The mapped results are presented in a 4 km X 4 km grid reporting unit and/or 5th level Hydrologic Unit (HUC5), as appropriate for each issue.

Generalized Change Agent Conceptual Diagram



Current Terrestrial Landscape Intactness Logic Model



Data Sources for Current Terrestrial Landscape Intactness

Model Input Label	Data Source	Relative Quality
Ground Transportation Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition
Utility Line Density	Powerlines in the Western United States (USGS)	Good
Pipeline Density	Pipelines (proprietary, provided by BLM)	Good
Low Urban Development	Impervious Surfaces (NLCD 2006)	Very Good
Low Agriculture Development	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Mining Count	Arizona Mines (Arizona Electronic Atlas)	Good
	Active Mineral Operations (USGS)	Good
	California Mines (California Department of Conservation, Office	Good
Geothermal Count	Geothermal Wells in California (State of California, Department of	Good
Oil & Gas Count	Oil & Gas Wells (proprietary, provided by BLM)	Good
Low Fire Regime Departure	Current Fire Regime and Vegetation Departure (see Appendix A MQE3)	Fair
Low Invasives	Current Predicted Distribution of Major Invasive Vegetation Species	Fair
Low Natural Habitat Fragmentation	Natural Vegetation Fragmentation (4KM) (CBI)	Fair-Good

Overall Model Certainty: High – biggest weakness is lack of more detailed invasives data. Additional recreation data and grazing condition data would also improve the model.

Model output reported using both 4mk x 4km grid cells and 5th level HUC.

Current Terrestrial Landscape Intactness (see threshold explanation, Chapter 3) Thresholds – 4km x 4km grid cells

Item	Data Type	Data Range	True Threshold	False Threshold
Fire Regime	Percent Area	7–100	7[1]	100
Invasive Grasses & Tamarisk	Percent Area	0–100	0[1]	100
Linear Development	Linear Density	0–75	0[2]	2.5
Urban Percent	Percent Area	0–100	0[3]	15
Agriculture Percent	Percent Area	0–97	0[3]	20
Energy & Mining Development	Number	0–10	0[1]	2.5
Number of Patches	Number	1–2,868	1[4]	700
Mean Nearest Neighbor	Linear Distance	60–1,897	60[5]	180
Percent Natural Core Area	Percent Area	0–97	97[3]	20

1: Used full range or full range with a few outliers ignored; 2: Skewed data range = 0.5 Standard Deviation from the mean; 3: Skewed data range = 1 Standard Deviation from the mean; 4: Skewed data range = 2 Standard Deviations from the mean; 5: Skewed data range = 2.5 Standard Deviations from the mean

Thresholds – 5th level HUC

Item	Data Type	Data Range	True Threshold	False Threshold
Fire Regime	Percent Area	8–73	8[1]	73
Invasive Grasses & Tamarisk	Percent Area	0–91	0[1]	91
Linear Development	Linear Density	0–9	0[2]	2.5
Urban Percent	Percent Area	0–51	0[3]	15
Agriculture Percent	Percent Area	0–81	0[3]	20
Energy & Mining Development	Number	0–1.98	0[1]	1.98
Number of Patches	Number	1–7,056	1[1]	700
Mean Nearest Neighbor	Linear Distance	60–229	60[1]	180
Percent Natural Core Area	Percent Area	0–93	93[2]	20

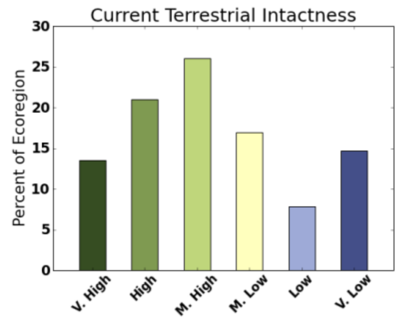
1: Used full range or full range with a few outliers ignored; 2: Skewed data range = 2 Standard Deviations from the mean; 3: Skewed data range = 1.5 Standard Deviations from the mean

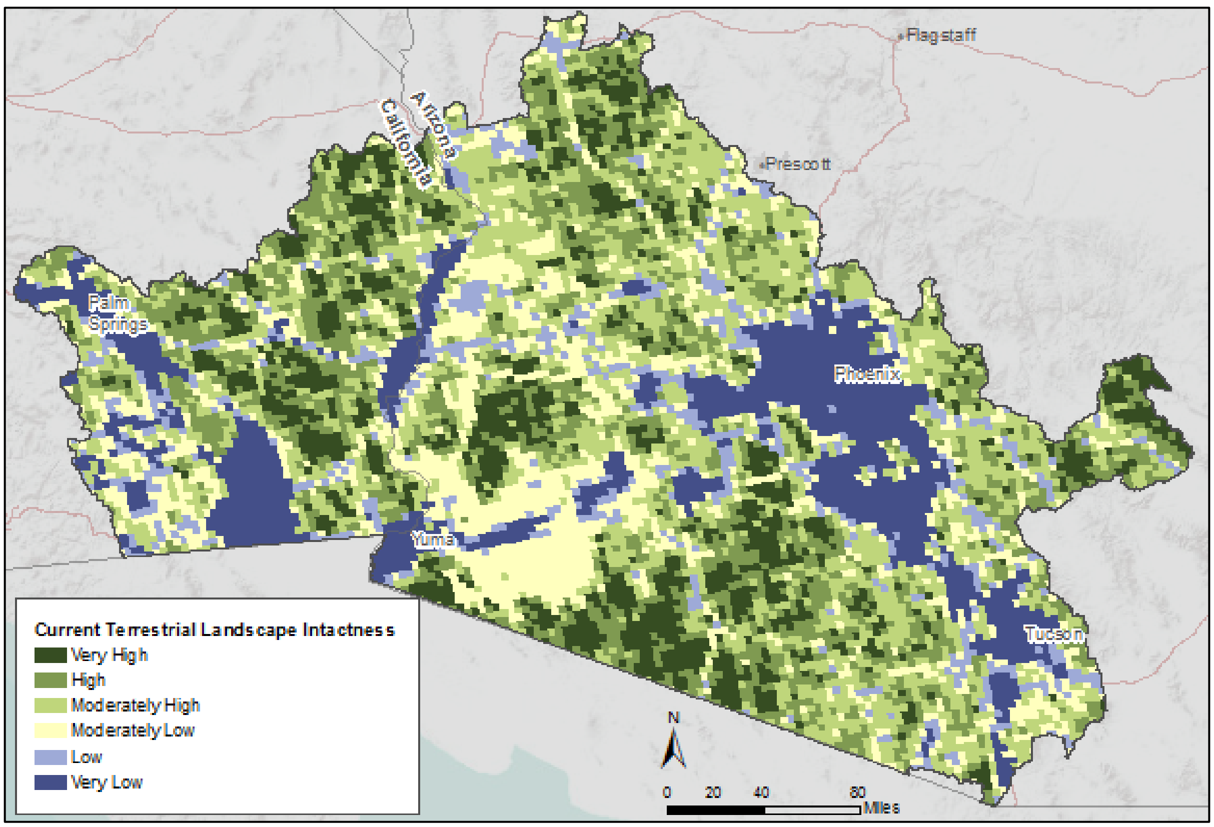
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

Results for Current Terrestrial Landscape Intactness

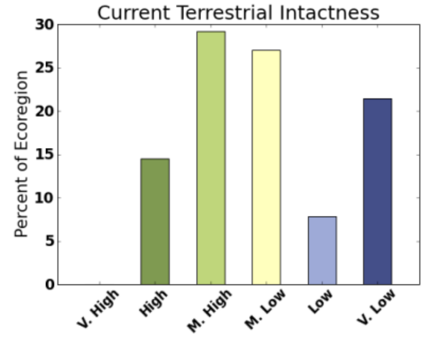
4km x 4km grid cells

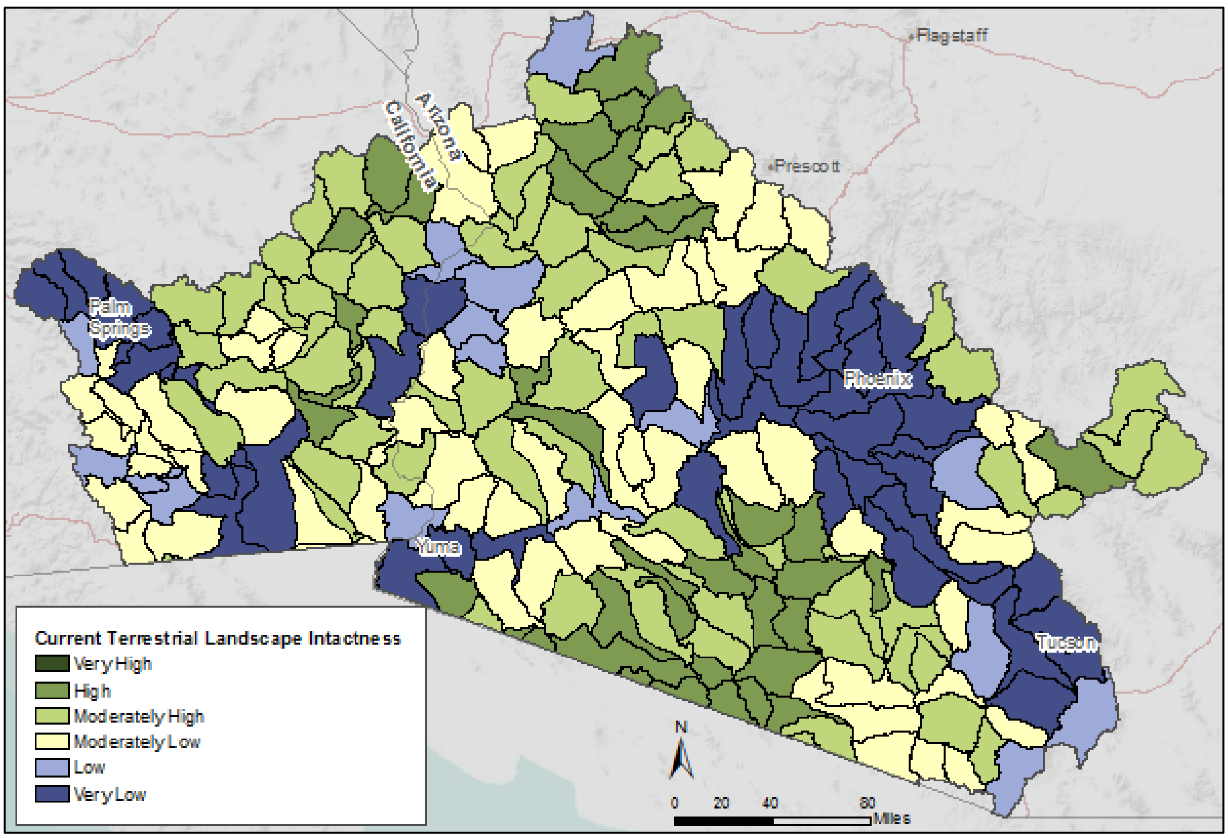




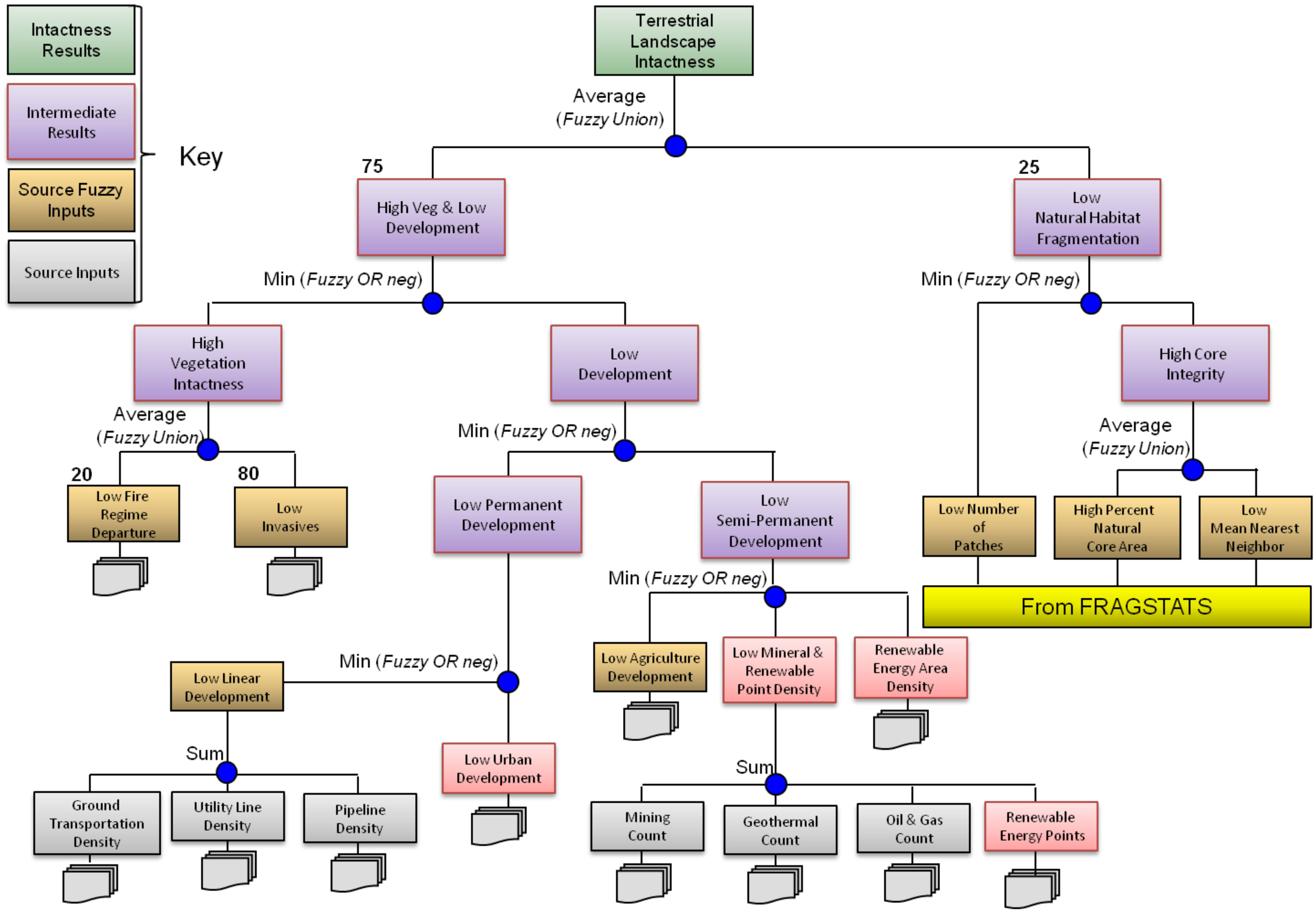
Results for Current Terrestrial Landscape Intactness

5th level HUC





Near-Term Future (2025) Terrestrial Landscape Intactness Logic Model



Data Sources for Near Term Future Terrestrial Landscape Intactness

Model Input Label	Data Source	Relative Quality
Ground Transportation Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition
Utility Line Density	Powerlines in the Western United States (USGS)	Good
Pipeline Density	Pipelines (proprietary, provided by BLM)	Good
Low Urban Development	Impervious Surfaces (NLCD 2006)	Very Good
	Development Risk, Contiguous US (David Theobald)	Good-Fair
Low Agriculture Development	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Renewable Energy	BLM Solar Projects	Good
	BLM Renewable Energy Projects (2011)	Good
	California BLM Preliminary Renewable Energy Rights of Way	Good
	California BLM Verified Renewable Energy Rights of Way	Good
Mining Count	Arizona Mines (Arizona Electronic Atlas)	Good
	Active Mineral Operations (USGS)	Good
	California Mines (California Department of Conservation, Office of	Good
Geothermal Count	Geothermal Wells in California (State of California, Department of	Good
Oil & Gas Count	Oil & Gas Wells (proprietary, provided by BLM)	Good
Low Fire Regime Departure	Current Fire Regime and Vegetation Departure (see Appendix A MQE3)	Fair
Low Invasives	Near-term Predicted Distribution of Major Invasive Vegetation Species (see	Fair
Low Natural Habitat Fragmentation	Natural Vegetation Fragmentation (4KM) (CBI)	Fair-Good

Overall Model Certainty: **Moderately Low –** A number of key datasets could not be projected (e.g. ground transportation density), resulting in a model that significantly under-estimates the near-term impacts.

Model output reported using both 5th level HUC and 4mk x 4km grid cells.
Boxes and accompanying rows shaded in pink indicate new data for near-term intactness.

Near Term Terrestrial Landscape Intactness (see threshold explanation, Chapter 3) Thresholds – 4km x 4km grid cells

Item	Data Type	Data Range	True Threshold	False Threshold
Fire Regime	Percent Area	7–100	7[1]	100
Invasive Grasses & Tamarisk	Percent Area	0–100	0[1]	100
Linear Development	Linear Density	0–75	0[2]	2.5
Urban Percent	Percent Area	0–100	0[3]	15
Agriculture Percent	Percent Area	0–97	0[3]	20
Renewable Energy	Percent Area	0–97	0[1]	20
Energy & Mining Development	Number	0–10	0[1]	2. 5
Number of Patches	Number	0–2,868	0[4]	700
Mean Nearest Neighbor	Linear Distance	60–1,897	60[5]	180
Percent Natural Core Area	Percent Area	0–97	97[3]	20

1: Used full range or full range with a few outliers ignored; 2: Skewed data range = 0.5 Standard Deviation from the mean; 3: Skewed data range = 1 Standard Deviation from the mean; 4: Skewed data range = 2 Standard Deviations from the mean; 5: Skewed data range = 2.5 Standard Deviations from the mean

Thresholds – 5th level HUC

Item	Data Type	Data Range	True Threshold	False Threshold
Fire Regime	Percent Area	8–73	8[1]	73
Invasive Grasses & Tamarisk	Percent Area	0–91	0[1]	91
Linear Development	Linear Density	0–9	0[2]	2.5
Urban Percent	Percent Area	0–60	0[3]	15
Agriculture Percent	Percent Area	0–81	0[3]	20
Energy & Mining Development	Number	0–2.01	0[1]	2.01
Renewable Energy	Percent Area	0–20	0[1]	20
Number of Patches	Number	1–7,056	1[1]	700
Mean Nearest Neighbor	Linear Distance	60–229	60[1]	180
Percent Natural Core Area	Percent Area	0–93	93[2]	20

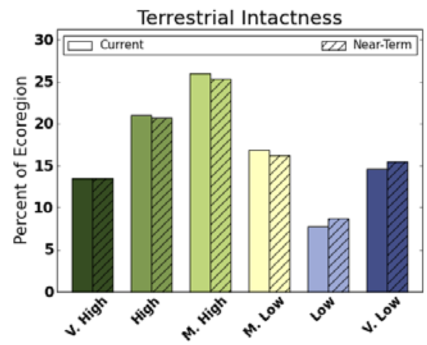
1: Used full range or full range with a few outliers ignored; 2: Skewed data range = 2 Standard Deviations from the mean; 3: Skewed data range = 1.5 Standard Deviations from the mean

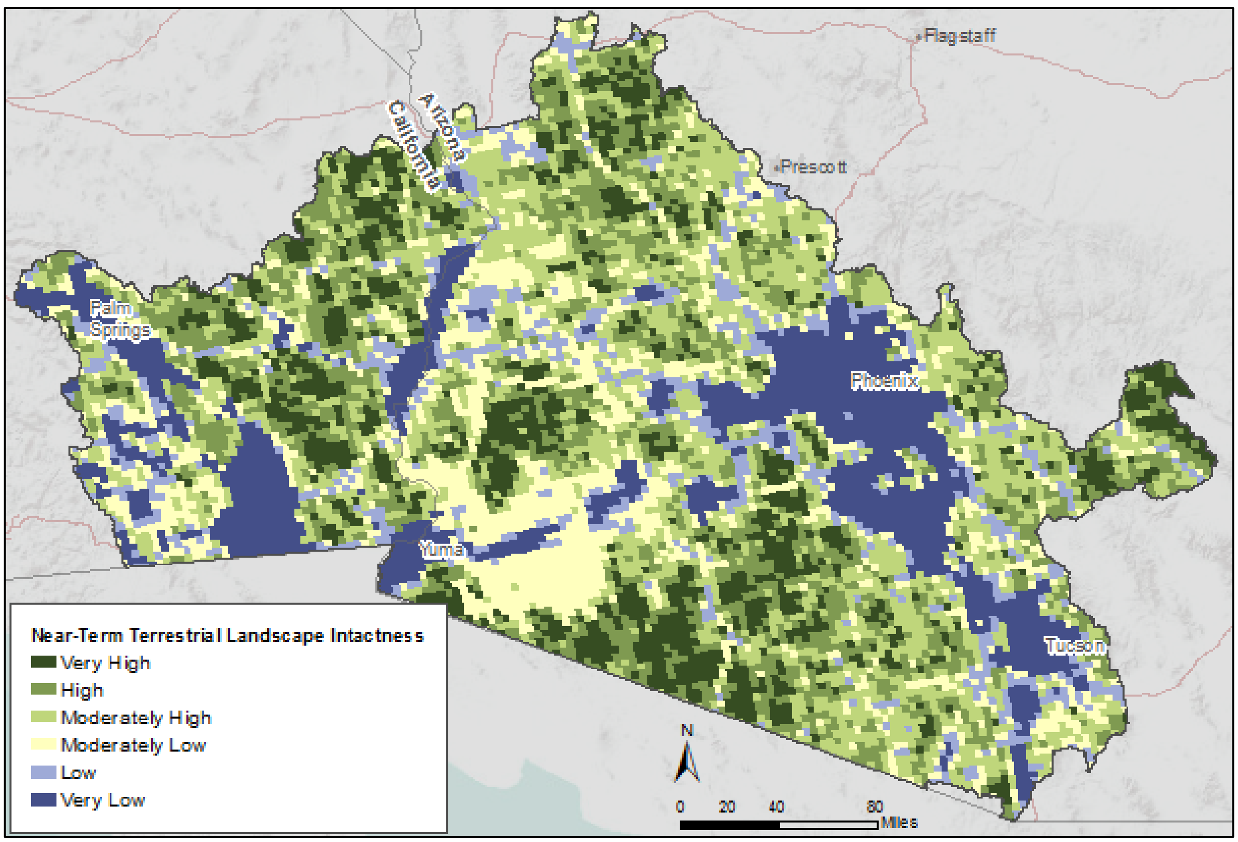
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

Results for Near Term Future Terrestrial Landscape Intactness

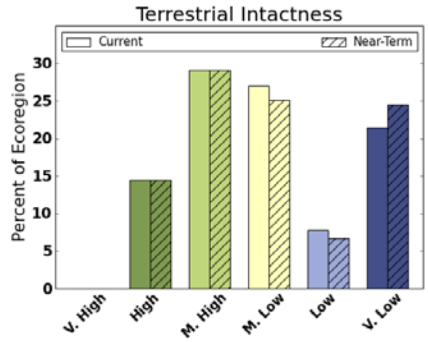
4km x 4km grid cells

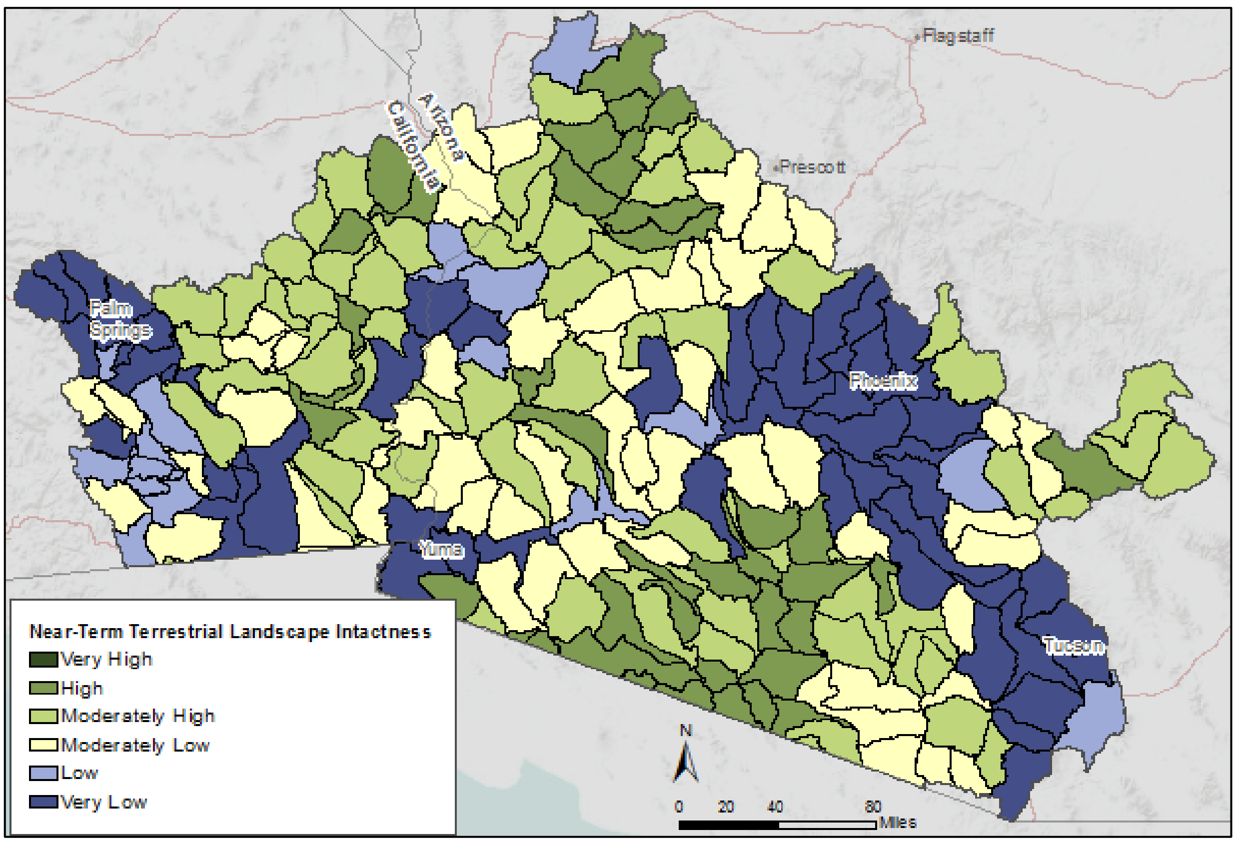




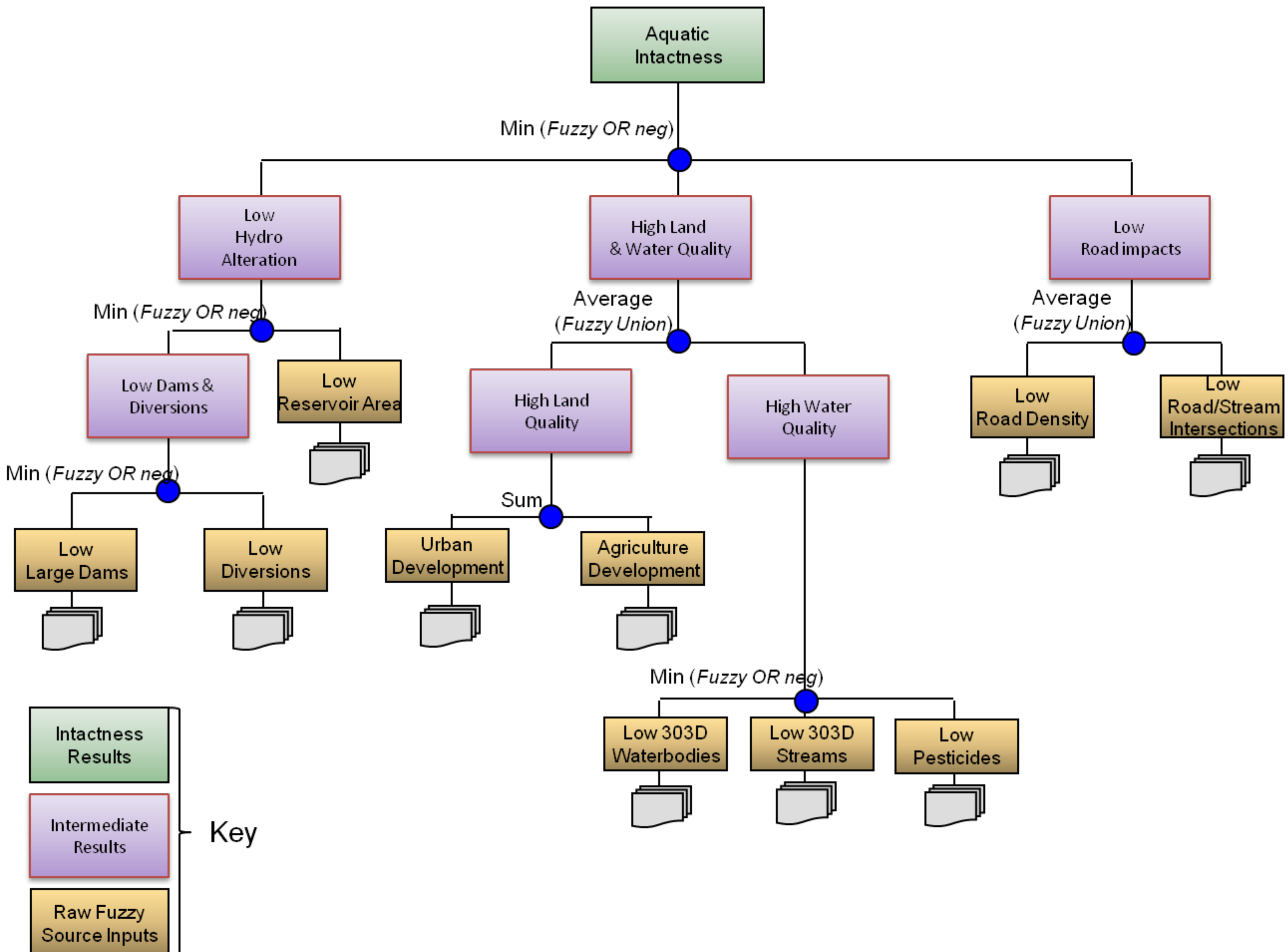
Results for Near Term Future Terrestrial Landscape Intactness

5th level HUC





Current Aquatic Intactness Logic Model



Data Sources for Current Aquatic Intactness

Model Input Label	Data Source	Relative Quality
Low Large Dams	National Inventory of Dams (US Army Corps of Engineers)	Very Good
Low Diversions	Surface Water Rights in Imperial County (California Environmental Protection Agency)	Very Good
	Surface Water Rights in Arizona (Arizona Department of Water Resources)	Very Good
Low Reservoir Area	National Hydrography Dataset (waterbodies) (USGS)	Very Good
Urban Development	Impervious Surfaces (NLCD 2006)	Very Good
Agriculture Development	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Low 303D Waterbodies	EPA Office of Water (OW): 303(d) Listed Impaired Waters (waterbodies and streams) (EPA)	Very Good
Low 303D Streams	EPA Office of Water (OW): 303(d) Listed Impaired Waters (waterbodies and streams) (EPA)	Very Good
Low Pesticides	Agricultural Pesticide Use in the Conterminous United States (USGS)	Very Good
Low Road Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition
Low Road/Stream Intersections	National Hydrography Dataset (flowlines) (USGS)	Fair-Good – surface type would be useful addition
	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition

Overall Model Certainty: **Fairly High –** BUT a number of potentially valuable datasets were not available that would have improved this model (e.g. grazing density, exotic species, and streamside habitat quality).

Model output reported at 5th level HUC only.

Current Aquatic Intactness (see threshold explanation, Chapter 3)

Thresholds

Item	Data Type	Data Range	True Threshold	False Threshold
Low Large Dams	Point Density	0–0.031	0[1]	0.02
Low Diversions	Point Density	0–0.9	0[2]	0.9
Low Reservoir Area	Percent Area	0–100	0[2]	2
Land Use	Percent Area	0–87	0[3]	20
Low 303D Waterbodies	Percent Area	0–99	0[1]	1
Low 303D Streams	Linear Density	0–0.9	0[4]	0.2
Low Pesticides	Weighted Sum	0–0.066	0[4]	0.02
Low Road Density	Linear Density	0–8	0[3]	2.5
Low Road/Stream Intersections	Point Density	0–0.82	0[3]	0.28

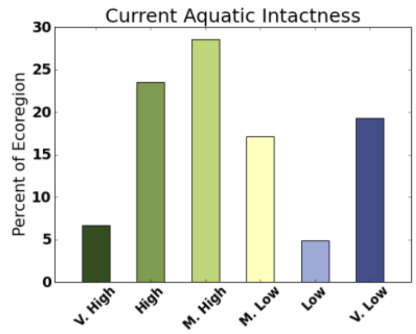
1: Skewed data range = 0.5 Standard Deviation from the mean; 2: Used full range or full range with a few outliers ignored; 3: Skewed data range = 1 Standard Deviation from the mean; 4: Skewed data range =2 Standard Deviations from the mean

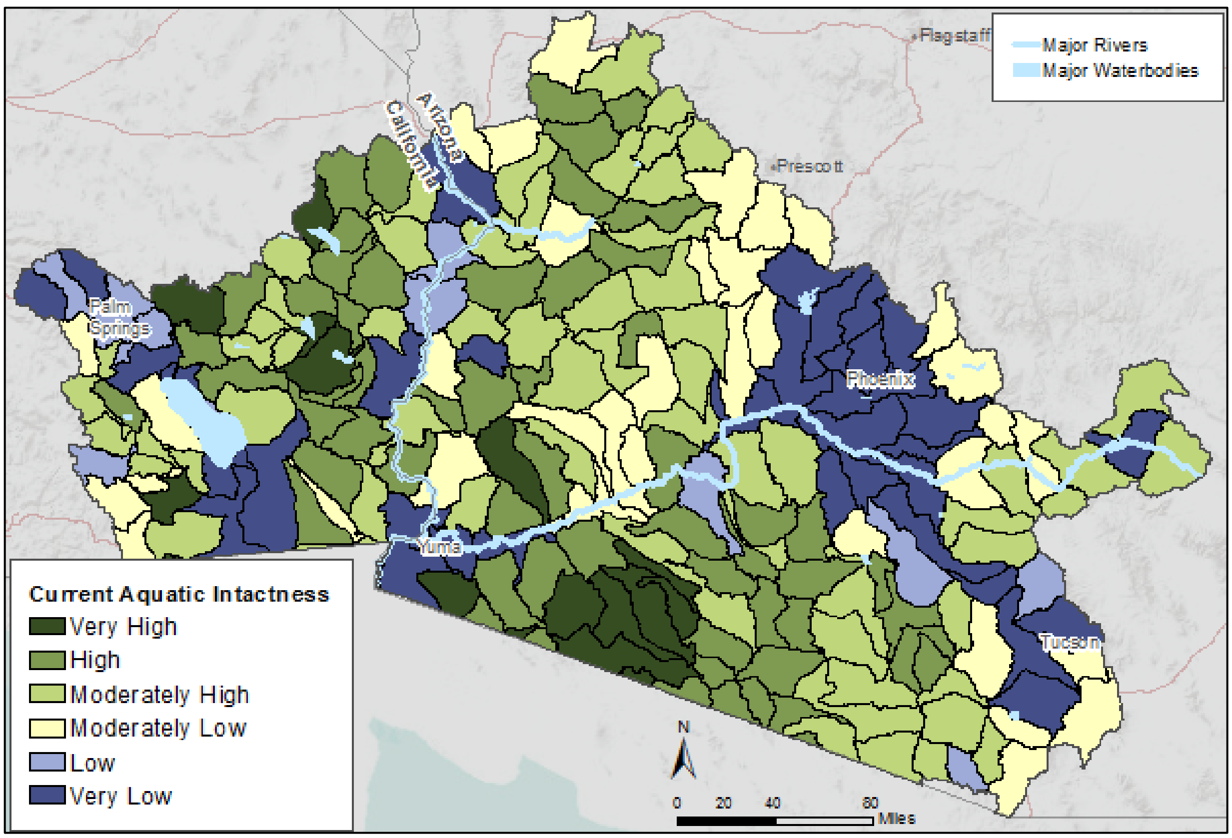
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

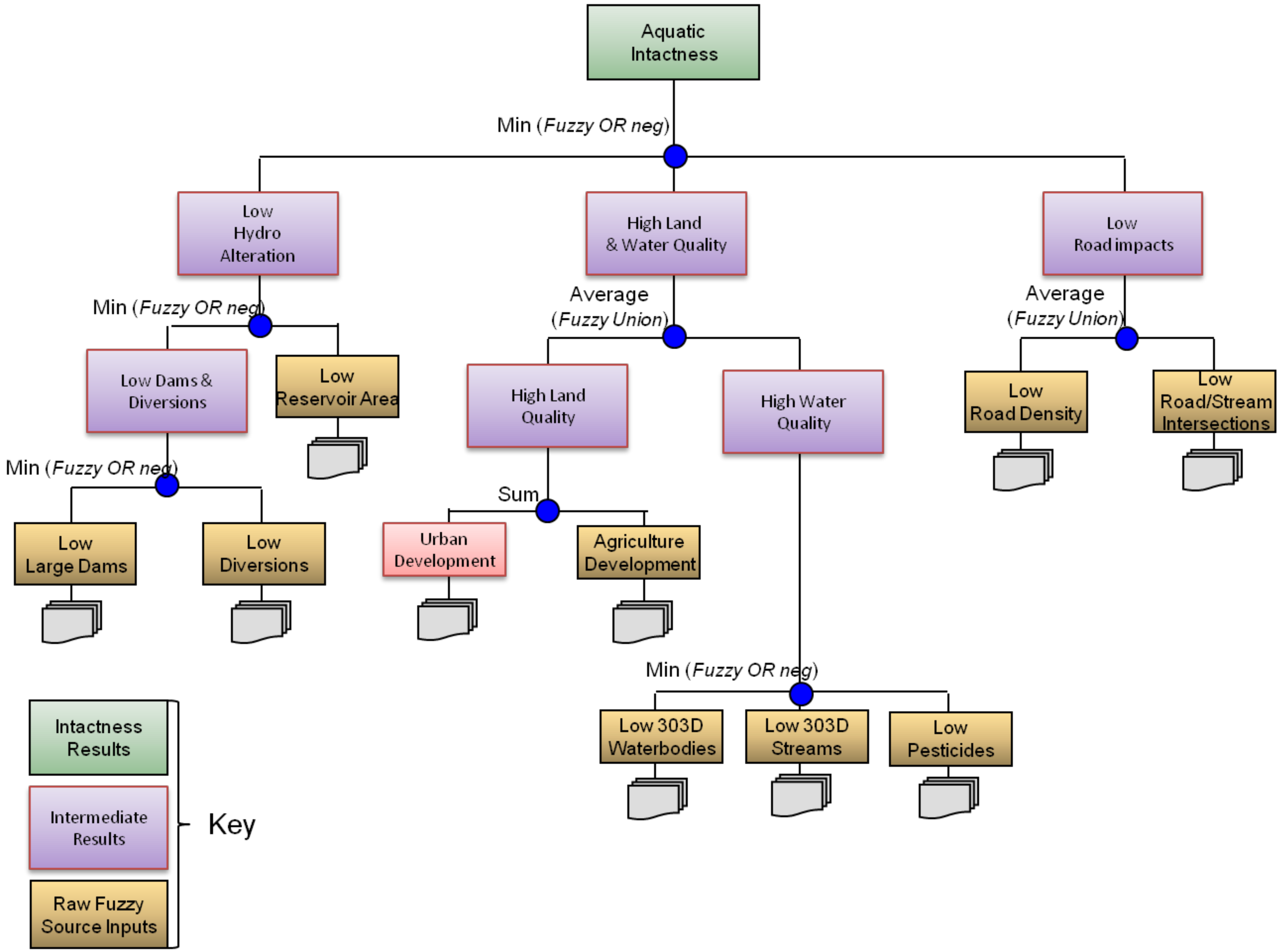
Results for Current Aquatic Intactness

5th level HUC





Near-Term Future (2025) Aquatic Intactness Logic Model



Data Sources for Near Term Future Aquatic Intactness

Model Input Label	Data Source	Relative Quality
Low Large Dams	National Inventory of Dams (US Army Corps of Engineers)	Very Good
Low Diversions	Utah Surface Water Diversions (Utah Department of Natural Resources,	Very Good
	Surface Water Rights in Arizona (Arizona Department of Water	Very Good
	Colorado Surface Water Diversions (Colorado Division of Water	Very Good
	New Mexico Surface Water Diversions (New Mexico Water	Very Good
Low Reservoir Area	National Hydrography Dataset (waterbodies) (USGS)	Very Good
Urban Development	Impervious Surfaces (NLCD 2006)	Very Good
	Development Risk, Contiguous US (David Theobald)	Fair-Good
Agriculture Development	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Low 303D Waterbodies	EPA Office of Water (OW): 303(d) Listed Impaired Waters (waterbodies	Very Good
Low 303D Streams	EPA Office of Water (OW): 303(d) Listed Impaired Waters (waterbodies	Very Good
Low Pesticides	Agricultural Pesticide Use in the Conterminous United States (USGS)	Very Good
Low Road Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition
Low Road/Stream Intersections	National Hydrography Dataset (flowlines) (USGS)	Fair-Good – surface type would be useful addition
	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful addition

Overall Model Certainty: Moderately Low – A number of key datasets could not be forecasted (e.g. ground transportation density), resulting in a model that significantly under-estimates the near-term impacts.

Model output reported at 5th level HUC only.

Boxes and accompanying rows shaded in pink indicate new data for near-term aquatic intactness.

Near Term Future Aquatic Intactness (see threshold explanation, Chapter 3) Thresholds

Item	Data Type	Data Range	True Threshold	False Threshold
Low Large Dams	Point Density	0–0.031	0[1]	0.02
Low Diversions	Point Density	0–0.9	0[2]	0.9
Low Reservoir Area	Percent Area	0–100	0[2]	2
Land Use	Percent Area	0–92	0[3]	20
Low 303D Waterbodies	Percent Area	0–99	0[1]	1
Low 303D Streams	Linear Density	0–0.9	0[4]	0.2
Low Pesticides	Weighted Sum	0–0.066	0[4]	0.02
Low Road Density	Linear Density	0–8	0[3]	2.5
Low Road/Stream Intersections	Point Density	0–0.82	0[3]	0.28

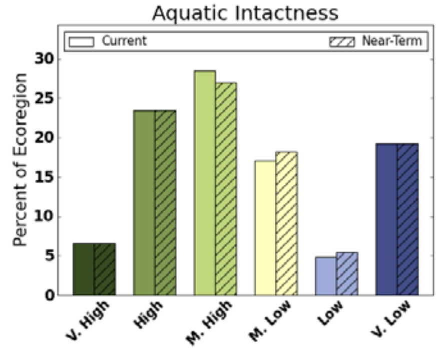
1: Skewed data range = 0.5 Standard Deviation from the mean; 2: Used full range or full range with a few outliers ignored; 3: Skewed data range = 1 Standard Deviation from the mean; 4: Skewed data range = 2 Standard Deviations from the mean

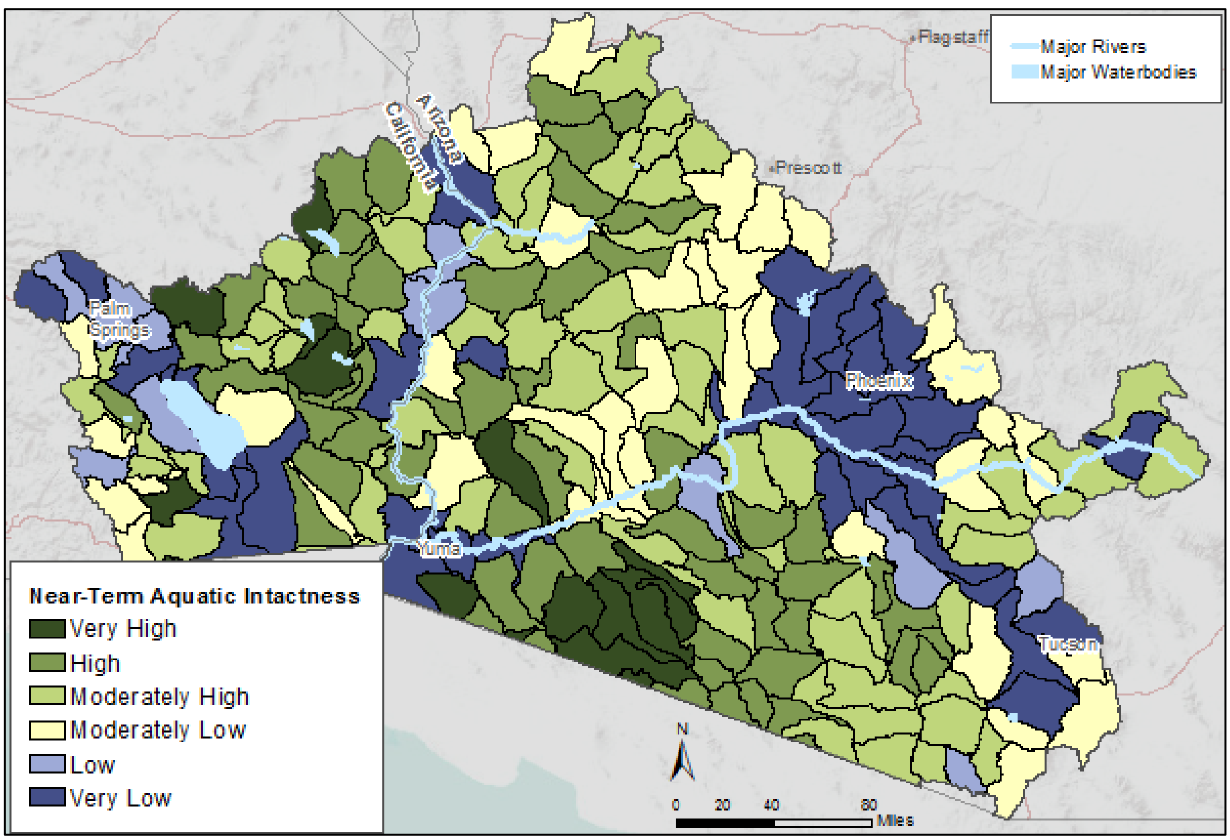
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

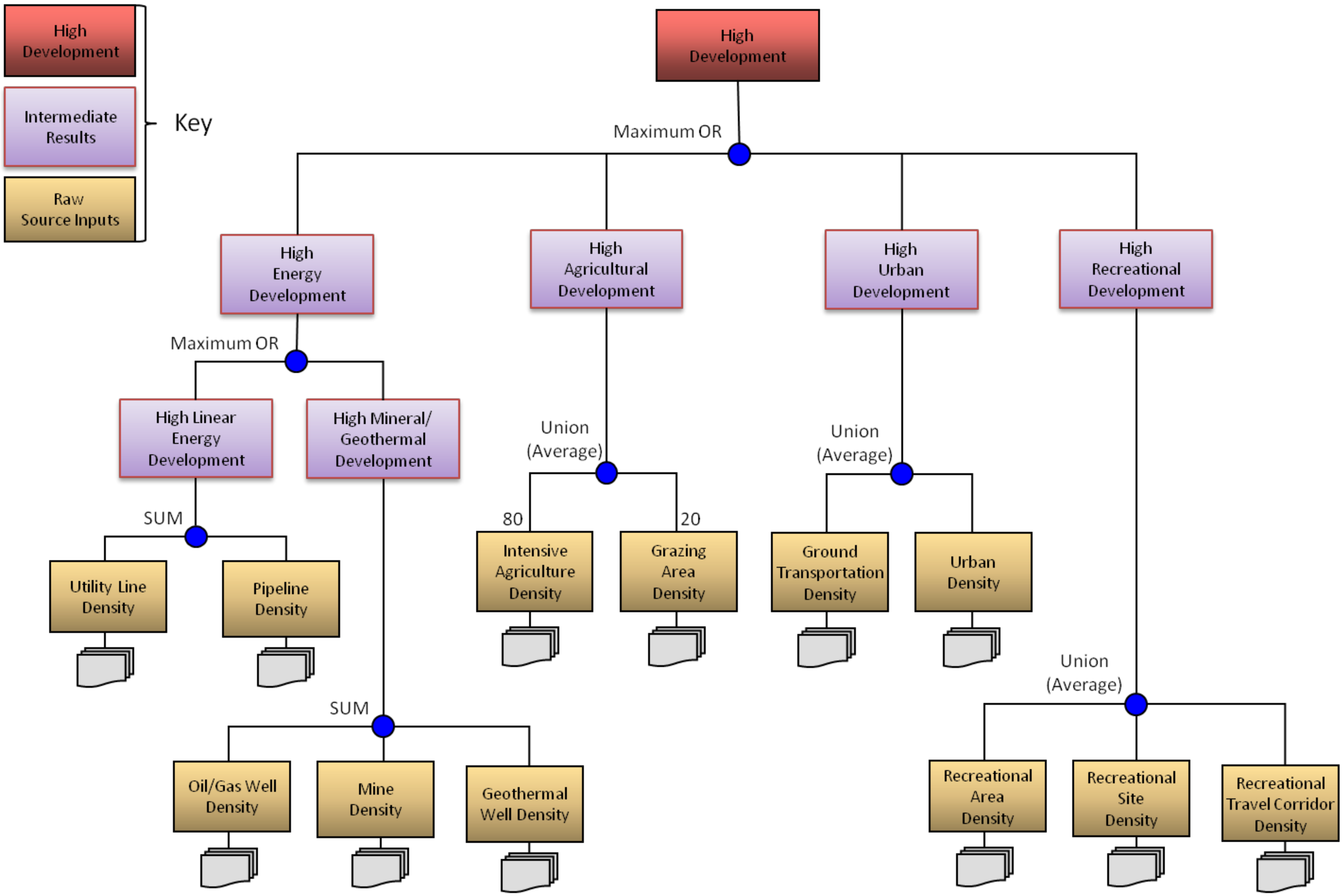
Results for Near Term Future Aquatic Intactness

5th level HUC





Current Development Logic Model



Data Sources for Current Development

Model Input Label	Data Source	Relative Quality
Utility Line Density	Powerlines in the Western United States (USGS)	Good
Pipeline Density	Pipelines (proprietary, provided by BLM)	Good
Oil/Gas Well Density	Oil & Gas Wells (proprietary, provided by BLM)	Good
Mine density	Arizona Mines (Arizona Electronic Atlas)	Good
	California Mines (California Department of Conservation, Office of Mine Reclamation)	Good
Geothermal Well Density	Geothermal Wells in California (State of California, Department of Conservation, Division of Oil, Gas, and Geothermal Resources)	Good
Intensive Agriculture Density	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Grazing Area Density	BLM and USFS Grazing Allotments (MQH4)	Poor-Fair – herd density history or current would be useful
Ground Transportation Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful
Urban Density	Impervious Surfaces (NLCD 2006)	Very Good
Recreational Area Density	Land-Based Recreation Areas – areas (MQH1)	Fair-Poor - no standard source; missing data likely
Recreational Site Density	Land-Based Recreation Areas – points (MQH1)	Fair-Poor - no standard source; missing data likely
Recreational Travel Corridor Density	Land-Based Recreation Travel Corridors (MQH2)	Fair-Good

Overall Model Certainty: Fairly High – BUT a number of potentially valuable datasets were not available that would have improved this model (e.g. grazing density, recreation data, OHV data).

Model output reported at 4km x 4km grid only.

Current Development Model (see threshold explanation, Chapter 3) Thresholds – 4km x 4km grid cells

Item	Data Type	Data Range	True Threshold	False Threshold
High Linear Energy	Linear Density	0–4.7	0.65	0
High Mineral/Geothermal	Point Density	0–9.3	0.70	0
Intensive Agriculture Density	Percent Area	0–97	39.71	0
Grazing Density	Percent Area	0–100	100	0
Ground Transportation Density	Linear Density	0–75	6	0
Urban Density	Percent Area	0–100	30.75	0
Recreational Area Density	Area Density	0–100	13.44	0
Recreational Site Density	Point Density	0–2.55	1.10	0
Recreational Travel Corridor Density	Linear Density	0–36.2	1.58	0

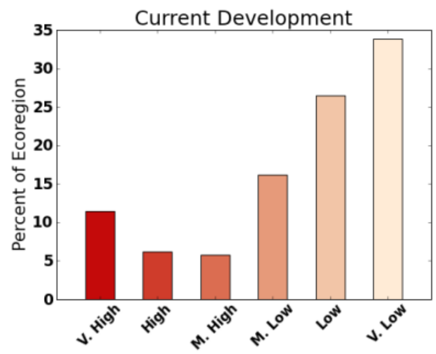
All thresholds based on 2 standard deviations from the mean value for each component.

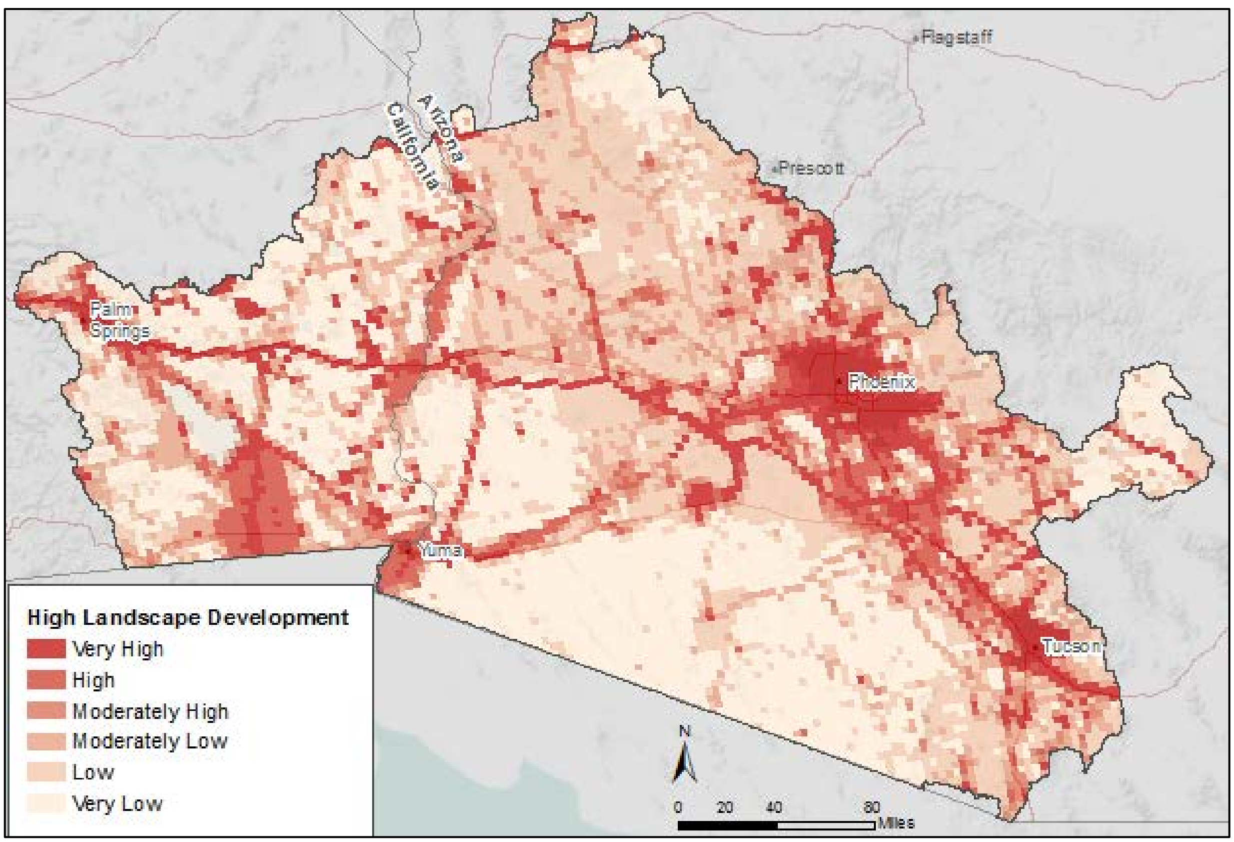
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

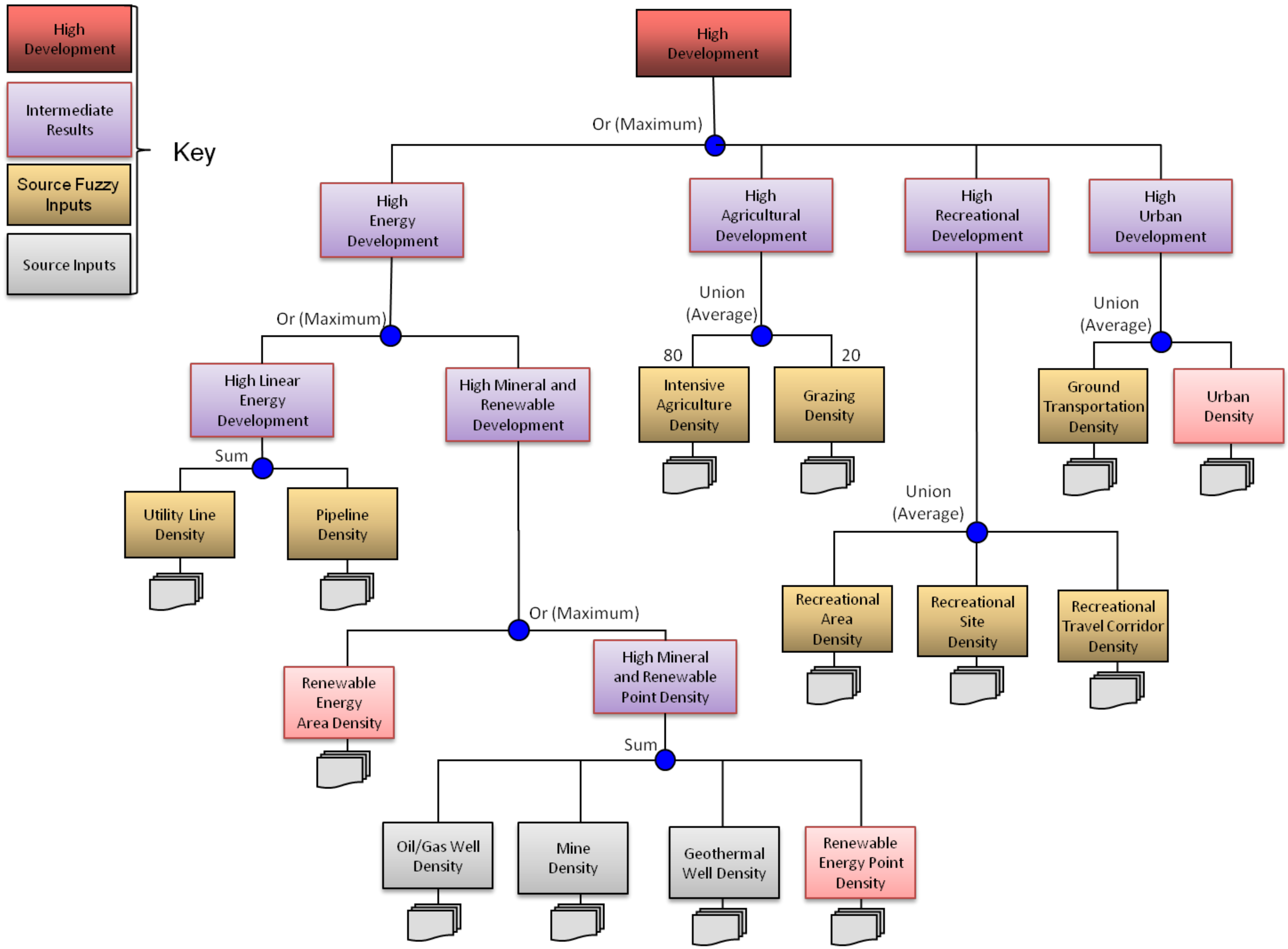
Results for Current Development

4km x 4km grid cells





Near-term Future (2025) Development Logic Model



Data Sources for Near Term Future Development

Model Input Label	Data Source	Relative Quality
Utility Line Density	Powerlines in the Western United States (USGS)	Good
Pipeline Density	Pipelines (proprietary, provided by BLM)	Good
Renewable Energy	BLM Solar Priority Projects	Good
	BLM Renewable Energy Projects (2011)	Good
	California BLM Preliminary Renewable Energy Rights of Way	Good
	California BLM Verified Renewable Energy Rights of Way	Good
Oil/Gas Well Density	Oil & Gas Wells (proprietary, provided by BLM)	Good
Mine density	Arizona Mines (Arizona Electronic Atlas)	Good
	California Mines (California Department of Conservation, Office of	Good
Geothermal Well Density	Geothermal Wells in California (State of California, Department of	Good
Intensive Agriculture Density	LANDFIRE - Existing Vegetation Type (version 1.1)	Very Good
Grazing Area Density	BLM and USFS Grazing Allotments (MQH4)	Poor-Fair – herd density history or current would be useful
Ground Transportation Density	BLM Ground Transportation Linear Features	Fair-Good – surface type would be useful
Urban Density	Impervious Surfaces (NLCD 2006)	Very Good
	Development Risk, Contiguous US (David Theobald)	Fair-Good
Recreational Area Density	Land-Based Recreation Areas – areas (MQH1)	Fair-Poor - no standard source; missing data likely
Recreational Site Density	Land-Based Recreation Areas – points (MQH1)	Fair-Poor - no standard source; missing data likely
Recreational Travel Corridor Density	Land-Based Recreation Travel Corridors (MQH2)	Fair-Good

Overall Model Certainty: **Moderately Low –** A number of key datasets could not be forecasted (e.g. ground transportation density, future grazing density, future recreation), resulting in a model that significantly under-estimates the near-term impacts.

Model output reported at 4km x 4km grid

Near Term Future Development Model (see threshold explanation, Chapter 3) Thresholds

Item	Data Type	Data Range	True Threshold	False Threshold
High Linear Energy	Linear Density	0–5.2	0.64	0
High Oil/Mineral/Geothermal	Point Density	0–37	4.11	0
High Oil/Gas Polygons	Percent Area	0–100	7.35	0
Renewable Energy Areas	Percent Area	0–100	8.74	0
Intensive Agriculture Density	Percent Area	0–90	18.5	0
Grazing Density	Percent Area	0–91	91	0
Ground Transportation Density	Linear Density	0–100	4	0
Urban Density	Percent Area	0–99	10	0
Recreational Area Density	Area Density	0–44	1.15	0
Recreational Site Density	Point Density	0–4.6	0.12	0
Recreational Travel Corridor Density	Linear Density	0–16	2.5	0

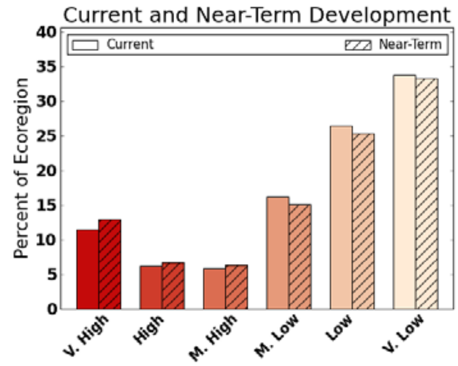
All thresholds based on 2 standard deviations from the mean value for each component.

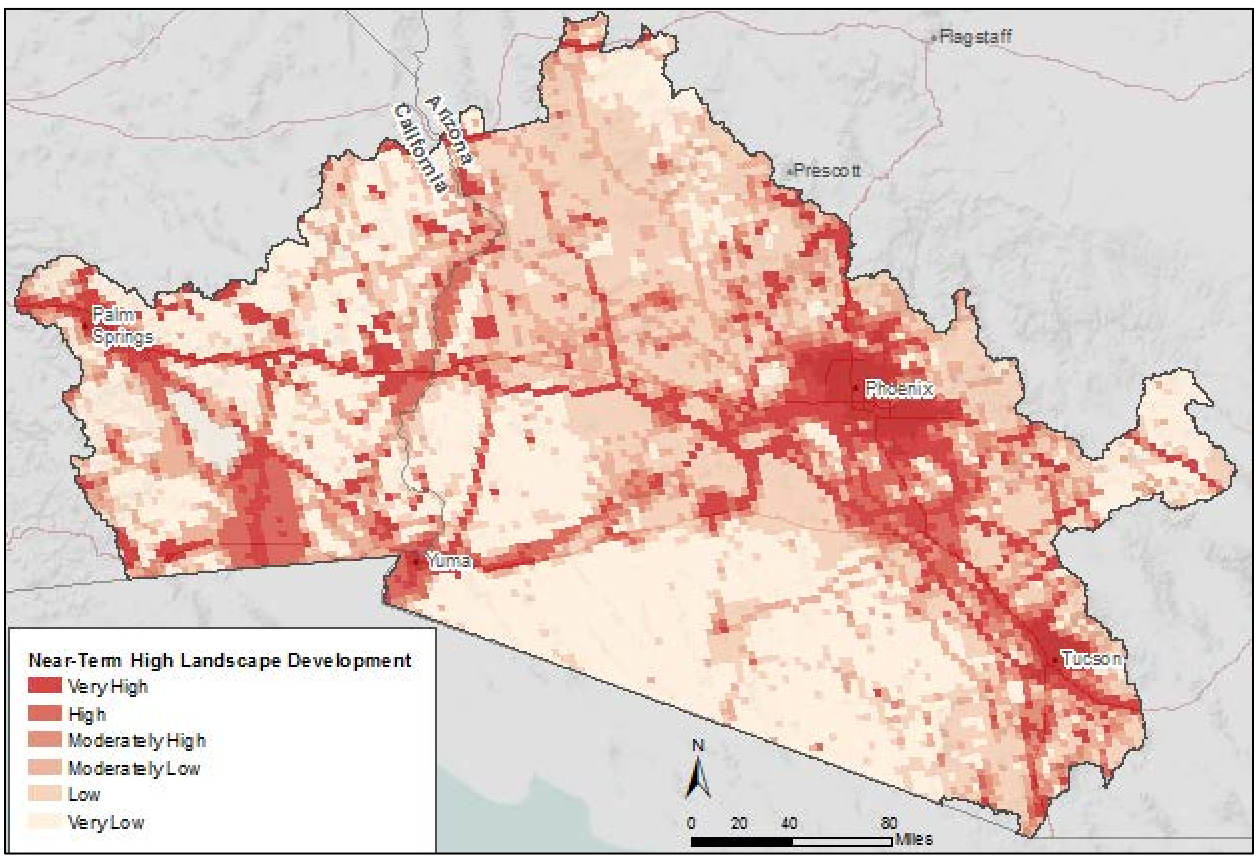
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.000 to -0.750	Very Low
-0.750 to -0.500	Low
-0.500 to 0.000	Moderately Low
0.000 to 0.500	Moderately High
0.500 to 0.750	High
0.750 to 1.000	Very High

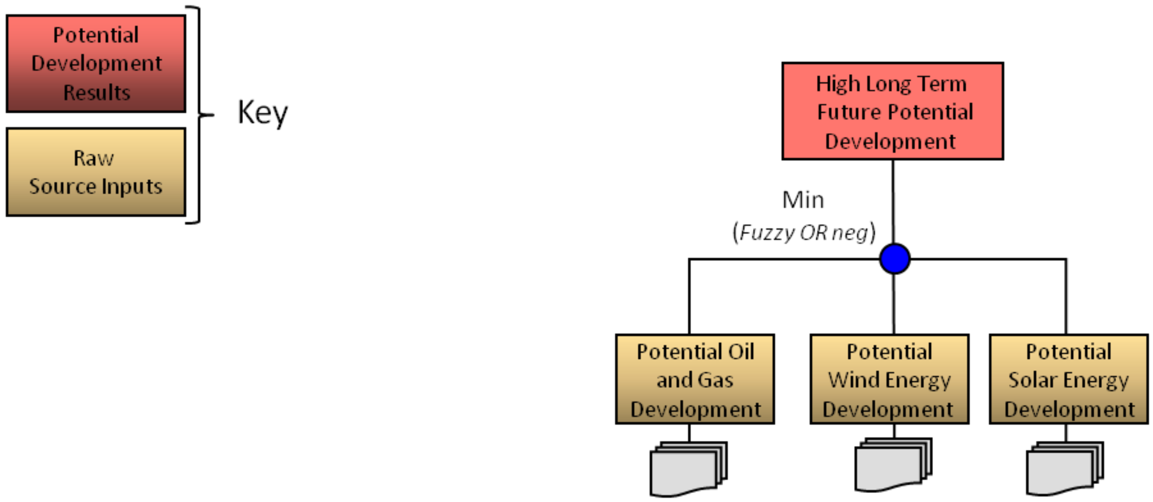
Results for Near Term Future (2025) Development

4km x 4km grid cells





Maximum (Long Term) Potential Energy Development Logic Model



Data Sources for Maximum Potential Energy Development

Model Input Label	Data Source	Relative Quality
Oil/Gas Well Density	Oil & Gas Wells (proprietary, provided by BLM)	Good
Potential Solar Energy Development	Average Solar Resource Potential (filtered to less than 1% slope)	Good
	BLM Solar Priority Projects	Good
	California BLM Preliminary Renewable Energy Rights of Way	Good
	California BLM Verified Renewable Energy Rights of Way	Good
	BLM Restoration Design Energy Project - Solar Analysis Area	Good
	BLM Restoration Design Energy Project - Alternative 1 Areas	Good
	BLM Solar Developable Areas (SEZ8)	Good
Potential Wind Energy Development	Wind Power Density (W/m2) at 50 Meters Above Ground Level	Good

Removed areas using PAD-US (CBI Edition) v 1.1 – GAP codes 1&2

Overall Model Certainty: **Fairly High –** BUT this is just POTENTIAL energy. Not all of these areas are likely to be developed.

Model reported for 4km x 4km grid cells only.

Maximum (Long Term) Potential Energy Development Model (see threshold explanation, Chapter 3)

Thresholds – 4km x 4km grid cells

Item	Data Type	Data Range	True Threshold	False Threshold
Oil and Gas	Percent Area	0–100	0	100
Solar	Percent Area	0–100	0	100
Wind	Percent Area	0–100	0	100

Thresholds – 5th level HUC

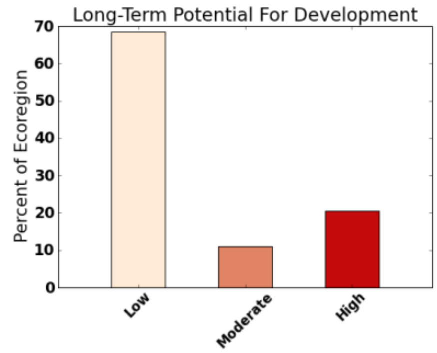
Item	Data Type	Data Range	True Threshold	False Threshold
Oil and Gas	Percent Area	0–29.3	0	29.3
Solar	Percent Area	0–93.5	0	93.5
Wind	Percent Area	0–59.4	0	59.4

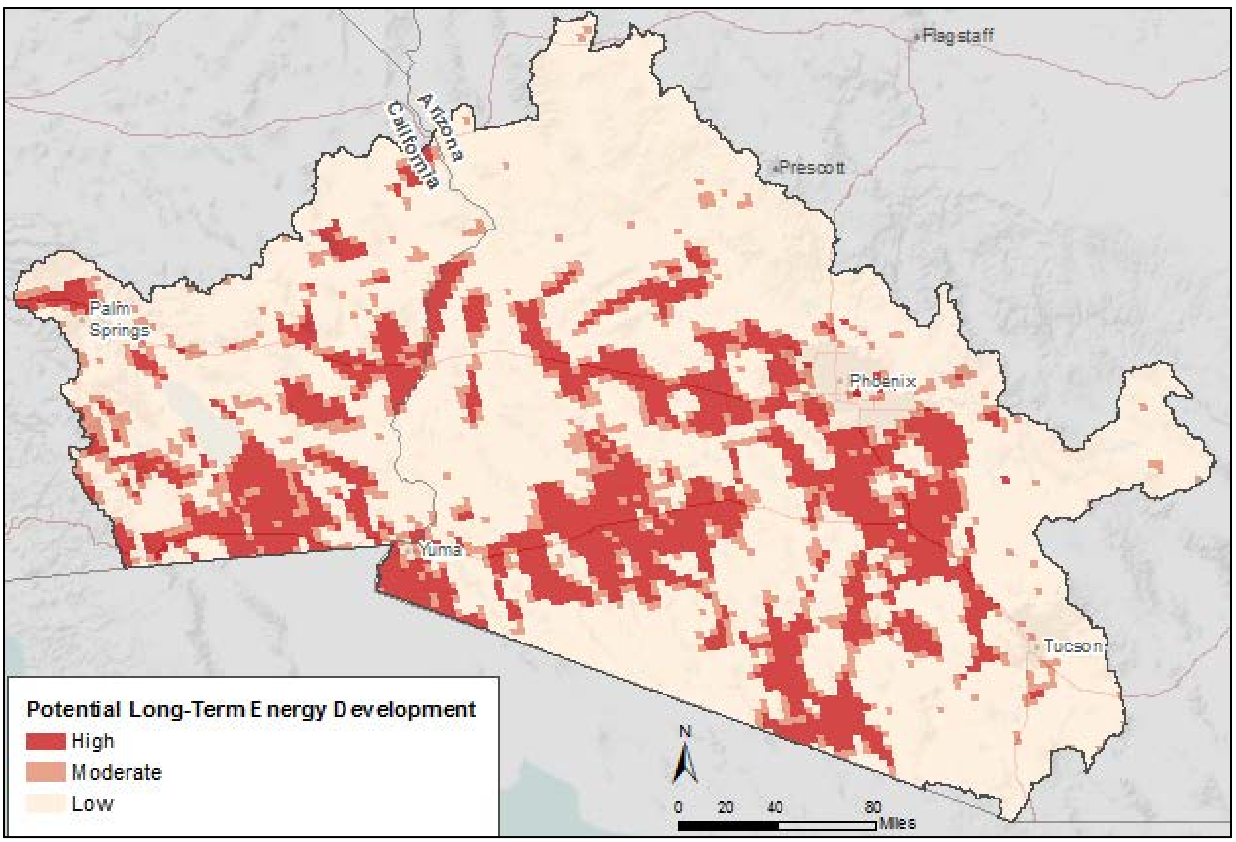
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
0.333 to 1.0	High
--0.333 to 0.333	Medium
-0.333 to -1.0	Low

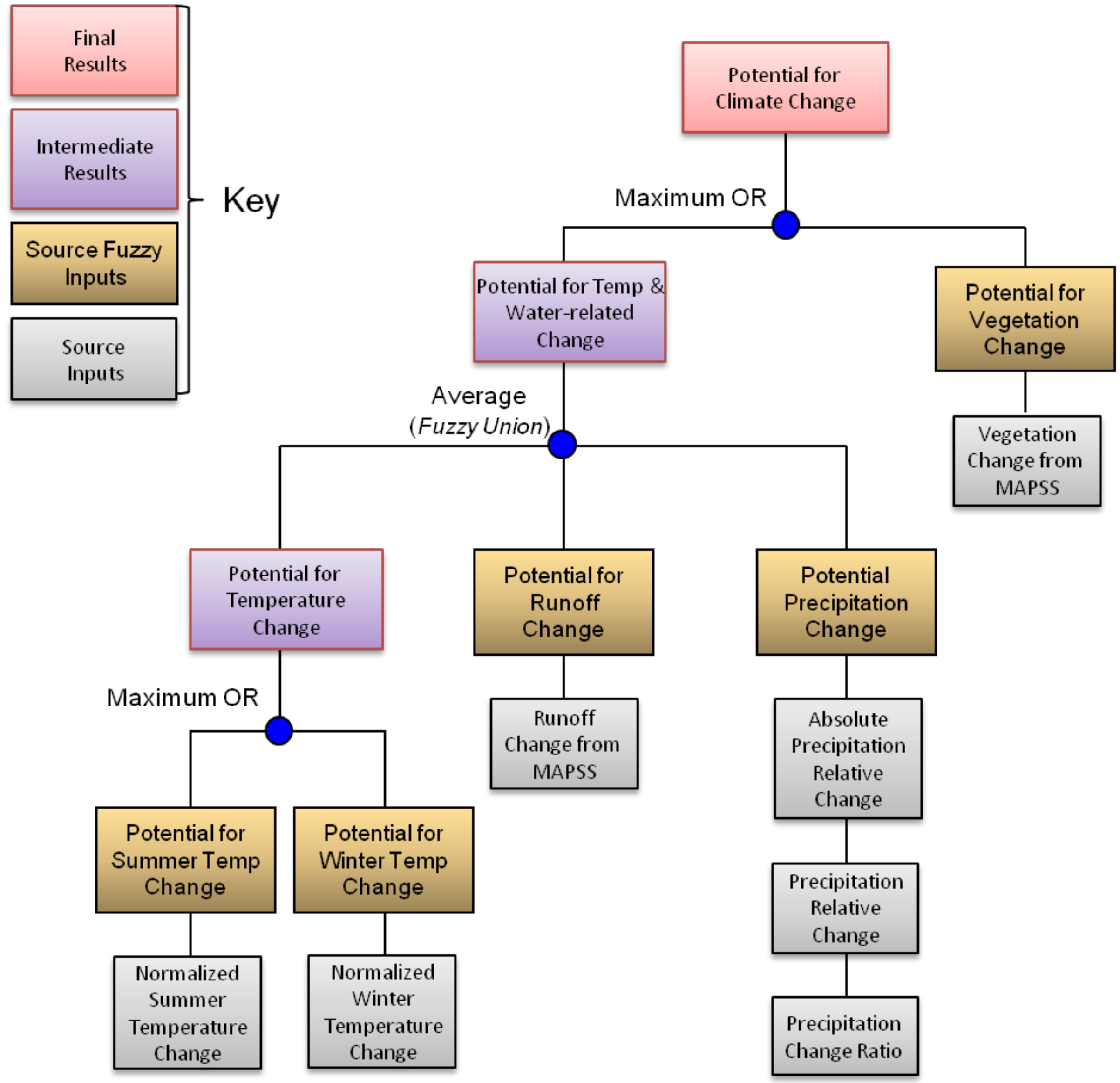
Results for Maximum (Long Term) Potential Energy Development

4km x 4km grid cells





Potential Climate Change Impacts



Data Sources for Potential Climate Change Impacts

Model Input Label	Data Source	Relative Quality
Potential for Summer Temp Change	RegCM3 ECHAM5	Fair
Potential for Winter Temp Change	RegCM3 ECHAM5	Fair
Potential for Runoff	MAPSS model output	Fair
Potential Precipitation Change	RegCM3 ECHAM5	Fair
Potential for Vegetation Change	MAPSS model output	Fair

Overall Model Certainty: **Moderately Low –** The climate change data are the best available and the basic trends and general patterns posses fairly high certainty; however, there is inherent uncertainty as discussed in the text that cautions over-interpretation, especially as it applies at site-specific scales.

Model output reported at 4km x 4km grid cells only.

Potential Climate Change Impacts Model (see threshold explanation, Chapter 3) Thresholds – 4km x 4km grid cells

Item	Data Type	Data Range	True Threshold	False Threshold
Potential for Summer Temp Change	See Below	1.14–3.74	3.74	1.14
Potential for Winter Temp Change	See Below	0.47–1.44	1.44	0.47
Potential for Runoff	Percent Change	0.9–10	2[1]	0
Potential Precipitation Change	See Below	0–2.16	2.16	0
Potential for Vegetation Change	Percent Area	0–100	100	0

[1] – Tail cutoff

Thresholds – 5th level HUC

Item	Data Type	Data Range	True Threshold	False Threshold
Potential for Summer Temp Change	See Below	2.15–3.67	3.67	2.15
Potential for Winter Temp Change	See Below	1.05–1.67	1.67	1.05
Potential for Runoff	Percent Change	0–2.71	2[1]	0
Potential Precipitation Change	See Below	0.59–2.63	2.63	0.59
Potential for Vegetation Change	Percent Area	0–100	100	0

[1] – Tail cutoff

For temperature, potential for change calculated by RegCM3 (ECHAM5) 2045-2060 TEMP – PRISM TEMP/SD PRISM TEMP – values are unit-less

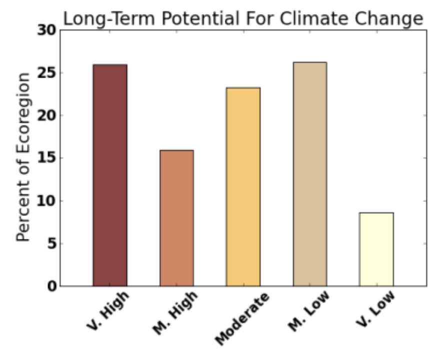
For precipitation, potential for change calculated by RegCM3 (ECHAM5) 2045-2060 PRECIP – PRISM PRECIP/PRISM PRECIP/SD PRISM PRECIP – values are unit-less

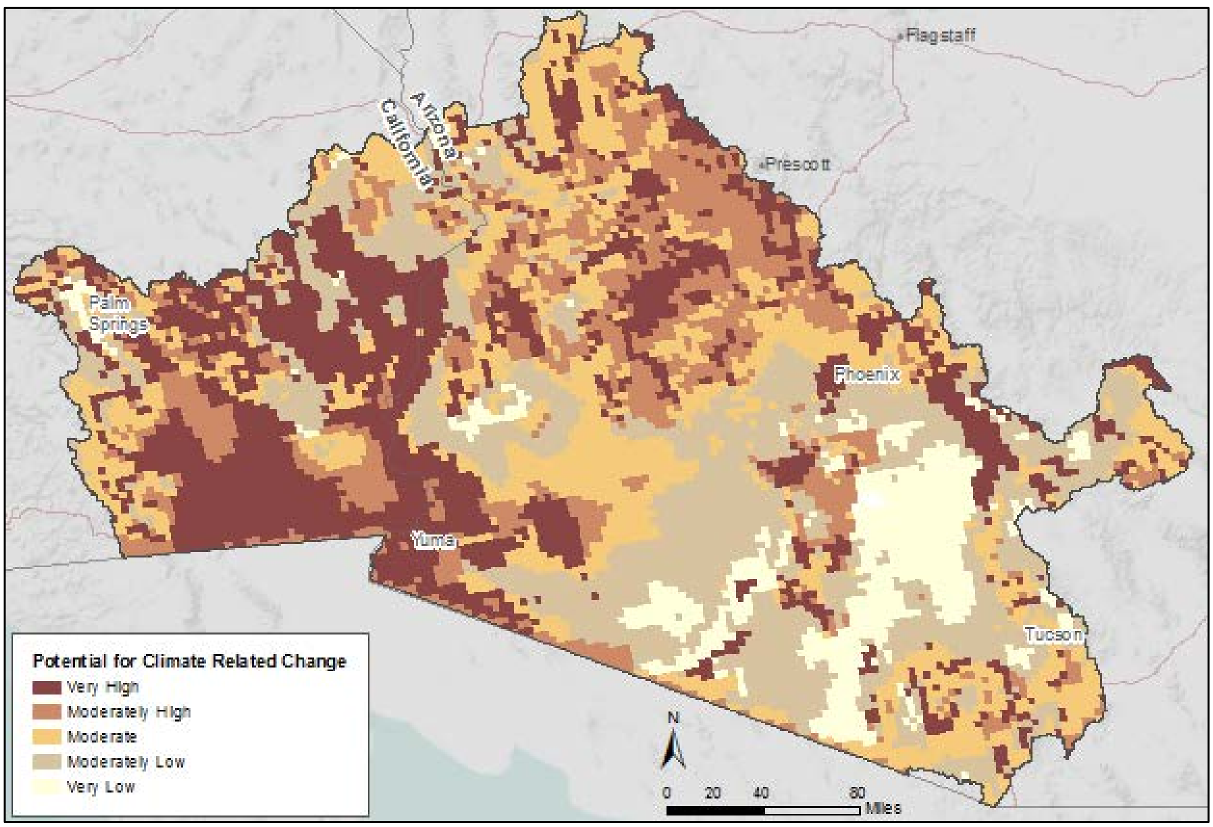
Intactness Value Ranges and Legend Descriptions

Intactness Value	Legend
-1.00 to -0.66	Very Low
-0.66 to -0.22	Moderately Low
-0.22 to 0.22	Moderate
0.22 to 0.66	Moderately High
0.66 to 1.00	Very High

Results for Potential Climate Change Impacts

4 km x 4 km grid cells





U.S. Department of the Interior
Bureau of Land Management

Data Request Method

Rapid Ecoregional Assessments (REAs)—National Operations Center, CO

Individual REA data layers and some other products are still available but are no longer being published.

If you would like to obtain more information, including data and model zip files* (containing Esri ModelBuilder files for ArcGIS 10.x and relevant Python scripts), please email **BLM_OC_REA_Data_Portal_Feedback_Team@blm.gov**.
*Note that a few models require software that BLM does not provide such as R, Maxent, and TauDEM.

Models associated with individual REAs may require data links to be updated to function properly. REA reports, technical appendices, and model overviews (for some REAs) contain detailed information to determine what products are available and what datasets are necessary to run a certain model.

Please include the report name and any specific data information that you can provide with your request.

Other BLM data can be found on the Geospatial Business Platform Hub (https://gbp-blm-egis.hub.arcgis.com).