Appendix B: Conservation Elements

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CONSERVATION ELEMENTS

B-1 Model Approach

B-1.1 Conceptual Modeling

Documents containing the completed conceptual models for CEs are provided as separate documents from this appendix, due to their length. There are four documents- one each for the terrestrial coarse-filter, aquatic coarse-filter, landscape species, and species assemblage CEs. These documents are housed on the BLM data portal. The file names for each are as follows:

MBR_ConceptualModels_TerrestrialCoarseFilterCEsSept_2012_final.pdf
MBR_ConceptualModels_AquaticCoarseFilterCEsSept_2012_final.pdf
MBR_ConceptualModels_LandscapeSpeciesSept_2012_final.pdf
MBR_ConceptualModels_SpeciesAssemblagesSept_2012.pdf

B-1.1.1 Selection criteria and categorization for species CEs

The “fine-filter” includes species that, due to their conservation status and/or specificity in their habitat requirements, are likely vulnerable to being impacted or lost from the ecoregion unless resource management is directed towards their particular needs. For species to be addressed in this assessment, we proposed, and the AMT accepted, several selection criteria for their inclusion and treatment in the assessment. These criteria include:

a. All taxa listed under Federal or State protective legislation for all or a portion of their range within the REA (including species, subspecies, or designated subpopulations)
b. Full species with NatureServe Global Conservation Status rank of G1-G3[1]
c. Full species or subspecies listed as BLM Special Status and those listed by applicable SWAPs with habitat included within the ecoregion
d. Full species and subspecies scored as *Vulnerable* within the ecoregion according to the NatureServe Climate Change Vulnerability Index (CCVI)[2].

One additional species, mule deer (*Odocoileus hemionus*), was included as a desired conservation element. Table B - 1 includes a current list of species meeting criteria a-d above for the MBR ecoregion. A total of 605 taxa are listed for this ecoregion.

Several distinct approaches were established for treating species that meet established criteria for inclusion in the REA. These include:

a) ***Species assumed to be adequately represented indirectly through the assessment of major “coarse-filter”*** ecological systems of the ecoregion. Habitat requirements for these species align closely with coarse-filter CEs. While typically uncommon, these selected “fine-filter” CEs have a moderate probability of being found among any extant and high-quality occurrence of the affiliated coarse-filter element across the majority of the ecoregion, but a very low probability of being found in any other environment. For example, species strongly affiliated with desert springs may be adequately treated in the REA through

[1] See http://www.natureserve.org/explorer/ranking.htm for NatureServe Conservation Status Rank definitions

[2] See http://www.natureserve.org/prodServices/climatechange/ccvi.jsp for more on the NatureServe CCVI

assessment of desert springs themselves. Individual species to be treated within these coarse-filter CEs are flagged within the overall list of species CEs (Table B - 1).

b) ***Species assumed to be adequately represented indirectly as ecologically-based assemblages***. That is, due to similar group behavior and habitat requirement, a recognizable species assemblage is defined and treated as the unit of analysis. These species do not correspond to the a)-group above because they are typically affiliated with specialized components of the major coarse-filter CEs (e.g., sandy soils and localized outcropping among one of the desert scrub systems) and/or are not reliably affiliated with any one of the coarse-filter CEs. Examples include migratory bird stopover sites, and carbonate rock outcrops; these will be treated as multi-species assemblages. Individual species to be treated as part of these assemblages are flagged within the overall list of species CEs (Table B - 1).

c) ***Landscape Species which should be best addressed as individuals*** in the assessment. These include vertebrate species with moderate to large home ranges that tend to include a diversity of coarse-filter CEs as important habitat components. These species occur over large proportions of the ecoregion and have habitat requirements that are clearly distinct from all other taxa of concern.

d) ***Local Species of concern that have very narrow distributions;*** typically limited to one BLM management jurisdiction. This also included species that do not fall within categories a-c. Individual species treated as Local are so indicated in Table B - 1.

A habitat-relationships database was developed that facilitated documentation of current knowledge for most candidate species CEs. Information captured within this database provides a reference for placement of each species into the above-mentioned categories for treatment within the REA. The database contains lists of the candidate taxa, coarse-filter ecosystems, and species assemblages, as well as a list of habitat attributes that can be used for developing species assemblages. Each taxon can be assigned to one or more ecosystems, assemblages, or habitat attributes, using the approach that best suits that taxon within the ecoregion. It was anticipated that this database will contribute towards subsequent BLM ecoregional direction and management phases where specialized knowledge of habitat requirements for at-risk species is desired.

Biologists from the Nevada Natural Heritage Program used the database to designate a species to either a coarse filter or a species assemblage, based on the knowledge of experts within the program as well as known distributions. Throughout the ecoregion, there are certain groups of species that naturally occur in certain habitats but those habitats are spread throughout multiple ecosystems. For example, cave and mine-roosting bats can be found throughout the ecoregion in a variety of habitats, from high elevations to low elevations as long as there is a suitable cave or mine to occupy. Using expert knowledge of such groups, biologists created some 20 species assemblages. Further review of the available data resulted in reducing this list to 9 species assemblages for spatial distribution modeling and assessment. Species that were strongly affiliated with a coarse filter were assigned to a coarse filter rather than a species assemblage. Species associated predominantly with “wet” sites were *a priori* assumed would all readily fall within either a coarse filter or an assemblage. As input to this expert-attribution process, GIS layers were used of the coarse filters and overlaid with known rare species occurrences. Habitat descriptions from published sources were also used and compared to coarse filter descriptions.

Table B - 1. Final list of species treated in the Mojave Basin & Range REA, with assessment approach identified. Landscape species are listed first; then the table is sorted by species found predominantly in upland habitats, by animals then plants, then by informal taxonomy and scientific name. Wetland associated species are listed secondly, animals then plants, by informal taxonomy and then by scientific name.

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
Landscape	Birds	Cooper's Hawk	Accipiter cooperii	No	Yes	G5	CA		PS	10
Landscape	Birds	Sage Sparrow	Amphispiza belli	No	Yes	G5	NV, UT		MV	2
Landscape	Birds	Golden Eagle	Aquila chrysaetos	No	Yes	G5	CA	CA, UT	PS	14
Landscape	Birds	Northern Harrier	Circus cyaneus	No	Yes	G5	AZ, CA			1
Landscape	Birds	Prairie Falcon	Falco mexicanus	No	Yes	G5	CA		PS	178
Landscape	Birds	Bald Eagle	Haliaeetus leucocephalus	No	Yes	G5	AZ, CA, NV, UT	CA, UT	PS	16
Landscape	Birds	Loggerhead Shrike	Lanius ludovicianus	No	Yes	G4	CA, NV		PS	34
Landscape	Birds	Sage Thrasher	Oreoscoptes montanus	No	Yes	G5	AZ, UT		MV	
Landscape	Birds	Brewer's Sparrow	Spizella breweri	No	Yes	G5	CA, NV, UT		MV	
Landscape	Mammals	Big Brown Bat	Eptesicus fuscus	No	No	G5		NV		49
Landscape	Mammals	Mule Deer	Odocoileus hemionus	No	Yes	G5	NV, UT	CBR, MBR	PS	
Landscape	Mammals	Desert Bighorn Sheep	Ovis canadensis nelsoni	No	Yes	T4	CA, NV	CA	PS	159
Landscape	Mammals	Bighorn Sheep - Peninsular Ranges	Ovis canadensis pop. 2	Yes	Yes	T3				4
Landscape	Mammals	Brazilian Free-tailed Bat	Tadarida brasiliensis	No	Yes	G5	AZ		PS	63
Landscape	Mammals	Kit Fox	Vulpes macrotis	Yes	Yes	G4	NV, UT	UT	PS	7
Landscape	Mammals	Mohave Ground Squirrel	Xerospermophilus mohavensis	No	Yes	G2	CA	CA		352
Landscape	Reptiles	Glossy Snake	Arizona elegans	No	No	G5	UT		PS	14
Landscape	Reptiles	Northern Rubber Boa	Charina bottae	No	No	G5	UT		PS	
Landscape	Reptiles	Western Banded Gecko	Coleonyx variegatus	No	Yes	G5	NV, UT	UT	MV	14
Landscape	Reptiles	Mohave Rattlesnake	Crotalus scutulatus	No	Yes	G5	UT	UT		8
Landscape	Reptiles	Great Basin Collared Lizard	Crotaphytus bicinctores	No	Yes	G5	NV		PS	5
Landscape	Reptiles	Desert Tortoise - Mohave Population	Gopherus agassizii	Yes	Yes	T3				1378
Landscape	Reptiles	Sonoran Desert Tortoise	Gopherus morafkai	Yes	Yes	T4				67
Landscape	Reptiles	Gila Monster	Heloderma suspectum	No	Yes	G4	UT	CA, UT	HV	339
Landscape	Reptiles	Common Kingsnake	Lampropeltis getula	No	No	G5	UT			13
Landscape	Reptiles	Coachwhip	Masticophis flagellum	No	No	G5	UT			20
Landscape	Reptiles	Western Patch-nosed Snake	Salvadora hexalepis	No	No	G5	UT		PS	17
Landscape	Reptiles	Northern Sagebrush Lizard	Sceloporus graciosus graciosus	No	No	T5	CA	AZ, CA		1
Species generally found in upland habitats										
Assemblage	Ants, Wasps, & Bees	Mojave Gypsum Bee	Andrena balsamorhizae	No	No	G2				50
Local	Ants, Wasps, & Bees	A Chrysidid Wasp	Ceratochrysis gracilis	No	No	G1				1
Local	Ants, Wasps, & Bees	Menke's Chrysidid Wasp	Ceratochrysis menkei	No	No	G1				
Local	Ants, Wasps, & Bees	Redheaded Sphecid Wasp	Eucerceris ruficeps	No	No	G2				
Local	Ants, Wasps, & Bees	An Ant	Lasius nevadensis	No	No	G1				1

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
Coarse Filter	Ants, Wasps, & Bees	Red-tailed Blazing Star Bee	Megandrena mentzeliae	No	No	G2				83
Local	Ants, Wasps, & Bees	An Ant	Neivamyrmex nyensis	No	No	G1				2
Local	Ants, Wasps, & Bees	A Cleptoparasitic Bee	Paranomada californica	No	No	G1				3
Local	Ants, Wasps, & Bees	Borrego Parnopes Chrysidid Wasp	Parnopes borregoensis	No	No	G1				1
Coarse Filter	Ants, Wasps, & Bees	Big-headed Perdita	Perdita cephalotes	No	No	G2				7
Coarse Filter	Ants, Wasps, & Bees	Mojave Poppy Bee	Perdita meconis	No	No	G2				35
Local	Ants, Wasps, & Bees	A Cleptoparasitic Bee	Rhopalolemma robertsi	No	No	G1				1
Coarse Filter	Birds	Northern Goshawk	Accipiter gentilis	No	Yes	G5	CA, NV, UT	CA, UT	MV	8
Coarse Filter	Birds	Sharp-shinned Hawk	Accipiter striatus	No	Yes	G5	CA		PS	
Coarse Filter	Birds	White-throated Swift	Aeronautes saxatalis	No	Yes	G5	NV		PS	
Local	Birds	American Pipit	Anthus rubescens	No	Yes	G5	AZ			
Local	Birds	Short-eared Owl	Asio flammeus	No	Yes	G5	CA, NV, UT	UT	PS	3
Local	Birds	Long-eared Owl	Asio otus	No	Yes	G5	CA			13
Local	Birds	Western Burrowing Owl	Athene cunicularia hypugaea	No	Yes	T4	NV	AZ	PS	565
Coarse Filter	Birds	Verdin	Auriparus flaviceps	No	Yes	G5	NV		PS	
Local	Birds	Oak Titmouse	Baeolophus inornatus	No	No	G5	CA			
Coarse Filter	Birds	Juniper Titmouse	Baeolophus ridgwayi	No	Yes	G5	NV			
Local	Birds	Common Black-Hawk	Buteogallus anthracinus	No	Yes	G4	AZ			4
Coarse Filter	Birds	Gambel's Quail	Callipepla gambelii	No	Yes	G5	UT		PS	
Coarse Filter	Birds	Costa's Hummingbird	Calypte costae	No	Yes	G5	CA, NV		IL	5
Local	Birds	Northern Cardinal	Cardinalis cardinalis	No	Yes	G5	CA			2
Assemblage	Birds	Cassin's Finch	Carpodacus cassinii	No	Yes	G5	AZ, NV		PS	
Coarse Filter	Birds	Swainson's Thrush	Catharus ustulatus	No	Yes	G5	AZ		PS	
Local	Birds	Vaux's Swift	Chaetura vauxi	No	Yes	G5	CA			
Local	Birds	Lark Sparrow	Chondestes grammacus	No	Yes	G5	CA			
Local	Birds	Lesser Nighthawk	Chordeiles acutipennis	No	Yes	G5				6
Assemblage	Birds	Evening Grosbeak	Coccothraustes vespertinus	No	Yes	G5	AZ			
Local	Birds	Gilded Flicker	Colaptes chrysoides	No	Yes	G5	CA	CA	PS	
Local	Birds	Inca Dove	Columbina inca	No	Yes	G5				4
Assemblage	Birds	Olive-sided Flycatcher	Contopus cooperi	No	Yes	G4	AZ, CA, NV		IL	
Assemblage	Birds	Grace's Warbler	Dendroica graciae	No	Yes	G5	NV		PS	
Coarse Filter	Birds	Black-throated Gray Warbler	Dendroica nigrescens	No	Yes	G5	UT			
Coarse Filter	Birds	Gray Flycatcher	Empidonax wrightii	No	Yes	G5				
Local	Birds	California Horned Lark	Eremophila alpestris actia	No	No	T3	CA			4
Local	Birds	Merlin	Falco columbarius	No	Yes	G5	CA			1
Local	Birds	Peregrine Falcon	Falco peregrinus	No	Yes	G4	NV, UT		PS	54
Coarse Filter	Birds	Greater Roadrunner	Geococcyx californianus	No	Yes	G5				2

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
Local	Birds	California Condor	Gymnogyps californianus	Yes	Yes	G1	AZ, CA, UT			
Coarse Filter	Birds	Pinyon Jay	Gymnorhinus cyanocephalus	No	Yes	G5	NV		PS	
Local	Birds	Yellow-breasted Chat	Icteria virens	No	Yes	G5	CA		PS	29
Coarse Filter	Birds	Hooded Oriole	Icterus cucullatus	No	Yes	G5				4
Local	Birds	Scott's Oriole	Icterus parisorum	No	Yes	G5	NV		PS	
Local	Birds	Gray-headed Junco	Junco hyemalis caniceps	No	No	T5	CA			10
Local	Birds	Acorn Woodpecker	Melanerpes formicivorus	No	Yes	G5				2
Coarse Filter	Birds	Gila Woodpecker	Melanerpes uropygialis	No	Yes	G5	CA	CA		6
Local	Birds	Lincoln's Sparrow	Melospiza lincolnii	No	Yes	G5	AZ			
Local	Birds	Elf Owl	Micrathene whitneyi	No	Yes	G5	CA	CA		6
Coarse Filter	Birds	Brown-crested Flycatcher	Myiarchus tyrannulus	No	Yes	G5	CA			8
Assemblage	Birds	Flammulated Owl	Otus flammeolus	No	Yes	G4	CA		PS	
Coarse Filter	Birds	Blue Grosbeak	Passerina caerulea	No	Yes	G5				5
Assemblage	Birds	Band-tailed Pigeon	Patagioenas fasciata	No	Yes	G4	UT		PS	6
Coarse Filter	Birds	Phainopepla	Phainopepla nitens	No	Yes	G5	NV		PS	203
Coarse Filter	Birds	Ladder-backed Woodpecker	Picoides scalaris	No	Yes	G5				1
Coarse Filter	Birds	Abert's Towhee	Pipilo aberti	No	Yes	G3	CA, NV, UT		IL	12
Coarse Filter	Birds	Green-tailed Towhee	Pipilo chlorurus	No	Yes	G5	AZ		PS	
Local	Birds	Inyo California Towhee	Pipilo crissalis eremophilus	Yes	Yes	T1	CA	CA		35
Coarse Filter	Birds	Summer Tanager	Piranga rubra	No	Yes	G5	CA			15
Coarse Filter	Birds	Black-tailed Gnatcatcher	Polioptila melanura	No	Yes	G5	CA			10
Coarse Filter	Birds	Vermilion Flycatcher	Pyrocephalus rubinus	No	Yes	G5	CA		PS	20
Assemblage	Birds	Ruby-crowned Kinglet	Regulus calendula	No	Yes	G5	AZ			
Local	Birds	Golden-crowned Kinglet	Regulus satrapa	No	Yes	G5	AZ			
Local	Birds	Bank Swallow	Riparia riparia	No	Yes	G5	CA	CA	MV	
Local	Birds	Broad-tailed Hummingbird	Selasphorus platycercus	No	Yes	G5	UT		PS	
Local	Birds	Rufous Hummingbird	Selasphorus rufus	No	Yes	G5	CA, NV		PS	
Assemblage	Birds	Pygmy Nuthatch	Sitta pygmaea	No	Yes	G5				
Coarse Filter	Birds	Red-naped Sapsucker	Sphyrapicus nuchalis	No	Yes	G5	AZ			
Coarse Filter	Birds	Red-breasted Sapsucker	Sphyrapicus ruber	No	Yes	G5	CA, NV		PS	
Coarse Filter	Birds	Williamson's Sapsucker	Sphyrapicus thyroideus	No	Yes	G5	UT		PS	1
Coarse Filter	Birds	Lesser Goldfinch	Spinus psaltria	No	Yes	G5				
Coarse Filter	Birds	Black-chinned Sparrow	Spizella atrogularis	No	Yes	G5	CA, NV		PS	
Coarse Filter	Birds	Chipping Sparrow	Spizella passerina	No	Yes	G5	CA			
Coarse Filter	Birds	Calliope Hummingbird	Stellula calliope	No	Yes	G5			PS	
Local	Birds	Mexican Spotted Owl	Strix occidentalis lucida	Yes	Yes	T3	AZ, UT			6
Coarse Filter	Birds	Tree Swallow	Tachycineta bicolor	No	Yes	G5	AZ			

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
Coarse Filter	Birds	Bendire's Thrasher	Toxostoma bendirei	No	Yes	G4	CA, NV, UT	CA	PS	84
Coarse Filter	Birds	Crissal Thrasher	Toxostoma crissale	No	Yes	G5	CA, NV, UT		IL	25
Coarse Filter	Birds	Le Conte's Thrasher	Toxostoma lecontei	No	Yes	G4	AZ, CA, NV	CA	PS	177
Coarse Filter	Birds	American Robin	Turdus migratorius	No	Yes	G5				
Coarse Filter	Birds	Cassin's Kingbird	Tyrannus vociferans	No	Yes	G5				
Coarse Filter	Birds	Orange-crowned Warbler	Vermivora celata	No	Yes	G5	AZ			
Coarse Filter	Birds	Lucy's Warbler	Vermivora luciae	No	Yes	G5	CA, NV, UT	CA	PS	1
Coarse Filter	Birds	Virginia's Warbler	Vermivora virginiae	No	Yes	G5	CA, NV, UT		PS	5
Coarse Filter	Birds	Gray Vireo	Vireo vicinior	No	Yes	G4	CA, NV, UT	CA	PS	34
Coarse Filter	Birds	White-winged Dove	Zenaida asiatica	No	Yes	G5				
Coarse Filter	Birds	White-crowned Sparrow	Zonotrichia leucophrys	No	Yes	G5	AZ			
Local	Butterflies & Skippers	Desert Green Hairstreak	Callophrys comstocki	No	No	G2				
Local	Butterflies & Skippers	Spring Mountains Acastus Checkerspot	Chlosyne acastus robusta	No	No	T1		NV		74
Local	Butterflies & Skippers	Giuliani's Blue	Euphilotes ancilla giulianii	No	No	T3		NV		13
Local	Butterflies & Skippers	Square-dotted Blue	Euphilotes battoides	Yes	No	G5				
Local	Butterflies & Skippers	Mojave Blue	Euphilotes mojave virginensis	No	No	T1		NV		
Local	Butterflies & Skippers	Mcneill's Saltbush Sootywing	Hesperopsis gracielae	No	No	G2		AZ		19
Local	Butterflies & Skippers	San Emigdio Blue	Plebulina emigdionis	No	No	G2				5
Local	Butterflies & Skippers	Eunus Skipper	Pseudocopaeodes eunus alinea	No	No	T2		NV		
Local	Butterflies & Skippers	Carol's Fritillary	Speyeria carolae	No	No	G2				143
Local	Grasshoppers	Desert Monkey Grasshopper	Psychomastax deserticola	No	No	G1				4
Local	Katydids & Crickets	Kelso Jerusalem Cricket	Ammopelmatus kelsoensis	No	No	G1				2
Local	Katydids & Crickets	Kelso Giant Sand Treader Cricket	Macrobaenetes kelsoensis	No	No	G1				2
Local	Katydids & Crickets	Coachella Giant Sand Treader Cricket	Macrobaenetes valgum	No	No	G1				8
Local	Katydids & Crickets	Coachella Valley Jerusalem Cricket	Stenopelmatus cahuilaensis	No	No	G1				2
Local	Mammals	Pallid Bat	Antrozous pallidus	No	Yes	G5	CA	CA		116
Coarse Filter	Mammals	Ringtail	Bassariscus astutus	No	No	G5	NV		PS	5
Local	Mammals	Dulzura California Pocket Mouse	Chaetodipus californicus femoralis	No	No	T3	CA			1
Local	Mammals	Northwestern San Diego Pocket Mouse	Chaetodipus fallax fallax	No	No	T3	CA			10
Local	Mammals	Pallid San Diego Pocket Mouse	Chaetodipus fallax pallidus	No	No	T3	CA			55
Coarse Filter	Mammals	Desert Pocket Mouse	Chaetodipus penicillatus	No	No	G5	NV		MV	9
Local	Mammals	Mexican Long-tongued Bat	Choeronycteris mexicana	No	Yes	G4	AZ, CA			
Local	Mammals	Townsend's Big-eared Bat	Corynorhinus townsendii	No	Yes	G4	CA, NV, UT	CA, UT	PS	162
Assemblage	Mammals	Desert Kangaroo Rat	Dipodomys deserti	No	No	G5	NV, UT		PS	12
Local	Mammals	Merriam's Kangaroo Rat	Dipodomys merriami	Yes	No	G5				27
Local	Mammals	Earthquake Merriam's Kangaroo Rat	Dipodomys merriami collinus	No	No	T1	CA			2

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
Coarse Filter	Mammals	Panamint Kangaroo Rat	Dipodomys panamintinus	No	No	G5	NV			
Local	Mammals	Argus Mountains Kangaroo Rat	Dipodomys panamintinus argusensis	No	No	T2	CA			8
Local	Mammals	Panamint Kangaroo Rat	Dipodomys panamintinus panamintinus	No	No	T3	CA			6
Local	Mammals	Stephens's Kangaroo Rat	Dipodomys stephensi	Yes	Yes	G2	CA	CA		2
Coarse Filter	Mammals	Spotted Bat	Euderma maculatum	No	Yes	G4	AZ, CA, NV, UT	CA, UT	PS	51
Local	Mammals	Greater Bonneted Bat	Eumops perotis	No	Yes	G5	CA			21
Local	Mammals	San Bernardino Flying Squirrel	Glaucomys sabrinus californicus	No	No	T2	CA			4
Local	Mammals	Allen's Big-eared Bat	Idionycteris phyllotis	No	Yes	G3	NV, UT	AZ, UT	PS	28
Assemblage	Mammals	Silver-haired Bat	Lasionycteris noctivagans	No	No	G5	CA		PS	26
Coarse Filter	Mammals	Western Red Bat	Lasiurus blossevillii	No	Yes	G5	AZ, CA, NV, UT	UT	PS	7
Assemblage	Mammals	Hoary Bat	Lasiurus cinereus	No	No	G5	CA, NV		IL	38
Local	Mammals	Western Yellow Bat	Lasiurus xanthinus	No	Yes	G5	AZ, CA, NV		PS	17
Local	Mammals	Californian Leaf-nosed Bat	Macrotus californicus	No	Yes	G4	AZ, CA, NV	CA	PS	46
Local	Mammals	Mohave Vole	Microtus californicus mohavensis	No	No	T1	CA			6
Local	Mammals	Amargosa Vole	Microtus californicus scirpensis	Yes	Yes	T1	CA	CA		7
Local	Mammals	Owens Valley Vole	Microtus californicus vallicola	No	No	T1	CA	CA		9
Local	Mammals	Ash Meadows Montane Vole	Microtus montanus nevadensis	No	Yes	TH			PS	3
Local	Mammals	Western Small-footed Myotis	Myotis ciliolabrum	No	No	G5	CA, NV	AZ, CA	PS	46
Assemblage	Mammals	Long-eared Myotis	Myotis evotis	No	No	G5	CA	AZ, CA	IL	29
Assemblage	Mammals	Little Brown Myotis	Myotis lucifugus	No	No	G5	CA, NV	AZ	IL	3
Local	Mammals	Arizona Myotis	Myotis occultus	No	No	G3	CA			1
Local	Mammals	Fringed Myotis	Myotis thysanodes	No	Yes	G4	CA, NV, UT	AZ, CA, UT	IL	56
Local	Mammals	Cave Myotis	Myotis velifer	No	No	G5	CA, NV	AZ, CA	PS	4
Assemblage	Mammals	Long-legged Myotis	Myotis volans	No	No	G5	CA	AZ		54
Local	Mammals	Yuma Myotis	Myotis yumanensis	No	No	G5	CA, UT	CA		33
Local	Mammals	Cliff Chipmunk	Neotamias dorsalis	No	Yes	G5				
Local	Mammals	Palmer's Chipmunk	Neotamias palmeri	No	Yes	G2	NV		HV	27
Local	Mammals	Kingston Mountain Chipmunk	Neotamias panamintinus acrus	No	No	T1	CA			11
Local	Mammals	Lodgepole Chipmunk	Neotamias speciosus speciosus	No	No	T2	CA			15
Local	Mammals	Hidden Forest Chipmunk	Neotamias umbrinus nevadensis	No	Yes	TH	NV		MV	3
Local	Mammals	Colorado Valley Woodrat	Neotoma albigula venusta	No	No	T3	CA			1
Local	Mammals	San Diego Desert Woodrat	Neotoma lepida intermedia	No	No	T3	CA			32
Coarse Filter	Mammals	Stephens's Woodrat	Neotoma stephensi	No	No	G5	UT			
Local	Mammals	Crawford's Gray Shrew	Notiosorex crawfordi	No	No	G5	UT		PS	4
Local	Mammals	Pocketed Free-tailed Bat	Nyctinomops femorosaccus	No	No	G4	CA	AZ		11
Local	Mammals	Big Free-tailed Bat	Nyctinomops macrotis	No	Yes	G5	AZ, CA, NV,	AZ, UT	PS	11

Assessment Approach	Taxonomic Group	Common Name	Scientific Name	Federally Listed	State Protected	Rounded Global Rank	Relevant SWAPs	Relevant BLM Special Status	NatureServe Climate Change Vulnerability Index	# of Element Occurrences
							UT			
Local	Mammals	Western Pipistrelle	Parastrellus hesperus	No	Yes	G5	AZ			65
Local	Mammals	White-eared Pocket Mouse	Perognathus alticolus alticolus	No	No	TH	CA			
Local	Mammals	Tehachapi Pocket Mouse	Perognathus alticolus inexpectatus	No	No	T1	CA			7
Local	Mammals	San Joaquin Pocket Mouse	Perognathus inornatus inornatus	No	No	T2	CA			5
Local	Mammals	Palm Springs Little Pocket Mouse	Perognathus longimembris bangsi	No	No	T2	CA	CA		10
Local	Mammals	Los Angeles Pocket Mouse	Perognathus longimembris brevinasus	No	No	T1	CA			6
Local	Mammals	Yellow-eared Pocket Mouse	Perognathus parvus xanthonotus	No	No	T2	CA	CA		7
Local	Mammals	Brush Deermouse	Peromyscus boylii	No	No	G5	NV		PS	
Coarse Filter	Mammals	Picon Deermouse	Peromyscus truei	No	No	G5				
Local	Mammals	Merriam's Shrew	Sorex merriami leucogenys	No	No	T5	NV		PS	3
Local	Mammals	Inyo Shrew	Sorex tenellus	No	No	G3	NV		PS	11
Coarse Filter	Mammals	Rock Squirrel	Spermophilus variegatus	No	Yes	G5				
Local	Mammals	American Badger	Taxidea taxus	No	No	G5	CA			51
Local	Mammals	Palm Springs Round-tailed Ground Squirrel	Xerospermophilus tereticaudus chlorus	No	No	T2	CA	CA	PS (species)	9
Local	Other Beetles	Aegialian Scarab Beetle	Aegialia knighti	No	No	G1				2
Local	Other Beetles	Large Aegialian Scarab Beetle	Aegialia magnifica	No	No	G1				2
Local	Other Beetles	Big Dune Aphodius Scarab Beetle	Aphodius sp. 1	No	No	G1		NV		
Local	Other Beetles	Valley Elderberry Longhorn Beetle	Desmocerus californicus dimorphus	Yes	No	T2				3
Local	Other Beetles	Casey's June Beetle	Dinacoma caseyi	Yes	No	G1				
Local	Other Beetles	Kelso Dune Glaresis Scarab Beetle	Glaresis arenata	No	No	G2				
Local	Other Beetles	Nelson's Miloderes Weevil	Miloderes nelsoni	No	No	G2				2
Local	Other Beetles	Rulien's Miloderes Weevil	Miloderes sp. 1	No	No	G1				2
Local	Other Beetles	Saline Valley Snow-front Scarab Beetle	Polyphylla anteronivea	No	No	G1				1
Local	Other Beetles	Spotted Warner Valley Dunes Scarab Beetle	Polyphylla avittata	No	No	G2				2
Local	Other Beetles	A Polyphyllan Scarab Beetle	Polyphylla erratica	No	No	G1				4
Local	Other Beetles	Giuliani's Dune Scarab Beetle	Pseudocotalpa giulianii	No	No	G1				4
Local	Other Beetles	Brown-tassel Trigonoscuta Weevil	Trigonoscuta brunnotesselata	No	No	G1				
Local	Other Insects	Lacewing or Ally	Oliarces clara	No	No	G2		AZ		3
Local	Reptiles	Silvery Legless Lizard	Anniella pulchra pulchra	No	No	T3	CA			12
Local	Reptiles	Plateau Striped Whiptail	Aspidoscelis velox	No	No	G5	UT			6
Coarse Filter	Reptiles	Zebra-tailed Lizard	Callisaurus draconoides	No	Yes	G5	UT	UT		41
Local	Reptiles	Southern Rubber Boa	Charina umbratica	No	Yes	G2	CA			27
Local	Reptiles	Western Diamond-backed Rattlesnake	Crotalus atrox	No	No	G5	NV		PS	

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Assemblage	Reptiles	Sidewinder	Crotalus cerastes	No	Yes	G5	UT	UT	MV	12
Local	Reptiles	Speckled Rattlesnake	Crotalus mitchellii	No	Yes	G5	UT	UT	PS	2
Local	Reptiles	Red Diamond Rattlesnake	Crotalus ruber ruber	No	No	T5	CA			17
Local	Reptiles	Ring-necked Snake	Diadophis punctatus	No	Yes	G5	UT		MV	7
Assemblage	Reptiles	Desert Iguana	Dipsosaurus dorsalis	No	Yes	G5	NV, UT	UT	MV	2
Local	Reptiles	Panamint Alligator Lizard	Elgaria panamintina	No	No	G2	CA	CA	PS	8
Local	Reptiles	Long-nosed Leopard Lizard	Gambelia wislizenii	No	No	G5	NV, UT		PS	7
Coarse Filter	Reptiles	Western Threadsnake	Leptotyphlops humilis	No	Yes	G5	UT	UT		8
Local	Reptiles	Rosy Boa	Lichanura trivirgata	No	No	G4	CA	AZ	PS	17
Local	Reptiles	Flat-tailed Horned Lizard	Phrynosoma mcallii	Yes	Yes	G3	AZ, CA	CA		12
Local	Reptiles	Desert Horned Lizard	Phrynosoma platyrhinos	No	No	G5	NV		PS	
Assemblage	Reptiles	Spotted Leaf-nosed Snake	Phyllorhynchus decurtatus	No	No	G5	UT		PS	1
Local	Reptiles	Gilbert's Skink	Plestiodon gilberti	No	No	G5	NV		PS	14
Local	Reptiles	Long-nosed Snake	Rhinocheilus lecontei	No	Yes	G5	UT		PS	6
Local	Reptiles	Common Chuckwalla	Sauromalus ater	No	Yes	G5	CA, NV, UT	UT	MV	15
Local	Reptiles	Western chuckwalla	Sauromalus ater pop. 2	No	No	GNR		AZ (at species level)	FOR SPECIES	
Local	Reptiles	Groundsnake	Sonora semiannulata	No	Yes	G5	UT			22
Local	Reptiles	Smith's Black-headed Snake	Tantilla hobartsmithi	No	No	G5	AZ, UT		PS	13
Local	Reptiles	Two-striped Gartersnake	Thamnophis hammondii	No	No	G4	CA	CA	PS (for species	11
Local	Reptiles	Western Lyresnake	Trimorphodon biscutatus	No	No	G5	UT		MV	
Local	Reptiles	Sonoran Lyresnake	Trimorphodon lambda	No	No	G5	NV		FOR SPECIES/SUB	4
Local	Reptiles	Coachella Valley Fringe-toed Lizard	Uma inornata	Yes	Yes	G1	CA	CA		115
Assemblage	Reptiles	Mojave Fringe-toed Lizard	Uma scoparia	No	Yes	G3	AZ, CA	CA		23
Local	Reptiles	long-tailed brush lizard	Urosaurus graciosus	No	No	G5	NV		HV	
Coarse Filter	Reptiles	Desert Night Lizard	Xantusia vigilis	No	Yes	G5	AZ, UT	UT	MV	16
Local	Terrestrial Snails	Morongo Desertsnail	Eremarionta morongoana	No	No	G2				1
Local	Tiger Beetles	Mojave Giant Tiger Beetle	Amblycheila schwarzi	No	No	G3				1
Local	Conifers & relatives	Death Valley Mormon-tea	Ephedra funerea	No	No	G2				8
Coarse Filter	Conifers & relatives	Bristlecone Pine	Pinus longaeva	No	Yes	G4				
Local	Ferns & relatives	Utah Spike-moss	Selaginella utahensis	No	No	G2				8
Local	Flowering Plants		Allium marvinii	No	No	G1				
Assemblage	Flowering Plants	Charleston Pussytoes	Antennaria soliceps	No	No	G1				44
Local	Flowering Plants	Unequal Rockcress	Arabis dispar	No	No	G3				51
Local	Flowering Plants	Parish's Rockcress	Arabis parishii	No	No	G2				52
Local	Flowering Plants	Darwin Rock Cress	Arabis pulchra var. munciensis	No	No	T4		CA		6
Local	Flowering Plants	Shockley's Rockcress	Arabis shockleyi	No	No	G3				121

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Assemblage	Flowering Plants	Las Vegas Bear-poppy	Arctomecon californica	No	Yes	G3		NV		390
Local	Flowering Plants	Dwarf Bear-poppy	Arctomecon humilis	Yes	No	G1				14
Coarse Filter	Flowering Plants	White Bear-poppy	Arctomecon merriamii	No	No	G3				445
Local	Flowering Plants	Meadow Valley Sandwort	Arenaria stenomeres	No	No	G2				44
Assemblage	Flowering Plants	Ackerman's Milkvetch	Astragalus ackermanii	No	No	G2				19
Coarse Filter	Flowering Plants	Clokey's Milkvetch	Astragalus aequalis	No	No	G2		NV		84
Local	Flowering Plants	Cushenbury Milkvetch	Astragalus albens	Yes	No	G1		CA		21
Coarse Filter	Flowering Plants	Sheep Mountain Milkvetch	Astragalus amphioxys var. musimonum	No	No	T2		NV		32
Local	Flowering Plants		Astragalus ampullarioides	Yes	No	G1				6
Local	Flowering Plants	Gumbo Milkvetch	Astragalus ampullarius	No	No	G2				2
Local	Flowering Plants	Darwin Mesa Milkvetch	Astragalus atratus var. mensanus	No	No	T2		CA		13
Local	Flowering Plants	Cima Milkvetch	Astragalus cimae var. cimae	No	No	T2		NV		27
Local	Flowering Plants	Pagumpa Milkvetch	Astragalus ensiformis var. gracilior	No	No	T1		NV		12
Local	Flowering Plants	Black Milkvetch	Astragalus funereus	No	No	G2		CA, NV		35
Assemblage	Flowering Plants	Sand Milkvetch	Astragalus geyeri var. triquetrus	No	Yes	T2		AZ, NV		774
Local	Flowering Plants	Gilman's Milkvetch	Astragalus gilmanii	No	No	G2				20
Local	Flowering Plants	Holmgren's Milkvetch	Astragalus holmgreniorum	Yes	Yes	G1				7
Local	Flowering Plants	Lane Mountain Milkvetch	Astragalus jaegerianus	Yes	No	G1		CA		36
Assemblage	Flowering Plants	Mottled Milkvetch	Astragalus lentiginosus var. stramineus	No	No	T2		NV		17
Local	Flowering Plants	Big Bear Valley Woollypod	Astragalus leucolobus	No	No	G2				75
Local	Flowering Plants	Half-ring Pod Milkvetch	Astragalus mohavensis var. hemigyrus	No	No	T2		NV		276
Coarse Filter	Flowering Plants	Mokiah Milkvetch	Astragalus mokiacensis	No	No	G2		NV		15
Local	Flowering Plants	Nye Milkvetch	Astragalus nyensis	No	No	G3				61
Assemblage	Flowering Plants	Charleston Milkvetch	Astragalus oophorus var. clokeyanus	No	No	T2		NV		55
Local	Flowering Plants	Ash Meadows Milkvetch	Astragalus phoenix	Yes	Yes	G2		NV		514
Coarse Filter	Flowering Plants	Spring Mountain Milkvetch	Astragalus remotus	No	No	G2		NV		363
Local	Flowering Plants	Silver Reef Milkvetch	Astragalus straturensis	No	No	G2				11
Local	Flowering Plants	Triple-rib Milkvetch	Astragalus tricarinatus	Yes	No	G1		CA		19
Local	Flowering Plants		Atriplex argentea var. longitrichoma	No	No	T1		NV		11
Local	Flowering Plants	Parish's Saltbush	Atriplex parishii	No	No	G1				1
Local	Flowering Plants	Kofka Barberry	Berberis harrisoniana	No	No	G1		AZ, CA		1
Assemblage	Flowering Plants	Last Chance Rock Cress	Boechera yorkii	No	No	G1				3
Local	Flowering Plants	Panamint Mountain Mariposa Lily	Calochortus panamintensis	No	No	G3				3
Local	Flowering Plants	Plummer's Mariposa-lily	Calochortus plummerae	No	No	G3				1
Local	Flowering Plants	Alkali Mariposa-lily	Calochortus striatus	No	No	G2		CA, NV		162
Local	Flowering Plants	Baird's Camissonia	Camissonia bairdii	No	No	G1				4
Local	Flowering Plants	Diamond Valley Suncup	Camissonia gouldii	No	No	G1				2

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Local	Flowering Plants	Intermountain Evening-primrose	Camissonia megalantha	No	No	G3		NV		61
Local	Flowering Plants	White Canbya	Canbya candida	No	No	G3				33
Local	Flowering Plants	Hays' Sedge	Carex haysii	No	No	G1				1
Local	Flowering Plants	Crucifixion Thorn	Castela emoryi	No	Yes	G3				30
Local	Flowering Plants	Ash Grey Indian-paintbrush	Castilleja cinerea	Yes	No	G2				47
Local	Flowering Plants	San Bernardino Owl's-clover	Castilleja lasiorhyncha	No	No	G2				35
Local	Flowering Plants	Jaeger's Caulostramina	Caulostramina jaegeri	No	No	G1		CA		8
Local	Flowering Plants	Spring-loving Centaury	Centaurium namophilum	Yes	Yes	G2		NV		554
Local	Flowering Plants	Flatseed Spurge	Chamaesyce platysperma	No	No	G3		CA		2
Assemblage	Flowering Plants	Pintwater Rabbitbrush	Chrysothamnus eremobius	No	No	G1				8
Local	Flowering Plants	Clokey's Thistle	Cirsium clokeyi	No	No	G2				67
Coarse Filter	Flowering Plants		Coryphantha chlorantha	No	No	G2				45
Local	Flowering Plants	Clokey's Cat's-eye	Cryptantha clokeyi	No	No	G1		CA		18
Local	Flowering Plants	Unusual Cat's-eye	Cryptantha insolita	No	Yes	GH		NV		4
Local	Flowering Plants	Pipe Springs Cryptantha	Cryptantha semiglabra	No	No	G1				
Local	Flowering Plants	Desert Cymopterus	Cymopterus deserticola	No	No	G3		CA		82
Local	Flowering Plants	Sanicle Biscuitroot	Cymopterus ripleyi var. saniculoides	No	No	T3		CA		66
Local	Flowering Plants	July Gold	Dedeckera eurekensis	No	Yes	G2		CA		18
Local	Flowering Plants	Jaeger Whitlowgrass	Draba jaegeri	No	No	G2				55
Local	Flowering Plants	Charleston Draba	Draba paucifructa	No	No	G1				69
Local	Flowering Plants	Panamint Dudleya	Dudleya saxosa ssp. saxosa	No	No	T3		CA		12
Local	Flowering Plants	Engelmann's Hedgehog Cactus	Echinocereus engelmannii var. armatus	No	Yes	T2				
Local	Flowering Plants	Howe's Hedgehog Cactus	Echinocereus engelmannii var. howei	No	No	T1		CA		4
Assemblage	Flowering Plants	Silver-leaf Sunray	Enceliopsis argophylla	No	No	G2		AZ		26
Local	Flowering Plants	Panamint Daisy	Enceliopsis covillei	No	No	G3		CA		11
Local	Flowering Plants	Ash Meadows Sunray	Enceliopsis nudicaulis var. corrugata	Yes	Yes	T2		NV		1758
Assemblage	Flowering Plants	Nevada Willowherb	Epilobium nevadense	No	No	G2		NV		20
Local	Flowering Plants	Deer Goldenweed	Ericameria cervina	No	No	G3		NV		10
Assemblage	Flowering Plants	Charleston Mountain Heath-goldenrod	Ericameria compacta	No	No	G2				48
Local	Flowering Plants	Gilman Goldenweed	Ericameria gilmanii	No	No	G1		CA		8
Local	Flowering Plants	Bald Daisy	Erigeron calvus	No	No	G1				1
Assemblage	Flowering Plants	Sheep Fleabane	Erigeron ovinus	No	No	G2		NV		32
Local	Flowering Plants	Parish's Daisy	Erigeron parishii	Yes	No	G2		CA		35
Coarse Filter	Flowering Plants	Forked Buckwheat	Eriogonum bifurcatum	No	No	G2		CA, NV		95
Assemblage	Flowering Plants	Darin Buckwheat	Eriogonum concinnum	No	No	G2		NV		35
Local	Flowering Plants	Reveal's Buckwheat	Eriogonum contiguum	No	No	G2		CA		32

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Assemblage	Flowering Plants	Crispleaf Wild Buckwheat	Eriogonum corymbosum var. nilesii	Yes	No	T2		NV		207
Local	Flowering Plants	Wildrose Canyon Buckwheat	Eriogonum eremicola	No	No	G1		CA		10
Local	Flowering Plants	Thorne's Buckwheat	Eriogonum ericifolium var. thornei	No	Yes	T1				2
Local	Flowering Plants	Gilman's Buckwheat	Eriogonum gilmanii	No	No	G2				20
Local	Flowering Plants	Heermann's Buckwheat	Eriogonum heermannii var. clokeyi	No	No	T2		NV		21
Local	Flowering Plants	Hoffmann's Buckwheat	Eriogonum hoffmannii var. hoffmannii	No	No	T2		CA		5
Local	Flowering Plants	Jointed Buckwheat	Eriogonum intrafractum	No	No	G2				16
Local	Flowering Plants	Panamint Mountains Buckwheat	Eriogonum microthecum var. panamintense	No	No	T2		CA		10
Assemblage	Flowering Plants	Sticky Buckwheat	Eriogonum viscidulum	No	Yes	G2		AZ, NV		147
Local	Flowering Plants	Barstow Wooly-sunflower	Eriophyllum mohavense	No	No	G2		CA		63
Local	Flowering Plants	Twisselmann's Poppy	Eschscholzia minutiflora ssp. twisselmannii	No	No	T2		CA		25
Local	Flowering Plants	Cushion Fox-tail Cactus	Escobaria alversonii	No	No	G3				43
Local	Flowering Plants	Viviparous Foxtail Cactus	Escobaria vivipara var. rosea	No	Yes	T3				20
Coarse Filter	Flowering Plants	California flannelbush	Fremontodendron californicum	No	Yes	G4		AZ		
Local	Flowering Plants	Kingston Bedstraw	Galium hilendiae ssp. kingstonense	No	No	T2		CA		16
Local	Flowering Plants	Little San Bernardino Mountains gilia	Gilia maculata	No	No	G1				29
Assemblage	Flowering Plants	Ripley's Gilia	Gilia ripleyi	No	No	G3				113
Local	Flowering Plants	Golden Carpet	Gilmania luteola	No	No	G1				16
Assemblage	Flowering Plants	Clokey's Greasebush	Glossopetalon clokeyi	No	No	G2				34
Assemblage	Flowering Plants	Pacific Greasebush	Glossopetalon pungens	No	No	G2		CA		1
Assemblage	Flowering Plants	Smooth Dwarf Greasebush	Glossopetalon pungens var. glabrum	No	No	T1		CA, NV		24
Assemblage	Flowering Plants	Pacific Greasebush	Glossopetalon pungens var. pungens	No	No	T2		NV		15
Assemblage	Flowering Plants	Utah Sunflower	Helianthus deserticola	No	No	G2				10
Local	Flowering Plants	Red Rock tarplant	Hemizonia arida	No	Yes	G1				9
Local	Flowering Plants	Mohave Tarplant	Hemizonia mohavensis	No	Yes	G2				15
Local	Flowering Plants	Parish's Alumroot	Heuchera parishii	No	No	G2				4
Local	Flowering Plants	Rock Lady	Holmgrenanthe petrophila	No	Yes	G1				10
Local	Flowering Plants	Sanderson's Cheesebush	Hymenoclea sandersonii	No	No	G1				1
Assemblage	Flowering Plants	Spring Mountain Ankle-aster	Ionactis caelestis	No	No	G1		NV		5
Local	Flowering Plants	Silver-haired Ivesia	Ivesia argyrocoma	No	No	G2				41
Assemblage	Flowering Plants	Rock Purpusia	Ivesia arizonica var. saxosa	No	No	T1		NV		2
Assemblage	Flowering Plants	Hidden Ivesia	Ivesia cryptocaulis	No	No	G2				24
Assemblage	Flowering Plants	Jaeger's Ivesia	Ivesia jaegeri	No	No	G2		CA, NV		116
Local	Flowering Plants	Kingston Mountains Ivesia	Ivesia patellifera	No	No	G1		CA		7
Local	Flowering Plants	Bullfrog Hills Sweetpea	Lathyrus hitchcockianus	No	No	G2		NV		26
Assemblage	Flowering Plants	Hitchcock's Bladderpod	Lesquerella hitchcockii	No	No	G3				128

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Local	Flowering Plants	Lemon Lily	Lilium parryi	No	Yes	G3				29
Local	Flowering Plants	San Gabriel Linanthus	Linanthus concinnus	No	No	G2				13
Local	Flowering Plants	Baldwin Lake Linanthus	Linanthus killipii	No	No	G2				21
Local	Flowering Plants	Orcutt's Linanthus	Linanthus orcuttii	No	No	G4		CA		8
Local	Flowering Plants	Sage-like Loeflingia	Loeflingia squarrosa ssp. artemisiarum	No	No	T2		NV		19
Local	Flowering Plants	Wright's Hosackia	Lotus argyraeus var. multicaulis	No	No	T1		CA, NV		25
Local	Flowering Plants	Holmgren Lupine	Lupinus holmgrenianus	No	No	G2		NV		13
Local	Flowering Plants	Panamint Mountains Lupine	Lupinus magnificus var. magnificus	No	No	T1		CA		13
Local	Flowering Plants	Davidson's Bushmallow	Malacothamnus davidsonii	No	No	G1				3
Local	Flowering Plants	Ash Meadows Blazingstar	Mentzelia leucophylla	Yes	Yes	G1		NV		189
Local	Flowering Plants	Polished Blazingstar	Mentzelia polita	No	No	G2		CA, NV		25
Local	Flowering Plants	Three-tooth Blazingstar	Mentzelia tridentata	No	No	G2		CA		26
Local	Flowering Plants	San Bernardino Mountain Monkeyflower	Mimulus exiguus	No	No	G2				18
Local	Flowering Plants	Mojave Monkeyflower	Mimulus mohavensis	No	No	G2		CA		58
Local	Flowering Plants	Little Purple Monkeyflower	Mimulus purpureus	No	No	G2				18
Local	Flowering Plants	Bashful Four-o'clock	Mirabilis pudica	No	No	G3				12
Local	Flowering Plants	Robison's Monardella	Monardella robisonii	No	No	G2		CA		36
Local	Flowering Plants	California Muhly	Muhlenbergia californica	No	No	G3				2
Local	Flowering Plants	Eureka Dunes Evening-primrose	Oenothera californica ssp. eurekensis	Yes	Yes	T1				3
Local	Flowering Plants	Cave Evening-primrose	Oenothera cavernae	No	No	G2				4
Local	Flowering Plants	Golden Prickly-pear	Opuntia aurea	No	Yes	G3				3
Assemblage	Flowering Plants	Blue Diamond Cholla	Opuntia whipplei var. multigeniculata	No	Yes	T2		NV		85
Local	Flowering Plants	Woolly Mountain-parsley	Oreonana vestita	No	No	G3				11
Local	Flowering Plants	Fringed Grass-of-Parnassus	Parnassia cirrata	No	No	G2				1
Local	Flowering Plants	Siler Pincushion Cactus	Pediocactus sileri	Yes	Yes	G3				15
Local	Flowering Plants	Beaver Scurf-pea	Pediomelum castoreum	No	No	G3				93
Assemblage	Flowering Plants	White-margin Beardtongue	Penstemon albomarginatus	No	Yes	G2		AZ, CA, NV		97
Assemblage	Flowering Plants	Pinto beardtongue	Penstemon bicolor	No	No	G3		AZ		58
Assemblage	Flowering Plants	Bicolored Beardtongue	Penstemon bicolor ssp. bicolor	No	No	T2		NV		193
Assemblage	Flowering Plants	Rosy Bicolored Beardtongue	Penstemon bicolor ssp. roseus	No	Yes	T3		CA, NV		249
Local	Flowering Plants	Limestone Beardtongue	Penstemon calcareus	No	No	G2				24
Local	Flowering Plants	Death Valley Beardtongue	Penstemon fruticiformis ssp. amargosae	No	No	T3		NV		93
Assemblage	Flowering Plants	Pahute Mesa Beardtongue	Penstemon pahutensis	No	No	G3		NV		56
Local	Flowering Plants	Petiolate Beardtongue	Penstemon petiolatus	No	No	G2		AZ		13
Local	Flowering Plants	Stephen's Beardtongue	Penstemon stephensii	No	No	G2		CA		26
Local	Flowering Plants	Jaeger's Beardtongue	Penstemon thompsoniae ssp. jaegeri	No	No	T2		NV		93

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Local	Flowering Plants	Inyo Rock Daisy	Perityle inyoensis	No	No	G2		CA		7
Local	Flowering Plants	Hanaupah rock daisy	Perityle villosa	No	No	G1		CA		7
Local	Flowering Plants	Parry Sandpaper-plant	Petalonyx parryi	No	No	G2				6
Local	Flowering Plants	Death Valley Sandpaper-plant	Petalonyx thurberi ssp. gilmanii	No	No	T2		CA		19
Local	Flowering Plants	Aven Nelson's Phacelia	Phacelia anelsonii	No	No	G2				26
Local	Flowering Plants	Beatley's Phacelia	Phacelia beatleyae	No	No	G3				54
Assemblage	Flowering Plants	a Phacelia	Phacelia filiae	No	No	G2		NV		51
Assemblage	Flowering Plants	Geranium-leaf Scorpionweed	Phacelia geraniifolia	No	No	G2				26
Local	Flowering Plants	Nodding-flower Scorpionweed	Phacelia laxiflora	No	No	G2				4
Assemblage	Flowering Plants	Mono County Phacelia	Phacelia monoensis	No	No	G3		CA		1
Local	Flowering Plants	Death Valley Roundleaf Phacelia	Phacelia mustelina	No	No	G2		CA, NV		37
Local	Flowering Plants	Nash's Phacelia	Phacelia nashiana	No	No	G3		CA		73
Local	Flowering Plants	Bear Valley Phlox	Phlox dolichantha	No	No	G2				23
Local	Flowering Plants	Parish's Popcorn-flower	Plagiobothrys parishii	No	No	G1				6
Local	Flowering Plants	San Bernardino Bluegrass	Poa atropurpurea	Yes	No	G2				16
Local	Flowering Plants	Spiny Milkwort	Polygala heterorhyncha	No	No	G3				12
Local	Flowering Plants	Pygmy Poreleaf	Porophyllum pygmaeum	No	No	G2				26
Local	Flowering Plants		Prunus eremophila	No	No	G1				15
Local	Flowering Plants	Parish's Alkali Grass	Puccinellia parishii	No	Yes	G2		CA		1
Local	Flowering Plants		Saltugilia latimeri	No	No	G2		CA		17
Local	Flowering Plants	Clokey's Mountain Sage	Salvia dorrii var. clokeyi	No	No	T3		NV		101
Assemblage	Flowering Plants	Death Valley Sage	Salvia funerea	No	No	G3		NV		8
Local	Flowering Plants	Orocopia Sage	Salvia greatae	No	No	G2		CA		2
Local	Flowering Plants	Mohave Fishhook Cactus	Sclerocactus polyancistrus	No	Yes	G4				26
Local	Flowering Plants	Davidson's Stonecrop	Sedum niveum	No	No	G3				
Coarse Filter	Flowering Plants	Owens Valley Checker-mallow	Sidalcea covillei	No	Yes	G3		CA		18
Local	Flowering Plants	Pedate Checker-mallow	Sidalcea pedata	Yes	Yes	G1				16
Local	Flowering Plants	Clokey's Catchfly	Silene clokeyi	No	No	G2				28
Local	Flowering Plants		Sphaeralcea gierischii	Yes	No	G1				1
Local	Flowering Plants	Charleston Tansy	Sphaeromeria compacta	No	No	G2				47
Local	Flowering Plants	California Jewelflower	Stanfordia californica	Yes	Yes	G1				
Local	Flowering Plants	Laguna Mountains Streptanthus	Streptanthus bernardinus	No	No	G3				11
Local	Flowering Plants	Southern Jewelflower	Streptanthus campestris	No	No	G2				10
Assemblage	Flowering Plants	Eureka Dunes Grass	Swallenia alexandrae	Yes	Yes	G1				4
Local	Flowering Plants	Charleston Kittentails	Synthyris ranunculina	No	No	G2				92
Local	Flowering Plants	Holly-leaf Tetracoccus	Tetracoccus ilicifolius	No	No	G1				7
Local	Flowering Plants	Slender-petal Thelypody	Thelypodium stenopetalum	Yes	Yes	G1				8

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Local	Flowering Plants	Charleston Ground-daisy	Townsendia jonesii var. tumulosa	No	No	T3		NV		125
Local	Flowering Plants	Black Rock Ground-daisy	Townsendia smithii	No	No	G1		AZ		5
Local	Flowering Plants	Three hearts	Tricardia watsonii	No	No	G4		AZ		7
Coarse Filter	Lichens		Dermatocarpon luridum	No	No	G4		NV		2
Assemblage	Mosses		Didymodon nevadensis	No	No	G2		NV		26
Local	Mosses		Entosthodon planoconvexus	No	No	G1				6
Local	Mosses		Grimmia americana	No	No	G1				2
Local	Mosses		Trichostomum sweetii	No	No	G2				6
Species generally found in wetland habitats										
Coarse Filter	Amphibians	Inyo Mountains Salamander	Batrachoseps campi	No	No	G2	CA	CA		19
Coarse Filter	Amphibians	Kern Plateau Salamander	Batrachoseps robustus	No	No	G2	CA			10
Coarse Filter	Amphibians	Western Toad	Bufo boreas	No	Yes	G4	UT	UT		
Coarse Filter	Amphibians	Arroyo Toad	Bufo californicus	Yes	No	G2	CA			4
Coarse Filter	Amphibians	Great Plains Toad	Bufo cognatus	No	Yes	G5	NV, UT	UT	PS	
Coarse Filter	Amphibians	Arizona Toad	Bufo microscaphus	No	Yes	G3	AZ, NV, UT	UT	PS	121
Coarse Filter	Amphibians	Amargosa Toad	Bufo nelsoni	No	Yes	G2	NV		PS	38
Coarse Filter	Amphibians	Yellow-blotched Salamander	Ensatina eschscholtzii croceator	No	No	T2	CA	CA		5
Coarse Filter	Amphibians	Mount Lyell Salamander	Hydromantes platycephalus	No	No	G3	CA			3
Coarse Filter	Amphibians	Canyon Treefrog	Hyla arenicolor	No	No	G5	AZ, UT			6
Coarse Filter	Amphibians	Pacific Chorus Frog	Pseudacris regilla	No	No	G5	AZ, UT			
Coarse Filter	Amphibians	California Red-legged Frog	Rana draytonii	Yes	No	G2	CA			
Coarse Filter	Amphibians	Southern Mountain Yellow-legged Frog	Rana muscosa	Yes	No	G2	CA			5
Coarse Filter	Amphibians	Relict Leopard Frog	Rana onca	Yes	Yes	G1	AZ, NV, UT		MV	22
Coarse Filter	Amphibians	Northern Leopard Frog	Rana pipiens	No	Yes	G5	AZ, CA, NV, UT	UT	PS	15
Coarse Filter	Amphibians	Yavapai Leopard Frog	Rana yavapaiensis	No	Yes	G4	AZ, CA	CA		6
Coarse Filter	Amphibians	Couch's Spadefoot	Scaphiopus couchii	No	No	G5	CA	CA		
Coarse Filter	Amphibians	Great Basin Spadefoot	Spea intermontana	No	No	G5	AZ	CA	MV	1
Coarse Filter	Birds	Clark's Grebe	Aechmophorus clarkii	No	Yes	G5	AZ, NV		PS	4
Coarse Filter	Birds	Western Grebe	Aechmophorus occidentalis	No	Yes	G5	AZ, NV		PS	
Assemblage	Birds	Northern Pintail	Anas acuta	No	Yes	G5	AZ, NV		PS	
Assemblage	Birds	American Wigeon	Anas americana	No	Yes	G5	AZ			
Assemblage	Birds	Northern Shoveler	Anas clypeata	No	Yes	G5	AZ			
Assemblage	Birds	Cinnamon Teal	Anas cyanoptera	No	Yes	G5	NV		PS	
Assemblage	Birds	Blue-winged Teal	Anas discors	No	Yes	G5	AZ			
Local	Birds	Great Egret	Ardea alba	No	Yes	G5	AZ, CA			
Local	Birds	Great Blue Heron	Ardea herodias	No	Yes	G5	CA			

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Assemblage	Birds	Lesser Scaup	Aythya affinis	No	Yes	G5				
Assemblage	Birds	Redhead	Aythya americana	No	Yes	G5	NV		PS	
Assemblage	Birds	Canvasback	Aythya valisineria	No	Yes	G5	AZ, CA, NV		PS	
Assemblage	Birds	Canada Goose	Branta canadensis	No	Yes	G5	AZ			
Coarse Filter	Birds	Cattle Egret	Bubulcus ibis	No	Yes	G5	AZ			
Assemblage	Birds	Barrow's Goldeneye	Bucephala islandica	No	Yes	G5	CA			
Coarse Filter	Birds	Green Heron	Butorides virescens	No	Yes	G5				3
Assemblage	Birds	Least Sandpiper	Calidris minutilla	No	Yes	G5	NV		PS	
Coarse Filter	Birds	Mountain Plover	Charadrius montanus	Yes	Yes	G3	AZ, CA, UT	AZ, CA, UT		2
Coarse Filter	Birds	Black Tern	Chlidonias niger	No	Yes	G4	CA, NV		PS	
Coarse Filter	Birds	American Dipper	Cinclus mexicanus	No	Yes	G5	AZ			
Coarse Filter	Birds	Western Yellow-billed Cuckoo	Coccyzus americanus occidentalis	Yes	Yes	T3	AZ, CA, NV	CA	MV	84
Coarse Filter	Birds	A Yellow Warbler	Dendroica petechia brewsteri	No	No	T3	CA		PS (for species	12
Coarse Filter	Birds	Sonoran Yellow Warbler	Dendroica petechia sonorana	No	No	T2	CA		PS (for species	1
Coarse Filter	Birds	Snowy Egret	Egretta thula	No	Yes	G5	AZ, CA, NV		PS	
Coarse Filter	Birds	Southwestern Willow Flycatcher	Empidonax traillii extimus	Yes	Yes	T1	AZ, CA, NV, UT	CA	PS	100
Coarse Filter	Birds	Wilson's Snipe	Gallinago delicata	No	Yes	G5	AZ			
Assemblage	Birds	Common Moorhen	Gallinula chloropus	No	Yes	G5				4
Assemblage	Birds	Common Loon	Gavia immer	No	Yes	G5	CA, NV		PS	
Local	Birds	Common Yellowthroat	Geothlypis trichas	No	Yes	G5			PS	5
Assemblage	Birds	Black-necked Stilt	Himantopus mexicanus	No	Yes	G5	NV, UT		PS	
Coarse Filter	Birds	Caspian Tern	Hydroprogne caspia	No	Yes	G5	CA, UT			
Coarse Filter	Birds	Least Bittern	Ixobrychus exilis	No	Yes	G5	CA			6
Coarse Filter	Birds	Western Least Bittern	Ixobrychus exilis hesperis	No	Yes	T3	NV		PS	5
Coarse Filter	Birds	California Gull	Larus californicus	No	Yes	G5	CA			
Coarse Filter	Birds	California Black Rail	Laterallus jamaicensis coturniculus	No	Yes	T1	AZ, CA	CA		5
Assemblage	Birds	Long-billed Dowitcher	Limnodromus scolopaceus	No	Yes	G5	NV		PS	
Assemblage	Birds	Hooded Merganser	Lophodytes cucullatus	No	Yes	G5				
Assemblage	Birds	Common Merganser	Mergus merganser	No	Yes	G5	AZ			
Coarse Filter	Birds	Long-billed Curlew	Numenius americanus	No	Yes	G5	CA, NV, UT	UT	PS	
Coarse Filter	Birds	Black-crowned Night-Heron	Nycticorax nycticorax	No	Yes	G5	CA			1
Coarse Filter	Birds	Osprey	Pandion haliaetus	No	Yes	G5	AZ, CA, UT		PS	
Coarse Filter	Birds	American White Pelican	Pelecanus erythrorhynchos	No	Yes	G4	CA, NV, UT		MV	2
Coarse Filter	Birds	Double-crested Cormorant	Phalacrocorax auritus	No	Yes	G5	CA			
Assemblage	Birds	red-necked phalarope	Phalaropus lobatus	No	Yes	G4	NV		MV	
Coarse Filter	Birds	Wilson's Phalarope	Phalaropus tricolor	No	Yes	G5			MV	

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Assemblage	Birds	White-faced Ibis	Plegadis chihi	No	Yes	G5	CA, NV		PS	4
Local	Birds	Horned Grebe	Podiceps auritus	No	Yes	G5				
Local	Birds	Eared Grebe	Podiceps nigricollis	No	Yes	G5	AZ, NV		PS	
Local	Birds	Yuma Clapper Rail	Rallus longirostris yumanensis	Yes	Yes	T3	AZ, CA, NV	CA	PS	38
Assemblage	Birds	American Avocet	Recurvirostra americana	No	Yes	G5	AZ, NV, UT		PS	3
Coarse Filter	Birds	Black Phoebe	Sayornis nigricans	No	Yes	G5	NV		IL	
Coarse Filter	Birds	Forster's Tern	Sterna forsteri	No	Yes	G5	CA, NV		PS	
Assemblage	Birds	Willet	Tringa semipalmata	No	Yes	G5	NV		PS	
Coarse Filter	Birds	Bell's Vireo	Vireo bellii	Yes	Yes	G5	UT			3
Coarse Filter	Birds	Arizona Bell's Vireo	Vireo bellii arizonae	No	Yes	T4	CA, NV	CA	PS	9
Coarse Filter	Birds	Least Bell's Vireo	Vireo bellii pusillus	Yes	Yes	T2	CA	CA		17
Coarse Filter	Birds	Yellow-headed Blackbird	Xanthocephalus xanthocephalus	No	Yes	G5	CA			
Local	Caddisflies	Denning's Cryptic Caddisfly	Cryptochia denningi	No	No	G1				1
Coarse Filter	Freshwater & Anadromous Fishes	Desert Sucker	Catostomus clarkii	No	Yes	G3		AZ, UT		21
Coarse Filter	Freshwater & Anadromous Fishes	Bluehead Sucker	Catostomus discobolus	No	Yes	G4		UT		1
Coarse Filter	Freshwater & Anadromous Fishes	Flannelmouth Sucker	Catostomus latipinnis	No	Yes	G3		AZ, UT	PS	19
Coarse Filter	Freshwater & Anadromous Fishes	White River Springfish	Crenichthys baileyi baileyi	Yes	Yes	T1			PS	4
Coarse Filter	Freshwater & Anadromous Fishes	Moapa White River Springfish	Crenichthys baileyi moapae	No	Yes	T2			PS	14
Coarse Filter	Freshwater & Anadromous Fishes	Devil's Hole Pupfish	Cyprinodon diabolis	Yes	Yes	G1			PS	8
Coarse Filter	Freshwater & Anadromous Fishes	Desert Pupfish	Cyprinodon macularius	Yes	Yes	G1		CA		4
Coarse Filter	Freshwater & Anadromous Fishes	Amargosa Pupfish	Cyprinodon nevadensis amargosae	No	No	T1		CA		6
Coarse Filter	Freshwater & Anadromous Fishes	Ash Meadows Pupfish	Cyprinodon nevadensis mionectes	Yes	Yes	T2			PS	34
Coarse Filter	Freshwater & Anadromous Fishes	Warm Springs Amargosa Pupfish	Cyprinodon nevadensis pectoralis	Yes	Yes	T1			PS	13
Coarse Filter	Freshwater & Anadromous Fishes	Cottonball Marsh Pupfish	Cyprinodon salinus milleri	No	Yes	T1				1
Coarse Filter	Freshwater & Anadromous Fishes	Pahrump poolfish	Empetrichthys latos	Yes	Yes	G1			MV	
Coarse Filter	Freshwater & Anadromous Fishes	Pahrump Poolfish	Empetrichthys latos latos	Yes	Yes	T1			MV	8
Coarse Filter	Freshwater & Anadromous Fishes	Mohave Tui Chub	Gila bicolor mohavensis	Yes	Yes	T1		CA		5

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Coarse Filter	Freshwater & Anadromous Fishes	Humpback Chub	Gila cypha	No	Yes	G1		NV		4
Coarse Filter	Freshwater & Anadromous Fishes	Bonytail	Gila elegans	Yes	Yes	G1			PS	16
Coarse Filter	Freshwater & Anadromous Fishes	Arroyo Chub	Gila orcuttii	No	No	G2				3
Coarse Filter	Freshwater & Anadromous Fishes	Virgin River Chub	Gila seminuda	Yes	Yes	G1			PS	15
Coarse Filter	Freshwater & Anadromous Fishes	Virgin River Chub - Muddy River Population	Gila seminuda pop. 2	Yes	Yes	T1				19
Coarse Filter	Freshwater & Anadromous Fishes	Virgin Spinedace	Lepidomeda mollispinis	Yes	Yes	G1				15
Coarse Filter	Freshwater & Anadromous Fishes	Virgin River Spinedace	Lepidomeda mollispinis mollispinis	No	Yes	T1		UT	PS	10
Coarse Filter	Freshwater & Anadromous Fishes	Moapa Dace	Moapa coriacea	Yes	Yes	G1			PS	16
Coarse Filter	Freshwater & Anadromous Fishes	Woundfin	Plagopterus argentissimus	Yes	Yes	G1			PS	25
Coarse Filter	Freshwater & Anadromous Fishes	Colorado Pikeminnow	Ptychocheilus lucius	Yes	Yes	G1		CA		1
Coarse Filter	Freshwater & Anadromous Fishes	Speckled Dace	Rhinichthys osculus	Yes	No	G5		AZ		42
Coarse Filter	Freshwater & Anadromous Fishes	Moapa Speckled Dace	Rhinichthys osculus moapae	No	Yes	T1			PS	12
Coarse Filter	Freshwater & Anadromous Fishes	Ash Meadows Speckled Dace	Rhinichthys osculus nevadensis	Yes	Yes	T1			PS	20
Coarse Filter	Freshwater & Anadromous Fishes	Meadow Valley Speckled Dace	Rhinichthys osculus ssp. 11	No	No	T2		NV	PS	16
Coarse Filter	Freshwater & Anadromous Fishes	Oasis Valley Speckled Dace	Rhinichthys osculus ssp. 6	No	Yes	T1	NV	NV	PS	16
Coarse Filter	Freshwater & Anadromous Fishes	White River Speckled Dace	Rhinichthys osculus ssp. 7	No	No	T2			MV	
Coarse Filter	Freshwater & Anadromous Fishes	Razorback Sucker	Xyrauchen texanus	Yes	Yes	G1		CA	IL	42
Coarse Filter	Freshwater Snails	Badwater Snail	Assiminea infima	No	No	G1			PS	5
Local	Freshwater Snails	Robust Tryonia	Ipnobius robustus	No	No	G1				3
Coarse Filter	Freshwater Snails	Moapa Pebblesnail	Pyrgulopsis avernalis	No	No	G1		AZ	PS	14
Coarse Filter	Freshwater Snails	Blue Point Pyrg	Pyrgulopsis coloradensis	No	No	GH		AZ	MV	2
Coarse Filter	Freshwater Snails	Crystal Springsnail	Pyrgulopsis crystalis	No	No	G1		AZ	PS	2
Coarse Filter	Freshwater Snails	Spring Mountains Pyrg	Pyrgulopsis deaconi	No	No	G1		AZ	HV	10
Coarse Filter	Freshwater Snails	Desert Springsnail	Pyrgulopsis deserta	No	Yes	G2		AZ		7

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Coarse Filter	Freshwater Snails	Ash Meadows Pebblesnail	Pyrgulopsis erythropoma	No	No	G1		AZ	PS	6
Coarse Filter	Freshwater Snails	Fairbanks Springsnail	Pyrgulopsis fairbanksensis	No	No	G1		AZ	PS	2
Coarse Filter	Freshwater Snails	Corn Creek Pyrg	Pyrgulopsis fausta	No	No	G1		AZ	PS	4
Coarse Filter	Freshwater Snails	Elongate-gland Springsnail	Pyrgulopsis isolata	No	No	G1		AZ	PS	2
Coarse Filter	Freshwater Snails	Toquerville Springsnail	Pyrgulopsis kolobensis	No	No	G5		AZ		3
Coarse Filter	Freshwater Snails	Oasis Valley Springsnail	Pyrgulopsis micrococcus	No	No	G3		AZ	MV	38
Coarse Filter	Freshwater Snails	Distal-gland Springsnail	Pyrgulopsis nanus	No	No	G1		AZ	PS	13
Coarse Filter	Freshwater Snails	Median-gland Springsnail	Pyrgulopsis pisteri	No	No	G1		AZ	PS	6
Coarse Filter	Freshwater Snails	Southeast Nevada Pyrg	Pyrgulopsis turbatrix	No	No	G2		AZ	HV	22
Coarse Filter	Freshwater Snails	Wong's Springsnail	Pyrgulopsis wongi	No	No	G2		AZ	MV	25
Coarse Filter	Freshwater Snails	Sportinggoods Tryonia	Tryonia angulata	No	No	G1			PS	6
Coarse Filter	Freshwater Snails	Grated Tryonia	Tryonia clathrata	No	No	G2			PS	15
Coarse Filter	Freshwater Snails	Point of Rocks Tryonia	Tryonia elata	No	No	G1			PS	4
Coarse Filter	Freshwater Snails	Minute Tryonia	Tryonia ericae	No	No	G1			PS	4
Coarse Filter	Freshwater Snails	Grapevine Springs Elongate Tryonia	Tryonia margae	No	No	G1				2
Coarse Filter	Freshwater Snails	Grapevine Springs Squat Tryonia	Tryonia rowlandsi	No	No	G1				1
Coarse Filter	Freshwater Snails	Amargosa Tryonia	Tryonia variegata	No	No	G2			PS	37
Local	Mammals	American Beaver	Castor canadensis	No	Yes	G5	AZ		PS	
Local	Mammals	Common Muskrat	Ondatra zibethicus	No	Yes	G5	AZ			
Coarse Filter	Other Beetles	Death Valley Agabus Diving Beetle	Agabus rumppi	No	No	G2				6
Coarse Filter	Other Beetles	Simple Hydroporus Diving Beetle	Hydroporus simplex	No	No	G1				2
Coarse Filter	Other Beetles	Furnace Creek Riffle Beetle	Microcylloepus formicoideus	No	No	G1				1
Local	Other Beetles	Devil's Hole Warm Spring Riffle Beetle	Stenelmis calida calida	No	No	T1		NV		10
Coarse Filter	Other Beetles	Ash Springs riffle beetle	Stenelmis lariversi	No	No	G1				2
Coarse Filter	Other Beetles	Moapa Warm Springs Riffle Beetle	Stenelmis moapa	No	No	G1				2
Coarse Filter	Other Insects	Ash Meadows Naucorid	Ambrysus amargosus	Yes	No	G1				4
Coarse Filter	Other Insects	Nevares Spring Naucorid Bug	Ambrysus funebris	Yes	No	G1				2
Coarse Filter	Other Insects	Saratoga Springs Belostoman Bug	Belostoma saratogae	No	No	G1				1
Coarse Filter	Other Insects	Amargosa Naucorid Bug	Pelocoris shoshone	No	No	G2				5
Coarse Filter	Other Insects	Pahranagat Naucorid Bug	Pelocoris shoshone shoshone	No	No	T1		NV		8
Coarse Filter	Other Insects	A Naucorid Bug	Usingerina moapensis	No	No	G1				2
Coarse Filter	Tiger Beetles	Riparian Tiger Beetle	Cicindela praetextata	No	No	G2				1
Coarse Filter	Turtles	Western Pond Turtle	Actinemys marmorata	No	No	G3	CA	CA	PS	14
Coarse Filter	Turtles	Sonoran Mud Turtle	Kinosternon sonoriense	No	No	G4	CA			
Local	Ferns & relatives	Upward-lobed Moonwort	Botrychium ascendens	No	No	G2				14
Local	Ferns & relatives	Crenulate Moonwort	Botrychium crenulatum	No	No	G3				22

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Local	Ferns & relatives	Narrowleaf Grapefern	Botrychium lineare	No	No	G2				
Coarse Filter	Flowering Plants	Rough Angelica	Angelica scabrida	No	No	G2		NV	HV	70
Coarse Filter	Flowering Plants	Horn's Milkvetch	Astragalus hornii var. hornii	No	No	T2		CA		2
Coarse Filter	Flowering Plants	Sodaville Milkvetch	Astragalus lentiginosus var. sesquimetralis	No	Yes	T1		NV		1
Coarse Filter	Flowering Plants	Virgin Thistle	Cirsium virginense	No	Yes	G2		NV		19
Coarse Filter	Flowering Plants	Tecopa Bird's-beak	Cordylanthus tecopensis	No	No	G2		CA, NV		272
Coarse Filter	Flowering Plants	Wasatch Draba	Draba brachystylis	No	No	G1				10
Coarse Filter	Flowering Plants	Catchfly Prairie-gentian	Eustoma exaltatum	No	No	G5		NV		5
Local	Flowering Plants	Ash Meadows Gumweed	Grindelia fraxinopratensis	Yes	Yes	G2		NV		247
Coarse Filter	Flowering Plants	California Satintail	Imperata brevifolia	No	No	G2		NV		13
Coarse Filter	Flowering Plants	King's Ivesia	Ivesia kingii	Yes	No	G3				
Coarse Filter	Flowering Plants	Ash Meadows Mousetail	Ivesia kingii var. eremica	Yes	Yes	T1		NV		123
Local	Flowering Plants	Amargosa Niterwort	Nitrophila mohavensis	Yes	Yes	G1		CA, NV		97
Local	Flowering Plants	Parish's Phacelia	Phacelia parishii	No	No	G2		AZ, CA, NV		30
Coarse Filter	Flowering Plants	Funeral Mountain Blue-eyed-grass	Sisyrinchium funereum	No	No	G2				16
Coarse Filter	Flowering Plants	Big-root Blue-eyed-grass	Sisyrinchium radicatum	No	No	G2		NV		11
Coarse Filter	Flowering Plants	Ash Meadows Ladies'-tresses	Spiranthes infernalis	No	No	G1				207

B-1.1.2 Species CEs of Conservation Concern

Summaries of the at-risk status for species treated as CEs within the MBR ecoregion are included in Table B - 2 through Table B - 5. See Table B - 1 for details of this information for the MBR. The tables summarize species according to the assessment approach, or how they were treated in the assessment, and by informal taxonomic category. While "species" are referred to throughout this report, there are actually a number of subspecies or varieties of full species included in the assessment. Landscape species (Table B - 2) for the REA were entirely associated with 'dry' or upland habitats. These included birds, mammals, and reptiles. Vulnerable species assemblages (Table B - 3) included a broader variety of species by informal taxonomy, and included species associated with both upland and wetland/aquatic habitats. Local species (Table B - 4) are the most extensive in number (306), with 286 in uplands and 20 known to be in wet habitats; Figure B - 1 depicts them as summarized by watershed. A total of 214 species meeting criteria for inclusion in the REA were efficiently assessed indirectly through analysis of coarse-filter CEs (Table B - 5), spanning a range of upland and aquatic environments.

All but one of the landscape species are relatively common (Table B - 2), the Mohave ground squirrel is the only species to have a high at-risk status rank under the NatureServe ranking methodology with a global rank of G3. Only 4 of the 27 landscape species, (kit fox, desert bighorn-Peninsular Ranges, and the two desert tortoise populations), have Federal status in all or a portion of their range. Most of the landscape species are protected or recognized by some sort of state legislation (21 species), and many of them were also listed in one or more state wildlife action plans (23 species). The BLM has 11 species listed within their state special status lists.

Table B - 2. Summary of species treated individually as landscape species

Informal Taxonomy	Total Species	# with Federal Status	# with State Status	# with G1 - G3 Status Rank	# BLM Special Status	# listed in SWAPS
Birds	9	0	9	0	2	9
Mammals	7	2	6	1	5	5
Reptiles	11	2	6	0	4	9
Total	**27**	**4**	**21**	**1**	**11**	**23**

There were a total of 78 species treated within the species assemblages (Table B - 3); of these many were plants, and birds were also important assemblage components. More than a third (38%) of the assemblage species have high at-risk status ranks (30 species). Many species are protected by state legislation (predominantly birds), are considered special status by BLM (most are plants), or were listed in a SWAP (birds in particular). Only two plants have Federal status, the Crispleaf Wild Buckwheat (*Eriogonum corymbosum var. nilesii*), and Eureka Dunes Grass (*Swallenia alexandrae*).

Table B - 3. Summary of species treated within species assemblages.

Informal Taxonomy	Total Species	# with Federal Status	# with State Status	# with G1 - G3 Status Rank	# BLM Special Status	# listed in SWAPS
Birds	29	0	29	0	0	25
Mammals	6	0	0	0	3	6
Reptiles	4	0	3	1	3	4
Ants, Wasps, & Bees	1	0	0	1	0	0

Informal Taxonomy	Total Species	# with Federal Status	# with State Status	# with G1 - G3 Status Rank	# BLM Special Status	# listed in SWAPS
Mosses	1	0	0	1	1	0
Flowering Plants	37	2	7	27	25	0
Total	**78**	**2**	**39**	**30**	**32**	**35**

Species treated in the assessment as "local" species totaled 306, of which over half (156) are plants, 106 are vertebrates, and the remainder (44) are invertebrates (Table B - 4). Fifty-six percent of these species are considered globally rare, including most of the plants and invertebrates. Most of the vertebrates are listed in a SWAP, and most of the bird species also have some state protection. Many of the plants (44%) are of particular concern to the state BLM offices, being on special status lists; a limited number of vertebrates and invertebrates have BLM special status. Thirty-four species have any Federal status; most (21) are plants. Figure B - 1 summarizes the number of local species occurring in each 5th level watershed, based on natural heritage element occurrence records. These species localities are somewhat concentrated in the northwestern area, in southwestern Utah and adjacent areas of Arizona, in the watersheds to the north and northwest of Las Vegas, and the southwestern part of the ecoregion.

Table B - 4. Summary of species treated as local species.

Informal Taxonomy	Total Species	# with Federal Status	# with State Status	# with G1 - G3 Status Rank	# BLM Special Status	# listed in SWAPS
Birds	34	4	31	1	7	29
Mammals	49	3	18	5	16	46
Reptiles	23	2	8	4	8	22
Total Vertebrates	**106**	**9**	**57**	**10**	**31**	**97**
Ants, Wasps, & Bees	8	0	0	8	0	0
Butterflies & Skippers	9	1	0	4	5	0
Caddisflies	1	0	0	1	0	0
Freshwater Snails	1	0	0	1	0	0
Grasshoppers	1	0	0	1	0	0
Katydids & Crickets	4	0	0	4	0	0
Other Beetles	15	2	0	13	2	0
Other Insects	3	1	0	3	1	0
Terrestrial Snails	1	0	0	1	0	0
Tiger Beetles	1	0	0	1	0	0
Total Invertebrates	**44**	**4**	**0**	**37**	**8**	**0**
Conifers & relatives	1	0	0	1	0	0
Ferns & relatives	4	0	0	4	0	0
Flowering Plants	148	21	25	117	68	0
Mosses	3	0	0	3	0	0
Total Plants	**156**	**21**	**25**	**125**	**68**	**0**
Total	**306**	**34**	**82**	**172**	**107**	**97**

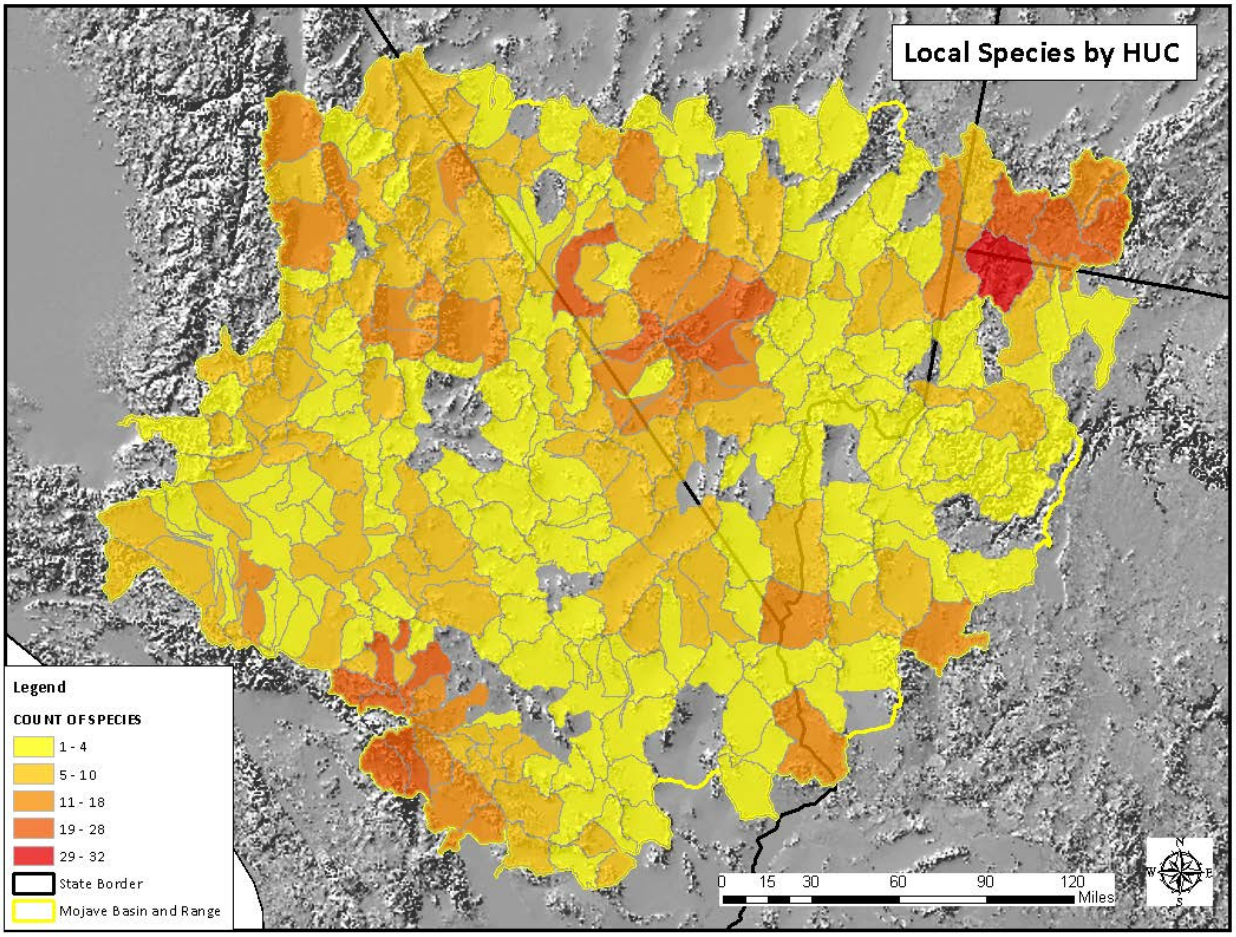


Figure B - 1. Local species summarized by number known to occur within each 5th level watershed of the MBR.

A total of 193 species were assigned to one or more of the coarse-filter CEs (Table B - 5). These species are considered to be adequately assessed and captured by the coarse-filter CEs, which were assessed separately. Many of the species captured through coarse-filter CEs are aquatic species such as freshwater fish or snails, all closely associated with aquatic habitats; while others such as birds and amphibians utilize the riparian or wetland vegetation found adjacent to aquatic habitats for portions of their life cycle. Most of the species (160 or 83%) are associated with the aquatic/wetland/riparian coarse-filter CEs (Table B - 5), and a much smaller number were captured in one of the terrestrial coarse-filter CEs. Many species are considered globally rare (36%), and over 60% of them have state protective status. Of the 111 vertebrates captured in the aquatic coarse-filter CEs, 26 of them have Federal status- more species than in the other 3 assessment approaches. Of these 18 are fish species, 5 are birds, and 4 are amphibians. Of the invertebrates, only 2 have Federal status yet almost all of them are considered globally rare; many of the 30 G1-G3 species in the aquatic category are freshwater snails, although several diving beetles are also globally rare. Of the species captured in the terrestrial coarse-filter CEs, most are vertebrates followed by plants.

Table B - 5. Summary of species captured and treated within a coarse-filter CE.

Approach	Informal Taxonomy	Total Species	# with Federal Status	# with State Status	# with G1 - G3 Status Rank	# BLM Special Status	# listed in SWAPS
Captured in aquatic coarse-filter	Vertebrates	111	26	88	25	33	70
Captured in aquatic coarse-filter	Invertebrates	33	1	1	30	16	0
Captured in aquatic coarse-filter	Plants	16	1	4	11	13	0
Captured in terrestrial coarse-filter	Vertebrates	43	1	38	2	13	35
Captured in terrestrial coarse-filter	Invertebrates	2	0	0	2	0	0
Captured in terrestrial coarse-filter	Plants	9	1	2	6	5	0
	Total	**214**	**30**	**133**	**76**	**80**	**105**

*Note: Out of the 193 species captured in the coarse-filter CEs, 21 species are associated with both an aquatic coarse-filter and a terrestrial coarse-filter; hence the total species in the above table is higher than 193.

B-1.1.3 Terrestrial coarse filter *(includes fire regime models)*

Conceptual models developed for this REA combine text, concept diagrams, and tabular summaries in order to clearly state assumptions made about the ecological composition, structure, dynamic processes, and interactions with major CAs within the ecoregion. These conceptual models lead then to spatial models to enable us to gauge the relative ecological status of each CE within 5th level watersheds. Content included for each CE is described below. Some text is repeated for each CE within the conceptual model, such as the VDDT modeling information, to allow the reader to view or print the entire material for an individual CE.

All of the terrestrial coarse-filter conceptual models are included in this document: MBR_ConceptualModels_TerrestrialCoarseFilterCEs22June2012.pdf

The descriptive material builds upon the descriptions for terrestrial ecological systems that NatureServe has and serves on its website(http://www.natureserve.org/explorer/index.htm to search and download existing descriptions). For this REA, additional material was added for each coarse-filter CE, especially focusing on content describing natural and altered vegetation dynamics, as well as threats and stressors to the system. The information developed is intended to cover the full range of distribution of the CEs, which can extend beyond the ecoregion, and does not specifically focus on it's characteristics or dynamics as they occur within this ecoregion.

The descriptions include many names of plant species that are characteristic of the coarse-filter ecological system type. In the text sections these names are provided as scientific names. Vascular plant species nomenclature follows the nationally standardized list of Kartesz (1999), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990) and Anderson et al. (1990) for mosses, Egan (1987, 1989, 1990, 1991) and Esslinger and Egan (1995) for lichens, and Stotler and Crandall-Stotler (1977) for liverworts/hornworts. Within Appendix E a table is included with common names for each species.

For some coarse-filter types, animal or plant species of conservation or management concern were identified that are known to be strongly associated. Assessment of these species is presumed to be well-addressed through assessment of these coarse-filter CEs. These species are listed by informal taxonomic groups, with common names followed by scientific names.

Each model begins by characterizing what the CE is and how it nests within the broader conceptual model already established for the ecoregion. Each CE is placed within one of the 4 major model components and within one of the Model Groups within those (Table B - 6).

The next component of the conceptual model clarifies relevant taxonomic relationships, with "(CES304.773)" referring to the standard NatureServe element code for this ecological system type. The LANDFIRE Biophysical Settings code is also listed.

Table B - 6. Terrestrial Coarse-Filter CEs for Mojave Basin and Range Ecoregion

Ecoregion Conceptual Model		
Level 1	**Level 2**	**Coarse-filter Element Name**
Montane Dry Land System	Montane Shrublands	Mogollon Chaparral
		Sonora-Mojave Semi-Desert Chaparral
	Subalpine/Montane Forests & Woodlands	Great Basin Pinyon-Juniper Woodland
Basin Dry Land System	Cliff & Outcrop	North American Warm Desert Badland
		North American Warm Desert Bedrock Cliff and Outcrop
		North American Warm Desert Pavement
	Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub
		Mojave Mid-Elevation Mixed Desert Scrub
		Sonora-Mojave Creosotebush-White Bursage Desert Scrub
		Sonora-Mojave Mixed Salt Desert Scrub
		Sonoran Mid-Elevation Desert Scrub
	Dunes	North American Warm Desert Active and Stabilized Dune
	Semi-desert Shrub & Steppe	Great Basin Xeric Mixed Sagebrush Shrubland

Conservation Element Characterization

This section of the conceptual model includes a narrative of the CE distribution, biophysical setting, and floristic composition. For terrestrial coarse-filter CEs, a direct linkage is provided between the CE concept and Ecological Site Descriptions (ESDs) applicable to the ecoregion. Crosswalks are provided only to approved ESDs by NRCS Multiple Resource Land Area (MLRA) that overlap the ecoregion. The NRCS Site ID in the crosswalk table identifies each type as determined by NRCS. This list is not a complete cross-walk as some MLRAs do not have approved ESDs. Additionally, the user should consider that ESDs are based on landform/soil concepts, so the match between these concepts and ecological system concepts - defined as an integration between biophysical and natural floristic composition - will be imperfect and may vary from type to type.

Vegetation dynamics, both natural and altered, are described in narrative text, with supporting literature cited. Again, this information is developed across the range-wide distribution of the ecological system type.

Change Agent Effects on the CE

In this section the primary change agents are characterized and as possible, current knowledge of their effects on this CE. Some CAs have specific effects on each CE such as the alteration of expected fire regimes and the interacting effects of introduced weed infestations. Narrative is provided on the effects of CAs on the individual CE, in an "altered dynamics" section. Wildfire and invasive plant CAs are described and modeled within the context of their effects on coarse filter CEs.

The impacts of wildfire and invasive plants are modeled through the use of the Vegetation Dynamics Development Tool (VDDT) and simulations were run in the Path Landscape Model (ESSA Technologies). Models were developed by the Nevada chapter of The Nature Conservancy, and modified for use in this REA. VDDT is a state-and-transition modeling platform that simulates vegetation dynamics based on user-defined states and transitions. States (boxes) represent a vegetation community defined by a cover type and structural stage. Transitions link states through processes such as succession, disturbance, and management, and can be either deterministic or probabilistic. Deterministic transitions usually simulate successional changes by defining the number of years until a transition occurs from one successional stage to the next, in the absence of disturbance. Probabilistic transitions specify an annual transition probability of moving from one state to another. Probabilistic transitions represent disturbances (e.g., fire and drought), ecological processes (e.g. tree encroachment and natural recovery), and land management activities (e.g., seeding and prescribed fire).

For each simulation, the landscape is partitioned into a number of cells or simulation units and allocated among state classes in the model. At each time step, deterministic transitions occur based on the age of the cell and probabilistic transitions may occur based on the specified transition probability. VDDT is a nonspatial model, and all cells are simulated independently of other cells. The Path model uses VDDT as a simulation engine but allows users to organize model runs, run many models simultaneously, and view output across all model runs simultaneously. Each coarse-filter CE was described using two VDDT models – one describing the natural range of variation (NRV) under historic conditions, and one describing contemporary dynamics and including uncharacteristic states such as annual grass or depleted shrub. The contemporary model includes all states and transitions from the NRV model in addition to a set of uncharacteristic states and transitions.

Ecological Status Criteria and Indicators

To assess ecological status for each CE within the ecoregion, NatureServe's ecological integrity framework sets up practical criteria and indicators for this purpose (Faber-Langendoen et al. 2006, Unnasch et al. 2008). This framework provides a scorecard for reporting on the ecological status of a given CE within a given location, and facilitates the aggregation and synthesis of the component results for broader measures of ecological integrity at landscape and ecoregional scales. Using this framework, indicators were chosen to provide a measurement for a limited set of key ecological attributes, or ecological drivers for each CE. Ecological attributes may include natural characteristics, such as native species composition, or stressors such as effects of relevant change agents, that are well known to affect the natural function and integrity of the CE.

In part because of project constraints, indicators that were identified *emphasize ecosystem stressors* that can be more readily measured using available remotely sensed data. Spatial models that reflect these indicators serve as the link between the conceptual models and the spatial representation of ecological status. For each CE, the definitions and justifications for each of the indicators assessed for that CE are provided, organized in an Ecological Status Scorecard table. Each indicator is scored according to criteria described in the table and is calculated between 0 and 1, with 1 indicating highest ecological status and 0 indicating lowest status (and presumably transitional to a wholly different ecological state).

References for the CE

Literature is listed that is relevant to the classification, distribution, floristic composition, ecological processes, threats, stressors, or management of the CE, in some cases form portions of it's range outside of the ecoregion. These are not exhaustive literature surveys, rather are an accumulation of known references. Some documents may be listed that are not cited in the narrative text.

B-1.1.4 Aquatic coarse-filter

The conceptual models combine text, concept diagrams, and tabular summaries in order to clearly state assumptions about the ecological composition, structure, dynamic processes, and interactions with major CAs within the ecoregion. These conceptual models lead then to spatial models used to gauge the relative ecological status of each CE within 5th level watersheds. Below the content included for each CE is described. Some text is repeated for each CE, such as the indicator justification information, to allow the reader to view or print the entire material for an individual CE.

All of the aquatic coarse-filter conceptual models are included in this document: MBR_ConceptualModels_AquaticCoarseFilterCEsJune22_2012.pdf

The descriptive material builds upon the descriptions for terrestrial ecological systems that NatureServe has developed (http://www.natureserve.org/explorer/index.htm). For this REA, additional material was developed for each coarse-filter CE, especially focusing on adding aquatic components, aquatic dynamics and describing natural and altered dynamics, as well as threats and stressors to the system. The information developed is intended to cover the full range of distribution of the CEs, which may extend beyond the ecoregion, and does not specifically focus on the characteristics or dynamics as they occur within this ecoregion.

Some descriptions include many names of plant species that are characteristic of riparian, wetland, spring and lacustrine fringe coarse-filter ecological system types. In the text sections these names are provided as scientific names. Vascular plant species nomenclature follows the nationally standardized list of Kartesz (1999), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990) and Anderson et al. (1990) for mosses, Egan (1987, 1989, 1990, 1991) and Esslinger and Egan (1995) for lichens, and Stotler and Crandall-Stotler (1977) for liverworts/hornworts. Within Reference Appendices not yet developed we will include a table with common names for each species.

For all coarse-filter types, both aquatic and terrestrial species of conservation or management concern that are known to be strongly associated with these ecosystems are listed. Assessment of these species is presumed to be well-addressed through the assessment of the coarse-filter CE. Species are listed by informal taxonomic groups, with common names followed by scientific names (Table B - 1, and within each conceptual model for the CE).

Each model begins by characterizing what the CE is and how it nests within the broader conceptual model already established for the ecoregion. Each CE is placed within one of the 2 major model components (Level 1, Table B - 7), and then into one of the sub-model groups (Level 2).

Table B - 7. Aquatic Coarse-filter CEs in the MBR and placement in Ecoregional Conceptual Model

Aquatic Coarse-filter CEs in the MBR and placement in Ecoregional Conceptual Model		
Level 1	**Level 2**	**Coarse-filter Element Name**
Montane Wet System	Montane Streams & Riparian	North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream
Basin Wet System	Playa & Washes	North American Desert Playa
		North American Desert Wash
	Basin and Foothill Streams & Riparian	North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream
	Basin Lake/Reservoir	Mojave Desert Lake / Reservoir*
	Desert Springs, Seeps	Mojave Springs and Seeps*

* Lakes/Reservoirs and Springs and Seeps CEs can and do occur in the Montane regions of the Mojave Desert Ecoregion

Conservation Element Characterization

This section of the conceptual model includes a narrative of the CE distribution, biophysical and hydrologic setting, and floristic composition. Vegetation, species and hydrologic dynamics, both natural and altered, are described in narrative text, with supporting literature cited. Again, this information is developed across the range-wide distribution of the ecological system type. One section of the conceptual model is devoted to the aquatic habitat component of the CE.

Change Agent Effects on the CE

In this section the primary change agents are characterized and current knowledge of their effects on this CE are described. Some CAs have specific effects on each CE such as the alteration of hydrologic regimes and the interacting effects of introduced weed infestations. Narrative is provided on the effects of CAs on the individual CE, in an "altered dynamics" section. Invasive aquatic and terrestrial plant species CAs are described and modeled within the context of their effects on coarse filter CEs.

Conceptual Model Diagram

For each CE, a diagram is provided (composed of three sub-figures) conceptualizing the relationships between Change Agents, the stresses they induce in the CE, the response of the CE to those stressors, and the measure of either the stress or the CE response with indicators. It is intended to be illustrative of the effect of each Change Agent on Aquatic CE's ecological integrity. Change Agents are a source of different types of stressors, and different types of stressors invoke different responses. Indicators are metrics by which the amount of stress or response within each type of CE can be directly or indirectly measured.

Not all change agents, stresses, or responses are listed, and the indicators are generally those applied in the assessment, rather than a complete suite of possible indicators.

Ecological Status Criteria and Indicators

To assess ecological status for each CE within the ecoregion, NatureServe's ecological integrity framework sets up practical criteria and indicators for this purpose (Faber-Langendoen et al. 2006, Unnasch et al. 2008). This framework provides a scorecard for reporting on the ecological status of a given CE within a given location, and facilitates the aggregation and synthesis of the component results for broader measures of ecological integrity at landscape and ecoregional scales. Using this framework, indicators are chosen to provide a measurement for a limited set of key ecological attributes, or ecological drivers for each CE. Ecological attributes may include natural characteristics, such as native species composition, or stressors such as effects of relevant change agents, that are well known to affect the natural function and integrity of the CE.

In part because of project constraints, *indicators identified for this REA emphasize ecosystem stressors that can be more readily measured using available remotely sensed data*. Spatial models that reflect these indicators serve as the link between the conceptual models and the spatial representation of ecological status. For each CE, the definitions and justifications for each of the indicators are provided, organized in an Ecological Status Scorecard table. Each indicator is scored according to criteria described in the table and is calculated between 0 and 1, with 1 indicating highest ecological status and 0 indicating lowest status (and presumably transitional to a wholly different ecological state).

References for the CE

Literature is listed that is relevant to the classification, distribution, floristic composition, ecological processes, threats, stressors, or management of the CE, in some cases from portions of it's range outside of the ecoregion. These are not exhaustive literature surveys, rather are an accumulation of known references. Some documents may be listed that are not cited in the narrative text.

B-1.1.5 Vulnerable species assemblages

The species assemblages were identified by botany and zoology staff of the Nevada Natural Heritage Program. They were limited to selecting species to include in an assemblage to those which met criteria established early on in the REA process; NatureServe provided them a list of species meeting these criteria. These criteria were:

- All taxa listed under Federal or State protective legislation (including species, subspecies, or designated subpopulations)
- Full species with NatureServe Global Conservation Status rank of G1-G3[3]
- Full species or subspecies listed as BLM Special Status and those listed by applicable SWAPs with habitat included within the ecoregion
- Full species and subspecies scored as *Vulnerable* within the ecoregion according to the NatureServe Climate Change Vulnerability Index (CCVI).

A number of assemblages were identified, and proposed to the AMT. The ones included in this appendix are those for which we were able to develop a spatial model of habitat distribution for the assemblage; several others were dropped due to a lack of data from which to build a model, or because the model itself yielded a poor result. These assemblages range from having only two species (one assemblage), to being composed of a couple of dozen species; some are entirely flowering plants, others a mix of plants and animals including birds, mammals, invertebrates, and reptiles.

All of the vulnerable species assemblage conceptual models are included in this document: MBR_ConceptualModels_SpeciesAssemblages22June_2012.pdf

Each model begins by characterizing what the CE is and how it nests within the broader conceptual model already established for the ecoregion. Each CE is placed within one of the 2 major model components (Level 1, see table below for the list), and then into one of the sub-model groups (Level 2).

[3] See http://www.natureserve.org/explorer/ranking.htm for NatureServe Conservation Status Rank definitions

Table B - 8. Vulnerable Species Assemblage CEs in the MBR and placement in Ecoregional Conceptual Model

Species Assemblage CEs in the MBR and placement in Ecoregional Conceptual Model		
Level 1	**Level 2**	**Species Assemblage Name**
Basin Wet System	Basin River & Riparian	Migratory waterfowl & shorebirds
Montane Dry Land System	Alpine Uplands	Carbonate (Limestone/Dolomite) alpine
		Non-carbonate alpine
	Subalpine/Montane Forests & Woodlands	Montane conifer
Basin Dry Land System	Cliff & Outcrop	Azonal carbonate rock crevices
		Azonal non-carbonate rock crevices
	Desert Scrub	Gypsum soils
	Semi-desert Shrub & Steppe	Clay soil patches
		Sand dunes/sandy soils (when deep and loose)

Conservation Element Characterization

Because these are concepts developed specifically for the REA assessment, our descriptive information for these assemblages has been kept to relatively simple summarizing of information we had available for the species within the assemblage, and some information about the environmental setting in which the assemblage is found. A couple of the assemblages were particularly difficult to describe (montane conifer, for example) because the species in the assemblage are diverse in their habitat requirements, many of them are highly mobile, and the "montane conifer zone" itself is a complex mosaic of vegetation types.

The descriptions include a short summary of the concept of the assemblage, it's general range within the ecoregion, the environmental setting for it, and the "habitat" or the ecosystem setting for it. Scientific names are generally used for the plants when they are mentioned in the text, although in places the common name for a genus might be used, such as "cottonwood", or "willow". A complete listing of the species in the assemblage organized by informal taxonomy is provided with both common and scientific names. All Tables and Figures are numbered within each CEs conceptual model, not sequentially through the entire document.

Vascular plant species nomenclature follows the nationally standardized list of Kartesz (1999), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990) and Anderson et al. (1990) for mosses, Egan (1987, 1989, 1990, 1991) and Esslinger and Egan (1995) for lichens, and Stotler and Crandall-Stotler (1977) for liverworts/hornworts. Within Reference Appendices not yet developed we will include a table with common names for each species.

Change Agent Effects on the CE

In this section we characterize the primary change agents and current knowledge of their effects on the assemblage. In most cases, this information was derived by reviewing information for the species within the assemblage, but also by expert knowledge of some of the impacts of change agents on particular habitats (e.g. rock climbing is a probable change agent for assemblages found in rock crevices). Some CAs have specific effects on each CE such as the alteration of hydrologic regimes and the interacting effects of introduced weed infestations. Narrative on the effects of CAs on the individual CE, in an "altered dynamics" section is provided.

Conceptual Model Diagram

A diagram (composed of three sub-figures) conceptualizing the relationships between Change Agents is provided and includes the stresses they induce in the CE, the response of the CE to those stressors, and how they will be measured, either the stress or the CE response with indicators. It is intended to be illustrative of the effect of each Change Agent on the CE's ecological condition. Change Agents are a source of different types of stressors. Different types of stressors invoke different responses, and Indicators are metrics by which we can directly measure the amount of stress or response within each CE.

Not all possible change agents, stresses, or responses, and indicators are listed, but rather only those applied in the assessment.

Ecological Status Criteria and Indicators

To assess ecological status for each CE within the ecoregion, NatureServe's ecological integrity framework sets up practical criteria and indicators for this purpose (Faber-Langendoen et al. 2006, Unnasch et al. 2008). This framework provides a scorecard for reporting on the ecological status of a given CE within a given location, and facilitates the aggregation and synthesis of the component results for broader measures of ecological integrity at landscape and ecoregional scales. Using this framework, indicators are chosen to provide a measurement for a limited set of key ecological attributes, or ecological drivers for each CE. Ecological attributes may include natural characteristics, such as native species composition, or stressors such as effects of relevant change agents, that are well known to affect the natural function and integrity of the CE.

In part because of project constraints, indicators that we have identified emphasize ecosystem stressors that can be more readily measured using available remotely sensed data. Spatial models that reflect these indicators serve as the link between the conceptual models and the spatial representation of ecological status. For each CE, we provide the definitions and justifications for each of the indicators we will be assessing for that CE, organized in an Ecological Status Scorecard table. Each indicator is scored according to criteria described in the table and is calculated between 0 and 1, with 1 indicating highest ecological status and 0 indicating lowest status (and presumably transitional to a wholly different ecological state).

References for the CE

Each species within each assemblage has an extensive list of literature references associated with it. However, we do not provide all of those for each assemblage, as in some cases it would be many dozens of citations. Hence, for each assemblage we have provided a selection of references; a full listing of references for each assemblage will be provided separately to BLM if requested. These are not exhaustive literature surveys, rather are an accumulation of known references. Documents may be listed that are not cited in the narrative text.

B-1.1.6 Landscape species

In the section that follows, the content included for each species CE is described. Characterization data that has been developed for these species is intended to represent the taxon across the entire range of its distribution (i.e., global-level data). Species CE data has been obtained from a biodiversity database developed centrally at NatureServe over the past thirty-five years. This database is dynamic, maintained and refined through updates made to reflect current changes to taxonomy, and by the periodic import of new records that are developed according to standard methodology by natural heritage member program scientists and other collaborators, including government agencies, universities, natural history museums and botanical gardens, and additional conservation organizations.

This ongoing process of information being added and existing records revised helps to maintain currentness and enhance completeness of the data. All of the landscape species conceptual models are included in this document: MBR_ConceptualModels_LandscapeSpeciesJune 22_2012.pdf

NatureServe's database contains an array of information about elements of biodiversity, with particular emphasis on those that are more threatened across their range. Tracked data includes taxonomy, conservation status, ecological and life history, habitat requirements, and distribution, with primary sources of this information consisting of scientific literature, museum specimen records, reliably documented observation records, species lists, range maps, external databases, and experts, including scientists from natural heritage member programs. While centrally NatureServe maintains range maps and/or data representing all native full species vertebrates and vascular plants, at the local member program level, resources generally limit tracking specific locations where elements occur within their jurisdictions to those having the highest conservation concern.

NatureServe scientists use a set of references generally accepted by researchers working on a given taxonomic group, supplemented by recent scientific literature and expert opinion, to establish a standard "global" scientific name and taxon circumscription for every element of biodiversity contained in the central database. Arranged by taxonomic level and species type, the major references NatureServe used (December 2011) for the species CE names and taxonomy follows.

HIGHER TAXONOMY

Phyla and Subphyla

- Integrated Taxonomic Information System. Integrated Taxonomic Information System: Biological Names. Available online at: http://www.itis.gov/.
- Margulis, L., and K. V. Schwartz. 1998. Five kingdoms: An Illustrated Guide to the Phyla of Life on Earth. Third edition. W. H. Freeman and Company, New York. 520 pp.

PHYLUM CRANIATA (VERTEBRATES)

Class Mammalia (Mammals)

- American Society of Mammalogists. Mammalian species. Cumulative index available online: http://www.science.smith.edu/departments/Biology/VHAYSSEN/msi/default.html
  [ASM publishes 20-30 species accounts each year; each summarizes the current understanding of a species' biology.]
- Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, R. S. Hoffman, C. A. Jones, F. Reid, D. W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Museum of Texas Tech University Occasional Papers 229:1-23.
- Da Fonseca, G., G. Herrmann, Y. Leite, R. Mittermeier, A. Rylands, and J. L. Patton. 1996. Lista anotada dos mamíferos do Brasil. Conservation International, Washington, D.C.
- Hall, E. R. 1981. The Mammals of North America. Second edition. John Wiley & Sons, New York. [Used for North American mammal subspecies names, within the framework of the species classification of the major sources cited here.]
- Reid, F. A. 1997. A field guide to the mammals of Central America and southern Mexico. Oxford University Press, New York.
- Wilson, D. E., and F. R. Cole. 2000. Common names of mammals of the world. Smithsonian Institution Press, Washington, D.C.
- Wilson, D. E., and D. M. Reeder (editors). 2005. Mammal species of the world: a taxonomic and geographic reference. Third edition. The Johns Hopkins University Press, Baltimore. Two volumes. 2,142 pp. Available online at: http://www.bucknell.edu/msw3/.

Class Aves (Birds)

- American Ornithologists' Union. 1957. Checklist of North American birds. Fifth edition. Port City Press, Inc., Baltimore, Maryland. [Used for North American bird subspecies names, within the framework of the species classification in AOU checklist.]
- American Ornithologists' Union (AOU). 1998. Check-list of North American birds. Seventh edition. American Ornithologists' Union, Washington, D.C. [as modified by subsequent supplements and corrections published in *The Auk*]. Also available online: http://www.aou.org/.
- The Birds of North American Online. Available at: http://bna.birds.cornell.edu/BNA/. [subscription required]
- Howard, R. and A. Moore. 2003. A complete checklist of the birds of the world. Third edition. Princeton University Press, Princeton, New Jersey. 1039 pp.
- Remsen, J. V., Jr., A. Jaramillo, M. Nores, M. B. Robbins, T. S. Schulenberg, F. G. Stiles, J. M. C. da Silva, D. F. Stotz, and K. J. Zimmer. Version [11 November 2011]. A classification of the bird species of South America. American Ornithologists' Union. http://www.museum.lsu.edu/~Remsen/SACCBaseline.html.

Classes Chelonia, Crocodylia, and Reptilia (Turtles, Crocodilians, and Reptiles)

- Collins, J. T., S. L. Collins, and T. W. Taggart. 2010. Amphibians, reptiles, and turtles in Kansas. Eagle Mountain Publishing, Eagle Mountain, Utah. xvi + 312 pp.
- Crother, B. I. (editor). 2008. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Sixth edition. Society for the Study of Amphibians and Reptiles Herpetological Circular 37:1-84.
- Ernst, C. H., and R. W. Barbour. 1989. Turtles of the world. Smithsonian Institution Press, Washington, D.C.
- Ernst, C. H., R. W. Barbour, and J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C.
- Ernst, C. H., and E. M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, D.C.
- Iverson, J. B. 1992. A revised checklist with distribution maps of the turtles of the world. Privately printed, Earlham, Indiana.
- King, F. W., and R. L. Burke, editors. 1989. Crocodilian, tuatara, and turtle species of the world: a taxonomic and geographic reference. Association of Systematics Collections, Washington, D.C. 216 pp.
- McDiarmid, R. W., J. A. Campbell, and T. A. Touré. 1999. Snake species of the world: a taxonomic and geographic reference. Volume 1. The Herpetologists' League, Washington, D.C.
- Schwartz, A., and R.W. Henderson. 1988. West Indian amphibians and reptiles: a check-list. Milwaukee Public Museum, Contributions in Biology and Geology. No. 74:1-264. [Major source for West Indian reptiles]
- Society for the Study of Amphibians and Reptiles. 1971 et seq. Catalogue of American Amphibians and Reptiles. (Published by the American Society of Ichthyologists and Herpetologists, 1963-1970.)
- Stebbins, R. C. 2003. A field guide to western reptiles and amphibians. Third edition. Houghton Mifflin Company, Boston.

The primary purpose of the species CE characterization is to provide sufficient information on classification, range, ecology and life history, and habitat requirements to permit assumptions about effects on the species that would likely result from change agents such as development, invasive plant species, or changes in fire regime, that are components of the assessment process. Thus, the CE characterization provides narrative detailing individual attributes of the element, and information on Change Agents (CAs) that may threaten its survival.

Each model begins by characterizing what the CE is and how it nests within the broader conceptual model already established for the ecoregion. Each CE is placed within one of the 2 major model components (Level 1, see table below for the list), and then into one of the sub-model groups (Level 2).

Table B - 9. Landscape Species CEs in the MBR and placement in Ecoregional Conceptual Model

Species CEs in the MBR and placement in Ecoregional Conceptual Model		
Level 1	**Level 2**	**Taxon Name**
Montane Dry Land System	Montane Canyons	Desert Bighorn Sheep *Ovis canadensis nelsoni*
		Golden Eagle *Aquila chrysaetos*
	Montane Shrublands	Loggerhead Shrike *Lanius ludovicianus*
		Mule Deer *Odocoileus hemionus*
	Subalpine/Montane Forests & Woodlands	Big Brown Bat *Eptesicus fuscus*
		Cooper's Hawk *Accipiter cooperii*
		Northern Rubber Boa *Charina bottae*
Basin Dry Land System	Cliff & Outcrop	Brazilian Free-tailed Bat *Tadarida brasiliensis*
		Great Basin Collared Lizard *Crotaphytus bicinctores*
	Desert Scrub	Mojave Desert Tortoise *Gopherus agassizii*
		Coachwhip *Masticophis flagellum*
		Gila Monster *Heloderma suspectum*
		Glossy Snake *Arizona elegans*
		Mohave Ground Squirrel *Xerospermophilus mohavensis*
		Mohave Rattlesnake *Crotalus scutulatus*
		Sonoran Desert Tortoise *Gopherus morafkai*
		Western Banded Gecko *Coleonyx variegatus*
		Western Patch-nosed Snake *Salvadora hexalepis*
	Semi-desert Shrub & Steppe	Brewer's Sparrow *Spizella breweri*
		Kit Fox *Vulpes macrotis*

Species CEs in the MBR and placement in Ecoregional Conceptual Model		
Level 1	**Level 2**	**Taxon Name**
		Northern Sagebrush Lizard *Sceloporus graciosus graciosus*
		Prairie Falcon *Falco mexicanus*
		Sage Sparrow *Amphispiza belli*
		Sage Thrasher *Oreoscoptes montanus*
Montane Wet System	Montane Lakes & Wetlands	Northern Harrier *Circus cyaneus*
Basin Wet System	Basin River & Riparian	Bald Eagle *Haliaeetus leucocephalus*
		Common Kingsnake *Lampropeltis getula*

Conservation Element Characterization

Below, the individual components included in each species CE are described. Characterization data that has been developed for species CEs is intended to represent the taxon across the entire range of its distribution (i.e., global-level data); therefore, the information may be more relevant to subpopulations or specific areas within that range, which might extend beyond the ecoregion. Note that for some species, particular components of information may be lacking.

The narrative provided includes information on classification, range, ecology and life history, and habitat requirements, as well as major threats. Each field of information is described below with a brief description of the field's contents.

CLASSIFICATION COMMENTS

Brief clarification of any anomalies or changes in the element taxonomy concerning the validity or taxonomic distinctness of the species.

RANGE

Current total geographic range-wide extent of the species, with breeding/nonbreeding or seasonal ranges specified, if different.

OCCURRENCES

Estimate of total number of precise locations where the species is known to occur across its range, including information on how the estimate was derived. Occurrence data is developed and maintained by natural heritage member programs, which document and delimit the presence and extent of individual species on the landscape. Species occurrences commonly reflect populations or subpopulations.

POPULATION

Estimate of total population size for the species across its range, including information on how the estimate was derived, variations, and data for specific portions of the range.

Habitat
Summary of the habitats and microhabitats commonly used by the species throughout its range, including any daily, seasonal, and geographic variation in habitat use.

Phenology
Summary of the seasonal variations of the species across its range, including differences in seasons of activity and periods of daily activity.

Ecology
Summary of the ecology of the species across its range, including any additional information resulting from studies that have been conducted, and citations where appropriate. Information on population density, dispersal distances, home range size, annual and seasonal fluctuations in population size, nonbreeding coloniality/sociality, major predators, competitors, parasites, age-specific survival rates, and other significant ecological factors could be included.

Mobility
Discussion of the seasonality, direction, distances, major routes, sociality/dispersion, daily timing, and variability (e.g., between populations) in movement/migration patterns of the species across its range.

Food
Information on food types, food location (e.g., microhabitat), foraging methods/strategy, seasonal and geographic variation in diet, and major differences in diet among age classes (e.g., young vs. adults) for the species across its range. Additional information resulting from studies that have been conducted should be included, along with citations where appropriate. If the species is classically considered to be an omnivore, this fact should be included, along with appropriate references.

Reproduction
Description of the reproduction of the species across its range, including information on clutch/litter size and frequency, gestation/incubation period, seasonal timing of reproductive activities, nature and period of any parental care, age of sexual maturity, and size and general nature of breeding aggregations. Additional information resulting from studies that have been conducted is included, along with citations where appropriate.

Change Agent (CA) Characterization
Altered Dynamics
Description of the primary change agents, including information on the scope, severity, and immediacy (timing) of threats, and current knowledge of their effects on the species across its range. Comments should include whether the scope and severity of the threats to species are observed, inferred, or suspected, or result from qualitative observation of its impact on the CE. The extent, including geographic variation, and effects of current or projected extrinsic influences on the species should be described, along with any additional threats or interactions among different threats, including high-magnitude threats considered insignificant in immediacy.

Conceptual Model Diagram
A diagram is provided (composed of three sub-figures) conceptualizing the relationships between Change Agents, the stresses they induce in the CE, the response of the CE to those stressors, and how we plan to measure either the stress or the CE response with indicators. It is intended to be illustrative of the effect of each Change Agent on the CE's ecological condition. Change Agents are a source of different types of stressors. Different types of stressors invoke different responses, and Indicators are metrics by which we can directly measure the amount of stress or response within each CE.

Not all change agents, stresses, or responses, and indicators are listed, but rather only those applied in the assessment.

Ecological [Habitat] Status Criteria and Indicators

To assess ecological status for each CE within the ecoregion, NatureServe's ecological integrity framework sets up practical criteria and indicators for this purpose (Faber-Langendoen et al. 2006, Unnasch et al. 2008). This framework provides a scorecard for reporting on the ecological status of a given CE within a given location, and facilitates the aggregation and synthesis of the component results for broader measures of ecological integrity at landscape and ecoregional scales. Using this framework, indicators are chosen to provide a measurement for a limited set of key ecological attributes, or ecological drivers for each CE. Ecological attributes may include natural characteristics, such as native species composition, or stressors such as effects of relevant change agents, that are well known to affect the natural function and integrity of the CE.

In part because of project constraints, indicators that we have identified emphasize ecosystem stressors that can be more readily measured using available remotely sensed data. Spatial models that reflect these indicators serve as the link between the conceptual models and the spatial representation of ecological status. For each CE, we provide the definitions and justifications for each of the indicators we will be assessing for that CE, organized in an Ecological Status Scorecard table. Each indicator is scored according to criteria described in the table and is calculated between 0 and 1, with 1 indicating highest ecological status and 0 indicating lowest status (and presumably transitional to a wholly different ecological state).

For most of the landscape species conservation elements, we have developed spatial models predicting distribution of habitat for the species; only a few species have current occupied habitat mapped. Hence for the ecological status assessment, the unit of assessment for most species is its predicted habitat, rather than current occupied habitat. Only greater sage-grouse, mule deer and desert bighorn sheep have occupied habitat models; for bald and golden eagles habitat is represented by point localities for actual occurrences and those will be the assessment units. For all other species predicted habitat is the habitat unit of assessment.

References for the CE

Literature is listed that is relevant to the classification, distribution, ecology and life history, threats, and habitat requirements of the individual CE, in some cases from portions of its range outside of the ecoregion. These are not exhaustive literature surveys, but rather an accumulation of known references. Some documents may be listed that are not cited in the narrative text.

B-1.2 Spatial Modeling of Distribution

Spatial models were documented in the form of 'box and arrow' diagrams for each analyses (or category of analyses) that illustrated data inputs, analytical processes, and outputs. Data generation models explained how distribution maps for certain CEs and CAs could be created for those features that lacked complete or acceptable distribution data from existing sources. Spatial models for assessments are described in subsequent sections below.

Spatial modeling for CEs first takes the form of distribution modeling, indicating the location of the CE. Most often, this simply refers to the current known location, such as the mapped distribution of, e.g., the North American Warm Desert Lower Montane Riparian Woodland and Shrubland/Stream. However, distributions for CEs take several forms. For some landscape species CEs, spatial distributions are developed for three distinct habitat components. For example, as specified in its conceptual model, mule deer is spatially represented using three distinct map units; summer range, winter range, and year-around range. Terrestrial coarse-filter units have been mapped in two forms; there current distribution and their biophysical setting. The biophysically setting, as developed for LANDFIRE aims to depict the potential distribution of the unit, given natural landscape disturbance regimes like wildfire.

One additional form of CE distribution modeling comes in the form of climate envelope models, where the climate variables that characterize the current distribution of the CE are developed; and then forecasted to future decades using the predicted climate distributions. These models should not be construed to predict the future distribution of a given CE, *but rather simply to indicate the degree and magnitude of potential change in climate regime relative to a particular CE*. See Section B-1.3 below for methods of bioclimate envelope modeling. Below we summarize the primary methods use in distribution modeling for CEs.

Deductive and Inductive Models

Deductive models utilize existing mapped information, and then recombine them according to a set of rules determined by the modeler. This contrasts with ***inductive models,*** where most commonly, geo-referenced observations (e.g., known observations of a given species) are combined with maps of potential explanatory variables (climate, elevation, landform, soil variables, etc.). Statistical relationships between dependent variables (observations) and independent explanatory variables are used to derive a new spatial model.

In many instances for this REA, existing data were previously derived through inductive modeling. Review of these models led to suggestions for their refinement, which were implemented through deductive methods. In other instances, only deductive, or only inductive methods were used. Here we briefly summarize and illustrate each category of spatial models.

B-1.2.1 Terrestrial coarse filter deductive models

Building from the framework of the ecoregional conceptual model, the major ecological systems were identified for the ecoregion. The "coarse filter" includes terrestrial ecological system types that express the predominant ecological pattern and dynamics of uplands of the ecoregion (Table B - 10). These classified units a) characterize each component of the ecoregion's conceptual model, b) define the vast majority of this ecoregion's lands, and c) reflect described ecological types with distributions concentrated within this ecoregion.

Ecological models (both conceptual and spatial) for these coarse filter elements formed a major focus for this ecoregional assessment. NatureServe ecological classifications provided the basis for several existing national or regional map products (e.g., NatureServe national map, ReGAP in CA and SW region, LANDFIRE EVT & BpS, etc.) and/or may be readily reconciled with locally-desired classification systems for plant communities (see the Terrestrial Coarse-filter Conceptual Models appendix for more detailed descriptions of ecosystem types listed in this appendix). NatureServe databases, existing map products and the list of ecosystems of interest identified in REA statement of work were used to establish the list of these core CEs.

Terrestrial coarse filter CEs were defined and described using the the NatureServe ecological systems classification (Comer et al. 2003) and depicted initially with data derived from SW ReGAP, CAGAP, and LANDFIRE EVT (for California portions), all of whom used inductive modeling methods. As depicted in Figure B - 2, each of these current and potential distributions was reviewed to determine, from an expert point of view, where error occurred that could be addressed using deductive modeling with ancillary spatial data (e.g., landforms, soils, hydrography, elevation, etc.).

Table B - 10. Terrestrial Coarse-Filter CEs for Mojave Basin and Range Ecoregion

Ecoregion Conceptual Model		Coarse-filter Element Name
Level 1	**Level 2**	
Montane Dry Land System	Montane Shrublands	Mogollon Chaparral
		Sonora-Mojave Semi-Desert Chaparral
	Subalpine/Montane Forests & Woodlands	Great Basin Pinyon-Juniper Woodland
Basin Dry Land System	Cliff & Outcrop	North American Warm Desert Badland
		North American Warm Desert Bedrock Cliff and Outcrop
		North American Warm Desert Pavement
	Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub
		Mojave Mid-Elevation Mixed Desert Scrub
		Sonora-Mojave Creosotebush-White Bursage Desert Scrub
		Sonora-Mojave Mixed Salt Desert Scrub
		Sonoran Mid-Elevation Desert Scrub
	Dunes	North American Warm Desert Active and Stabilized Dune
	Semi-desert Shrub & Steppe	Great Basin Xeric Mixed Sagebrush Shrubland

Terrestrial coarse-filter units are defined using the NatureServe ecological systems classification (Comer et al. 2003) and their distributions were depicted intitally with data derived from SW ReGAP, CA GAP, and LANDFIRE EVT (for CA portions). These map sources applied inductive modeling methods to derive their maps. As depicted in Figure B - 2, each of these current distributions was reviewed to determine, from an expert point of view, where error occurred that could be addressed using other ancillary spatial data (e.g, landforms, soils, hydrography, elevation, etc.).

NatureServe Terrestrial Ecological Systems Map for the Continental United States

NatureServe's terrestrial ecological systems map for the coterminous U.S. was the first, and the major, source dataset used to develop the coarse-filter distributions.

The NatureServe dataset represents compilation of the work of multiple state and Federal agencies as part of the US Gap Analysis and LandFire programs, all of whom used inductive models. Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 acre. Landcover classes were drawn from NatureServe's Ecological System concept. Five-hundred and fourty-four land cover classes composed of 12 cultural and 532 Natural/Semi-natural types were mapped across the coterminous U.S. Land cover classes were mapped with a variety of techniques including decision tree classifiers, terrain modeling, inductive modeling, and unsupervised classification. The 67 USGS mapping zones were modeled independently of one another by multiple spatial analysis laboratories.

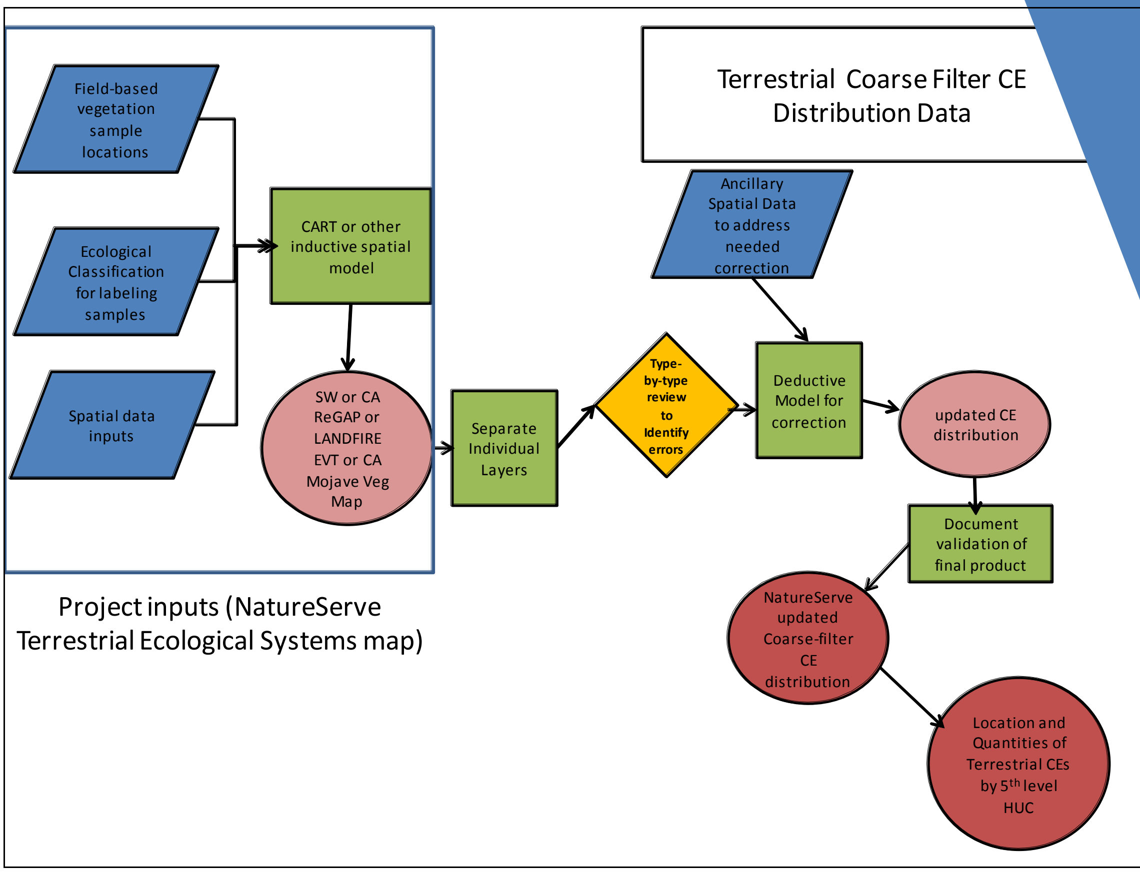


Figure B - 2. Process steps for mapping terrestrial coarse-filter CEs.

Prior to the initiation of the BLM REAs, NatureServe stitched together the resultant spatial data from the Gap and LANDFIRE efforts, into one comprehensive map for the coterminous US. In the western US, SW ReGap data were used for the 5 southwestern states (AZ, CO, NM, NV, UT), and LANDFIRE data were used for California. PNW ReGap was the source for data from ID, MT, OR, WA and WY. Following completion of the national dataset, each individual land cover type was evaluated by NatureServe (again prior to the initiation of the BLM REAs) through individual working groups and two regional workshops attended by State, Federal, and Natural Heritage Program ecologists. Where individual systems were identified with likely errors a description was recorded of the issue and a fix where available was described and initiated by NatureServe. All changes are available in supporting documentation (see National Ecologial Systems Modification.pdf for documentation of all changes made) and represent the opinion of multiple experts. Updates to specific system types were peformed to update known errors in the data layer.

Additional Processing to Represent Current Coarse-filter Distributions for the REA

The current distribution of the thirteen terrestrial coarse-filters CEs within the MBR ecoregion (Table B - 10) were reviewed and, if necessary, revised (Table B - 12). The main focus of this review was on the boundary between Arizona or Nevada and California, since the source data for California was LANDFIRE, and there were major unresolved discrepancies along the state borders. In addition, the sparsely vegetated coarse-filters, such as badlands, pavement, cliff & outcrop, or dunes, were systematically reviewed because of *a priori* knowledge they'd been poorly mapped on the California side of the ecoregions.

Six source datasets were used in this review (Table B - 11): NatureServe Ecological System types v2.7 (ES, described above), LANDFIRE Existing Vegetation Types Refresh 2008 (EV), LANDFIRE Existing Vegetation Cover Refresh 2008 (EC), LANDFIRE Biophysical Settings Refresh 2001 (BP), California ReGAP Land Cover 2003 (CG), and USGS Mojave Vegetation Map 2000 (MV).

Three ancillary datasets were used to subset the distributions of these ecosystem/vegetation maps including: National Resource Conservation Service (NRCS) Multiple Resource Land Area (MRLA), US Forest Service (USFS) EcoMap 2005 (EcoMap), and US Geological Survey (USGS) 30 meter National Elevation Dataset (NED). All source and ancillary datasets were 30 meter pixel resolution and masked/snapped to the MBR boundary.

Table B - 11. Source and ancillary datasets used for current coarse-filter distributions.

Source Dataset Name	Delivered File Name(s)	Methods Abbreviation
California ReGAP Land Cover 2003	CBR_TES_C_GAP_CALIFORNIA_2008_CA_ ESLF.img	CG
LANDFIRE Biophysical Settings Refresh 2001	TES_H_Landfire_BPS.img	BP
LANDFIRE Existing Vegetation Cover Refresh 2008	TES_C_Landfire_EVC.img	EC
LANDFIRE Existing Vegetation Types Refresh 2008	TES_C_Landfire_EVTR.img	EV
National Elevation Dataset (NED) - 30 m	CBR_ELV_USGS_NED_30m MBR_ELV_USGS_NED_30m	NED
National Resource Conservation Service (NRCS) Multiple Resource Land Area (MRLA)	CBR_MRLA_Subregions_poly MBR_MRLA_Subregions_poly	MRLA
NatureServe Terrestrial Ecosystems and Landcover	C_NATURESERVE_L48_ESLF_V2_7.img	ES
US Forest Service (USFS) EcoMap 2005 (EcoMap)	CBR_EcoMap_Subregions_poly MBR_Ecomap_Subregions_poly	EcoMap
USGS Mojave Vegetation Map 2000	MBR_TES_C_CA_Mojave_vegcda_poly	MV

For each terrestrial coarse-filter CE, its distribution was extracted from the NatureServe ecological systems v2.7 map (the ES), and clipped to the combined MBR and CBR area. Each was then reviewed across its distribution within the MBR boundary, by NatureServe ecology staff familiar with the type's concept and distribution. Draping the individual CE distribution onto a shaded relief map helped to identify areas where the CE was correctly or incorrectly mapped. During the review, the expert also had on-hand the California ReGAP land cover map (CG), the refreshed LANDFIRE existing vegetation types (EV), and the Mojave vegetation map (MV) to cross-check how the type was mapped in a particular area by those efforts. Locations where the mapping of the type needed correction were identified. Each area would then be corrected by selecting the type's pixels within that area and applying a conversion to a different type.

The revised distributions of these ecological systems were then combined into a current terrestrial coarse-filter CEs dataset for the MBR and CBR ecoregions and all other cells were coded as null. This dataset was then clipped for each REA boundary.

Table B - 12. Revisions made to terrestrial coarse-filter CE current distributions during expert review.

Terrestrial Coarse-filter	Changes Made
Great Basin Pinyon-Juniper Woodland	The complete distributions of this class within ES, EV and CG were combined;
Great Basin Xeric Mixed Sagebrush Shrubland	The complete distributions of this class within EV and CG were combined.
Inter-Mountain Basins Mixed Salt Desert Scrub	The complete distributions of this class within ES, EV and CG were combined, excluding occurrences of this class within the Owens Valley, Saline Valley-Cottonwood Mountains and High Desert Plains subsections of the USFS ECOMAP.
Mogollon Chaparral	No change from ES
Mojave Mid-Elevation Mixed Desert Scrub (Joshua Tree)	The complete distributions of this class within CG and MV were combined, plus occurrences of this class within EV within all of the MBR, as well as the extent 50 to 100 kilometers north of the MBR boundary, based on expert knowledge of the on the ground distribution, plus the distribution of this class within BP below 1575 meters in elevation (using USGS NED) within the Grand Canyon.
North American Warm Desert Active and Stabilized Dune	No change from ES
North American Warm Desert Badland	No change from ES
North American Warm Desert Bedrock Cliff and Outcrop	No change from ES
North American Warm Desert Pavement	Updated with a change in elevation moving window model based upon the 10m DEM; adjacent sparse & unspecified disturbed land cover types with less than 50m of elevation change in $100m^2$ moving window were updated to North American Warm Desert Pavement.
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	The complete distributions of this class within ES and CG were combined, excluding small occurrences of this class within CG along the northeast boundary of its distribution based on expert knowledge of the on the ground distribution;
Sonora-Mojave Mixed Salt Desert Scrub	The complete distribution of this class within ES, EV, CG and MV were combined, plus the distribution of Inter-Mountain Basins Mixed Salt Desert Scrub occurrences within ES, EV, and CG within the Owens Valley, Saline Valley-Cottonwood Mountains, and High Desert Plains subsections of the ECOMAP
Sonora-Mojave Semi-Desert Chaparral	No change from ES
Sonoran Mid-Elevation Desert Scrub	No change from ES

B-1.2.1.1 Potential (Biophysical Settings) Distributions

B-1.2.1.1.1 LANDFIRE Biophysical Settings Data

The biophysical settings (BpS) data layer represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime. It is an attempt to incorporate current scientific knowledge regarding the functioning of ecological processes - such as fire - in the centuries preceding non-indigenous human influence. LANDFIRE mapped biophysical settings across the United States, using NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units (Comer et al. 2003). The BpS data layer is used in LANDFIRE to depict reference conditions of vegetation, and the actual time period for this data set is a composite of both the historical context provided by the fire regime and vegetation dynamics models, and the more recent field and geospatial data used to create it.

Prior to initiation of the BLM REAs, NatureServe compiled the LANDFIRE BpS data into one comprehensive BpS map for the coterminous U.S., and this was the primary source dataset for the potential distributions of the coarse-filter CEs.

Additional Processing to Represent Potential Coarse-filter Distributions

The potential (BpS) distributions of the terrestrial coarse-filter CEs were used in conjunction with the current distributions described above to assess “change in extent”, one of the indicators of ecological status for the terrestrial coarse-filter CEs.

One source dataset was used in the review (Table B - 13): LANDFIRE Biophysical Settings Refresh 2001 (BP). Three ancillary datasets were used to subset the distributions of these ecosystem/vegetation maps including: National Resource Conservation Service (NRCS) Multiple Resource Land Area (MRLA), US Forest Service (USFS) EcoMap, 2005 (EcoMap), and US Geological Survey (USGS) 30 meter National Elevation Dataset (NED). All source and ancillary datasets are 30 meter pixel resolution and masked/snapped to the MBR boundary.

Table B - 13. Source and ancillary datasets used for potential coarse-filter distributions.

Source Dataset Name	Delivered File Name(s)	Methods Abbreviation
LANDFIRE Biophysical Settings Refresh 2001	TES_H_Landfire_BPS.img	BP
National Elevation Dataset (NED) - 30 m	MBR_ELV_USGS_NED_30m	NED
National Resource Conservation Service (NRCS) Multiple Resource Land Area (MRLA)	MBR_MRLA_Subregions_poly	MRLA
US Forest Service (USFS) EcoMap 2005 (EcoMap)	MBR_Ecomap_Subregions_poly	EcoMap

Ten terrestrial ecological systems within the MBR ecoregion were reviewed and, if necessary, revised (Table B - 14). For the review, each CE distribution was extracted from the compiled BpS map (the BP), and clipped to the CBR/MBR area. Each was then reviewed across its distribution within the MBR boundary, by NatureServe ecology staff familiar with the type’s concept and distribution. Draping the individual CE distribution onto a shaded relief map helped to identify areas where the CE was correctly or incorrectly mapped.

Three coarse-filter CEs were not reviewed for potential distribution as their potential and current distributions were assumed to be completely congruent (North American Warm Desert Active and Stabilized Dune, North American Warm Desert Badland, and North American Warm Desert Pavement).

The revised or unchanged distributions of these ecological systems were then combined into a potential biophysical settings dataset for the combined CBR and MBR ecoregions, and all other cells were coded as null. This dataset was then clipped for each REA boundary.

Table B - 14. Revisions made to terrestrial coarse-filter CE potential distributions during expert review.

Terrestrial Coarse-filter	Changes Made
Great Basin Pinyon-Juniper Woodland	The complete distribution within BP.
Great Basin Xeric Mixed Sagebrush Shrubland	The complete distribution within GB, plus occurrences within BP within the Carson Basin and Mountains and Southern Nevada Basin and Range MRLA subregions.
Inter-Mountain Basins Mixed Salt Desert Scrub	The complete distribution of this class within BP, excluding occurrences within the Owens Valley, Saline Valley-Cottonwood Mountains and High Desert Plains subsections of the USFS ECOMAP.
Mogollon Chaparral	No change
Mojave Mid-Elevation Mixed Desert Scrub (Joshua Tree)	The complete distribution of this class within BP, excluding occurrences above 1575 meters in elevation (using USGS NED) within the Grand Canyon.
North American Warm Desert Bedrock Cliff and Outcrop	No change
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	The complete distribution of this class of BP.
Sonora-Mojave Mixed Salt Desert Scrub	The complete distribution of this class within BP, plus the distribution of Inter-Mountain Basins Mixed Salt Desert Scrub occurrences within BP within the Owens Valley, Saline Valley-Cottonwood Mountains, and High Desert Plains subsections of the ECOMAP
Sonora-Mojave Semi-Desert Chaparral	No change
Sonoran Mid-Elevation Desert Scrub	No change

B-1.2.2 Sensitive Soils

MQ28 - Where are sensitive soil types within the ecoregion?

As a desired CE, sensitive soils were defined by BLM. Sensitive soils are those which are extremely susceptible to impact and difficult to restore and reclaim, including those with high erosion potential (water and wind), high salinity (excess salt and excess sodium), high gypsum content, low water-holding capacity (droughty), restricted rooting depth, or hydric qualities (Bryant, L. BLM internal communication). The approach for this REA was designed to identify soils with these characteristics given the best available data at any given location. BLM provided a list of vulnerable soil properties, to which 2 additional categories were added: gypsum soils, and hydric soils. Shallow soils (restricted rooting depth) could not be reliably modeled form the available data and were dropped form further analysis; soils with excessive sodium and salts were combined into one model for "sodium adsorption ratio".

Where available, the SSURGO 1:24,000 dataset provided by NRCS provided one of the best means for identifying these soils (Table B - 15). In portions of the study area for which SSURGO was unavailable, 1:250,000 scale STATSGO data were utilized when finer-scale draft soil survey data could not be obtained. A 10-meter resolution digital elevation model (DEM), processed for landform characteristics (slope, aspect, concavity, surface flow character, etc), was used in conjunction with SSURGO/STATSGO to identify soils vulnerable to water erosion. Additional datasets used in the modeling of these distributions included surficial geology, NWI wetland classes, and NatureServe's terrestrial ecological systems land cover map to exclude upland areas, or select land cover types likely to have excess sodium or salts in the soils. Below in Figure B - 3 through Figure B - 7 are provided the spatial modeling diagrams for each soil type, with criteria used from each input dataset. Three sensitvie soils distributions are displayed in Figure B - 8, Figure B - 9, and Figure B - 10. Most of the soils have such minor areal extent that maps are not useful. The data have all been provided to BLM.

Table B - 15. Sensitive soils groups and criteria for definition.

Properties	Low	Moderate	High	Restrictive Feature / Vulnerability Category[1]
Slope (Pct) Kw < 0.20[1,2] Kw 0.20 – 0.36[2,3] Kw >0.36[2,3]	<20 <15 <10	20 - 40 15 - 35 10 - 25	>40 >35 >25	Steep Slopes – Water Erosion
Wind Erodibility Group (Surface Layer)	5, 6, 7, 8	3,4, 4l	1, 2	Wind Erosion Hazard
Available Water Capacity[3] (Average To 40 Inches Or Limiting Layer) (In/In)	>0.10	0.05 - 0.10	<0.05	Droughty Soils
Salinity[3] (Mmhos/Cm) (Surface Layer)	<8	8 – 15.9	≥16	Excess Salt [note: this was combined with Sodium Adsorption Ratio]
Sodium Adsorption Ratio[3] (Surface Layer)	<8	8 - 12.9	≥13	Excess Sodium
Gypsum > 10%[5] (% by weight of hydrated calcium sulfates in the fraction of soil less than 20mm in size)	< 10%		>10%	Gypsum Soils
Soils with Hydric Properties	Field: hydclprs value = "All Hydric"	Field: Hydric Rating Value = Yes Land Cover Type = not upland	[Many Factors; see below spatial Model]	Hydric Soils

[1] Table content, with the exception of gypsum and hydric soils, is based on values developed by BLM Soil Specialist Bill Ypsilantis (Bryant, L. BLM internal communication).
[2] K Factor of surface layer adjusted for the effect of rock fragments (Kw).
[3] The representative value for the range in soil properties
[4] For Central Great Basin, include soils in WEG 3 that have formed from volcanic parent materials or Bonneville Lake Sediments in the "high" category, based on experience in NV and UT in which soils from these parent materials have high potential to blow following wildfire or other vegetation loss, even with the finer surface textures characteristic of WEG.
[5] Food and Agriculture Organization of the United Nations (FAO) 1990.

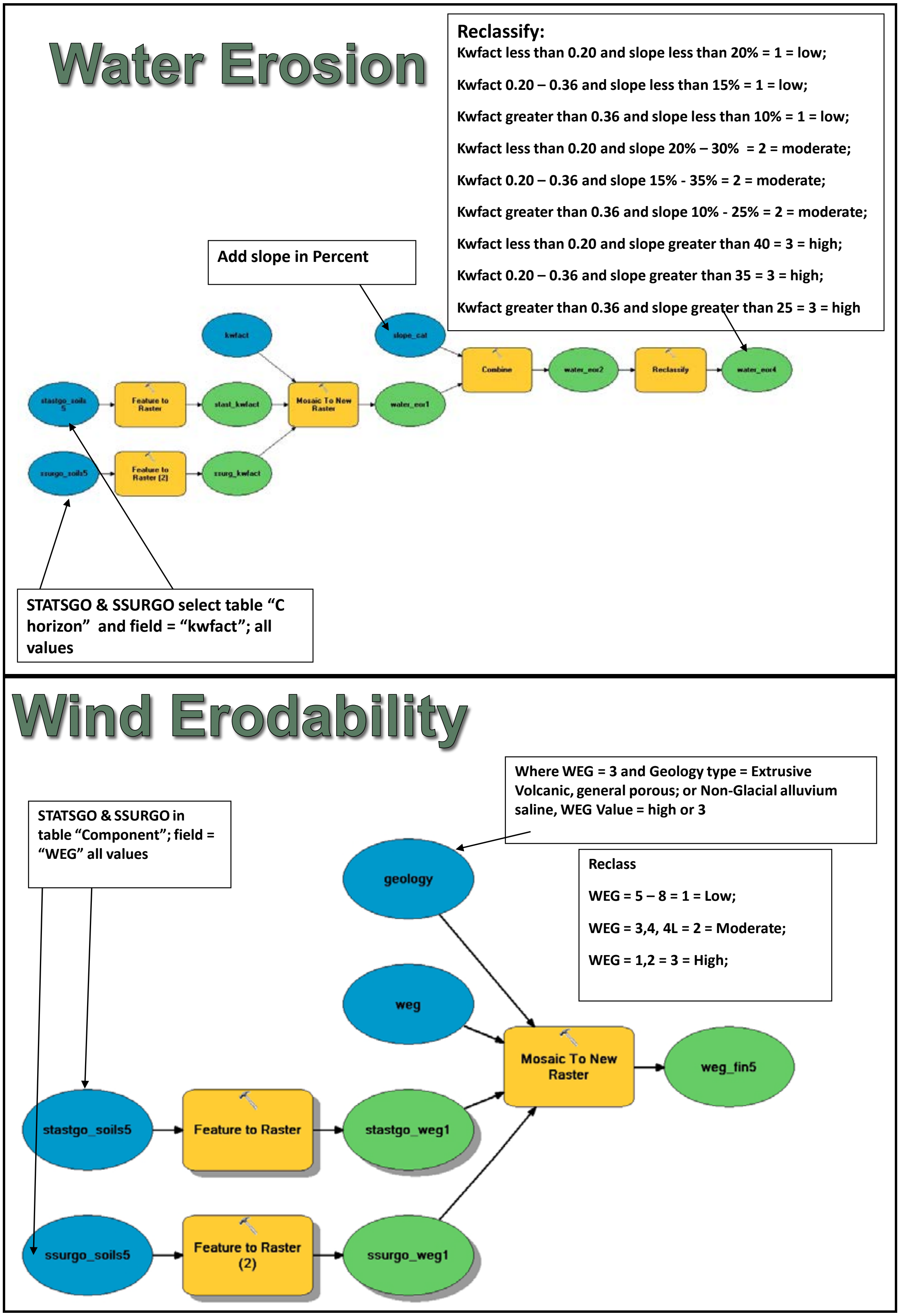


Figure B - 3. Conceptual and spatial models for modeling distribution of sensitive soils: criteria used for Water Erosion and Wind Erodability

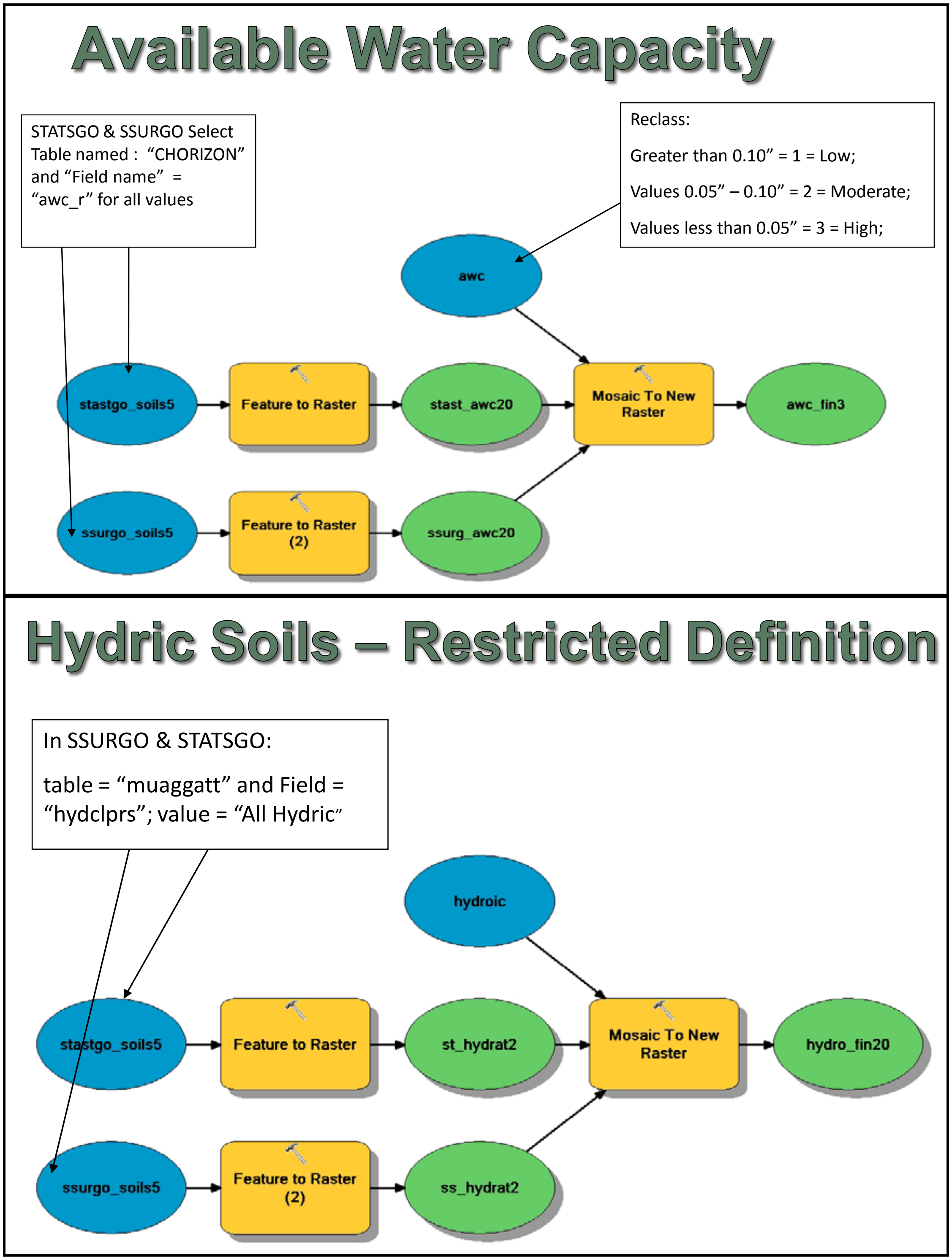


Figure B - 4. Conceptual and spatial models for modeling distribution of sensitive soils: criteria used for Available Water Capacity and Hydric Soils - Restricted Definition

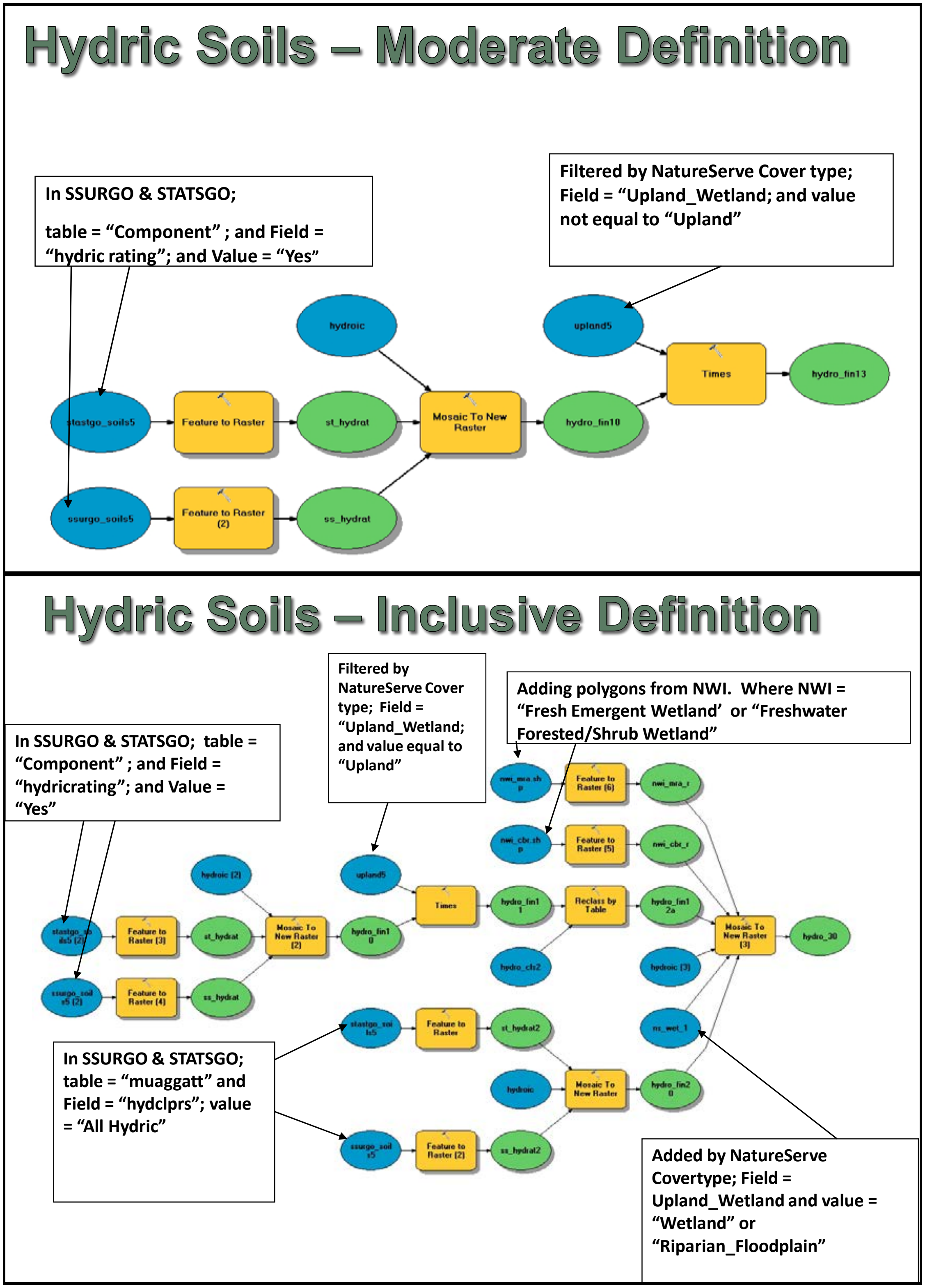


Figure B - 5. Conceptual and spatial models for modeling distribution of sensitive soils: criteria used for Hydric Soils – Moderate and Inclusive Definitions

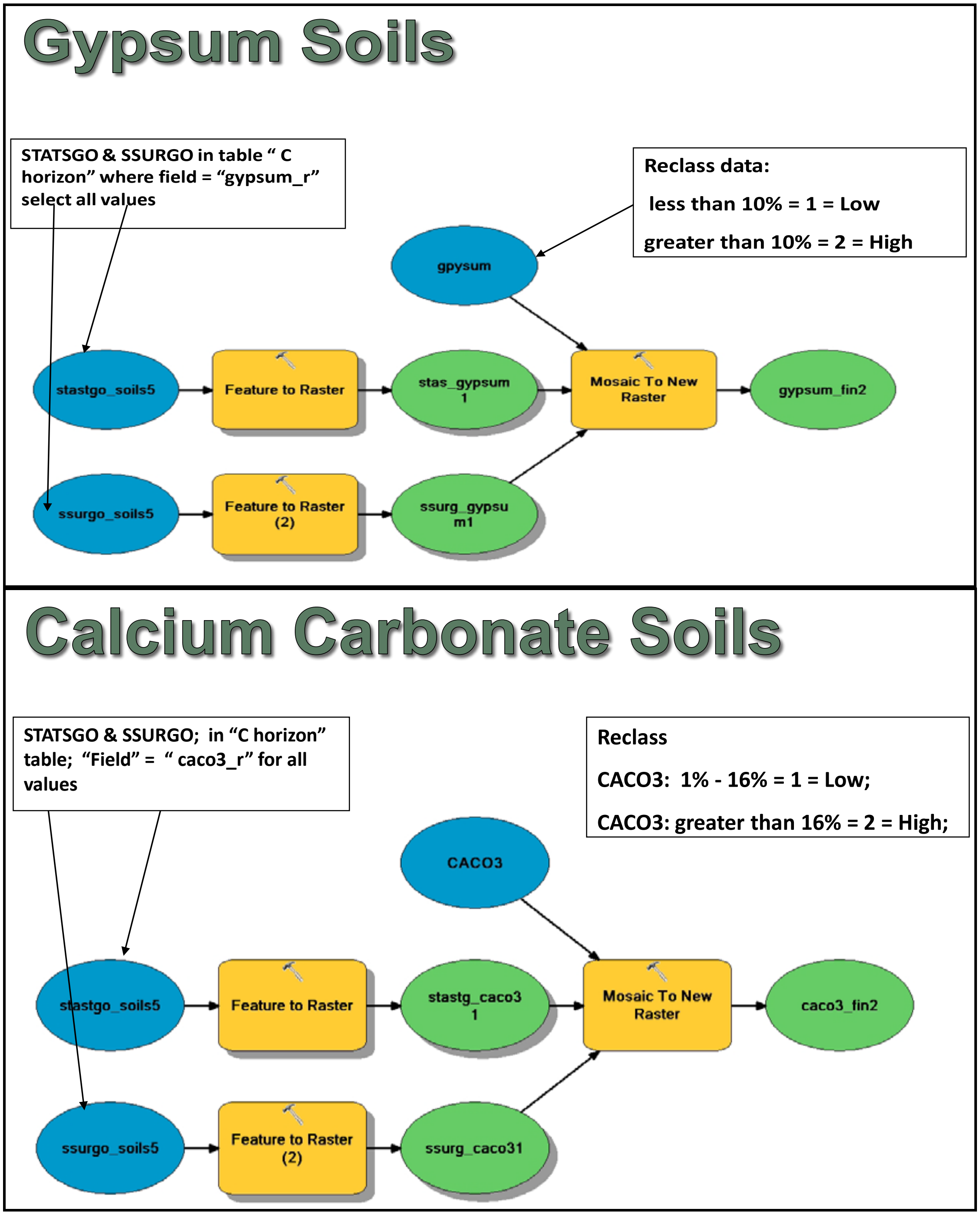
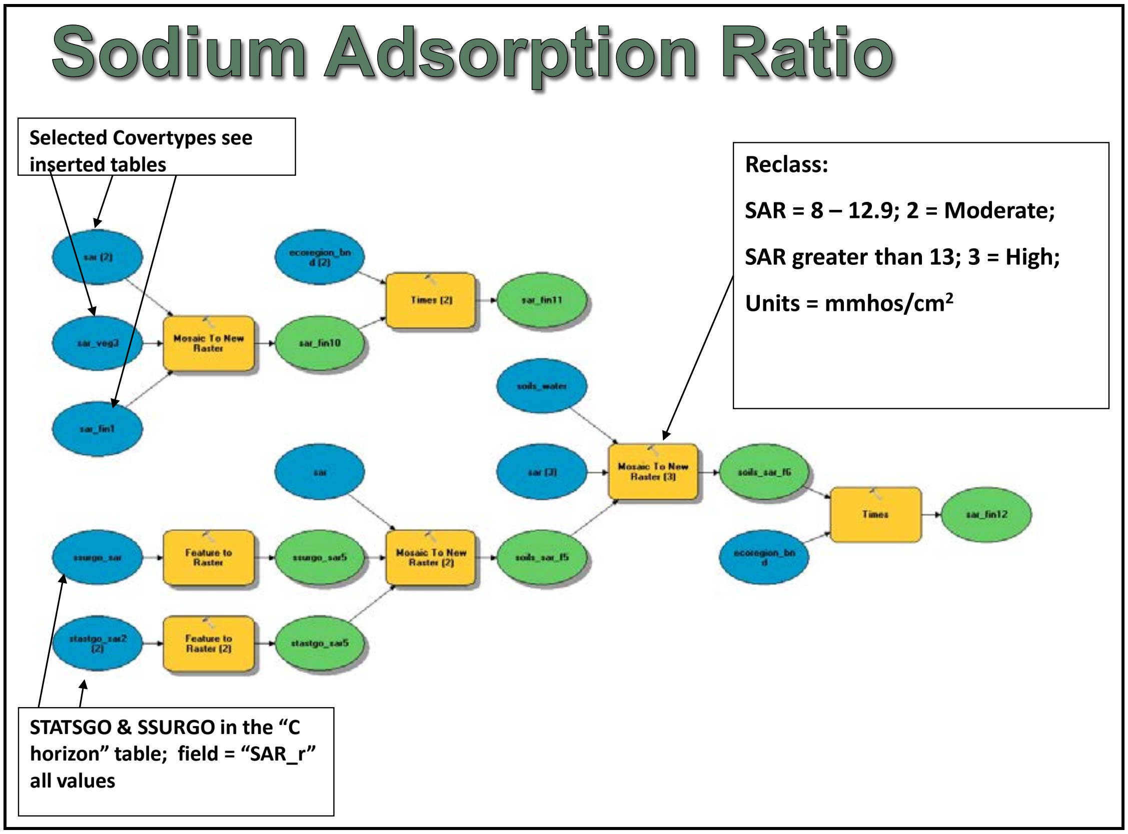


Figure B - 6. Conceptual and spatial models for modeling distribution of sensitive soils: criteria used for Gypsum Soils and Calcium Carbonate Soils



a)

Sodium Absorption/Excess Salt scores by ecological system type

Mode Group	Conservation Element Name (Mojave)	SAR
Basin Wet	North American Warm Desert Playa	3
Basin Dry	Sonora-Mojave Mixed Salt Desert Scrub	2
Basin Dry	Mojave Mid-Elevation Mixed Desert Scrub	1
Basin Dry	Sonoran Mid-Elevation Desert Scrub	1

b)

Figure B - 7. Conceptual and spatial models for modeling distribution of sensitive soils : criteria used for Sodium Adsorption Ratio (soils with excess salts or sodium) (figure a); figure b shows the ecological systems used for deductive modeling of these soil properties.

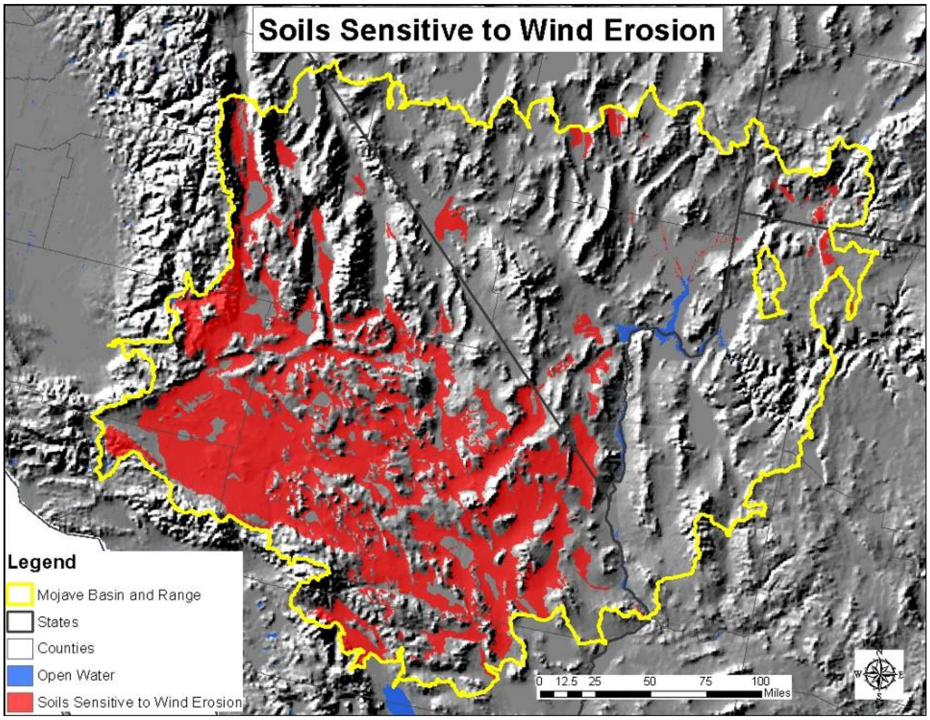


Figure B - 8. Distribution of soils vulnerable to wind erosion.

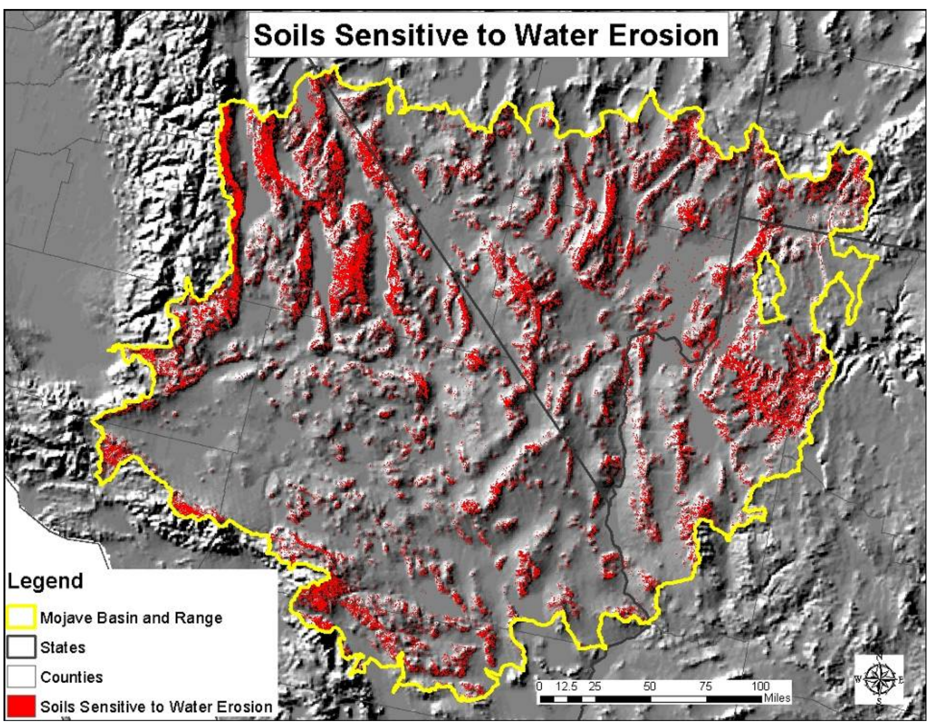


Figure B - 9. Distribution of soils vulnerable to water erosion.

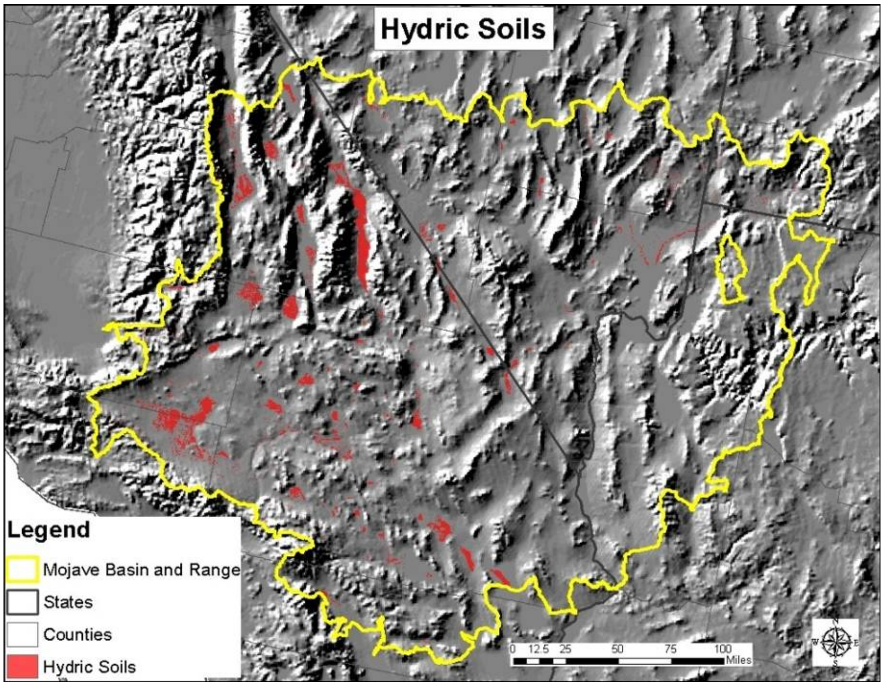


Figure B - 10. Distribution of hydric soils of the most inclusive definition.

Data Limitations and Uncertainty for Modeling Soils

SSURGO provides a moderately good means for identifying sensitive soils in those locations where it is available. Where SSURGO is not available, our ability to accurately map sensitive soil areas was somewhat compromised. Where SSURGO is not available, STATSGO was used. In conjunction with those data sources, DEM-derived landform data was utilized, along with land cover datasets. While soil attributes analogous to those available from SSURGO can be used to define sensitive soils based on STATSGO map units, the coarse resolution of that data increases the potential for errors of omission regarding occurrences of sensitive soils in these areas. It was beyond the scope of this REA to incorporate landscape context (e.g., wind pattern) into the calculation of wind erosion potential. There is undoubtedly some error introduced by the use of these spatial inputs of distinct spatial and thematic resolutions. While these are issues, for the purposes of the REA the results provide moderately certain predictions of where these vulnerable soils types occur.

B-1.2.3 Aquatic coarse filter: Deductive models

MQ30 - WHERE ARE CURRENT NATURAL AND MAN-MADE SURFACE WATER RESOURCES?

MQ58 - WHERE ARE ARTIFICIAL WATER BODIES INCLUDING EVAPORATION PONDS, ETC.?

Building from the framework of our ecoregional conceptual model, we first identified the major wetland and aquatic ecological systems for the ecoregion. The "coarse filter" includes aquatic ecological system types that express the predominant ecological pattern and dynamics of wetlands and aquatic habitats of the ecoregion (Table B - 16). These classified units a) characterize each component of the ecoregion's conceptual model, b) define the variety of wetland and aquatic resources of this ecoregion, and c) reflect described ecological types with distributions concentrated within this ecoregion.

Ecological models (both conceptual and spatial) for these coarse filter elements form a major focus for this ecoregional assessment. NatureServe ecological classifications provided the basis for several existing national or regional map products (e.g., NatureServe national map, ReGAP in CA and SW region, LANDFIRE EVT & BpS, etc.) and/or may be readily reconciled with locally-desired classification systems for plant communities (see the Aquatic Coarse-filter Conceptual Models appendix for more detailed descriptions of ecosystem types listed in this appendix). NatureServe databases, existing map products and the list of ecosystems of interest identified in REA statement of work were used to establish a list of these core CEs.

Table B - 16. Aquatic Coarse-Filter CEs for Mojave Basin and Range Ecoregion

CE Name	Input Data Layers and specific values	Elevation Rule	Notes
Mojave Desert Lake / Reservoir	C_NATURESERVE_L48_ESLF_V2_7.img, value = openwater	none	any water body within MBR
Mojave Desert Springs and Seeps	MBR_AQ_USGS_NHD_NHDWaterbody_poly AQ_C_NVHP_Spring_locations_Veg_poly	none	any seep/spring within MBR
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	C_NATURESERVE_L48_ESLF_V2_7.img, value = 9172 + MBR_AQ_USGS_NHD_nhdflowline_ln, value = perennial streams	between 1100-1800 m in elevation	
North American Warm Desert Riparian Woodland and Shrubland (including Mesquite Bosque) / Stream	C_NATURESERVE_L48_ESLF_V2_7.img, value = 9182 & 9178 + MBR_AQ_USGS_NHD_nhdflowline_ln, value = perennial streams	< 1200 m in elevation	
North American Warm Desert Playa	C_NATURESERVE_L48_ESLF_V2_7.img, value = 3161, (no NHD streams)	none	flat barren internal drainage basin bottoms
North American Warm Desert Wash	C_NATURESERVE_L48_ESLF_V2_7.img, value = 9151 + MBR_AQ_USGS_NHD_nhdflowline_ln, value = ephemeral streams	none	throughout the MBR

Aquatic/wetland/riparian coarse-filter units are defined using the NatureServe ecological systems classification (Comer et al. 2003) and their distributions were depicted initially with data derived from SW ReGAP, CA GAP, and LANDFIRE EVT (for CA portions). These map sources applied inductive modeling methods to derive their maps. As depicted in Figure B - 12, each of these current distributions was reviewed to determine, from an expert point of view, where error occurred that could be addressed using other ancillary spatial data (e.g, landforms, soils, hydrography, elevation, etc.). In addition our intent was to include in the distributions, as possible with available spatial data, the aquatic components of thes CEs, so distributions of streams, rivers, open water bodies, and other aquatic habitat were added to the intitial mapped distributions of riparian or wetland vegetation.

In addition to modeling the distribution of aquatic course filter conservation elements, all water bodies mapped by the NHD were reviewed in GIS to determine if they were a naturally occurring waterbody or a construct. All lakes behind dams were labeled man-made, except for known natural lakes that have dams that augment their water levels. Water treatment ponds, mine tailing ponds and evaporation ponds were labled as man-made. Tell-tale signs of human construct are square-sided ponds, cluster of angular-shaped ponds, lakes and ponds with straight edges on one or more sides. Linear features that are constructed such as aquaeucts, were also labeled as man-made. The location of these waterbodies and their "natural vs man-made label" are available for review in the GIS file MBR_MQ31_Lakes_NHD_v27_NaturalManmade_poly, and are shown in Figure B - 11.

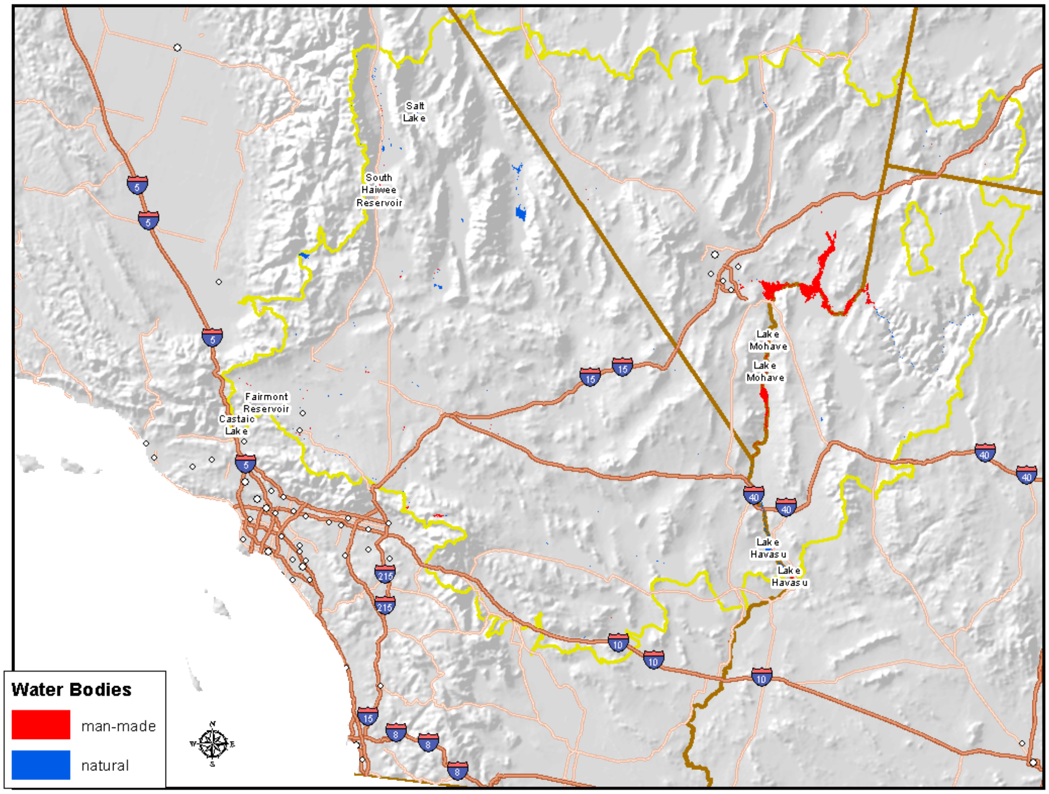


Figure B - 11. Map of current surface water bodies in MBR, including natural and man-made bodies.

NatureServe Ecological Systems Map for the Continental United States

NatureServe's ecological systems map for the coterminous U.S. was the first, and the major, source dataset used to develop the coarse-filter distributions. This effort includes both upland, riparian and wetland ecosystems, and mapped locations of open bodies of water.

The NatureServe dataset represents compilation of the work of multiple state and Federal agencies as part of the US Gap Analysis and LandFire programs. Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 acre. Landcover classes were drawn from NatureServe's Ecological System concept. Five-hundred and forty-four land cover classes composed of 12 cultural and 532 Natural/Semi-natural types were mapped across the coterminous U.S. Land cover classes were mapped with a variety of techniques including decision tree classifiers, terrain modeling, inductive modeling, and unsupervised classification. The 67 USGS mapping zones were modeled independently of one another by multiple spatial analysis laboratories.

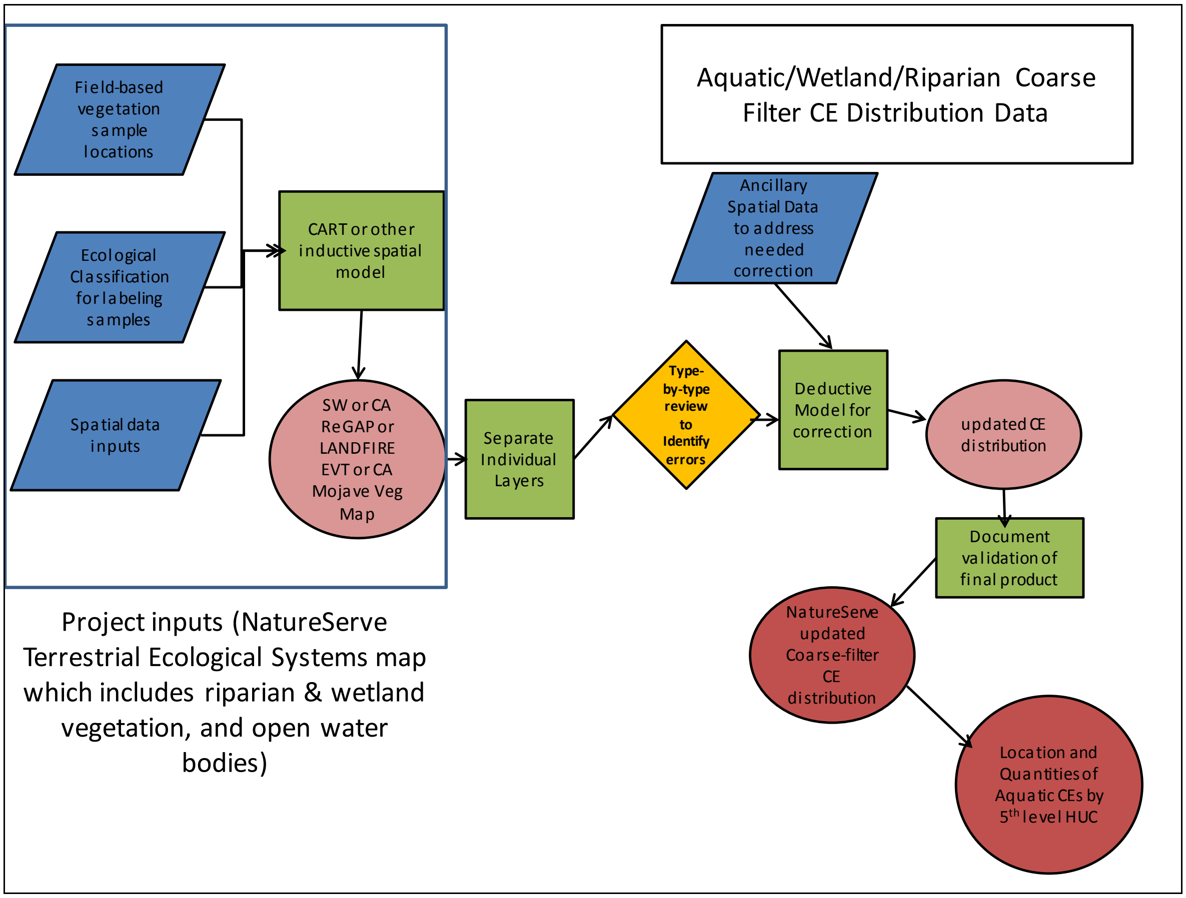


Figure B - 12. Process steps for mapping aquatic coarse-filter CEs.

NatureServe stitched together the resultant spatial data from the Gap and LANDFIRE efforts, into one comprehensive map for the coterminous US. In the western US, SW ReGap data were used for the 5 southwestern states (AZ, CO, NM, NV, UT), and LANDFIRE data were used for California. PNW ReGap was the source for data from ID, MT, OR, WA and WY. Following completion of the national dataset, each individual land cover type was evaluated by NatureServe (prior to the initiation of the BLM REAs) through individual working groups and two regional workshops attended by State, Federal, and Natural Heritage Program ecologists. Where individual systems were identified with likely errors a description was recorded of the issue and a fix where available was described and initiated by NatureServe. All changes are available in supporting documentation (see National Ecological Systems Modification.pdf for documentation of all changes made) and represent the opinion of multiple experts. Updates to specific system types were performed to update known errors in the data layer.

Additional Processing to Represent Aquatic/Wetland Coarse-filter Distributions for the REA

The current distribution of the six aquatic coarse-filters CEs within the MBR ecoregion (Table B - 16) were reviewed and, if necessary, revised by adding USGS National Hydrography Dataset (NHD) stream miles and correcting the elevational distributions. Two source datasets were used in this review (Table B - 17): NatureServe Ecological System types v2.7 (ES, described above) and the USGS NHD. Two ancillary datasets were used to subset the distributions of these ecosystem/vegetation maps including: National Wetland Inventory maps (USFWS NWI), and USGS 30 m Digital Elevation Model and US

Geological Survey (USGS) 30 meter National Elevation Dataset (NED).   All source and ancillary datasets are 30 meter pixel resolution and masked/snapped to the MBR boundary.

First the distribution of the riparian, wash, and playa ecosystems were examined and updates or corrections were made where they did not match the elevational rules (see Table B - 16). For all riparian aquatic CEs perennial stream segments from NHD Streams were added to the mapped distribution. Each 30 m pixel of perennial stream within the elevation rule (Table B - 16) were labeled as part of the riparian ecosystem CE. Lakes and Reservoirs distribution came from NatureServe Ecosystem map pixels labeled “open water”. This source was more complete and accurate than the lakes/reservoirs found in the NHD.

Springs and Seeps distribution came from the USGS NHD Springs. The USGS spring data was compared to the Nevada Natural Heritage Program (NVHP) spring inventory data; if a USGS point was located within 200m (100m on either side) of an existing Heritage Program occurrence, the NVHP point was considered a duplicate and was deleted. The NV Heritage Program data were in polygon format and converted to points (“feature to points”). The USGS data were already in point format. The two resultant point shapefiles were merged and stored as the final springs and seeps point layer. All NVHP spring locations were already included in the NHD spring layer, however information from the NVHP springs data was retained in the final data layer. NVHP information included the spring name and an element occurrence rank (a condition assessment) for the vegetative community surrounding the spring.

The main focus of this review was to increase the riparian and wash distributions by adding NHD Streams that were not previously included in the ES map, and to correct errors in the elevational distribution of montane vs basin riparian ecosystems.

Table B - 17. Source and ancillary datasets used for aquatic/wetland coarse-filter distributions.

Source Dataset Name	Delivered File Name(s)	Methods Abbreviation
NatureServe Terrestrial Ecosystems and Landcover	C_NATURESERVE_L48_ESLF_V2_7.img	ES
National Fish & Wildlife Service Wetland Inventory Map	AQ_FWS_L1_NWI_wrkng_poly;	NWI
National USGS Hydrography Dataset	MBR_AQ_USGS_NHD_nhdflowline_ln	NHD Streams
National USGS Hydrography Dataset	MBR_AQ_USGS_NHD_NHDWaterbody_poly	NHD Springs
Nevada Heritage Program Spring Inventory Dataset	AQ_C_NVHP_Spring_locations_Veg_poly	NVHP Springs
National Elevation Dataset (NED) - 30m	MBR_ELV_USGS_NED_30m	NED

For each aquatic coarse-filter CE, its distribution was extracted from the NatureServe ecological systems v2.7 map (the ES), and clipped to the MBR area. Each was then reviewed across its distribution within the MBR boundary, by NatureServe ecology staff familiar with the type’s concept and distribution. Draping the individual CE distribution onto a shaded relief map helped to identify areas where the CE was correctly or incorrectly mapped. During the review, the expert also had on-hand the USFWS NWI map to cross-check how the type was mapped in a particular area by those efforts. Locations where the mapping of the type needed correction were identified. Each area would then be corrected by selecting the type’s pixels within that area and applying a conversion to a different type or by applying the elevation rules (Table B - 16).

The revised distributions of these ecological systems were then combined with perennial or ephemeral NHD stream segments (where appropriate, see Table B - 16) for a complete mapping of the aquatic resources within the ecoregion. This combination of NHD streams, and NatureServe ES map was turned into the current aquatic (including wetland & riparian) coarse-filter CEs dataset for the MBR ecoregion and all other cells were coded as null. This dataset was then clipped for the REA boundary. After comparing to the Nevada Natural Heritage Program's springs and seeps dataset, the NHD Springs and Seeps were retained as the MBR Springs and Seeps CE.

B-1.2.4 Vulnerable species assemblages: Maxent models

MQ1 -WHAT IS THE CURRENT DISTRIBUTION OF POTENTIAL HABITAT FOR EACH SPECIES CE?

MaxEnt (Maximum Entropy Species Distribution Modeling, Version 3.3.3e, November 2010) was used to model nine species assemblages (Table B - 8). The resultant models represent the probability of occurrence for a particular species or a particular suite of species within the MBR Ecoregion. The models are the composites of multiple cross-validated inductive MaxEnt models of species distributions using non-spectral landscape variables.

Input Variables

Model Inputs:

1) Known Occurrences or Presence Localities (point file format)
2) Environmental Variables (grid file format)

The Maxent principle is to estimate the probability distribution of species by finding the largest spread (maximum entropy) on a geographic dataset of species presences in relation to a set of "background" environmental variables. Model parameters differed by species but included a suite of non-spectral landscape variables. Variables were all re-sampled to a standard 100m resolution because of the variability in the resolution of the source data and inputs. Also required by the model are known presence locations of a particular species or suite of species. In the case of species assemblages, the known element occurrences of species within the assemblage were used. Point representations of the element occurrences were created by using several selection criteria. First, the element occurrences needed to be relatively small (low level of uncertainty associated with the occurrence, less than 1260ha). Polygon features were then converted to points using the "feature to point" tool. Point localities were then used as inputs for modeling.

Each model was run specifying parameters unique to the species assemblages or species being modeled. Maxent used these parameters to build models of species occurrence starting with a uniform distribution of probability values over the entire grid and then conducts an optimization routine that iteratively improves model fit, recorded as gain.

Models were validated using the k- fold cross-validation technique, which withholds random subsets of the presence localities to test the model as it is built. The k-fold cross validation technique randomly divides the presence localities into k subsets and replicate models are run testing the model on those k subsets. The replicate runs of the model are then averaged into a final composite model. The number of subsets should vary based on the number of presence localities. For the models of species and assemblages described below, a standard rule was applied that if the species or assemblage had less than 150 presence localities, a 5-fold cross validation was run, and greater than 150 localities, a 10-fold cross validation was run. If an assemblage or species had more than 1500 presence localities, a 15-fold cross validation was run.

Model Outputs

Model outputs include an ASCII file which was converted to a continuous raster grid for import into ArcGIS (Figure B - 13). Each cell in the raster grid contains a probability value that represents the probability of occurrence for that particular species or assemblage at that location. There are many methods for generating a model of habitat from this probability raster. For these models, a threshold was applied, a probability of occurrence value below which areas were considered non-habitat (NoData) and above which areas were considered to have high habitat potential (values recorded in the raster as 1). The threshold values were obtained by using the known presence localities and extracting the probability values from the resultant MaxEnt model raster to those presence localities. The probability values were summarized and one of two types of thresholds was applied (Liu et al, 2005):

1) The average probability value at known occurrences for the particular species or assemblage (more conservative and less inclusive) or

2) The average probability value at known occurrences minus one standard deviation for the particular species or assemblage (less conservative and more inclusive).

Decisions regarding the threshold application were based on expert opinion after visual inspection of the two types of thresholds. The distributions after threshold application were compared and the threshold was chosen that captured the known occurrences but didn't overestimate the amount of potential habitat. The threshold application does affect the model output in that option 1 above provides a more conservative output and generally produces a distribution that is smaller in extent than option 2, which is more inclusive. The decision to apply either option 1 or option 2 was made by experts who thoroughly analyzed and compared both distribution outputs from both methods.

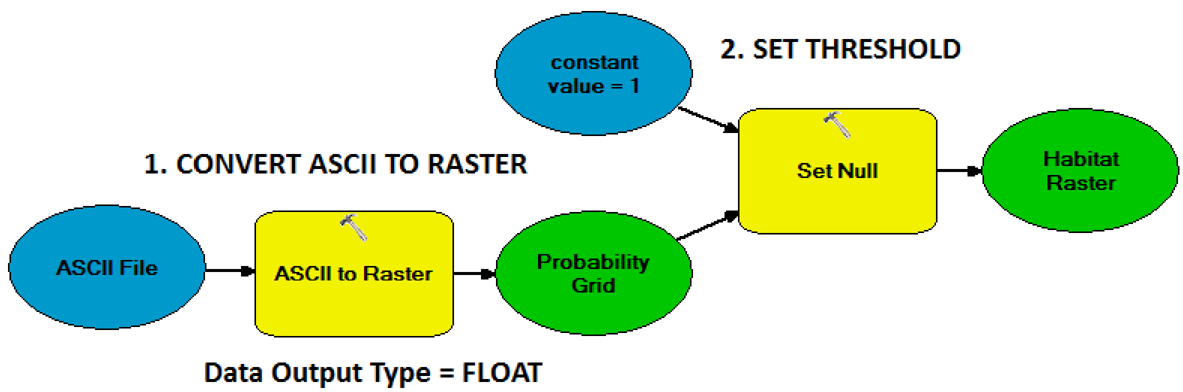


Figure B - 13. Schematic of habitat map derivation from MaxEnt outputs.

Data Interpretation

Additional outputs include summarizes of model performance, the importance of each predictor variable and the shape of its influence, documentation of the options chosen, and information regarding the raw data. For more specifics on the individual models, see the supplemental materials provided with each of the modeled outputs. Also provided is an analysis of variable contributions (See Table B - 18 below) which ranks the importance of the predictor variables. Maxent tracks the overall gain in the model when small changes are made to each coefficient value associated with a particular feature. The gains associated with each feature are then summed and taken as a proportion of all contributions.

References

Liu, C., P.M. Berry, T.P. Dawson, and R.G. Pearson. 2005. Selecting thresholds of occurrence in the prediction of species distributions. Ecography 28: 385 – 393.

Carbonate Alpine Species Assemblage

The carbonate alpine species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 167 point localities consisting of 8 different species within the "Flowering Plants" and "Terrestrial Snails" Info Taxa. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) digital elevation model, (2) geology, (3) distance to calcium carbonate soils, (4) NatureServe's Ecological Systems Map, (5) soil ph, (6) available water holding capacity, (7) slope, and (8) aspect. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.997). A probability threshold of 0.69 was applied to distinguish between habitat (greater than 0.69) and non-habitat (less than 0.69). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.86) minus one standard deviation (0.17). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Noncarbonate Alpine Species Assemblage

The noncarbonate alpine species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 29 point localities consisting of 2 different species within the "Flowering Plants" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) digital elevation model, (2) geology, (3) NatureServe's Ecological Systems Map, (4) distance to calcium carbonate soils, (5) soil ph, (6) slope, and (7) aspect. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.996). A probability threshold of 0.66 was applied to distinguish between habitat (greater than 0.66) and non-habitat (less than 0.66). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.78) minus one standard deviation (0.12). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Azonal Carbonate Rock Crevices

The azonal carbonate rock crevices species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 1015 point localities consisting of 23 different species within the "Flowering Plants" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) NatureServe's Ecological Systems Map, (2) soil ph, (3) distance to calcium carbonate soils, (4) digital elevation model, (5) slope, (6) geology, (7) distance to hydric soils, (8) distance to perennial streams, (9) distance to intermittent streams, (10) average percentage of large rock fragments within soil, (11) aspect, and (12) available water holding capacity. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.955). A probability threshold of 0.73 was applied to distinguish between habitat (greater than 0.73) and non-habitat (less than 0.73). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.73). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Azonal noncarbonate Rock Crevices Species Assemblage

The azonal noncarbonate rock crevices species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 137 point localities consisting of 5 different species within the "Flowering Plants" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) NatureServe's Ecological Systems Map, (2) average percent large rock fragments within soil, (3) geology, (4) soil ph, and (5) digital elevation model. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.945). A probability threshold of 0.63 was applied to distinguish between habitat (greater than 0.63) and non-habitat (less than 0.63). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.63). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Clay Soil Patches Species Assemblage

The clay soil patches species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 779 point localities consisting of 13 different species within the "Flowering Plants" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) average percent clay in soil, (2) digital elevation model, (3) soil ph, (4) geology, (5) NatureServe's Ecological Systems Map, (6) average percent large rock fragments within soil, (7) slope, and (8) aspect. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.955). A probability threshold of 0.74 was applied to distinguish between habitat (greater than 0.74) and non-habitat (less than 0.74). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.74). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Gypsum Soils Species Assemblage

The gypsum soils species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 697 point localities consisting of 6 different species within the "Ants, Bees, Wasps", "Flowering Plants", and "Mosses" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) digital elevation model, (2) distance to gypsum soils, (3) soil ph, (4) geology, (5) NatureServe's Ecological Systems Map, (5) available water holding capacity, (6) aspect, and (7) slope. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.955). A probability threshold of 0.74 was applied to distinguish between habitat (greater than 0.74) and non-habitat (less than 0.74). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.74). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Montane Conifer Species Assemblage

The montane conifer species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 723 point localities consisting of 13 different species within the "Flowering Plants", "Birds", and "Mammals" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) digital elevation model, (2) NatureServe's Ecological Systems Map, (3) thermotype, (4) soil ph, (5) geology, (6) ombrotype, (7) aspect, and (8) slope. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.859). A probability threshold of 0.66 was applied to distinguish between habitat (greater than 0.66) and non-habitat (less than 0.66). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.66). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Sand Dunes and Sandy Soils Species Assemblage

The sand dunes and sandy soils species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 1586 point localities consisting of 30 different species within the "Ants, Wasps, Bees", "Flowering Plants", "Mammals", "Other Beetles", and "Reptiles" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) digital elevation model, (2) NatureServe's Ecological Systems Map, (3) soil ph, (4) percentage of coarse sands within soil, (5)average sand totals, (6) distance to hydric soils, (7) total sand, (8) slope, (9) geology, (10) aspect, (11) available water holding capacity. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.992). A probability threshold of 0.74 was applied to distinguish between habitat (greater than 0.74) and non-habitat (less than 0.74). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.74). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Migratory Waterfowl and Shorebirds Species Assemblage

The migratory shorebirds and waterfowl species assemblage was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs for the model included known occurrences or presence localities of species within the assemblage and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data. Element occurrence inputs included 41 point localities consisting of 4 different species within the "Birds" Info Tax. The specific environmental variables used (and ordered according to their contribution toward overall model development) include: (1) Distance to waterbodies, (2) distance to hydric soils, (3) NatureServe's Ecological Systems Map, (4) distance to perennial streams, (5) slope, (6) distance to riparian conservation elements, (7) distance to wetland conservation elements, (8) distance to intermittent streams, (9) distance to springs and seeps, (10) available water holding capacity, and (11) digital elevation model. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.926). A probability threshold of 0.43 was applied to distinguish between habitat (greater than 0.43) and non-habitat (less than 0.43). The value was obtained by determining the average probability value of the modeled output at the known occurrences or point localities (0.66) minus one standard deviation (0.23). The values for the final model are "1" for high potential habitat and "NoData" for non-habitat.

Table B - 18. Description of model inputs and model performance. *For explanation of input environmental variables, their derivation, and their source datasets, see Table B - 19.

Model	Input Occurrence Locations	Input Environmental Variables (Ordered by Contribution to Model Output)*	Model Performance (as determined by AUC)	Threshold
Carbonate Alpine	167 point localities with: • 8 different species • "Flowering Plants" and "Terrestrial Snails" Informal Taxonomy	(1) digital elevation model, (2) geology, (3) distance to calcium carbonate soils, (4) NatureServe's Ecological Systems Map, (5)soil ph, (6) available water holding capacity, (7) slope, and (8) aspect	0.997	0.69 mean (0.86) – std (0.17)
Noncarbonate Alpine	29 point localities with: • 2 species • "Flowering Plants" Informal Taxonomy	(1) digital elevation model, (2) geology, (3) NatureServe's Ecological Systems Map, (4) distance to calcium carbonate soils, (5) soil ph, (6) slope, and (7) aspect	0.996	0.66 mean (0.78) – std (0.12)
Azonal Carbonate Rock Crevices	1015 point localities with: • 23 species • "Flowering Plants" Informal Taxonomy	(1) NatureServe's Ecological Systems Map, (2) soil ph, (3) distance to calcium carbonate soils, (4) digital elevation model, (5) slope, (6) geology, (7) distance to hydric soils, (8) distance to perennial streams, (9) distance to intermittent streams, (9) average percentage of large rock fragments within soil, (10) aspect, and (11) available water holding capacity	0.955	0.73 mean (0.73)
Azonal Noncarbonate Rock Crevices	137 point localities with: • 5 species • "Flowering Plants" Informal Taxonomy	(1) NatureServe's Ecological Systems Map, (2) average percent large rock fragments within soil, (3) geology, (4) soil ph, and (5) digital elevation model	0.945	0.63 mean (0.63)
Clay Soil Patches	779 point localities with: • 13 species • "Flowering Plant" Informal Taxonomy	(1) average percent clay in soil, (2) digital elevation model, (3) soil ph, (4) geology, (5) NatureServe's Ecological Systems Map, (6) average percent large rock fragments within soil, (7) slope, and (8) aspect	0.955	0.74 mean (0.74)
Gypsum Soils	697 point localities with: • 6 species • "Ants, Bees, Wasps", "Flowering Plants", and "Mosses" Informal Taxonomy	(1) digital elevation model, (2) distance to gypsum soils, (3) soil ph, (4) geology, (5) NatureServe's Ecological Systems Map, (5) available water holding capacity, (6) aspect, and (7) slope	0.994	0.77 mean (0.77)
Montane Conifer	723 point localities with: • 13 species • "Flowering Plants", "Birds", and "Mammals: Informal Taxonomy	(1) digital elevation model, (2) NatureServe's Ecological Systems Map, (3) thermotype, (4) soil ph, (5) geology, (6) ombrotype, (7) aspect, and (8) slope	0.859	0.66 mean (0.66)
Sand Dunes and Sandy Soils	1586 point localities with: • 30 species • "Ants, Wasps, Bees", "Flowering Plants", "Mammals", "Other Beetles", and "Reptiles" Informal Taxonomy	(1) digital elevation model, (2) NatureServe's Ecological Systems Map, (3) soil ph, (4) percentage of coarse sands within soil, (5)average sand totals, (6) distance to hydric soils, (7) total sand, (8) slope, (9) geology, (10) aspect, (11) available water holding capacity	0.992	0.74 mean (0.74)
Migratory Waterfowl and Shorebirds	41 point localities with: • 4 species • "Birds" Informal Taxonomy	(1) Distance to waterbodies, (2) distance to hydric soils, (3) NatureServe's Ecological Systems Map, (4) distance to perennial streams, (5) slope, (6) distance to riparian conservation elements, (7) distance to wetland conservation elements, (8) distance to intermittent streams, (9) distance to springs and seeps, (10) available water holding capacity, and (11) digital elevation model	0.926	0.43 mean (0.66) – std (0.23)

Table B - 19. Detailed description of input environmental variables.

DESCRIPTIVE DATASET NAME	ABBREVIATION	DATA SOURCE FILENAME	Intermediate	Explanation
aspect	Aspect	OT1_USGS_US_NED_ALB83	Yes	Aspect was calculated from the digital elevation model.
available water holding capacity	Awc	CEIII_NATURESERVE_SOILS_CBR_AWC_FIN CEIII_NATURESERVE_SOILS_MBR_AWC_FIN	No	
average percent large rock fragments in soil	Rock_frags	NA	Yes	Maximum percentage value of frag10 (RV) from STATSGO for main component within each soil map unit (the % by weight of the horizon occupied by rock fragments greater than 10 inches in size)
Clay percentage within soil	Clay	NA	Yes	Average percentage value of claytotal (RV) from STATSGO for main component within each soil map unit (mineral particles less than 0.002mm in equivalent diameter as a weighted % within the less than 2.0mm fraction of soil)
digital elevation model	Dem	OT1_USGS_US_NED_ALB83	No	
distance to calcium carbonate soils	Cacao3	CEIII_NATURESERVE_SOILS_CBR_CACO3_FIN CEIII_NATURESERVE_SOILS_MBR_CACO3_FIN	Yes	Euclidean distance function applied to calcium carbonate soils.
distance to gypsum soils	Gypsum	CEIII_NATURESERVE_SOILS_CBR_GYP_FIN CEIII_NATURESERVE_SOILS_MBR_GYP_FIN	Yes	Euclidean distance function applied to gypsum soils.
distance to hydric soils	Hydric_dist	CEIII_NATURESERVE_SOILS_CBR_HYDRO20 CEIII_NATURESERVE_SOILS_MBR_HYDRO20	Yes	Euclidean distance function applied to hydric soils.
distance to intermittent streams	Intermit_d	NA	Yes	
distance to perennial streams	Perenn_d	NA	Yes	
distance to riparian conservation elements	Ripce_dist	CEI_NATURESERVE_L48_ESLF_V2_7	Yes	Derived from the "Upland_Wetland" attribute field. Euclidean distance function applied to selections from the attribute field.
distance to springs	Springs_dist	CEV_final_USGS_NVHP_LCI_spring_locations	Yes	Euclidean distance function applied to springs locations.
Distance to waterbodies	Waterbdy_dist	CEIII_USGS_NHD_NHDWaterbody	Yes	Euclidean distance function applied to lakes and reservoirs.
distance to wetlands	Wetland_dist	CEI_NATURESERVE_L48_ESLF_V2_7	Yes	Derived from the "Upland_Wetland" attribute field. Euclidean distance function applied to selections from the attribute field.
geology	Geology	CEIII_USGS_GEOSS_GEOLOGY_1KM	No	
NatureServe's ecological systems map	Eslf_v27	CEI_NATURESERVE_L48_ESLF_V2_7	No	
ombrotype	Ombrotype	CEIII_USGS_GEOSS_OMBROTYPES	No	
percentage of coarse sands within soils	Coarse_sands	CEIII_NATURESERVE_SOILS_CBR_SAND_CRS CEIII_NATURESERVE_SOILS_MBR_SAND_CRS	No	Average percentage value of coarse sands (representative value) from STATSGO for main component within each soil map unit (mineral particles 0.5 – 1.0mm as a weighted % of the less than 2mm fraction of soil)
percentage of total sands within soil	Total_sand	CEIII_NATURESERVE_SOILS_CBR_SAND_TOT CEIII_NATURESERVE_SOILS_MBR_SAND_TOT	No	Maximum percentage value of sand total (representative value) from STATSGO for main component within each soil map unit (mineral particles 0.05 – 2.0mm as a weighted % of the less than 2mm fraction of soil)
Average percentage of total sand within largest component of soil	Avg_tot_sand	NA	Yes	Average percentage value of sand total(representative value) from STATSGO for main component within each soil map unit (mineral particles 0.05 – 2.0mm as a weighted % of the less than 2mm fraction of soil)
slope	Slope	OT1_USGS_US_NED_ALB83	Yes	Slope calculated from the digital elevation model.
soil pH	Ph1to1	CEIII_NATURESERVE_SOILS_CBR_PH1TO1 CEIII_NATURESERVE_SOILS_MBR_PH1TO1	No	
thermotype	Thermotype	CEIII_USGS_GEOSS_THERMOTYPES	No	

B-1.2.5 Landscape species

MQ1 - WHAT IS THE CURRENT DISTRIBUTION OF POTENTIAL HABITAT FOR EACH SPECIES CE?

MQ3 - WHAT IS THE CURRENT DISTRIBUTION OF SUITABLE HABITAT, INCLUDING SEASONAL HABITAT AND MOVEMENT CORRIDORS, FOR EACH LANDSCAPE SPECIES AND SPECIES ASSEMBLAGE CE?

Landscape Species CE distributions were either directly from BLM and REA partners (e.g., mule deer, desert bighorn sheep); or derived through deductive and inductive modeling steps. Some landscape species were represented spatially using multiple habitat components (e.g., winter range vs. summer range); as established in conceptual models and then articulated as distinct spatial models. Southwest ReGAP maps provided the starting point for most landscape species; with existing habitat location/ suitability models available for all but the California portion of their distribution. The same rules were applied (e.g., vegetation type, elevation thresholds, etc.) to extend these models into California as appropriate. See species-specific summaries for detailed explanation.

Spatial data for landscape species distributions came from four general sources: (1) BLM-provided or recommended existing data sets, (2) expansions/updates to species models originally created by the USGS Southwest Regional Gap Analysis Project (SWReGAP), (3) a maximum entropy (MaxEnt) model created by NatureServe for the Mojave ground squirrel, and (4) element occurrences records representing the distributions of bald and golden eagles. This document provides an overview of these data sets.

For Mohave ground squirrel, occurring outside the range of the SW ReGAP project in California, Maximum Entropy (Maxent) was used with available georeferenced observations produce a probability surface for suitable habitat (e.g., Guisan & Thuiller, 2005; Liu et al. 2005). Map surface inputs included vegetation type, vegetation structure, climate variables, landform, landscape position, and soil variables among others. These models provide limited predictive power for the actual occurrence of CE populations but can provide a powerful indication of the location of habitats that are most similar to known occupied habitat.

B-1.2.5.1 Species with BLM Provided/Recommended Data

Desert Bighorn Sheep Occupied Habitat

Data used to represent desert bighorn sheep occupied habitat were assembled (merged) from spatial data provided by BLM and several state agencies. For desert bighorn sheep, the distribution was derived from habitat use areas compiled by the BLM from state Fish and Wildlife agencies that are partners in WAFWA, then provided to the REA contractor. These use areas were determined by state wildlife biologists. Data is recommended for analysis and display at 1:100,000 scale. The original data, which was provided as polygon shapefiles, was converted to a 30-meter resolution raster and clipped to the REA boundaries.

Mule Deer Winter, Summer, and Year-Round Range

Data used to represent summer, winter, and year-round mule deer habitat was provided by BLM and clipped to the REA boundaries. This data originates from the RemoteSensing/GIS Laboratory at Utah State University. The distribution was derived from habitat use areas compiled from state Fish and Wildlife agencies that are partners in WAFWA, then provided to the REA contractor by BLM. Habitat delineations were identified through a Delphi process on a state-by-state basis and were subsequently tablet-digitized from 1:250,000 scale maps. The original data, which was provided as polygon shapefiles, was converted to a 30-meter resolution raster and clipped to the REA boundaries.

Mojave Desert Tortoise

The distribution of the Mojave desert tortoise is represented based on the results of a USGS maximum entropy model of tortoise (Nussear et al. 2009). A threshold value of 0.7 was used to convert the continuous surface of habitat suitability values generated by this model into a binary representation of habitat/non-habitat, and clipped the model extent at the Colorado River to only capture the Mojave population. The original data is mapped at 1-km resolution but was resampled to 30 meters for consistency with other data sets.

Sonoran Desert Tortoise

Data representing the distribution of the Sonoran desert tortoise population was developed by the Arizona Game and Fish Department. This dataset is part of a suite of models that depict the predicted distribution of Arizona's wildlife species based on parameters including vegetational associations, elevational associations, slope associations, and known occurrences. Data is mapped at 30-meter resolution.

B-1.2.6 Species Models based on SWReGap Parameters

This section details the creation of species distributions based upon models previously developed by the U.S. Geological Survey's Southwest Regional Gap Analysis Project (SWReGAP). Models were created for the twenty species listed on Table B - 20. The habitat parameters identified by SWReGAP were used to map habitat for the entire study area using updated data sets and for areas not covered by the original models (i.e. portions of California, Idaho , and Oregon).

Where SWReGAP mapped multiple habitat components for a single species (e.g. breeding AND year-round habitat) we retained only the most restrictive habitat component (e.g. breeding); the modeled component for each species is listed on Table B - 20. For Brewer's sparrow, we provide separate distributions for both breeding and migratory habitat. For the big brown bat, both breeding and year-round habitat were modeled together.

Model parameters differed by species, but included elevation, landform, and ecological systems. For two of the modeled species (Great Basin collared lizard and kit fox) SWReGAP also specified soil type as a model parameter. These soil parameters were not incorporated in the models due to the relatively unspecific nature of the specified soil types and coarse resolution of readily-available soils data. Excluding these soil parameters had relatively little impact on the final habitat distributions, as verified by comparing the new results to the original distribution as modeled by SWReGap.

Elevation and landform were derived from USGS GEOSS data. Ecological systems were defined using Version 2.8 of NatureServe's terrestrial ecological systems map. Where ecological systems are listed for individual species, the list includes the entire set of ecological systems SWReGap used in their models, but not all of these systems occur within the REA boundary (e.g. Madrean Encinal system is found in southeastern Arizona, was used in the SWReGap model but not in the MBR). File names for these source data sets are listed below.

- Terrestrial ecological systems: CEI_TERRESTRIAL_ECOLOGICAL_SYSTEMS_CBRMBR
- Elevation: OT1_USGS_US_NED_ALB83
- Landform: CEIII_USGS_GEOSS_LANDFORM_30M

Table B - 20. Habitat components and model parameters for 20 species modeled from SWReGap parameters.

Common Name	Included Component	Model Parameters
Big Brown Bat	Known or probable occurrence, breeding, summering & Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Brazilian Free-tailed Bat	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Brewer's Sparrow	Known or probable occurrence, breeding, summering	Ecological systems
	Known or probable occurrence, non-breeding, migratory	Ecological systems
Coachwhip	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Common Kingsnake	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Cooper's Hawk	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Gila Monster	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Glossy Snake	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Great Basin Collared Lizard	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation, Landform
Kit Fox	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Loggerhead Shrike	Known or probable occurrence, breeding, summering	Ecological systems, Elevation
Mohave Rattlesnake	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation, Landform
Northern Harrier	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems
Northern Rubber Boa	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Northern Sagebrush Lizard	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Prairie Falcon	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems
Sage Sparrow	Known or probable occurrence, breeding, summering	Ecological systems, Elevation
Sage Thrasher	Known or probable occurrence, breeding, summering	Ecological systems, Elevation
Western Banded Gecko	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation
Western Patch-nosed Snake	Known or probable occurrence, breeding and non-breeding, winter and summer	Ecological systems, Elevation

Within the area originally covered by SWReGAP models, we clipped our results to the species range, defined by 8-digit hydrologic units (4th level watersheds or watersheds) by SWReGAP. Where it was necessary to extend these ranges into California, Idaho, and/or Oregon, we did so by consulting range maps provided in the California Wildlife Habitat Relationships database (http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx), NatureServe species distribution shapefiles, and expert opinion. These ranges are stored together in a GIS shapefile, with an attribute field for each species indicating whether or not each 4th level watershed is included in the range for that species.

The expanded models were generated via the following geoprocessing steps, as shown in the schematic model (Figure B - 14):

1a. Reclassification of the ecological systems raster into suitable (1) and non-suitable(0) values based on the parameters for each species as listed later in this appendix;
1b. Use of the raster calculator (conditional statement) to create rasters of suitable(1) and non-suitable (0) values from the elevation and landform rasters as required for each species, based on the parameters for each species as listed later in this appendix ;
2. Use of the raster calculator to combine the raster values from steps 1 & 2;
3. Use of the set null command to set null all cells where the systems, elevation, and landform do not ALL indicate suitable habitat (note that for some species, only 1 or 2 of these three variables is used) and return "1" for all cells where suitable habitat is indicated;
4. Clipping of the results of step 4 to the species range, as defined by 4th level watersheds. Note that prior to performing this clip, a definition query was in the range map feature class properties to select only those Hucs considered range for the species in question.
5. The final model is displayed with a value of "1" for high potential habitat and "NoData" for non-habitat.

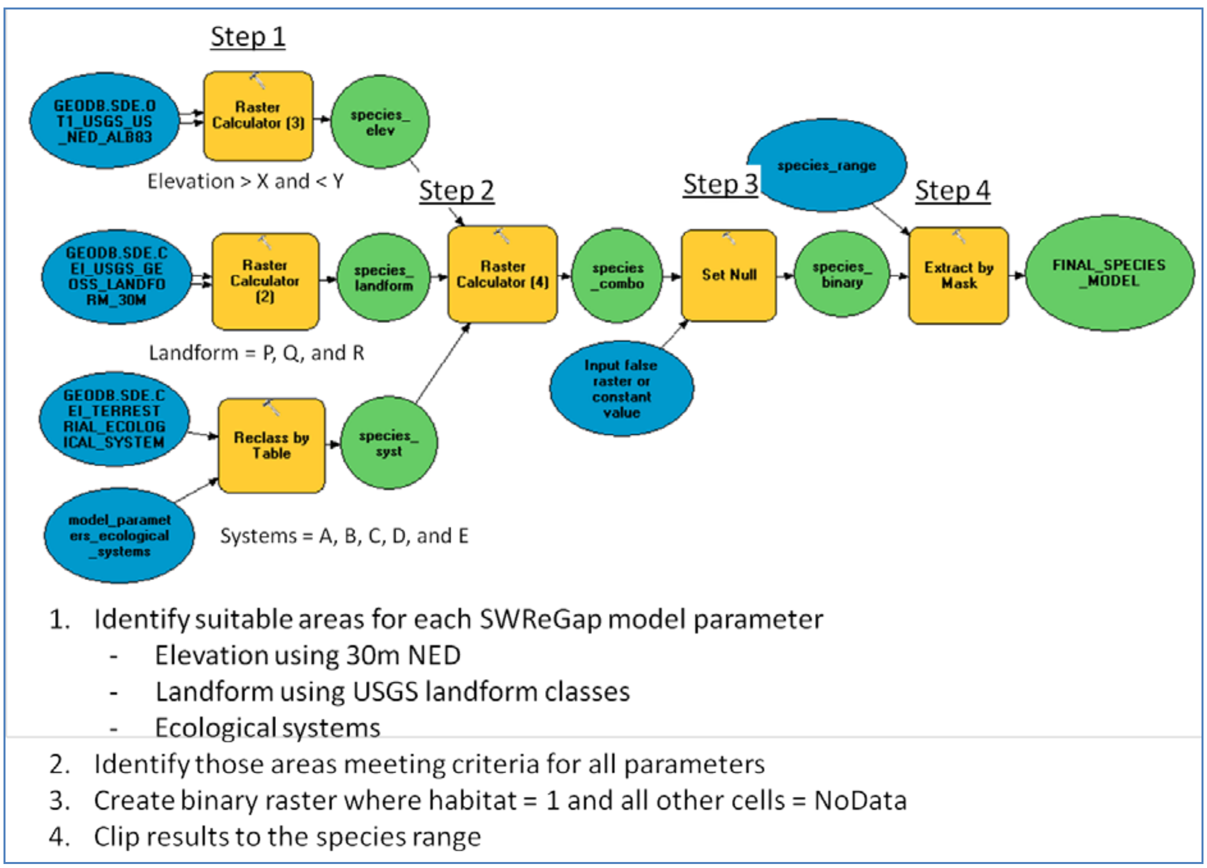
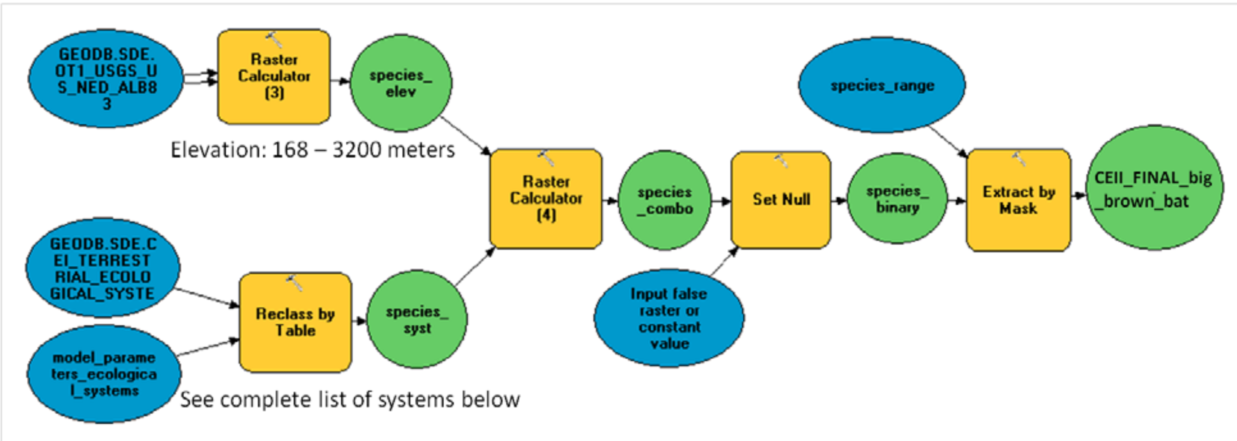


Figure B - 14. General process model for creating species distribution data based on SWReGap models.

The remainder of this section provides the species-specific model parameters and a schematic model tailored for each species.

BIG BROWN BAT

The distribution of the big brown bat (*Eptesicus fuscus*) was mapped using ecological systems and elevation (168 to 3220 meters) to define habitat as shown in the schematic model below. For this species, the provided model includes habitat for both breeding and year-round habitat (Table B - 20).

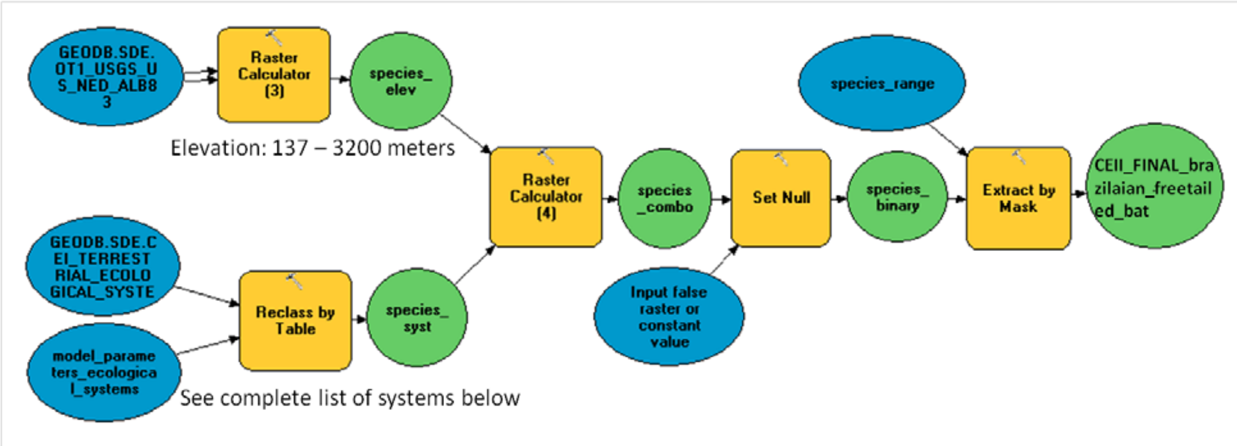


ESLF Code	System Name
11	Open Water
21	Developed-Open Space
22	Developed-Low Intensity
23	Developed-Medium Intensity
24	Developed-High Intensity
80	Agriculture – General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
3120	North American Warm Desert Bedrock Cliff and Outcrop
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3160	Inter-Mountain Basins Active and Stabilized Dune
3173	Inter-Mountain Basins Cliff and Canyon
3179	Inter-Mountain Basins Playa
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4104	Rocky Mountain Aspen Forest and Woodland
4105	Rocky Mountain Bigtooth Maple Ravine Woodland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4207	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland
4210	Madrean Encinal
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
4213	Madrean Upper Montane Conifer-Oak Forest and Woodland

4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4237	Rocky Mountain Lodgepole Pine Forest
4238	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
4239	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4242	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
4243	Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
4244	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
5252	Chihuahuan Mixed Salt Desert Scrub
5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5308	Colorado Plateau Pinyon-Juniper Shrubland
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7107	Inter-Mountain Basins Semi-Desert Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9153	Western Great Plains Floodplain
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9171	Rocky Mountain Subalpine-Montane Riparian Woodland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

BRAZILIAN FREE-TAILED BAT

The distribution of the Brazilian free-tailed bat (*Tadarida brasiliensis*) was mapped using ecological systems and elevation (137 to 3220 meters) to define habitat as shown in the schematic model below.



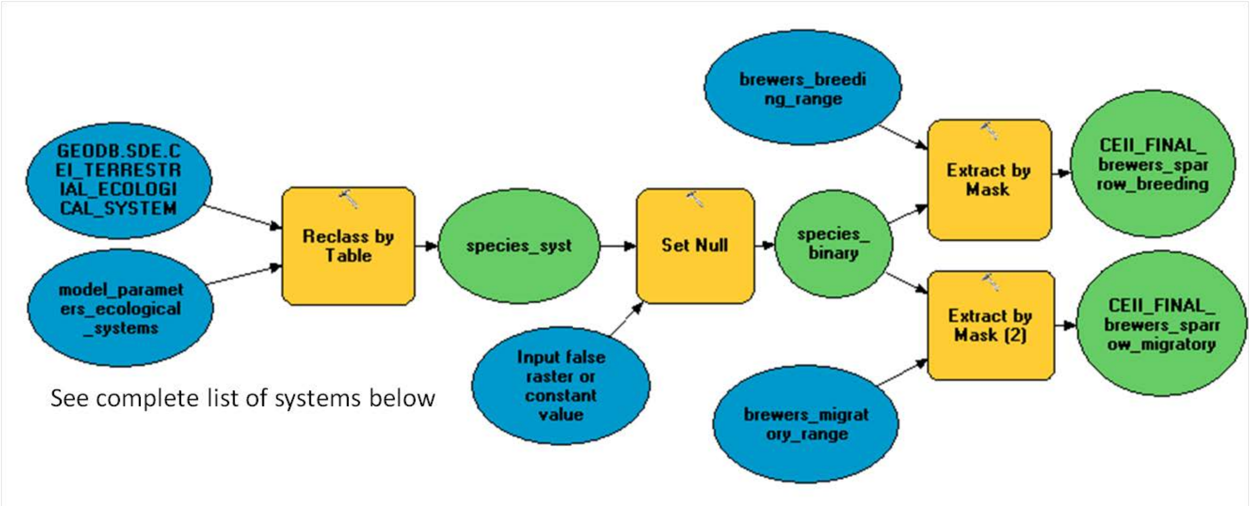
ESLF Code	System Name
21	Developed-Open Space
22	Developed-Low Intensity
23	Developed-Medium Intensity
24	Developed-High Intensity
80	Agriculture - General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
3120	North American Warm Desert Bedrock Cliff and Outcrop
3121	North American Warm Desert Active and Stabilized Dune
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3160	Inter-Mountain Basins Active and Stabilized Dune
3179	Inter-Mountain Basins Playa
4105	Rocky Mountain Bigtooth Maple Ravine Woodland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4207	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland
4210	Madrean Encinal
4212	Madrean Pinyon-Juniper Woodland
4213	Madrean Upper Montane Conifer-Oak Forest and Woodland
4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4238	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
4239	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4244	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
4303	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland
5252	Chihuahuan Mixed Salt Desert Scrub

5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7104	Central Mixedgrass Prairie
7107	Inter-Mountain Basins Semi-Desert Grassland
7119	Southern Rocky Mountain Montane-Subalpine Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9151	North American Warm Desert Wash
9153	Western Great Plains Floodplain
9171	Rocky Mountain Subalpine-Montane Riparian Woodland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

BREWER'S SPARROW

The distribution of Brewer's sparrow (*Spizella breweri*) was mapped using only ecological systems to define habitat.

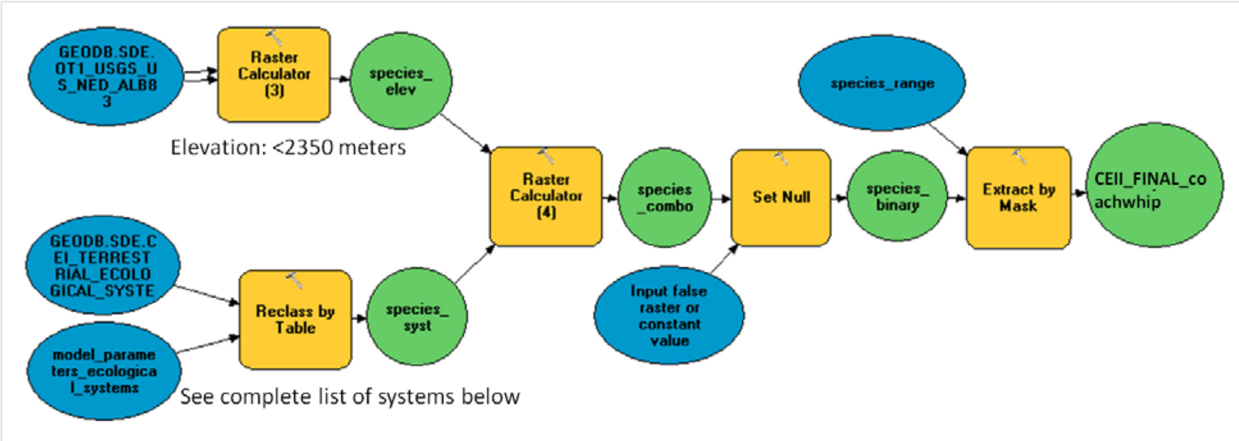
Two habitat distributions were created for this species: (1) breeding habitat, and (2) migratory habitat. The same parameters were used for both, but the model extent was clipped to separate defined ranges for each as shown in the schematic model below.



ESLF Code	System Name
3139	Inter-Mountain Basins Shale Badland
3143	North American Warm Desert Pavement
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5263	Rocky Mountain Lower Montane-Foothill Shrubland
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5308	Colorado Plateau Pinyon-Juniper Shrubland
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5454	Inter-Mountain Basins Big Sagebrush Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
7104	Central Mixedgrass Prairie
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Coachwhip

The distribution of the coachwhip (*Masticophis flagellum*)was mapped using ecological systems and elevation (less than 2350 meters) to define habitat as shown in the schematic model below.

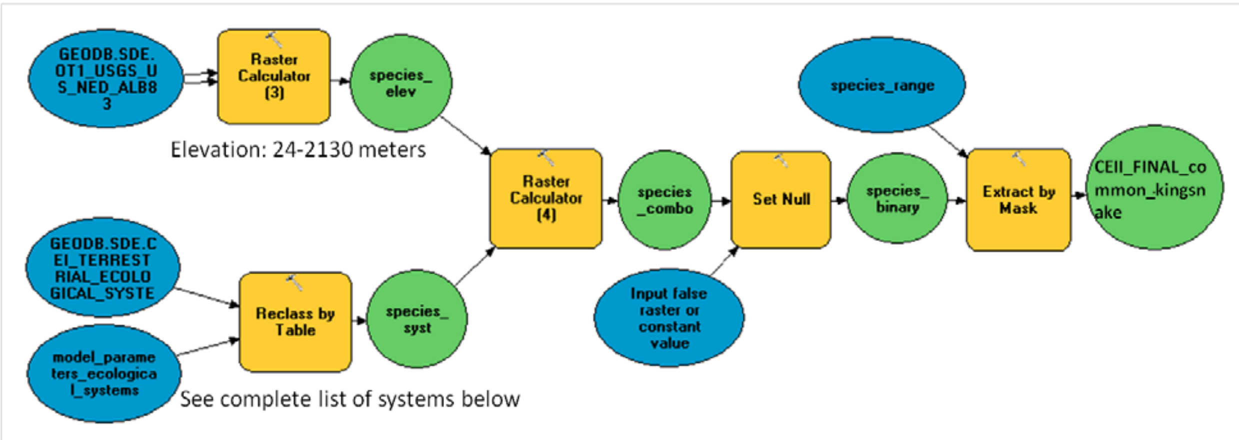


ESLF Code	System Name
3120	North American Warm Desert Bedrock Cliff and Outcrop
3121	North American Warm Desert Active and Stabilized Dune
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3160	Inter-Mountain Basins Active and Stabilized Dune
3173	Inter-Mountain Basins Cliff and Canyon
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4210	Madrean Encinal
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
5252	Chihuahuan Mixed Salt Desert Scrub
5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5308	Colorado Plateau Pinyon-Juniper Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5404	Inter-Mountain Basins Juniper Savanna

5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7107	Inter-Mountain Basins Semi-Desert Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9153	Western Great Plains Floodplain
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

COMMON KINGSNAKE

The distribution of the common kingsnake (*Lampropeltis getula)* was mapped using ecological systems and elevation (24 - 2130 meters) to define habitat as shown in the schematic model below.



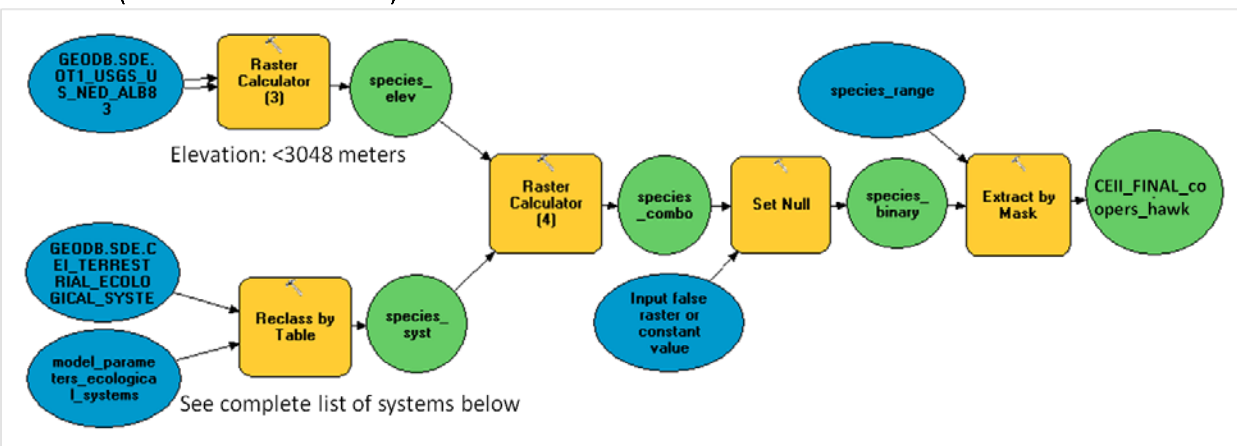
ESLF Code	System Name
80	Agriculture - General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
3120	North American Warm Desert Bedrock Cliff and Outcrop
3121	North American Warm Desert Active and Stabilized Dune
3123	North American Warm Desert Badland
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3139	Inter-Mountain Basins Shale Badland
3143	North American Warm Desert Pavement
3160	Inter-Mountain Basins Active and Stabilized Dune
3161	North American Warm Desert Playa
3171	Sierra Nevada Cliff and Canyon
3173	Inter-Mountain Basins Cliff and Canyon

3179	Inter-Mountain Basins Playa
3180	North American Warm Desert Volcanic Rockland
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4210	Madrean Encinal
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
5252	Chihuahuan Mixed Salt Desert Scrub
5253	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5307	Madrean Oriental Chaparral
5310	Mogollon Chaparral
5314	Sonora-Mojave Semi-Desert Chaparral
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9151	North American Warm Desert Wash
9153	Western Great Plains Floodplain
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9187	Rocky Mountain Subalpine-Montane Riparian Shrubland
9222	North American Arid West Emergent Marsh
9256	Western Great Plains Saline Depression Wetland
9329	Western Great Plains Riparian

Cooper's Hawk

The distribution of Cooper's hawk (*Accipiter cooperii)* was mapped using ecological systems and elevation (less than 3048 meters) to define habitat as shown in the schematic model below.

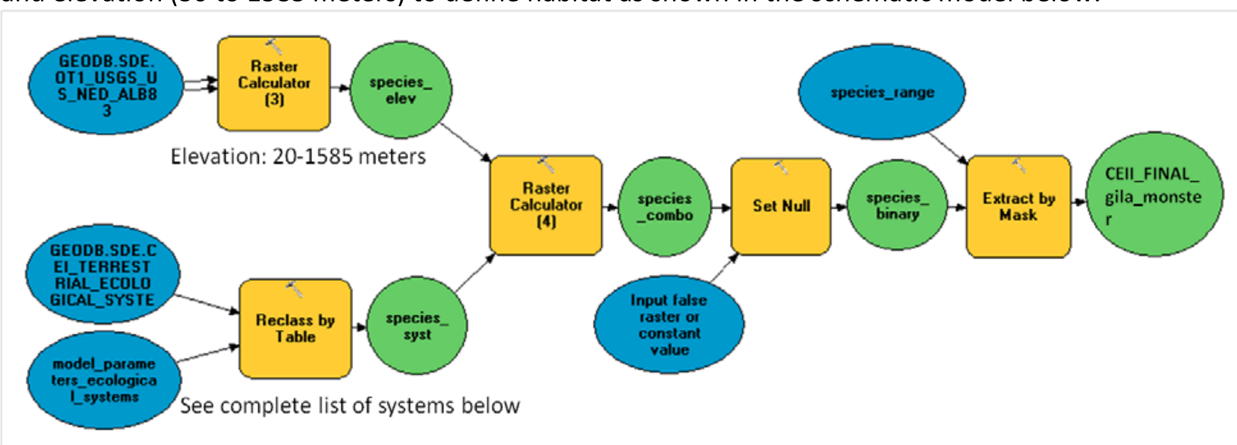


ESLF Code	System Name
21	Developed-Open Space
22	Developed-Low Intensity
23	Developed-Medium Intensity
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3173	Inter-Mountain Basins Cliff and Canyon
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4104	Rocky Mountain Aspen Forest and Woodland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
4213	Madrean Upper Montane Conifer-Oak Forest and Woodland
4237	Rocky Mountain Lodgepole Pine Forest
4238	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
4239	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4242	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
4243	Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland

4244	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4302	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
5308	Colorado Plateau Pinyon-Juniper Shrubland
7104	Central Mixedgrass Prairie
7122	Western Great Plains Shortgrass Prairie
9153	Western Great Plains Floodplain
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9171	Rocky Mountain Subalpine-Montane Riparian Woodland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9329	Western Great Plains Riparian

Gila Monster

The distribution of the gila monster (*Heloderma suspectum*) was mapped using ecological systems and elevation (30 to 1585 meters) to define habitat as shown in the schematic model below.

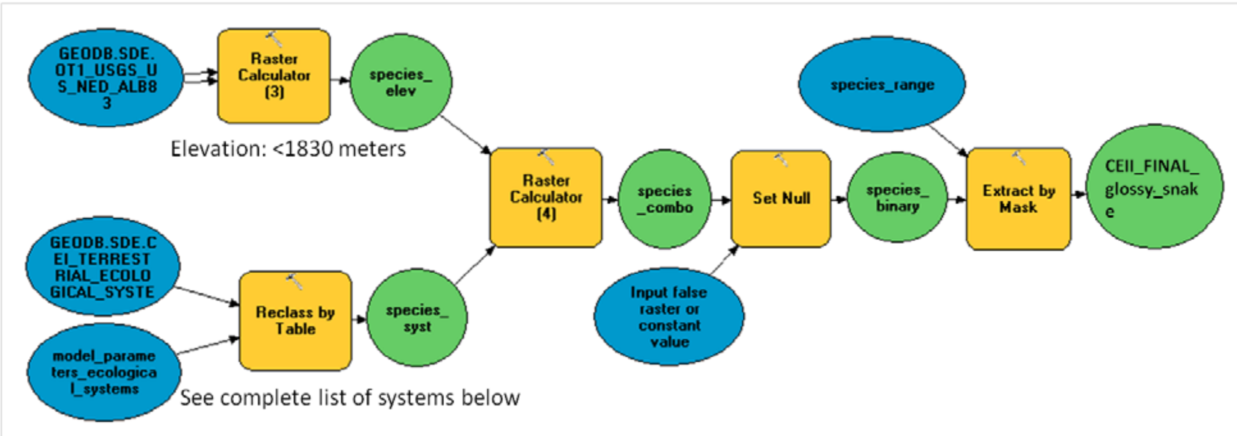


ESLF Code	System Name
4212	Madrean Pinyon-Juniper Woodland
5254	Chihuahuan Succulent Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5310	Mogollon Chaparral
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5405	Madrean Juniper Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland

9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Glossy Snake

The distribution of the glossy snake (*Arizona elegans*) was mapped using ecological systems and elevation (less than 1830 meters) to define habitat as shown in the schematic model below.

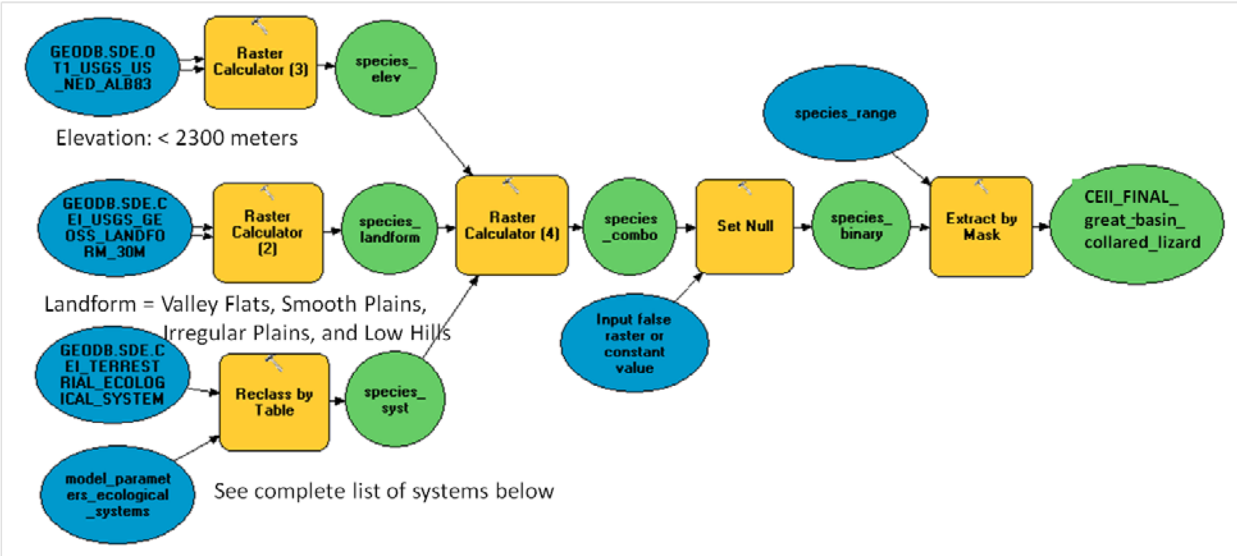


ESLF Code	System Name
3121	North American Warm Desert Active and Stabilized Dune
3179	Inter-Mountain Basins Playa
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
5252	Chihuahuan Mixed Salt Desert Scrub
5253	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub
5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7104	Central Mixedgrass Prairie
7107	Inter-Mountain Basins Semi-Desert Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9151	North American Warm Desert Wash
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

9178	North American Warm Desert Riparian Mesquite Bosque

GREAT BASIN COLLARED LIZARD

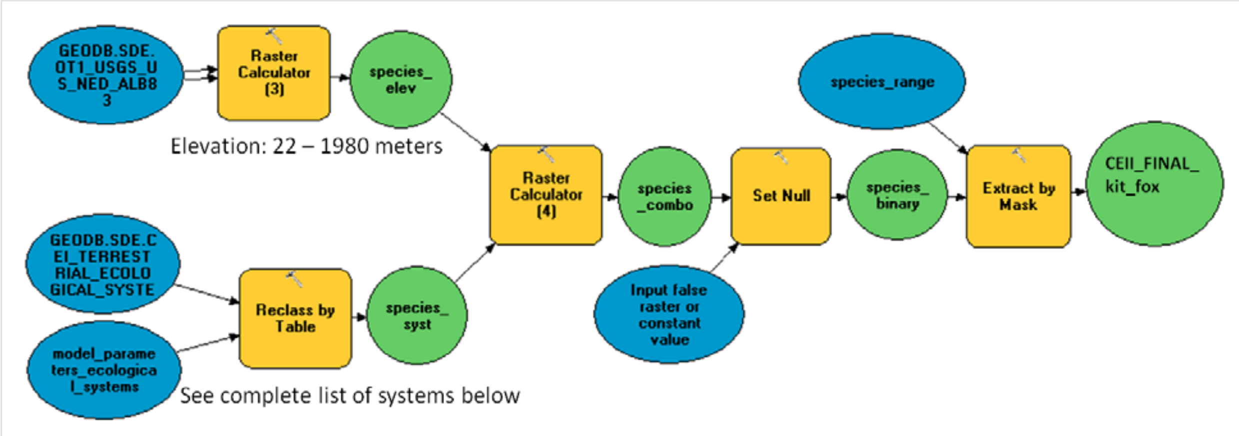
The distribution of the Great Basin collared lizard (*Crotaphytus bicinctores*) was mapped using ecological systems, elevation (less than 2300 meters), and landform (valley flats, smooth plains, irregular plains, and low hills) to define habitat as shown in the schematic model below.



ESLF Code	System Name
3120	North American Warm Desert Bedrock Cliff and Outcrop
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3171	Sierra Nevada Cliff and Canyon
3173	Inter-Mountain Basins Cliff and Canyon
3180	North American Warm Desert Volcanic Rockland
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
9151	North American Warm Desert Wash

KIT FOX

The distribution of the kit fox (*Vulpes macrotis*) was mapped using ecological systems and elevation (22 to 1980 meters) to define habitat as shown in the schematic model below.

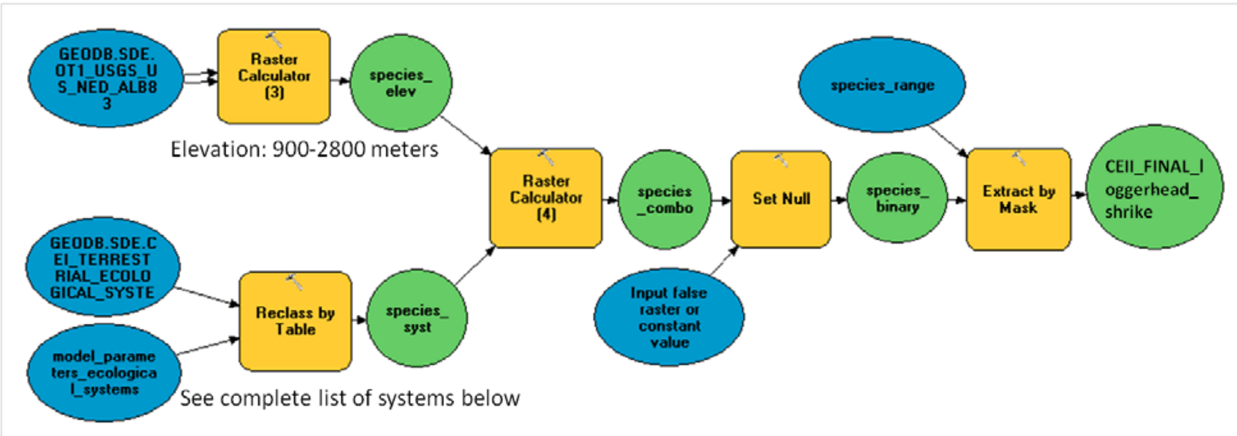


ESLF Code	System Name
3121	North American Warm Desert Active and Stabilized Dune
3123	North American Warm Desert Badland
3139	Inter-Mountain Basins Shale Badland
3152	Inter-Mountain Basins Wash
3161	North American Warm Desert Playa
3179	Inter-Mountain Basins Playa
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5203	Inter-Mountain Basins Mat Saltbush Shrubland
5209	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe
5252	Chihuahuan Mixed Salt Desert Scrub
5253	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub
5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5307	Madrean Oriental Chaparral
5308	Colorado Plateau Pinyon-Juniper Shrubland

5309	Great Basin Semi-Desert Chaparral
5310	Mogollon Chaparral
5314	Sonora-Mojave Semi-Desert Chaparral
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5454	Inter-Mountain Basins Big Sagebrush Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7122	Western Great Plains Shortgrass Prairie
9151	North American Warm Desert Wash

LOGGERHEAD SHRIKE

The distribution of the loggerhead shrike (*Lanius ludovicianus*) was mapped using ecological systems and elevation (900 to 2800 meters) to define habitat as shown in the schematic model below.



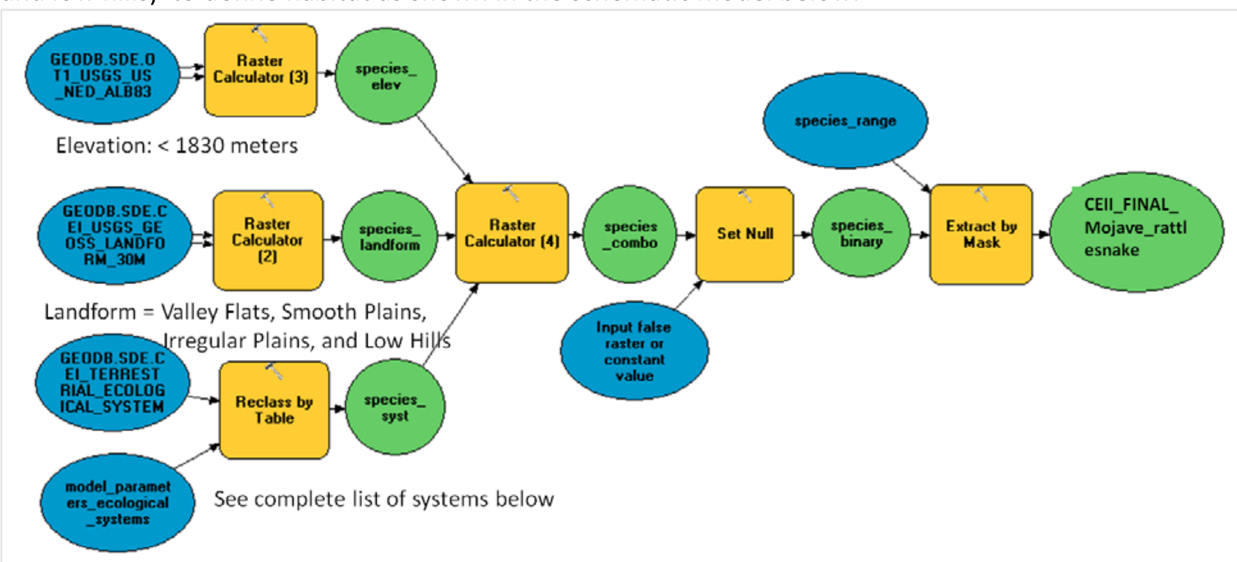
ESLF Code	System Name
21	Developed-Open Space
22	Developed-Low Intensity
80	Agriculture - General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
3152	Inter-Mountain Basins Wash
3173	Inter-Mountain Basins Cliff and Canyon
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4203	Colorado Plateau Pinyon-Juniper Woodland
4210	Madrean Encinal
4211	Madrean Lower Montane Pine-Oak Forest and Woodland

4212	Madrean Pinyon-Juniper Woodland
4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5252	Chihuahuan Mixed Salt Desert Scrub
5253	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub
5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5263	Rocky Mountain Lower Montane-Foothill Shrubland
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5308	Colorado Plateau Pinyon-Juniper Shrubland
5309	Great Basin Semi-Desert Chaparral
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5317	Western Great Plains Mesquite Woodland and Shrubland
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7104	Central Mixedgrass Prairie
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7119	Southern Rocky Mountain Montane-Subalpine Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9151	North American Warm Desert Wash

9153	Western Great Plains Floodplain
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9329	Western Great Plains Riparian
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

MOJAVE RATTLESNAKE

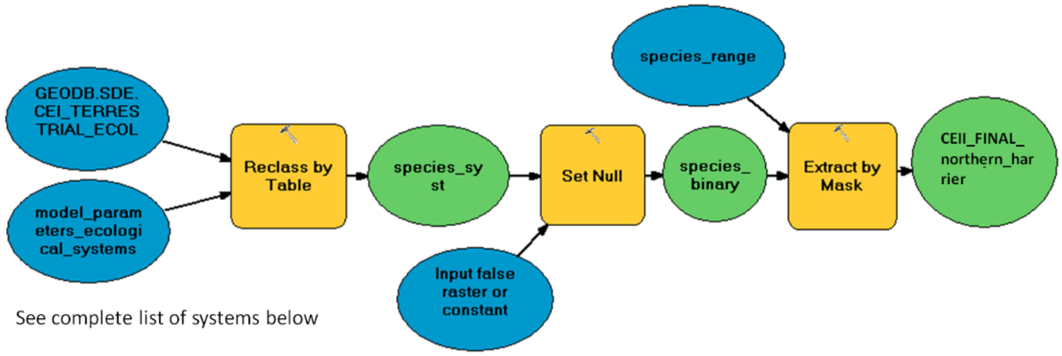
The distribution of the Mojave rattlesnake (*Crotalus* scutulatus) was mapped using ecological systems, elevation (less than 1830 meters), and landform (valley flats, smooth plains, irregular plains, and low hills) to define habitat as shown in the schematic model below.



ESLF Code	System Name
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
7107	Inter-Mountain Basins Semi-Desert Grassland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Northern Harrier

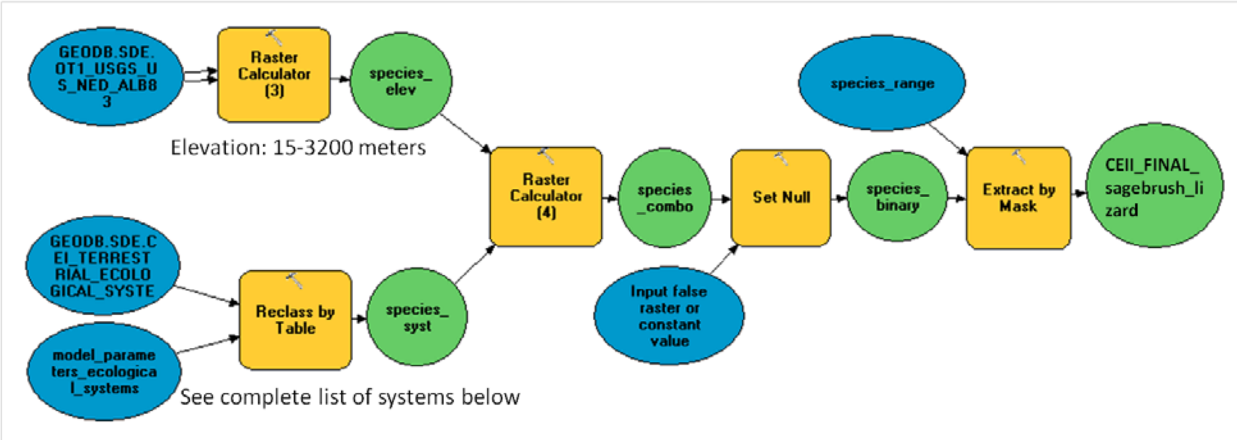
The distribution of the northern harrier (*Circus cyaneus*) was mapped based solely on the distribution of ecological systems as shown in the schematic model below.



ESLF Code	System Name
2	Recently Burned
80	Agriculture - General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
5252	Chihuahuan Mixed Salt Desert Scrub
5254	Chihuahuan Succulent Desert Scrub
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
7104	Central Mixedgrass Prairie
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9103	Inter-Mountain Basins Greasewood Flat
9153	Western Great Plains Floodplain
9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9222	North American Arid West Emergent Marsh
9256	Western Great Plains Saline Depression Wetland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

NORTHERN SAGEBRUSH LIZARD

The distribution of the northern sagebrush lizard (*Sceloporus graciosus grasiosus*) was mapped using ecological systems and elevation (15 to 3200 meters) to define habitat as shown in the schematic model below.

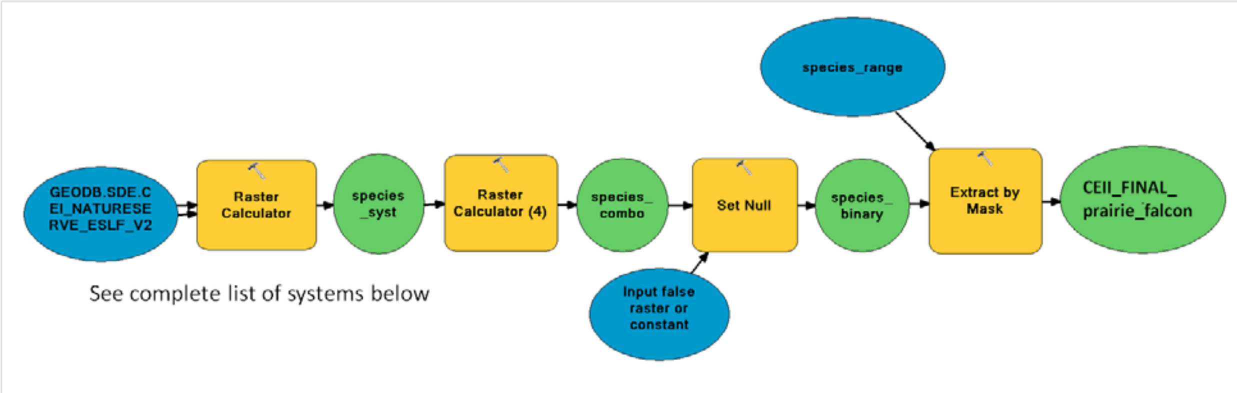


ESLF Code	System Name
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3173	Inter-Mountain Basins Cliff and Canyon
3179	Inter-Mountain Basins Playa
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5259	Mojave Mid-Elevation Mixed Desert Scrub
5263	Rocky Mountain Lower Montane-Foothill Shrubland
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5308	Colorado Plateau Pinyon-Juniper Shrubland
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5455	Inter-Mountain Basins Montane Sagebrush Steppe

5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

Prairie Falcon

The distribution of the prairie falcon (*Falco mexicanus*) was mapped based solely on the distribution of ecological systems as shown in the schematic model below.

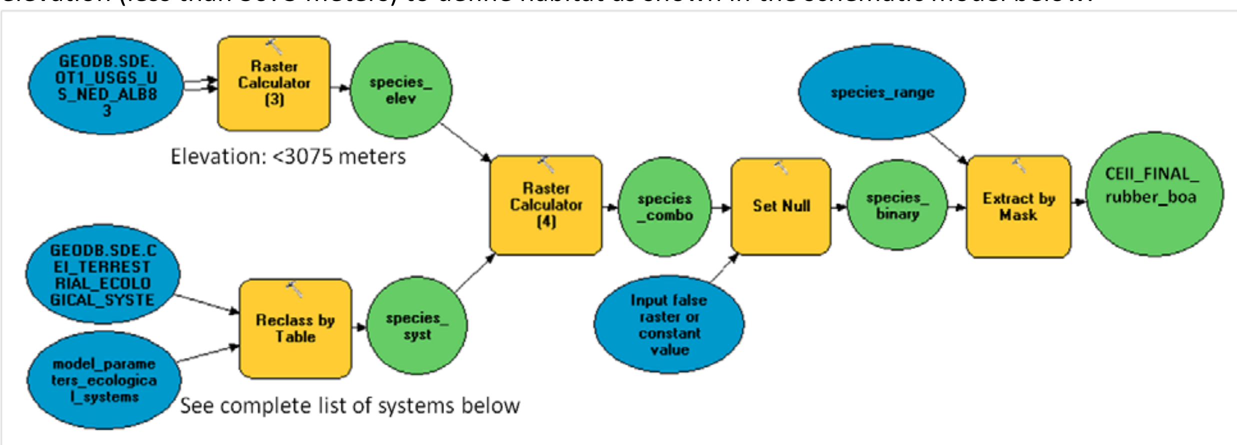


ESLF Code	System Name
80	Agriculture - General
81	Agriculture - Pasture/Hay
82	Agriculture - Cultivated Crops and Irrigated Agriculture
3120	North American Warm Desert Bedrock Cliff and Outcrop
3129	Rocky Mountain Cliff, Canyon and Massive Bedrock
3142	Western Great Plains Cliff and Outcrop
3171	Sierra Nevada Cliff and Canyon
3173	Inter-Mountain Basins Cliff and Canyon
4210	Madrean Encinal
4241	Southern Rocky Mountain Ponderosa Pine Woodland
5203	Inter-Mountain Basins Mat Saltbush Shrubland
5252	Chihuahuan Mixed Salt Desert Scrub
5254	Chihuahuan Succulent Desert Scrub
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5307	Madrean Oriental Chaparral
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5314	Sonora-Mojave Semi-Desert Chaparral
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe

7104	Central Mixedgrass Prairie
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7117	Rocky Mountain Alpine Turf
7120	Western Great Plains Foothill and Piedmont Grassland
7122	Western Great Plains Shortgrass Prairie
7123	Western Great Plains Tallgrass Prairie
9151	North American Warm Desert Wash
9153	Western Great Plains Floodplain
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Northern Rubber Boa

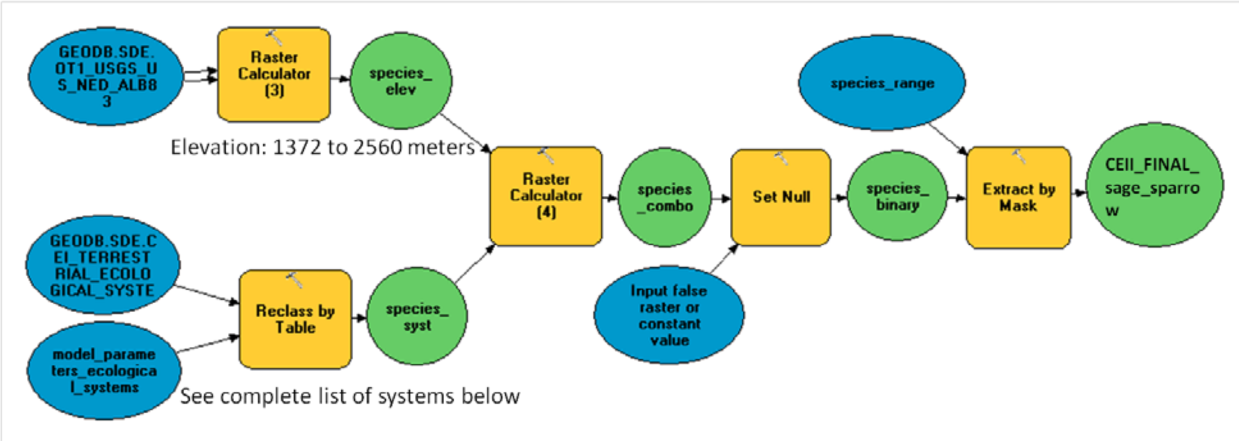
The distribution of the rubber boa (*Charina bottae*) *was* mapped using ecological systems and elevation (less than 3075 meters) to define habitat as shown in the schematic model below.



ESLF Code	System Name
4239	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
4241	Southern Rocky Mountain Ponderosa Pine Woodland
4302	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
5309	Great Basin Semi-Desert Chaparral
7118	Rocky Mountain Subalpine-Montane Mesic Meadow
9168	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
9171	Rocky Mountain Subalpine-Montane Riparian Woodland
9182	North American Warm Desert Riparian Woodland and Shrubland

Sage Sparrow

The distribution of the sage sparrow (*Amphispiza belli*) was mapped using ecological systems and elevation (1372 to 2560 meters) to define habitat as shown in the schematic model below.

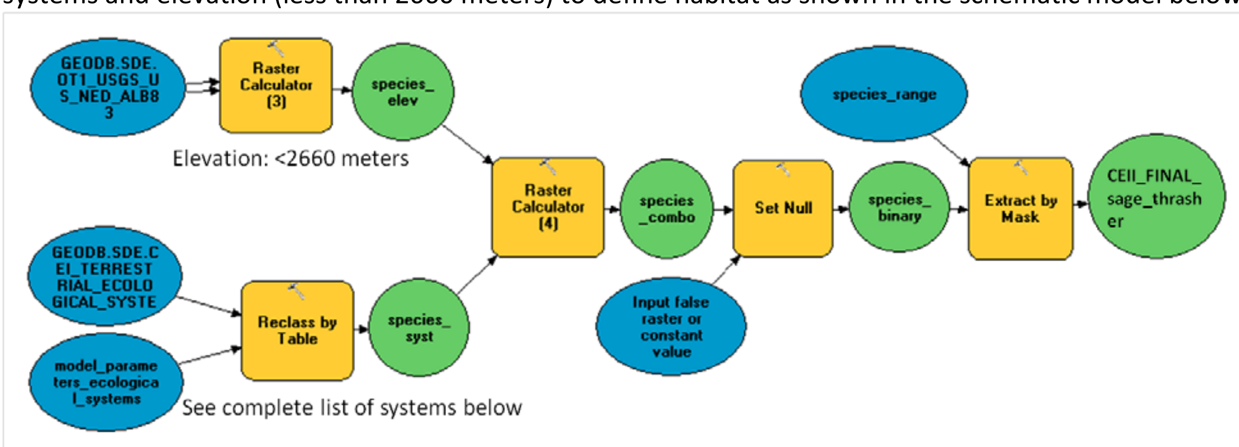


ESLF Code	System Name
3121	North American Warm Desert Active and Stabilized Dune
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3139	Inter-Mountain Basins Shale Badland
3143	North American Warm Desert Pavement
3160	Inter-Mountain Basins Active and Stabilized Dune
3161	North American Warm Desert Playa
3173	Inter-Mountain Basins Cliff and Canyon
3183	Colorado Plateau Mixed Bedrock Canyon and Tableland
4203	Colorado Plateau Pinyon-Juniper Woodland
4212	Madrean Pinyon-Juniper Woodland
4236	Rocky Mountain Foothill Limber Pine-Juniper Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
4260	Southern Coastal Plain Mesic Slope Forest
4303	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5203	Inter-Mountain Basins Mat Saltbush Shrubland
5252	Chihuahuan Mixed Salt Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5263	Rocky Mountain Lower Montane-Foothill Shrubland
5265	Sonora-Mojave Mixed Salt Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5271	Western Great Plains Sandhill Steppe
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5307	Madrean Oriental Chaparral
5308	Colorado Plateau Pinyon-Juniper Shrubland
5309	Great Basin Semi-Desert Chaparral

5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5314	Sonora-Mojave Semi-Desert Chaparral
5317	Western Great Plains Mesquite Woodland and Shrubland
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5451	Chihuahuan Gypsophilous Grassland and Steppe
5454	Inter-Mountain Basins Big Sagebrush Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
7120	Western Great Plains Foothill and Piedmont Grassland
9103	Inter-Mountain Basins Greasewood Flat
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

SAGE THRASHER

The distribution of the sage thrasher (*Oreoscoptes montanus) was* mapped using ecological systems and elevation (less than 2660 meters) to define habitat as shown in the schematic model below.

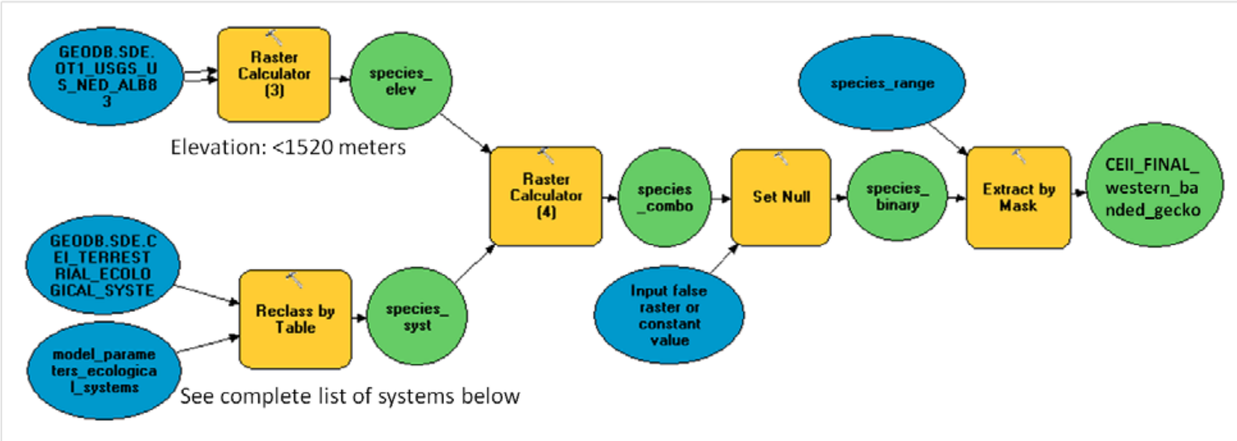


ESLF Code	System Name
3121	North American Warm Desert Active and Stabilized Dune
3128	Inter-Mountain Basins Volcanic Rock and Cinder Land
3152	Inter-Mountain Basins Wash
4203	Colorado Plateau Pinyon-Juniper Woodland
4212	Madrean Pinyon-Juniper Woodland
4246	Southern Rocky Mountain Pinyon-Juniper Woodland
5201	Colorado Plateau Mixed Low Sagebrush Shrubland
5252	Chihuahuan Mixed Salt Desert Scrub
5253	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub

5254	Chihuahuan Succulent Desert Scrub
5255	Colorado Plateau Blackbrush-Mormon-tea Shrubland
5256	Great Basin Xeric Mixed Sagebrush Shrubland
5257	Inter-Mountain Basins Big Sagebrush Shrubland
5258	Inter-Mountain Basins Mixed Salt Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5306	Chihuahuan Mixed Desert and Thorn Scrub
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5317	Western Great Plains Mesquite Woodland and Shrubland
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5408	Southern Rocky Mountain Juniper Woodland and Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5451	Chihuahuan Gypsophilous Grassland and Steppe
5454	Inter-Mountain Basins Big Sagebrush Steppe
5455	Inter-Mountain Basins Montane Sagebrush Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7104	Central Mixedgrass Prairie
7105	Chihuahuan Sandy Plains Semi-Desert Grassland
7107	Inter-Mountain Basins Semi-Desert Grassland
9103	Inter-Mountain Basins Greasewood Flat
9151	North American Warm Desert Wash
9153	Western Great Plains Floodplain
9155	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
9156	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9329	Western Great Plains Riparian
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

WESTERN BANDED GECKO

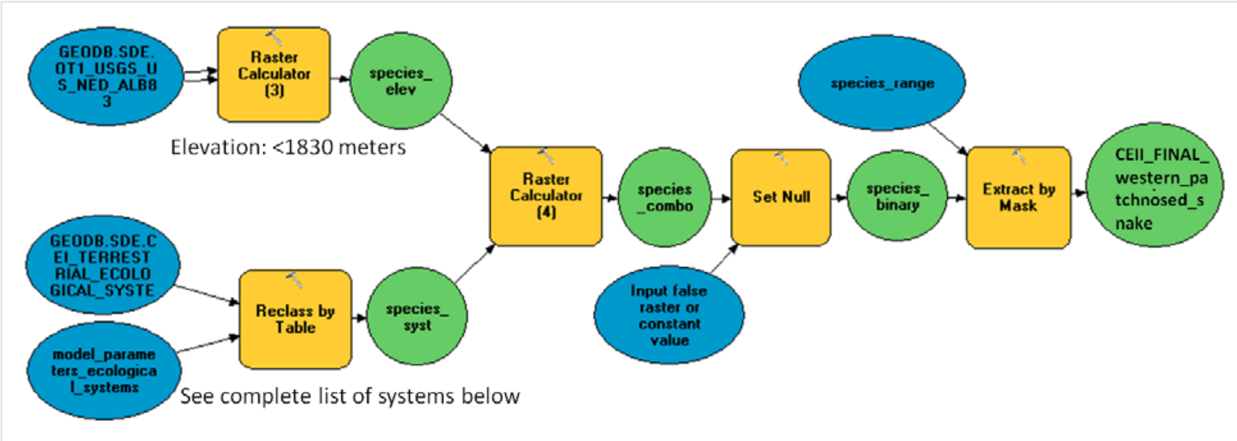
The distribution of the western banded gecko (*Coleonyx variegates*) was mapped using ecological systems and elevation (less than 1520 meters) to define habitat as shown in the schematic model below.



ESLF Code	System Name
3161	North American Warm Desert Playa
4203	Colorado Plateau Pinyon-Juniper Woodland
4206	Great Basin Pinyon-Juniper Woodland
4210	Madrean Encinal
4212	Madrean Pinyon-Juniper Woodland
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5265	Sonora-Mojave Mixed Salt Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5270	Southern Colorado Plateau Sand Shrubland
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5310	Mogollon Chaparral
5313	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5404	Inter-Mountain Basins Juniper Savanna
5405	Madrean Juniper Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
7107	Inter-Mountain Basins Semi-Desert Grassland
9151	North American Warm Desert Wash
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

Western Patch-nosed Snake

The distribution of the western patch-nosed snake (*Salvadora hexalepis*) was mapped using ecological systems and elevation (less than 1830 meters) to define habitat as shown in the schematic model below.



ESLF Code	System Name
4210	Madrean Encinal
4211	Madrean Lower Montane Pine-Oak Forest and Woodland
4212	Madrean Pinyon-Juniper Woodland
5259	Mojave Mid-Elevation Mixed Desert Scrub
5264	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5268	Sonoran Mid-Elevation Desert Scrub
5301	Apacherian-Chihuahuan Mesquite Upland Scrub
5314	Sonora-Mojave Semi-Desert Chaparral
5315	Sonoran Paloverde-Mixed Cacti Desert Scrub
5405	Madrean Juniper Savanna
5450	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5456	Inter-Mountain Basins Semi-Desert Shrub-Steppe
9172	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
9178	North American Warm Desert Riparian Mesquite Bosque
9182	North American Warm Desert Riparian Woodland and Shrubland
9411	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland

B-1.2.6.1 Species with MaxEnt Distribution Model

B-1.2.6.1.1 Mohave Ground Squirrel

The distribution of the Mohave Ground Squirrel was modeled using MaxEnt (Maximum Entropy for Species Distribution Modeling). Inputs to the model included known occurrences as point localities (point file format) and non-spectral environmental variables (grid file format, all standardized to 100m resolution to reflect the variability in resolution of the source data). The specific environmental variables used (and ordered according to their contribution toward overall model development) were: (1) digital elevation model, (2) soil ph, (3) percentage of sand totals within the soil, (4) percentage of coarse sands in soil, (5) NatureServe's Ecological Systems Map, and (6) geology. Overall performance of the model (as recorded by AUC or Area Under the Curve) was relatively high (0.966). A threshold of 0.63 was applied to distinguish between habitat and non-habitat. The value 0.63 was obtained by determining the average probability value of the modeled output at the known occurrences or point localities. The final model is displayed with a value of "1" for high potential habitat and "NoData" for non-habitat.

B-1.2.7 Species Represented by Element Occurrence Records

Element occurrence (EOs) records from NatureServe's multi-jurisdictional database were used to map the distribution of two species: the bald eagle and the golden eagle. These records were derived from species occurrence observations tracked by individual state natural heritage programs and downloaded data for these two birds from the Global Biodiversity Information Facility (http://data.gbif.org/welcome.htm). The GBIF data were merged with data from NatureServe member programs and standard attributes were applied. Both EOs and GBIF data are spatially represented by point locations. Due to the sensitive nature of these data records, their distribution is restricted. Thus, the data were incorporated into analyses of landscape species CEs for the REA, but not provided in raw form to the BLM.

The element occurrence / GBIF data set for the bald eagle contains 272 point occurrence records within the MBR boundaries, collected between 2000 and 2011. The element occurrence / GBIF data set for the golden eagle contains 236 point occurrence records within the MBR boundaries, collected between 2000 and 2011.

B-1.2.8 Local species: Handling of Element Occurrences

MQ1 - WHAT IS THE CURRENT DISTRIBUTION OF POTENTIAL HABITAT FOR EACH SPECIES CE?

Local species data were derived primarily from field observations and/or Element Occurrence records from Natural Heritage programs. Species presumed to be addressed in the REA through assessment of coarse-filter CEs, and those local-scale species treated within summaries by watershed, required no additional modeling steps, although data for use in by watersehd summaries were aggregated as described below.

Element Occurrence (EO) / Observation data were provided by NatureServe member programs in Arizona, California, Idaho, Nevada, Oregon, and Utah for use in the MBR REA project. NatureServe aggregated these data into a single dataset with standardized taxonomy and conservation status attributes. The initial dataset was created by selecting all EO / Observation data within or overlapping the final MBR boundary. Since the focus of this analysis is on taxa that are believed to be current and extant, several exclusions were applied to remove extirpated or historical populations from the dataset:

- Excluded EO / Observation records for extirpated populations (Eorank = "X" or "X?"),
- Using median Landscape Condition Model (LCM) calculated values for each EO / Obs record, excluded EO / Observation records that are only known from historical records (Eorank = "H" or "H?"; or last observed date older than 1980) with a low median LCM value (<=30) and the area of the EO / Observation is less than 1260 ha, and
- For large EO / Obs records (>1260 ha), excluded all records with a last observed date older than 1980.

As needed, subspecies and varieties were "rolled up" to the relevant "full species". The "assessment type" was assigned to all records according to the final MBR species list. The final EO / Observation dataset for MBR contains 18,583 records.

For the Landscape Species, the EOs for these species were combined with the 5th level watersheds (watershed10) raster layer, and the resulting raster tables were converted to geodatabase tables. These data were summarized by pixels, and converted to acres for each landscape species distribution per watershed10. All records where the landscape species has less than 248 acres (100 ha) in a watershed10 watershed were excluded as not likely to occur in the watershed.

The final summary lists for 5th level watersheds was created by performing a spatial join between the EO/Observation, Bald Eagle, Golden Eagle, and Landscape Species Distribution Model datasets and the MBR watershed10 watershed layer. The tabular results of the spatial join were exported from GIS to text (CSV) files, that were then imported to an Access database. In Access, the results of the various analyses were merged, and updates were conducted as needed with attributes from the final MBR species list (such as conservation statuses). A series of queries were conducted to create a list of the unique species per watershed, and from that summarized the unique species list to get the number of rare plant species and EOs per watershed.

Figure B - 15 summarizes the number of local species occurring in each 5th level watershed, based on natural heritage element occurrence records. These species localities are generally concentrated along the northeastern, central, and southwestern portions of the ecoregion.

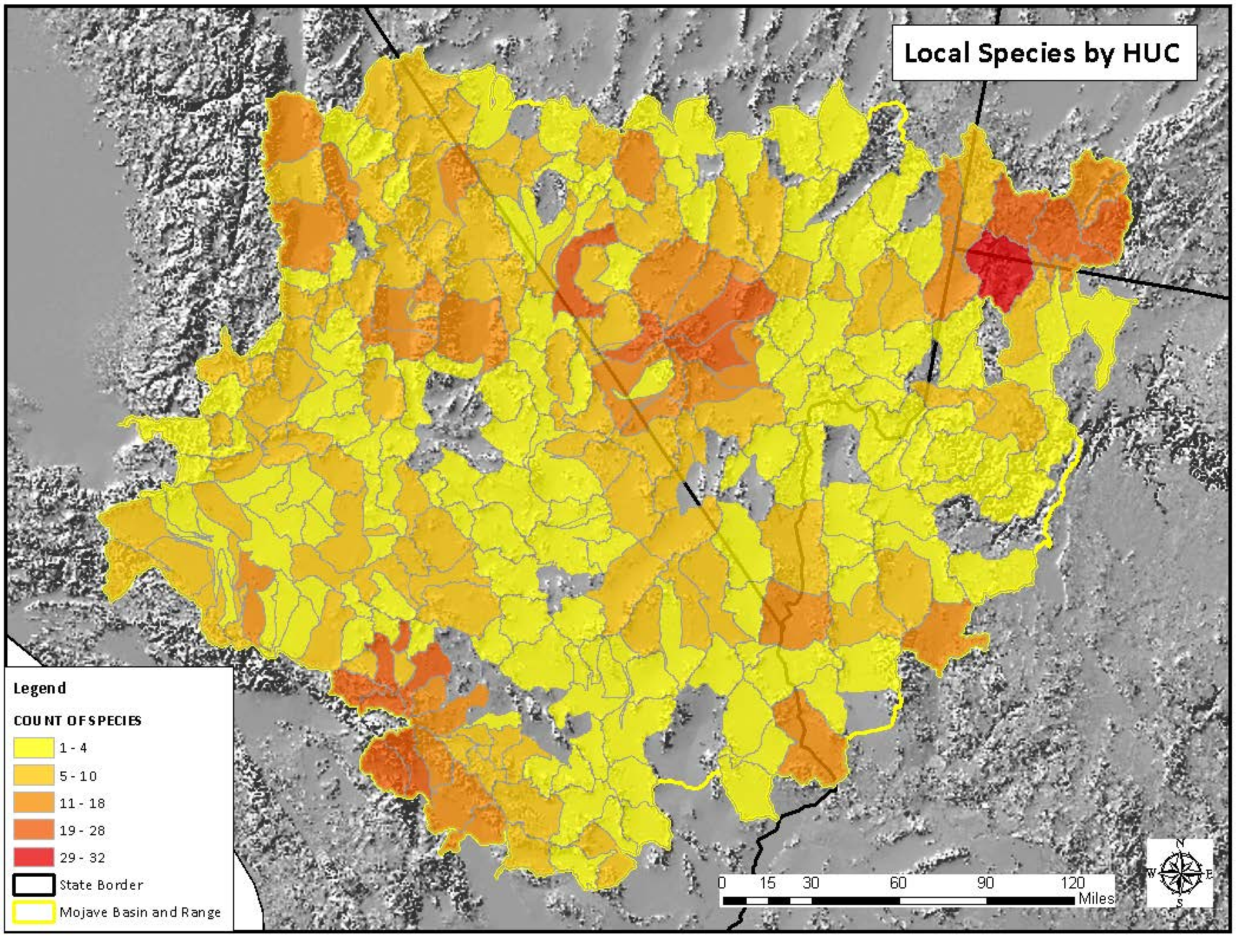


Figure B - 15. Local species summarized by number known to occur within each 5th level watershed of the MBR.

B-1.3 Bioclimatic Envelope Modeling

B-1.3.1 Introduction

In order to forecast how climate change may result in geographic shifts of the suitable climatic conditions for a species, we must first define its 'bioclimactic envelope'. Species distribution models, also called ecological niche models, perform this task by correlating known localities of a species' current range with current climatic conditions. Of course, climactic conditions such as air temperature and precipitation levels are not the sole defining characteristics of species occupied range. Some species, for example, may be limited or facilitated by the presence of particular vegetation communities, or by other habitat characteristics such as topography or soil type, etc. Nonetheless, climatic conditions play a broad role in determining the suitability of habitat for most species, and they have indirect influence on those other factors, such as the extent of certain vegetation communities or the characteristics of local hydrology, that in turn influence habitat selection for species. Thus, there is value for management in anticipating the geographic changes in bioclimatic suitability that climate change may bring. This information can serve as one of many inputs in developing an understanding of how climate change might affect a given species of management interest.

More informative and quantifiable estimates of potential range shifts can be obtained by projecting current bioclimates defined by species distributions into future climatic conditions based on the most recent climate model data (e.g. Gonzales et al. 2010; Jiguet et al. 2011). This approach integrates observations of occurrence data for a target species with digital grids of spatial climate observations to generate a species' multidimensional bioclimatic 'envelope' or 'niche'. The species' identified n-dimensional bioclimatic envelope can then be projected into 21st century climate scenarios developed by the Intergovernmental Panel on Climate Change (IPCC), resulting in a map of the future distribution of the species current bioclimatic niche. This information offers one basic building block for a myriad of studies that include prediction of extinction risk, analysis of future conservation priorities and species range shifts.

However, IPCC GCMs present two challenges: 1) the coarse spatial resolution at which they are produced (with grid cells ranging from 1^o to 5^o, with an average of over 2.0^o) and 2) the difficulty comparing across the many different GCMs that exist, each of which are run under alternative emissions scenarios, and each of which archive different climate variable outputs. Both challenges limit our ability to compare and contrast results based on different model simulations, quantify the associated uncertainties inherent to multiple simulations, or understand the impacts of climate change on the spatial scales relevant to biodiversity (Dettinger 2006; Beaumont et al. 2007). To address the first issue, GCMs are downscaled to finer spatial resolutions using one of several approaches. To quantify uncertainties confronting conservationists, an ensemble approach was used to increase the statistical confidence on the likelihood of various future climate outcomes (Salathé Jr. et al. 2007, Kremen et al. 2008).

B-1.3.1.1 Limitations and uncertainties

Results from climate space trend and bioclimatic envelope analyses should be carefully considered in light of the limitations and uncertainties that constrain virtually all scientific efforts to understand the potential impacts of changes in climate. This is particularly true when the analysis objective requires an understanding of current and future climate conditions at fine spatial and temporal scales relevant to plants and animal populations of management concern.

Every dataset and modeling approach that is used in forecasting climate change impacts contains an inherent degree of uncertainty. Here, we discuss each source of uncertainty in modeling climate change impacts to the distributions of CEs and vegetation assemblages or in analyzing trends in climate space over time.

B-1.3.1.1.1 Climate observations

Historical and recent climate data from observations is restricted to scattered weather stations, whose density patterns generally reflect patterns of human settlement. Weather station locations are inherently biased towards easily accessible, low elevation sites (Figure B - 16). For analysis of current climate space trends, we use the PRISM spatial climate dataset for the years 1900-2010 (Daly et al. 2002). PRISM uses a sophisticated, proprietary interpolation algorithm to create gridded climate data for the conterminous U.S., which is freely available at 4km2 resolution (http://www.prism.oregonstate.edu/products/matrix.phtml?view=data). PRISM is widely accepted as the highest quality spatial climate dataset available for the U.S., and it has been adopted as the official climate data for the U.S. Dept of Agriculture. Nonetheless, all efforts to interpolate sparse weather station observations face challenges. While temperature interacts with topography in a relatively predictable manner, the interpolation of precipitation, particularly over topographically complex regions, is a known weakness of all gridded climate datasets. *Therefore results of spatial and temporal precipitation analyses from gridded climate data are less certain than those for temperature, particularly over mountainous terrain.*

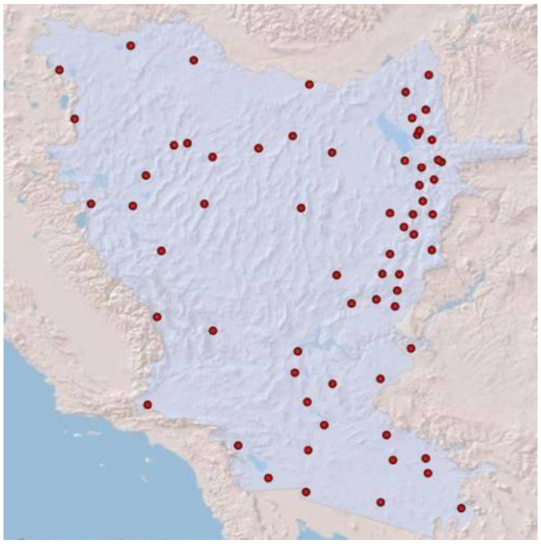


Figure B - 16.Verified weather stations measuring temperature and precipitation in the Central and Mojave basin and range ecoregions.

Source: Global Historical Climatology Network v.2

A second, higher resolution gridded climate dataset is available from the PRISM group for purchase, and this 800m^2 resolution is recognized as a superior product. The for-sale product offers a more sophisticated and validated algorithm that better accounts for interactions of climate and topography, such as cold air drainages, temperature inversions, and microclimates generated by slope and aspect. Also, the much finer spatial scale of the purchased product more closely reflects the scale at which plants and animals interact with climate. If the observed climate space trend analysis of the MBR at 4km^2 proves to be a useful product, we strongly recommend that a finer spatial scale analysis with a more sophisticated gridded climate dataset would be a worthy investment in support of management planning.

B-1.3.1.1.2 Future climate projections

Any effort to understand the impacts of future climate change on biodiversity requires outputs from global or regional climate models. There are a wide range of models to choose from – almost two dozen global circulation models (GCM – also called global climate models) were vetted by the Intergovernmental Panel on Climate Change (IPCC) in their last assessment report (IPCC 2007). Global climate models attempt to capture the patterns, forcings and feedbacks of the entire global climate system over time, and are therefore relatively limited in their direct applications to regional scale questions. The process of climate model *downscaling* uses alternative approaches to create gridded climate data based on GCM outputs at much finer spatial resolution for regional to local scale impacts analyses.

To assess model performance, climate models are initialized with known atmospheric conditions from the recent past (such as 1950-2000), and their outputs compared to observed conditions. No single climate model outperforms all others in reproducing patterns of climate across the globe. The climate modeling community supports the concept that multimodel ensembles, that is, the average of a suite of climate models, generally outperform any single climate model in reproducing observed patterns of global climate (Tebaldi & Knutti 2007). Comparing results across a range of models also supports an evaluation of model agreement, which is one approach to decreasing uncertainty in future climate impacts assessments (Tebaldi et al. 2011).

For this REA, we use a range of global and regional climate model results to analyze climate change impacts on the biodiversity and landscapes of the MBR. As dictated by the scope of the REA, all climate model results reflect only the A2 greenhouse gas emissions scenario, which forecasts steadily increasing amounts of heat trapping gases emitted into the atmosphere for the remainder of this century (IPCC 2000). Therefore, *uncertainty due to the rate and magnitude of greenhouse gas emissions is not* *explored in this REA*. However, within the scenario described by the A2 future, the bioclimatic envelope modeling and climate space trend analysis are conducted with multiple climate model outputs. Our intention is to capture a reasonable range of model variation and to provide measures of degree of climate model agreement, both of which reduce the uncertainty inherent in impacts assessments relying on one or a very few models.

B-1.3.1.1.3 Biogeographic distributions

The distribution of any given species or vegetation assemblage can rarely be assessed with complete confidence. Even painstaking fieldwork, museum collection records, or computer algorithms classifying satellite data, cannot fully characterize the dynamic distribution of biodiversity in time and space. Point observations of species distributions are always an underestimate of actual distributions. Range maps drawn by creating convex hulls around the outermost point observations are usually overestimates, as species are not continuously distributed in space.

Samples were selected from the mapped distributions of either landscape speices or terrestrial coarse filter, to be used as input to the bioclimate modleing. For specific methods on input landscape species distribution data see section B-1.2.5 in this appendix for the Landscape Species. For specific methods on terrestrial coarse filter input distribution data see B-1.2.1.

The samples used to develop the climate envelope models were based upon two datasets. The individual animal species models were developed using the intersection of SW-ReGap species range maps and a 16Km2 derived hexagon map encompassing the combined CBR and MBR boundaries extended to the Sonoran and the Northern Basin and Range Ecoregions (Figure B - 17 shows this analysis boundary). Each species was statistically summarized to define the quartile distribution of percent area included in all the intersecting hexagons. Those hexagons meeting the 75% quartile or higher were defined as a sample point.

The ecological systems samples utilized the same sample design as used for the species, but used additional field based sample points (geo-referenced vegation samples form the LANDIFRE reference database, keyed to ecological system) to define a confirmed hexagon of occurrence. Each hexagon was coded to enable the identification of the source of the hexagon selection as to mapped distribution, field based sample, or both.

B-1.3.1.1.4 Ecological niche models

Ecological niche models, also called species distribution models, correlate observations of species known distributions with spatial data on climate and/or environment from those same locations. Their use has dramatically increased over the last decade as researchers seek to understand the relationship between species distributions and global change in areas as diverse as food security, public health, ecology and conservation.

There are a range of alternative algorithms that build correlative models of species distributions, and different modeling approaches can produce different results (Pearson et al. 2006). For biogeographic data that is presence-only, that is, when locality information confirms where a species has been observed, but cannot confirm where a species does not occur, the modeling algorithm called Maxent has demonstrated superior performance (Elith & Graham 2006). There are many additional factors that can affect the performance of niche models, including the quality of the species locality data inputs, the quality and choice of inputs for climate and/or environmental variables, and the degree to which the chosen variables actually influence the distribution of the target species. Niche models make several simplifying assumptions. They do not account for the varying dispersal ability of different taxa; they do not consider genetic or evolutionary adaptive potential across individuals or populations, and they do not account for the influence of biotic interactions.

For a rapid assessment focused on climate change impacts to species and vegetation assemblages of management concern, there exists neither the time nor the resources to produce in-depth, species-specific niche modeling efforts. Our assessment analyzes the current and future distribution of bioclimatic envelopes defined by monthly variables of temperature and precipitation. For future distributions, we independently model six different bioclimatic envelopes per species, based on the six downscaled GCMs in the EcoClim 4km^2 dataset. With this approach, we can describe the relatively stability or vulnerability to change of each species bioclimatic envelope, and assess degree of model agreement across the six models as a measure of the confidence in these projections. Where multiple climate models agree that the existing bioclimate for a given species remains relatively geographically stable, this is an indication of lower vulnerability. Alternatively, where multiple climate models agree that existing bioclimate will shift significantly from its current location, this indicates high vulnerability to climate change. The analysis produced here should not emphasize the question "Where will a given species live in the future?" – this question requires much further in-depth analysis of species-specific ecology to be incorporated into the modeling effort. But the multimodel ensemble approach used in this rapid assessment can produce a hypothesis of the relative stability or vulnerability of species bioclimatic envelopes to the climate changes forecast by midcentury under an A2 scenario. By combining the results for multiple species, patterns of stability and turnover in species richness across the MBR can be estimated.

B-1.3.2 Methods

B-1.3.2.1 Regional Analysis Boundary

For purposes of the bioclimate envelope modeling a regional analysis boundary (Figure B - 17) was delineated for summarizing and analyzing the bioclimatic envelope model results because it is consistent with the species and coarse filter range data that was input into the model. The regional boundary was chosen to sample the species and coarse filters, and other input data and these samples were used to model species' or coarse filter niches within this boundary. Because bioclimatic envelope modeling only represents the part of a species niche that is defined by the occurrence data provided, it is more accurate to include a larger sample so the model has a correct representation of a species niche and its associated bioclimatic variables. There are many species and coarse filters whose distribution crosses boundaries, such as the bald eagle and golden eagle whose ranges are extensive in both CBR and MBR. Results for species bioclimatic shift in the future also cross boundaries, and these results might be misunderstood if summarized separately for MBR and CBR.

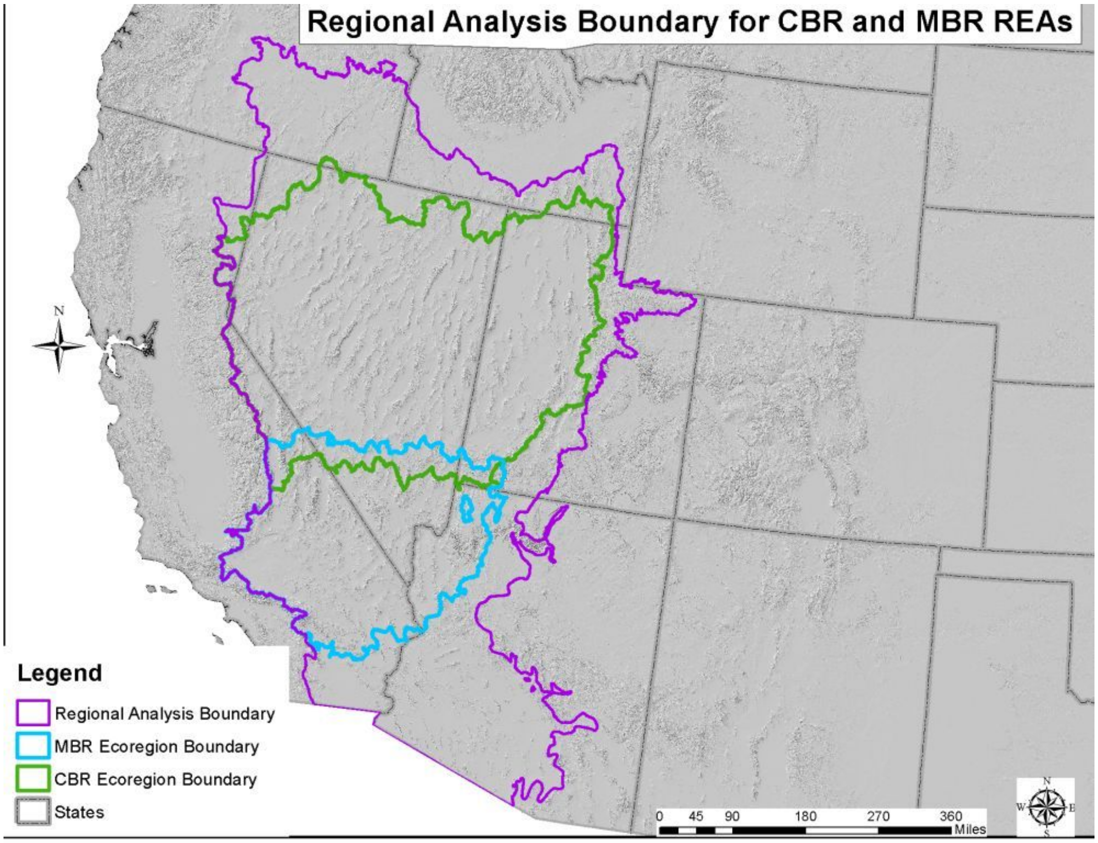


Figure B - 17. Regional analysis boundary used for the bioclimate envelope modeling of coarse-filter and landscape species CEs.

B-1.3.2.2 Bioclimatic envelope modeling

In order to predict how climate change may shift the suitable climatic conditions for a species or vegetation class, we first define its bioclimactic niche by correlating its current range with current climatic conditions. The species' identified niche can then be projected into the future using downscaled Global Circulation Models (GCMs) to predict where a niche will occur at different timeslices in 21st century climate scenarios. This information offers one basic building block for a myriad of biogeographic studies that include prediction of extirpation risk, analysis of future conservation priorities and species range shifts. A total of 41 terrestrial coarse filter or landscape species CEs received bioclimate envelope modeling, across both the CBR and MBR REAs (Table B - 21). For Brewer's sparrow and mule deer one or 2 additional habitat components were modeled.

The species distribution modeling algorithm MaxEnt (Phillips et al. 2006, Phillips and Dudik 2008) was used in conjunction with spatial climate data from PRISM and EcoClim 4km^2 to model current and future bioclimate of conservation elements in the CBR and MBR regions. Maxent is a correlative niche model that uses the principle of maximum entropy to estimate a set of functions that relate environmental variables and species known occurrences in order to approximate species' niche and potential geographic distribution (Figure B - 18). Maxent was chosen because of its established performance with presence-only data relative to alternative niche modeling techniques, and its built-in capacity to deal with multi-colinearity in the environmental variables (Elith et al. 2006, Elith and Leathwick 2009). Maxent is a machine learning algorithm related to Bayesian theory that considers redundant information without penalizing models by over-fitting, eliminating the need to apply any type of variable reduction technique before running the models. Maxent calculates a surface of probability across geographic space, where each cell has a value of the probability that a species niche will occur there at a given time. Maxent focuses on how the environment where the species is known to occur relates to the environment across the rest of the study area (the "background"). The model does not identify either the species occupied niche or fundamental niche; rather the model identifies only that part of the niche defined by the observed records (for further explanation on the algorithm refer to: Phillips et al. 2006, Elith et al. 2011).

Table B - 21. List of coarse filter and landscape species with bioclimate envelope models.

REA	Conservation Element Name
Terrestrial Coarse Filter CEs	
Both	Great Basin Pinyon-Juniper Woodland
Both	Great Basin Xeric Mixed Sagebrush Shrubland
CBR	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
CBR	Inter-Mountain Basins Big Sagebrush Shrubland
CBR	Inter-Mountain Basins Big Sagebrush Steppe
CBR	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland
Both	Inter-Mountain Basins Mixed Salt Desert Scrub
CBR	Inter-Mountain Basins Montane Sagebrush Steppe
CBR	Inter-Mountain Basins Semi-Desert Shrub-Steppe
CBR	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland
Both	Mojave Mid-Elevation Mixed Desert Scrub
CBR	Rocky Mountain Aspen Forest and Woodland
MBR	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
MBR	Sonora-Mojave Mixed Salt Desert Scrub
MBR	Sonora-Mojave Semi-Desert Chaparral
Landscape Species CEs	
Both	Bald Eagle
Both	Brewer's Sparrow - Breeding
Both	Brewer's Sparrow - Migratory
CBR	Clark's Nutcracker
Both	Coachwhip
CBR	Columbian Sharp-tailed Grouse
Both	Common Kingsnake
Both	Cooper's Hawk
Both	Desert Bighorn Sheep
MBR	Desert Tortoise - Mohave Population
MBR	Desert Tortoise - Sonoran Population
CBR	Ferruginous Hawk
MBR	Gila Monster
MBR	Glossy Snake

REA	Conservation Element Name
Both	Golden Eagle
CBR	Greater Sage-Grouse (just occupied habitat)
MBR	Mohave Ground Squirrel
MBR	Mohave Rattlesnake
Both	Mule Deer - summer range
Both	Mule Deer - winter range
Both	Mule Deer - yr round range
Both	Northern Harrier
Both	Northern Rubber Boa
Both	Northern Sagebrush Lizard
CBR	Pygmy Rabbit
Both	Sage Sparrow
CBR	Swainson's Hawk
Both	Western Patch-nosed Snake
CBR	White-tailed Jackrabbit

B-1.3.2.2.1 Threshold selection

In order to translate the raw Maxent probability distribution into estimates of species presence or absence a specific threshold needs to be selected, a necessary post-processing step when using an ensemble approach. The threshold used in this analysis is the “equal training sensitivity plus specificity” threshold. This threshold maximizes the agreement between observed and predicted distributions, a choice that has proven to produce the most accurate predictions (Jimenes-Valverde and Lobo 2007; Lobo et al. 2007; Liu et al. 2005).

B-1.3.2.2.2 Model evaluation

Model evaluation was performed using the area under the curve (AUC) of the receiver operating characteristic (ROC) plot analysis (Fielding and Bell 1997). Twenty percent of occurrence points for a given conservation element were withheld from the model to be used as independent test data in calculating the AUC. The AUC is a widely accepted, threshold-independent metric of species distribution model performance (Marmion et al., 2009; Warren et al., 2010) that provides an overall picture of how well the data fits the model and has previously been used in comprehensive SDM evaluations (Elith et al. 2006).

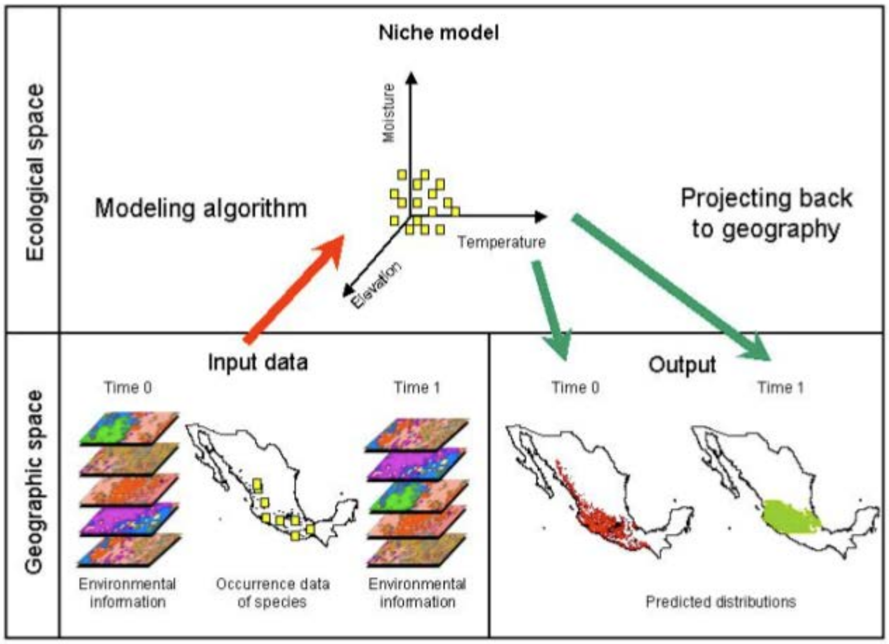


Figure B - 18**.** The process used in this study defines certain aspects of a species' niche in environmental space by relating observed species occurrence to environmental variables. The process does not identify a species' realized or fundamental niche, but rather only the part of the niche defined by the occurrence data provided. In this case, the process defines a potential suitable bioclimate, which can then be projected into the future under various climate change scenarios. (adapted from Martinez-Meyer, 2005)

B-1.3.2.2.3 Ensemble Approach

The ensemble approach focuses on the degree of agreement among multiple GCMs. Various GCMs predict different outcomes for future climatic conditions, even when provided the same input data, because each model accounts for the interactions of various elements of the oceanic-atmospheric system differently. Therefore, an ensemble approach, wherein multiple GCMs are run using the same input data and emissions scenarios and their results compared, averaged, or otherwise aggregated, is increasingly accepted as the preferred method for applying climate projections for a variety of purposes (Tebaldi et al. 2011).

Bioclimatic envelope modeling is conducted with a range of GCMs that have been downscaled to $4km^2$ using a 50-year 20th century baseline derived from PRISM, following the statistical downscaling methods of Tabor & Williams (2010). Each timeslice (2020s and 2050s) was run independently with each of the 6 different GCMs. The six downscaled GCMs are part of a larger spatial future climate dataset called EcoClim (Hamilton *et al.* in prep), and were selected on the basis of climate variable availability. The six GCMs used here were the only models vetted for the IPCC's 4th Assessment Report that archived monthly maximum and minimum temperatures, and were all run under the A2 emissions scenario (as required by scope of REA). Below are the names of the 6 GCMs downscaled to 4km2 and used for bioclimatic envelope modeling and climate space trend analysis.

- BCCR_BCM2_0
- CSIRO_MK3_0
- CSIRO_MK3_5
- INMCM3_0
- MIROC3_2_MEDRES
- NCAR_CCSM3_0

The probability outputs were then converted to presence absence and then combined using an additive function. Therefore, each timeslice for a given species has 6 values, with 6 being the highest level of agreement (all 6 GCMs agree on a species predicted suitable bioclimate) and 1 being the lowest, (only1 GCM predicts suitable bioclimate). This approach supports an assessment of multimodel agreement in projections of bioclimatic shifts.

B-1.3.2.3 Model Post processing: Change Summary Layer

In order summarize change in bioclimate for a species, we created a change surface which is the difference between current and 2050s. A2 2050 outputs were reclassified to a presence/absence layer (absence = 1, presence = 5). A desired GCM agreement of at least 2 GCMs was chosen. Current layers were already presence/absence but were reclassified to coded values (0 = 1 and 1= 4). The last step was subtracting the current from the future which created a surface with the coded values: -3 = lost bioclimate, 0 = absence, 1 = maintained bioclimate, 4 = gained bioclimate (Figure B - 19). Pixels with lost bioclimate are areas where there was suitable bioclimate but in 2050 climate models predict this climate envelope will no longer exist for that pixel. Maintained bioclimate are areas that are predicted to be suitable under both current and future climate regimes. "Gained" bioclimate are pixels that were predicted to be suitable for current conditions, but may be suitable in the future. Gained bioclimate is essentially showing a potential geographic shift in future suitable climate conditions for a species.

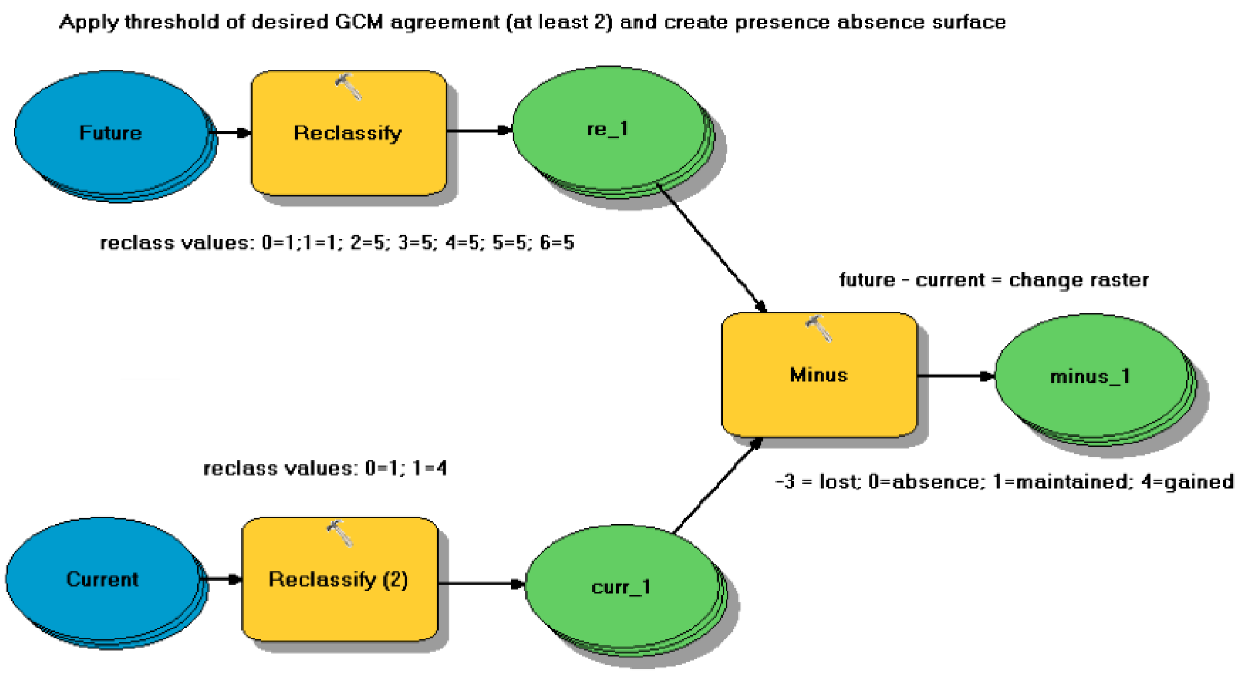


Figure B - 19. Change in Climate Suitability Future vs. Current

B-1.4 Ecological Status Modeling

B-1.4.1 Indicators of Ecological Status – Spatial Models

Relative effects of co-occurrences of CAs and CEs are primarily addressed by gauging ecological status of CEs within a given assessment scenario (i.e., current conditions vs. forecasted conditions at 2025). The approach taken was based upon existing methods aiming to gauge relative ecological integrity. Ecological integrity is variously defined to express the ability of an ecological system to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion. Therefore, methods for assessment first aim to characterize reference conditions for each CE, including natural composition, structure, and dynamic processes. Additionally, they characterize common stressors and their observed ecological effects. With these observations and assumptions described, indicators of integrity are identified and measured to compare current or forecasted conditions to reference conditions; resulting in a series of ecological status scores for each CE. The primary reporting unit for ecological status of CEs is the 5th level watershed; however, for landscape species and the species assemblages, a 4 km^2 grid was used.

Conceptual models for each CE were used to characterize natural attributes, primary change agents, and current knowledge of their effects on each CE. Current knowledge of CA effects on CEs was documented to reliably differentiate where CAs are likely to cause ecological stress to a given CE. Where CAs can be viewed as 'stressors' to CEs, the potential responses to each stressor are identified. Measurable indicators are then identified to gauge that effect.

Using NatureServe's ecological integrity framework (Faber-Langendoen et al. 2006, Unnasch et al. 2008, Rocchio and Crawford 2011), indicators are chosen to provide a measurement for a limited set of **key ecological attributes**, or ecological drivers, for each CE. Key ecological attributes (KEAs) may include natural characteristics, such as native species composition, or *stressors* such as effects of relevant change agents that are well known to affect the natural function and integrity of the CE. The KEAs are organized by the "rank factors" of **Landscape Context**, **Condition,** and **Relative Extent**. Given the rapid and regional nature of an REA, stressor-based indicators were relied upon for this assessment. Indicators were selected that practically enabled reporting at 5th level watershed and 4 km^2 grid cells as reporting units.

Figure B - 20 and Figure B - 21 illustrate conceptual linkages between CAs and Stressors (A), Stressors and expected Responses (B) and the Indicators used to gauge Stressors and their Responses (C), for a given CE.

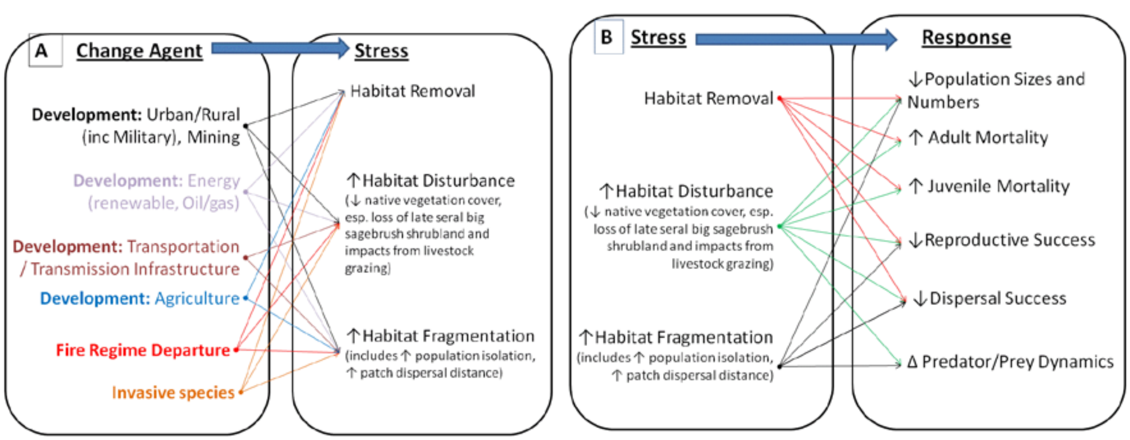


Figure B - 20. Example of conceptual model linking change agents, ecological stressors and their anticipated effects for a landscape species CE

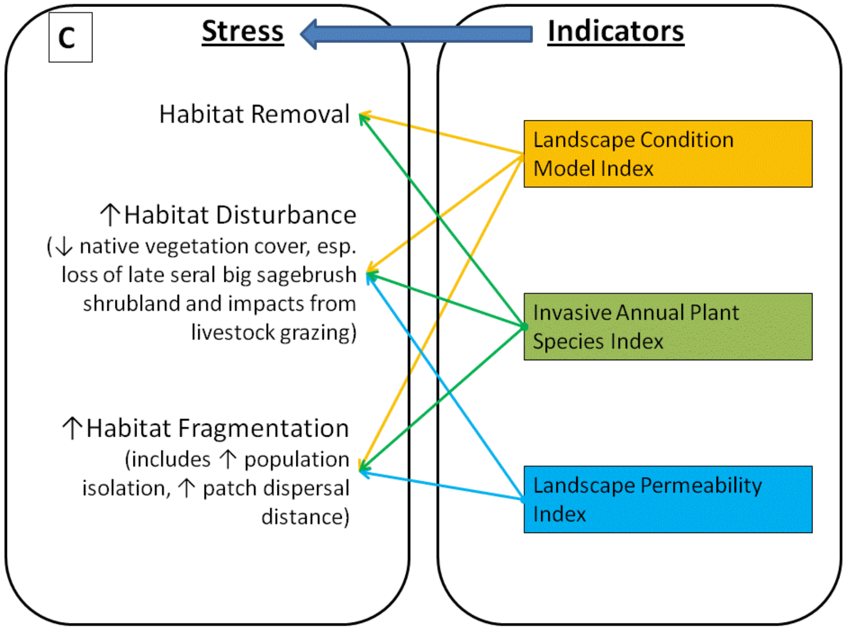


Figure B - 21. Example of conceptual model linking ecological stressors and their anticipated responses to their measurable indicators for a landscape species CE

Spatial models that reflect these indicators serve as the link between the conceptual models and the spatial representation of ecological status. These indicators were applied in varying combinations with each CE.

Table B - 22 and Table B - 23 include a listing of indicators used for each CE, and detailed explanations of each indicator where spatial models were developed. In this section we provide more detail for each indicator used for the terrestrial CEs and how they were spatially scored; similarly detailed methods are provided for indicators and metrics for the aquatic coarse filter CEs in B-2.2.4.

Table B - 22. Ecological status indicators for MBR terrestrial coarse filter and vulnerable species assemblage CEs. "Y" denotes when the indicator was assessed for the CE.

	Key Ecological Attribute -->	I. Extent/Size	II. Landscape Condition		III. Landscape Connectivity	IV. Stressors on Biotic Condition
Ecoregional Conceptual Model Group	Metric--> **Conservation Element Name**	**1. Change in extent**	**2. Landscape Condition Index**	**3. Fire Regime Departure Index**	**4. Landscape Connectivity Index**	**5. Invasive Annual Grass Index**
Terrestrial Coarse Filter CEs						
Subalpine/Montane Forests & Woodlands	Great Basin Pinyon-Juniper Woodland	Y	Y	Y	N	Y
Montane Shrublands	Mogollon Chaparral	N	Y	Y	N	Y
Montane Shrublands	Sonora-Mojave Semi-Desert Chaparral	N	Y	Y	N	Y
Semi-desert Shrub & Steppe	Great Basin Xeric Mixed Sagebrush Shrubland	Y	Y	Y	N	Y
Desert Scrub	Inter-Mountain Basins Mixed Salt Desert Scrub	Y	Y	Y	N	Y
Desert Scrub	Mojave Mid-Elevation Mixed Desert Scrub	Y	Y	Y	N	Y
Desert Scrub	Sonora-Mojave Creosotebush-White Bursage Desert Scrub	Y	Y	Y	N	Y
Desert Scrub	Sonora-Mojave Mixed Salt Desert Scrub	Y	Y	Y	N	Y
Desert Scrub	Sonoran Mid-Elevation Desert Scrub	N	Y	Y	N	Y
Cliff & Outcrop	North American Warm Desert Badland	N	Y	N	N	Y
Cliff & Outcrop	North American Warm Desert Bedrock Cliff and Outcrop	N	Y	N	N	Y
Cliff & Outcrop	North American Warm Desert Pavement	N	Y	N	N	Y
Dunes	North American Warm Desert Active and Stabilized Dune	N	Y	N	N	Y
Vulnerable Species Assemblage CEs						
Alpine uplands	Carbonate (Limestone/Dolomite) alpine	N	Y	N	N	N
Alpine uplands	Non-carbonate alpine	N	Y	N	N	N
Subalpine/Montane Forests & Woodlands	Montane conifer	N	Y	N	N	Y
Semi-desert Shrub & Steppe	Clay soil patches	N	Y	N	N	Y
Semi-desert Shrub & Steppe	Sand dunes/sandy soils (when deep and loose)	N	Y	N	N	Y

	Key Ecological Attribute -->	I. Extent/Size	II. Landscape Condition		III. Landscape Connectivity	IV. Stressors on Biotic Condition
Ecoregional Conceptual Model Group	**Metric--> Conservation Element Name**	**1. Change in extent**	**2. Landscape Condition Index**	**3. Fire Regime Departure Index**	**4. Landscape Connectivity Index**	**5. Invasive Annual Grass Index**
Cliff & Outcrop	Azonal carbonate rock crevices	N	Y	N	N	N
Cliff & Outcrop	Azonal non-carbonate rock crevices	N	Y	N	N	N
Desert Scrub	Gypsum soils	N	Y	N	N	Y
Basin River & Riparian	Migratory waterfowl & shorebirds	N	Y	N	N	N

Table B - 23. Ecological status indicators for MBR Landscape Species CEs. "Y" denotes when the indicator was assessed for the CE. Two indicators measured for coarse filter, change in extent and fire regime departure, were not assessed for any species CEs.

			Key Ecological Attribute -->	II. Landscape Condition	III. Landscape Connectivity	IV. Stressors on Biotic Condition
Taxonomic Group	**Ecoregional Conceptual Model Group**	**Scientific Name**	**Metric--> Species CE**	**2. Landscape Condition Index**	**4. Landscape Connectivity Index**	**5. Invasive Annual Grass Index**
birds	Basin River & Riparian	Haliaeetus leucocephalus	Bald Eagle	Y	N	N
birds	Montane Canyons	Aquila chrysaetos	Golden Eagle	Y	N	N
birds	Montane Lakes & Wetlands	Circus cyaneus	Northern Harrier	Y	N	N
birds	Montane Shrublands	Lanius ludovicianus	Loggerhead Shrike	Y	N	N
birds	Semi-desert Shrub & Steppe	Spizella breweri	Brewer's Sparrow	Y	N	Y
birds	Semi-desert Shrub & Steppe	Falco mexicanus	Prairie Falcon	Y	N	N
birds	Semi-desert Shrub & Steppe	Amphispiza belli	Sage Sparrow	Y	N	N
birds	Semi-desert Shrub &	Oreoscoptes montanus	Sage Thrasher	Y	N	Y

			Key Ecological Attribute -->	II. Landscape Condition	III. Landscape Connectivity	IV. Stressors on Biotic Condition
Taxonomic Group	**Ecoregional Conceptual Model Group**	**Scientific Name**	**Metric--> Species CE**	**2. Landscape Condition Index**	**4. Landscape Connectivity Index**	**5. Invasive Annual Grass Index**
	Steppe					
birds	Subalpine/Montane Forests & Woodlands	Accipiter cooperii	Cooper's Hawk	Y	N	N
mammals	Cliff & Outcrop	Tadarida brasiliensis	Brazilian Free-tailed Bat	Y	N	N
Mammals	Desert Scrub	Xerospermophilus mohavensis	Mohave Ground Squirrel	Y	N	Y
mammals	Montane Canyons	Ovis canadensis nelsoni	Desert Bighorn Sheep	Y	N	N
mammals	Montane Shrublands	Odocoileus hemionus	mule deer	Y	N	N
mammals	Semi-desert Shrub & Steppe	Vulpes macrotis	Kit Fox	Y	N	N
mammals	Subalpine/Montane Forests & Woodlands	Eptesicus fuscus	Big Brown Bat	Y	N	N
reptiles	Basin River & Riparian	Lampropeltis getula	Common Kingsnake	Y	N	N
reptiles	Cliff & Outcrop	Crotaphytus bicinctores	Great Basin Collared Lizard	Y	N	N
reptiles	Desert Scrub	Masticophis flagellum	Coachwhip	Y	N	N
reptiles	Desert Scrub	Gopherus agassizii	Mojave Desert Tortoise	Y	Y	N
reptiles	Desert Scrub	Gopherus morafkai	Sonoran Desert Tortoise	Y	N	N
reptiles	Desert Scrub	Heloderma suspectum	Gila Monster	Y	N	N
reptiles	Desert Scrub	Arizona elegans	Glossy Snake	Y	N	N
reptiles	Desert Scrub	Crotalus scutulatus	Mohave Rattlesnake	Y	N	N
reptiles	Desert Scrub	Coleonyx variegatus	Western Banded Gecko	Y	N	N
reptiles	Desert Scrub	Salvadora hexalepis	Western Patch-nosed Snake	Y	N	N
reptiles	Semi-desert Shrub & Steppe	Sceloporus graciosus graciosus	Northern Sagebrush Lizard	Y	N	N
reptiles	Subalpine/Montane Forests & Woodlands	Charina bottae	Northern Rubber Boa	Y	N	N

B-1.4.1.1 Key Ecological Attribute: Landscape Context

Landscape Condition Indicator

Ecological condition commonly refers to the state of the physical, chemical, and biological characteristics of natural ecosystems, and their interacting processes. Many human land uses affect ecological condition, (e.g., through vegetation removal or alteration, stream diversion or altered natural hydrology, introduction of non-native and invasive species, etc.). Landscape condition assessments commonly apply principles of landscape ecology with mapped information to characterize ecological condition for a given area (e.g., US-EPA 2001, Sanderson et al. 2002). Since human land uses - such as built infrastructure for transportation or urban/industry, and land cover such as for agriculture or other vegetation alteration – are increasingly available in mapped form, they can be used to spatially model inferences about ecological condition.

Maps of this nature can be particularly helpful for identifying relatively unaltered landscape blocks, or for making inferences about the relative ecological integrity of natural habitats on the ground. They can also be used for screening ecological reference sites; i.e., a set of sites where anthropogenic stressors range from low to high. Ecological condition within reference sites is often further characterized in the field to determine how ecological processes respond to specific stressors, but spatial models can provide a very powerful starting point to build upon (Faber-Langendoen et al. 2006, 2012). Knowledge from reference sites may then apply to surroundings for many types of environmental decisions.

Nearly all studies documenting ecological effects of land use features on ecosystems are quite context-specific (e.g., Knight, et al. 1993, Gelbard and Belnap 2003); limiting their applicability to more generalized modeling. However, some researchers have developed more generalized models with less context-specific inputs and applications in mind. That is, they use generalizations about the relative ecological effects of human land uses to transparently construct the spatial model, and then use field-based observations to calibrate and validate the model relative to their intended use. For example, Brown and Vilas (2005) scored 25 common land use classes along a continuum of estimated "energy intensity values" (i.e., energy input for their development and maintenance); from lowest-intensity "pine plantations" to highest-intensity "central business district (average 4 stories)." This initial scoring enabled development of a "Landscape Development Index" varying from 1.00 to 10.00. These indices were applied to land use map classes to generate an inference of land use intensity in Florida. The result was validated using selected field-based observations.

The **Landscape Condition Model** builds on this and the growing body of published methods and software tools for ecological effects assessment and spatial modeling; all aiming to characterize relative ecological condition of landscapes (e.g., Knick and Rottenberry 1995, Forman and Alexander 1998, Trombulak and Frissel 1999, Theobald 2001, Seiler 2001, Sanderson et al. 2002, Riitters and Wickham 2003, Brown and Vivas 2005, Hansen 2005, Leu et al. 2008, Comer and Hak 2009, Theobald 2010, Rocchio and Crawford, 2011). The intent of this model is to use regionally available spatial data to transparently express user knowledge regarding the relative effects of land uses on natural ecosystems and habitats. The authors' expert knowledge forms the basis of stressor selection, and relative weightings, but numerous examples from published literature have been drawn upon to parameterize the model for application across the western United States, and this ecoregion. Independent data sets from across the western United States were drawn upon for subsequent model evaluation.

Technical Description: Table B - 24 summarizes the data sets and parameters for this model. Mapped information available for across the western conterminous United States was compiled into 20 categories, organized by a) *Transportation,* b) *Urban and Industrial Development,* and c) *Managed and*

Modified Land Cover. No attempt was made to depict ecological stressors that act at spatially broad scales, such as air pollutants or climate change. In most cases, original data exist as a 30m grid. Line and polygon features were summarized to 90m grids. Transportation features, derived from ESRI StreetMap data *circa* 2010, depict roads of five distinct sizes. These data provide a practical measure of human population centers and primary transportation networks that link those centers. While these road size classes do not coincide directly with traffic volume along a given stretch of road, their engineering and construction aimed to support distinct levels of traffic volume. Therefore, inferences of expected traffic volume can be derived from these mapped classes, especially when applied on this sub-continental scale.

As a compliment to Transportation features, Urban and Industrial Development includes industrial (e.g., mines, energy development) and built infrastructure across a range of densities, from high density urban and industrial zones, to suburban residential development and urban open spaces (golf courses, for outdoor recreation. These data were derived from national land cover data through combined efforts of the inter-agency LANDFIRE, USGS ReGAP (*circa 2001*), and National Land Cover Data (*the latter updated to 2006*). Other data sets in this category included oil/gas well, surface mining activity, and transmission line right-of-ways.

The third category, Managed and Modified Land Cover, includes the gradient of land cover types that reflect vegetation-based land use stressors at varying intensities. Again, national data from USGS ReGAP and LANDFIRE provide a consistent depiction of these varying land cover classes, from intensive (cultivated and/or irrigated) agriculture, vineyards and industrial tree plantations, areas dominated by introduced non-native vegetation in upland and wetland environments, and finally, areas where native vegetation predominates, but modifications have clearly taken place. These modifications include recently logged areas, or areas that have seen historic conversion, but have recovered some combination of mainly native vegetation (e.g., 'ruderal' old fields, etc.). For these latter classes, model users should presume varying degrees of accuracy and completeness in their original mapping, and map classes of 'introduced' vegetation should likely only include areas where substantial and obvious infestation has occurred. One can safely presume that the presence of introduced plant species, especially when at low densities, is not reliably represented by this regional model.

Model Parameters: Each input data layer is summarized to a 90m grid and, *where the land use occurs*, given a **site impact score** from 0.05 to 0.9 (Table B - 24) reflecting presumed ecological stress or impact. Values close to 1.0 imply relatively little ecological impact from the land use. For example, a given patch of 'ruderal' vegetation – historically cleared for farming, but recovering towards natural vegetation over recent decades, is given a Very Low (0.9) score for site impact as compared with irrigated agriculture (High Impact 0.3) or high-density urban/industrial development (Very High Impact 0.05). Certainly, there are some ecological values supported in these intensively used lands, but their relative condition is quite limited when compared with areas dominated by natural vegetation.

In this first step, 20 distinct data layers are produced, each with the impact score applied to pixels where a given land use occurs, and a value of 1 for all other pixels. Euclidian distance for each input layer is then populated for each 90m grid cell with a distance (in 90m increments) extending way from each pixel with and impact score <1 (Table B - 24).

A second model parameter – again, for each data layer - represents a **distance decay** function, expressing a decreasing ecological impact with distance away from the mapped location of each feature as applied to the Euclidian Distance value described above. Mathematically, this applies a formula that characteristically describes a "bell curve" shape that falls towards plus/minus infinity. This base formula is:

$$f(d) = \left(1 - \frac{d^2}{h^2}\right)^2, d < r$$

where *d* = Euclidian distance (in meters, as measured in 90m increments), and *h* equals the distance decay score (from 0.05 – 1.0). In this formula, *r* = the maximum distance across the model analysis area, so the value for *d* must be less than *r*. Applying this formula, grid cells will have scores approaching r – 1.

Those features given a high decay score (*h* values approaching 1.0) result in a surface where the impact value dissipates within a relatively short distance. Those features given a low decay score (*h* values approaching 0.0) create a surface where the per-pixel impact value dissipates more gradually with distance away from the impacting feature. Note that given this formula, per-pixel values will actually never reach *r*, but will only approach *r*. Each layer is then normalized by dividing 1 by the per pixel value, this results in a grid with values >0 to 1.0.

Combining Input Layers: Figure B - 22 summarizes all processing steps, beginning with the selection of individual input layers for land use features. Querying a Table of Weights, per-pixel values for **site impact** apply to all pixels overlapping the land use layer. Where more than one land-use feature occurs in a given 90m grid cell, the **minimum site impact score** of all applicable features is applied to each grid cell (**site impact minimum** between 0.05 and 0.9).

Then, the distance decay formula utilizes per pixel Euclidian Distance and the Distance Decay formula to create a per-pixel value for each land use feature layer. As noted above, the result is a grid of >0 to 1.0 values. All 90m grids are then combined additively resulting in a grid of values between >0 to *m* (*m* up to 18 for this model). Because the resulting grid has the potential to include grid cell values greater than 1.0 the overall model is normalized against the maximum value *m.* The final grid represents a layer of > 0 to 1.0.

Finally, the site impact and distance decay minimum values for each 90m grid cells are compared and the lowest number is carried forward to the final landscape condition surface. The combined result is a wall-to-wall grid surface of Landscape Condition values falling between >0 and 1.0. The resultant model is shown in Figure B - 23.

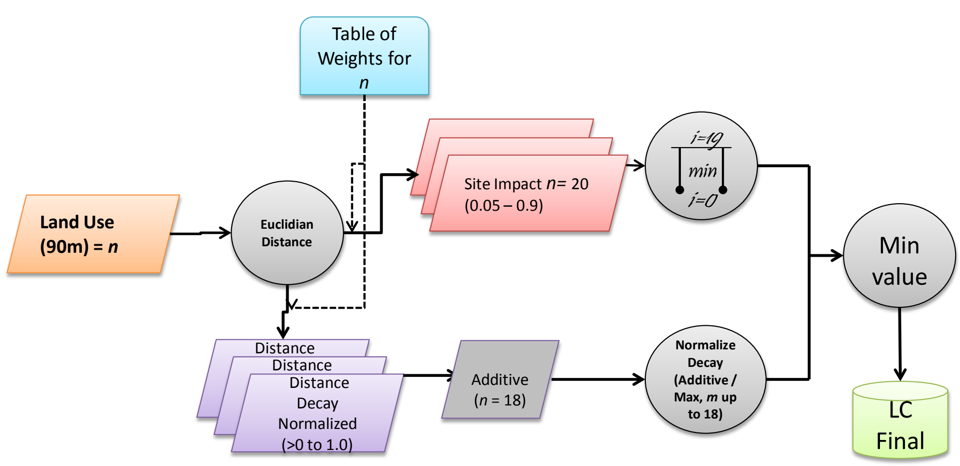


Figure B - 22. Landscape Condition model process

Table B - 24. Landscape Condition model weighting values

Land Use	Site Impact	Distance Decay
Transportation		
dirt roads & 4wd	0.7	Moderate
Local, neighborhood and connecting roads	0.5	Moderate
Secondary and connecting roads	0.2	Gradual
Primary Highways with limited access	0.05	very gradual
Primary Highways without limited access	0.05	very gradual
Landuse		
Pasture & Hay	0.9	Abrupt
Wind*	0.8	Gradual
Pipelines	0.7	Moderate
Utility	0.7	Gradual
Low Intensity Development*	0.6	Moderate
Geothermal	0.5	Moderate
Medium Intensity Development*	0.5	Moderate
Solar*	0.5	Moderate
mines/landfills	0.05	Abrupt
Developed High Intensity*	0.05	very gradual
Land Cover		
Open Space*	0.9	Abrupt
Recently Logged	0.9	Moderate
Introduced Wetland	0.3	Abrupt
Agriculture	0.3	Moderate
Introduced Uplands mapped	0.3	Moderate

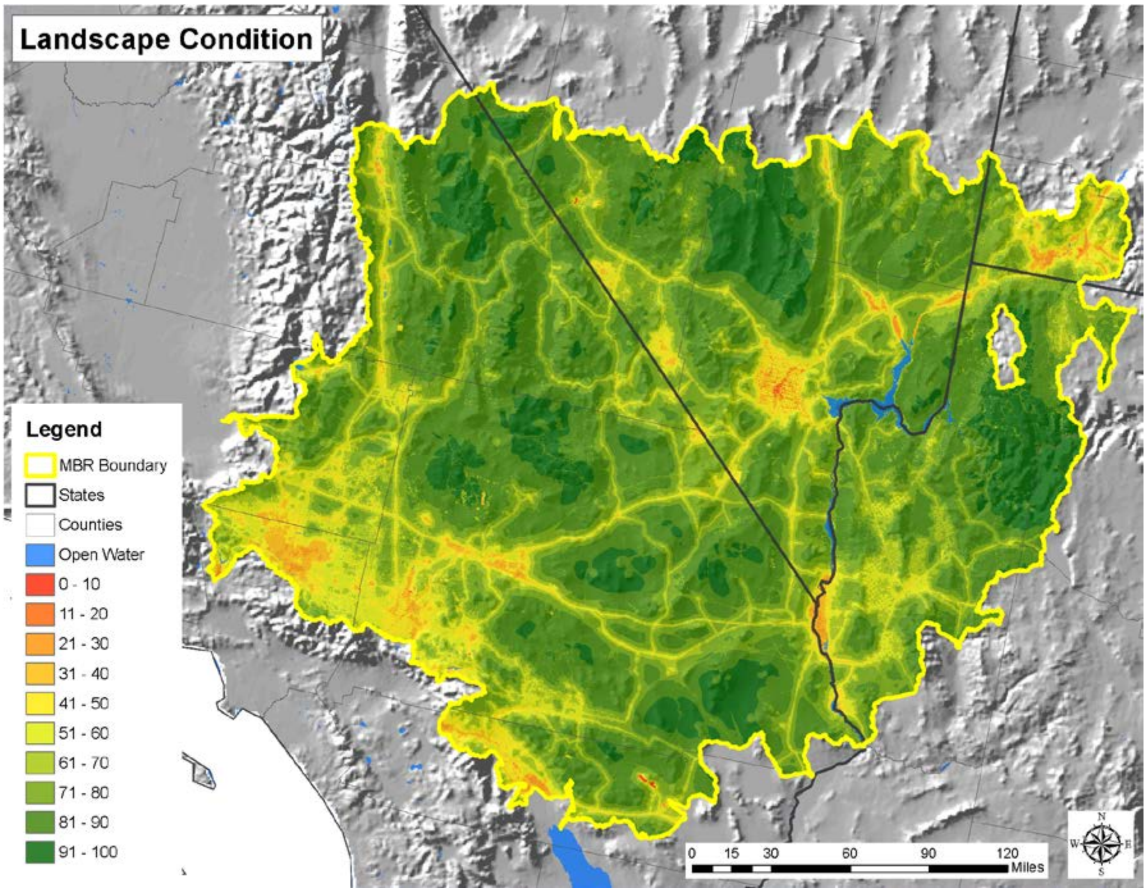


Figure B - 23. Current landscape condition model (90 m) for the Mojave Basin & Range ecoregion.

Model Evaluation: *The Landscape Condition Model developed in this REA follows directly from a western United States model being developed for the Western Governors Association-sponsored Crucial Wildlife Habitats and Corridors mapping effort. Through that effort, west wide information was gathered for use in evaluating the west-wide landscape condition model. This information is applicable to understanding the relative performance of the model applied to this ecoregion. The following discussion applies to this west-wide model.*

In order to evaluate this model, field based measurements of ecological condition were gathered from several sources. By intersecting these geo-referenced observation data with the landscape condition model, the relative predictive power of the model was better understood. Field observations documenting the relative quality of biodiversity (e.g., at-risk species), field samples of vegetation plots (including abundance of invasive plant species), and local expert review of samples of aerial imagery, have been utilized to evaluate, calibrate, and validate this model. Each is briefly discussed below.

Natural Heritage Element Occurrences: Natural Heritage programs conduct biodiversity inventories within each state, documenting the location and relative ecological condition for at-risk species and rare and representative community types. While by no means complete, occurrence data provide one independent source of field-based observations of relative ecological condition suitable for use on landscape model evaluation. Natural Heritage methods involve development of criteria for evaluation of occurrence size, condition, and landscape context. The Element Occurrence Rank rates each occurrence along a scale from A-D. Occurrences with “A” and “B” ratings are considered of very high or high ecological condition, respectively. The “C” rated occurrences are considered of fair condition, and “D” rated occurrences are considered to be in poor ecological condition. “X” occurrences were documented historically, but with subsequent survey effort, were verified as extirpated from the location (typically through habitat loss). Care should be taken in evaluations of this nature utilizing these data, as criteria for ratings may vary, some at-risk species may have been rated relatively high due to large sub-population size while landscape context has been compromised (i.e., population size as a potential lagging indicator of condition), or their rating reflects viability requirements not addressed in the landscape condition model.

A total of 73,575 occurrences of at-risk species, each having been rated for condition (as well as extirpated), was intersected with the landscape condition model. ‘Box-and-whisker’ plots were developed to visualize the relative correspondence between these two data sets (Figure B - 24). The ‘box’ portions captures 50% of samples, the middle line of each box described the median of sample values, while the “whisker” or dotted lines capture the 95% of all samples. The ‘notch’ in each box provides an indication of significant difference among median values. So when boxes are paired together, if the ‘notch’ areas do not overlap, there is likely a statistically significant difference between pairs of samples.

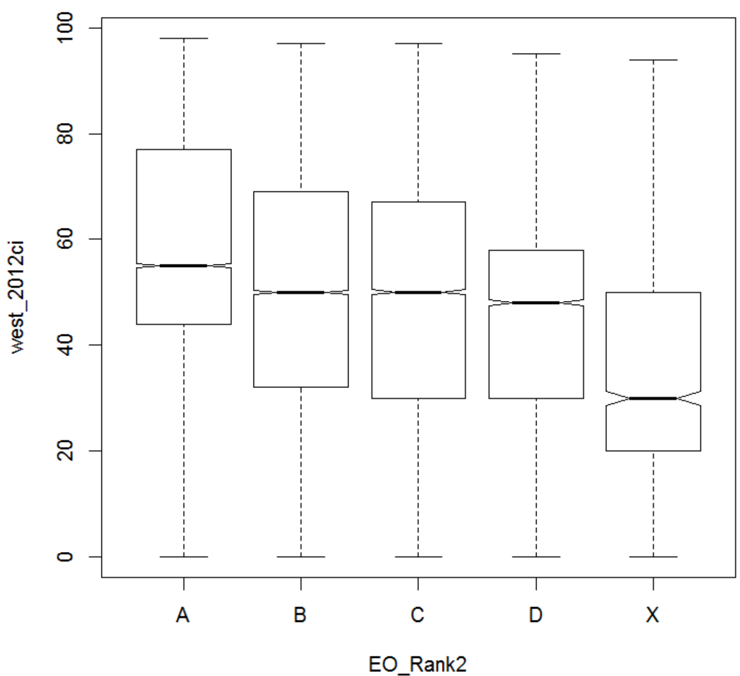


Figure B - 24. Summary correspondence between Natural Heritage Element Occurrences rated for condition as compared with predicted values from the NatureServe Landscape Condition model.

Note here that landscape condition is represented on the Y axis with scores between 1 and 100. Integer transformation was used prior to overlays with evaluation data sets. Again, the original landscape condition values were 0.0-1.0. While considerable variability is reflected in these results, significant differences are likely between A-rated occurrences vs. B and C occurrences. Likewise, significant differences (albeit less so) are apparent between BC and D rated occurrence. And finally, X occurrences are clearly distinguished from others along the continuum described by the landscape condition model.

LANDFIRE vegetation plot samples: Vegetation plots samples were compiled nationwide to provide reference locations for vegetation mapping by the inter-agency LANDFIRE effort. Gathered sample data were evaluated by LANDFIRE to ensure that they a) were located with adequate precision for mapping with a 30m grid resolution, b) reflected conditions from the past decade, and c) had sufficient floristic information to support their labeling to the LANDFIRE map legend. Therefore, sample plots tended to have information on plant species composition and relative abundance. For our purposes, the presence and relative abundance of invasive plants species, especially invasive annual grasses, were adequate for use in model evaluation. We would expect to see increasing abundance of invasive annual grasses throughout the middle ranges of scores (on Y axis: 40-70) from the landscape condition model (Figure B - 25) Sample plots with relative abundance values of invasive annual grasses were categorized into five classes, from Category 1 (<5% cover), Category 2 (5-10%), Category 3 (11-25%), category 4 (26-45%), and Category 5 (>45% cover). A total of 21,195 sample plots from across the West were intersected with the integer-transformed landscape condition model, and box plots were developed to visualize the relative correspondence between these two data sets. Again, a clear trend in correspondence may be observed from these results. Statistically significant differences in median values are likely between Category 1 vs. Category 2&3 vs. Category 4 vs. Category 5 along the continuum of values from the landscape condition model.

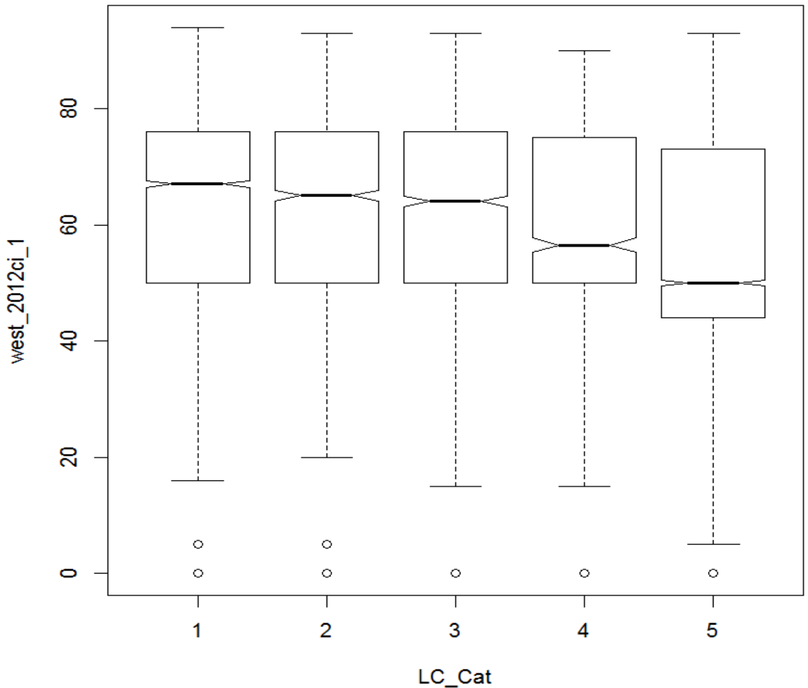


Figure B - 25. Summary correspondence between LANDFIRE vegetation samples categorized for invasive annual grass abundance as compared with predicted values from the NatureServe Landscape Condition model.

State review of high-resolution imagery: Experts from across all western states were asked to review sample areas with high-resolution aerial imagery to document their perspective on the relative ecological condition or intactness. A total of 1,560 stratified random points were established and buffered with 18 acre circles. An online survey included 21 questions about the ecological condition of each location. These included aspects of on-the-ground knowledge of the site (by the surveyor), predominant land use and land cover, and generalized summary of ecological condition (high, moderate, low, very low). Surveyors were also allowed to create their own survey locations and report on those. All states except UT and TX included respondents. Some 1,129 pre-selected samples were reviewed. Another 264 user-defined samples were created, concentrated in WA, OR, ID, WY, AZ, NE and KS. Results of the survey were overlain on the landscape condition to explore their relative correspondence.

Table B - 25 summarizes overall results of this comparison. When generalized to two primary categories above and below 0.5 landscape condition scores, there is general agreement between predicted values of the model and expert interpretations. An agreement of 89.7% was documented for the high-moderate condition predictions with a somewhat lower 53.6% correspondence for the low-very low condition category. **From these data, and overall model accuracy of 78.8% was calculated**.

Table B - 25. Summary comparison of expert-reviewed aerial imagery and landscape condition model.

NatureServe Landscape Condition	High-Moderate 1.0 – 0.51	Low-Very Low 0.50 – 0.0	Total Samples	% of Samples
High – to - Moderate	874	196	1,070	81.7%
Low – to – Very Low	100	226	326	69.3%
Total Samples	974	422	1,396	
% of Samples	89.7%	53.6%		

Applying Landscape Condition to CE Distributions

The ecological assessment of all CEs was evaluated using the landscape condition model score for both current and the 2025 time frames. Landscape condition modeling is used as an indicator of ecological status of the element's distribution at a particular location (pixel or occurrence).

In addition to current landscape condition, the 2025 time period was addressed by an additional model. All layers types and disturbance weights were identical to the current condition layers, but updated with either future planning attributes or land use projections. Sites where renewable energy is in the process of planning were included. Future land use development was described using the 2030 SERGoM land use predictions. No information was available to estimate where future infrastructure such as roads may take place. The resultant map layer (Figure B - 26) shows little change between current and 2025 conditions; as described in Chapter 5, 2025 development is projected to only increase from less than 7.1% currently, to 7.6% by 2025. While this represents over 500,000 acres, it is not apparent in the below map.

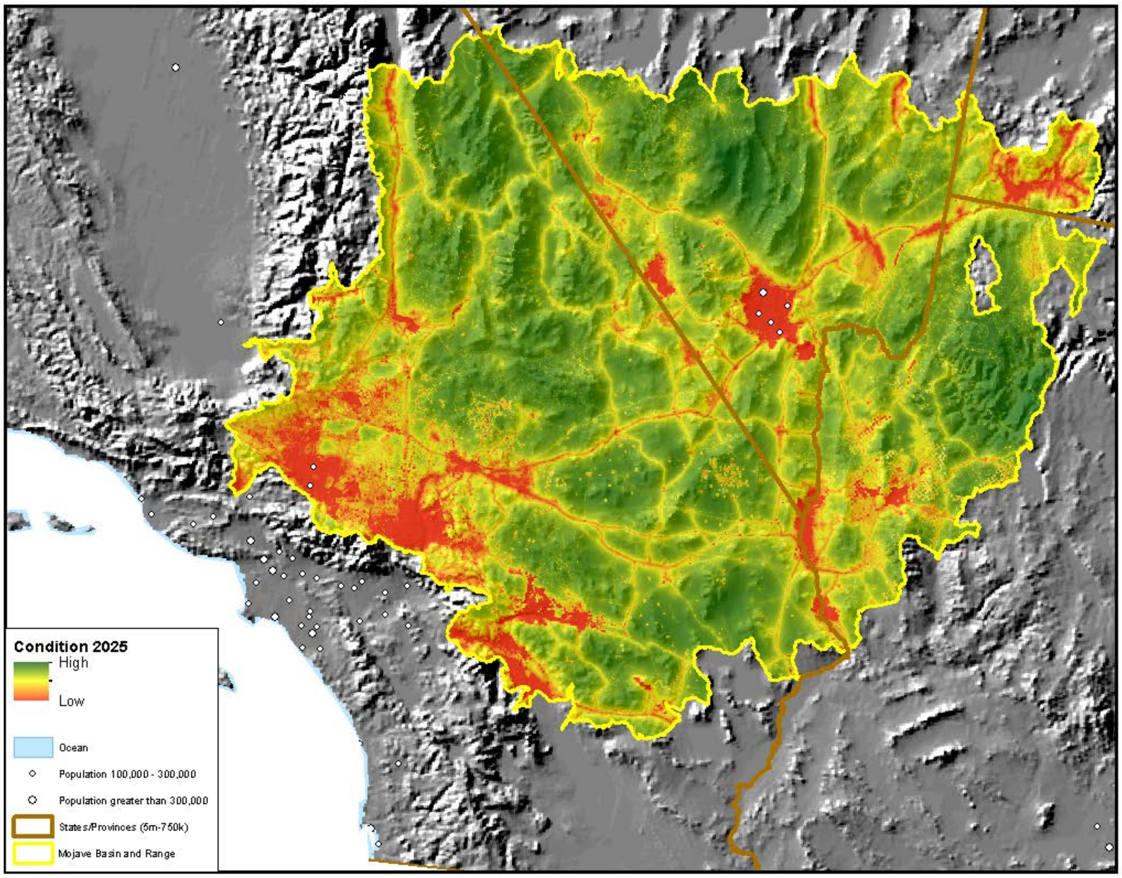


Figure B - 26. 2025 Landscape condition model.

Both the current (2010) and future (2025) landscape condition models are utilized in scoring CE's at multiple scales, the 4x4Km blocks (Figure B - 27a) and the 5th level watersheds (Figure B - 27b). For analysis each landscape condition model is converted to a 0-100 integer based raster. Following the conversion, each 4x4Km grid cell is summarized as an area weighted value based upon the following formula: *condition_wt = sum(cell count * landscape condition) / sum(cell count)*.

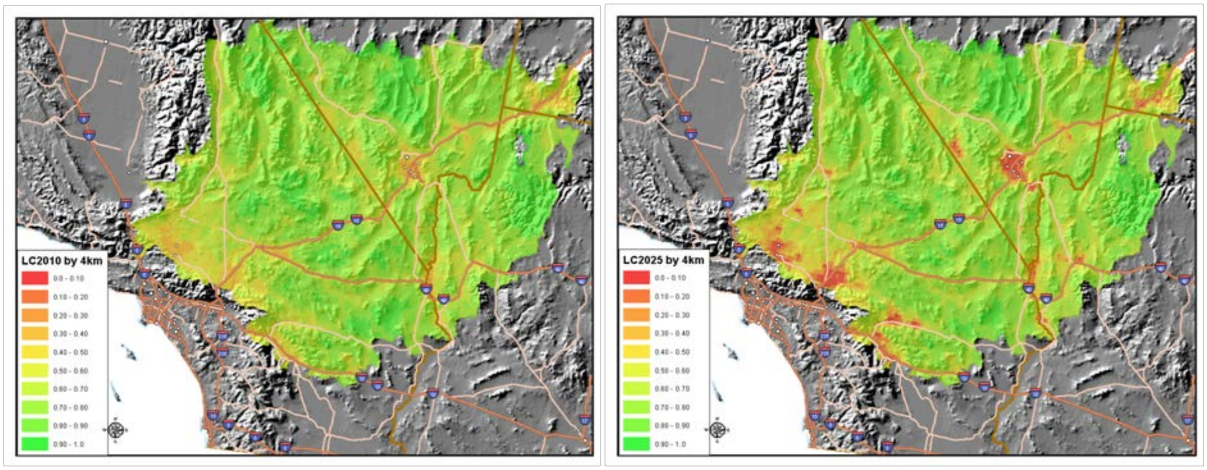


Figure B - 27. a, b. Rollup of current and 2025 landscape condition to the 4x4km block.

B-1.4.1.1.2 Landscape Connectivity

CircuitScape was used to address the function of connectivity in the ecological assessment. The advantage of using circuit theory for predicting landscape connectivity is the ability to define the connections via multiple channels of passage that better simulate the naturally occurring connections in landscape. One CE in the MBR was selected to address the influence of landscape connectivity in the ecological status assessment. The Mojave desert tortoise was evaluated using the application of circuit theory using CircuitScape.

The USGS model of tortoise habitat potential (Nussear et al. 2009) was used as the foundation to create the series of 166 points representing tortoise habitat throughout the Mojave Basin and Range ecoregion to be assessed for connectivity. Areas with high habitat potential (0.7 or higher) were selected and converted to polygons, and polygons smaller than 4,000 acres were removed from consideration in the analysis. Point centroids were generated for these habitat polygons, and additional points were added within the habitat polygons to create a more extensive distribution of tortoise habitat areas to connect. The resulting points were assessed for landscape-scale connectivity across the Mojave Basin and Range ecoregion in Circuitscape.

A landscape conductance surface for desert tortoise was built using two layers to modify the landscape condition model data layers: 1) the USGS tortoise habitat potential model (Nussear *et al.* 2009), and 2) a model of steepness.

The USGS model of tortoise habitat potential was a critical input for the conductance layer. It provided a known probability of a particular area being suitable for tortoise occupancy or dispersal. Higher habitat potential equates to higher conductance; therefore, the values were not altered to build the overall conductance surface. A model of "steepness" was developed using slope values from the 10 meter Digital Elevation Model (DEM). This layer provides a unitless index of terrain steepness throughout the assessment area. High values indicate very steep areas, while low values are flatter areas. Steep terrain is less conducive to tortoise movement, while flatter areas are more conducive. Therefore, the inverse of the steepness values were calculated and served as the actual input to the overall conductance surface.

Beginning with the LCM developed for the Mojave REA, a number of adjustments were made to the model inputs layers and their intensity or decay scores to reflect the effects of various inputs on desert tortoise. The intensity and decay scores were reviewed and adjusted to be generally consistent with the relative ranking of similar inputs used in the USFWS Desert Tortoise Recovery Office's (DTRO's) Spatial Decision Support System (SDSS) for desert tortoise. For example, solar projects were assigned somewhat lower site intensity scores (relative to the national model and the Mojave Basin and Range model) because they completely remove habitat for desert tortoise for the lifetime of the project (and beyond). Transmission lines and major roads were assigned slightly lower distance decay scores due to their potential to promote the presence of corvids, which prey on juvenile tortoises (Boarman 2002). A data set used by DTRO representing a range of developed recreation areas was added to the model because of the potential indirect effects of such recreation areas on desert tortoise (corvids, various human activities associated with recreation areas); they also were assigned lower intensity and decay scores. Grazing allotments were added to the model, but with higher values to represent the relatively diffuse impacts that livestock may have on desert tortoise. Inputs to the tortoise-specific model and assumptions regarding the intensity and distance decay effects of these features are summarized in Table B - 26. The lower the site intensity score, the greater the impact; the lower the distance decay score, the farther away the impact is felt. The decay to zero is the distance at which the impact of the feature has decreased to zero.

Table B - 26. Inputs to revised Landscape Condition Model for use in desert tortoise connectivity model.

Category	**Data set or subset**	**Site intensity**	**Distance decay score**	**Distance decay to zero** (meters)
Development	High intensity development	0.05	0.05	2,000
Development	Medium intensity development	0.5	0.5	200
Development	Military urban areas	0.05	0.05	2,000
Development	Developed recreation areas	0.5	0.5	200
Roads	Primary and secondary highways	0.05	0.05	2,000
Roads	Local, neighborhood and connecting roads	0.5	0.5	200
Roads	Other unclassified roads	0.5	0.5	200
Roads	Unimproved roads and 4WD tracks	0.7	0.5	200
Roads	Trails / non-motorized	0.9	0.7	143
Railroads	Railroads	0.5	0.7	143
Extractive / Other	Mines/landfills	0.05	0.5	200
Energy	Solar	0.05	0.5	200
Energy	Oil and gas wells	0.5	0.5	200
Energy	Wind	0.8	0.6	167
Other Linear	Pipelines	0.7	0.5	200
Other Linear	Utility	0.7	0.5	200
Other Linear	Water transmission (canals, ditches)	0.5	0.7	143
Agriculture	Row crops and irrigated pasture	0.5	0.5	200
Grazing	Grazing allotments	0.8	1	0

Because the USGS model of habitat potential was developed at a 1 km resolution, narrow segments of the Colorado River appear to be suitable habitat; these areas were converted to No Data so that the river would be treated as a complete barrier to tortoise movement.

The Large-Scale Translocation Site (LSTS) for desert tortoise is located in southeastern Nevada. This facility is one of the locations where previously captive desert tortoises from Clark County, Nevada may be released, and where tortoises being relocated from infrastructure project sites in southern Nevada may be released. It is approximately 22,000 acres in size and is characterized by creosote bush and white bursage scrub community (Field et al. 2007). It presents an interesting circumstance for modeling habitat connectivity. Although the area is tortoise habitat and supports a density of approximately 5.7-7.7 tortoises per square mile (USFWS, unpublished data), three sides are fenced with tortoise exclusion fencing, and the west side is effectively blocked by the Spring Mountains. Therefore, this area was also converted to NoData and treated as a barrier for the natural movement and gene flow of the tortoise population as a whole. The final Mojave Desert Tortoise connectivity model is shown in Figure B - 28.

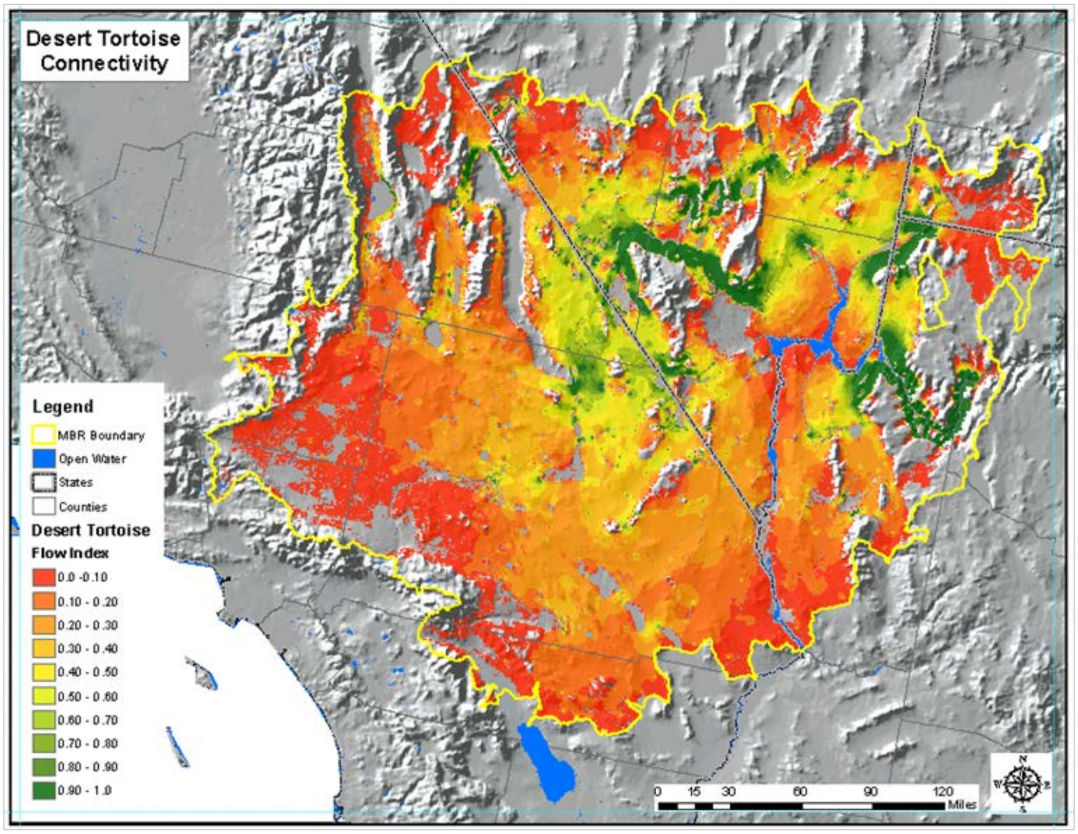


Figure B - 28. Model of Mojave and Sonoran desert tortoise habitat connectivity. Warm colors (yellows to oranges) indicate where generalized connectivity exists, and there are many alternative pathways for connecting the current population. Areas depicted in red remain connected, but extend to the apparent periphery of the tortoise populations in the MBR.

B-1.4.1.2 Interpreting the landscape-scale desert tortoise connectivity results: considerations, recommendations, and limitations

There are some important and related considerations for interpreting the specific desert tortoise results in this assessment. Movement and gene flow of the Mojave desert tortoise can be described as a continuous-distribution model; that is, gene flow occurs through their continuous distribution across a landscape of suitable habitat, rather than by individuals migrating through or across areas of unsuitable habitat to access areas of suitable occupied habitat. Consequently, the relatively discrete areas or bands of high connectivity shown in the connectivity model results are not corridors in the sense that many tortoises will regularly pass through them to get to other, more suitable habitat. Instead, these areas have the potential to act as population linkages by providing a limited area of habitat that a smaller number of individuals may occupy and thereby interact with individuals in adjoining larger habitat areas. Because these linkages aren't movement corridors in the metapopulation sense, it is important for the linkages to be of sufficient size and quality to permit their on-going occupancy by desert tortoise over time. However, the design of Circuitscape is not intended to address home range sizes, movement distances, or other spatial requirements for the size and configuration of potential habitat connections. USFWS has used tortoise home range size and movement patterns to hypothesize a minimum width of 1.4 miles for potential habitat linkages (see USFWS 2012). When reviewing the conductance outputs, understanding these types of spatial requirements is necessary to begin to assess these potential connections.

In addition to reviewing the results with an understanding of the spatial requirements of desert tortoise, it is also important to review the results with an adequate understanding of the inputs to the model and detailed knowledge of the landscape on the ground. From a practical standpoint, it is not possible to develop a conductance data set that represents the area and the species' needs with complete and detailed accuracy. In addition, the model software will try to find connections through narrow bands that may have poor conductance. Therefore, the model outputs must be compared to the model inputs and to detailed information or knowledge of the local landscape features and configuration to determine whether areas of connection identified by the model actually have potential to be viable for the species being assessed.

With these considerations in mind, the potential linkages identified in this connectivity assessment are a starting point for further evaluation. A field assessment of site-specific conditions, such as habitat quality, current tortoise occupancy, and potential for edge effects or other constrictions, is required to fully assess the potential for these areas to provide habitat connections with long-term viability.

One consequence of evaluating points rather than patches of habitat in the Circuitscape software is that it will show high levels of connection immediately around the habitat points that were assessed. It appears that each habitat point is a hot-spot for connectivity. This is an artifact of how the model works, and those hot points should generally be ignored. Instead the user should view the broader patterns of connection across the landscape, without particular reference to the points. In this particular assessment, because the patches of potential habitat for desert tortoise are so large, even with features like Las Vegas and various infrastructure footprints removed, it is somewhat more difficult to evaluate the landscape-level connections when modeling with patches. The advantage of using points rather than patches in this particular situation is the ability to see continuous patterns of connection across a landscape, including within the extensive tortoise habitat patches.

B-1.4.1.3 Key Ecological Attribute: Ecological Condition

Invasive Annual Grasses Indicator

In order to apply the annual grasses model to analysis units (4x4Km or 5th level watershed) a summation was required that utilized both the extent of the annual grass category and the severity of the type. The following formula was utilized at all analysis units scales:

$$Index = \frac{\frac{C0 * 0.5 + C1 * 0.15 + C2 * 0.15 + C3 * 0.1 + C4 * 0.1 + C5 * 0.05}{Total\ in\ Unit}}{0.5}$$

C0=pixels with no annual grass in unit
C1=pixels with <= 5% annual grass cover
C2=pixels with > 5% and <= 15% annual grass cover
C3=pixels with > 15% and <= 25% annual grass cover
C4=pixels with > 25% and <= 45% annual grass cover
C5=pixels with > 45% annual grass cover

The weighting values as applied score areas with no annual grass extent the greatest proportional weight and the calculated value will be equal to 1. As annual grasses encroach into the analysis unit the maximum value of 1.0 is degraded progressively with pixels representing the >45% cover value having the greatest ability to drive down the maximum value. Figure B - 29 represents the application of the annual grasses to all 4x4 Km analysis units. In individual CE's the intersection of the CE with the annual grasses composite and summarized using the above formula.

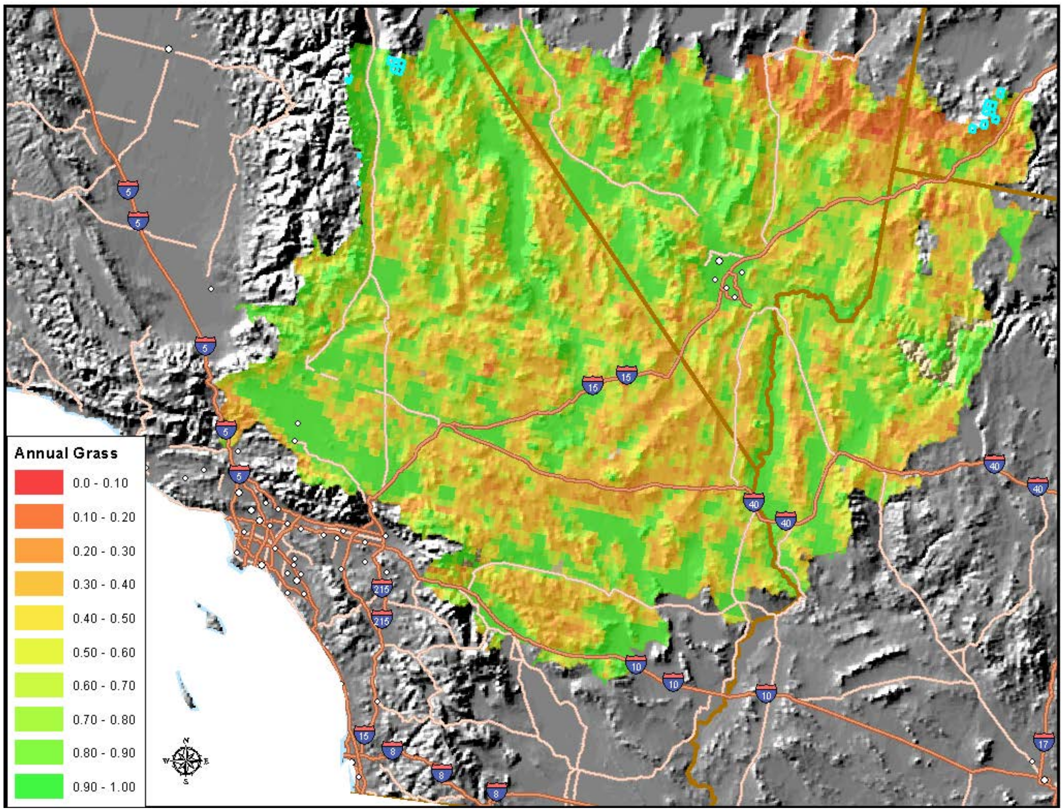


Figure B - 29.Total extent of annual grasses composite summarized by 4x4Km analysis unit.

Fire Regime Departure Indicator

By first constructing a conceptual model of successional dynamics, one can develop a powerful simulation tool to better understand the current conditions and forecast future trends. As noted in the methods section, state-and-transition models were developed using the Vegetation Dynamics Development Tool (VDDT) and simulations were run in the Path Landscape Model (ESSA Technologies). Models were run initially using historic conditions and fire regimes in order to characterize the Natural Range of Variation (NRV) which is used as a reference to compare to current and future conditions.

Given expected fire frequencies, one can anticipate a mix of successional stages for a given vegetation type across a defined landscape (in this case, a 5^{th} level watershed). Changes to those fire frequencies, (e.g., through introduction of fine fuels or fire suppression over decades), results in a different distribution of vegetation succession class. For example, historical fire suppression might result in a proportional increase in late successional stages. Introduction of new fine fuels could result in increased fire frequency and a proportional increase in early successional stages. This change from NRV can be measured as an index of Ecological Departure (ED). Ecological Departure describes the dissimilarity between NRV and current, or predicted future, combinations of successional stages. ED is driven by two interacting factors, including a) the distribution of natural seral classes change, and b) the proportion of natural seral stages are displaced by uncharacteristic states. Uncharacteristic states could include areas where invasive non-native vegetation dominates, or in some cases, 'invasion' by native species; as occurs with juniper invasion from pinyon-juniper woodlands into nearby shrublands.

Current vegetation was then modeled by appending current, uncharacteristic states and transitions to the historic model. For example, the Mojave Mid-Elevation Mixed Desert Scrub model adds five uncharacteristic states to the reference model. These uncharacteristic states are the result of the introduction of annual grasses into the region and/or effects of juniper invasion into this desert scrub.

A map of succession classes describes the current mixture of vegetation stages. An updated view of the succession classes for the entire ecoregion (Figure B - 30) includes early (A-B), intermediate (C-D), and late (E) successional stages. It also includes uncharacteristic vegetation stages, relative to expected natural patterns, including areas where invasive annual grasses dominate the landscape. It can also include uncharacteristic native vegetation, such as where pinyon pine and junipers have extended into adjacent desert scrub due to historic land uses and changes in fire regimes.

The spatial extent of each CE within each HUC was calculated from the LANDFIRE biophysical settings (potential distribution) data. Each observation was then inspected and those occurrences in the smallest 5% were deleted from the data set. By and large, this excluded those occurrences that appeared in such small spatial extents as to be most likely classification errors, and those whose extent was less than the minimum dynamic area for that CE. This step was necessary in order to ensure that the initial starting conditions, based on these observed data, were not unduly biased by these relatively small occurrences.

This indicator was assessed by calculating and summarizing the updated LANDFIRE Succession classes (SClass) layer which characterizes current vegetation succession classes for the distribution of each CE within each 5th-level watershed. The resulting proportional calculation for current conditions is compared to the expected proportions, as derived from the VDDT or Path-Tools model characterizing the expected natural range of variation (NRV). This comparison defines the degree of departure (%). The Fire Regime Departure Index is calculated by subtracting the Departure percent from 1 to produce a normalized scale from 0 to 1 with 1 being no departure from NRV in distribution of succession classes and 0 being complete departure from NRV. The fire regime departure by system score is solely associated within each 5^{th} level watershed, and cannot be summarized to individual CE extent as described in other measures of ecological integrity.

Since small spatial extent within a watershed was a criterion to remove a CE from a watershed in the dataset, not all watersheds with a CE have reported scores for departure. Minimum area thresholds were applied to each vegetation type (Table B - 27) to ensure that calculations were completed where there was sufficient aerial extent present to support the characteristic proportions of successional stages. This calculation of departure provides a 0.0 – 1.0 score for each CE within each watershed; with numbers closer to 0.0 showing increasingly severe departure.

Confidence in the modifications made to the SClass map are moderately high, but are limited to the overall model performance as completed by LandFire. The modifications of SClass made by NatureServe are applied based upon the overlap of the invasive annual grasses model representing the 15-25% cover model, which has high model performance (AUC=0.811), and the base SClass data layer as received from LandFire. Due to the modeling protocol followed by LANDFIRE it is difficult to define an overall model performance of the complete SClass data layer.

Table B - 27. Minimum area thresholds applied to coarse-filter CEs to ensure adequate areal extent for calculations of proportions of successional stages, for fire regime departures.

Terrestrial Coarse-filter Name	**Minimum # of hectares required for a departure score**
Great Basin Pinyon-Juniper Woodland	500
Great Basin Xeric Mixed Sagebrush Shrubland	150
Inter-Mountain Basins Mixed Salt Desert Scrub	400
Mogollon Chaparral	300
Mojave Mid-Elevation Mixed Desert Scrub-Mesic	1000
Mojave Mid-Elevation Mixed Desert Scrub-Thermic	500
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	1500
Sonora-Mojave Mixed Salt Desert Scrub	400
Sonora-Mojave Semi-Desert Chaparral	500
Sonoran Mid-Elevation Desert Scrub-Mesic	400
Sonoran Mid-Elevation Desert Scrub-Thermic	400

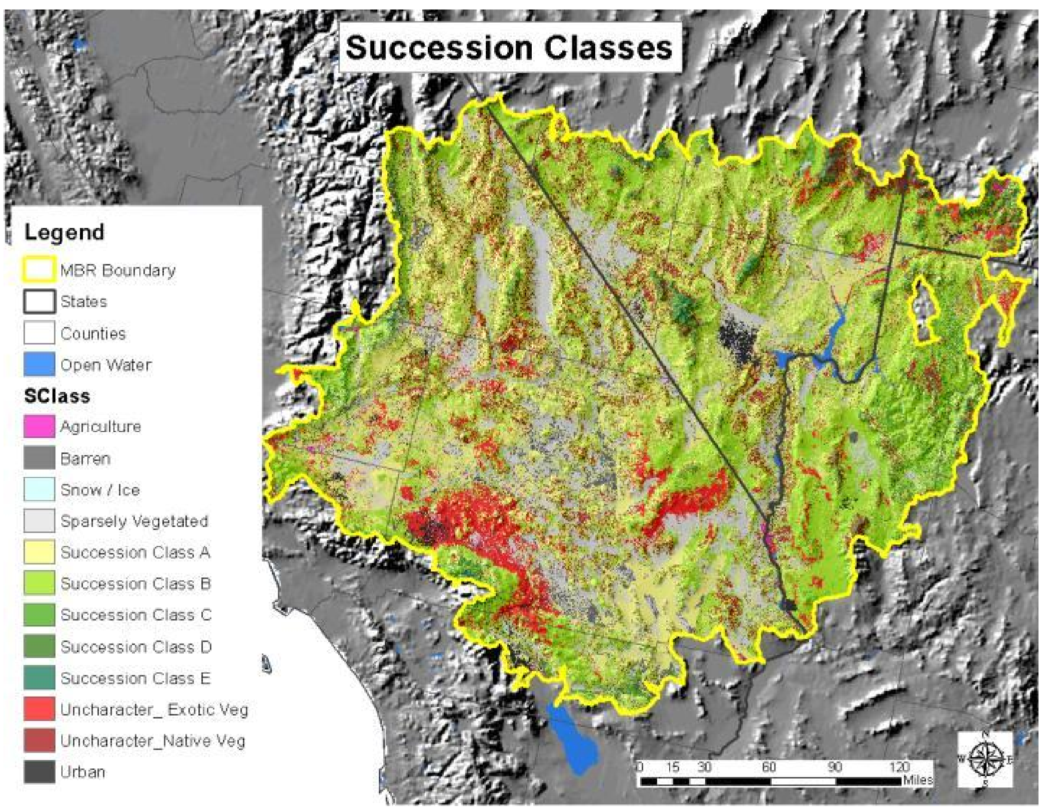


Figure B - 30. Updated succession class map for the ecoregion. These succession classes (SCLass) describe the stages within a systems ecological sere. SClasses are defined by relative age and canopy closure; for example Succession Class A captures all early seral stages whereas Class E captures late seral - closed canopy systems. Not all systems are divided into all 5 classes; 2-, 3-, and 4-class systems are common.

B-1.4.1.4 Key Ecological Attribute: Size

Change in Extent Indicator

Where a substantial change in extent for a given CE has occurred, it provides an indication of past/current land use practices and/or changing environmental conditions that could limit the provision of ecological services. It therefore serves as an appropriate indicator, among others, for gauging ecological integrity for each CE within each watershed. This indicator is assessed by intersecting the mapped current extent (*circa* early 2000s) of individual terrestrial coarse filter CEs with the biophysical setting (BpS) layer for this same CE (Figure B - 31). The BpS layer is an approximation of the potential (or historic) distribution of the CE, under a natural disturbance regime. The indexing of change in extent for ecological systems was performed at the watershed level by intersecting both the BpS and current ecological systems layers with the 5th level watersheds. The BpS represents an estimate of extent and does not comprise the actual historic extent of the system. With the requirement that the change index represents a 0 - 1.0 range with 1 being no change the following was applied:

$$\lim_{100\%}\left(1 - abs\left(Change = \frac{BPS - Current}{BPS}\right)\right)$$

Multiple watersheds by ecological systems experienced more than 100% (+/-) change. To address the extreme events with greater than 100% change which occurs predominately in watersheds intersected with very low amounts of either BpS, or current systems, the change was limited in two ways. First, all watersheds that do not meet the requirement for the area threshold applied in the VDDT Fire Departure models (Table B - 27) were excluded from the change calculation. Secondly, all watersheds by systems that continue to exceed the 100% change ceiling were limited to a 100% change value. In the final change index these extreme change values are represented by zero (Figure B - 32). As a result of the first requirement, not all watersheds with a CE will have a reported score for change in extent.

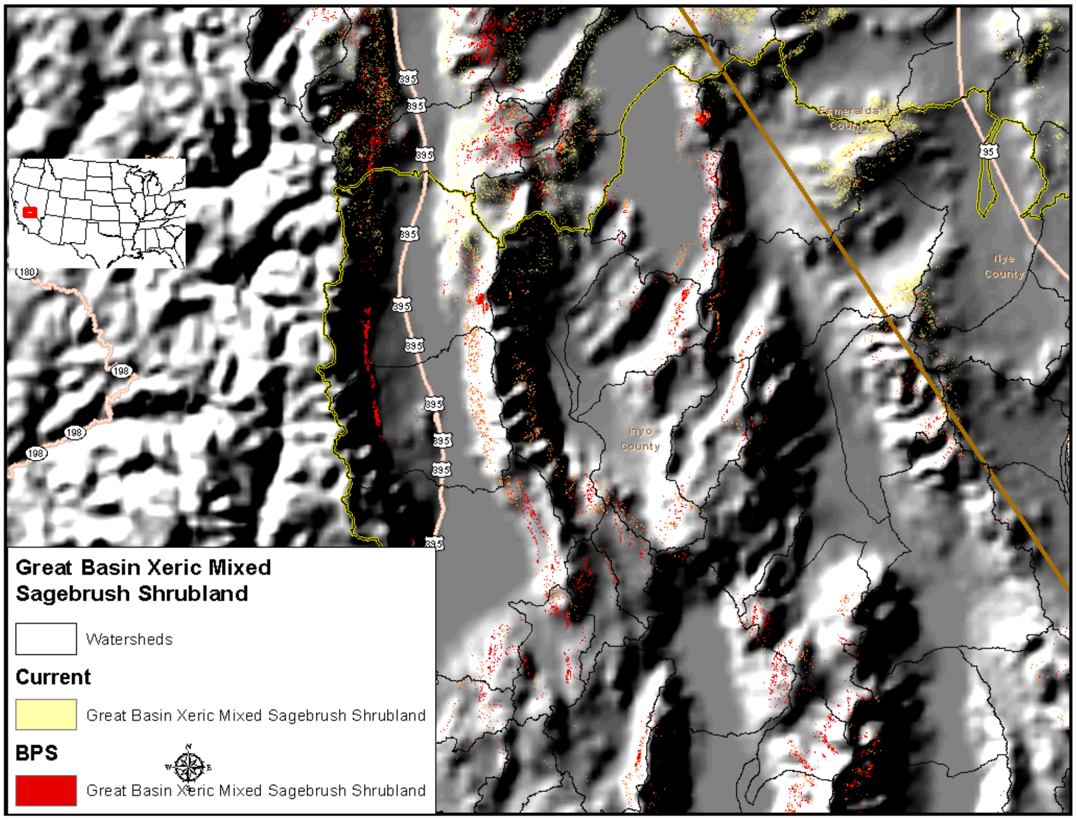


Figure B - 31. Current and potential ((“historic”, as represented by BpS) distribution of the Great Basin Xeric Mixed Sagebrush Shrubland.

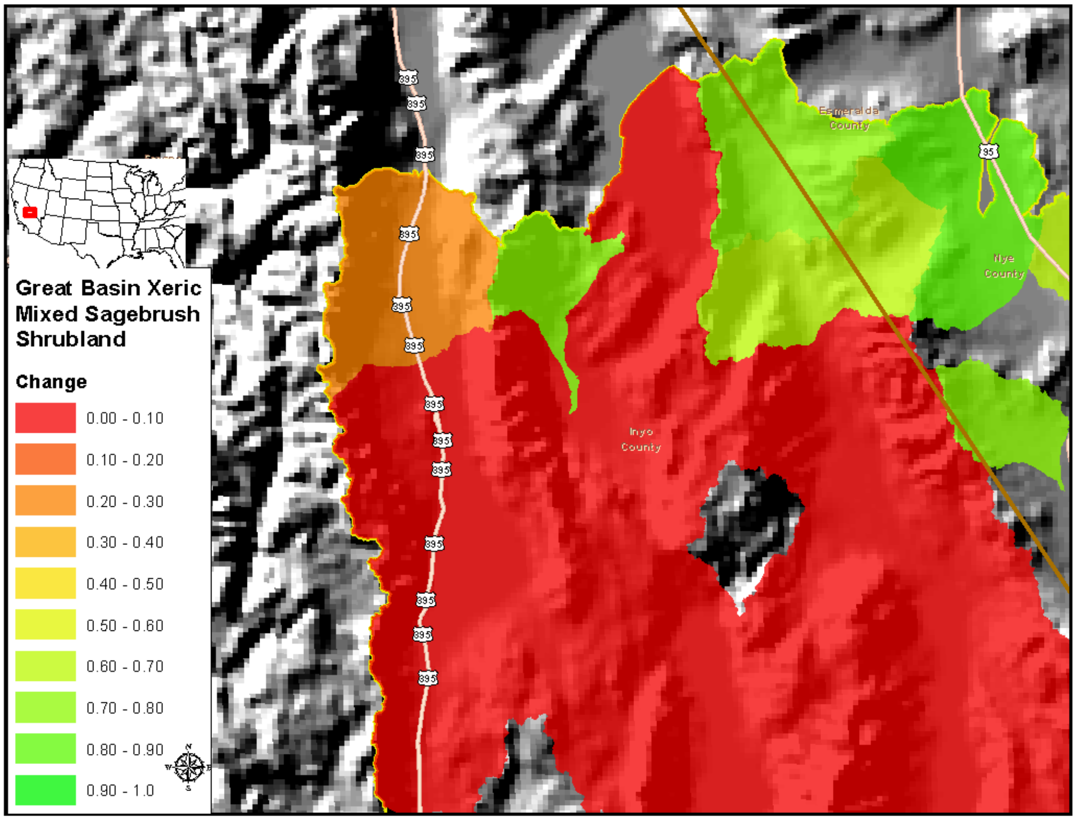


Figure B - 32. Change in extent scoring for Great Basin Xeric Mixed Sagebrush Shrubland, by 5th level watershed.

B-1.5 Summary Indices of Ecological Integrity

Given practical limitations of an REA, a simple, overall index of ecological integrity was desired. However, upon review of the various options for building such an index, several factors contributed to the conclusion that several distinct, but complimentary, indices would provide the best summary information on ecological integrity. The first factor was the distinct nature of many groups of CEs and their chosen indicators of ecological integrity or status. Combining results for terrestrial coarse filter, landscape species, and aquatic CEs implies the combination of scores for indicators that are decidedly non-complimentary (e.g., scores for water quality having no known effect on terrestrial ecological integrity). A second factor was that two primary spatial reporting units were selected for using the REA. As previously mentioned, the 5th level watershed unit was selected as one primary reporting unit. This reporting unit was appropriate for addressing aquatic integrity, and was relied upon to encompass sufficient area of upland vegetation to address indicators of fire regime departure for individual vegetation CEs. However in the latter case, an overall score for fire regime departure, if summarized by watershed, would necessarily combined scores for high and low elevation vegetation types. Therefore, four summary indices of integrity, reported by watershed, were developed. The first summarized fire regime departure scores for types falling with Montane Upland and Basin Upland categories of the ecoregion-wide conceptual model (Table B - 6).

A 4 km^2 grid was used to report on overall indicators of Landscape Condition Index and Invasive Annual Grass index, providing two additional ecoregion-scale summary indices of ecological integrity. This approach resulted in six complimentary, summary indices of ecological integrity (Table B - 28).

Table B - 28. Summary indices of ecological integrity with associated reporting units.

Summary Indicator	Montane Upland	Basin Upland	Aquatic/Wetland, and Riparian
Landscape Condition	4km^2 grid		
Invasive Annual Grass	4km^2 grid		
Fire Regime Departure	Watershed	Watershed	
Hydrologic Condition			Watershed
Water Quality			Watershed

B-2 Findings in terms of Management Questions

B-2.1 Current Distribution and Ecological Status

Many management questions are addressed in this section of the appendix. Tabular summaries are provided of the results for the ecological status assessment of all CE groups (terrestrial and aquatic coarse filter CEs, vulnerable species assemblages, and landscape species). For maps, only a cross-section of CE results are provided, since distribution and status maps for all CEs and all indicators of status would result in several hundred maps. The spatial data have all been provided to BLM and are avaialble through the BLM data management portal.

MQ1 -WHAT IS THE CURRENT DISTRIBUTION OF POTENTIAL HABITAT FOR EACH SPECIES CE?

MQ3 - WHAT IS THE CURRENT DISTRIBUTION OF SUITABLE HABITAT, INCLUDING SEASONAL HABITAT AND MOVEMENT CORRIDORS, FOR EACH LANDSCAPE SPECIES AND SPECIES ASSEMBLAGE CE?

MQ4 - WHERE ARE EXISTING CHANGE AGENTS POTENTIALLY AFFECTING THIS CURRENT HABITAT AND/OR MOVEMENT CORRIDORS, FOR LANDSCAPE SPECIES AND SPECIES ASSEMBLAGE CES?

MQ10 - WHERE ARE INTACT CE VEGETATIVE COMMUNITIES LOCATED?

MQ11 - WHERE ARE THE LIKELIEST CURRENT LOCATIONS FOR HIGH-INTEGRITY EXAMPLES OF EACH MAJOR TERRESTRIAL ECOLOGICAL SYSTEM?

MQ30 - WHERE ARE CURRENT NATURAL AND MAN-MADE SURFACE WATER RESOURCES?

MQ34 - WHERE ARE THE LIKELY RECHARGE AREAS WITHIN A HUC?

MQ36 - WHAT IS THE CONDITION (ECOLOGICAL INTEGRITY) OF AQUATIC CONSERVATION ELEMENTS?

MQ39 - WHERE ARE THE AQUATIC CE OCCURRENCES WITH THE MOST DEGRADED CONDITION (ECOLOGICAL INTEGRITY)?

MQ42 - WHAT AREAS NOW HAVE UNPRECEDENTED FUELS COMPOSITION (INVASIVE PLANTS), AND ARE THEREFORE AT HIGH POTENTIAL FOR FIRE?

MQ45 - WHAT AREAS ARE SIGNIFICANTLY ECOLOGICALLY AFFECTED BY INVASIVE SPECIES?

MQ50 - WHERE DO DEVELOPMENT CAS CAUSE SIGNIFICANT LOSS OF ECOLOGICAL INTEGRITY?

MQ57 - WHERE ARE THE AQUATIC CES SHOWING DEGRADED ECOLOGICAL INTEGRITY FROM EXISTING GROUNDWATER EXTRACTION?

MQ58 - WHERE ARE ARTIFICIAL WATER BODIES INCLUDING EVAPORATION PONDS, ETC.?

MQ80 - WHERE ARE AREAS AFFECTED BY ATMOSPHERIC DEPOSITION OF POLLUTANTS, AS REPRESENTED SPECIFICALLY BY NITROGEN DEPOSITION, ACID DEPOSITION, AND MERCURY DEPOSITION?

B-2.2 Terrestrial CEs Current

B-2.2.1 Ecological Status: Terrestrial Coarse-Filter Conservation Elements

Table B - 29 summarizes the ecological status for each terrestrial coarse filter CE according to the each of four ecological status indicators. Ecological status indicators are scored from 0 to 1 for the distribution of each CE within each 5th level watershed. Higher scores (1 is the highest) indicate relatively higher ecological status. The table provides a count of 5th level watersheds having a score within each of ten specified intervals (e.g., 0.3 – 0.4, 0.4 – 0.5) for each CE, for each indicator. For a given indicator, if most watersheds for a particular CE have scores in the higher intervals, it indicates high ecological status for that CE in relation to that indicator. If all indicators are similarly highly scored for a particular CE, one can be more confident in the overall ecological status of the CE. However, one may also encounter relatively high scores for some indicators, while lower scores are common for others, for a given CE. This indicates some potential management concerns relative to ecological status for that CE. If all indicators skew towards lower scores, significant cause for management concern is warranted.

To facilitate review of ecological status across the full set of terrestrial coarse filter CEs, the higher watershed counts are bolded in Table B - 29 to make it easier to see how the scores are distributed for a given indicator for a given CE. In many cases, the counts are clustered either toward the high end of the scores or the low end. However, some are more evenly distributed, or show a bimodal or multimodal distribution.

Great Basin Pinyon-Juniper Woodland (shown in bold throughout Table B - 29) is used here as an example to illustrate the summary of indicator scores in Table B - 29. The indicator for change in extent of the CE shows that for watersheds where it experienced some change, it was often a relatively limited change; 101 of the 180 watersheds had a change in extent score between 0.9 and 1. For the landscape condition indicator, nearly three-quarters (229 out of 315) of the watersheds where it is found had landscape condition values between 0.7 and 1, indicating that much of this woodland distribution is located in landscapes with relatively little impact from development change agents. This would be expected for a type found at higher elevations, in relatively more remote parts of the ecoregion. Conversely, substantial alteration in fire regime is indicated for this CE, with 162 of 180 watersheds having a fire departure index of 0.5 or less. The invasive annuals cover indicator shows a majority of watersheds (232 out of 315) having scores distributed somewhat evenly across the top half of the range, from 0.5 to 1; this suggests that some areas of this woodland type are likely effected by invasive annual grasses, but not a majority of its area. While change in extent and landscape condition indicators were generally high, fire regime departure scores were low, and invasives were intermediate. Together, the latter two scores suggest a focus for management direction related to this CE in the MBR.

Overall, Table B-25 indicates many expected trends in ecological status among terrestrial coarse-filter CEs (see e.g., Brooks and Chambers 2011). One could expect that the higher elevation ecological systems, and those characteristic of the most remote portions of the MBR ecoregion, would tend to occur in the least-impacted landscapes. For most types across this desert landscape, that holds true. The landscape condition indicator tends to be in the top three categories for most types.

Fire regime departure appears to have affected vegetation beginning at montane elevations, such as among Great Basin Pinyon-Juniper Woodland and Mogollon Chaparral, and extending down into basin bottoms, with Sonora-Mojave Mixed Salt Desert Scrub and Sonora-Mojave Creosote-White Bursage

Desert Scrub. This indicator is strongly correlated with the invasive annual grass indicator for most types. The pervasive presence of at least trace amounts of invasive annual grasses is reflected across nearly all major terrestrial coarse-filter CEs in the MBR.

Table B - 29. Indicator results by watershed for terrestrial coarse-filter CEs (Current). For each indicator the count of 5th level watersheds is shown for each CE, broken out by indicator score interval.

KEA: Change in Extent/Size											
Change in extent											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	301	**28**	7	9	14	19	14	**29**	**41**	**63**	**77**
Mojave Mid-Elevation Mixed Desert Scrub	238	14	1		6	6	9	10	23	**41**	**128**
Great Basin Pinyon-Juniper Woodland	180	5	8	7	7	11	9	8	11	13	**101**
Sonora-Mojave Mixed Salt Desert Scrub	149	**72**	9	10	13	11	6	8	10	6	4
Great Basin Xeric Mixed Sagebrush Shrubland	131	**104**	3	2	1	3	2	3	4	7	2
Inter-Mountain Basins Mixed Salt Desert Scrub	114	**52**	22	8	12	4	4	6	4	2	
Mogollon Chaparral	111	**27**	16	11	12	6	6	7	5	12	9
Sonora-Mojave Semi-Desert Chaparral	56	**12**	9	7	6	4	4	5	3	4	2
Sonoran Mid-Elevation Desert Scrub	26	1	1	3	5	3	3	5	1	4	

KEA: Landscape Condition											
Landscape Condition Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Inter-Mountain Basins Mixed Salt Desert Scrub	362	**66**	2		4	14	12	30	**74**	**124**	36
Great Basin Pinyon-Juniper Woodland	315				1	12	27	46	**62**	**139**	28
Mojave Mid-Elevation Mixed Desert Scrub	315					8	20	36	**81**	**140**	30
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	312	2			5	12	27	**57**	**96**	**96**	17
North American Warm Desert Pavement	299	6		1	4	19	26	**66**	**82**	**80**	15
North American Warm Desert Bedrock Cliff and Outcrop	298			1	3	3	16	36	**96**	**122**	21
Sonora-Mojave Mixed Salt Desert Scrub	289	8			2	15	32	46	**67**	**98**	21

Great Basin Xeric Mixed Sagebrush Shrubland	192	15				3	4	5	**32**	**107**	26
Mogollon Chaparral	190	15			1	2	2	8	**31**	**107**	24
North American Warm Desert Badland	107	4			4	4	17	16	**23**	**35**	4
Sonora-Mojave Semi-Desert Chaparral	89	10				2	13	10	**16**	**31**	7
Sonoran Mid-Elevation Desert Scrub	61	9				2	4	7	**18**	**20**	1
North American Warm Desert Active and Stabilized Dune	34				3	2		1	**8**	**14**	**6**
Fire Regime Departure Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	301	7	14	**44**	**57**	**63**	**58**	31	16	9	2
Mojave Mid-Elevation Mixed Desert Scrub	238	3	1	9	17	22	**52**	**95**	35	3	1
Great Basin Pinyon-Juniper Woodland	180	8	**32**	**52**	**47**	23	11	4	2		1
Sonora-Mojave Mixed Salt Desert Scrub	150	19	**41**	**22**	**24**	20	7	4	3	9	1
Great Basin Xeric Mixed Sagebrush Shrubland	131			5	18	19	**27**	**36**	19	7	
Inter-Mountain Basins Mixed Salt Desert Scrub	116	2	4	4	18	10	18	16	**34**	10	
Mogollon Chaparral	111	5	15	**22**	**24**	**21**	18	2	4		
Sonora-Mojave Semi-Desert Chaparral	57	5	5	9	5	4	6	4	7	9	3
Sonoran Mid-Elevation Desert Scrub	26	2		1	1	4	**6**	**6**	**6**		
KEA: Stressors on Biotic Condition											
Invasive Annual Cover Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Inter-Mountain Basins Mixed Salt Desert Scrub	358	**46**	30	34	**58**	36	**42**	16	26	22	**48**
Great Basin Pinyon-Juniper Woodland	315		8	21	25	29	**35**	**44**	**55**	**55**	**43**
Mojave Mid-Elevation Mixed Desert Scrub	315		21	**50**	**55**	**50**	**46**	36	28	20	9
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	310		16	19	**44**	32	**43**	**54**	**38**	32	32
North American Warm Desert Pavement	299	2	26	**34**	32	25	29	**37**	33	32	**49**
North American Warm Desert Bedrock Cliff and Outcrop	298	3	**35**	**48**	**47**	28	**46**	**35**	26	14	16
Sonora-Mojave Mixed Salt Desert Scrub	289	10	**36**	**36**	28	32	24	20	26	27	**50**

Great Basin Xeric Mixed Sagebrush Shrubland	189	16	10	11	13	**23**	24	18	22	**26**	**26**
Mogollon Chaparral	187	9	9	9	17	17	17	17	23	16	**53**
North American Warm Desert Badland	100	11	8	9	8	5	5	13	9	7	**25**
Sonora-Mojave Semi-Desert Chaparral	90	7	3	8	8	6	3	4	4	**17**	**30**
Sonoran Mid-Elevation Desert Scrub	60	7	**17**	**16**	5	4	3	3	1		4
North American Warm Desert Active and Stabilized Dune	34	3	4	3	3	4	1	3	4	2	7

Limitations on available data for the ecoregion suggest caution in interpreting results from among the several indicators included in Table B-23. Landscape condition indicators, primarily reflecting patterns of built infrastructure, provides the highest-confidence result from among these indicators. However, there are clear deficiencies in available roads data, where de-commissioned roads have sometimes been removed from actively managed digital roads layers, but the ecological effects of those roads could continue for some time.

The invasive annual grass indicator should be viewed as a preditor of potential invasive grass abundance, but not a field-verified map. Therefore, while strong patterns of invasive grass presence pervade CE distributions, field verification of particular sites is required prioir to taking management action. However, given concern for the introduction of novel fire regimes by relatively small abundances of these fine fuels, overall indicator patterns should be considered reasonable at an ecoregional scale.

The fire regime departure models depend in part on modeled distributions of invasive grasses and fine-fuels, so while ecoregion-wide patterns of departure described in these tables should be realistic, local site evaluation will be required prior to planning management actions.

Finally, given previously stated limitations of both existing map distributions and LANDFIRE BpS maps (see map edits documented in tables B-12 and B-14), the Change in Extent Indicator is most likely of the four indicators to include substantial error. Users should rely primarily on results of other indicators, and view the results of this indicator only as it is corroborated by other indicator results.

Maps of terrestrial coarse filter CEs current distribution and ecological status

The current distribution and the spatial results of the ecological status assessment for a selection of the terrestrial coarse filter CEs are presented in Figure B - 33 and Figure B - 38. These are organized within the ecoregional conceptual model, with Montane Dry Land systems presented first; then the Basin Dry Land systems. Within each group systems are sorted from high to low elevation.

MONTANE DRY LAND SYSTEMS

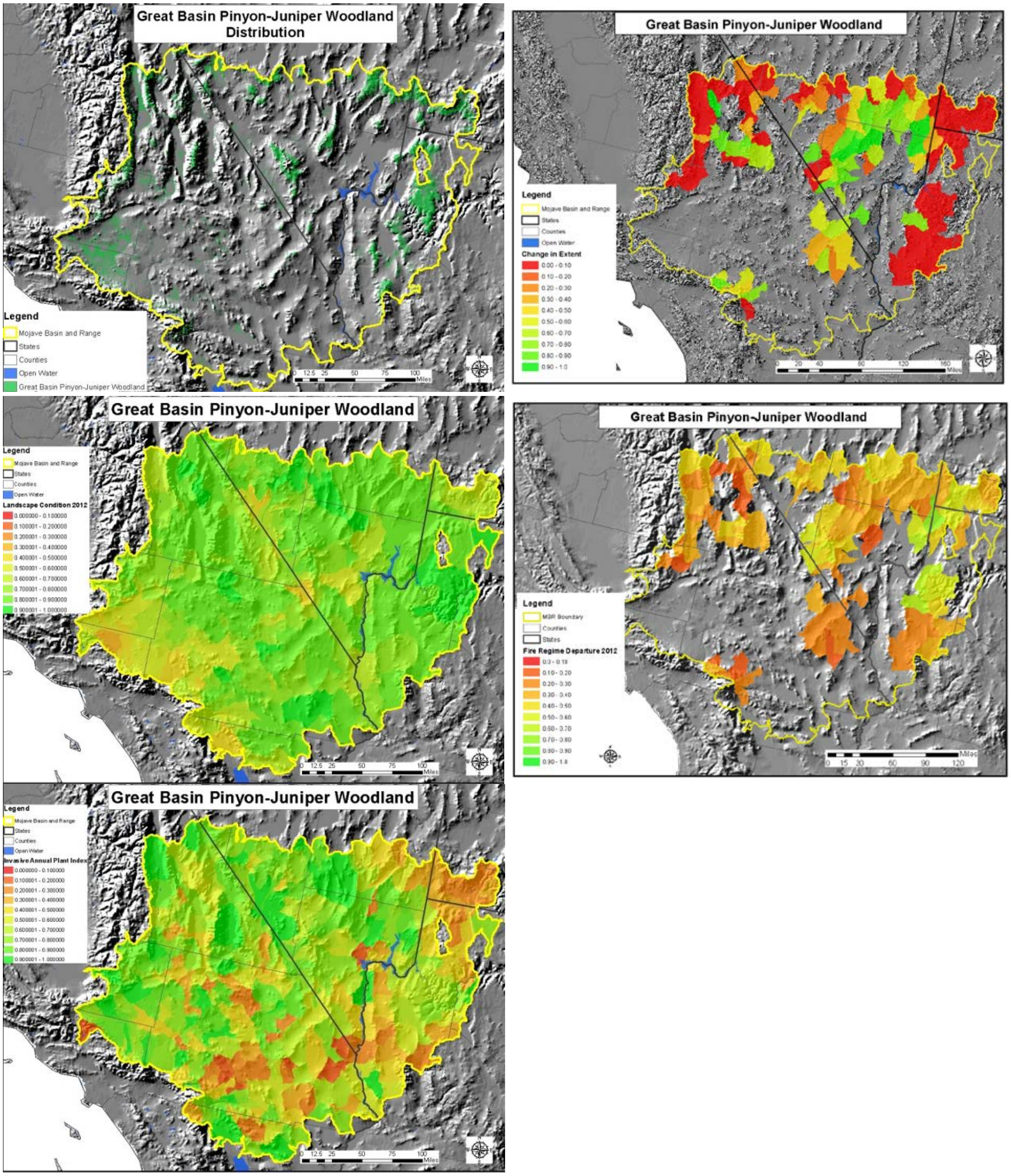


Figure B - 33. Great Basin Pinyon-Juniper Woodland distribution and status: current distribution (top left), Change in Extent scores (top right), current Landscape Condition Index scores (middle left), Fire Regime Departure Index scores (middle right), Invasive Annual Grass Index scores (bottom)

BASIN DRY LAND SYSTEMS

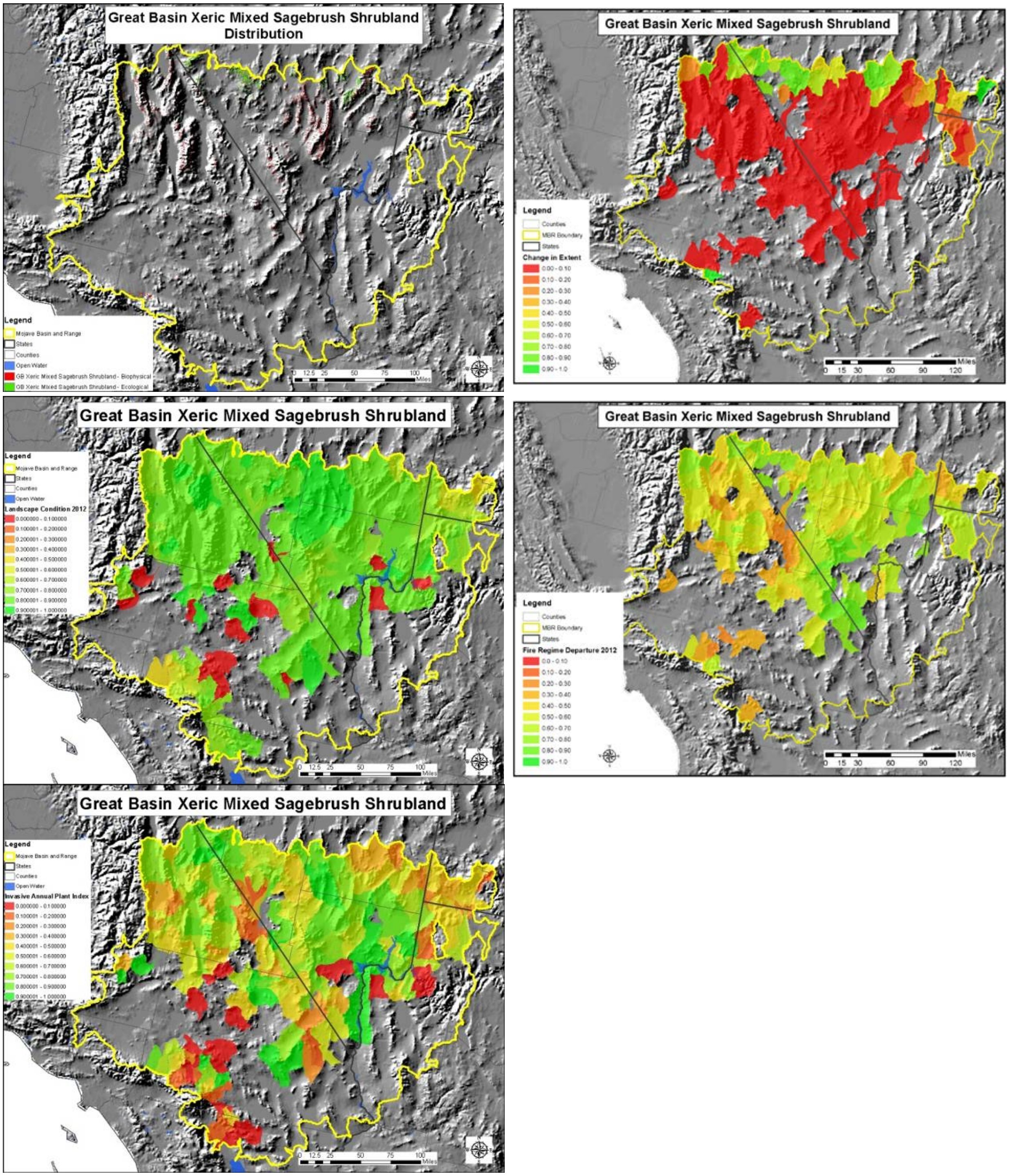


Figure B - 34. Great Basin Xeric Mixed Sagebrush Shrubland distribution and status: current distribution (top left), Change in Extent scores (top right), current Landscape Condition Index scores (middle left), Fire Regime Departure Index scores (middle right), Invasive Annual Grass Index scores (bottom)

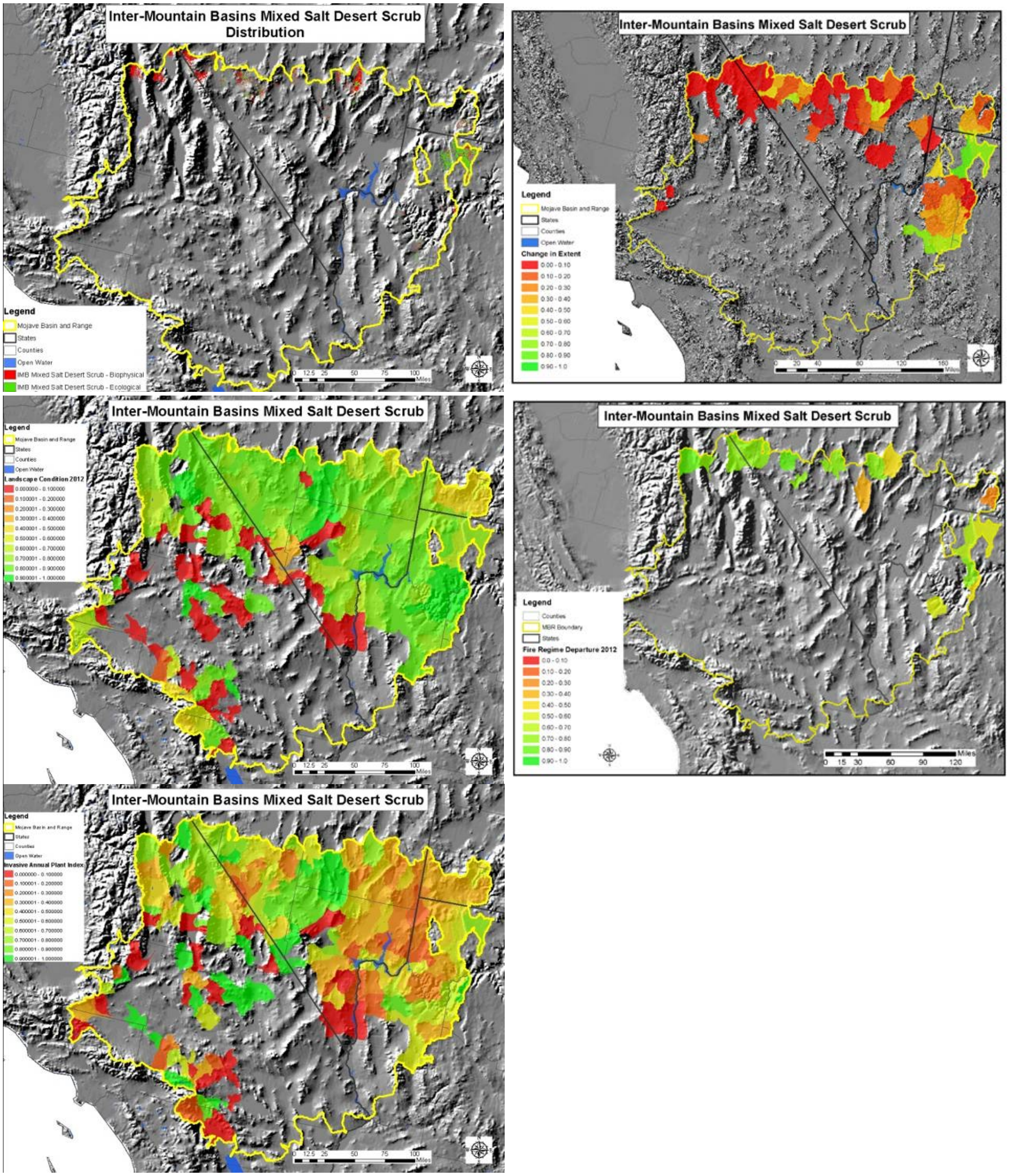


Figure B - 35. Inter-Mountain Basins Mixed Salt Desert Scrub distribution and status: current distribution (top left), Change in Extent scores (top right), current Landscape Condition Index scores (middle left), Fire Regime Departure Index scores (middle right), Invasive Annual Grass Index scores (bottom)

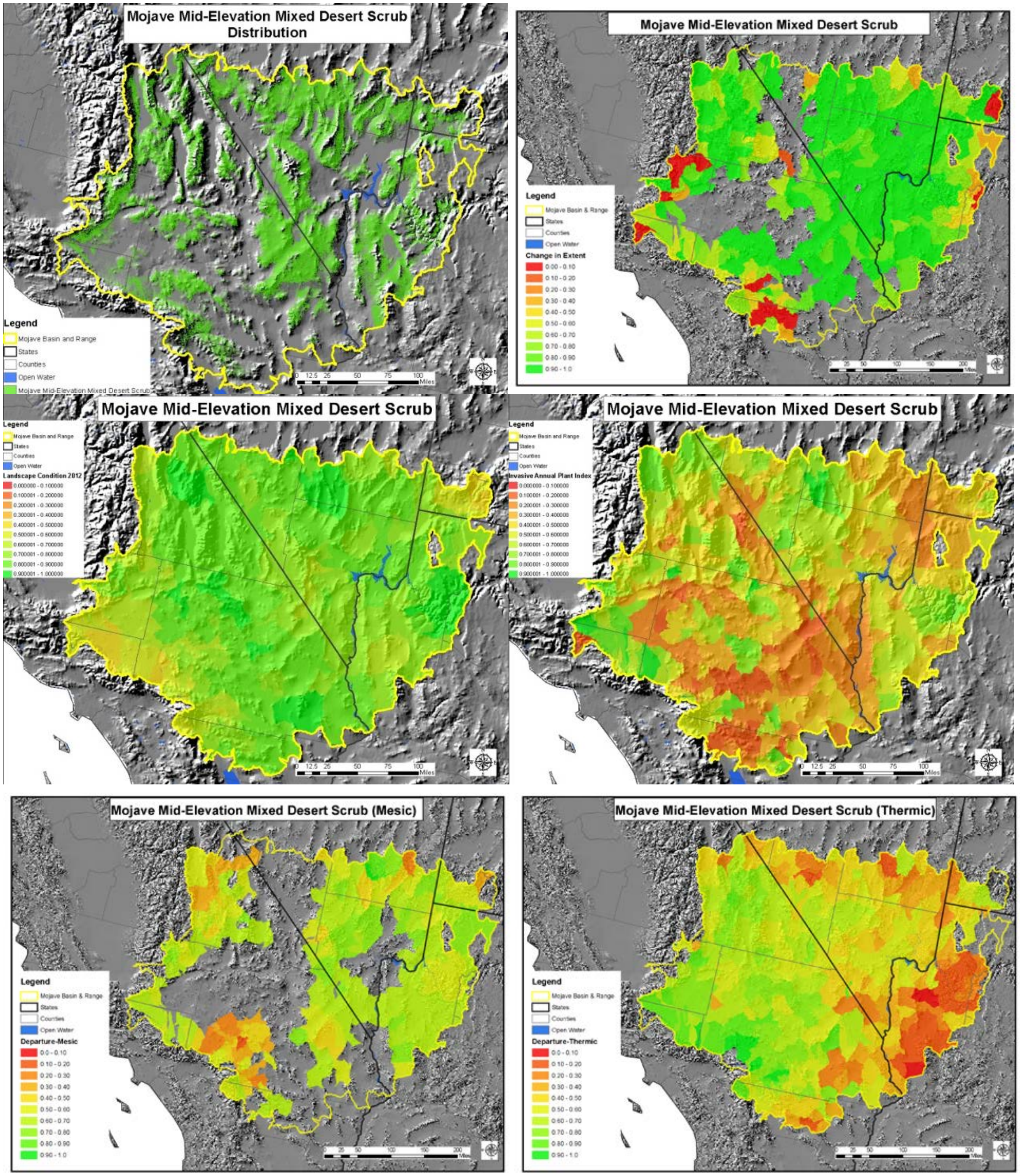


Figure B - 36. Mojave Mid-Elevation Mixed Desert Scrub distribution and status: current distribution (top left), Change in Extent scores (top right), current Landscape Condition Index scores (middle left), Invasive Annual Grass Index scores (middle right), and Fire Regime Departure Index scores (bottom) for mesic and thermic variants.

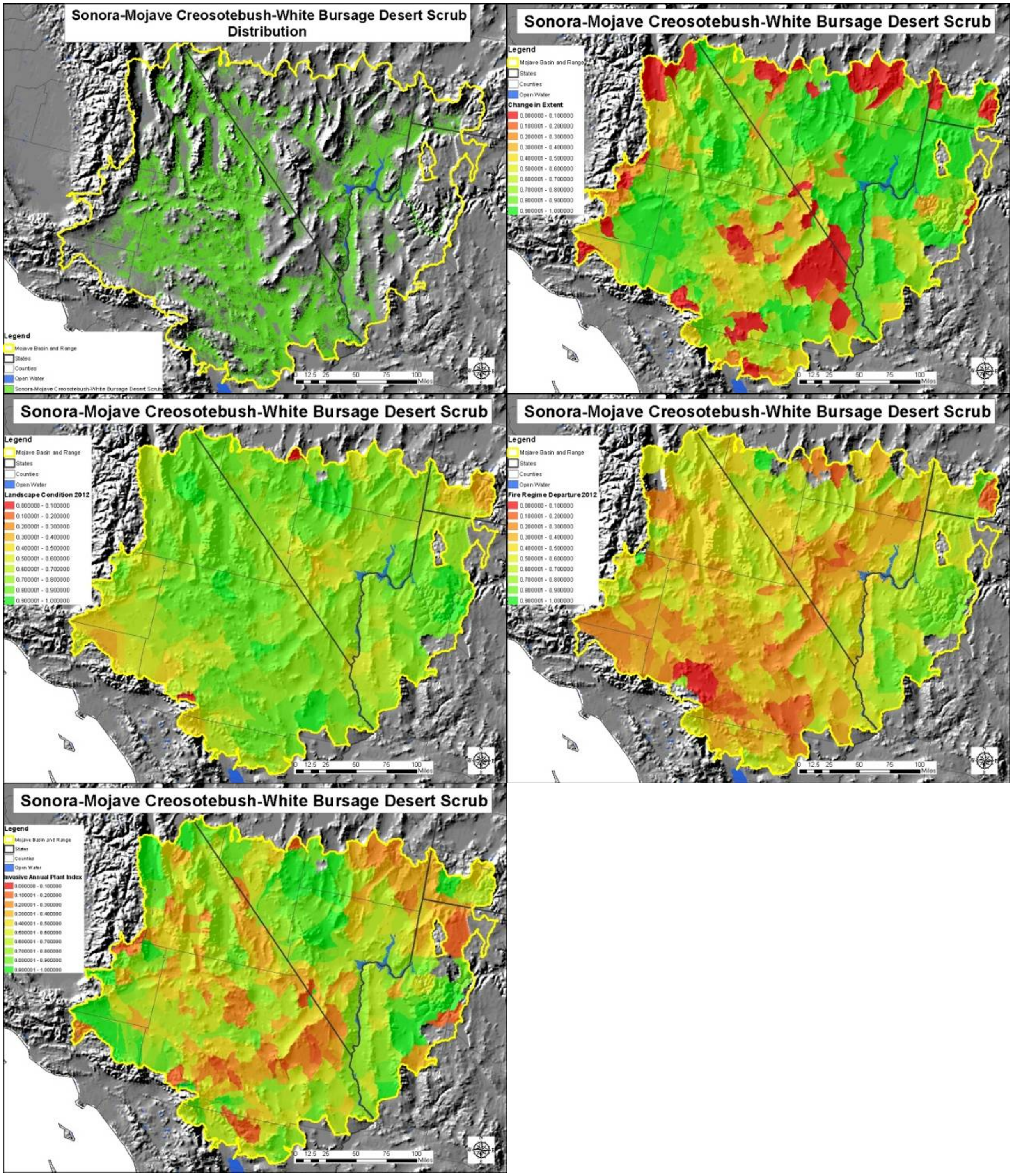


Figure B - 37. Sonora-Mojave Creosotebush-White Bursage Desert Scrub distribution and status: current distribution (top left), Change in Extent scores (top right), current Landscape Condition Index scores (middle left), Fire Regime Departure Index scores (middle right), Invasive Annual Grass Index scores (bottom)

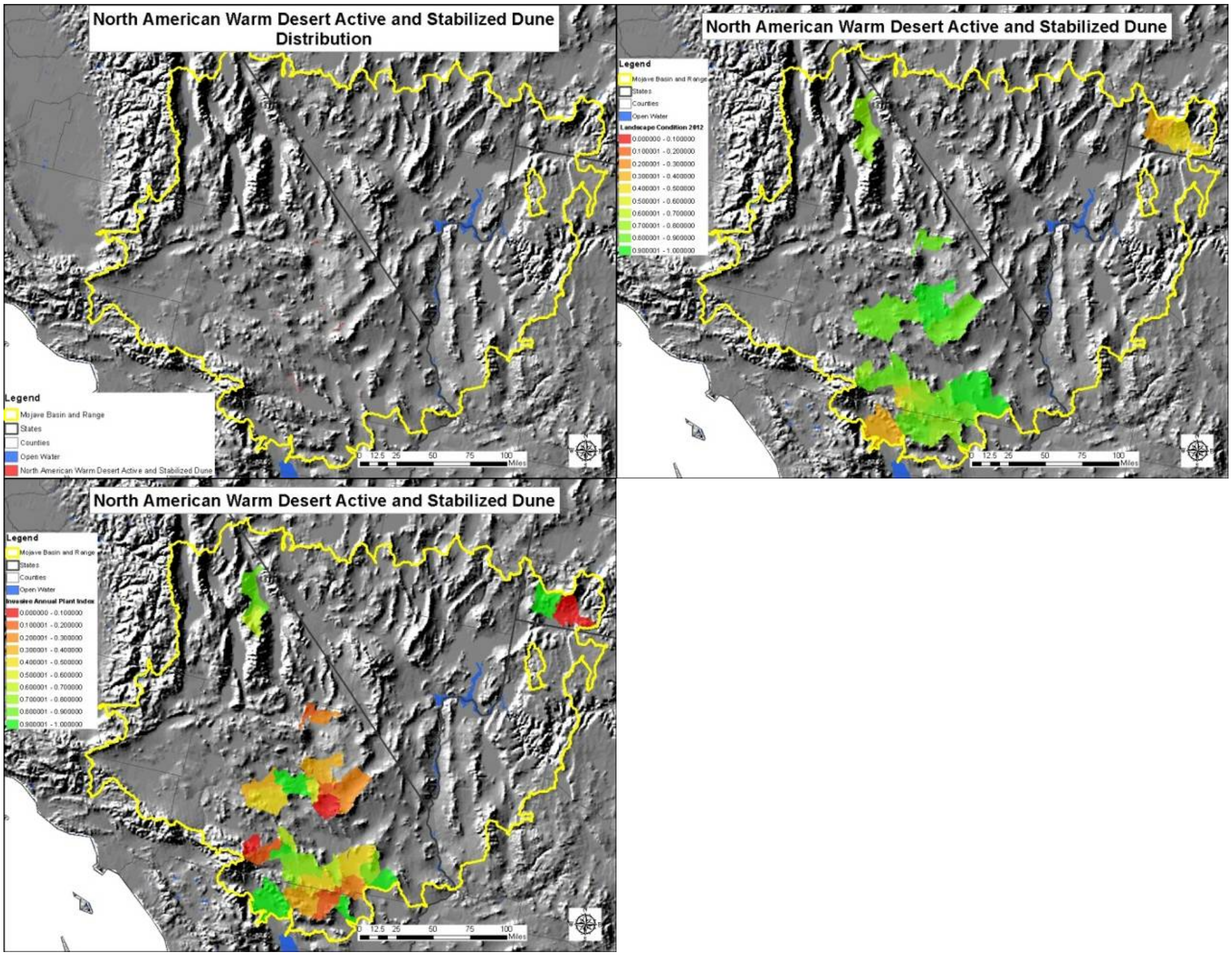


Figure B - 38. North American Warm Desert Active and Stabilized Dune distribution and status : current distribution (top left), current Landscape Condition Index scores (top right), Invasive Annual Grass Index scores (bottom)

B-2.2.2 Ecological Status: Landscape Species

Assessment of ecological status for landscape species was completed for each distribution that had been summarized by 4 X 4 km grid. This was in contrast to 5th level watersheds, the spatial analysis units used for coarse-filter CE assessments. Table B - 30 includes summary scores for grid cells in the same format utilized above for terrestrial coarse-filter CEs. Fewer indicators were available for use in assessment of landscape species. The emphasis was on using the landscape condition model (for most species) and for others, the landscape condition indicator was used in combination with invasive annual grasses vulnerability. Table B - 30 is sorted by overall extent (number of grid cells) for each species. Average areal extent of habitat for landscape species was 6,331 square miles.

Among the 28 landscape species in this ecoregion, landscape condition tends to be moderate to high across most of their distribution but with concentrated areas of low scores. This reflects the relatively dispersed, but also pervasive, effects of roads and other localized development change agents occurring across these generally widespread CE distributions. Several species concentrated at higher elevations, including Bighorn Sheep, Northern Sagebrush Lizard, Brewer's Sparrow, Sage Sparrow, Northern Harrier, and Mule Deer appear to be concentrated in the highest scoring watersheds. In contrast, species such as Golden Eagle, Bald Eagle, known to occur in more variable landscape contexts, including close to surface waters close to converted agricultural lands, scored generally lower for landscape condition. The other consistent pattern among landscape species is a more variable distribution for Invasive Annual Grass scores, with on the one hand, large percentages of grid cells falling among the highest scores, while the second largest percentage fall in the middle-lower range of scores. Given that this pattern is common among sage-brush associated species, such as Mohave Ground Squirrel, Brewer's Sparrow (breeding habitat), and Sage Thrasher, etc., this reflects preponderance of invasive annual grass infestation among portions of these species habitats, most concentrated along the northern fringe of the ecoregion.

The Mojave desert tortoise does not score well for landscape connectivity, with a preponderance of the 4x4 km grid cells scoring below 0.4. Rolling the connectivity for desert tortoise up to the 4km grids is not as informative as considering the connectivity scored for the native resolution of that model (1x1 km grid cells), as seen in Figure B - 28.

Table B - 30. Indicator results by 4 x 4 km grid cell for landscape species CEs (Current). For each indicator the count of 4 x 4 km grid cells is shown for each CE, broken out by indicator score interval.

KEA: Landscape Condition											
Landscape Condition Index											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Bald Eagle	84			3	6	**25**	**23**	15	11	1	
Big Brown Bat	9,665			14	134	384	759	**1316**	**2258**	**3729**	**1071**
Brazilian Free-tailed Bat	9,702			12	135	359	725	**1342**	**2309**	**3759**	**1061**
Brewer's Sparrow - Breeding Habitat	2,188			4	55	115	248	301	**413**	**758**	294
Brewer's Sparrow - Migrating Habitat	4,214		2	4	23	72	122	**400**	**1006**	**1976**	**609**
Coachwhip	9,685			17	110	362	713	**1320**	**2331**	**3764**	**1068**
Common Kingsnake	9,716			16	132	335	692	**1377**	**2337**	**3737**	**1090**
Cooper's Hawk	7,978		3	30	197	508	929	982	**1413**	**2936**	980
Desert Bighorn Sheep	4,614			3	9	62	178	481	**1147**	**2123**	611
Gila Monster	2,863			4	28	85	155	**479**	**909**	**1050**	153
Glossy Snake	9,382			25	117	352	683	**1347**	**2253**	**3589**	**1016**
Golden Eagle	131			2	11	**27**	**24**	**26**	**24**	12	5
Great Basin Collared Lizard	9,400			14	108	290	619	**1298**	**2287**	**3708**	**1076**
Kit Fox	8,510			13	122	322	658	**1311**	**2193**	**3166**	725
Mojave Desert Tortoise	5,186	1	1	6	85	233	470	**882**	**1289**	**1806**	413
Mojave Ground Squirrel	2,368			2	74	170	332	**421**	**415**	**746**	208
Mojave Rattlesnake	6,068			9	104	282	596	**1079**	**1483**	**2074**	441
Mule Deer Summer	455						9	54	**132**	**217**	43
Mule Deer Winter	584				3	21	62	103	**179**	**188**	28
Mule Deer Yearlong	1,867			16	26	80	166	286	**445**	**762**	86
Northern Harrier	153				3	9	3	6	**58**	**74**	
Northern Rubber Boa	397			2	6	28	66	**82**	**99**	**113**	1
Northern Sagebrush Lizard	4,913		1	8	44	133	216	519	**1142**	**2088**	**762**
Prairie Falcon	9,746			27	143	356	694	**1367**	**2351**	**3749**	**1059**
Sage Sparrow	405					1	5	23	**126**	**190**	60

KEA: Landscape Condition											
Landscape Condition Index											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Sage Thrasher	1,192			7	18	56	86	**132**	**291**	**498**	**104**
Sonoran Desert Tortoise	592			1	7	9	58	**138**	**203**	**176**	
Western Banded Gecko	2,404			3	30	77	154	**396**	**711**	**848**	185
Western Patch-nosed Snake	9,072			19	117	342	664	**1296**	**2154**	**3444**	**1036**
KEA: Connectivity											
Landscape Connectivity Index											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Mojave Desert Tortoise	5,010	**1029**	**909**	**1052**	**639**	390	370	243	113	76	189
KEA: Stressors on Biotic Condition											
Presence of Invasive Plant Species											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Brewer's Sparrow - Breeding Habitat	2,103		6	75	151	97	76	70	76	131	**1421**
Brewer's Sparrow - Migrating Habitat	4,186		2	51	78	86	100	97	126	214	**3432**
Mojave Ground Squirrel	2,368	**267**	**374**	205	182	141	149	150	153	181	**566**
Sage Sparrow	386							1	3	20	**362**
Sage Thrasher	1,162		4	53	**115**	97	55	64	77	80	**617**

Maps of landscape species CEs current distribution and ecological status

The current distribution and the spatial results of the ecological status assessment for a selection of the landscape species CEs are presented in Figure B - 39 through Figure B - 51. These are organized within the ecoregional conceptual model, with species associated with Montane Dry Land System presented first, then the species found in Basin Dry Land System. Species associated with either Basin or Montane Wet System are presented as a third group of CEs.

MONTANE DRY LAND ASSOCIATED SPECIES

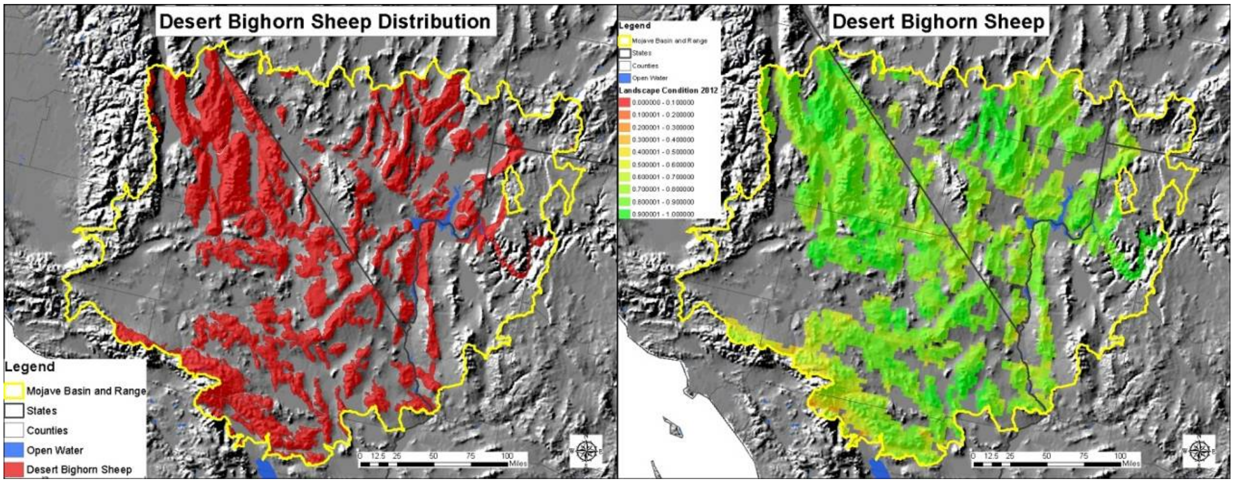


Figure B - 39. Desert Bighorn Sheep current distribution and current Landscape Condition Index scores

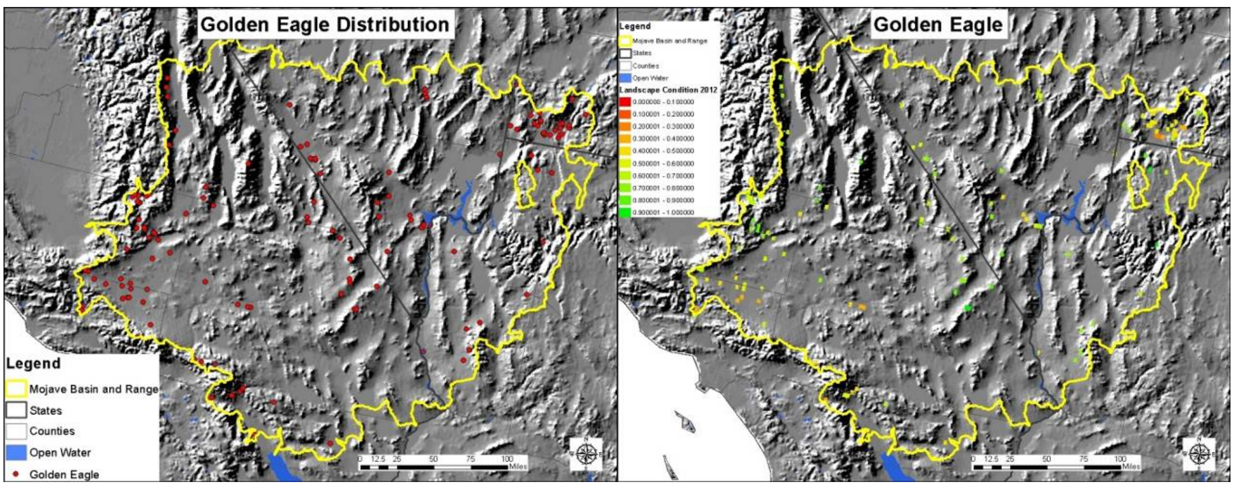


Figure B - 40. Golden Eagle current distribution and current Landscape Condition Index scores

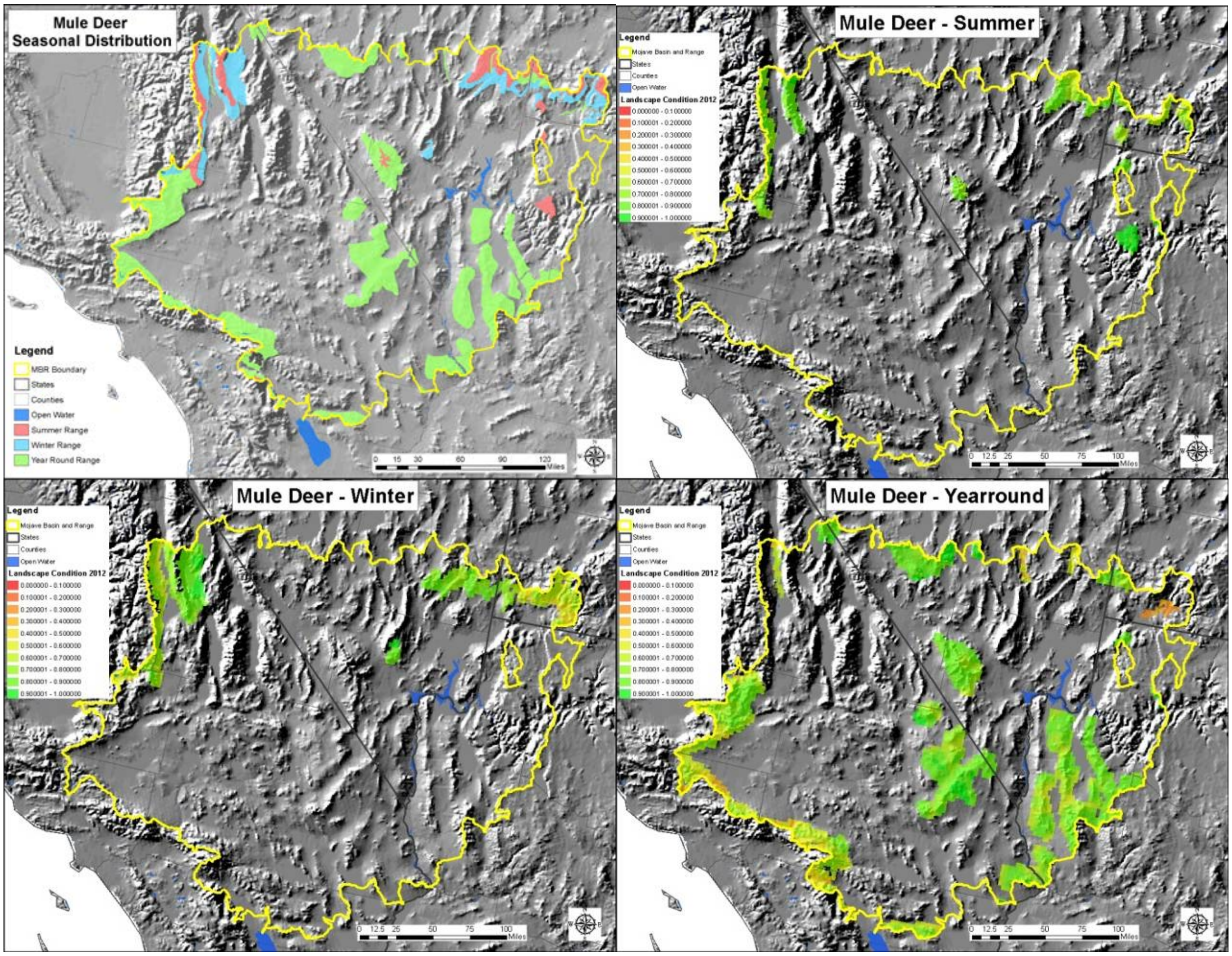


Figure B - 41. Mule Deer current distribution (upper left) and current Landscape Condition Index scores for Summer (upper right), Winter (lower left), and Yearlong (lower right) ranges.

BASIN DRY LAND ASSOCIATED SPECIES

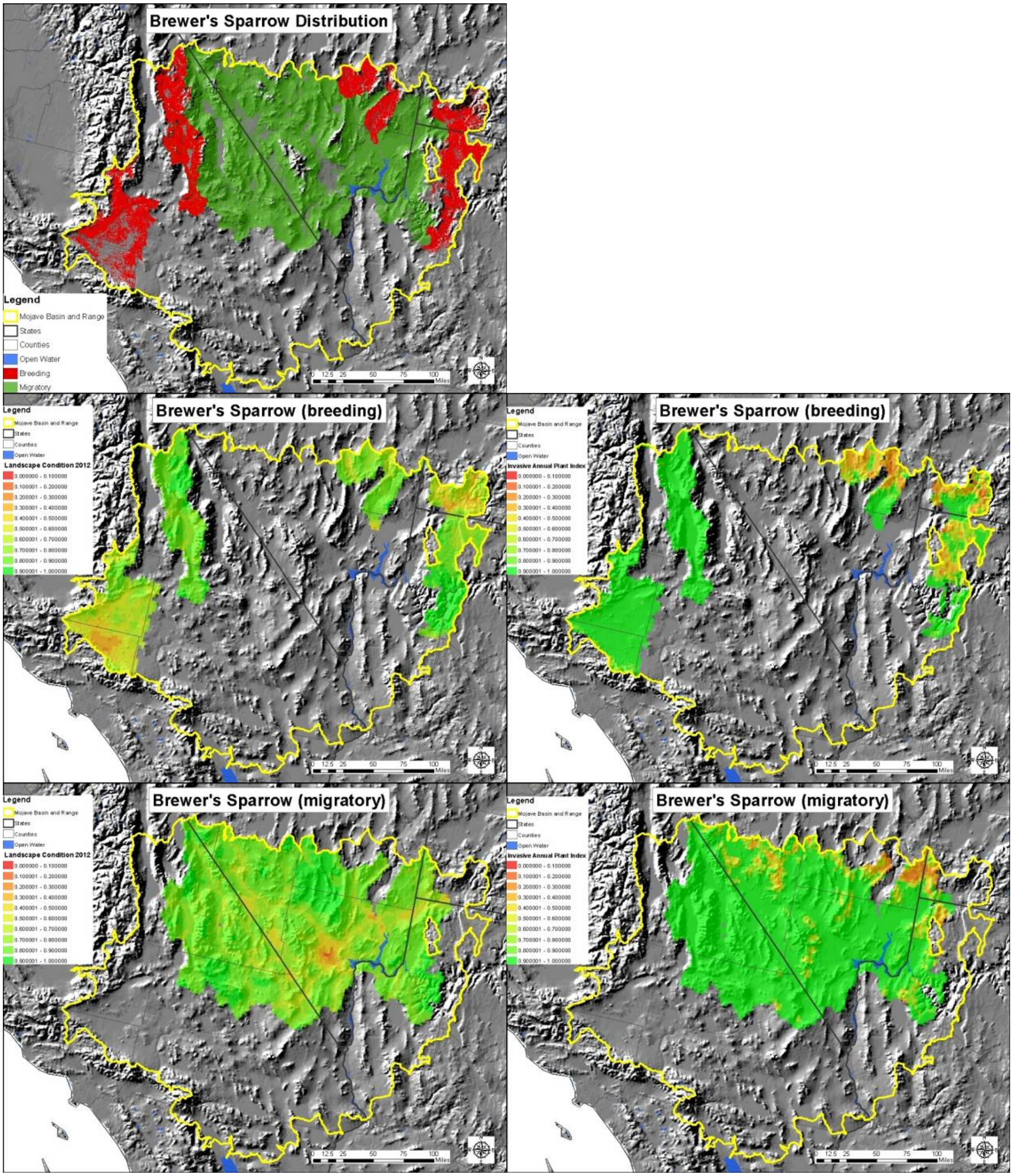


Figure B - 42. Brewer's Sparrow distribution and status: current distribution (top) and current Landscape Condition Index scores (left) and Invasive Annual Grass Index (right) for Breeding (middle) and Migratory (bottom) habitats.

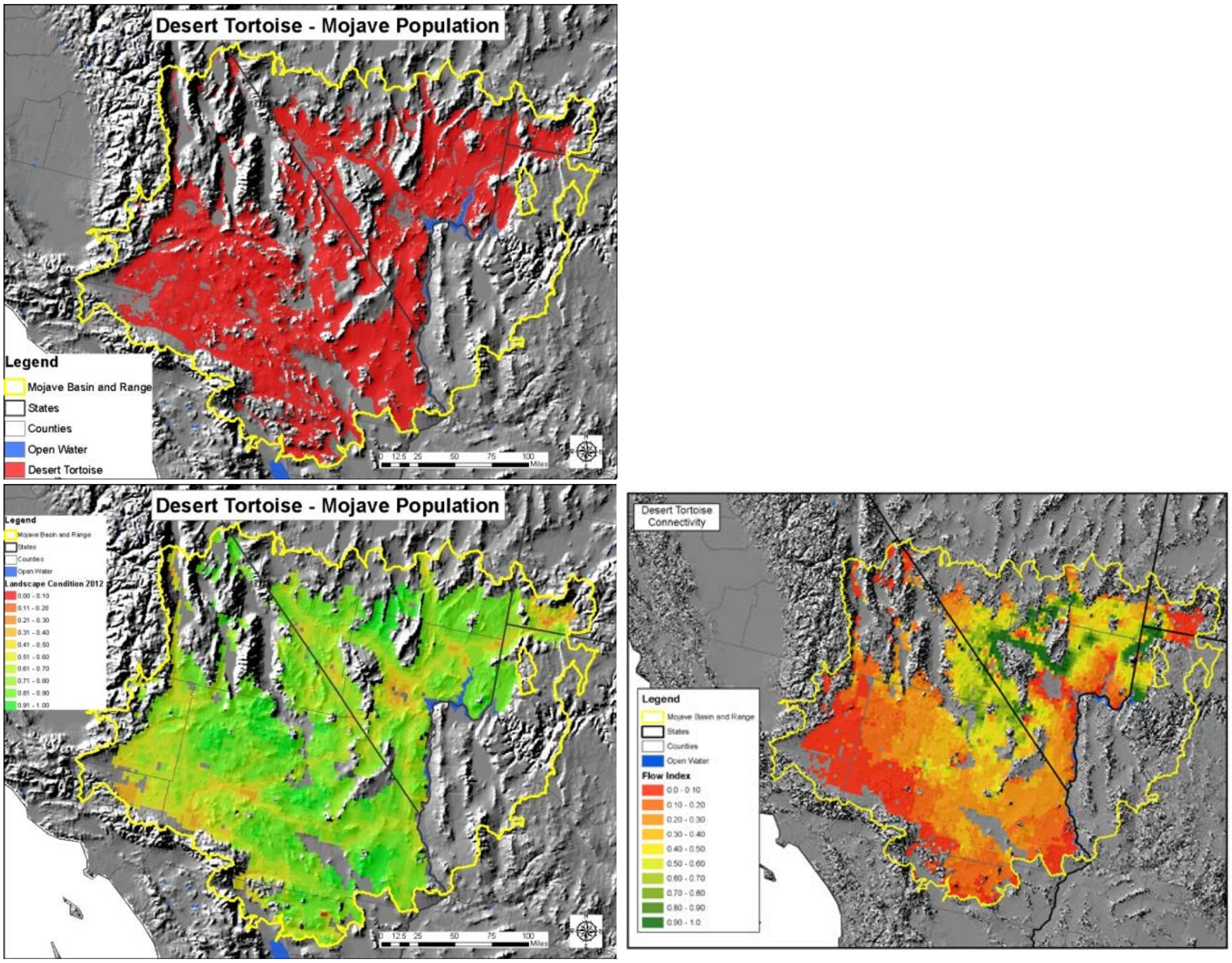


Figure B - 43. Mojave Desert Tortoise current distribution and status: current distribution (top), current Landscape Condition Index scores (left), and Landscape Connectivity scores (right)

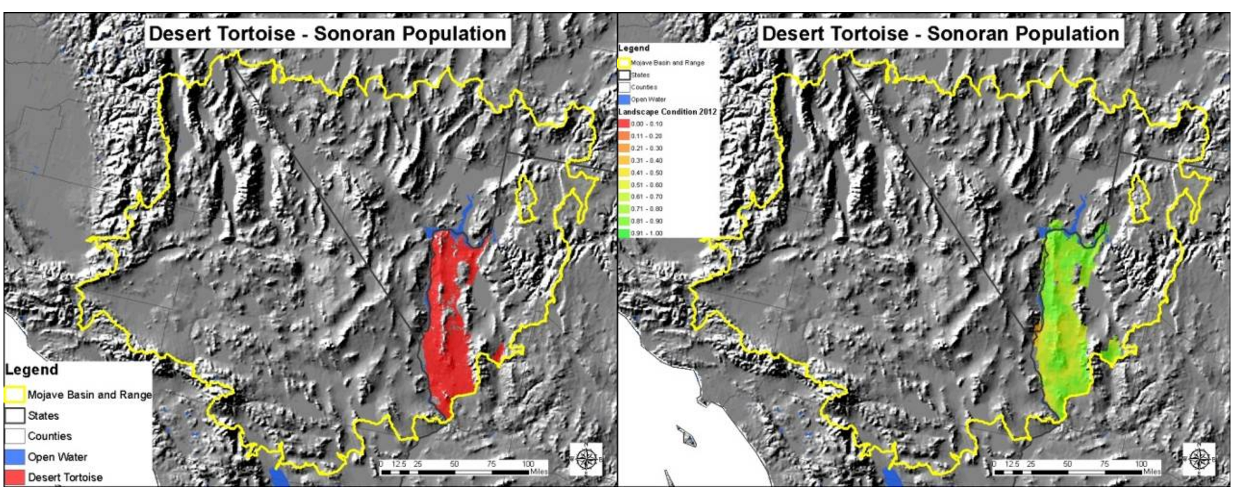


Figure B - 44. Sonoran Desert Tortoise current distribution and current Landscape Condition Index scores

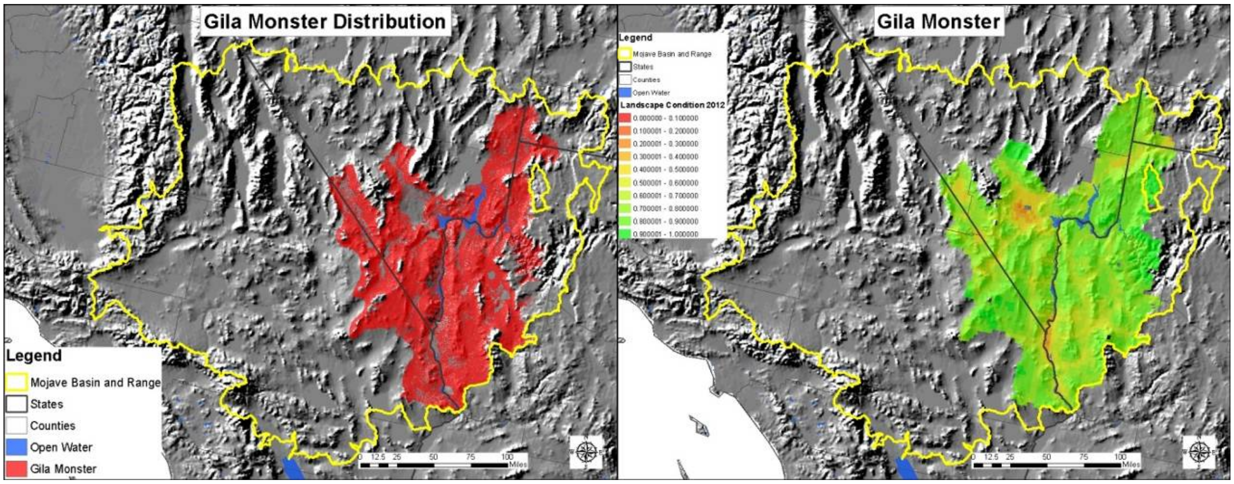


Figure B - 45. Gila Monster current distribution and current Landscape Condition Index scores

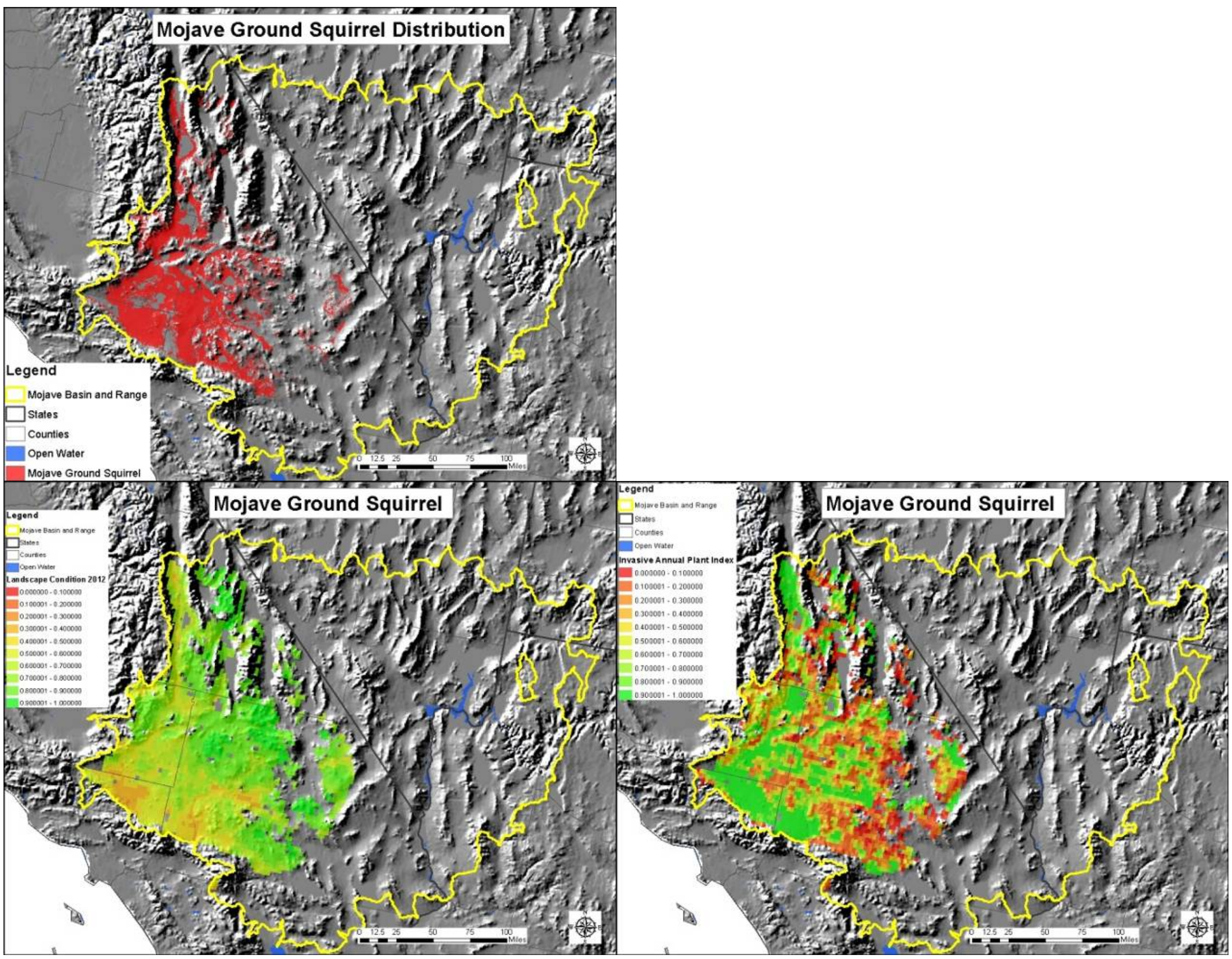


Figure B - 46. Mojave Ground Squirrel current distribution and status: current distribution (top), current Landscape Condition Index scores (left), and Invasive Annual Grass Index scores (right)

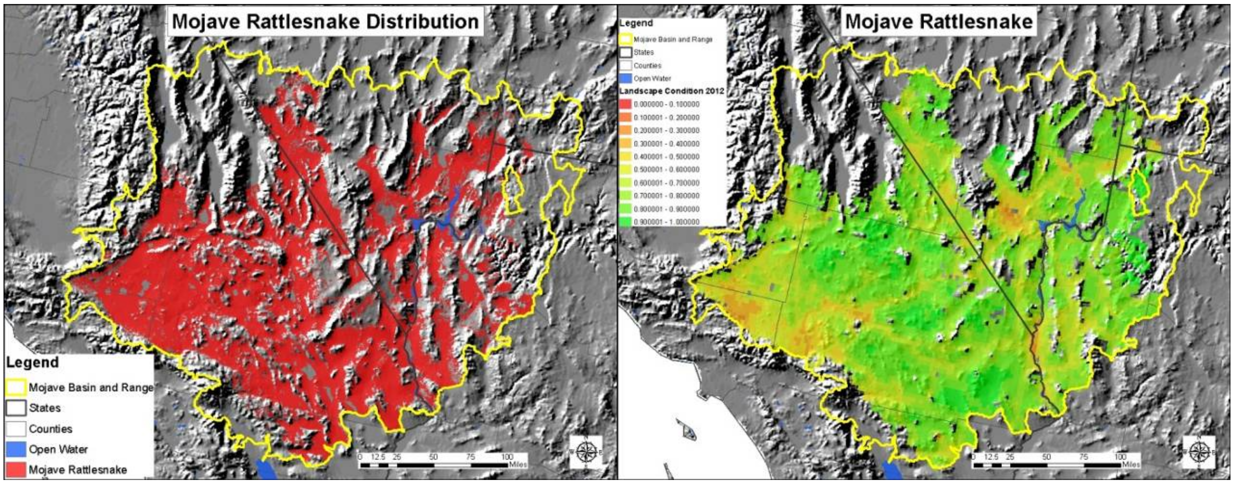


Figure B - 47. Mojave Rattlesnake current distribution and current Landscape Condition Index scores

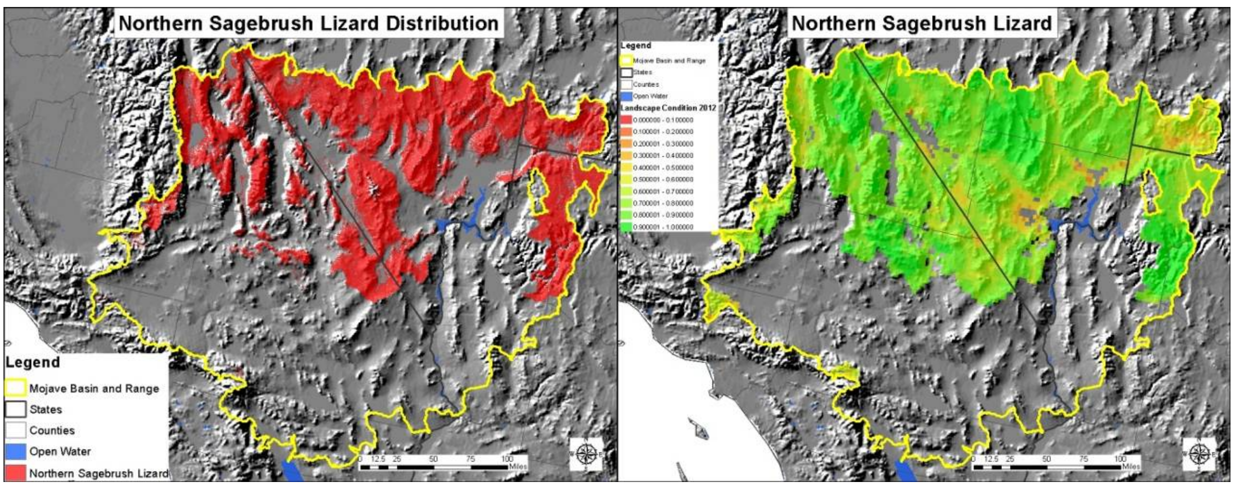


Figure B - 48. Northern Sagebrush Lizard current distribution and current Landscape Condition Index scores

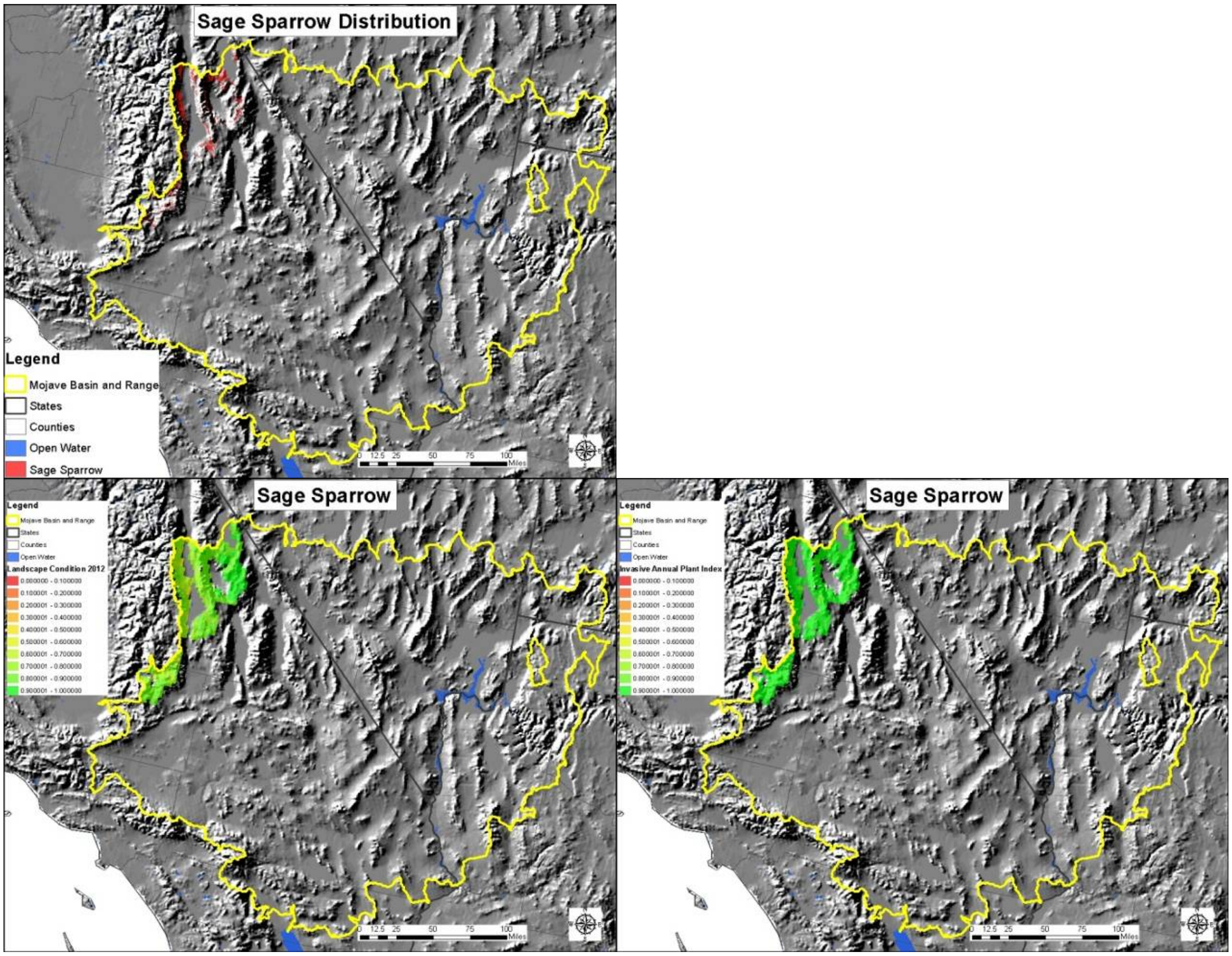


Figure B - 49. Sage Sparrow current distribution and status: current distribution (top), current Landscape Condition Index scores (left), and Invasive Annual Grass Index scores (right)

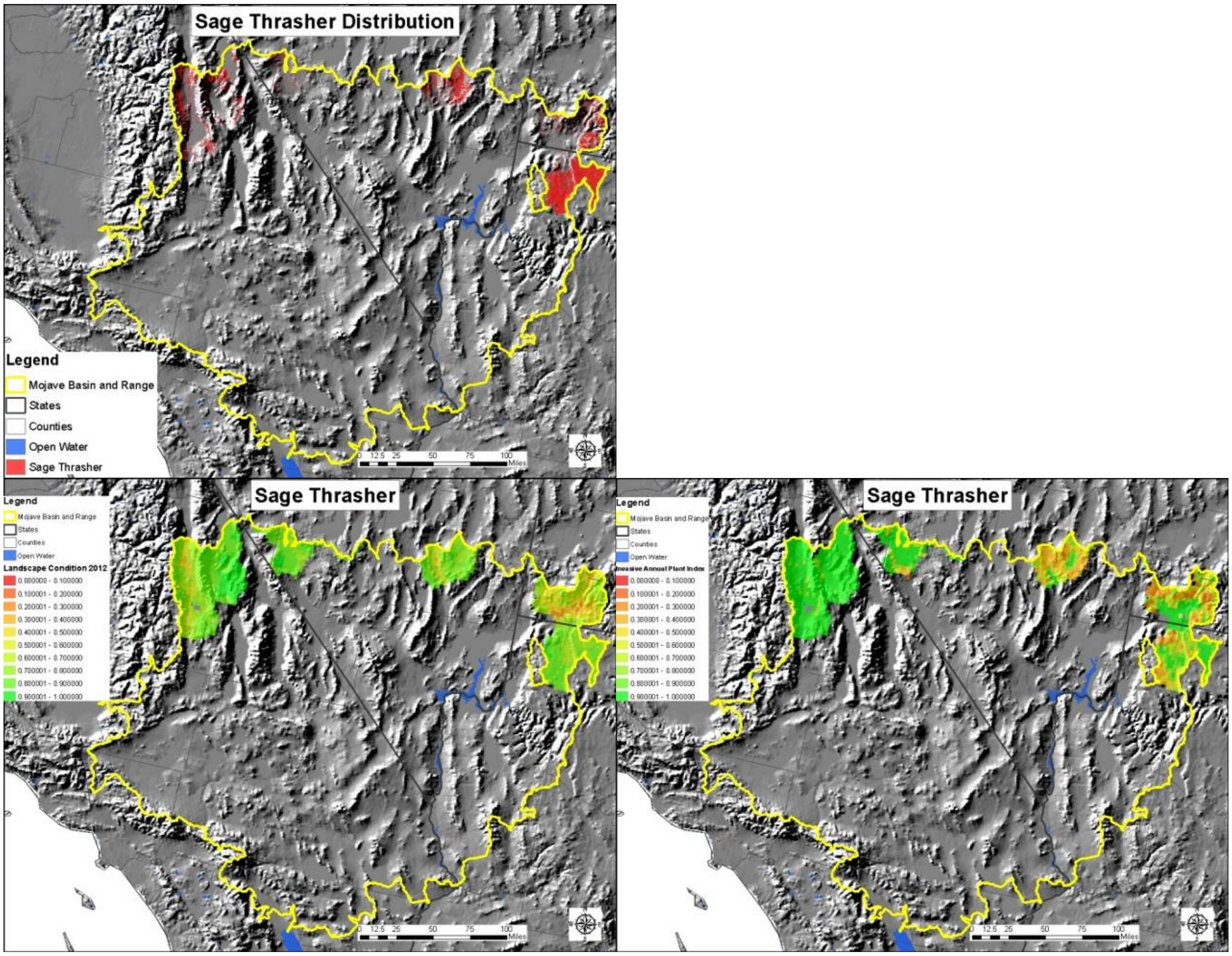


Figure B - 50. Sage Thrasher current distribution and status: current distribution (top), current Landscape Condition Index scores (left), and Invasive Annual Grass Index scores (right)

MONTANE OR BASIN WET ASSOCIATED SPECIES

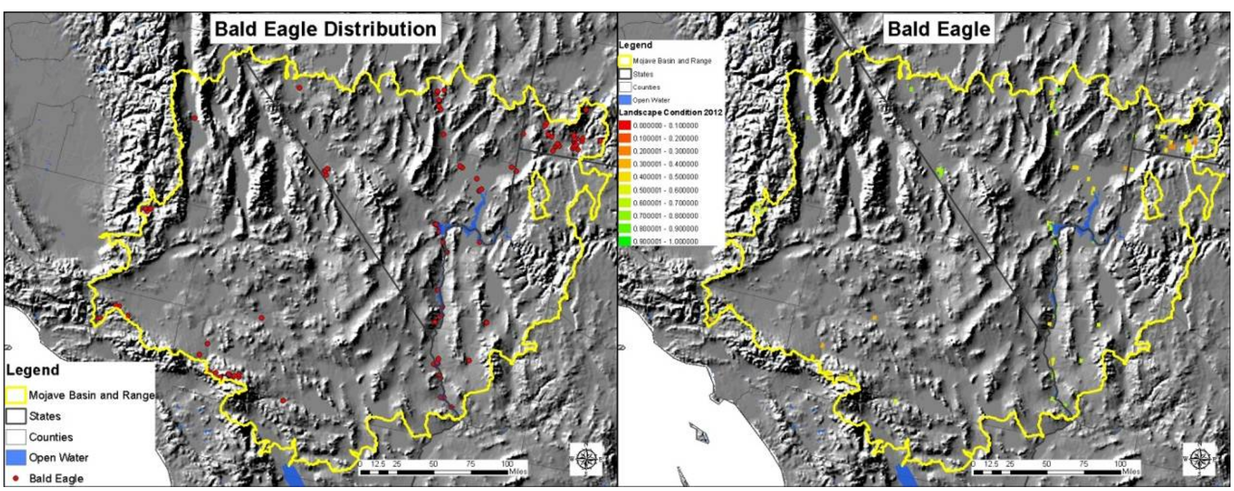


Figure B - 51. Bald Eagle current distribution and current Landscape Condition Index scores

B-2.2.3 Ecological Status: Vulnerable Species Assemblages

Distributions and ecological status for vulnerable species assemblages were assessed across their ecoregional extent using both 4x4 km grid cells and their native 90x90m pixel sizes. The latter were feasibly applied here because indicators were limited to landscape condition and annual grass models, both of which were developed at 90x90m spatial resolution.

Landscape condition appears to be relatively high for the majority of the distribution for each of these CEs, although for Migratory waterfowl & shorebird sites, all of which include margins of waterbodies, generally fragmented landscapes are more characteristic (Table B - 31). The invasive annual grass indicator results appear to vary somewhat among these CEs. In the case of the montane conifer assemblage, there appears to be a distinct bimodal distribution, where some relatively high percentage of each distribution occurs in a relatively high-quality (low invasive abundance) context. This likely indicates a common elevational gradient where portions of these CEs occur above the current elevation for abundant annual invasive grasses, and another portion of the distribution falls below and squarely within the range of landscapes vulnerable to annual invasive species.

Table B - 31. Indicator results by 4 x 4 km grid cell for vulnerable Species Assemblage CEs (Current). For each indicator the count of 4 x 4 km grid cells is shown for each CE, broken out by indicator score interval.

KEA: Landscape Condition											
Landscape Condition Index											
	Count of 4 x 4 km grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Montane conifer	3,867	1	3	68	207	310	419	**553**	**834**	**1175**	297
Azonal carbonate rock crevices	3,456			10	54	131	206	**379**	**787**	**1457**	**432**
Sand dunes/sandy soils (when deep and loose)	2,734	1	1	10	64	149	254	**424**	**721**	**929**	181
Gypsum soils	811		1	7	38	58	80	**157**	**250**	**199**	21
Migratory waterfowl & shorebirds	472		2	18	68	69	**82**	**96**	**80**	42	15
Azonal non-carbonate rock crevices	261						3	7	32	**162**	**57**
Carbonate (Limestone/Dolomite) alpine	68						1	8	12	**35**	12
Non-carbonate alpine	56							4	6	**43**	3
KEA: Stressors on Biotic Condition											
Presence of Invasive Plant Species											
	Count of 4 x 4 km grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Montane conifer	3,868		37	**169**	**120**	87	101	96	133	197	**2928**
Sand dunes/sandy soils (when deep and loose)	2,729		9	32	9		14	5	8	22	**2630**
Gypsum soils	810			7	3	3	2		2	1	**792**

Maps of Vulnerable Species Assemblage CEs Current Distribution and Ecological status

The current distribution and the spatial results of the ecological status assessment for a selection of the vulnerable species assemblages CEs are presented in Figure B - 52 and Figure B - 53.

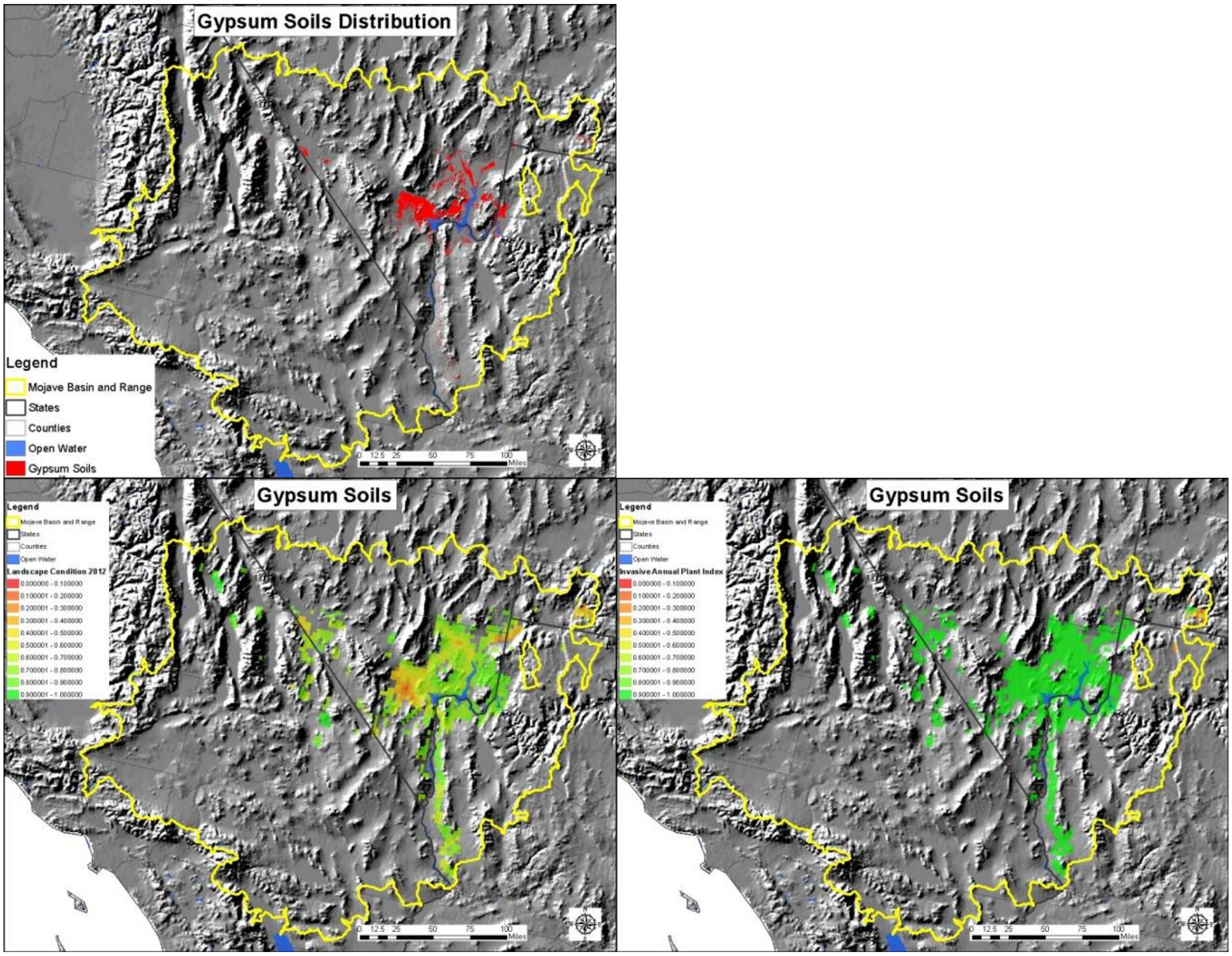


Figure B - 52. Gypsum Soils Species Assemblage distribution and status: current distribution (top left), current Landscape Condition Index scores (bottom left), and Invasive Annual Grass Index scores (bottom right).

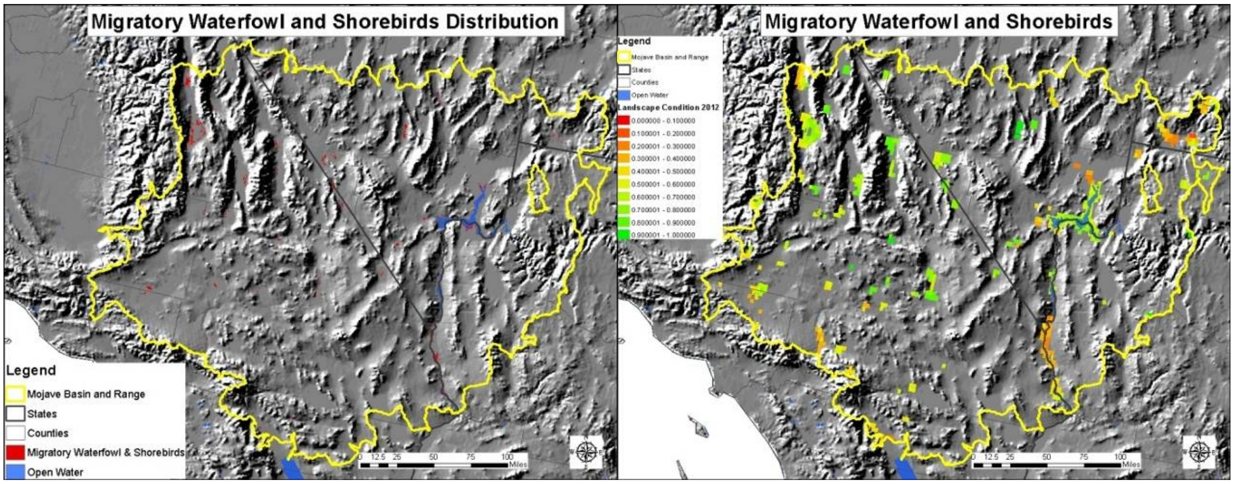


Figure B - 53. Migratory waterfowl & shorebirds current distribution and current Landscape Condition Index scores

B-2.2.4 Ecological Status: Aquatic Conservation Elements (Methods and Results)

The ecological status of aquatic conservation elements (see Table B - 33 and Figure B - 54 through Figure B - 69 below) shows a consistent pattern across all coarse-filter CEs. Most of the impact arises in the more developed areas of the ecoregion, where agriculture and urban development are greatest. Water quality is potentially affected by Nitrate atmospheric deposition. Atmospheric deposition of Mercury, while present, occurs at rates among the lowest in the country. Riparian areas & bosques, washes, playas, springs and lakes at lower elevations are experiencing greater degrees of stressor impacts than occurrences of these CE types at higher elevations. In exception to this pattern, however, flow modification by dams has a greater impact on upper elevation riparian resources, as dams are generally located higher in the watershed. Of the 16 calculated metrics (Table B - 32), 9 are measured at the watershed scale such that the scores do not vary by CE. The remaining 7 are measured at the local scale, at the CE occurrence. These indicators scores change based on the CE type. So overall watershed summary statistics are best found in the watershed scale indicators and local, site-specific scores, are available by CE by watershed.

Table B - 32. Indicators used to assess ecological condition of 5 Key Ecological Attributes of Aquatic Resources and their scale of measurement.

Key Ecological Attribute	Occurrence Scale Indicators	Watershed Scale Indicators
I. Change in Extent/Size	01. Riparian Corridor Continuity	
II. Surrounding Land Use Context	03. Fragmentation by Dams	02. Landscape Condition Index
III. Stressors on Hydrology Condition		04. Surface Water Use
		05. Groundwater Use
		06a. Perennial Flow Modification by Diversion Structures
	06b. Flow Modification by Dams	
		07. Condition of Groundwater Recharge Zone
		KEA-Hydrology Condition (average of indicators 4-7)

		08a. Atmospheric Deposition - Nitrate Loading (NO_3)
		8b. Atmospheric Deposition - Toxic Mercury Loading (Hg)
IV. Stressors on Water Quality	09. State-Listed Water Quality Impairments	
	10. Sediment Loading Index (within 100 m buffer)	
		KEA- Water Quality (average of indicators 8-10)
V. Stressors on Biotic Condition	11. Presence of Invasive Plant Species	
	12. Presence of Invasive Aquatic Species	

B-2.2.4.1 Aquatic Indicator Summary

I. Change in Extent/Size

Indicator 01 Riparian Corridor Continuity

Definition: Changes in riparian corridor connectivity affect the flow of animals and nutrients with larger, longer corridors providing greater extent of habitat for wildlife and increased buffering capacity to the aquatic resource. **Corridor Connectivity**—a measure of the degree to which the riparian area buffered to 200 m exhibits an uninterrupted (linear, un-fragmented) vegetated corridor of natural vegetation (as opposed to agricultural or developed areas).

Rationale: Historic land contemporary and use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. The intensity of land use within the buffered area of the riparian area is a surrogate measure for direct impact land use limiting movement of water, sediments, nutrients and animals within the aquatic corridor. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. The extent of this conservation element (riparian ecosystem) has decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Methods: NatureServe Terrestrial Ecosystems and Land Cover 2000-2003 and the NatureServe Landscape Condition, data current as of 2005. The distribution of a riparian CE was buffered it by 100 m (each side), and calculated the number of continuous polygons within a 5th level watershed. The Landscape Condition Model 30 m grid was overlain and where values were <.70 within the polygon, the riparian corridor was considered fragmented or broken at that point. The number of resulting polygons was divided by the original number to calculate the % or degree of continuity. Continuity was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value), where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: The riparian corridor is fragmented by land development in more watersheds containing occurrences of the North American Warm Desert Riparian Woodland and Mesquite Bosque/ Stream CE than in watersheds containing the higher elevation North American Warm Desert Lower Montane Riparian Woodland and Shrubland/ Stream CE. The worst scoring watersheds are located in the northern part of the ecoregion, where military lands have numerous roads crisscrossing the valley floors. Watersheds with low scores on this indicator also occur in areas with significant land development, such as around Henderson, NV. (Figure B - 54)

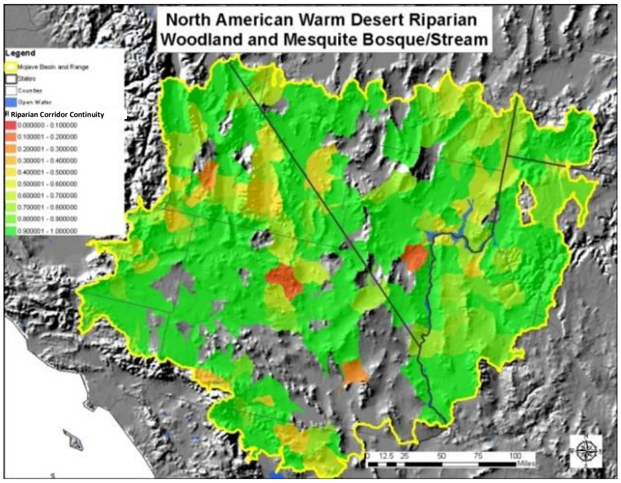


Figure B - 54. Riparian Corridor Continuity

II. Surrounding Land Use Context

<u>Indicator 02 Landscape Condition Index</u>

Definition: Surrounding Land Use Context—a measure of landscape condition related to land use that affects aquatic and wetland conditions. **Landscape Condition Model Index**—a measure of the intensity of various land uses on ecosystem processes, including intensity of nutrient, pollutant, sediment and surface water runoff into aquatic CEs. The Landscape Condition Index is a 30 meter by 30 meter resolution map or surface that incorporates a land use intensity rating and a distance decay function, reflecting decreasing ecological impact with distance from the source. The results are a score for landscape condition from 0 to 1 with 1 being very high landscape condition and values close to 0 likely having very poor condition.

Rationale: There are growing sets of information on various kinds of stressors that impact ecosystems. Danz et al. (2007) noted that “Integrated, quantitative expressions of anthropogenic stress over large geographic regions can be valuable tools in environmental research and management.” When they take the form of a map, or spatial model, these tools initially characterize ecological conditions on the ground; from highly disturbed to apparently unaltered conditions. They can be particularly helpful for screening candidate reference sites; i.e., a set of sites where anthropogenic stressors range from low to high. Ecological condition of reference sites are further characterized to determine how ecological attributes are responding to apparent stressors. This knowledge may then apply in other similar sites. Anthropogenic stressors come in many forms, from regional patterns of acid deposition or climate induced ecosystem change, to local-scale patterns in agricultural drainage ditches and tiles, pointsource pollution, land-conversion, and transportation corridors, among others. To be effective, a landscape condition model needs to incorporate multiple stressors, their varying individual intensities, the combined and cumulative effect of those stressors, and if possible, some measure of distance away from each stressor where negative effects remain likely. Since our knowledge of natural ecosystems is varied and often limited, a primary challenge is to identify those stressors that likely have the most degrading effects on ecosystems or species of interest. A second challenge is to acquire mapped information that realistically portrays those stressors. In addition, there are tradeoffs in costs, complexity, the often varying spatial resolutions in available maps, and the variable ways stressors operate across diverse land and waterscapes.

Historic land contemporary and use practices have impacted hydrologic, geomorphic, and biotic structure and function of aquatic resources. Human land uses both within buffer zones as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian and wetland patches and upland areas. The intensity of land use within the surrounding watershed affects downstream wetlands and riparian areas. Land use impacts vary in their intensity, affecting ecological dynamics that support ecological systems. This includes indices for Nutrient Loading, Sediment loading, and Surface water runoff in the surrounding 5th level watershed (10 digit watershed). The Landscape condition Model index is a surrogate measure for direct impact land use affecting the amount and timing of water, sediments, nutrients and animals movement within the surrounding landscape that supports the aquatic corridor and other resources. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. The extent of this conservation element (riparian ecosystem) has decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Methods: NatureServe Landscape Condition, data current as of 2011. This index of landscape condition is modeled on the presence of various infrastructure features, anthropogenic land uses, and other factors (e.g., invasive species) that may negatively affect native biodiversity. The condition model goes beyond a basic anthropogenic footprint by incorporating the intensity of the impact of the footprint feature or land use (e.g., an interstate highway has a greater impact than an unpaved road) and the distance to which the effects of the feature or land use are felt (i.e., for some features the impact extends with decreasing intensity to some distance away from that feature). The model is 30 m pixel raster. For Aquatic conservation elements this model represents the surrounding landscape context for aquatic CEs. Values were averaged of all 30 m pixels by watershed for a 5th level watershed single value. This single average value was applied to all aquatic CEs within each watershed.

Results: The score values for this indicator, across all aquatic CEs, mostly fall within the mid-range. This indicates that most watersheds are somewhat compromised for this indicator across the ecoregion. Many of the compromised watersheds are concentrated around Las Vegas, NV, Victorville, CA and St. George, UT. The scores range from 0.48 to 0.84, not a wide range. The scores are an average of the Landscape Condition Model output for all 30 m pixels in each watershed, and each watershed contains both lower basin and upper basin topography. Most development in the ecoregion occurs across the basin (valley) floors, while higher elevations mostly show little development. The effect on the indicator score for a given watershed from high development across the valley floor therefore is generally offset by the effects of low development across the higher elevations of the watershed, even in watersheds with dense development (e.g., Las Vegas, St. George, and Victorville). (Figure B - 55)

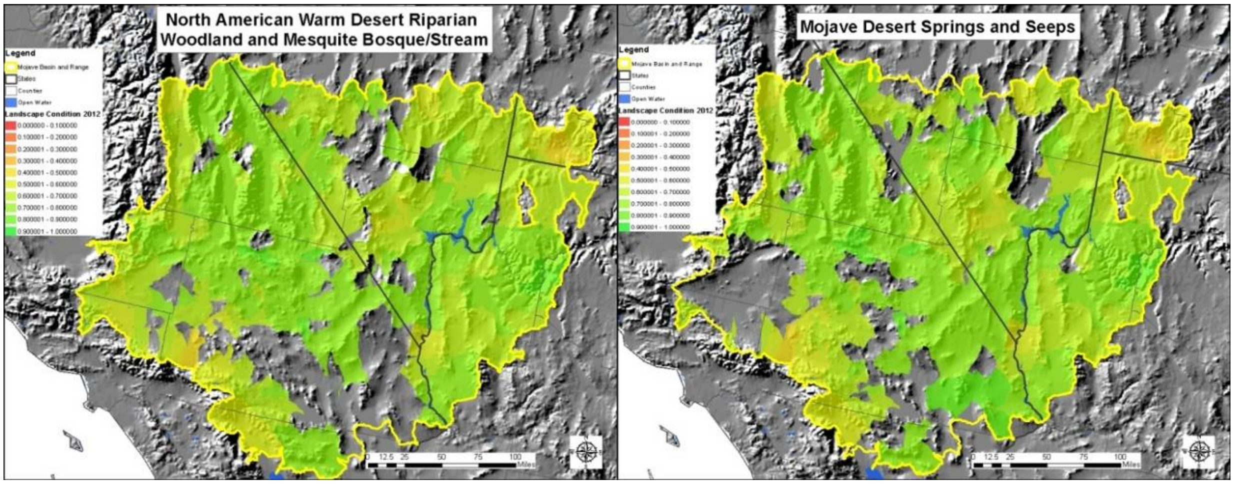


Figure B - 55. Landscape Condition Index

Indicator 03 Perennial Flow Network Fragmentation by Dams

Definition: Changes in perennial flow affect the flow of animals and nutrients with longer corridors providing greater extent of habitat for wildlife and increased buffering capacity to the aquatic resource. **Perennial Flow fragmentation by dams**—a measure of the degree to which the perennial flow is interrupted by dams (as provided by the NHD data).

Rationale: Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Specifically dams limit the movement of water, sediments, nutrients and animals within the aquatic corridor. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. The extent of this conservation element (riparian ecosystem) has decreased in extent due to dams for water, agricultural and recreational development, and other flood-control activities.

Methods: National Hydrography Dataset - 1:100,000, data current as of 2005. The number of dams (designated by the National Inventory of Dams) that occur on NHD designated perennial streams were summed by each 5th level watershed. The number of Dams per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Few watersheds in this ecoregion have perennial flowing water, and the ecoregion therefore provides few locations suitable for dams. Specifically, only 17 of the 315 watersheds contain dams (according to NHD), 13 of those 17 contain only a single dam, three contain 2-5 dams, and one, the Moapa Valley, has 10 dams. The dams in Moapa Valley are not large (compare to Indicator 06b, below), simply numerous. (Figure B - 56)

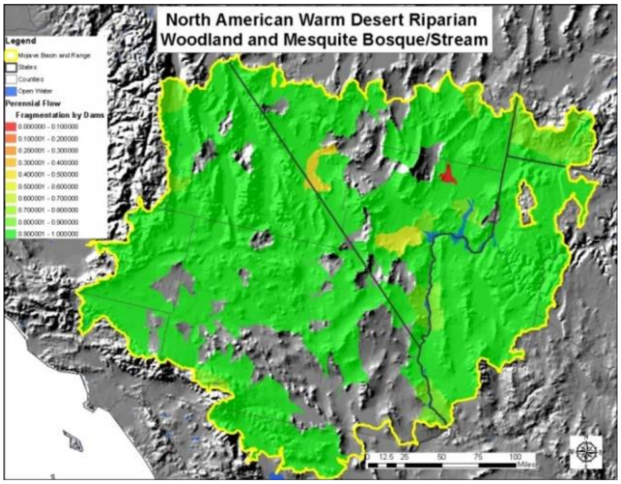


Figure B - 56. Perennial Flow Network Fragmentation by Dams

III. Stressors to Hydrology Condition

<u>Indicator 04 Surface Water Use</u>

Definition: Surface Water Use measures the intensity of use of surface water resources within a watershed for agricultural irrigation and for public water supply. Intensity is defined not as the absolute volume of annual consumption of surface water resources, but as the ratio of this annual consumption to the average amount of surface water available for discharge by the watershed. This ratio represents the annual rate of surface water use relative to natural surface water availability, in order to control for (i.e., cancel out) the effects of natural differences in surface water availability between watersheds due to differences in watershed size, weather, and topography. The calculation does not assume that the surface water consumed in a watershed derives exclusively from natural runoff within the watershed. It merely provides a convenient basis for making comparisons among watersheds. As the results indicate, importation of surface water (through inter-basin transfers) provides significant amounts of the surface water consumed in some watersheds.

Raw annual surface water consumption is calculated from the results of the USGS Southwest Principal Aquifers (SWPA) Study (Anning et al. 2009; McKinney and Anning 2009). The methodology for this study rests on the long-term USGS program for reporting on water use in the conterminous U.S., which reports on water use by county on a five-year cycle. The SWPA used the county values for the year 2000, and allocated water use within counties to 100 x 100 meter cells. Specifically, it allocated agricultural consumptive water use based on the distribution of irrigated lands; and allocated public water supply consumptive use based on the distribution of "urban" lands. Urban lands were defined as areas with a population density greater than 386 persons per square kilometer, based on the 2000 census. Average annual surface water availability is calculated from the National Hydrography Dataset. The raw ratio of annual surface water consumption to average annual water availability has a theoretical range from 0 to >100% for any given year, depending on weather conditions and the availability of imported surface water.

Rationale: Surface water use for agriculture and public water supply in desert ecoregions removes water from natural surface waters where it otherwise would have supported natural aquatic ecosystems. Consumptive use of surface waters reduces the total amount of surface water available to support these natural ecosystems; the timing of water withdrawals alters the timing of water availability (i.e., the hydrologic regime) in these natural ecosystems; and return flows (if any) from surface water use may alter the chemistry of natural surface waters as well as contribute to further changes in their hydrologic regime. Impoundments built to store surface water for later use also cause further alterations to the hydrologic regime of natural surface waters downstream. And water use built on imported surface water has the potential to result not only in greater water consumption but greater recharge of local aquifers and greater return flows, both of which can affect the chemistry and hydrologic regime of natural surface waters. Surface water use is thus a potentially significant stressor affecting overall water availability and the hydrologic regime of natural surface waters. These latter factors are critical to the ecological integrity of these natural surface waters. The indicator identifies watersheds in which surface water use is low or high relative to the natural availability of surface water, in order to identify those watersheds in which the risk of impacts to natural surface waters from surface water use is low or high.

Methods: USGS Southwest Principal Aquifer Study, 2008 and the National Hydrography Dataset - 1:100,000, data current as of 2005. The watershed average annual surface discharge in acre-feet/year (afy) was calculated by summing the total annual flow (cfs) from NHD perennial reaches per watershed. Surface water use (afy) for each watershed was calculated by summing the gridded (100m x 100m) values provided by the USGS Southwest Principal Aquifer Study for that watershed. To compare values across watersheds, we needed to correct the data for watershed size and amount of precipitation or wetness, otherwise larger and more wet watersheds would always show the highest values. By calibrating the use data by the total surface runoff we can compare water use watershed to watershed. The ratio of surface water use to average annual surface discharge was calculated for each watershed. To do this we had to convert the NHD-derived data on average annual surface discharge in cubic-feet/second (cfs) to acre-feet/year (afy) by multiplying cfs by 724 (rounded conversion factor). [A stream flowing at 1 cfs, 24 hours/day, 365 days/year, will discharge a total of 31,536,000 cubic feet of water, which is enough to cover an area of 1.13 square miles a foot deep in water. There are 640 acres in a square mile, and therefore 640 acre-feet in a square mile of water that is one foot deep. Hence, that dribble of 1 cfs produces 1.1312 * 640 = 724 acre-feet of water in a year.]

The resulting ratio of Surface water usage per watershed was subject to a log (base 10) transformation. To normalize the scores between 0 and 1, the lowest value was added back to each score to create all positive value scores, then converted to a normalized score by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Surface water use is generally very low in the ecoregion, as a percentage of natural surface runoff (as recorded in the NHD). Several watersheds show use rates well above 100% of natural surface runoff, covering the Lancaster, Banning, and Palm Springs-Indio areas in California; and the Las Vegas area in Nevada. Surface water use in these areas exceeds 100% of natural surface runoff as a result of the consumption of water imported from watersheds of varying distance. Surface water use rates approaching 100% of natural surface runoff also occur in watersheds adjacent to those with higher rates, and in a cluster in northwest Arizona presumably associated with local diversions from the Colorado River and/or Bill Williams River. These results are consistent with the distribution of urban and agricultural development within the ecoregion. Alterations to natural stream and river, and possibly lake hydrologic regimes are likely significant in these watersheds. (Figure B - 57)

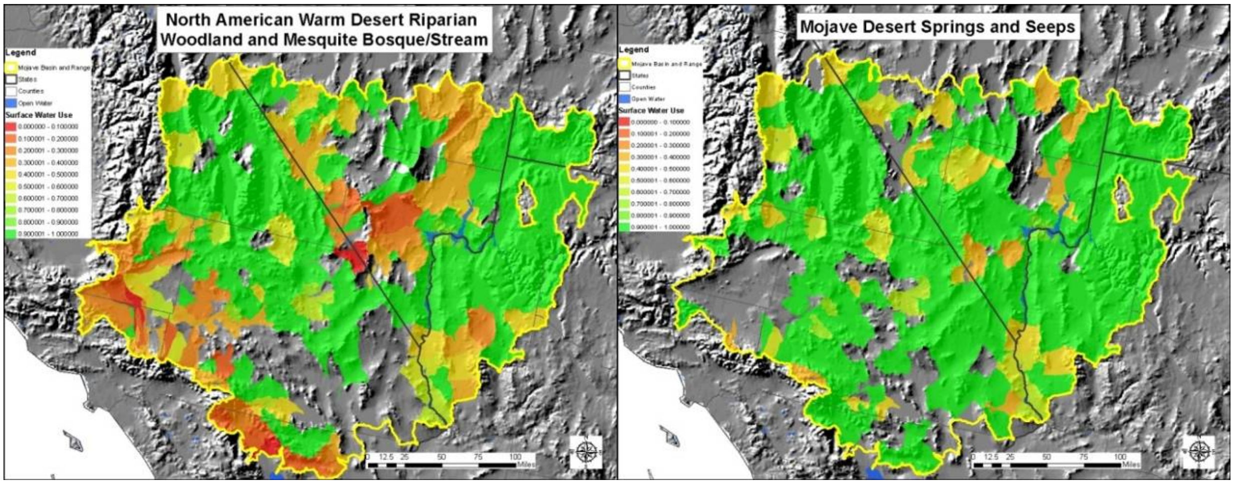


Figure B - 57. Surface Water Use

Indicator 05 Groundwater Use

Definition: Groundwater Use measures the intensity of use of groundwater resources within a watershed for agricultural irrigation and for public water supply. Intensity is defined not as the absolute volume of annual consumption of groundwater resources, but as the ratio of this annual consumption to the average amount of surface water naturally available for discharge by the watershed. This ratio merely provides a convenient basis for making comparisons among watersheds, which differ in the availability of groundwater due to differences in their size and geology, particularly the size of their basin-fill aquifer(s) and the connection of these basin-fill aquifers to regional aquifers (e.g., Heilweil and Brooks 2011). No systematic, map-ready data on groundwater resource distributions were available for the ecoregion as a whole, against which to compare groundwater use rates. Such data are available only for select areas subject to individual resource studies (e.g., BLM 2011; Heilweil and Brooks 2011). Nevertheless, some basis was needed to assess groundwater use at the watershed scale while controlling for the effects of variation in watershed size, topography, and the availability of precipitation to supply recharge. In the absence of direct measures of these effects, the availability of surface water was used instead as a basis for standardization, since this latter variable is readily quantified and is at least sensitive to variation in watershed. Use of this ratio does not require any assumption that the groundwater consumed in a watershed was recharged exclusively from the natural runoff within the watershed; or that there was any other hydrologic connection between the runoff of a watershed and its groundwater system. The ration merely allows more meaningful comparisons between watersheds.

Raw annual groundwater consumption is calculated from the results of the USGS Southwest Principal Aquifers (SWPA) Study (Anning et al. 2009; McKinney and Anning 2009). The methodology for this study rests on the long-term USGS assessment of water use in the conterminous U.S., which reports on water use by county on a five-year cycle. The SWPA used the county values for the year 2000, and allocated water use within counties to 100 x 100 meter cells. Specifically, it allocated agricultural consumptive water use based on the distribution of irrigated lands; and allocated public water supply consumptive use based on the distribution of “urban” lands. Urban lands were defined as areas with a population density greater than 386 persons per square kilometer, based on the 2000 census. Average annual surface water availability is calculated from the National Hydrography Dataset.

The raw ratio of annual groundwater consumption to average annual surface water availability for a given year can register as low as 0%, in watersheds with no groundwater use; and can register as far greater than 100% in watersheds with very high levels of groundwater use. However, a value greater than 100% *may or may not* indicate groundwater withdrawals are occurring at a rate greater than local (within-watershed) average annual recharge. The relationship between average annual surface water availability and local recharge depends on the interplay of numerous factors. These factors include the magnitude of local recharge and evapotranspiration; the effects of regional groundwater systems; and the connectivity among alluvial, basin-fill, and regional aquifers. These factors are subject to intense debate wherever conflicts arise – as they frequently do – over groundwater withdrawals (e.g., BLM 2011; GBWN 2011; Burns et al. 2011). In general, however, regional aquifer systems and rivers with alluvial deposits that span multiple watersheds may support groundwater levels in individual watersheds independent of locally available recharge (BLM 2011; Heilweil and Brooks 2011).

The raw within-watershed ratio of annual groundwater consumption to average annual surface water availability in the MBR ecoregion varies from 0% to 6,702%, but with a highly skewed distribution; most values fall toward the lower end of the scale. This skewing makes it difficult to distinguish significant differences. For example, there may be little practical difference between a watershed with a use ratio of 1,000%, from a watershed with a ratio of 6,000%; both represent instances of very intense groundwater use. Conversely, a use ratio of 50% may represent a far lower rate of use than a ratio of 100%. To facilitate analysis, therefore, the raw values were transformed to their logarithms ($\log_{10}$), resulting in a far less skewed distribution. Watersheds with a raw use rate of 0 were assigned a log value equal to that of the lowest non-zero percentage measured for any watershed in the ecoregion ($\log_{10}$ = -3.7). The resulting range of log values from -3.7 to +3.8 better distinguishes among use rates by their order of magnitude. For purposes of the scorecard, the results were then normalized to range from 0 to 1.

Rationale: Natural groundwater discharges in desert ecoregions, including the MBR ecoregion, support islands and corridors of aquatic and riparian biodiversity within these ecoregions, which in turn often support rare or unique biotic assemblages. The integrity of ecosystems strongly affected by groundwater discharges depends both on the amount of groundwater discharged to the ecosystem; and (usually) on the unique temperature and chemistry regimes of the groundwater, as well (e.g., Winkler, ed., 1977; Constantz 1998; Manning 1999; Deacon et al. 2007; Patten et al. 2007; Jones et al. 2009; Abele, ed. 2011; BLM 2011). Groundwater use for agriculture and public water supply in these ecoregions removes water from aquifer systems, the potentiometric surfaces and natural discharges of which originally supported groundwater levels in wetlands; spring discharges and stream baseflows; subsurface discharges to lakes; and surface water levels in wetlands that received inflows from these latter sources. The removal of groundwater therefore has the potential to disrupt several kinds of natural aquatic ecosystem types in desert ecoregions in general, including the MBR ecoregion. Groundwater withdrawals in an individual watershed potentially may also affect groundwater dependent ecosystems in other watersheds, by intercepting groundwater that otherwise would have flowed to these other watersheds along regional and alluvial aquifer flow paths.

Groundwater use is thus a potentially significant stressor affecting overall water availability, temperature, and chemistry in natural groundwater dependent habitats. The indicator identifies watersheds in which groundwater use is low or high relative to the natural availability of surface water, in order to identify those watersheds in which the risk of impacts to natural surface waters from groundwater use is low or high. These risks may apply within the immediate watershed where the use takes place, or in additional watersheds that lie down-gradient along regional and alluvial groundwater flow paths. Mapping such possible groundwater flow paths, however, was not possible within the scope of this rapid assessment; such flow paths are in fact commonly topics of great uncertainty and debate (e.g., Deacon et al. 2007; BLM 2011; GBWN 2011; Burns et al. 2011).

Development of the MBR ecoregion for human settlement and farming has necessarily involved withdrawals of groundwater. These withdrawals have reduced or eliminated natural groundwater contributions to springs, streams, seeps, and wetlands. The sustainability of this development of water resources is a topic of increasing heated debate, particularly as surface water supplies become increasingly over-allocated and uncertain (e.g., Gleick 2010; Deacon et al. 2007; BLM 2011; GBWN 2011; Burns et al. 2011; SNWA 2011).

Methods: USGS Southwest Principal Aquifer Study, 2008 and the National Hydrography Dataset - 1:100,000, data current as of 2005. The watershed average annual surface discharge in acre-feet/year (afy) was calculated by summing the total annual flow (cfs) from NHD perennial reaches per watershed. Groundwater use (afy) for each watershed was calculated by summing the gridded (100m x 100m) values provided by the USGS Southwest Principal Aquifer Study for that watershed. To compare values across watersheds, we needed to correct the data for watershed size and amount of precipitation or wetness, otherwise larger and more wet watersheds would always show the highest values. By calibrating the use data by the total surface runoff we can compare water use watershed to watershed. Even though the amount of surface runoff may have no bearing on the amount of groundwater available or its rate of re-charge, there are no groundwater data available for this REA, and again we wanted to calibrate the use data in order to compare watershed to watershed use data. The ratio of groundwater use to average annual surface discharge was calculated for each watershed. The NHD-derived data on average annual surface discharge in cubic-feet/second (cfs) was converted to acre-feet/year (afy) by multiplying cfs by 724 (rounded conversion factor). [A stream flowing at 1 cfs, 24 hours/day, 365 days/year, will discharge a total of 31,536,000 cubic feet of water, which is enough to cover an area of 1.13 square miles a foot deep in water. There are 640 acres in a square mile, and therefore 640 acre-feet in a square mile of water that is one foot deep. Hence, that dribble of 1 cfs produces 1.1312 * 640 = 724 acre-feet of water in a year.]

The resulting ratio of groundwater usage per watershed was subject to a log (base 10) transformation. To normalize the scores between 0 and 1, the lowest value was added back to each score to create all positive values, then converted to a normalized score by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Groundwater use is generally low in the MBR ecoregion when expressed (for comparison purposes only) as a percentage of natural surface runoff as recorded in the NHD, but many watersheds nevertheless exhibit high rates of groundwater use. watersheds with extremely high use rates, well above 100% of natural surface runoff, occur in the vicinities of Lancaster, Victorville, Banning, Pearsonville, Barstow, and Palm Springs in California; and the greater Las Vegas area in Nevada. Additional watersheds show use rates approaching 100% of natural surface runoff, mostly immediately adjacent to the extreme cases, but also in the Owens Valley of CA, along the valleys extending northwest and northeast of Las Vegas, and in northwestern AZ. These results are consistent with the distribution of urban and agricultural development within the ecoregion. The agricultural uses involve center-pivot irrigation, which is readily identifiable in satellite imagery. Withdrawals from alluvial, basin fill, and regional aquifers have the potential to affect the hydrologic regime of perennial streams, wetlands, and springs in all affected watersheds, as well as in watersheds that receive or once received surface or groundwater from the affected watersheds. Some groundwater use in the ecoregion may also draw from aquifers recharged artificially by infiltration from surface water use and/or long-term leakage from large aqueducts. (Figure B - 58)

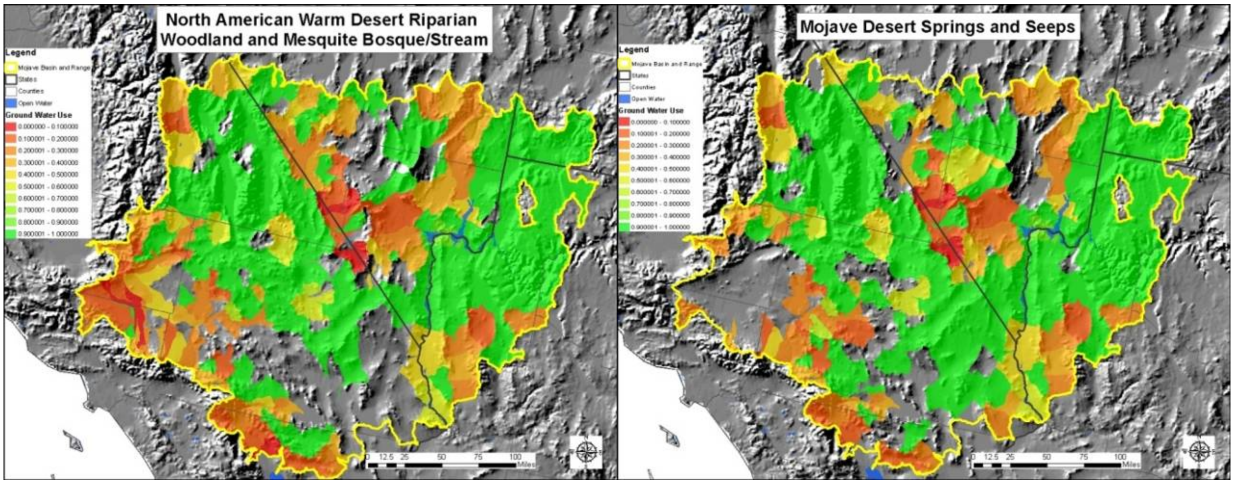


Figure B - 58. Groundwater Use

Indicator 06a Perennial Flow Modification by Diversion Structures

Definition: Flow modification by diversion structures (aqueducts) is measured by a tally of the number of diversions per watershed. During the growing season and periods of high flow, diversions modify the downstream flow and can lower the peak flow, changing the dynamics of the stream flow, nutrient and oxygen inputs, thereby altering the habitat for aquatic species and other species that utilize the stream habitat. Data on the timing and amount of flow diverted was not available ecoregion-wide, so the number of diversions per watershed is a surrogate for the degree of potential flow modification by diversion within the watershed.

Rationale: Most diversions on natural river channels operate on a schedule designed to divert water when it is abundant. The diversions are mainly for irrigation (Graf 1999; Collier et al. 2000). These actions can significantly alter the flow regime downstream from the diversion point in a watershed, at the very least by reducing high-flows, diversions from the reservoirs can reduce total annual discharge (see also Poff and Hart 2002; Graf 2006; Poff et al. 2007; Richter and Thomas 2007). The resulting flow alterations can restructure the entire aquatic and riparian ecosystem, reducing or eliminating the natural pattern of variation in water availability and flow velocities to which the native plant and animal communities have evolved their unique adaptations (e.g., Richter et al. 1996; Richter et al. 1997; Poff et al. 1997; Merritt et al. 2010; Poff et al. 2010).

Methods: National Hydrography Dataset - 1:100,000, data current as of 2005. The number of aqueducts intersecting or branching from NHD perennial streams, total per Huc. The number of aqueducts that intersected perennial reaches as defined by NHD were summed per huc. These values were applied to riparian and lake CEs. The number of diversions per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Watersheds with high numbers of diversion structures (aqueducts) in the MBR ecoregion do not consistently lie uphill from watersheds with high intensities of surface water use (see Indicator 04, above). Only two clusters of watersheds are evident with high values for Indicator 06a: (1) in the vicinity of St. George, UT, in the Virgin River valley; and in the vicinity of Banning, CA. Ordinarily, watersheds with high numbers of diversion structures mostly lie uphill from watersheds with high intensities of surface water use; the latter receive their water from the former. The most likely explanation for the lack of correspondence in the MBR would be twofold: (1) most diversions in this ecoregion are too small and localized either to appear in the NHD or to extend beyond their watershed of origin; and (2) the few major aqueducts in the ecoregion carry water great distances from their sources to their users, many watersheds away. Given the severity of desert conditions in the ecoregion and the limited distribution of perennial water, this twofold explanation seems reasonable. (Figure B - 59)

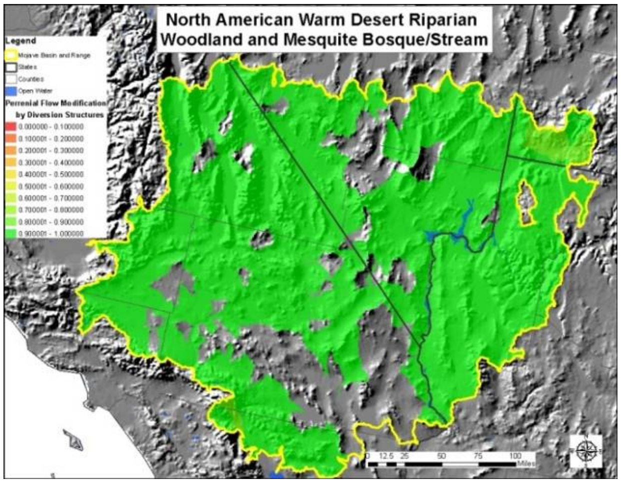


Figure B - 59. Perennial Flow Modification by Diversion Structures

Indicator 6b. Flow Modification by Dams

Definition: Flow Modification by Dams measures the capacity of dams within a watershed to alter the flow regime of the watershed. Specifically, it uses the "F" Index developed by Theobald et al. (2010) to assess the cumulative storage capacity of dams within a watershed relative to the average annual unaltered stream discharge from that watershed. A higher value of this Index in a watershed indicates that the dams in that watershed have a greater cumulative capacity to alter flows by storing and releasing water. Use of the index does not require any assumptions about dam operations, which can vary in the extent to which they alter the flow regime. The index merely provides a convenient basis for making comparisons among watersheds based on the potential capacity of dams to modify the flow regime in each watershed.

The specific methods used to calculate the raw values are presented in Theobald et al. (2010). Their analysis used data on dams and their associated reservoirs from the 2007 National Inventory of Dams (NID; USACE 2008). The NID contains data on dams that meet any of several criteria related to height, hazard classification, and reservoir storage volume. Average annual unaltered discharge per watershed was estimated using regression-based equations developed by Vogel et al. (1999). The equations estimate average annual discharge as a function of catchment area, average annual precipitation, and average temperature.

The raw values for the Index were calculated on a 6^{th}-Level watershed scale. In order to attribute these values to specific riparian/stream CE types, these raw values were averaged separately for lower (<1,200 m elevation) and higher (>1,200 m elevation) portions of each 5^{th}-Level watershed. This elevation break corresponds to the difference between the lower- versus higher-elevation riparian/stream CE types in the ecoregion.

The raw value for the index can register as low as 0.0 in watersheds with no dams; and can register above 1.0 in watersheds with reservoirs designed to hold more than a single year of runoff and/or to store water transferred from another basin (Theobald et al. 2010). The present analysis capped high values at 1.0 to minimize the effects of such unusual conditions on the overall distribution of F values. The raw watershed values of the index in the MBR ecoregion therefore range from 0.0 to 1.0 (least to most altered). For purposes of the scorecard, these raw results were then normalized to range from 1.0 to 0.0 (least to most altered).

Rationale: Most dams on natural river channels operate on a schedule designed to store water when it is abundant and release it when it is less so. The reasons for these operations may be to minimize downstream flooding; shift the time of year when water is available for irrigation, navigation, or hydropower generation; or any combination of these purposes (Graf 1999; Collier et al. 2000). These actions can significantly alter the flow regime downstream from the dam(s) in a watershed, at the very least by reducing high-flows, increasing low-flows, and changing the timing of both; and diversions from the reservoirs can reduce total annual discharge (see also Poff and Hart 2002; Graf 2006; Poff et al. 2007; Richter and Thomas 2007). The resulting flow alterations can restructure the aquatic and riparian ecosystem, reducing or eliminating the natural pattern of variation in water availability and flow velocities to which the native plant and animal communities have evolved their unique adaptations (e.g., Richter et al. 1996; Richter et al. 1997; Poff et al. 1997; Merritt et al. 2010; Poff et al. 2010).

Dam storage capacity is a key variable determining the ability of dam operations to alter the flow regime of a watershed. Individual dams within a watershed typically operate in tandem, so that the operations at individual dams enhance or, at the very least, do not interfere with each other (Graf 1999; Collier et al. 2000; Poff and Hart 2002; Graf 2006; Poff et al. 2007; Richter and Thomas 2007). The combined storage capacity of the reservoirs in a watershed, relative to the volume of water normally discharged by that watershed, thus provide a useful indicator of the capacity of reservoirs in a watershed to alter the flow regime (Theobald et al. 2010). However, the analysis requires careful consideration of the placement of dams within a watershed. Dams placed at higher elevations may cause significant changes to flow patters at these higher elevations. However, unless dams are also present at lower elevations, cumulative inflows from other tributaries at lower elevations below the higher-elevation dams can reestablish the basic shape of the flow regime.

This indicator therefore measures the potential for flow alteration associated with dams, rather than actual flow alteration. Measuring actual flow alteration across an ecoregion requires a dense network of stream gages with long-term records. Unfortunately, long-term stream gage data are extremely scarce in the MBR ecoregion, except for the few perennially flowing river reaches on valley floors, and these records are highly altered by the history of water use in these valleys. As a result, this assessment focuses on factors that are predictive of flow alteration, i.e., at stressors rather than actual stress.

Development of the MBR ecoregion for human settlement and farming has necessarily involved the use of dams to control and divert surface waters for human consumption, and for flood control. A need for hydropower generation has never driven dam construction in the ecoregion. The use of large reservoirs to store inter-basin transfers appears minimal. The sustainability of surface water use is a topic of increasing debate (e.g., Gleick 2010). The MBR ecoregion contains only a few rivers and perennial streams with sufficiently predictable and potable discharges to support large-scale diversions, and these are heavily used, as shown in the results for this indicator and for Indicators 04, Surface Water use and 06a, Perennial Flow Modification by Diversion Structures.

Results: This indicator identifies watersheds with impoundments that have the capacity to store a large fraction of the drainage network runoff. Such impoundments or networks of impoundments have the potential to significantly alter stream and river flow regimes. The indicator values for the MBR ecoregion provide information that diverges somewhat from that provided by Indicators 04 and 06a. Watersheds with very high levels of flow modification by dams occur in the Virgin River valley around St. George, where there is also a high level of surface water diversions and surface water use, consistent with the results for Indicators 04 and 06a. Elsewhere, however, there is less congruence. The reservoirs on the north side of the San Bernardino Mts. (e.g., Big Bear Lake) result in a cluster of watersheds with low scores for 06b, i.e., with high levels of flow modification by dams; and reservoirs also result in a cluster of watersheds with low scores (high levels of impairment) for 06b in the upper Trout Creek and Burro Creek watersheds in Arizona, both tributaries to the Big Sandy River east and northeast of Wikieup, Arizona; Upper Meadow Wash and the White River in NV near the UT border; and in the Spring Mountains immediately west of Las Vegas. (Figure B - 60)

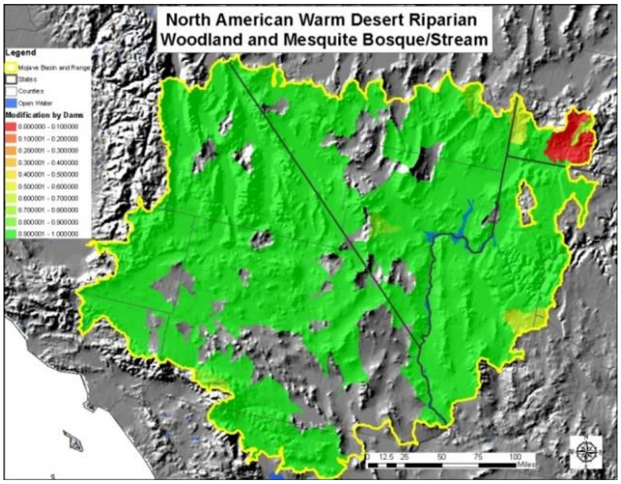


Figure B - 60. Flow Modification by Dams

<u>Indicator 07 Condition of Groundwater Recharge Zones</u>

Definition: Groundwater Recharge Zone Condition is a measure of the degree of human footprint that prevents or inhibits groundwater recharge. Groundwater recharge zones are specific areas where runoff is likely to seep into shallow and deep aquifers. A simple model of likely groundwater recharge zones was developed, identifying topographic areas above 6,562 feet (2,000 m) as likely recharge zones (see below). The amount of hard surface development (pavement, asphalt, buildings, roads, paved parking areas and the like) within these zones prohibits water from entering the aquifers.

Rationale: Regional groundwater flow in the MBR occurs primarily within the carbonate-rock aquifer system (Heilwell and Brooks 2011). Much of the carbonate-rock aquifer system is fractured and, where continuous, forms a regional ground-water flow system that receives recharge from high-altitude areas where fractured carbonate rocks are exposed (Flint and Flint 2007; Heilwell and Brooks 2011). Water moving through this regional aquifer system provides vertical recharge to basin-fill aquifers, which also receive local recharge along the mountain fronts, where runoff from higher elevations first encounter the basin fill sediments. The regional aquifer system sustains many perennial low-altitude springs; and hydraulically connects similar aquifers in adjacent basins. The basin fill aquifers, composed primarily of gravel and sand deposits, sustain additional low-altitude springs and wetlands; and the primary source of perennial flow and seasonal baseflow in mid- to lower-elevation streams. These basin-fill aquifers are the primary targets of wells for agricultural, domestic, or municipal use (Flint and Flint 2007). The land use activity on top of the groundwater recharge zones can greatly modify the amount of recharge entering the both the regional and basin-fill aquifers. Loss of groundwater recharge can adversely impact the health of springs, streams, and wetlands and the yield of water supply wells and can do so over very long time-spans (NJSWBMP 2004). The amount of hard-surface development on top of a recharge zone is a measure of the reduced capacity of the recharge zone to absorb runoff waters.

Methods: A simple model of likely groundwater recharge zones was created, consisting of areas above 6,562 feet (2,000 m) in elevation, based on maps published by USGS but not obtained by NatureServe (Flint & Flint, Regional Analysis of Ground-Water Recharge, 2007). These maps were overlaid the National Land Use/ Land Cover map and the percentage of area of lands with hard surfaces were calculated. Hard surfaces include urban high and medium density, and roads , called “non-natural”, and occurs within the modeled likely recharge zone are per watershed. The percent “non-natural” land use per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value), where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Groundwater recharge zones occur only at higher elevations, in the mountains and at the interface between bedrock and basin fill surface geology along the foothills of mountain ranges. Such zones have a highly limited distribution within the MBR ecoregion, where they are strongly affected by development only in two limited areas: (1) along the crest and north side of the San Bernardino Mountains above (south of) Hesperia; and (2) in the headwaters of the Mojave River just to the west, where the Interstate Highway 15 corridor crosses over the mountains. (Figure B - 61)

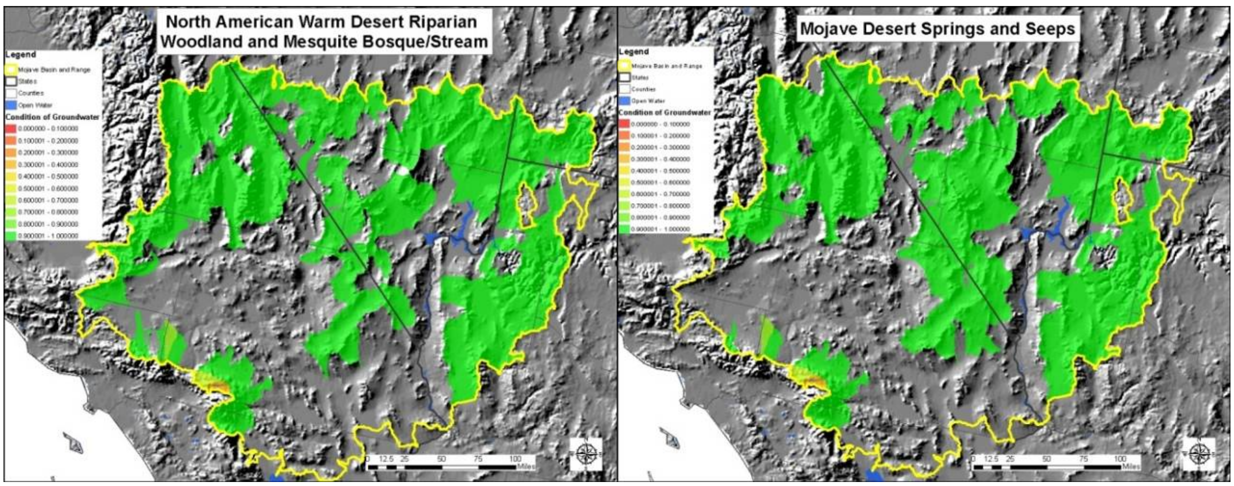


Figure B - 61. Condition of Groundwater Recharge Zone

<u>KEA Stressors on Hydrology Condition</u>

Definition: Key Ecological Attribute-Hydrology Condition is an average of Indicators 4, 5, 6a, 6b and 7. It provides a way to summarize all of the impacts or stressors to hydrologic function occurring within 5th level watersheds.

Rationale: The roll-up or summarization is a way to combine many indicators of stress into a single variable, and will underline areas of cumulative stressor effects. Rolling up several indicators into a single KEA score is part of the Ecological Integrity Method (Faber-Langendoen et al. 2008), and provides a means of a “quick” look summary of impacts from different scales.

Methods: This is a summary, or roll-up, of all the hydrologic indicators into a single score. This is an average of the normalized scores for four indicators: Surface water Use, Groundwater Use, Flow modification by Dams “F”-index, and Groundwater Recharge Zone Condition. Not all of these indicators were applied to all CEs, so the KEA varies by CE.

Results: A substantial fraction of the watersheds in the ecoregion exhibit low scores for KEA III, Hydrology Condition, indicating a high level of impact across Indicators 04-07. Consistent with the results for these indicators, the most altered watersheds occur in an arc along the west-southwestern side of the ecoregion, along the valleys northwest and northeast of Las Vegas, in the upper Meadow Valley Wash along the NV-UT border, and in a handful of watersheds in northwestern Arizona. These results are consistent with the distribution of urban and agricultural development within the ecoregion. As noted above, this development is supported by surface water diverted from nearby sources or imported from distant watersheds (e.g., from the Colorado River); and by groundwater withdrawals from aquifers recharged either by natural infiltration or by artificial infiltration associated with surface water use and/or aqueduct leakage. (Figure B - 62)

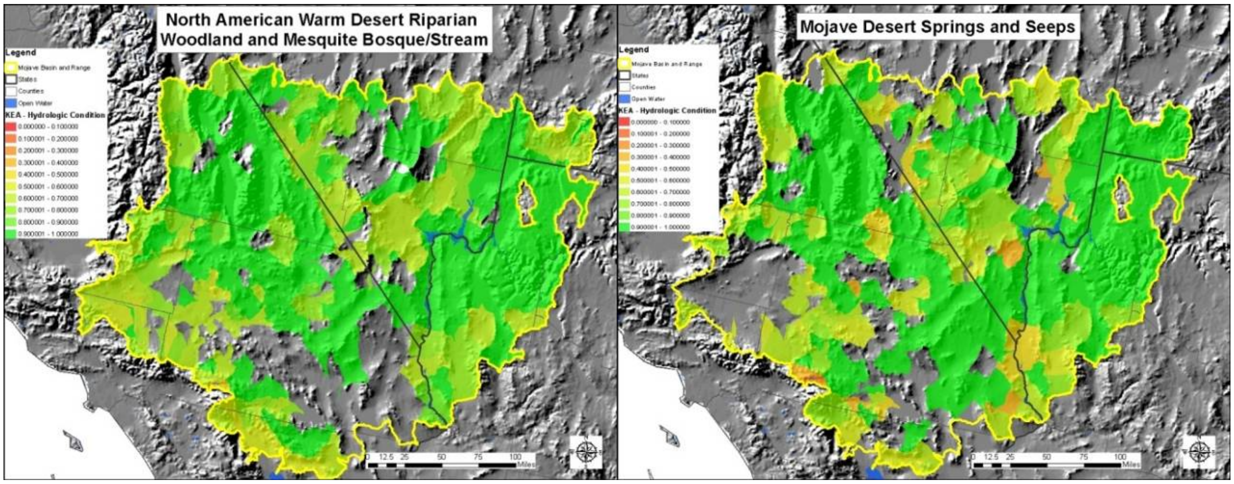


Figure B - 62. KEA Summary (Stressors on Hydrology Condition)

IV. Stressors to Water Quality

Indicator 08a Atmospheric Deposition-Nitrate Loading (NO_3)

Definition: Indicator 08a, Atmospheric Deposition-Nitrate Loading, measures the intensity of wet deposition of nitrate (NO_3^-) ions within a HUC from air pollution. The raw values have units of kg-N/ha/yr (kilograms of Nitrogen per hectare per year). The indicator serves as a representative of a broad class of common air pollutants, consisting of oxides of nitrogen and sulfur (often denoted NO_x and SO_x). When deposited back on the earth surface through precipitation (i.e., carried with rainfall, snowfall, etc.), these compounds can alter the pH and/or the nutrient balances of the soils and waters into which they are deposited, with ecological consequences. Geographically comprehensive data do not exist for this ecoregion on water pH and nutrient concentrations, nor on bioassessment indicators, with which to assess stresses to water quality. The assessment of nitrate deposition therefore provides a means to assess a common *source* of alteration (stressor) that may affect water pH and nutrient concentrations.

Nitrate deposition per HUC is calculated using data from the National Atmospheric Deposition Program (NADP), National Trends Network (NADP 2012), which maintains a network of monitoring stations throughout the nation. These stations are located irregularly across the MBR ecoregion and surrounding ecoregions, mostly at higher elevations. The NADP integrates these data with spatial models that produce 2.5 km x 2.5 km gridded estimates of deposition rates for a suite of acids, nutrients, and base cations. The gridded data for nitrate wet deposition were integrated by watershed to calculate the average deposition rate per HUC. Raw values range from 0.5201 to 2.6994 kg-N/ha/yr. For purposes of the scorecard, the results are normalized to range from 0 to 1.

Rationale: Atmospheric deposition introduces pollutants into watersheds and their aquatic ecological systems from distant sources. As summarized for the western U.S. by Fenn et al. (2003a, 2003b), nitrate emissions arise from a variety of urban and agricultural sources. These can include internal combustion engines (e.g., cars and trucks), incinerators, and fuel-burning power plants; and concentrated animal feeding facilities. Even low levels of N-deposition can result in biological changes, by causing acidification in waters with naturally low buffering capacity (*aka* acid-neutralizing capacity), such as exist in alpine and upper montane zones in the MBR ecoregion; and can act as a nutrient pollutant in well-buffered waters at both high and low elevations, as documented in the Sierra Nevada and Rocky Mountain regions (e.g., Brooks and Williams 1999; Baron et al. 2000; Williams and Tonnesen 2000; Coats and Goldman 2001; Wolfe et al. 2001, 2003; Burns 2003, 2004; Hunsaker et al. 2007; Fenn et al. 2008; 2010; Ingersoll et al. 2008; Allen et al. 2009a, Allen et al. 2009b; Saros et al. 2010; Pardo et al. 2011). Acidification presents a stress to all aquatic organisms; in extreme cases it leads to the elimination of most native organisms from an affected water body. Nutrient enrichment boosts aquatic productivity (e.g., phytoplankton and periphyton productivity), changing the algal assemblage in an individual water body. This in turn can lead to changes in the assemblage of organisms that consume the algae, and in the assemblage of organisms that prey on these primary consumers, thus altering the composition of the natural aquatic community. Nitrate uptake along streams and riparian zones is a natural process, further, but increased nitrate availability can alter not only in-stream biotic composition but riparian vegetation dynamics (Ranalli and Macalady 2010).

As documented in the deserts of the southwest, chronic N deposition also can lead to increased terrestrial plant productivity across watersheds and favor the spread of non-native grasses, leading to increases in fuel for wildfire that affect the frequency and intensity of fire. Such changes in wildfire, in turn, can alter watershed runoff dynamics and degrade riparian vegetation, resulting in increased stress to riparian-stream ecosystems (see also Bytnerowicz et al. 2001; Allen et al. 2009a, 2009b; Fenn et al. 2010; Rao and Allen 2010; Rao et al. 2010; Pardo et al. 2011). Finally, Nitrogen deposition during droughts has been implicated in the spread of the Western pine beetle and Mountain pine beetle in the San Bernardino and San Jacinto Mountains of southern California (Jones et al. 2004). Although this study took place outside the MBR, the species involved also occur in the MBR. This suggests an additional pathway by which N-deposition could affect aquatic ecosystems in the MBR ecoregion, not only through altered watershed fire dynamics but through altered organic litter production in forested watersheds, where such litter may be an important source of nutrients to streams.

Fenn et al. (2003a, 2003b) further note that N deposition is highly uneven in the western U.S., with "hotspots" of deposition surrounded by wide areas of low deposition. Wet deposition in particular requires precipitation, and therefore in the MBR ecoregion is concentrated at higher elevations, especially immediately down-wind from major source areas. Fenn et al. (2008) suggest a critical load of 3.1 kg-N/ha/yr as for mountain and desert regions in California, above which ecological changes occur in alpine/montane environments. Other researchers working both in California and in the Rocky Mountains suggest higher or lower thresholds for this critical load in the western or southwestern U.S. (e.g., Baron 2006; Bowman et al. 2006; Allen et al. 2009a, 2009b; Fenn et al. 2010; Rao et al. 2010; Saros et al. 2010; Pardo et al. 2011), with historic and paleoecological data pointing to the lower values (e.g., 1.4 to 1.5 kg-N/ha/yr – Baron 2006; Saros et al. 2010).

Methods: National Atmospheric Deposition Program (NADP) Atmospheric Deposition Nitrogen, data current as of 1994- 2011 (varies by station). These data are a measure of the annual rate of deposition of Nitrate in Kg/ha. This continuous surface raster data, obtained from the National Atmospheric Deposition Program (NADP), was summarized by 5th level hydrologic units. The Nitrate deposition per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Atmospheric deposition of nitrate across the ecoregion follows a clear pattern, with highest rates of deposition across the watersheds immediately east of the southern end of the Sierra Nevada Range, from Owens Valley to Death Valley; lower but still high rates of deposition in an arc across the entire rest of the northwestern sector of the ecoregion as well as across the entire northeast quadrant; and another cluster of higher rates across the watersheds on the north side of the San Gabriel Mountains. The high rates from the Owens Valley to Death Valley extend south only as far as Edwards AFB. This pattern suggests that this particular area of high deposition does not result from air transport from the Los Angeles basin but rather from sources located in the air force base and/or along the valleys (and roadways) across this region; or perhaps from activities at the China Lake military facilities. Nitrate deposition alters nutrient regimes in aquatic CEs that receive runoff from the affected watersheds; and causes acidification of alpine/sub-alpine lakes and wetlands in watersheds with granitic bedrock geology. (Figure B - 63)

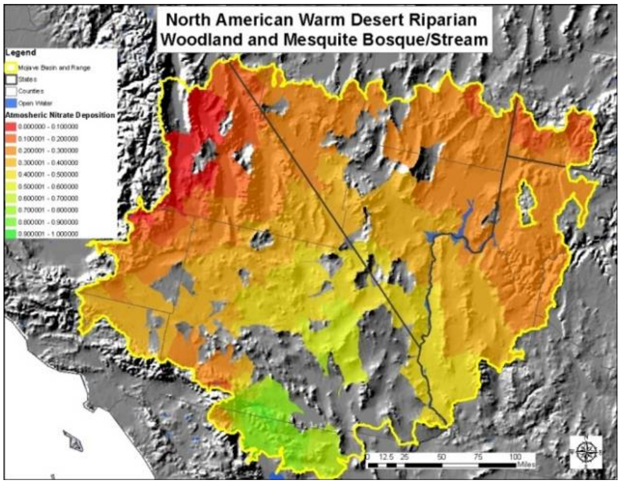


Figure B - 63. Atmospheric Deposition-Nitrate Loading (NO_3)

Indicator 08b Atmospheric Deposition-Toxic Mercury Loading (Hg)

Definition: Atmospheric Deposition-Mercury Loading, measures the intensity of wet deposition of Mercury within a watershed from air pollution. The raw values have units of μg-Hg/m^2/yr (micrograms of Mercury per square meter per year). The indicator serves as a representative of a broad class of air pollutants, consisting of metals and organic compounds that have toxic effects on wildlife and have the ability to bioaccumulate in food webs, particularly those anchored in aquatic ecosystems. When deposited back on the earth surface through precipitation (i.e., carried with rainfall, snowfall, etc.), these compounds and their byproducts can impair the health and reproduction of invertebrates and vertebrates contaminated by these compounds, with ecological consequences. Methyl-mercury, a byproduct of Mercury, is particularly toxic. Geographically comprehensive data do not exist for this ecoregion on Mercury or Methyl-mercury concentrations in water or tissues, nor on bioassessment indicators, with which to assess stresses to water quality. The assessment of Mercury deposition therefore provides a means to assess a common *source* of alteration (stressor) that may affect ecological water quality in the ecoregion.

Mercury wet deposition per watershed is calculated using data from the National Atmospheric Deposition Program (NADP), Mercury Deposition Network (NADP 2012), which maintains a network of monitoring stations throughout the nation, some placed to monitor specific emission sources. Fewer than ten stations are located irregularly across the MBR ecoregion and immediately surrounding ecoregions, mostly at higher elevations. The NADP integrates these data with spatial models that produce 2.5 km x 2.5 km gridded estimates of deposition rates. The gridded data for Mercury wet deposition were integrated by watershed to calculate the average deposition rate per watershed. Average rates per watershed range from 4.5503 to 8.3653 μg-Hg/m^2/yr. For purposes of the scorecard, the results are normalized to range from 0 to 1.

Rationale: Atmospheric deposition introduces pollutants into watersheds and their aquatic ecological systems from distant sources. As summarized by the states of California, Nevada, and Utah (California OEHHA 2012; Nevada DEP 2012; Utah DEQ 2012) and in numerous scientific publications (e.g., Driscoll et al. 2007a; Peterson et al. 2009; Selin 2009; USEPA 2009; Chalmers et al. 2010; Nydick and Williams 2010), Mercury (Hg) atmospheric deposition arises mostly from the burning of coal and industrial wastes in power generation plants, cement manufacturing plants, and incinerators. Coal-fired power plant and incinerator emissions are regulated in the US, but the best available technologies for the removal of Hg are not fully effective; and other industrial sources are not regulated (e.g., Driscoll et al. 2007a, 2007b). Individual emission sources identified within and immediately surrounding the MBR ecoregion consist entirely of coal-fired power plants and industrial facilities (e.g., Abbott 2005; NPCA 2008). Incineration, cement manufacturing, and power-generation sources also exist upwind, in California west of the Sierra Nevada range (NADP 2012). In addition, Hg emissions can travel thousands of miles in the atmosphere before returning to the earth surface; deposition in any locality always includes Hg from both near and distant sources (e.g., Selin 2007), although nearby sources contribute the most. Deposition of Hg occurs in both "dry" and "wet" forms. The former consists of deposition along with dry particulate matter; the latter consists of deposition along with rainfall, snowfall, and other forms of precipitation. Wet deposition is more easily measured and has the longest history of measurement in the U.S. (NADP 2012).

Mercury deposition per se does not cause direct ecological damage. However, microbes that live in wet soils, wetlands – including riparian wetlands – and aquatic sediments with high organic matter content convert Hg into a biologically reactive, toxic compound, Methyl-mercury (MeHg) (e.g., Driscoll et al. 2007a, 2007b; McNaughton 2008; Ward et al. 2009). Hg deposited or washed into these settings bio-accumulates through the food web in these environments, and in lakes and streams that receive inflows from these environments. Top aquatic predators (e.g., native trout) and insectivorous and larger avian predators (e.g., bald eagle) that feed along these lakes and streams accumulate MeHg in their body tissues sufficient to cause biological harm, consisting of reduced reproductive success and impaired neurological development in offspring (e.g., Driscoll et al. 2007a, 2007b; Schwindt et al. 2008; see recent reviews in Chalmers et al. 2010; Nydick and Williams 2010). Long-lived predator species are particularly at risk. Such biological effects can alter predator-prey dynamics in aquatic ecosystems. The processes leading to bioaccumulation work somewhat differently in saline lakes such as Pyramid Lake and the Great Salt Lake because of their unique chemistry and biota, but the result is the same: top predators accumulate potentially harmful body loads (Weimeyer et al. 2007; Darnall and Miles 2009; Naftz et al. 2009; Wurtsbaugh et al. 2011).

High levels of MeHg bioaccumulation in fish also makes them unhealthy for human consumption, leading to fish consumption advisories. California, Nevada, and Utah regulatory agencies have all posted such advisories for water bodies within the MBR ecoregion (California OEHHA 2012; Nevada DEP 2012; Utah DEQ 2012). However, the Hg responsible for these advisories may also derive from past mining ore processing, as is the case in the Carson River basin, including Lahontan Reservoir (Bevans et al. 1998; Scudder et al. 2009).

Mercury deposited in forested settings in the MBR ecoregion may accumulate in the upper (organic) soils and forest floor litter, without undergoing methylation (e.g., Perry et al. 2009; Obrist et al. 2009, 2011). High levels of organic matter (with high levels of Carbon and Nitrogen) contribute to this storage. However, fires in these settings can release the accumulated Hg, allowing it to move into wetter settings where it may be methylated and drawn into aquatic, wetland, or terrestrial food webs (see also Burke et al. 2010). Changes in wildfire regimes – which in turn may be driven by changes in climate, fuel accumulations supported by nitrate deposition, and other factors – therefore could alter the rate at which Hg enters aquatic food webs (see discussion of nitrate deposition and wildfire for Indicator 08a). Nitrate deposition, by stimulating primary productivity in lakes and streams, may increase the concentration of dissolved organic matter (DOM) in these waters, another potential factor promoting methylation and, therefore, promoting MeHg bioaccumulation (McNaughton 2008).

Mercury deposition is highly uneven across the western U.S., with "hotspots" of deposition surrounded by wide areas of lower deposition (NADP 2012). For example, current deposition rates for total Hg for the MBR can range above 70 μg-Hg/m^2/yr in the eastern Sierra Nevada range (Sanders et al. 2008), and above 140 μg-Hg/m^2/yr along the Rocky Mountain crest well to the east of the ecoregion (e.g., Mast et al. 2010). However, wet deposition rates reported at individual study sites in the MBR ecoregion mostly range an order of magnitude less, even in high elevations (e.g., Lyman et al. 2007, 2008; Sanders et al. 2008; Peterson et al. 2009; Drevnick et al. 2010; Mast et al. 2010; NADP 2012). Wet deposition may account for as little as 30% or up to 90% of total Hg deposition in some settings within and immediately east of the MBR ecoregion (Lyman et al. 2007, 2008; Sanders et al. 2008; Drevnick et al. 2010; Mast et al. 2010). Wet deposition in particular requires precipitation, and therefore in the MBR ecoregion is concentrated at higher elevations, especially immediately down-wind from major source areas. Studies in both the Sierra Nevada and Rocky Mountain ranges point to natural, pre-industrial deposition rates of 2-4 μg-Hg/m^2/yr in these higher-elevation settings (Lyman et al. 2007; Sanders et al. 2008; Drevnick et al. 2010; Mast et al. 2010). Natural wet deposition would have been correspondingly lower in areas with lower precipitation.

Methods: National Atmospheric Deposition Program (NADP) Atmospheric Deposition Mercury, data current as of 1994- 2011 (varies by station). These data are a measure of the annual rate of deposition of Mercury in μg/m^2. This continuous surface raster data, obtained from the National Atmospheric Deposition Program (NADP), was summarized by 5th level hydrologic units. Mercury scores were calibrated against background natural mercury amounts using the equation: 1-((score-minscore)/(maxscore-minscore)). The mercury deposition per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Per-watershed Mercury wet deposition in the MBR ecoregion varies from 3.0601 to 6.4352 μg-Hg/m^2/yr, as noted above. These rates exceed the estimated natural rates for high-elevation sites noted above; for lower-elevations, these rates necessarily exceed natural rates by an even greater margin. However, none of the per-watershed rates for wet deposition in the MBR rises even close to the levels of "hotspot" conditions. The highest rates are concentrated north and south of the Grand Canyon, across both Arizona and Utah. Lower but still high rates (2^{nd} quartile) also occur along the rest of the eastern side of the ecoregion, and in a cluster extending eastward from the southern end of the Sierra Nevada range. Emissions from two coal-fired power plants in the area may contribute to the eastern zone of elevated deposition: (1) the Arizona Public Service Navajo Generating Station at Page, Arizona, near the Utah border; and (2) the Nevada Power Company Reid Gardner Generating Station in Clark County, Nevada (Nevada DEP 2005). The Southern California Edison Mohave Generating Station at Laughlin, Nevada, on the Colorado River, ceased operation in 2005. The high rates north and south of the Grand Canyon also represent the southern end of a zone of elevated deposition noted in the adjacent CBR ecoregion, extending south and southwest from Provo, Utah, and including the areas of Cedar City and St. George, Utah. As noted for the CBR ecoregion, these high rates in Utah presumably are caused by the concentration of urban and industrial activity along the western front of the Rocky Mountains, with air circulation patterns carrying some emissions westward (see also NPCA 2008). The zone of moderately high deposition rates in the northwestern corner of the MBR ecoregion, in turn, includes or lies downwind from several coal-fired power generating stations, including the Argus Cogeneration Station at the southern edge of this cluster of watersheds; the TXI Riverside Cement Power House near Victorville; and the Rio Bravo Poso, Mt. Poso, and Rio Bravo Jasmin stations located just north of Bakersfield (Center for Media and Democracy 2012). Higher deposition rates supported by emissions from these stations would be expected at higher elevations in the mountains as well as in the immediate vicinity of the Argus station. However, an evaluation of the possible sources of Mercury emissions affecting the MBR ecoregion was not part of this assessment.(Figure B - 64)

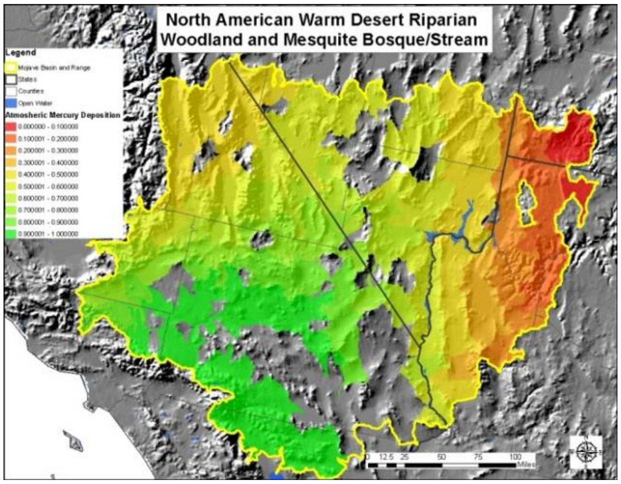


Figure B - 64. Atmospheric Deposition-Toxic Mercury Loading (Hg)

Indicator 09 State Listed Water Quality Impairments

Definition: Presence and severity of water quality impairments identified in State 303(d) report , where the State Listed Water Quality of Impaired Waters includes are those waters that exceed standards for total phosphates, temperature, turbidity, suspended solids, pH, nitrates, and other pollutants. These standards are applied to stream reaches and to lakes and ponds.

Rationale: Impaired water quality is a measure of aquatic stress on aquatic life integrity. Pollutants can cause harm or death and may accumulate in upper food chain (fish) tissues; increased sediment loading can reduce oxygen availability and reduce spawning habitat.

Methods: (USEPA National Database of State Water Quality Status Listings, data current as of 2009). State listed impairment is documented by stream reach and by waterbody or lake. For riparian CEs we divided the number of impaired stream miles by the total miles of a given riparian CE to determine the percent impairment. For lakes, we divided the number of listed impaired lakes by the total number of lakes by watershed to determine the percentage of lake CEs impaired. The percent impairment per watershed was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value) where 0 = worst or highest degree of impact and 1 = best or least impacted score.

Results: Very few waters are listed as impaired for water quality within the Mojave Desert. Those that were registered are lakes/reservoirs. This distribution does not necessarily indicate a lack of ecological water quality impairment in other water bodies, but only the pattern of what water bodies each state has assessed and the water quality standards set for those types of water bodies. (Figure B - 65)

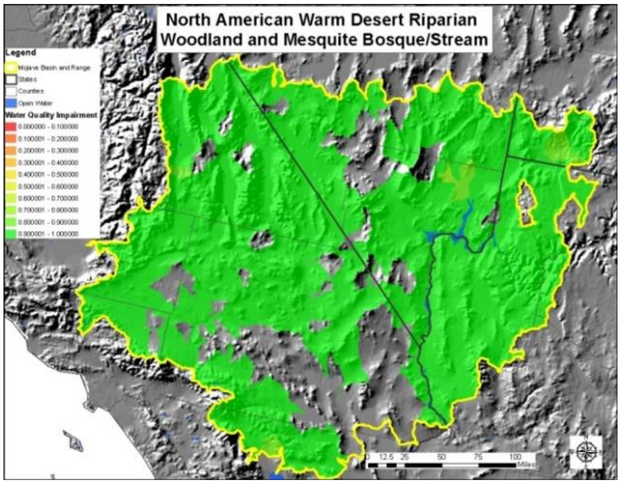


Figure B - 65. State-Listed Water Quality Impairments

Indicator 10 Sediment Loading Index

Definition: Percent cover by land use/cover within a 200 m buffer area of each aquatic CE multiplied by a nationally standard sediment loading index for that type of land use/cover. This is a surrogate for a direct measure of the amount of suspended solid sediment. It is important to estimate both the surrounding landscape (see Indicator Surrounding Land Use Context) and the immediate buffer area to get a more accurate picture of impact on the aquatic resources, because the amount of natural vegetative cover within the buffer area can decrease the larger surrounding area use sediment loading, and conversely, certain land use/cover may be a source of sediment within the buffer zone that may otherwise be surrounded by non-sediment producing land use/cover. Land use sediment loading indices used in NSPECT were cross-walked with land cover classes mapped for the ecoregion. Values ranged from 0.5 for high sediment loading uses such as paved roads, bare ground, and tilled agriculture to 0.89, for very low sediment loading land cover such as natural forest or grassland cover. To compare the land use/land cover within the buffered area of each aquatic CE to the surrounding land use context NSPECT could not be deployed, as it would have only provided a watershed-based sediment load at the terminal pour point for the watershed. In addition, NSPECT would show that the most downstream watershed within the ecoregion has, by default definition, the greatest sediment loading. This scale of analysis is too course for an aquatic CE assessment.

Rationale: Sediments in aquatic recourses can have detrimental effects on biotic life, change the chemical and physical parameters of the aquatic and substrate habitat, and can be a source of pollutants. Sediments have been shown to reduce oxygen levels, bury fish spawning gravels, reduce visibility, clog gills and be a source of heavy metals and other pollutants such as polychlorinated dibenzo-p-dioxins (PCDDs), furans (PCDFs), biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), brominated flame retardants (BFRs), heavy metals, and pesticides (Apitz et al. 2005, Curry et al. 2004, Chapman 1988, Salomons 1987, Culp et al. 1986).

Methods: This index measures the sediment load index based on land use with 100 m buffer of each CE occurrence The sediment loading index for a given land use (as listed in Non-point Source Pollution and Erosion Comparison tool (N-SPECT: Technical Guide 2008 v.1.5, page 25) was applied to land use categories of the National Land Cover/Land Use map. The index values were summed by the amount of each land use within the buffered area.

Results Within the Mojave Desert, lakes and reservoirs with their proximity to human development and are often surrounded by access roads, carry the highest potential for sediment loading. Basin valley riparian CE also carry high sediment loads as they are also located where greater human development occurs, while the upper watershed montane riparian CE are less impacted by sediment loading. (Figure B - 66)

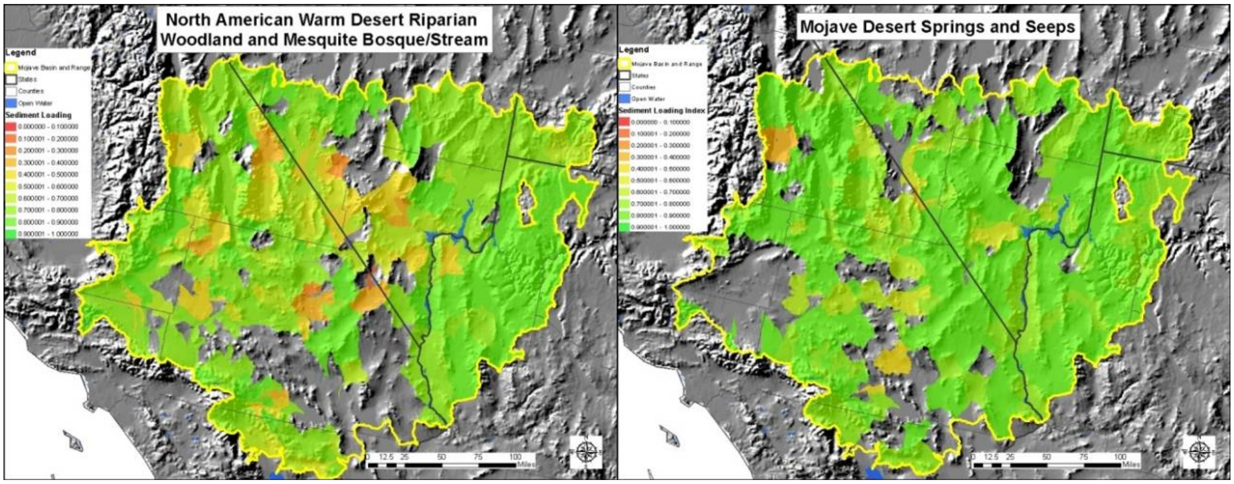


Figure B - 66. Sediment Loading Index

KEA Stressors on Water Quality

Definition: An average of water quality indicators 8-10.

Rationale: A summarization of several stressors, to show cumulative effects.

Method: This is a summary, or roll-up, of all the water quality indicators into a single score. This is an average of four indicators normalized scores: Nitrate Atmospheric Deposition, Mercury Atmospheric Deposition, State Impaired Waters, and Sediment Loading Index. Not all of these indicators were applied to all CE, so the KEA varies by CE.

Results: This KEA is tracked by Indicators 08-10, discussed individually above. As noted for these indicators, water quality is most affected in this ecoregion by nitrate and mercury deposition. As an average of these indicators, we see pattern of potential water quality stressor in the areas of highest $N0_3$ and Hg deposition. (Figure B - 67)

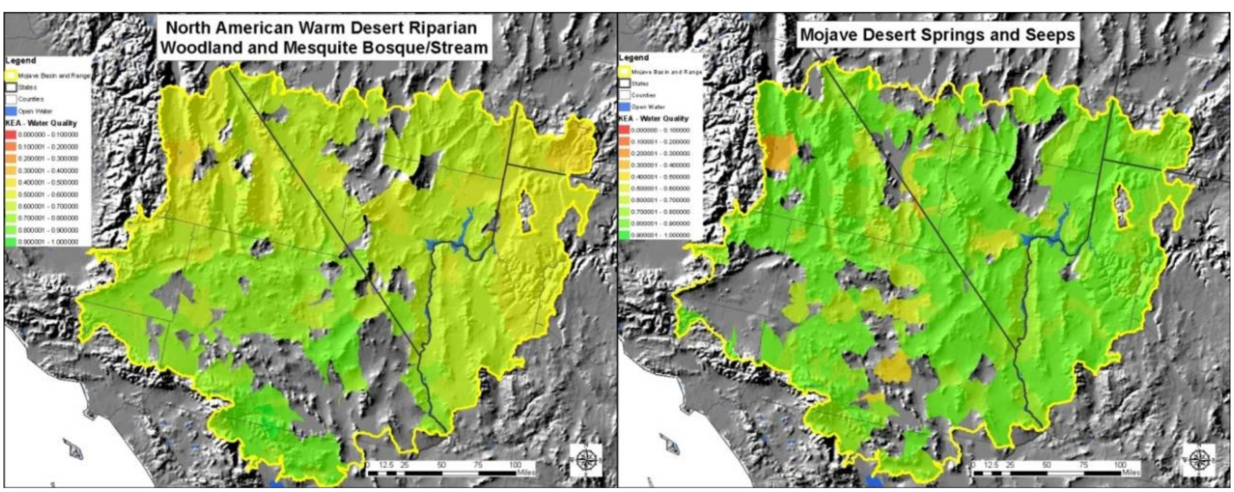


Figure B - 67. KEA Summary (Stressors on Water Quality)

V. Stressors on Biotic Condition

<u>Indicator 11 Presence of Invasive Plant Species</u>

Definition: Presence of Exotic/Non-native Invasive Plant Species: Not all non-native species are aggressive. This indicator measures the presence of aggressive non-native plant species known to invade wetlands, especially those with human disturbance.

Rationale: Globally terrestrial non-native (aka “exotic”) invasive plant species can have detrimental effects and some documented positive effects on native ecosystems. From a conservation perspective, where possible, maintaining the native biodiversity of an ecosystem helps the resiliency and resistance of the ecosystem to climate change and other stressors. The presence of terrestrial non-native invasive plant species is a rapidly observed indicator of current or past disturbance and is a direct measure of current plant species composition within an ecosystem. The negative effects of terrestrial non-native invasive plant species on native ecosystems are becoming increasing well documented. They can cause of biotic homogenization of ecosystems (Houlahan and Findlay 2004). Non-native invasive species have been documented to have a competitive advantage over native species by altering the rate of decomposition and litter nitrogen loss (Ashton et al. 2005), reducing soil moisture and changing wildfire frequency and intensity (Smith et al. 2008, Wisdom and Chambers 2009). Invasive non-native species have been documented to have larger seed sizes in their introduced range than their native range, indicating a high competitive advantage over local native species (Buckley et al. 2003). Invasive non-native species in grasslands have lowered N availability by outcompeting native plants for mineral N, making it difficult for native species to reestablish and promoting the spread of the non-native invasive over native grass species (Scott et al. 2001).

Within this ecoregional assessment we focus on three non-native invasive plant species: Cheatgrass (*Bromus tectorum*), Tamarisk (*Tamarix* spp.) and Russian Olive (*Eleagnus angustifolia*). Each has their own impact on native ecosystems. Cheatgrass (*Bromus tectorum*) begins growth earlier in the spring than most native perennials, depletes soil moisture and causes excessive competition when they emerge with other native species (Smith et al. 2008). Cheatgrass can change the timing and frequency of wildfires in such a way that completely eliminates native sagebrush species (Wisdom and Chambers 2009). Tamarisk (*Tamarix* spp.) causes changes to ecosystems structure, function and animal use. These changes include: supporting fewer bird species and individuals than native trees (Sogge et al. 2008), a reduction in stream flow volume and groundwater levels, an increase wildfire frequency, an increase soil salinity on controlled rivers, reduced agricultural production and drop in recreational use of invested reaches (Lewis et al. 2003). While the amount of water use by tamarisk has been disputed (Stromberg et al. 2009) and the fact that Southwest willow flycatcher, an endangered species, successfully nests in Tamarisk trees (Sogge et al. 2008), efforts to remove this species may better be served by restoring ecosystems processes that supports riparian areas (i.e. flooding) rather than targeting tamarisk removal *per se* (Stromberg et al. 2009). Russian Olive (*Eleagnus angustifolia*) reduces the habitat for some invertebrates which can affect the food chain for aquatic species (Moline and Poff 2008). A reduction in the density of Russian Olive can be beneficial to native lizard populations (Bateman et al. 2008).

Results: The combined data from known tamarisk, Russian olive and annual invasive grass species reveal infestations in just 6% of the aquatic conservation element locations. The low percentage is due to a lack of specific inventory for invasive species and suspect the number of CE affected by infestation is actually much higher. The bulk of the tamarisk and Russian olive invasions are within the Colorado, White and Muddy River watersheds. (Figure B - 68)

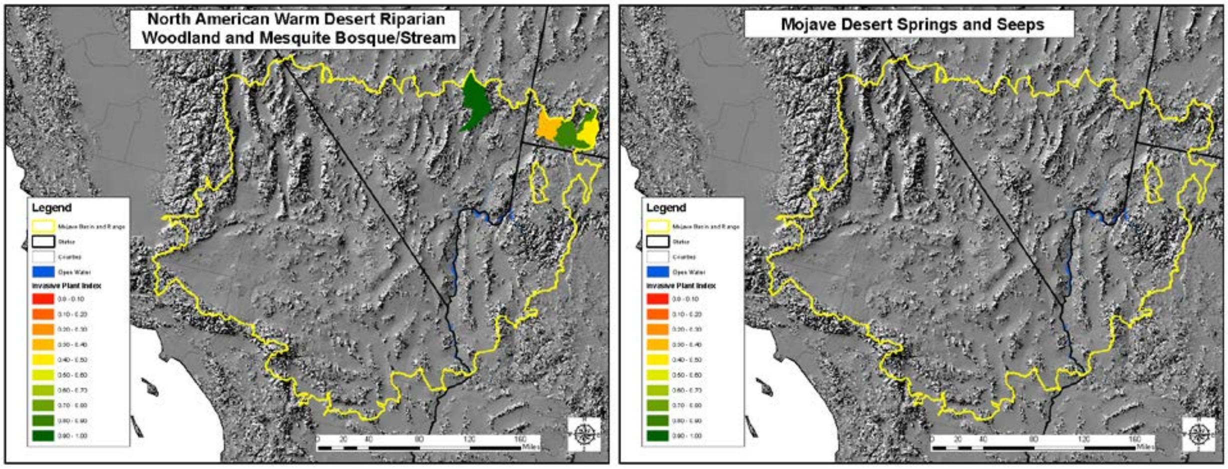


Figure B - 68. Presence of Invasive Plant Species . Watersheds lacking scores did not have any invasive plants occurring in the CE, based on the available data. For example, Mojave Desert Springs and Seeps did not have any records of invasive plants occuring in one of the seeps or springs, hence no watersheds have a score.

Indicator 12 Presence of Invasive Aquatic Species

Definition: The most important metric (and most heavily weighted) in the entire suite of metrics is the number of invasive taxa present. This is simply because the greater the number of invasive taxa there are in a CE; the greater the loss of 'ecological integrity'. Obviously, if no invasive taxa are in a CE within a watershed there is no invasive impact to that CE although there is always future potential.

Rationale: The Known Status Index contains a single metric 'the number of invasive taxa in a CE'. Other than the didymo database, which also included absence data, available databases only contained reported presence sites. Unreported sites do not imply absences. If a taxon was reported in our database then the taxon was most likely well established and had reached some detection threshold. Unreported sites could have been a result of two factors; 1) no surveys were conducted or 2) surveys were below detection threshold levels of invasive taxa. Detection threshold is a function of observer survey methods and skills, amount of search effort used, observability of the taxon (e.g. some taxa are more easily observed than others ex. carp vs. didymo), and the density of the taxon. There were no metadata available relating survey methods or amount of search effort used for any of our invasive taxa data points in the database. It was assumed that many different types of survey methods and amounts of search effort were used and were not standardized. This most likely resulted in reported false absences or in locations not being reported. Also, timeliness (time lag) of reporting, lack of awareness of centralized invasive species databases, or failure to understand the importance of a centralized database, were also factors that most likely resulted in under reporting of invasive taxa in the databases. Thus the number of invasive taxa metric should be considered as under representative. Most likely the number of invasive taxa in CEs and watershedS in the ecoregions are much higher. The Known Status Index metric was scored conservatively to take these factors into consideration.

Method: USGS Nonindigenous Aquatic Species database (NAS), data current as of 2010, and the Didymo (*Didymosphenia geminata*) distribution map: USGS Fort Collins, data current as of 2008. Of the reported locations of invasive species most included verbal descriptions of the water body infested (e.g. Anderson Springs). This allowed us to directly model which CE type was infested in a watershed. However, some of the reported invasive species locations were not at a high enough resolution to determine the exact type of water body (CE) that the species occurred in (i.e. data were reported at the watershed level or the narrative description was vague, e.g. Muddy River drainage). For the inexact, vague data, we used the available literature and our knowledge of each invasive species' habitat requirements and ecology to narrow the possible water body types. The point location using GIS was identified to further verify their probable CE type.

Results: For Aquatic Invasive species, the data are very poor. Only 23 records of aquatic invasive species occurrences were coincidental with known CE distributions within the ecoregion. However, this lack of data/observations does not mean aquatic invasives have been confirmed to *not* occur. Further systematic inventory is needed. (Figure B - 69)

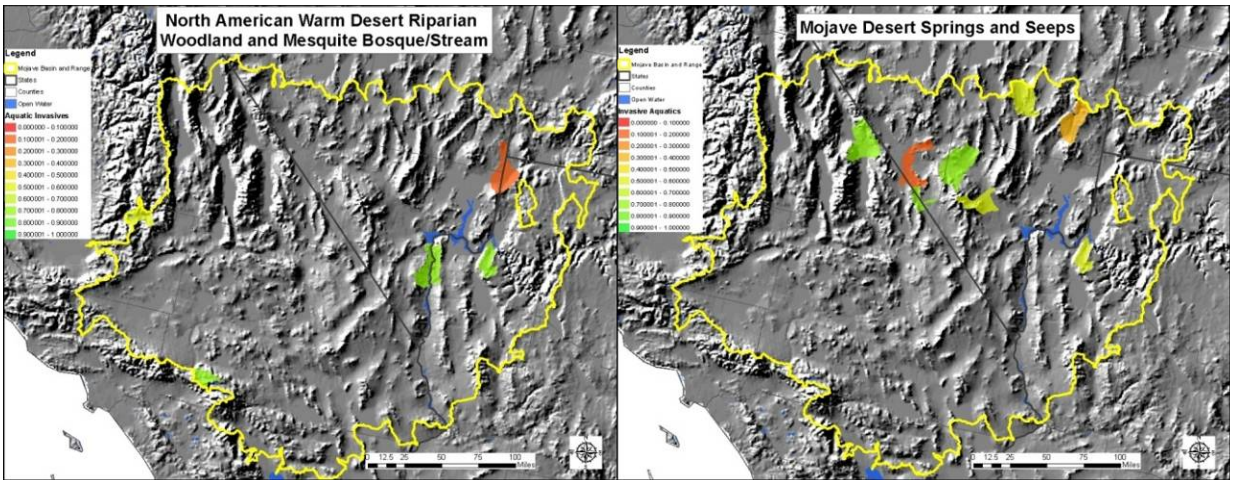


Figure B - 69. Presence of Invasive Aquatic Species

Table B - 33. Indicator results by watershed for aquatic coarse-filter CEs (Current). For each indicator the count of 5th level watersheds is shown for each CE, broken out by indicator score interval.

KEA: Change in Extent/Size											
Riparian Corridor Continuity											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87					1	2	4	2	4	74
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246		2	2	1	9	8	15	22	23	164
KEA: Surrounding Land Use Context											
Landscape Condition Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87					1	14	45	26	1	
North American Warm Desert Playa	269					2	24	90	137	16	
North American Warm Desert Riparian	246					2	27	96	115	6	

	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
Woodland and Mesquite Bosque / Stream											
North American Warm Desert Wash	315					2	29	112	154	18	

Perennial Flow Network Fragmentation by Dams

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87								1	9	77
North American Warm Desert Playa	269	1				1	1		1	9	256
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	1				1	1		1	13	229
North American Warm Desert Wash	315	1				1	1		1	13	298

KEA: Stressors on Hydrology Condition

Surface Water Use

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87		6	5	10	8	5				53
North American Warm Desert Playa	269				15	18	11	5	4	1	215
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	3	15	20	31	19	8	5	2	1	142
North American Warm Desert Wash	315				17	19	12	5	4	1	257

Groundwater Use

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	2	9	9	8	8	1				50
North American Warm Desert Playa	269	8	27	29	24	19	6	3		1	152
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	7	23	31	25	15	4	2		1	138
North American Warm Desert Wash	315	7	28	34	27	20	6	3		1	189

Perennial Flow Modification by Diversion Structures

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	1	1		2				1		82
North American Warm Desert Riparian	246	1	1		2				2		240

Woodland and Mesquite Bosque / Stream											

Flow Modification by Dams

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	6	1		4	1	2	9	3	8	53
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	3						2	2	3	236

Condition of Groundwater Recharge Zone

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	80	1					1			2	76
North American Warm Desert Playa	133	1					1			3	128
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	145	1					2			2	140
North American Warm Desert Wash	169	1					2			3	163

KEA Summary (Stressors on Hydrology Condition)

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87					2	4	15	18	7	41
North American Warm Desert Playa	269			1	9	10	29	35	31	1	153
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246					1	9	49	45	7	135
North American Warm Desert Wash	315			1	10	10	31	37	36	1	189

KEA: Stressors on Water Quality

Atmospheric Deposition-Nitrate Loading (NO_3)

	Count of watersheds by Score interval										
	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	8	13	45	18	1		1	1		
North American Warm Desert Playa	269	12	18	76	77	36	18	18	13	1	
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	14	23	90	67	26	7	7	10	2	

North American Warm Desert Wash	315	18	24	102	82	36	19	19	13	2	
Atmospheric Deposition-Toxic Mercury Loading (Hg)											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	4	5	8	3	20	27	9	3		8
North American Warm Desert Playa	269	1	3	4	6	41	51	27	33	26	77
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	5	10	12	6	45	49	25	24	17	53
North American Warm Desert Wash	315	5	10	13	6	50	59	31	33	28	80
State-Listed Water Quality Impairments											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87									1	86
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246							1	3	2	240
Sediment Loading Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87							2	39	46	
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246		1	2	6	18	14	29	107	69	
KEA Summary (Stressors on Water Quality)											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87					2	22	48	13	2	
North American Warm Desert Playa	269		3	18	54	45	43	58	24	23	1
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246					5	58	101	61	19	2
North American Warm Desert Wash	315	1	9	36	62	52	45	60	25	24	1

KEA: Stressors on Biotic Condition											
Presence of Invasive Plant Species											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87								2	2	
North American Warm Desert Playa	269									1	
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246				1	1				2	
North American Warm Desert Wash	315	1		1	2	1	1	2	2	9	
Presence of Invasive Aquatic Species											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	2	1			1						
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	5		1				1		3		
North American Warm Desert Wash	1								1		

B-2.3 Summary Indices of Ecological Integrity: Results

Six summary indices of integrity, reported by watershed, were developed. These six indicators, each scaled from 0.0 (= low integrity) to 1.0 (= high integrity) can each provide a complimentary perspective on the integrity of the ecoregional landscape (Table B - 34).

Table B - 34. Summary indices of ecological integrity with associated reporting units.

Summary Indicator	Montane Upland	Basin Upland	Aquatic/Wetland, and Riparian
Landscape Condition	$4km^2$ grid		
Invasive Annual Grass	$4km^2$ grid		
Fire Regime Departure	Watershed	Watershed	
Hydrologic Condition			Watershed
Water Quality			Watershed

The first indicator summarized terrestrial landscape condition (Figure B - 70). As utilized in numerous places elsewhere in this assessment, this indicator was summarized here by $4km^2$ grid cell.

This indicator provides a concise visual summary of landscape intactness relative to built infrastructure and land conversion across the ecoregion. Generally, indicators score reflect the relative distance from major population centers and transportation corridors, clearly highlighting the most remote landscapes coinciding with the highest relative scores. In this ecoregion, these include such iconic landscapes as Death Valley, the western extreme of the Grand Canyon, and other remote areas such as the Sheep Range and Spring Mountains. Management directions aiming to restore landscape intactness in currently fragmented situations, and to maintain current levels of intactness where it currently remains, should be a consideration for meeting ecological goals across the MBR.

The second summary indicator compliments landscape condition by summarizing the potential abundance of invasive annual grass; also summarized by $4km^2$ grid cell (Figure B - 71). Mapping this summary indicator required the combination of values from 5 distinct invasive annual grass models; each of which predicts the location of multiple invasive annual grass species at different cover abundances (see Appendix A for a description of these models). An area and abundance weighting formula was used to combine per-pixel values from each model as they fell within each summary grid cell. This applied score areas with no annual grass extent the greatest proportional weight and the calculated value will be equal to 1. As annual grass encroach into the analysis unit the maximum value of 1.0 is degraded progressively with pixels representing the >45% cover value having the greatest ability to drive down the maximum value.

This provides a distinct perspective indicative of this pervasive ecological change, especially across middle elevations, of the ecoregional landscape. With the introduction of annual grasses through a variety of past and current land uses, and subsequent introduction of wildfire among desert scrub, there is much potential to further transform vegetation of the MBR.

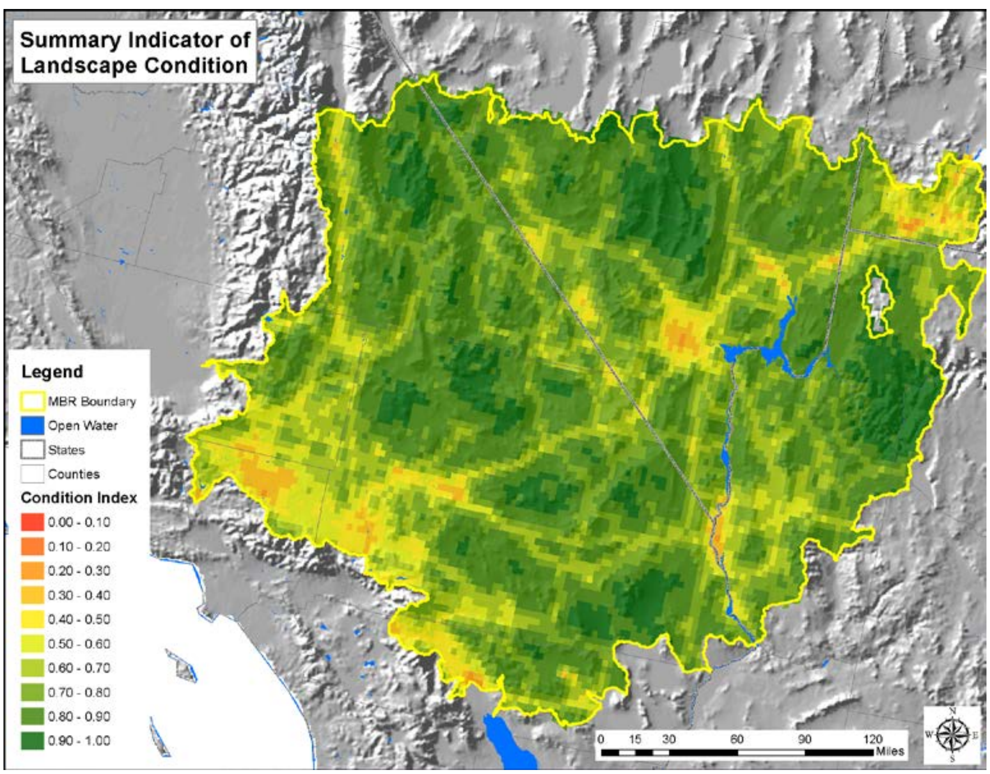


Figure B - 70. Summary Indicator of Landscape Condition for the MBR (by 4x4 km grid cells), scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green).

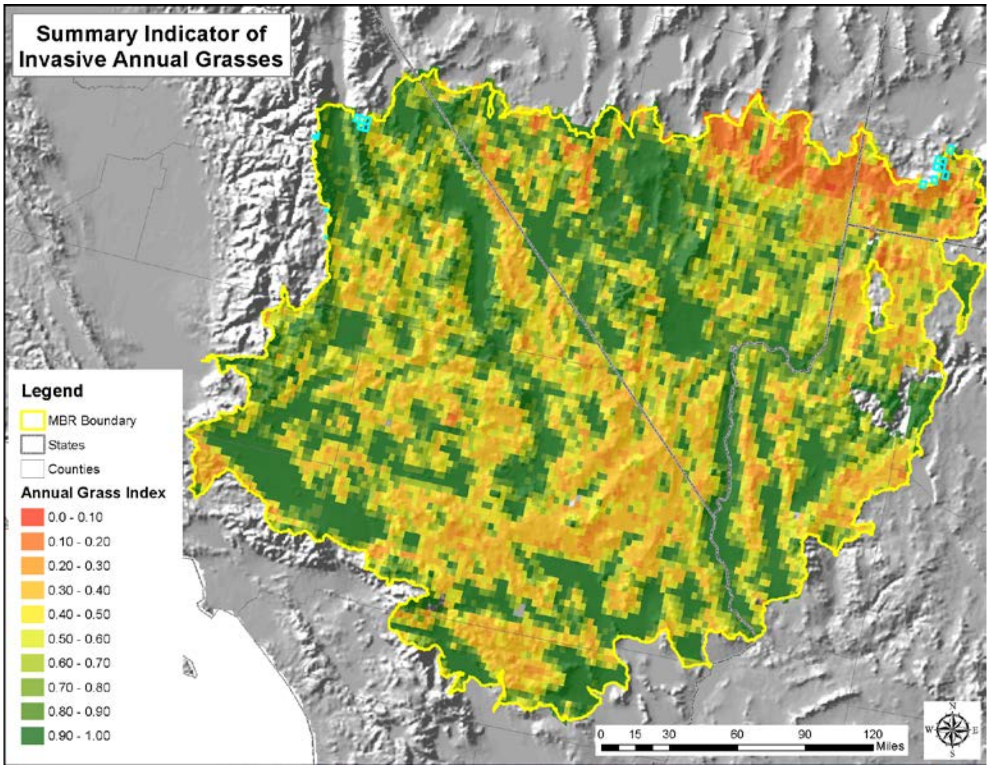


Figure B - 71. Summary Indicator of Invasive Annual Grass Potential for the MBR (by 4x4 km grid cells), scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green).

The third and fourth summary indicators address fire regime departure scores for types falling with Montane Upland and Basin Upland categories of the ecoregion-wide conceptual model. This distinction was made to better differentiate the distinctive fire regimes and fuel conditions that characterize the elevational gradients across the basin and range landscape. Since 5th level watersheds were used as spatial reporting units, they necessarily include vegetation from across this elevational gradient. But these two summary indicators were derived from vegetation CE scores that were organized within Montane Upland vs. Basin Upland categories of the ecoregional conceptual model.

These indicators suggest overall that substantial fire regime departure has occurred throughout the montane woodland vegetation of the MBR; especially throughout the eastern half of the ecoregion. While somewhat limited in overall extent, and effectively absent from many watersheds (see no data areas in Figure B - 72), many watersheds, shaded in Figure B - 72 in the yellow (0.5 scores) to orange (0.3 scores) range, indicate severe departure. This indication of integrity is concentrated in the SE Nevada/SW Utah border watersheds, and further south in California and Arizona on mountain ranges on either side the Colorado River. Fire regime departure for basin uplands (Figure B - 73) is overall somewhat more severe, and reflects a similar spatial pattern to that provided by the invasive annual grass indicator; especially where wildfire has likely been introduced as a novel disturbance process among mid-elevation desert scrub vegetation. These lower scores are somewhat more concentrated across the west Mojave than elsewhere in the ecoregion. Management implications for these fire regime indicator results follow closely to those mentioned above for invasive annual grasses.

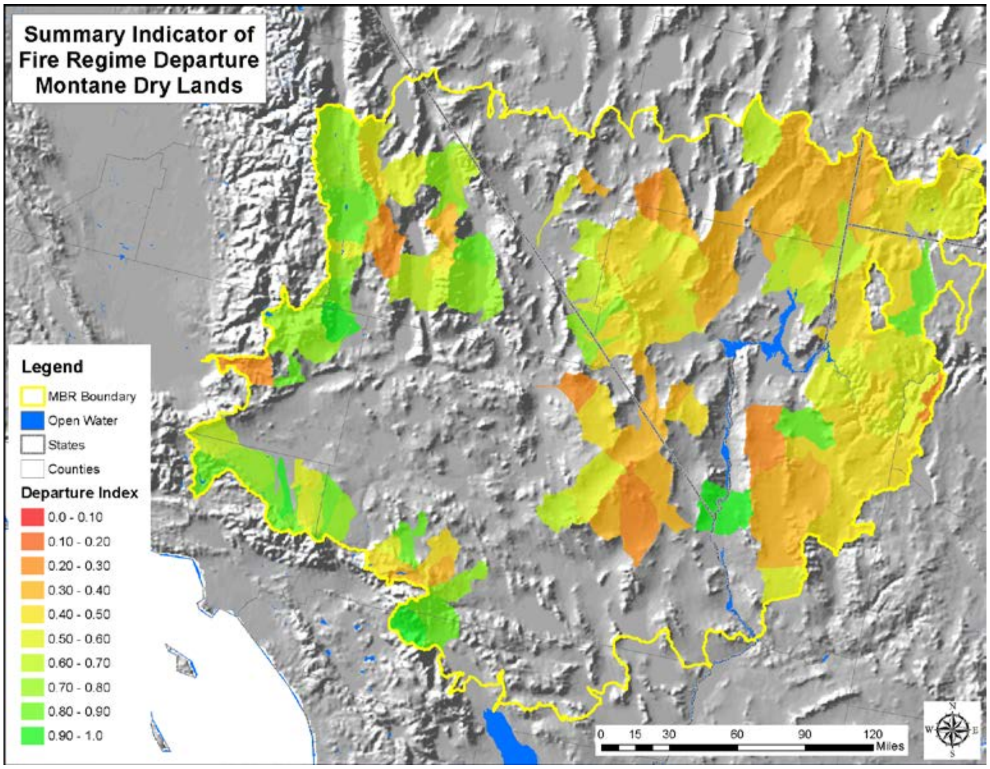


Figure B - 72. Summary Indicator of Fire Regime Departure – Montane Uplands for the MBR (by 4x4 km grid cells), scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green).

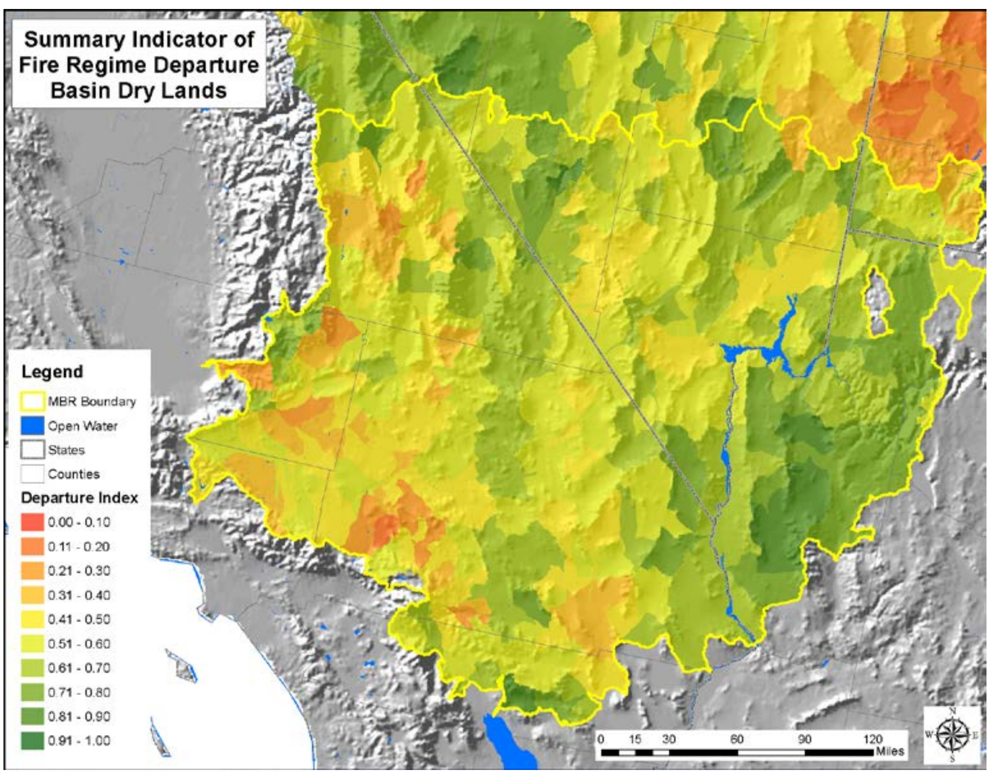


Figure B - 73. Summary Indicator of Fire Regime Departure – Basin Uplands for the MBR (by 4x4 km grid cells), scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green).

The last two summary indicators address aquatic ecosystems and utilized estimates of hydrologic condition and water quality, also summarized by 5th level watershed (Figure B - 74 and Figure B - 75). Stressors on Hydrologic Condition summarizes 5 individual measures of stress on hydrologic intactness, including surface water use, groundwater use, number of diversions, flow modification by dams, and condition of groundwater recharge zones.

Stressors on Water Quality summarizes 4 measures, including Nitrate and Mercury deposition rates, state-listed water impairments and sediment load indices.

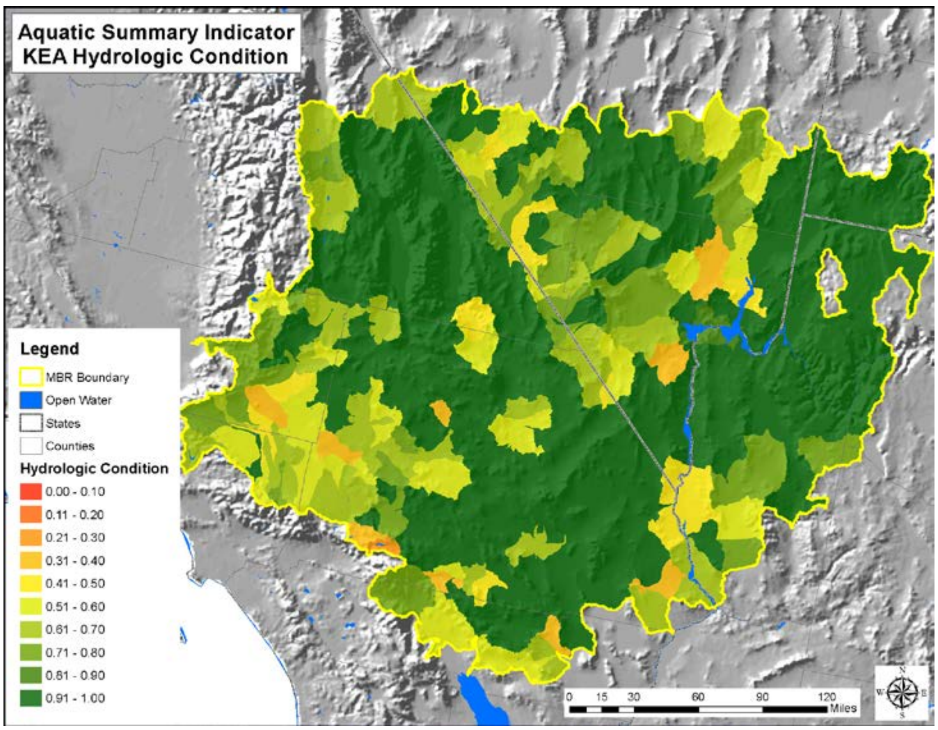


Figure B - 74. Summary Indicator of Stressors on Hydrologic Condition for the Mojave Basin & Range ecoregion , scaled from 0.0 (= low integrity, red or dark orange) to 1.0 (= high integrity, dark green). This summary indicator for the KEA includes individual indicators of stress on surface water use, groundwater use, flow modification by diversion structures, flow modification by dams, and condition of groundwater recharge zones.

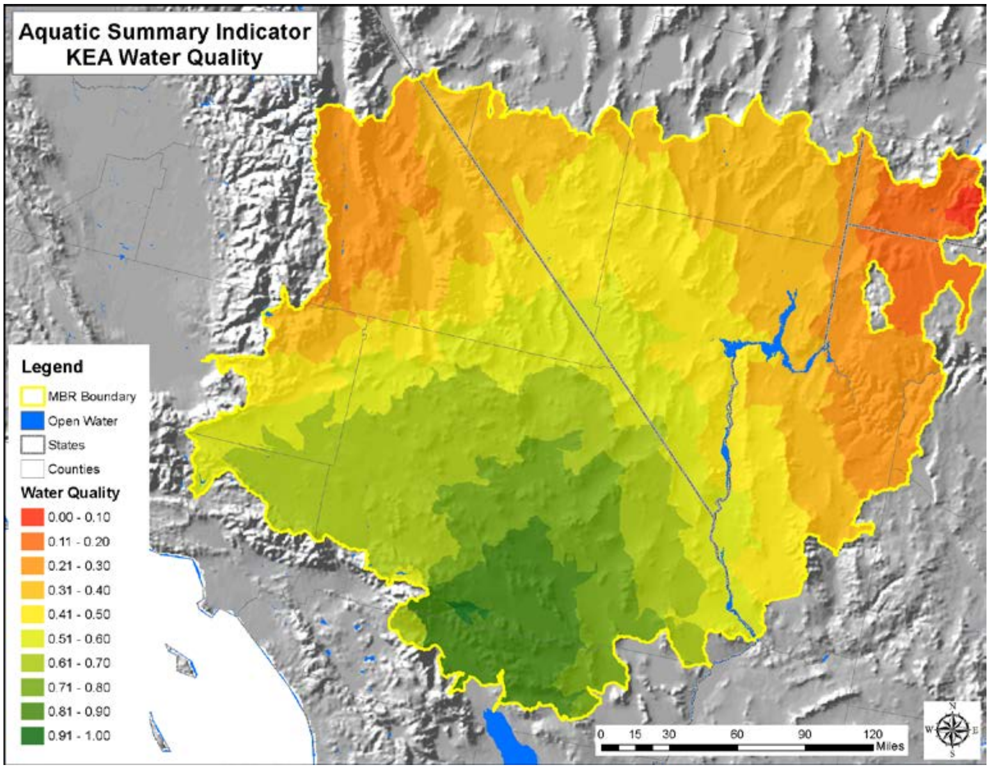


Figure B - 75. Summary Indicator of stressors on Water Quality for the Mojave Basin & Range ecoregion , scaled from 0.0 (= low integrity, red) to 1.0 (= high integrity, dark green). This summary indicator for the KEA includes individual indicators of stress on water quality from mercury and nitrate deposition, state-listed water quality impairments, and sediment loading.

B-2.4 2025 distribution and status

B-2.4.1 2025 Status: Terrestrial Coarse-Filter Conservation Elements

Table B - 35 can be compared to Table B - 29 to identify indicator trends forecasted for the upcoming decade. Due to limitations of available data, forecasted trends could only be reported for two indicators: landscape condition and fire regime departure. For most types across this desert landscape, landscape condition indicator tends to be in the top three categories. One can see in Table B - 35 where the numbers of watersheds for each type tend to remain in a similar distribution to current results (Table B - 29). However, one can see slight declines in the numbers of watersheds in the highest indicator categories, shifting to somewhat lower categories. This reflects predicted development from transporatation, urban, and energy infrastructure as of 2025.

General trends for fire regime departure would be expected to continue patterns for current conditions, as change in fire regime condition take decades to show measurable differences. The general trends among selected types in the MBR, where current substantial fire regime departure is indicated, carry forward throughout the 2025 time period and beyond. Clearly, management interventions for vegetation protection and restoration, addressing invasive plant species and their fire-regime effects in the MBR will remain an urgent priority.

Table B - 35. Indicator results by watershed for Terrestrial coarse-filter CEs (Future). For each indicator the count of 5th level watersheds is shown for each CE, broken out by indicator score interval.

KEA: Surrounding Land Use Context											
Future Landscape Condition Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Great Basin Pinyon-Juniper Woodland	315	1		8	8	17	20	**44**	**71**	**124**	22
Mojave Mid-Elevation Mixed Desert Scrub	315		2	4	10	8	21	27	**94**	**126**	23
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	312		5	9	7	16	**34**	**43**	**97**	**90**	11
North American Warm Desert Pavement	299	4	6	8	14	15	21	**58**	**89**	**74**	10
North American Warm Desert Bedrock Cliff and Outcrop	298		3	2	4	8	20	**34**	**93**	**119**	15
Sonora-Mojave Mixed Salt Desert Scrub	289	7	5	9	8	14	20	**43**	**75**	**94**	14
Great Basin Xeric Mixed Sagebrush Shrubland	192	1		1		2	6	5	**39**	**120**	18
Mogollon Chaparral	190	1	1	1	1	1	4	9	**42**	**109**	21
Inter-Mountain Basins Mixed Salt Desert Scrub	181	4		1	4	5	15	19	**42**	**76**	15
North American Warm Desert Badland	107		1	4	6	6	13	15	**21**	**40**	1
Sonora-Mojave Semi-Desert Chaparral	89		1	2	3	6	5	9	**17**	**37**	9
Sonoran Mid-Elevation Desert Scrub	61	1		1	3	1	4	**12**	**18**	**20**	1
North American Warm Desert Active and Stabilized Dune	34	1	2		2	1		1	**10**	**14**	3
2025 Fire Regime Departure Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	244	9				19	**102**	**114**			
Mojave Mid-Elevation Mixed Desert Scrub - mesic	174		5			23	24	**122**			
Great Basin Pinyon-Juniper Woodland	127			10	**64**	**25**	**28**				
Sonora-Mojave Mixed Salt Desert Scrub	67	6					3	11	**47**		
Great Basin Xeric Mixed Sagebrush Shrubland	53			10		10		**16**	**17**		
Mogollon Chaparral	38										**38**
Sonora-Mojave Semi-Desert Chaparral	31	1						5			**25**
Inter-Mountain Basins Mixed Salt Desert Scrub	24						3		**21**		
Sonoran Mid-Elevation Desert Scrub - mesic	22			2			**15**	5			

Sonoran Mid-Elevation Desert Scrub - thermic	13	1	**12**									

Maps of terrestrial coarse filter CEs 2025 ecological status

The 2025 spatial results of the ecological status assessment for a selection of the terrestrial coarse filter CEs are presented in Figure B - 76 through Figure B - 81. These are organized within the ecoregional conceptual model, with Montane Dry Land systems presented first; then the Basin Dry Land systems. Within each group systems are sorted from high to low elevation.

MONTANE DRY LAND SYSTEMS

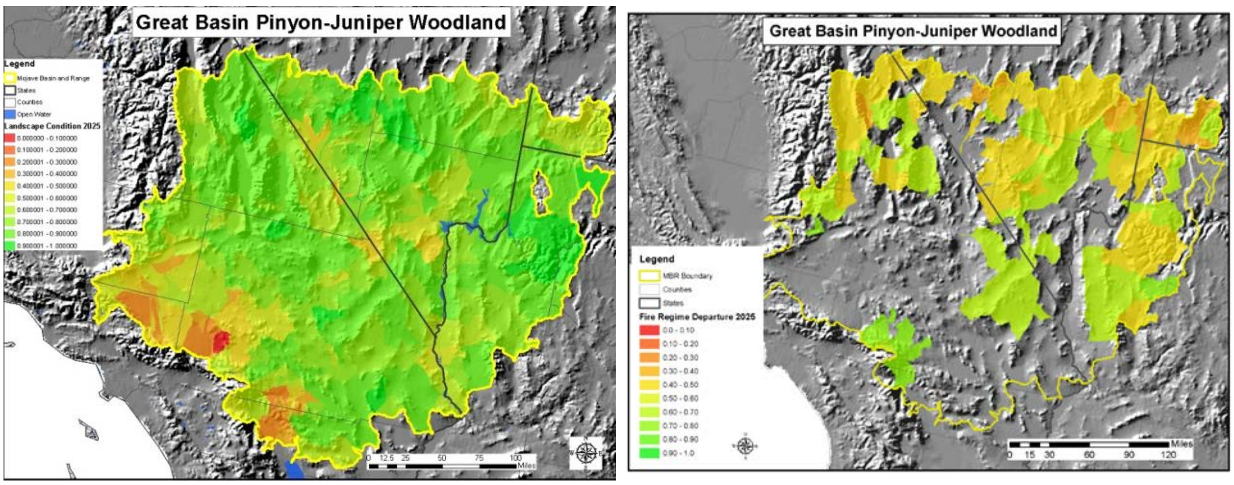


Figure B - 76. Great Basin Pinyon-Juniper Woodland 2025 status: 2025 Landscape Condition Index scores (left) and 2025 Fire Regime Departure Index scores (right)

BASIN DRY LAND SYSTEMS

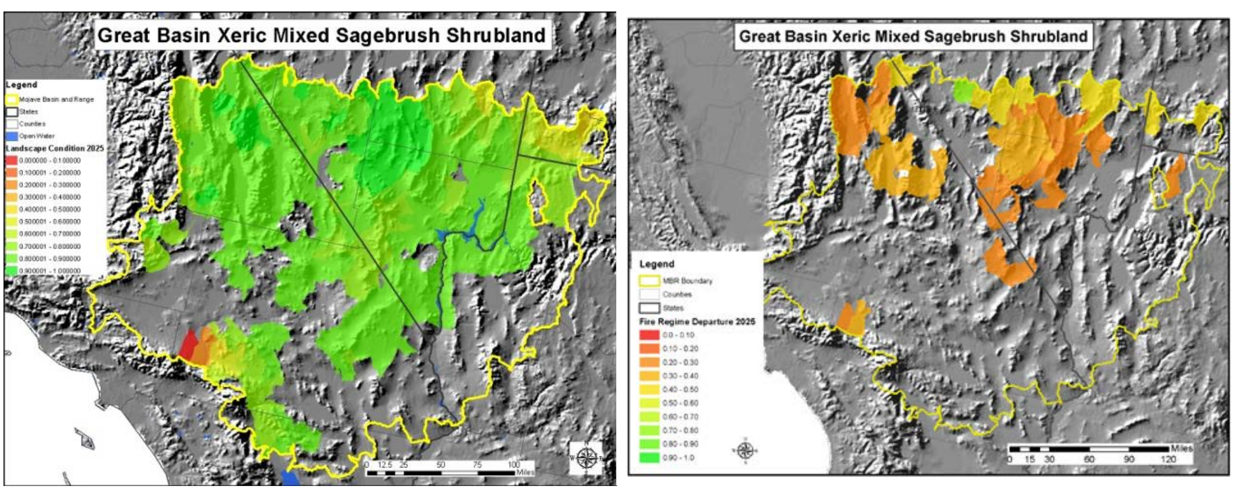


Figure B - 77. Great Basin Xeric Mixed Sagebrush Shrubland 2025 status: 2025 Landscape Condition Index scores (left) and 2025 Fire Regime Departure Index scores (right)

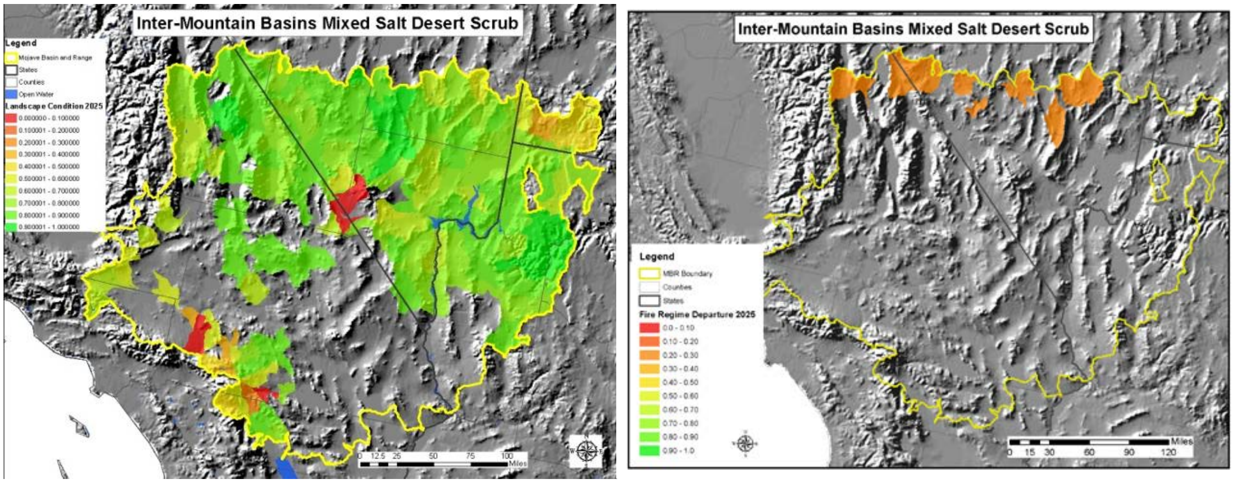


Figure B - 78. Inter-Mountain Basins Mixed Salt Desert Scrub 2025 status: 2025 Landscape Condition Index scores (left) and 2025 Fire Regime Departure Index scores (right)

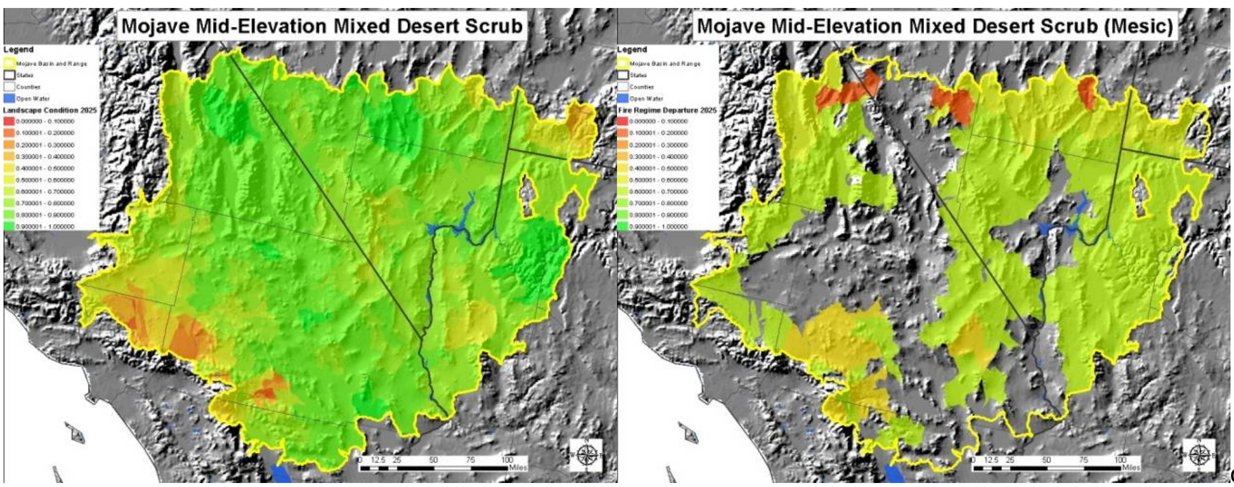


Figure B - 79. Mojave Mid-Elevation Mixed Desert Scrub 2025 status: 2025 Landscape Condition Index scores (left) and 2025 Fire Regime Departure Index scores (right) for mesic variant.

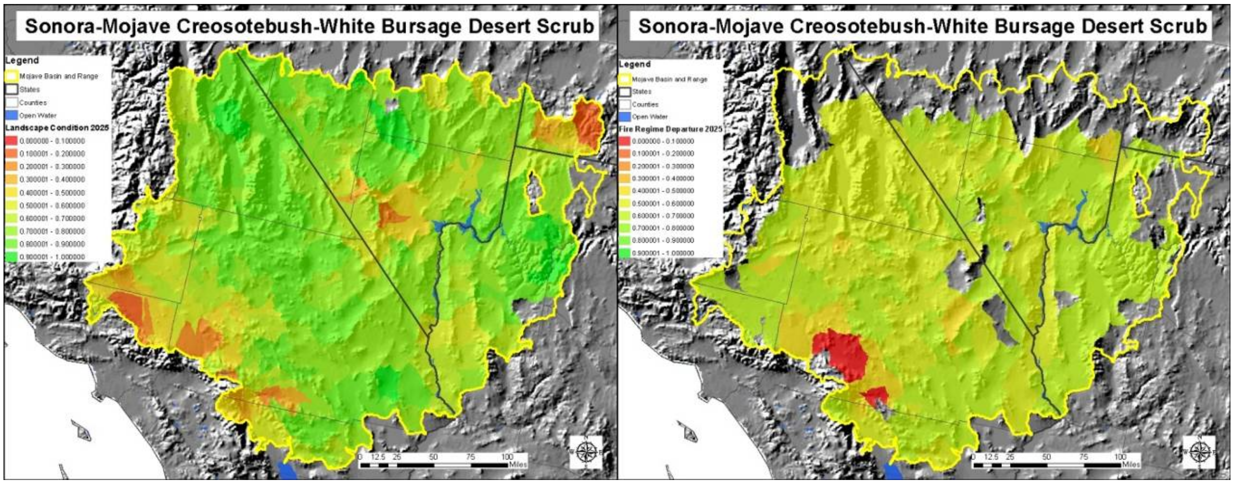


Figure B - 80. Sonora-Mojave Creosotebush-White Bursage Desert Scrub 2025 status: 2025 Landscape Condition Index scores (left) and 2025 Fire Regime Departure Index scores (right)

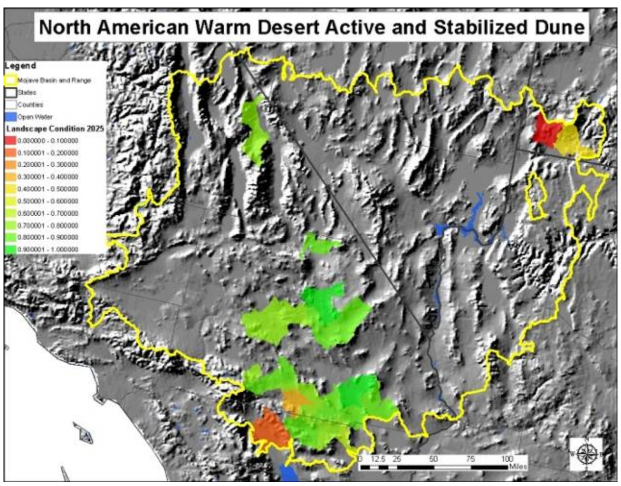


Figure B - 81. North American Warm Desert Active and Stabilized Dune 2025 Landscape Condition Index scores

B-2.5 2025 Status: Landscape Species

Table B - 36 can be compared to Table B - 30 to identify indicator trends forecasted for the upcoming decade. Due to limitations of available data, forecasted trends could only be reported for one indicator for the landscape species: landscape condition. For most species across this desert landscape, landscape condition indicator tends to be in the top four intervals of scores. One can see in Table B - 36 where the numbers of 4x4 km grid cells tend to remain in a similar distribution to current results (Table B - 30). However, one can see slight declines in the numbers of grid cells in the highest indicator categories, shifting to somewhat lower categories. This reflects predicted development from transporatation, urban, and energy infrastructure as of 2025.

Table B - 36. Indicator results by 4 x 4 km grid cell for landscape species CEs (2025). For each indicator the count of 4 x 4 km grid cells is shown for each CE, broken out by indicator score interval.

KEA: Landscape Condition											
Future Landscape Condition Index											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Bald Eagle	84	3	3	8	**14**	**16**	**16**	**13**	10	1	
Big Brown Bat	9,665	135	108	128	169	354	**734**	**1315**	**2368**	**3524**	**830**
Brazilian Free-tailed Bat	9,702	124	104	129	171	334	**713**	**1333**	**2421**	**3557**	**816**
Brewer's Sparrow Breeding	2,188	24	25	34	73	131	259	270	**444**	**670**	258
Brewer's Sparrow Migrating	4,214	39	22	20	21	43	126	418	**1052**	**1952**	521
Coachwhip	9,685	121	99	111	170	329	**717**	**1323**	**2428**	**3560**	**827**
Common Kingsnake	9,716	114	92	120	179	327	**693**	**1387**	**2426**	**3527**	**851**
Cooper's Hawk	7,978	179	152	138	194	440	**805**	**971**	**1535**	**2794**	**770**
Desert Bighorn Sheep	4,613	16	16	22	35	86	183	**459**	**1185**	**2152**	**459**
Gila Monster	2,863	40	35	33	32	60	176	**491**	**953**	**928**	115
Glossy Snake	9,382	126	96	105	187	321	**695**	**1338**	**2328**	**3415**	**771**
Golden Eagle	131	5	7	8	14	**19**	**18**	**26**	**21**	11	2
Great Basin Collared Lizard	9,400	107	81	100	173	271	**637**	**1307**	**2375**	**3515**	**834**
Kit Fox	8,510	115	95	105	183	300	**668**	**1309**	**2265**	**2921**	**549**
Mojave Desert Tortoise	5,186	109	71	66	116	204	**454**	**838**	**1332**	**1740**	256
Mojave Ground Squirrel	2,368	65	52	61	84	168	**310**	**383**	**414**	**709**	122
Mojave Rattlesnake	6,068	138	97	90	142	247	**594**	**1054**	**1482**	**1959**	265
Mule Deer Summer	455					4	25	**61**	**147**	**178**	**40**
Mule Deer Winter	584	1	1	4	3	21	**67**	**116**	**187**	**163**	21
Mule Deer Yearlong	1,865	18	21	16	42	89	187	**314**	**482**	**641**	55
Northern Harrier	153				3	9	3	7	**70**	**61**	
Northern Rubber Boa	397		1	2	13	32	**72**	**91**	**103**	**82**	1
Northern Sagebrush Lizard	4,913	30	34	33	48	96	239	**547**	**1213**	**2004**	**669**
Prairie Falcon	9,746	114	110	117	199	318	**710**	**1366**	**2430**	**3569**	**813**
Sage Sparrow	405					1	5	28	**145**	**171**	55
Sage Thrasher	1,192	3	8	8	25	46	86	139	**308**	**475**	94
Sonoran Desert Tortoise	589	8	8	5	9	18	62	**143**	**214**	**122**	
Western Banded Gecko	2,404	9	21	21	43	82	180	**408**	**748**	**724**	168
Western Patch-nosed Snake	9,072	117	97	117	182	297	667	**1278**	**2193**	**3318**	806

Maps of landscape species CEs 2025 ecological status

The 2025 spatial results of the ecological status assessment for a selection of the landscape species CEs are presented in Figure B - 82 through Figure B - 87. These are organized within the ecoregional conceptual model, with species associated with Montane Dry Land System presented first, then the species found in Basin Dry Land System. Species associated with either Basin or Montane Wet System are presented as a third group of CEs.

MONTANE DRY LAND ASSOCIATED SPECIES

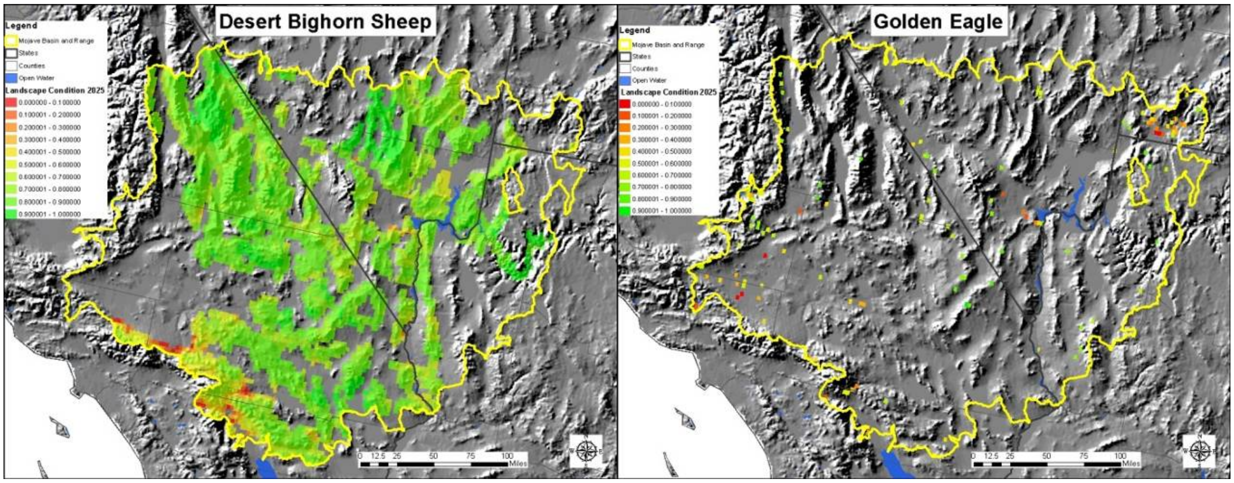


Figure B - 82. 2025 Landscape Condition Index scores for Desert Bighorn Sheep and Golden Eagle

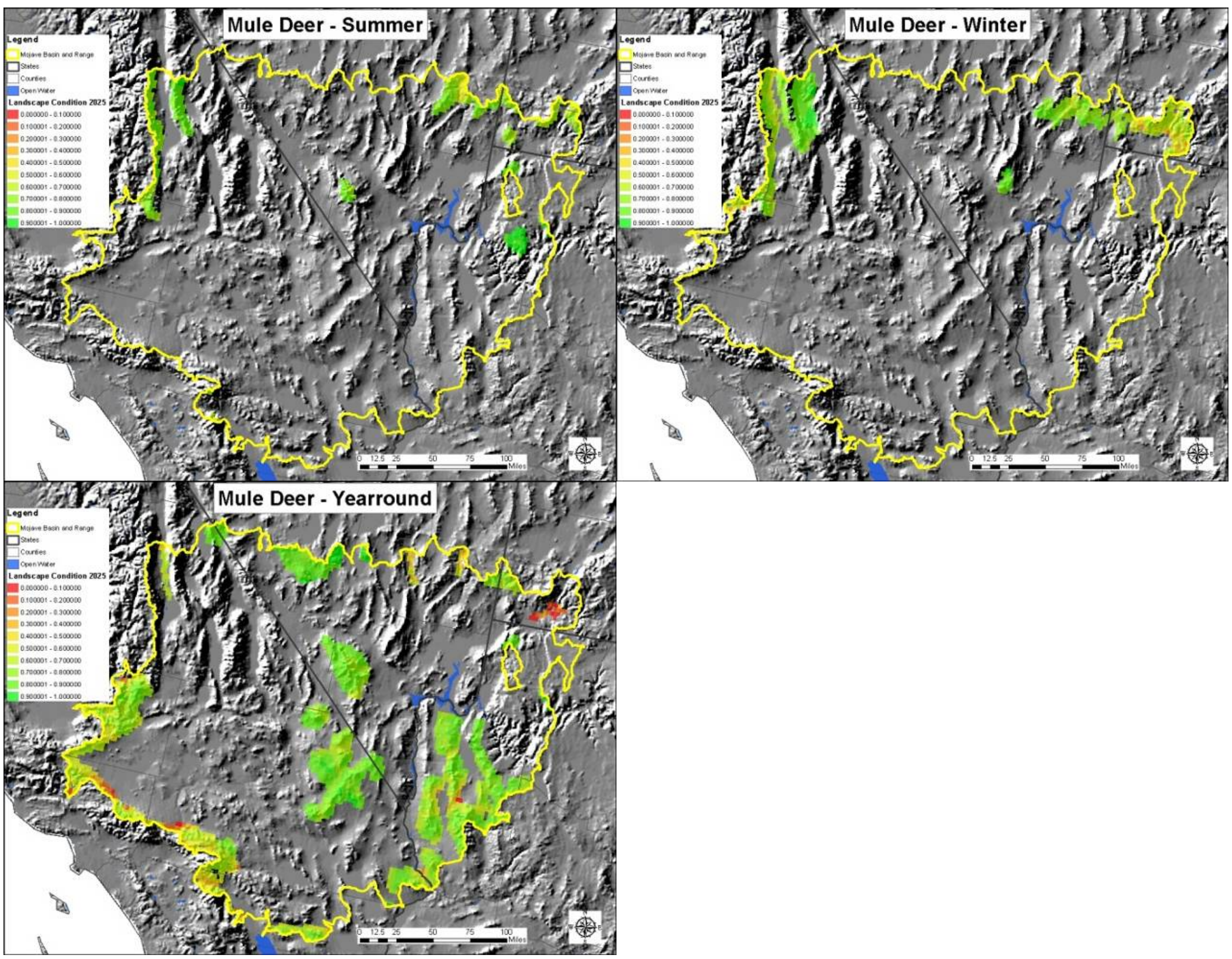


Figure B - 83. Mule Deer 2025 Landscape Condition Index scores for Summer, Winter, and Year-round habitats

BASIN DRY LAND ASSOCIATED SPECIES

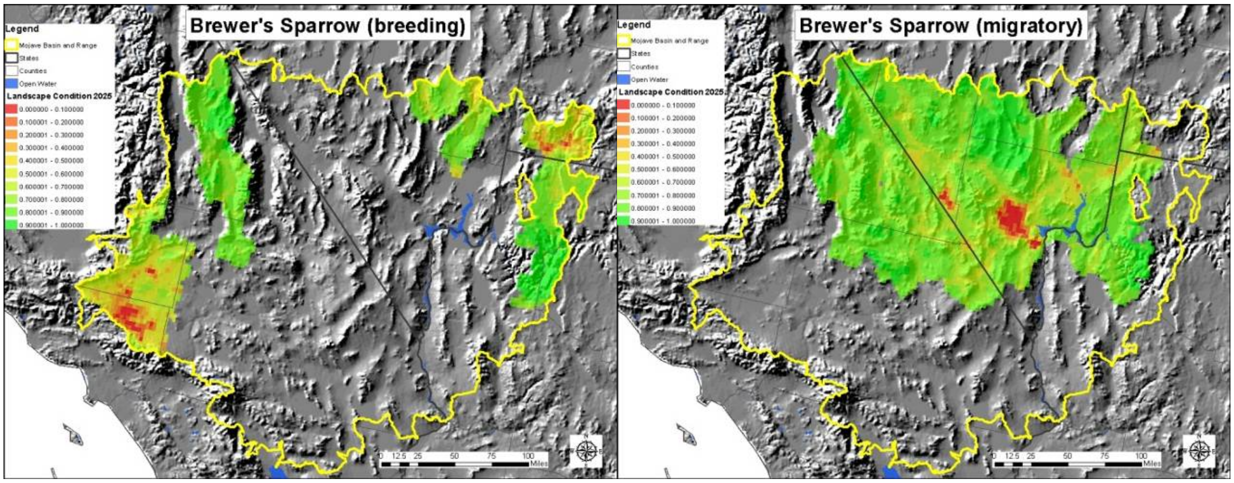


Figure B - 84. Brewer's Sparrow 2025 Landscape Condition Index scores for Breeding and Migratory habitats

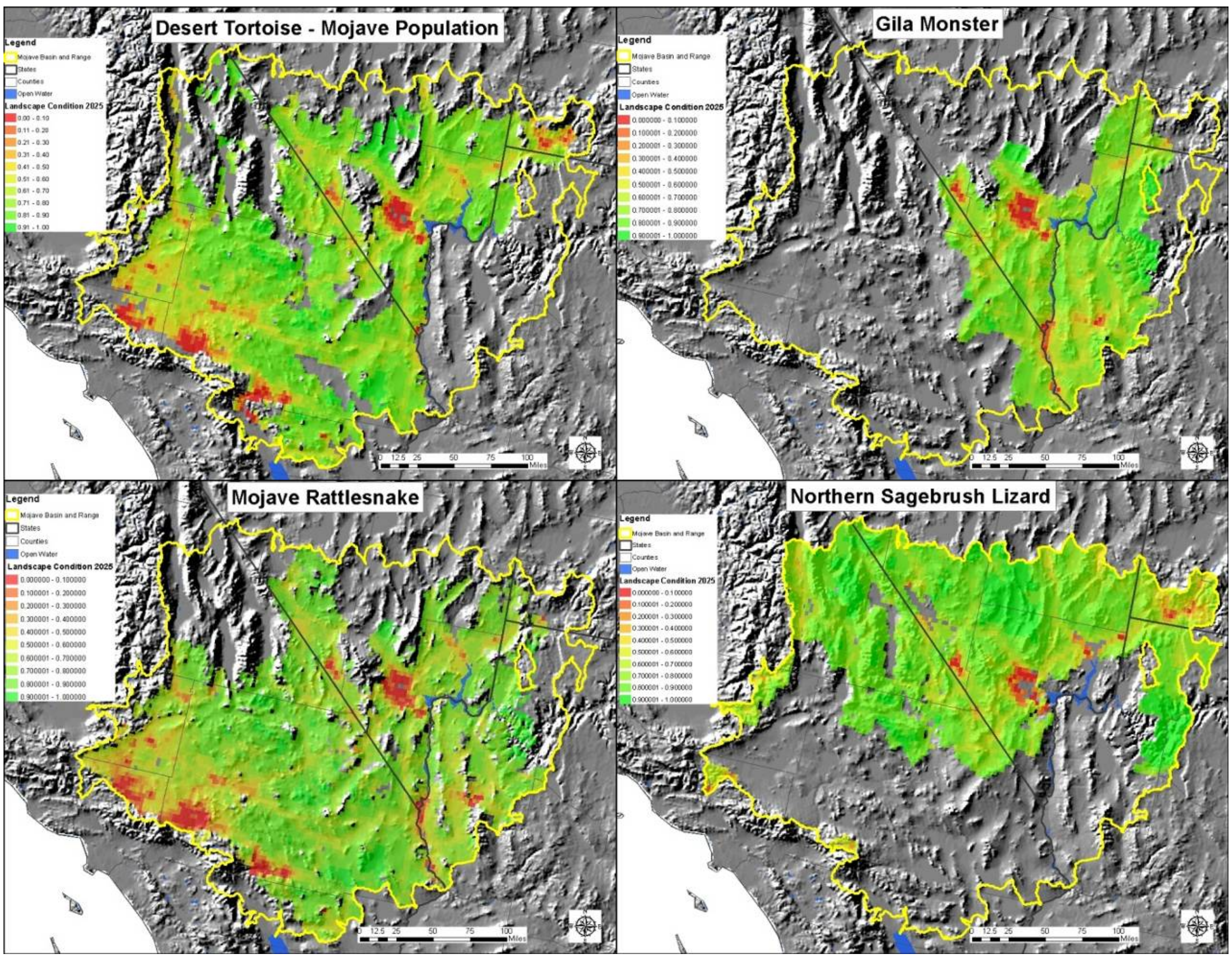


Figure B - 85. 2025 Landscape Condition Index scores for Mojave Desert Tortoise, Gila Monster, Mojave Rattlesnake,and Northern Sagebrush Lizard

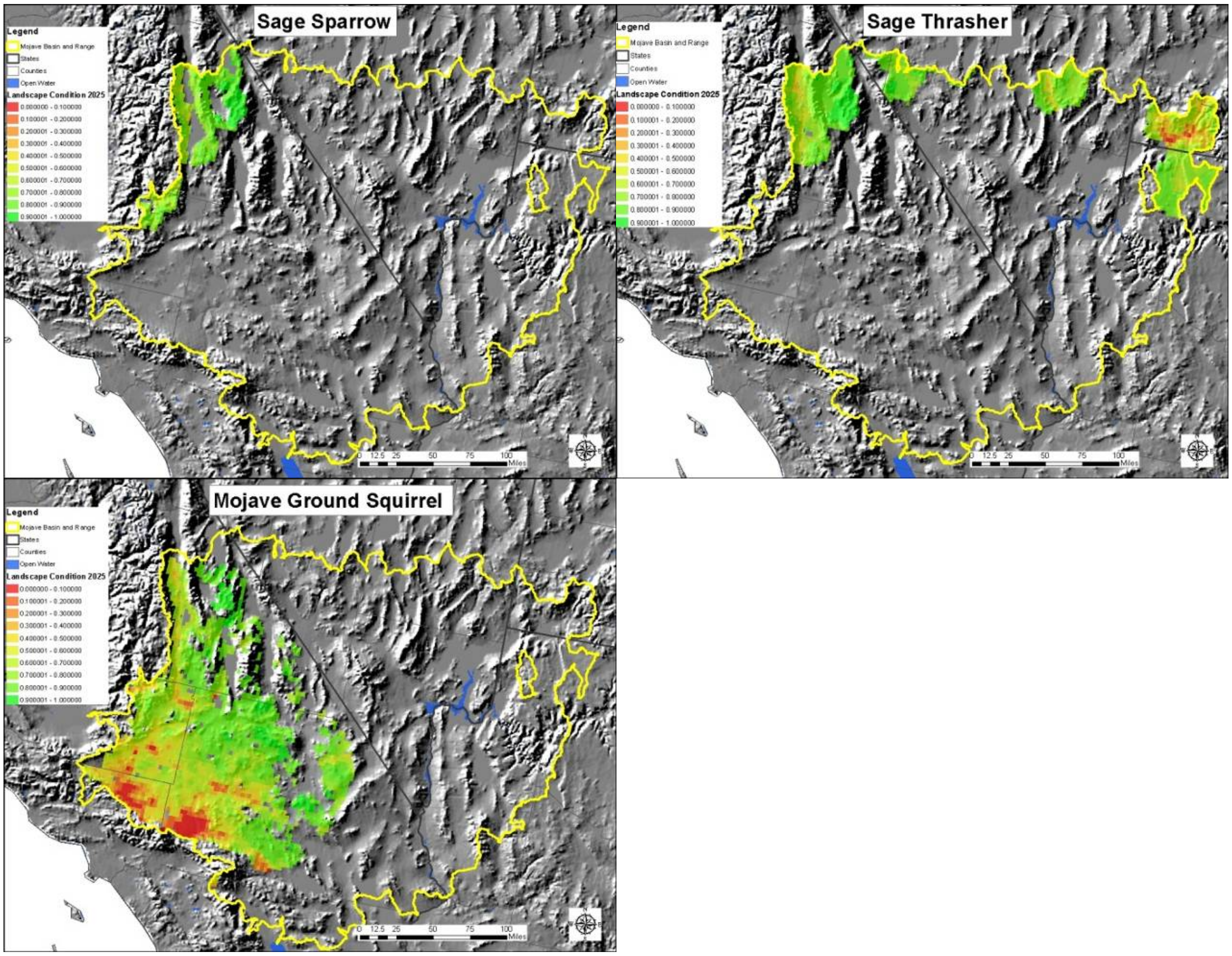


Figure B - 86. 2025 Landscape Condition Index scores for Sage Sparrow, Sage Thrasher, and Mojave Ground Squirrel

MONTANE OR BASIN WET ASSOCIATED SPECIES

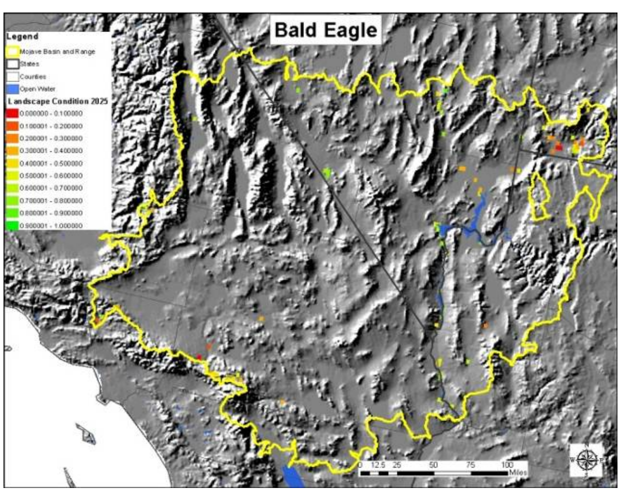


Figure B - 87. Bald Eagle 2025 Landscape Condition Index scores

B-2.6 2025 Status: Vulnerable Species Assemblages

Table B - 37 can be compared to Table B - 31 to identify indicator trends forecasted for the upcoming decade. Due to limitations of available data, forecasted trends could only be reported for two indicators: landscape condition and fire regime departure. Due to limitations of available data, forecasted trends could only be reported for one indicator for the assemblages: landscape condition. For most species assemblages across this desert landscape, landscape condition indicator tends to be in the top four intervals of scores. One can see in Table B - 37 where the numbers of 4x4 km grid cells tend to remain in a similar distribution to current results (Table B - 31). However, one can see slight declines in the numbers of grid cells in the highest indicator categories, shifting to somewhat lower categories. This reflects predicted development from transporatation, urban, and energy infrastructure as of 2025.

Table B - 37. Indicator results by 4 x 4 km grid cell for species assemblage CEs (2025). For each indicator the count of 4 x 4 km grid cells is shown for each CE, broken out by indicator score interval.

KEA: Landscape Condition											
Future Landscape Condition Index											
	Count of 4 x 4 grid cells by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Montane conifer	3,867	185	109	83	129	234	404	**567**	**871**	**1018**	267
Azonal carbonate rock crevices	3,456	63	36	21	44	87	211	**390**	**808**	**1422**	**374**
Sand dunes/sandy soils (when deep and loose)	2,734	50	45	33	65	106	264	396	**737**	**926**	112
Gypsum soils	811	38	15	7	20	50	85	**160**	**239**	**188**	9
Migratory waterfowl & shorebirds	472	33	24	25	42	48	**81**	**89**	**77**	44	9
Azonal non-carbonate rock crevices	261					1	5	8	**46**	**147**	**54**
Carbonate (Limestone/Dolomite) alpine	68						1	8	**14**	**36**	9
Non-carbonate alpine	56						1	4	5	**43**	3

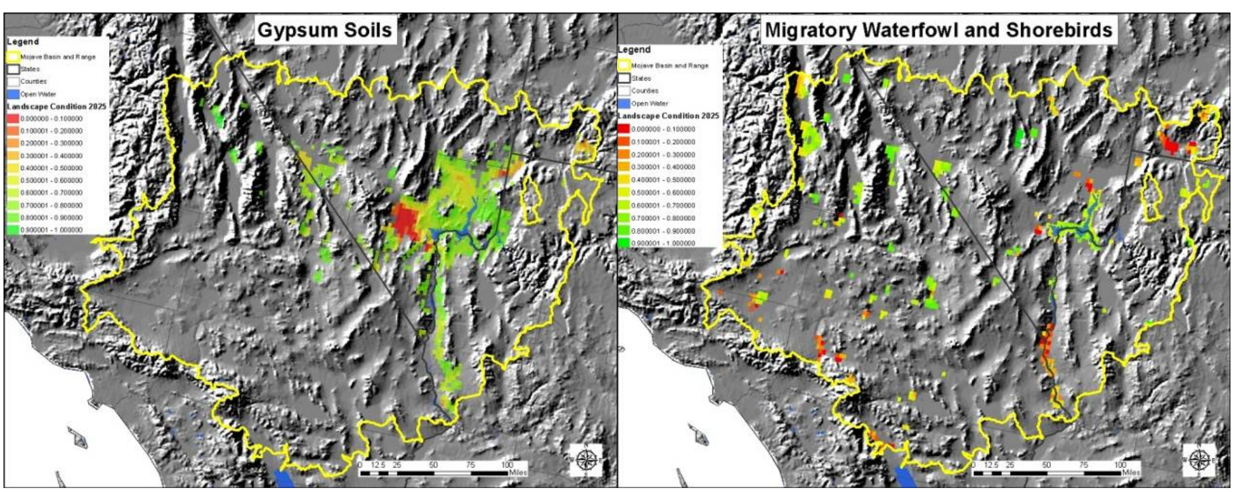


Figure B - 88. 2025 Landscape Condition Index scores for Gypsum Soils and Migratory waterfowl & shorebirds Species Assemblages

B-2.6.1 2025 Status: Aquatic Conservation Elements

This section addresses the impact of the projected future increase in Development (urban growth) on Surface Water Use, Groundwater Use, and Riparian Corridor Continuity. The possibility of future Aquatic Invasive Species infestation is explored through the 'At Risk' Index, which uses biology and dispersal mechanisms to measure risk of infestation on currently un-infested aquatic resources, and the 'Future Impact' Index, which looks at the degree of infestation of upstream watersheds and increased recreational usage to gage likelihood of future infestations.

B-2.6.1.1 Surface Water and Groundwater Use Change

MQ #54: WHERE WILL CHANGE AGENTS POTENTIALLY IMPACT GROUNDWATER-DEPENDENT AQUATIC CEs?

MQ #60: WHERE ARE THE AREAS OF POTENTIAL FUTURE CHANGE IN SURFACE WATER CONSUMPTION AND DIVERSION?

This section builds on the separate assessment of future Development. In particular this section addresses the potential impacts on groundwater-dependent aquatic CEs from Development alone. Specifically, answering this question requires (a) identifying where (in which watersheds) Development is forecast to change in ways that would affect water use, and (b) estimating how much of the resulting change in water use will involve a change in groundwater use.

The second MQ concerns only the potential impacts on surface water use from Development. Specifically, this requires (a) identifying where (in which watersheds) Development is forecast to change in ways that would affect water use, and (b) estimating how much of the resulting change in water use will involve a change in surface water use.

Methods

Systematic databases are not available for enough of the MBR ecoregion, to attribute groundwater discharges at individual groundwater-dependent aquatic CE occurrences to specific aquifer sources (see discussion for Aquatic CE Indicator Groundwater Use). However, the data assembled to assess Groundwater Use do make it possible to assess the overall intensity of groundwater use in each watershed, as a potential source of stress to groundwater-dependent aquatic CE occurrences. It is not possible with the data assembled for this rapid assessment to systematically identify individual watersheds where Development potentially will impact specific groundwater-dependent aquatic CE occurrences. Rather, the data available make it possible to identify watersheds containing groundwater-dependent aquatic CE types, in which Development potentially could lead to a change in groundwater use.

The separate assessment of the Development Change Agent, further, only provides estimates of future urban development, not development of agriculture. The assessment of these management questions therefore must focus on the potential impacts of urban development on groundwater and surface water use, respectively. The data on current water use required for this analysis come from the U.S. Geological Survey, Southwest Principal Aquifer (SWPA) study (Anning et al. 2009; McKinney and Anning 2009), as discussed in the assessments of Aquatic CE Indicators Surface Water Use, and Groundwater Use.

The SWPA study identified all water use associated with urban areas as "Public Water Supply" (PWS) use, with urban areas defined as those with a population density greater than 1,000 persons per square mile (386 persons per square kilometer). The SWPA study further divided PWS use into two components, consisting of the amount of PWS use supplied from surface water and from groundwater sources, respectively. These two components are calculated from per-capita use rates for surface and ground water estimated for 2000, combined with population data from 2005 (Anning et al. 2009; McKinney and Anning 2009).

The separate assessment of the Development Change Agent has generated estimates of the change in area of urban development expected between the years 2010 and 2030. The estimates of urban development in this case come from a separate geographic analysis using U.S. Environmental Protection Agency methods from the Integrated Climate and Land Use Scenarios (ICLUS) project, Spatially Explicit Regional Growth Model (SERGoM) (USEPA 2010). The SWPA study "urban" threshold of 1,000 persons per square mile corresponds closely to the SERGoM threshold for housing density Class 8 (1,754 housing units per 12 km^2 grid unit).

The calculations required to evaluate these management questions for the MBR ecoregion therefore involved the following five steps, for each watershed:

1. *Total PWS water use for 2010*, *PWS surface water use for 2010*, and *PWS groundwater use for 2010* were calculated from the SWPA study data. These represent use rates for 2005 but based on per-capita water use rate estimates for 2000 combined with population data from 2005, as noted above. Units are in acre-feet per year (afy).
2. *Total PWS water use per unit of urban area for 2010* was calculated by dividing *Total PWS water use for 2010* by the *urban area for 2010* (acres) contained in each watershed, based on the area values estimated in the Development Change Agent analysis. Resulting units are in afy per acre.
3. *Total PWS water use for 2030* was calculated by multiplying the estimates of *urban area for 2030* (from the Development Change Agent analysis) by the value of *Total PWS water use per unit of urban area for 2010* calculated in Step. 2. Resulting units are in afy.
4. *Change in total PWS water use 2010-2030*, was calculated by subtracting the estimated *Total PWS water use for 2030* from *Total PWS water use for 2010* and expressing that difference as a percentage of *Total PWS water use for 2010*. Units are %.
5. *Change in PWS <u>surface</u> water use 2010-2030* and *change in PWS <u>groundwater</u> use 2010-2030* were calculated from the value for *Change in total PWS water use 2010-2030* based on the ratio of *PWS surface water use for 2010* to *PWS groundwater use for 2010*.

Methods Rationale

The methods used to calculate change in PWS surface water use 2010-2030 and change in PWS groundwater use 2010-2030 entail two assumptions:

- The calculations assume that increases in PWS demand for water will be met through some as-yet unknowable combination of improvements in water-use efficiency (affecting per-capita water use), conversion of agricultural water use rights to public water supply rights, inter-basin transfers of surface water, and additional groundwater withdrawals. The additional withdrawals of groundwater could take place within the immediate watershed of interest, or take place in other watersheds from which the water is then transferred to the watershed of interest. The Southern Nevada Water Authority applications for groundwater rights in multiple basins in the MBR and Central Basin & Range ecoregions, to support water use in the Las Vegas metropolitan area, is an example of the latter method for acquiring additional ground water (SNWA 2011). At present there are no data or methods available with which to forecast the exact combination of methods that water authorities will be able to implement across the MBR ecoregion to meet future water demands. In fact, the topic is a matter of considerable debate (e.g., Cooley et al. 2007; Gleick 2010; BLM 2011; SNWA 2011).
- The calculations also assume that the <u>ratio</u> of PWS surface water use to PWS groundwater use will not change, between 2010 and 2030. That is, the calculations assume that, whatever combination of methods the water authorities use to meet future water demand between 2010 and 2030, the balance between PWS surface water use and groundwater use will not

change. This assumption is necessary to allow the estimation of future PWS surface and groundwater use. However, water authorities in localities that presently rely in part on surface water supplies may seek to offset expected uncertainties in these supplies by using more groundwater resources. That is, they may seek to change the ratio of surface to groundwater use in their localities, as is proposed, for example, for the Las Vegas metropolitan area (SNWA 2011).

In combination, the methods and assumptions result in estimates of PWS surface and groundwater use in 2030, per watershed, expressed as a percentage change from PWS surface and groundwater use in 2010. The estimates thus represent a specific scenario for change in water use, allowing an assessment of where large changes may take place that overlap with the distributions of aquatic CEs. The methods can be easily modified to assess other, alternative scenarios. For example, they could be modified to assess the potential impacts of increased water-use efficiency (reduced per-capita PWS water use rates), or a switch in the relative use of surface versus ground water in a given watershed. However, an evaluation of such alternative future scenarios is outside the scope of the present rapid assessment.

The projected values for *change in PWS surface water use 2010-2030* range from a minimum of 0% to a maximum of 948.1%. The projected values for *change in PWS groundwater use 2010-2030* range from 0% to 611.9%. However, the distributions of values are highly skewed for both variables. Most watersheds show little or no change. To facilitate analysis, therefore, the raw values were transformed to their logarithms ($\log_{10}$), resulting in a far less skewed distribution. watersheds with a raw use rate of 0 were assigned a log value equal to that of the lowest non-zero percentage measured for any watershed in the ecoregion ($\log_{10}$ = -2.2 for surface water use, -2.0 for ground water use). The resulting ranges of logarithm values, from -2.2 to +1.0 for PWS surface water use and -2.0 to +0.8 for groundwater use, better distinguish among use rates by their order of magnitude. For ease of presentation, the results were then normalized to range from 0 to 1.

Results and Implications

As noted above, the projected values for *change in PWS surface water use 2010-2030* in the MBR ecoregion range from a minimum of 0% to a maximum of 948.1%, and the projected values for *change in PWS groundwater use 2010-2030* range from 0% to 611.9%. Thus, all changes are positive; no watershed is projected to experience a decrease in either PWS surface or groundwater use. As also noted above, further, the distributions of values are highly skewed for both variables. Most watersheds experience little or no change, but a few experience large changes. For PWS surface water use, 24 out of 315 watersheds show a change greater than 25%; and 9 watersheds experience a change greater than 100%. For PWS groundwater use, 46 watersheds experience a change greater than 25%; and 14 watersheds experience a change greater than 100%.

Watersheds with an estimated 2010-2030 increase in PWS surface water use greater than 25% occur in two major clusters: (1) Las Vegas, Nevada, and its surrounding valleys, including along the Colorado River and the Moapa Valley, Indian Springs, and Pahrump areas; and (2) the watersheds immediately north of the San Bernardino and San Gabriel Mountains in California, from Interstate Highway 5 eastward to Twentynine Palms and northward to the Barstow area, including the areas around Palmdale/Lancaster and Victorville/Apple Valley/Hesperia. In turn, watersheds with an estimated 2010-2030 increase in PWS groundwater use greater than 25% occur in two clusters and two isolated locations, as follows: (1) areas surrounding Las Vegas, Nevada, including the Moapa Valley and Pahrump areas; (2) along Sacramento Wash between Kingman, Arizona, and the Colorado River; (3) along the South Fork of the Kern River near Weldon, California (east of Isabella Lake) at the southern end of the Sierra Nevada range; and (4) most intensively in a broad band in California extending from the northern slopes of the San Bernardino and San Gabriel Mountains north to the southern end of

Owens Valley, and from Interstate Highway 5 eastward to Twentynine Palms and the Palm Springs/Indio area, including the areas of Palmdale/Lancaster, Ridgecrest, Victorville/Apple Valley/Hesperia, and Barstow. These results correspond to the areas of greatest projected urban growth in the ecoregion. The estimates of the potential impacts of this growth on surface and groundwater resources, respectively, depend on the present-day (2010) observed relative rates of PWS surface versus groundwater use.

All of the watersheds projected to see increases in PWS surface water use contain occurrences of the Mojave Desert Lake/Reservoir; North American Warm Desert Riparian Woodland and Shrubland/Stream (Including Mesquite Bosque); North American Warm Desert Wash; and North American Warm Desert Playa aquatic CE types. Many watersheds projected to see increases in PWS surface water use also contain occurrences of the North American Warm Desert Lower Montane Riparian Woodland and Shrubland/Stream aquatic CE types, but this CE type has only a limited distribution within the ecoregion. The projected increases in PWS surface water use from 2010 to 2030 therefore pose threats to almost the entire spectrum of aquatic CE types supported by surface water flows present in the ecoregion in the affected watersheds.

All of the watersheds projected to see increases in PWS groundwater use also contain occurrences of the Mojave Desert Springs and Seeps aquatic CE type, and contain individual reaches of the North American Warm Desert Riparian Woodland and Shrubland/Stream (Including Mesquite Bosque) CE type with perennial flow (e.g., along the Mojave River). Both of these CE types or reaches within them depend on groundwater discharges. Unfortunately, as discussed for Indicator Ground Water Use, it is not possible to identify which aquifers support which CE occurrences, and which aquifers support PWS groundwater withdrawals, using the regional-scale data available. Consequently, it is impossible to assess the potential impacts of the projected increases in PWS groundwater use on specific individual groundwater-dependent CE types or occurrences. Nevertheless, watersheds with large projected increases in PWS groundwater use warrant close attention, to determine how such increases might affect individual aquatic CE types.

Indicator Data and Knowledge Gaps

As noted above, the estimates of change in PWS surface and groundwater water use rest on information assembled independently by the SWPA study (Anning et al. 2009; McKinney and Anning 2009) and by the SERGoM analyses (USEPA 2010) carried out for this REA. Two kinds of minor discrepancies are evident in the measurements of urban area per watershed, between the SWPA and SERGoM analyses, as follows:

- Five watersheds in the MBR ecoregion have positive values for total PWS water use, but SERGoM values of 0 for urban area (watersheds 1501001505, 1606001421, 1606001422, 1809020815, and 1809020826). These five watersheds present discrepancies, because the SWPA study estimated PWS use based on areas with urban development. Any watershed with a positive value for total PWS water use identified by the SWPA study therefore should have a positive value for urban area as well. These five discrepancies appear to arise for two reasons: (1) SERGoM assesses urban growth only on private lands, while SWPA addressed all urban cover. watersheds with urban areas enclosed entirely within military lands therefore would not register in the SERGoM analysis of urban growth. For example, watershed 1501001501 includes military urbanized areas associated with Nellis Air Force Base that did not register in the SERGoM analysis. (2) The methods for defining “urban” differ slightly between the SWPA and SERGoM analyses, and they take their demographic and land cover data from different years. The discrepancies therefore may also result simply from minor differences in methods and data, such as can easily arise in rapid assessments using data from multiple independent sources. The amounts of PWS water use involved vary: total PWS water use in watershed 1809020815 is over 2,300 afy; in watershed 1501001505, over 860 afy; in watersheds, 1606001421 and 1809020826, over 60 afy; and in watershed 1606001422, less than 2 afy. Nevertheless, total PWS water use even in watershed 1809020815 is less than 1/100th that recorded in the highest water-use watersheds in the ecoregion.

- Sixty-four (64) watersheds in MBR have total PWS water use values of 0 afy, based on the SWPA data, but have more than an acre of urban area based on the SERGoM values data. These sixty-four watersheds present discrepancies again because the SWPA study estimated PWS use based on areas with urban development. Any watershed with a positive value for urban area therefore should have a positive value for total PWS water use identified by the SWPA study as well. Most of this second set of discrepant cases involves small (< 25 acres) areas of urban cover. However, ten watersheds have SERGoM values > 25 acres for urban area and still have total PWS water use values of 0 afy based on the SWPA study (watersheds 1501000805, 1501000808, 1501000809, 1501000906, 1501001003, 1501001006, 1503010201, 1606001505, 1810010009, and 1810010015). The first six of these ten discrepant cases cluster in the vicinity of St. George, Utah and the northern portions of Mohave County, Arizona, immediately south of St. George. watershed 1503010201 is located west of Laughlin, Nevada, in the lower Colorado River valley; watershed 1606001505 is located in the Pahrump area of Nevada; and 1810010009 and 1810010009 are located in the area of Twentynine Palms and Yucca Valley, California. These discrepancies may again result from the differences between the SWPA and SERGoM methods for classifying urban land cover. In any case, none of the discrepant watersheds has more than 600 acres (less than 1 square mile) of urban area, based on the SERGoM analysis. The areas of urban cover in the four most discrepant watersheds are as follows: watershed 1501000809, 585 ac.; 1501001006, 448 ac.; 1501000808, 418 ac.; and 1501001003, 107 ac. The remaining watersheds contain less than 100 acres of urban area each. Using the SWPA definition of urban (>1,000 persons per square mile), none of the four most discrepant watersheds involves PWS water use by more than 1,000 persons; and watersheds with less than 25 acres of urban area experience PWS water use by fewer than 40 people.

These discrepancies point to ways to improve the assessment in future cycles. Specifically, the estimates could be improved by standardizing the methods use to estimate per-household surface water, per-household surface water groundwater use, and urban area for the underlying assessment grid units; and by constructing the estimates using a single timeframe.

The methods used to estimate changes in PWS surface and groundwater water use also entail several assumptions, noted both implicitly and explicitly above, as follows:

1. Change in urban area accurately predicts the areas subject to change in PWS surface and groundwater use;
2. Increases in PWS demand for water will be met through some as-yet unknowable combination of improvements in water-use efficiency (affecting per-capita water use), conversion of agricultural water use rights to public water supply rights, inter-basin transfers of surface water, and additional groundwater withdrawals or inter-basin transfers of groundwater; and
3. The ratio of PWS surface water use to PWS groundwater use in each watershed will not change, between 2010 and 2030.

The estimates of change in PWS surface and groundwater water use therefore together constitute a specific future scenario, linked closely to the 2010-2030 Development scenario itself. Alternative future scenarios for PWS surface and groundwater water use could be devised and evaluated by modifying any of the assumptions noted here.

Finally, as also noted above, it is not possible with the available regional-scale data to estimate how changes in groundwater use might affect individual aquatic CE types and their individual occurrences (see also Aquatic CE Indicator 05, Ground Water Use). Any estimates of increased groundwater use in a watershed, whether for PWS or agricultural irrigation, need to be investigated individually, to assess whether such an increase might affect aquatic CE occurrences within that watershed based on the aquifers involved.

B-2.6.1.2 Changes in Riparian Corridor Continuity

When we re-calculated the percent fragmentation based on the projected development Landscape Condition Index, we found that some sections of riparian habitat disappeared all together, such that when compared to current state, it would appear the percent fragmentation had gone down (Figure B - 89). To correctly account for an increase in riparian corridor connectivity loss, we compared the number of 30 m by 30 m pixels that had Landscape Condition Model Index scores <0.7. The degree of change is more accurately represented by comparing number of pixels with high impact scores, rather than comparing the percent fragmentation. The amount of change was converted to a normalized score (between 0 and 1) by the following formula: 1-(indicator value/maximum value), where 0 = worst or highest degree of impact and 1 = best or least impacted score.

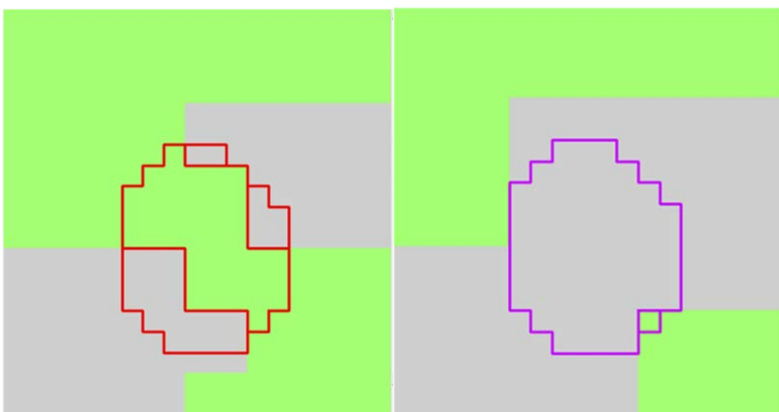


Figure B - 89. Fragmentation resulting in near complete loss of Riparian CE Corridor. Green = Landscape Condition Index >0.7, Gray = <0.7. Under Current 2010 LCM, riparian area is fragmented into 4 polygons (left). Under Future 2025 LCM, only single 30 m by 30 m pixel of original corridor remains (right).

About a dozen watersheds located in the heaviest urban use areas showed the greatest loss in riparian corridor connectivity, while about 70 watersheds experienced less than 50% loss. This is mainly due to the location of development increase, which generally shows a growth in the extent of existing urban areas.

B-2.6.1.3 Aquatic Invasive At Risk Status Index

The At Risk Status Index (Table B - 38) is based on data reported at the time the databases were modeled (circa 2010). It is not a future predicted index (see Future Impact Index next section). The At Risk Status Index models additional risk due to factors that were not reported within the individual CE. These include: novel invasive taxa that occurred in other CEs within the watershed, trophic status of novel taxa within the watershed, and the amount of aquatic recreational use within the watershed. All previously used metrics from earlier drafts of this report have been either modified or eliminated in order to develop and refine the At Risk Status Index.

Number of novel invasive taxa

Water quality, water temperatures and other physico-chemical conditions, and aquatic and riparian habitats in CE types within a watershed (5th level watershed) are more similar than are conditions in CE types that are further physical distance apart (e.g. 4th level watersheds or watershed4s) due to their relatively smaller sized areas and hydrological relatedness. Given a watershed's small size (mean = 220 mile^2) and hydrological relatedness; all of the invasive taxa (CAs) in our assessments have the potential to occupy any of the CE types within a watershed. This is not the case for larger watershed units and becomes less true as watershed unit areas increase. Therefore, any of the invasive taxa that already were reported in other CEs within a watershed likely were present in the CE but may not have been reported.

Trophic level

The invasive taxa used in the indices encompassed all trophic levels except for decomposer trophic level.

Connectivity and dispersal

A 5th level watershed is a relatively small hydrological unit (i.e. watershed), which infers a greater level of connectivity than larger sized units (e.g. sub basin 4th level watershed). All streams within a watershed are surficially connected, at least perennially or ephemerally. Lakes and reservoirs can be considered large temporary pools within the context of the geological history of the longer lived stream or rivers from which they arose and are by definition connected to these streams or rivers. Springs and seeps are typically more hydrologically connected within a watershed than between watersheds. However, it is difficult to remotely determine if CEs other than isolated springs in a watershed are truly connected or not. If there is any physical connectivity between CEs within a watershed, then invasive taxa will find ways to exploit these connections. An invasive taxon's spread is also inversely related to distance between infested and uninfested sites (often modeled as a decreasing power curve), with dispersal ability and rate of dispersal much greater at shorter distances. Therefore, invasive taxa disperse more rapidly within a watershed than between watersheds. A connectivity metric was not included in the At Risk Index, given that dispersal within a watershed is such a short term limiting factor.

Invasive taxa generally disperse better downstream than upstream. However, invasive taxa were reported as point locations. An invasive taxon could have occurred either upstream or downstream of a reported site but was not reported. Thus, we do not know if an invasive taxon occurred upstream or downstream of that point location. The exception to this would be isolated springs which would have no connectivity associated with them. Therefore, we did not include an upstream/downstream metric in the At Risk Index.

Land Use

Invasiveness is strongly related to the amount of human use within a CE and watershed. The more human economic activity, the more likely a CE is to be impacted by invasives via increased spread rate or multiple introductions. In addition, invasion potential is also a function of human use and activity in nearby areas. The popularity of a CE for recreational use can supersede the distance function for many invasive taxa. Popular recreational areas disproportionally attract users from long distances and these users may inadvertently or intentionally harbor aquatic invasives (Bossenbroek et al. 2001). This phenomenon is often modeled in what are referred to as invasive species 'gravity' models. Given the importance of human economic activities in the spread of invasives, we have included recreational use in the At Risk Index.

Additional avenues of spread

There are additional known and postulated avenues of invasive species spread including dispersal by: waterfowl, biologists, irrigational use, city water supply, fire fighting water use, or other types of diversions, etc. (Aquatic Nuisance Species Task Force 2011). The dispersal levels for these avenues of spread are difficult to evaluate but are assumed to be, for the most part, less important than the types of spread that we have included in the At Risk and Future Impact Indices. Other avenues of spread were not included given the assumption that these addition spread agents were either correlated with the amount of recreational use and were thus implicit in the Use metric or not enough data were available for their inclusion.

Time

Time is inherent in any ecological model. Time since first invasion in a CE and watershed can affect the level of impact. The longer a taxon has been in a CE in a watershed the more time it has had to elicit a negative impact and to reduce ecological integrity. In general, very recent arrivals have not had enough time to reach their potential impacts but given enough time they may. Effects of invasives are often not manifested for 50 to 100 years since initial invasion.

Many of the invasive taxa on our list are recent arrivals (e.g. New Zealand mudsnails, Eurasian water milfoil, Zebra and Quagga mussels, etc.) or have recently become problematic (e.g. Didymo). Alternatively, if a taxon has been present for a long time it most likely occurs in all CEs but again more recent surveys may not have been conducted and up- to- date status was not available for this analysis. If an invasive species was reported in any of our databases then it most likely was well established and had to have reached some minimum detection level. Given all of these unknowns and the limited data, a time metric was not included, although the effects of time on invasion impacts should be strongly considered in any management strategy.

Table B - 38. Aquatic Invasive Species Impact Index scoring criteria for **At Risk** status for each CE within a 5th level watershed that was scored 'Undetermined' or 'Transitioning' in Known Status Index).

At Risk Index					
Type of Indicator	**Metric category**	**Metric**	**Justification**	**Data Source**	**Evaluation and score**
Biotic	**Number of invasives**	<u>2. Number of novel invasive taxa present in all CEs within 5th level watershed</u>	The greater the number of invasive taxa there are in a watershed, the greater a CE is at risk	USGS NAS, USGS didymo database, Natural Heritage Programs attributed to specific CEs (~90% of the records). + Assignment of records in datasets that lack specific CE attributes (~ 10% of data) based on CE invasive potential (Appendix 1) and closest CE.	0 taxa = NA 1 taxon = 0.67 > 1 taxa = 0.33
	Trophic levels	<u>3. Number of novel trophic levels in all CEs within 5th level watershed</u>	The greater the number of trophic levels infested in the watershed, the greater the impairment	Based on data from Metric #2	0 taxa= NA 1 trophic level = 0.67 > 1 trophic level = 0.33

	Use	4. Number of Aquatic Recreational Use Sites within a 4th level watershed	Access sites are invasion hotspots. The greater the number of access sites, the greater the impact	NLUD_AQUATIC data set	0-1 sites = 1.00 2 sites = 0.67 > 2 sites = 0.33

Scoring for At Risk Status metrics

The following is the scoring method for At Risk Status for individual CEs**:**

1) If aquatic invasives were found in a CE then the At Risk Status score equals the product of Metrics 1, 2, 3, and 4. An At Risk Final Score of 0.67 = Transitioning and < 0.67 = Degraded.
2) If no invasive taxa were found in a CE in a watershed and its Known Status Index was rated as 'undetermined' but invasives were reported in other CEs within the watershed, then its At Risk Status score is equal to the CE in the same watershed with the highest At Risk Status Final score.
3) If no invasive taxa were found in a CE and its Known Status Index was rated as 'undetermined' and no invasives were reported in other CEs within the watershed, then its At Risk Status score is 'undetermined'.

The following figure (Figure B - 90) is the flow chart for the At Risk Status Index scoring.

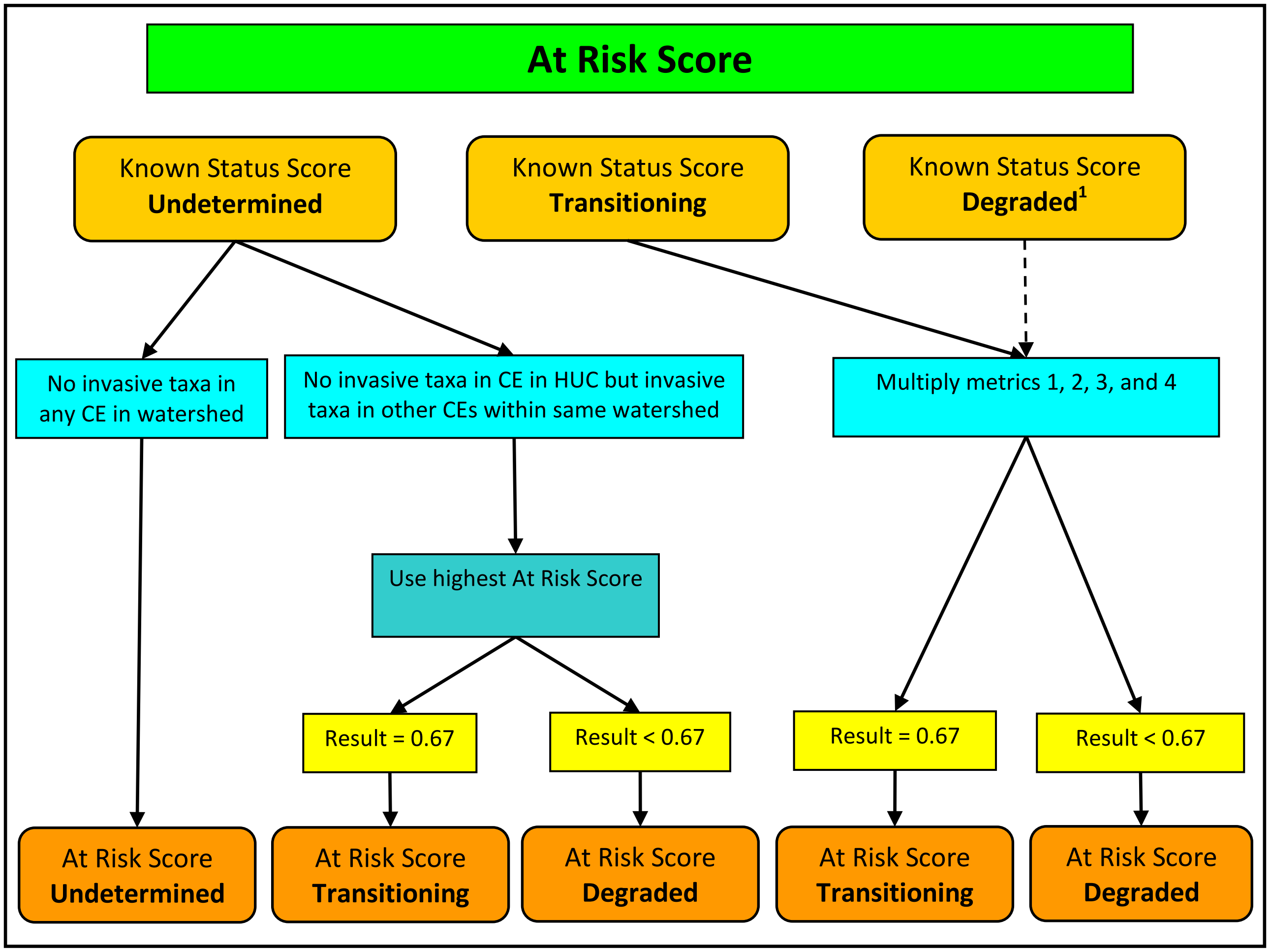


Figure B - 90. Flow chart of Scoring for At Risk Status Index

[1]If Known Score and At Risk Score = Degraded then it is not necessary to continue with evaluation, however an estimate of relative At Risk impact score for comparison with other CEs and watersheds can be made.

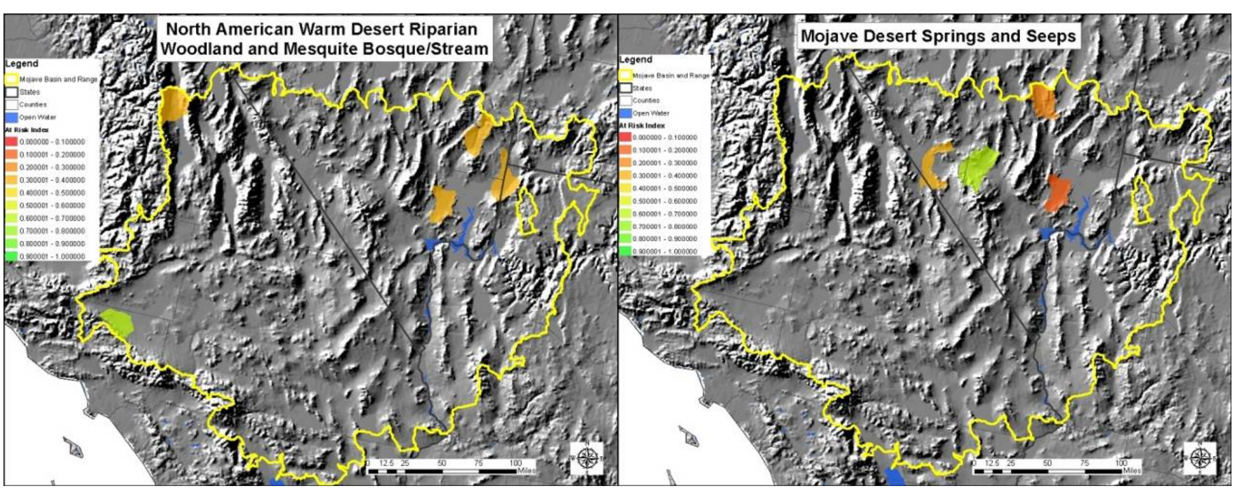


Figure B - 91. Aquatic Invasive At Risk Status Index 2025 Results for 2 CEs.

The final results of the Aquatic Invasive At Risk Status Index (Figure B - 91) underline that risk is more likely to occur where there are known current locations of aquatic invasive species. However new infestations are highly likely where ever recreation occurs.

B-2.6.1.4 Future Aquatic Invasives Impact Index 2025

No CE or watershed is an island and invasion potential is strongly related to conditions in surrounding watersheds. Invasion potential is strongly correlated with distance from nearest invaded location and distance is considered to be one of the most important factors in invasion theory (Shigesada and Kawasaki 1997). Therefore, we included two metrics from surrounding 5th level watersheds within the same 4th level watersheds for development of the Future Aquatic Invasives Impact Index: the Number of novel invasive taxa present in all CEs within 4th level watershed and the Number of novel trophic levels in all CEs within 4th level watershed metrics (Table B - 39).

Upstream and downstream dispersal and connectivity strongly affects invasion potential in freshwater ecosystems with invasive taxa more prone to downstream dispersal than upstream dispersal in connected systems. Thus, the location of a watershed relative to other watersheds is important. An upstream/downstream/closed basin metric was included in the Future Aquatic Invasives Impact Index: the Upstream or downstream from other 4th level watersheds metric (Table B - 39). This metric was based on whether a 4th level watershed was upstream, downstream, or in a closed basin regardless if any invasive species were reported in the other upstream or downstream 4th level watersheds. This was done because of the very limited data on invasives available (i.e. it was unknown if invasive species already occurred in many of the surrounding watersheds) and because in general, unknown future aquatic invasives are also expected to disperse more readily downstream than upstream and less readily from closed basins.

Human economic activity, particularly recreational activity, is also a major factor for the spread of aquatic invasive species in the future. Recreational activities and economic conditions are directly related but their relationship is often complex and difficult to predict. It is not known whether the number of recreational use sites and users will decrease or increase in the future given economic uncertainties, therefore the Use metric, the Number of Aquatic Recreational Use Sites within a 4th level watershed (Table B - 39), was based solely on the known number of recreation sites at the time of the index generation.

Table B - 39. Future Aquatic Invasive Species Impact Index 2025 scoring criteria for each CE within a 5th level watershed

Future Aquatic Invasive Species Impact Index 2025					
Type of Indicator	**Metric category**	**Metric**	**Justification**	**Data Source**	**Evaluation and score**

Biotic	**Number of invasives**	5. Number of novel invasive taxa present in all CEs within 4th level watershed	The greater the number of invasive taxa there are in a watershed, the greater a CE is at risk	USGS NAS, USGS didymo database, Natural Heritage Programs attributed to specific CEs (~90% of the records). + Assignment of records in datasets that lack specific CE attributes (~ 10% of data) based on CE invasive potential (Appendix 1) and closest CE.	0 taxa = NA 1-2 taxa = 0.67 > 2 taxa = 0.33
	Trophic levels	6. Number of novel trophic levels in all CEs within 4th level watershed	The greater the number of trophic levels infested in the watershed, the greater the impairment	Based on data from Metric #1	0 taxa= NA=1.00 1 trophic level = 0.67 > 1 trophic level = 0.33
Physical	**Watershed Connectivity**	7. Upstream or downstream from other 4th level watersheds	Most invasive taxa are better able to disperse downstream (drift) than upstream	MSU Graphical Locator	Closed basin = 1.00 Upstream watershed = 1.00 Downstream watershed = 0.67
Landscape context	**Use**	8. Number of Aquatic Recreational Use Sites within a 4th level watershed	Access sites are invasion hotspots. The greater the number of access sites, the greater the impact	NLUD_AQUATIC data set	0 sites = 1.00 1-3 site = 0.67 > 3 site = 0.33

Scoring for Future Aquatic Invasive Species Impact Index 2025 Metrics

The following is our scoring method (Figure B - 92) for Future Aquatic Invasive Species Impact Index 2025:

1. If a CE had a final score of 'degraded' in the Known Status Index and At Risk Status Index then no further calculations are necessary and its final Future Score is 'Degraded'(however, the Future Index values can be calculated to generate a relative impact estimation compared to other CEs and watersheds but this is not necessary).
2. If a CE had a final At Risk Status score of 'undetermined' and there were no invasive species in any CE within the 4th level watershed, then its final Future Aquatic Invasive Impact score remains 'undetermined'.
3. If a CE had a final At Risk Status score of 'undetermined' and there were invasive species in other CEs within the 4th level watershed, then its final Future Aquatic Invasives Impact score is

equal to the highest Future Aquatic Invasives Impacts score for other CEs within the 4th level watershed.

4. If a CE had a final At Risk Status score of ‘transitioning’ then multiply its final At Risk Status score by metrics 5, 6, 7, and 8. A final Future Aquatic Invasives Impact score of 0.67 = ‘transitioning’, a score < 0.67 = ‘degraded’.

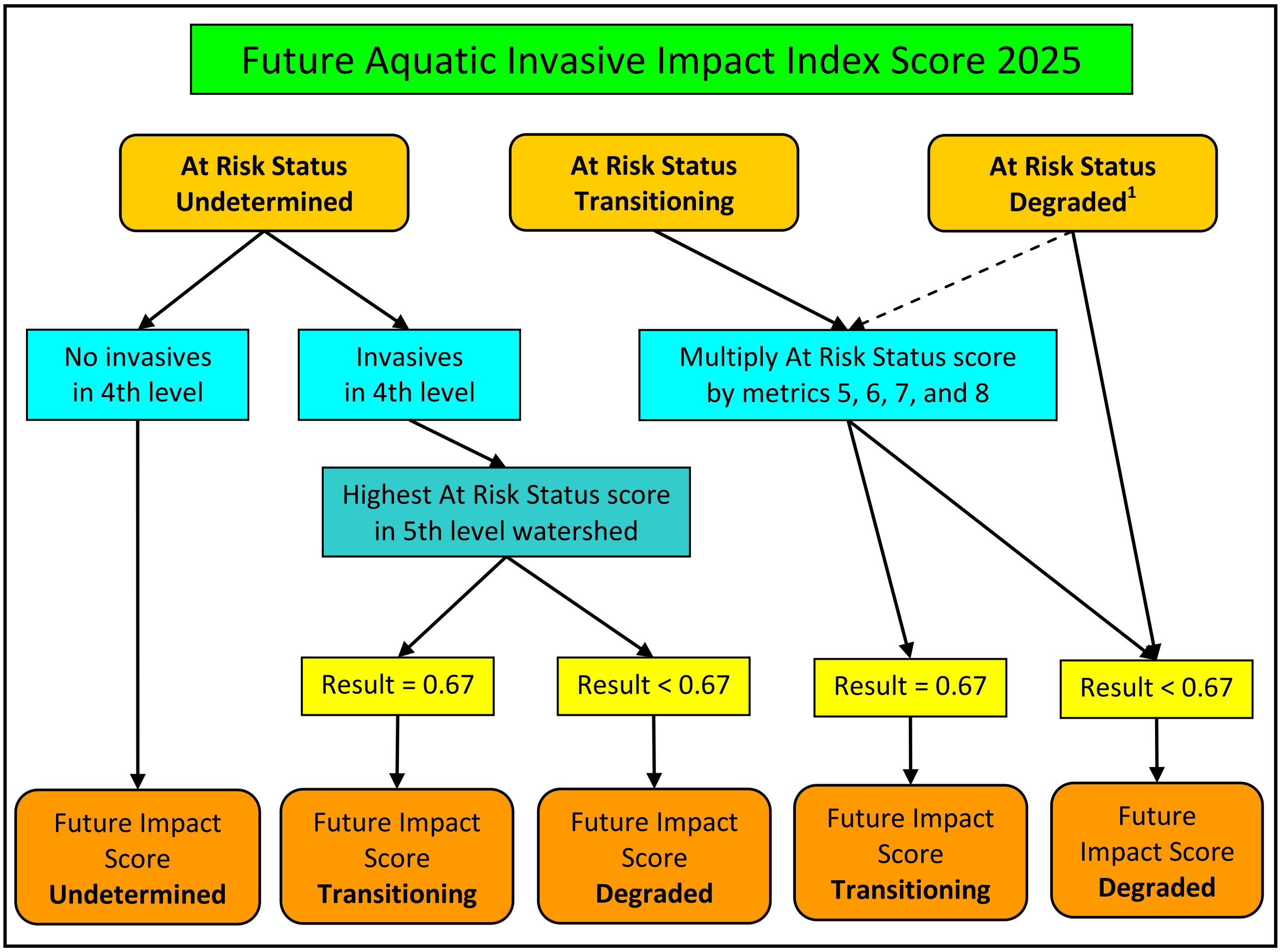


Figure B - 92. Flow chart of Scoring for Future Aquatic Invasive Impact Index
[1]If At Risk Status Score = Degraded then it is not necessary to continue with evaluation, however an estimate of relative Future Impact score for comparison with other CEs and watersheds can be made.

Table B - 40. Indicator results by watershed for Aquatic coarse-filter CEs (Future). For each indicator the count of 5th level watersheds is shown for each CE, broken out by indicator score interval.

KEA: Change in Extent/Size											
Future Riparian Corridor Continuity											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87	3			1	4		2	5	7	65

	Total	0-.1	.1-.2	.2-.3	.3-.4	.4-.5	.5-.6	.6-.7	.7-.8	.8-.9	.9-1
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246	1			1		1	3	2	15	223

KEA: Surrounding Land Use Context

Future Landscape Condition Index

	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Great Basin Lake / Reservoir	184			7	2	17	26	30	48	46	8
Great Basin Springs and Seeps	228			3	2	11	20	33	68	81	10
North American Warm Desert Lower Montane Riparian Woodland and Shrubland / Stream	87					6	10	8	24	35	4
North American Warm Desert Playa	269			7	2	19	20	40	83	88	10
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	246			6	2	17	25	37	71	79	9
North American Warm Desert Wash	315			7	2	19	27	44	95	107	14

KEA: Stressors on Biotic Condition

Aquatic Invasive At Risk Index

	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Great Basin Lake / Reservoir	3	1	1		1						
Great Basin Springs and Seeps	4		1	1	1			1			
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	5				4			1			

Aquatic Invasive Future Impact Index

	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Great Basin Lake / Reservoir	3	2	1								
Great Basin Springs and Seeps	4	2			1			1			
North American Warm Desert Riparian Woodland and Mesquite Bosque / Stream	5	1	1	1	1			1			

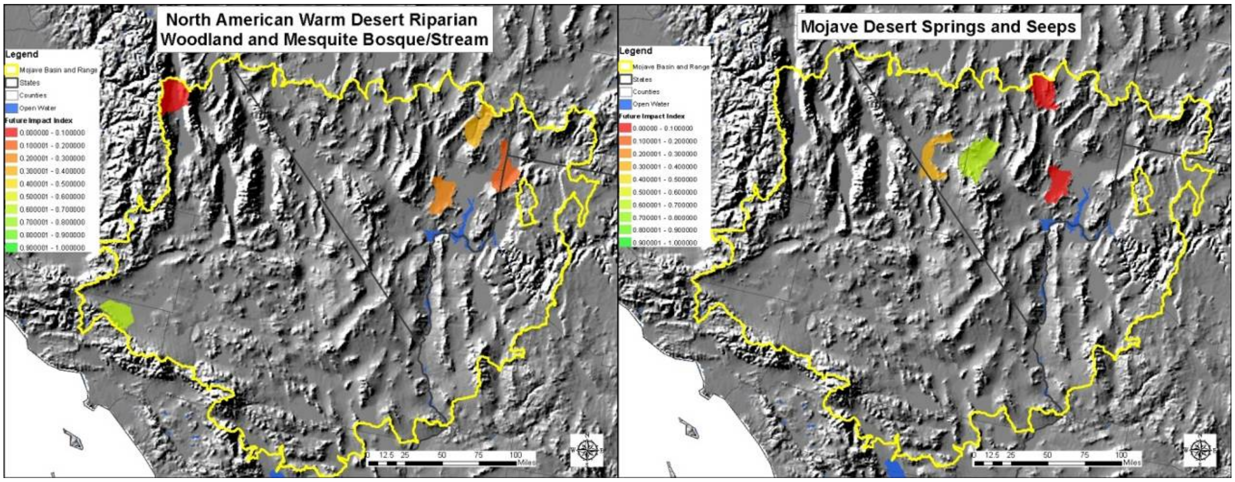


Figure B - 93. Aquatic Invasive 2025 Impact Index results for 2 CEs.

B-2.7 2060 Distribution

B-2.7.1 2060 Fire Regime Departure Status: Terrestrial Coarse-Filter Conservation Elements

Fire regime departure for mid-century (2060) was calculated for some of the terrestrial coarse filter CEs. Table B - 41 is organized as above, with counts of 5th level watersheds by score interval.

Table B - 41. Indicator results by watershed for Terrestrial coarse-filter CEs (2060). For each indicator the count of 5th level watersheds is shown for each CE, broken out by indicator score interval.

KEA: Surrounding Land Use Context											
2060 Fire Regime Departure Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Mojave Mid-Elevation Mixed Desert Scrub - thermic	273	25	**212**					1		35	
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	244	9			19		**102**	**114**			
Mojave Mid-Elevation Mixed Desert Scrub - mesic	174				23		**45**	**101**		5	
Great Basin Pinyon-Juniper Woodland	127				**37**	**29**	**24**	**37**			
Sonora-Mojave Mixed Salt Desert Scrub	67	6				3	11	**47**			
Great Basin Xeric Mixed Sagebrush Shrubland	53				12		9	**31**		1	
Mogollon Chaparral	38										**38**
Sonora-Mojave Semi-Desert Chaparral	31	1						5		**10**	**15**

KEA: Surrounding Land Use Context											
2060 Fire Regime Departure Index											
	Count of watersheds by Score interval										
	Total	**0-.1**	**.1-.2**	**.2-.3**	**.3-.4**	**.4-.5**	**.5-.6**	**.6-.7**	**.7-.8**	**.8-.9**	**.9-1**
Inter-Mountain Basins Mixed Salt Desert Scrub	24				**11**	3		**10**			
Sonoran Mid-Elevation Desert Scrub - mesic	22			2		5	5	**10**			
Sonoran Mid-Elevation Desert Scrub - thermic	13		**13**								

B-2.7.2 2060 Bioclimate Envelope Analysis

MQ9 - WHERE WILL LANDSCAPE SPECIES CES EXPERIENCE CLIMATE OUTSIDE THEIR CURRENT CLIMATE ENVELOPE?

MQ66 - GIVEN ANTICIPATED CLIMATE SHIFTS AND THE DIRECTION SHIFTS IN CLIMATE ENVELOPES FOR CES, WHERE ARE POTENTIAL AREAS OF SIGNIFICANT CHANGE IN EXTENT?

MQ67 - WHICH NATIVE PLANT COMMUNITIES WILL EXPERIENCE CLIMATE COMPLETELY OUTSIDE THEIR NORMAL RANGE?

MQ69 - WHERE ARE WILDLIFE SPECIES RANGES (ON THE LIST OF SPECIES CES) THAT WILL EXPERIENCE SIGNIFICANT DEVIATIONS FROM NORMAL CLIMATE VARIATION?

Tabular summary tables (Table B - 42 and Table B - 43) are aimed at answering this management question by summarizing all model results and looking at patterns in species or terrestiral coarse-filter change in bioclimate under future climate scenarios. These summaries use the change summary layer, which is a raster of the difference between 2050 and current for each species. From this layer we can determine the percent of pixels (area) projected to be lost, maintained, or gained for each species. Each species change summary layer was clipped to the greater regional boundary that encompasses CBR and MBR, from which their sample points came from. In other words, *the data presented in these tables is for the entire regional analysis boundary, rather than for the areas within either the CBR or MBR REA boundaries (see methods for bioclimate modeling presented in Appendix B).*

Percent model agreement is also added to the tabular summary tables. We created a change summary layer for each GCM output for a species, and then added these change summary layers to get model agreement for each condition: lost, maintained, and gained. Low model agreement = 1-2 models, Medium model agreement = 3-4 models, High model agreement = 5-6 models.

It is important to note that model agreement should not be judged for loss of bioclimate because it will always be low to no model agreement. This is because model agreement is conceptually stacking presence/absence outputs on top of each other. Therefore if a species loses a significant amount of bioclimate, and all models agree, there will be no presence values to stack to account for agreement. The stacking of models with lost bioclimate essentially adds up to nothing because there is no bioclimate to account for. Model agreement is only useful for maintained and gained bioclimate.

Table B - 44 shows an analysis of top 3 variable contributions for species of interest. The path that the Maxent code uses to get to the output defines these percent contributions. A different modeling algorithm could get to the output via a different path and therefore result in different percent contributions. Therefore, highly correlated variables should be interpreted with caution. However, variable contributions are a useful to see how the model came to its projection and a starting point for understanding how climate change might affect certain species differently.

Table B - 42. Terrestrial coarse-filter CE Tabular Summary; results are summarized for the entire regional analysis boundary.

Coarse-filter CE	% Lost Bioclimate	% Maintained Bioclimate	% Gained Bioclimate	% Low Model Agreement	% Medium Model Agreement	% High Model Agreement
Great Basin Pinyon-Juniper Woodland	34	46	20	69	26	4
Great Basin Xeric Mixed Sagebrush Shrubland	68	24	7	90	10	0
Inter-Mountain Basins Mixed Salt Desert Scrub	24	44	31	59	31	10
Mojave Mid-Elevation Mixed Desert Scrub	53	21	27	87	12	1
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	41	37	22	59	25	16
Sonora-Mojave Mixed Salt Desert Scrub	22	47	30	64	35	1
Sonora-Mojave Semi-Desert Chaparral	18	42	40	79	14	7

Table B - 43. Landscape Species Tabular Summary; results are summarized for the entire regional analysis boundary.

Species CE	% Lost Bioclimate	% Maintained Bioclimate	% Gained Bioclimate	% Low Model Agreement	% Medium Model Agreement	% High Model Agreement
Bald Eagle	5	62	32	42	36	23
Brewer's Sparrow breeding	34	52	13	59	32	10
Brewer's Sparrow migratory	30	41	28	75	24	1
Coachwhip	40	24	36	59	35	6
Common Kingsnake	25	38	37	58	36	6
Cooper's Hawk	33	52	15	67	25	8
Desert Bighorn Sheep	23	61	16	58	27	15
Gila Monster	42	42	16	44	29	27
Glossy Snake	15	51	33	49	36	15
Golden Eagle	3	72	25	25	42	33
Mojave Desert Tortoise	72	18	10	97	3	0
Mojave Ground Squirrel	62	23	15	91	9	0
Mojave Rattlesnake	60	11	30	49	34	16
Mule Deer summer	39	45	17	58	36	6
Mule Deer winter	35	44	20	63	32	5
Mule Deer yearlong	12	55	32	48	38	15
Northern Harrier	74	17	9	81	16	2
Northern Rubber Boa	57	34	9	66	23	11
Northern Sagebrush Lizard	47	35	18	85	15	0

Species CE	% Lost Bioclimate	% Maintained Bioclimate	% Gained Bioclimate	% Low Model Agreement	% Medium Model Agreement	% High Model Agreement
Sage Sparrow	73	24	4	87	13	0
Sonoran Desert Tortoise	34	46	21	51	33	16
Western Patch-nosed Snake	52	22	26	67	32	2

Table B - 44. Top 3 variables that contributed to current and future model results for species of interest. The number next to the variable refers to the month; for example, Prcp1 is January precipitation.

Species	Current variable contribution	2050 variable contribution
Mojave Desert Tortoise	prcp6 45.5%	prcp6 54.9%
	prcp10 21.7%	prcp10 16.9%
	tmax8 12.7%	tmax8 11.2%
Mojave Ground Squirrel	prcp10 55.7	prcp10 57.9
	prcp6 27.7	prcp6 27
	prcp8 7.8	prcp8 5.2
Northern Harrier	prcp7 62.8	prcp7 61.3
	prcp9 8.5	prcp9 8.5
	tmin11 5.6	tmin11 7.1
Sage Sparrow	prcp7 65.9	prcp 7 62.2
	tmin4 11.8	tmin4 8.8
	tmax1 5.5	tmax1 5.9

B-2.7.2.1 Terrestrial Coarse-filter CEs

Table B - 42 summarizes all model results for terrestrial coarse-filter ecosystem CEs within the MBR and helps to understand patterns in ecosystem change in bioclimate under future climate scenarios.

The desert scrub ecosystems are vulnerable to future climate scenarios, however parts of the MBR region are shown to maintain bioclimate for desert scrub. Sonoran Mojave Mixed Salt Desert Scrub and the Sonora Mojave Creosotebush White Bursage Desert Scrub are both projected to lose bioclimate in the southern part of their range, however most areas that show maintained bioclimate are within the Mojave REA boundary.

Mojave Mid Elevation Mixed Desert Shrub and the Sonora Mojave Semi Desert Chaparral are characteristic of higher elevation CEs in thier pattern of projected loss at lower elevations, maintained bioclimate at higher elevations, and a pattern of moving up slope into the future. Mojave Mid elevation Mixed Desert Scrub is projected to lose 53% of its bioclimate mainly in lower elevation areas. The Semi Desert Chaparral is less vulnerable with 18% loss in bioclimate and 42% maintained at high elevations in the mountainous regions surrounding the boundary of the MBR.

Terrestrial Coarse-filter CEs- Maps of bioclimate change

In the maps below (Figure B - 94 and Figure B - 95), the areas of 2060 bioclimate expansion, contraction, and overlap with current bioclimate are shown for a selection of terrestrial coarse-filter CEs. The CEs are grouped into figures by ecoregional conceptual model group: Montane Dry Land System (Figure B - 94), Basin Dry Land System (Figure B - 95). Blue represents contraction, pink expansion, and green is areas of overlap. These areas will not always match the mapped current distribution of the individual CE, since this is the bioclimate niche of the CE, not its current distribution.

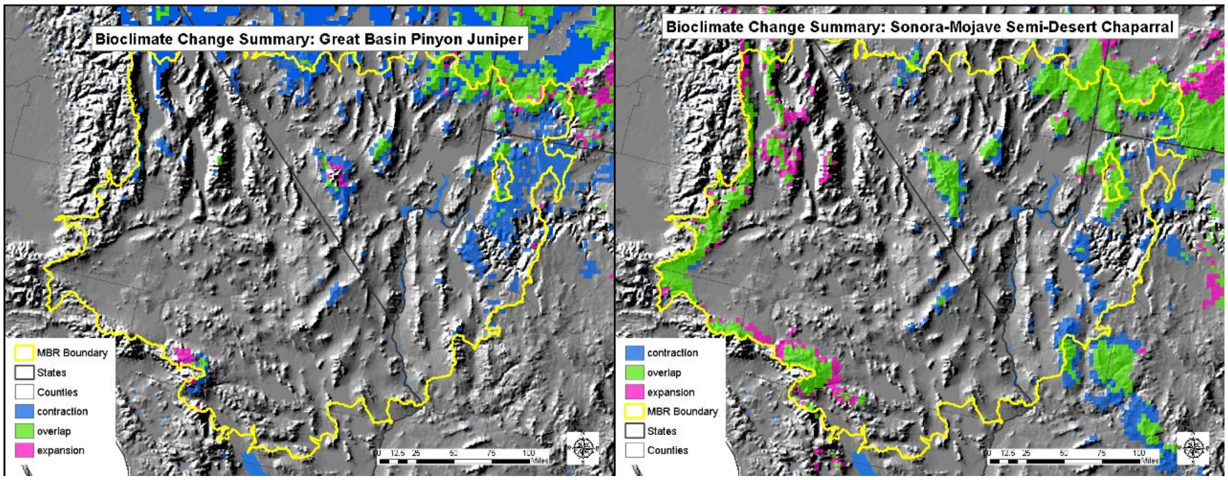


Figure B - 94. Bioclimate change summary for selected Montane Dry Land Ecosystems: Great Basin Pinyon-Juniper Woodland and Sonora-Mojave Semi-Desert Chaparral

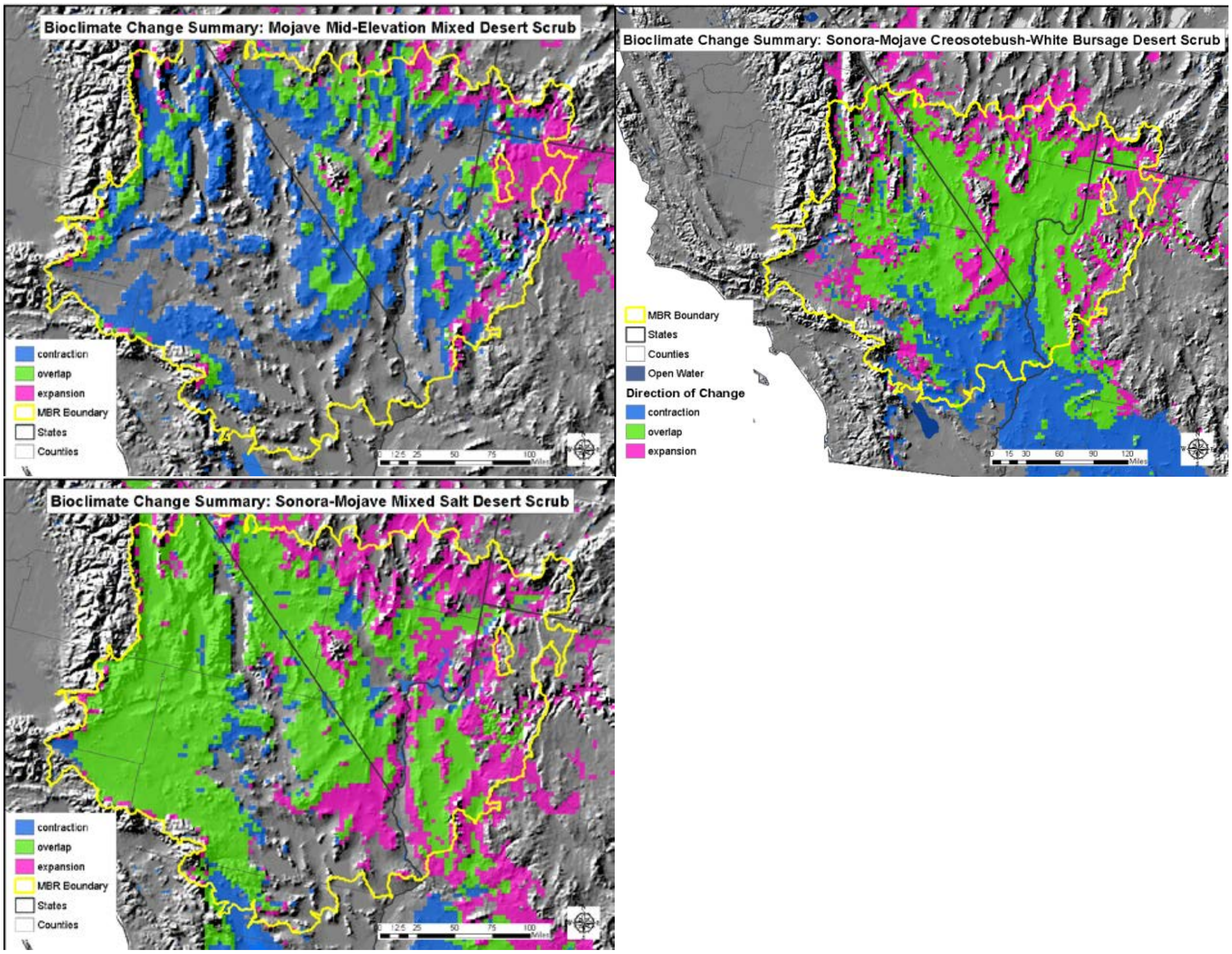


Figure B - 95. Bioclimate change summary for selected Basin Dry Land Ecosystems: Mojave Mid-Elevation Mixed Desert Scrub, Sonora-Mojave Creosotebush-White Bursage Desert Scrub, and Sonora-Mojave Mixed Salt Desert Scrub

Potential climate change refugia

One additional application of climate envelope models is to explore the results of overlaying multiple forecasts for major vegetation types of the ecoregion. For each envelope summary, where "overlap" is indicating (in green from previous figures), this indicates that climate regimes characteristic of current distributions for the type are forecasted to be maintained. Therefore, by combining multiple envelope forecasts for major vegetation types, one can begin to identify portions of the ecoregion where multiple lines of evidence suggest that 2060 climate regimes will tend to be closer to current regimes. Figure B - 96 indicates that as many as four out of seven major vegetation types show an overlap between current and forecasted climate envelopes. The mountain range and inter-montane basins throughout the ecoregion, along with mountain ranges along the west and eastern margins of the ecoregion, appear to be locations forecasted to experience the least severe shifts in climate regime, at least from the perspective of climate envelopes that characterize major vegetation.

However, this analysis also indicates several areas, primarily concentrated in Death Valley, and throughout the southern transition into the Sonoran Desert, where no climate envelope overlap is indicated for major vegetation. This provides additional indication of the potential for desert basins to experience effects of severe increases in temperature; likely resulting in expansion of sparsely vegetated desert pavements and bedrock exposures.

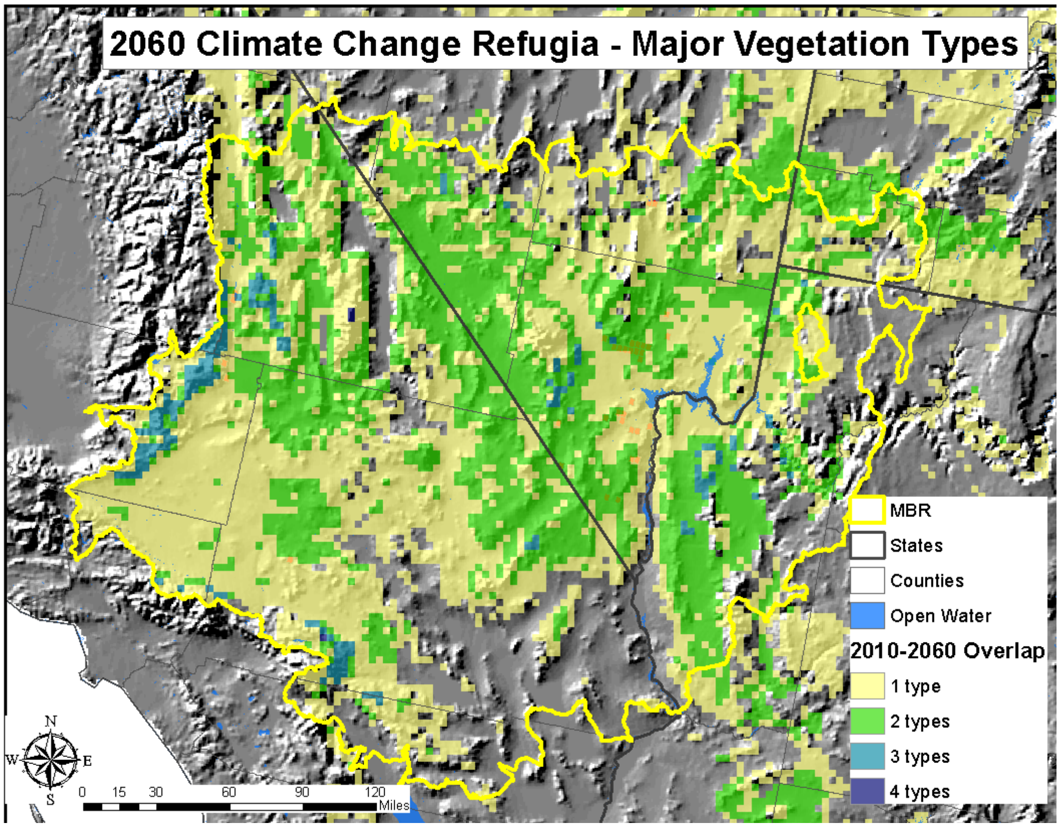


Figure B - 96. Potential climate-change refugia, based on 2060 forecasts of climate envelopes, for seven major vegetation types within the ecoregion. This map indicates where between one and 4 types are forecasted by 2060 to have climate envelopes overlapping current distributions; thus providing one indication of potential climate-change refugia.

B-2.7.2.2 Landscape Species

Table B - 43 summarizes all model results for landscape species within the MBR and helps to understand patterns in species change in bioclimate under future climate scenarios. There are five snakes analyzed within the Mojave REA and, although they all differ with percentage of maintained and gained bioclimate, the pattern of bioclimate shift is relatively the same. All snake species lose bioclimate in the southern part of their range, often with some gain north or north east. Some are more extreme, such as the Mojave Rattlesnake, which is projected to lose 60% of its bioclimate, the Western Patched Nosed Snake projected to lose 52%, and the Coachwhip projected to lose 40%. The Glossy Snake and King Snake both do well with projected minimal loss and some maintained bioclimate, but the loss that is projected is in the southern part of its range.

The two species within the Mojave that show the most vulnerability to a potential bioclimatic loss are the Mojave Desert Tortoise and the Mojave Ground Squirrel. The Desert Tortoise is projected to lose 72% of its range, mostly in the center of the REA. The little bioclimate that is maintained is in the western edges and a little in the eastern edge. The Mojave Ground Squirrel is projected to have a major constriction of range (62% loss) with little to no "shift." Both of these species have major loss of bioclimate without maintained or gained regions, which suggests that their niche might be disappearing rather than shifting. The Sonoran Desert Tortoise is projected to maintain more of its bioclimate, but loses 34% at the western edge of its range.

Raptors whose range extends into the MBR are shown to have resilient bioclimatic niches. The Bald Eagle & the Swainsons Hawk are projected to have little loss in bioclimate (5-15% of its range) and mostly maintained within the MBR. Brewers sparrow breeding and migratory ranges however are almost completely lost within the MBR.

Landscape Species: Maps of bioclimate change

Bioclimate change summaries for selected landscape species CEs are shown in Figure B - 97 through Figure B - 100. The species are grouped into figures by ecoregional conceptual model group: Montane Dry Land System (Figure B - 97), Basin Dry Land System (Figure B - 98 and Figure B - 99), and Basin Wet System (Figure B - 100).

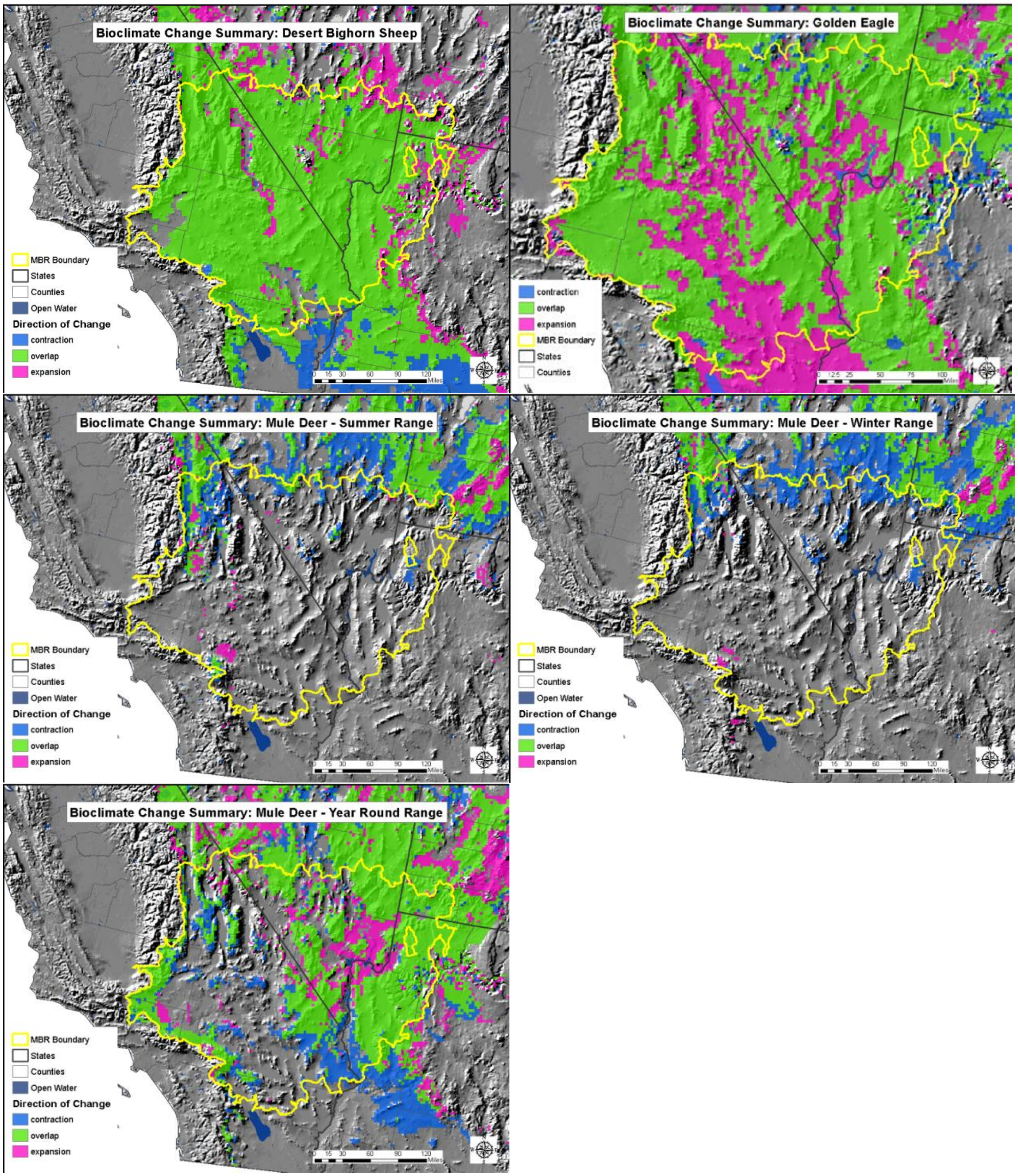


Figure B - 97. Bioclimate change summary of 3 landscape species CEs associated with the Montane Dry Land System: Desert Bighorn Sheep (top left), Golden Eagle (top right), and Mule Deer Summer (middle left), Winter (middle right,) and Year-round (bottom) ranges

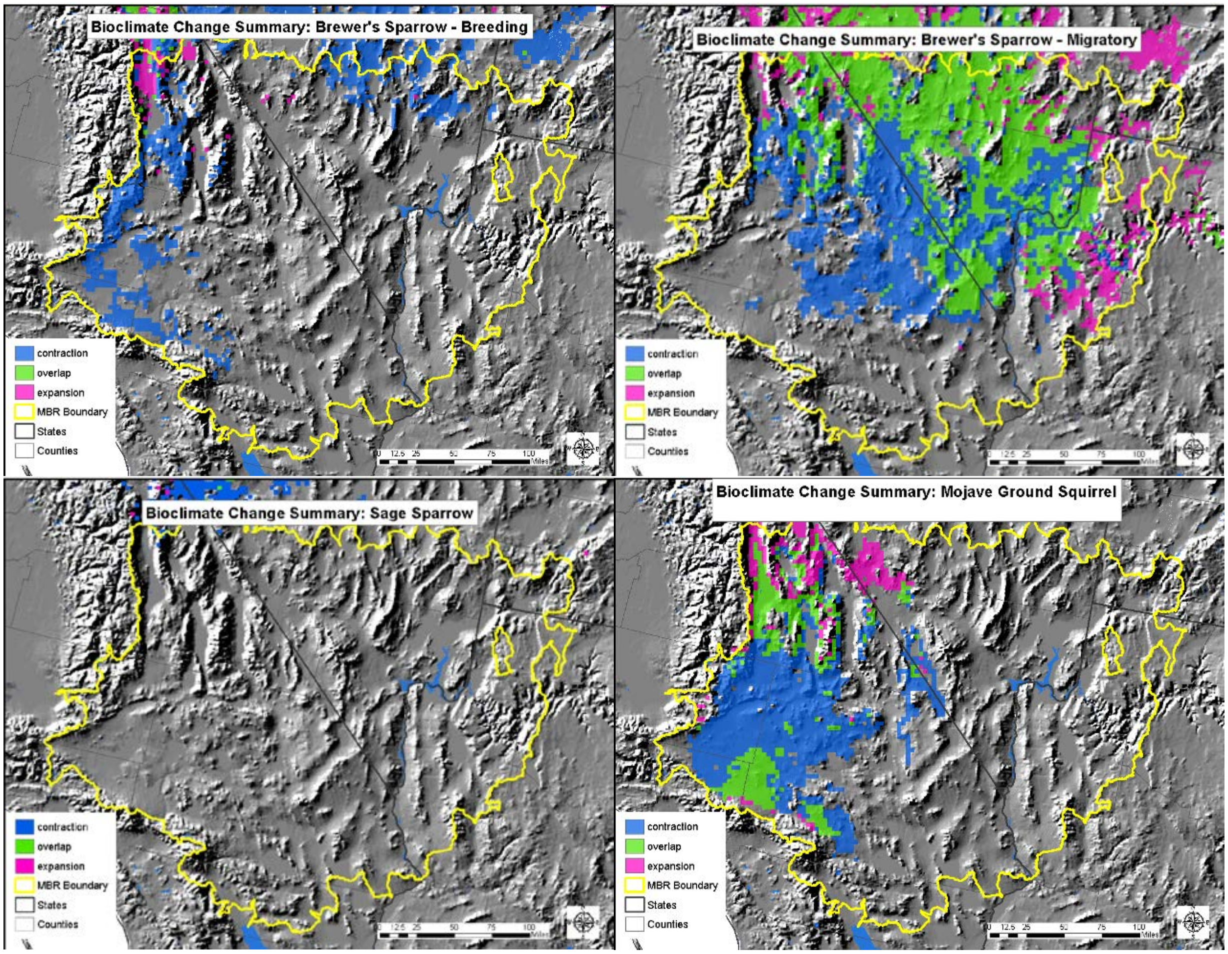


Figure B - 98. Bioclimate change summary of 2 bird species and 1 mammal species associated with the Basin Dry Land System: Brewer's Sparrow (Breeding and Migratory ranges, top), Sage Sparrow (bottom left) and Mojave Ground Squirrel (bottom right)

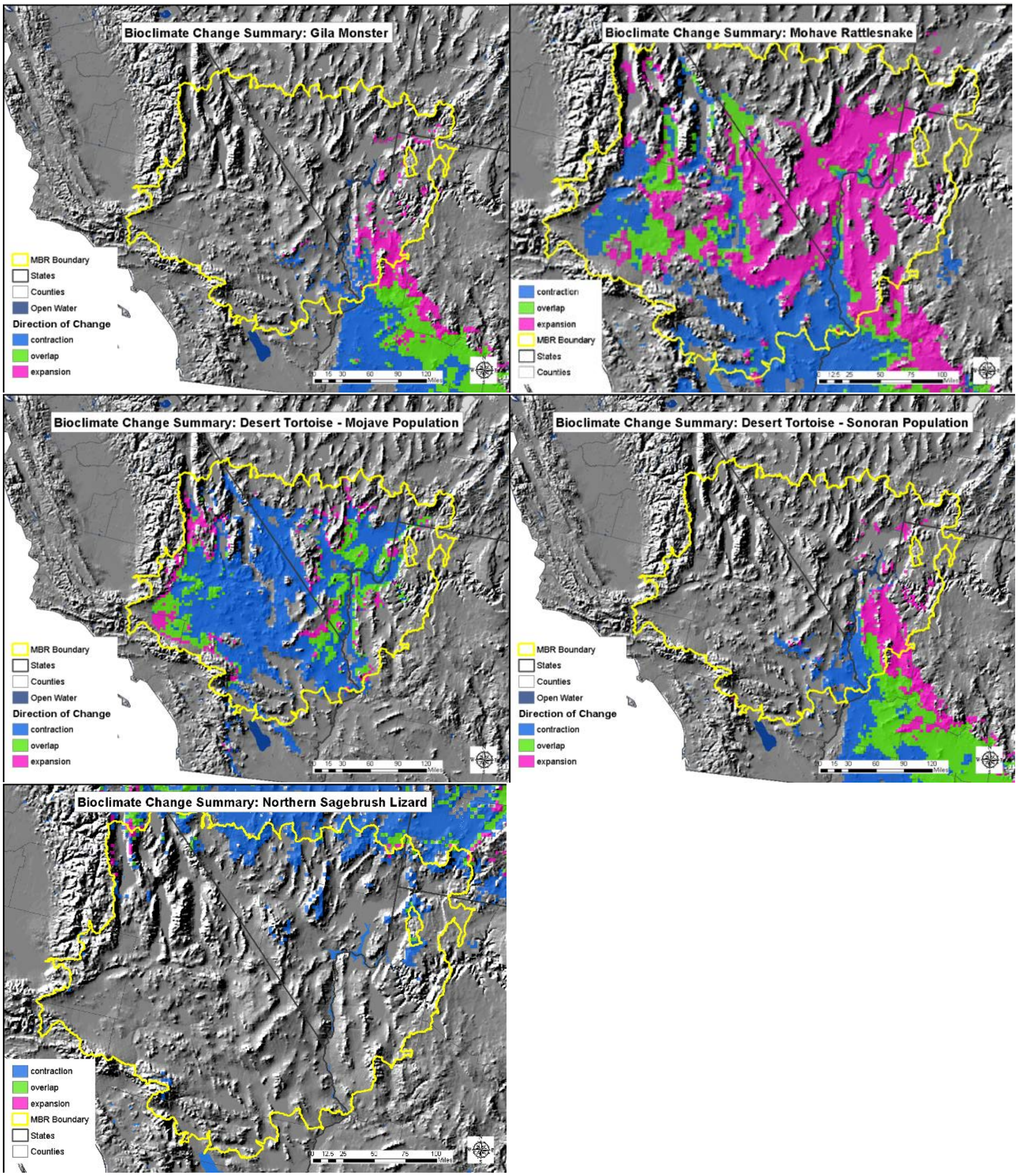


Figure B - 99. Bioclimate change summary of 4 reptile CEs associated with the Basin Dry Land System: Gila Monster, Mojave Rattlesnake, Mojave Desert Tortoise, Sonoran Desert Tortoise, and Northern Sagebrush Lizard

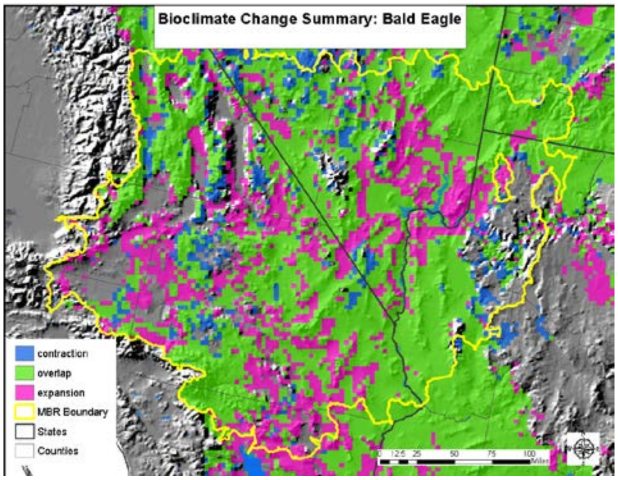


Figure B - 100. Bioclimate change summary of Bald Eagle (associated with the Basin Wet System)

B-2.8 Use in Assessment: overall Uncertainty, Limitations and Data Gaps

B-2.8.1 Species Survey Effort

MQ6 - WHAT IS THE RELATIVE SURVEY INTENSITY TO DATE WITHIN THE ECOREGION FOR SPECIES CES?

Taxonomic experts from the Nevada Natural Heritage Program (botany and zoology) populated information on survey effort for many of the species identified in Table B - 45. For each species, the documentation was done for survey effort within the state of Nevada, pertinent to the portion of the MBR in Nevada. In addition, where they had knowledge of the species in its range within the other states (California, Arizona or Utah), survey effort was also populated (Idaho was not done). When possible the experts consulted published materials for the taxonomic groups outside of Nevada to attempt completion of the survey effort fields. These data were delivered to BLM in the MS Access Species Conservation Elements Database (MasterBLM_HabitatsDB_Deliverable28June2012.accdb).

For purposes of this assessment "survey" was defined as an effort targeting the particular species; in other words, if someone is surveying for plants and see a Gila monster and notes it in their notebook, that is not a Gila monster survey. In all likelihood such a record would not make it into the surveyor's database, and hence would not be available for review. It was particularly noted theat "cryptic species" that require specialized survey methods (e.g. aquatic snails, nocturnal and secretive reptiles). Surveying for birds and most plants is much less dificult than for many other animal groups.

For each species in each state, survey effort was populated in the database for three levels of effort using the definitions below. In addition "unknown" was used used when the level of effort wass not known. Each level of offort is relevant to the state by ecoregion for the species. The "low" effort category included situations where no known surveys have occurred; a Low survey effort suggests the lack of information about that species and the need for additional surveys. Comments were recorded about surveys for some species.

1. High = high extent, high or moderate intensity
2. Medium = medium extent, high or moderate intensity; or high extent, low intensity
3. Low = low extent, moderate or low intensity; or moderate extent, low intensity; or low extent, high intensity. Note: "Low" includes none .
4. Unknown = extent/intensity of survey effort too poorly known to allow categorization as high, medium, or low.

The results in Table B - 45 suggest that surveys for many species are lacking or have not been intensive or comprehensive across the range of that species in Nevada. Many species across all taxonomic groups have effort category of Low or Unknown. For flowering plants, the Nevada Natural Heritage Program Botanist attempted to rate survey effort for Arizona, California and Utah, but in many cases Unknown was applied.

The number of element occurrences needs to be interpreted with care, especially in conjunction with survey effort. Most natural heritage programs only survey and track occurrences for rare species, or species that are of conservation concern within the state. For example, American Beaver is a very common species, not of conservation concern across most of the west, but in Arizona it is listed in the State Wildlife Action Plan, and in Nevada has some status of concern. Yet, survey effort for American beaver in Nevada is Low, and there are no element occurrences records for it in the MBR.

In contrast, many of the freshwater snails (*Pyrgulopsis* spp.) are rare, of conservation concern, have very few populations or occurrences, yet survey effort, at least for some of them, has been Moderate and for many others is Unknown, at least in Nevada.

These results suggest a number of data gaps for species of concern, but again this work was only completed for the Nevada portion of the range of many species; further work should be done to categorize survey effort across the other states.

Table B - 45. Survey effort results for many species in the Mojave Basin & Range ecoregion. Each species was rated for survey effort using categories of High, Medium and Low, or Unknown, for each state overlapping the MBR. The number of Element Occurrences from Natural Heritage databases is also provided, as it can give an indication of whether the species has been catalogued in a state database. Comments are also provided when available.

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Freshwater Snails								
Pyrgulopsis avernalis	Moapa Pebblesnail	Coarse Filter	14	L				
Pyrgulopsis coloradensis	Blue Point Pyrg	Coarse Filter	2	M				Recent survey work
Pyrgulopsis crystalis	Crystal Springsnail	Coarse Filter	2	U				
Pyrgulopsis deaconi	Spring Mountains Pyrg	Coarse Filter	10	U				
Pyrgulopsis erythropoma	Ash Meadows Pebblesnail	Coarse Filter	6	M				Recent survey work
Pyrgulopsis fairbanksensis	Fairbanks Springsnail	Coarse Filter	2	H				This spring has been rotenoned in 2009, high degree of habitat work conducted along with eradication to non native taxa
Pyrgulopsis fausta	Corn Creek Pyrg	Coarse Filter	4	M				Recent survey work
Pyrgulopsis isolata	Elongate-gland Springsnail	Coarse Filter	2	U				
Pyrgulopsis kolobensis	Toquerville Springsnail	Coarse Filter	3	U				
Pyrgulopsis micrococcus	Oasis Valley Springsnail	Coarse Filter	38	L				Recent survey work, including habitat restoration efforts
Pyrgulopsis nanus	Distal-gland Springsnail	Coarse Filter	13	U				
Pyrgulopsis pisteri	Median-gland Springsnail	Coarse Filter	6	U				
Pyrgulopsis turbatrix	Southeast Nevada Pyrg	Coarse Filter	22	U				
Pyrgulopsis wongi	Wong's Springsnail	Coarse Filter	25	U				
Tryonia angulata	Sportinggoods Tryonia	Coarse Filter	6	U				
Tryonia clathrata	Grated Tryonia	Coarse Filter	15	U				
Tryonia elata	Point of Rocks Tryonia	Coarse Filter	4	L				
Tryonia ericae	Minute Tryonia	Coarse Filter	4	U				
Tryonia variegata	Amargosa Tryonia	Coarse Filter	37	U				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Freshwater & Anadromous Fishes								
Catostomus clarkii	Desert Sucker	Coarse Filter	21	H				
Catostomus latipinnis	Flannelmouth Sucker	Coarse Filter	19	H				
Crenichthys baileyi baileyi	White River Springfish	Coarse Filter	4	H				
Crenichthys baileyi moapae	Moapa White River Springfish	Coarse Filter	14	H				
Cyprinodon diabolis	Devil's Hole Pupfish	Coarse Filter	8	H				
Cyprinodon nevadensis mionectes	Ash Meadows Pupfish	Coarse Filter	34			H		
Cyprinodon nevadensis pectoralis	Warm Springs Amargosa Pupfish	Coarse Filter	13	H				
Empetrichthys latos	Pahrump poolfish	Coarse Filter						Not really a distinct taxon, this species was split into 3 subspecies, of which only one is still extant.
Empetrichthys latos latos	Pahrump Poolfish	Coarse Filter	8	H				
Gila elegans	Bonytail	Coarse Filter	16	U				
Gila seminuda	Virgin River Chub	Coarse Filter	15	M				
Gila seminuda pop. 2	Virgin River Chub - Muddy River Population	Coarse Filter	19	H				Yearly surveys in Muddy and Virgin rivers
Lepidomeda mollispinis mollispinis	Virgin River Spinedace	Coarse Filter	10	M				
Moapa coriacea	Moapa Dace	Coarse Filter	16	H				Surveys conducted in Feb and Oct each year
Plagopterus argentissimus	Woundfin	Coarse Filter	25	M				Efforts to establish a viable population in the Virgin River have been un successful
Rhinichthys osculus	Speckled Dace	Coarse Filter	42	M				
Rhinichthys osculus moapae	Moapa Speckled Dace	Coarse Filter	12	H				Surveys conducted in Feb and Oct each year
Rhinichthys osculus nevadensis	Ash Meadows Speckled Dace	Coarse Filter	20	H				Annual surveys, habitat enhancement projects, reintroductions
Rhinichthys osculus ssp. 11	Meadow Valley Speckled Dace	Coarse Filter	16	M				Annual surveys conducted
Rhinichthys osculus ssp. 6	Oasis Valley Speckled Dace	Coarse Filter	16	M				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Rhinichthys osculus ssp. 7	White River Speckled Dace	Coarse Filter		L				
Xyrauchen texanus	Razorback Sucker	Coarse Filter	42	H				Annual Surveys, RIT Team, habitat enhancements.
Reptiles								
Crotaphytus bicinctores	Great Basin Collared Lizard	Landscape	5	L				
Gopherus agassizii	Mojave Desert Tortoise	Landscape	1378	H				
Heloderma suspectum	Gila Monster	Landscape	339	H				
Sauromalus ater	Common Chuckwalla	Local	15	M				
Sceloporus graciosus graciosus	Northern Sagebrush Lizard	Landscape	1	L				
Birds								
Accipiter cooperii	Cooper's Hawk	Landscape	10	M				
Accipiter gentilis	Northern Goshawk	Coarse Filter	8	H				
Accipiter striatus	Sharp-shinned Hawk	Coarse Filter		M				
Aechmophorus clarkii	Clark's Grebe	Coarse Filter	4	L				
Aechmophorus occidentalis	Western Grebe	Coarse Filter		L				
Aeronautes saxatalis	White-throated Swift	Coarse Filter		L				
Amphispiza belli	Sage Sparrow	Landscape	2	L				
Anas acuta	Northern Pintail	Assemblage		H				
Anas americana	American Wigeon	Assemblage		H				
Anas clypeata	Northern Shoveler	Assemblage		H				
Anas cyanoptera	Cinnamon Teal	Assemblage		H				
Anas discors	Blue-winged Teal	Assemblage		H				
Anthus rubescens	American Pipit	Local		L				
Aquila chrysaetos	Golden Eagle	Landscape	14	H				
Ardea alba	Great Egret	Local		L				
Ardea herodias	Great Blue Heron	Local		L				
Asio flammeus	Short-eared Owl	Local	3	L				
Asio otus	Long-eared Owl	Local	13	L				
Athene cunicularia hypugaea	Western Burrowing Owl	Local	565	M				
Auriparus flaviceps	Verdin	Coarse Filter		L				
Aythya affinis	Lesser Scaup	Assemblage		H				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Aythya americana	Redhead	Assemblage		H				
Aythya valisineria	Canvasback	Assemblage		H				
Baeolophus inornatus	Oak Titmouse	Local		L		M		
Baeolophus ridgwayi	Juniper Titmouse	Coarse Filter		L				
Branta canadensis	Canada Goose	Assemblage		H				
Bubulcus ibis	Cattle Egret	Coarse Filter		L				
Bucephala islandica	Barrow's Goldeneye	Assemblage		M				
Buteo regalis	Ferruginous Hawk	Landscape	11	H				
Buteogallus anthracinus	Common Black-Hawk	Local	4	L				
Butorides virescens	Green Heron	Coarse Filter	3	L				
Calidris minutilla	Least Sandpiper	Assemblage		H				
Callipepla gambelii	Gambel's Quail	Coarse Filter		L				
Calypte costae	Costa's Hummingbird	Coarse Filter	5	L				
Cardinalis cardinalis	Northern Cardinal	Local	2	L				
Carpodacus cassinii	Cassin's Finch	Assemblage		L				
Catharus ustulatus	Swainson's Thrush	Coarse Filter		L				
Chaetura vauxi	Vaux's Swift	Local		L				
Charadrius montanus	Mountain Plover	Coarse Filter	2	L				
Chlidonias niger	Black Tern	Coarse Filter		L				
Chondestes grammacus	Lark Sparrow	Local		L				
Chordeiles acutipennis	Lesser Nighthawk	Local	6	L				
Cinclus mexicanus	American Dipper	Coarse Filter		L				
Circus cyaneus	Northern Harrier	Landscape	1	M				
Coccothraustes vespertinus	Evening Grosbeak	Assemblage		L				
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	Coarse Filter	84	H				
Colaptes chrysoides	Gilded Flicker	Local		L				
Columbina inca	Inca Dove	Local	4	L				
Contopus cooperi	Olive-sided Flycatcher	Assemblage		L				
Dendroica graciae	Grace's Warbler	Assemblage		L				
Dendroica nigrescens	Black-throated Gray Warbler	Coarse Filter		L				
Dendroica petechia brewsteri	A Yellow Warbler	Coarse Filter	12	L				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Dendroica petechia sonorana	Sonoran Yellow Warbler	Coarse Filter	1	L				
Egretta thula	Snowy Egret	Coarse Filter		L				
Empidonax traillii extimus	Southwestern Willow Flycatcher	Coarse Filter	100	H				
Empidonax wrightii	Gray Flycatcher	Coarse Filter		L				
Eremophila alpestris actia	California Horned Lark	Local	4	L				
Falco columbarius	Merlin	Local	1	M				
Falco mexicanus	Prairie Falcon	Landscape	178	H				
Falco peregrinus	Peregrine Falcon	Local	54	H				
Gallinago delicata	Wilson's Snipe	Coarse Filter		L				
Gallinula chloropus	Common Moorhen	Assemblage	4	L				
Gavia immer	Common Loon	Assemblage		L				
Geococcyx californianus	Greater Roadrunner	Coarse Filter	2	L				
Geothlypis trichas	Common Yellowthroat	Local	5	L				
Gymnorhinus cyanocephalus	Pinyon Jay	Coarse Filter		M				
Haliaeetus leucocephalus	Bald Eagle	Landscape	16	H				
Himantopus mexicanus	Black-necked Stilt	Assemblage		L				
Hydroprogne caspia	Caspian Tern	Coarse Filter		L				
Icteria virens	Yellow-breasted Chat	Local	29	L				
Icterus cucullatus	Hooded Oriole	Coarse Filter	4	L				
Icterus parisorum	Scott's Oriole	Local		L				
Ixobrychus exilis	Least Bittern	Coarse Filter	6	L				
Ixobrychus exilis hesperis	Western Least Bittern	Coarse Filter	5	L				
Junco hyemalis caniceps	Gray-headed Junco	Local	10	L				
Lanius ludovicianus	Loggerhead Shrike	Landscape	34	L				
Larus californicus	California Gull	Coarse Filter		L				
Laterallus jamaicensis coturniculus	California Black Rail	Coarse Filter	5	L				
Limnodromus scolopaceus	Long-billed Dowitcher	Assemblage		M				
Lophodytes cucullatus	Hooded Merganser	Assemblage		H				
Melanerpes formicivorus	Acorn Woodpecker	Local	2	L				
Melanerpes uropygialis	Gila Woodpecker	Coarse Filter	6	L				
Melospiza lincolnii	Lincoln's Sparrow	Local		L				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Mergus merganser	Common Merganser	Assemblage		H				
Micrathene whitneyi	Elf Owl	Local	6	L				
Myiarchus tyrannulus	Brown-crested Flycatcher	Coarse Filter	8	L				
Numenius americanus	Long-billed Curlew	Coarse Filter		M				
Nycticorax nycticorax	Black-crowned Night-Heron	Coarse Filter	1	L				
Oreoscoptes montanus	Sage Thrasher	Landscape		L				
Otus flammeolus	Flammulated Owl	Assemblage		L				
Pandion haliaetus	Osprey	Coarse Filter		H				
Passerculus sandwichensis	Savannah Sparrow	Landscape		L				
Passerina caerulea	Blue Grosbeak	Coarse Filter	5	L				
Patagioenas fasciata	Band-tailed Pigeon	Assemblage	6	L				
Pelecanus erythrorhynchos	American White Pelican	Coarse Filter	2	H				
Phainopepla nitens	Phainopepla	Coarse Filter	203	M				
Phalacrocorax auritus	Double-crested Cormorant	Coarse Filter		L				
Phalaropus lobatus	red-necked phalarope	Assemblage		M				
Phalaropus tricolor	Wilson's Phalarope	Coarse Filter		M				
Picoides scalaris	Ladder-backed Woodpecker	Coarse Filter	1	L				
Pipilo aberti	Abert's Towhee	Coarse Filter	12	L				
Pipilo chlorurus	Green-tailed Towhee	Coarse Filter		L				
Pipilo crissalis eremophilus	Inyo California Towhee	Local	35	L				
Piranga rubra	Summer Tanager	Coarse Filter	15	L				
Plegadis chihi	White-faced Ibis	Assemblage	4	M				
Podiceps auritus	Horned Grebe	Local		M				
Podiceps nigricollis	Eared Grebe	Local		M				
Polioptila melanura	Black-tailed Gnatcatcher	Coarse Filter	10	L				
Pyrocephalus rubinus	Vermilion Flycatcher	Coarse Filter	20	L				
Rallus longirostris yumanensis	Yuma Clapper Rail	Local	38	H				
Recurvirostra americana	American Avocet	Assemblage	3	M				
Regulus calendula	Ruby-crowned Kinglet	Assemblage		L				
Regulus satrapa	Golden-crowned Kinglet	Local		L				
Riparia riparia	Bank Swallow	Local		L				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Sayornis nigricans	Black Phoebe	Coarse Filter		L				
Selasphorus platycercus	Broad-tailed Hummingbird	Local		L				
Selasphorus rufus	Rufous Hummingbird	Local		L				
Sitta pygmaea	Pygmy Nuthatch	Assemblage		L				
Sphyrapicus nuchalis	Red-naped Sapsucker	Coarse Filter		L				
Sphyrapicus ruber	Red-breasted Sapsucker	Coarse Filter		L				
Sphyrapicus thyroideus	Williamson's Sapsucker	Coarse Filter	1	L				
Spinus psaltria	Lesser Goldfinch	Coarse Filter		L				
Spizella atrogularis	Black-chinned Sparrow	Coarse Filter		L				
Spizella breweri	Brewer's Sparrow	Landscape		L				
Spizella passerina	Chipping Sparrow	Coarse Filter		L				
Stellula calliope	Calliope Hummingbird	Coarse Filter		L				
Sterna forsteri	Forster's Tern	Coarse Filter		L				
Tachycineta bicolor	Tree Swallow	Coarse Filter		L				
Toxostoma bendirei	Bendire's Thrasher	Coarse Filter	84	L				
Toxostoma crissale	Crissal Thrasher	Coarse Filter	25	L				
Toxostoma lecontei	Le Conte's Thrasher	Coarse Filter	177	L				
Tringa semipalmata	Willet	Assemblage		M				
Turdus migratorius	American Robin	Coarse Filter				L		
Tyrannus vociferans	Cassin's Kingbird	Coarse Filter		L				
Vermivora celata	Orange-crowned Warbler	Coarse Filter		L				
Vermivora luciae	Lucy's Warbler	Coarse Filter	1	L				
Vermivora virginiae	Virginia's Warbler	Coarse Filter	5	L				
Vireo bellii	Bell's Vireo	Coarse Filter	3	L				
Vireo bellii arizonae	Arizona Bell's Vireo	Coarse Filter	9	L				
Vireo bellii pusillus	Least Bell's Vireo	Coarse Filter	17	L				
Vireo vicinior	Gray Vireo	Coarse Filter	34	L				
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	Coarse Filter		L				
Zenaida asiatica	White-winged Dove	Coarse Filter		L				
Zonotrichia leucophrys	White-crowned Sparrow	Coarse Filter		L				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Mammals								
Antrozous pallidus	Pallid Bat	Local	116	H				
Bassariscus astutus	Ringtail	Coarse Filter	5	L				
Castor canadensis	American Beaver	Local		L				
Chaetodipus penicillatus	Desert Pocket Mouse	Coarse Filter	9	L				
Choeronycteris mexicana	Mexican Long-tongued Bat	Local		H				
Corynorhinus townsendii	Townsend's Big-eared Bat	Local	162	H				
Dipodomys deserti	Desert Kangaroo Rat	Assemblage	12	L				
Dipodomys merriami	Merriam's Kangaroo Rat	Local	27	L				
Dipodomys panamintinus	Panamint Kangaroo Rat	Coarse Filter		L				
Dipodomys panamintinus argusensis	Argus Mountains Kangaroo Rat	Local	8	L				
Dipodomys panamintinus panamintinus	Panamint Kangaroo Rat	Local	6	L				
Eptesicus fuscus	Big Brown Bat	Landscape	49	H				
Euderma maculatum	Spotted Bat	Coarse Filter	51	H				
Eumops perotis	Greater Bonneted Bat	Local	21	H				
Idionycteris phyllotis	Allen's Big-eared Bat	Local	28	H				
Lasionycteris noctivagans	Silver-haired Bat	Assemblage	26	H				
Lasiurus blossevillii	Western Red Bat	Coarse Filter	7	H				
Lasiurus cinereus	Hoary Bat	Assemblage	38	H				
Lasiurus xanthinus	Western Yellow Bat	Local	17	H				
Macrotus californicus	Californian Leaf-nosed Bat	Local	46	H				
Microtus montanus nevadensis	Ash Meadows Montane Vole	Local	3	H				
Myotis ciliolabrum	Western Small-footed Myotis	Local	46	H				
Myotis evotis	Long-eared Myotis	Assemblage	29	H				
Myotis lucifugus	Little Brown Myotis	Assemblage	3	H				
Myotis thysanodes	Fringed Myotis	Local	56	H				
Myotis velifer	Cave Myotis	Local	4	H				
Myotis volans	Long-legged Myotis	Assemblage	54			H		
Myotis yumanensis	Yuma Myotis	Local	33	H				

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Neotamias dorsalis	Cliff Chipmunk	Local		L				
Neotamias palmeri	Palmer's Chipmunk	Local	27	H				
Neotamias umbrinus nevadensis	Hidden Forest Chipmunk	Local	3	H				
Notiosorex crawfordi	Crawford's Gray Shrew	Local	4	L				
Nyctinomops macrotis	Big Free-tailed Bat	Local	11	H				
Odocoileus hemionus	Mule Deer	Landscape		H				
Ondatra zibethicus	Common Muskrat	Local		L				
Ovis canadensis nelsoni	Desert Bighorn Sheep	Landscape	159	H				
Parastrellus hesperus	Western Pipistrelle	Local	65	H				
Peromyscus boylii	Brush Deermouse	Local		L				
Peromyscus truei	Piñon Deermouse	Coarse Filter		L				
Sorex merriami leucogenys	Merriam's Shrew	Local	3	L				
Sorex tenellus	Inyo Shrew	Local	11	L				
Spermophilus variegatus	Rock Squirrel	Coarse Filter		L				
Tadarida brasiliensis	Brazilian Free-tailed Bat	Landscape	63	H				
Taxidea taxus	American Badger	Local	51	L				
Vulpes macrotis	Kit Fox	Landscape	7	L				
Lichens, Mosses, Ferns & relatives								
Dermatocarpon luridum		Coarse Filter	2	L	U	U	U	
Didymodon nevadensis		Assemblage	26	M	U	U	U	
Entosthodon planoconvexus		Local	6	M	U	U	U	
Grimmia americana		Local	2	M	U	U	U	
Trichostomum sweetii		Local	6	M	U	U	U	
Botrychium ascendens	Upward-lobed Moonwort	Local	14	L	U	U	U	
Botrychium crenulatum	Crenulate Moonwort	Local	22	L	U	U	U	
Botrychium lineare	Narrowleaf Grapefern	Local		L	U	U	U	
Selaginella utahensis	Utah Spike-moss	Local	8	L	U	U	U	
Conifers & relatives								
Ephedra funerea	Death Valley Mormon-tea	Local	8	L	U	U	U	
Pinus longaeva	Bristlecone Pine	Coarse Filter		M	U	M	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Flowering Plants								
Allium marvinii		Local		U	U	U	U	
Angelica scabrida	Rough Angelica	Coarse Filter	70	H	U	U	U	
Antennaria soliceps	Charleston Pussytoes	Assemblage	44	H	U	U	U	
Arabis dispar	Unequal Rockcress	Local	51	L	U	U	U	
Arabis parishii	Parish's Rockcress	Local	52	L	U	U	U	
Arabis pulchra var. munciensis	Darwin Rock Cress	Local	6	L	U	U	U	
Arabis shockleyi	Shockley's Rockcress	Local	121	L	U	U	U	
Arctomecon californica	Las Vegas Bear-poppy	Assemblage	390	H	M	U	U	
Arctomecon humilis	Dwarf Bear-poppy	Local	14	L	U	U	H	
Arctomecon merriamii	White Bear-poppy	Coarse Filter	445	M	U	M	U	
Arenaria stenomeres	Meadow Valley Sandwort	Local	44	M	U	U	U	
Astragalus ackermanii	Ackerman's Milkvetch	Assemblage	19	M	U	U	U	
Astragalus aequalis	Clokey's Milkvetch	Coarse Filter	84	H	U	U	U	
Astragalus albens	Cushenbury Milkvetch	Local	21	L	U	U	U	
Astragalus amphioxys var. musimonum	Sheep Mountain Milkvetch	Coarse Filter	32	M	U	U	U	
Astragalus ampullarioides		Local	6	L	U	U	U	
Astragalus ampullarius	Gumbo Milkvetch	Local	2	L	U	U	U	
Astragalus atratus var. mensanus	Darwin Mesa Milkvetch	Local	13	L	U	U	U	
Astragalus cimae var. cimae	Cima Milkvetch	Local	27	L	U	U	U	
Astragalus ensiformis var. gracilior	Pagumpa Milkvetch	Local	12	L	U	U	U	
Astragalus funereus	Black Milkvetch	Local	35	M	U	U	U	
Astragalus geyeri var. triquetrus	Sand Milkvetch	Assemblage	774	M	U	U	U	
Astragalus gilmanii	Gilman's Milkvetch	Local	20	L	U	U	U	
Astragalus holmgreniorum	Holmgren's Milkvetch	Local	7	L	U	U	U	
Astragalus hornii var. hornii	Horn's Milkvetch	Coarse Filter	2	L	U	U	U	
Astragalus jaegerianus	Lane Mountain Milkvetch	Local	36	L	U	U	U	
Astragalus lentiginosus var. sesquimetralis	Sodaville Milkvetch	Coarse Filter	1	H	U	H	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Astragalus lentiginosus var. stramineus	Mottled Milkvetch	Assemblage	17	L	U	U	U	
Astragalus leucolobus	Big Bear Valley Woollypod	Local	75	L	U	U	U	
Astragalus mohavensis var. hemigyrus	Half-ring Pod Milkvetch	Local	276	M	U	H	U	
Astragalus mokiacensis	Mokiah Milkvetch	Coarse Filter	15	M	U	U	U	
Astragalus nyensis	Nye Milkvetch	Local	61	L	U	U	U	
Astragalus oophorus var. clokeyanus	Charleston Milkvetch	Assemblage	55	M	U	U	U	
Astragalus phoenix	Ash Meadows Milkvetch	Local	514	H	U	U	U	
Astragalus remotus	Spring Mountain Milkvetch	Coarse Filter	363	M	U	U	U	
Astragalus straturensis	Silver Reef Milkvetch	Local	11	L	U	U	U	
Astragalus tricarinatus	Triple-rib Milkvetch	Local	19	L	U	U	U	
Atriplex argentea var. longitrichoma		Local	11	L	U	U	U	
Atriplex parishii	Parish's Saltbush	Local	1	L	U	U	U	
Berberis harrisoniana	Kofka Barberry	Local	1	L	U	U	U	
Boechera yorkii	Last Chance Rock Cress	Assemblage	3	L	U	M	U	
Calochortus panamintensis	Panamint Mountain Mariposa Lily	Local	3	L	U	L	U	
Calochortus plummerae	Plummer's Mariposa-lily	Local	1	L	U	U	U	
Calochortus striatus	Alkali Mariposa-lily	Local	162	M	U	U	U	
Camissonia bairdii	Baird's Camissonia	Local	4	L	U	U	U	
Camissonia gouldii	Diamond Valley Suncup	Local	2	L	U	U	U	
Camissonia megalantha	Intermountain Evening-primrose	Local	61	M	U	U	U	
Canbya candida	White Canbya	Local	33	L	U	U	U	
Carex haysii	Hays' Sedge	Local	1	L	U	U	U	
Castela emoryi	Crucifixion Thorn	Local	30	L	U	U	U	
Castilleja cinerea	Ash Grey Indian-paintbrush	Local	47	L	U	U	U	
Castilleja lasiorhyncha	San Bernardino Owl's-clover	Local	35	L	U	U	U	
Caulostramina jaegeri	Jaeger's Caulostramina	Local	8	L	U	M	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Centaurium namophilum	Spring-loving Centaury	Local	554	H	U	M	U	
Chamaesyce platysperma	Flatseed Spurge	Local	2	L	U	U	U	
Chrysothamnus eremobius	Pintwater Rabbitbrush	Assemblage	8	L	U	U	U	
Cirsium clokeyi	Clokey's Thistle	Local	67	M	U	U	U	
Cirsium virginense	Virgin Thistle	Coarse Filter	19	L	U	U	U	
Cordylanthus tecopensis	Tecopa Bird's-beak	Coarse Filter	272	M	U	M	U	
Coryphantha chlorantha		Coarse Filter	45	L	U	U	U	
Cryptantha clokeyi	Clokey's Cat's-eye	Local	18	L	U	U	U	
Cryptantha insolita	Unusual Cat's-eye	Local	4	M	U	U	U	
Cryptantha semiglabra	Pipe Springs Cryptantha	Local		L	U	U	U	
Cymopterus deserticola	Desert Cymopterus	Local	82	L	U	U	U	
Cymopterus ripleyi var. saniculoides	Sanicle Biscuitroot	Local	66	M	U	U	U	
Dedeckera eurekensis	July Gold	Local	18	M	U	M	U	
Draba brachystylis	Wasatch Draba	Coarse Filter	10	M	U	U	U	
Draba jaegeri	Jaeger Whitlowgrass	Local	55	H	U	U	U	
Draba paucifructa	Charleston Draba	Local	69	H	U	U	U	
Dudleya saxosa ssp. saxosa	Panamint Dudleya	Local	12	L	U	U	U	
Echinocereus engelmannii var. armatus	Engelmann's Hedgehog Cactus	Local		L	U	U	U	
Echinocereus engelmannii var. howei	Howe's Hedgehog Cactus	Local	4	L	U	U	U	
Enceliopsis argophylla	Silver-leaf Sunray	Assemblage	26	L	U	U	U	
Enceliopsis covillei	Panamint Daisy	Local	11	L	U	M	U	
Enceliopsis nudicaulis var. corrugata	Ash Meadows Sunray	Local	1758	H	U	U	U	
Epilobium nevadense	Nevada Willowherb	Assemblage	20	L	U	U	U	
Ericameria cervina	Deer Goldenweed	Local	10	L	U	U	U	
Ericameria compacta	Charleston Mountain Heath-goldenrod	Assemblage	48	M	U	U	U	
Ericameria gilmanii	Gilman Goldenweed	Local	8	L	U	U	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Erigeron calvus	Bald Daisy	Local	1	L	U	U	U	
Erigeron ovinus	Sheep Fleabane	Assemblage	32	L	U	U	U	
Erigeron parishii	Parish's Daisy	Local	35	L	U	U	U	
Eriogonum bifurcatum	Forked Buckwheat	Coarse Filter	95	M	U	U	U	
Eriogonum concinnum	Darin Buckwheat	Assemblage	35	L	U	U	U	
Eriogonum contiguum	Reveal's Buckwheat	Local	32	L	U	U	U	
Eriogonum corymbosum var. nilesii	Crispleaf Wild Buckwheat	Assemblage	207	H	U	U	U	
Eriogonum eremicola	Wildrose Canyon Buckwheat	Local	10	L	U	U	U	
Eriogonum ericifolium var. thornei	Thorne's Buckwheat	Local	2	L	U	U	U	
Eriogonum gilmanii	Gilman's Buckwheat	Local	20	L	U	U	U	
Eriogonum heermannii var. clokeyi	Heermann's Buckwheat	Local	21	L	U	U	U	
Eriogonum hoffmannii var. hoffmannii	Hoffmann's Buckwheat	Local	5	L	U	U	U	
Eriogonum intrafractum	Jointed Buckwheat	Local	16	L	U	M	U	
Eriogonum microthecum var. panamintense	Panamint Mountains Buckwheat	Local	10	L	U	U	U	
Eriogonum viscidulum	Sticky Buckwheat	Assemblage	147	H	U	U	U	
Eriophyllum mohavense	Barstow Wooly-sunflower	Local	63	L	U	U	U	
Eschscholzia minutiflora ssp. twisselmannii	Twisselmann's Poppy	Local	25	L	U	U	U	
Escobaria alversonii	Cushion Fox-tail Cactus	Local	43	L	U	U	U	
Escobaria vivipara var. rosea	Viviparous Foxtail Cactus	Local	20	L	U	U	U	
Eustoma exaltatum	Catchfly Prairie-gentian	Coarse Filter	5	M	U	U	U	
Fremontodendron californicum	California flannelbush	Coarse Filter		L	U	U	U	
Galium hilendiae ssp. kingstonense	Kingston Bedstraw	Local	16	L	U	U	U	
Gilia maculata	Little San Bernardino Mountains gilia	Local	29	L	U	U	U	
Gilia ripleyi	Ripley's Gilia	Assemblage	113	L	U	U	U	
Gilmania luteola	Golden Carpet	Local	16	L	U	U	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Glossopetalon clokeyi	Clokey's Greasebush	Assemblage	34	M	U	U	U	
Glossopetalon pungens	Pacific Greasebush	Assemblage	1	M	U	U	U	
Glossopetalon pungens var. glabrum	Smooth Dwarf Greasebush	Assemblage	24	M	U	U	U	
Glossopetalon pungens var. pungens	Pacific Greasebush	Assemblage	15	M	U	U	U	
Grindelia fraxinopratensis	Ash Meadows Gumweed	Local	247	H	U	U	U	
Helianthus deserticola	Utah Sunflower	Assemblage	10	M	U	U	U	
Hemizonia arida	Red Rock tarplant	Local	9	L	U	U	U	
Hemizonia mohavensis	Mohave Tarplant	Local	15	L	U	U	U	
Heuchera parishii	Parish's Alumroot	Local	4	L	U	U	U	
Holmgrenanthe petrophila	Rock Lady	Local	10	L	U	U	U	
Hymenoclea sandersonii	Sanderson's Cheesebush	Local	1	L	U	U	U	
Imperata brevifolia	California Satintail	Coarse Filter	13	M	U	U	U	
Ionactis caelestis	Spring Mountain Ankle-aster	Assemblage	5	H	U	U	U	
Ivesia argyrocoma	Silver-haired Ivesia	Local	41	L	U	U	U	
Ivesia arizonica var. saxosa	Rock Purpusia	Assemblage	2	L	U	U	U	
Ivesia cryptocaulis	Hidden Ivesia	Assemblage	24	H	U	U	U	
Ivesia jaegeri	Jaeger's Ivesia	Assemblage	116	H	U	U	U	
Ivesia kingii	King's Ivesia	Coarse Filter		L	U	U	U	
Ivesia kingii var. eremica	Ash Meadows Mousetail	Coarse Filter	123	H	U	U	U	
Ivesia patellifera	Kingston Mountains Ivesia	Local	7	L	U	U	U	
Lathyrus hitchcockianus	Bullfrog Hills Sweetpea	Local	26	M	U	U	U	
Lesquerella hitchcockii	Hitchcock's Bladderpod	Assemblage	128	L	U	U	U	
Lilium parryi	Lemon Lily	Local	29	L	U	U	U	
Linanthus concinnus	San Gabriel Linanthus	Local	13	L	U	U	U	
Linanthus killipii	Baldwin Lake Linanthus	Local	21	L	U	U	U	
Linanthus orcuttii	Orcutt's Linanthus	Local	8	L	U	U	U	
Loeflingia squarrosa ssp. artemisiarum	Sage-like Loeflingia	Local	19	L	U	U	U	
Lotus argyraeus var. multicaulis	Wright's Hosackia	Local	25	L	U	U	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Lupinus holmgrenianus	Holmgren Lupine	Local	13	L	U	U	U	
Lupinus magnificus var. magnificus	Panamint Mountains Lupine	Local	13	L	U	U	U	
Mentzelia leucophylla	Ash Meadows Blazingstar	Local	189	H	U	U	U	
Mentzelia polita	Polished Blazingstar	Local	25	L	U	U	U	
Mentzelia tridentata	Three-tooth Blazingstar	Local	26	L	U	U	U	
Mimulus exiguus	San Bernardino Mountain Monkeyflower	Local	18	L	U	U	U	
Mimulus mohavensis	Mojave Monkeyflower	Local	58	L	U	M	U	
Mimulus purpureus	Little Purple Monkeyflower	Local	18	L	U	U	U	
Mirabilis pudica	Bashful Four-o'clock	Local	12	M	U	U	U	
Monardella robisonii	Robison's Monardella	Local	36	L	U	U	U	
Muhlenbergia californica	California Muhly	Local	2	L	U	U	U	
Nitrophila mohavensis	Amargosa Niterwort	Local	97	H	U	H	U	
Oenothera californica ssp. eurekensis	Eureka Dunes Evening-primrose	Local	3	L	U	H	U	
Oenothera cavernae	Cave Evening-primrose	Local	4	L	U	U	U	
Opuntia aurea	Golden Prickly-pear	Local	3	L	U	U	U	
Opuntia whipplei var. multigeniculata	Blue Diamond Cholla	Assemblage	85	H	U	U	U	
Oreonana vestita	Woolly Mountain-parsley	Local	11	L	U	U	U	
Parnassia cirrata	Fringed Grass-of-Parnassus	Local	1	L	U	U	U	
Pediocactus sileri	Siler Pincushion Cactus	Local	15	L	U	U	U	
Pediomelum castoreum	Beaver Scurf-pea	Local	93	M	U	U	U	
Penstemon albomarginatus	White-margin Beardtongue	Assemblage	97	H	H	H	U	
Penstemon bicolor	Pinto beardtongue	Assemblage	58	H	H	H	U	
Penstemon bicolor ssp. bicolor	Bicolored Beardtongue	Assemblage	193	H	H	H	U	
Penstemon bicolor ssp. roseus	Rosy Bicolored Beardtongue	Assemblage	249	H	H	H	U	
Penstemon calcareus	Limestone Beardtongue	Local	24	L	U	M	U	
Penstemon fruticiformis ssp. amargosae	Death Valley Beardtongue	Local	93	M	U	U	U	
Penstemon pahutensis	Pahute Mesa Beardtongue	Assemblage	56	M	U	U	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Penstemon petiolatus	Petiolate Beardtongue	Local	13	L	U	U	U	
Penstemon stephensii	Stephen's Beardtongue	Local	26	L	U	U	U	
Penstemon thompsoniae ssp. jaegeri	Jaeger's Beardtongue	Local	93	L	U	U	U	
Perityle inyoensis	Inyo Rock Daisy	Local	7	L	U	U	U	
Perityle villosa	Hanaupah rock daisy	Local	7	L	U	U	U	
Petalonyx parryi	Parry Sandpaper-plant	Local	6	L	U	U	U	
Petalonyx thurberi ssp. gilmanii	Death Valley Sandpaper-plant	Local	19	M	U	U	U	
Phacelia anelsonii	Aven Nelson's Phacelia	Local	26	L	U	U	U	
Phacelia beatleyae	Beatley's Phacelia	Local	54	M	U	U	U	
Phacelia filiae	a Phacelia	Assemblage	51	M	U	U	U	
Phacelia geraniifolia	Geranium-leaf Scorpionweed	Assemblage	26	L	U	U	U	
Phacelia laxiflora	Nodding-flower Scorpionweed	Local	4	L	U	U	U	
Phacelia mustelina	Death Valley Roundleaf Phacelia	Local	37	L	U	U	U	
Phacelia nashiana	Nash's Phacelia	Local	73	L	U	U	U	
Phacelia parishii	Parish's Phacelia	Local	30	H	H	H	U	
Phlox dolichantha	Bear Valley Phlox	Local	23	L	U	U	U	
Plagiobothrys parishii	Parish's Popcorn-flower	Local	6	L	U	U	U	
Poa atropurpurea	San Bernardino Bluegrass	Local	16	L	U	U	U	
Polygala heterorhyncha	Spiny Milkwort	Local	12	L	U	U	U	
Porophyllum pygmaeum	Pygmy Poreleaf	Local	26	L	U	U	U	
Prunus eremophila		Local	15	L	U	U	U	
Puccinellia parishii	Parish's Alkali Grass	Local	1	L	U	U	U	
Saltugilia latimeri		Local	17	L	U	U	U	
Salvia dorrii var. clokeyi	Clokey's Mountain Sage	Local	101	M	U	U	U	
Salvia funerea	Death Valley Sage	Assemblage	8	M	U	M	U	
Salvia greatae	Orocopia Sage	Local	2	L	U	U	U	
Sclerocactus polyancistrus	Mohave Fishhook Cactus	Local	26	L	U	U	U	
Sedum niveum	Davidson's Stonecrop	Local		L	U	U	U	
Sidalcea covillei	Owens Valley Checker-mallow	Coarse Filter	18	L	U	M	U	
Sidalcea pedata	Pedate Checker-mallow	Local	16	L	U	U	U	

Scientific Name	Common Name	Assessment Approach	EOs	NV	AZ	CA	UT	Comments
Silene clokeyi	Clokey's Catchfly	Local	28	H	U	U	U	
Sisyrinchium funereum	Funeral Mountain Blue-eyed-grass	Coarse Filter	16	M	U	U	U	
Sisyrinchium radicatum	Big-root Blue-eyed-grass	Coarse Filter	11	L	U	U	U	
Sphaeralcea gierischii		Local	1	L	U	U	U	
Sphaeromeria compacta	Charleston Tansy	Local	47	H	U	U	U	
Spiranthes infernalis	Ash Meadows Ladies'-tresses	Coarse Filter	207	H	U	U	U	
Stanfordia californica	California Jewelflower	Local		L	U	U	U	
Streptanthus bernardinus	Laguna Mountains Streptanthus	Local	11	L	U	U	U	
Streptanthus campestris	Southern Jewelflower	Local	10	L	U	U	U	
Swallenia alexandrae	Eureka Dunes Grass	Assemblage	4	L	U	H	U	
Synthyris ranunculina	Charleston Kittentails	Local	92	H	U	U	U	
Tetracoccus ilicifolius	Holly-leaf Tetracoccus	Local	7	L	U	U	U	
Thelypodium stenopetalum	Slender-petal Thelypody	Local	8	L	U	U	U	
Townsendia jonesii var. tumulosa	Charleston Ground-daisy	Local	125	M	U	U	U	
Townsendia smithii	Black Rock Ground-daisy	Local	5	L	U	U	U	
Tricardia watsonii	Three hearts	Local	7	L	U	U	U	

B-2.8.2 Aquatics

Riparian Corridor Connectivity ("2010 Scenario")

Indicator Data and Knowledge Gaps

The coarse scale of the assessment for the Mojave Desert precludes on the ground measurements and observations of land use and activity within riparian corridors. For example it is possible that some road crossings may have used bridges rather than culverts. Well designed bridges allow for animal movement as well as unconfined water and sediment movement, much better than perched culverts. However we assumed roads within the buffered area cause stress and limit movement. Additionally small in-stream earth dams maybe present that are not included in the Landscape Condition Model data, and may be present but not accounted for. The cumulative effect of multiple stressors all in separate pixels within the same riparian corridor is not accounted for. No comprehensive data was available on the impact of livestock use on stream banks, riparian vegetation and water quality. Riparian areas that have no fragmentation issues may in fact be heavily impacted by livestock use.

Flow Modification by Dams, Current Condition ("2010 Scenario")

Indicator Data and Knowledge Gaps

The ratio of reservoir storage capacity to average annual surface water availability provides a reasonable but very coarse estimate of the potential ability of dams in a watershed to alter the flow regime. However, it presents a very simple picture. Reservoirs may not operate at their full capacity, and operating permits may stipulate that some water be released to satisfy in-stream flow requirements, for example as in the case with Alamo Dam on the Bill Williams River (Shafroth and Beauchamp 2006; Shafroth et al. 2010). Further, as noted above, this indicator measures a potential source of stress to aquatic ecosystems, not the degree of actual alteration of flows. A detailed scientific assessment of flow alteration associated with dams in the ecoregion requires long-term stream gage data, the ecoregion largely lacks.

A more complete assessment of this indicator might also include an analysis not only of reservoir capacity relative to average annual discharge, but relative to discharge during both significantly wet and dry years. Ecological conditions in the ecoregion along riparian/stream ecosystems depend on the natural occurrence both high- and low-flow years to shape channel habitat, reset riparian vegetation succession, and trigger other biological events. The U.S. Geological Survey, StreamStats information system (USGS 2011) will provide information not only on average annual discharge but on seasonal and inter-annual variation as well, when fully implemented for all states in the ecoregion. The F Index could be calculated separately for wet and dry years, to assess the capacity of dams to affect not just average discharges but natural extreme. Unfortunately, as noted in the discussion of data and knowledge gaps for Indicator 04, Surface Water use, Nevada and Arizona have not yet completed their implementations of StreamStats. Alternatively, the assessment of variation in natural discharge would be aided by completion of regional runoff and baseflow models or watershed water budget models. This presents significant challenges because of the unique topography, geology, and climate of the ecoregion. However, regardless of the methods used, future assessments would benefit from an improved quantitative representation of not merely average stream hydrologic behavior but also the natural range of variation in key hydrologic variables such as annual and seasonal stream discharge. Building and calibrating models that can generate such output may well require additional gauging data.

Surface Water Use, Current Condition ("2010 Scenario")

Indicator Data and Knowledge Gaps

The ratio of annual surface water consumption to average annual surface water availability provides a reasonable but very coarse estimate of relative surface water use by watershed. However, it presents a static picture. The runoff of individual watersheds varies naturally as a result of seasonal and inter-annual variation in precipitation and temperature. The natural flow regimes of streams and rivers varied in concert, with baseflows (where present) affected by local and sometimes regional aquifer dynamics as well. The native stream ecosystems of the ecoregion consist of species adapted to this natural variability. However, currently, years of greater runoff in areas of intensive surface water use in the ecoregion may not result in greater water availability for natural stream ecosystems. Rather, they may simply allow dam managers to store more water for later use, or may provide sufficient water to allow holders of junior surface water rights to exercise those rights. As a result, surface water use has the potential to alter not only average annual stream flow and its timing, but natural and ecologically important inter-annual variation in this flow as well. Unfortunately, the available data do not support an analysis of surface water use that addresses impacts to flow variation. Long-term stream gage data are extremely scarce, except for perennially flowing river reaches on valley floors – and these records are highly altered by the history of water use in these valleys.

The U.S. Geological Survey, StreamStats information system (USGS 2011) will provide information not only on average annual discharge but on seasonal and inter-annual variation as well, when fully implemented for all states in the ecoregion. Unfortunately, Nevada and Arizona have not yet completed their implementations. Alternatively, the assessment of surface water use and its impacts on stream flow regimes would be aided by completion of regional runoff and baseflow models or watershed water budget models. This presents significant challenges because of the unique topography, geology, and climate of the ecoregion. However, regardless of the methods used, future assessments would benefit from an improved quantitative representation of not merely average stream hydrologic behavior but also the natural range of variation in key hydrologic variables such as annual and seasonal stream discharge, timing of flow maxima and minima, timing of the annual snowmelt cycle and the "center point" of discharge, and so forth. Building and calibrating models that can generate such output may well require additional gauging data.

Perennial stream-flow and perennial discharge from springs also support surface water use in the MBR ecoregion. For scientific accuracy, it would be better to assess the use of such perennial flows separately from the use of water from runoff-driven streams. Similarly, it might be useful to assess the use of surface water imported via inter-basin transfers separately from the use of surface water diverted within the same drainage network. However, watersheds with high levels of use of water imported from other basins may also be highly modified in ways that "overwrite" the natural drainage network or incorporate it into the local water supply network.

Ground Water Use, Current Condition ("2010 Scenario")

Indicator Data and Knowledge Gaps

The ratio of annual ground water consumption to average annual surface water availability provides a reasonable but very coarse estimate of relative ground water use by watershed. The spatial data and regional ground water models available for the MBR ecoregion are inadequate to identify which aquifers discharge to or support the potentiometric surfaces at which springs, streams, and wetlands; let alone to assess their relative contributions to the hydrology of each CE in each watershed. The controversies associated with almost any application for ground water withdrawal permits in the ecoregion highlight the importance of closing this data gap: the BLM Clark, Lincoln, and White Pine Counties Groundwater Development Project Draft Environmental Impact Statement (BLM 2011), and the competing groundwater models of the Southern Nevada Water Authority (SNWA) and other stakeholder groups concerned with this project (e.g., Burns et al. 2011; GBWN 2011), present a particularly clear example of such a controversy. Groundwater models continue to improve for the ecoregion (e.g., Stamos et al. 2001; Heilweil and Brooks 2011), but may need to be coupled with improvements in the chemical "fingerprinting" of ground water discharges to better associate them with specific geological sources. Perennial flow along basin-floor riparian corridors may also occur in locations where these rivers pass over/through bedrock features that force ground water to the surface (e.g., Webb et al. 2001). Such geological constraints may make such bedrock-dependent stream reaches less sensitive to minor alterations in ground water flows, but still sensitive to major alterations. Better data are needed to differentiate between perennial flow reaches that depend on such bedrock features from those that do not, to better identify their unique sensitivities to withdrawals and support management.

Atmospheric Deposition-Nitrate Loading ("2010 Scenario")

Indicator Data and Knowledge Gaps

The values of nitrate deposition used in this assessment are interpolated values in the NADP deposition model for the U.S. Fewer than five NADP-National Trends Network monitoring stations are located within the ecoregion, with additional stations located in immediately adjacent areas. The assessment therefore is likely strongly affected by variation among these widely spaced stations and the interpolation methods used by the NADP. Matters such as the exposure rates for particularly sensitive alpine water bodies, and the reality of the cluster of higher rates in the Owens Valley-Death Valley-Edwards Air Force Base triangle, require a denser monitoring network and/or site-specific studies (e.g., Hunsaker et al. 2007) along with improved spatial modeling (e.g., Tonnesen et al. 2007). On the other hand, the potential interplay among N-deposition, non-native grasses, fuel loads, and wildfire appears well established, pointing to a risk to watershed runoff and riparian vegetation independent of changes to water chemistry. The interplay of bark beetle dynamics with these processes in the forested portions of the ecoregion also may warrant additional investigation.

ATMOSPHERIC DEPOSITION-MERCURY LOADING ("2010 SCENARIO")

Indicator Data and Knowledge Gaps

The raw estimates of Mercury wet deposition rates used in this assessment are interpolated values in the NADP deposition model for the U.S. Fewer than five NADP-Mercury Deposition Network long-term monitoring stations are located within the ecoregion, with only a handful of additional long-term monitoring stations located in immediately adjacent areas. The assessment therefore is likely strongly affected by variation among these widely spaced monitoring stations and the interpolation methods used by the NADP. The nearest studies of Hg-deposition and bioaccumulation are concentrated northwest of the ecoregion, in California (e.g., Lyman et al. 2007; Sanders et al. 2008; Drevnick et al. 2010). Further, studies of the biological and ecological effects of MeHg bioaccumulation are lacking even in these high-elevation settings, in contrast to other parts of the U.S. with high deposition rates (e.g., Driscoll et al. 2007a). The potential interplay among N-deposition, forest fuel loads, climate change, wildfire, and release of Hg stored in forest soils and litter also warrants further investigation, to determine if this interplay indeed poses additional biological and ecological risk within the MBR ecoregion.

Sediment Loading Index ("2010 Scenario")

Indicator Data and Knowledge Gaps

The coarse scale of the assessment for the Mojave Desert precludes on the ground measurements and observations of land use and activity within surrounding landscapes. Sediment Loading Index is based on the category of land use, which is a national standard provided by NSPECT (2004), and may not reflect actual values for each situation on the ground. The degree of surface slope, while a very important factor in determining sediment runoff, was not included due to computational and time limitation for this rapid, ecoregion-wide assessment. No comprehensive data was available on the impact of livestock use on stream banks, riparian vegetation and water quality. Riparian areas that have high Sediment Loading Index may in fact be heavily impacted by livestock use.

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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).