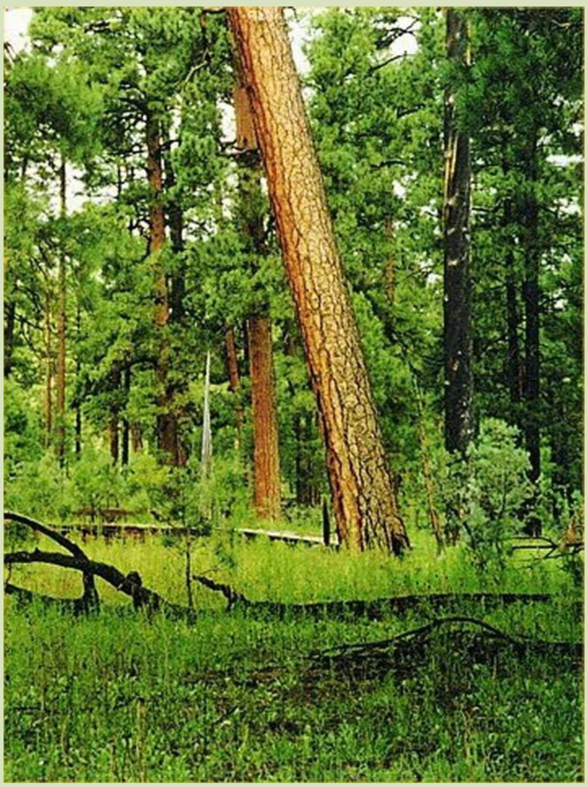
New Mexico Statewide Natural Resources Assessment & Strategy and Response Plan



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NEW MEXICO STATE FORESTRY

Data Atlases

Methods and Descriptions of Core Data Models Used in the Development of the New Mexico Statewide Natural Resource Assessment.

Inside cover

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Table of Contents

Lists of Maps and Tables

Volume II: New Mexico Statewide Natural Resource Assessment, Strategy and Response Plan Data Atlases - Methods and Descriptions of Core Data Models Used in the Development of the Statewide Natural Resource Assessment

Maps

Tables

Lists of Spatial Layers Used

Volume II: New Mexico Statewide Natural Resource Assessment, Strategy and Response Plan Data Atlases - Methods and Descriptions of Core Data Models Used in the Development of the Statewide Natural Resource Assessment

Spatial Layers (Alphabetical Listing)

1. 2000/2030 Development Density Data
2. 305b Impaired Watersheds
3. Accessibility
4. Aquifer Recharge
5. Aquifer Sensitivity
6. Availability of Woody Biomass Products
7. Availability of Timber
8. Basal Area Loss
9. Cougar Corridors
10. Crown Fire Potential
11. CWCS Key Areas
12. Distance to Use
13. Erosion Risk
14. Fire Regime Condition Class
15. Flame Length
16. Forest Patch Continuity
17. Forest Patch Size
18. Forest Patch Size
19. Forested Species Habitat
20. Game (Hunting)
21. Grassland Patch Continuity
22. Grassland Patch Size
23. Ignition Probability
24. Impervious Surfaces
25. Insect and Disease Surveys
26. Landcover that Lowers Priority (SWReGAP)
27. NHNM Wildlife Occurrences
28. NM Highlands Wildlands Network Design - Corridors
29. NM Highlands Wildlands Network Design - Hubs
30. NMDGF Corridors Assessment for WGA
31. NMED Water Quality Risk Factors
32. Non-native Phreatophytes
33. Outstanding Natural Rivers

34. Patch Diversity
35. Patch Rarity
36. Percent Irrigated Cropland and Pasture
37. Percent Normal Precipitation
38. Perennial Streams and Intermittent Streams
39. Precipitation
40. Priority Water Quality Watersheds (NMED)
41. Public Drinking Supply Sources
42. Rare Plant Occurrences
43. Rate of Spread
44. Riparian Patch Continuity
45. Riparian Patch Size
46. Roads and Railroads
47. Scenic Byways
48. Shrub/Scrub Patch Continuity
49. Shrub/Scrub Patch Size
50. Species Specific Crucial Habitat (NMDGF/WGA)
51. Stand Density Index
52. SWReGAP Landcover
53. SWReGAP Landcover (Rangeland Productivity)
54. SWReGAP Stewardship
55. SWReGAP Stewardship - GAP Status
56. T&E Spp Habitat
57. TNC Conservation Areas
58. TNC Fish Atlas
59. TNC Rangeland Ecosystem Assessment
60. Unfragmented Natural Landcover (SWReGAP/TIGER)
61. US Census 2000 Tiger - Roads
62. Visitation
63. Watershed with Specific Water Quality Impaired/Impacted Streams
64. Wildland Urban Interface (WUI)
65. Woodland Patch Continuity
66. Woodland Patch Size
67. Working Forests

Executive Summary

The data of the New Mexico Statewide Natural Resources Assessment were organized around eight core data themes suggested in the 2008 Farm Bill. The eight core data themes include: Fish and Wildlife Habitat (Biodiversity), Development Risk (Potential), Economic Development (Potential), Forest Health, Fragmentation, Green Infrastructure, Water Quality and Supply, and Wildfire Risk. For each core data theme, models were developed and served as the foundation for identifying the priority landscapes within New Mexico for the Statewide Strategy and Response Plan. The data are presented in Volume II by alphabetical order of their titles, not in order of prioritization. Detailed descriptions of each of the core data models are provided in this volume. The Strategy and Response Plan developed using the data can be found in Volume I: New Mexico Statewide Strategy, Assessment, and Response Plan.

While the 2008 Farm Bill provided the framework for the models developed, the Forest and Watershed Health Plan provided the vision for the content of each model and placed emphasis on expanding the scope to include all natural resources, not just forest resources. Technical teams, comprised of volunteer subject and technical experts from agencies and other partners, served as the advisors in the development of each of the data models. One technical team was formed for each of the eight core data models. Individuals on the technical teams came from environmental organizations, private industry, federal, state, and municipal agencies, private landowners, conservation organizations, and citizen's groups.

Technical teams played a critical role in the assessment. They identified the existing statewide data layers to include in each model, and determined how that data layer inputs for each model would be classified. Each model in this volume includes a description of the intent model, the model design, and its input data layers including the data layer function (why it was used in the model), criteria for classifying the data layer (all inputs were reclassified to a scale of 1 to 5), justification of using the data layer, description of the data layer, and the source of the data layer. The criteria for classifying data relied on a natural breaks classification, a statistical procedure that compares the sum of squared differences of values from the means of their classes. This means of displaying data was the default, unless the technical team had a compelling reason to actively create rules for weighting or grouping data using a different method or based on expert opinion. Also included is a listing of data considered but not used, the current data gaps identified for each model, and a list of technical team members.

The Division hopes that partners can work together to fill the data gaps over time. All spatial layers used in the analyses are considered public information and are housed by the New Mexico Resource Geographic Information System Program (RGIS), a cooperative program between the University of New Mexico and the New Mexico Information Technology Commission. Data can be found at http://rgis.unm.edu.

Fish and Wildlife Habitat (Biodiversity)

Fish and Wildlife Habitat (Biodiversity): This data layer identifies areas that provide habitat for plants and animals, including, but not limited to, threatened and endangered species. This layer will be used in the State Strategy and Response plan to help emphasize areas which will enhance public benefit from forested areas. *The scale of the data is meant for broad scale planning and prioritizing.*

Model Design: Combines threatened and endangered species potential habitat, important forested species habitat, TNC fish atlas, occurrences of terrestrial species tracked by Natural Heritage New Mexico (NHNM), occurrences of rare plants on Rare Plant Technical Council list and tracked by NHNM, TNC ecoregional conservation areas, and Comprehensive Wildlife Conservation Strategy key areas using an additive overlay. A forested species sub-model was also created to further emphasize habitat for forest and woodland species. Forest and woodland relative patch value and potential habitat for 14 forest and woodland species were added to the above described model (Maps 1-1 and 1-2). Final priority classes and values for statewide and forest model priorities are: Low = 1-8; Low/Medium = 9-12; Medium = 13-17; Medium/High = 18-22; High = 23-37.

Description of Factors:

1. Threatened and Endangered Species Habitat

Function: Gives value to land that provides potential habitat for threatened and endangered (T&E) species.

Criteria: Pixels that are modeled as potential T&E habitat are given value from 1 to 5 based on number of species with predicted habitat (1 = 1 to 3 T&E species; 2 = 4 to 5 T&E species; 3 = 6 to 8 T&E species; 4 = 9 to 11 T&E species; and 5 = 12 to 20 T&E species); otherwise 0 indicates no predicted habitat.

Justification: All land with the potential to provide habitat for T&E species is considered valuable for T&E species conservation and recovery because it is needed for population growth and range expansion. Habitat destruction or degradation of potential habitat would likely impede range expansion and could negatively impact existing populations.

Data Description: The Comprehensive Wildlife Conservation Strategy (CWCS) for New Mexico (NMDGF, 2006) developed potential habitat models for a majority of T&E species in New Mexico. For terrestrial wildlife species, the potential habitat is based on the concept of wildlife habitat relationships developed for gap analysis and represents areas where a species could potentially persist, reproduce, or otherwise occur. For the aquatic species, the potential habitat is based on a deductive model and highlights the stream order where fish species might occur. Modeling of all predicted species habitat was completed for the CWCS. See Table 1-1, the New Mexico T&E species list; no invertebrate species were modeled or included in this layer. The potential habitat layers were combined, and the number of species with predicted potential habitat was summed from the combined layer. The final layer represents richness of T&E species in New Mexico with lower classes indicating that the fewest number of species is predicted to occur and the higher class indicating that the greatest number of T&E species is predicted to occur.

Data Source: The T&E potential habitat models were obtained from the Center for Applied Spatial Ecology with the New Mexico Cooperative Fish and Wildlife Research Unit at New Mexico State University. The potential habitat layers are based on SWReGAP landcover data from 2001. Details of the methodology are described in the CWCS. The Nature Conservancy in New Mexico created the combined potential habitat layer in 2009.

2. TNC Fish Atlas

Function: Gives value to riparian areas where sensitive fish species occur.

Criteria: Pixels of reaches with current or historical (up to 1970s) occurrences are given value of 5; otherwise 0.

Justification: Riparian areas foster high species richness and abundance of wildlife, and particularly in the southwest they serve as important habitat corridors between larger areas of habitat facilitating dispersal, recruitment, and movement of wildlife.

Data Description: The TNC Atlas is based on information from Natural Heritage New Mexico occurrence records and literature searches. Perennial and intermittent reaches were defined using National Hydrography Dataset at a 1:100,000 scale. The Atlas represents fish occurrence from 1975 to 2005 for 26 native fish species including: desert sucker, Zuni bluehead sucker, Sonora sucker, flannelmouth sucker, Rio Grande sucker, blue sucker, Pecos pupfish, White Sands pupfish, greenthroat darter, Pecos gambusia, Gila chub, Chihuahua chub, Rio Grande chub, roundtail chub, Rio Grande silvery minnow, headwater catfish, Arkansas River speckled chub, spikedace, Arkansas River shiner, Rio Grande shiner, Pecos bluntnose shiner, Rio Grande Cutthroat trout, Gila trout, Colorado pikeminnow, loach minnow, razorback sucker.

Reaches with fish occurrences were buffered 100 feet and converted to a raster layer.

Data Source: The TNC Fish Atlas was developed by The Nature Conservancy in New Mexico and completed in 2007. The Fish occurrence raster layer was created by The Nature Conservancy in New Mexico in 2009.

3. TNC conservation areas

Function: Gives value to land identified as critical to the conservation of biodiversity in New Mexico.

Criteria: Pixels that are modeled as conservation areas are given value of 5; otherwise 0.

Justification: Ecoregional assessments are comprehensive and systematic efforts to identify conservation priorities. TNC conservation areas identify areas containing the full distribution and diversity of native species and natural communities.

Data Description: TNC conservation areas are a product of a priority-setting process described in Designing a Geography of Hope (The Nature Conservancy, 2000). They represent the best remaining areas to conserve. Over 200 terrestrial and aquatic conservation areas were identified in New Mexico.

Data Source: Seven ecoregional assessments that identified the portfolio of conservation areas were completed from 1999 to 2007. TNC ecoregional assessments can be found on the New Mexico Conservation Science website (http://nmconservation.org/projects/ecoregions/).

4. CWCS key areas

Function: Gives value to land considered to be priority for conservation by the CWCS.

Criteria: The key areas layer developed for the CWCS was categorized into five classes based on a Natural Breaks classification (1 = 4 to 6; 2 = 6 to 8; 3 = 8 to 10; 4 = 10 to 12; 5 = 12 to 16).

Justification: Key areas for conservation are important for conservation because they provide valuable fish and wildlife habitat, contain high species diversity, and are the least protected lands within New Mexico.

Data Description: The layer represents potential key areas for conservation efforts. The CWCS key areas are those areas that are within key habitats, have a high number of terrestrial and aquatic Species of Greatest Conservation Need, may be potentially altered by synergistic effects that influence habitats, and lack long-term legally-binding management plans protecting them from degradation.

Data Source: The approach for developing the key areas for conservation layer is described in the Comprehensive Wildlife Conservation Strategy for New Mexico (NMDGF, 2006).

5. Corridors

Function: Gives value to land considered to be important wildlife corridors by the NMDGF.

Criteria: Identified corridors were given a value of 5, else 0 indicating habitat is not a priority corridor.

Justification: Connectivity of wildlife habitat across landscape ensures habitat linkages that promote the long-term viability of species through movement, gene flow, and plant community continuity.

Data Description: The corridor layer was developed by the NMDGF for the Western Governor's Association and represents priority corridors for conservation of large game animals.

Data Source: The corridor data were developed by NMDGF in 2007.

6. Rare Plant Occurrences

Function: Gives value to land in proximity to recorded occurrences of rare plants.

Criteria: Watersheds categorized into five classes based on number of rare plant species found using a Natural Breaks classification (1 = 1 to 6 species; 2 = 7 to 10 species; 3 = 11 to 15 species; 4 = 16 to 32 species; 5 = 33 to 47 species).

Justification: Protection of rare plants is important for conservation of those species and conservation of the overall biodiversity in New Mexico.

Data Description: The layer represents number of rare plant species found per 5th code (or HUC10) watershed. All rare plants tracked by NHNM that are on the Rare Plant Technical Council List and/or those species with a State S1 to S3 ranking were included in the data layer. Number of species per watershed was created in Access by counting the number of rare plant species per watershed then joining to the HUC10 watershed

Data Source: Occurrences per HUC10 watershed data was provided by NHNM. Summary of rare plant species per watershed was created by The Nature Conservancy in New Mexico in 2009.

7. Wildlife Occurrences

Function: Gives value to land in proximity to recorded occurrences of selected wildlife focal species.

Criteria: Watersheds categorized into five classes based on number of wildlife focal species found using a Natural Breaks classification (1 = 1 to 10 species; 2 = 11 to 19 species; 3 = 20 to 36 species; 4 = 37 to 56 species; 5 = 57 to 102 species).

Justification: Protection of wildlife is important for conservation of those species and conservation of the overall biodiversity in New Mexico.

Data Description: The layer represents number of wildlife species found per 5th code (or HUC10) watershed. All wildlife tracked by NHNM with a State S1 to S3 ranking was included in the data layer. Number of species per watershed was created in Access by counting the number of species per watershed then joining to the HUC10 watershed layer.

Data Source: Occurrences per HUC10 watershed data was provided by NHNM. Summary of rare plant species per watershed was created by The Nature Conservancy in New Mexico in 2009.

Forested Sub-Model

1. Forested Species Habitat

Function: Gives value to land that provides potential habitat for key forested species (Table 1-2).

Criteria: Pixels that are modeled as forested habitat for selected key forested species are scaled from 1 to 5 based on richness (number) of species predicted (1 = 0 to 1 species; 2 = 2 to 3 species; 3 = 4 to 5 species; 4 = 6 to 7 species; 5 = 8 to 11 species); otherwise 0.

Justification: All land with potential to provide habitat for key species will serve as a proxy for valuable wildlife habitat for forested species conservation. Habitat destruction or degradation of potential habitat would likely impede range expansion and could negatively impact existing populations.

Data Description: The key forested species list was developed by the Fish & Wildlife Technical Team (Table 1-2). Important forest and woodland species considered but not included are listed at the bottom of Table 1-2. The forested potential habitat is based on the concept of wildlife habitat relationships developed for gap analysis and represents areas where habitat features are predicted to support a species persisting, reproducing, or otherwise occurring. Modeling of each predicted species habitat was completed for the CWCS. The potential habitat layers were combined, and the number of species with predicted potential habitat was summed from the combined layer. The final layer represents richness of key forest species in New Mexico with lower classes indicating areas where habitat for the fewest species is predicted to occur and the higher class indicating areas where habitat for the greatest number of species is predicted to occur.

Data Source: The forested species habitat is taken from the CWCS. The modeling approach is described in the CWCS plan (NMDGF 2006).

Table 1-2: Key Forested & Woodland Species

Key Forest Species List*		Reason included
1	band-tailed pigeon	obligate forest species, good indicator
2	piñon jay	management indicator species, representative of PJ woodland
3	gray vireo	management indicator species, representative of PJ woodland
4	Abert's squirrel	management indicator species, representative of Ponderosa Pine
5	northern goshawk	management indicator species, representative of Ponderosa Pine
6	Mexican spotted owl	management indicator species, representative of Mixed Conifer
7	red squirrel	management indicator species, representative of Mixed Conifer
8	Williamson's sapsucker	management indicator species, representative of Aspen
9	dusky grouse	management indicator species, representative of Aspen
10	American marten	management indicator species, representative of Spruce Fir
11	Clark's nutcracker	management indicator species, representative of Spruce Fir
12	gray jay	management indicator species, representative of Spruce Fir
13	boreal owl	management indicator species, representative of Spruce Fir
14	Gunnison's prairie dog	representative of meadows and openings

Species considered by technical team but not used in the forest species habitat layer included: Mule Deer, Cordilleran flycatcher, Hammond's flycatcher, Dusky's flycatcher, Gray flycatcher. These species were considered important forest indicators but also considered generalists and were removed from model.

2. Forest Patch – Majority Richness

Function: Gives value to patches of forest habitat regardless of size.

Criteria: Patches were classified into 5 classes based on the majority richness of 64 terrestrial species (1 = 1-7; 2 = 8 – 11; 3 = 12-15; 4 = 16 – 19; 5 = 20 – 33); otherwise 0.

Justification: Small, isolated patches of forest and woodland habitat have value for the conservation of biodiversity, and require greater recognition and protection. The majority richness layer was developed to represent both large and small areas that provide important forest and woodland habitat.

Data Description: Forest and woodland habitat patches were developed by reclassifying SWReGAP landcover data reclassified to NLCD forest/nonforest classes. The Tiger Roads (2006) converted to raster, and road pixels were used to reclassify forested areas to nonforested. The resulting layer had 1 = forested , 0 = nonforested. Region Group was used to assign a unique number to each continuous forested region (four adjacent cells used for grouping). Zonal statistics tool was used to calculate the majority richness for 160 terrestrial species of each patch (Table 1-3).

Data Source: The SWReGAP landcover layer is available online at http://earth.gis.usu.edu/swgap/ . Tiger Roads (2006) is available from NM Resource Geographic

Information System Program (RGIS) at http://rgis.unm.edu/intro.cfm. The vertebrate species richness layer was provided by CASE and created as a part of the CWCS (NMDGF 2006).

Data Considered But Not Used

1. *Forest and Woodland Patch Size*: The original model included a patch size measure to emphasize large areas that would provide habitat for the greatest number of forest species. The technical team decided to remove this variable as it would weight the model heavily away from small patches that provide key habitat for movement and viability of species.

Data Gaps/Data Needs

Table 1-4: Fish and Wildlife Habitat (Biodiversity) Data Gaps

Rank	Data Gap Description
High	Soils data at finer scale to inform restoration potential, ecological site descriptions, and state and transition models to help describe the natural range of variation.
High	Better data sharing for wildlife occurrence data. Need a coordinated strategic approach instead of species by species
High	Statewide Linkages Habitat Assessment
High	Refined Birds/Bat flyway data
High - Medium	Statewide analysis that shows loss of habitat
Medium	National Vegetation Classification: Develop crosswalk to existing data such as Landfire and ReGap
Low	Identify trigger points or flag conditions to avoid missing gathering critical information on biodiversity.

Technical Advisory Team

Bob Sivinski – Energy Minerals and Natural Resources Department, Forestry Division, Botanist
Bruce Thompson – Energy Minerals and Natural Resources Department, Conservation Initiatives Coordinator
Bud Starnes – New Mexico Department Agriculture, Wildlife Resources Specialist
Esteban Muldavin – Natural Heritage New Mexico, Program Director
Gail Tunberg – United States Forest Service, Region 3, Wildlife Specialist
Ken Boykin – New Mexico State University, Center for Applied Spatial Ecology, Director
Kevin Winter – Fish and Wildlife Service, Region 2, Biologist
Marcus Miller – Natural Resources Conservation Service, Biologist
Mark Watson – New Mexico Department of Game and Fish, Wildlife Specialist
Mary Stuever – Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer
Rayo McCullough – Natural Heritage New Mexico, Information Management Specialist
Ron Maes – United States Forest Service, Region 3, Wildlife Specialist
Wally Murphy - Fish and Wildlife Service, Region 2, Biologist

Will Amy – United States Forest Service, Santa Fe National Forest, Biologist

Citations

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Hackett, Jan and Jacob Frost, 2005. Forest Stewardship Spatial Analysis Project Methodology Report for Colorado. 20 pages.

New Mexico Department of Game and Fish. 2006. Comprehensive Wildlife Conservation Strategy for New Mexico. New Mexico Department of Game and Fish. Santa Fe, New Mexico. 526 pp + appendices.

The Nature Conservancy. 2000. Designing a Geography of Hope, Second Edition. The Nature Conservancy, Arlington, Virginia.

USGS National Gap Analysis Program. 2004. Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

Table 1-1: New Mexico Threatened and Endangered Species List

Common Name	Scientific Name	Status	Model
Chub, Chihuahua	Gila nigrescens	Federal: Threatened State NM: Endangered	Yes
Chub, Gila	Gila intermedia	Federal: Endangered State NM: Endangered	Yes
Chub, Roundtail	Gila robusta	State NM: Endangered	Yes
Chub, Headwater	Gila nigra	State NM: Endangered	Yes
Chub, Peppered	Macrhybopsis tetranema	State NM: Threatened	Yes
Dace, Redbelly, Southern	Phoxinus erythrogaster	State NM: Endangered	Yes
Darter, Greenthroat	Etheostoma lepidum	State NM: Threatened	Yes
Gambusia, Pecos	Gambusia nobilis	Federal: Endangered State NM: Endangered	Yes
Logperch, Bigscale	Percina macrolepida (Native pop.)	State NM: Threatened	Yes
Minnow, Loach	Tiaroga cobitis	Federal: Threatened State NM: Threatened	Yes
Minnow, Silvery, Rio Grande	Hybognathus amarus	Federal: Endangered State NM: Endangered	Yes
Minnow, Suckermouth	Phenacobius mirabilis	State NM: Threatened	Yes
Pupfish, Pecos	Cyprinodon pecosensis	State NM: Threatened	Yes
Pupfish, White Sands	Cyprinodon tularosa	State NM: Threatened	Yes
Redhorse, Gray	Moxostoma congestum	State NM: Threatened	Yes
Shiner, Arkansas River	Notropis girardi (Native pop.)	Federal: Threatened State NM: Endangered	No
Shiner, Bluntnose, Pecos	Notropis simus pecosensis (NM)	Federal: Threatened State NM: Endangered	Yes
Spikedace	Meda fulgida	Federal: Threatened State NM: Endangered	Yes
Pikeminnow, Colorado	Ptychocheilus lucius	Federal: Endangered State NM: Endangered	Yes
Sucker, Blue	Cycleptus elongatus	State NM: Endangered	Yes
Sucker, Bluehead, Zuni	Catostomus discobolus yarrowi (NM)	State NM: Endangered	No
Sucker, Razorback	Xyrauchen texanus	Federal: Endangered	Yes
Tetra, Mexican	Astyanax mexicanus	State NM: Threatened	Yes
Topminnow, Gila	Poeciliopsis occidentalis occidentalis (NM,AZ)	Federal: Endangered State NM: Threatened	Yes

Common Name	Scientific Name	Status	Model
Trout, Gila	Oncorhynchus gilae	Federal: Threatened State NM: Threatened	Yes
Frog, Leopard, Chiricahua	Rana chiricahuensis	Federal: Threatened	Yes
Frog, Leopard, Lowland	Rana yavapaiensis	State NM: Endangered	Yes
Salamander, Jemez Mtns.	Plethodon neomexicanus	State NM: Endangered	Yes
Salamander, Sacramento Mtn.	Aneides hardii	State NM: Threatened	Yes
Toad, Mountain	Bufo boreas complex (NM)	State NM: Endangered	Yes
Toad, Desert, Sonoran	Bufo alvarius	State NM: Threatened	Yes
Toad, Narrowmouth, Great Plains	Gastrophryne olivacea	State NM: Endangered	Yes
Cooter, River, Western	Pseudemys gorzugi	State NM: Threatened	Yes
Lizard, Bunchgrass, Slevin's	Sceloporus slevini	State NM: Threatened	No
Lizard, Sand Dune	Sceloporus arenicolus	State NM: Endangered	Yes
Monster, Gila, Reticulate	Heloderma suspectum suspectum (NM,AZ)	State NM: Endangered	Yes
Rattlesnake, Ridgenose, NM	Crotalus willardi obscurus (NM)	Federal: Threatened State NM: Endangered	Yes
Rattlesnake, Rock, Mottled	Crotalus lepidus lepidus (NM)	State NM: Threatened	No
Skink, Mountain	Eumeces callicephalus	State NM: Threatened	No
Snake, Garter, Mexican	Thamnophis eques megalops (NM)	State NM: Endangered	Yes
Snake, Garter, Narrowhead	Thamnophis rufipunctatus rufipunctatus (NM)	State NM: Threatened	Yes
Kingsnake, Gray-banded	Lampropeltis alterna	State NM: Endangered	Yes
Snake, Rat, Green	Senticolis triaspis intermedia (NM,AZ)	State NM: Threatened	No
Snake, Ribbon, Western	Thamnophis proximus diabolicus (NM)	State NM: Threatened	Yes
Snake, Water, Plainbelly	Nerodia erythrogaster transversa (NM)	State NM: Endangered	Yes
Whiptail, Gray-checkered	Aspidoscelis dixoni	State NM: Endangered	Yes
Whiptail, Spotted, Canyon	Aspidoscelis burti stictogrammus (NM,AZ);xanthonotus (AZ)	State NM: Threatened	Yes
Tyrannulet, Beardless, N.	Camptostoma imberbe ridgwayi (NM)	State NM: Endangered	Yes
Black-Hawk, Common	Buteogallus anthracinus anthracinus (NM)	State NM: Threatened	Yes
Bunting, Varied	Passerina versicolor versicolor (NM);dickeyae (NM)	State NM: Threatened	Yes
Cormorant, Neotropic	Phalacrocorax brasilianus	State NM: Threatened	Yes

Common Name	Scientific Name	Status	Model
Crane, Whooping	Grus americana	Federal: Endangered State NM: Endangered	No
Eagle, Bald	Haliaeetus leucocephalus alascanus (NM)	State NM: Threatened	Yes
Falcon, Aplomado	Falco femoralis septentrionalis (NM)	Federal: Endangered State NM: Endangered	Yes
Falcon, Peregrine	Falco peregrinus anatum	State NM: Threatened	Yes
Falcon, Peregrine, Arctic	Falco peregrinus tundrius	State NM: Threatened	Yes
Flycatcher, Willow, SW.	Empidonax traillii extimus	Federal: Endangered State NM: Endangered	Yes
Ground-dove, Common	Columbina passerina pallescens (NM)	State NM: Endangered	Yes
Hummingbird, Broad-billed	Cynanthus latirostris magicus (NM)	State NM: Threatened	Yes
Hummingbird, Costa's	Calypte costae	State NM: Threatened	Yes
Hummingbird, Lucifer	Calothorax lucifer	State NM: Threatened	Yes
Hummingbird, Violet-crowned	Amazilia violiceps ellioti (NM)	State NM: Threatened	Yes
Hummingbird, White-eared	Hylocharis leucotis borealis (NM)	State NM: Threatened	No
Junco, Yellow-eyed	Junco phaeonotus palliatus (NM)	State NM: Threatened	Yes
Kingbird, Thick-billed	Tyrannus crassirostris	State NM: Endangered	Yes
Nightjar, Buff-collared	Caprimulgus ridgwayi ridgwayi (NM)	State NM: Endangered	No
Owl, Boreal	Aegolius funereus	State NM: Threatened	Yes
Screech-Owl, Whiskered	Megascops trichopsis asperus (NM)	State NM: Threatened	Yes
Owl, Spotted, Mexican	Strix occidentalis lucida (NM,AZ)	Federal: Threatened	Yes
Pelican, Brown	Pelecanus occidentalis carolinensis (NM)	State NM: Endangered	No
Plover, Piping	Charadrius melodus circumcinctus (NM)	Federal: Threatened State NM: Threatened	No
Ptarmigan, White-tailed	Lagopus leucura altipetens (NM)	State NM: Endangered	Yes
Sparrow, Baird's	Ammodramus bairdii	State NM: Threatened	Yes
Sparrow, Grasshopper, AZ	Ammodramus savannarum ammolegus (NM,AZ)	State NM: Endangered	Yes
Tern, Least	Sterna antillarum athalassos (NM)	Federal: Endangered State NM: Endangered	Yes
Towhee, Abert's	Pipilo aberti aberti (NM)	State NM: Threatened	Yes
Trogon, Elegant	Trogon elegans canescens (NM)	State NM: Endangered	Yes
Turkey, Wild, Gould's	Meleagris gallopavo mexicana (NM,AZ)	State NM: Threatened	Yes

Common Name	Scientific Name	Status	Model
Vireo, Bell's	Vireo bellii arizonae (NM,AZ);medius (NM)	State NM: Threatened	Yes
Vireo, Gray	Vireo vicinior	State NM: Threatened	Yes
Woodpecker, Gila	Melanerpes uropygialis uropygialis (NM)	State NM: Threatened	Yes
Bat, Long-nosed, Mexican	Leptonycteris nivalis	Federal: Endangered State NM: Endangered	Yes
Bat, Long-nosed, Southern	Leptonycteris curasoae yerbabuenae (NM,AZ)	Federal: Endangered State NM: Threatened	No
Bat, Spotted	Euderma maculatum	State NM: Threatened	
Bat, Yellow, Western	Lasiurus xanthinus	State NM: Threatened	No
Chipmunk, Colorado, Organ Mtns.	Neotamias quadrivittatus australis (NM)	State NM: Threatened	Yes
Chipmunk, Colorado, Oscura Mtns.	Neotamias quadrivittatus oscuraensis (NM)	State NM: Threatened	Yes
Chipmunk, Least, Penasco	Neotamias minimus atristriatus (NM)	State NM: Endangered	Yes
Gopher, Pocket, Southern	Thomomys umbrinus emotus (NM)	State NM: Threatened	Yes
Jaguar	Panthera onca arizonensis (NM,AZ)	Federal: Endangered	Yes
Marten, American	Martes americana origenes (NM)	State NM: Threatened	Yes
Mouse, Jumping, Meadow	Zapus hudsonius luteus (NM,AZ)	State NM: Endangered	Yes
Rabbit, Jack, White-sided	Lepus callotis gaillardi (NM)	State NM: Threatened	Yes
Sheep, Bighorn, Desert	Ovis canadensis mexicana (endangered pops)	State NM: Endangered	Yes
Shrew, Arizona	Sorex arizonae	State NM: Endangered	No
Shrew, Least	Cryptotis parva parva (NM);berlandieri (NM)	State NM: Threatened	Yes
Vole, Montane, Arizona	Microtus montanus arizonensis (NM,AZ)	State NM: Endangered	Yes
Wolf, Gray, Mexican	Canis lupus baileyi (NM,AZ)	Federal: Endangered State NM: Endangered	Yes
Woodlandsnail, Hacheta Grande	Ashmunella hebardi	State NM: Threatened	No
Woodlandsnail, Cooke's Peak	Ashmunella macromphala	State NM: Threatened	No
Snail, Assiminea, Pecos	Assiminea pecos	Federal: Endangered State NM: Endangered	No
Snail, Snaggletooth, Shortneck	Gastrocopta dalliana dalliana (NM)	State NM: Threatened	No
Paper Pondshell	Utterbackia imbecillis	State NM: Endangered	No
Hornshell, Texas	Popenaias popeii	State NM: Endangered	No
Mountainsnail, Mineral Creek	Oreohelix pilsbryi	State NM: Threatened	No

Common Name	Scientific Name	Status	Model
Fingernailclam, Swamp	Musculium partumeium	State NM: Threatened	No
Peaclam, Lilljeborg's	Pisidium lilljeborgi	State NM: Threatened	No
Fingernailclam, Lake	Musculium lacustre	State NM: Threatened	No
Peaclam, Sangre De Cristo	Pisidium sanguinichristi	State NM: Threatened	No
Fingernailclam, Long	Musculium transversum	State NM: Threatened	No
Springsnail, Hot, New Mexico	Pyrgulopsis thermalis	State NM: Threatened	No
Marshsnail, Wrinkled	Stagnicola caperata	State NM: Endangered	No
Snail, Star Gyro	Gyraulus crista	State NM: Threatened	No
Springsnail, Alamosa	Pseudotryonia alamosae	Federal: Endangered State NM: Endangered	No
Springsnail, Chupadera	Pyrgulopsis chupaderae	State NM: Endangered	No
Springsnail, Gila	Pyrgulopsis gilae	State NM: Threatened	No
Springsnail, Koster's	Juturnia kosteri	Federal: Endangered State NM: Endangered	No
Springsnail, Pecos	Pyrgulopsis pecosensis	State NM: Threatened	No
Springsnail, Roswell	Pyrgulopsis roswellensis	Federal: Endangered State NM: Endangered	No
Springsnail, Socorro	Pyrgulopsis neomexicana	Federal: Endangered State NM: Endangered	No
Talussnail, Dona Ana	Sonorella todseni	State NM: Threatened	No
Snail, Vertigo, Ovate	Vertigo ovata	State NM: Threatened	No
Amphipod, Noel's	Gammarus desperatus	Federal: Endangered State NM: Endangered	No
Isopod, Socorro	Thermosphaeroma thermophilum	Federal: Endangered State NM: Endangered	No

Table 1-3: Terrestrial Species Included in the Majority Richness Filter

Common Name	Scientific Name
ARIZONA MYOTIS	*Myotis occultus*
NORTHERN LEOPARD FROG	*Rana pipiens*
RIO GRANDE LEOPARD FROG	*Rana berlandieri*
PLAINS LEOPARD FROG	*Rana blairi*
CHIRICAHUA LEOPARD FROG	*Rana chiricahuensis*
YAVAPAI LEOPARD FROG	*Rana yavapaiensis*
GREAT PLAINS NARROWMOUTH TOAD	*Gastrophryne olivacea*

Common Name	Scientific Name
COLORADO RIVER TOAD	*Bufo alvarius*
WESTERN TOAD	*Bufo boreas*
SOUTHWESTERN TOAD	*Bufo microscaphus*
MOUNTAIN TREEFROG	*Hyla eximia*
TIGER SALAMANDER	*Ambystoma tigrinum*
JEMEZ MOUNTAINS SALAMANDER	*Plethodon neomexicanus*
SACRAMENTO MOUNTAIN SALAMANDER	*Aneides hardii*
SONORAN MUD TURTLE	*Kinosternon sonoriense*
ORNATE BOX TURTLE	*Terrapene ornata*
PAINTED TURTLE	*Chrysemys picta*
BUNCH GRASS LIZARD	*Sceloporus scalaris*
COLLARED LIZARD	*Crotaphytus collaris*
REGAL HORNED LIZARD	*Phrynosoma solare*
MOUNTAIN SKINK	*Eumeces callicephalus*
CANYON SPOTTED WHIPTAIL	*Cnemidophorus burti*
GRAY-CHECKERED WHIPTAIL	*Cnemidophorus dixoni*
TEXAS BANDED GECKO	*Coleonyx brevis*
GILA MONSTER	*Heloderma suspectum*
COMMON GARTER SNAKE	*Thamnophis sirtalis*
MEXICAN GARTER SNAKE	*Thamnophis eques*
WESTERN RIBBON SNAKE	*Thamnophis proximus*
NARROW-HEADED GARTER SNAKE	*Thamnophis rufipunctatus*
MILK SNAKE	*Lampropeltis triangulum*
SONORAN MOUNTAIN KINGSNAKE	*Lampropeltis pyromelana*
PLAIN-BELLIED WATER SNAKE	*Nerodia erythrogaster*
YAQUI BLACK-HEADED SNAKE	*Tantilla yaquia*
MASSASAUGA	*Sistrurus catenatus*
WESTERN DIAMONDBACK RATTLESNAKE	*Crotalus atrox*
ROCK RATTLESNAKE	*Crotalus lepidus*
RIDGE-NOSED RATTLESNAKE	*Crotalus willardi*
EARED GREBE	*Podiceps nigricollis*
AMERICAN BITTERN	*Botaurus lentiginosus*
WHITE-FACED IBIS	*Plegadis chihi*
NORTHERN PINTAIL	*Anas acuta*
NORTHERN GOSHAWK	*Accipiter gentilis*
FERRUGINOUS HAWK	*Buteo regalis*
COMMON BLACK-HAWK	*Buteogallus anthracinus*
GOLDEN EAGLE	*Aquila chrysaetos*
BALD EAGLE	*Haliaeetus leucocephalus*
NORTHERN HARRIER	*Circus cyaneus*
OSPREY	*Pandion haliaetus*
PEREGRINE FALCON	*Falco peregrinus*
APLOMADO FALCON	*Falco femoralis*
WHITE-TAILED PTARMIGAN	*Lagopus leucurus*
LESSER PRAIRIE-CHICKEN	*Tympanuchus pallidicinctus*
BLUE GROUSE	*Dendragapus obscurus*

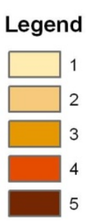
Common Name	Scientific Name
SCALED QUAIL	*Callipepla squamata*
MONTEZUMA QUAIL	*Cyrtonyx montezumae*
WILD TURKEY	*Meleagris gallopavo*
SANDHILL CRANE	*Grus canadensis*
SNOWY PLOVER	*Charadrius alexandrinus*
MOUNTAIN PLOVER	*Charadrius montanus*
LONG-BILLED CURLEW	*Numenius americanus*
WILSON'S PHALAROPE	*Phalaropus tricolor*
LEAST TERN	*Sterna antillarum*
BAND-TAILED PIGEON	*Columba fasciata*
MOURNING DOVE	*Zenaida macroura*
COMMON GROUND-DOVE	*Columbina passerina*
YELLOW-BILLED CUCKOO	*Coccyzus americanus*
WHISKERED SCREECH-OWL	*Otus trichopsis*
ELF OWL	*Micrathene whitneyi*
SPOTTED OWL	*Strix occidentalis*
BOREAL OWL	*Aegolius funereus*
BURROWING OWL	*Athene cunicularia*
BLACK SWIFT	*Cypseloides niger*
LUCIFER HUMMINGBIRD	*Calothorax lucifer*
COSTA'S HUMMINGBIRD	*Calypte costae*
VIOLET-CROWNED HUMMINGBIRD	*Amazilia violiceps*
BROAD-BILLED HUMMINGBIRD	*Cynanthus latirostris*
ELEGANT TROGON	*Trogon elegans*
RED-HEADED WOODPECKER	*Melanerpes erythrocephalus*
LEWIS'S WOODPECKER	*Melanerpes lewis*
GILA WOODPECKER	*Melanerpes uropygialis*
WILLIAMSON'S SAPSUCKER	*Sphyrapicus thyroideus*
THICK-BILLED KINGBIRD	*Tyrannus crassirostris*
WILLOW FLYCATCHER	*Empidonax traillii*
GREATER PEWEE	*Contopus pertinax*
NORTHERN BEARDLESS-TYRANNULET	*Camptostoma imberbe*
BANK SWALLOW	*Riparia riparia*
SPRAGUE'S PIPIT	*Anthus spragueii*
LOGGERHEAD SHRIKE	*Lanius ludovicianus*
BENDIRE'S THRASHER	*Toxostoma bendirei*
SAGE THRASHER	*Oreoscoptes montanus*
LUCY'S WARBLER	*Vermivora luciae*
YELLOW WARBLER	*Dendroica petechia*
BLACK-THROATED GRAY WARBLER	*Dendroica nigrescens*
GRACE'S WARBLER	*Dendroica graciae*
RED-FACED WARBLER	*Cardellina rubrifrons*
PAINTED REDSTART	*Myioborus pictus*
BELL'S VIREO	*Vireo bellii*
GRAY VIREO	*Vireo vicinior*
HOODED ORIOLE	*Icterus cucullatus*

Common Name	Scientific Name
VARIED BUNTING	*Passerina versicolor*
PAINTED BUNTING	*Passerina ciris*
ABERT'S TOWHEE	*Pipilo aberti*
GRASSHOPPER SPARROW	*Ammodramus savannarum*
BAIRD'S SPARROW	*Ammodramus bairdii*
BOTTERI'S SPARROW	*Aimophila botterii*
SAGE SPARROW	*Amphispiza belli*
YELLOW-EYED JUNCO	*Junco phaeonotus*
PINYON JAY	*Gymnorhinus cyanocephalus*
ARIZONA SHREW	*Sorex arizonae*
PREBLE'S SHREW	*Sorex preblei*
LEAST SHREW	*Cryptotis parva*
SPOTTED BAT	*Euderma maculatum*
ALLEN'S BIG-EARED BAT	*Idionycteris phyllotis*
WESTERN RED BAT	*Lasiurus blossevillii*
SOUTHERN YELLOW BAT	*Lasiurus ega*
MEXICAN LONG-TONGUED BAT	*Choeronycteris mexicana*
MEXICAN LONG-NOSED BAT	*Leptonycteris nivalis*
POCKETED FREE-TAILED BAT	*Nyctinomops femorosaccus*
AMERICAN PIKA	*Ochotona princeps*
SNOWSHOE HARE	*Lepus americanus*
WHITE-SIDED JACK RABBIT	*Lepus callotis*
WHITE-TAILED JACK RABBIT	*Lepus townsendii*
ABERT'S SQUIRREL	*Sciurus aberti*
ARIZONA GRAY SQUIRREL	*Sciurus arizonensis*
GUNNISON'S PRAIRIE DOG	*Cynomys gunnisoni*
BLACK-TAILED PRAIRIE DOG	*Cynomys ludovicianus*
LEAST CHIPMUNK	*Tamias minimus*
COLORADO CHIPMUNK	*Tamias quadrivittatus*
BEAVER	*Castor canadensis*
SOUTHERN POCKET GOPHER	*Thomomys umbrinus*
MONTANE VOLE	*Microtus montanus*
PRAIRIE VOLE	*Microtus ochrogaster*
YELLOW-NOSED COTTON RAT	*Sigmodon ochrognathus*
NORTHERN PYGMY MOUSE	*Baiomys taylori*
MEADOW JUMPING MOUSE	*Zapus hudsonius*
AMERICAN BLACK BEAR	*Ursus americanus*
RIVER OTTER	*Lontra canadensis*
MARTEN	*Martes americana*
JAGUAR	*Panthera onca*
GRAY WOLF	*Canis lupus*
SWIFT FOX	*Vulpes velox*
MULE DEER	*Odocoileus hemionus*
WHITE-TAILED DEER	*Odocoileus virginianus*
BIGHORN SHEEP	*Ovis canadensis*
BOREAL CHORUS FROG	*Pseudacris maculata*

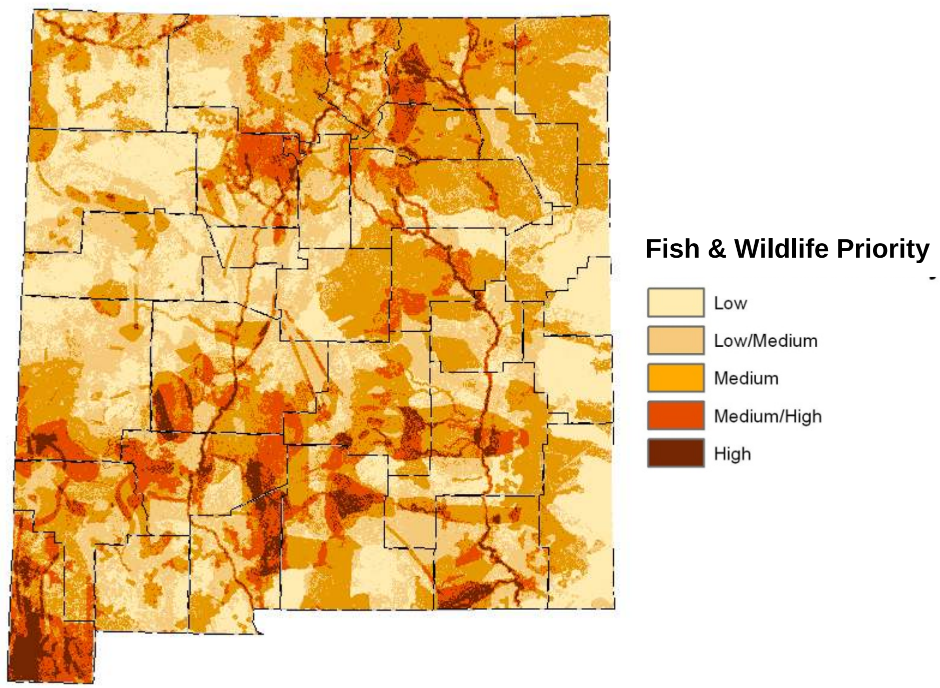
Common Name	Scientific Name
BARKING FROG	*Eleutherodactylus augusti*
BIG BEND SLIDER	*Trachemys gaigeae*
SMOOTH SOFTSHELL TURTLE	*Apalone mutica*
MADREAN ALLIGATOR LIZARD	*Elgaria kingii*
COMMON KINGSNAKE	*Lampropeltis getula*
GRAY-BANDED KINGSNAKE	*Lampropeltis alterna*
GREEN RAT SNAKE	*Senticolis triaspis*
RIO GRANDE RIVER COOTER	*Pseudemys gorzugi*
WHITE-NOSED COATI	*Nasua narica*
SOUTHERN LONG-NOSED BAT	*Leptonycteris curasoae*
JUNIPER TITMOUSE	*Baeolophus ridgwayi*
OLIVE-SIDED FLYCATCHER	*Contopus cooperi*
NEOTROPIC CORMORANT	*Phalacrocorax brasilianus*
NEW MEXICO SHREW	*Sorex neomexicanus*
SAND DUNE LIZARD	*Sceloporus arenicolus*

Map 1-1: Statewide Model – 1. T&E Species Habitat; 2. TNC Fish Atlas; 3. TNC Conservation Areas; 4. CWCS Key Areas; 5. WGA Corridors; 6. NHNM Rare Plant Occurrences; 7. NHNM Wildlife Occurrences. Final priority classes and values for statewide and forest model priorities are: Low (least important habitat) = 1-8; Low/Medium = 9-12; Medium = 13-17; Medium/High = 18-22; High (most important habitat) = 23-37.

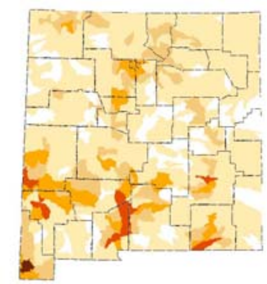
Fish & Wildlife Model: The intent of the fish & wildlife data layer is to identify areas that provide habitat for plants and animals including, but not limited to threatened and endangered species



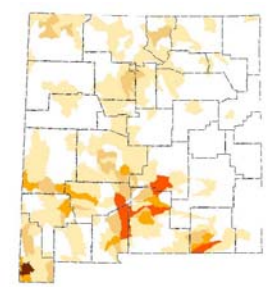
*** See model factor descriptions for class categories.*



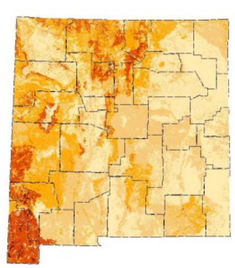
Wildlife Occurrence



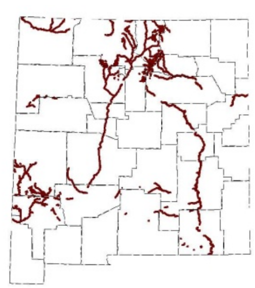
Rare Plant Occurrence



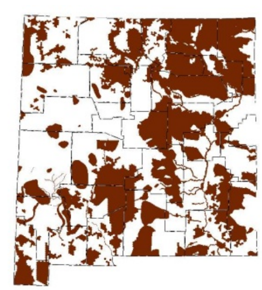
T&E Potential Habitat



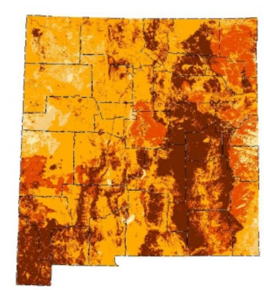
TNC Fish Atlas



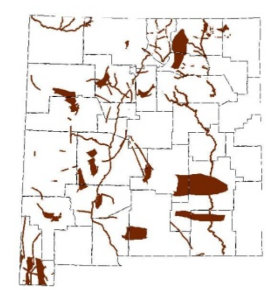
TNC Cons Areas



CWCS Key Areas



WGA Corridors



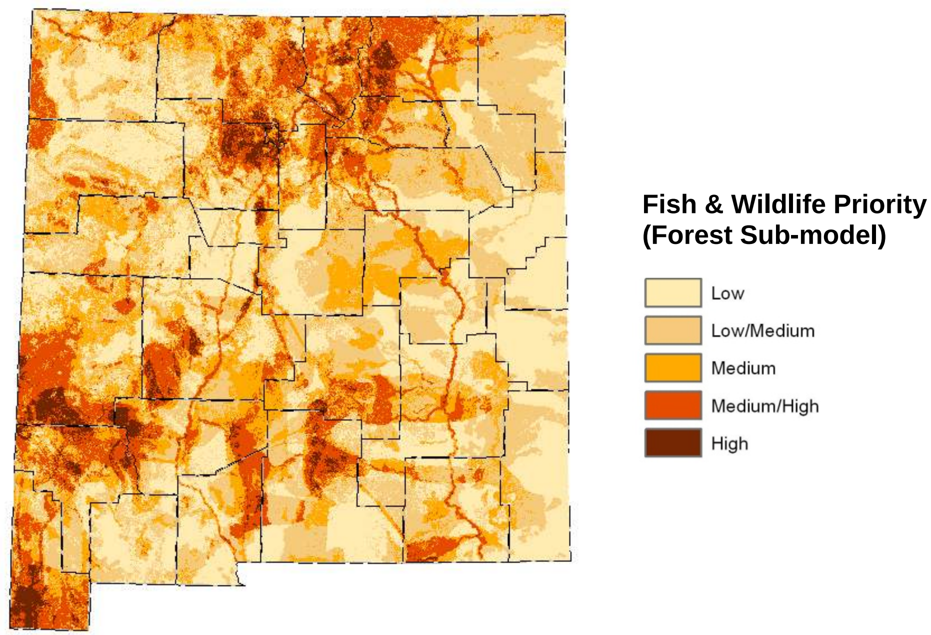
Map 1-2: Forest Sub-model – 1. Priority Statewide Model; 2. Forest Species Potential Habitat; 3. Forest & Woodland Patch – Majority Richness. Final priority classes and values for statewide and forest model priorities are: Low (least important habitat) = 1-8; Low/Medium = 9-12; Medium = 13-17; Medium/High = 18-22; High (most important habitat) = 23

Forest Sub-model: The intent of the forest sub-model is to emphasize forest areas that provide habitat for plants and animals including, but not limited to threatened and endangered species

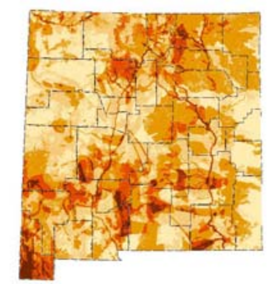
Legend

1
2
3
4
5

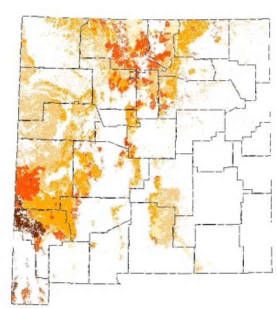
*** See model factor descriptions for class categories.*



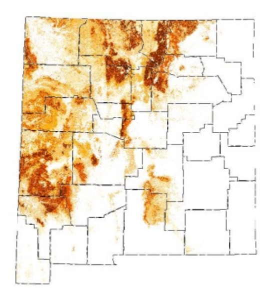
Statewide Priority



Patch – Maj. Rich



Forest Species Pot Hab



Development Potential (Risk)

Development Potential (Risk): This data layer emphasizes areas that are projected to experience increased housing development in the next 30 years. This layer will be used in the State Strategy and Response plan to help emphasize areas which will conserve working forests. *The scale of the data is meant for broad scale planning and prioritizing*

Model Design: Combine 2030 development density projection with the 2000 development density data, reclassify into development change categories and prioritize (Map 2-1).

Description of Factors:

1. 2030 and 2000 Development Density Data

Function: Gives value to areas expected to experience increased housing density.

Criteria: Lands expected to have housing development by 2030 are given value of 1 to 5 indicating development change priority; otherwise 0. See Table 2-1 for a description of the development classification.

Justification: Increases in population create need to expand housing and associated infrastructure. Identification of the areas within New Mexico most likely to experience increase in housing density will allow agencies to better plan and manage natural resources for the benefit of future generations.

Data Description: The housing development density data were derived using the Spatially Explicit Regional Growth Model (SERGoM) developed by Dr. Dave Theobald, and more fully described below. The SERGoM model provides historical, current, and future estimates of housing density for the coterminous United States. The 2000 and 2030 development projections were clipped to New Mexico and combined. The expected development change was grouped into development classes defined by the Theobald data (Table 2-1). Priority classes for each type of development change were set through stakeholder input. A web survey was sent to the technical team, larger stakeholder group, New Mexico Municipal League, and New Mexico zoning officials. Forty–five respondents completed the survey by ranking Development Change categories (Table 2-1).

Data Source: The data are an updated version (v12) of the housing density data produced by Dr. Dave Theobald as a part of the USFS Forest on the Edge study (Stein et al., 2005). The data were downloaded directly from Dr. Theobald's ftp site http://www.nrel.colostate.edu/ftp/theobald/.

Table 2-1: Description of Development Density Data and Development Change Ranking

Development Category/ Type Change	Priority Rank	2000 Dev Density Class	2030 Dev Density Class
Private to Exurban	High	0	4, 5, 6
Private to Urban/suburban	High	0	7, 8, 9
Rural to Exurban	High	1, 2, 3	4, 5, 6
Rural to Urban/suburban	High	1, 2, 3	7, 8, 9
Exurban increase	Medium	4, 5	5, 6
Exurban to Urban/suburban	Medium	4, 5, 6	7, 8, 9
Private to Rural	Medium	0	1, 2, 3
Rural increase	Low	1, 2	2, 3
Urban/suburban increase	Low	7, 8	8, 9
Commercial/industrial	Zero/No Change	10	10
Exurban	Zero/No Change	4, 5, 6	4, 5, 6
Private undeveloped	Zero/No Change	0	0
Rural	Zero/No Change	1, 2, 3	1, 2, 3
Urban/suburban	Zero/No Change	7, 8, 9	7, 8, 9

0 = Undev. Private; 1= >80 acres / unit 2 = 50-80 acres per unit; 3= 40-50 acres per unit; 4= 30-40 acres per unit; 5 = 20-30 acres per unit; 6=10-20 acres per unit; 7= 1.7-10 acres per unit; 8= 0.6-1.7 acres per unit; 9=<0.6 acres per unit; 10= Commercial

Data Considered But Not Used

1. *Proximity to Protected Areas:* A distance to protected areas layer was created and intersected with the development potential data. The data were considered useful for specific legacy programs but not an effective measure of development potential. The technical team decided that inclusion of this layer in the model would weight too heavily toward specific conservation areas, and the intent of the layer is to look at development potential regardless of location within the state.

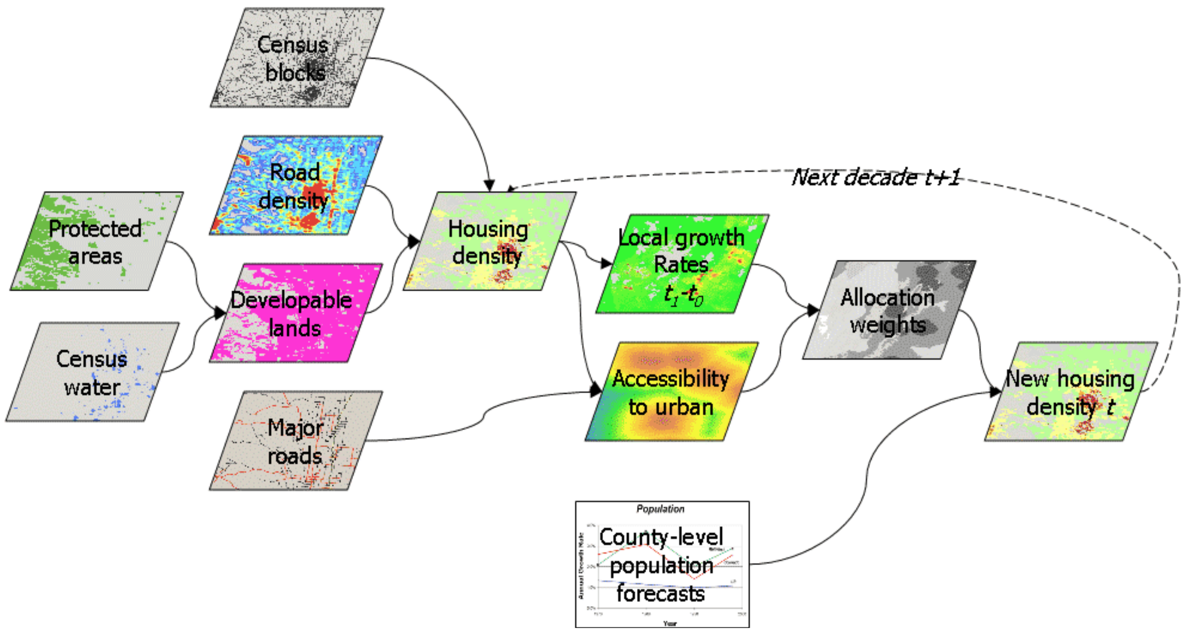
Data Gaps/Data Needs

Table 2-2: Development Potential Data Gaps

Rank	Data Gap Description
High	Regional/county/municipal master plans reflecting future designated land use classifications in GIS
High	Statewide layers representing likelihood of future energy (wind, solar, geothermal, conventional extractive) development. This layer would include availability of resource, proximity to transmission and future transmission, and areas for exclusion (e.g., T&E species habitat, crucial habitats and important wildlife corridors)
High	Zoning information for development needed to show state development patterns
High	SLO disposal areas
Medium/High	Well permits for housing or other water measure for potential development
Medium	Tax rates for properties - Identify areas where it is less expensive to locate and manage utilities. Development will occur in areas where utilities locate assets
Medium/Low	Statewide parcel level land/property use/management intent classifications

SERGoM Description taken from ICLUS SERGoM v3 User's Manual: ArcGIS Tools and Datasets for Modeling US Growth (2008)

SERGoM, unlike the majority of land use change models, allocates a full continuum of housing density, from urban to rural. This allows a more comprehensive examination of growth patterns, since exurban/low-density development generally has a footprint 10 times as large as urban areas and is growing at a faster rate than urban areas (Theobald 2005). In addition, SERGoM forecasts housing development by establishing a relationship between neighboring housing density, population growth rates, and transportation infrastructure (Theobald 2005). The model is dynamic in that as new urban core areas emerge, the model re-calculates travel time from these areas. However, the expected changes in functional connectivity that would result from such emerging urbanization were not fed back into the functional connectivity calculations used to calculate domestic migration. SERGoM also incorporates a detailed layer of developable/un-developable areas that incorporates public protected lands as well as private protected (e.g., through conservation easements) lands. Finally, population forecasts are a principal driver of SERGoM; in the model, population growth is converted to housing units, which are spatially allocated in response to the spatial pattern of previous growth and transportation infrastructure. Growth rates and other model parameters can be specified spatially-explicitly, so different regions (even census tracts or neighborhoods) have different parameters (e.g., lower household size in amenity areas, etc.). The benefit to this approach is that there are fewer (internal to coterminous United States) discrete differences across artificial analytical boundaries imposed by "piecing" individual model runs into a nationwide map, although the allocation of new housing units is restricted to counties.



The spatial database generated by SERGoM provides historical, current, and future estimates of housing density for the coterminous United States. Housing density (number of housing units per acres) was computed for each 1 hectare cell (100 m x 100 m raster; 2.47 acres). There are five main input spatial datasets used to estimate housing density.

Technical Advisory Team

Kim Kostelnik – Energy Minerals and Natural Resources Department, Forestry Division, Program Manager
Lance Davission – Energy Minerals and Natural Resources Department, Forestry Division, Urban and Community Forestry
Larry Brotman – New Mexico Tax and Revenue Department, Information Technology Division
Macario Herrera – United States Forest Service, Region 3, Private and State Forestry
Mary Stuever - Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer

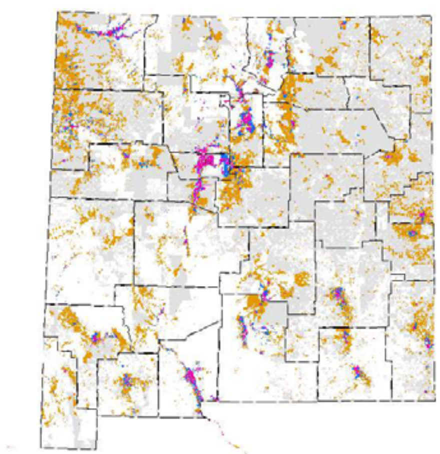
Citations

Stein, Susan M.; McRoberts, Ronald E.; Alig, Ralph J.; Nelson, Mark D.; Theobald, David M.; Eley, Mike; Dechter, Mike; Carr, Mary. 2005. Forests on the edge:housing development on America's private forests. Gen. Tech. Rep. PNW-GTR-636. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 16 p.

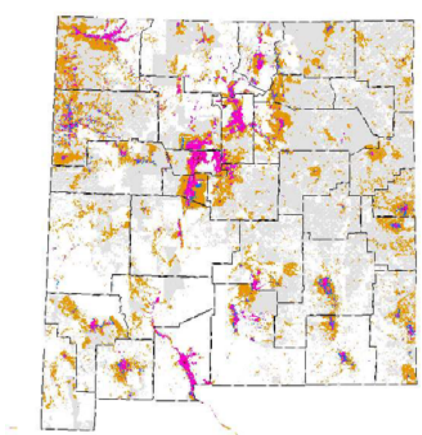
Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32/

U.S. Environmental Protection Agency (EPA). 2008. ICLUS SERGoM v3 User's Manual: ArcGIS Tools and Datasets for Modeling US Growth. Global Change Research Program, National Center for Environmental Assessment, Washington, DC; EPA/600/R-08/XXX. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea.

Map 2-1 - Development Potential (Risk) Model: This data layer emphasizes areas that are projected to experience increased housing development in the next 30 years.



2000 Housing Density

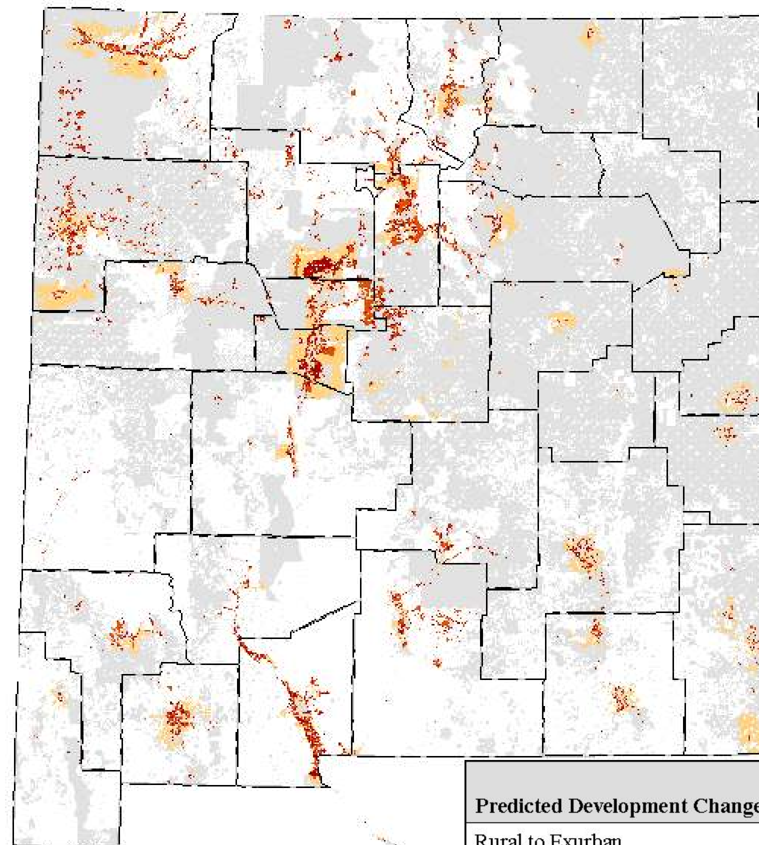


2030 Housing Density

Projected Housing Density

- Private undeveloped
- Rural
- Exurban
- Urban/suburban
- Commercial/industrial

Priv. undeveloped = undeveloped;
Rural = >80 acres / unit to 40-50 acres per unit;
Exurban = 30-40 acres per unit to 10-20 acres per unit;
Urban = 1.7-10 acres per unit to <0.6 acres per unit
Commercial/industrial = built up



Development Potential Priority

- High
- Medium
- Low
- Zero/No Change

Predicted Development Change	Priority
Rural to Exurban	high
Undeveloped to Exurban	high
Rural to Suburban/Urban	high
Undeveloped to Suburban/Urban	high
Undeveloped to Rural	medium
Exurban Increase	medium
Exurban to Suburban/Urban	medium
Suburban/Urban Increase	low
Rural Increase	low

Economic Potential

Economic Potential from Forests and Rangelands: This data layer highlights areas where forests and rangelands play a major role in local or state economic growth or could in the future. The data layer also highlights areas that contribute to the development of emerging markets, such as biomass energy. We have divided economic potential into four categories: one based on the availability of saw timber, one based on the availability of lower value material such as firewood or biomass for energy, another based on the economic importance of natural resources-based recreation, and one based on the importance of rangeland productivity.

Proposed Model: The data layers use *current conditions* (not future scenarios or predictions) to identify economically valuable resources such as timber, biomass, outdoor recreation, and range productivity (Map 3-1). Some of these resources are currently being used while other could be used in the future. The data layer will specifically identify areas where: timber (larger diameter trees – traditional lumber markets) could be economically important; low value wood product (smaller diameter trees – emerging markets), specifically biomass, could be economically important; active and passive recreation is known to occur and hence economically important; and rangeland is or could be supporting economic activity.[1] The technical team identified data gaps such as: biomass volume from non-native riparian forests, amount of forest or rangeland carbon, value of ski areas, and water capture from forest lands. There are clear limits on the utility of the data and the scope of this project. The data layer does not provide: supply of game; amount of range fodder available for grazing; or monetary estimates of any ecosystem service, value, or product.

Timber and Biomass Models: Combine distance to use along roads and railroads, forest type, land tenure, accessibility, and areas of non-native phreatophytes for biomass potential, and forest attributes using an additive Boolean overlay.

Description of Factors:

1. Distance to use

Function: Gives a scaled value of 1 to 10 to forest land based on distance to a wood processor or harvester (forest management capacity).

Criteria: The distance from each pixel to the nearest wood utilization or harvesting entity is measured along roads and railways lines and then distances are scaled such that those pixels with the shortest distances to utilization are labeled 5 and the longest distances are label 1. Distance was calculated along roads.

[1] These four inputs will also be available as separate spatial models at the end of the project.

Justification: Forest land closer to utilization facilities is more likely to contribute to economic activity.

Data Description: New Mexico Highlands University maintains a geospatial data layer of wood processors in New Mexico in cooperation with the New Mexico Forest Industry Association. Each facility is labeled with the type of material it uses.

Data Source: The "wood_infrastructure" layer from New Mexico Highlands University and the "Transportation Geodatabase" from RGIS (see metadata for more information).

2. Working Forests

Function: Identifies forest land in New Mexico that may be available for harvest of wood products.

Criteria: Pixels that are in a land tenure or status that may allow harvest of wood products are given value of 1; otherwise 0.

Justification: Not all forest land is available for harvest of wood products. For example wilderness areas should not be considered in the assessment of economic potential.

Data Description: The following land tenures were labeled as **not** available for harvest of wood products:

- National Parks, Monuments, and other NPS lands
- Wilderness Areas (including BLM, USFS, FWS and NPS)
- Wilderness Study Areas
- Inventoried Roadless Areas

Data Source: We used both the State Engineer's Office's "Administrative Geodatabase" (see metadata) "USDA FS Inventoried Roadless Areas in New Mexico, Sept. 2000" to map roadless areas (see metadata).

3. Accessibility

Function: Gives value to areas where slopes would permit harvest.

Criteria: Pixels with a slope less than 40% are given value of 1; otherwise 0.

Justification: Steep slopes prohibit safe and ecologically sound harvest of wood products.

Data Description: Slope was calculated from a digital elevation model for the state.

Data Source: The digital elevation model is part of the National Elevation Dataset (see metadata).

4. Roads and Railroads

Function: Identifies roaded and railroaded areas of the state where timber or biomass could be accessed.

Criteria: Pixels that contained a road or railroad were coded with a 1 while pixels without transportation infrastructure were coded 100.

Justification: Use of roads and railroads allow for the calculation of more realistic distances to utilization.

Data Description: The roads and railroad map was an input for the "Distance to use" map.

Data Source: The "Transportation Geodatabase" from RGIS (see metadata for more information).

5. Availability of Timber

Function: The goal of this map is to identify areas in New Mexico's forests where sawtimber could be harvested.

Criteria: Each pixel has a value from 1 to 5 where 1 represents very little potential for sawtimber and 5 represents the best potential to harvest sawtimber.

Justification: While some stands may have many trees that could be cut for sawtimber other nearby stands of the same forest type may have no trees large enough to sell for saw timber.

Data Description: We used the maps of basal area and quadratic mean diameter (QMD) from the National Insect and Disease Risk Map (NIDRM). The NIDRM maps are based on the Forest Inventory and Analysis plot data, but account for recent forest mortality caused by fires or detected by insect and disease mortality surveys or change-detection remote sensing imagery. We reclassified basal area in the following way to identify stands with more wood:

Old basal area : new scaled value

0 : 0
0 to 20 : 1
21 to 60 : 2
61 to 80 : 3
81 to 120 : 4
> 120 : 5

We reclassified QMD in the following way to identify stands with larger trees:

Old QMD : new scaled value

0 to 6 : 0
7 to 10 : 2
11 to 12 : 3
13 to 14 : 4
> 14 : 5

We then combined basal area and QMD to identify stands with both high basal areas and larger trees, i.e., those stands where timber could be harvested. Using the maps described above of working forests and accessibility, we excluded reserve lands and steep slopes from the timber map. We also used the distance to use map to prioritize those areas closer to utilization.

Data Source: National Insect and Disease Risk Map (see program webpage http://www.fs.fed.us/foresthealth/technology/nidrm.shtml)

6. Availability of Woody Biomass Products

Function: The goal of this map is to identify areas in New Mexico's forests where forest products besides sawtimber, often small diameter and underutilized material, could be harvested.

Criteria: Each pixel has a value from 1 to 5 where 1 represents very little potential for wood products and 5 represents the best potential to harvest wood products other than saw timber.

Justification: Though sawtimber commands the best price, many other products can be harvested from New Mexico's forests including poles, firewood, and wood for energy production.

Data Description: As with the map of timber above, we used the maps of basal area and QMD from NIDRM. We reclassified basal area in the following way to identify stands with more biomass:

Old basal area: new scaled value

0 : 0
0 to 20 : 1
21 to 60 : 2
61 to 80: 3
81 to 120 : 4
> 120 : 5

We reclassified QMD in the following way to identify stands with smaller trees:

Old QMD : new scaled value
0 : 0
0 to 10 : 5
> 10 : 0

We then combined basal area and QMD to identify stands with both high basal areas and smaller trees, i.e., those stands most appropriate for biomass harvest. We added a map of Non-native Phreatophytes (described below) to include this additional potential resource. Using the maps described above of working forests and accessibility, we excluded reserve lands and steep slopes from the timber map. We also used the distance to use map to prioritize those areas closer to utilization.

Data Source: National Insect and Disease Risk Map (see program webpage http://www.fs.fed.us/foresthealth/technology/nidrm.shtml)

7. Non-native Phreatophytes

Function: Identifies areas of the state where non-native phreatophytes have biomass utilization potential.

Criteria: Areas mapped as containing non-native phreatophytes were assigned a value of 3. All other pixels have a value of 0.

Justification: Non-native phreatophytes are often removed to restore ecosystems, but the removed material could be used to generate energy and woody biomass.

Data Description: Areas mapped as containing non-native phreatophytes were assigned a value of 3. All other pixels have a value of 0.

Data Source: Map data were provided by the New Mexico State University's non-native phreatophyte program.

Data considered But Not Used in Timber and Biomass Models

1. *Combined FIA data from 1980s and 1990:* These data were not used due to lack of confidence in their accuracy and the recommendation from FIA regional staff not to attempt to grow the existing FIA data to show current timber and biomass availability.

Recreation Model: Combine scenic byways, visitation to state parks and national forests, presence of national park service units, and number of elk and antelope licenses/authorizations issued in 2008 by game management units using an additive Boolean overlay.

1. Scenic Byways

Function: Gives value to the suite of recognized scenic byways in the state managed by a variety of agencies.

Criteria: Areas were coded on a scale from 1 to 5 from least to greatest importance for scenic byways.

Justification: Scenic byways are an important source of economic activity in New Mexico. For example, a study from CDC Associates under contract from the New Mexico Tourism Department indicates that 4.8 million visitors drove to New Mexico.

Data Description: The map data include roads designated as scenic byways. We then created a ½ mile buffer (on either side of road), which we coded a 5. We also used the GIS to calculate areas visible from these scenic byways. Areas visible from scenic byways were scaled from 1 to 5 (least to most visible) and combine with the buffer of the scenic byways themselves.

Data Source: Data were provided by the National Scenic Byways Program (http://www.byways.org/ and metadata available at: ftp://byways.org/GIS_Byway_Routes)

2. Visitation

Function: Gives value to public lands as tourist destinations due to their unique natural and cultural landscape resources.

Criteria: Areas were coded on a scale from 1 to 5 from least to greatest visitation.

Justification: Parks and other public lands provide important recreation values as tourist destinations.

Data Description: To create this data layer we combined data and estimates on visitation for State Parks, USFS National Forest Units, National Parks, US Fish and Wildlife Refuges, and BLM lands. Each land management agency's visitation was scaled separately from 1 to 5 before combining all agencies because the units of measurement were different. New Mexico State Parks were scaled based on the average visitation to each unit from 2008 and 2009. National Forest units were scaled based on visitation in 2006. National Parks and Monuments were assigned a value of 5 because visitation data were not available. Based on input from the technical team, Wildlife Refuges were assigned a value of 4 except for Bosque Del Apache which was assigned a 5. Based on input from the technical team, BLM lands within 25 miles of urban areas were assigned a 3 and BLM land more than 25 miles but less than 50 miles from urban areas were assigned a 2.

Data Source: Geographic boundaries for visitation came from the "Transportation Geodatabase" from RGIS (see metadata for more information).

Data on visitation to USDA National Forest units came from a 2006 USFS report entitled, *Revised Visitation Estimates: NVUM Round 1 Results*. Visitation data for New Mexico State Parks were provided by New Mexico State Parks, a division of EMNRD.

3. Game/Hunting Values

Function: The map of game values provides a representation of the values provided by big game hunting in New Mexico.

Criteria: Areas were coded on a scale from 1 to 5 from least to greatest visitation.

Justification: Big game hunting provides significant income to the state and relies on healthy forests and rangelands to support animal populations.

Data Description: We combined elk and pronghorn antelope data because they are two of the most important economic game species and represent different ecosystem (i.e., elk and pronghorn tend to rely on different ecosystems). We scaled the number of licenses/authorizations issued by the NM Game and Fish Department for elk in 2008 and pronghorn licenses/permits issued in 2007-08. We then combined the two scaled sets of management units and rescaled to the 1 to 5 scale.

Data Source: The geographic boundaries of the game management units and antelope management units as well as the number of licenses/authorizations came from NM Department of Game and Fish (http://www.wildlife.state.nm.us/recreation/hunting/).

Data Considered But Not Used in Recreation Model

1. *NM Tourism data from CDC reports*: These data were only available at the statewide scale and were too coarse to add value to the analysis.
2. *Ski Area values*: These data would need to be researched and developed which was outside the scope of this effort.
3. *Carbon storage*: These data would need to be researched and developed which was outside the scope of this effort.
4. *Trails*: These data would need to be researched and developed which was outside the scope of this effort.
5. *Deer permits*: The technical team discussed potential inputs for the Recreation sub-model and commented that Elk licenses were highly valued, perhaps the highest value game license in the state. They were not sure though and recommended that the EMNRD Forestry Division sub-contractor, the Forest Guild, contact experts to navigate this issue. Experts at NMDGF and EMNRD were contacted in September 2009. The feedback provided indicated that Elk licenses were of higher value than deer licenses. After stakeholder review, however, it was recommended that future models include deer licenses as the total value of revenue generated exceeds that of elk. The feedback also recommended that Pronghorn Antelope licenses be included to more accurately depict natural resource based recreation across the state and across ecosystems. The Forest Guild evaluated the recommendations from the experts and determined that

including Deer licenses as a third input would not meaningfully alter the hunting spatial input of the Recreation sub-model.

6. Fishery data: These data were not able to be accessed.
7. Data from Statewide 5 yr hunting and fishing report (USFWS, 2006): These data were only available at the statewide scale and were too coarse to add value to the analysis.
8. Habitat Stamp Program: These data were only available at the National Forest and BLM Field Office level and so were too coarse to add value to the analysis.

Rangeland Productivity Model: Combine reclassified SWreGAP landcover classes with precipitation data using an additive Boolean overlay.

1. Precipitation

Function: Use precipitation data to augment the landcover-based estimates of rangeland productivity.

Criteria: Each pixel on the map represents the average amount of precipitation scaled from 1 to 5 (from least to greatest amount of precipitation).

Justification: Precipitation is a prime determinant of rangeland productivity.

Data Description: We used the average annual rainfall for the past 40 years to augment landcover reclassification. By scaling the precipitation data from 1 to 5, we made it compatible with the landcover data.

Data Source: Precipitation data came from the National Atlas (http://www.nationalatlas.gov/mld/prism0p.html)

2. SWreGAP Landcover

Function: Reclassify the landcover classes based on expert knowledge of each landcover class's rangeland productivity.

Criteria: Each landcover class was evaluated by Les Owen, range resources and GIS specialist, from the NM Department of Agriculture and scaled from 1 to 5 (5 greatest forage potential).

Justification: The technical team evaluated several models for forage production and potential and decided this approach was most appropriate and offered complete coverage for the state.

Data Description: We used expert opinion to reclassify the SWReGAP landcover data to reflect rangeland productivity on a scale from 1 to 5. Les Owen provided the reclassification of the SWReGAP data, which was reviewed by the technical team.

Data Source: SWReGAP landcover data and metadata are available at: http://earth.gis.usu.edu/swgap/.

Data Considered But Not Used in Rangeland Model

1. SSURGO County Range productivity values
2. STATSGO Statewide Range productivity values

Data Gaps/Data Needs

Table 3-1: Economic Potential Data Gaps

Rank	Data Gap Description
High	Carbon capture and storage potential by ecosystem
High	Value of surface and ground water originating from forests and rangelands and potential markets for ecosystem services
High	Value of vistas and scenic areas
High	Value of active and passive recreation by spatially discreet units
High - Medium	Value of ski areas
Medium	Tourism and recreation numbers by more discrete units such as by county, town, ranger district, etc.
Low	Improved lbs/acre data consistency and coverage from SSURGO and STATSGO data set.

Technical Advisory Team

Bill Griggs – United States Forest Service, Santa Fe National Forest, Supervisory Forester
Brent Racher – Restoration Solutions
Carmen Austin – Energy Minerals and Natural Resources Department, Forestry Division
Ernesto Hurtado - Energy Minerals and Natural Resources Department, Forestry Division, District Forester
Ernie Lopez - Energy Minerals and Natural Resources Department, Forestry Division, District Forester
Ian Fox - United States Forest Service, Cibola National Forest, Timber Management Officer
Jerry Payne - United States Forest Service, Region 3, Biomass Utilization Specialist
John Fowler – New Mexico State University, Professor in Agricultural Economics and Agricultural Business
Kim Kostelnik - Energy Minerals and Natural Resources Department, Forestry Division, Division Manager
Les Owen – New Mexico Department of Agriculture, Range Specialist
Michael Bain – Quivira Coalition, Land and Water Coordinator
Steve Kadas – Natural Resources Conservation Science, Assistant State Conservationist

Citations:

New Mexico Department of Game and Fish. 2009. Elk Permit Report. New Mexico Department of Game and Fish. Santa Fe, New Mexico.

United States Department of Agriculture (USDA). 2006. Revised Visitation Estimates: NVUM Round 1 Results. Washington, D.C.: US Forest Service.

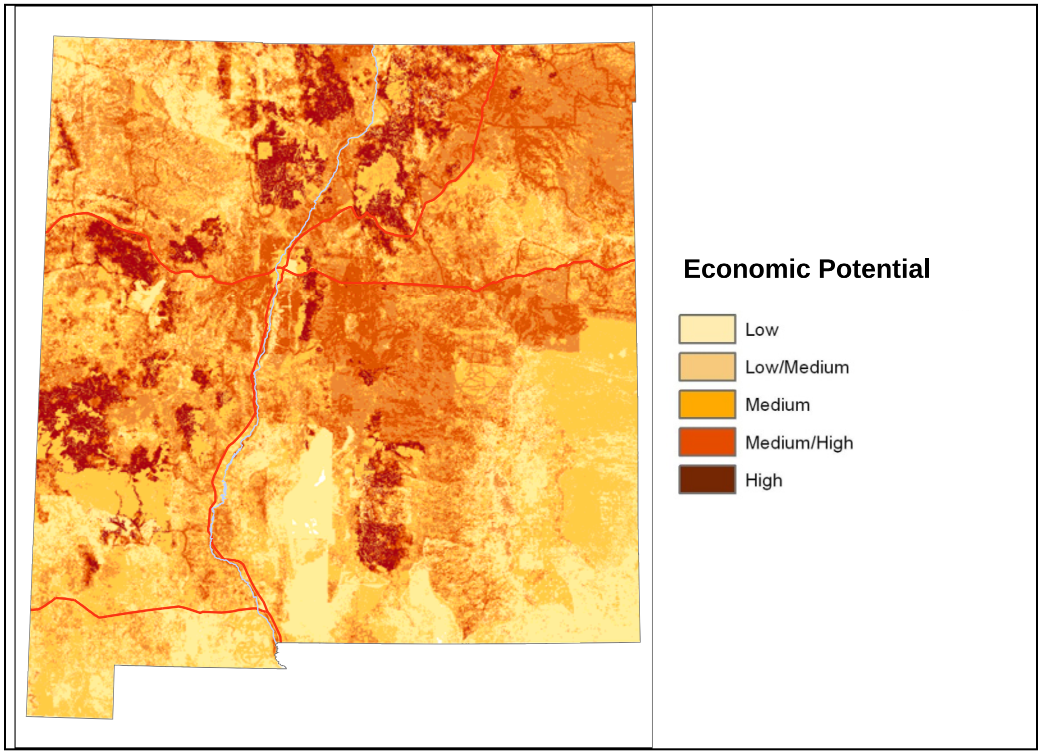
United States Fish & Wildlife Service (USFWS). 2006. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, New Mexico. Washington, D.C.: US Department of the Interior.

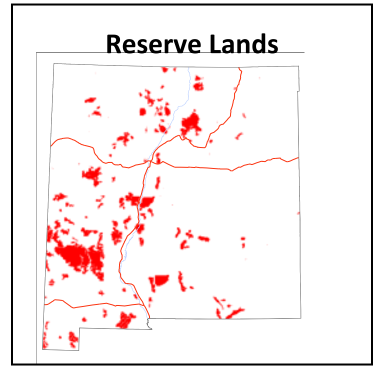
USGS National Gap Analysis Program. 2004. Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

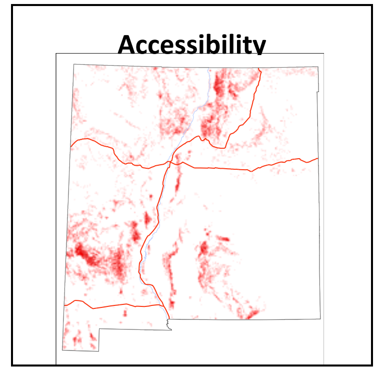
Map 3-1: Economic Potential Model

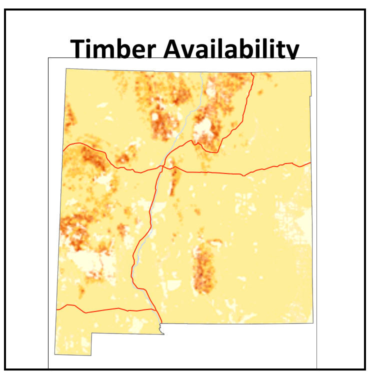
Economic Potential Model: This data layer highlights areas where forests and rangelands play a major role in local or state economic growth or could in the future.

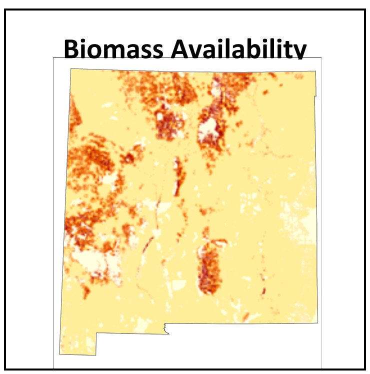
*** See model factor descriptions for class categories.*

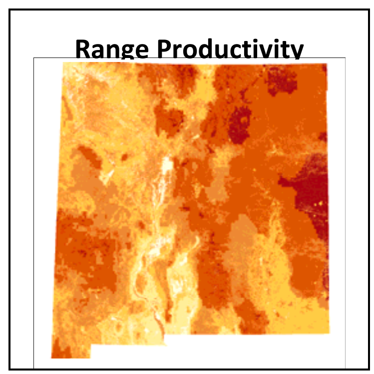


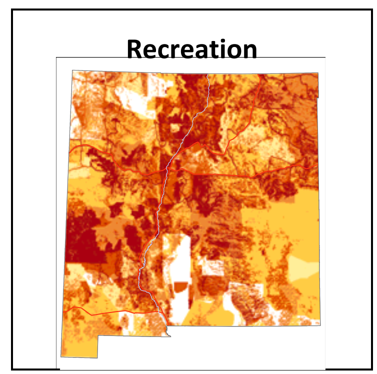












Forest Health

Forest Health Risk: This data layer identifies areas that make a forest area more susceptible to insect and disease outbreaks. This layer will be used in the State Strategy and Response plan to help prioritize areas where management of threats to forest health is most needed. *The scale of the data is meant for broad scale planning and prioritizing*

Model Design: Combine stand density index, basal area loss, drought stress, and insect and disease surveys using an equal weight overlay (Map 4-1). Final priority classes and values for statewide forest health priorities are: Low = 1-4; Low/Medium = 5-9; Medium = 10-15; Medium/High = 15-20; High = 21-32.

Description of Factors:

1. Stand Density Index (SDI)

Function: Gives scaled value to watersheds with higher relative density of trees.

Criteria: Maximum SDI (SDI_{max}) is categorized into five classes: 25% SDI_{max} = 1; 35% SDI_{max} = 2; 60% SDI_{max} = 3; 100% SDI_{max} = 4; and >100% SDI_{max} = 5.

Justification: Dense forests and woodlands are more susceptible to insect and disease outbreaks in dense stands. SDI determines the relative density of a stand. SDI is a measure of the stocking of a stand of trees based on the number of trees per unit area and diameter at breast height of the tree of average basal area. It may also be defined as the degree of crowding within stocked areas, using various growing space ratios based on crown length or diameter, tree height or diameter, and spacing. Stand density index is usually well correlated with stand volume and growth.

Data Description: SDI data layers were derived as a part of the 2006 National Insect and Disease Risk Map (NIDRM) and based on New Mexico's Forest Inventory Analysis Data from 1987-1999. The purpose of the forest parameter surfaces is to provide uniformly constructed, accurate, moderate-resolution GIS-ready data surfaces of critical tree species' attributes. Maximum SDI values were determined by John Shaw, Research Ecologist from IWFIA, RMRS (Table 4-1). The relative percent of SDI_{max} was then calculated for each forest type and categorized into the above classes for each of the forest types. The relative percent indicate silviculturally and ecologically important competition thresholds.

Data Source: The Forest Health Technology Enterprise Team developed the NIDRM products as a part of a collaborative process coordinated by the USFS to strategically evaluate risk of insect and disease outbreaks of forests and woodlands across the nation. The spatial data can be downloaded from http://www.fs.fed.us/foresthealth/technology/products.shtml. The Nature Conservancy in New Mexico derived the relative percentages in 2009.

Table 4-1: Maximum SDI (SDI_{max})

Forest type	SDI max
Pinyon-juniper woodland	370
Douglas fir	485
Ponderosa pine	375
White fir	500
Subalpine fir	485

2. Basal Area Loss

Function: Gives scaled value to watersheds with higher density of trees.

Criteria: The basal area loss values represent predicted square feet of basal area loss. The original values (0 – 462) were grouped and given a value from 1 to 5 using a Natural Breaks classification.

Justification: Dense forests and woodlands are more susceptible to insect and disease outbreaks in dense stands. The purpose of the 2006 NIDRM is to provide policy makers, USDA officials, and federal and state land managers with a periodic strategic assessment for risk of tree mortality due to major insects and diseases. NIDRM defined basal area (BA) loss as “the expectation that, without remediation, 25 percent or more of the standing live basal area of trees greater than 1 inch in diameter will die over the next 15 years (starting in 2005).” For the purposes of the NM State Assessment, the total basal area loss data layer represents areas of dense forest/woodlands with large diameter trees expected to experience mortality from insects and disease.

Data Description: This data layer represents “the total potential BA loss resulting from the application of the NIDRM Project. Specifically, it is the compilation of all BA losses resulting from running all 188 models of agent/host interactions which result in mortality. Values of 0 - 462 represent the square feet of BA loss per pixel at that location.”

Data Source: The Forest Health Technology Enterprise Team developed the NIDRM products as a part of a collaborative process coordinated by the USFS to strategically evaluate risk of insect and disease outbreaks of forests and woodlands across the nation. The spatial data can be downloaded from http://www.fs.fed.us/foresthealth/technology/products.shtml

3. Percent Normal Precipitation

Function: Gives values to areas that have experienced winter drought stress within the past three years.

Criteria: Areas that have experienced < 50% of normal precipitation are given a value of 5; otherwise 0.

Justification: Moisture stress increases susceptibility to insect and disease outbreak as well as wildfire and tree mortality, eventually leading to shifts in vegetation type and distribution. The percent of normal precipitation is one of the simplest and most commonly used drought indices. The technical team noted that there is little literature to support relating a precise number (e.g., 75% normal precipitation) to a quantified increase in susceptibility; however, the general assumption that areas which have experienced less than 50% of normal winter precipitation are more likely to experience insect and disease outbreaks is reasonable based on current knowledge and studies in forest health.

Data Description: The percent of normal precipitation is calculated by dividing actual precipitation by normal precipitation and multiplying by 100%. Normal winter precipitation was derived from PRISM precipitation data from the years 1951-2006. Actual winter precipitation was derived from PRISM precipitation data from 2006 to 2008. The PRISM precipitation data contains spatially gridded average monthly and annual precipitation. The average winter annual precipitation was calculated by calculating mean winter (December, January, and February) precipitation for each year (2006 to 2008) then averaging using the Map Algebra tool in Spatial Analyst. The normal precipitation layer was downloaded directly from the Southwest Climate Change Initiative site (SWCCI).

Data Source: The normal precipitation data were calculated using the climate wizard designed by Dr. Evan Girvetz from the University of Washington. The normal winter precipitation data layer can be downloaded directly from SWCCI as an ASCII grid (http://faculty.washington.edu/girvetz/ClimateWizard/SWCCI/index_new.html). The annual precipitation grids were downloaded as individual years from the PRISM site (http://prism.oregonstate.edu/).

4. Insect and Disease Surveys

Function: Gives value to areas with known outbreaks of budworm and tent caterpillar.

Criteria: Pixels with codes representing budworm and tent caterpillar were selected and given a value of 5; otherwise 0.

Justification: Insects and diseases play an important role in maintaining forest health. They are essential to the function of dynamic ecosystems; they serve to thin out some of the trees, recycle nutrients, create habitat and provide food to many wildlife species. However, stressful conditions (e.g., drought-stressed, dense forests) favor extensive outbreaks of forest pests, which can have serious negative effects on the structure and function of forested systems. Unlike other insect and diseases, recurrence of budworm and tent caterpillar outbreaks is likely in areas where outbreaks have previously been detected.

Data Description: USFS Forest Health Aerial Survey data from 1987-2008 were combined into one layer. Polygons representing western spruce budworm (*Choristoneura tambertiana*) and western tent caterpillar (*Malacosoma californicum*) (DCA1 codes 12040 and 12094) were selected and converted to a grid where 5 = aerial detection and 0 indicates no known occurrence. Annual aerial surveys are conducted to monitor changes in forest health conditions and detect forest insect and disease activity. The surveys are conducted by an observer in a small high-wing aircraft, typically flying at approximately 1,000 feet above ground level. During the surveys, only currently fading trees (typically those with yellow, orange, or red foliage) or trees that are experiencing current defoliator activity are mapped. Older mortality (those trees that have older faded needles or have lost most or all of their needles) are not mapped.

Data Source: The aerial survey data were downloaded for the USFS, Region 3 web site (http://www.fs.fed.us/r3/gis/nm_data.shtml). The classified layer was created by the Nature Conservancy in New Mexico in 2009.

Data Considered But Not Used

1. *Moisture Stress (1951-2006):* The Nature Conservancy in New Mexico mapped recent trends using data from 1951-2006 in a combined temperature-precipitation variable, the climate water deficit (Enquist et al, 2008). This variable indicates biological moisture stress, or drying of an area. The technical team noted that insect and disease susceptibility is driven primarily by drought stress from the past 3 years and more particularly winter drought stress and decided that moisture stress trends would not be an effective indicator.
2. *Insect and Disease Surveys*: The aerial insect and disease survey data are a compilation of forest insect and disease activity of 942 agents mapped from aerial detection surveys in the state of New Mexico. The surveys have been occurring from 1987 to 2008. The intent of this layer is to map areas susceptible to future activity. Excepting western spruce budworm and western tent caterpillar, the polygon data was excluded from the model.
3. *Forest Inventory Analysis Data*: The forest inventory analysis data served as the basis for the NIDRM effort. Modeling of FIA data to represent stand density was not needed since it had already been completed as a part of the national effort. However, it was noted that updated FIA data are needed statewide.

Data Gaps/Data Needs

Table 4-2: Forest Health Data Gaps

Rank	Data Gap/Data Need
High	Specific stand exam data and updated and complete FIA data. More specifically, forest density and species make-up information as a statewide GIS coverage, including all non-National Forest Lands.
High	Comprehensive invasive species GIS layer at statewide level
High	Aspen and other upper elevation vegetation plot/baseline data
High	Lower elevation gallery forest plot data related to invasive species and loss of native riparian forest

Technical Advisory Team

Bruce Bauer – Santa Clara Pueblo, Forester
Craig Allen – United States Geologic Survey, Jemez Mountains Field Station, Scientist
Dan Ryerson – United States Forest Service, Region 3, Forest Health Specialist
David Lawrence – United States Forest Service, Region 3
Deb Allen-Reid – United States Forest Service, Region 3, NM Zone Leader
George Chavez – Natural Resources Conservation Service, State Resource Conservationist
James Menlove – United States Forest Service, Rocky Mountain Research Station, Ecologist
Jessi Ouzts – Natural Resources Conservation Service, Cooperating Forester
John Harrington – New Mexico State University, Professor - Forest Biology, Reforestation, Native Plant Propagation and Disturbed Land Restoration
Mark Meyers – New Mexico State Land Office, Biologist
Mary Stuever - Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer
Renee O'Brien – United States Forest Service, Rocky Mountain Research Station, Ecologist
Terry DeLay – United States Forest Service, Region 3

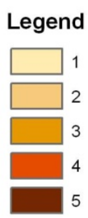
Citations

Enquist, C., Evan Girvetz, and D. Gori. 2008. Conservation Implications of Emerging Moisture Stress due to Recent Climate Changes in New Mexico. Technical report, The Nature Conservancy. 32 p. http://www.nmconservation.org.

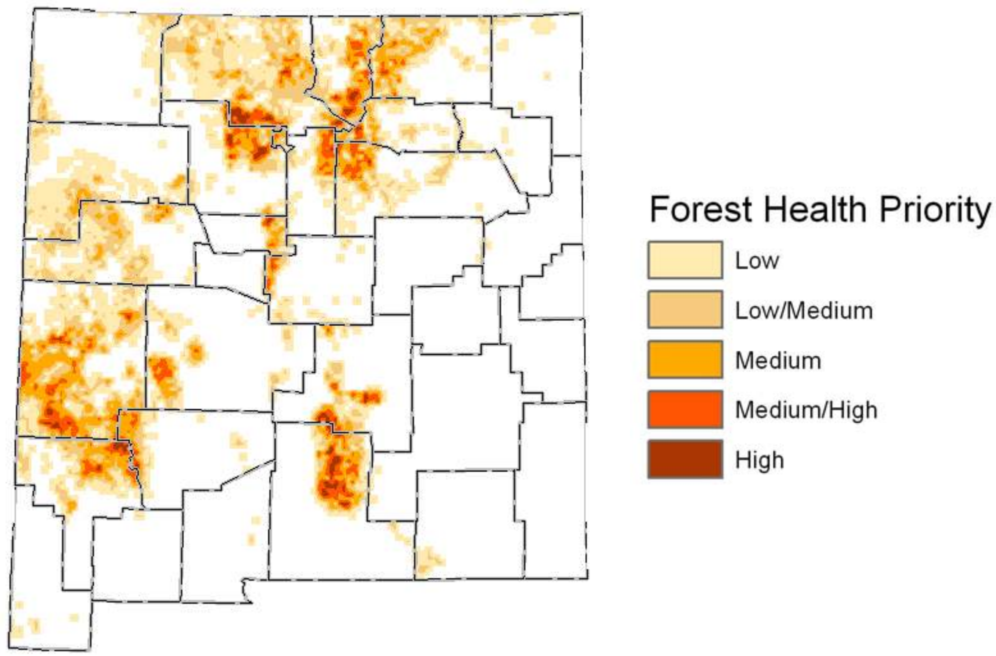
PRISM - Parameter-elevation Regressions on Independent Slopes Model (PRISM Group). 2009. http://prism.oregonstate.edu/.

Map 4-1 - Forest Health Risk: 1. Stand Density Index; 2. Basal Area Loss; 3. Percent of Normal Winter Precipitation; and 4. Insect and Disease Survey. Final priority classes and values for statewide forest health priorities are: Low (least susceptible to outbreaks) = 1-4; Low/Medium = 5-9; Medium = 10-15; Medium/High = 15-20; High (most susceptible to outbreaks) = 21-32.

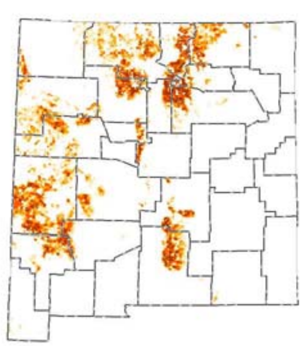
Forest Health: The intent of the forest health risk data layer is to identify areas that make a forest area more susceptible to insect and disease outbreaks



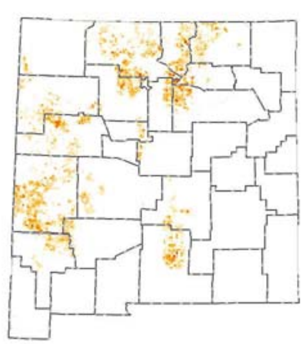
*** See model factor descriptions for class categories.*



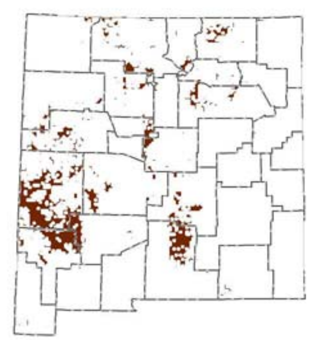
Stand Density Index



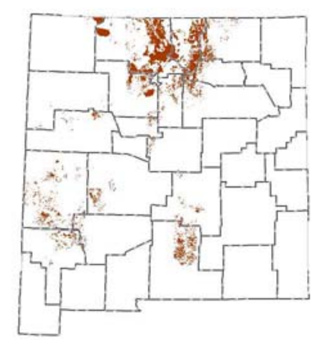
Basal Area Loss



% of Normal Winter Precip



Insect & Disease Survey



Fragmentation

Fragmentation: This data layer is intended to identify the extent of fragmentation on forests, woodlands, and rangelands. This layer will be used in the State Strategy and Response plan to help prioritize areas important for conservation of working forests. *The scale of the data is meant for broad scale planning and prioritizing*

Model Design: Create a statewide fragmentation layer by combining forest continuity, forest patch size, woodland continuity, woodland patch size, shrub/scrub continuity, shrub/scrub patch size, grassland continuity, grassland patch size, riparian continuity, riparian patch size, diversity of vegetation types per patch, and rarity of vegetation types per patch in an equal weight overlay (Map 5-1). Final priority classes and values for statewide fragmentation model are: Low = 1-4; Low/Medium = 5-6; Medium = 7-8; Medium/High = 9-11; High = 12-15.

Description of Factors:

1. Forest Patch Continuity

Function: Gives higher value to more continuous, less fragmented forest patches.

Criteria: Pixels are assigned values based on continuity of the patch, where larger values mean greater areas of continuous forest; smaller values represent smaller areas with more fragmentation and greater amounts of edge habitat. Continuity classes were categorized from 1 to 5 using a Natural Breaks classification (1= 2.84 to 4.304; 2 = 4.305 to 4.815; 3 = 4.816 to 5.236; 4 = 5.237 to 5.671; 5 = 5.672 to 6.678).

Justification: Edge habitat favors invasive species, increases parasitism and predation, reduces forest and woodland system ability to recover from disturbance events such as wind-throw, fires, or insect and disease infestations, and reduces viability of interior and wide-ranging forest species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A forest mask layer was derived using the crosswalk shown in Table 5-1 and used to extract forested patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each forest region. The circularity ratio determined for each region using the formula: $4\pi * \textit{area}/\textit{perimeter}^2$ (Selkirk 1982); then continuity = LOG10 (circularity ratio * Area), where larger values mean greater areas of continuous forest, smaller values represent smaller areas with more fragmentation and edge.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) were used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

2. Forest Patch Size

Function: Gives higher value to larger forest patches and is an indicator of degree of fragmentation.

Criteria: Pixels are assigned values based on size of patches, where larger values mean greater areas of forest; smaller values represent smaller areas of forest. Size classes were categorized from 1 to 5 using a Natural Breaks classification (1= 900 – 66,337,835 m^2; 2 = 66,337,835.1 to 162,157,852 m^2; 3 = 162,157,852.1 to 287,460,951.7 m^2; 4 = 287,460,951.8 to 538,067,150.7 m^2; 5 = 538,067,150.8 to 1,879,547,392 m^2).

Justification: Larger patches of forest are more ecologically and economically viable. As forest patch size decreases, habitat becomes isolated and viability of populations dependent on large blocks is reduced significantly. In addition, the sustainability of private forestry activities depends on the maintenance of large intact blocks as a resource base.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A forest mask layer was derived using the crosswalk shown in Table 5-1 and used to extract forested patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each forest region.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

3. Woodland Patch Continuity

Function: Gives higher value to more continuous, less fragmented woodland patches.

Criteria: Pixels are assigned values based on continuity of the patch, where larger values mean greater areas of continuous woodland; smaller values represent smaller areas with more fragmentation and greater amounts of edge habitat. Continuity classes were categorized from 1 to 5 using a Natural Breaks classification (1= 2.84 to 4.136; 2 = 4.137 to 4.519; 3 = 4.520 to 4.862; 4 = 4.863 to 5.272; 5 = 5.273 to 6.341).

Justification: Edge habitat favors invasive species, increases parasitism and predation, reduces the system's ability to recover from disturbance events such as wind-throw, fires, or insect and disease infestations, and reduces viability of interior and wide-ranging species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A woodland mask layer was derived using the crosswalk shown in Table 5-1 and used to extract woodland patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each woodland region. The circularity ratio determined for each region using the formula: $4\pi * \textit{area perimeter}^2$ (Selkirk 1982); then continuity = LOG10 (circularity ratio * Area), where larger values mean greater areas of continuous woodland, smaller values represent smaller areas with more fragmentation and edge.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

4. Woodland Patch Size

Function: Gives higher value to larger woodland patches and is an indicator of degree of fragmentation.

Criteria: Pixels are assigned values based on size of patches, where larger values mean greater areas of woodland; smaller values represent smaller areas of woodland. Size classes were categorized from 1 to 5 using a Natural Breaks classification (1= 900 – 53,419,021 m^2; 2 = 53,419,021.1 to 148,808,523.7 m^2; 3 = 148,808,523.8 to 316,694,047.8 m^2; 4 = 316,694,047.9 to 572,337,914.1 m^2; 5 = 572,337,914.2 to 972,973,824 m^2).

Justification: Larger patches of woodland are more ecologically and economically viable. As woodland patch size decreases, habitat becomes isolated and the viability of populations dependent on large blocks is reduced significantly. In addition, the sustainability of private forestry activities depends on the maintenance of large intact blocks as a resource base.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A woodland mask layer was derived using the crosswalk shown in Table 5-1 and used to extract woodland patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each woodland region.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

5. Shrub/Scrub Patch Continuity

Function: Gives higher value to more continuous, less fragmented shrub/scrub patches.

Criteria: Pixels are assigned values based on continuity of the patch, where larger values mean greater areas of continuous shrub/scrub; smaller values represent smaller areas with more fragmentation and greater amounts of edge habitat. Continuity classes were categorized from 1 to 5 using a Natural Breaks classification (1= 2.84 to 4.244; 2 = 4.245 to 4.764; 3 = 4.765 to 5.348; 4 = 5.349 to 6.029; 5 = 6.030 to 6.988).

Justification: Edge habitat favors invasive species, increases parasitism and predation, reduces the system's ability to recover from disturbance events such as wind-throw, fires, or insect and disease infestations, and reduces viability of interior and wide-ranging species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A shrub/scrub mask layer was derived using the crosswalk shown in Table 5-1 and used to extract patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each shrub/scrub region. The circularity ratio determined for each region using the formula: $4\pi * area/perimeter^2$ (Selkirk 1982); then continuity = LOG10 (circularity ratio * Area), where larger values mean greater areas of continuous shrub/scrub, smaller values represent smaller areas with more fragmentation and edge.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

6. Shrub/Scrub Patch Size

Function: Gives higher value to larger shrub/scrub patches and is an indicator of degree of fragmentation.

Criteria: Pixels are assigned values based on size of patches, where larger values mean greater areas of shrub/scrub; smaller values represent smaller areas of shrub/scrub. Size classes were categorized from 1 to 5 using a Natural Breaks classification (1= 900 – 21,725,170.27 m^2; 2 = 21,725,170.28 to 67,346,137.85 m^2; 3 = 67,346,137.86 to 156,415,646.0 m^2; 4 = 156,415,646.1 to 328,037,381.1 m^2; 5 = 328,037,381.2 to 553,969,792 m^2).

Justification: Larger patches are more ecologically and economically viable. As patch size decreases, habitat becomes isolated and the viability of populations dependent on large blocks is reduced significantly. In addition, the sustainability of private forestry activities depends on the maintenance of large intact blocks as a resource base.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A shrub/scrub mask layer was derived using the crosswalk shown in Table 5-1 and used to extract shrub/scrub patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each shrub/scrub region.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

7. Grassland Patch Continuity

Function: Gives higher value to more continuous, less fragmented grassland patches.

Criteria: Pixels are assigned values based on continuity of the patch, where larger values mean greater areas of continuous grassland; smaller values represent smaller areas with more fragmentation and greater amounts of edge habitat. Continuity classes were categorized from 1 to 5 using a Natural Breaks classification (1= 2.84 to 4.380; 2 = 4.381 to 4.872; 3 = 4.873 to 5.411; 4 = 5.412 to 6.052; 5 = 6.053 to 7.149).

Justification: Edge habitat favors invasive species, increases parasitism and predation, reduces the system's ability to recover from disturbance events such as wind-throw, fires, or insect and disease infestations, and reduces viability of interior and wide-ranging species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated.. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A grassland mask layer was derived using the crosswalk shown in Table 5-1 and used to extract grassland patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each grassland region. The circularity ratio determined for each region using the formula: $4\pi * \textit{area perimeter}^2$ (Selkirk 1982); then continuity = LOG10 (circularity ratio * Area), where larger values mean greater areas of continuous grassland, smaller values represent smaller areas with more fragmentation and edge.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

8. Grassland Patch Size

Function: Gives higher value to larger grassland patches and is an indicator of degree of fragmentation.

Criteria: Pixels are assigned values based on size of patches, where larger values mean greater areas of grassland; smaller values represent smaller areas of grassland. Size classes were categorized from 1 to 5 using a Natural Breaks classification (1= 900 – 38,857,055.67 m^2; 2 = 38,857,055.68 to 113,331,354.0 m^2; 3 = 113,331,354.1 to 242,851,872.9 m^2; 4 = 242,851,873.0 to 472,750,794.0 m^2; 5 = 472,750,794.1 to 825,694,208 m^2).

Justification: Larger patches of grassland are more ecologically and economically viable. As patch size decreases, habitat becomes isolated and the viability of populations dependent on large blocks is reduced significantly. In addition, the sustainability of private forestry activities depends on the maintenance of large intact blocks as a resource base.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A grassland mask layer was derived using the crosswalk shown in Table 5-1 and used to extract grassland patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each grassland region.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

9. Riparian Patch Continuity

Function: Gives higher value to more continuous, less fragmented riparian patches.

Criteria: Pixels are assigned values based on continuity of the patch, where larger values mean greater areas of continuous riparian areas; smaller values represent smaller areas with more fragmentation and greater amounts of edge habitat. Continuity classes were categorized from 1 to 5 using a Natural Breaks classification (1= 2.84 to 3.711; 2 = 3.712 to 3.974; 3 = 3.975 to 4.357; 4 = 4.358 to 4.884; 5 = 4.885 to 5.903).

Justification: Edge habitat favors invasive species, increases parasitism and predation, reduces the system's ability to recover from disturbance events such as wind-throw, fires, or insect and disease infestations, and reduces viability of interior and wide-ranging species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A riparian mask layer was derived using the crosswalk shown in Table 5-1 and used to extract riparian patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each riparian region. The circularity ratio determined for each region using the formula: $4\pi * \textit{area}$ $\textit{perimeter}^2$ (Selkirk 1982); then continuity = LOG10 (circularity ratio * Area), where larger values mean greater areas of continuous riparian areas, smaller values represent smaller areas with more fragmentation and edge.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

10. Riparian Patch Size

Function: Gives higher value to larger riparian patches and is an indicator of degree of fragmentation.

Criteria: Pixels are assigned values based on size of patches, where larger values mean greater areas of riparian vegetation; smaller values represent smaller areas of riparian vegetation. Size classes were categorized from 1 to 5 using a Natural Breaks classification (1= 900 – 4,738,309.41 m^2; 2 = 4,738,309.42 to 15,002,696.47 m^2; 3 = 15,002,696.48 to 30,004,492.94 m^2; 4 = 30,004,492.95 to 62,376,790.59 m^2; 5 = 62,376,790.6 to 201,340,800 m^2)

Justification: Larger patches of riparian vegetation are more ecologically and economically viable. As patch size decreases, habitat becomes isolated and the viability of populations dependent on large blocks is reduced significantly. In addition, the sustainability of private forestry activities depends on the maintenance of large intact blocks as a resource base.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). A riparian mask layer was derived using the crosswalk shown in Table 5-1 and used to extract riparian patches from the vegetated region group layer. Zonal geometry was used to calculate the area and perimeter of each riparian region.

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch size and continuity layers were created by The Nature Conservancy in New Mexico in 2009.

11. Patch Diversity

Function: Gives higher value to more diverse patches.

Criteria: Pixels are assigned values based on normalized variety measure where normalized variety measures >1 were grouped into 3 classes (1 = 1 to 2.3 avg # landcover types; 3 = 2.4 to 2.67 avg # of landcover types; 5 = 2.68 to 5 avg # of landcover types.)

Justification: Diversity refers to the number of different types of vegetation types within a patch. Patches with variety of habitat have potential for supporting greater diversity of species.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping. Zonal statistics was used to calculate the variety or the number of vegetation types per patch. The variety calculation was normalized using an average variety calculation derived in Access (Table 5-2). The resulting normalized variety table was joined to the Region Group layer and classified into three classes where 1 = 1 to 2.3 avg # landcover types; 3 = 2.4 to 2.67 avg # of landcover types; 5 = 2.68 to 5 avg # of landcover types

Table 5-2: Patch Variety Statistics

Patch Size	# of Patches	Avg. # of Landcover types	Min # of Landcover Types	Max# of Landcover Types	Total Acres
<100 acres	104,216	2	1	10	1,283,560
100 to 500 acres	19,218	4	1	14	4,667,353
501 to 1000 acres	7205	5	1	15	5,063,161
1001 to 5000 acres	8848	7	1	20	18,841,725
5001 to 10,000 acres	1456	10	2	24	10,070,208
10,001 to 50,000 acres	1094	14	3	53	21,510,936
> 50,000 acres	126	24	10	86	11,178,378

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch variety layer was created by The Nature Conservancy in New Mexico in 2009.

12. Patch Rarity

Function: Gives higher value to patches important for conserving rare habitat.

Criteria: Pixels are assigned values based on rarity of landcover type where higher numbers indicate larger percentage of total vegetation within the state is represented in a patch. (e.g., 69% of a vegetation type is found in a patch). Percentages were grouped into five classes where 1 = 1 to 5% of a vegetation type is found in patch; 2 = 5.01 to 10% of a vegetation type is found in patch; 3 = 10.1 to 30% of a vegetation type is found in patch; 4 = 30.1 to 50% of a vegetation type is found in patch; 5 = 50.1 to 100% of a vegetation type is found in patch.

Justification: Composition of patches is important for conservation of diversity of habitat within New Mexico. Certain patches contain large percentage of total acreage of a vegetation type, and conservation of these types is important to conservation of biodiversity and overall management within the state.

Data Description: SWReGAP landcover (2004) was reclassified to two classes: vegetated (1) and non-vegetated (0) classes. A combined Tiger Roads, Tiger Rails, and utilities raster layer was used to reclassify vegetated areas to non–vegetated. The resulting binary layer had 1 = vegetated, 0 = non-vegetated. Region Group was used to assign a unique number to each continuous vegetated region (four adjacent cells used for grouping). The region group layer was then combined with the SWReGAP vegetation layer and its resulting table was imported into Access. For each patch, the percent of total for each landcover type was calculated using the SQL query expression below. Agricultural, recently burned, recently chained, recently mined, and non-specific barren lands were excluded from the calculation. The maximum percentages per patch were exported and joined to the Region Group layer and grouped into five classes where 1 = .001 to 5% of a vegetation type is found in patch; 2 = 5.01 to 10% of a vegetation type is found in patch; 3 = 10.1 to 30% of a vegetation type is found in patch; 4 = 30.1 to 50% of a vegetation type is found in patch; 5 = 50.1 to 100% of a vegetation type is found in patch

SQL query

```
SELECT Allvegsum_patchstats.RGValue, Allvegsum_patchstats.Acres, Lndcvr.DESCRIPTION,
Export_Output_3.["LANDCOVER"], Sum(Export_Output_3.["ACRES"]) AS [SumOf"ACRES"],
Export_Output_3!["ACRES"]/landcoversum![SumOf"ACRES"]*100 AS PerTotal

FROM landcoversum INNER JOIN (RGAcres INNER JOIN ((Allvegsum_patchstats INNER JOIN
Export_Output_3 ON Allvegsum_patchstats.RGValue = Export_Output_3.["REGGRP_ALLVEG"])
INNER JOIN Lndcvr ON Export_Output_3.["LANDCOVER"] = Lndcvr.VALUE_) ON
RGAcres.RGValue = Allvegsum_patchstats.RGValue) ON landcoversum.VALUE_ = Lndcvr.VALUE_

GROUP BY Allvegsum_patchstats.RGValue, Allvegsum_patchstats.Acres, Lndcvr.DESCRIPTION,
Export_Output_3.["LANDCOVER"],
Export_Output_3!["ACRES"]/landcoversum![SumOf"ACRES"]*100
```

HAVING (((Allvegsum_patchstats.RGValue)>0) AND ((Allvegsum_patchstats.Acres)>0) AND ((Export_Output_3.["LANDCOVER"])<>114 And (Export_Output_3.["LANDCOVER"])<>116 And (Export_Output_3.["LANDCOVER"])<>124 And (Export_Output_3.["LANDCOVER"])<>113 And (Export_Output_3.["LANDCOVER"])<>110 And (Export_Output_3.["LANDCOVER"])<>123 And (Export_Output_3.["LANDCOVER"])<>117 And (Export_Output_3.["LANDCOVER"])<>0));

Where: Allvegsum_patchstat = Region Group layer, give unique value to each patch

RGAcres = sums acres per patch

Export_Output3 = combined RG and ReGAP, distinguishes different ReGAP veg per patch

Lndcvr = ReGAP landcover layer, assigns description to combined layer

Landcoversum = sum of each ReGAP landcover acreage for State

Data Source: The Tiger (2006) roads and rails layer combined with the SWReGAP landcover data (2004) was used to create patches. Patch rarity layer was created by The Nature Conservancy in New Mexico in 2009.

Table 5-1: SWReGAP/Fragmentation System Crosswalk

Type	SWReGAP Description	SWReGAP Value
agriculture	Agriculture	114
burn	Recently Burned	116
forest	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex	38
forest	Madrean Pine-Oak Forest and Woodland	33
forest	Madrean Upper Montane Conifer-Oak Forest and Woodland	91
forest	Recently Logged Areas	123
forest	Rocky Mountain Aspen Forest and Woodland	22
forest	Rocky Mountain Bigtooth Maple Ravine Woodland	23
forest	Rocky Mountain Lodgepole Pine Forest	29
forest	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	30
forest	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	32
forest	Rocky Mountain Ponderosa Pine Woodland	34
forest	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	26
forest	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	28
forest	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	24

Type	SWReGAP Description	SWReGAP Value
grassland	Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	65
grassland	Chihuahuan Gypsophilous Grassland and Steppe	68
grassland	Chihuahuan Sandy Plains Semi-Desert Grassland	93
grassland	Chihuahuan-Sonoran Desert Bottomland and Swale Grassland	90
grassland	Inter-Mountain Basins Semi-Desert Grassland	76
grassland	Invasive Perennial Grassland	119
grassland	Rocky Mountain Dry Tundra	69
grassland	Rocky Mountain Subalpine Mesic Meadow	70
grassland	Southern Rocky Mountain Montane-Subalpine Grassland	71
grassland	Western Great Plains Foothill and Piedmont Grassland	72
grassland	Western Great Plains Shortgrass Prairie	74
open/rock/wash	Barren Lands, Non-specific	113
open/rock/wash	Colorado Plateau Mixed Bedrock Canyon and Tableland	9
open/rock/wash	Inter-Mountain Basins Active and Stabilized Dune	11
open/rock/wash	Inter-Mountain Basins Shale Badland	10
open/rock/wash	Inter-Mountain Basins Volcanic Rock and Cinder Land	12
open/rock/wash	Inter-Mountain Basins Wash	13
open/rock/wash	North American Warm Desert Active and Stabilized Dune	17
open/rock/wash	North American Warm Desert Bedrock Cliff and Outcrop	15
open/rock/wash	North American Warm Desert Pavement	20
open/rock/wash	North American Warm Desert Volcanic Rockland	18
open/rock/wash	North American Warm Desert Wash	19
open/rock/wash	Recently Mined or Quarried	117
open/rock/wash	Rocky Mountain Alpine Bedrock and Scree	2
open/rock/wash	Rocky Mountain Alpine Fell-Field	4
open/rock/wash	Rocky Mountain Cliff and Canyon	5
open/rock/wash	Western Great Plains Cliff and Outcrop	7
riparian	Inter-Mountain Basins Playa	14
riparian	Invasive Southwest Riparian Woodland and Shrubland	118
riparian	North American Arid West Emergent Marsh	85
riparian	North American Warm Desert Lower Montane Riparian Woodland and Shrubland	80
riparian	North American Warm Desert Playa	21
riparian	North American Warm Desert Riparian Mesquite Bosque	84
riparian	North American Warm Desert Riparian Woodland and Shrubland	83
riparian	Rocky Mountain Alpine-Montane Wet Meadow	86
riparian	Rocky Mountain Lower Montane Riparian Woodland and Shrubland	79
riparian	Rocky Mountain Subalpine-Montane Riparian Shrubland	77
riparian	Rocky Mountain Subalpine-Montane Riparian Woodland	78
riparian	Western Great Plains Riparian Woodland and Shrubland	81

Type	SWReGAP Description	SWReGAP Value
riparian	Western Great Plains Saline Depression Wetland	89
scrub/shrub	Apacherian-Chihuahuan Mesquite Upland Scrub	52
scrub/shrub	Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	56
scrub/shrub	Chihuahuan Mixed Salt Desert Scrub	96
scrub/shrub	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	59
scrub/shrub	Chihuahuan Succulent Desert Scrub	55
scrub/shrub	Coahuilan Chaparral	97
scrub/shrub	Colorado Plateau Blackbrush-Mormon-tea Shrubland	53
scrub/shrub	Colorado Plateau Mixed Low Sagebrush Shrubland	50
scrub/shrub	Inter-Mountain Basins Big Sagebrush Shrubland	48
scrub/shrub	Inter-Mountain Basins Greasewood Flat	82
scrub/shrub	Inter-Mountain Basins Mixed Salt Desert Scrub	58
scrub/shrub	Inter-Mountain Basins Montane Sagebrush Steppe	62
scrub/shrub	Inter-Mountain Basins Semi-Desert Shrub Steppe	67
scrub/shrub	Mogollon Chaparral	51
scrub/shrub	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	41
scrub/shrub	Rocky Mountain Lower Montane-Foothill Shrubland	42
scrub/shrub	Sonora-Mojave Creosotebush-White Bursage Desert Scrub	60
scrub/shrub	Sonoran Mid-Elevation Desert Scrub	105
scrub/shrub	Sonoran Paloverde-Mixed Cacti Desert Scrub	57
scrub/shrub	Southern Colorado Plateau Sand Shrubland	108
scrub/shrub	Western Great Plains Mesquite Woodland and Shrubland	109
scrub/shrub	Western Great Plains Sandhill Shrubland	43
weed	Invasive Annual and Biennial Forbland	122
woodland	Colorado Plateau Pinyon-Juniper Woodland	36
woodland	Inter-Mountain Basins Juniper Savanna	64
woodland	Madrean Encinal	45
woodland	Madrean Juniper Savanna	95
woodland	Madrean Pinyon-Juniper Woodland	92
woodland	Recently Chained Pinyon-Juniper Areas	124
woodland	Southern Rocky Mountain Juniper Woodland and Savanna	63
woodland	Southern Rocky Mountain Pinyon-Juniper Woodland	35

Data Considered But Not Used

1. *Distance to Roads:* The distance to roads was considered as a measure of edge habitat. Edge habitat favors invasive species and increases parasitism and predation. The continuity metric was used instead to assess patch edge.
2. *Connectivity:* As habitat becomes more and more isolated, the viability of populations is reduced significantly. Connectivity measures were not included since it was considered duplicative of the Green Infrastructure and Fish and Wildlife Habitat models

Data Gaps/Data Needs

Table 5-3: Fragmentation Data Gaps

Rank	Data Gap Description
High	Keeping current with threat of development and changes in the landscape
High	Structure and Diversity Data to evaluate patch quality
High	Landcover Data that more accurately shows Riparian Vegetation Extent.

Technical Advisory Team

Alexious Becenti – Navajo Nation, Forest Manager
Craig Allen – United States Geologic Survey, Jemez Mountains Field Station, Scientist
Don Bright – United States Forest Service, Region 3
Doug Boykin – Energy Minerals and Natural Resources Department, Forestry Division, District Forester
James Wanstall – New Mexico Department of Agriculture, Soil and Water Conservation Specialist
Jennifer Cramer – United States Forest Service, Santa Fe National Forest, NEPA Coordinator
John Harrington - New Mexico State University, Professor - Forest Biology, Reforestation, Native Plant Propagation and Disturbed Land Restoration
Macario Herrera – United States Forest Service, Region 3, State and Private Forestry
Mary Stuever – Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer
Nathan Schroeder – Santa Ana Pueblo, Division Manager
Seth Fiedler – Natural Resources Conservation Service, Resource Conservationist
Teri Neville – Natural Heritage New Mexico, GIS Specialist

Citations

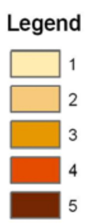
Selkirk, KE. 1982. Pattern and place an introduction to the mathematics of geography. Cambridge University Press, Cambridge

U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2006, TIGER/Line Files, 2006 Second Edition, http://www.census.gov/geo/www/tiger

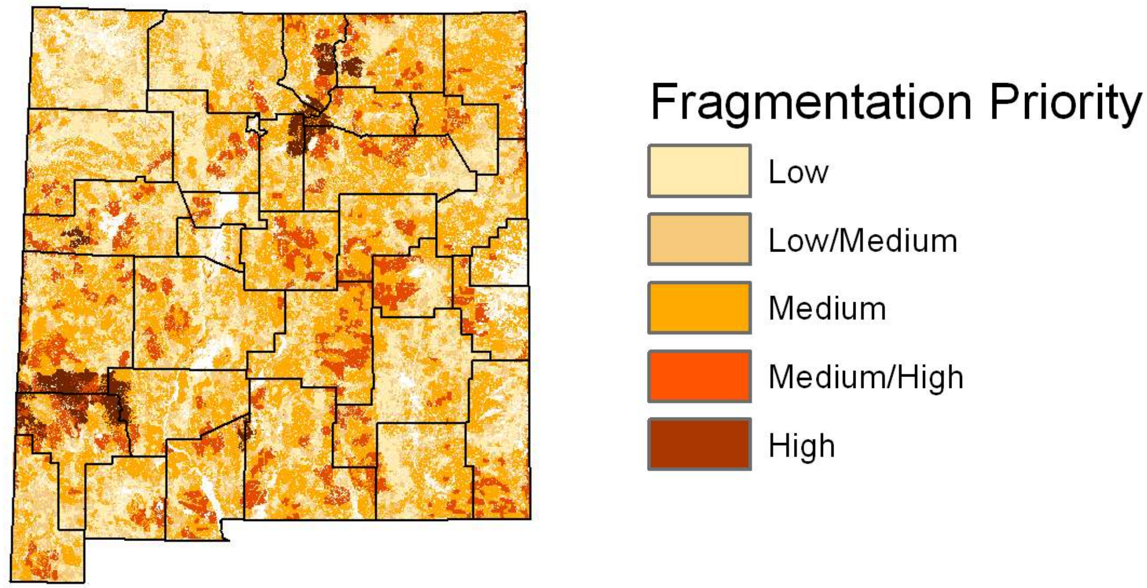
USGS National Gap Analysis Program. 2004. Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

Map 5-1 - Fragmentation Model: 1. Patch Continuity: Forest, Woodland, Grassland, Riparian, Shrub/Scrub; 2. Patch Size: Forest, Woodland, Grassland, Riparian, Shrub/Scrub. 3. Patch Diversity/Variety; and 4. Patch Rarity. Final priority classes and values for statewide fragmentation model are: Low (least fragmented) = 1-4; Low/Medium = 5-6; Medium = 7-8; Medium/High = 9-11; High (most fragmented) = 12-15.

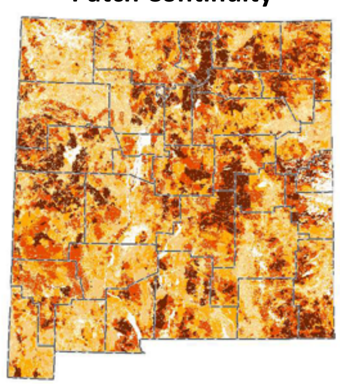
Fragmentation Model: The intent of the fragmentation data layer is to identify the extent of fragmentation on forests, woodlands, and rangelands.



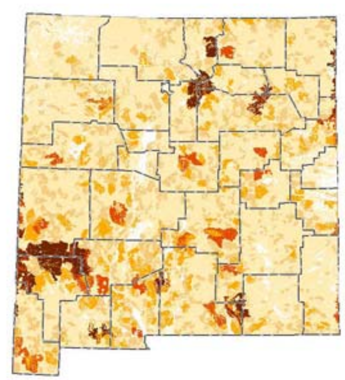
*** See model factor descriptions for class categories.*



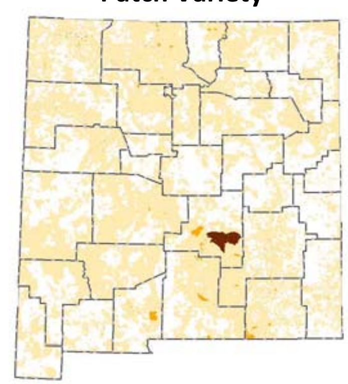
Patch Continuity



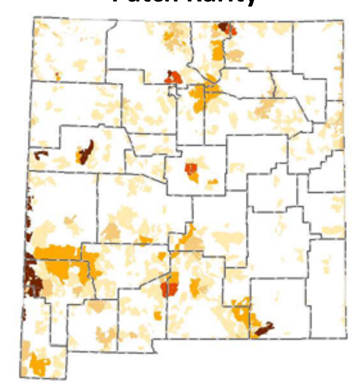
Patch Size



Patch Variety



Patch Rarity



Green Infrastructure

Green Infrastructure: This data layer identifies landscapes with the potential to form an interconnected green space network. This layer will be used in the State Strategy and Response plan to help emphasize areas which are the best lands to conserve and the best lands to accommodate development, in order to help communities balance environmental and economic goals. *The scale of the data is meant for broad scale planning and prioritizing*

Model Design: Use available data to select the best areas to serve as “Hubs” and use a least cost path GIS analysis to delineate “Corridors” (linkages) among these hubs. The least cost path model works to connect these origins to the destinations by crossing through a cost layer created for the model. A least cost path analysis produces a one pixel wide result from destination to origin. That result is guaranteed to be the lowest cost or “path of least resistance” between the two locales. In this case, a typical least cost path analysis would produce a corridor 30 meters wide. To create the cost layer, each pixel in the state is assigned a cost value. Cells with lower values will be preferred, as the model will calculate the sums of each path. The model calculates the sums as it moves from one cell to the next in trying to reach a destination point. As it crosses each cell it will add up the cost of that cell. A value of zero would be assigned to a feature that represented a highly preferable path through the landscape. A variety of datasets that identified the best and worst features on the landscape that would make a strong corridor system were used. These datasets included a NMDGF assessment of high priority corridors. These along with other features such as perennial stream are features that are considered good or low cost opportunities and are assigned a low cost value of either 0 or 5.

The datasets are overlaid on each other spatially to create the cost layer, with each cell in our study area receiving a cost value. Features that are considered good but not excellent are given a slightly higher or more costly value. Protected lands with a gap analysis status of 3 received a cost of 25, meaning that the model would prefer a wildlife corridor or perennial stream but will use this type of protected land if no stream feature or corridor is available to make the connection. Gradually greater costs are then overlaid using the SWReGAP landcover data, with natural landcover types having a moderately high cost of 35 but not as costly as highly developed areas which had a high cost of 200. The highest cost layer includes interstates, with a high cost of 1000, meaning that the model will work to avoid interstate crossings except at crossing points identified in the cougar corridor study. The cost layer was built with the datasets and cost values described below.

With the cost layer built, the least cost path model can be run. For this model, several iterations of the least cost path analysis were used to create a corridor system that has important, geographical and ecologically sound connections. The first run identified statewide linkages that may cross ecosystem types. Following iterations confined the analysis to ecologically similar ecotypes. A final iteration was run to connect a select group of urban communities to the statewide green infrastructure network. The communities selected were Albuquerque, Santa Fe, Ruidoso and Roswell. Each of these communities is classified as “managing” in the CARS (community accomplishment reporting system) database. This is a Forest Service product designed to document accomplishments by urban and community forestry programs. These four urban areas are described as having an existing or “managing”urban forestry program. Connections are made to these areas to support these programs alignment with the statewide assessment.

Upon completion of the least cost path analysis, the selected path is buffered by one mile. The one-mile buffer of the least cost path corridors and the hubs are further analyzed to create a scale of priority from 1to 5, with 5 representing highest priority. Areas outside the corridors and hubs are not considered in this analysis and have a value of zero in the final output. The priority analysis was completed by overlaying a “priority” layer to identify the degree of priority of the individual pixels within the hub and corridor system.

The prioritization layer is created by overlaying numerous datasets, much in the same way that the cost layer was constructed, except in this prioritization layer, higher values are an indicator of higher priority. Each dataset used in the overlay analysis was assigned a range of values that is an indicator of the value of that feature in identifying the highest priority areas to focus conservation and management efforts. Datasets used are described below.

Final priority classes and values for statewide Green Infrastructure priorities are: No Priority = 0; Low = 1; Low/Medium = 2; Medium = 3; Medium/High = 4; High = 5 (Map 6-1).

Considerations for the results of this model: It should be noted that these are potential corridors. These are not the only potential corridors that may exist on the landscape, but these results offer an assessment of one corridor plan that is designed to focus on wildlife corridors, streams and important natural landcover for a variety of habitat types. Roads and highly developed areas are avoided. Areas that have a low priority in this model offer better opportunities for development, as they are unlikely to affect the sensitive resources, which are identified as high priority in this model. There are no doubt numerous important areas outside this hub and corridor system; however, this model offers guidance on where to focus limited resources for management and conservation and a corridor system that can create a strong linkage of ecological communities across the state.

Description of Factors:

1. Hubs

a. TNC Ecoregional Assessment – Conservation Areas

Function: Priority Conservation Areas delineated with the number of imperiled species found within them. Identifies the most diverse region of the state for a range of habitat types. Serves as origin in the least cost path analysis.

Criteria: The area for each habitat type with the most number of target species (see definition above) as delineated by TNC was selected as the origin hub. The entire conservation area will serve as one part of the hub network. Individual cells within the hub will be prioritized 1to 5 dependent on the value of the prioritization overlay described above.

Justification: This dataset presents the only assessment of regions within the state that includes all habitat types. Most assessments were restricted to the high elevation areas in the north and central part of the state. This dataset provided a means to prioritize areas based on the number of target species located within it. The most diverse area for each ecotype was selected as it is expected to provide the best source area for species using these habitat types.

Data Description: Conservation areas are geographic areas that have been prioritized because of the sensitive biological species, habitats, and features (targets) that are known to occur in these areas.

Data Source: The Nature Conservancy in Arizona; Priority Conservation Areas Western North America v1: 2007

b. SWReGAP Stewardship Layer – GAP Status

Function: The stewardship layer delineates the gap analysis status of each protected area in New Mexico. These areas served as the destination for least cost path analysis originating from the conservation areas described above.

Criteria: The final destination hubs were selected by choosing the 10 largest blocks of land that had a GAP status of 1 or 2. The entire protected area will serve as one part of the hub network. Individual cells within the hub will be prioritized 1-5 dependent on the value of the prioritization overlay described above.

Justification: The North Carolina Department of Forestry defines green infrastructure as "an interconnected system of natural areas and other open spaces that are protected and managed for the ecological benefits they provide to people and the environment. It is the idea that trees and natural areas provide ecosystem function and value to sustain clean air and water, reduce soil erosion, provide wildlife habitat, and various other benefits to people." Existing protected lands are an important part of a green infrastructure design. Selection of the PAD 1 and 2 designated protected lands ensures that these hubs will offer long term ecological benefits to people and wildlife.

Data Description: These destination hubs are made up of the 10 largest areas that have the following GAP protection status: Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.

Data Source: USGS National Gap Analysis Program. 2007. Digital Land Stewardship Map for the Southwestern United States. Version 1.0. New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University.

2. Corridors

a. Cougar Corridor Data

Function: This dataset was created to identify the best corridors for movement of mountain lions. Using these crossing points in the least cost path analysis is assumed to provide the best opportunity to put in measures that protect animals and drivers.

Criteria: The cougar corridor model is divided into 11 classes of "quality;" the different classes were given values of 0-5 points in the cost layer, with the best corridor path getting a value of 0, so having the least possible cost.

Justification: The selection of cougars is justified for the following reasons: 1) Cougars have been identified as a species of conservation concern in regional conservation plans; 2) this is the only wide ranging species for which adequate habitat data existed to conduct such an analysis; 3) it was assumed that cougar could serve as a surrogate for other wide ranging carnivorous species such as black bear (Ursus americanus), marten (Martes americana), gray wolf (Canis lupus), jaguar (Panthera onca), and gray fox (Urocyon cinereoargenteus) where habitat overlaps. With these data NMDGF will be able to begin to plan for the needs of other species with large home ranges, seasonal migration requirements, and sensitivities to human disturbance.

This dataset is especially useful in that it provides important crossing points across the New Mexico freeway system.

Data Description: In total 26 corridors were modeled. Four crossed Critical Risk Highway Segments, five crossed High Risk Segments and six crossed Moderate Risk Segments. Several corridors showed strong correlations to carnivore roadkill records.

Data Source: courtesy: Kurt Menke – Birds Eye View GIS http://www.birdseyeviewgis.com/. *Locating Potential Cougar (Puma concolor) Corridors in New Mexico Using a Least-Cost Path Corridor GIS Analysis*; May 31, 2008: http://www.wildlife.state.nm.us/conservation/share_with_wildlife/documents/SwW08Menke.pdf

b. NMDGF Corridors Assessment for Western Governors Association

Function: This dataset offers an existing assessment of important wildlife habitat and corridors across the state. This dataset was used in the creation of the cost layer.

Criteria: Areas prioritized by this plan received a cost of 1-A very low cost value.

Justification: This dataset was created under the advice of NMDGF staff. It is assumed that these represent informed delineations of important habitat and corridors for game species.

Data Description: Important wildlife corridors provided to the Western Governors Association Wildlife Corridors Initiative in December 2007. Important wildlife corridor areas digitized under direction of NMDGF's biologists and big game manager.

Data Source: Courtesy of NMDGF and Western Governors Association http://www.westgov.org/wga/publicat/OilGas07.pdf

c. New Mexico Highlands Wildlands Network Design

Function: This dataset offers an existing assessment of important wildlife habitat in a large portion of the state. This dataset was used in the creation of the cost layer.

Criteria: Areas prioritized by this plan received a cost of 5, a low cost value.

Justification: It is assumed that these areas are of high value for the protection of wildlife and the maintenance of a healthy ecosystem.

Data Description: In 2003 The Wildlands Project published the New Mexico Highlands Wildlands Network Vision 1. This was the first attempt to look at the landscape in terms of core wildlife habitat, compatible use areas and dispersal corridors. To map the landscape in this manner a series of spatial analyses as conducted to identify the portions of the landscape that need to be protected to support healthy ecosystems in New Mexico. However, the corridors were only vaguely identified.

Data Source: New Mexico Highlands Wildlands Network Vision by Dave Foreman et al. (The Wildlands Project 2003). CD available from Kim Vacariu, The Wildlands Project, 520-884-0875 or kim@wildlandsproject.org. Wildlands Network http://wildlandsnetwork.org/cms/page1112.cfm

d. Outstanding Natural Resource Waters

Function: This dataset provides a high value linear feature for use in the cost layer. It also provides a water quality value to the green infrastructure model.

Criteria: Areas prioritized by this plan received a cost of 5, a low cost value.

Justification: High quality rivers and associated riparian border should be protected and offer an excellent opportunity for movement of wildlife. Protection of these areas will help provide for higher quality water resources. Designation as an outstanding national resource water (ONRW) helps to ensure that water quality is maintained or improved from the point in time of designation. ONRW designation does not limit existing uses as long as these uses do not degrade water quality from the levels at the time of designation.

Data Description: The objective of the federal Clean Water Act is to restore and maintain the chemical, physical and biological integrity of the nation's waters. One tool for achieving this objective is the designation of ONRWs. The concept is found in the U.S. Environmental Protection Agency (US EPA) water quality standards (WQS) regulations at 40 CFR 131.12

Data Source: Provided by the New Mexico Environment Department http://www.nmenv.state.nm.us/swqb/ONRW/

e. Perennial Streams and Intermittent Streams

Function: This dataset provides a high value linear feature for use in the cost layer. It also provides a water quality value to the green infrastructure model.

Criteria: Areas prioritized by this plan received a cost of 10, a moderate cost value.

Justification: Perennial streams are a highly valuable resource to people and wildlife. Maintaining a healthy system of perennial streams will serve the needs of people and the movement of wildlife.

Data Description: This dataset contains hydrographic data (reach codes for networked features and isolated lakes, flow direction, names, stream level, and centerline representations for water bodies) for New Mexico. The source data is the National Hydrography Dataset (NHD). The NHD is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that comprise the nation's surface water drainage system. Medium resolution NHD is based on the content of the U.S. Geological Survey 1:100,000-scale Digital Line Graph (DLG) hydrography data, integrated with reach-related information from the U.S. Environmental Protection Agency Reach File Version 3.0 (RF3).

Data Source: Derived from the National Hydrography dataset. http://nhd.usgs.gov/

f. SWReGAP Stewardship Layer

Function: This dataset provides the highest value non-linear feature for use in the cost layer.

Criteria: Areas selected were those that have a GAP status of 3. These areas were assigned a cost of 25, a moderate level cost.

Justification: Use of lands that have an existing degree of protection will help make the most of New Mexico's current public land system and possibly identify areas in which protection measures may be increased if necessary. Working with lands currently under some degree of management is assumed to offer cost and administrative advantages over areas under private ownership.

Data Description: The cost layer selects out areas with a GAP status of 3, defined as "An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.”

Data Source: USGS National Gap Analysis Program. 2007. Digital Land Stewardship Map for the Southwestern United States. Version 1.0. New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University.

g. SWReGAP Landcover

Function: This dataset provides a non-linear feature for use in the cost layer.

Criteria: Landcover was classified as natural, developed open space, agriculture, developed high intensity, and mines and quarries. These classifications were assigned the following scores in the cost layer:

- Natural Landcover, includes disturbed types = **35**
- Developed Open Space = **75**
- Agriculture = **100**
- Developed - Medium/High Intensity = **200**
- Mined or Quarried = **500**

Justification: It is assumed that if none of the features listed above are available for use in a corridor system, that use of land that is currently in a natural state is best for a green infrastructure network. Open space areas tend to have large fields of vegetation, which is also of value for wildlife and stormwater management, so they are assigned a slightly more costly value. As agricultural fields have a small degree of development, but are not preferred over areas with native landcover, their costs are higher than open space. Highly developed areas in areas of significant disturbance such as mines were assigned very high costs.

Data Description: Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect) to model natural and semi-natural vegetation. Landcover classes are drawn from NatureServe’s Ecological System concept, with 109 of the 125 total classes mapped at the system level. For the majority of classes, a decision tree classifier was used to discriminate landcover types, while a minority of classes (e.g. urban classes, sand dunes, burn scars) were mapped using other techniques. Twenty mapping areas, each characterized by similar ecological and spectral characteristics, were modeled independently of one another. These mapping areas, which included a 4 km overlap, were subsequently mosaiced to create the regional dataset. An internal validation for modeled classes was performed on a withheld 20% of the sample data.

Data Source: USGS National Gap Analysis Program. 2004. Provisional Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

h. US Census 2000 TIGER/Line files – Roads

Function: This dataset identifies significant obstacles for the connectivity of a green infrastructure network for use in the cost layer.

Criteria: Roads were classified as local paved roads, unseparated highway, separated highway and Interstate. These classifications were assigned the following scores in the cost layer:

- Local Paved Road = **100**
- Unseparated Highway = **250**
- Separated Highway = **500**
- Interstate = **1000**
- Dirt roads – not assigned a cost.

Justification: Local paved roads were assigned a cost designed to make the corridors cross as few roads as possible, but not to make them impassable. Unseparated highways are presumed to cause a significant obstacle to movement of wildlife. Separated highways have a higher cost as it is assumed these are busier and more difficult to cross without a danger to people and wildlife. Interstates are assumed to be the most significant obstacle to a green infrastructure network. This high cost value is designed to prevent crossings other than at cross points identified in the cougar corridor data.

Data Description: The TIGER/Line files are extracts of selected geographic and cartographic information from the Census Bureau's TIGER® (Topologically Integrated Geographic Encoding and Referencing) database.

Data Source: http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html

3. Prioritization

a. Comprehensive Wildlife Conservation Strategy Key Areas

Function: These values were used as a primary input in the prioritization layer to rank the areas within the hub and corridor system with a 1-5 priority rating.

Criteria: Used the final score in the CWCS points system, all values 4-16.

Justification: The CWCS offers the best assessment of a given areas value to wildlife that exists in digital format.

Data Description: The CWCS is a culmination of two years of efforts on the part of resource professionals, conservation organizations, commodity interests, private individuals, Tribal interests, municipal governments, and others to construct a better wildlife conservation overview for New Mexico. Those efforts have been directed by a national initiative for accomplishing such a perspective through Congressional interest in the State Wildlife Grants program. The need for comprehensive strategies has been recognized for many years and led to establishment of the October 2005 deadline for states to present strategies that address local and state-level conservation needs and which promote an ability to advise regional and national perspectives on wildlife conservation at landscape scales.

Importantly, the CWCS is the springboard to an important conservation future for wildlife in New Mexico and the Southwest. In addressing the eight essential elements prescribed by Congress for strategy construction, New Mexico has *consolidated* important insight about long-term needs of wildlife in the state, *articulated* an ecologically-based approach to strategic actions that reverse declines and maintain beneficial population levels, and *formulated* the public engagement processes necessary to ensure involvement in, and acceptance and implementation of conservation strategies for years to come.

The CWCS is dedicated to expressing sensible approaches to conserving biological diversity in New Mexico in context with surrounding areas. We identify focus points on species and habitats warranting conservation actions. Further, we organize existing information and recognize where important information gaps remain. From that foundation, we identify cooperative and collaborative approaches to addressing the most important wildlife and habitat conservation needs in time and cost effective ways. The potential of the CWCS can only be realized through a broad array of natural resource agencies, other public programs, and private interests, all accepting this approach, being guided by it in operational planning, and pulling together to implement the actions.

Data Source: NMDGF http://fws-nmcfwru.nmsu.edu/cwcs/default.htm

b. New Mexico Highlands Wildlands Network Vision Priority Conservation Areas

Function: Identify lands prioritized in this assessment. Provides 10 points in the summation of the prioritization layer.

Criteria: All areas selected.

Justification: It is assumed that these areas are of high value for the protection of wildlife and the maintenance of a healthy ecosystem as this dataset was created to identify Areas of High Biological Significance within the New Mexico Highlands Wildlands Network Design.

Data Description: In 2003 The Wildlands Project published the New Mexico Highlands Wildlands Network Vision. This was the first attempt to look at the landscape in terms of core wildlife habitat, compatible use areas and dispersal corridors. To map the landscape in this manner, a series of spatial analyses were conducted to identify the portions of the landscape that need to be protected to support healthy ecosystems in New Mexico. However, the corridors were only vaguely identified.

Data Source: New Mexico Highlands Wildlands Network Vision by Dave Foreman et al. (The Wildlands Project 2003). CD available from Kim Vacariu, The Wildlands Project, 520-884-0875 or kim@wildlandsproject.org. Wildlands Network http://wildlandsnetwork.org/cms/page1112.cfm

c. Priority Watersheds (NMED)

Function: Emphasizes priority watersheds identified by NMED through the 2009 Nonpoint Source Management Program. Provides eight points in the summation of the prioritization layer.

Criteria: All watersheds identified as priorities are given a value of 10.

Justification: Priority watersheds indicate areas that NMED has prioritized for efforts to improve water quality in the state. The effort was prepared by NMED in accordance with the requirements of the Clean Water Act and adopted by the New Mexico Water Quality Control Commission (WQCC 2009).

Data Description: The NMED identified priority watersheds showing watersheds with impaired streams for which Total Maximum Daily Loads have been developed or have a category 4c ranking. A detailed description of the prioritization process can be found in the New Mexico Nonpoint Source Management Program planning document (WQCC 2009).

Data Source: The priority water quality watersheds layer was supplied by the NMED in 2009.

d. Species Specific Crucial Habitat Data

Function: Provides one point for every species core habitat with which the hub and corridor network overlap.

Criteria: One point is allotted for each species core habitat.

Justification: The NMDGF delineated the core habitats for 10 species. Inclusion of these data allows for an incremental increase in value for an areas value to individual species.

Data Description: Crucial habitats provided to Western Governors Association Wildlife Corridors Initiative in December 2007. Crucial habitat areas digitized under direction of NMDGF's endangered and non-game mammal biologist. Species for which habitats were mapped include Black Bear, Burrowing Owl, Black Tailed Prairie Dog, Elk, Leopard Frog, Long Billed Curlew, Marmot, Mountain Lion, Mule Deer, NM Bighorn, Pronghorn, and Priority Vegetation Communities.

Data Source: Courtesy of NMDGF and Western Governors Association http://www.westgov.org/wga/publicat/OilGas07.pdf

e. Unfragmented Natural Landcover ***(unfragmented by paved roads)*** **Derived from SWReGAP Landcover and Tiger Roads**

Function: Prioritize unfragmented landcover

- Unfragmented landcover that is in the 70th to 80th percentile provided four points in the summation of the prioritization layer.
- Unfragmented landcover in the 80thto 90th percentile provided 8 points in the summation of the prioritization layer.
- Unfragmented landcover in the 90thto 100th percentile provided 12 points in the summation of the prioritization layer.

Criteria: Unfragmented blocks of landcover were scored in the way described above.

Justification: Maintenance of unfragmented natural landcover is very beneficial to the preservation of wildlife and healthy ecosystems.

Data Description: removing all paved roads and measuring the area of the remaining blocks identified unfragmented blocks.

Data Source : SWReGAP Landcover created by USGS National Gap Analysis Program. 2004. Provisional Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University. Tiger Roads available at http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html

f. Landcover That Lowers Priority

Function: To lower the priority of areas known to have potential for development and disruption of a green infrastructure network.

- High intensity landcover – subtract 12
- Agriculture - subtract 8
- Developed open space – subtract 4
- Paved roads – remove from results, make a non-priority

Criteria: areas with the above landcover classifications will be given the score described.

Justification: Highly developed areas are not a quality landcover for a statewide green infrastructure network. On a finer scale, networks can be identified, but not at a statewide scale with this project. Agriculture is an important use of the land, but not the best land to run a network through, so these landcover types are of lower value to this network than natural landcover types, but not as unsuitable as high density development. Developed open space tends to be rangelands and hayfields. These landcover types are less intensively used than agriculture, so are assigned a lower negative value. All paved roads will be removed from the hub and corridor results.

Data Description: Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect) to model natural and semi-natural vegetation. Landcover classes are drawn

from NatureServe's Ecological System concept, with 109 of the 125 total classes mapped at the system level. For the majority of classes, a decision tree classifier was used to discriminate landcover types, while a minority of classes (e.g. urban classes, sand dunes, burn scars) were mapped using other techniques. Twenty mapping areas, each characterized by similar ecological and spectral characteristics, were modeled independently of one another. These mapping areas, which included a 4-km overlap, were subsequently mosaiced to create the regional dataset. An internal validation for modeled classes was performed on a withheld 20% of the sample data.

Data Source: SWReGAP Landcover created by USGS National Gap Analysis Program. 2004. Provisional Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University. Tiger Roads available at http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html

g. TNC Rangeland Ecosystem Assessment (REA)

Function: To identify the quality of rangelands in southern New Mexico. Assign points to increase priority for better quality rangelands. Priority scoring is as follows:

- Maintain Habitat – 8 points
- Moderate/difficult restoration potential – 6 points
- Moderate restoration potential – 4 points
- Complex Restoration Potential – 2 points
- Difficult Restoration Potential – 0 points

Criteria: Areas where this dataset exists will be given the scoring described above. Higher value points will make that area higher priority in the hub and corridor network.

Justification: This dataset offers an assessment of rangelands in southern New Mexico, it is the only such assessment identified by this project. It offers a valuable assessment of the quality of the rangelands and where to focus management and conservation resources.

Data Description: The REA estimates the condition of 14.2 million acres of land in southern New Mexico. It is based on states described in “ecological site descriptions” (ESDs) and expert knowledge. ESDs have been developed by the Natural Resource Conservation Service, and they are a consistent, science- and expert-based resource increasingly used by land managers. It focuses on public rangelands - grasslands, shrublands, and savannas - managed by the BLM, and includes some other lands as well. The REA compares current condition to the expected or “reference” condition, and summarizes the vegetation, ecological processes and restorative management options of these states. Depending on these management options the REA interprets restoration potential, or the effort needed to restore states toward or to reference condition.

Data Source: Data and report created by The Nature Conservancy in New Mexico and available for download at:
http://nmconservation.org/projects/rangeland_ecological_assessment/

Data Gaps/Data Needs

Table 6-1: Green Infrastructure Data Gaps

Ranking	Data Gap Description
High	A new area of research is focused on new modeling techniques for delineation of corridors. This research is ongoing but should be available in the near future for consideration. We encourage follow-up on the methodologies of Brian Brost, MS student in the Beier Lab of Conservation and Wildlife Ecology at Northern Arizona University. Brief Description: A new method will use elevation, slope, aspect, and landform as surrogates for vegetation in linkage design. The rationale is that future vegetation communities will be determined by topography, temperature, precipitation, and soils. By maximizing continuity of elevation, slope, aspect, and landform elements, a linkage design should also maximize continuity of vegetation communities in a changing climate.
High	Delineation of sites, or small patches of land along the corridors, that would serve as larger islands along the corridor network would be a useful addition to this model. These types of sites require more refined data and on the ground assessment of parcels of valuable land along the network. Consideration of these types of areas would be an important addition.
High	Creation of an urban Green Infrastructure plan could not be completed for this project assessment. Statewide green infrastructure is created using coarser scale analysis than urban programs. The pixel size for a statewide assessment is often 30 meters, while a quality urban assessment requires 2 foot resolution landcover data. This data is costly and rarely available at the local level. This assessment attempted to find any local data from urban programs in the state but no such data existed. The strongest program was in Albuquerque where the high resolution data exists, but it has not been derived into a plan yet. In future statewide assessments, a derived urban green infrastructure plan should be complete in Albuquerque and may be available for inclusion in the statewide assessment. With the current data available, however, no analyses could be completed within urban boundaries.
High	Assessment of the quality of habitat in the north east and northwest part of the state. The New Mexico Highlands and TNC Rangeland Ecosystem Assessment did not have data for these areas.
High	Conservation Easements data were not available, information on locations of easements would be useful for the cost layer.
High	Information catalogued spatially identifying grazing allotments and livestock operations was indicated as useful by the technical team, however this data was not available.

Technical Advisory Team

Bruce Thompson – Energy Minerals and Natural Resources Department, Conservation Initiatives Coordinator

Bryce Rickel – United States Forest Service, Region 3, Biologist

Lance Davission – Energy Minerals and Natural Resources Department, Forestry Division, Urban and Community Forestry

Les Owen – New Mexico Department of Agriculture, Range Specialist

Mary Stuever - Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer

Nick Kuhn – City of Albuquerque, City Forester

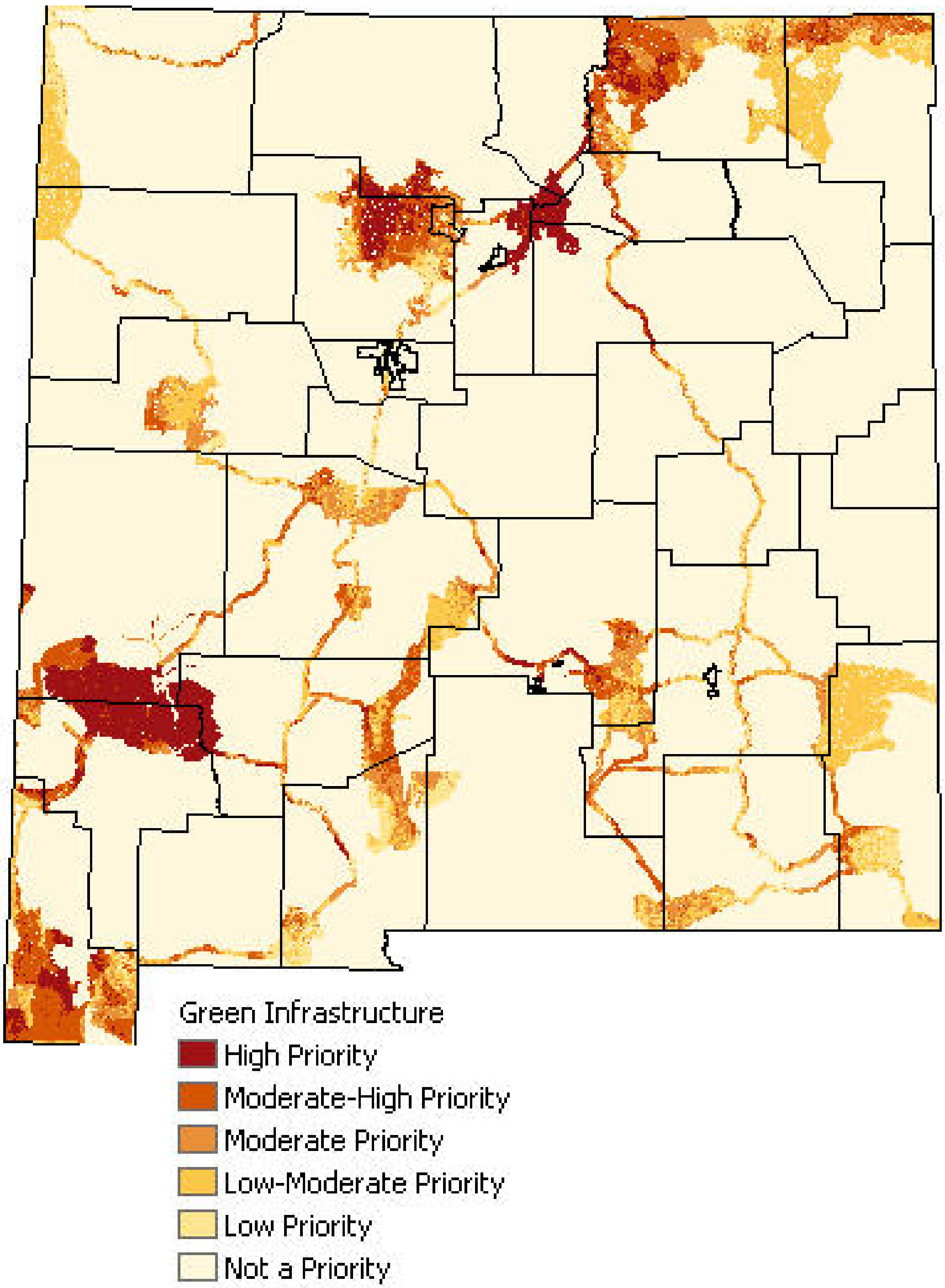
Pat Walsh – Cimmaron Watershed Alliance

Reuben Montes – United States Forest Service, Santa Fe National Forest, CFRP/Rural Community Assistance Coordinator
Steve Kadas – Natural Resources Conservation Service, Assistant State Conservationist
Sue Probart – Tree New Mexico
Teri Neville – New Mexico Natural Heritage Program, GIS Specialist
Yasmeen Najimi – Middle Rio Grande Conservancy District, Planner

Citations

Water Quality Control Commission. 2009. New Mexico Nonpoint Source Management Program. (www.nmenv.state.nm.us/swqb/wps).

Map 6-1 – Green Infrastructure Model Results:



Water Quality and Supply

Water Quality and Supply: This data layer identifies watersheds important for supplying sustainable water supply along with the potential risks to supplying clean water. This layer will be used in the State Strategy and Response Plan to help emphasize areas which will enhance public benefit from forested areas. *The scale of the data is meant for broad scale planning and prioritizing.*

Model Design: Combine public drinking supply, priority water quality watersheds, 305b category 4 and 5 impaired waters, specific New Mexico Environment Department (NMED) impaired/impacted (bacteria, nutrient, siltation impaired and septic impacted) watersheds, percent irrigated cropland and pasture, water quality risks (including active landfills, hazardous waste sites, and petroleum sites), aquifer recharge areas, aquifer vulnerability, impervious surface, and erosion risk using an additive equal weight overlay (Map 7-1). The public drinking supply, aquifer recharge areas, and 305b impaired layers identify priority areas for protection and restoration. The erosion risk, aquifer vulnerability, and impervious surfaces identify risks to water quality and supply. Final priority classes and values for statewide water quality and supply model are: Low = 1-8; Low/Medium = 9-13; Medium = 14-16; Medium/High = 17-22; High = 23-37 (Map 7-2).

Description of Factors:

1. Public Drinking Supply Sources

Function: Identifies watersheds with public drinking supply source as a priority watershed.

Criteria: HUC10 watersheds containing public drinking supply sources are given value of the number of intakes within that watershed; otherwise 0.

Justification: Protection of public drinking supply sources.

Data Description: The NMED developed a public drinking supply layer that identifies surface water intake points for the state. The surface water intake points were summarized by HUC10 watersheds. If a watershed contained a public drinking supply source it was given the value of the number of sources in the watershed. If not, the watershed was given a value of 0 indicating it does not contain a public drinking supply source. The data were scaled from 1 to 5 using Natural Breaks classification, where 5 indicates many drinking supply sources within a HUC10 watershed and 1 indicating fewest sources.

Data Source: The public drinking supply layer was supplied by the NMED with permission and is not available for release. The summarized layer was created by NMED in New Mexico in 2009.

2. Priority Water Quality Watersheds

Function: Emphasizes priority watersheds identified by NMED through the 2009 Nonpoint Source Management Program planning document.

Criteria: Watersheds identified as priorities are given a value of 5; otherwise 0.

Justification: Priority watersheds indicate areas that NMED has prioritized for efforts to improve water quality in the state. The effort was prepared by NMED in accordance with the requirements of the Clean Water Act and adopted by the New Mexico Water Quality Control Commission (WQCC).

Data Description: The NMED identified priority watersheds showing watersheds with impaired streams for which Total Maximum Daily Loads (TMDLs) have been developed or have a category 4c ranking. A detailed description of the prioritization process can be found in the 2009 Nonpoint Source Management Program planning document.
http://www.nmenv.state.nm.us/SWQB/wps/plan/index.html

Data Source: The priority water quality watersheds layer was supplied by the NMED in 2009.

3. 305b Category 4 or 5 Impaired Watersheds

Function: Identifies watersheds with 305b impaired reaches as priorities.

Criteria: Watersheds containing category 4 or category 5 impaired reaches are given a value from 1 to 5 indicating number of impaired reaches within the watershed; otherwise 0.

Justification: Impaired watersheds indicate areas in need of restoration and management.

Data Description: The NMED maintains an impaired reaches layer that identifies all impaired water in the state, in the 305b assessment of stream conditions for the *State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report* (WQCC 2008). The impaired waters reaches were summarized by 6th code or HUC12 watersheds. If a watershed contained an impaired reach it was given the value of the number of reaches in the watershed. If not, the watershed was given a value of 0 indicating it does not contain an impaired reach. The data were scaled from 1 to 5 using Natural Breaks classification, where 5 indicates many 305b impaired reaches within a HUC12 watershed and 1 indicates fewest impaired reaches. Note: The technical team recommendation was to include the 305b watershed layer in addition to the priority water quality watersheds layer developed by the NMED in the 2009 Nonpoint Source Management Program planning document. The 305b layer included watersheds with identified impairments but without developed TMDLs.

Data Source: The 305b impaired waters reach layer was supplied by the New Mexico Environment Department in 2009. The summarized layer was created by The Nature Conservancy in New Mexico in 2009.

4. NMED Water Quality Risk Factors

Function: Emphasizes watersheds containing water quality risks (WQR), including petroleum tanks, hazardous waste sites, and active landfills.

Criteria: Watersheds containing WQRs were given a value of 1 to 5 based on the number of risks found in the watershed; otherwise 0 indicates no WQRs recorded within the watershed. Classes were defined using a Natural Breaks classification (1 = 1 to 7 WQR; 2 = 8-18 WQR; 3 = 19 to 42 WQR; 4 = 43 to 90 WQR; 5 = 91 to 250 WQR).

Justification: Watersheds with greater numbers of WQR factors are in need of greater management.

Data Description: The NMED maintains GIS layers showing locations of petroleum tanks, hazardous waste sites, and active landfills. The locations of the WQR factors were summarized by HUC12 watersheds. If a watershed contained a WQR it was given the value of the number of petroleum tanks, hazardous waste sites or active landfills within the watershed. If not, the watershed was given a value of 0 indicating it does not contain a risk factor. A raster layer was created for each WQR factor.

Data Source: The locations of the WQRs were supplied by the NMED in 2009. The summarized layer was created by The Nature Conservancy in New Mexico in 2009.

5. Watersheds with Specific Water Quality Impairment or Impacted Stream

Function: Identifies watersheds with reaches impaired by bacteria, nutrients and/or siltation as well as reaches impacted by septic contamination as priorities.

Criteria: Watersheds containing reaches impaired by value from 1 to 5 indicating number of impaired reaches within the watershed; otherwise 0.

Justification: Impaired watersheds indicate areas in need of restoration and management. The first layer provided identifies watersheds with stream reaches that are impaired by nutrients and bacteria. The second layer provided shows watersheds which contain significant concentrations of septic systems. The data have not been evaluated or approved through a public process, described more fully in Onsite Sewage Management in New Mexico (NMED 2006), and are provisional

Data Description: The NMED maintains GIS layers showing reaches impaired by bacteria, nutrients, and siltation as well as reaches with indications of septic system caused groundwater contamination feeding into these reaches. The impaired/impacted reaches were summarized by HUC12 watersheds. If a watershed contained a reach impaired by bacteria, nutrients and/or siltation or if it contained a reach impacted by septic system, it was given the value of the number of reaches in the watershed. If not, the watershed was given a value of 0 indicating it does not contain an impaired or impacted reach. A raster layer was created for each impairment and septic impact factor.

Data Source: The impaired/impacted waters layers were supplied by the NMED in 2009. The summarized layer was created by The Nature Conservancy in New Mexico in 2009.

6. Impervious Surfaces

Function: Identifies watersheds with impervious surfaces.

Criteria: Watersheds with mean impervious surface greater than 0.5% are given a value from 1 to 5 based on expert recommendation (1 = 0.5 to 1% impervious surface; 2 = 1.01 to 3% impervious surface; 3 = 3.01 to 5% impervious surface; 4 = 5.01 to 15% impervious surface; 5 => 15% impervious surface); otherwise 0 indicates < 0.5% impervious surface.

Justification: Percentage of impervious surfaces is a good indicator of potential water quality impacts. Impervious surfaces increase stream sedimentation, increase stormflows, concentrate nutrients and pollutants in streams, and decrease infiltration impacting groundwater recharge.

Data Description: Impervious surfaces were derived from the National Land Cover Dataset (NLCD) 2001 impervious layer. The NLCD layer was produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium (www.mrlc.gov). The NLCD impervious layer was summarized to HUC12 watersheds using zonal mean and classified into five groups: 1 = 0.5 to 1% impervious surface; 2 = 1.01 to 3% impervious surface; 3 = 3.01 to 5% impervious surface; 4 = 5.01 to 15% impervious surface; and 5 => 15% impervious surface. The groups were based on recommendations from the technical team after review of data. Watersheds with <0.5% impervious surface were classified as 0.

Data Source: For a detailed description of the MRLC impervious layer and other landcover products, see http://ww.mlrc.gov/mrlc2k.asp. The NLCD reclassed zonal mean impervious surfaces layer data layer was created by The Nature Conservancy in New Mexico in 2009.

7. Percent Irrigated Cropland and Pasture(ICP)

Function: Identifies watersheds with large amounts of irrigated cropland and pasture (ICP).

Criteria: Watersheds with ICP greater than 0% are classified from 1 to 5 based on expert recommendation (1 = 1 to 10% ICP; 2 = 11-25% ICP; 3 = 26-50% ICP; 4 = 51-75% ICP; and 5 = 76-100 % ICP); otherwise 0 indicates no ICP.

Justification: Irrigation-induced water contamination can include salts, nitrates, and pesticides to the point where major water resources can no longer be used for drinking without further (and expensive) treatment. Irrigation drainage can also include toxic concentrations of selenium, arsenic, and other metals that can result in adverse health effects and death in exposed fish and wildlife.

Data Description: Percent ICP was derived from the National Land Cover Dataset (NLCD) 2007 landcover layer. The NLCD layer was produced through a cooperative project conducted MRLC Consortium (www.mrlc.gov). The NLCD agriculture classes were converted from raster to polygon features and intersected with the HUC12 watershed layer. The acres of irrigated land were calculated using the calculate geometry tool on the intersected polygon layer and the percent irrigated cropland and pasture was derived using the field calculator (sum of acres of ICP per HUC12 watershed/acres of HUC12 watershed * 100). The table was joined to a HUC12 polygon layer and classified into five groups: (1 = 1 to 10% ICP; 2 = 11-25% ICP; 3 = 26-50% ICP; 4 = 51-75% ICP; and 5 = 76-100 % ICP). The groups were based on recommendations from the technical team after review of data.

The technical team noted that this layer only emphasized ICP and that non-irrigated pasture and fallow agriculture are not represented.

Data Source: For a detailed description of the MRLC impervious layer and other landcover products, see http://ww.mlrc.gov/mrlc2k.asp. The NLCD reclassed zonal mean impervious surfaces layer data layer was created by The Nature Conservancy in New Mexico in 2009.

8. Aquifer Recharge

Function: Identifies areas with potential to recharge aquifers.

Criteria: Areas with predicted recharge are given a value from 1 to 5 based on a Natural Breaks classification (1 = 0 to 2.69 in.; 2 = 2.70 to 3.53 in; 3 = 3.54 to 4.49 in; 4 = 4.5 to 5.64 in; 5 = 5.65 to 7.91 in); otherwise 0 indicates no recharge is predicted by the model.

Justification: Areas where groundwater recharge is occurring are important to protect and manage.

Data Description: This data layer represents coarse scale potential for groundwater recharge developed using the Chaturvedi formula:

$$R = 2.0\,(P-15)^{0.4}$$ **Where**

R = recharge due to rainfall (in)
P = annual precipitation (in)

The formula relates precipitation to recharge for areas receiving more than 16 in. and is more fully described in the "Estimation of Natural Groundwater Recharge" edited by Simmers (1997). The precipitation data were collected from the PRISM group at Oregon State University. This data set contains spatially-gridded average monthly and annual precipitation for the climatological period 1951-2006. A statewide groundwater elevation layer was provided by the OSE to qualitatively evaluate the results of the Chaturvedi model. The technical team reviewed the overlay. The derived aquifer sensitivity broadly depicts important areas for aquifer recharge.

Data Source: For a detailed description of the MRLC impervious layer and other landcover products, see http://ww.mlrc.gov/mrlc2k.asp. The NLCD reclassed zonal mean impervious surfaces layer data layer was created by The Nature Conservancy in New Mexico in 2009.

9. Aquifer Sensitivity

Function: Identifies the relative ease with which a contaminant applied on or near a land surface can migrate to the aquifer of interest.

Criteria: Areas ranked from 1 to 5, with 1 indicating areas where contaminant migration is less likely and 5 indicating areas where migration is most likely.

Justification: Management of areas where contaminant migration is likely making an aquifer more sensitive or vulnerable is a priority.

Data Description: The DRASTIC model is the basis for the aquifer sensitivity rating. DRASTIC models several components that are important in determining the level of aquifer sensitivity including:

D – Depth to water (difference between the well-head elevation and that of the water level in the aquifer)
R – Net Recharge (amount of water that reaches the aquifer)
A – Aquifer Media (primary type of aquifer material)
S – Soil Media (primary type and size of soil particles)
T – Topography (the slope of the land surface)
I – Impact of the Vadose Zone (primary type and size of vadose zone material)
C – Hydraulic Conductivity (the ease at which water is able to move through the aquifer material)

The layer used for the analysis is the composite index of the DRASTIC results.

Data Source: The aquifer sensitivity layer was provided by the New Mexico Water Resources Research Institute.

10. Erosion Risk

Function: Identifies areas with high erosion potential.

Criteria: Erosion potential of an area is given a scaled value from 1 to 5; 1 indicates low potential and 5 indicates high potential.

Justification: Water erosion is a serious and continuous environmental problem. Excessive sedimentation clogs stream channels and is a source of contamination.

Data Description: The Revised Universal Soil Loss Equation (RUSLE) was used to assess mean erosion potential at the watershed scale.

RUSLE: A = R*K*L*S*C*P where

R = Rainfall-Runoff Erosivity Factor
K = Soil Erodibility Factor
L = Slope-Length Factor
S = Slope Steepness Factor
C = Cover Management Factor
P = Support Practice Factor

The erosion potential values were scaled from 1 to 5 where 1 indicates low potential and 5 indicates high potential. The Rainfall-Runoff Erosivity Factor was derived using methodology developed by Renard and Friedmund (1994) who modeled erosivity equations based on the amount of precipitation. The precipitation data were collected from the PRISM group at Oregon State Univeristy. This data set contains spatially-gridded average monthly and annual precipitation for the climatological period 1951-2006 (PRISM). The Soil Erodibility Factor (Kfactor) was developed by the NRCS as a part of the STATSGO statewide soils layers. The Slope Length and Slope Steepness factors were derived using ArcGIS 9.2 hydrology tools. The Cover Management Factor (c-factor) was developed through a reclassification of the NLCD 2001 landcover dataset (Table 7-1). Recently burned fire perimeters were obtained from RSAC and USFS R3 website. The cover factor for forest and woodland areas that have burned in the last seven years were updated to a c-factor of 0.024 to represent changed cover conditions.

The technical team recognized that the RUSLE model is a very broad scale measure for erosion potential and is not the most effective measure, but it was also the best available statewide erosion layer given the time frame of the project. A statewide WEPP model was the preferred modeling approach for erosion potential and was identified as a data gap/data need.

Table 7-1: NLCD/C-Factor reclassification

NLCD Class	Description	C-Factor
11	Open Water	0.001
12	Perennial Ice/Snow	0.001
21	Low Intensity Residential	0.010
22	High Intensity Residential	0.010
23	Commercial/ Industrial	0.010
31	Bare Rock	0.010
41	Deciduous Forest	0.003
42	Evergreen Forest	0.003
43	Mixed Forest & Woodland	0.003
52	Evergreen Shrubland	0.003
71	Grassland Herbaceous	0.020
81	Pasture Hay	0.24
82	Cropland	0.46
Update	Recently Burned	0.024

Data Source: This data layer was created by The Nature Conservancy in New Mexico in 2009. The base layers used to derive the RUSLE factors included PRISM precipitation, STATSGO soils, New Mexico Digital Elevation Model (DEM) maintained by RGIS, and the NLCD 2001 landcover dataset.

Technical Advisory Team

Abraham Franklin – New Mexico Environment Department, Program Manager, Watershed Protection Specialist
Andrew Erdmann – Office of State Engineer
Barbara Johnson – Rio Puerco Alliance
Bill Skinner – New Mexico Environment Department, Information/GIS Specialist
Geoff Rawling – New Mexico Bureau of Geology and Mineral Resources, Field Geologist
Linda Scheffe – Natural Resource Conservation Service, State Water Quality Specialist
Mark Murphy – Interstate Stream Commission
Ondrea Hummel – Unites States Army Corps of Engineers
Pat Walsh –New Mexico State Parks
Richard Asbury - New Mexico Environment Department, Drinking Water Bureau
Roy Jemison – United States Forest Service, Region 3, Hydrologist
Susan Rich – Energy Minerals and Natural Resources Department, Forestry Division, Forest and Watershed Health Coordinator
Talon Newton – New Mexico Bureau of Geology and Mineral Resources, Hydrogeologist
Yasmeen Najmi – Middle Rio Grande Conservancy District, Planner

Data Considered But Not Used

1. *Point of Diversion Data*: The New Mexico Office of the State Engineer maintains a point of diversion layer in its statewide geodatabase. The point of diversion is the well or surface water diversion where the appropriated water is diverted from its natural course to be beneficially used. The data were excluded because the technical team did not think the data could be summarized using existing attributes to accurately reflect agricultural use. The recommendation was to use percent agriculture instead.

2. *Arsenic Vulnerability*: The technical team recommended inclusion of the arsenic vulnerability layer. Raw arsenic data are available from the NMED, however, an interpolated data layer showing vulnerability is not available. The NMED is working on the layer. The layer could be added when completed.

Data Gaps/Data Needs

Table 7-2 Water Quality and Supply Data Gaps

Rank	Data Gap Description
High	Statewide Wetlands Data Layer
High	Pollutant source identification for impaired reaches identified in the State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report. The sources of pollutants in stream reaches where water quality does not meet standards have generally not been comprehensively identified. The identification should have a spatial component and, where possible, pollutant loading from major source activities or mechanisms should be quantitatively estimated. Filling this data gap is an important component of an objective identified in the New Mexico Nonpoint Source Management Program ("Objective 1 – Watershed-Based Planning").
High	WEPP model for Erosion Risk
High	Impairment Data for Ephemeral and Intermittent Reaches. This assessment should be directed towards creating a systematic approach for ephemeral/intermittent streams combined with more accurate erosion risk to give a better picture of the impact of water quality issues surrounding ephemeral reaches.
High	Surface Water Flow Trends over Time
High	Statewide Water Balance
High	Refined Cover Data Attributed with Percent Cover and Condition of Vegetation.
Medium	Statewide Grazing Layer
Medium	Ecological Site Description Crosswalk to Existing Landcover Types
Medium	Statewide Data on Gaining and Losing Reaches
Medium	Completion of a WRASTIC model for Surface Water Vulnerability
Medium	Statewide Parcel Data Attributed with County Zoning
Medium	Road Densities for Impervious Areas

Citations

Jennings, David B., S.T. Jarnagin and D.W. Ebert. 2004. A Modeling Approach for Estimating Watershed Impervious Surface Area from National Land Cover Data 92. Photogrammetric Engineering & Remote Sensing. 70(11): 1295-1307.

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Reinard K.G., and J. Freimund (1994). Using monthly precipitation data to estimate the R-factor in the revised USLE. Journal of Hydrology 157, pp. 287-306.

Simmers, Ian I (1997) Estimation of Natural Groundwater Recharge. Reidel, Boston, 510 pp.

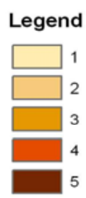
New Mexico Environment Department. 2009 Nonpoint Source Management Program planning document.(ftp://ftp.nmenv.state.nm.us/www/swqb/WPS/NPSPlan/WQCC-Approved2009NPSPlan.pdf)

Water Quality Control Commission. 2008. 2008-2010 State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report. (www.nmenv.state.nm.us/swqb).

Water Quality Control Commission. 2009. New Mexico Nonpoint Source Management Program. (www.nmenv.state.nm.us/swqb/wps).

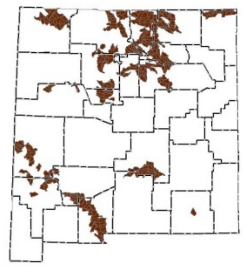
Map 7-1 - Water Quality and Supply Model: 1. Public Drinking Supply; 2. NMED Priority Water Quality Watersheds; 3. 305b Impaired Watersheds; 4. Bacteria, Nutrient, Siltation Impaired and Septic Impacted Watersheds; 5. % Irrigated Cropland & Pasture; 6. Water Quality Risks; 7. Aquifer Recharge Areas; 8. Aquifer Sensitivity; 9. % Impervious Surface; 10. Erosion Risk. Model Factors shown below. See next page for final result.

Water Quality and Supply Model: The intent of the water quality and supply data layer is to emphasize landscapes that impact long-term watershed function in supplying sustainable public water supplies

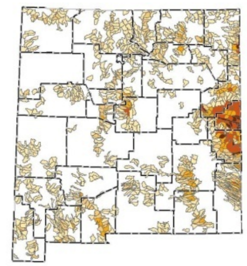


*** See model factor descriptions for class categories.*

2. NMED Priority Sheds

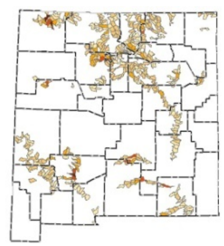


5. % Irr. Cropland

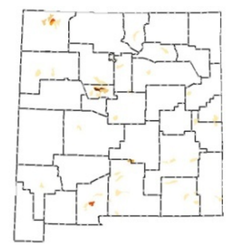


8. Aquifer Sensitivity

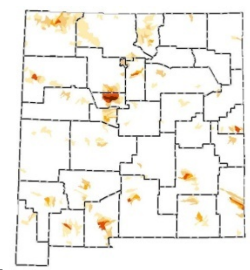
3. 305b Watersheds



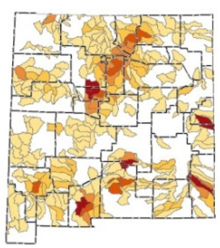
6. Water Quality Risks



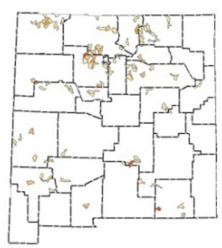
9. % Impervious Surface



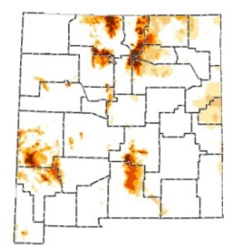
1. Public Drinking



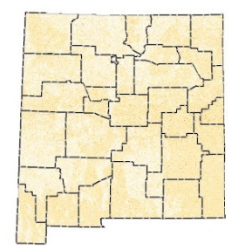
4. Specific Impaired Sheds



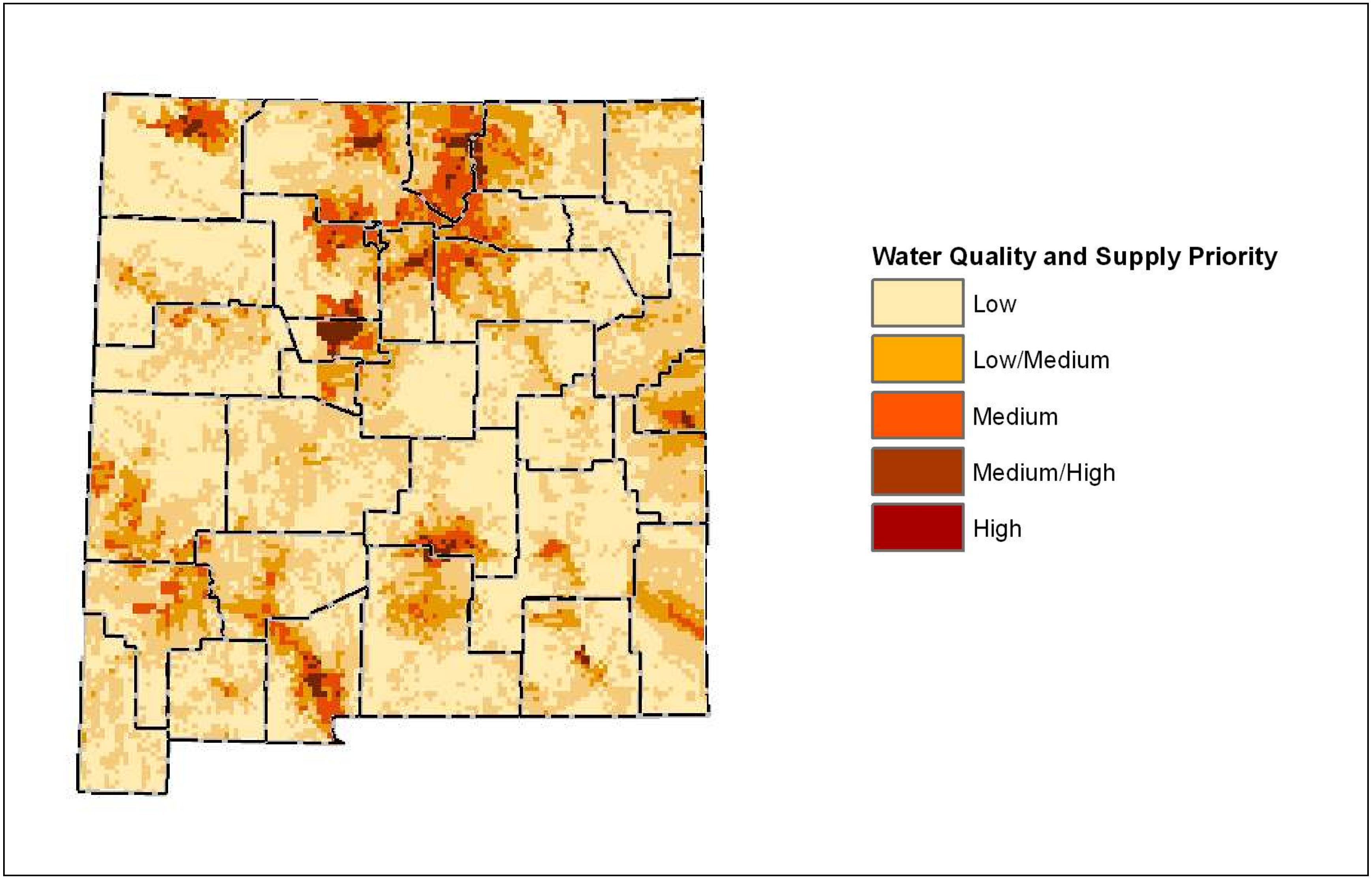
7. Aquifer Recharge



10. Erosion Risk



Map 7-2 - Water Quality and Supply Model: Final priority classes and values for statewide water quality and supply model are: Low (low value and low risk) = 1-8; Low/Medium = 9-13; Medium = 14-16; Medium/High = 17-22; High (high value and high risk) = 23-37.



Wildfire Risk

Wildfire Risk: This data layer identifies areas with a relatively high risk of destructive wildfire. The intent of this layer is to identify areas where forest management is most likely to reduce the risk of wildfire damage (or reduce the impact of wildfire on natural resources, and human infrastructure and development). This layer has been developed for the State Strategy and Response Plan to help prioritize areas which will minimize potential and reduce impact of wildfire. *The scale of the data is meant for broad scale planning and prioritizing.*

Proposed Model: Combine rate of spread, flame length, crown fire potential, wildland urban interface, fire occurrence, fire regime condition class in an additive equal weight overlay (Map 8-1)

Description of Factors:

1. Rate of Spread (feet per minute)

Function: Gives value to areas with potential for high rate of spread (ROS).

Criteria: Areas are classified into three groups: low (1 = <5.5ft/min); medium (3 = 5.5 to 55 ft/min), and high (5 = > 55 ft/min).

Justification: ROS is the horizontal distance that the flame zone moves per unit of time (feet/minute) and is influenced strongly by type of fuels, wind, and topography of an area. ROS is important in indicating how fast a fire will travel and reach a point of concern, and impacts the type and number of suppression resources needed to contain a fire.

Data Description: ROS was modeled using FlamMap, an interagency fire behavior mapping and analysis program that computes potential fire behavior characteristics. The tool uses eight spatial input data layers to represent biophysical conditions and weather parameters to simulate wind and fuel moisture conditions. The spatial input layers were created by Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) and include elevation, slope, aspect, canopy closure, fuel model 40 (using 40 fuel models described by Scott and Burgan, 2005), canopy base height, and canopy bulk density. The weather parameters were collected from the RAWS weather stations in New Mexico. ROS was modeled by individual fire zones, created by the Southwest Coordination Center (SWCC). The weather data for the northern and western fire zones (101, 102, 103, 109, 110, and 113) represent the average early summer (May and June) conditions; the weather data for the eastern fire zones (104, 108, 114, 115) represent the average early spring (March and April) conditions; and the weather data for the southern and central fire zones (105, 106, 107, 111, 112) represent the average spring (April and May) conditions.

Data Source: The ROS layer was created by The Nature Conservancy in New Mexico in 2009.

2. Flame Length (Feet)

Function: Gives value to areas with the potential for high and extreme flame lengths.

Criteria: Areas are classified into five groups: 1 = low flame length (0 to 1 feet); 2 = low/medium flame length (1 to 4 feet); 3 = medium flame length (4 to 8 feet); 4 = high flame length (8 to 11 feet); and 5 = extreme flame length (>11 feet).

Justification: Flame length is the distance from the base of the flame to the tip of the flame in a fire burning in surface fuels. Flame length is an indicator of fire intensity at the active, flaming front and is a good measure of what suppression resources can be used on a fire. The intensity of a surface fire is also an important measure of the likelihood of a fire moving into the forest canopy. As a general rule, flame lengths less than four feet can be managed by ground crews, between four and eleven feet requires aerial equipment, greater than eleven feet are unmanageable even with aerial equipment.

Data Description: Flame length was modeled using FlamMap, an interagency fire behavior mapping and analysis program that computes potential fire behavior characteristics. The tool uses eight spatial input data layers to represent biophysical conditions and weather parameters to simulate wind and fuel moisture conditions. The spatial input layers were created by LANDFIRE and include elevation, slope, aspect, canopy closure, fuel model 40, canopy base height, and canopy bulk density. The weather parameters were collected from the RAWS weather stations in New Mexico.

Flame length was modeled by individual fire zones, created by the Southwest Coordination Center (SWCC). The weather data for the northern and western fire zones (101, 102, 103, 109, 110, and 113) represent the average early summer (May and June) conditions; the weather data for the eastern fire zones (104, 108, 114, 115) represent the average early spring (March and April) conditions; and the weather data for the southern and central fire zones (105, 106, 107, 111, 112) represent the average spring (April and May) conditions.

The technical team reviewed the initial FlamMap results and noted that the results were lower than expected given their knowledge of the area for fire zone 101 (northwest portion of state, particularly in the Navajo checkerboard area), fire zone 102 (in the piñon-juniper and sagebrush surrounding the Jemez and Taos Box), and fire zone 113 (in the upper elevations of the Sacramento Mountains). For fire zone 101 and 102 much of the landscape that was identified as piñon juniper, sagebrush and intermountain steppe were modeled by LANDFIRE as grass fuel models. The fuel model 40 input layer was changed for those vegetation types to a shrub model and the FlamMap models were re-run. In fire zone 113, the timber models more closely correlated to the vegetation classification of timber, however, the recorded RAWS data were significantly lower than what the technical team expected for the area. The model was rerun with averages from Gila with no significant increase. The technical team noted that for this zone the flame length is lower than what they would expect. However, overall the statewide flame length layer is representative of expectations and useful for landscape (not project) planning and prioritization.

Data Source: The Flame Length layer was created by The Nature Conservancy in New Mexico in 2009.

3. Crown Fire Potential

Function: Gives value to areas with potential for high to extreme crown fire.

Criteria: Areas with potential for crown fire are given a value of 5; otherwise 0, indicating surface fire or no data.

Justification: Crown fire is the movement of fire into and through the tree canopy. Crown fires typically move rapidly, and are very intense. Passive crown fire does not carry continuously through the canopy, but burns crown fuels intermittently (i.e. when individual trees or groups of trees burn). Active crown fire carries continuously through the canopy. Crown fires are the most difficult and dangerous types of fire to fight.

Data Description: Crown fire potential was modeled using FlamMap, an interagency fire behavior mapping and analysis program that computes potential fire behavior characteristics. The tool uses eight spatial input data layers to represent biophysical conditions and weather parameters to simulate wind and fuel moisture conditions. The spatial input layers were created by LANDFIRE and include elevation, slope, aspect, canopy closure, fuel model 40, canopy base height, and canopy bulk density. The weather parameters were collected from the RAWS weather stations in New Mexico. Crown fire potential was modeled by individual fire zones, created by the SWCC then combined using the mosaic to new raster function in ArcGIS. The weather data for the northern and western fire zones (101, 102, 103, 109, 110, and 113) represent the average early summer (May and June) conditions; the weather data for the eastern fire zones (104, 108, 114, 115) represent the average early spring (March and April) conditions; and the weather data for the southern and central fire zones (105, 106, 107, 111, 112) represent the average spring (April and May) conditions. The FlamMap model result classifies crown fire potential into three categories: surface fire, passive crown fire, and active crown fire. The technical team recommended that the result be grouped into two categories: 1. areas with *no* crown fire potential, and 2. areas with crown fire potential.

Data Source: The Crown Fire Potential layer was created by The Nature Conservancy in New Mexico in 2009.

4. Ignition Probability (# fires per square kilometer)

Function: Gives value to areas where fires are likely to occur.

Criteria: Pixels are given value of the number of fires that have occurred per square kilometer.

Justification: There will be an increase in probability of a fire occurring in areas where they have occurred in the past.

Data Description: USFS, State Forestry, BLM, and DOI fire occurrence point locations from 1987 to 2008 were combined and converted into a fire occurrence probability or density grid using the point statistic spatial analyst tool in ArcGIS.

Data Source: The fire occurrence point data were supplied by New Mexico State Forestry, BLM, BIA, and USFS. The fire occurrence density layer was created by The Nature Conservancy in New Mexico in 2009.

5. Fire Regime Condition Class (FRCC)

Function: Gives value to areas considered in departure from historic range of variability.

Criteria: Areas identified as FRCC 2 are given a value of 1 and areas identified as FRCC 3 are given a value of 2; otherwise 0 indicates FRCC 1 or no data.

Justification: FRCC is a tool for determining how similar a landscape's fire regime is to its natural or historical state. FRCC 1 indicates low departure or areas that contain vegetation, fuels, and disturbances characteristic of the natural regime; FRCC 2 indicates moderate (33-66 %) departure from the natural regime; and FRCC 3 (> 66%) indicates high departure. A watershed in FRCC 1 reflects a landscape with key ecosystem structure and processes intact; whereas a watershed predominantly in FRCC 3 reflects a landscape that has lost key ecosystem characteristics. For example, the departure could be a dominance of dense stands within forested systems which historically were more open or the loss of characteristic large trees due to unusually large wildfires.

Data Description: FRCC was modeled using an ArcGIS tool developed by the National Interagency Fuels, Fire, and Vegetation Technology Transfer (NIFFT) project. The tool uses two GIS data layers created by LANDFIRE including biophysical setting and succession class to evaluate current condition. The tool then compares current condition to a database of historic conditions to derive relative departure of vegetation and structure. All data layers were downloaded from landfire.gov in 2009.

While an ecological measure was considered to be important for accurately modeling fire risk across the state, FRCC was intentionally weighted lower in the model. FRCC was not regarded as an effective measure of ecological health. The technical team identified the development and incorporation of an ecological health measure that more accurately reflects impact of catastrophic wildfire on functioning of ecosystems as a high priority data gap.

Data Source: The FRCC layer was created by The Nature Conservancy in New Mexico in 2009.

6. Wildland Urban Interface (WUI)

Function: Gives value to areas considered to be Wildland Urban Interface (WUI).

Criteria: Pixels considered to be WUI given a value of 5; otherwise 0.

Justification: WUI is the area where structures and other human development meet or intermingle with undeveloped wildland.

Data Description: The USFS, Silvis Lab developed a statewide WUI layer (see metadata for more information). New Mexico State Forestry provided Community Wildfire Protection Plans (CWPPs), developed by individual counties and communities. These plans identified WUI areas. CWPPs for 26 of 33 counties have been completed and are available.

The Silvis WUI and CWPP WUI layers were combined, except where county CWPPs had identified the entire county as a WUI. These large CWPP identified WUI areas were removed because the technical team did not want to bias the statewide prioritization toward counties that had taken a more general approach to identifying WUI and away from counties that had identified smaller WUI areas. For this reason, the technical team recommended removal of large blocks of CWPP identified WUI areas in Torrance and Socorro County as well. However, it is important to note that the CWPP identified WUI areas that were removed should be considered priorities for planning, particularly at county level. The Silvis WUI and CWPP WUI were combined, converted to raster and were assigned a value of 5, otherwise 0.

Data Source: USFS, Silvis WUI layer was downloaded from http://silvis.forest.wisc.edu/projects/WUI_Main.asp in 2009. The CWPP WUI polygons were obtained from New Mexico State Forestry. The combined WUI layer was created by The Nature Conservancy in New Mexico in 2009

Data Considered but not Used

1. *Index of Community Capacity for Protection from Wildfires (ICCPW).* The ICCPW is designed to integrate social, human, financial, and political capital into a single measure. Nine indicators, including age dependency ratio, percent without disabilities, female only headed households, education, percent employed, English proficiency, median income, percent of community below poverty line, were used to the ICCPW. The community capacity data layer was created by the Forest Guild in 2007. Details of the methodology can be found in Evans et al. (2007). The technical team decided the layer was too general to be used as a community capacity metric in the fire risk model.

2. *Distance to roads*. A distance to roads measure was recommended as a proxy for community capacity. The distance to roads layer primarily emphasized wilderness areas and the metric was removed.
3. *ISO fire ranking*. This data source was recommended to display community capacity to respond to fires. The data exist but were not available in the time frame of the project and was not reviewed by the technical team. A portion of the technical team was unsure about its applicability to a statewide model since it focus on fire capacity is most applicable to structural fires and not to wildland fires.
4. *Distance to fire station*. This measure was recommended to show community capacity. A statewide fire station layer was not available.

Data Gaps/Data Needs

Table 8-1: Wildfire Risk Data Gaps

Ranking	Data Gap Description
Very High	Compatible information and data layers representing a consistent, standard method for assessing wildfire conditions by all the agencies with jurisdictional responsibilities. The technical team viewed this data need as the highest priority as it needs to happen before the other identified needs.
High	Development and incorporation of an ecological health measure into wildfire protection planning that more accurately reflects impact of catastrophic fire on functioning of ecosystems. Fire Regime Condition Class was not considered an effective measure by the technical team.
High - 2	A comprehensive, statewide spatial layer representing all vegetation manipulation actions (wildfire, RX fire, mechanical treatment (harvest, TSI, etc.)) for a minimum of the last 20 years but preferably for the last 50 to 75 years. This layer would be invaluable for planning and implementation of wildfire management at the landscape scale.
High - 3	Development of a comprehensive, statewide value at risk layers. The values need to include cultural resource sites and high density recreation areas but may also include riparian corridors, habitat for species of concern layers, private improvements on government lands that need protection, or private improvements in the wildland urban interface that require consideration. Some CWPPs address this issue but a consistent, comprehensive, statewide approach is lacking.

Technical Advisory Team

Bill Armstrong – USFS, Santa Fe National Forest, AMFO Fuels
Bill Van Bruggen – United States Forest Service, Region 3, Deputy Regional Fire Director
Bruce Bauer – Santa Clara Pueblo, Forester
Craig Allen – United States Geologic Survey, Jemez Mountains Field Station, Scientist
Doug Boykin – Energy Minerals and Natural Resources Department, Forestry Division, District Forester
Fred von Bonin – Bureau Indian Affairs, Forestry Specialist
Hal Luedtke – Bureau Indian Affairs, Forestry Specialist
Harold Riggs – United States Forest Service, Region 3, Regional Fire Planner
Jennifer Myslivy – Bureau Land Management, Fuels Specialist
John Tunberg – Natural Resources Conservation Service

Joy Esparsen – New Mexico Association of Counties
Kent Reid – New Mexico Highlands University, New Mexico Forest and Watershed Restoration Institute, Interim Director
Linda Gaume Jaramillo – New Mexico Municipal League
Mary Stuever – Energy Minerals and Natural Resources Department, Forestry Division, State Timber Management Officer
Melissa Savage – Four Corners Institute
Steve Cary – New Mexico State Parks
Terrell Treat – Energy Minerals and Natural Resources Department, Forestry Division, Wildland Urban Interface Specialist

Citations

Evans, A. M., M. DeBonis, E. Krasilovsky, and M. Melton. 2007. Measuring Community Capacity for Protection from Wildfire. Forest Guild, Santa Fe, NM.

FlamMap, the interagency tool used to model crown fire potential, flame length and rate of spread - http://www.firemodels.org/content/view/14/28/

Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) – source of all spatial inputs for crown fire, flame length and rate of spread modeling - http://www.landfire.gov/datatool.php

Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

Southwest Coordination Center (SWCC): source for fire weather zones - http://gacc.nifc.gov/swcc/predictive/weather/weather.htm

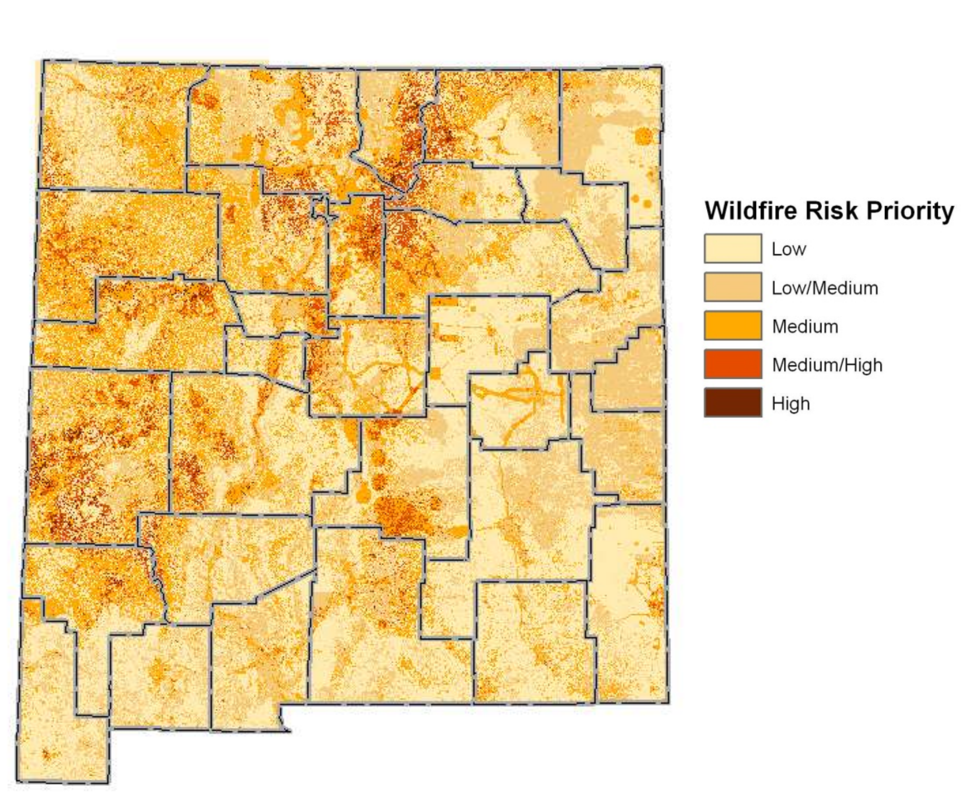
Map 8-1 - Wildfire Risk Model: 1. Crown Fire Potential; 2. Flame Length (feet); 3. Rate of Spread (feet/minute); 4. Wildland Urban Interface; 5. Ignition Probability (# fires/sq. km.); 6. Fire Regime Condition Class

Wildfire Risk: The intent of the wildfire risk data layer is to identify areas where planning and management are likely to reduce a relatively high risk of *destructive* fire.

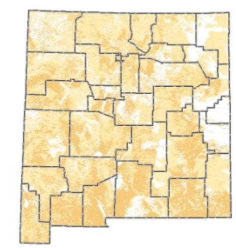
Legend

- 1
- 2
- 3
- 4
- 5

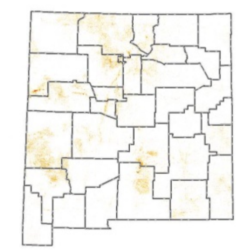
**See Model Factor Descriptions for Class Categories*



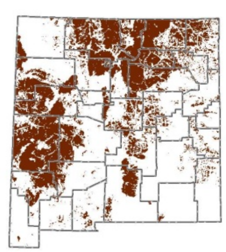
FRCC



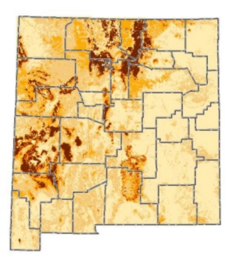
Ignition Probability



Crown Fire Potential



Flame Length



Rate of Spread

WUI