San Luis Valley – Taos Plateau Level IV Ecoregion Landscape Assessment

Draft Final Report

BLM

ANL/EVS-16/5

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NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

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CONTENTS

NOTATION .... **x**

1 INTRODUCTION **1**

1.1 Purpose of Rapid Ecoregional Assessments 1
1.2 Purpose of this Landscape Assessment 1
1.3 Elements of this Landscape Assessment 3
1.3.1 Management Questions 4
1.3.2 Conceptual Models 5
1.3.3 Conservation Elements 5
1.3.4 Change Agents 11
1.3.5 Landscape Intactness Model 11
1.4 Assumptions, Data Limitations, and Data Gaps 11
1.5 Landscape Assessment Workflow 14

2 BACKGROUND ON THE SAN LUIS VALLEY – TAOS PLATEAU LEVEL IV ECOREGION **15**

2.1 Climate 16
2.2 Ecological Resources 17
2.3 Hydrology 18
2.4 Cultural History 18

3 SUMMARY OF METHODOLOGY **19**

3.1 Data Management 19
3.2 Models, Methods, and Tools 20
3.2.1 Conceptual Models 20
3.2.2 Geoprocessing Models 24
3.2.3 Landscape Intactness Modeling 24
3.2.4 Climate Change Modeling 30
3.2.5 Human Development Intensity Modeling 37
3.2.6 Invasive Species, Insects, and Disease Modeling 40
3.2.6.1 Current Invasive Species, Insects, and Disease Distribution 43
3.2.6.2 Near-Term Future Invasive Species, Insects, and Disease Potential 46
3.2.7 Wildfire Modeling 50

4 EVALUATION OF CURRENT AND FUTURE CONDITIONS **55**

5 SUMMARY AND CONCLUSION **69**

5.1 Application of Landscape Assessment Results to Conservation Planning 69
5.2 Limitations and Information Gaps 73
5.3 Conclusion 74

6 REFERENCES **75**

CONTENTS (Cont.)

APPENDIX A: EVALUATION OF MANAGEMENT QUESTIONS A-1

A.1 Management Questions for Soils and Air Quality A-6
A.2 Management Questions for Hydrology A-21
A.3 Management Questions for Ecological Systems Conservation Elements A-51
A.4 Management Questions for Focal Species Conservation Elements A-57
A.5 Management Questions for Wildfire A-105
A.6 Management Questions for Invasive Species, Insects, and Disease A-119
A.7 Management Questions for Human Development and Resource Use A-130
A.8 Management Questions Related to Climate Change A-146
A.9 Management Questions for Human and Cultural Elements A-154
A.10 Management Questions Pertaining to Landscape Intactness A-155
A.11 Management Questions for Visual Resources A-163
References for Appendix A A-183

APPENDIX B: EVALUATION OF CONSERVATION ELEMENTS B-1

B.1 Ecological Systems Conservation Elements B-19
B.2 Focal Species Conservation Elements B-63
B.3 Sites of Conservation Concern Conservation Element B-199
B.4 Ecosystem Function Conservation Elements B-210
B.5 Cultural and Historic Conservation Elements B-211
References for Appendix B B-212

APPENDIX C: DATA INVENTORY C-1

APPENDIX D: GLOSSARY D-1

FIGURES

1-1 Study area for the San Luis Valley-Taos Plateau Level IV Ecoregion Landscape Assessment, located in southern Colorado and northern New Mexico. 2

1-2 Distribution of Ecological Systems Conservation Elements in the San Luis Valley-Taos Plateau Landscape Assessment study area. Data Source: LANDFIRE Existing Vegetation Types. 10

3-1 General ecosystem-based Conceptual Model for the San Luis Valley – Taos Plateau Level IV Ecoregion. 22

3-2 Conceptual model for the Basin Grassland and Shrubland Ecological System Conservation Element. Additional CE-specific conceptual models are provided in Appendix B. 23

3-3 Example geoprocessing model to union wetland datasets in Colorado and New Mexico. 24

FIGURES (Cont.)

3-4 Distance decay functions for the three types of roadways evaluated in the development of the Landscape Intactness Model. Refer to Table 3-2 for model parameterization. 27

3-5 Histogram and breakpoints used to assign intactness categories for the current landscape intactness model and near-term future landscape intactness model. Breakpoints correspond to the following intactness categories: Very Low, Low, Moderately Low, Moderately High, High, and Very High. 28

3-6 Current and Near-term Future Landscape Intactness Model for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. Landscape intactness is summarized to 1 km^2 reporting units and categorized from very low intactness to very high intactness. 29

3-7 Process model for the characterization of current climate change. The current climate change model was developed using PRISM monthly averages in precipitation and temperature over a 30-year current period compared to a historic reference period. 32

3-8 Process model for the characterization of long-term future climate change. The future climate change model was developed using 30-year period average IPCC A1B estimates for the period 2040-2069 compared to PRISM estimates for the current period. 33

3-9 Histogram and breakpoints used to assign categories current climate change and long-term future climate change. Breakpoints correspond to the following categories used to describe potential for climate change: Very Low, Low, Moderate, High, and Very High. 34

3-10 Current change in climate for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 35

3-11 Long-term future climate change potential for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 36

3-12 Histogram and breakpoints used to assign categories of current human development intensity. The same breakpoints were used to assign categories for near-term future human development intensity. 37

3-13 Current human development intensity modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 38

3-14 Near-term future human development intensity modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 39

3-15 Process model to characterize current distribution of invasive species, insects, and disease. 44

FIGURES (Cont.)

3-16 Current distribution of invasive species, insects, and disease modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment... 45

3-17 Distance decay functions for human land use datasets categorized by moderate risk classes and high risk classes to develop the future exotic species invasion risk model.. 48

3-18 Near-term future distribution of invasive species, insects, and disease modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment.............................. 49

3-19 Process model to characterize historic-current distribution of wildfire........................... 50

3-20 Distribution of historic and current wildfire modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 51

3-21 Near-term future potential for wildfire modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 53

4-1 Current Vegetation Departure.. 58

4-2 Current Distribution of the Basin Grasslands and Shrubland. Data Source: LANDFIRE EVT. 59

4-3 Current vegetation departure from historic conditions within the Basin Grassland and Shrubland Ecological System. Data Sources: LANDFIRE EVT and VDEP. Data were Summarized to 1 km^2 Reporting Units.. 60

4-4 Current and Future Landscape Intactness of Basin Grasslands and Shrublands. NOTE: This landscape intactness model does not include LANDFIRE Vegetation Departure. Data Sources: LANDFIRE EVT and landscape intactness. 63

4-5 Current distribution and status of the Basin Grassland and Shrubland Ecological System relative to change agents. Data Sources: LANDFIRE EVT and change agent models. 64

4-6 Potential future vulnerability of the Basin Grassland and Shrubland Ecological System to change agents. Data Sources: LANDFIRE EVT and change agent models. Future climate change projections were made for a 2040-2069 temporal period; all other future change agent models were developed for a 2015-2030 temporal period. 65

4-7 Predicted Trends in Basin Grassland and Shrubland Habitat within the Study Area....... 66

4-8 Basin Grassland and Shrubland Aggregate Potential for Change. Data Sources: LANDIFRE EVT and Potential for Change. 67

5-1 Current and Future Landscape Intactness within Sites of Conservation Concern. Data Sources: Sites of conservation concern and landscape intactness........................... 70

FIGURES (Cont.)

5-2 Trends in Landscape Intactness within Sites of Conservation Concern. 71

5-3 Current and Future Landscape Intactness of Wildlife CHAT Habitat. 72

5-4 Trends in Landscape Intactness within Crucial Wildlife CHAT Habitats. 73

TABLES

1-1 Major components of the San Luis Valley – Taos Plateau Landscape Assessment. 4

1-2 Management Questions identified for the San Luis Valley –Taos Plateau Landscape Assessment. 6

1-3 Conservation Elements Evaluated in the San Luis Valley-Taos Plateau Landscape Assessment. 9

1-4 Summary of Assumptions, Data Limitations, and Data Gaps 14

2-1 Counties Included in the Landscape Assessment. 15

2-2 Land management within the San Luis Valley – Taos Plateau Landscape Assessment study area. 16

3-1 Example effects of proximity to human developments on wildlife and habitat. 25

3-2 Landscape Intactness Model impacting factors, site impact scores, and distance decay scores for the San Luis Valley – Taos Plateau Landscape Assessment. 26

3-3 Future Exotic Species Invasion Risk Model Input Human Land-Use Data and Risk Classes for the San Luis Valley – Taos Plateau Landscape Assessment. 47

3-4 Input datasets used to characterize the historic-current distribution of wildfire in the study area. 50

4-1 Total current distribution area for ecological systems and terrestrial focal species for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. 55

NOTATION

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
AMT	Assessment Management Team
Argonne	Argonne National Laboratory, Environmental Science Division
BLM	Bureau of Land Management
CA	Change Agent
CE	Conservation Element
DMP	Data Management Plan
EVT	Existing Vegetation Type
FGDC	Federal Geographic Data Committee
GEOMAC	Geospatial Multi-Agency Coordination
IDT	Interdisciplinary Team
IID	Invasive species, Insects, and Disease
LA	Landscape Assessment
MQ	Management Question
NOC	National Operations Center
REA	Rapid Ecoregional Assessment
SEZ	Solar Energy Zone
SRMS	Solar Regional Mitigation Strategy
VDEP	Vegetation Departure

UNITS OF MEASURE

km^2	square kilometers(s)
m	meter(s)

UNIT CONVERSIONS

1 km^2	0.39 mi^2
1 m	3.28 ft

1 INTRODUCTION

1.1 Purpose of Rapid Ecoregional Assessments

Rapid Ecoregional Assessments (REAs) undertaken by the Bureau of Land Management (BLM) provide a broad-scale synthesis of natural resource status and trends within an ecoregion. Through the assessment of available data using relatively rapid assessment approaches and GIS analyses, REAs are useful in addressing a broad range of regional management questions in a timely fashion and identifying knowledge gaps for future study. Fifteen BLM REAs have been completed or are underway in 2015 (http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html). Ecoregions are areas of general similarity in terms of the type, quality, and quantity of environmental resources (Omernick and Griffith 2014). The REAs characterize the current status of select Conservation Elements (CEs) and forecast trends and future vulnerability of these resources to Change Agents (CAs). The REAs have received particular emphasis in the BLM's landscape approach to land management, and are tools in implementing U.S. Department of the Interior Secretarial Orders to use landscape approaches in evaluating the impacts of climate change, energy development, and other activities occurring on public lands (USDOI 2010, 2013). The REAs are intended to serve several purposes pertaining to natural resource management:

- Understand landscape-level status and trends of Conservation Elements;
- Characterize current and potential influences (Change Agents) in the ecoregion;
- Understand landscape-level impacts of human development activities;
- Inform the development of ecoregion-based conservation strategies;
- Inform landscape planning decisions (including identification of regional mitigation opportunities); and
- Provide baseline for long-term monitoring and adaptive management.

REAs are useful in landscape-scale management by compiling, maintaining, and synthesizing regional data and making the data and syntheses transparent and available to land managers and the public. The REAs rely on available information and are not designed to involve field data collection or research. REAs also provide a baseline condition from which to evaluate the results of adaptive management and to characterize potential trends in resource condition over time. While REAs are developed at an ecoregional scale, and for a finite set of management questions, they provide conceptual models and an assessment framework that can be revised for use at different scales (e.g., field office level) and for a different suite of resource issues.

1.2 Purpose of this Landscape Assessment

This Landscape Assessment (LA) was developed following the methodology of existing BLM REAs. The assessment was conducted within the San Luis Valley –Taos Plateau Level IV ecoregion (**Figure 1-1**) to document the current status of Conservation Elements at the ecoregional scale and evaluate the trends and vulnerability of these resources to Change Agents over time. This LA is based on approaches similar but not identical to BLM REA approaches completed for the Colorado Plateau and Mojave Basin and Range Ecoregions (Bryce et al. 2012, Comer et al. 2013a). The main distinctions like in scope:

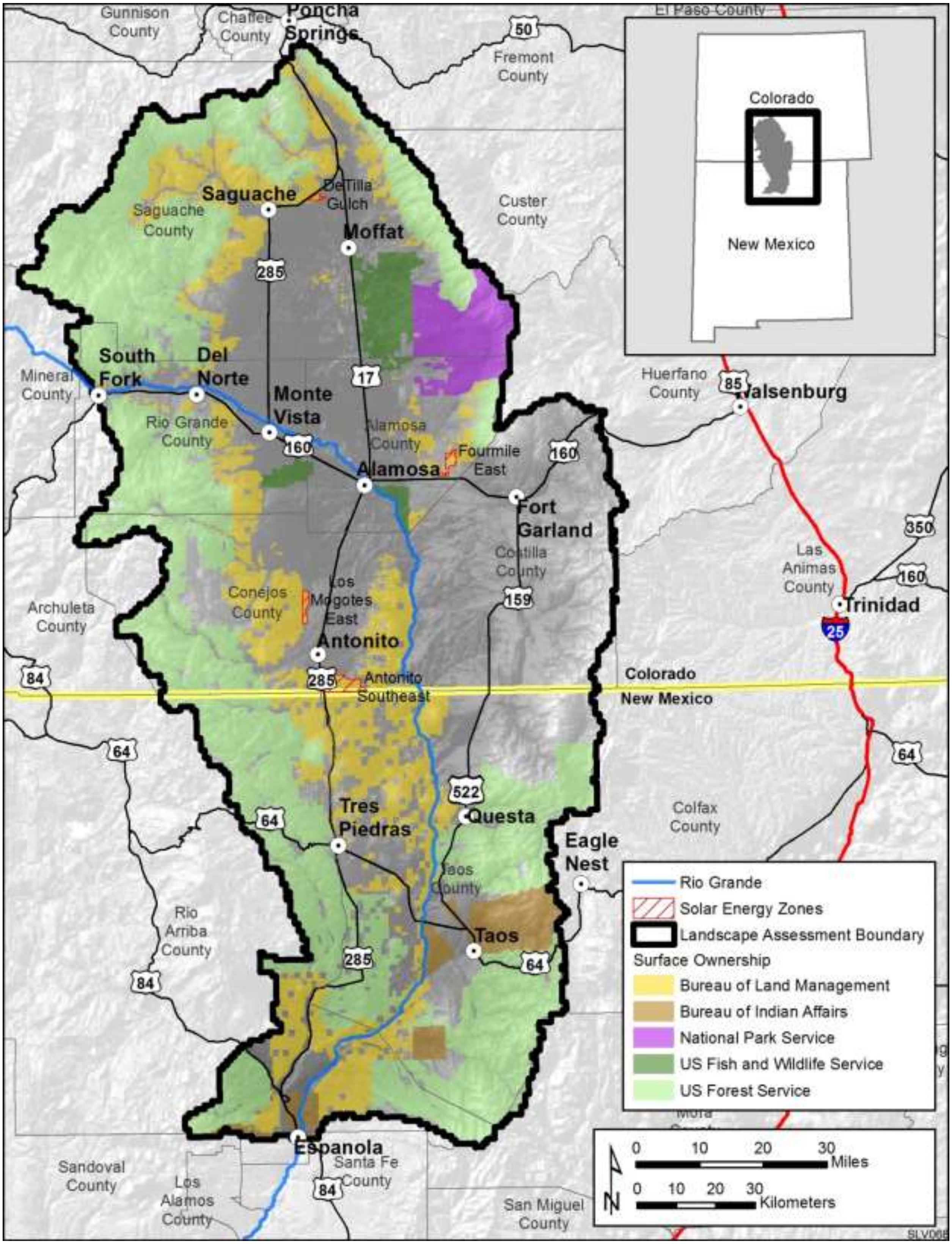

Figure 1-1. Study area for the San Luis Valley-Taos Plateau Level IV Ecoregion Landscape Assessment, located in southern Colorado and northern New Mexico (inset).

- Whereas BLM REAs are generally prepared at the scale of a Level III Ecoregion (generally >100,000 km^2 in size), the focus for this LA is a smaller Level IV Ecoregion (approximately 25,346 km^2) of the Upper Rio Grande landscape occurring within the CO-NM Plateau. This smaller LA study area contains three BLM Colorado Solar Energy Zones (SEZs)[1] defined as priority areas for renewable energy (solar) development (BLM 2012a).

- The primary objective of this LA is to inform landscape-based mitigation strategies for solar energy development in Colorado within these SEZ priority areas. Management Questions (MQs) and Conservation Elements (CEs) selected for this LA were developed to inform regional mitigation planning for solar development that is ongoing through a concurrent Solar Regional Mitigation Strategy (SRMS) development process. Although this LA was prepared with focus on mitigation planning for utility-scale solar energy development, the assessment is intended to have applicability to other resource and conservation issues and future land management decisions. It is anticipated that this LA will inform other BLM land use planning activities in the region (e.g., Rio Grande del Norte National Monument planning efforts).

- In addition, this LA also includes an initial identification of MQs and CEs for cultural and visual resources within the study area in an effort to inform solar regional mitigation strategies. Although some resources with cultural resource values (such as Specially Designated Areas) have typically been evaluated in previous REAs (e.g., Bryce et al. 2012, Comer et al. 2013a), these REAs have primarily focused on ecological resources and have not thoroughly evaluated cultural and visual resources. For this LA, greater efforts have been made to assess condition and trends of cultural and visual landscapes, values, and areas of connectivity. In this LA, MQs and CEs for cultural and visual resources are identified and presented; associated separate reports present more detailed information on cultural and visual resource assessment. A separate report on potential air quality issues associated with dust in the study area also supports the evaluation of air quality MQs and CEs (Chang et al. 2016).

1.3 Elements of this Landscape Assessment

The major components of the LA are discussed below and summarized in **Table 1-1**. This LA is grounded in Management Questions (MQs) that are used to frame regionally important land management issues for the BLM. The MQs guide the identification and evaluation of Conservation Elements (CEs) and how they interact with and may be influenced by Change Agents (CAs). Conceptual models are also an important component of this LA to illustrate key relationships between CEs, biophysical properties of the environment, and CAs.

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[1] As of May 2015, the BLM has designated four SEZs in the study area. However, one SEZ (Fourmile East) is not prioritized for regional mitigation planning. Maps shown in this LA may show all four SEZs but priority is given to the following three SEZs for regional mitigation planning: Antonito Southeast, DeTilla Gulch, and Los Mogotes East.

Table 1-1. Major components of the San Luis Valley – Taos Plateau Landscape Assessment.

Component	Description
Management Questions	Questions about important resources and their attributes for addressing land management responsibilities. Management Questions guide the selection and evaluation of Conservation Elements.
Change Agents	Primary drivers that either currently influence or could influence Conservation Elements. The four change agents evaluated in this LA include climate change, human development, invasive species, and wildfire.
Conservation Elements	A limited number of resources with regional conservation importance. Resources addressed through Conservation Elements in this LA include species, species assemblages, ecological systems, habitats, physical resources (e.g., air, soils, hydrology), and cultural and visual resources.
Conceptual Models	Illustrative depictions of the interactions between Conservation Elements, the biophysical properties of the environment, and Change Agents. Conceptual Models show the relationships and mechanisms of their interactions.

1.3.1 Management Questions

The MQs were identified in 2013-2014 by the BLM interdisciplinary team (IDT) and assessment management team (AMT) to identify the information needed for addressing public land management responsibilities as defined in the BLM San Luis Resource Area Resource Management Plan (BLM 1991) and amendments, and BLM Taos Resource Area RMP (BLM 2012a). The MQs form the foundation of the LA by guiding the selection of CEs and identifying information needed to understand how CAs influence those CEs. The MQs helped to focus the LA process and ensured that the most relevant datasets were compiled, analyzed, and summarized. The MQs may pertain to either CEs or CAs. There are also integrative MQs that address the interaction of CAs and CEs. Common aspects of MQs include the following:

- What and where are key attributes of Conservation Elements?
- What and where are the Change Agents?
- Where do the Change Agents overlap with key attributes of Conservation Elements?
- How do the Change Agents affect the key attributes of Conservation Elements?

A total of 56 MQs in 11 topical areas were identified as relevant for this LA. The list of MQs for this LA is provided in **Table 1-2**. Most MQs are presented with their results in **Appendix A**; however, a few MQs were deferred from assessment in this LA due to lack of data, or were assessed through other efforts associated with the SRMS for Colorado solar energy zones.

1.3.2 Conceptual Models

Conceptual models are graphical representations of the role of CEs and their interactions between biophysical properties and CAs. The scientific literature was used to develop two types of conceptual models for this Landscape Assessment. The first type of conceptual model consisted of a general ecosystem-based model to illustrate the roles of CAs and CEs and their interactions in the ecosystem. In addition, conceptual models for ecological CEs (ecological systems and focal species) were developed to highlight the major processes by which CAs may affect each ecological CE. These more detailed models also identify which mechanisms may be spatially addressed in this Landscape Assessment, as well as data gaps. Conceptual models are useful in highlighting important ecosystem components and interactions that may be used to inform land management decisions (DiGennaro et al. 2012). Conceptual models are discussed further in **Section 3.2.1** and all CE-specific conceptual models are provided in **Appendix C**.

1.3.3 Conservation Elements

A regionally significant CE has attributes that give it more than local significance, especially compared to similar resources. Regionally significant CEs considered in this LA represented a number of resources with regional conservation importance in 2014. CEs that were selected for final inclusion in this LA are listed in **Table 1-3**. Information on the selection process for the CEs evaluated in this LA is provided in the Phase I report (Argonne 2014). It is important to note that while a finite list of CEs was selected for this LA, the assessment process demonstrated in this LA can be repeated in the future for additional CEs with available data. The 23 CEs evaluated in this LA consisted of (A) four broad Ecological System Macrogroups–basin grassland and shrubland systems, montane and subalpine conifer forest systems, pinyon-juniper woodland systems, and riparian and wetland systems; (B) twelve focal wildlife species; (C) sites of conservation concern; and (D) six ecosystem functions. In addition, cultural and historic CEs have been identified and evaluated as part of a separate yet parallel Cultural Heritage Values and Risk Assessment (Wescott et al. 2016). A map representing the spatial distribution of the four Ecological Systems across the study area is provided in **Figure 1-2**. A total of twelve focal species and assemblages were also chosen for evaluation. Detailed discussion of the natural history, status, and distribution of these focal species CEs is provided in species accounts in **Appendix B**.

Table 1-2. Management Questions identified for the San Luis Valley –Taos Plateau Landscape Assessment.[2]

Management Questions	
A. Soils and Air Quality	
MQA1	Where are Class I Prevention of Significant Deterioration (PSD) areas?
MQA2	Where are soil systems with potential for erosion (including coarse-textured, calcic, saline, sodic, and shallow soils; salt crusts, low water holding capacity soils, and soils susceptible to wind erosion)?
MQA3	Where are soil systems of concern vulnerable to change agents?
MQA4	Where are communities and hydrologic basins susceptible and/or sensitive to fugitive dust and dust-on-snow events?
MQA5	Where are Clean Air Act (CAA) criteria pollutant source areas for PM10 and PM2.5?
B. Hydrology	
MQB1	Where are and what are the conditions of hydrologic features including lotic and lentic features and artificial surface water bodies (e.g., perennial, intermittent, and ephemeral streams and springs; playas; wetlands; lakes; reservoirs; wells; ponds; livestock and wildlife watering tanks)?
MQB2	Where are impaired waters and aquatic systems (such as those included in the EPA 303(d) and 305(b) lists)?
MQB3	Where are mountain snow pack, rainfall, and alluvial aquifers and their recharge areas?
MQB4	Where are hydrologic systems vulnerable to change agents?
MQB5	Where are the areas that are susceptible to early snow melt due to dust on snow?
MQB6	What are seasonal discharge maxima and minima for the Rio Grande, Closed Basin, and major tributaries at gaging stations?
MQB7	Where are the confined and unconfined recharge or discharge areas?
C. Ecological Systems Conservation Elements	
MQC1	Where are existing vegetative communities?
MQC2	Where are vegetative communities vulnerable to change agents in the future?
MQC3	Where are areas of highest carbon sequestration and what are conditions and trends of carbon sequestration in the study area?
MQC4	What change agents have affected existing vegetation communities?
MQC5	How will vegetation communities be altered (e.g. state-in-transition) according to the change agents?
D. Focal Species Conservation Elements	
MQD1	What is the current distribution and status of available and suitable habitat for focal species Conservation Elements?
MQD2	What is the distribution of current and potentially suitable habitat, if available, for aquatic, terrestrial, and riparian biodiversity sites, and special status species?
MQD3	Where are focal species vulnerable to change agents in the future?

[2] Please refer to the Phase I Report (Argonne 2014) for information on how Management Questions were selected for this Landscape Assessment. Management Questions are addressed in this Landscape Assessment in Appendix A.

Management Questions	
D. Focal Species Conservation Elements (Cont.)	
MQD4	Where are aquatic, terrestrial, and riparian biodiversity sites, and special status species vulnerable to change agents in the future?
MQD5	What is the current distribution and status of big game crucial habitat and movement corridors (including bighorn sheep, elk, mule deer, and pronghorn)?
E. Wildfire	
MQE1	Where has wildfire occurred in the past 20 years?
MQE2	Where are the Fire Regime Condition Classes?
MQE3	Where is fire adverse to ecological communities, features, and resources of concern?
MQE4	Where are the areas with potential to change from wildfire in the future?
MQE5	Where is fire likely to change in relation to climate change?
MQE6	Where might fire interfere with future human development (e.g., development risk)?
F. Invasive Species	
MQF1	Where are areas that invasive species occur or could potentially occur (e.g. tamarisk, Russian Olive, cheatgrass)?
G. Human Development and Resource Use	
MQG1	Where are linear recreation features such as OHV roads and trails?
MQG2	Where are Special Recreation Permits (SRPs) and permitted uses such as grazing and wood gathering?
MQG3	Where are the locations of irrigated lands
MQG4	Where are high-use recreation areas, (High Intensity Recreation Areas (HIRA's) Special Recreation Management Areas, National Parks, etc.)?
MQG5	Where are areas of current and planned development (e.g., plans of operation, urban growth, wildland-urban interface, energy development, mining, transmission corridors, governmental planning)?
MQG6	Where are federally owned water rights that are adjudicated for wildlife and irrigation?
MQG7	Where are areas of potential future development (e.g., under lease), including renewable energy sites and transmission corridors?
MQG8	Where are areas of potential human land use change (e.g., agricultural fallowing)?
MQG9	What are the conditions and locations of surface and groundwater rights?
MQG10	Where are current conservation efforts prohibiting human development?
MQG11	Where is the acoustic environment affected by human development?
H. Climate Change	
MQH1	Where are areas with greatest long-term potential for climate change?
MQH2	Where have conservation elements experienced climate change and where are conservation elements vulnerable to future climate change?

Management Questions	
I. Human and Cultural Elements	
MQI1	Where do areas of cultural resource management and protection occur (National Monuments, ACECs, National Historic Landmarks, World Heritage Areas, Los Caminos Scenic and Historic Byway, etc)?
MQI2	Where are known historic properties, traditional cultural properties, and sacred sites and landscapes?
MQI3	What are the traditional cultural land use patterns?
MQI4	Where are known historic properties, traditional cultural properties, and sacred sites vulnerable to change agents?
MQI5	Where are high potential areas or high density areas for historic properties that address the highest priority research goals?
MQI6	Where is cultural landscape connectivity vulnerable to change agents (human development, fire, invasive species, climate change)?
MQI7	Where are sensitive socioeconomic populations and how are they affected by change agents?
J. Landscape Intactness	
MQL1	What is current and future predicted landscape intactness?
K. Visual Resources	
MQK1	Where are specially designated/managed areas with associated visual resource considerations/mandates/prescriptions?
MQK2	Where are visual resource inventoried areas with high scenic quality, public sensitivity for scenic quality, and distance zones where people commonly view the landscape?
MQK3	Where are the highest quality night skies and where are they vulnerable to change agents (NPS inventory)?
MQK4	Where are high scenic quality values within the region and where are they vulnerable to change agents?
MQK5	Where are areas of high relative visual values (based on Visual Resource Inventory (VRI) classes) and where are they vulnerable to change agents?
MQK6	Where are current Visual Resource Management (VRM) classes that specify retention or partial retention of existing landscape character and where are they vulnerable to change agents?

Table 1-3. Conservation Elements Evaluated in the San Luis Valley-Taos Plateau Landscape Assessment.[3]

A. Ecological Systems[1]		
	Ecological System Macrogroup	**Percent of Ecoregion**
A.1	Montane and Subalpine Conifer Forest	35.2%
A.2	Basin Grassland and Shrubland	27.6%
A.3	Piñon-Juniper Woodland	10.2%
A.4	Riparian and Wetland Systems (playa, marsh, open water, wetland)	8.6%
B. Focal Species		
B.1	Native fish assemblage (Rio Grande cutthroat trout, Rio Grande chub, and Rio Grande sucker)	
B.2	Brewer's sparrow (representative migratory bird species)	
B.3	Ferruginous hawk	
B.4	Northern goshawk (representative montane species)	
B.5	Gunnison sage-grouse	
B.6	Waterfowl/shorebird assemblage	
B.7	Mexican free-tailed bat (representative bat species)	
B.8	Bighorn sheep	
B.9	Grassland fauna assemblage (burrowing owl, mountain plover, and Gunnison's prairie dog)	
B.10	Mountain lion	
B.11	Pronghorn	
B.12	Elk-mule deer assemblage	
C. Sites of Conservation Concern		
C.1	Sites of Conservation Concern Assemblage	
D. Ecosystem Functions		
D.1	Soils with potential for erosion	
D.2	Aquatic systems (including streams, lake, ponds, reservoirs, wetlands/playas, ponds livestock and wildlife watering tanks, springs, wells, diversions, ditches, canals and other artificial water bodies)	
D.3	Riparian areas	
D.4	Hydrologic systems	
D.5	Species richness and biodiversity	
D.6	Big game ranges (including summer & winter range, fawning, lambing, and calving areas, and migration corridors)	
E. Cultural and Historic Conservation Elements		
	Cultural and historic CEs are identified and assessed through a concurrent Cultural Landscape Assessment effort (Wescott et al. 2016).	

[1] Macrogroups determined from LandFire EVT associations and compliant with BLM vegetation mapping standards (IM 2013-111 [BLM 2013b] : http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2013/im_2013-111_the_national.html)

[3] Please refer to the Phase I Report (Argonne 2014) for information on how Conservation Elements were selected for this Landscape Assessment. Conservation Elements are evaluated in this Landscape Assessment in Appendix B.

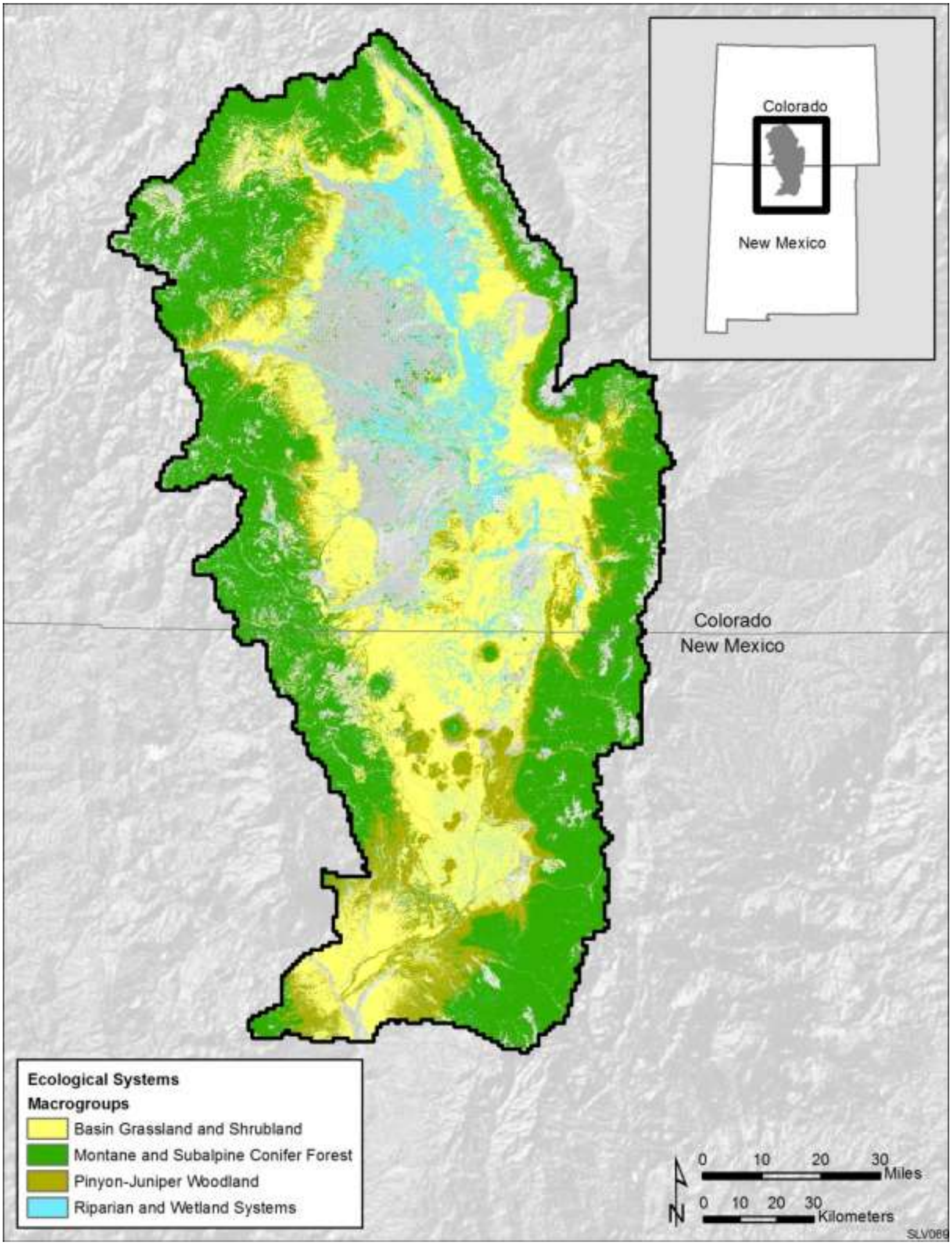

Figure 1-2. Distribution of Ecological Systems Conservation Elements in the San Luis Valley-Taos Plateau Landscape Assessment study area. Data Source: LANDFIRE Existing Vegetation Types (EVT) (USGS, 2010).

1.3.4 Change Agents

The assessment of CE status and trends requires an evaluation of natural and anthropogenic disturbance factors to understand the risks that CEs may experience from Change Agents (CAs). Four primary CAs were evaluated in this Landscape Assessment: (1) climate change, (2) human development, (3) invasive species, insects, and disease, and (4) wildfire. Several factors were considered in the development of CAs. These include grazing, recreation activities, and other agricultural practices (e.g., fallowing). The BLM IDT recommended that these factors be included and characterized as human development activities. Results of the CA distribution models are presented in **Section 3.2**. The CA model for wildfire did not consider prescribed fires used by management agencies. It is important to note that CAs were chosen based on their regional importance for multiple resources. While some CAs may threaten one resource and benefit another, the CAs selected for this LA typically have a negative influence on resources in the region.

1.3.5 Landscape Intactness Model

One important model developed to assist in the evaluation of CE status and trends was the Landscape Intactness Model[4]. This model builds on a growing body of existing methods that aim to spatially characterize ecological integrity across landscapes (Theobald 2001, 2010, 2013; Leu et al. 2008; Comer and Hak 2012). This model incorporated regionally available spatial data on human development and landcover change to characterize intactness of natural systems as a function of the degree of human modification across the landscape. Based on the work in other REAs (e.g., Bryce et al. 2012), landscape intactness is defined as a quantifiable estimate of naturalness across a region with respect to the level of human disturbance. Existing geospatial data on human activities and infrastructure were used to create a current landscape intactness model. In addition, spatial data on potential future human activities (e.g., energy development and urban sprawl) were used to model future landscape intactness for a near-term future time period (e.g., 2025-2030). Because the intensity of and proximity to human activities is a fundamental driver of ecological condition (Theobald 2013), the landscape intactness models prepared for this LA were used as general indicators of CE condition and trends. Additional explanation on landscape intactness model development, including maps of model results, is provided in **Section 3.2.3.**

1.4 Assumptions, Data Limitations, and Data Gaps

See **Table 1-4** for a summary of assumptions, data limitations, and data gaps. One of the overarching requirements of the LA was to use pre-existing data as assessment inputs. This requirement, coupled with the objective of providing an assessment within a relatively short schedule, presented a number of challenges and limitations:

- The evaluations presented in this LA were developed to provide landscape-scale information on CE status and trends. Additional information or analysis may be needed for decision making at other geographic scales (e.g., local project scale).

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4 Note that these models were referred to as Landscape Condition Models in other applications (e.g., Comer et al. 2013a,b).

- For some CEs, the nature of the resource and/or its occurrence within the LA study area made a spatial assessment either inappropriate or infeasible.

- Existing data on particular CEs (e.g., soils, wildlife habitat) tend to vary widely in data quality and collection methodology across sources, which in some cases made it difficult to create a seamless dataset of uniform quality across the study area.

- Several MQs identified by the BLM could not be addressed or were limited in their assessment, either due to scarce or inconsistent data or due to assessment and modeling requirements that would exceed the schedule of this study. As such, several Management Questions identified in **Table 1-2** were identified as information gaps that might be addressed in future research. MQs not addressed in this LA that could warrant future study are identified in **Appendix A**.

It is important for readers to understand the limitations and key information gaps of this LA. These data gaps may be used to direct future land planning research, as discussed in the following bullets.

- A finite list of CEs was identified and evaluated in this LA to accommodate scope and schedule. Through the demonstration in this LA of how CE status and trends may be considered, the assessment of other CEs not presented in this LA may be conducted in the future by repeating the evaluation using additional data on key attributes of other CEs.

- Through the process of evaluating Change Agents (CAs), the availability and distribution of surface water and groundwater through hydrologic processes was suggested as a fifth CA that could influence the distribution, status, and trends of several CEs (e.g., shorebird/waterfowl assemblage). The combined effects of climate- and human-induced changes in surface and groundwater resources on CEs warrants further assessment. Although water was not evaluated as a separate CA in this LA, the influence of surface water and groundwater availability was acknowledged as a data gap for several CEs. Given the importance of hydrology in this region, however, hydrologic features were evaluated as a CE in this assessment.

- The assessment of CE condition and trend incorporated generalized indicators of landscape intactness and measures of CAs. While this approach provides a standard baseline to evaluate all CEs, not all species and ecological systems respond similarly to CAs. For example, some CEs may be more vulnerable to climate change than other CEs (e.g., van Riper et al. 2014). In addition, CE condition may be a function of other factors that could not be measured for this LA. For example, the condition of aquatic and hydrologic systems is related to the amount of human surface and groundwater use, which could not be adequately quantified and spatially represented in this LA. Assessment of CE-specific responses to disturbance factors and integration of other factors that may influence CE condition have been identified as potential areas for future study.

- This LA spatially characterized where proximal changes in CA measures could occur and did not address the implications of CA changes to other regions of the study area. For example, this LA demonstrated that future climate change (in terms of changes in precipitation and temperature) is expected to be greatest in higher elevation montane regions of the study area. This change in montane climate has implications for mountain snowpack accumulation and runoff, which could affect hydrologic processes and functions at downgradient basin locations (Lukas et al. 2014; Elias et al. 2015). However, this LA did not model how climate change in higher elevation regions would alter ecological functions and processes in lower elevation basin shrubland, wetland, and riparian systems. Although the assessment of basin shrubland, wetland, and riparian systems in this LA indicate a relatively low to moderate vulnerability to future climate change, the vulnerability of these systems to climate change is likely higher due to the top-down effects of changes in precipitation and temperature in higher elevation regions.

- Inconsistencies were identified in availability of high quality, locally-accurate, and seamless data across the entire ecoregion for some themes, including:
    - Up-to-date wildlife habitat maps across state boundaries, including big game seasonal ranges and migration corridors
    - Soil properties and map units mapped by NRCS across state boundaries.

- Uniform projections of future human development were not available (e.g., urban growth, change in agriculture areas, and potential development of oil, gas, and renewable energy sources).

- The assessments of CE condition and trend were made individually with respect to the CAs. While these assessments provide a preliminary first step towards understanding the role of CAs on CE conditions and trends, these analyses do not address the additive or synergistic interactions among CAs. For example, wildfire and invasive species often interact to result in second-order impacts in terms of state transitions in vegetation communities. The additive or synergistic interactions of multiple CAs on CE condition and trend was not evaluated in this LA and represents an area for future research.

- Additional information gaps that could be addressed with future research include:
    - Fine-scale assessment of some CEs (e.g., habitat for sensitive species, some hydrologic features);
    - Spatially-explicit status and trends assessment of groundwater resources;
    - How some CEs may be affected by CAs (e.g., state and transition models for ecological systems responses to CAs);
    - Interactions between CAs (e.g., where potential for wildfire and invasive species may change in relation to climate change).

Table 1-4. Summary of Assumptions, Data Limitations, and Data Gaps

Additional information or analysis may be needed for decision making at geographic scales smaller than the landscape.
Spatial assessments of some CEs were inappropriate or infeasible.
Data quality and content may vary across the study area, especially across state boundaries.
Several MQs could not be addressed or were limited in their assessment in this LA.
A finite list of CEs was identified and evaluated in this LA.
The influence of surface water and groundwater availability is a data gap for several CEs.
This LA did not address the implications of CA changes to other regions of the study area such as downgradient basin locations.
Uniform projections of future human development were not available.
The additive or synergistic interactions among CAs was not addressed in this LA.
Additional information gaps could be addressed with future research.

1.5 Landscape Assessment Workflow

This LA was developed in two phases: a pre-assessment phase and an assessment phase. The pre-assessment phase was completed with the development of the Phase I Report (Argonne 2014), which discussed in detail the scope of the LA, how MQs, CEs, and CAs were determined, and outlined the assessment process. The Phase I report also provided the work plan for the assessment phase, which culminated in the preparation of this final Landscape Assessment report. Throughout the assessment phase, CE and CA models were developed and reviewed by the BLM IDT to determine their feasibility in addressing MQs. The BLM IDT and AMT provided oversight, collaborative input, and consensus throughout the assessment process. A peer review is also planned to provide external collaborators and the public an opportunity to review the data, models, and results and offer constructive feedback.

2 BACKGROUND ON THE SAN LUIS VALLEY – TAOS PLATEAU LEVEL IV ECOREGION

The San Luis Valley – Taos Plateau Level IV Ecoregion (hereafter, “the study area”) encompasses approximately 9,786 mi^2 (25,346 km^2) and includes portions of southern Colorado and Northern New Mexico (**Figure 1-1**). **Figure 1-1** also notes locations of the BLM Solar Energy Zones (SEZs) under consideration for regional mitigation planning that were used in scoping of this LA. About 65% of the study area occurs in Colorado and 35% in New Mexico, with portions of 12 counties in Colorado and 6 counties in New Mexico included (**Table 2-1**). The study area is situated in a north-south dimension, with the longest north-south axis of approximately 172 mi (277 km) and longest east-west axis of approximately 95 mi (153 km). The dimensions of the study area are influenced and bound by two dominant mountain ranges in the region: the Sangre de Cristo Mountains in the east, and the San Juan Mountains in the west. Elevations within the study area range from approximately 5,000 to 14,000 ft (1,524 to 4,267 m).

Approximately one-half of the study area (53.8%) is under federal land management (**Figure 1-1**), with nearly one-third of the study area under land management by the U.S. Forest Service (**Table 2-2**). The BLM is responsible for management of approximately 15% of the study area (913,865 acres). Approximately 46.2% (2,823,306 acres) of the study area is under private, local, or state ownership.

Table 2-1. Counties Included in the Landscape Assessment.

County	County Area within Study Area (mi^2)[a]
Colorado Counties	
Saguache	2387.6
Costilla	1202.8
Conejos	1153.5
Rio Grande	806.0
Alamosa	723.6
Huerfano	28.5
Mineral	15.3
Custer	13.4
Fremont	7.9
Archuleta	5.6
Chaffee	2.4
Las Animas	0.6
New Mexico Counties	
Taos	2204.4
Rio Arriba	1191.3
Colfax	26.3
Mora	18.2
Sandoval	2.6
Santa Fe	2.2

[a] To convert to km^2, multiply by 2.59

Table 2-2. Land management within the San Luis Valley – Taos Plateau Landscape Assessment study area.

Land Ownership or Management Agency	Acres	Percent of Study Area
Private	2,560,938	41.9%
U.S. Forest Service	1,984,751	32.5%
Bureau of Land Management	913,865	15.0%
Local / State	262,368	4.3%
Bureau of Indian Affairs	140,265	2.3%
National Park Service	136,902	2.2%
U.S. Fish and Wildlife Service	112,312	1.8%
Bureau of Reclamation	241	0.0%
TOTAL	6,111,642	

According to the two most recent Resource Management Plans (RMPs) for the BLM Field Offices in the study area, the San Luis RMP in Colorado (BLM 1991) and the Taos RMP in New Mexico (BLM 2012b), BLM lands in the study area are managed for a variety of human uses including:

- Renewable and nonrenewable energy development and management (e.g., minerals, geothermal, solar, wind)
- Livestock grazing
- Conservation and management of cultural and archaeological resources
- Conservation and management of historical and paleontological resources
- Conservation and management of ecological resources
- Management of land ownership, acquisition, and withdrawal
- Determinations of special area designations (e.g., ACEC designations, Wild and Scenic Rivers)
- Recreation management
- Visual resource management
- Hydrology management (e.g., waterpower/storage)

The BLM management decisions presented above are to be in accordance with the multiple use mandate required by the Federal Land Policy and Management Act (FLPMA) of 1976.

2.1 Climate

The climate of the San Luis Valley and Taos Plateau is consistent with climate in high mountain desert settings, with substantial 24-hour temperature swings because of cold air drainage from the surrounding mountains. In the San Luis Valley, the mid-January high averages 34 °F while the low averages –2 °F, and the mid-July high averages 83 °F while the low averages 37 °F. The montane and alpine ecosystems experience much cooler weather than the valley and basins in the study area.

Precipitation in the study area is strongly influenced by the surrounding mountains. The Sangre de Cristo mountain range is in the rain shadow of the San Juan Mountains and therefore somewhat drier. The higher elevation of the Sangre de Cristos receive 30 to 40 inches of precipitation per year mostly in the form of winter snow and to a lesser extent frequent afternoon showers in the summer. The precipitation in the foothills is about 12 inches while the valley floor gets only 7 inches per year and is considered a high desert. The higher elevations of the San Juan, Culebra, and Sangre de Cristo mountains receive 30 inches of precipitation a year mostly in the form of winter snows and to lesser extent afternoon showers during the summer months. The foothills receive 10 to 12 inches and the valley floor gets only 7 to 8 inches annually and is considered a high desert. The windward side of the mountain ranges, particularly the San Juan Mountains, receives a substantial amount of orographic precipitation, which is caused when air masses rise and subsequently cool, dumping their precipitation at higher elevations. This results in added rainfall on the lee side of the San Juan Mountains, in the higher elevations of the west side of the study area (USFWS 2012). Annual precipitation in Alamosa, CO and Taos, NM averages 7.31 and 12.8 inches per year, respectively (National Weather Service 2015).

In the state of Colorado, annual average temperatures have increased by 2.0°F over the past 30 years and 2.5°F over the past 50 years. Warming trends have been observed over these periods in most parts of the state. All climate model projections indicate future warming in Colorado. This projected future warming trend is expected to result in more frequent heat waves, droughts and wildfires will increase in frequency and severity in Colorado by the mid-21st century. State-wide in Colorado, average annual temperatures are projected to warm by +2.5°F to +5°F by 2050 relative to a 1971–2000 baseline under a medium-low emissions scenario (RCP 4.5). Summer temperatures are projected to warm slightly more than winter temperatures. Typical summer temperatures by 2050 are projected under RCP 4.5 to be similar to the hottest summers that have occurred in past 100 years (Lukas et al. 2014).

2.2 Ecological Resources

The study area is known for its high ecological values. The San Luis Valley floor contains primarily grassland and shrubland, much of which has been converted to agricultural fields, while the hills surrounding the valley are forested. The wide variety of vegetation types includes intermountain basins dominated by semi-desert shrub-steppe communities interspersed with wetlands and riparian areas and piñon-juniper forests. The topography of this region consists of volcanic cones rising upwards of 2,000-4,000 feet from the plateau with oak and mixed conifer forests of ponderosa pine, douglas fir, white pine and aspen, and other foothill woodland communities. High elevation mountain ranges around the periphery of the study area support montane and subalpine forests. Many of the basin grassland and shrubland plants are drought resistant and tolerant of high soil salinity. These shrublands are characterized by an open to moderately dense assemblage of species including rubber rabbitbrush, greasewood, fourwing saltbush, shadscale, and winterfat. Slightly higher elevations contain desert scrub and shrub-steppe habitats that have a significant cover of big sagebrush and/or sand sagebrush. Basin grasses include Indian ricegrass, alkali sacaton, western wheat grass, and blue grama (BLM 1991, 2012b; USFWS 2012). Typically, short grass and short-emergent species such as sedges (*Carex* spp.), Baltic rush (*Juncus balticus*), and western wheat grass (*Pascopyrum smithii*) are also found.

Networks of basin wetlands within the study area are formed from snowmelt in the surrounding mountains and provide important habitat for over 200 species of migratory waterfowl and shorebirds as well as other wildlife, including many threatened, endangered, and sensitive species (USFWS 2012). The study area also provides important habitat for big game wildlife species – including bighorn sheep, elk, mule deer, and pronghorn – and supports one of the largest elk herds in New Mexico (Smallidge et al. 2003).

2.3 Hydrology

The most important source of water in the upper Rio Grande basin results from snowmelt in the surrounding mountains (Rango 2006). There are many perennial streams and wetlands in the study area that are fed by runoff from the surrounding mountains. The valley floor in the center of the study area is underlain by unconfined (water table) and confined (artesian) groundwater aquifers. Groundwater discharge is recorded at approximately 100 springs on BLM lands in the San Luis Valley (BLM 1991). Agriculture represents the majority of the human water use in the study area and the Rio Grande Basin faces continued shortages associated with existing agricultural demands. By 2050, between 83,000 and 84,000 acres of farmland could be dried-up primarily due to urbanization and water transfers (Colorado Water Conservation Board 2011).

Future climate warming in the study area is projected to generally reduce spring snowpack, cause earlier snowmelt and runoff, and increase the water use by crops, landscaping, and natural vegetation (Lukas et al. 2014). Projections of future hydrology based on the latest climate model outputs show decreases in annual streamflow by 2050 for the Rio Grande basin. The timing of snowmelt and peak runoff has shifted earlier in the spring by 1–4 weeks across Colorado's river basins over the past 30 years, due to the combination of lower SWE (snow-water equivalent) since 2000, the warming trend in spring temperatures, and enhanced solar absorption from dust-on-snow (Lukas et al. 2014).

2.4 Cultural History

The San Luis Valley and Taos Plateau also have a rich cultural history beginning with the Paleo-Indian culture approximately 11,000 years ago (USDA 2014a). Native American use of the area was primarily nomadic, including hunting, gathering, trading, and other activities, and occurred throughout the region until the late 1800s. Spanish explorers first entered the area in the late 1500s and land grants were established, but the area was largely unsettled until around 1850 when the San Luis Valley became a territory of the United States. Agricultural potential and mining opportunities attracted settlers. Agriculture and stock-raising (sheep and cattle) remains a major base of the present economy (USDA 2014a).

3 SUMMARY OF METHODOLOGY

3.1 Data Management

Because most of the MQs addressed in this Landscape Assessment (LA) were spatial in nature (e.g., "*Where is this particular feature?*"), many geospatial datasets were reviewed, compiled, and considered for analysis. The majority of the data considered for this LA were handled in accordance with the BLM's Data Management Plan (DMP). Over 250 datasets were collected and reviewed for the LA, and over 150 datasets were ultimately used as inputs in analyses for the San Luis Valley-Taos Plateau LA. In addition, there were many derived datasets generated through the evaluation of input data. The inventory of source input data and derived data in the LA are presented in **Appendix C**.

The analytical extent of the LA study area was the outer boundary of all 5th level hydrologic units (HUCs) that intersected the Level IV Ecoregion boundary of the San Luis Valley – Taos Plateau (Figure 4). For the most part, results were summarized to 1 km^2 reporting units, so the analytical extent was further refined to include complete 1 km^2 reporting unit grids that intersected the edge of the 5th level HUCs. All datasets were clipped to this extent and re-projected, if necessary, to a common projection system (USA Contiguous Albers Equal Area [USGS Version]). Prior to delivery to the BLM National Operations Center (NOC), all spatial data were standardized into ArcGIS File Geodatabase (for vector data) and raster file formats using a folder structure per DMP specifications.

All datasets required development of Federal Geographic Data Committee (FGDC) compliant metadata per DMP specifications. FGDC compliant metadata was created by Argonne National Laboratory's Environmental Science Division (Argonne) staff and BLM staff for all datasets created for or derived from this LA. For source data, the source metadata were used. However, FGDC metadata for some source datasets were incomplete or not available. In those cases, Argonne worked with BLM to provide metadata to achieve DMP standards. Because Argonne and BLM were not the originators of many of the source input datasets, it was not possible – nor was it appropriate in some cases – for the groups to completely populate all source metadata fields.

Maps reported in this LA were displayed at a scale of the entire study area (e.g., 1:1,250,000). Maps that depict source input data were displayed using native resolution (e.g., 30 or 90 m raster pixels). Data derived from process models and other data derived from the evaluations in this LA were summarized to one or more of the following reporting units prior to display in the final report: 1 km^2, 4 km^2, or HUC10 or HUC12 boundaries. The default reporting unit size selected for this LA was 1 km^2. When possible, model output was summarized to the 1 km^2 reporting units. However, in some cases where source input data were coarser than 1 km^2 (such as for climate data) derived model outputs were summarized to either 4 km^2 reporting units or HUC boundaries, as appropriate.

The geoprocessing framework to evaluate the data involved the use of several ArcGIS ArcTools, ArcGIS ModelBuilder models, and python scripts. These tools, models, and scripts were developed to provide a user-friendly means for the analyses to be repeated or to be re-run using different input datasets. All custom tools, models, and scripts were delivered to the BLM NOC per DMP requirements.

3.2 Models, Methods, and Tools

This section discusses in greater detail development of ecological conceptual models, geoprocessing models to evaluate the data, the landscape intactness modeling process, and the change agent modeling processes.

3.2.1 Conceptual Models

Conceptual models are useful in highlighting important ecosystem components and interactions that may be used to inform land management decisions (DiGennaro et al. 2012). The conceptual models developed for this LA illustrated the interactions (actual or potential) between Conservation Elements (CEs), the biophysical properties of the environment, and Change Agents (CAs). Conceptual models developed for this LA consisted primarily of box and arrow diagrams that show the relationships and mechanisms of their interactions. Two types of conceptual models were prepared and guided by the scientific literature: (1) an overarching general ecosystem-based model for the entire ecoregion and (2) individual conceptual models for each ecological CE (ecological systems and focal species).

The general ecosystem-based model (**Figure 3-1**) presents the interaction between CAs and CEs and the climatic and physiographic setting of the region. The four primary CAs evaluated in this LA are shown in the red box. The broader ecological systems CEs are separated into terrestrial (green box) and aquatic (blue box) systems. Focal species CEs are listed in the primary ecological systems they inhabit. Focal species CEs may inhabit more than one ecological system. For example, within the LA study area, shorebirds may inhabit riparian and wetland systems as well as grassland and shrubland systems.

In addition to the general ecosystem-based conceptual model shown in **Figure 3-1**, individual CE-specific conceptual models were developed to more specifically identify and depict the interactions between individual CEs, CAs, and the region's biophysical settings. All CE-specific conceptual models are provided in **Appendix B**. An example conceptual model for the basin grassland and shrubland ecological system is provided in **Figure 3-2**. The basin grassland and shrubland system is an aggregation of several grassland and shrubland vegetation communities that occur in the study area. Many of the basin grassland and shrubland plants within these communities are drought resistant and tolerant of high soil salinity. These shrublands are characterized by an open to moderately dense assemblage of species including rubber rabbitbrush, greasewood, fourwing saltbush, shadscale, and winterfat. Also present in these communities are yucca, cactus, and various grasses. Slightly higher elevations contain desert scrub and shrub-steppe habitats that have a significant cover of big sagebrush and/or sand sagebrush. Grasses in these areas include Indian ricegrass, alkali sacaton, western wheat grass, and blue grama (USFWS Complex 2012).

Multiple disturbances have affected the distribution and ecological function of the basin grassland and shrubland assemblage. Human activities such as urban and rural development, energy development, agriculture, grazing, and recreation have affected this system. Climatic events such as periods of excessive moisture (Sturges and Nelson 1986) as well as long droughts impact this assemblage and related species (Anderson and Inouye 2001). The Aroga moth (*Aroga websteri*) and leaf beetles *(Trirhabda pilosa*) have been observed to cause sagebrush mortality in other regions (Pringle 1960, Gates 1964). Other disturbances such as burning or mechanical removal of this community can also promote invasive grasses altering the system even further (Bryce et al. 2012). Heavy grazing can increase soil water losses and reduce the biomass of deep roots (CNHP 2005).

Wildfire frequency and seasonality of wildfire is important. Sagebrush generally responds favorably to spring fires, but fall fires tend to cause significant mortality in sagebrush. Recovery of big sagebrush after fire is slow. Fire suppression and livestock grazing have significantly degraded this ecological system (NatureServe 2009). Fire suppression in grasslands can lead to conversion to shrub lands (CNHP 2005).

Grazing continues to be widespread in these grasslands, with cheatgrass and other species expanding into areas where native grasses die out (Colorado Partners In Flight 2000). Extensive amounts of land are also being converted to agricultural production (grazing and cultivated crop production). Once these ecosystems are converted, there is only limited potential for conversion back to native grasslands, either mechanically or by removal of livestock (Land Use History of North America 2014). Although conversion back to native grasslands depends on the current use (e.g., cultivated crop production vs. grazed pasture), the challenges of restoring native grasslands are further complicated by changes in soil chemistry, soil physical properties, hydrology, invasive species, and water quality and availability.

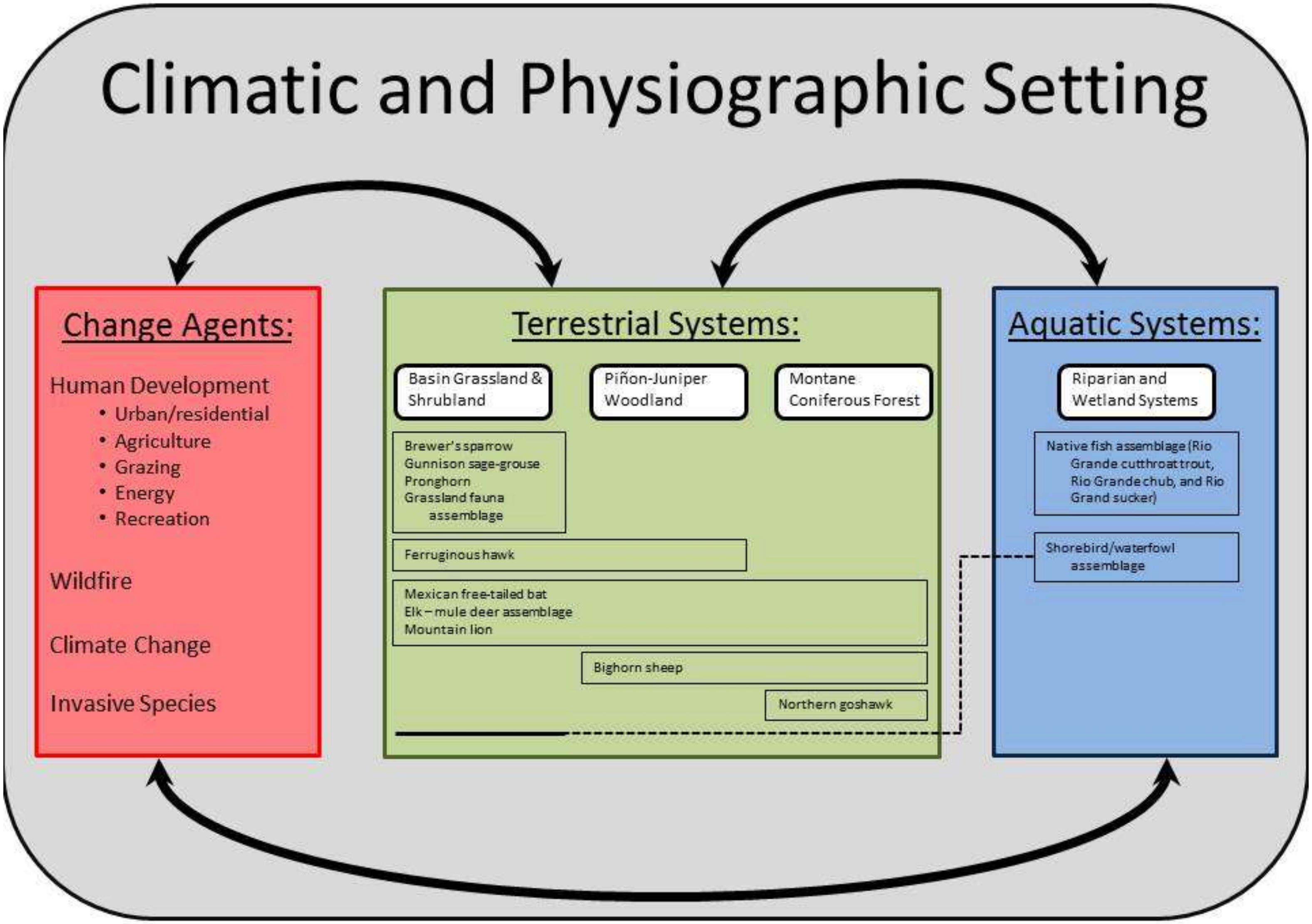


Figure 3-1. General ecosystem-based Conceptual Model for the San Luis Valley – Taos Plateau Level IV Ecoregion.

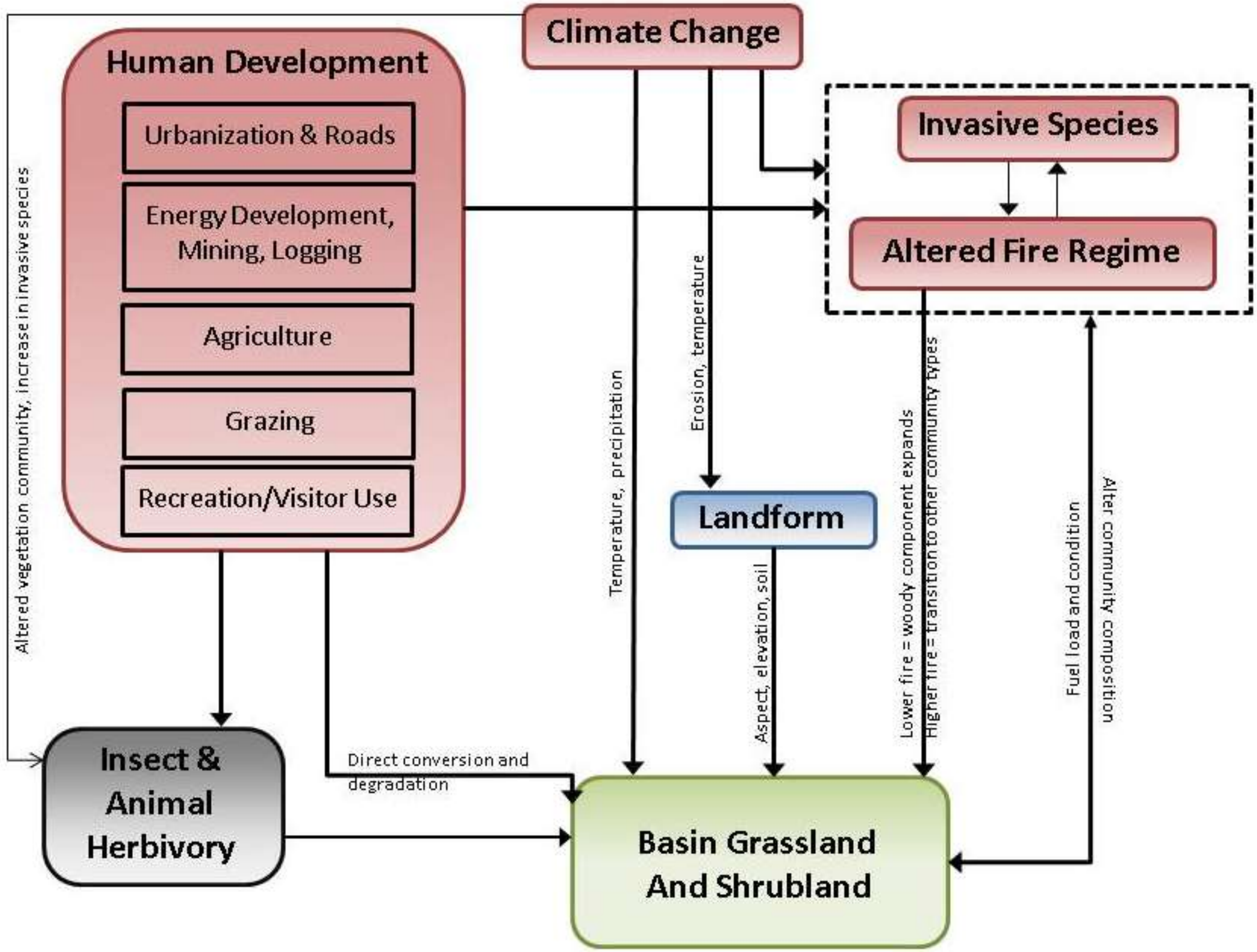


Figure 3-2. Conceptual model for the Basin Grassland and Shrubland Ecological System Conservation Element. Additional CE-specific conceptual models are provided in Appendix B.

3.2.2 Geoprocessing Models

The conceptual models were used to inform the fundamental relationships between resources and change agents that were used to address Management Questions (MQs). Geoprocessing models were used to graphically display the data used and the GIS analyses implemented. In most cases, the geoprocessing models were developed using ArcGIS ModelBuilder (v. 10.2), which provided a graphical display of the data and processing steps, as well as a means to implement the geoprocesses by executing the models through ArcGIS. Some MQs required a series of geoprocessing steps and therefore required rather large geoprocessing models. Other MQs were addressed without the need for geoprocessing models. An example geoprocessing model is shown in **Figure 3-3**, which illustrates how the union of Colorado NWI wetlands and New Mexico NWI wetlands was used to generate an overall NWI wetlands dataset for the study area.

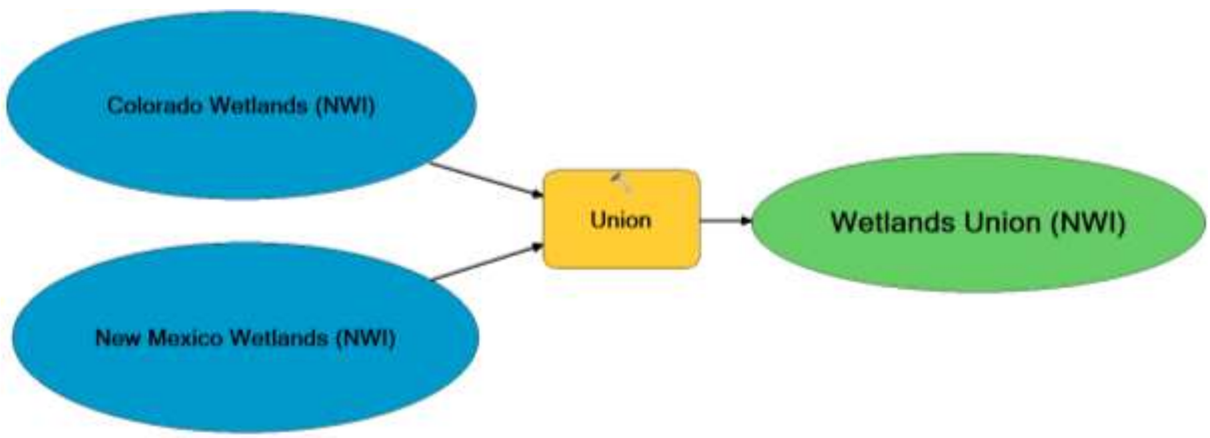


Figure 3-3. Example geoprocessing model to union wetland datasets in Colorado and New Mexico.

3.2.3 Landscape Intactness Modeling

One important model that was developed to assist in the evaluation of CE status and trends is the Landscape Intactness Model. This model builds on a growing body of existing methods that aim to characterize ecological integrity across landscapes (Theobald 2001, 2010, 2013; Leu et al. 2008; Comer and Hak 2012). The landscape intactness modeling approach used in this Landscape Assessment incorporated regionally available spatial data on human development and landcover change to characterize intactness of natural systems as a function of the degree of human modification across the landscape.

General landscape intactness modeling approaches involve the parameterization of indicators used to score the level of human influence in the ecosystem. This scoring system is quantified as a degree of human modification, *h*, which is often represented as a function of human modification intensity and the spatial influence of the human activity (Brown and Vivas 2005; Woolmer et al. 2008; Theobald 2013), but it is also regarded as a site impact score. The goal of these modeling efforts is to spatially characterize landscape intactness along a relative continuum ranging from low human modification to high human modification.

Indicators and their scores were selected for the Landscape Intactness Model based upon knowledge of their amount and distribution in the study area and understood level of impact to natural systems. Estimates of the degree of human modification, *h*, from previous modeling efforts (e.g., Brown and Vivas 2005; Woolmer et al. 2008; Theobald 2013) were used to parameterize the site impact scores for each indicator in this model. The Landscape Intactness Model for this LA consists of a site impact score of human land uses (ranging from 0.015 to 0.95), reflecting the relative level of ecological stress or impact. Values close to 1.0 imply relatively little ecological impact from the land use. For example, recently logged areas are given a relatively high site impact score (0.7) compared to cultivated agriculture (0.35) or high-density urban development (0.015). This range of values (0 to 1) is similar to the range of values modelled in previous landscape modeling efforts (e.g., Brown and Vivas 2005; Woolmer et al. 2008; Comer and Hak 2012; Theobald 2013).

Proximity to human modifications is a fundamental driver of landscape ecological condition (e.g., Theobald 2013). Habitat quality and use by wildlife generally decreases with proximity to human developments. For example, Rowland et al. (2000) found there was a measurable decline in elk habitat use up to 1.8 km (1.1 mi) away from roadways. Other example effects of proximity to human development on wildlife and habitat are provided in **Table 3-1**. Most reported effects to wildlife have been observed within 4 km (2.5 mi) from human development (**Table 3-1**), although there are fewer reports of effects occurring at greater distances. For this reason, the Landscape Intactness Model was parameterized with a maximum distance of influence of 4 km (**Table 3-2**). For comparison purposes, a maximum distance of 2 km was utilized in the Landscape Condition Model for the BLM's Mojave Basin and Range REA (Comer et al. 2013a).

Table 3-1. Example effects of proximity to human developments on wildlife and habitat.

Ecological Attribute	Indicator	Distance (km)	Measured Response	Citation
Elk habitat	Distance to roads	1.8	Elk habitat use decreased up to 1.8 km from roadways	Rowland et al. (2000)
Elk habitat	Distance to human disturbances	3	Elk may avoid habitats within 3 km from human disturbances	Preisler et al. (2006), Naylor et al. (2009)
Elk habitat	Distance to roads	>4	Elk habitat use is greatest at distances >4 km away from roads	Montgomery et al. (2013)
Mule deer habitat	Distance from natural gas wells	3.7	Lower predicted probability of habitat use up to 3.7 km away from natural gas well developments	Sawyer et al. (2006)
Bighorn sheep observations	Distance to roads	>0.5	Bighorn sheep observations greatest at distances >500 m away from roads	Papouchis et al. (2001)
Elk habitat	Distance to human recreation	NA	Elk habitat use increases with increasing distance from human recreational areas	Zeigenfuss et al. (2011)
Sage grouse	Distance to energy development	3.2	Negative effects of energy development on sage grouse lek attendance and persistence within 3.2 km	Walker et al. (2007)

Table 3-2. Landscape Intactness Model impacting factors, site impact scores, and distance decay scores for the San Luis Valley – Taos Plateau Landscape Assessment.[1]

Human Land Use or Impact Factor	Site Impact Score[2]	Presumed Relative Stress[3]	Distance of Influence (m)[4]	Function[5]
Transportation				
Dirt roads, OHV trails	0.75	Low	500	linear
Local roads	0.3	Medium	1000	logistic
Primary highways	0.015	High	4000	logistic
Urban and Industrial Development				
Low density development (including rural development)	0.6	Medium	1000	logistic
Medium density development	0.35	Medium	2000	logistic
High density development	0.015	High	4000	logistic
Communication Towers	0.6	Low	200	linear
Powerlines / transmission lines	0.6	Low	200	linear
Mines and oil/gas well pad locations	0.2	High	1000	logistic
Urban Polygons (BLM and U.S. Census Bureau)	0.015	High	4000	logistic
High Impervious Surfaces (NLCD Imperv > 40% developed imperviousness)	0.3	Medium	500	logistic
Urban Lights (NASA Night Lights > 200)	0.05	High	4000	logistic
Managed and Modified Land Cover				
Low agriculture and invasives (ruderal forest, recently burned, recently logged, etc)	0.7	Low	500	linear
Pasture (landcover)	0.7	Low	500	linear
Grazing allotment polygons	0.7	Low	500	linear
Introduced vegetation	0.6	Medium	500	linear
Cultivated agriculture	0.35	Medium	2000	linear

1 Modeling approach and parameters are adopted from the Landscape Condition Model prepared for the Mojave Basin and Range Rapid Ecoregional Assessment (Comer et al. 2013a).

2 Site Impact Score ranges between 0 and 1 and provides an indication of presumed ecological stress or impact. Lower values (closer to 0) indicate a greater site impact. Values adopted from previous modeling efforts by Brown and Vivas (2005), Woolmer et al. (2008), Comer and Hak (2012), and Theobald (2013).

3 Presumed relative stress indicates the level of influence the impacting factor has relative to other impacting factors. For example, high-density developments such as urban areas have the highest relative stress scores.

4 Distance of influence is the minimum distance at which intactness values approach 1.0. Values adopted from previous modeling efforts by Comer and Hak (2012), which described the methodology for completing the Landscape Condition Model for the BLM Mojave Basin and Range REA (Bryce et al. 2012).

5 Distance decay functions for impacting factors with low or medium relative levels of stress were evaluated with linear or logistic functions. Distance decay functions for impacting factors with high relative levels of stress were evaluated with logistic functions.

To characterize the influence of proximity to human modifications on ecological intactness, each input data layer for the Landscape Intactness Model was parameterized with a distance decay function that expressed a decreasing ecological impact with distance away from the mapped location of the feature (**Table 3-2**). This process involved the use of Euclidean Distance mapping tools and other geoprocesses (e.g., raster calculator) to spatially represent the functional relationship between intactness value and distance away from the human land use indicator. Those features with a smaller distance of influence result in a map surface where the impact dissipates within a relatively short distance. Values for each layer approach 1.0 at the distance of influence, symbolizing an area of negligible impact. An example logistic functional relationship for major roadways is provided in **Figure 3-4**.

For comparability with results of other change agent models, landscape intactness model results were normalized along a scale ranging between -1 and 1, where modeled values of 0 correspond to normalized values of -1 and modeled values of 1 correspond to normalized values of 1. All values between -1 and 1 were estimated based on the linear relationship between the minimum and maximum values. For this LA, the landscape intactness model was developed using datasets for existing development (i.e., "current landscape intactness model") and for a near-term (i.e., 2015-2030) future timeframe using spatial data that project potential future human development. Inputs for the current landscape intactness model, which utilizes existing data and parameters, are presented in **Table 3-2**. For purposes of this LA, the normalized intactness values were summarized to 1 km^2 reporting units by calculating the average continuous intactness value within reporting units. For final map reporting, results were categorized based on equal intervals of intactness values within reporting units within six categories ranging from very low intactness to very high intactness. The histogram of summarized intactness values with equal interval breakpoints used to determine categories is shown in **Figure 3-5**. The resulting current Landscape Intactness Model, summarized to 1 km^2 reporting units, is shown in **Figure 3-6**. The near-term future (e.g., 2015-2030) landscape intactness model, summarized to 1 km^2 reporting units, is shown in **Figure 3-7**.

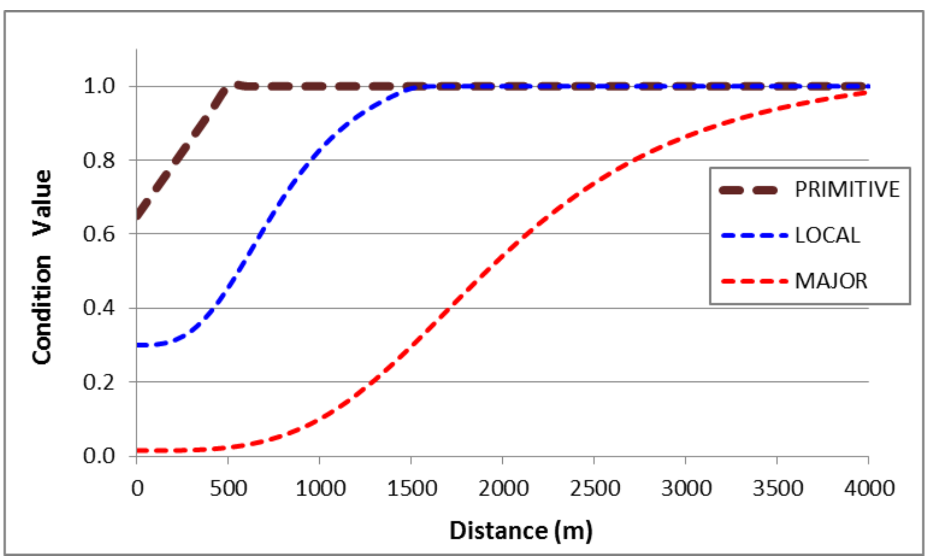
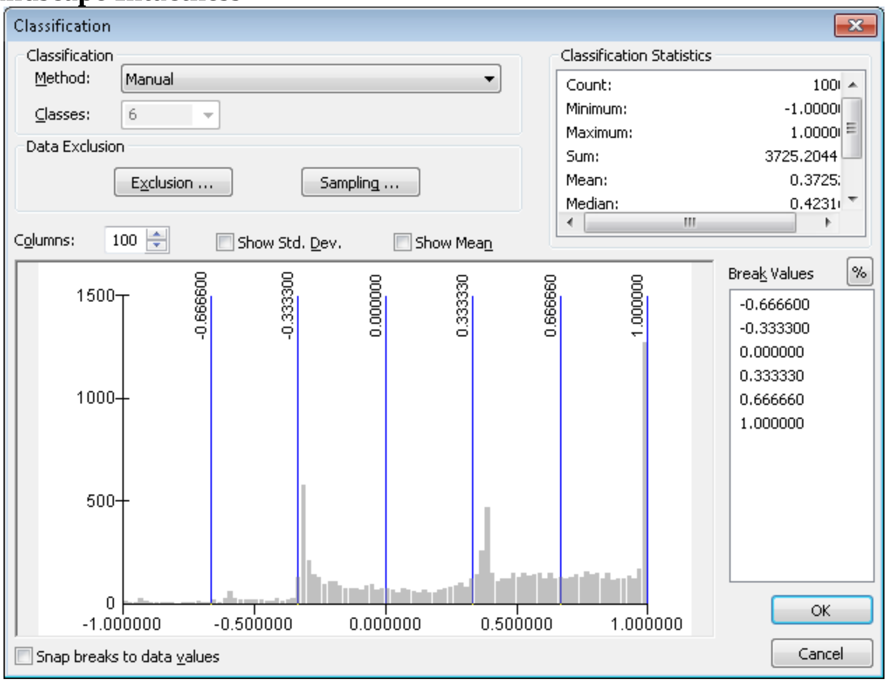


Figure 3-4. Distance decay functions for the three types of roadways (primitive, local, and major) evaluated in the development of the Landscape Intactness Model. Refer to Table 3-2 for model parameterization.

(a) Current Landscape Intactness



(b) Near-term Future Landscape Intactness

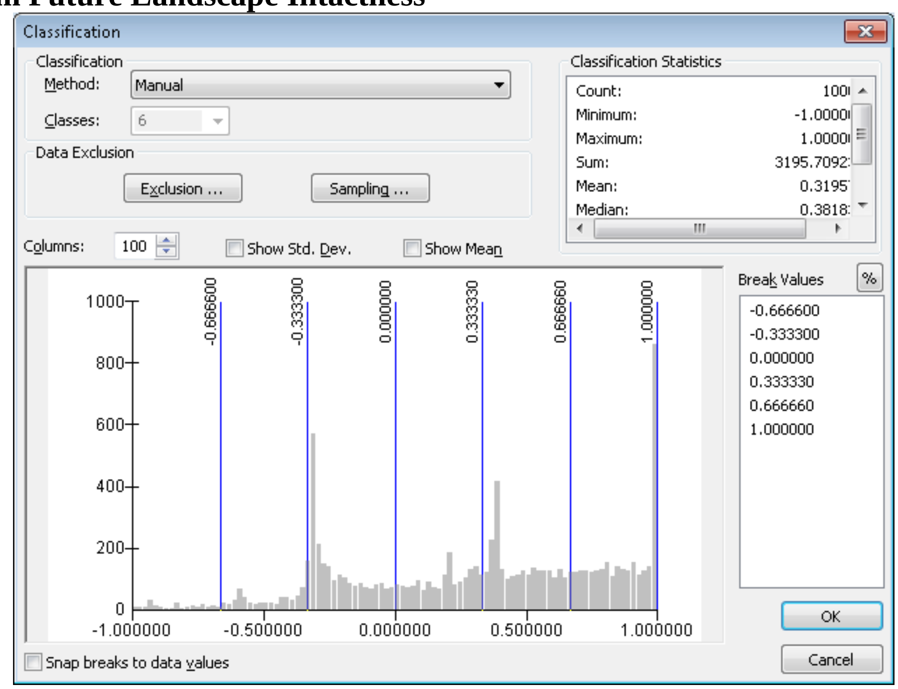


Figure 3-5. Histogram and breakpoints used to assign intactness categories for the (a) current landscape intactness model and (b) near-term future landscape intactness model. Breakpoints correspond to the following intactness categories: Very Low (<-0.666), Low (-0.666 – -0.333), Moderately Low (-0.333 – 0), Moderately High (0 – 0.333), High (0.333 – 0.666), and Very High (>0.666).

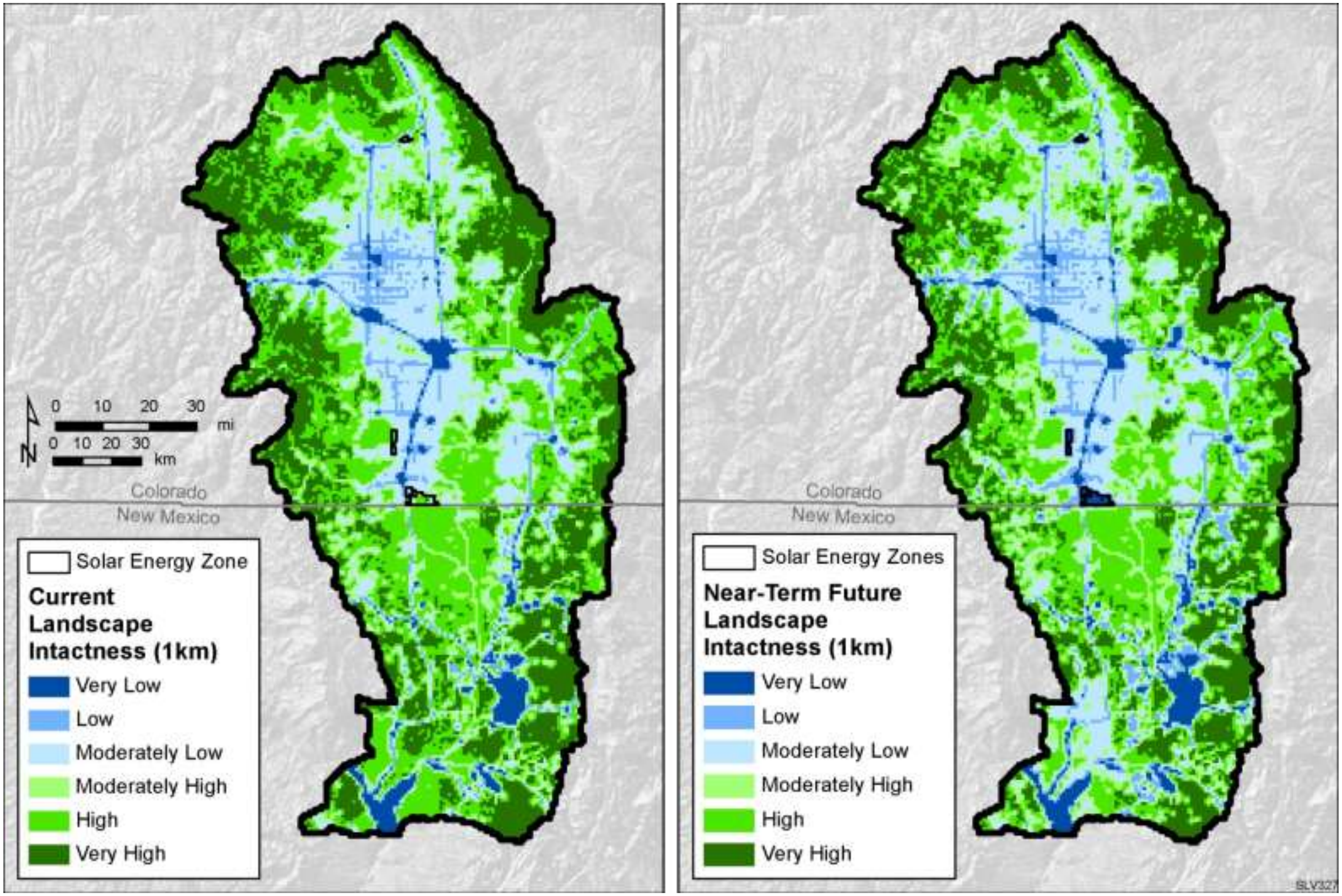


Figure 3-6. Current and Near-term Future Landscape Intactness Model for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014). Landscape intactness is summarized to 1 km^2 reporting units and categorized from very low intactness (dark blue) to very high intactness (dark green).

3.2.4 Climate Change Modeling

There has been unequivocal warming of the Earth's climate since the 1950s, as observed in the warming of the Earth's atmosphere and oceans, diminishing snow and ice, and sea level rise. In the Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (IPPC 2014) concluded that it is extremely likely that most of the observed changes in the Earth's climate since 1950 was caused by human activities (e.g., increases in greenhouse gas emissions). There have been several studies that have examined bioclimatic effects of climate change in predicting landscape-level changes in the distribution of vegetation communities and animal species in response to climate change (e.g., USFS 2012; van Riper et al. 2014). For example, the U.S. Forest Service (2012) estimated that, by the end of this century, approximately 55% of future landscapes in the western U.S. will likely have climates that are incompatible with current vegetation types on those landscapes.

Warming trends have been observed in the states of Colorado and New Mexico over the past 50 years. For example, annual average temperatures in the state of Colorado have increased by 2.0°F over the past 30 years and 2.5°F over the past 50 years (Lukas et al. 2014). Climate model projections indicate that these temperature increases are likely to continue into the future. This projected future warming trend is expected to result in more frequent heat waves, droughts and wildfires will increase in frequency and severity in Colorado by the mid-21st century. State-wide in Colorado, average annual temperatures are projected to warm by +2.5°F to +5°F by 2050 relative to a 1971–2000 baseline under a medium-low emissions scenario (Representative Concentration Pathway (RCP) 4.5). Summer temperatures are projected to warm slightly more than winter temperatures by 2050 (Lukas et al. 2014).

Climate change models used in various assessments and applications involve the downscaling of mathematical atmospheric general circulation models (GCMs) coupled with simulations of local/regional climate characteristics. Such climate models have been developed for the western United States (including this LA study area) to predict the implications of future climate change, including but not limited to:

- The role of climate change in the future range of reptiles and bird species (van Riper et al. 2014).
- The role of climate change in mountain snowmelt timing and volume with implications for water demand and availability in the Upper Rio Grande Basin (Lukas et al. 2014; Elias et al. 2015).

For this LA, current climate change and potential for future climate change were based on an evaluation of seasonal changes in precipitation and temperature. Data from the PRISM Climate Group (http://www.prism.oregonstate.edu/) were used to characterize the historic and current climate of the Western United States (historic period: 1905-1934; current period: 1981-2010). Current climate change was evaluated by calculating the absolute difference between current and historic seasonal temperature and precipitation values. PRISM mean monthly precipitation and temperature values correspond to mean monthly values provided in the IPCC (International Panel on Climate Change) AR4 GCM simulation results. Therefore, an ensemble average of

IPCC A1B (characterized by very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies that are balanced across all sources) emission scenarios was used to characterize long-term future climatic conditions (2040–2069). Results of the IPCC A1B scenarios were statistically downscaled to a 2.5-minute grid (approximately 4-km grid), as described by Garfin et al. (2010). PRISM data were obtained from the PRISM Climate Group at Oregon State University (http://prism.oregonstate.edu/). Results for the A1B scenario were obtained from The National Center for Atmospheric Research Community Climate System Model (https://gisclimatechange.ucar.edu/).

The process models describing the geospatial characterization of current and future climate change are shown in **Figures 3-7** and **3-8**, respectively. The process involves the calculation of absolute differences in seasonal precipitation and temperature. The resulting absolute differences were then summarized to the 1 km^2 reporting units (average) and normalized along a scale of -1 to 1 based on minimum and maximum thresholds. Values closest to -1 correspond to areas with relatively less change in temperature or precipitation, whereas values closest to 1 correspond to areas with relatively greater change in temperature or precipitation. A single operation was then applied to determine the minimum of all normalized values at each 1 km^2 reporting unit, which resulted in a single overall measure of current climate change. For final map reporting, results were categorized based on equal intervals of normalized climate change values within reporting units within five categories ranging from very low climate change potential to very high climate change potential. The future climate change model was developed in a similar manner using 30-year period average IPCC A1B estimates for the period 2040-2069 compared to PRISM estimates for the current period (1981-2010). The histogram of summarized normalized climate change values with equal intervals used to determine categories is shown in **Figure 3-9**.

The resulting current climate change model, summarized to 1 km^2 reporting units, is shown in **Figure 3-10**. The long-term future (e.g., 2040-2069) potential climate change model, summarized to 1 km^2 reporting units, is shown in **Figure 3-11**. These modeling results indicate the relatively greater change in current climate (in terms of changes in temperature and precipitation) in the montane regions along the periphery of the study area. These montane areas are also expected to experience relatively greater amounts of future climate change. These changes in montane climate have implications for mountain snowpack accumulation and runoff, which could affect hydrologic processes and functions at downgradient basin locations (Lukas et al. 2014; Elias et al. 2015). However, this LA did not model how climate change in higher elevation regions would alter ecosystem functions and processes in lower elevation systems. Although this assessment indicated relatively greater current and future climate change in montane regions, the vulnerability of other downgradient systems (e.g., basin wetlands and aquatic systems) to climate change is likely higher due to the top-down effects of changes in precipitation and temperature in higher elevations.

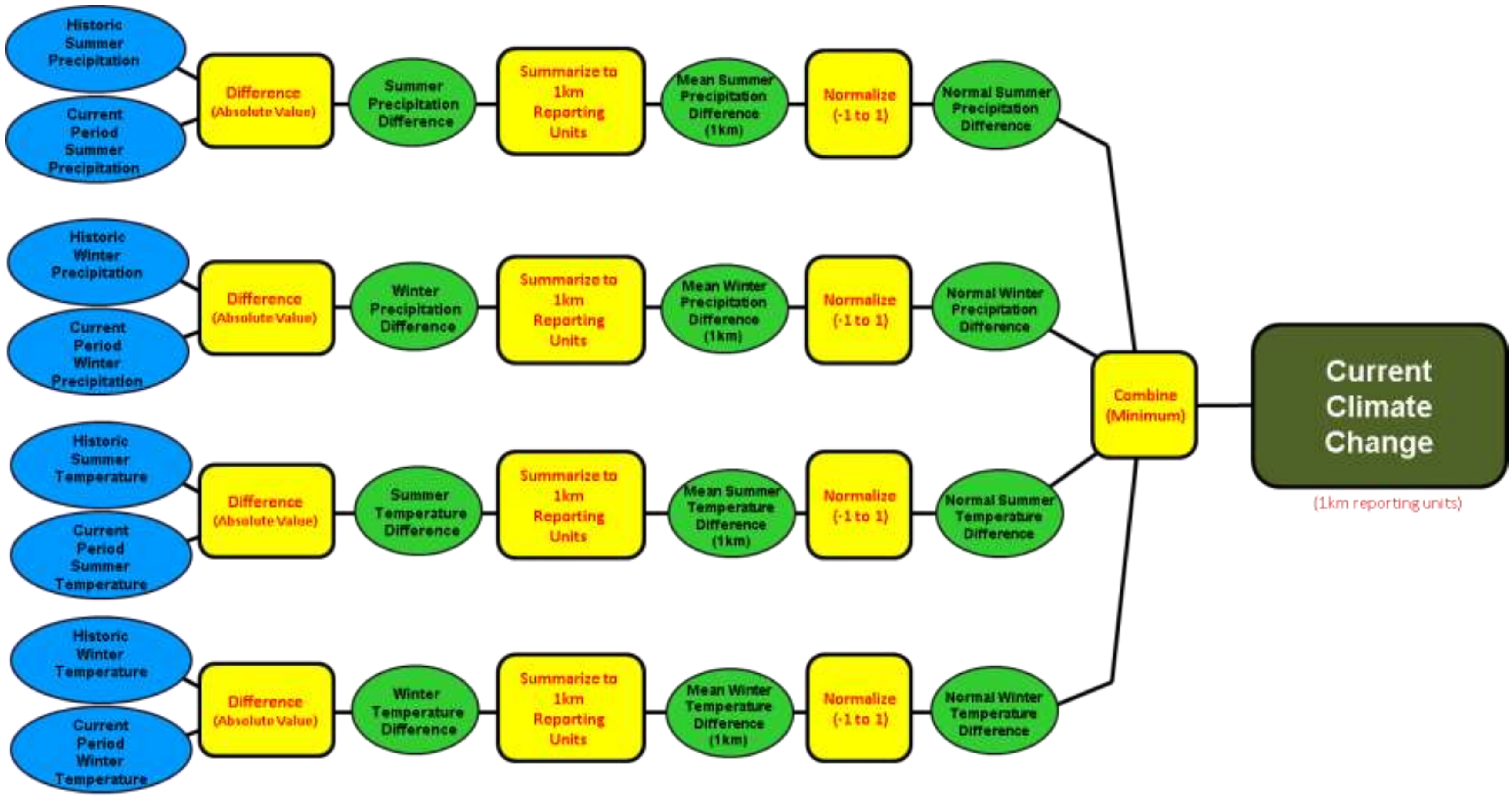


Figure 3-7. Process model for the characterization of current climate change. The current climate change model was developed using PRISM monthly averages in precipitation and temperature over a 30-year current period (1981-2010) compared to a historic reference period (1905-1934).

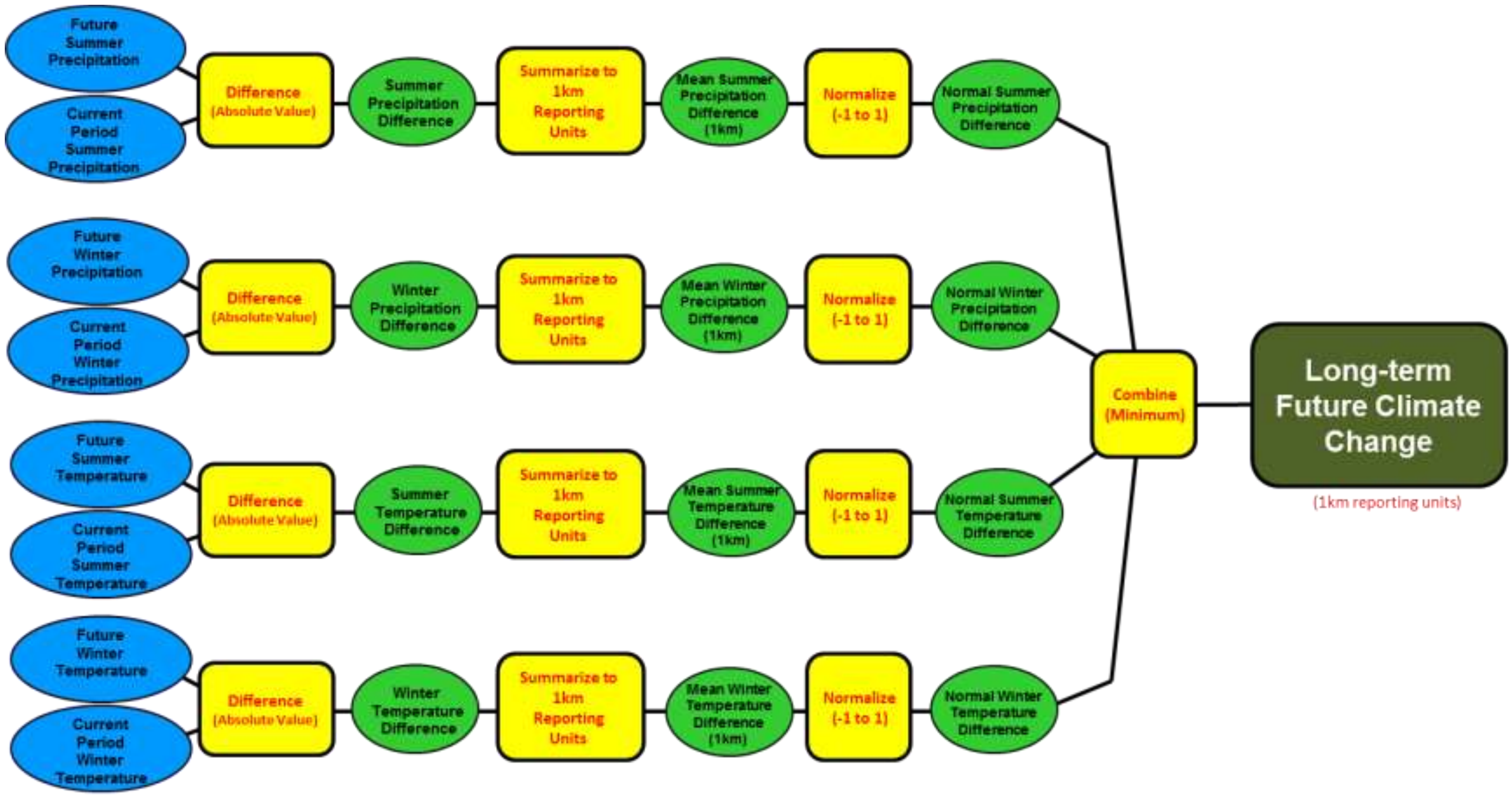
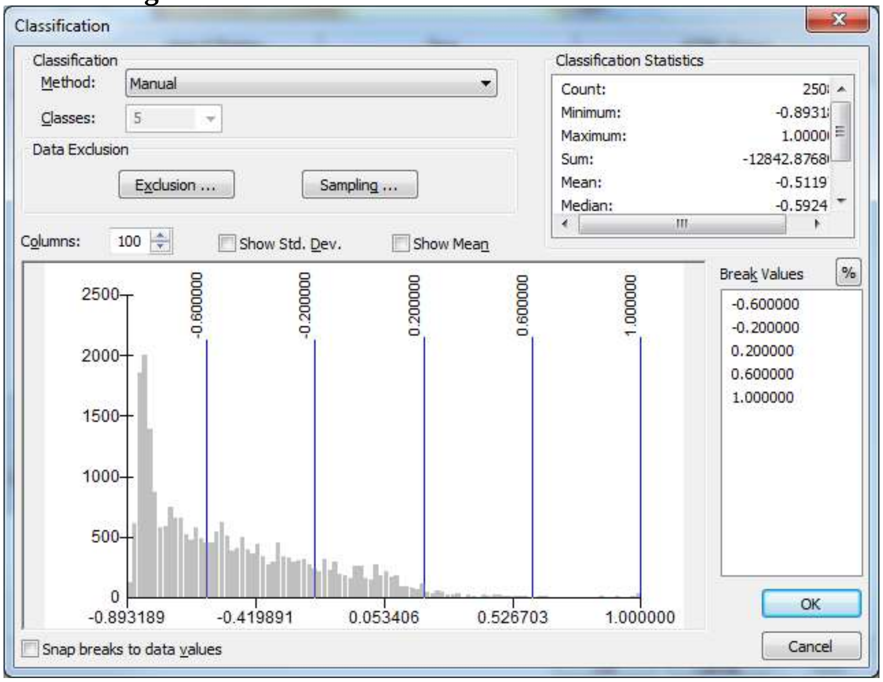


Figure 3-8. Process model for the characterization of long-term future climate change. The future climate change model was developed using 30-year period average IPCC A1B estimates for the period 2040-2069 compared to PRISM estimates for the current period (1981-2010).

(a) Current Climate Change



(b) Long-term Future Climate Change

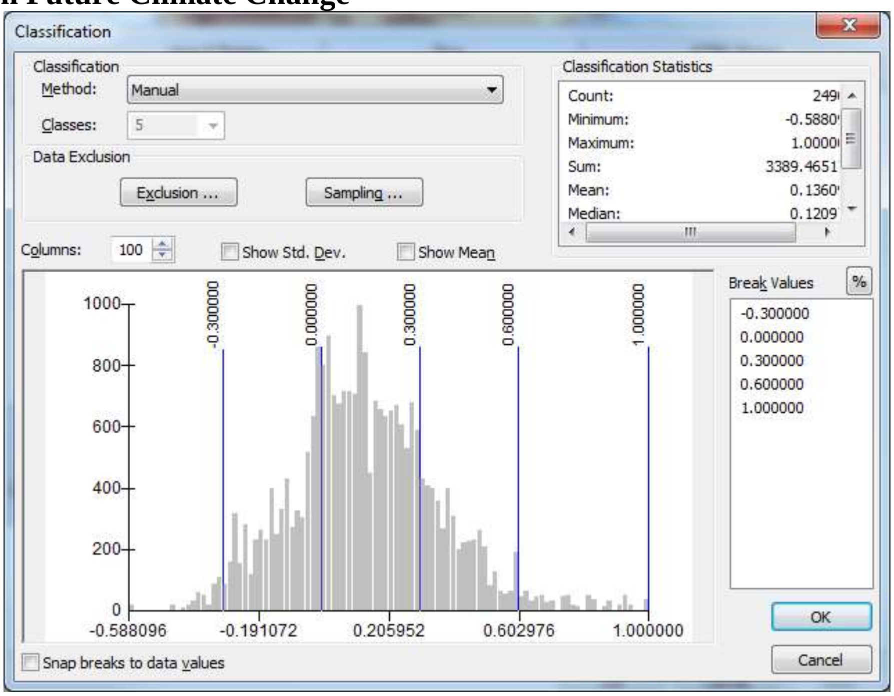


Figure 3-9. Histogram and breakpoints used to assign categories (a) current climate change and (b) long-term future climate change. Breakpoints correspond to the following categories used to describe potential for climate change: Very Low, Low, Moderate, High, and Very High.

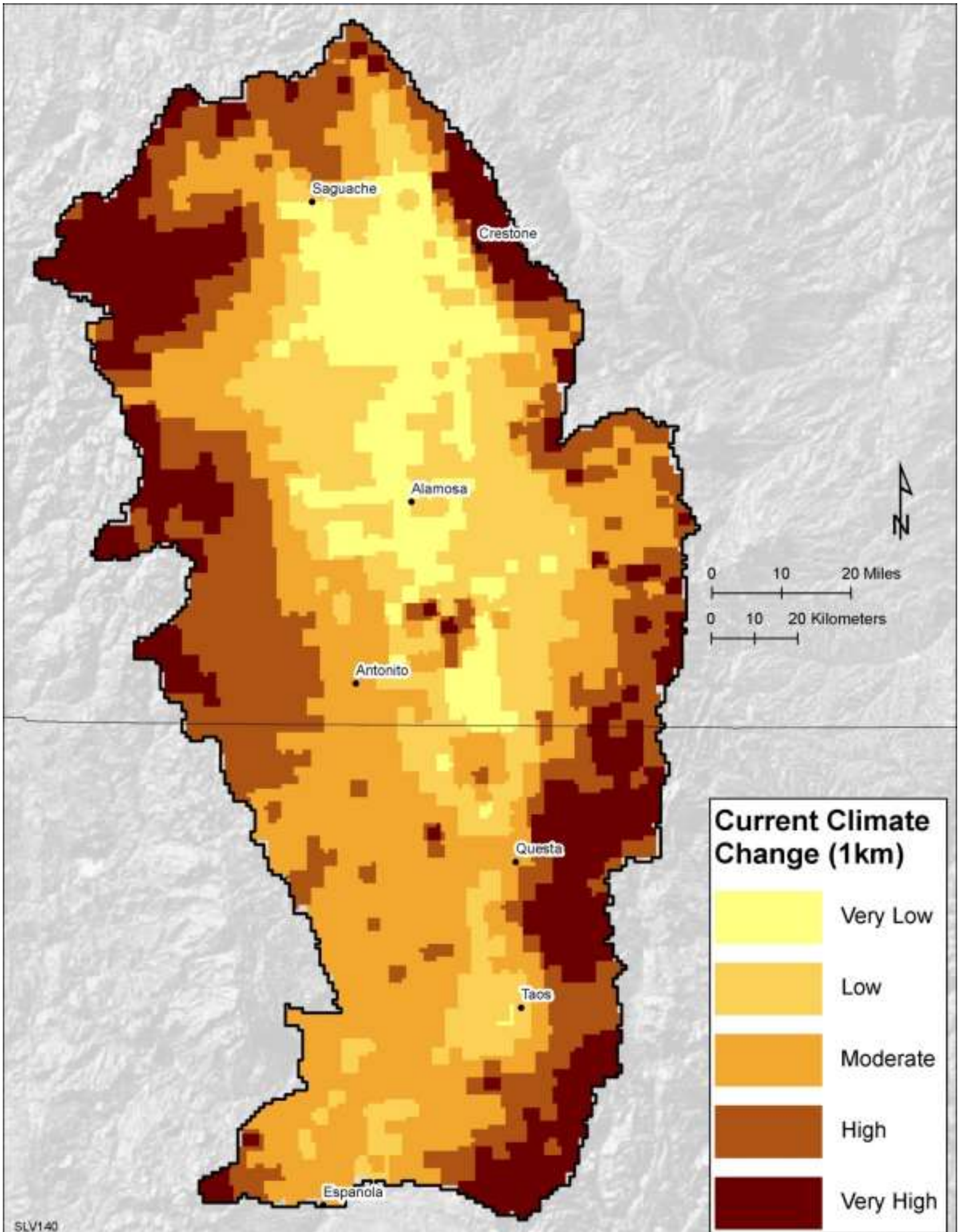


Figure 3-10. Current (1981-2010) change in climate (precipitation and temperature) for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

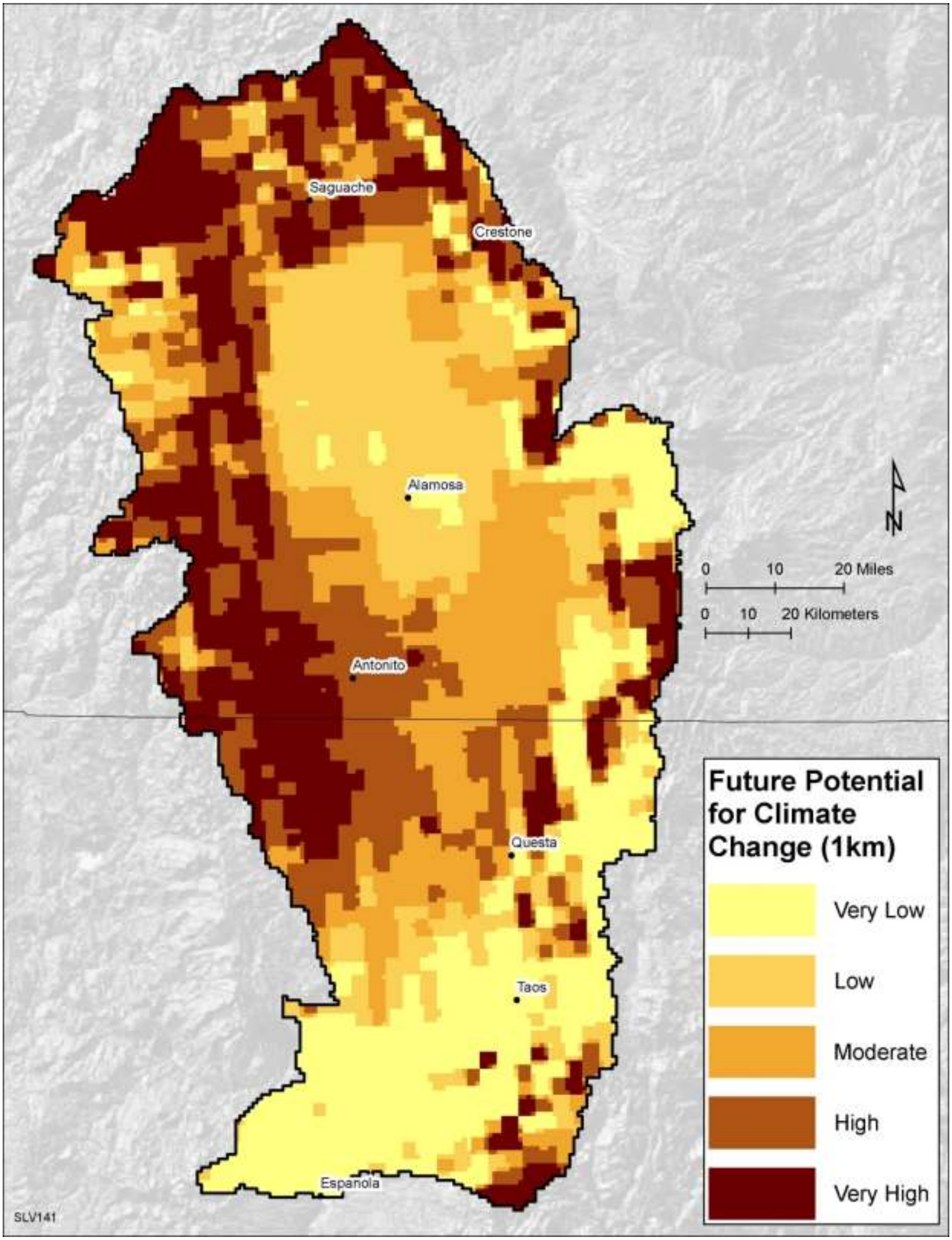


Figure 3-11. Long-term future (2040-2069) climate change potential for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

3.2.5 Human Development Intensity Modeling

The models developed to spatially characterize the current and near-term future distribution and intensity of human developments within the LA study area utilized datasets relevant to human activities – impervious surfaces such as roads and urban areas, areas of human activity such as agricultural areas (including grazing), and areas of current and potential energy development. Because these datasets and the process used to evaluate them is fundamentally similar to the approach used to characterize current and future landscape intactness (**Section 3.2.3**), the landscape intactness model was used as a measure of human development. To characterize human development, landscape intactness model values were inverted such that low normalized values (i.e., those values closer to -1) represented areas of low human development and high normalized values (i.e., those values closer to 1) represented areas of high human development. The histogram of the inverted normalized values was inspected to assign human development intensity categories at the following breakpoints (**Figure 3-12**): Very Low (<-0.60), Low (-0.60 - -0.20), Moderate (-0.20 – 0.20), High (0.20 – 0.60), and Very High (>0.60). The resulting maps of current and near-term future human development intensity are shown in **Figure 3-13** and **Figure 3-14**, respectively.

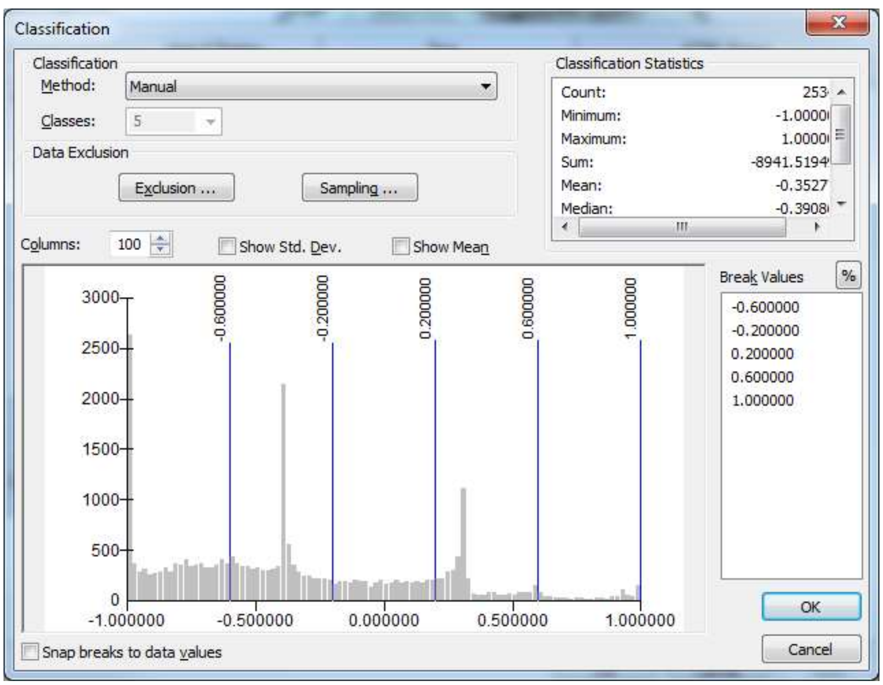


Figure 3-12. Histogram and breakpoints used to assign categories of current human development intensity. The same breakpoints were used to assign categories for near-term future human development intensity.

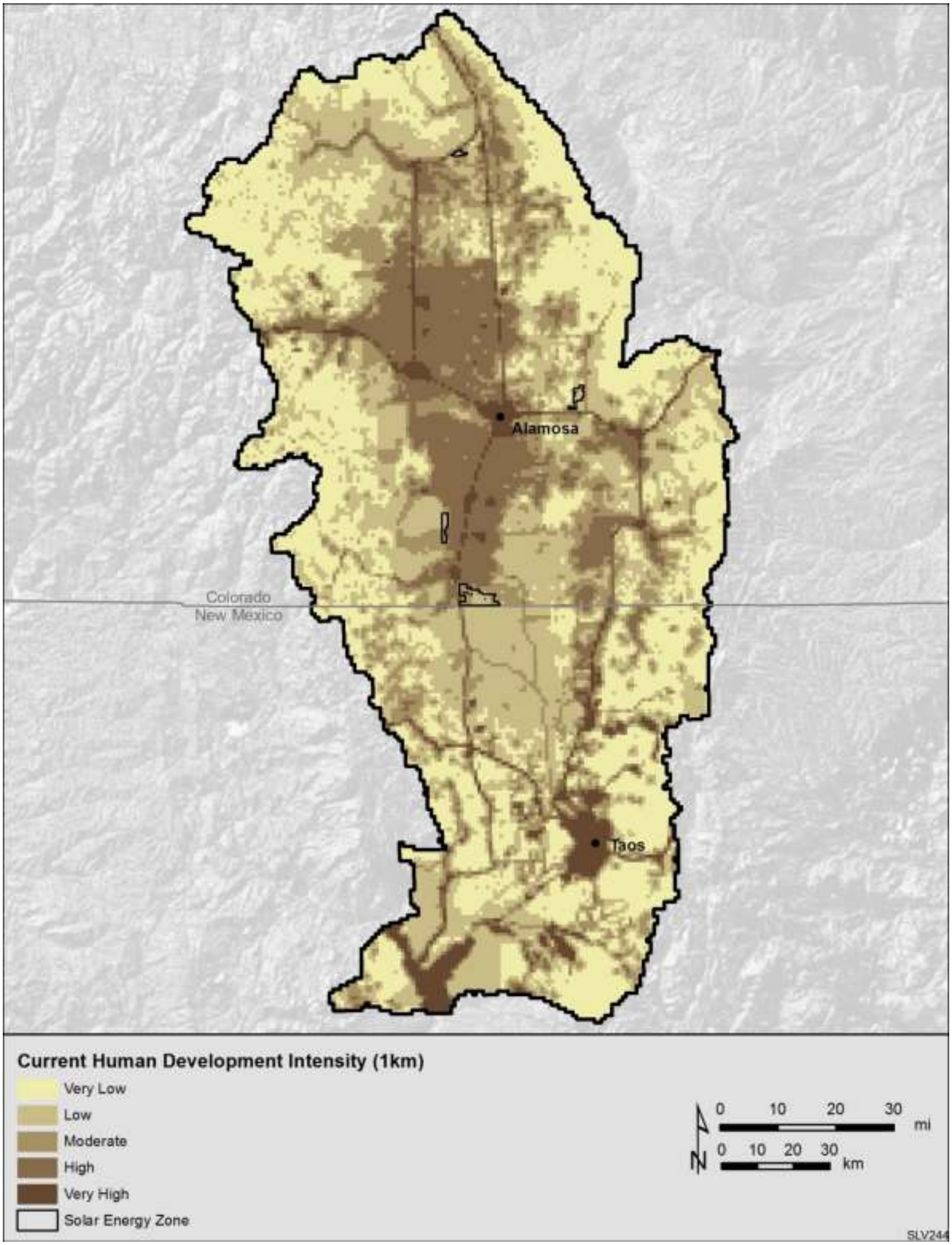


Figure 3-13. Current human development intensity modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

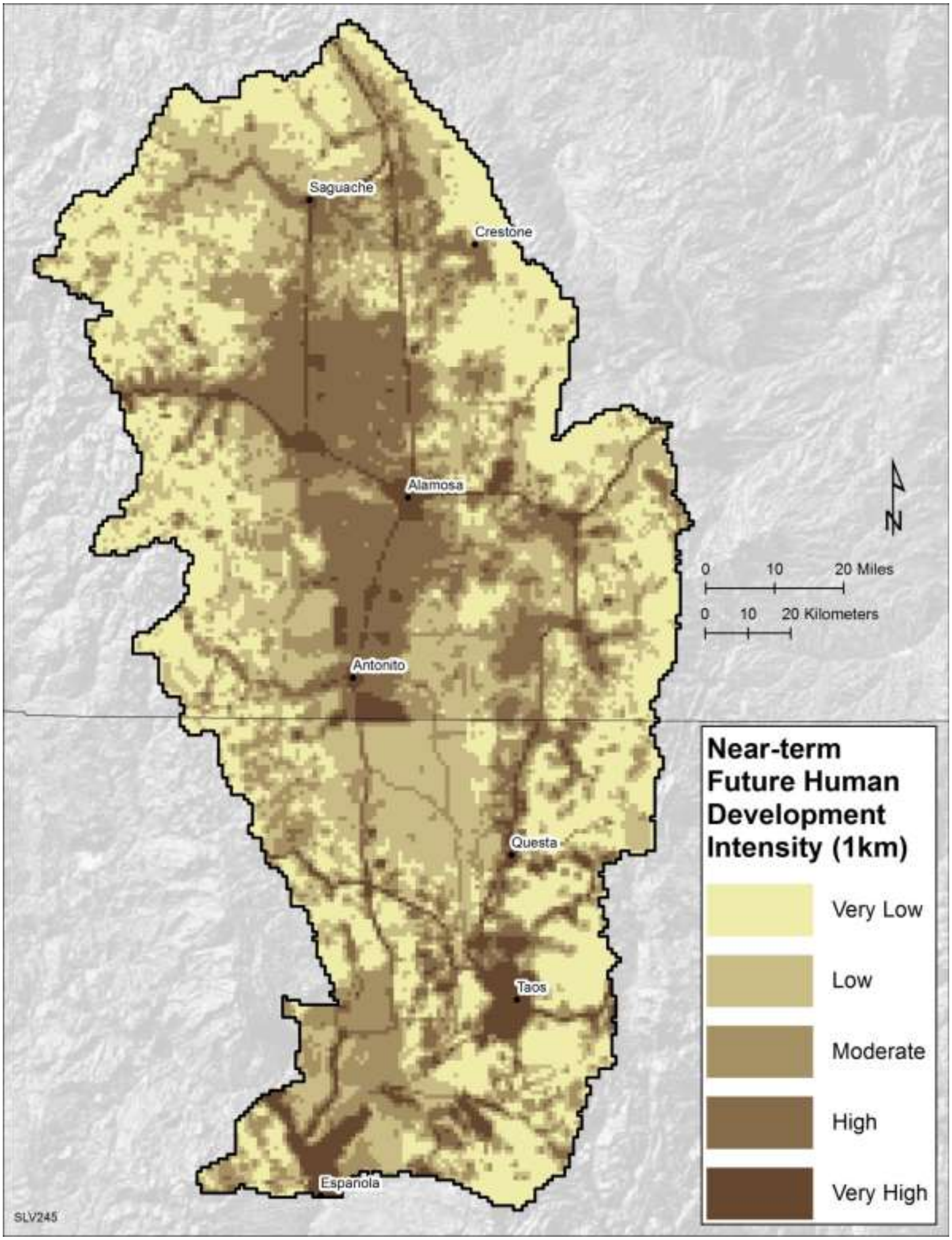


Figure 3-14. Near-term future (2015-2030) human development intensity modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

3.2.6 Invasive Species, Insects, and Disease Modeling

Multiple exotic and invasive species have become established in the San Luis Valley – Taos Plateau study area. Priority invasive species in the study area include the following (from USFS 2008):

- Yellow toadflax
- Russian knapweed
- Black henbane
- Cheatgrass (downy brome)
- Leafy spurge
- Oxeye daisy
- Tall and short white top
- Canada thistle
- Musk thistle
- Tamarisk
- Russian olive
- Leafy spurge
- Eurasian milfoil

Several of these species, such as cheatgrass and tamarisk, are known to alter ecosystem processes, such as fire regimes and hydrologic processes; they have the potential to expand their distribution in spite of human and natural disturbances and to adapt and shift their range in response to climate change. Invasive vegetation often out-competes native species by using soil nutrients and water at a greater rate or earlier in the season and regularly producing greater biomass (DeFalco et al. 2007).

In addition to invasive species, forest communities in the study area may become plagued by the presence of insect pests and diseases. Through the U.S. Forest Service National Forest Health Monitoring Program (USDA 2014b), data have been collected on the presence of insects and disease within the National Forests. In the study area, the most common insect pests recorded within the Carson and Rio Grande National Forests include spruce beetle (*Dendroctonus rufipennis*), western spruce budworm (*Choristoneura occidentalis*), Douglas-fir beetle (*Dendroctonus pseudotsugae*), tent caterpillar (*Malacosoma spp.*), and western balsam bark beetle (*Dryocoetes confusus*). The spruce beetle has become an increasingly dominant threat to spruce communities throughout North America by causing significant high mortality in mature high-elevation spruce forests.

Accurately mapping the full distribution of major invasive vegetation species and areas of forest insect and disease infestations is challenging due to the lack of survey effort across broad regions and the difficulty in using remote sensing to develop accurate land cover classifications. In addition, invasive species, insects, and diseases may be difficult to detect where they are co-dominants, present in the understory, or if vegetation has not shown symptoms of the presence of insects or disease.

The invasive species, insects, and disease (IID) change agent models were developed to (1) characterize the currently-known distribution of IIDs and (2) model the near-term future potential distribution of IIDs within the San Luis Valley – Taos Plateau study area. Based on available spatial data, modeling was focused on exotic and invasive vegetation and USFS Forest Health survey locations within the Carson and Rio Grande National Forests.

3.2.6.1 Current Invasive Species, Insects, and Disease Distribution

Available spatial datasets on current invasive species, insects, and disease distributions were used to characterize the current spatial distribution of IIDs in the study area. The following five datasets were used: LANDFIRE Existing Vegetation Type (v1.2), LANDFIRE Successional Class (v1.1), SWReGAP Landcover types, vector polygons from the San Luis Valley Public Lands weed infestation inventories, and USFS Forest Health survey locations that documented the presence of forest insects and disease. To create the current distribution map, invasive vegetation classes were extracted from remote sensing datasets (e.g., LANDFIRE Existing Vegetation Types, LANDFIRE Succession Classes, and SWReGAP Landcover types). The results of remotely sensed exotic/invasive vegetation were then merged with the distribution of San Luis Valley Public Lands weed infestation inventories and the USFS Forest Health survey locations to represent the distribution of IIDs throughout the study area. These datasets likely underestimate the total distribution of IIDs, because the methodology used to create the input datasets relied mostly on remotely-sensed imagery or aerial surveys and required dominance of a site by IIDs to be detectable. Where these IIDs occur as less dominant components of the vegetation community, they may expand and dominate quickly due to disturbance, land use, and climate change. The process diagram for the current invasive species distribution is shown in **Figure 3-15**.

The result of the current invasive species, insects, and disease distribution model is shown in **Figure 3-16**. Model results were summarized to the 1 km reporting units, where current invasive species distribution is represented by a measure of density within the reporting units symbolized along a scale from very low IID density (green) to very high IID density.

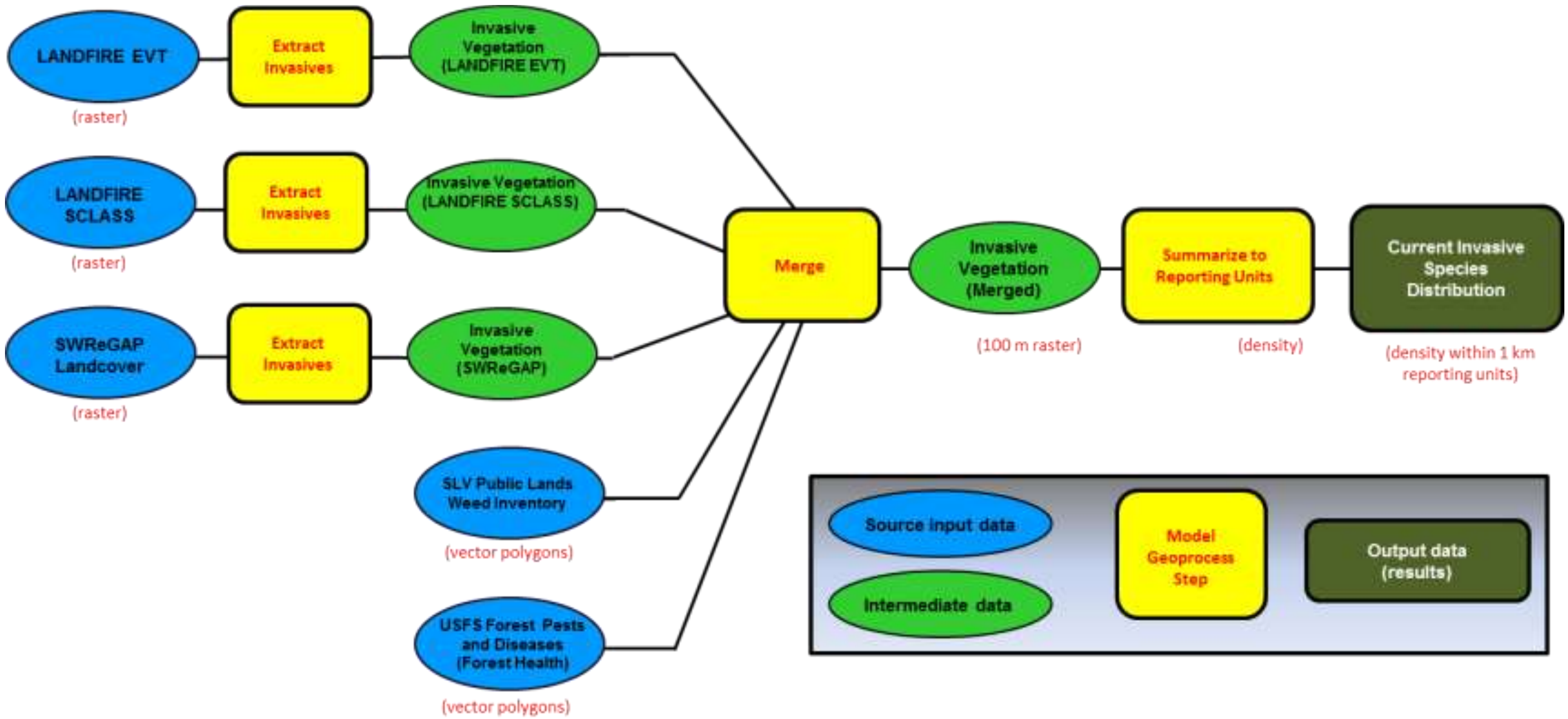


Figure 3-15. Process model to characterize current distribution of invasive species, insects, and disease.

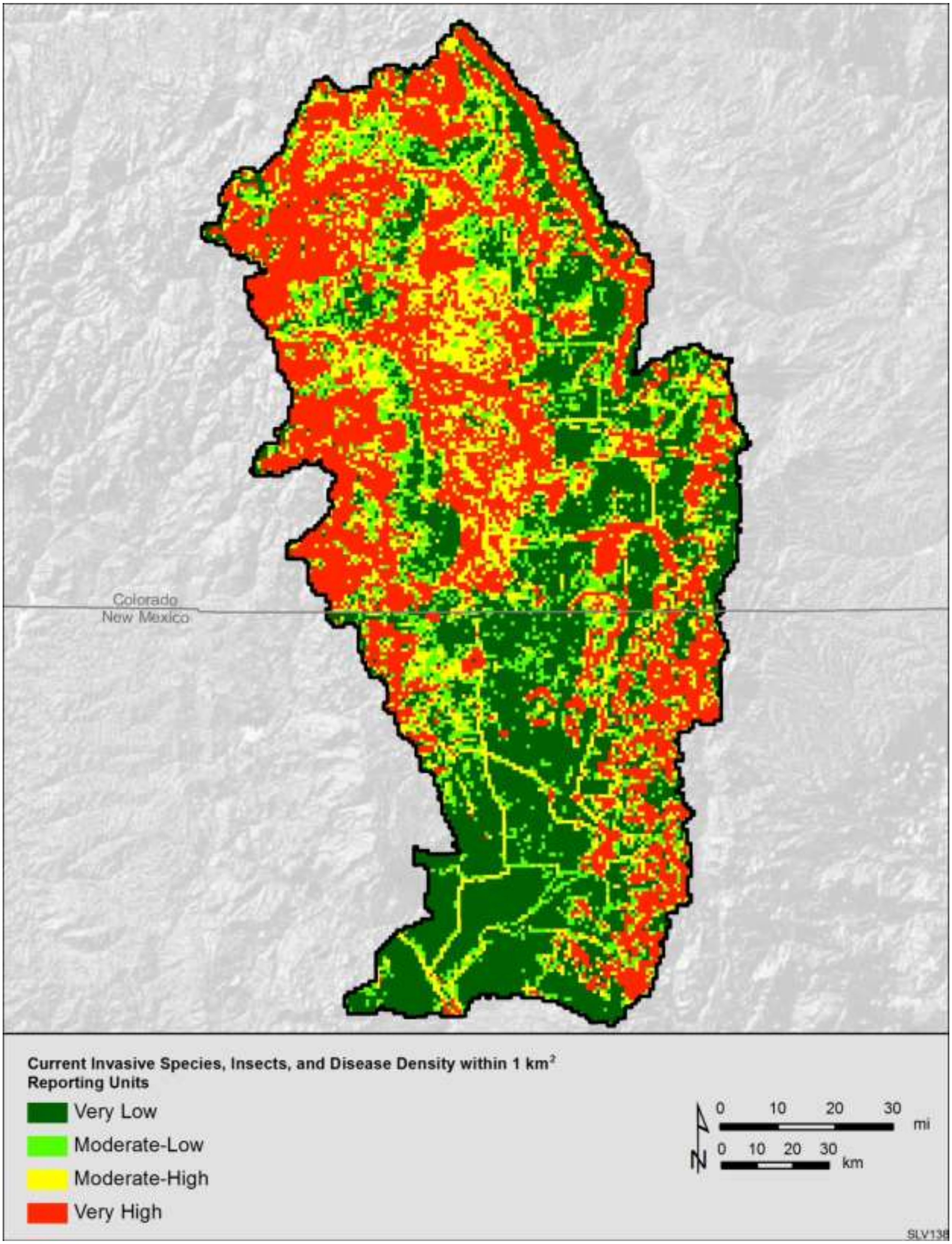


Figure 3-16. Current distribution of invasive species, insects, and disease (IID) modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

3.2.6.2 Near-Term Future Invasive Species, Insects, and Disease Potential

The model of future risk of exotic species invasion and insect and disease infestation to forest communities followed the methodology of previous landscape modeling efforts (e.g., Leu et al. 2008). A general model was first developed to predict the potential spread of exotic species as related to proximity to anthropogenic features. For example, roads may directly promote exotic plant establishment via vehicle dispersal (Schmidt 1989) or disturbance during road construction and maintenance (Tyser and Worley 1992, Parendes and Jones 2000, Safford and Harrison 2001). In Californian serpentine soil ecosystems several exotic plant species were found up to 1 km from the nearest road (Gelbard and Harrison 2003), and Russian thistle (*Salsola kali*), an exotic forb growing along roads, was wind-dispersed over distances >4 km (Stallings et al. 1995). Roads may also indirectly promote exotic plant establishment via seeding along road verges or in disturbed areas near roads as a management strategy to control the establishment of less desirable exotic grass species (Evans and Young 1978). Last, human populated areas and agricultural areas (Vitousek et al. 1997) act as conduits of exotic plant invasion.

The exotic species invasion model was adopted from previous invasive species modeling approaches (e.g., Leu et al. 2008) and follows the approach used in developing the landscape intactness model. The model integrates data on the existing distribution of invasive vegetation in the study area along with data on anthropogenic features and human land uses that may facilitate the spread of invasive species. The result of the current invasive species distribution (above) was used as input to this model.

The exotic species invasion risk model consists of a risk value along a continuum between -1 and 1, reflecting the risk of invasion. Values close to 1 imply a relatively high risk of exotic species invasion, whereas values close to -1 imply a low risk. The exotic species invasion risk model included 21 datasets from three human land use categories (transportation, urban and industrial development, and modified land cover types) (**Table 3-3**). Each dataset was assigned to either a moderate or high exotic plant invasion risk class. Areas of greater human activity were assigned to the high risk class and areas of lower human activity were assigned to the moderate risk class. For example, urban areas and major roadways were assigned to the high risk class and unpaved roads and agricultural areas were assigned to the moderate risk class. Human land-use input data for the invasive probability model are listed in **Table 3-3**.

Similar to the landscape intactness model, a distance decay function was applied to the input data for the exotic species invasive model to model the effect of distance away from the mapped human land-use datasets. This process involves the use of Euclidean Distance mapping tools and other geoprocesses (e.g., raster calculator) to spatially represent the functional relationship between exotic species invasion risk and distance away from human land uses. For purposes of modeling the exotic species invasion risk, two different linear distance decay functions were applied: one for land-uses with high risk of invasion and one for land-uses with moderate risk of invasion (**Figure 3-17**). A maximum distance of 1.5 km was applied as the maximum distance at which human land-uses influence the risk of invasion.

Integrating the mapped distance decay results for all human land uses, the resulting exotic species invasion risk model is a map surface indicating relative risk of invasion across the study area.

It was assumed that the current distribution of forest insects and diseases would also be a suitable predictor of their future distribution. Therefore, the USFS Forest Health survey areas were integrated into the final future exotic species invasion risk model to illustrate the predicted future distribution of invasive species, insects, and disease (**Figure 3-18**). The current and potential future distributions of invasive species, insects, and disease were characterized by categorizing current densities and future risk of invasion into 4 ordinal classes (very low, moderate-low, moderate-high, very high).

Table 3-3. Future Exotic Species Invasion Risk Model Input Human Land-Use Data and Risk Classes for the San Luis Valley – Taos Plateau Landscape Assessment.[1]

Human Land Use or Impact Factor	Risk Class[2]	Risk Value[3]
Transportation		
Dirt roads, OHV trails	Moderate	0.6
Local roads	High	0.95
Primary highways	High	0.95
Urban and Industrial Development		
Low density development (including rural development)	Moderate	0.6
Medium density development	High	0.95
High density development	High	0.95
Communication Towers	Moderate	0.6
Powerlines / transmission lines	Moderate	0.6
Mines and oil/gas well pad locations	Moderate	0.6
Urban Polygons (BLM and U.S. Census Bureau)	High	0.95
High Impervious Surfaces (NLCD Imperv > 40)	High	0.95
Urban Lights (NASA Night Lights > 200)	High	0.95
Wildland-Urban Interface (WUI)	High	0.95
Urban Development Risk – High and Moderate Risk	High	0.95
Urban Development Risk – Low Risk	Moderate	0.6
Potential for Solar Development (SEZs)	High	0.95
Managed and Modified Land Cover		
Low agriculture and invasives (ruderal forest, recently burned, recently logged, etc)	Moderate	0.6
Pasture (landcover)	Moderate	0.6
Grazing allotments with degraded habitat quality	Moderate	0.6
Introduced vegetation	High	0.95
Cultivated agriculture	Moderate	0.6

1 Modeling approach adopted from Leu et al. (2008).

2 Two risk classes considered (moderate and high). Risk was considered “high” in areas of more intense human activity or in areas of current introduced/exotic vegetation. Risk was considered “moderate” in areas of lower human activity.

3 The risk value was determined based on risk class (“high” = 0.95, “moderate” = 0.6).

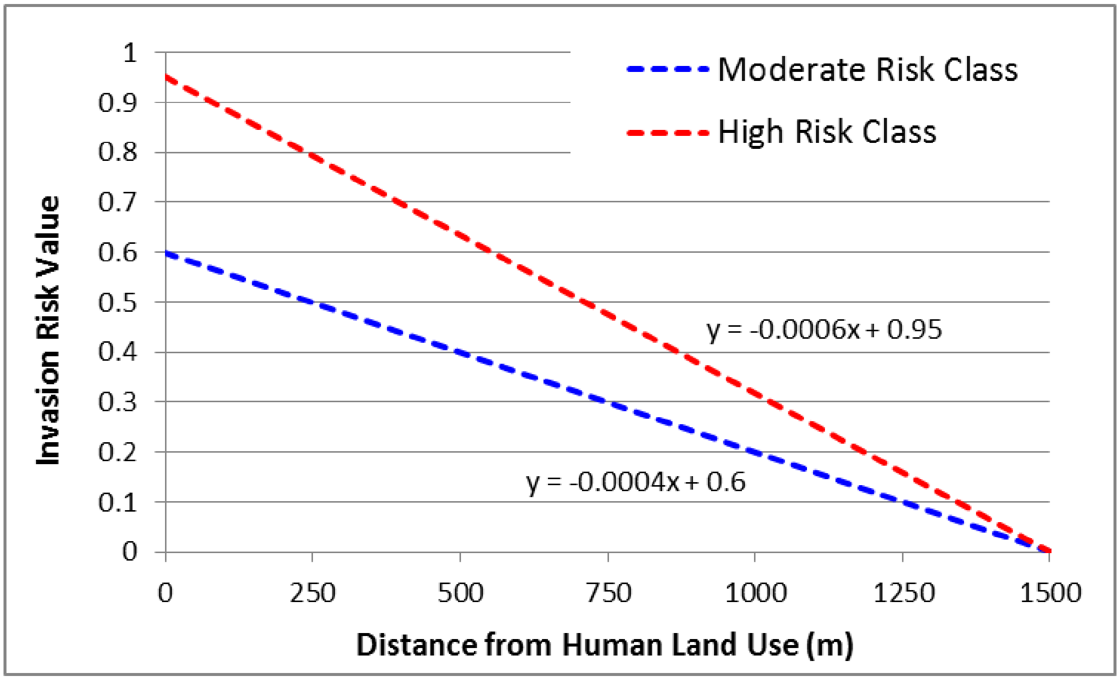


Figure 3-17. Distance decay functions for human land use datasets categorized by moderate risk classes and high risk classes to develop the future exotic species invasion risk model.

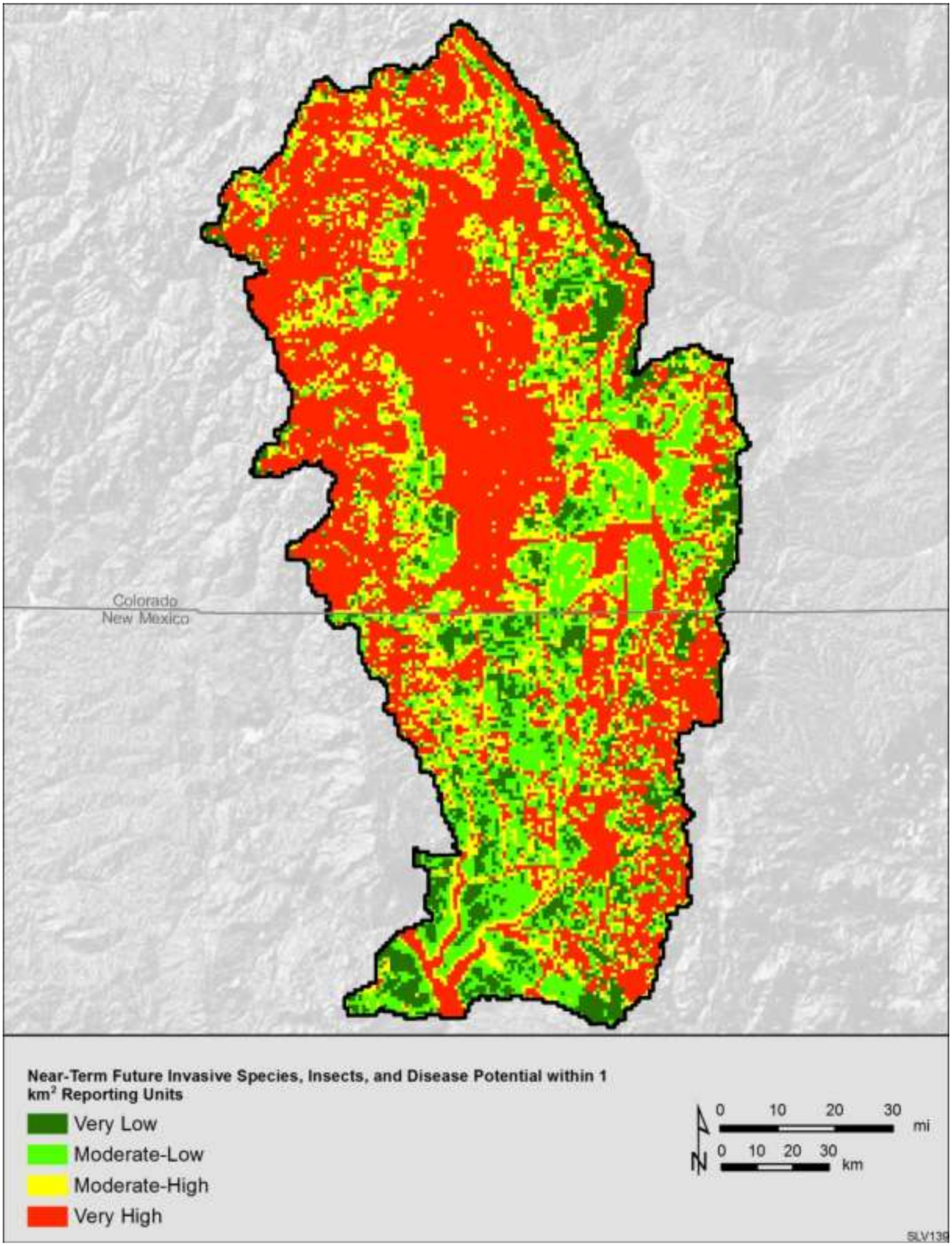


Figure 3-18. Near-term future distribution of invasive species, insects, and disease (IID) modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

3.2.7 Wildfire Modeling

Wildfire size, severity, and length have increased in recent years, largely due to effects from climate change, forest disease outbreaks, and spread of invasive species (Holden et al. 2007; Jolly et al. 2015). The distribution of historic and current fire occurrences was modeled from a process model. Input datasets characterized the location and size of historic fires in the study area and were obtained from several sources (**Table 3-4**), including the Geospatial Multi-Agency Coordination (GEOMAC), BLM, and USGS (LANDFIRE v1.20). The process model to characterize the historic and current distribution of wildfires is shown in **Figure 3-19**. The input datasets were summarized to the 1 km^2 reporting units and normalized along a scale of -1 to 1, where values closer to -1 indicated areas of low fire density and values closer to 1 indicated areas of high fire density. The resulting datasets were combined and the minimum normalized density value was calculated for each 1 km^2 reporting unit to determine the historic-current distribution of wildfire in the study area. Model results were then classified into one of five categories to describe fire density: Very Low, Low, Moderate, High, and Very High. The mapped model results for historic-current fire density is shown in **Figure 3-2-0**.

Table 3-4. Input datasets used to characterize the historic-current distribution of wildfire in the study area.

Source	Description
BLM	Fire locations in the study area (points)
GEOMAC	Fire locations in the study area (points)
USGS (LANDFIRE 1.20)	LANDFIRE Disturbances (raster)
GEOMAC	Fire perimeters in the study area (polygons)

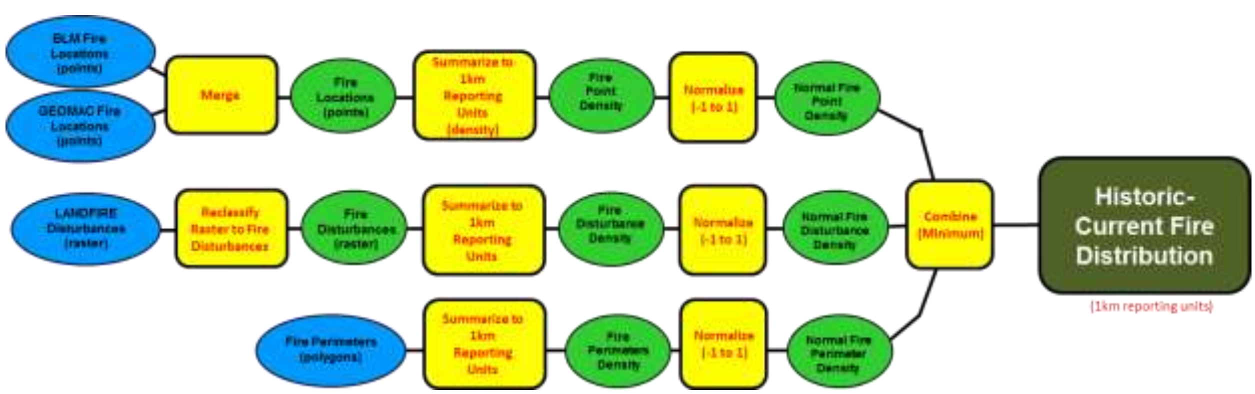


Figure 3-19. Process model to characterize historic-current distribution of wildfire.

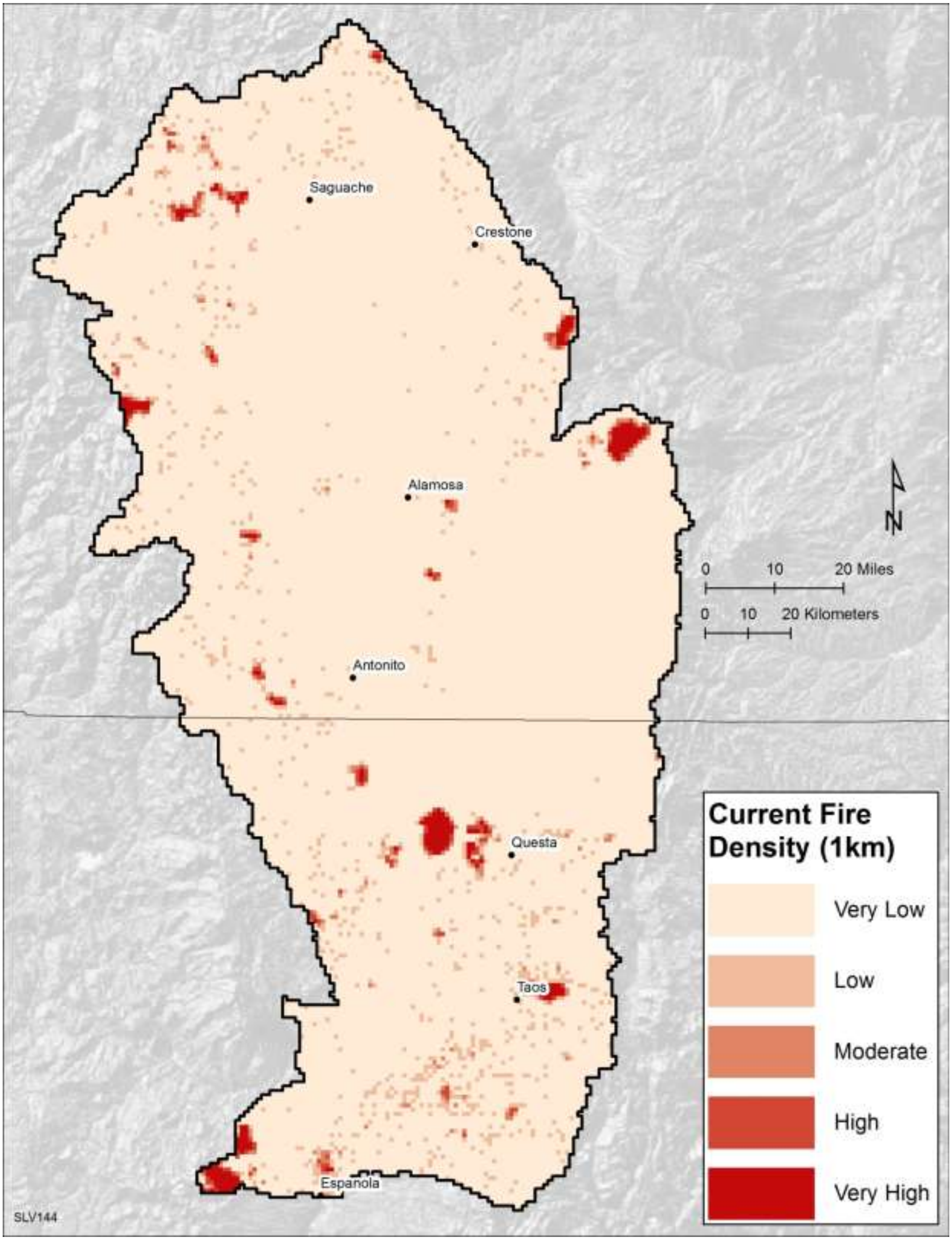


Figure 3-20. Distribution of historic and current wildfire modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

The wildland fire potential (WFP) dataset (USFS 2013) was used to characterize near-term future (2015-2030) potential for wildfire throughout the study area. The WFP dataset is a raster geospatial product produced by the USDA Forest Service, Fire Modeling Institute that is intended to be used in analyses of wildfire risk or hazardous fuels prioritization at regional or national scales. The WFP map builds upon, and integrates, estimates of burn probability (BP) and conditional probabilities of fire intensity levels (FILs) generated for the national interagency Fire Program Analysis system (FPA) using a simulation modeling system called the Large Fire Simulator (FSim; Finney et al. 2011). The specific objective of the 2012 WFP map is to depict the relative potential for wildfire that would be difficult for suppression resources to contain, based on past fire occurrence, 2008 fuels data from LANDFIRE, and 2012 estimates of wildfire likelihood and intensity from FSim. Areas with higher WFP values, therefore, represent fuels with a higher probability of experiencing high-intensity fire with torching, crowning, and other forms of extreme fire behavior under conducive weather conditions (e.g., drought).

To model near-term future wildfire potential, the WFP raster values were summarized to 1 km^2 reporting units and normalized along a scale ranging between -1 and 1, where values closer to -1 indicate non-burnable areas or areas with very low potential for future wildfire. Normalized values closer to 1 indicate areas with very high potential for future wildfire. Normalized values were then classified into one of five categories to map near-term future wildfire potential: Very Low, Low, Moderate, High, and Very High. The mapped model results for near-term future wildfire potential shown in **Figure 3-21**.

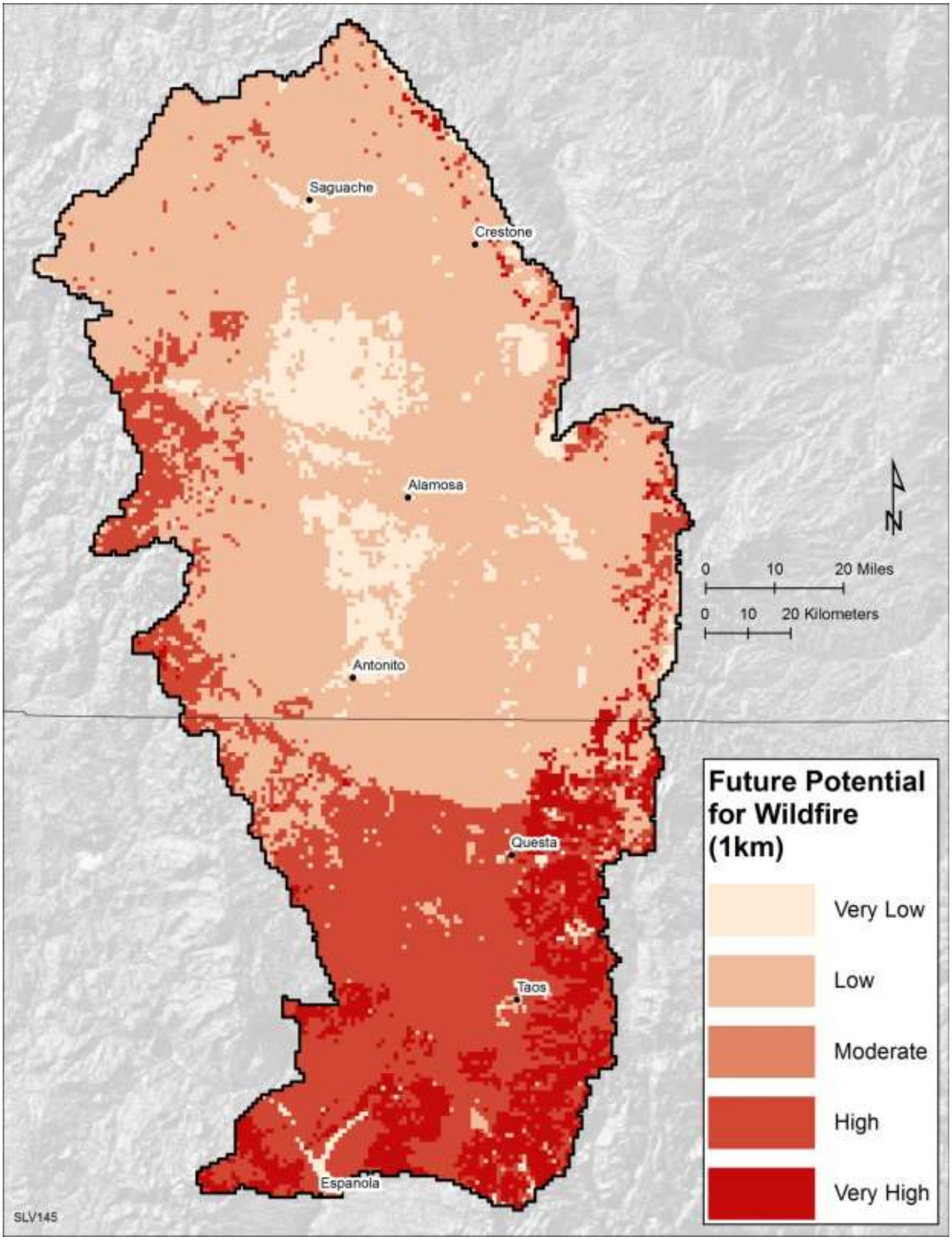


Figure 3-21. Near-term future potential for wildfire modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

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4 EVALUATION OF CURRENT AND FUTURE CONDITIONS

Current and future conditions of the San Luis Valley-Taos Plateau are introduced in this chapter with an overview of the assessment approach to characterize current condition of CEs. The assessment approach relies heavily on the current and future landscape intactness and change agent models that were previously described in Section 3.2. Because the assessments to evaluate current and future conditions result in large amounts of data, examples are presented within this chapter. Refer to Appendices A and B for evaluation of current and future conditions for all CEs.

For most CEs, particularly ecological systems and focal species, current distribution mapping was developed from Southwest ReGAP or LANDFIRE Existing Vegetation Type Macrogroup spatial data. For some CEs, other species-specific data were incorporated as the data were available. No additional modeling was performed to characterize CE distributions. The total size of the study area examined in this LA was 6,263,040 acres (25,346 km^2). Current distributions for the ecological systems and terrestrial focal species (including assemblages) within the study area ranged from 378,000 acres to over 5,500,000 acres (**Table 4-1**).

Table 4-1. Total current distribution area (acres) for ecological systems and terrestrial focal species for the San Luis Valley-Taos Plateau Level IV Landscape Assessment.

Ecological System or Species[a]	Total Distribution Area (Acres)	Percent of Study Area
Ecological Systems Macrogroups		
Montane and subalpine conifer forest	2,203,331	35.2%
Basin grassland and shrubland	1,731,530	27.6%
Piñon-juniper woodland	640,517	10.2%
Riparian and wetland systems (based on LANDFIRE)	537,345	8.6%
Focal Species		
Brewer's sparrow	803,397	12.8%
Ferruginous hawk	1,682,529	26.9%
Northern goshawk	2,137,752	34.1%
Gunnison sage-grouse[b]		
Potential Habitat	27,894	0.4%
Occupied Habitat	20,428	0.3%
Waterfowl/shorebird assemblage[c]	562,037	9.0%
Mexican free-tailed bat	4,763,064	76.1%
Bighorn sheep	1,668,580	26.6%
Grassland fauna assemblage	3,532,484	56.4%
Mountain lion	4,940,268	78.9%
Pronghorn	3,179,613	50.8%
Elk-mule deer assemblage	5,622,398	89.8%

[a] Data Sources: Ecological Systems: LANDFIRE EVT (USGS 2010); Focal Species: unless otherwise noted, habitats for all focal species were represented by SWReGAP habitat suitability models (USGS 2007).

[b] Habitat for the Gunnison sage-grouse was represented by occupied and potentially suitable habitats delineated in the Gunnison Sage-grouse Rangewide Conservation Plan (Gunnison Sage-grouse Rangewide Steering Committee 2005).

[c] Habitat for the waterfowl/shorebird assemblage was represented by an aggregation of hydrological and species-specific datasets from the USFWS NWI, CPW, and U.S. National Atlas. Refer to Appendix B (Section B.2.6) for more details on waterfowl/shorebird assemblage source data.

The current landscape intactness model is a fundamental component to assessing condition of each of the CEs. To assess current condition, CE distribution was intersected with the current landscape intactness model at the 1 km^2 reporting unit resolution. It is important to note that the landscape intactness model is a generalized indicator of condition throughout the study area and is not directly linked to specific species requirements. Not all species respond similarly to the disturbance factors used as intactness model inputs, but an overall intactness model provides a standard baseline from which to explore species-specific responses. Tailoring the landscape intactness model to species-specific responses is identified as a data gap for future study (**Section 1.4**).

Current CE condition also included an intersection with vegetation departure (VDEP) to characterize how current vegetation communities within the CE distribution have changed relative to historic simulated conditions. The USGS LANDFIRE Project produces maps of simulated historical fire regimes and vegetation conditions. The Vegetation Departure (VDEP) data layer categorizes departure between current vegetation conditions and reference vegetation conditions according to the methods outlined in the Interagency Fire Regime Condition Class Guidebook (Hann and others 2004). VDEP values range from 0 - 100 to depict the amount current vegetation has departed from simulated historical vegetation reference conditions. This departure results from changes to species composition, structural stage, and canopy closure. The map of VDEP, summarized to 1 km^2 reporting units, is shown in **Figure 4-1**. It is important to note that VDEP alone may not be a sufficient indicator of condition because systems that are of moderately low departure from historical states may still be in relatively high condition. In addition, systems that have experienced a relatively low departure from historic states may still be contracting in extent.

In addition to the assessment of CE current condition using the landscape intactness model and VDEP, CE condition was also evaluated on the basis of CE distribution relative to Change Agents. The CA models developed for this LA were used to examine the current distribution of change agents within the CE distributions. Intersections of CA-CE distributions were made to determine how CEs may experience CAs in the context of CA distributions throughout the study area.

The assessment of potential future condition included similar CA-CE intersections using the future landscape intactness and CA models. The potential future ecological condition of each CE was evaluated using the near-term future landscape intactness model and the potential vulnerability of each CE to the CAs was evaluated using the near-term and long-term (i.e., climate change) CA models. In addition, the near-term potential for human development and the long-term potential for climate change models were combined to represent an overall Potential for Change (PFC). The PFC model was calculated at each 1 km^2 reporting unit by calculating the maximum normalized CA model results for near-term future human development potential and long-term future climate change potential. The output provides a map surface indicating areas of low to great potential for change as a result of human development or climate change. An assessment of future vegetation departure within CE distributions using LANDFIRE VDEP was not performed because a spatial dataset representing future vegetation departure analogous to VDEP was not available.

Categorizing ecological condition and the change agent models provided a simple mechanism to evaluate status and trends. Current and potential future condition for each CE was evaluated by producing bar graphs to show which proportion of the CE distribution may experience the Change Agents differently.

An example evaluation of current and future conditions for one CE (the basin grassland and shrubland ecological system) is provided below. All other evaluations of CE current and future conditions are provided in **Appendix B**. The current distribution of the basin grassland and shrubland system, as mapped by LANDFIRE Existing Vegetation Types, is shown in **Figure 4-2**. Based on the evaluation of current vegetation departure (VDEP), the majority of vegetation within basin grassland and shrubland systems has a moderate degree of departure from historic reference vegetation conditions. Approximately 49% of the basin grassland and shrubland systems within the study area have a moderate degree of vegetation departure (**Figure 4-3**).

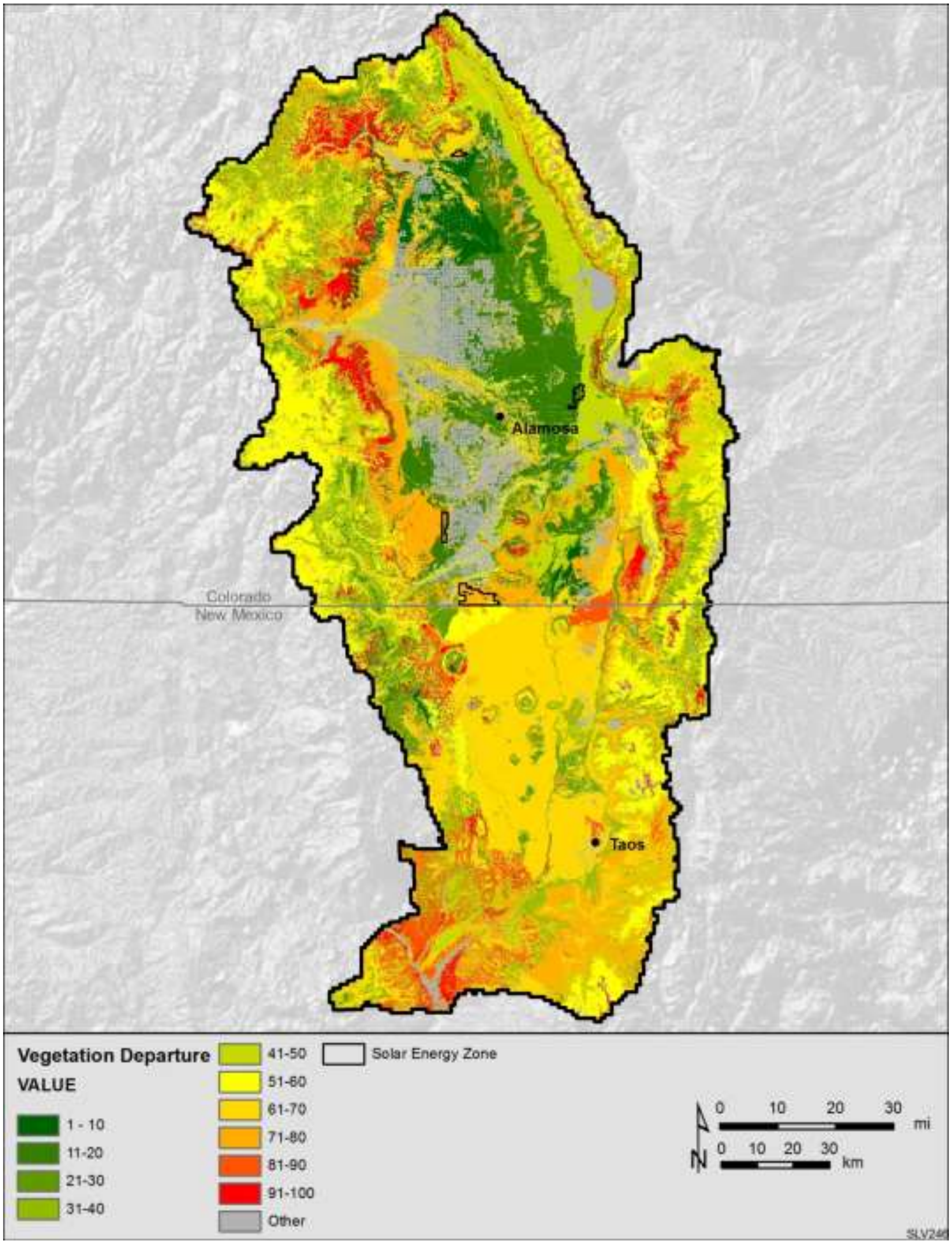

Figure 4-1. Current Vegetation Departure (VDEP) (LANDFIRE; USGS, 2008)

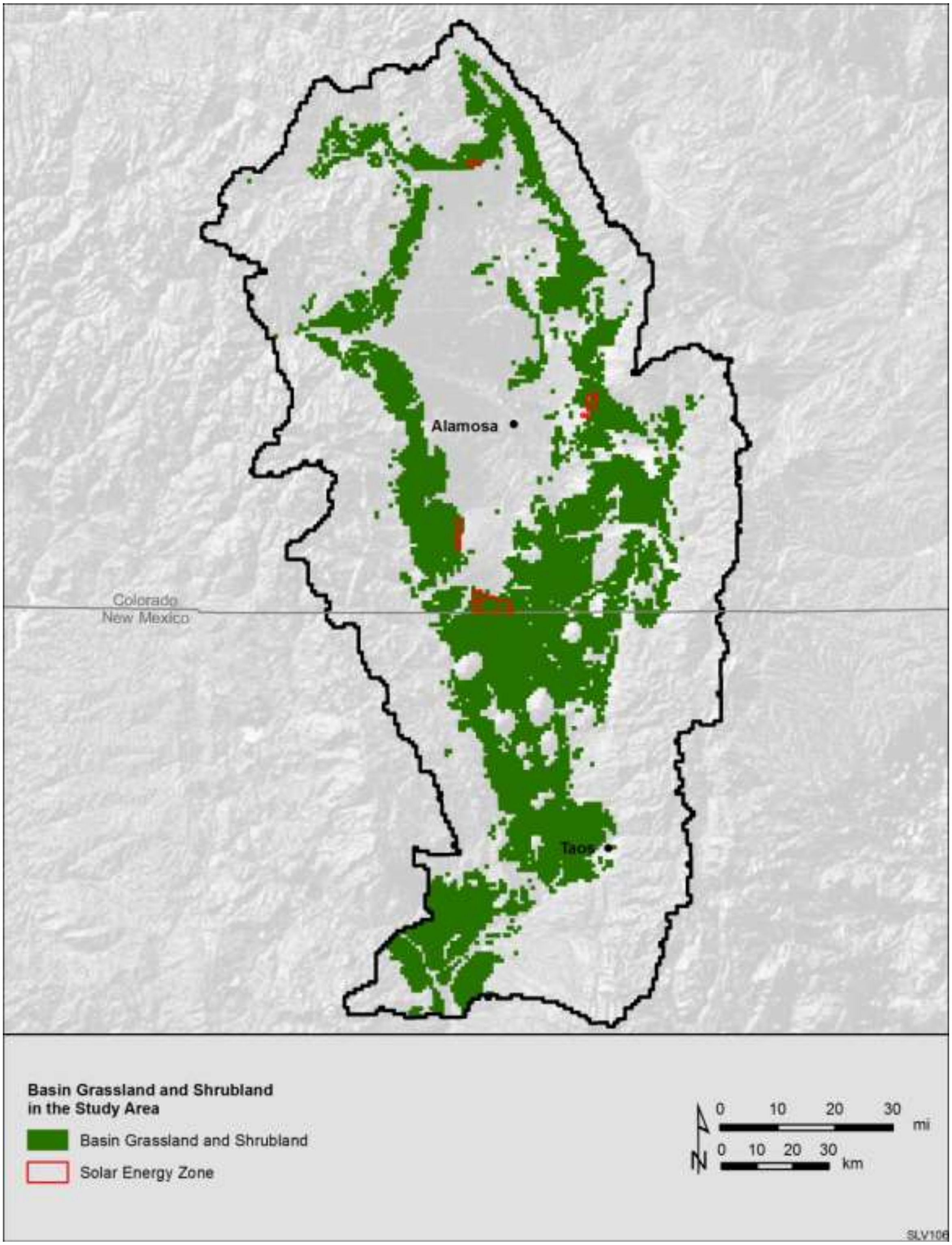

Figure 4-2. Current Distribution of the Basin Grasslands and Shrubland. Data Source: LANDFIRE EVT (USGS, 2010).

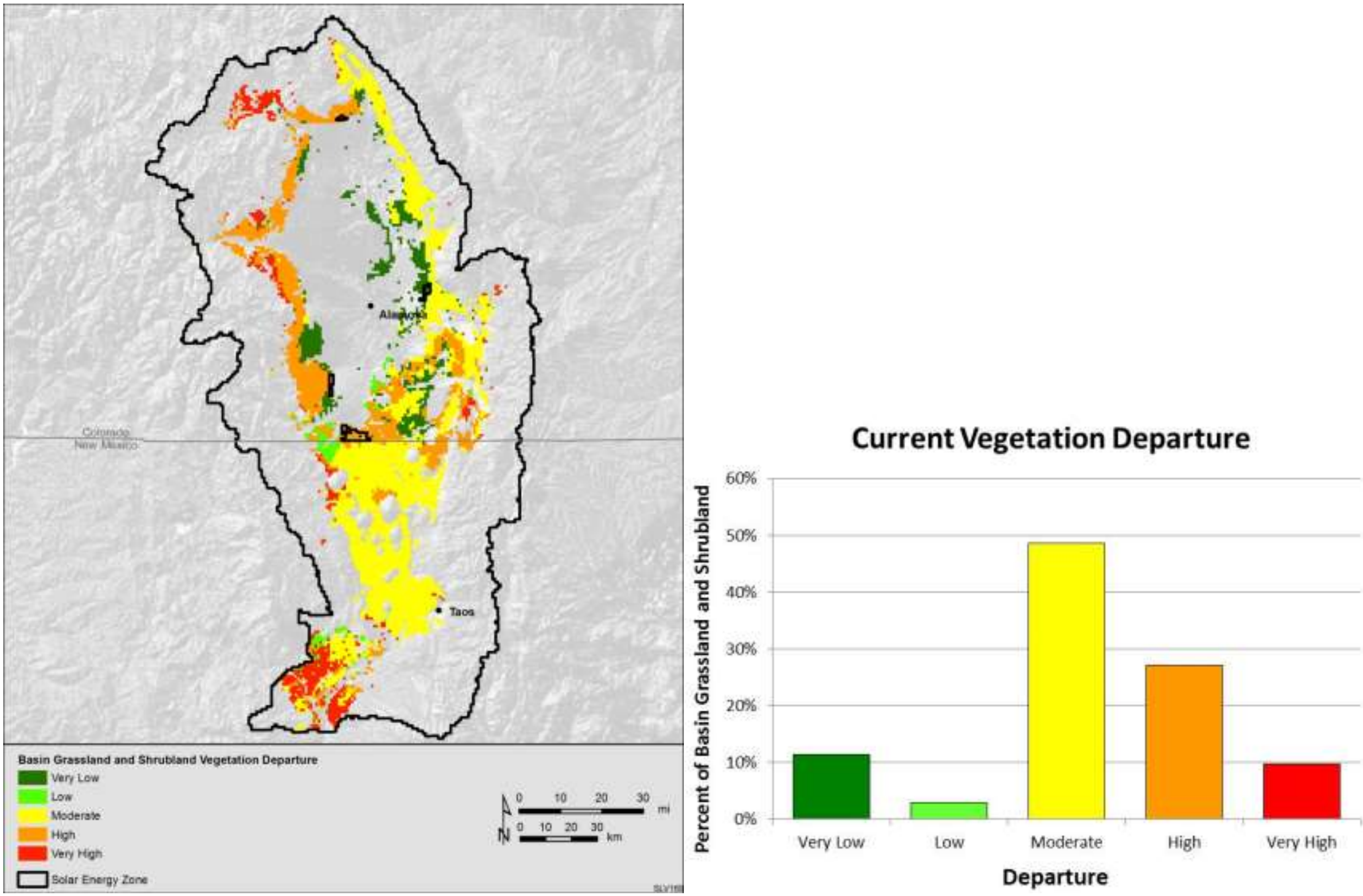

Figure 4-3. Current vegetation departure from historic conditions within the Basin Grassland and Shrubland Ecological System. Data Sources: LANDFIRE EVT (USGS, 2010) and VDEP (USGS, 2008). Data were Summarized to 1 km^2 Reporting Units.

The majority (46%) of basin grassland and shrubland systems are within areas of high current landscape intactness (**Figure 4-4; Figure 4-7**). Future trends in landscape intactness indicate a decrease in intactness within basin grassland and shrubland systems notably along a western axis that extends in the study area from Poncha Pass in the north to the Taos Plateau in the south. The amount of these systems occurring within areas of high and very high landscape intactness is expected to decrease by approximately 12% in the near-term (i.e., by 2030) (**Figure 4-7**).

Approximately 51% of the basin grassland and shrubland systems are within areas of low current human development intensity (**Figure 4-5; Figure 4-7**). Future trends in human development indicate an increase in human development intensity within these systems. The amount of basin grassland and shrubland systems occurring within areas high and very high human development intensity is expected to increase by approximately 10% in the near-term (i.e., by 2030) (**Figure 4-6; Figure 4-7**).

The majority of basin grassland and shrubland systems are within areas of low to moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure 4-5; Figure 4-7**). Future trends in climate change indicate portions of basin grassland and shrubland systems with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure 4-6; Figure 4-7**). Approximately 26% of these systems are located in areas with high or very high potential for future climate change (**Figure 4-6; Figure 4-7**).

The majority of basin grassland and shrubland systems are within areas of very low current fire occurrence density (**Figure 4-5**; **Figure 4-7**). Future trends in wildfire indicate little change in wildfire potential in these systems. Over 90% of basin grassland and shrubland systems have low or moderate near-term future (i.e. by 2030) potential for wildfire (**Figure 4-7**). The greatest potential for future wildfire occurs in the southern portion of the distribution of these systems in New Mexico (**Figure 4-6**).

The majority of basin grassland and shrubland systems are within areas of very low current density of invasive species, insects, and disease (**Figure 4-5; Figure 4-7**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of these systems in the study area (**Figure 4-6; Figure 4-7**). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural human expansion and potential energy development (**Figure 4-6**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 23% of the basin grassland and shrubland systems have the potential for high or very high future change among the change agents (**Figure 4-8**). Areas with greatest potential for change within these systems include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure 4-8**).

Although not addressed as a separate Conservation Element, ground and above ground nesting pollinators are widespread throughout the ecoregion and may be impacted by change agents within this system. Pollinators, such as honey bees, native bees, birds, bats, and butterflies, have been in decline over the last few decades (Presidential Memorandum 2014). Insect pollinators are important in maintaining biologically diverse plant and animal communities in all types of rangelands. Similarly, a heterogeneous rangeland landscape, including a variety of native grasses and forbs within a grassland, contributes to the diversity of insect pollinators (Gilgert and Vaughan 2011; Black et al. 2009). The most common grassland pollinators are solitary ground nesting bees, but flies, beetles, and butterflies are also found in grasslands. Shrubland and scrub habitat provide nesting sites for bees in twigs and holes in shrubs and trees. Some of the threats facing grassland pollinators include habitat loss and fragmentation, invasive species reducing floral diversity, overgrazing, mowing, burning, and pesticide use. Some threats facing shrubland and scrub pollinators include commercial livestock grazing, habitat fragmentation, burning, mowing, and pesticides (Black et al. 2009).

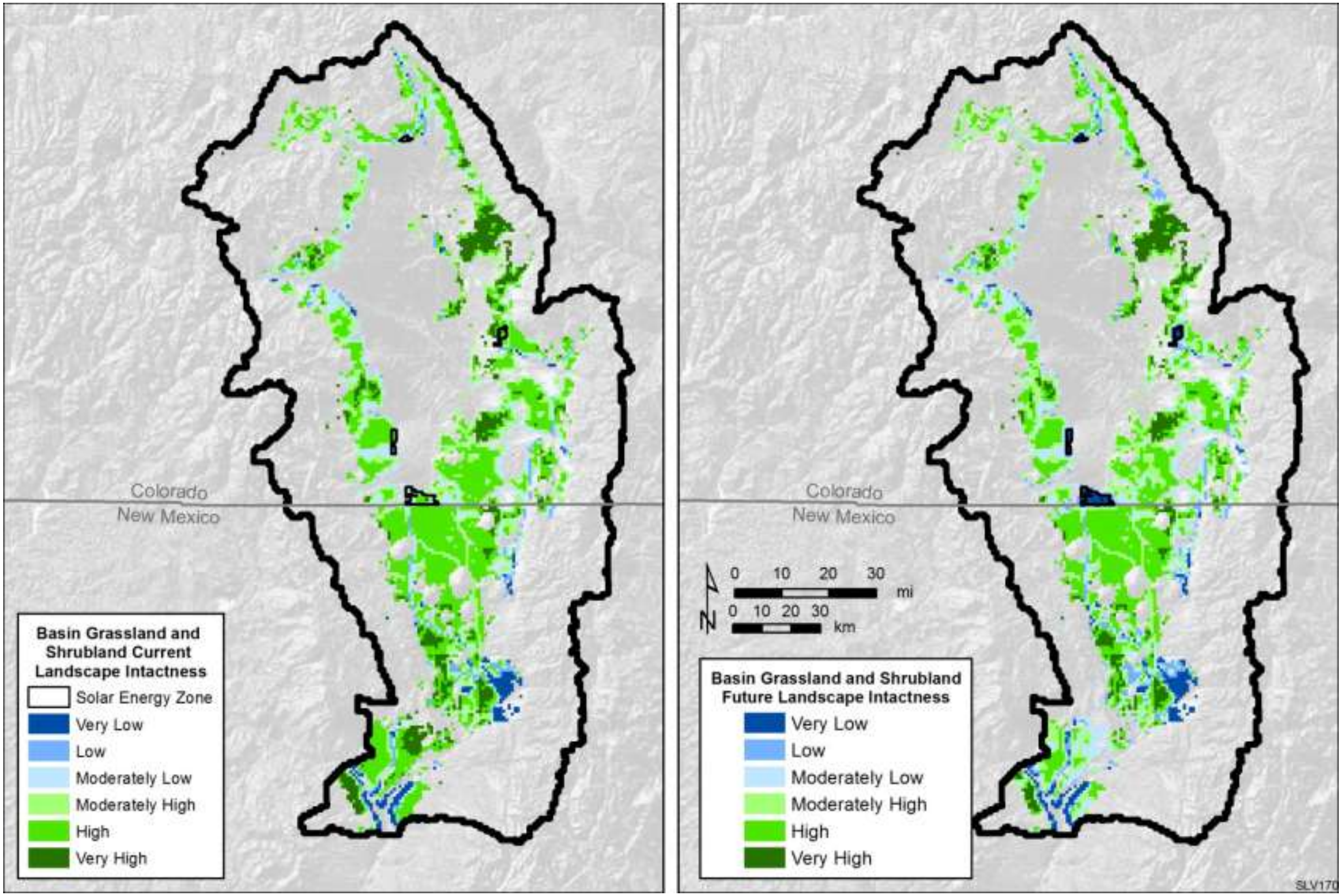

Figure 4-4. Current and Future Landscape Intactness of Basin Grasslands and Shrublands. NOTE: This landscape intactness model does not include LANDFIRE Vegetation Departure (VDEP). Data Sources: LANDFIRE EVT (USGS 2010) and landscape intactness (Argonne 2014).

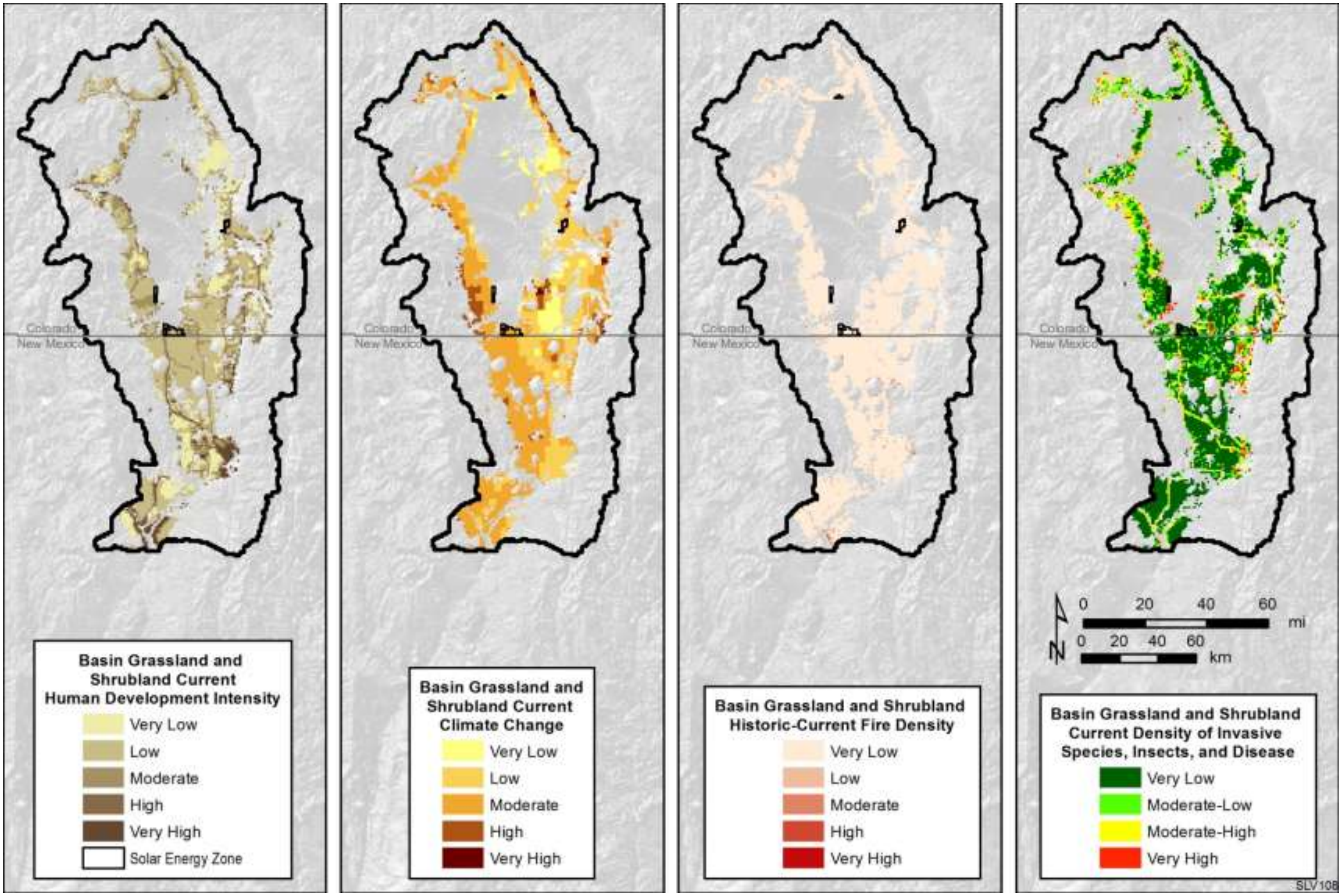

Figure 4-5. Current (2015) distribution and status of the Basin Grassland and Shrubland Ecological System relative to change agents. Data Sources: LANDFIRE EVT (USGS 2010) and change agent models (Argonne 2014).

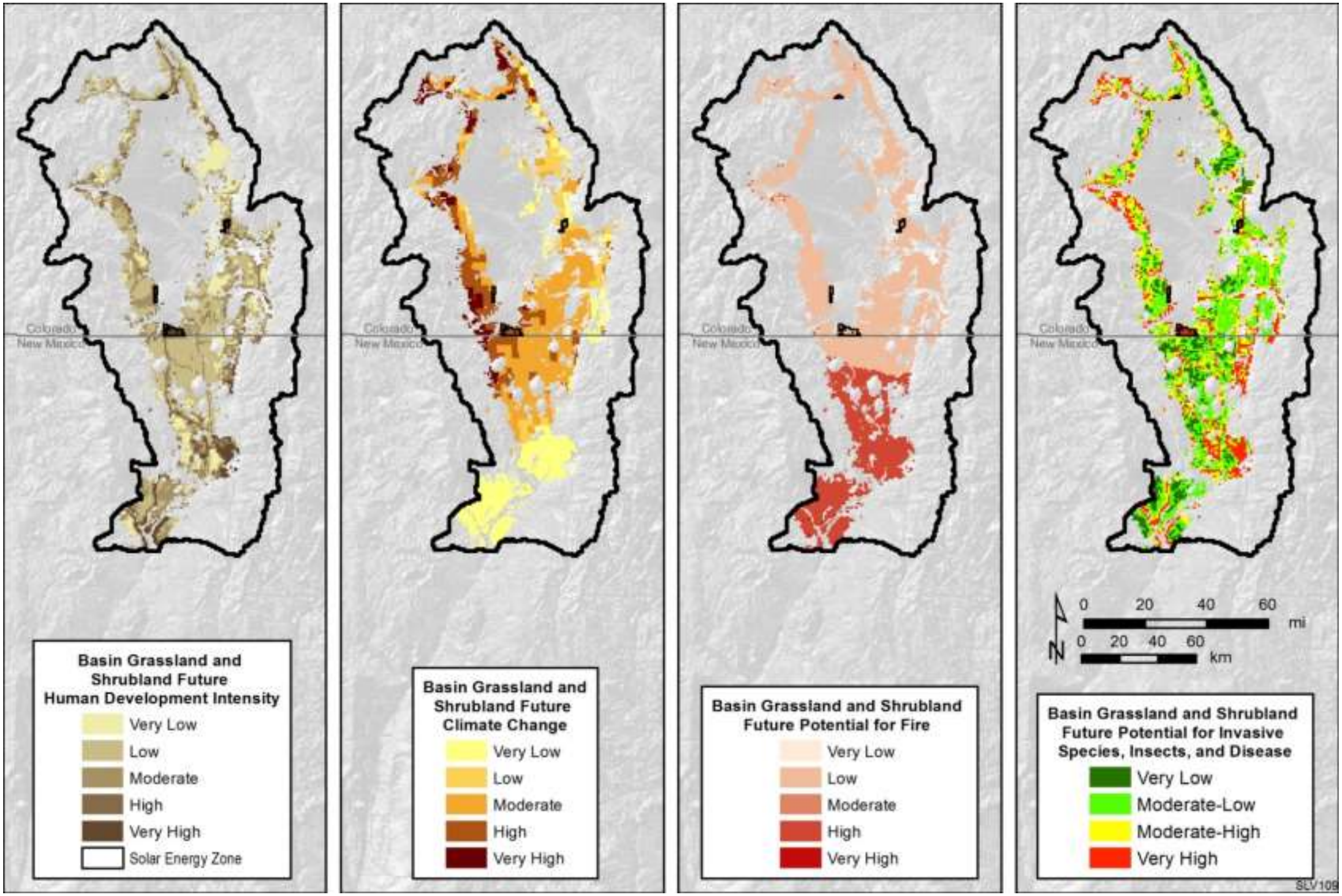

Figure 4-6. Potential future vulnerability of the Basin Grassland and Shrubland Ecological System to change agents. Data Sources: LANDFIRE EVT (USGS 2010) and change agent models (Argonne 2014). Future climate change projections were made for a 2040-2069 temporal period; all other future change agent models were developed for a 2015-2030 temporal period.

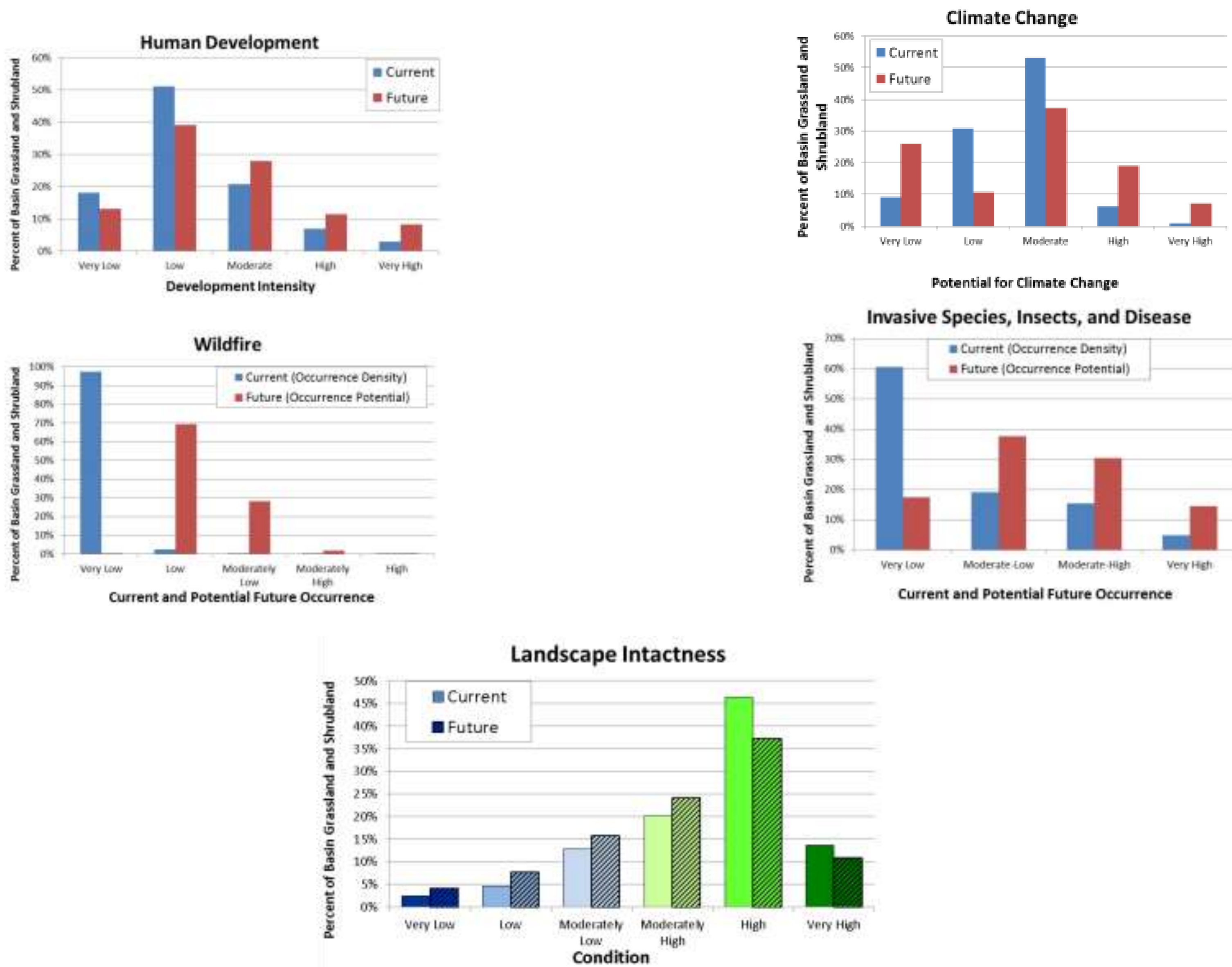

Figure 4-7. Predicted Trends in Basin Grassland and Shrubland Habitat within the Study Area

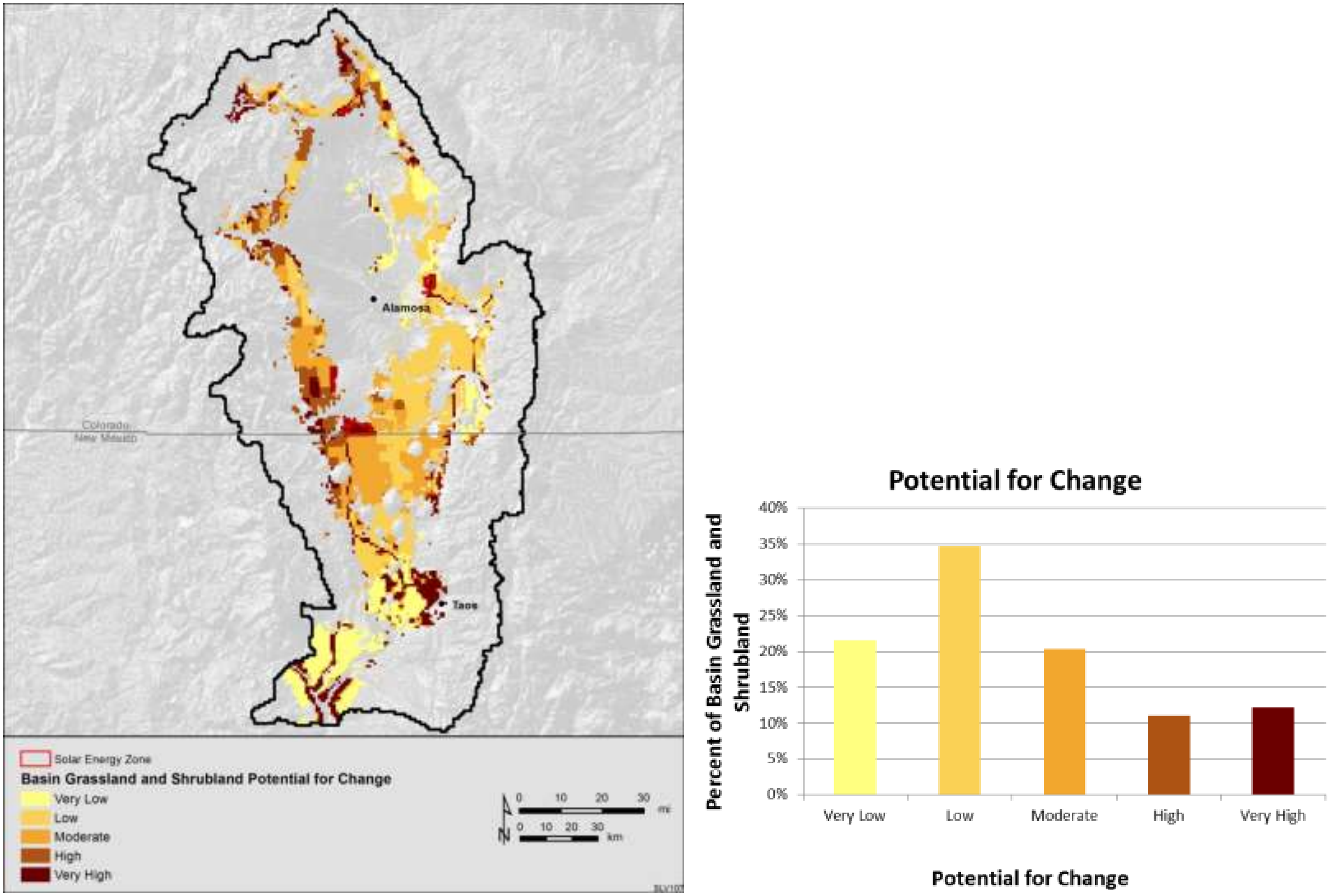

Figure 4-8. Basin Grassland and Shrubland Aggregate Potential for Change (combines potential future change model output for human development, climate change, fire, and invasive species change agents). Data Sources: LANDIFRE EVT (USGS 2010) and Potential for Change (Argonne 2014).

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5 SUMMARY AND CONCLUSION

This section presents a summary of the Landscape Assessment approach and discusses potential applications of assessment results for land management. Although the scope of this LA was focused on Management Questions and Conservation Elements relevant to issues associated with solar energy development on BLM-administered lands, the results of this LA may serve as an important resource for informing future BLM planning decisions for other activities. This section discusses several ways to use the assessment results (e.g., Landscape Intactness Model) to explore potential sites for restoration and/or preservation.

5.1 Application of Landscape Assessment Results to Conservation Planning

One primary way to use model results for conservation planning involves the evaluation of landscape intactness within sites of conservation concern. In this approach, landscape intactness within the Conservation Element "Sites of Conservation Concern" (**Appendix B; Section B.3.1**), can be mapped and quantified in a regional context (**Figures 5-1** and **5-2**). Areas of relatively low landscape intactness within these sites indicate potential opportunities for restoration (e.g., invasive species removal). For example, approximately 20% of the sites of conservation concern currently have moderately low to very low landscape intactness. These areas may be identified for further local-scale evaluation for restoration potential.

Similarly, Landscape Intactness Model results may be evaluated within other areas of potential ecological value to determine where restoration and/or preservation opportunities may occur. For example, evaluation of landscape intactness within wildlife crucial habitats ("CHAT") may provide insights into areas that could warrant future preservation based on wildlife values and landscape intactness. Landscape intactness can be mapped and quantified within the crucial wildlife CHAT habitat (**Figures 5-3** and **5-4**), and areas of greater landscape intactness within these habitats could indicate potential conservation/preservation opportunities. For example, approximately 33% of the crucial wildlife CHAT habitats in the study area have very high landscape intactness. These areas may be identified for further local-scale evaluation for preservation potential.

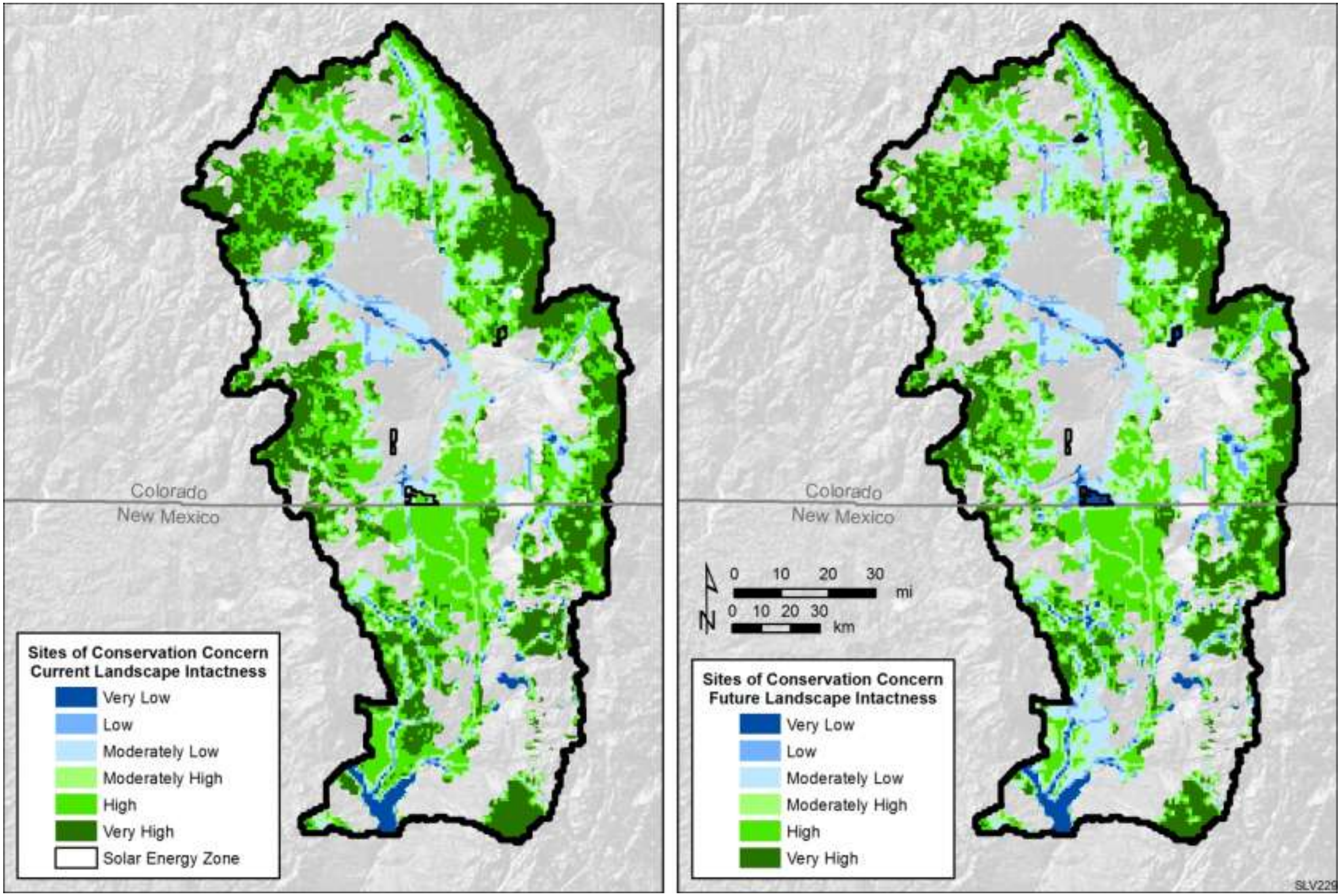

Figure 5-1. Current (2015) and Future (2015-2030) Landscape Intactness within Sites of Conservation Concern. Data Sources: Sites of conservation concern (data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012) and landscape intactness (Argonne 2014).

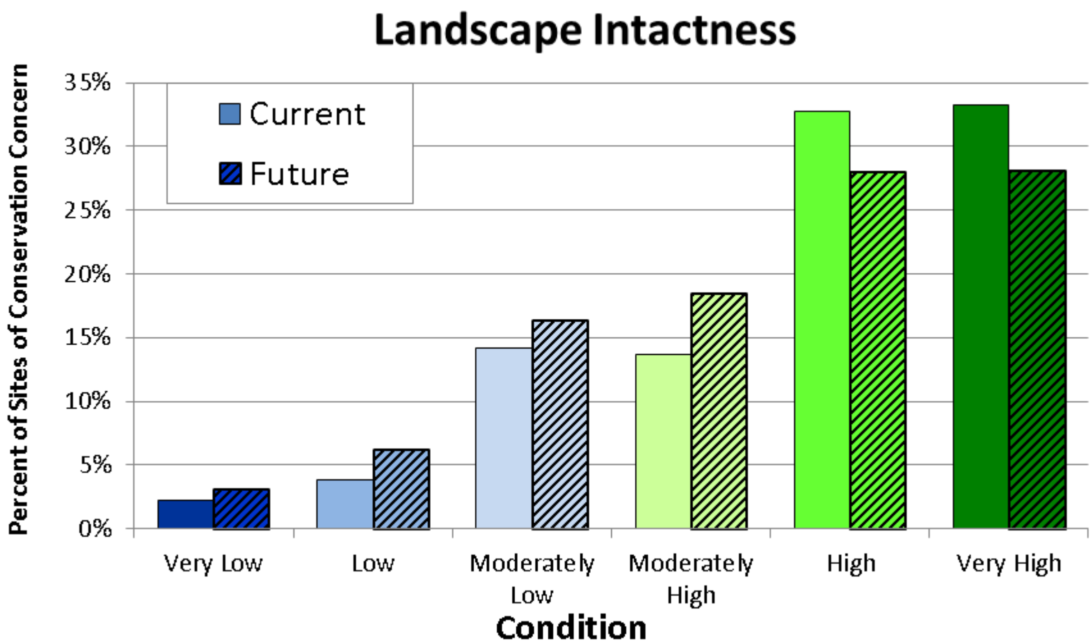

Figure 5-2. Trends in Landscape Intactness within Sites of Conservation Concern.

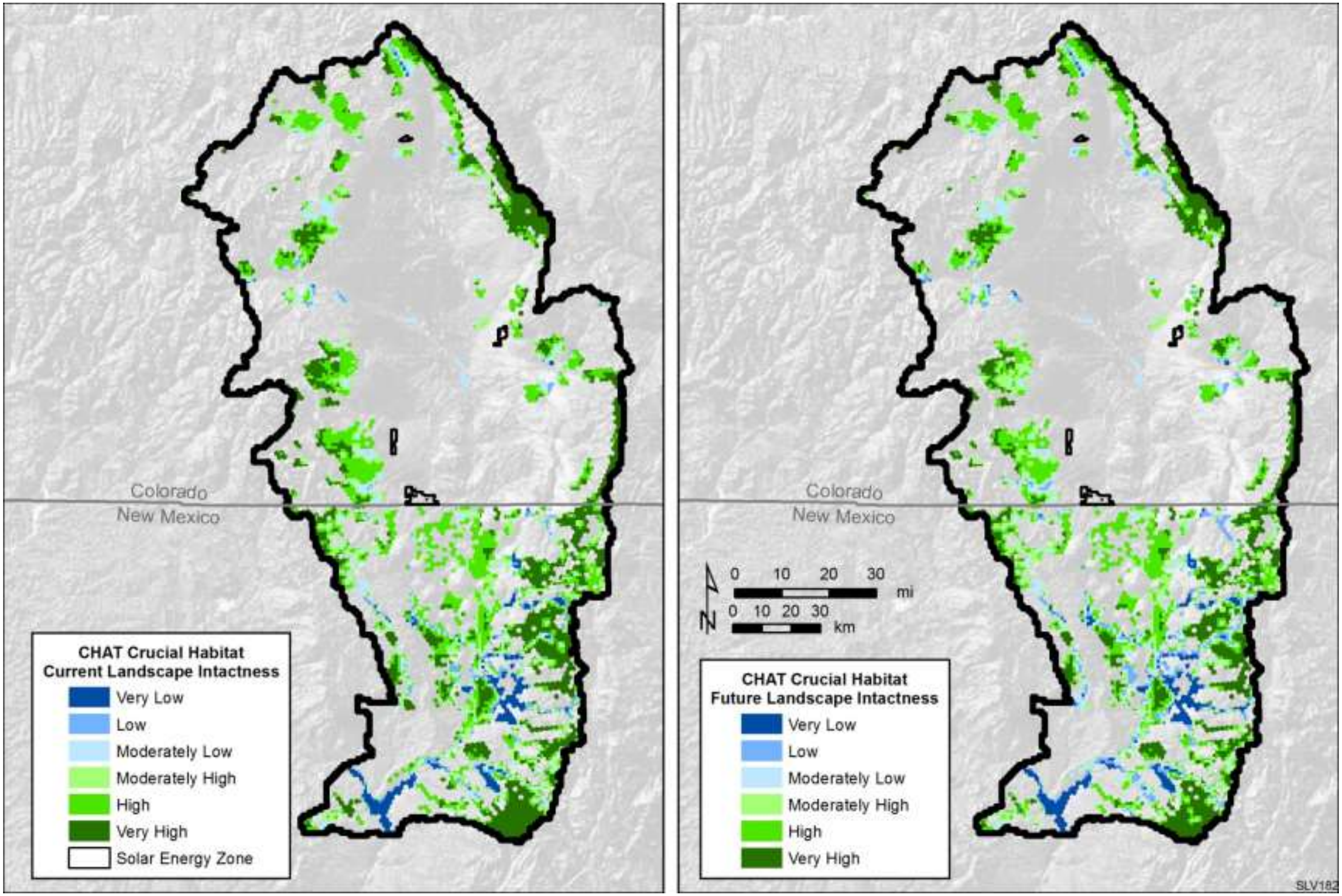

Figure 5-3. Current (2015) and Future (2015-2030) Landscape Intactness (Argonne 2014) of Wildlife CHAT Habitat (data obtained in April 2014).

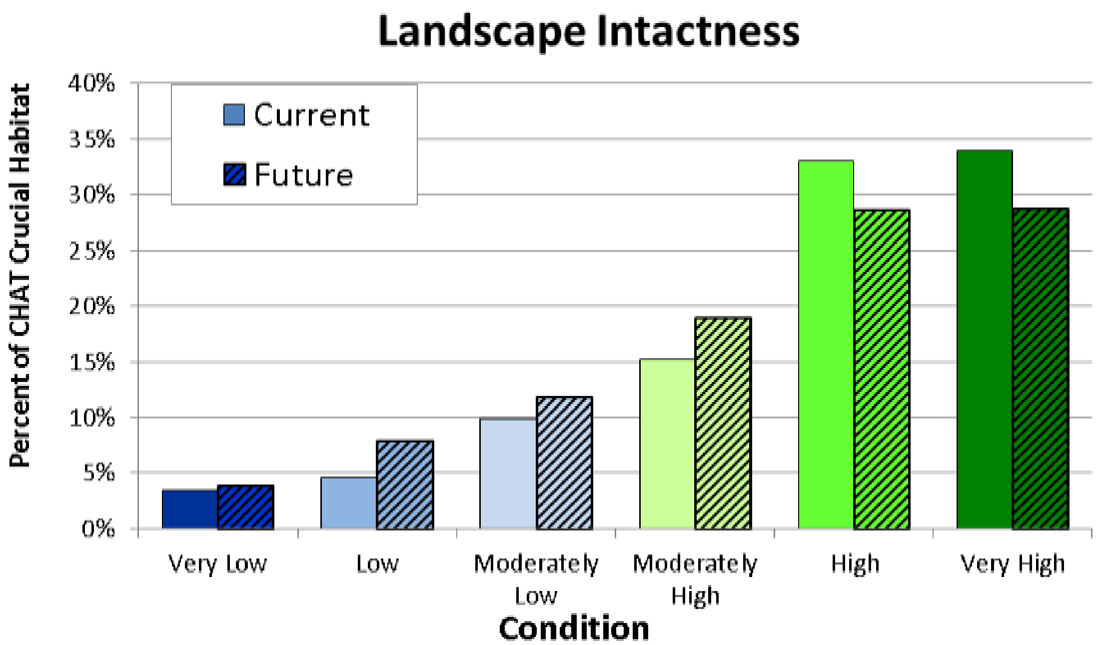

Figure 5-4. Trends in Landscape Intactness within Crucial Wildlife CHAT Habitats.

5.2 Limitations and Information Gaps

Through the development of this LA, several important limitations and information gaps have been identified. The most important of these include:

- Through the process of evaluating change agents, the availability and distribution of surface water and groundwater through hydrologic processes could be evaluated as an additional change agent that could influence the distribution, status, and trends of several Conservation Elements (e.g., shorebird/waterfowl assemblage). Although water was not evaluated as a change agent in this LA, its potential role as a change agent was acknowledged as a data gap for future study.

- The assessment of CE condition and trend incorporated generalized indicators of landscape condition and measures of change agents. While this approach provides a standard baseline to evaluate all CEs, not all species and ecological systems respond similarly to change agents. For example, some CEs may experience greater impacts from relatively small changes in climate (e.g., areas with low potential for future climate change). In addition, CE condition may be a function of other factors that could not be measured for this LA. For example, the condition of aquatic and hydrologic systems is related to the amount of human surface and groundwater use, which could not be adequately quantified and spatially represented in this LA. Assessment of CE-specific responses to disturbance factors and integration of other factors that may influence CE condition have been identified as a data gaps for future study.

- The assessments of CE condition and trend were made individually with respect to the CAs. While these assessments provide a preliminary first step towards understanding the role of CAs on CE conditions and trends, these analyses do not address the additive or synergistic interactions among CAs. For example, wildfire and invasive species often interact to result in second-order impacts in terms of state transitions in vegetation communities. The additive or synergistic interactions of multiple CAs on CE condition and trend were not evaluated in this LA and represent an area for future research.

5.3 Conclusion

There are many ways Landscape Assessments (and REAs) and their products may be used in land management planning. Use of this LA provides a regional coarse-scale filtering approach to land management that can be understood by users in a relatively short amount of time. However, application of results at local scales depends on understanding the limitations of the data. Availability of spatial data (or lack thereof) and limitations of the assessment approach to determine individual CE-specific responses to change agents should be considered. Understanding of the specific responses of CEs to change agents (such as specific changes in species' distributions) is largely outside the scope of this LA and has been identified as an information gap that could be the focus of future study.

This LA can serve as an important baseline for future planning efforts in the San Luis Valley – Taos Plateau Level IV ecoregion. This LA provided a coarse-scale regional evaluation of natural resource distribution, status, and trends, and catalogued relevant datasets used to produce mapped results. When this document is finalized (expected early 2017), users will be able to access the geospatial data and models for further analysis through the BLM REA data portal (http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas/dataportal.html).

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APPENDIX A:

EVALUATION OF MANAGEMENT QUESTIONS

This Appendix presents the assessment of Management Questions (MQs) identified by the BLM Inter-disciplinary team throughout the course of the Landscape Assessment (LA). A total of 56 MQs were identified (**Table A-1**). As discussed in Section 1.4, several MQs were determined to have insufficient data, to involve additional modeling or data processing requirements that are outside the scope of this LA, or to involve other complexities precluding evaluation in this LA. These MQs are identified in **Table A-1** in the column 'Notes'. All other MQs are evaluated in this Appendix following **Table A-1**.

In the tables below, MQs have been highlighted to represent how each MQ was evaluated in this LA, as follows:

Green – The MQ was evaluated in this LA.
Yellow – The evaluation for the MQ is either incomplete or is being evaluated in a separate assessment that has not yet been made available for inclusion in this LA.
Pink – Evaluation of this MQ could not be completed in this LA.

Table A-1. Management Questions identified in the San Luis Valley –Taos Plateau Landscape Assessment.

Management Questions		Notes
A. Soils and Air Quality		
MQA1	Where are Class I Prevention of Significant Deterioration (PSD) areas?	See Section A.1.1
MQA2	Where are soil systems with potential for erosion (including coarse-textured, calcic, saline, sodic, and shallow soils; salt crusts, low water holding capacity soils, and soils susceptible to wind erosion)?	See Section A.1.2
MQA3	Where are soil systems with potential for erosion vulnerable to change agents?	See Section A.1.3
MQA4	Where are communities and hydrologic basins susceptible and/or sensitive to fugitive dust and dust-on-snow events?	Refer to the regional dust modeling study (Chang et al. 2016) for assessment of fugitive dust. Assessment of dust-on-snow is addressed in MQB3.
MQA5	Where are Clean Air Act (CAA) criteria pollutant source areas for particulate matter (PM10 and PM2.5)?	Refer to the regional dust modeling study (Chang et al. 2016).
B. Hydrology		
MQB1	Where are and what are the conditions of hydrologic features including lotic and lentic features and artificial surface water bodies (e.g., perennial, intermittent, and ephemeral streams and springs; playas; wetlands; lakes; reservoirs; wells; ponds; livestock and wildlife watering tanks)?	See Section A.2.1
MQB2	Where are impaired waters and aquatic systems (such as those included in the EPA 303(d) and 305(b) lists)?	See Section A.2.2
MQB3	Where are mountain snow pack, rainfall, and alluvial aquifers and their recharge areas?	See Section A.2.3
MQB4	Where are hydrologic systems vulnerable to change agents?	See Section A.2.1
MQB5	Where are the areas that are susceptible to early snow melt due to dust on snow?	See Section A.2.5
MQB6	What are seasonal discharge maxima and minima for the Rio Grande, Closed Basin, and major tributaries at gaging stations?	See Section A.2.6
MQB7	Where are the confined and unconfined recharge or discharge areas?	See Section A.2.7
C. Ecological Systems Conservation Elements		
MQC1	Where are existing vegetative communities?	Refer to Appendix B
MQC2	Where are vegetative communities vulnerable to change agents in the future?	Refer to Appendix B
MQC3	Where are areas of highest carbon sequestration and what are conditions and trends of carbon sequestration in the study area?	See Section A.3.1
MQC4	What change agents have affected existing vegetation communities?	Refer to Appendix B
MQC5	How will vegetation communities be altered (e.g. state and transition) according to the change agents?	Information gap for future study. Not evaluated in this LA.
D. Focal Species Conservation Elements		
MQD1	What is the current distribution and status of available and suitable habitat for focal species Conservation Elements?	Refer to Appendix B

Management Questions		Notes
D. Focal Species Conservation Elements (Cont.)		
MQD2	What is the distribution of current and potentially suitable habitat, if available, for aquatic, terrestrial, and riparian biodiversity sites, and special status species?	See Section A.4.1
MQD3	Where are focal species vulnerable to change agents in the future?	Refer to Appendix B
MQD4	Where are aquatic, terrestrial, and riparian biodiversity sites, and special status species vulnerable to change agents in the future?	See Section A.4.2
MQD5	What is the current distribution and status of big game crucial habitat and movement corridors (including bighorn sheep, elk, mule deer, and pronghorn)?	See Section A.4.3
E. Wildfire		
MQE1	Where has wildfire has occurred in the past 20 years?	See Section A.5.1
MQE2	Where are the Fire Regime Condition Classes?	See Section A.5.2
MQE3	Where is fire adverse to ecological communities, features, and resources of concern?	See Section A.5.3
MQE4	Where are the areas with potential to change from wildfire in the future?	See Section A.5.4
MQE5	Where is fire likely to change in relation to climate change?	See Section A.5.5
MQE6	Where might fire interfere with future human development (e.g., development risk)?	See Section A.5.6
F. Invasive Species		
MQF1	Where are areas that invasive species occur or could potentially occur (e.g. tamarisk, Russian Olive, cheatgrass)?	See Section A.6.1
G. Human Development and Resource Use		
MQG1	Where are linear recreation features such as OHV roads and trails?	See Section A.7.1
MQG2	Where are Special Recreation Permits (SRPs) and permitted uses such as grazing and wood gathering?	See Section A.7.2
MQG3	Where are the locations of irrigated lands?	See Section A.7.3
MQG4	Where are high-use recreation areas, (High Intensity Recreation Areas (HIRA's) SRMAs, National Parks, etc)?	See Section A.7.4
MQG5	Where are areas of current and planned development (e.g., plans of operation, urban growth, wildland-urban interface, energy development, mining, transmission corridors, governmental planning)?	See Section A.7.5
MQG6	Where are federally owned water rights that are adjudicated for wildlife and irrigation?	See Section A.7.6
MQG7	Where are areas of potential future development (e.g., under lease), including renewable energy sites and transmission corridors?	See Section A.7.7
MQG8	Where are areas of potential human land use change (e.g., agricultural fallowing)?	Information gap for future study. Not evaluated in this LA.
MQG9	What are the conditions and locations of surface and groundwater rights?	See Section A.7.8
MQG10	Where are current conservation efforts prohibiting human development?	See Section A.7.9
MQG11	Where is the acoustic environment affected by human development?	Information gap for future study. Not evaluated in this LA.

Management Questions		Notes
H. Climate Change		
MQH1	Where are areas with greatest long-term potential for climate change?	See Section A.8.1
MQH2	Where have conservation elements experienced climate change and where are conservation elements vulnerable to future climate change?	Refer to Appendix B
I. Human and Cultural Elements		
MQI1	Where do areas of cultural resource management and protection occur (National Monuments, ACECs, National Historic Landmarks, World Heritage Areas, Los Caminos Scenic and Historic Byway, etc)?	Refer to Wescott et al. (2016)
MQI2	Where are known historic properties, traditional cultural properties, and sacred sites and landscapes?	Refer to Wescott et al. (2016)
MQI3	What are the traditional cultural land use patterns?	Refer to Wescott et al. (2016)
MQI4	Where are known historic properties, traditional cultural properties, and sacred sites vulnerable to change agents	Refer to Wescott et al. (2016)
MQI5	Where are high potential areas or high density areas for historic properties that address the highest priority research goals?	Refer to Wescott et al. (2016)
MQI6	Where is cultural landscape connectivity vulnerable to change agents (human development, fire, invasive species, climate change)	Refer to Wescott et al. (2016)
MQI7	Where are sensitive socioeconomic populations and how are they affected by change agents?	Information gap for future study. Not assessed in this LA or in the Cultural Landscape Assessment.
J. Landscape intactness		
MQL1	What is current and future predicted landscape intactness?	See Section A.10.1
K. Visual Resources		
MQK1	Where are specially designated/managed areas with associated visual resource considerations/mandates/prescriptions?	See Section A.11.1
MQK2	Where are visual resource inventoried areas with high scenic quality, public sensitivity for scenic quality, and distance zones where people commonly view the landscape?	See Section A.11.2
MQK3	Where are the highest quality night skies and where are they vulnerable to change agents (NPS inventory)?	See Section A.11.3
MQK4	Where are high scenic quality values within the region and where are they vulnerable to change agents?	See Section A.11.4
MQK5	Where are areas of high relative visual values (based on Visual Resource Inventory (VRI) classes) and where are they vulnerable to change agents?	See Section A.11.5
MQK6	Where are current Visual Resource Management (VRM) classes that specify retention or partial retention of existing landscape character and where are they vulnerable to change agents?	See Section A.11.6

A.1 Management Questions for Soils and Air Quality

A. Soils and Air Quality	
MQA1	Where are Class I Prevention of Significant Deterioration (PSD) areas? **See Section A.1.1 Below.**
MQA2	Where are soil systems with potential for erosion? **See Section A.1.2 Below.**
MQA3	Where are soil systems with potential for erosion vulnerable to change agents? **See Section A.1.3 Below.**
MQA4	Where are communities and hydrologic basins susceptible and/or sensitive to fugitive dust? **Deferred to dust modeling study. Model not yet complete.**
MQA5	Where are Clean Air Act (CAA) criteria pollutant source areas for PM10 and PM2.5? **Deferred to dust modeling study. Model not yet complete.**

A.1.1 MQA1 – Where are Class I PSD areas?

Dataset(s) and Source(s): USGS Protected Areas Database (http://gapanalysis.usgs.gov/padus/)

According to the EPA (http://www.epa.gov/NSR/psd.html), Class I Prevention of Significant Deterioration (PSD) areas are areas of special national or regional natural, scenic, recreational, or historic value for which the PSD regulations provide special protection. The Federal Land Manager (FLM), including the State or Indian governing body, where applicable, is responsible for defining specific Air Quality Related Values (AQRV's) for an area and for establishing the criteria to determine an adverse impact on the AQRV's. If a FLM determines that a source will adversely impact AQRV's in a Class I area, the FLM may recommend that the permitting agency deny issuance of the permit, even in cases where no applicable increments would be exceeded. However, the permitting authority makes the final decision to issue or deny the permit.

To determine Class I PSD areas, the protected areas database was queried to identify all National Parks (NPS) and Wilderness Areas. The list of Class I PSD areas in the LA Study Area includes the following:

- Columbine-Hondo Proposed Wilderness
- Cruces Basin Wilderness
- Deadman Creek RNA
- Great Sand Dunes National Park
- Great Sand Dunes Wilderness
- La Garita Wilderness Area
- Latir Peak Wilderness
- Mill Creek RNA
- North Zapata RNA
- Pecos Wilderness
- San Antonio Wilderness Study Area
- Sangre de Cristo Wilderness
- South San Juan Wilderness
- Wheeler Peak Wilderness

A map showing the spatial distribution of Class I PSD areas is provided in **Figure A.1.1-1**.

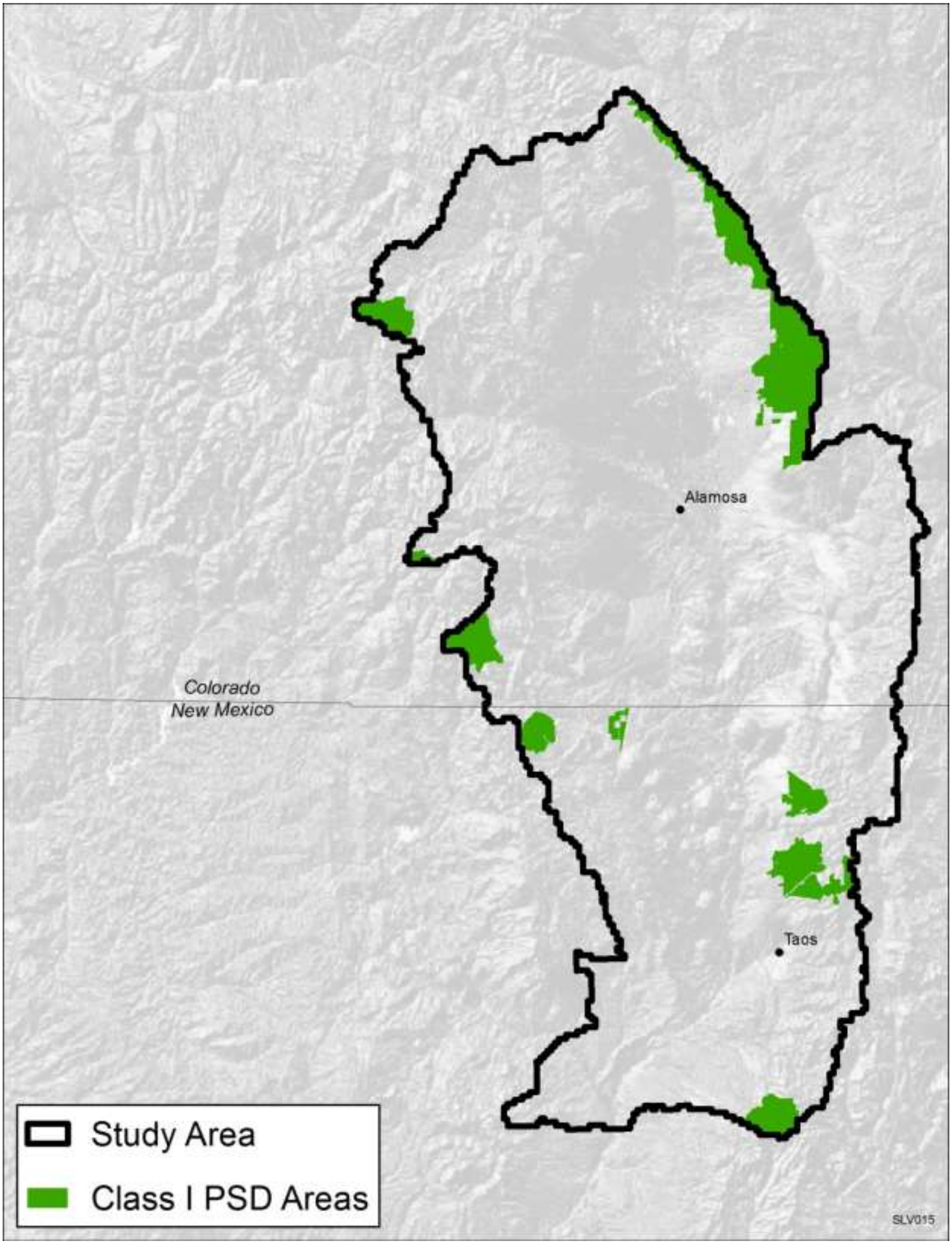


Figure A.1.1-1. Class I PSD Areas in the San Luis Valley – Taos Plateau Landscape Assessment Study Area. **Data Source: USGS 2012.**

A.1.2 MQA2 – Where are Soil Systems with Potential for Erosion?

Dataset(s) and Source(s):
* NRCS SSURGO Soils Database
* NRCS STATSGO2 Soils Database
* USGS 30 m Digital Elevation Model (used to generate slope)

Soil systems with potential for erosion include those soil properties identified by the USDA Natural Resource Conservation Service as being unique or susceptible to wind or water erosion, as defined by the parameters in **Table A.1.2-1**. The model for soil systems with potential for erosion was created using the NRCS's SSURGO soil survey data (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627) and supplemented with STATSGO data (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629) in areas where SSURGO was not available[5]. The SSURGO database contains information about soil as collected by the National Cooperative Soil Survey over the course of a century. The SSURGO maps outline areas called map units. The map units describe soils and other components that have unique properties, interpretations, and productivity. The STATSGO soils dataset is a broad-based inventory of soils that occur in a repeatable pattern on the landscape and that can be cartographically shown at the mapped scale of 1:250,000. The level of mapping is designed for broad planning and management uses covering state, regional, and multi-state areas. The STATSGO dataset is comprised of general soil association units and is maintained and distributed as a spatial and tabular dataset.

The model to characterize soil systems with potential for erosion uses, in part, the soil data viewer extension for ArcMap to query various attributes for specific threshold values. Based upon discussion with the BLM IDT and NRCS resource staff on 9 September, 2014, ten soil parameters were identified for model input based on SSURGO/STATSGO soil properties (**Table A.1.2-1**). The model was developed through the union of each of the ten soil parameters, as shown in **Figure A.1.2-1**. The slope parameter was obtained from the USGS Digital Elevation Model (DEM). Soil surface pH was originally considered as a parameter but it was later excluded at the recommendation of the NRCS because of its correlation with other inputs. The soil model is limited by availability of more detailed soils information from SSURGO, because this ecoregion contains areas not yet mapped by SSURGO.

In January 2015, revised SSURGO map units provided by NRCS were used to update the map units near the Colorado-New Mexico border. In addition, the BLM IDT requested revisions to two soil parameter inputs (slope and texture, see **Table A.1.2-1** below). The resulting characterization of soil systems with potential for erosion, based on these IDT-recommended updates, is shown in **Figure A.1.2-2**. The map depicts areas with unique soil attributes characteristic of those susceptible to erosion. Other unmapped soil properties in other areas within the study area may also influence susceptibility to erosion. For example, soil calcic composition and, more specifically, surface exposure of soil calcic horizons, can greatly influence soil erosion potential. However, calcic composition (or depth to calcic layer) was not factored into this model.

[5] NRCS STATSGO and SSURGO data available at: http://www.nrcs.usda.gov/wps/portal/nrcs/soilsurvey/soils/survey/state/.

Table A.1.2-1. Soil Systems with Potential for Erosion Model Input Parameters and Threshold Values[a].

Input Parameter	Threshold Value
Available Water Capacity	< 0.05 cm/cm
Hydric Rating	≥ 63
Electrical Conductivity	> 16 dS/m
Sodium Adsorption Ratio	≥ 13
Calcium Carbonate	> 5%
Depth to Any Soil Restrictive Layer	< 25.4 cm
Wind Erodibility	WEG Groups 1 and 2
Water erosion potential	K Factor > 0.4
Slope	> 30% (from DEM inputs)
Surface texture	Sandy and silty soils

[a] Data Source: NRCS (2015). Model parameters derived from Argonne National Laboratory. Soil systems with potential for erosion are represented by the union of locations in the study area that meet any of the above criteria.

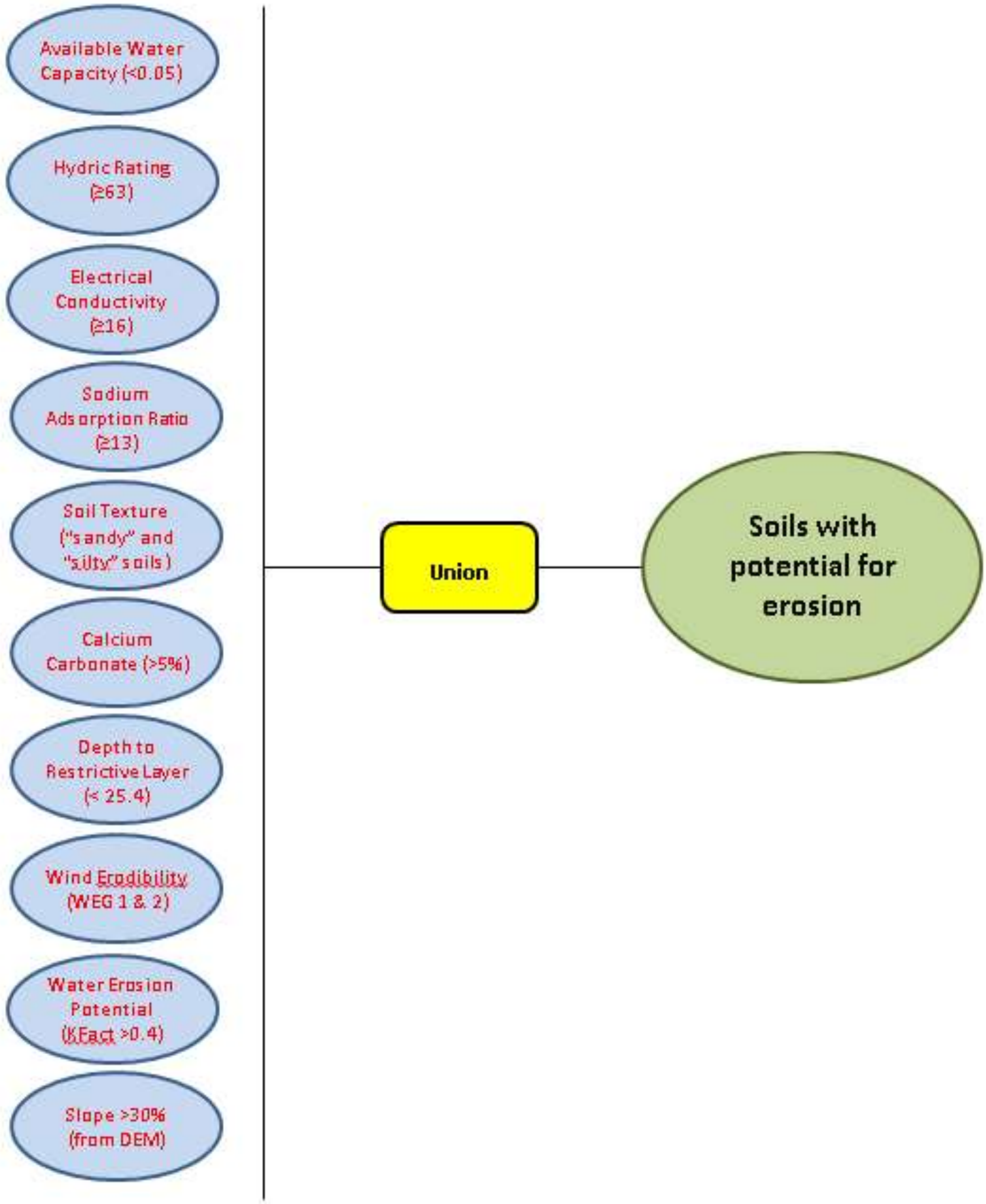


Figure A.1.2-1. NRCS soils data queries and Argonne geoprocessing steps to characterize Soil Systems with Potential for Erosion.

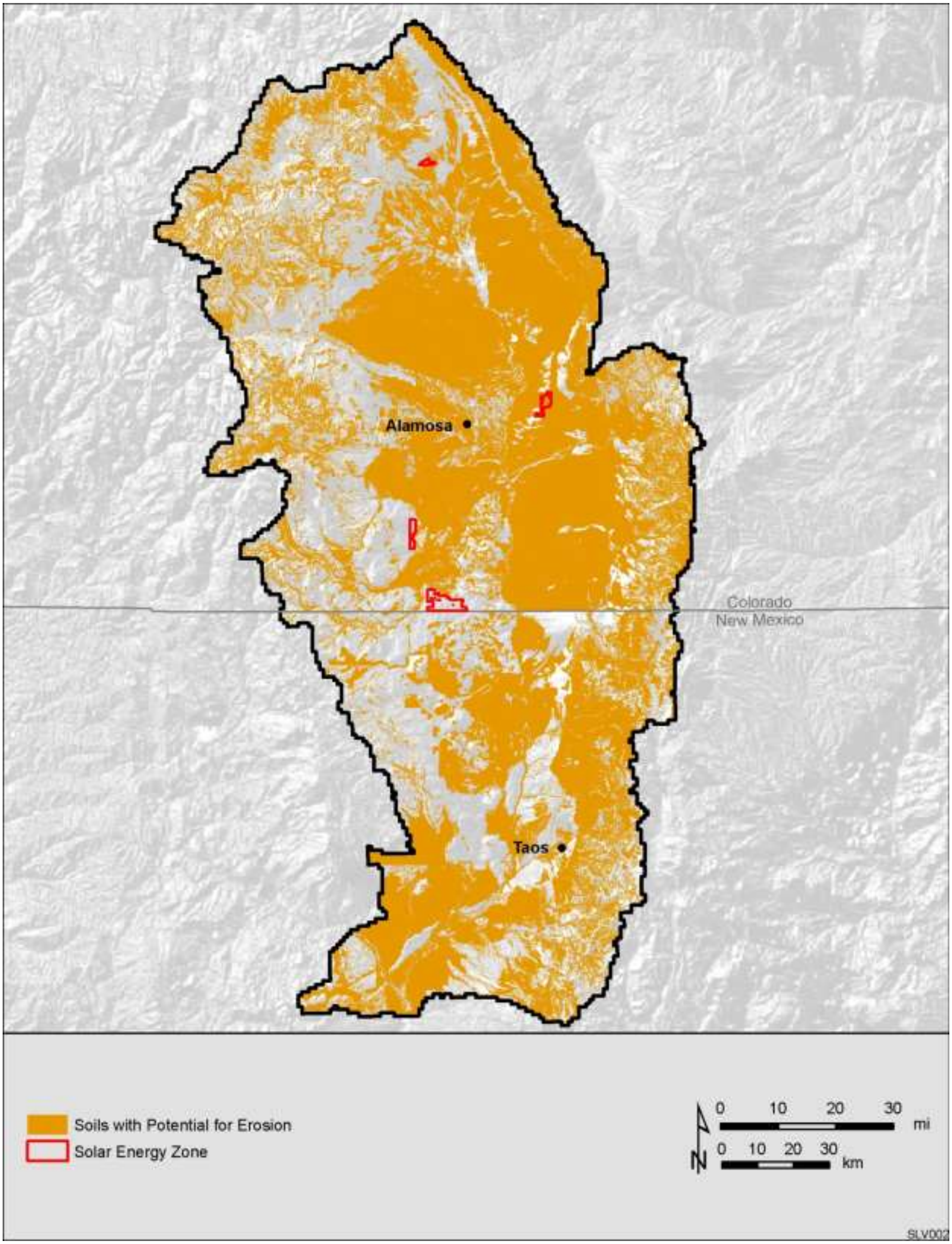


Figure A.1.2-2. Soil Systems with Potential for Erosion in the San Luis Valley – Taos Plateau Landscape Assessment Study Area. Data Sources: NRCS Web Soil Survey (NRCS 2015).

A.1.3 Where are Soil Systems with Potential for Erosion Vulnerable to Change Agents?

Refer to Section A.1.2 above for discussion on how soil systems with potential for erosion were characterized under MQA2. This MQ (MQA3) includes the assessment of soil systems with potential for erosion in relation to vegetation departure, landscape intactness, and change agents.

Figures A.1.3-1 through **A.1.3-6** show, respectively: **Figure A.1.3-1** – soil systems with potential for erosion with respect to current vegetation departure; **Figure A.1.3-2** – soil systems with potential for erosion with respect to current and future landscape intactness in the study area; **Figure A.1.3-3** – status of soil systems with potential for erosion with respect to the current status of change agents; **Figure A.1.3-4** – spatial trends in soil systems with potential for erosion; **Figure A.1.3-5** – graphical predicted trends in soil systems with potential for erosion; and **Figure A.1.3-6** - the aggregate potential for change in soil systems with potential for erosion.

The majority (35%) of vegetation within soil systems with potential for erosion has a moderate degree of departure from historic reference vegetation conditions (**Figure A.1.3-1**; **Figure A.1.3-5**). Most of the vegetation departure that has occurred within soil systems with potential for erosion is located in rural and shrubland areas of the Taos Plateau in northern New Mexico (**Figure A.1.3-1**).

The majority (58%) of the soil systems with potential for erosion are within areas of high and very high current landscape intactness (**Figure A.1.3-2**; **Figure A.1.3-5**). Future trends in landscape intactness indicate a decrease in landscape intactness within soil systems with potential for erosion. The amount of soil systems with potential for erosion occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (**Figure A.1.3-5**).

The majority (64%) of the soil systems with potential for erosion are within areas of very low and low current human development intensity (**Figure A.1.3-3**; **Figure A.1.3-5**). Future trends in human development indicate an increase in human development intensity within soil systems with potential for erosion. The amount of soil systems with potential for erosion occurring within areas of high and very high human development intensity is expected to increase by approximately 6% in the near-term (i.e., by 2030) (**Figure A.1.3-4**; **Figure A.1.3-5**).

The majority of the soil systems with potential for erosion are within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure A.1.3-3**; **Figure A.1.3-5**). Future trends in climate change indicate portions of the soil systems with potential for erosion with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure X-6**; **Figure X-7**). Approximately 27% of the soil systems with potential for erosion are located in areas with high or very high potential for future climate change (**Figure A.1.3-5**). The greatest potential for future climate change within soil systems with potential for erosion occurs in the western and northwestern portion of the soil distribution in the study area (**Figure A.1.3-4**).

The majority of the soil systems with potential for erosion are within areas of very low current fire occurrence density (**Figure A.1.3-3**; **Figure A.1.3-5**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the soil systems with potential for erosion in the study area. The greatest potential for future wildfire occurs in the southern portion of the habitat distribution in New Mexico (**Figure A.1.3-4**).

The majority of soil systems with potential for erosion are within areas of either very low or very high current density of invasive species, insects, and disease (**Figure A.1.3-3**; **Figure A.1.3-5**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of soil systems with potential for erosion in the study area. Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (**Figure A.1.3-4**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 35% of the soil systems with potential for erosion have the potential for high or very high future change among the change agents (**Figure A.1.3-6**). Areas with greatest potential for change within soil systems with potential for erosion include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure A.1.3-6**).

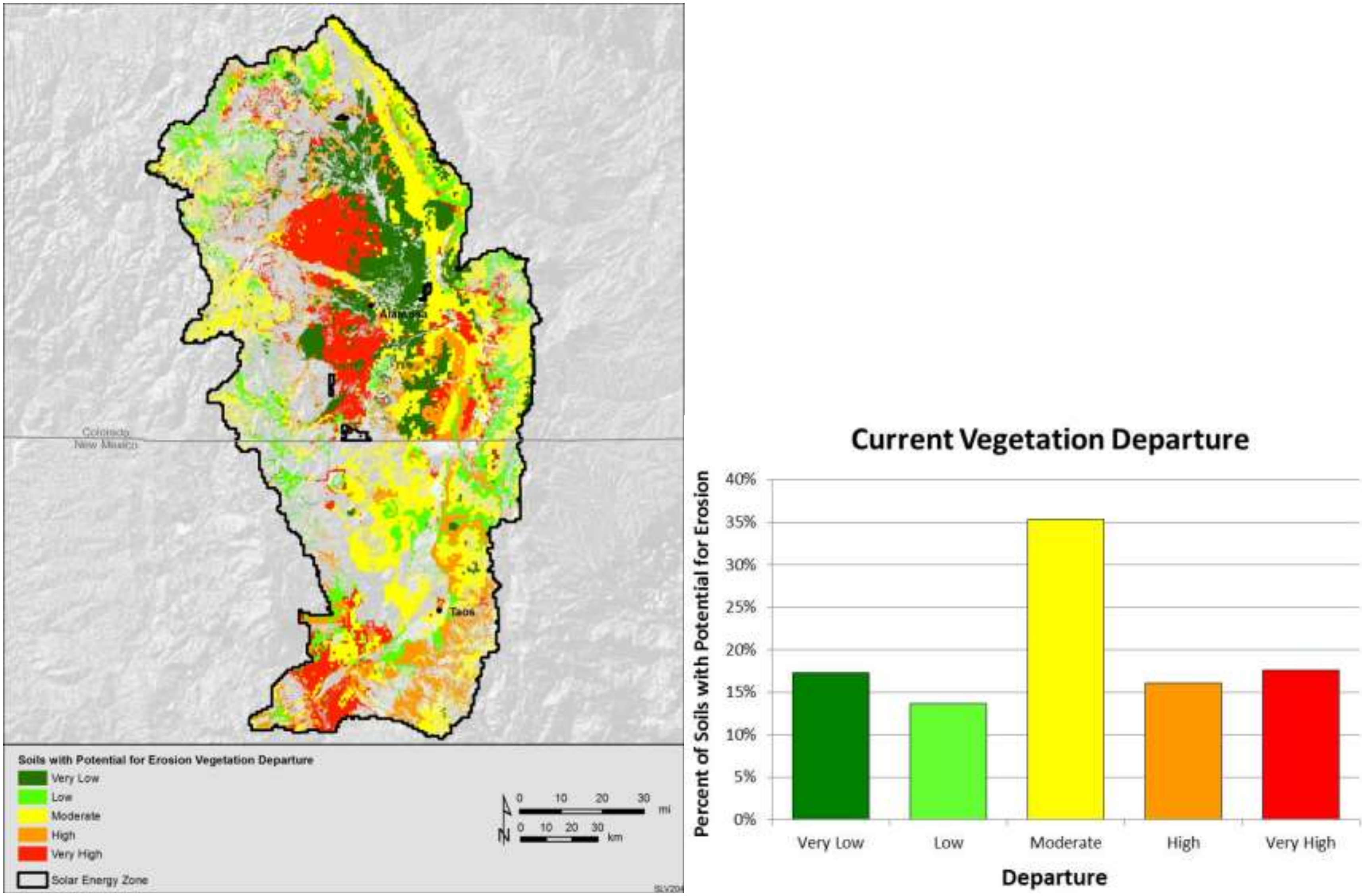


Figure A.1.3-1. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Soil Systems with Potential for Erosion. Data Sources: Current Vegetation Departure (VDEP) (USGS, 2008a), NRCS (2015).

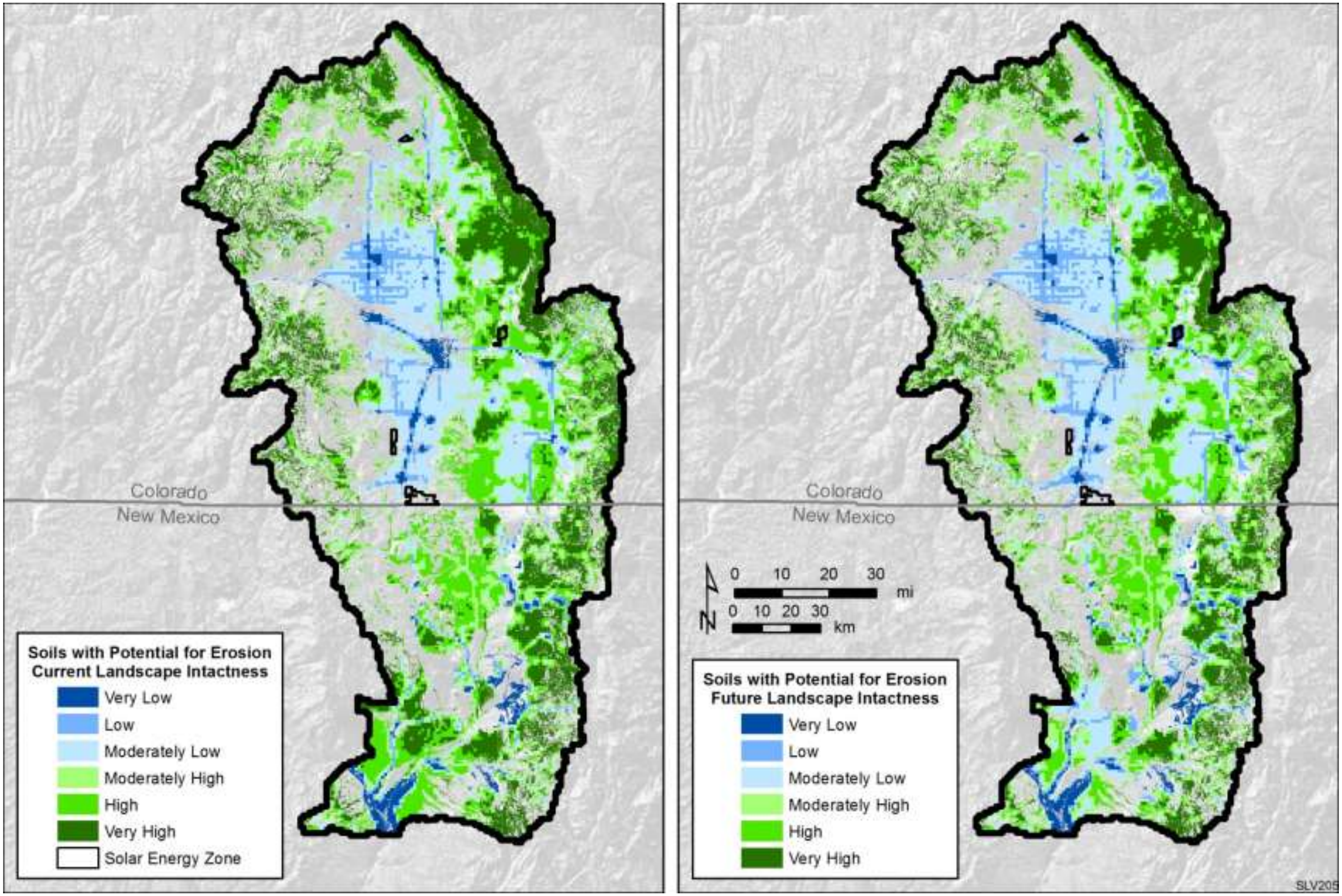


Figure A.1.3-2. Current and Future Landscape Intactness of Systems with Potential for Erosion. Data Sources: NRCS (2015) and Argonne 2014.

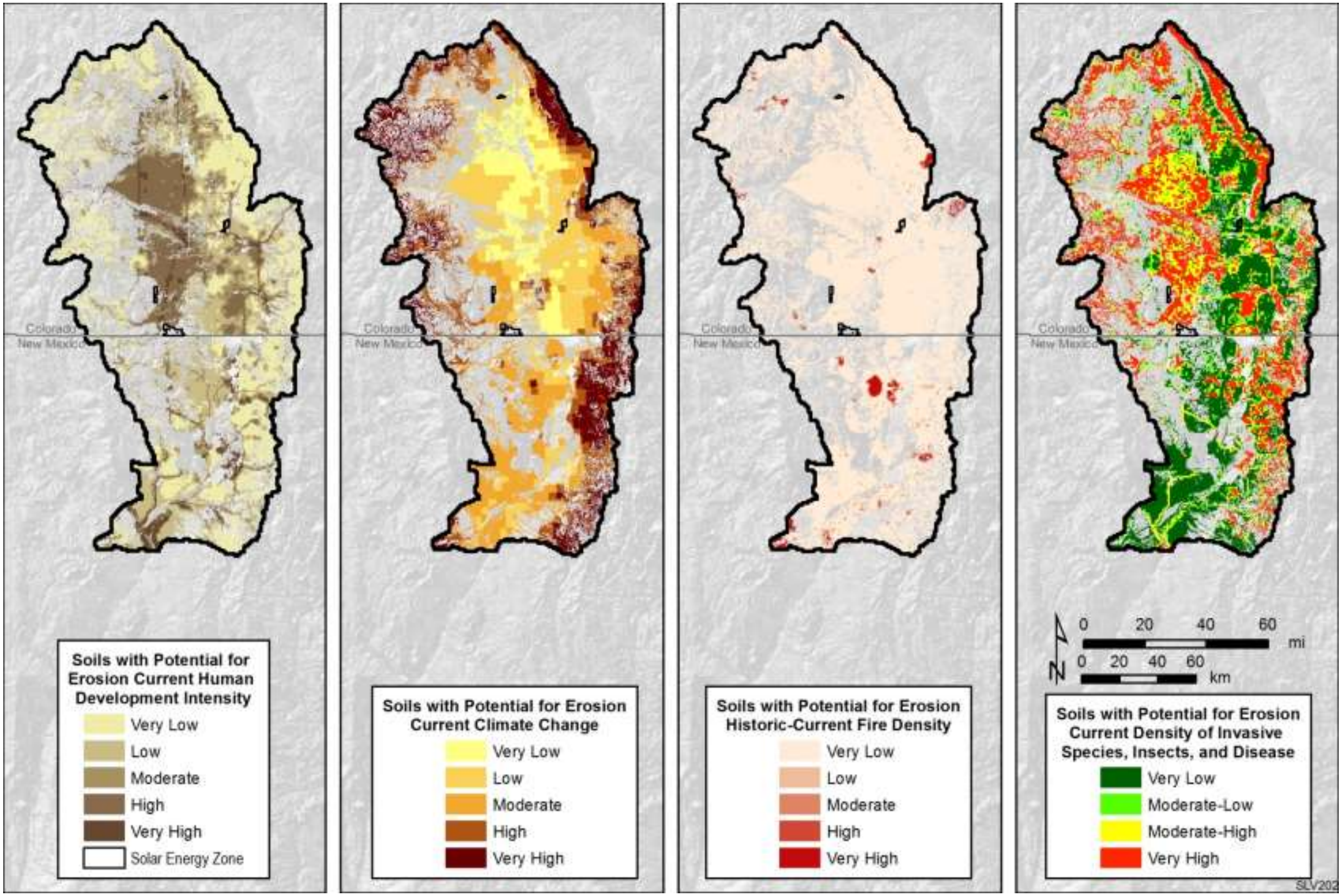


Figure A.1.3-3. Current Distribution and Status of Soil Systems with Potential for Erosion. Data Sources: NRCS (2015) and Argonne 2014.

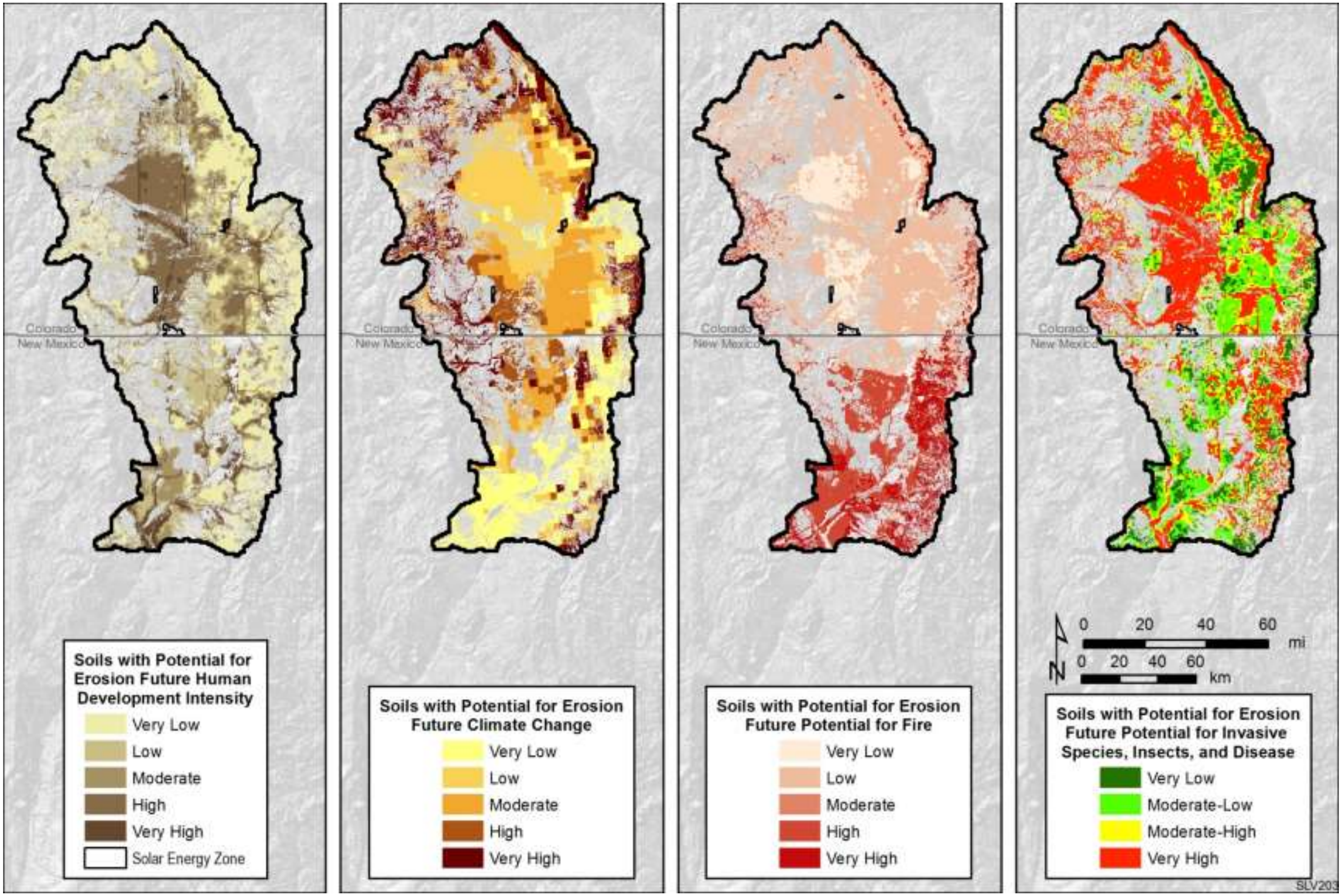


Figure A.1.3-4. Intersection Between Soil Systems with Potential for Erosion and Future Change Agent Models. Data Sources: NRCS (2015) and Argonne 2014.

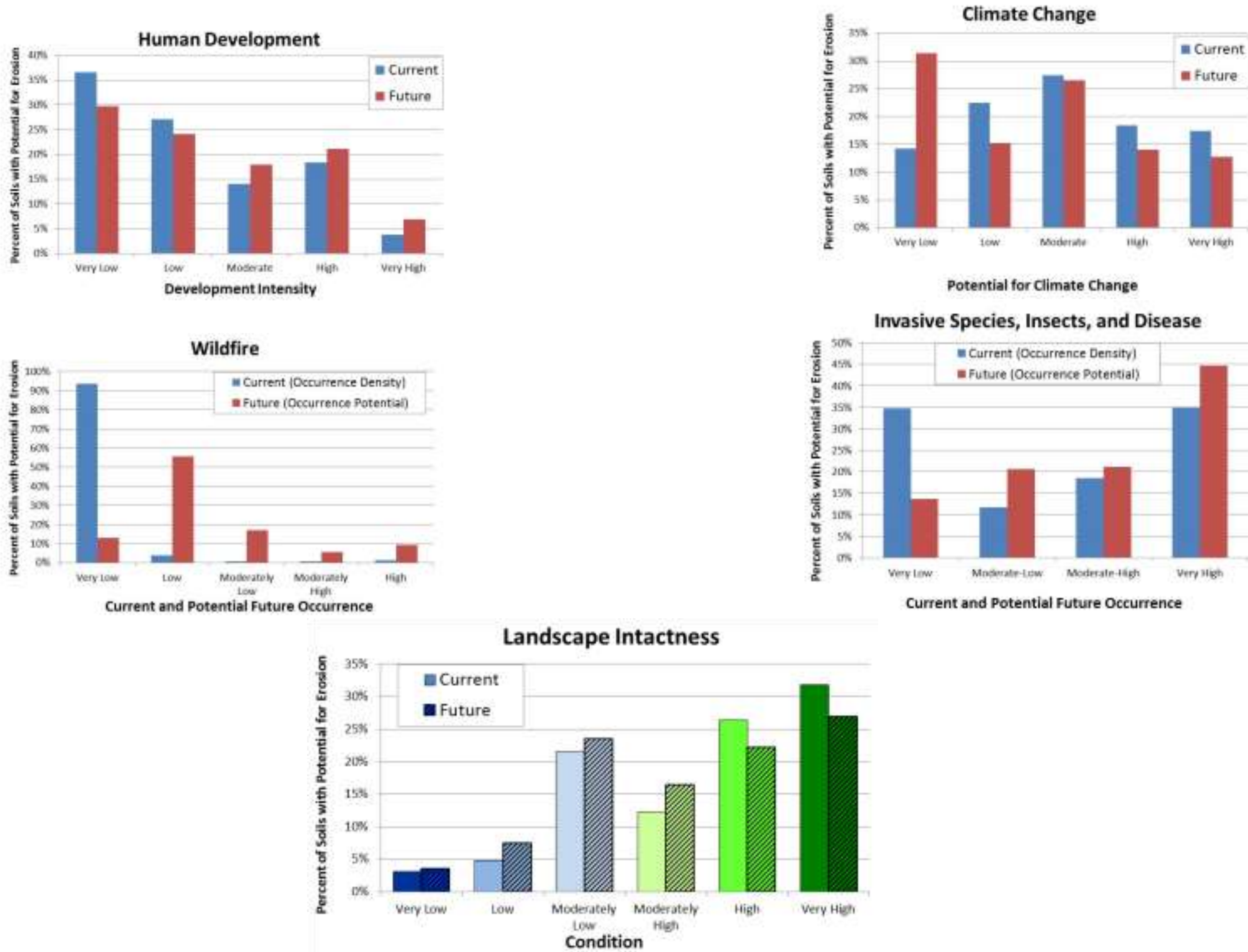


Figure A.1.3-5. Predicted Trends in Soil Systems with Potential for Erosion within the Study Area

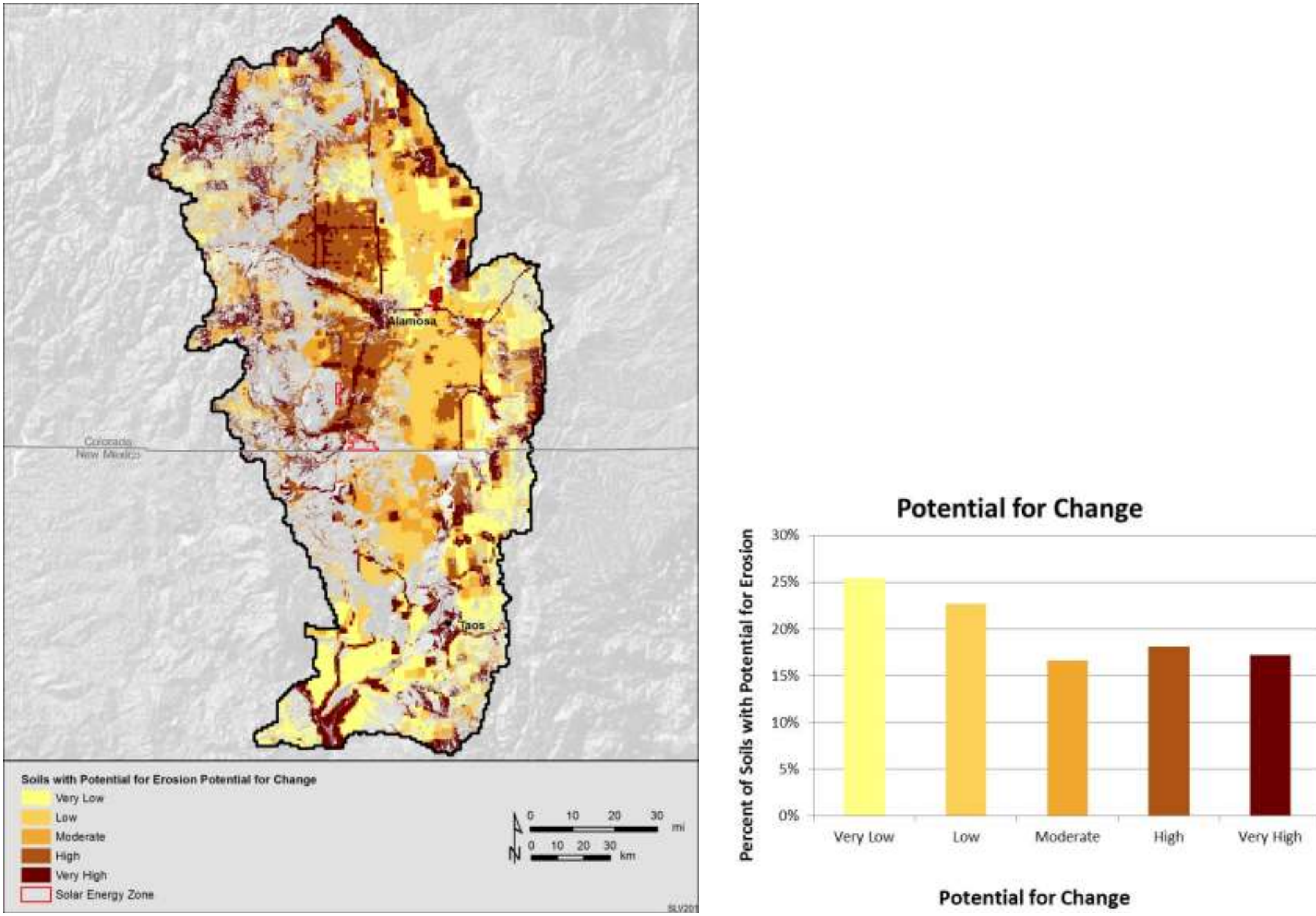


Figure A.1.3-6. Soil Systems with Potential for Erosion Aggregate Potential for Change. Data Sources: NRCS (2015) and Argonne 2014.

A.2 Management Questions for Hydrology

B. Hydrology	
MQB1	Where are and what are the conditions of hydrologic features including lotic and lentic features and artificial surface water bodies (e.g., perennial, intermittent, and ephemeral streams and springs; playas; wetlands; lakes; reservoirs; wells; ponds; livestock and wildlife watering tanks)? **See Section A.2.1 Below.**
MQB2	Where are impaired waters and aquatic systems (such as those included in the EPA 303(d) and 305(b) lists)? **See Section A.2.2 Below.**
MQB3	Where are mountain snow pack, rainfall, and alluvial aquifers and their recharge areas? **See Section A.2.3 Below.**
MQB4	Where are hydrologic systems vulnerable to change agents? **Refer to Section A.2.1.**
MQB5	Where are the areas that are susceptible to early snow melt due to dust on snow? **See Section A.2.4 Below.**
MQB6	What are seasonal discharge maxima and minima for the Rio Grande, Closed Basin, and major tributaries at gaging stations? **See Section A.2.5 Below.**
MQB7	Where are the confined and unconfined recharge or discharge areas? **See Section A.2.6 Below.**

A.2.1 MQB1: Where are and What are the Conditions of Hydrologic Features Including Lotic and Lentic Features and Artificial Surface Water Bodies?

Dataset(s) and Source(s):

Wetlands: National Wetlands Inventory (http://www.fws.gov/wetlands/). This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the conterminous United States. These data delineate the areal extent of wetlands and surface waters.

Waterbodies, Artificial Paths, Canals/Ditches, Connectors, Pipelines, Streams/Rivers, Springs/Seeps: The National Hydrography Dataset (http://nhd.usgs.gov/).

The hydrologic systems Conservation Element was selected to characterize water tanks, springs/seeps, wells, artificial paths, canals/ditches, connectors, pipelines, streams/rivers, lakes, ponds, reservoirs, and wetlands. This Conservation Element is an aggregation of spatial data from a number of sources including the National Wetlands Inventory (http://www.fws.gov/wetlands/), National Hydrography Dataset (http://nhd.usgs.gov/), and data provided by the BLM San Luis Valley and Taos Field Offices.

A composite map of all hydrologic features is shown in **Figure A.2.1-1**.

As estimated in the USGS report "Groundwater Depletion in the United States (1900-2008)" (Konikow 2013), a cumulative total of 3.6 km^3 of groundwater had been depleted from storage in confined and unconfined aquifers of the San Luis Valley between 1900 and 2008, primarily due to increased water demands to support agricultural developments.

The assessment of current and future conditions for hydrologic features involved summarizing the vegetation departure, landscape intactness, and change agent models within HUC 12 watersheds.

HUC12 boundaries were used to summarize the ways hydrologic systems may be affected within the San Luis Valley – Taos Plateau study area. **Figures A.2.1-2** through **A.2.1-7** show, respectively: **Figure A.2.1-2 -** the HUC12 boundaries with respect to current vegetation departure; **Figure A.2.1-3 -** the HUC12 boundaries with respect to current and future landscape intactness in the study area; **Figure A.2.1-4 -** the HUC12 boundaries with respect to the current status of change agents; **Figure A.2.1-5 -** the HUC12 boundaries with respect to predicted areas of change; **Figure A.2.1-6 -** predicted trends within the study area; and **Figure A.2.1-7 -** the aggregate potential for change within HUC12 boundaries.

The majority of vegetation within the HUC12 boundaries has a moderate degree of departure from historic reference vegetation conditions. Nearly 35% of the study area summarized to the HUC12 boundaries has a high or very high degree of vegetation departure (**Figure A.2.1-2**).

The majority (49%) of the study area summarized to the HUC12 boundaries is within areas of low and very low landscape intactness (**Figure A.2.1-3**). Future trends in landscape intactness indicate a decrease in landscape intactness within elk-mule deer potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 10% in the near-term (i.e., by 2030) (**FigureA.2.1-6**).

The majority (65%) of the HUC12 boundaries are within areas of low or very low human development intensity (**Figure A.2.1-4**). Future trends in human development indicate an increase in human development intensity within HUC12 boundaries. The amount of potential habitat occurring within areas of high and very high human development intensity is expected to increase by approximately 7.5% in the near-term (i.e., by 2030) (**Figure A.2.1-6**).

The majority of the study area summarized to the HUC12 boundaries is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature. Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the future (i.e., by 2069) (**Figure A.2.1-5**). Approximately 33% of the HUC12 boundaries are located in areas with high or very high potential for future climate change (**Figure A.2.1-6**). The greatest potential for future climate change occurs in the western and northwestern portion of the study area (**Figure A.2.1-5**).

The majority of the study area summarized to the HUC12 boundaries is within areas of very low current fire occurrence density (**Figure A.2.1-4**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. The greatest potential for near-term future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (**Figure A.2.1-5**).

The majority of the study area summarized to the HUC12 boundaries is within areas of either very low or very high current density of invasive species, insects, and disease (**Figure A.2.1-4**). Future trends indicate an increase in invasive species, insects, and disease potential in some portions of the study area. Areas of potential future spread of invasive species, insects, and disease include areas of urban and rural expansion, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (**Figure A.2.1-5**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, the majority of the HUC12 watersdheds are located in areas with moderate to high potential for change from the change agents (**Figure A.2.1-7**).

In addition to the four change agents modeled in this LA, the distribution and availability of water through natural and human-altered hydrologic processes can also be considered a unique change agent that could influence the distribution and status of several Conservation Elements, including hydrologic systems. As one outcome of this LA, the role of water as a change agent has been identified as an information gap where future research efforts may be directed. Future research to characterize spatio-temporal patterns of water availability and how these processes influence Conservation Elements is needed to adequately address the role of water availability on hydrologic systems.

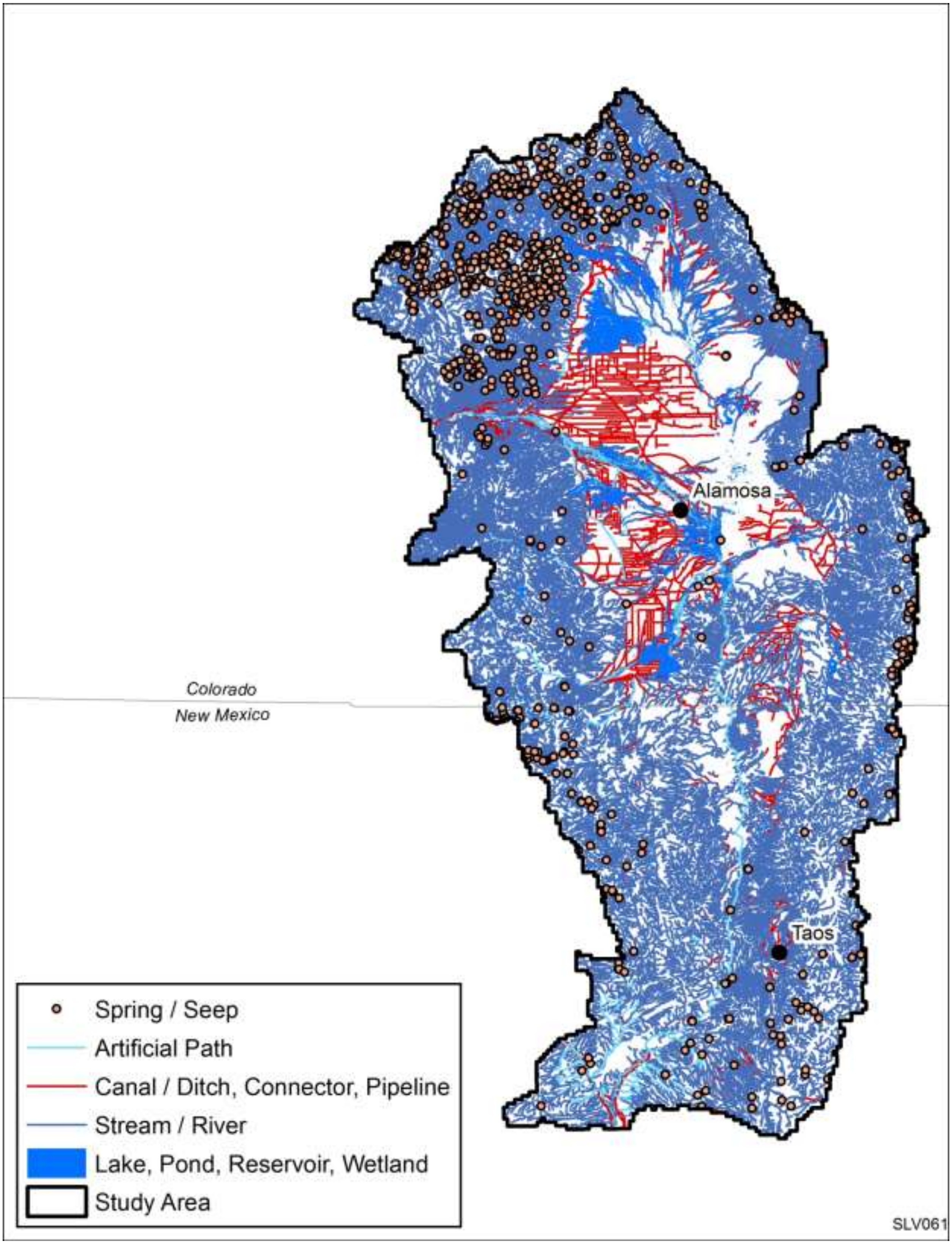


Figure A.2.1-1. Hydrologic features in the San Luis Valley – Taos Plateau Landscape Assessment Study Area. Data Sources: data received from BLM, USGS 2013, and USFWS 2014a.

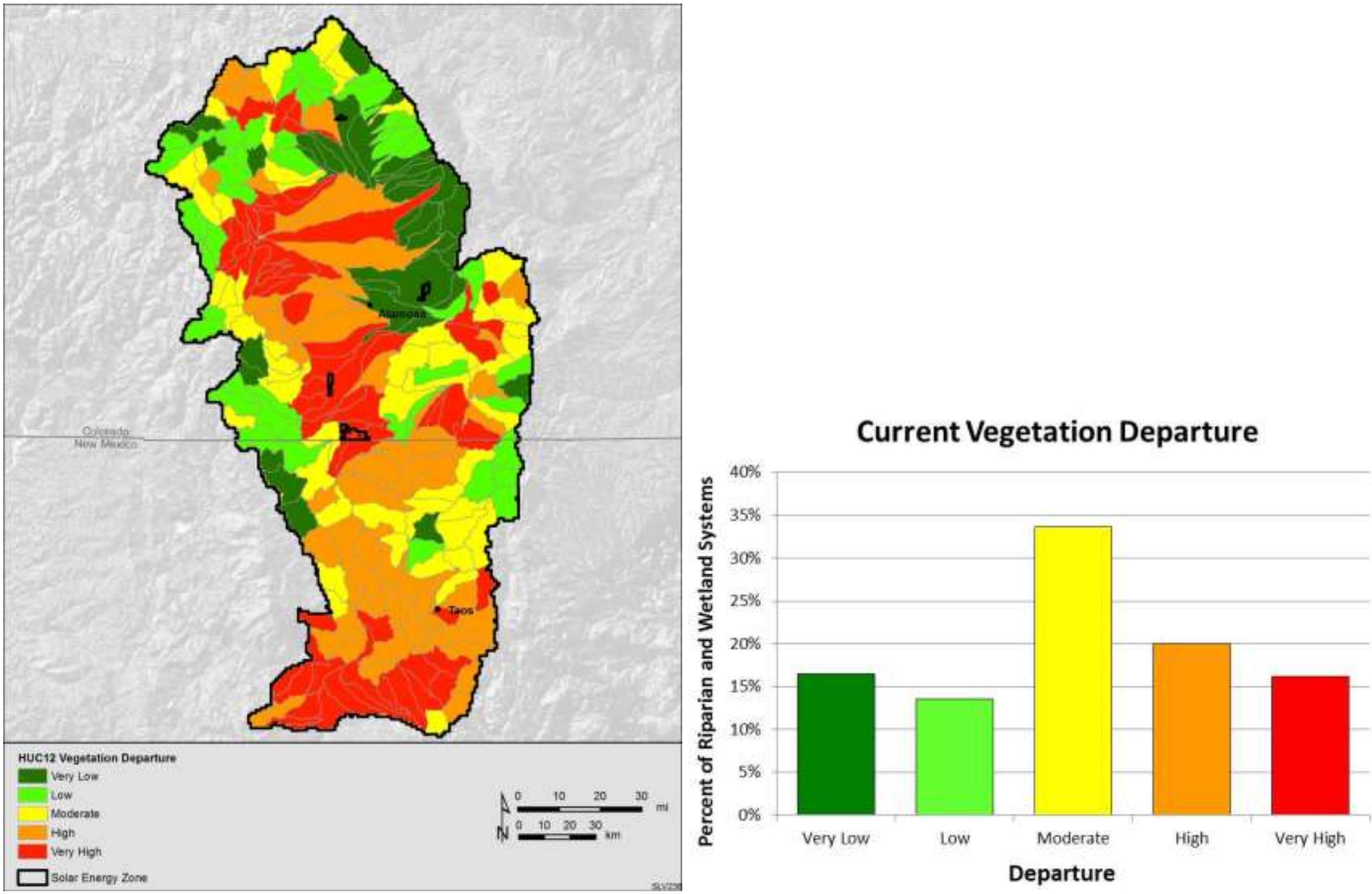


Figure A.2.1-2. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within HUC12 Boundaries. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a), and USGS 2014a.

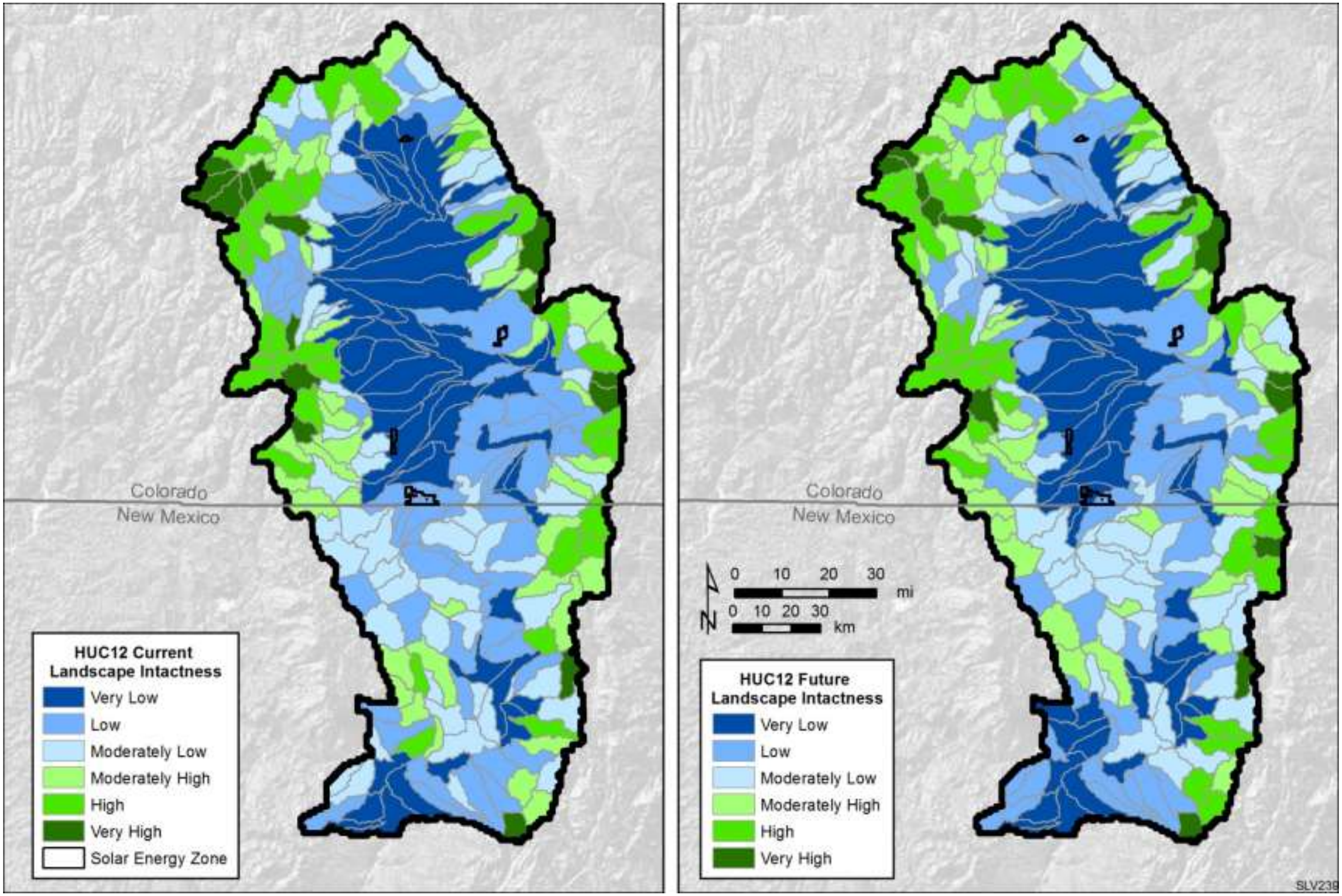


Figure A.2.1-3. Current and Future Landscape intactness within HUC12 Boundaries. Data Sources: Argonne 2014 and USGS 2014a.

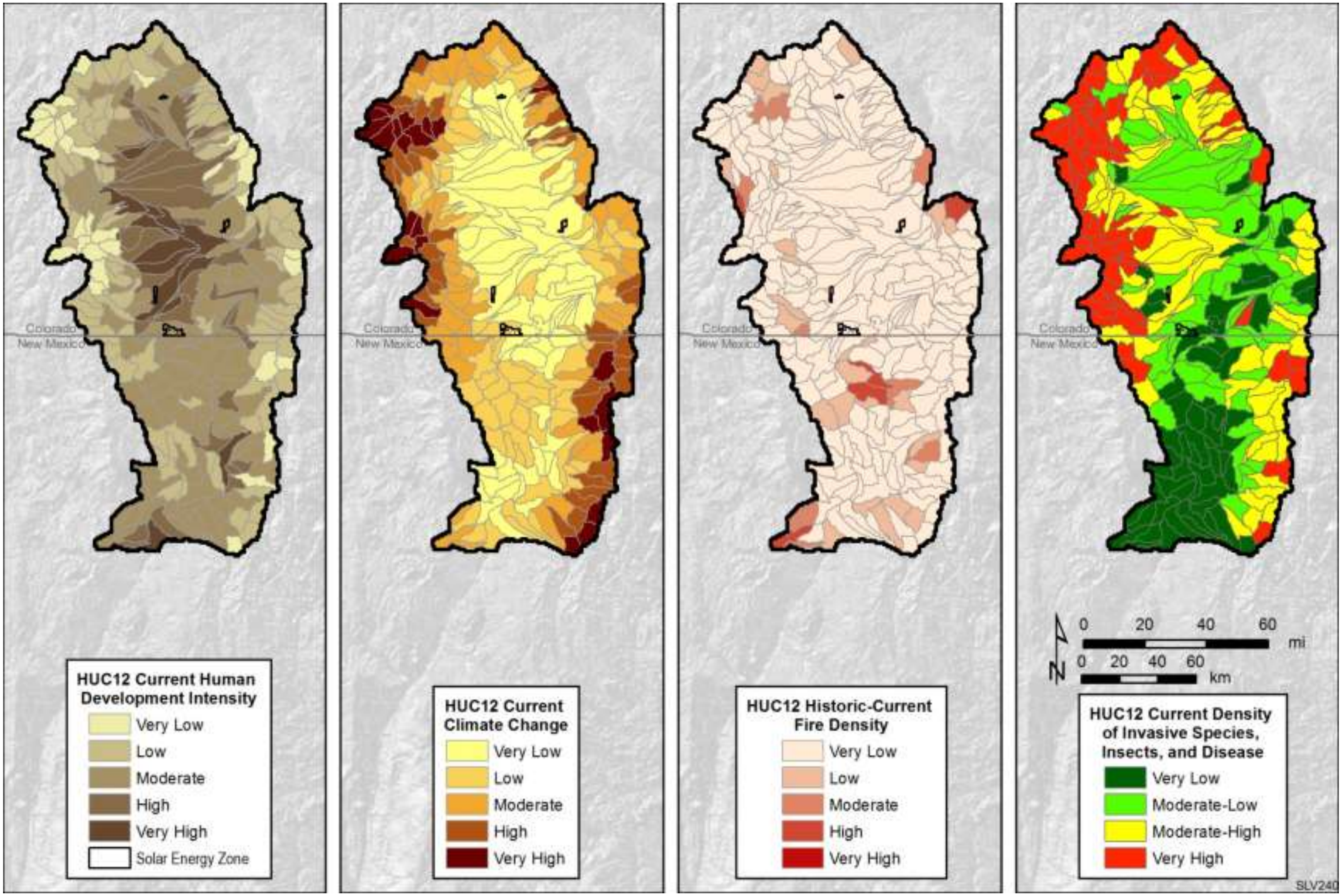


Figure A.2.1-4. Illustration for MQD1: What is the current distribution and status of hydrologic systems? Data Sources: Argonne 2014 and USGS 2014a.

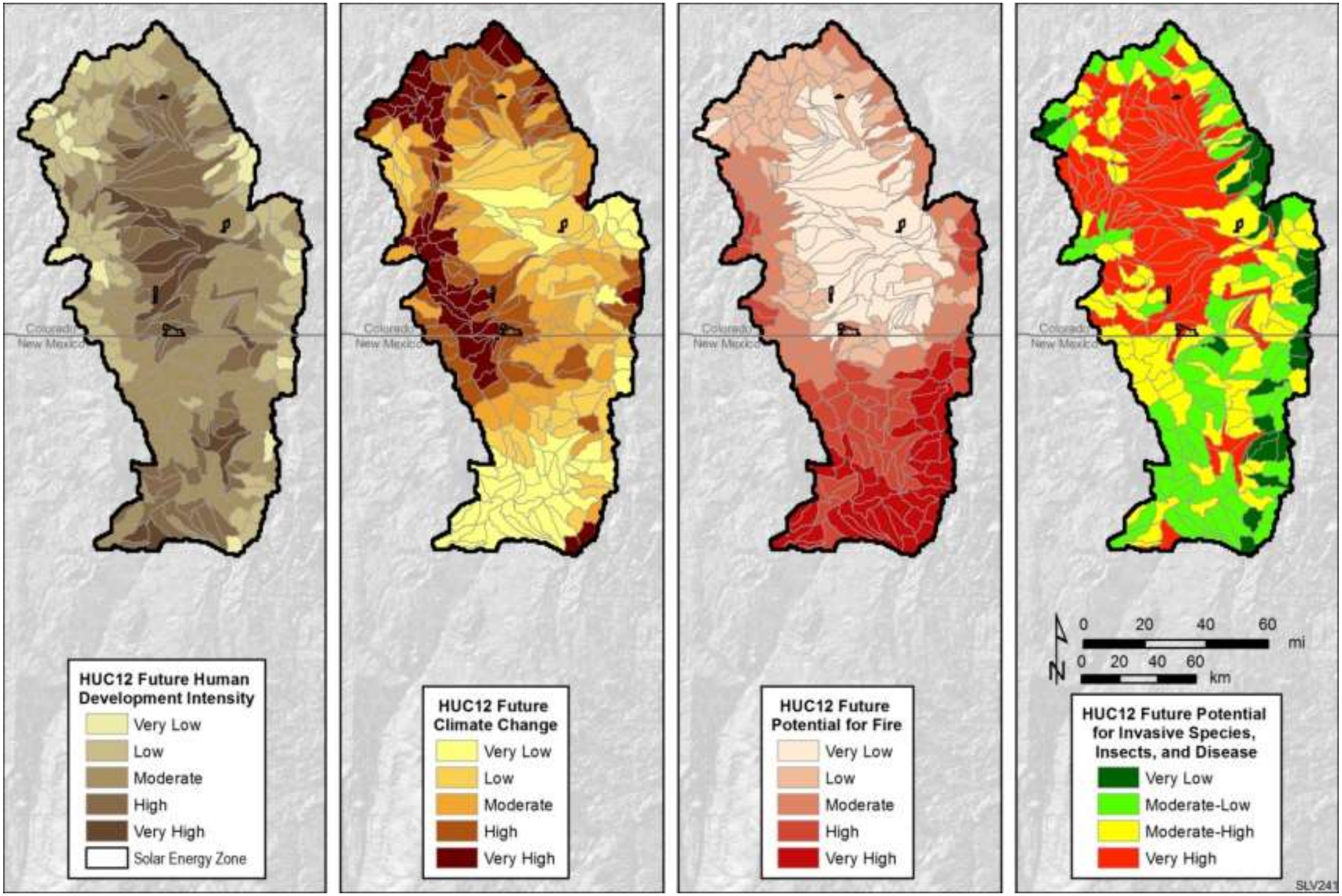


Figure A.2.1-5. Illustration for MQD3: Where are hydrologic systems vulnerable to change agents in the future? Data Sources: Argonne 2014 and USGS 2014a.

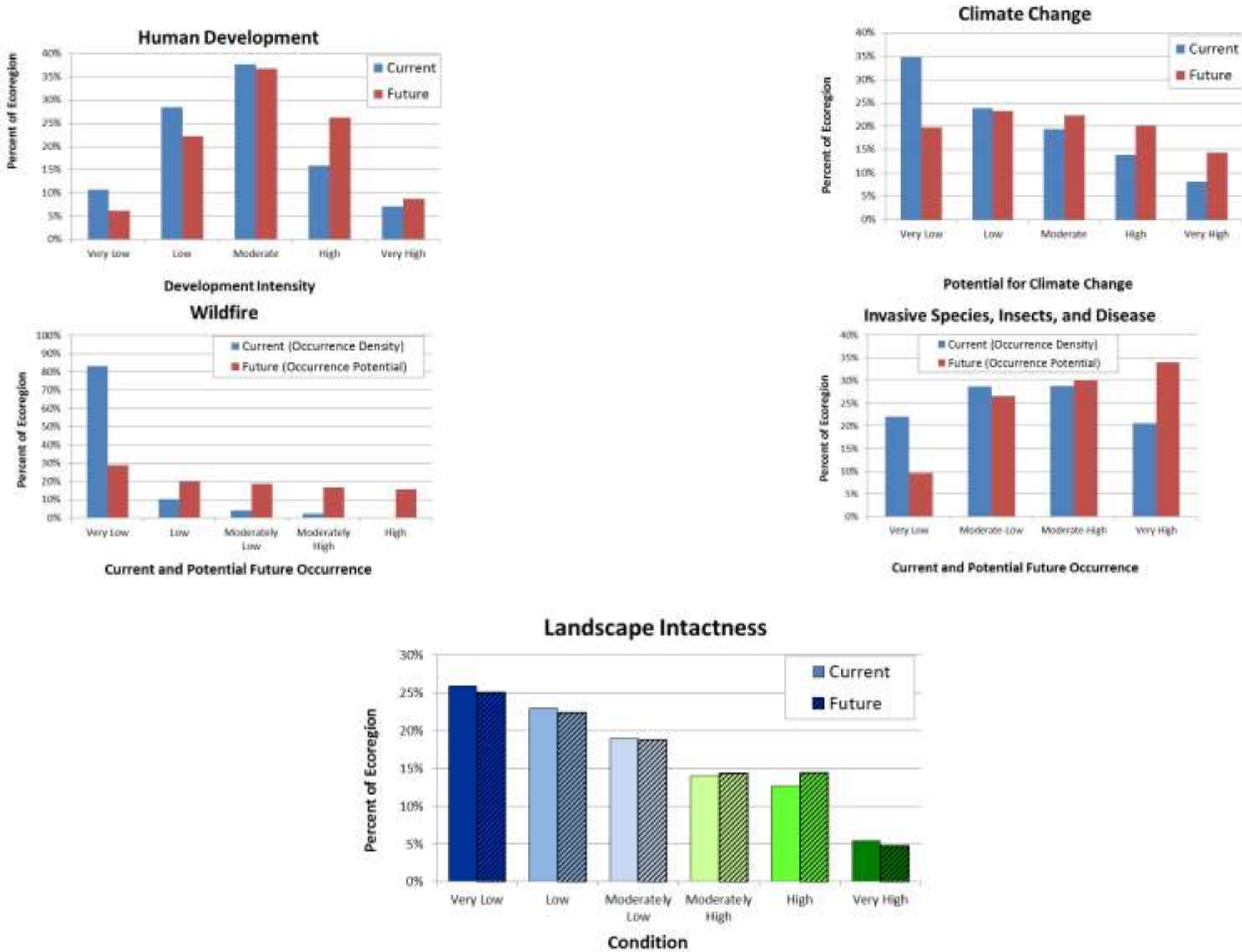


Figure A.2.1-6. Predicted Trends in hydrologic systems within the Study Area

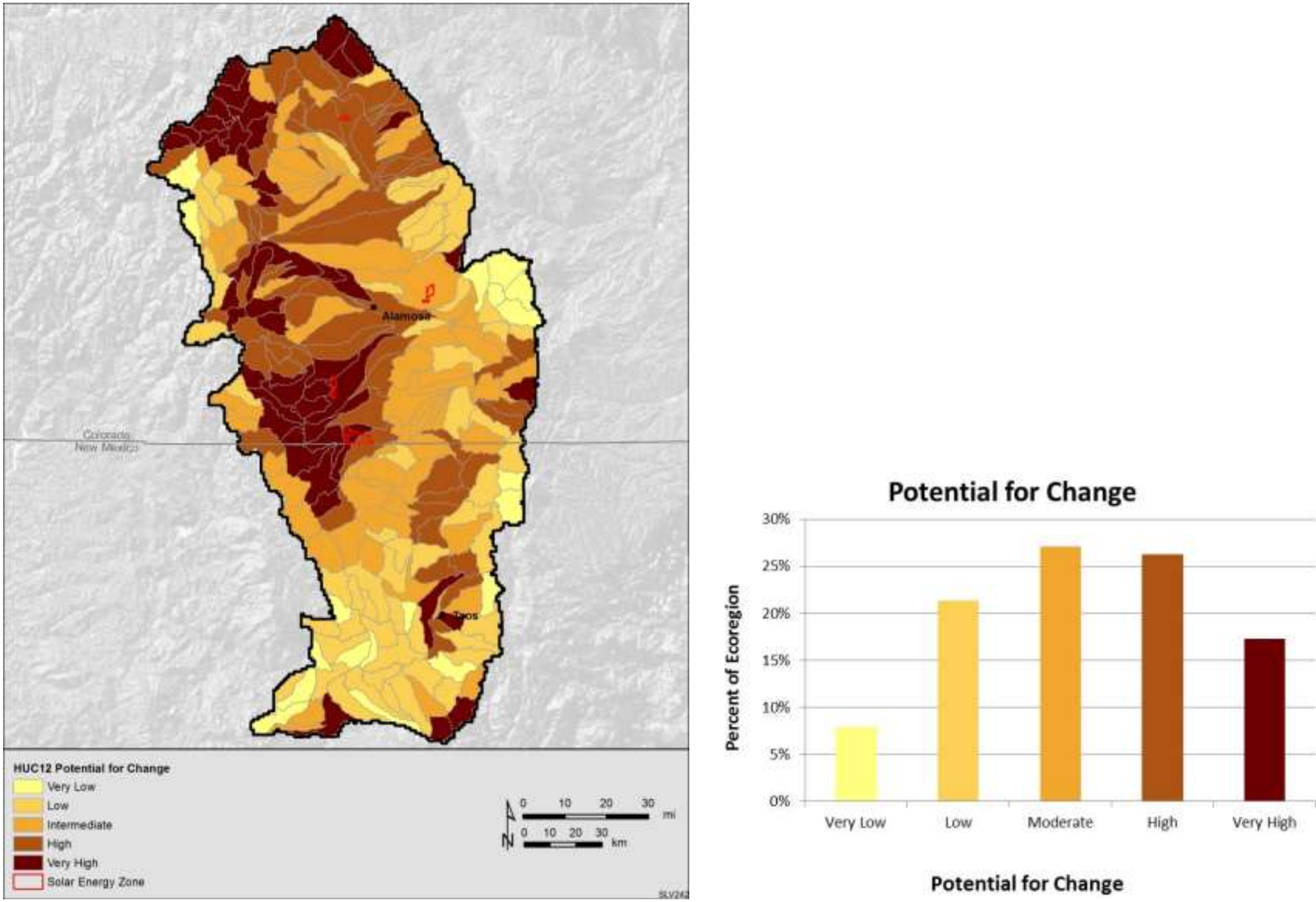


Figure A.2.1-7. Potential for change within HUC12 boundaries. Data Sources: Argonne 2014 and USGS 2014a.

A.2.2 MQB2: Where are Impaired Waters and Aquatic Systems?

Dataset(s) and Source(s): EPA 303(d) and 305(b) waters. Geospatial data available at http://water.epa.gov/scitech/datait/tools/waters/data/downloads.cfm.

Geospatial data for the Environmental Protection Agency (EPA) Office of Water Programs, including 303(d) Impaired Waters, 305(b) Waters As Assessed and Total Maximum Daily Loads (TMDLs) are available as prepackaged national downloads or as more current Geographical Information Systems (GIS) web and and data services. The EPA provides WATERS geospatial data in a variety of formats including GIS compatible shapefiles and geodatabases, as well as ESRI and OGC web mapping services. Features were identified in EPA 303(d) datasets. The explanation of 303(d) below is from the EPA website (http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/overview.cfm).

The term "303(d) list" refers to the list of impaired and threatened waters (stream and river segments, lakes) that the Clean Water Act requires all states to submit for EPA approval every two years on even-numbered years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for development of Total Maximum Daily Loads (TMDLs) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors. States then provide a long-term plan for completing TMDLs within 8 to 13 years from first listing.

The 303(d) Listed Impaired Waters program system provides impaired water data and impaired water features reflecting river segments, lakes, and estuaries designated under Section 303(d) of the Clean Water Act. Each State will establish Total Maximum Daily Loads (TMDLs) for these waters. Note the CWA Section 303(d) list of impaired waters does not represent waters that are impaired but have an EPA-approved TMDL established, impaired waters for which other pollution control mechanisms are in place and expected to attain water quality standards, or waters impaired not caused by a pollutant. Therefore, the "Impaired Waters" layers do not represent all impaired waters reported in a state's Integrated Report, but only the waters comprised of a state's approved 303(d) list. For more information regarding impaired waters refer to EPA's Integrated Reporting Guidance at: http://www.epa.gov/owow/tmdl/guidance.html. The 303(d) waterbodies are coded onto NHD linear and area features to create line, area, and point events. In addition to NHD reach indexed data there may also be custom event data (point, line, or polygon) that are not associated with NHD and are in an EPA standard format that is compatible with EPA's Reach Address Database. These custom features are used to represent locations of 303(d) waterbodies that are not represented well in NHD.

Locations of EPA 303(d) impaired waters and aquatic systems are shown in **Figure A.2.2-1**.

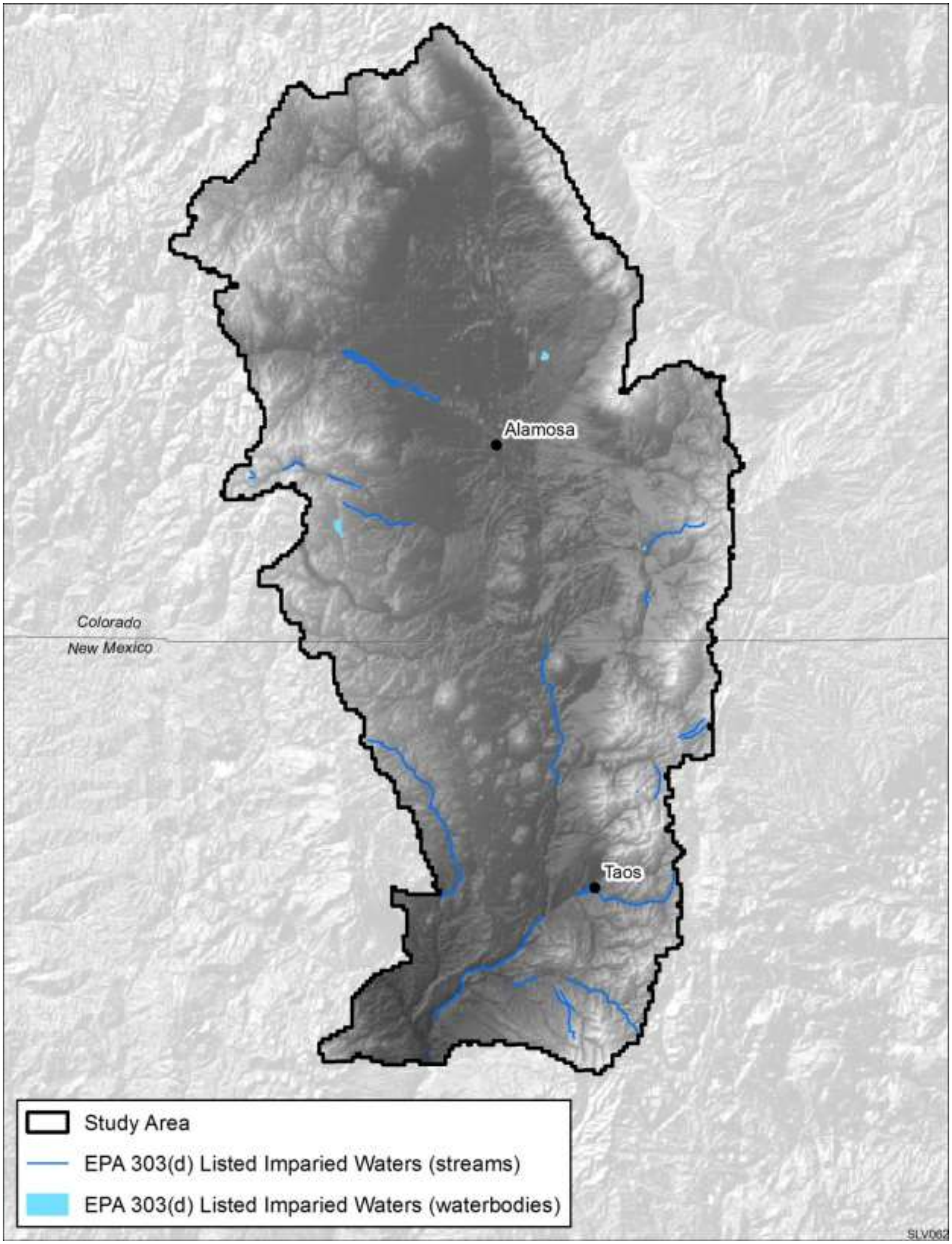


Figure A.2.2-1. Impaired waters and aquatic systems in the San Luis Valley – Taos Plateau Landscape Assessment Study Area. Data Source: EPA 2013.

A.2.3 MQB3: Where are Mountain Snowpack, Rainfall, and Alluvial Aquifers and Their Recharge Areas?

Dataset(s) and Source(s):

Snowpack Level: NRCS SNOTEL Sites (http://www.wcc.nrcs.usda.gov/snow/). There are 11 SNOTEL sites within the study area that record and monitor snow pack levels. Annual average snow pack levels for each of these 11 sites were calculated over the past 6-10 years (number of years depends on data availability and varies by site). A summary of average annual snow pack levels at each of these sites is presented in **Table A.2.3-1 and Figure A.2.3-1**.

Ephemeral Drainages: National Hydrography Dataset (NHD) flowlines (http://nhd.usgs.gov/). This dataset was queried to identify all streams and rivers in the study area, including ephemeral, intermittent, and permanent streams. These streams serve as recharge areas and are identified in **Figure A.2.3-2**.

Aquifers: Data provided by BLM to characterize spatial extent of alluvial and bedrock aquifers in Colorado. The distribution of these aquifers in Colorado is shown in **Figure A.2.3-3**.

Permitted Groundwater Wells in New Mexico: These data depict water tanks in North-central New Mexico. It was acquired by the Forest Ecosystem Restoration Analysis (ForestERA) project. Data were provided by the BLM Taos Field Office. The distribution of these permitted wells in New Mexico is shown in **Figure A.2.3-3**.

Permitted Groundwater Wells in Colorado: These data depict well permits in Colorado. Data were provided by BLM San Luis Valley Field Office. The distribution of these permitted wells in Colorado is shown in **Figure A.2.3-3**.

Table A.2.3-1. Annual Average Snow Pack at SNOTEL Sites in the Study Area. Refer to Figure A.2.3-1 for the Distribution of These Sites in the Study Area (Data source: NRCS 2014).

ID	Site Name	Average Annual Snow Pack Depth (Inches)	Notes
1	CULEBRA #2	15.8	Annual average of 10 years (2005 to 2014)
2	CUMBRES TRESTLE	27.7	Annual average of 10 years (2005 to 2014)
3	LILY POND	14.4	Annual average of 10 years (2005 to 2014)
4	TRINCHERA	11.1	Annual average of 10 years (2005 to 2014)
5	MEDANO PASS	6.5	Annual average of 10 years (2005 to 2014)
6	UTE CREEK	15.2	Annual average of 10 years (2005 to 2014)
7	GRAYBACK	15.7	Annual average of 10 years (2005 to 2014)
8	COCHETOPA PASS	4.7	Annual average of 10 years (2005 to 2014)
9	HAYDEN PASS	17.7	This site has only 8 yrs of data (2007-2014)
10	MOON PASS	9.6	This site has only 6 yrs of data (2009-2014)
11	SARGENTS MESA	14.9	This site has only 6 yrs of data (2009-2014)

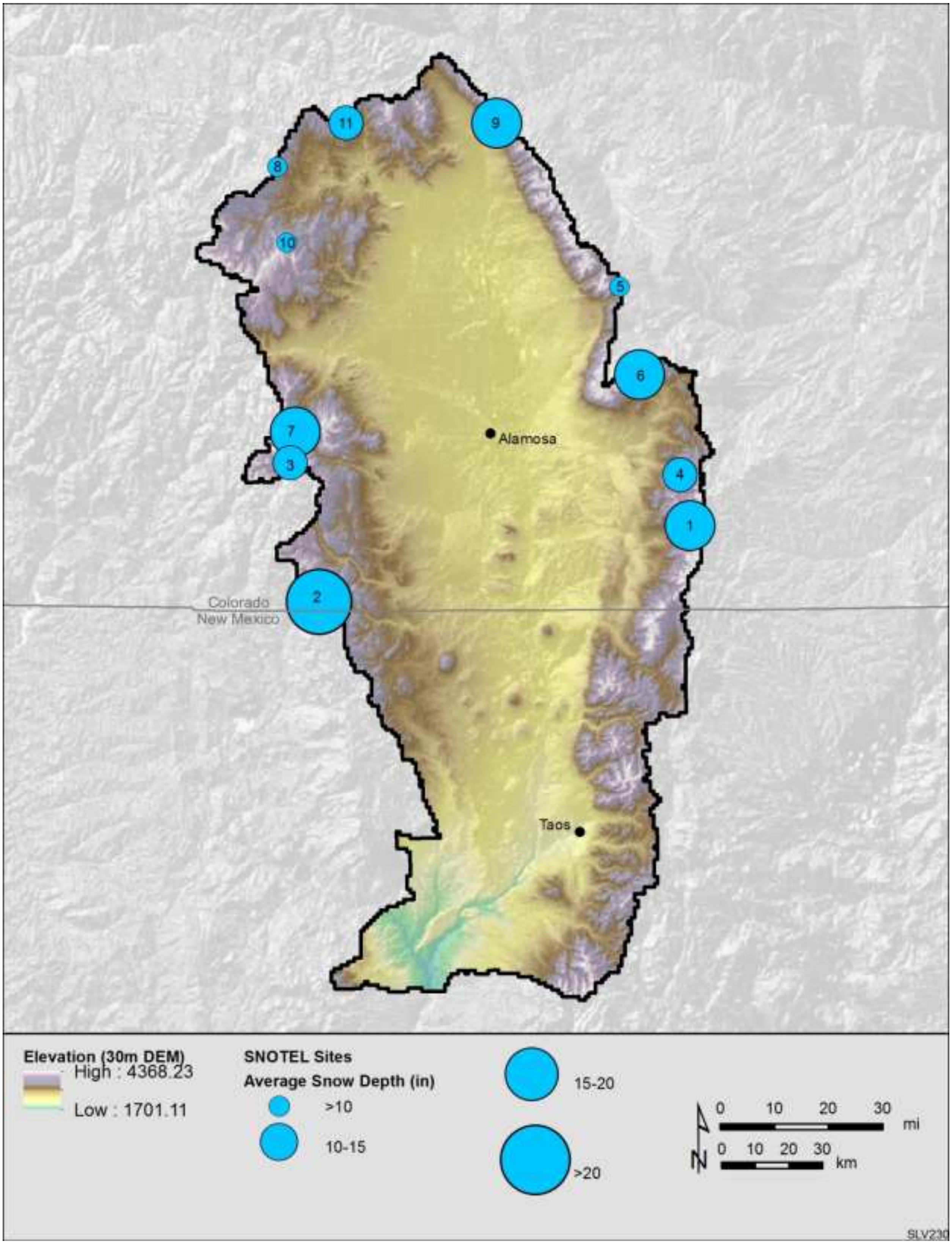


Figure A.2.3-1. Average Annual Snow Pack at SNOTEL Sites in the Study Area. Sites are labeled by IDs that are used in Table A.2.3-1. Data Source: NRCS 2014.

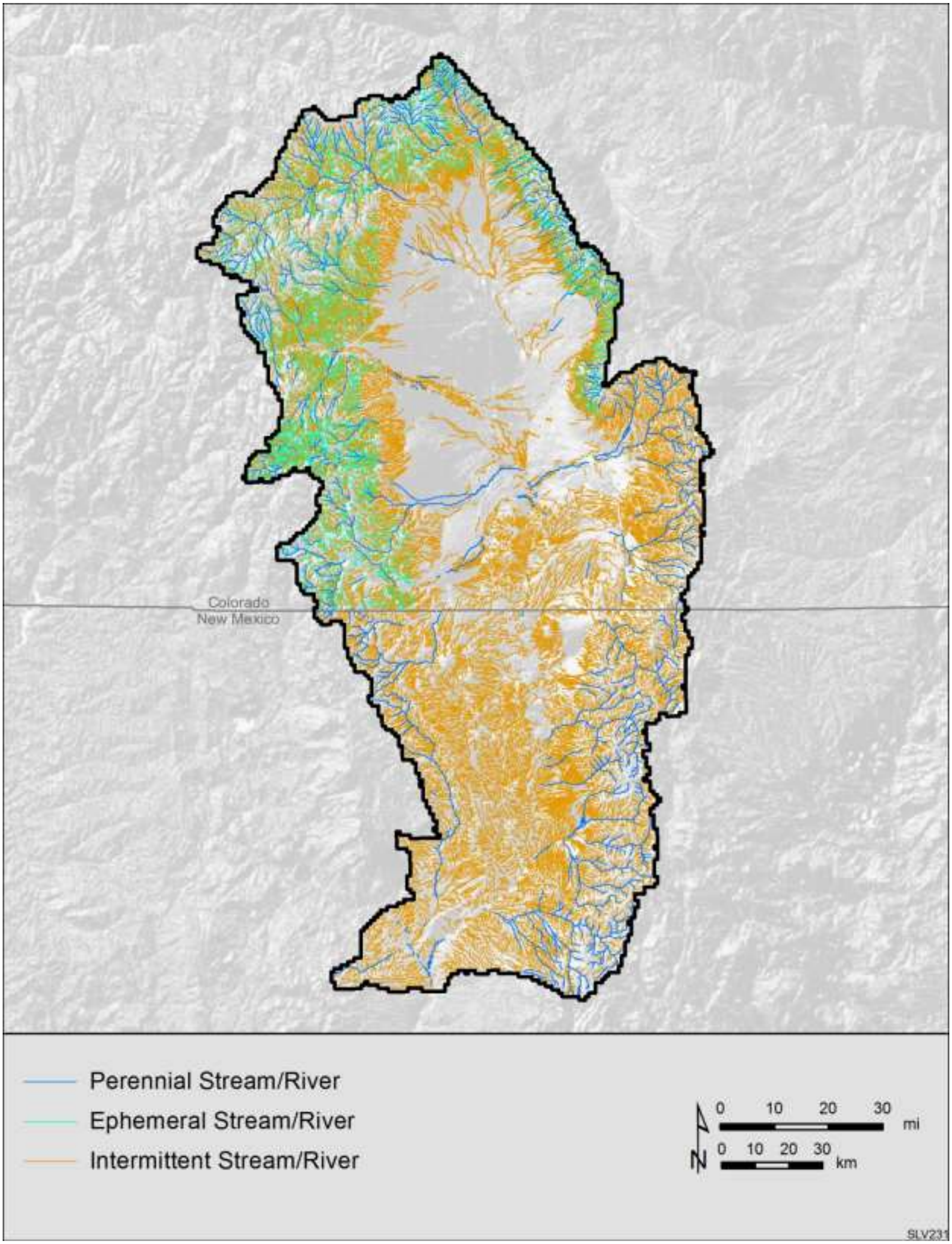


Figure A.2.3-2. Rivers, streams, and ephemeral drainages in the study area. Data Source: USGS 2013.

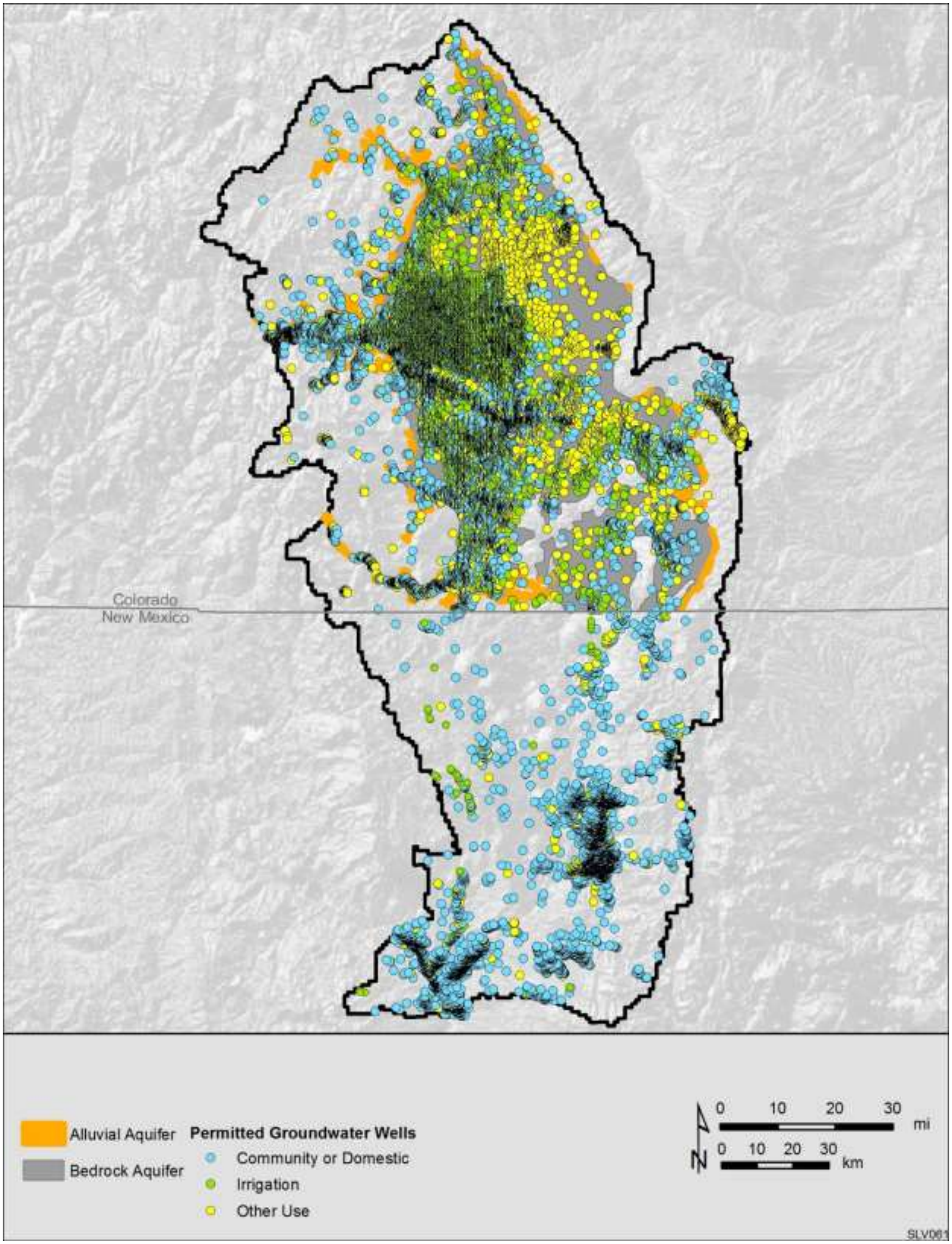


Figure A.2.3-3. Aquifers and permitted groundwater wells in the study area. Data Sources: data received from BLM and ForestERA 2006.

A.2.4 MQB4: Where are Hydrologic Systems Vulnerable to Change Agents?

Refer to Section A.2.1 above (MQB1).

A.2.5 MQB5: Where are Areas Susceptible to Early Snow Melt Due to Dust on Snow?

Dataset(s) and Source(s):

- USGS 30 m Digital Elevation Model (used to identify areas of mountain snowpack)
- Dust factors:
  1. BLM fire perimeters (polygons)
  2. LANDFIRE disturbance events (polygons)
  3. SSURGO Wind Erodibility Groups (WEG) (polygons)
  4. SSURGO Available Water Capacity (polygons)
  5. LANDFIRE Existing Vegetation Types (EVT) (raster)
  6. Oil and gas lease areas (polygons)
  7. Mine locations (points)

The process for identifying areas susceptible to early snow melt due to dust on snow involved 2 parts. The first part focused on characterizing areas of potential mountain snow pack. This was accomplished by querying the DEM to areas encompassing the SNOTEL sites (see MQB03 for SNOTEL sites in the study area). Based on the elevations of the SNOTEL sites, elevations >9,000 ft were selected from the DEM to represent elevations of potential mountain snow accumulation.

The second part focused on identifying areas where dust factors occurred. These factors included areas of fire, erodibility, vegetation type, and human development. The process model for integrating these datasets to identify dust source areas is shown in **Figure A.2.5-1**. The output dust source areas were then intersected with the area of potential mountain snow accumulation (determined in step 1) to characterize mountain snow pack areas that may be susceptible to dust on snow from the dust source factors. The map of the output model is shown in **Figure A.2.5-2**. An additional study examines the impacts of solar development on air quality (Chang et al. 2016).

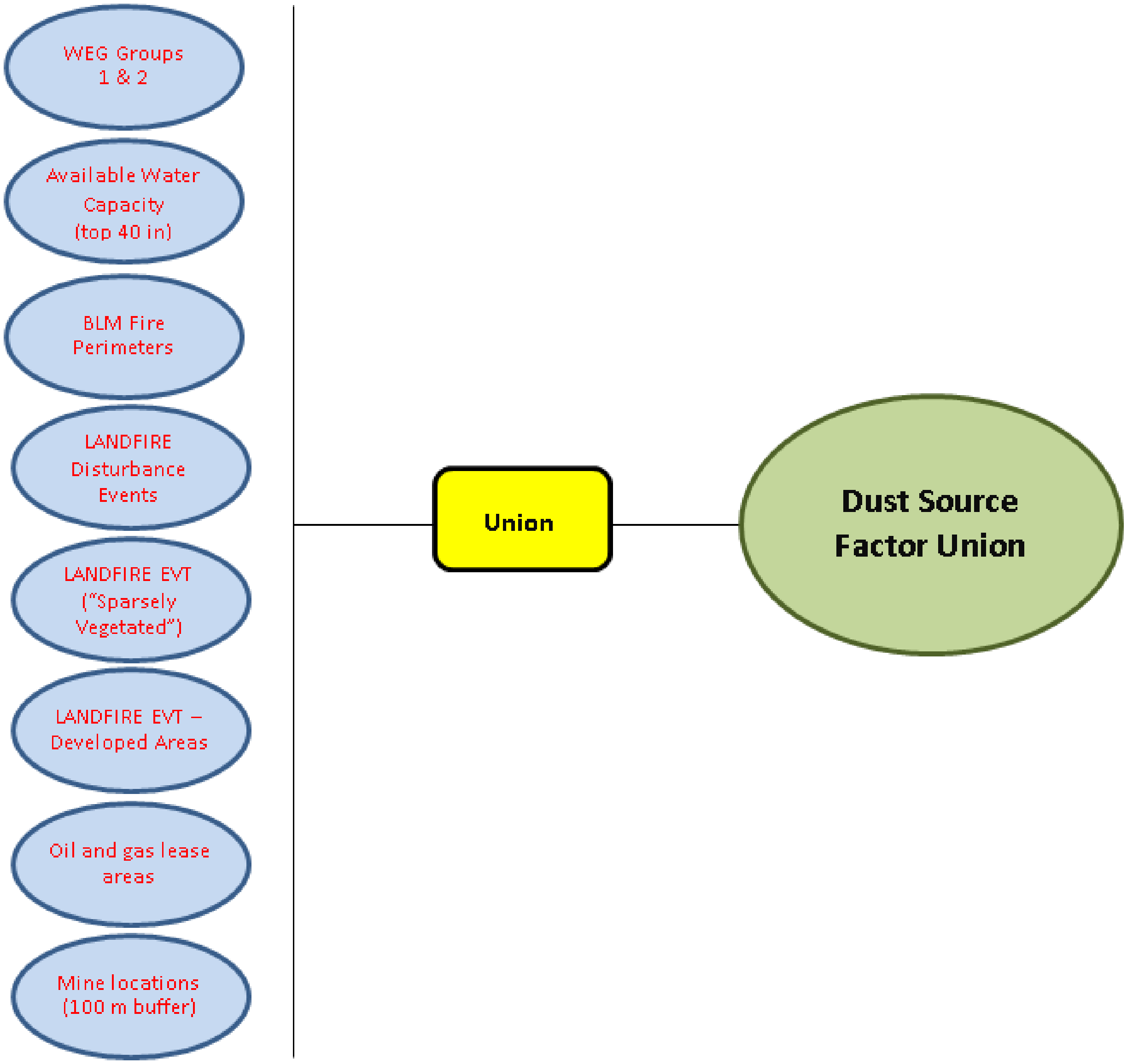


Figure A.2.5-1. Geoprocessing steps to Characterize the Union of Dust Source Factors.

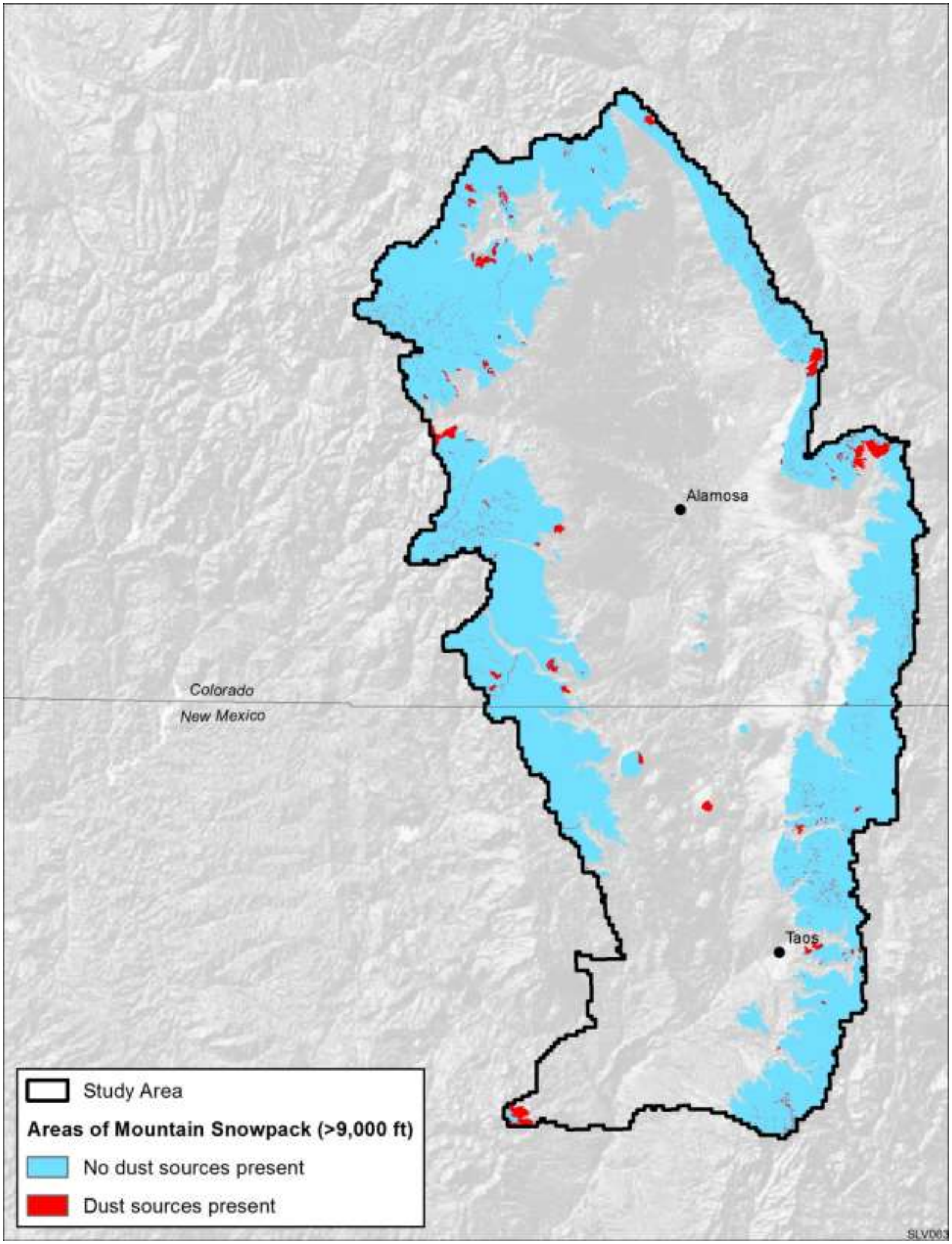


Figure A.2.5-2. Areas of potential mountain snow pack susceptible to dust source factors. Data Sources: Data received from BLM, USGS 2010a,b, NRCS 2015.

A.2.6 What are the Seasonal Discharge Maxima and Minima for the Rio Grande, Closed Basin, and Major Tributaries at Gaging Stations?

A total of 36 gaging stations were identified in the study area with a minimum of 10 years of available daily discharge statistics. Discharge statistics were obtained from USGS (http://waterdata.usgs.gov/nwis) for the periods of data availability through September 2014. Average seasonal maximum and minimum discharge (cubic feet per second) were calculated at each gaging station across all available years and presented below in **Table A.2.6-1**. The total number of years available for each gaging station is presented in the column 'Years'. The seasonal discharge results are also presented in **Figures A.2.6-1** to **A.2.6-4**.

Table A.2.6-1. Seasonal Maxima and Minima for Gage Stations. Data Source: USGS 2014b.

					Seasonal Discharge Maxima/Minima (Cubic Feet per Second)							
ID	**Gage Station**	**LONGITUDE**	**LATITUDE**	**Years**	**Spring Minimum**	**Spring Maximum**	**Summer Minimum**	**Summer Maximum**	**Fall Minimum**	**Fall Maximum**	**Winter Minimum**	**Winter Maximum**
1	RIO GRANDE NEAR DEL NORTE, CO.	-106.46115	37.68945	20	482.0	3620.0	443.0	1680.0	175.0	656.0	163.0	445.0
2	CONEJOS RIVER NEAR MOGOTE, CO.	-106.18753	37.05390	20	144.0	1240.0	140.0	612.0	42.0	181.0	44.0	136.0
3	SAN ANTONIO RIVER AT ORTIZ, CO.	-106.03863	36.99307	20	2.2	147.0	0.7	4.6	1.8	5.1	2.7	45.0
4	LOS PINOS RIVER NEAR ORTIZ, CO.	-106.07363	36.98224	20	91.0	603.0	17.0	95.0	15.0	31.0	16.0	85.0
5	CONEJOS RIVER NEAR LASAUSES, CO.	-105.74696	37.30029	20	117.0	531.0	11.0	209.0	17.0	61.0	63.0	202.0
6	COSTILLA CREEK ABOVE COSTILLA DAM, NM	-105.25467	36.89836	19	7.6	34.0	3.0	7.3	2.4	4.5	4.7	7.4
7	CASIAS CREEK NEAR COSTILLA, NM	-105.26046	36.89686	20	5.7	36.0	5.9	23.0	2.9	6.3	5.5	7.3
8	SANTISTEVAN CREEK NEAR COSTILLA, NM	-105.28111	36.88417	20	0.7	5.6	1.0	3.5	0.5	1.1	0.7	0.8
9	COSTILLA CREEK BELOW COSTILLA DAM, NM	-105.28367	36.87281	20	0.3	68.0	10.0	68.0	0.1	10.0	0.0	0.3
10	COSTILLA CREEK NEAR COSTILLA, NM	-105.50695	36.96697	20	26.0	139.0	31.0	83.0	9.4	20.0	8.0	29.0
11	COSTILLA CREEK NEAR GARCIA, CO	-105.53246	36.98903	20	0.0	35.0	1.1	28.0	0.0	7.6	0.7	6.7
12	RIO GRANDE NEAR CERRO, NM	-105.68529	36.73475	20	317.0	986.0	171.0	491.0	180.0	326.0	317.0	625.0
13	RED RIVER NEAR QUESTA, NM	-105.56834	36.70336	20	25.0	146.0	23.0	70.0	11.0	23.0	13.0	25.0
14	RED RIVER BELOW FISH HATCHERY, NEAR QUESTA, NM	-105.65640	36.68169	20	52.0	191.0	48.0	97.0	38.0	50.0	39.0	51.0
15	RIO HONDO NEAR VALDEZ, NM	-105.55640	36.54169	20	18.0	116.0	18.0	55.0	10.0	18.0	9.6	18.0
16	RIO PUEBLO DE TAOS NEAR TAOS, NM	-105.50362	36.43947	20	25.0	103.0	8.1	26.0	6.7	9.4	6.3	25.0
17	RIO LUCERO NEAR ARROYO SECO, NM	-105.53084	36.50836	20	12.0	67.0	10.0	32.0	5.8	10.0	5.4	12.0
18	RIO GRANDE DEL RANCHO NEAR TALPA, NM	-105.58251	36.29780	20	12.0	94.0	4.5	12.0	4.1	6.8	3.9	12.0
19	RIO PUEBLO DE TAOS BELOW LOS CORDOVAS, NM	-105.66862	36.37752	20	42.0	224.0	11.0	40.0	15.0	32.0	28.0	51.0
20	RIO GRANDE BLW TAOS JUNCTION BRIDGE NEAR TAOS, NM	-105.75446	36.32002	20	569.0	1600.0	329.0	949.0	341.0	512.0	498.0	851.0
21	RIO PUEBLO NR PENASCO, NM	-105.60279	36.16847	20	35.0	191.0	11.0	78.0	8.4	15.0	7.8	33.0

ID	Gage Station	LONGITUDE	LATITUDE	Years	Seasonal Discharge Maxima/Minima (Cubic Feet per Second)							
					Spring Minimum	Spring Maximum	Summer Minimum	Summer Maximum	Fall Minimum	Fall Maximum	Winter Minimum	Winter Maximum
22	EMBUDO CREEK AT DIXON, NM	-105.91363	36.21086	20	55.0	292.0	22.0	64.0	25.0	41.0	28.0	68.0
23	RIO GRANDE AT EMBUDO, NM	-105.96419	36.20558	20	646.0	1840.0	350.0	976.0	367.0	547.0	528.0	899.0
24	RIO OJO CALIENTE AT LA MADERA, NM	-106.04419	36.34974	20	13.0	352.0	6.7	21.0	9.5	24.0	19.0	116.0
25	RIO CHAMA NEAR CHAMITA, NM	-106.11169	36.07391	20	535.0	1380.0	380.0	698.0	151.0	436.0	137.0	531.0
26	CLOSED BASIN PROJECT CANAL NEAR ALAMOSA	-105.76500	37.47580	21	25.1	36.6	19.3	26.0	20.0	25.9	23.1	43.6
27	SAGUACHE CREEK NEAR SAGUACHE	-105.71167	38.16000	20	40.4	160.7	48.7	151.7	27.8	48.5	35.2	100.9
28	KERBER CREEK NEAR VILLA GROVE	-105.91300	38.22000	11	6.4	43.2	2.9	42.8	2.6	5.9	3.4	13.9
29	LAJARA CREEK AT GALLEGOS RANCH NEAR CAPULIN	-105.81417	37.20917	20	18.1	167.8	7.2	161.9	4.7	729.9	4.7	56.8
31	SAN ANTONIO RIVER AT ORTIZ	-105.96333	36.99250	20	30.2	151.5	1.2	31.0	0.8	12.4	4.7	24.8
32	CONEJOS RIVER NEAR MOGOTE	-105.81417	37.05250	20	145.5	1248.5	155.3	1201.1	55.6	188.7	65.4	270.6
33	CONEJOS RIVER BELOW PLATORO RESERVOIR	-105.45667	37.35333	20	21.2	287.5	83.7	346.7	4.8	141.7	4.6	24.7
34	ALAMOSA RIVER BELOW TERRACE RESERVOIR	-105.72167	37.35333	20	19.0	519.9	65.2	464.3	2.7	65.7	2.2	5.0
35	ALAMOSA RIVER BELOW RANGER CREEK NEAR JASPER	-105.62000	37.39083	10	85.1	457.7	34.1	411.6	12.3	111.2	0.0	0.0
36	ALAMOSA RIVER ABOVE TERRACE RESERVOIR	-105.66833	37.37167	20	46.0	547.6	43.5	513.8	24.9	182.7	6.6	54.0
37	ALAMOSA RIVER ABOVE WIGHTMAN FORK NEAR JASPER	-105.48000	37.40167	13	22.7	447.6	31.0	436.4	10.5	57.0	0.0	0.0

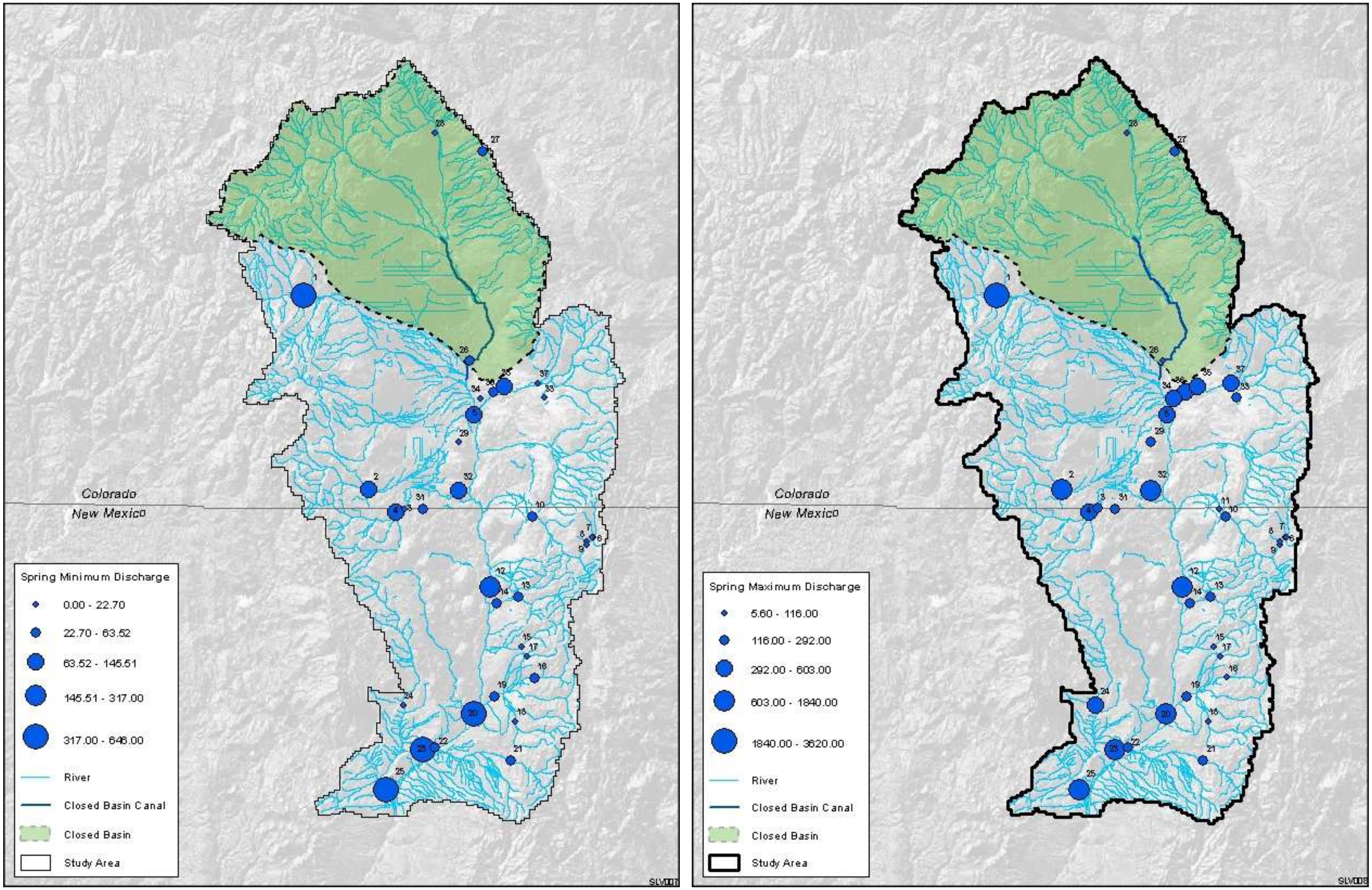


Figure A.2.6-1. Spring Minimum and Maximum Discharge (cfs) at 36 Gage Stations in the San Luis Valley-Taos Plateau Study Area. Data Source: data received from BLM, USGS 2013 and 2014b.

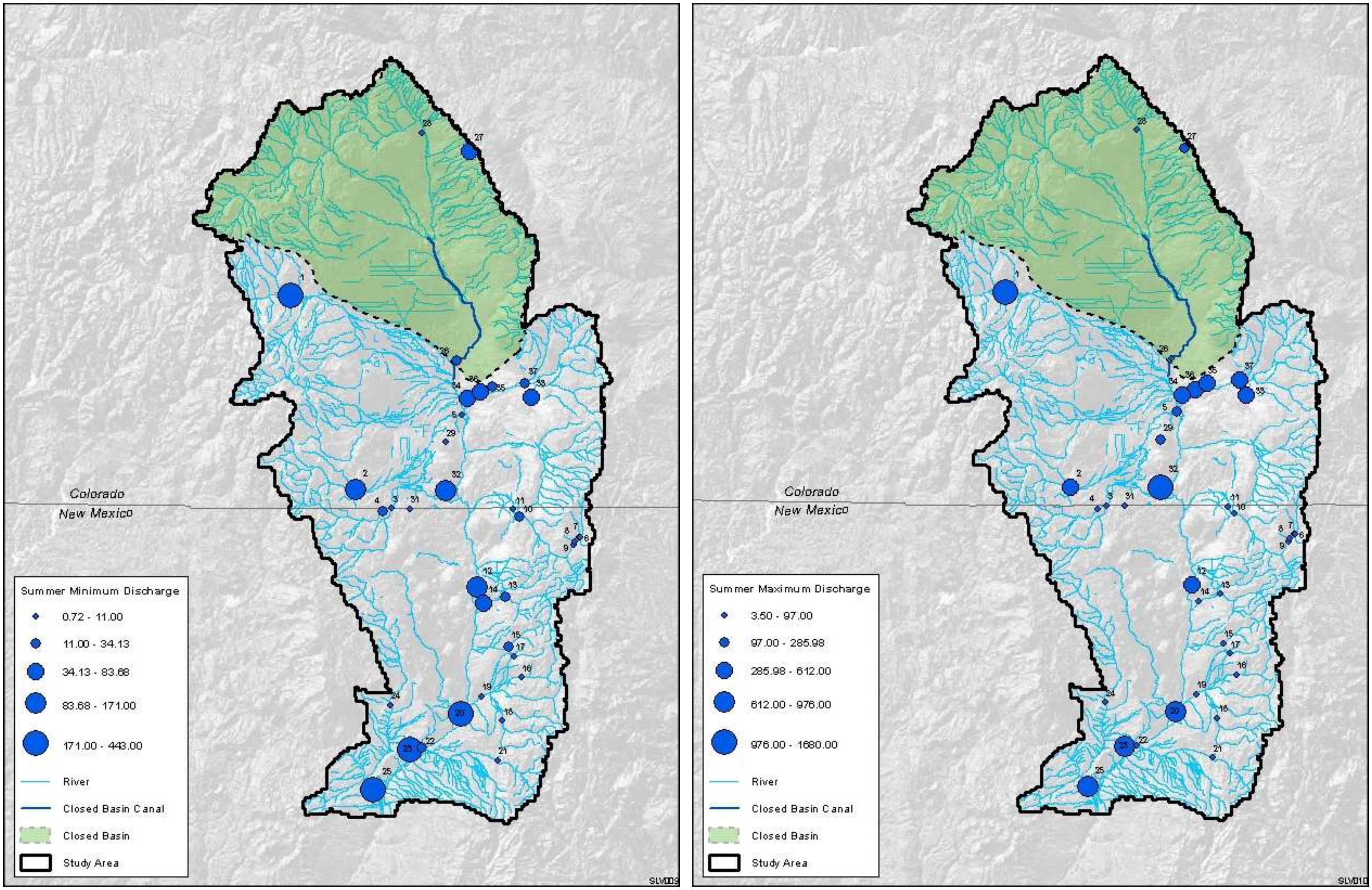


Figure A.2.6-2. Summer Minimum and Maximum Discharge (cfs) at 36 Gage Stations in the San Luis Valley-Taos Plateau Study Area. Data Source: data received from BLM, USGS 2013 and 2014b.

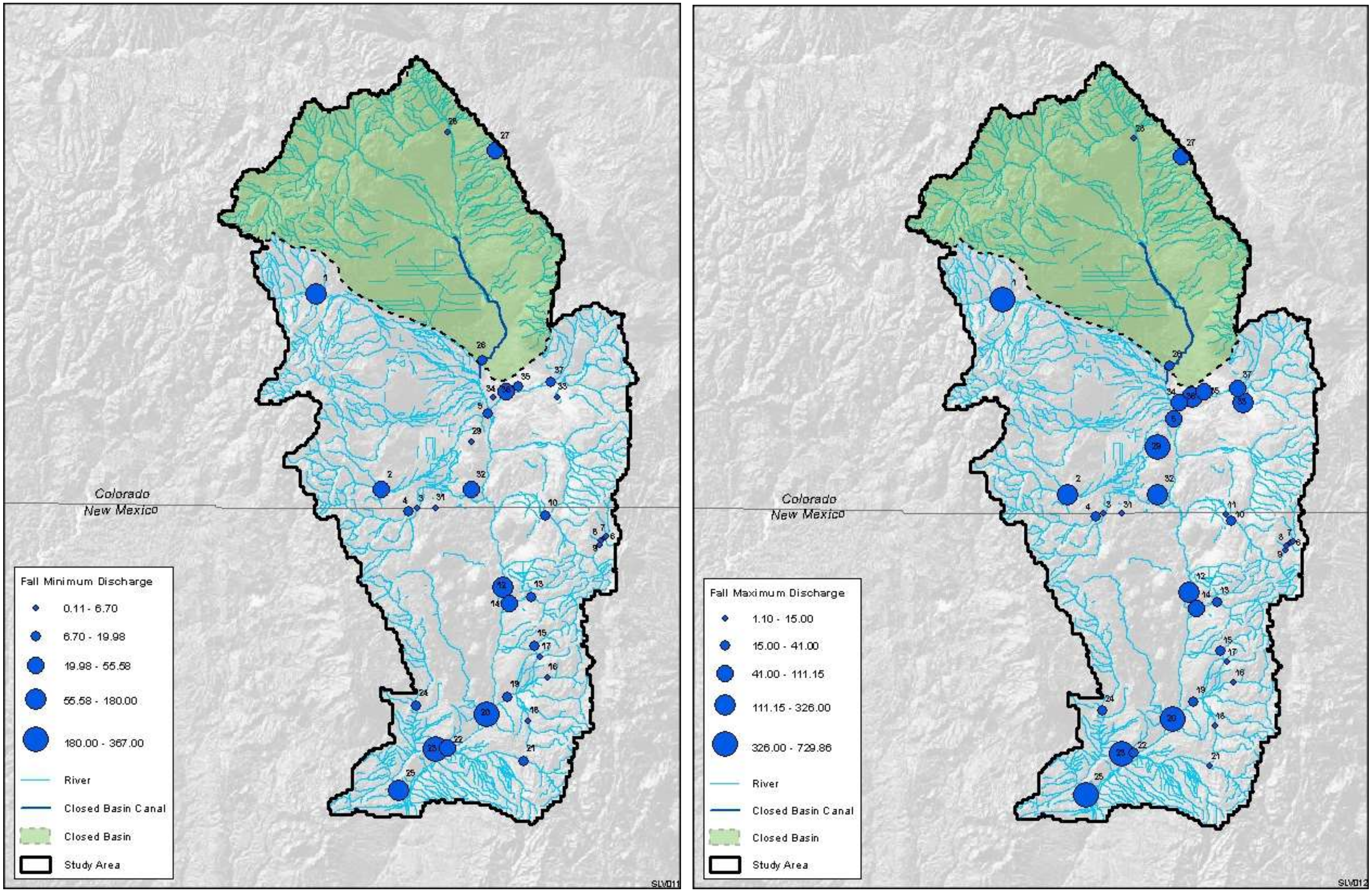


Figure A.2.6-3. Fall Minimum and Maximum Discharge (cfs) at 36 Gage Stations in the San Luis Valley-Taos Plateau Study Area. Data Source: data received from BLM, USGS 2013 and 2014b.

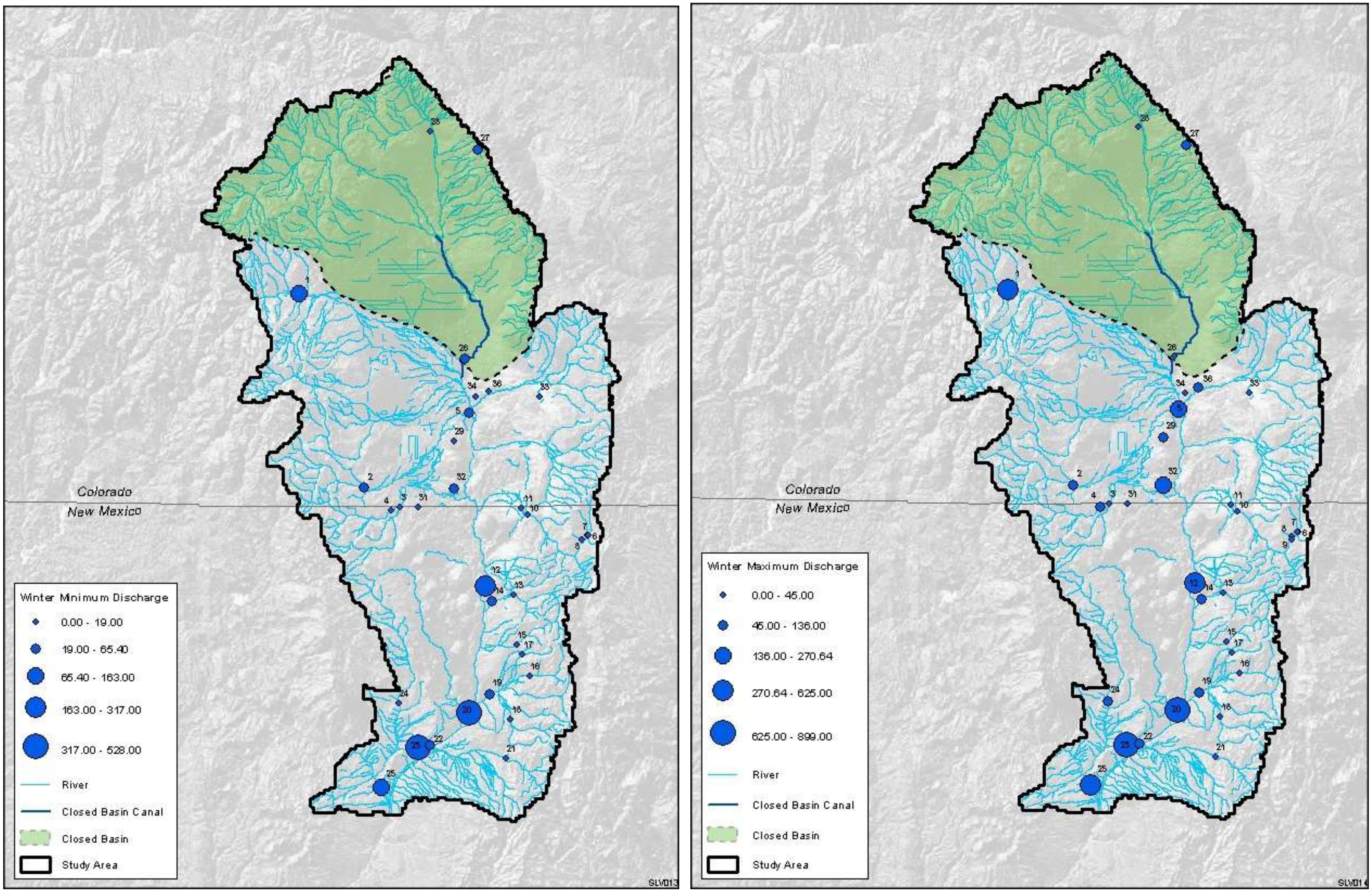


Figure A.2.6-4. Winter Minimum and Maximum Discharge (cfs) at 36 Gage Stations in the San Luis Valley-Taos Plateau Study Area. Data Source: data received from BLM, USGS 2013 and 2014b.

A.2.7 Where are the Confined and Unconfined Recharge or Discharge Areas?

See Section A.2.3 (MQB3) for mapped results of aquifers and permitted groundwater wells that serve as areas of recharge and discharge.

Aquifers and permitted groundwater wells in the study area are shown in **Figure A.2.7-1**. An assessment of groundwater trends is provided below.

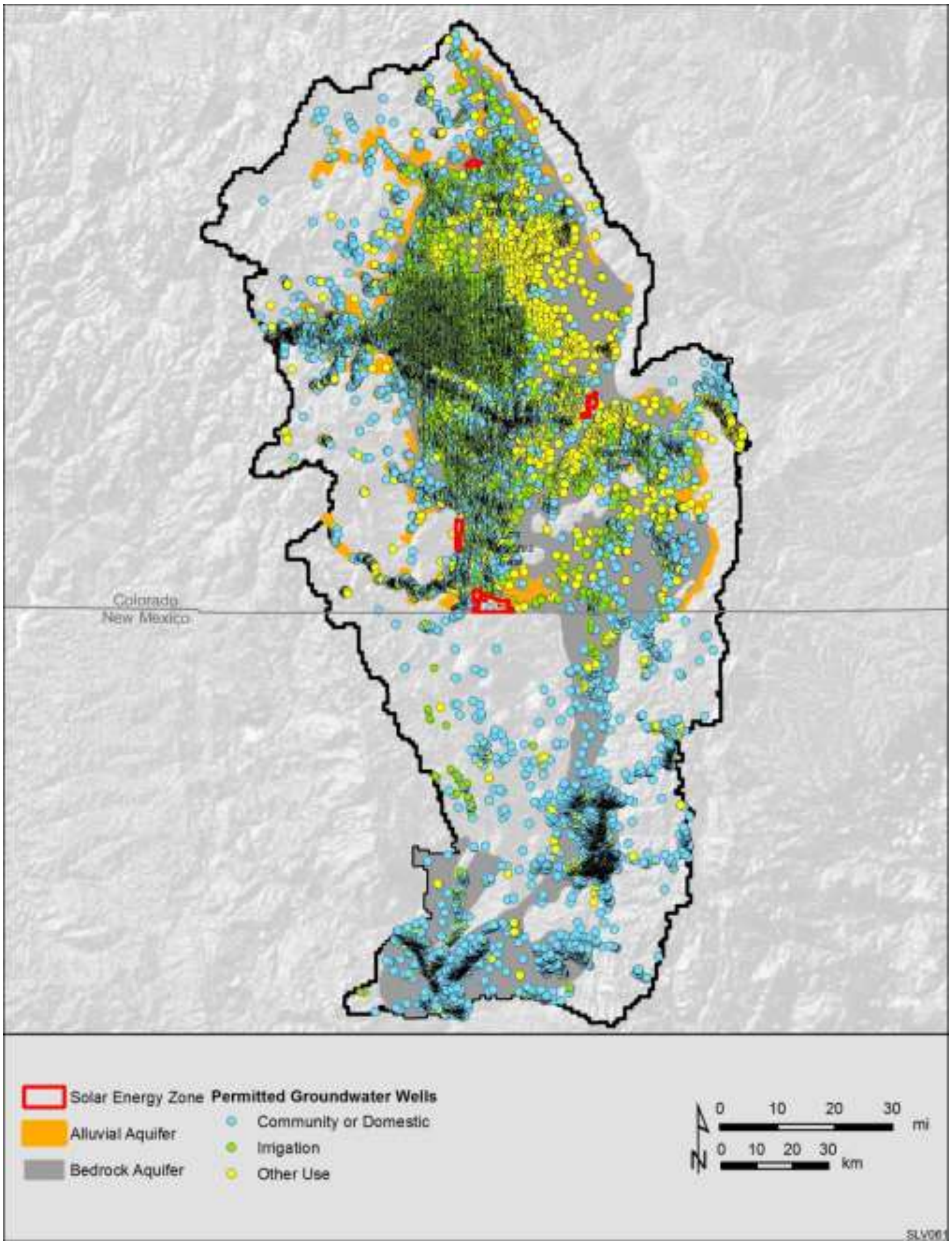


Figure A.2.7-1. Aquifers and permitted groundwater wells in the study area. (See Section A.2.3 for details on data and map development). Data Sources: data received from BLM and ForestERA 2006.

Assessment of Groundwater Trends in the Study Area

Data sources:

- USGS Groundwater Watch Network (http://groundwaterwatch.usgs.gov/StateMap.asp?sa=CO&sc=08)
- USGS National Ground Water Information System (http://waterdata.usgs.gov/nwis/gw)

The Groundwater Watch Network focuses on a smaller population of actively monitored wells and selects appropriate wells for inclusion in identifiable networks. These networks have specific criteria for the wells that are selected and enable ready analysis of the information on a national basis.

The Active Groundwater Level Network contains water levels and well information from more than 20,000 wells that have been measured by the USGS or USGS cooperators at least once within the past 13 months. This network includes all of these wells, regardless of measurement frequency, aquifer monitored, or the monitoring objective.

The U.S. Geological Survey has a database/archive of about 850,000 wells across the Nation. Information about these wells is available to the world via NWISWeb (http://waterdata.usgs.gov/nwis/gw). Through various groundwater programs, the USGS actively measures water levels in, or collects data from more than 20,000 of these wells each year. These wells are measured for a variety of disparate purposes, such as statewide monitoring programs, or more local effects like monitoring well drawdown, hydrologic research, aquifer tests, or even earthquake effects on water levels. The locations of active groundwater monitoring wells, as part of the USGS Groundwater Watch Network, are shown in **Figure A.2.7-2**.

There also are a variety of networks among these actively measured wells; a National Climate Response Network for wells, Regional Networks like the High Plains Aquifer Monitoring Program that is designed to monitor storage changes in the High Plains Aquifer, state-based networks that are designed to monitor statewide groundwater conditions, and local networks designed to monitor pumping effects.

The USGS National Water Information System (NWIS) contains extensive water data for the nation, including temporal trends in groundwater levels at monitored locations. The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored as either discrete field-water-level measurements or as continuous time-series data from automated recorders. Data from some of the continuous record stations are relayed to USGS offices nationwide through telephone lines or by satellite transmissions providing access to current groundwater data.

As estimated in the USGS report “Groundwater Depletion in the United States (1900-2008)” (Konikow 2013), a cumulative total of 3.6 km^3 of groundwater had been depleted from storage in confined and unconfined aquifers of the San Luis Valley between 1900 and 2008, primarily due to increased water demands to support agricultural developments. Groundwater depletion in the San Luis Valley from 1900 to 2008 is shown in figure A.2.7-3.

Groundwater statistics for monitored sites in the study area were obtained from NWIS. Annual average depth to water was calculated among all monitored sites from 1980 to 2014. A linear regression model (using ordinary least squares) resulted in a statistically significant linear temporal relationship in average annual depth to groundwater among monitored wells in the study area over the time period (**Figure A.2.7-4**). On average, depth to groundwater increased by 0.26 ft per year over a 35 year period between 1980 and 2014.

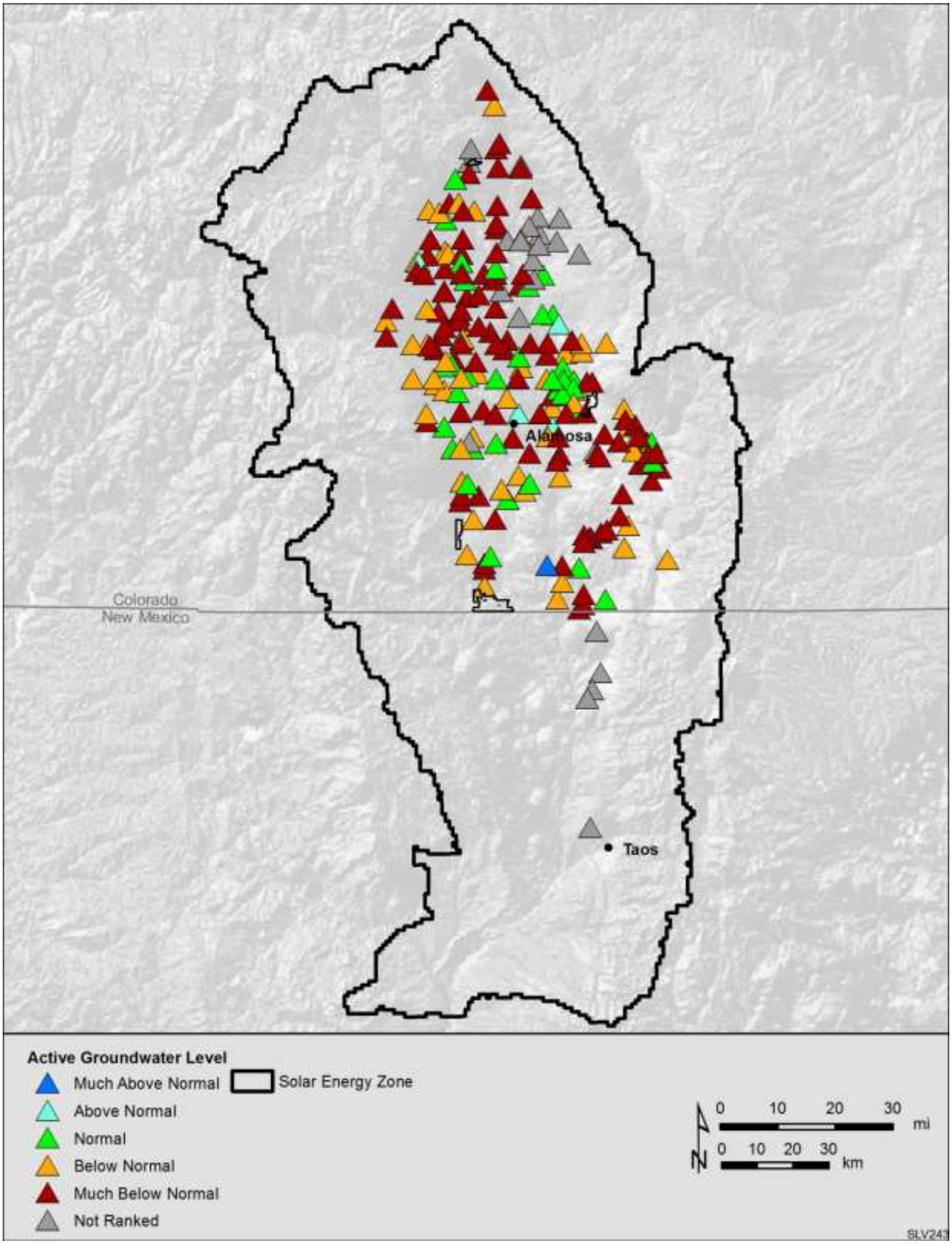


Figure A.2.7-2. Active monitoring well locations as part of the USGS 2015.

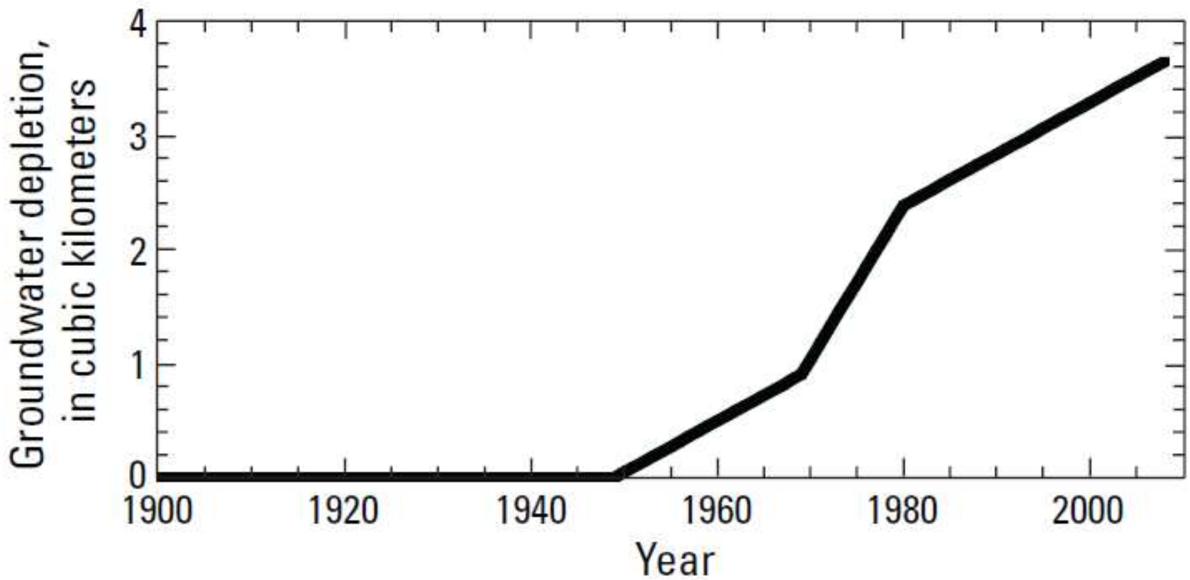


Figure A.2.7-3. Cumulative groundwater depletion in the San Luis Valley, Colorado, 1900 through 2008 (from Konikow 2013).

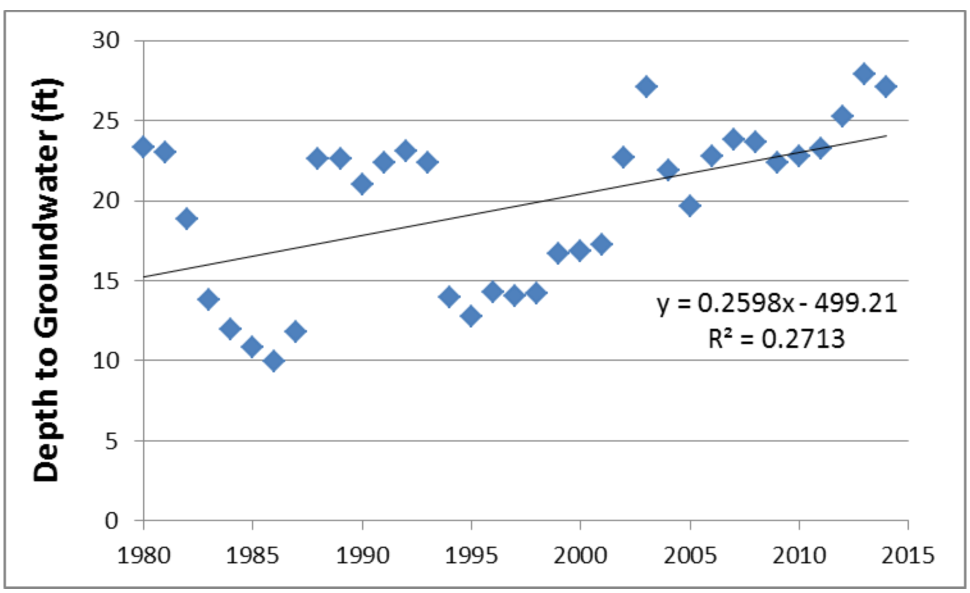


Figure A.2.7-4. Average depth to groundwater among USGS National Water Information System sites within the study area monitored from 1980 to 2014.

A.3 Management Questions for Ecological Systems Conservation Elements

C. Ecological Systems Conservation Elements	
MQC1	Where are existing vegetative communities? **Refer to Appendix B**
MQC2	Where are vegetative communities vulnerable to change agents in the future? **Refer to Appendix B**
MQC3	Where are areas of highest carbon sequestration and what are conditions and trends of carbon sequestration in the study area? **See Below**
MQC4	What change agents have affected existing vegetation communities? **Refer to Appendix B**
MQC5	How will vegetation communities be altered (e.g. state and transition) according to the change agents? **Additional time and modeling requirements are needed to address this MQ. This MQ was not addressed in this Landscape Assessment but has been identified as an information gap for potential future study. Spatial datasets such as LANDFIRE Biophysical Settings (BPS) and modeling tools such as ST-Sim (Apex Resource Management Solutions, 2015) could be used to spatially represent state and transition models and illustrate how vegetation communities may respond to change agents.**

A.3.1 MQC3: Where are Areas of Highest Carbon Sequestration and What are Conditions and Trends of Carbon Sequestration in the Study Area?

The map of global vegetation biomass carbon stocks at 1km resolution (Ruesch and Gibbs 2008) was used to characterize vegetation carbon biomass in the San Luis Valley – Taos Plateau study area.

The vegetation biomass carbon database was created in two main steps (Ruesch and Gibbs 2008): 1) estimate carbon stocks, and 2) map values using a range of spatially explicit climate and vegetation datasets. Creators followed the IPCC GPG Tier1 method for estimating vegetation carbon stocks using the globally consistent default values provided for aboveground biomass. They added belowground biomass (root) carbon stocks using the IPCC root to shoot ratios for each vegetation type, and then converted total living vegetation biomass to carbon stocks using the carbon fraction for each vegetation type (varies between forests, shrublands and grasslands). All estimates and conversions were specific to each continent, ecoregion and vegetation type (stratified by age of forest). Thus, the global dataset compiled a total of 124 carbon zones or regions with unique carbon stock values based on the IPCC Tier1 methods. Please refer to Tables 1a-i (http://cdiac.ornl.gov/epubs/ndp/global_carbon/carbon_documentation.html) to review the details associated with each of these carbon zones.

The global gridded dataset depicts vegetation biomass carbon stocks at the native processing resolution of 0.0089 decimal degrees (e.g., 1 km reporting units). The 1km data is expressed in 0.01 tons of biomass carbon per hectare. Based on the model developed by Ruesch and Gibbs (2008), the map of vegetation carbon biomass in the study area is shown in **Figure A.3.1-1**. This dataset was queried to select areas with > 3,300 tons carbon biomass per hectare to represent areas with highest carbon sequestration in the study area. The evaluation of current and potential future condition within areas of highest carbon sequestration involved the processing steps illustrated in **Figure A.3.1-2**, whereby the areas of high carbon sequestration were intersected with the current and near-term future landscape intactness models. The results were evaluated by calculating the proportion of landscape intactness categories within the area of high carbon sequestration. Current and near-term future condition within the areas of high carbon sequestration are shown in **Figures A.3.1-3** and **A.3.1-4**, respectively.

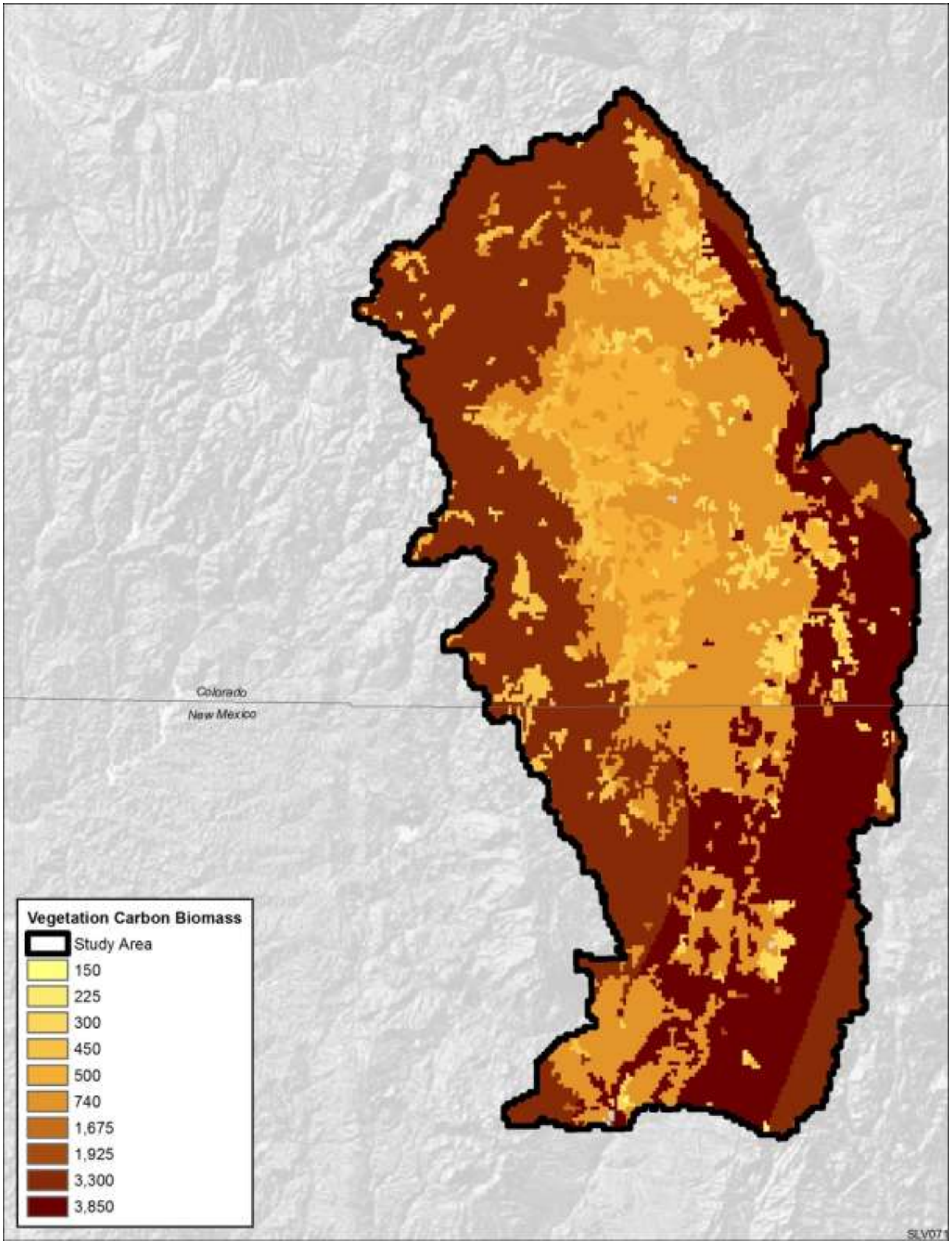


Figure A.3.1-1. Vegetation Carbon Biomass. Data Source: Ruesch and Gibbs (2008).

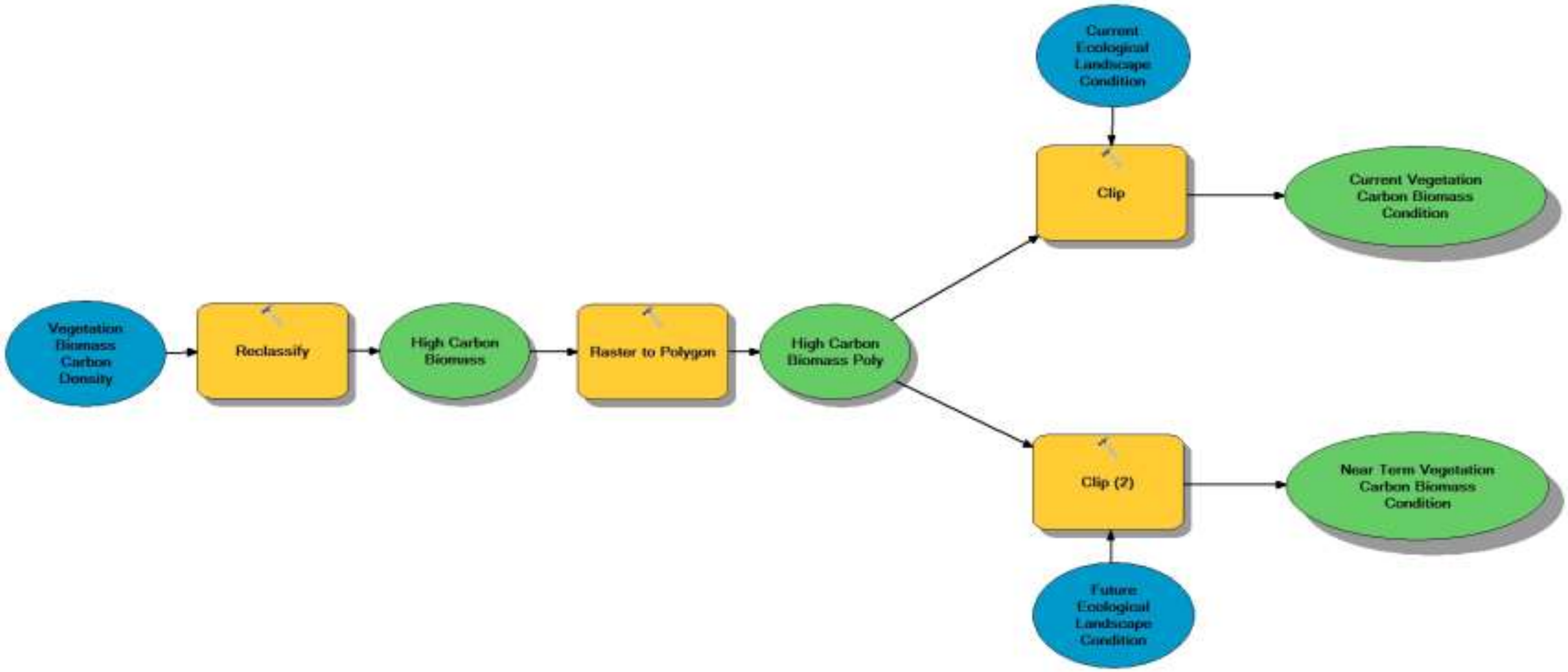


Figure A.3.1-2. Carbon Sequestration Geoprocessing Model.

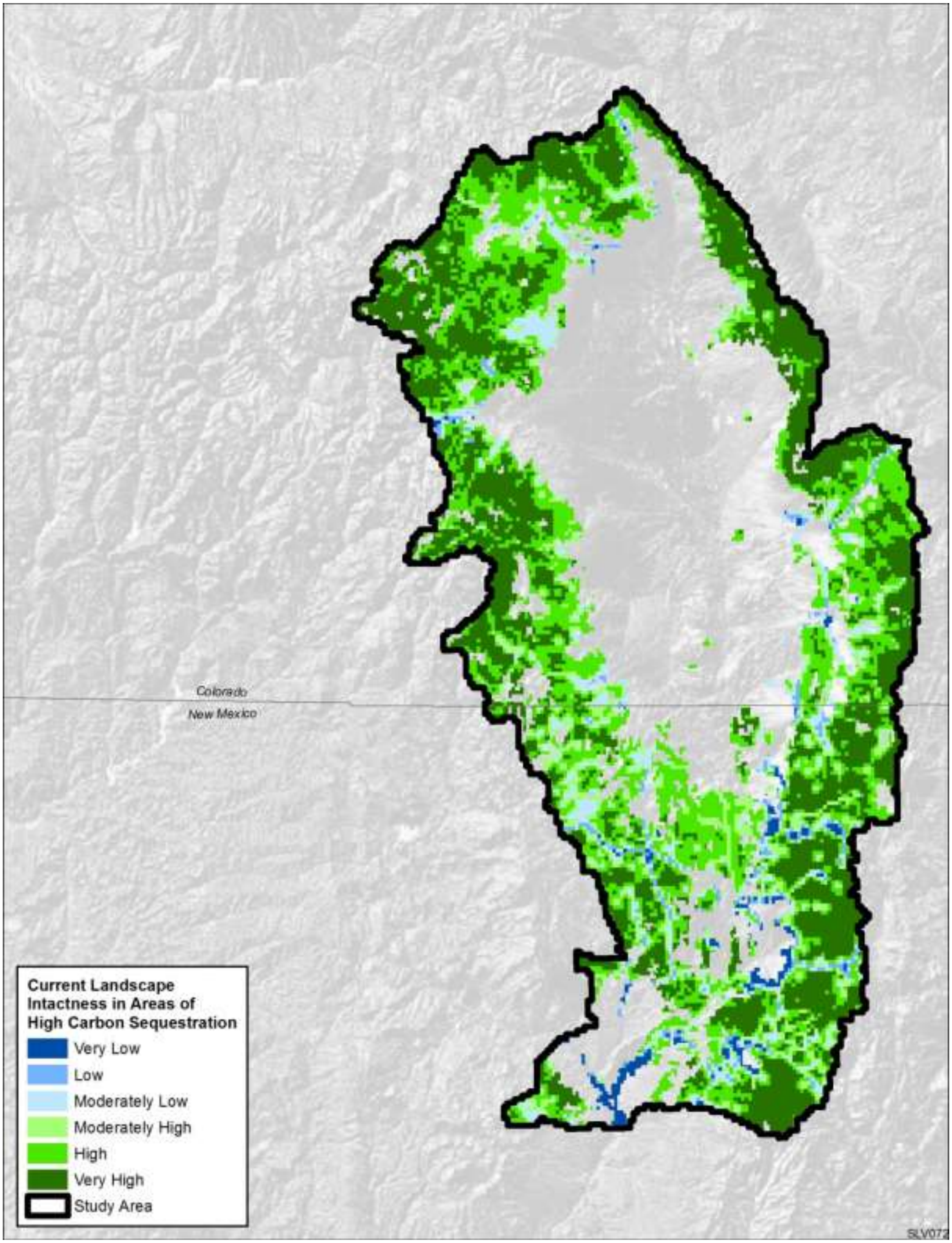
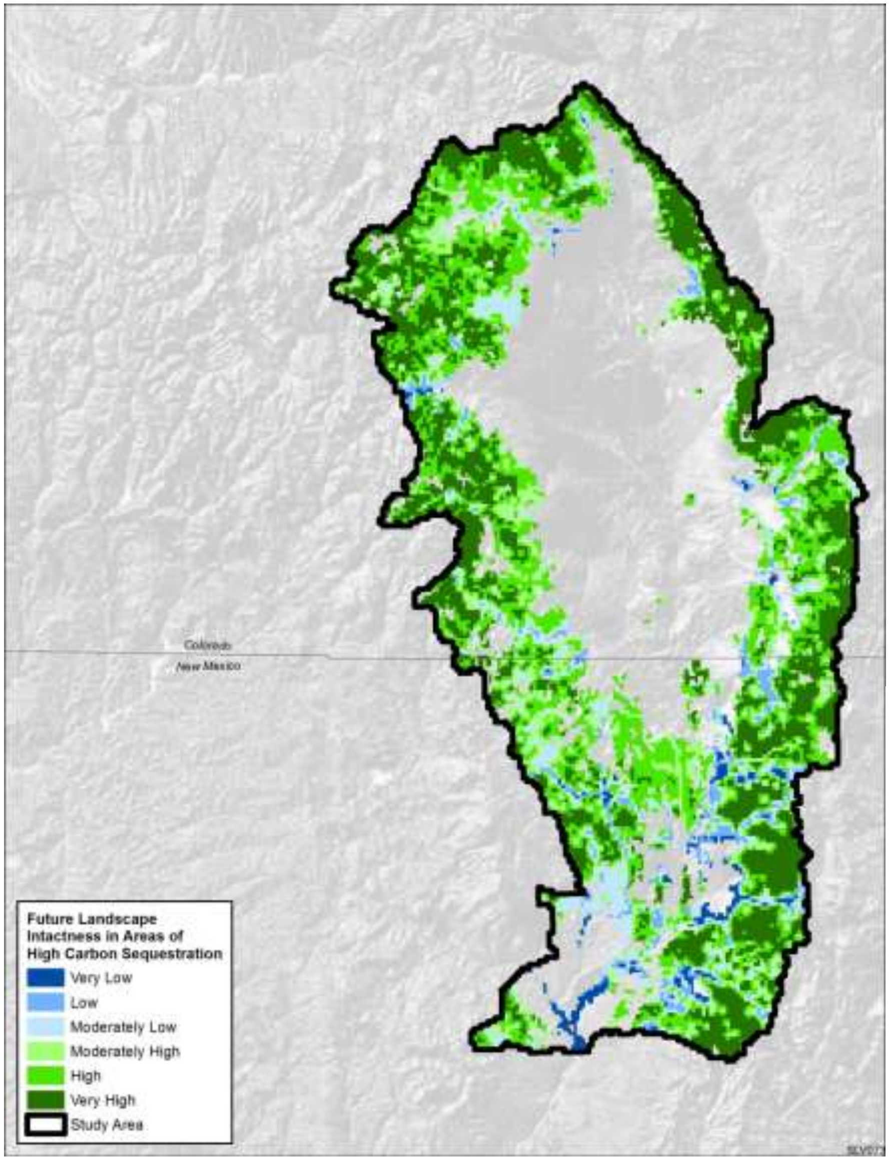


Figure A.3.1-3. Current Landscape Intactness of Areas of High Carbon Sequestration. Data Sources: Argonne 2014 and Ruesch and Gibbs (2008).



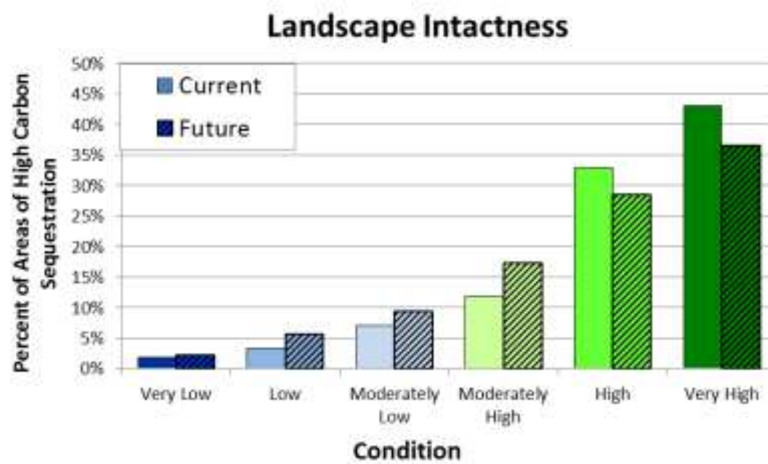


Figure A.3.1-4. Near-term Future Landscape Intactness of Areas of High Carbon Sequestration. Data Sources: Argonne 2014 and Ruesch and Gibbs (2008).

A.4 Management Questions for Focal Species Conservation Elements

The Management Questions MQD2, MQD4, and MQD5 are addressed below. Please refer to Appendix B for MQD1 and MQD3, which pertain to focal species Conservation Element distributions and potential interactions with Change Agents.

D. Focal Species Conservation Elements	
MQD1	What is the current distribution and status of available and suitable habitat for focal species Conservation Elements? **Refer to Appendix B**
MQD2	What is the distribution of current and potentially suitable habitat, if available, for aquatic, terrestrial, and riparian biodiversity sites, and special status species? **See Below**
MQD3	Where are focal species vulnerable to change agents in the future? **Refer to Appendix B**
MQD4	Where are aquatic, terrestrial, and riparian biodiversity sites, and special status species vulnerable to change agents in the future? **See Below**
MQD5	What is the current distribution and status of big game crucial habitat and movement corridors (including bighorn sheep, elk, mule deer, and pronghorn)? **See Below**

A.4.1 MQD2: What is the Distribution of Current and Potentially Suitable Habitat, if Available, for Aquatic, Terrestrial, and Riparian Biodiversity Sites, and Special Status Species?

Several approaches were used to characterize sites with potential biodiversity values and habitat for special status species. These approaches included: (1) mapping aggregate counts of at-risk species by watersheds, (2) mapping species richness, (3) mapping wildlife crucial habitats as determined by the Western Governors' Association (WGA), and (4) mapping areas managed for biodiversity.

Dataset(s) and Source(s):

- SWReGAP habitat suitability models for terrestrial wildlife (http://fws-nmcfwru.nmsu.edu/swregap/).
- BLM provided NatureServe tracked and at-risk species (includes globally rare [G1-G3] species and federally and state listed species).
- Wildlife crucial habitats in Colorado and New Mexico (http://westgovchat.org/data/download).
- Areas managed for biodiversity:
    - USGS Protected Areas Database (http://gapanalysis.usgs.gov/padus/) – areas managed for biodiversity (GAP codes 1 & 2).
    - BLM ACECs
    - Rio Grande del Norte National Monument
    - Proposed and designated critical habitat for threatened and endangered species
    - Areas managed by the U.S. Fish and Wildlife Service (e.g., National Wildlife Refuges)
    - Wilderness Areas and Wilderness Study Areas

A.4.1.1 Aggregation of Sensitive Species by Watershed

The purpose of this model was to spatially characterize the aggregated distribution of rare and at-risk species within the study area. NatureServe tracked species (including rare, at risk, and threatened/endangered species) were tabulated for each HUC 10 watershed. A spatial join was then performed to display the total number of NatureServe tracked species within each HUC 10 watershed in the study area. Results showing the total number of NatureServe tracked species within HUC 10 watersheds are shown in **Figure A.4.1-1**.

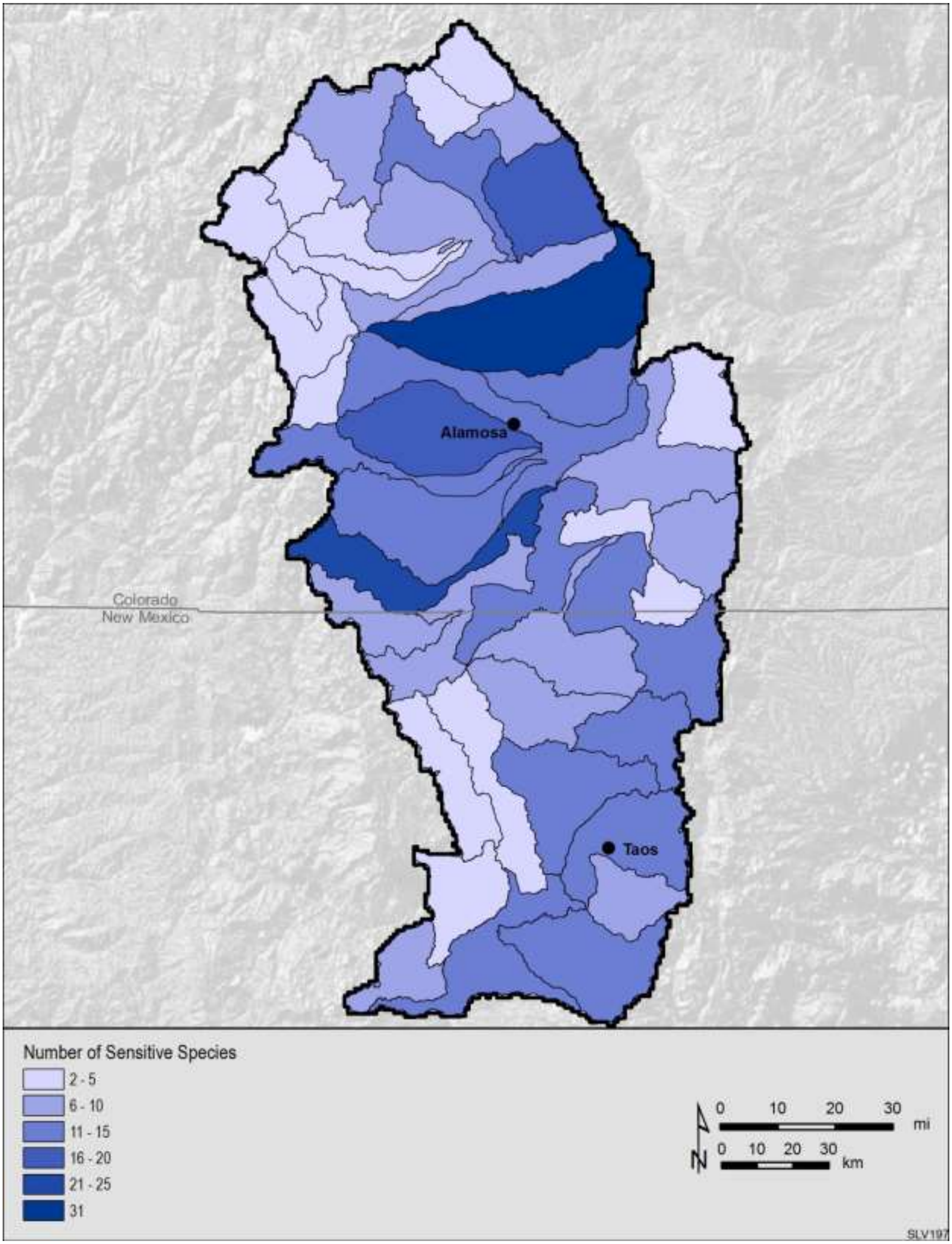


Figure A.4.1-1. Biodiversity Assemblage: Total Number of NatureServe Tracked Species at the HUC10 Watershed Level. Data Source: Natureserve 2011.

A.4.1.2 Mapping Species Richness

The purpose of this model was to spatially characterize areas with potential for greater number of terrestrial vertebrate species (species richness), based on SWReGAP habitat suitability models (http://fws-nmcfwru.nmsu.edu/swregap/). SWReGAP habitat distribution models for 137 species of vertebrates with modeled habitat occurring within the study area were used in this process (**Table A.4.1-1**). Input for each species consisted of a single 30 m integer raster dataset depicting various levels of habitat suitability. Python scripts were created to automatically clip each input raster dataset to the study area boundary and reclassify the rasters to binary datasets, where values of zero (0) indicate areas of no habitat suitability and values of one (1) indicate all areas where suitable habitat has been modeled. All 137 binary datasets were then summed using ArcGIS Spatial Analyst Cell Statistics to provide a single aggregate output dataset that indicated the amount of overlap among input datasets. The sum value provided a measure of the number of species habitat distribution models that occurred within each 30m cell and was used as a measure of species richness within the study area. The 30 m species richness output dataset was then summarized to the 1km reporting unit grids (vector).

Species richness process steps are shown in **Figure A.4.1-2**. The resulting species richness model is shown in **Figure A.4.1-3**. This model is limited to only terrestrial vertebrates for which SWReGAP data were available and does not include potential habitat distributions for plants, invertebrates, or fish. This model can be used as an indicator of biodiversity but should not be used as a sole indicator of biodiversity or as an indicator of sensitive or at-risk species. The species richness model should be considered with the other biodiversity measures used to address this MQ.

About SWReGAP Habitat Suitability Models: SWReGAP digital habitat suitability models were created as habitat models for a regional biodiversity assessment. These data are not intended to be used at scales larger than 1:100,000. This data was prepared in compliance with the National GAP effort. Distributions of 37 amphibians, 132 reptiles, 436 birds and 215 mammals were predicted by 8-digit HUC using a variety of sources. Most (650 of 820) models benefitted from review by taxa experts throughout the Southwest Regional Gap Analysis Project area. Habitat relationships for all terrestrial vertebrates were taken from various databases and most recent published scientific literature on each taxa, with review of collected relationships by species experts. These habitat relationships were cross-linked to one or several of the 52 land cover/vegetation types delineated on the Southwest Regional Gap Analysis Project land cover map. Predicted distribution maps were produced for each species based on count of occurrence and habitat affinities.

Table A.4.1-1. List of 137 Species with SWReGAP Habitat Models Included in the Species Richness Model. Data Source: USGS 2007.

N	IT IS Code	Taxonomic Group	Common Name
1	173429	Amphibian	Couch's Spadefoot Toad
2	173484	Amphibian	Great Plains Toad
3	173663	Amphibian	Jemez Mountains Salamander
4	173443	Amphibian	Northern Leopard Frog
5	173448	Amphibian	Plains Leopard Frog
6	173491	Amphibian	Red-Spotted Toad
7	173592	Amphibian	Tiger Salamander
8	173482	Amphibian	Western Toad
9	209400	Reptile	Bullsnake (Gopher Snake)
10	174017	Reptile	Chihuahuan Spotted Whiptail
11	174238	Reptile	Coachwhip
12	209247	Reptile	Common Kingsnake
13	174202	Reptile	Glossy Snake
14	174187	Reptile	Milk Snake
15	173956	Reptile	Side-Blotched Lizard
16	174319	Reptile	Western Rattlesnake
17	175622	Bird	American Kestrel
18	178979	Bird	American Redstart
19	174684	Bird	American White Pelican
20	178316	Bird	Ash-Throated Flycatcher
21	175420	Bird	Bald Eagle
22	175144	Bird	Barrow'S Goldeneye
23	178119	Bird	Belted Kingfisher
24	178636	Bird	Bendire'S Thrasher
25	177997	Bird	Black Swift
26	554382	Bird	Black-Capped Chickadee
27	174832	Bird	Black-Crowned Night-Heron
28	179395	Bird	Black-Throated Sparrow
29	179440	Bird	Brewer'S Sparrow
30	177946	Bird	Burrowing Owl
31	174803	Bird	Cattle Egret
32	554027	Bird	Clark's Grebe
33	555544	Bird	Common Poorwill
34	179725	Bird	Common Raven
35	175309	Bird	Cooper'S Hawk
36	179165	Bird	Dickcissel
37	175377	Bird	Ferruginous Hawk
38	175407	Bird	Golden Eagle
39	178625	Bird	Gray Catbird
40	177884	Bird	Great Horned Owl
41	177836	Bird	Greater Roadrunner
42	179310	Bird	Green-Tailed Towhee
43	-2	Bird	Gunnison Sage-Grouse
44	179884	Bird	Hepatic Tanager
45	554256	Bird	Horned Lark
46	179191	Bird	House Finch
47	176520	Bird	Killdeer Charadrius
48	178260	Bird	Ladder-Backed Woodpecker
49	176656	Bird	Least Sandpiper
50	178196	Bird	Lewis'S Woodpecker
51	178515	Bird	Loggerhead Shrike
52	177932	Bird	Long-Eared Owl
53	175613	Bird	Merlin
54	554385	Bird	Mountain Chickadee
55	176522	Bird	Mountain Plover
56	177125	Bird	Mourning Dove
57	178154	Bird	Northern Flicker
58	175300	Bird	Northern Goshawk
59	177942	Bird	Northern Saw-Whet Owl
60	175590	Bird	Osprey Pandion
61	175604	Bird	Peregrine Falcon
62	174505	Bird	Pied-Billed Grebe
63	179205	Bird	Pine Grosbeak
64	175603	Bird	Prairie Falcon
65	175350	Bird	Red-Tailed Hawk
66	175905	Bird	Ring-Necked Pheasant
67	175373	Bird	Rough-Legged Hawk
68	179870	Bird	Ruby-Crowned Kinglet
69	179402	Bird	Sage Sparrow
70	176177	Bird	Sandhill Crane
71	178333	Bird	Say'S Phoebe
72	175304	Bird	Sharp-Shinned Hawk
73	177935	Bird	Short-Eared Owl
74	179532	Bird	Snow Bunting
75	177925	Bird	Spotted Owl
76	179888	Bird	Summer Tanager

Table A.4.1-1. Cont'd

N	IT IS Code	Taxonomic Group	Common Name
77	175367	Bird	Swainson'S Hawk
78	179788	Bird	Swainson'S Thrush
79	178251	Bird	Three-Toed Woodpecker
80	175265	Bird	Turkey Vulture
81	179796	Bird	Veery Catharus
82	555388	Bird	Western Screech-Owl
83	178014	Bird	White-Throated Swift
84	178341	Bird	Willow Flycatcher
85	176736	Bird	Wilson'S Phalarope
86	178878	Bird	Yellow Warbler
87	177831	Bird	Yellow-Billed Cuckoo
88	178964	Bird	Yellow-Breasted Chat
89	180109	Mammal	American Pika
90	-3	Mammal	Arizona Myotis
91	180008	Mammal	Big Brown Bat
92	180086	Mammal	Big Free-Tailed Bat
93	180711	Mammal	Bighorn Sheep
94	180115	Mammal	Black-Tailed Jack Rabbit
95	180186	Mammal	Black-Tailed Prairie Dog
96	180582	Mammal	Bobcat
97	180222	Mammal	Botta'S Pocket Gopher
98	180088	Mammal	Brazilian Free-Tailed Bat
99	179991	Mammal	California Myotis
100	180201	Mammal	Colorado Chipmunk
101	180599	Mammal	Coyote
102	180122	Mammal	Desert Cottontail
103	179973	Mammal	Desert Shrew
104	179951	Mammal	Dwarf Shrew
105	180002	Mammal	Fringed Myotis
106	180184	Mammal	Gunnison'S Prairie Dog
107	180017	Mammal	Hoary Bat
108	180195	Mammal	Least Chipmunk
109	179988	Mammal	Little Brown Bat
110	179990	Mammal	Long-Legged Myotis
111	180585	Mammal	Lynx
112	180559	Mammal	Marten
113	180386	Mammal	Meadow Jumping Mouse
114	180553	Mammal	Mink

N	IT IS Code	Taxonomic Group	Common Name
115	180310	Mammal	Montane Vole
116	552479	Mammal	Mountain Lion
117	180698	Mammal	Mule Deer
118	180318	Mammal	Muskrat
119	180382	Mammal	Northern Grasshopper Mouse
120	179933	Mammal	Northern Water Shrew
121	180006	Mammal	Pallid Bat
122	179954	Mammal	Preble'S Shrew
123	180717	Mammal	Pronghorn
124	180717	Mammal	Pronghorn
125	180549	Mammal	River Otter
126	552496	Mammal	Rock Mouse
127	180262	Mammal	Silky Pocket Mouse
128	180014	Mammal	Silver-Haired Bat
129	179999	Mammal	Small-Footed Myotis
130	180376	Mammal	Southern Plains Woodrat
131	180010	Mammal	Spotted Bat
132	203452	Mammal	Townsend'S Big-Eared Bat
133	180343	Mammal	Western Harvest Mouse
134	180024	Mammal	Western Pipistrelle
135	180181	Mammal	White-Tailed Antelope Squirrel
136	180370	Mammal	White-Throated Woodrat
137	180004	Mammal	Yuma Myotis

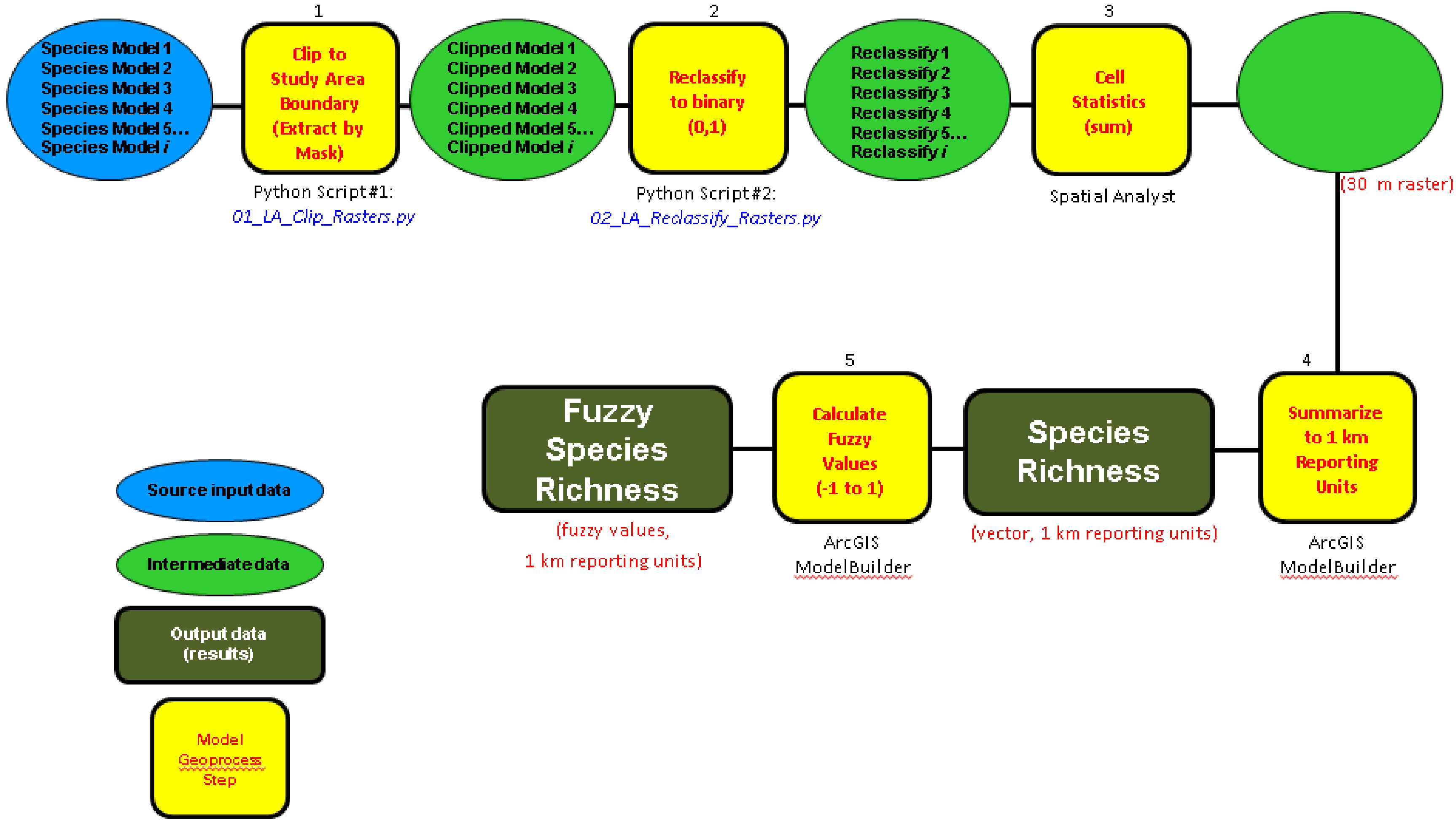


Figure A.4.1-2. Geoprocessing Diagram for the Species Richness Model using SWReGAP Habitat Suitability Models for Terrestrial Vertebrates.

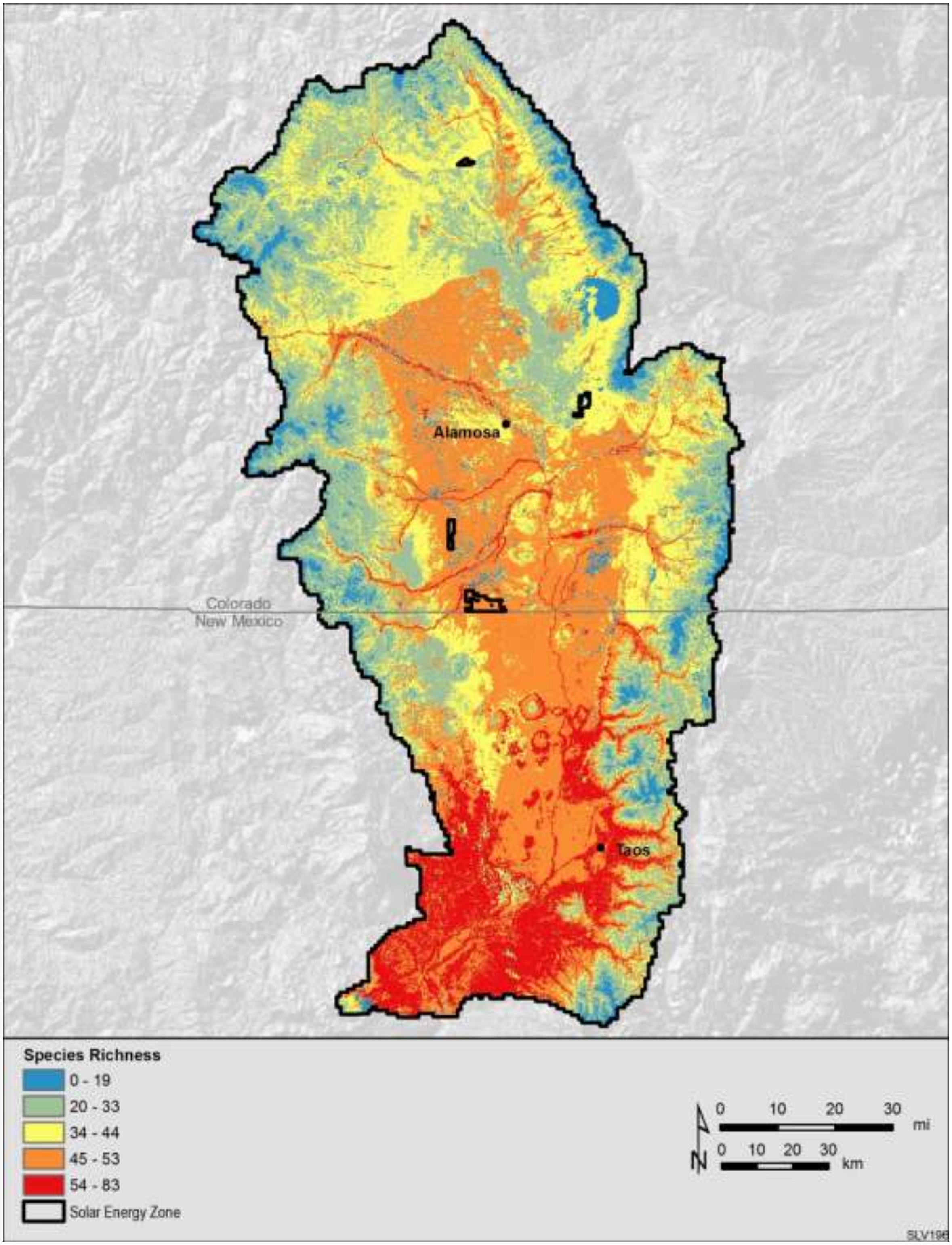


Figure A.4.1-3. Species Richness determined by summing the total number of species with suitable habitat in each cell. Data Source: SWReGAP Habitat Distribution Models (USGS 2007).

A.4.1.3 Mapping Wildlife Crucial Habitats

The Western Governors' Association and its Wildlife Council (WGWC) developed the Crucial Habitat Assessment Tool (CHAT) to identify wildlife values that could be incorporated into land use planning (WGWC 2013). This dataset represents an aggregated measure of crucial habitat for species of interest to the western states' fish and wildlife management agencies. Crucial habitat describes places that are expected to contain the resources necessary for continued health of fish and wildlife populations or important ecological systems expected to provide high value for a diversity of fish and wildlife. Specifically, the WGWC (2013) defined crucial habitat for fish and wildlife to include several data types and layers of information available to states:

- Habitat for Species of Concern (SOC): terrestrial and/or aquatic;
- Native and Unfragmented Habitat, which may include landscape condition; large natural areas; natural vegetation communities; ecological systems of concern; landscape corridors; and/or freshwater integrity;
- Riparian and wetland habitat;
- Connectivity or linkage areas (e.g., wildlife corridors);
- Quality habitat for species of importance not already accounted for in "Habitat for SOC"

This dataset represents an aggregated measure of crucial habitat for species of interest to the western states' fish and wildlife management agencies. Crucial habitat describes places that are expected to contain the resources necessary for continued health of fish and wildlife populations or important ecological systems expected to provide high value for a diversity of fish and wildlife. States compiled data and ranked areas as "crucial habitat" using a relative, six-level prioritization scheme, where 1 represents areas "most crucial," or those areas that most closely meet the definition of crucial habitat based on the WGWC definitions; and 6 represents "least crucial" areas, or those areas that least closely meet the definition of crucial habitat based on the WGWC definitions. Crucial habitat values are in no way regulatory and do not imply specific avoidance or mitigation measures for a given area. Crucial habitat values should be interpreted as the relative probability, or risk, that a high-priority species or habitat would be encountered in a given area based on the best available scientific information.

Wildlife crucial habitat ranks within the study area are shown in **Figure A.4.1-4**. For this assessment, CHAT areas ranked 1 and 2 were extracted to represent crucial habitat (i.e., areas with greatest importance for wildlife); these crucial areas are shown in **Figure A.4.1-5**. Data were obtained from the Western Governors' Association CHAT website (http://westgovchat.org/).

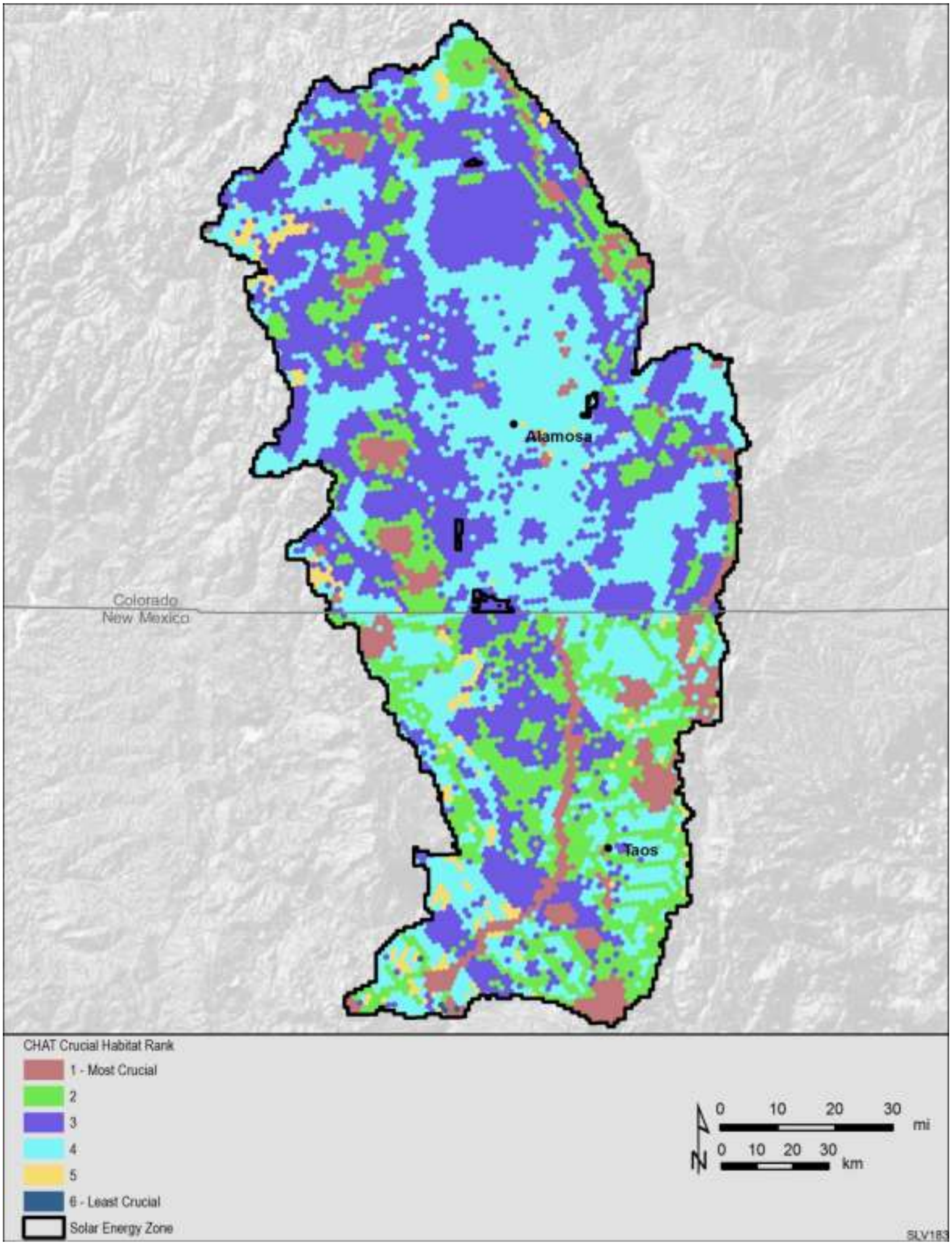


Figure A.4.1-4. Current Distribution of CHAT Crucial Habitat Areas ranked 1 – 6.
Data Source: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013).

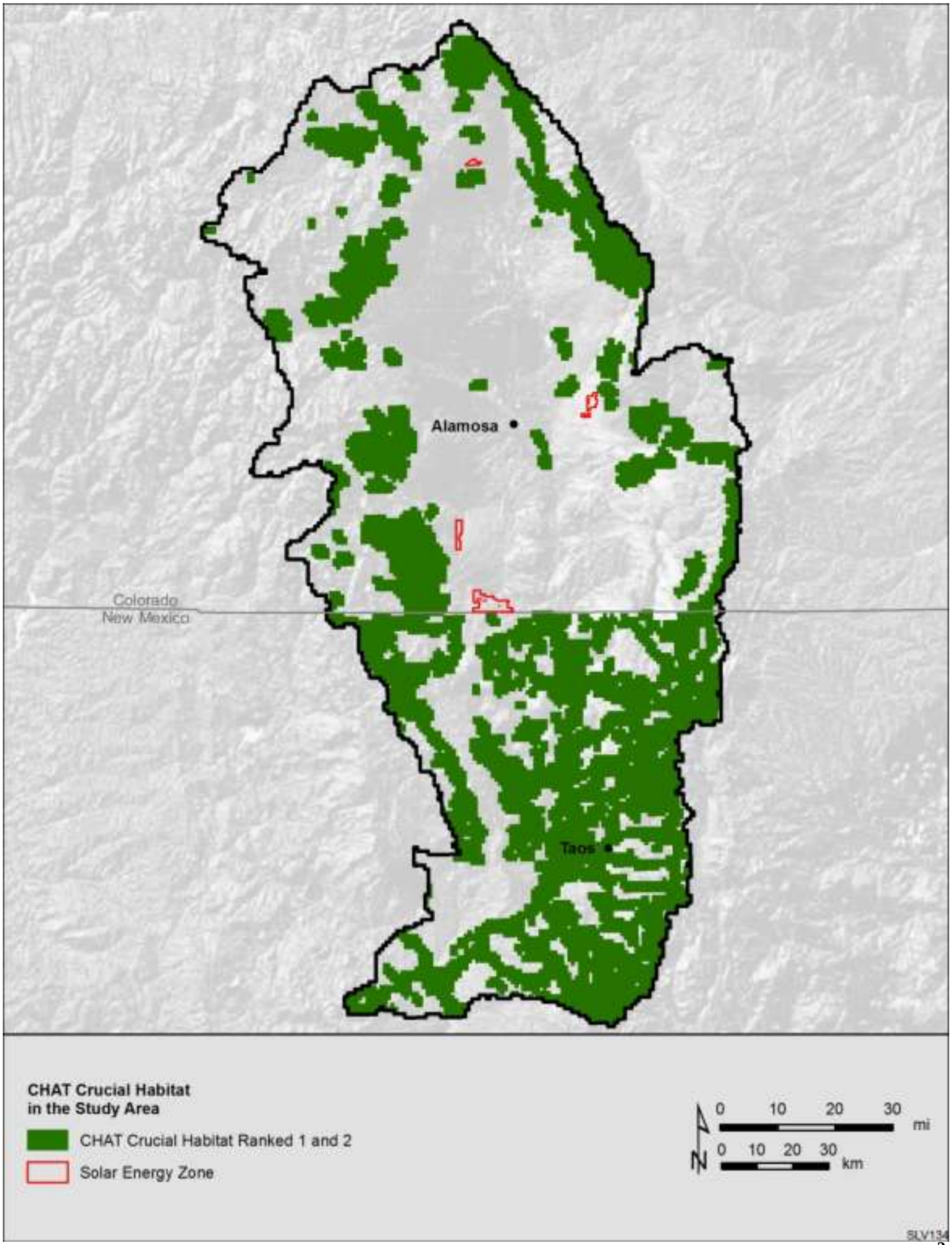


Figure A.4.1-5. CHAT "Crucial Habitat" areas ranked 1 and 2, Summarized to 1km^2 Reporting Units. Data Source: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013).

A.4.1.4 Mapping Areas Managed for Biodiversity

Areas managed for biodiversity were determined from the following geospatial datasets:

- USGS Protected Areas Database (http://gapanalysis.usgs.gov/padus/) – areas managed for biodiversity (GAP codes 1 & 2).
- BLM ACECs (http://www.geocommunicator.gov/GeoComm/)
- Rio Grande del Norte National Monument (Received from BLM)
- Proposed and designated critical habitat for threatened and endangered species (http://ecos.fws.gov/crithab/)
- Areas managed by the U.S. Fish and Wildlife Service (e.g., National Wildlife Refuges) (Surface Management Agency dataset - http://www.geocommunicator.gov/GeoComm/)
- Wilderness Areas and Wilderness Study Areas (Received from BLM)

The aggregate map of areas managed for biodiversity is shown in **Figure A.4.1-6**.

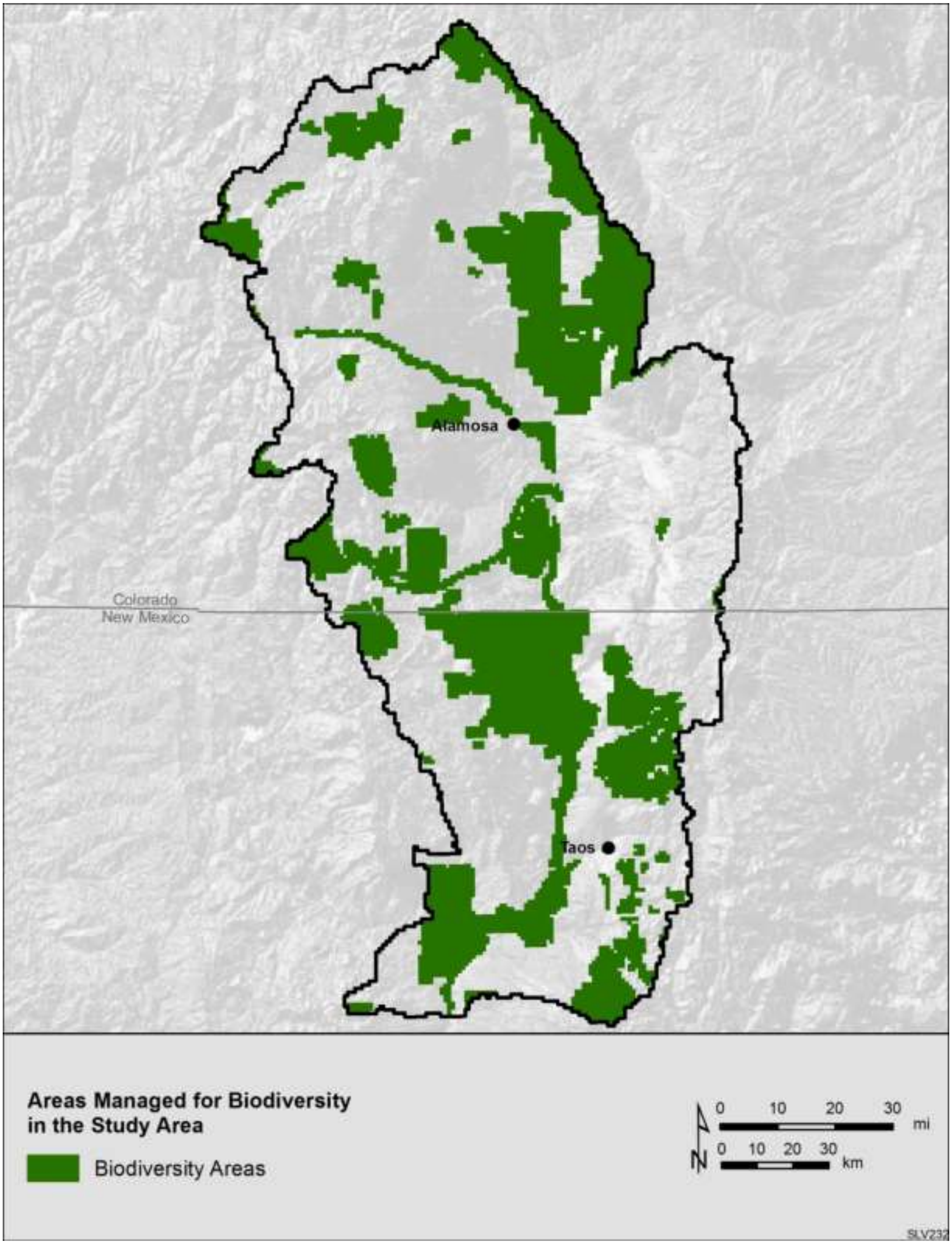


Figure A.4.1-6. Areas Managed for Biodiversity. Data Sources: data received from BLM, USGS 2012, and USFWS 2014b.

A.4.2 MQD4: Where are Aquatic, Terrestrial, and Riparian Biodiversity Sites and Special Status Species Vulnerable to Change Agents in the Future?

Refer to **MQD2 (Section A.4.1)** above for discussion of how sites of biodiversity were characterized in the study area. The assessment of status and trends presented here focus on the potential for change resulting from change agents within (1) wildlife crucial habitats and (2) sites managed for biodiversity.

A.4.2.1 Wildlife Crucial Habitats

Figure A.4.1-5 above shows the distribution of crucial wildlife habitats (habitat ranks 1 & 2) in the study area. **Figures A.4.2-2** through **Figure A.4.2-7** below show, respectively: **Figure A.4.2-2** – crucial habitat distribution with respect to current vegetation departure; **Figure A.4.2-3** – crucial habitat distribution with respect to current and future landscape intactness in the study area; **Figure A.4.2-4** – crucial habitat distribution and status with respect to the current status of change agents; **Figure A.4.2-5** – crucial habitat distribution with respect to predicted areas of change; **Figure A.4.2-6** – predicted trends in crucial habitat within the study area; and **Figure A.4.2-7 -** the aggregate potential for change in crucial habitat.

The majority (45%) of vegetation within the CHAT crucial habitat has a moderate degree of departure from historic reference vegetation conditions (**Figure A.4.2-2**).

The majority (67%) of the CHAT crucial habitat is within areas of high and very high current landscape intactness (**Figure A.4.2-3; Figure A.4.2-6**). Future trends in landscape intactness indicate a decrease in landscape intactness within CHAT crucial habitat. The amount of CHAT crucial habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (**Figure A.4.2-6**).

The majority (73%) of the CHAT crucial habitat is within areas of very low and low current human development intensity (**Figure A.4.2-4; Figure A.4.2-6**). Future trends in human development indicate an increase in human development intensity within CHAT crucial habitat. The amount of CHAT crucial habitat occurring within areas high and very high human development intensity is expected to increase by approximately 8% in the near-term (i.e., by 2030) (**Figure A.4.2-6**).

The majority of the CHAT crucial habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure A.4.2-4; Figure A.4.2-6**). Future trends in climate change indicate portions of the CHAT crucial habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure A.4.2-5; Figure A.4.2-6**). Approximately 37% of the CHAT crucial habitat is located in areas with high or very high potential for future climate change.

The majority of the CHAT crucial habitat is within areas of very low current fire occurrence density (**Figure A.4.2-4; Figure A.4.2-6**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the CHAT crucial habitat distribution in the study area.

The greatest potential for future wildfire occurs in the southern portion of the habitat distribution in New Mexico (**Figure A.4.2-5**).

The majority of CHAT crucial habitat is within areas of very low current density of invasive species, insects, and disease (**Figure A.4.2-4; Figure A.4.2-6**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of CHAT crucial habitat in the study area (**Figure A.4.2-6**). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (**Figure A.4.2-5**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 38% of the CHAT crucial habitat has the potential for high or very high future change among the change agents (**Figure A.4.2-7**). Areas with greatest potential for change within CHAT crucial habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure A.4.2-7**).

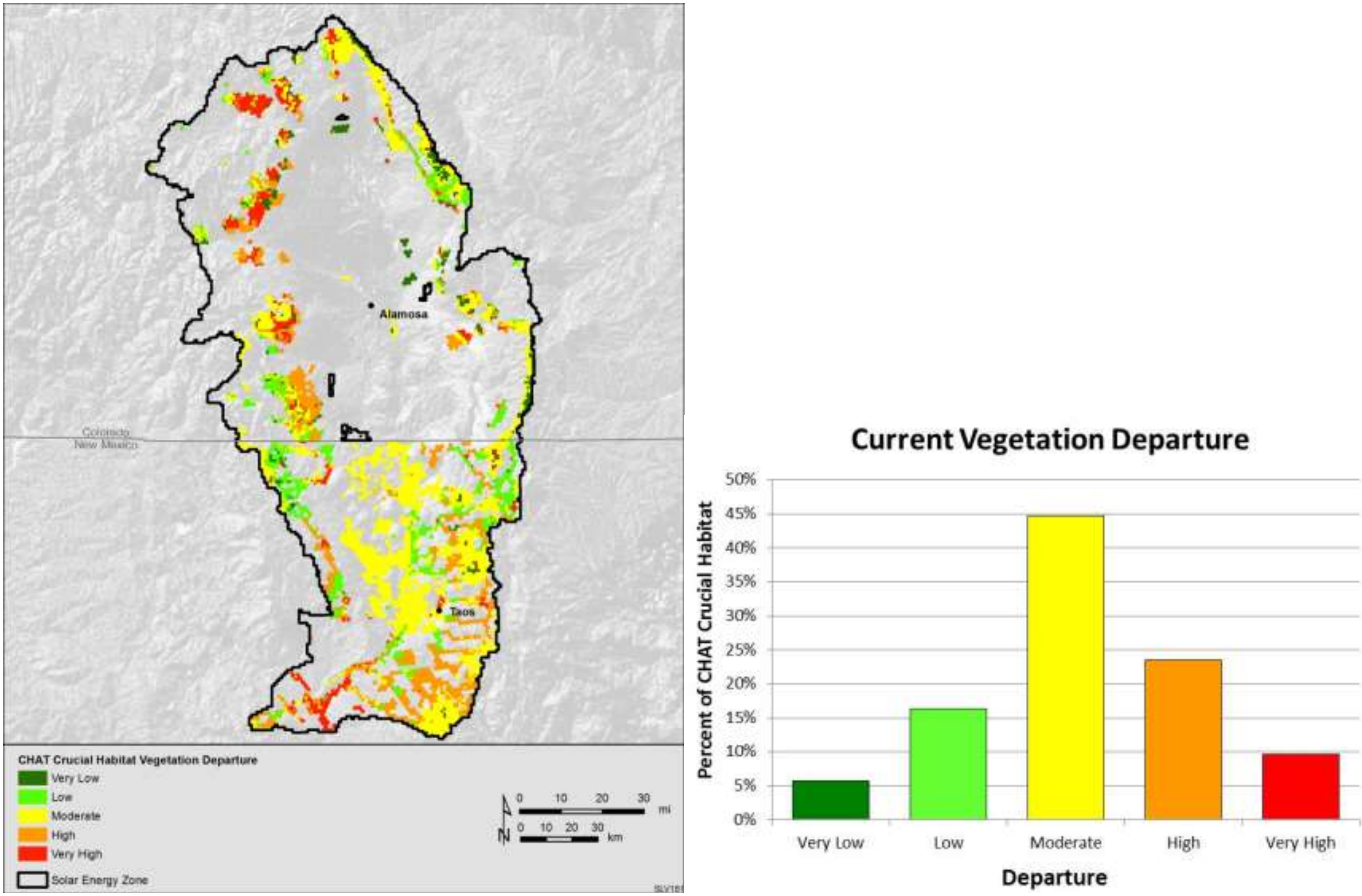


Figure A.4.2-2. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within CHAT Crucial Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a) and The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013). Data were Summarized to 1 km^2 Reporting Units.

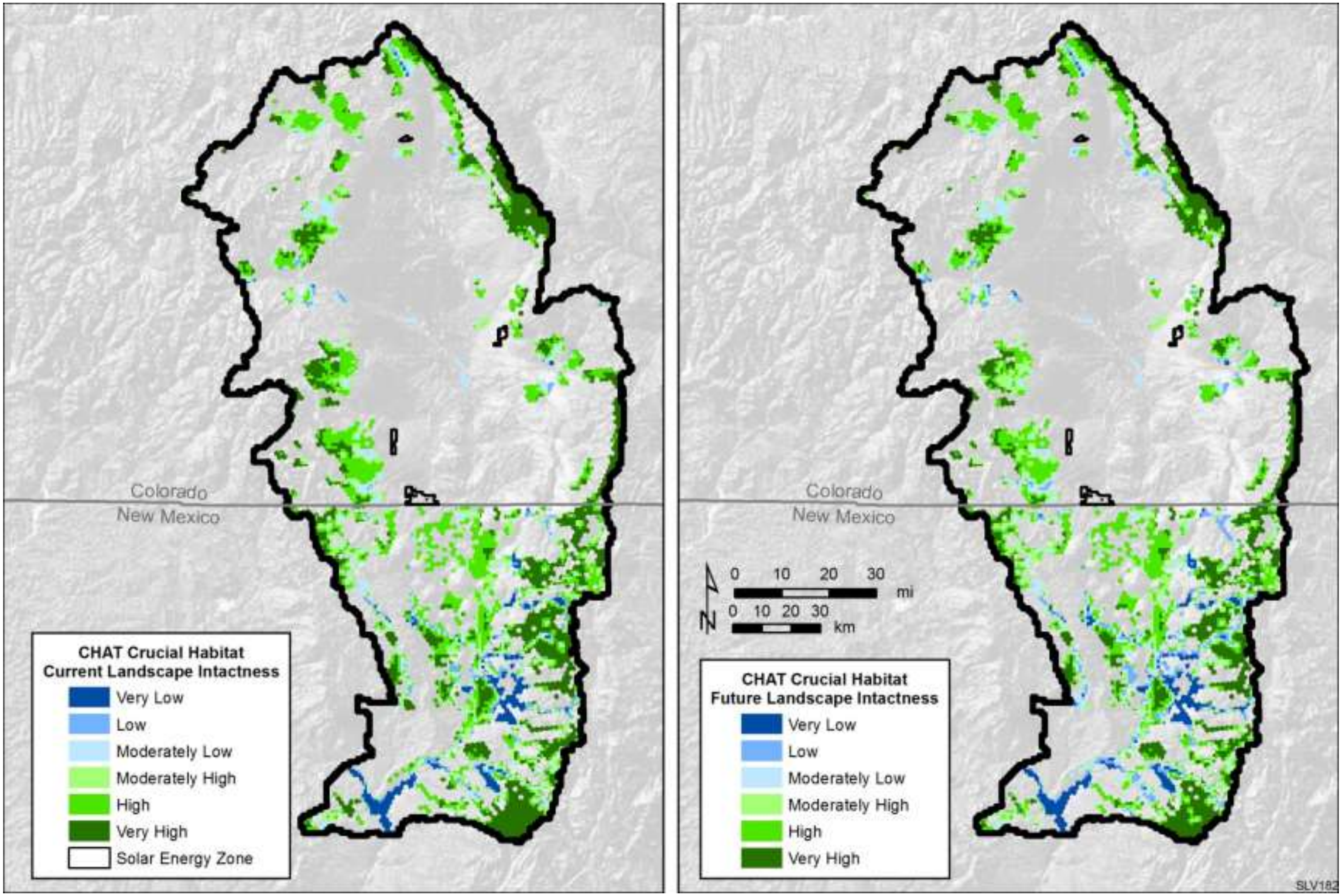


Figure A.4.2-3. Current and Future Landscape Intactness of CHAT crucial habitat. Data Sources: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013) and Argonne 2014.

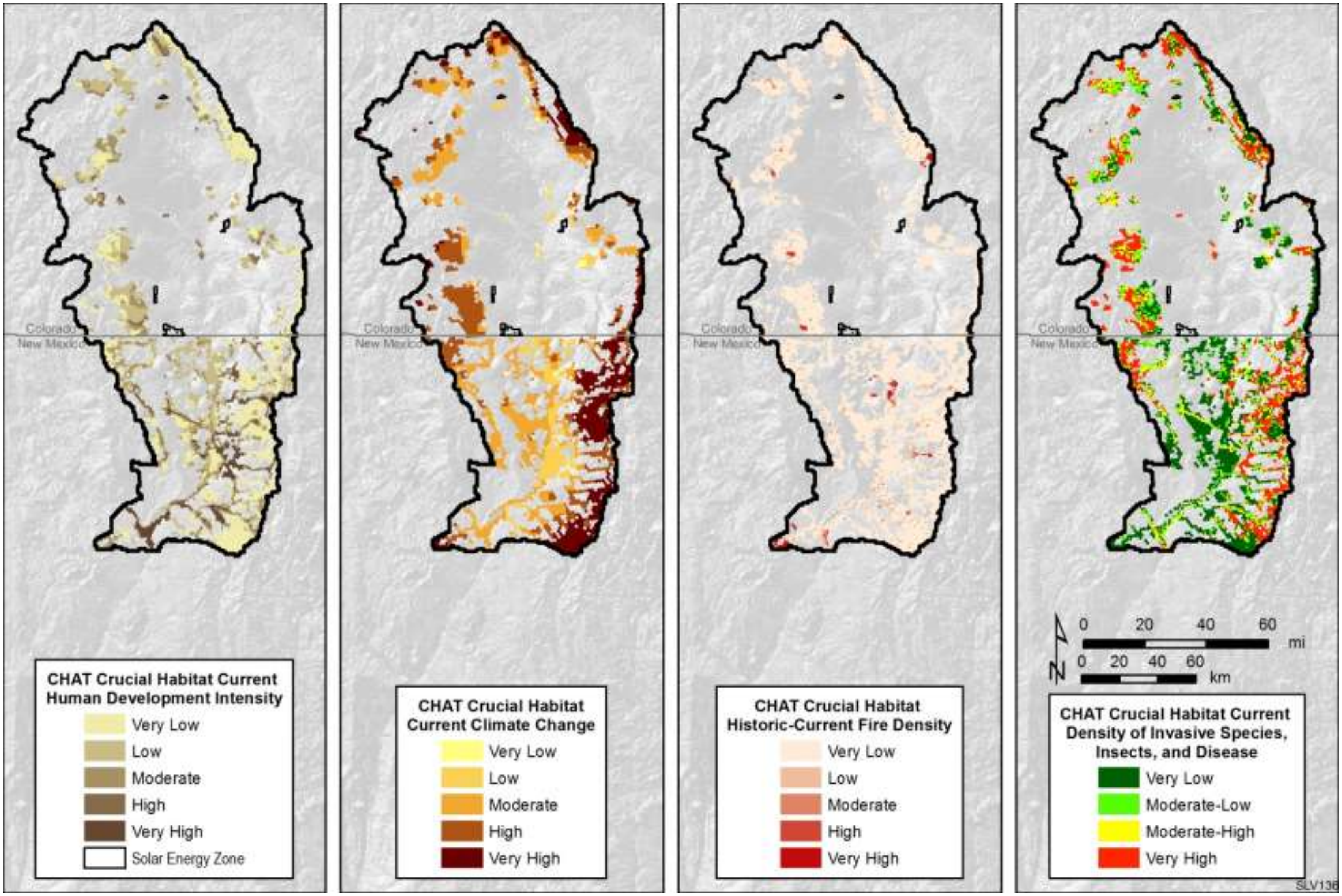


Figure A.4.2-4. Illustration for MQD1: What is the current distribution and status of CHAT crucial habitat? Data Sources: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013) and Argonne 2014.

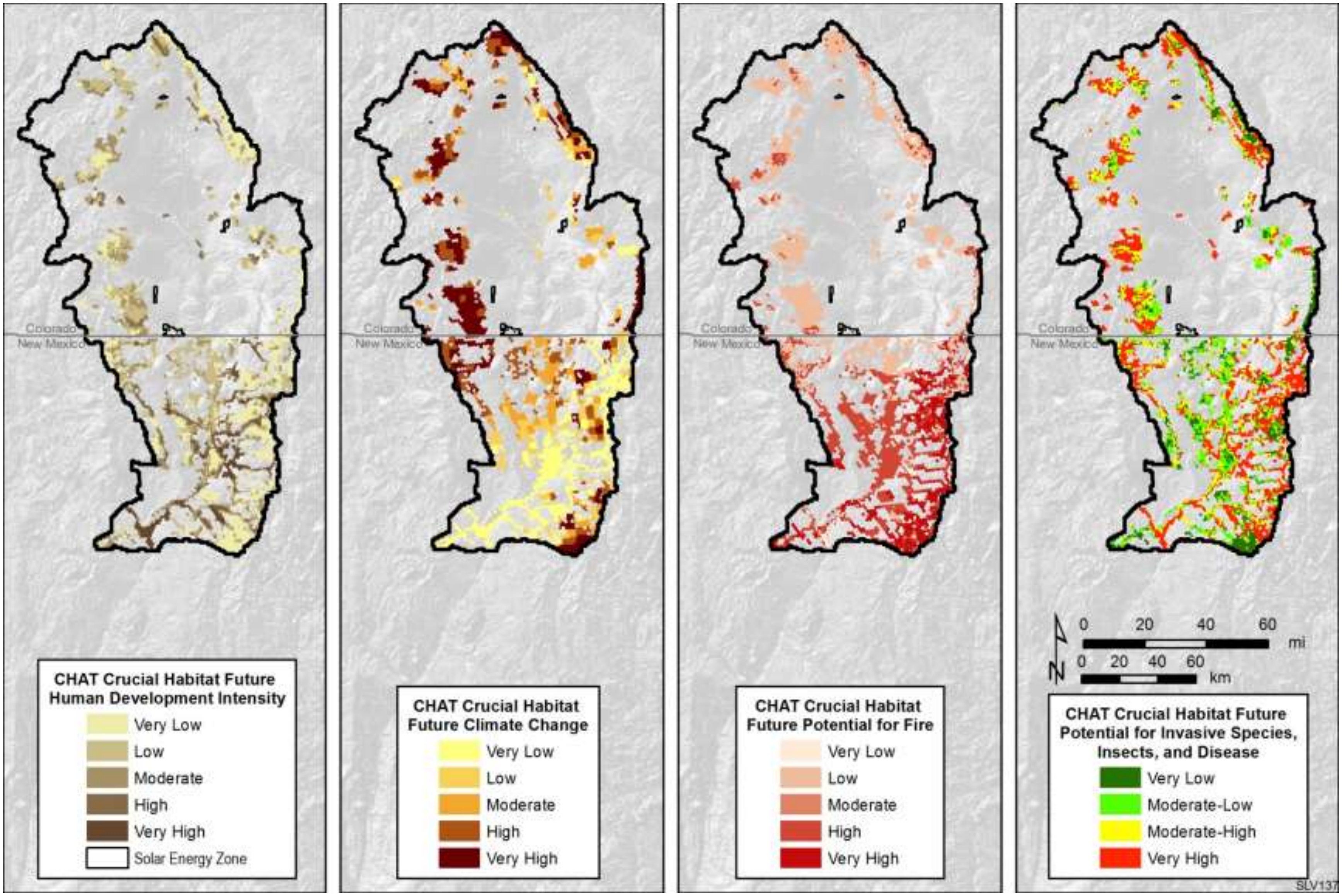


Figure A.4.2-5. Illustration for MQD3: Where is CHAT crucial habitat vulnerable to change agents in the future? Data Sources: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013) and Argonne 2014.

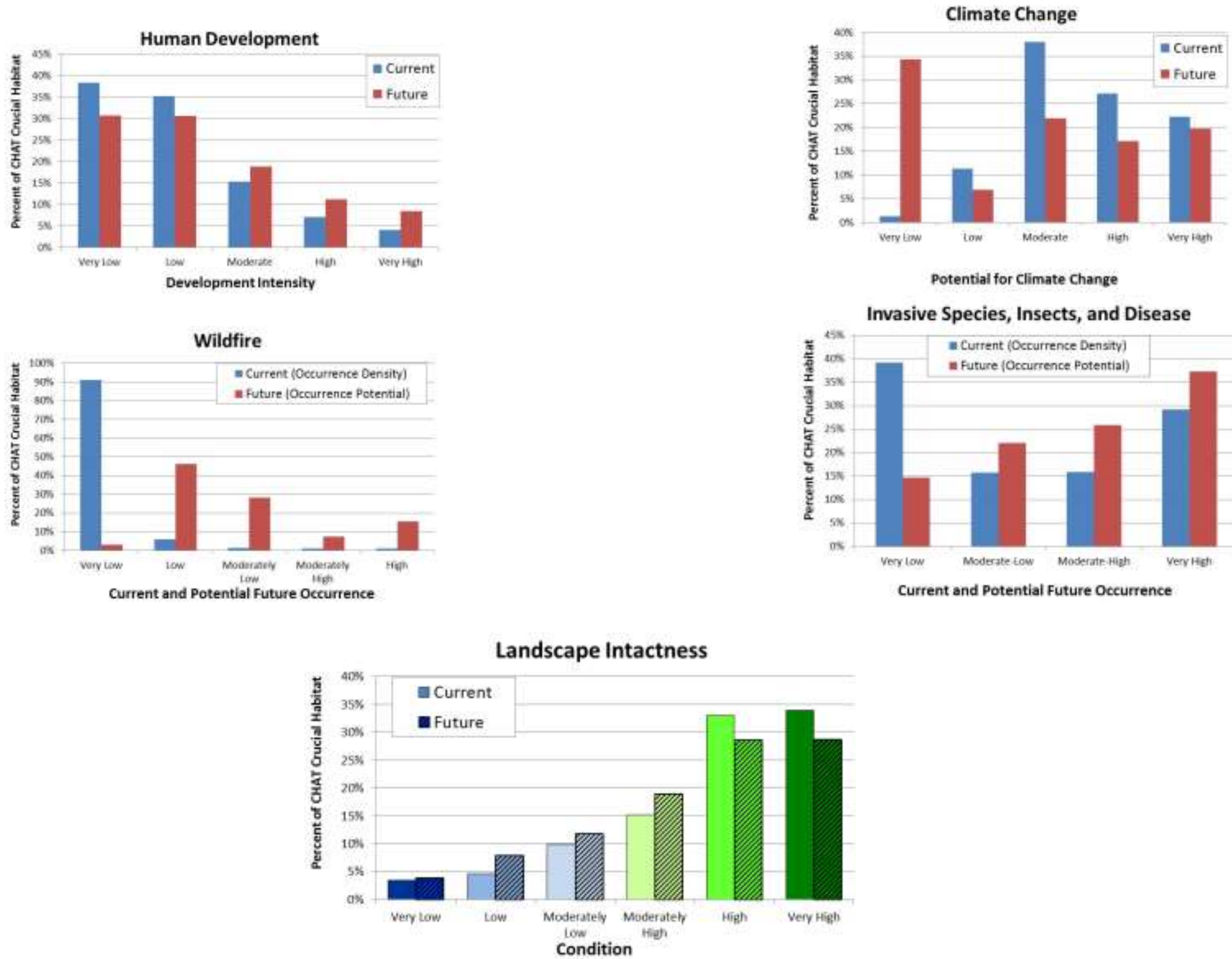


Figure A.4.2-6. Predicted Trends in CHAT Crucial Habitat within the Study Area

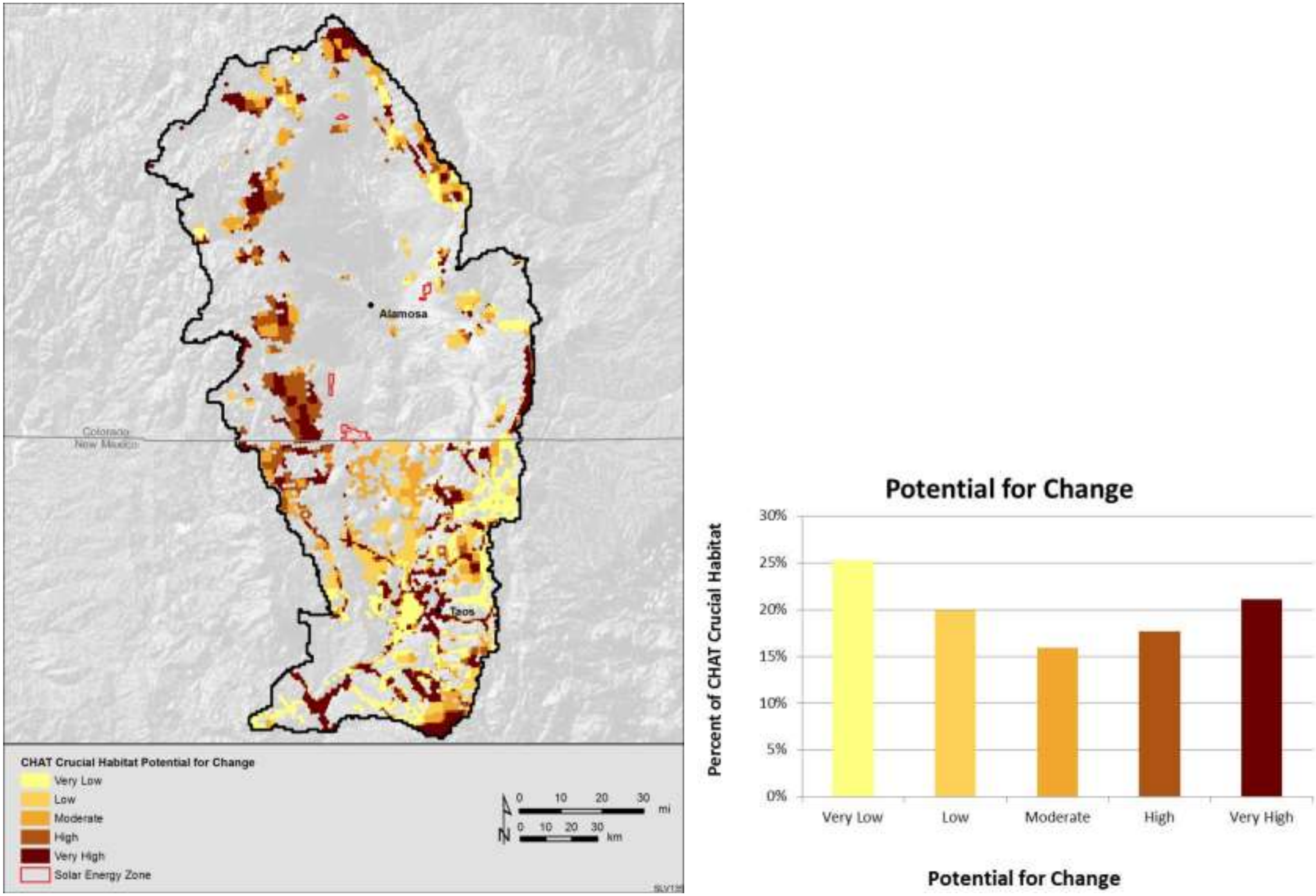


Figure A.4.2-7. CHAT Crucial Habitat Aggregate Potential for Change (combines potential future change model output for human development, climate change, fire, and invasive species change agents). Data Sources: The Western Governors' Crucial Habitat Assessment Tool (WGWC 2013) and Argonne 2014.

A.4.2.2 Sites Managed for Biodiversity

Figure A.4.1-6 above shows the distribution of sites managed for biodiversity in the study area. **Figures A.4.2-8** through **A.4.2-13** below show, respectively: **Figure A.4.2-8** - the areas managed for biodiversity with respect to current vegetation departure; **Figure A.4.2-9** - the areas managed for biodiversity with respect to current and future landscape intactness in the study area; **Figure A.4.2-10** - areas managed for biodiversity with respect to the current status of change agents; **Figure A.4.2-11** - areas managed for biodiversity with respect to predicted areas of change; **Figure A.4.2-12** - predicted trends within the study area; and **Figure A.4.2-13** - the aggregate potential for change in areas managed for biodiversity.

The majority (42%) of vegetation within areas managed for biodiversity has a moderate degree of departure from historic reference vegetation conditions (**Figure A.4.2-8**).

The majority (68%) of areas managed for biodiversity are within areas of high and very high current landscape intactness (**Figure A.4.2-9; Figure A.4.2-12**). Future trends in landscape intactness indicate a decrease in landscape intactness within areas managed for biodiversity. The amount of areas managed for biodiversity occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (**Figure A.4.2-9; Figure A.4.2-12**).

The majority (75%) of areas managed for biodiversity are within areas of very low and low current human development intensity (**Figure A.4.2-10; Figure A.4.2-12**). Future trends in human development indicate an increase in human development intensity within areas managed for biodiversity. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 5% in the near-term (i.e., by 2030) (**Figure A.4.2-11; Figure A.4.2-12**).

The majority of areas managed for biodiversity are within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure A.4.2-10; Figure A.4.2-12**). Future trends in climate change indicate portions of the areas managed for biodiversity with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure A.4.2-11; Figure A.4.2-12**). Approximately 16% of the areas managed for biodiversity are located in areas with high or very high potential for future climate change (**Figure A.4.2-12**).

The majority of areas managed for biodiversity are within areas of very low current fire occurrence density (**Figure A.4.2-10; Figure A.4.2-12**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the areas managed for biodiversity in the study area. The greatest potential for future wildfire occurs in the southern portion of the areas managed for biodiversity in New Mexico (**Figure A.4.2-11**).

The majority of areas managed for biodiversity are within areas of either very low or very high current density of invasive species, insects, and disease (**Figure A.4.2-10; Figure A.4.2-12**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of areas managed for biodiversity in the study area (**Figure A.4.2-11**).

Approximately 36% of the areas managed for biodiversity has a very high potential for near-term future (i.e., by 2030) spread of invasive species, insects, and diseases.

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 32% of the areas managed for biodiversity have the potential for high or very high future change among the change agents (**Figure A.4.2-13**). Areas with greatest potential for change within areas managed for biodiversity include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure A.4.2-13**).

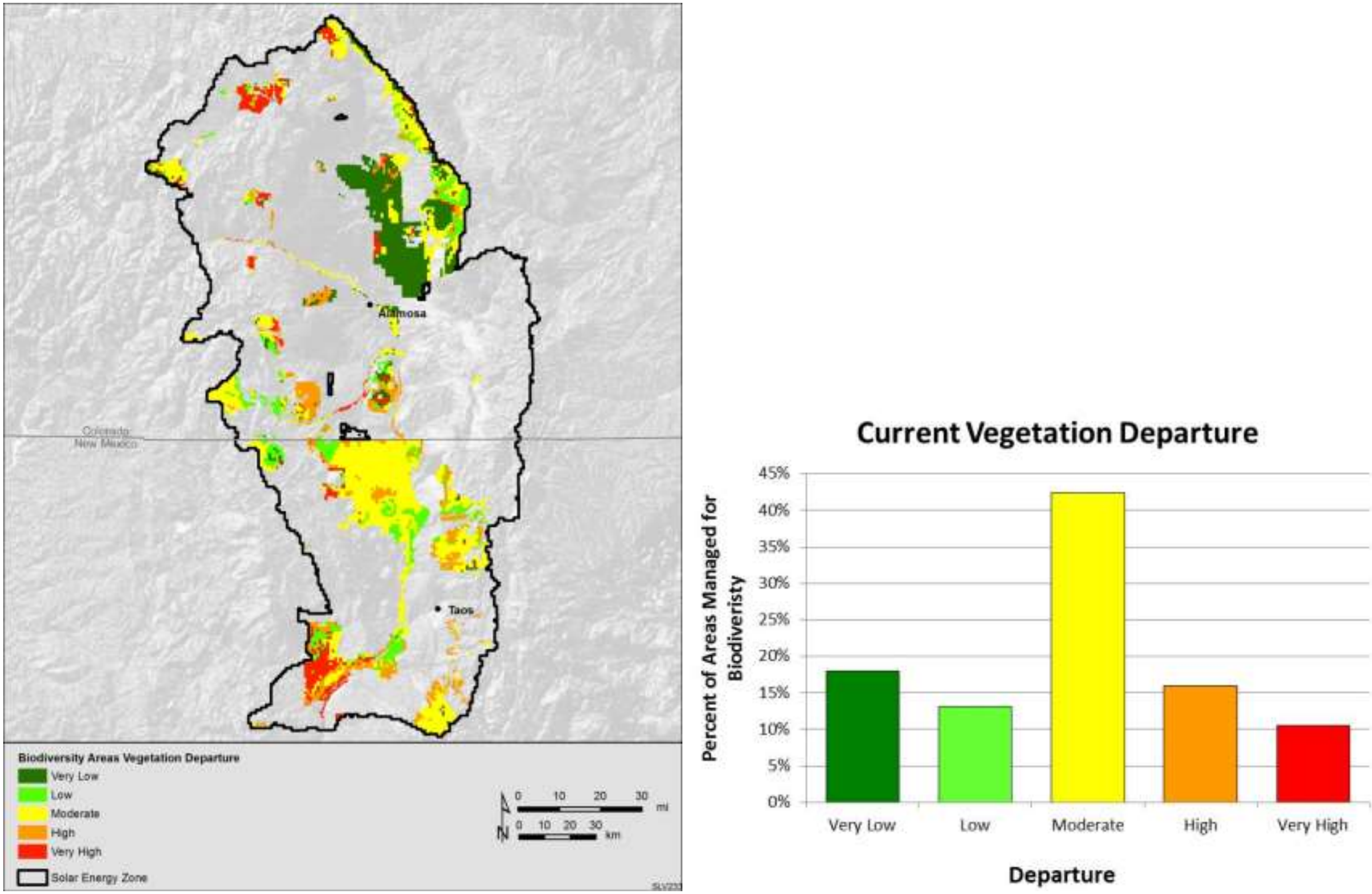


Figure A.4.2-8. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within areas managed for biodiversity. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a), BLM, USGS 2012, and USFWS 2014b. Data were Summarized to 1 km^2 Reporting Units.

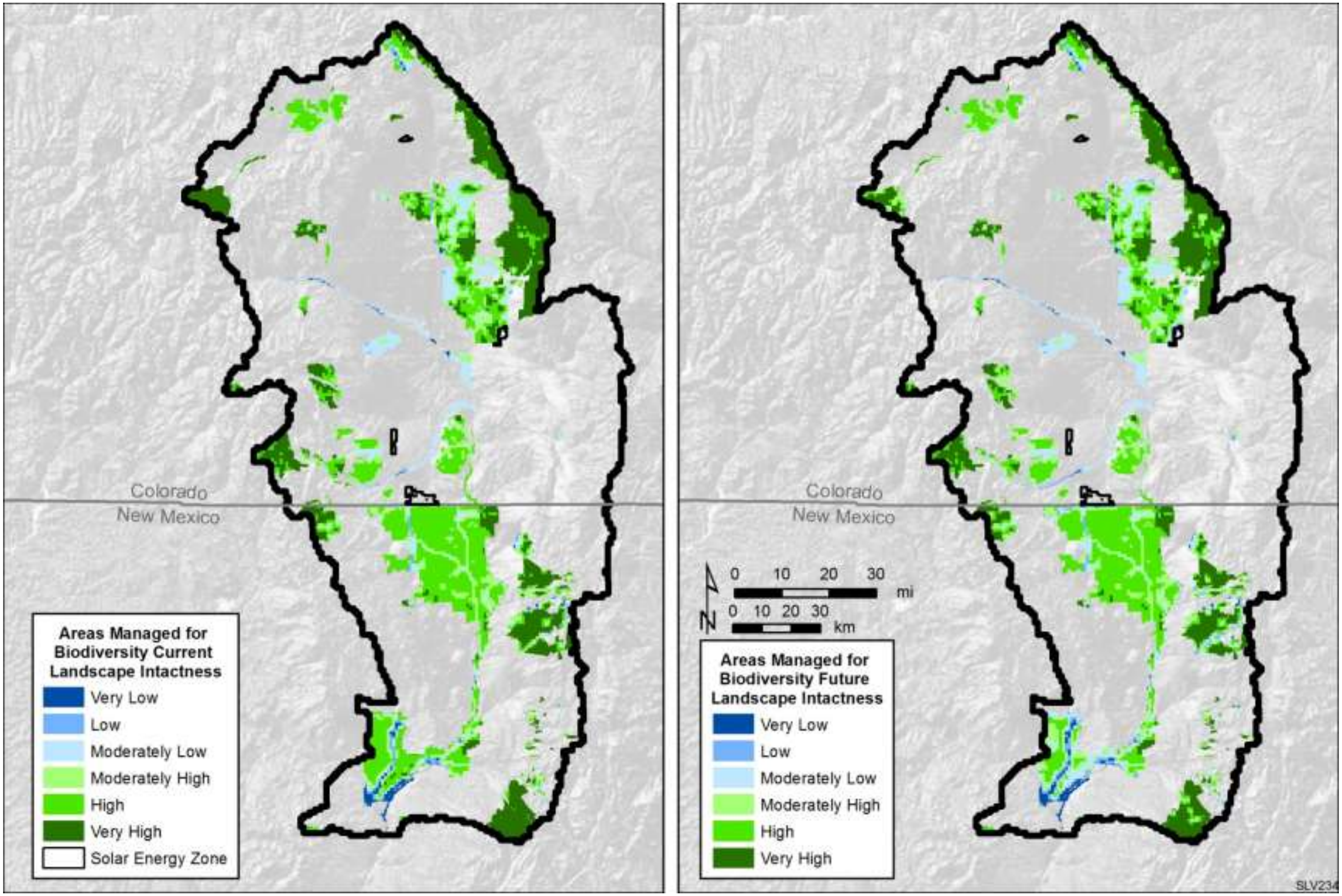


Figure A.4.2-9. Current and Future Landscape Intactness of Areas Managed for Biodiversity. NOTE: This landscape intactness model does not include LANDFIRE Vegetation Departure (VDEP). Data Sources: Argonne 2014, BLM, USGS 2012, and USFWS 2014b.

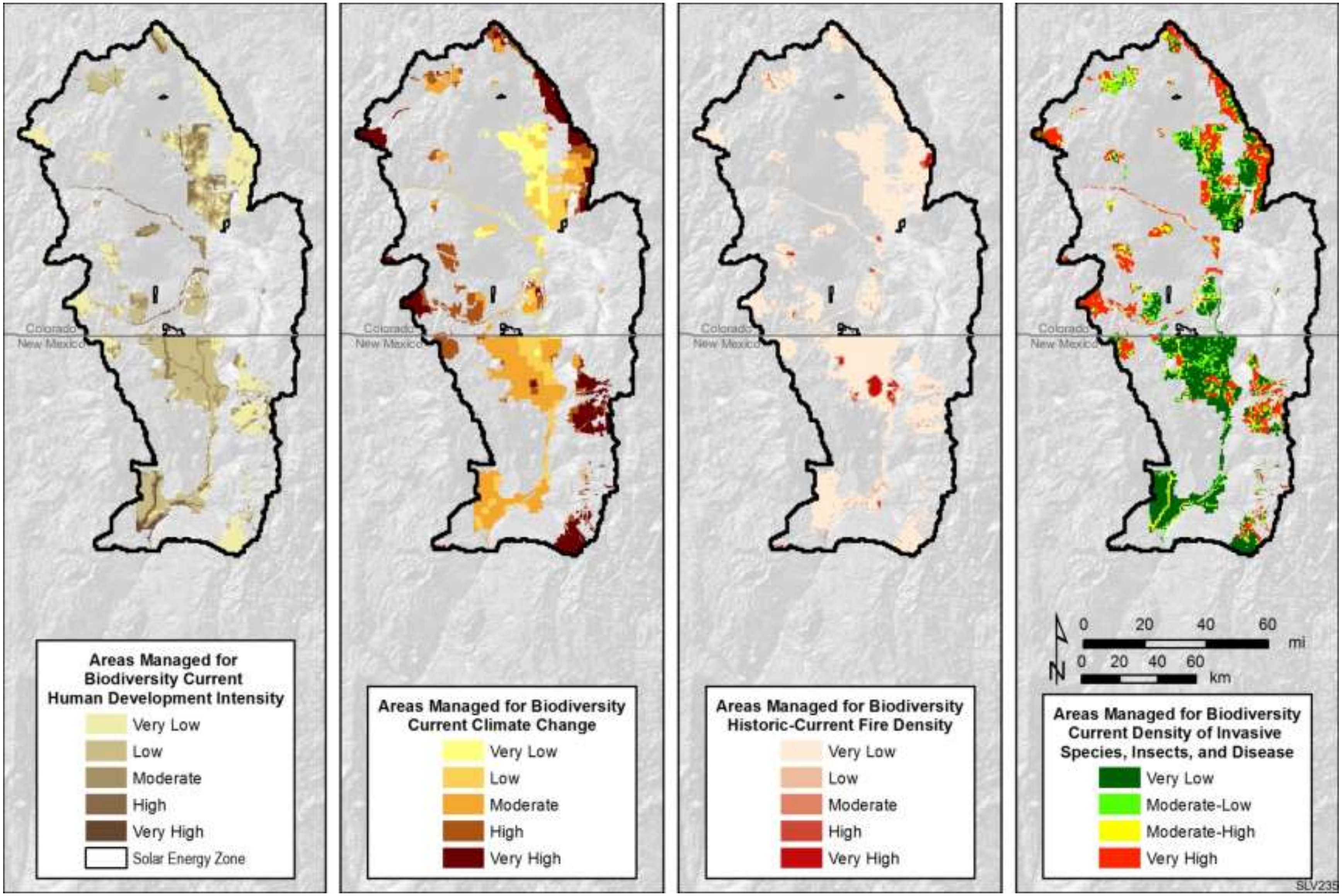


Figure A.4.2-10. Illustration for MQD1: What is the current distribution and status of areas managed for biodiversity? Data Sources: Argonne 2014, BLM, USGS 2012, and USFWS 2014b.

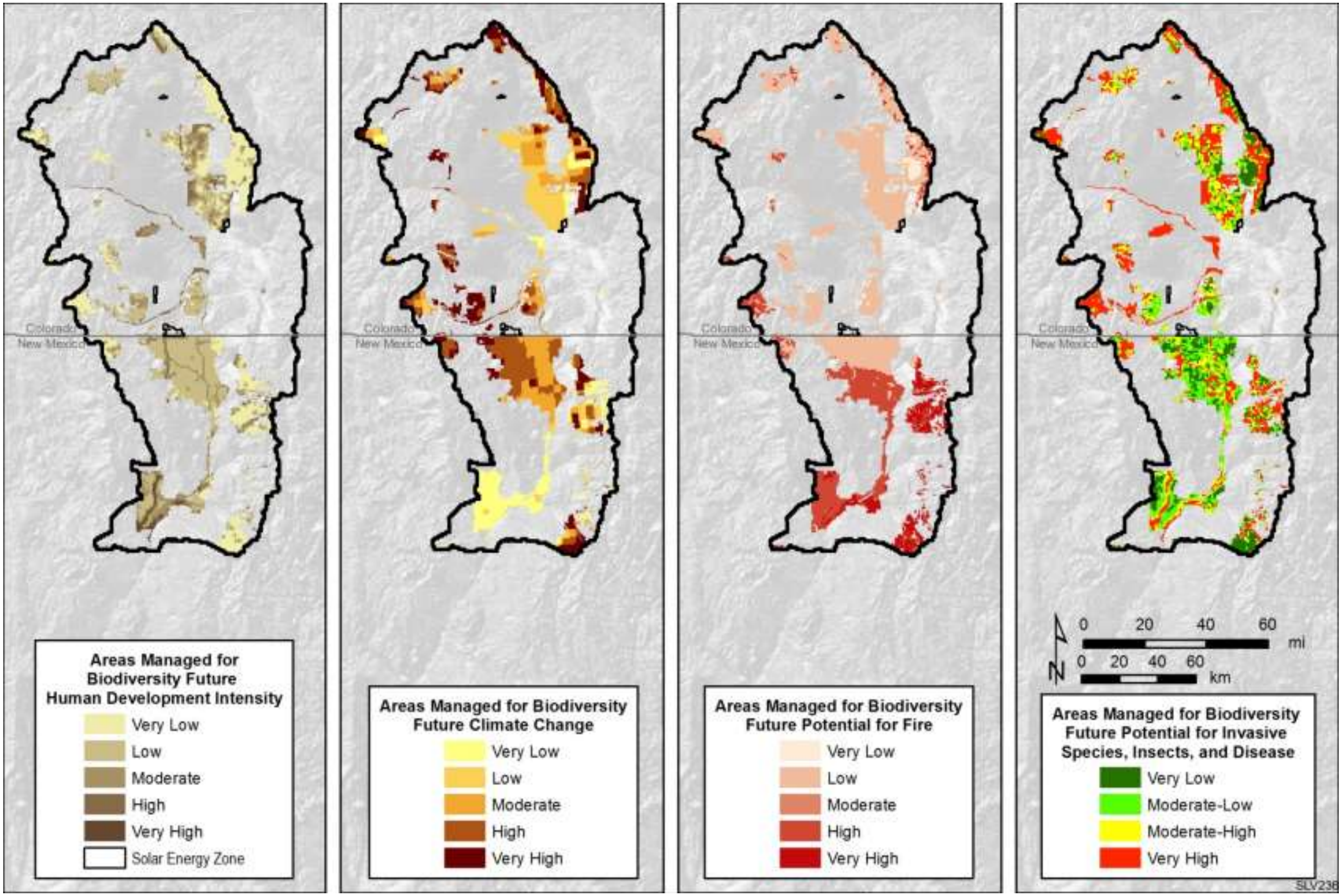


Figure A.4.2-11. Illustration for MQD3: Where are areas managed for biodiversity vulnerable to change agents in the future? Data Sources: Argonne 2014, BLM, USGS 2012, and USFWS 2014b.

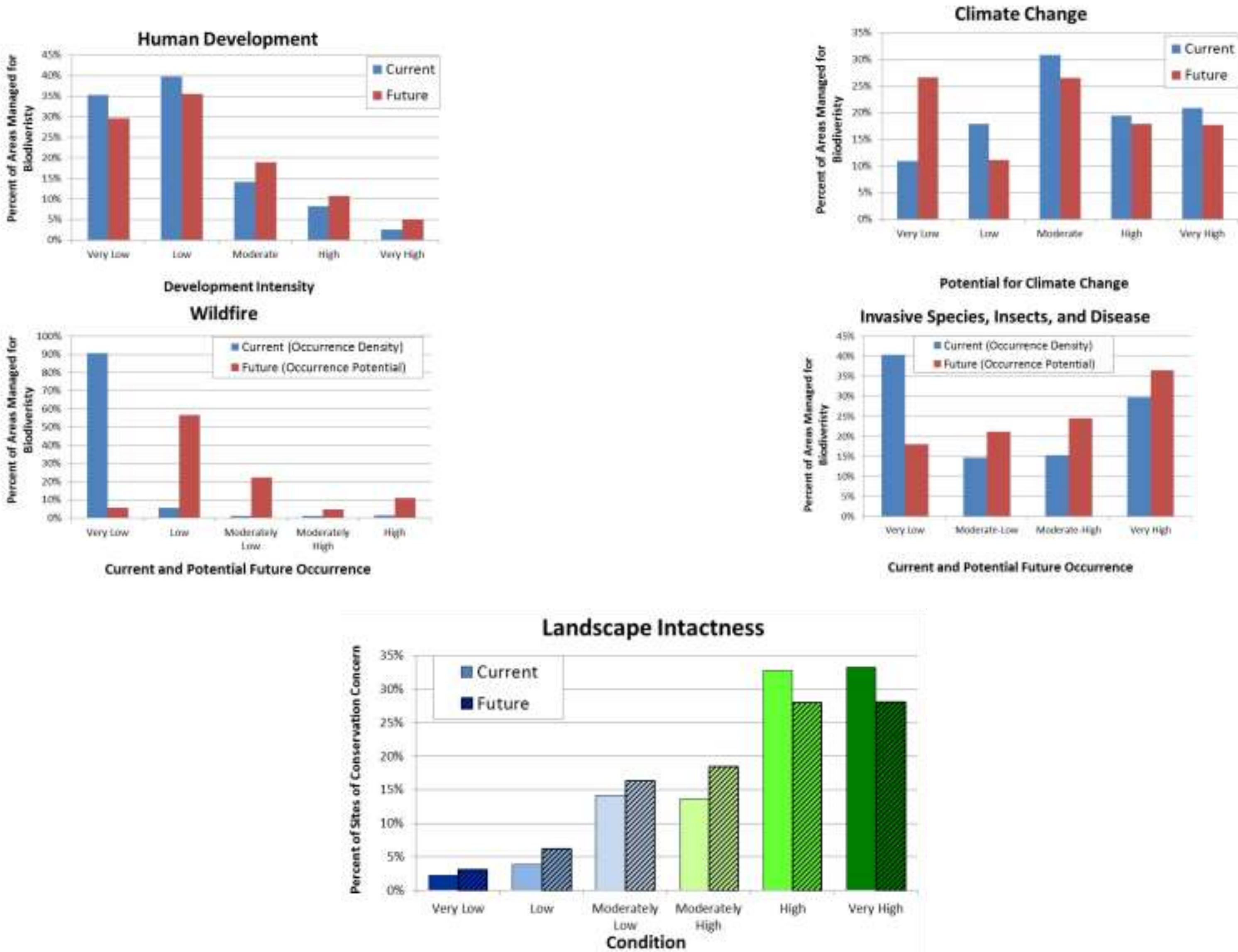


Figure A.4.2-12. Predicted Trends in Areas Managed for Biodiversity within the Study Area

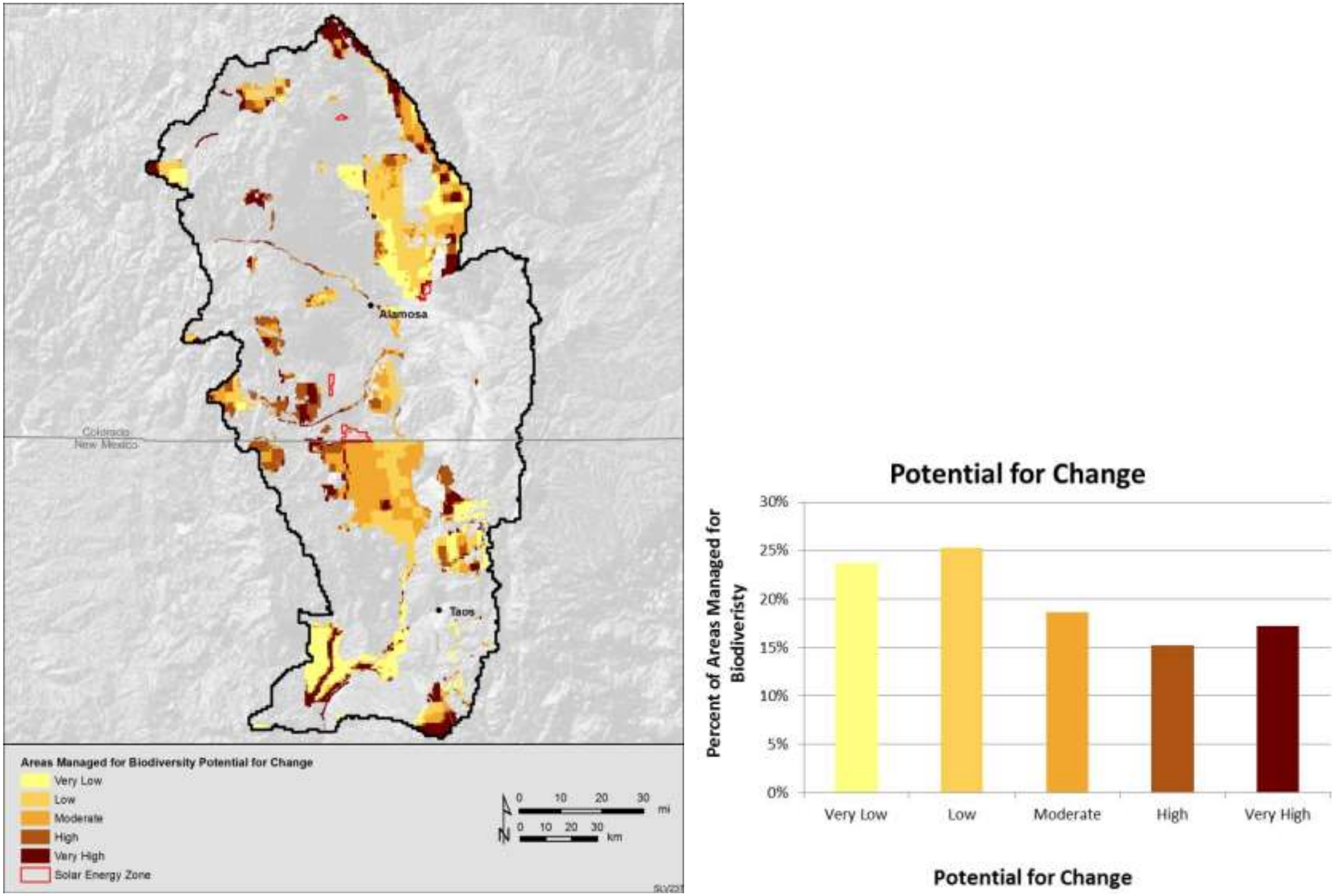


Figure A.4.2-13. Potential for Change within Areas Managed for Biodiversity (combines potential future change model output for human development, climate change, fire, and invasive species change agents). Data Sources: Argonne 2014, BLM, USGS 2012, and USFWS 2014b.

A.4.3 MQD5: What is the Current Distribution and Status of Big Game Crucial Habitat and Movement Corridors (Including Bighorn Sheep, Elk, Mule Deer, and Pronghorn)?

The Big Game Seasonal Ranges and migration corridors datasets were created through the aggregation of multiple datasets from Colorado Parks and Wildlife and clipping the data to the ecoregion boundary. Big game species included bighorn sheep, elk, pronghorn, and mule deer. Two aggregate datasets were created to combine all big game species: (1) crucial habitat and (2) migration corridors. Crucial habitats were determined form all available production, winter, and severe winter datasets. Datasets include:

- Bighorn Sheep Production Area: This dataset represents production (lambing) areas for bighorn sheep in Colorado. Production areas are defined as that part of the overall range occupied by pregnant females during a specific time period in the spring. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Elk Production Area: This dataset represents that part of the overall range of elk occupied by the females from May 15 to June 15 for calving. Only known areas are mapped and this does not include all production areas. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Elk Severe Winter Range: This dataset represents that part of the overall range of elk where 90% of the individuals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten. The winter of 1983-1984 is a good example of a severe winter. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Elk Summer Concentration Area: This dataset represents those areas where elk concentrate from mid-June through mid-August. High quality forage, security, and lack of disturbance are characteristics of these areas to meet the high energy demands of lactation, calf rearing, antler growth, and general preparation for the rigors of fall and winter. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Elk Winter Range: Winter range is that part of the overall range of elk where 90% of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site specific period of winter. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Pronghorn Severe Winter Range: This dataset represents that part of the winter range where 90% of the individuals are located when the snowpack is at its maximum and or temperatures are at a minimum in the two worst winters out of ten. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Pronghorn Winter Range: This dataset represents that part of the overall range where 90% of the individuals are located between the first heavy snowfall and spring green-up during the average five winters out of ten OR for a site specific period. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Mule Deer Winter Range: This dataset represents that part of the overall range where 90% of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site specific period of winter. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Mule Deer Severe Winter Range: This dataset represents that part of the overall range where 90% of the individuals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Mule Deer Concentration Area: This dataset represents that part of the overall range where higher quality habitat supports significantly higher densities than surrounding areas. These areas are typically occupied year round and are not necessarily associated with a specific season. Includes rough break country, riparian areas, small drainages, and large areas of irrigated cropland. Source: Colorado Parks and Wildlife (http://cpw.state.co.us/).

- Big Game Winter Range: Data provided by BLM on winter ranges for big game in Colorado and New Mexico.

- Migration corridors provided by the BLM San Luis Valley Field Office.

A.4.3.1 Big Game Crucial Habitat Areas

Figures A.4.3-1 through **A.4.3-7** show, respectively: **Figure A.4.3-1** – big game seasonal ranges in the study area; **Figure A.4.3-2** – distribution of big game seasonal ranges with respect to current vegetation departure; **Figure A.4.3-3** – distribution of big game seasonal ranges with respect to current and future landscape intactness in the study area; **Figure A.4.3-4** – distribution and status of big game seasonal ranges with respect to the current status of change agents; **Figure A.4.3-5** – distribution of big game seasonal ranges with respect to predicted areas of change; **Figure A.4.3-6** – predicted trends in big game seasonal ranges within the study area; and **Figure A.4.3-7 -** the aggregate potential for change in big game seasonal ranges.

The majority (36%) of vegetation within the big game seasonal ranges has a moderate degree of departure from historic reference vegetation conditions (**Figure A.4.3-6**). Most of the vegetation departure that has occurred within the big game seasonal ranges is located in rural and shrubland areas of the Taos Plateau in northern New Mexico (**Figure A.4.3-2**).

The majority (63%) of the big game seasonal ranges are located within areas of high and very high current landscape intactness (**Figure A.4.3-3; Figure A.4.3-6**). The amount of big game seasonal ranges occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (**Figure A.4.3-6**).

The majority (70%) of the big game seasonal ranges are within areas of very low and low current human development intensity (**Figure A.4.3-4; Figure A.4.3-6**). Future trends in human development indicate an increase in human development intensity within big game seasonal ranges. The amount of big game seasonal ranges occurring within areas high and very high human development intensity is expected to increase by approximately 7% in the near-term (i.e., by 2030) (**Figure A.4.3-5; Figure A.4.3-6**).

The majority of the big game seasonal ranges are within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure A.4.3-4; Figure A.4.3-6**). Future trends in climate change indicate portions of the big game seasonal ranges with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure A.4.3-5; Figure A.4.3-6**). Approximately 37% of the big game seasonal ranges are located in areas with high or very high potential for future climate change

(**Figure A.4.3-6**). The greatest potential for future climate change within big game seasonal ranges occurs in the western and northwestern portion of the habitat distribution in the study area (**Figure A.4.3-5**).

The majority of the big game seasonal ranges are within areas of very low current fire occurrence density (**Figure A.4.3-4; Figure A.4.3-6**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the big game seasonal ranges in the study area. The greatest potential for future wildfire occurs in the southern portion of the habitat distribution in New Mexico (**Figure A.4.3-5**).

The majority of big game seasonal ranges are within areas of either very low or very high current density of invasive species, insects, and disease (**Figure A.4.3-4; Figure A.4.3-6**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of big game seasonal ranges in the study area (**Figure A.4.3-6**). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (**Figure A.4.3-5**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 34% of the big game seasonal ranges have the potential for high or very high future change among the change agents (**Figure A.4.3-7**). Areas with greatest potential for change within big game seasonal ranges include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure A.4.3-7**).

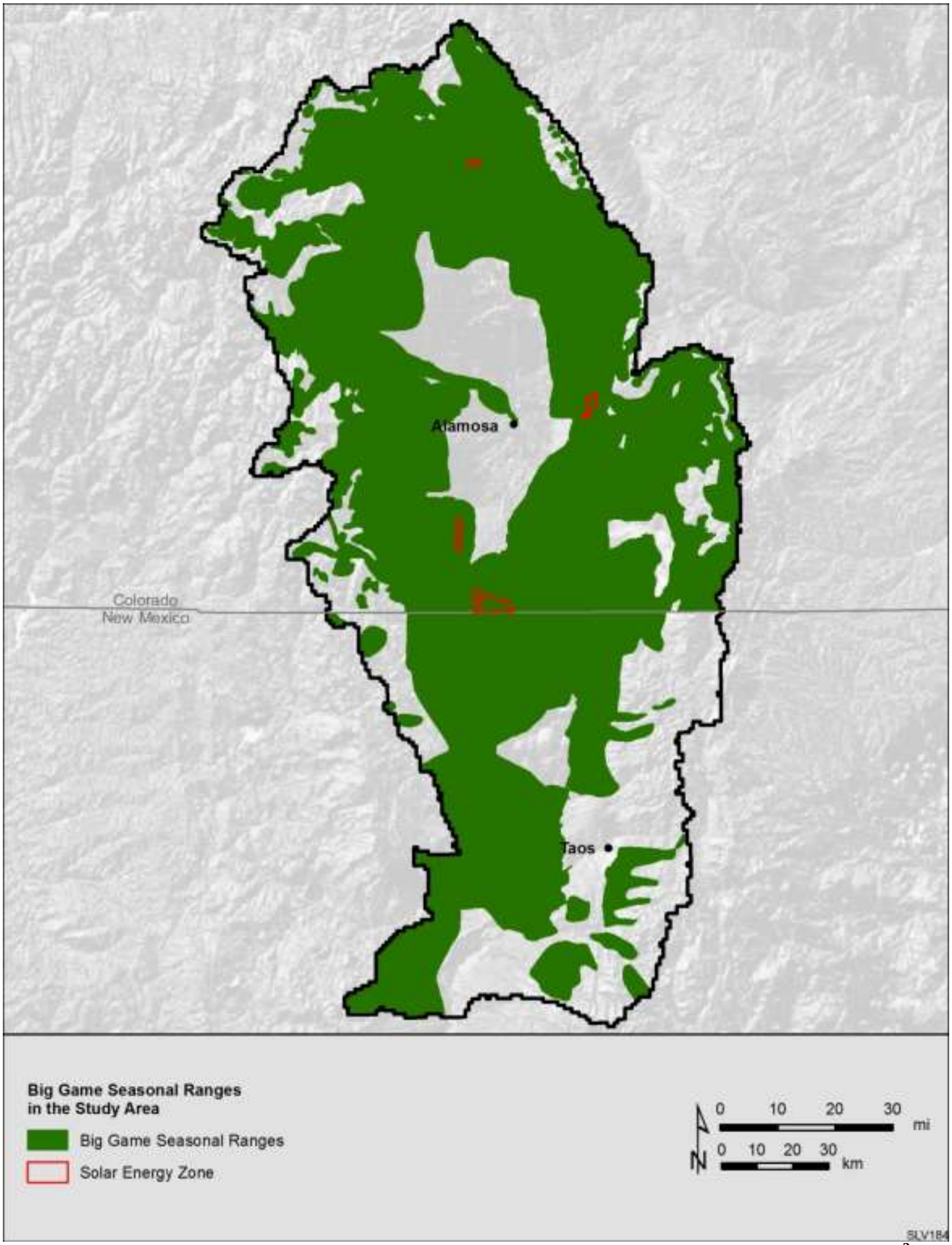


Figure A.4.3-1. Current Distribution of Big Game Seasonal Ranges, Summarized to 1km^2 Reporting Units. Data Sources: data received from BLM and CPW 2012.

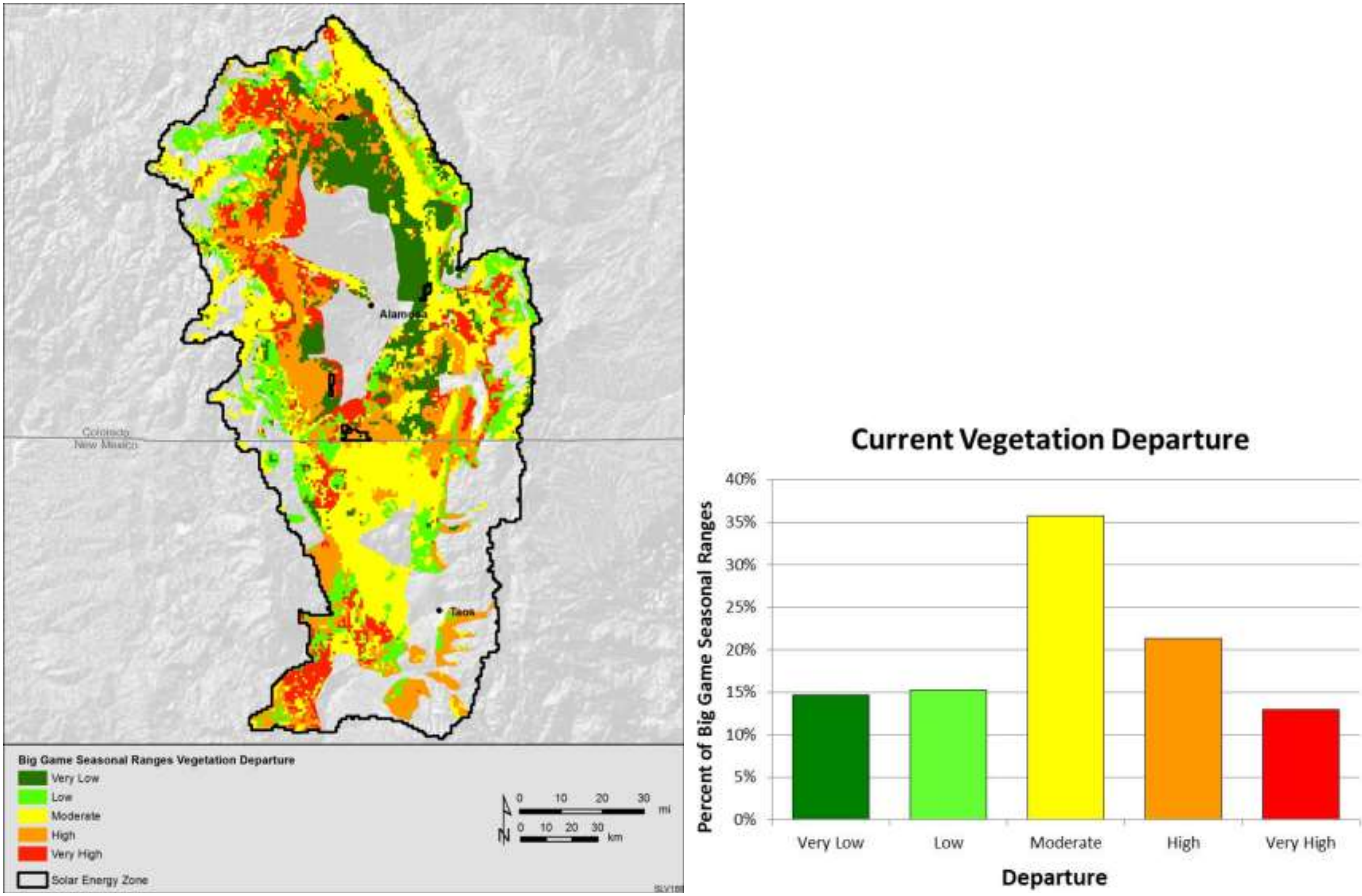


Figure A.4.3-2. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Big Game Seasonal Ranges. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a), data received from BLM and CPW 2012. Data were Summarized to 1 km^2 Reporting Units.

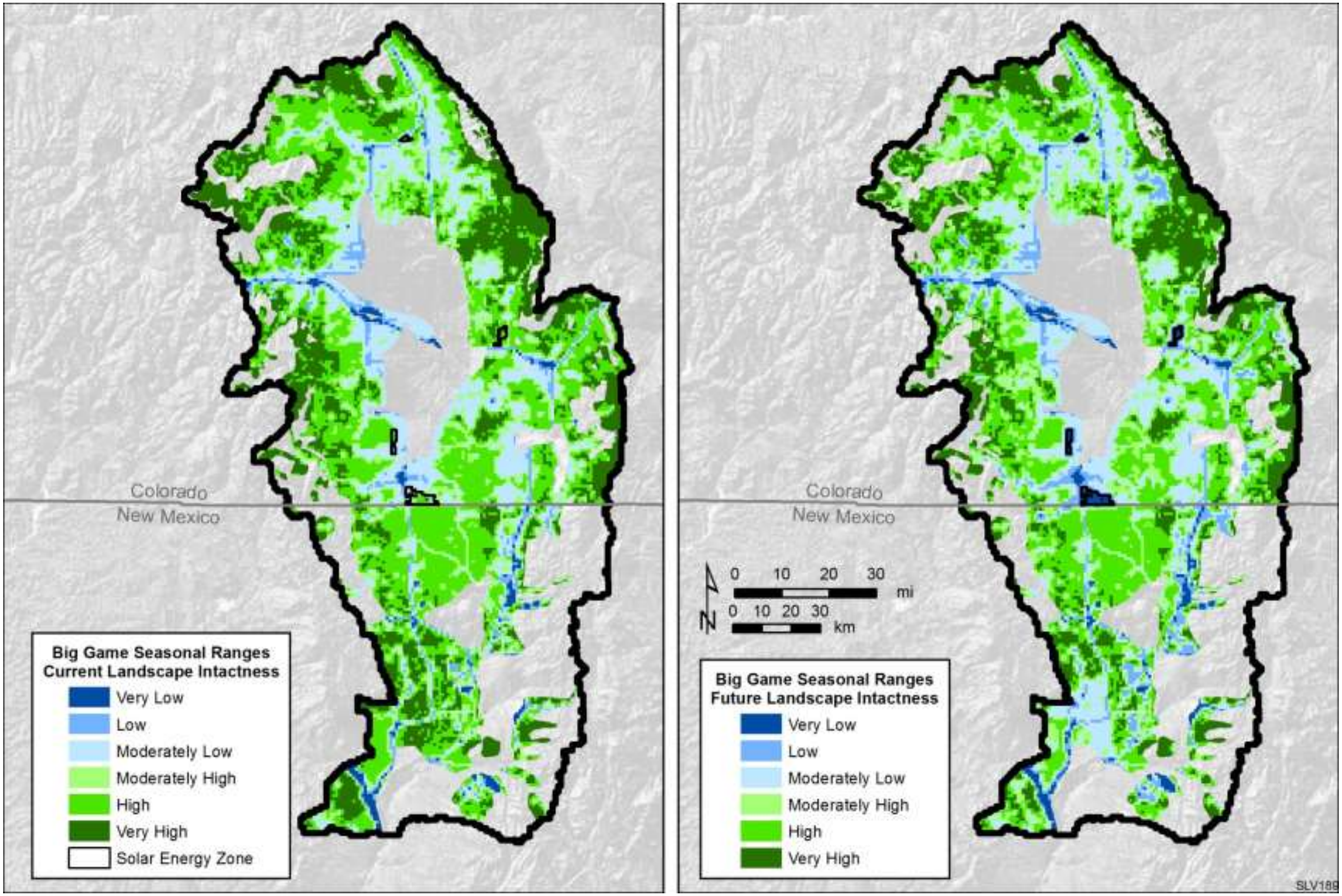


Figure A.4.3-3. Current and Future Landscape Intactness of Big Game Seasonal Ranges. Data Sources: Argonne 2014, data received from BLM and CPW 2012.

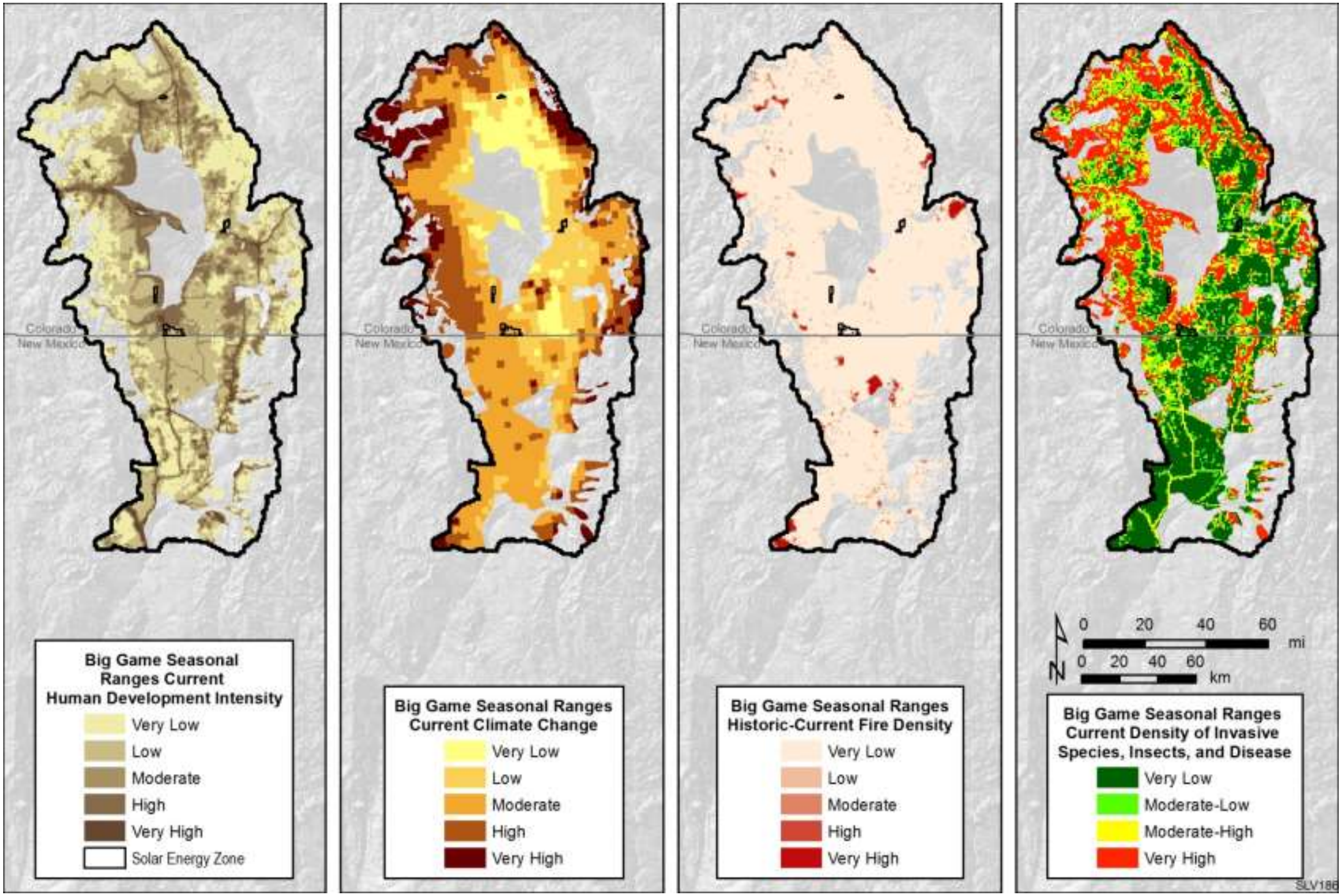


Figure A.4.3-4. Illustration for MQD1: What is the current distribution and status of Big Game Seasonal Ranges? Data Sources: Argonne 2014, data received from BLM and CPW 2012.

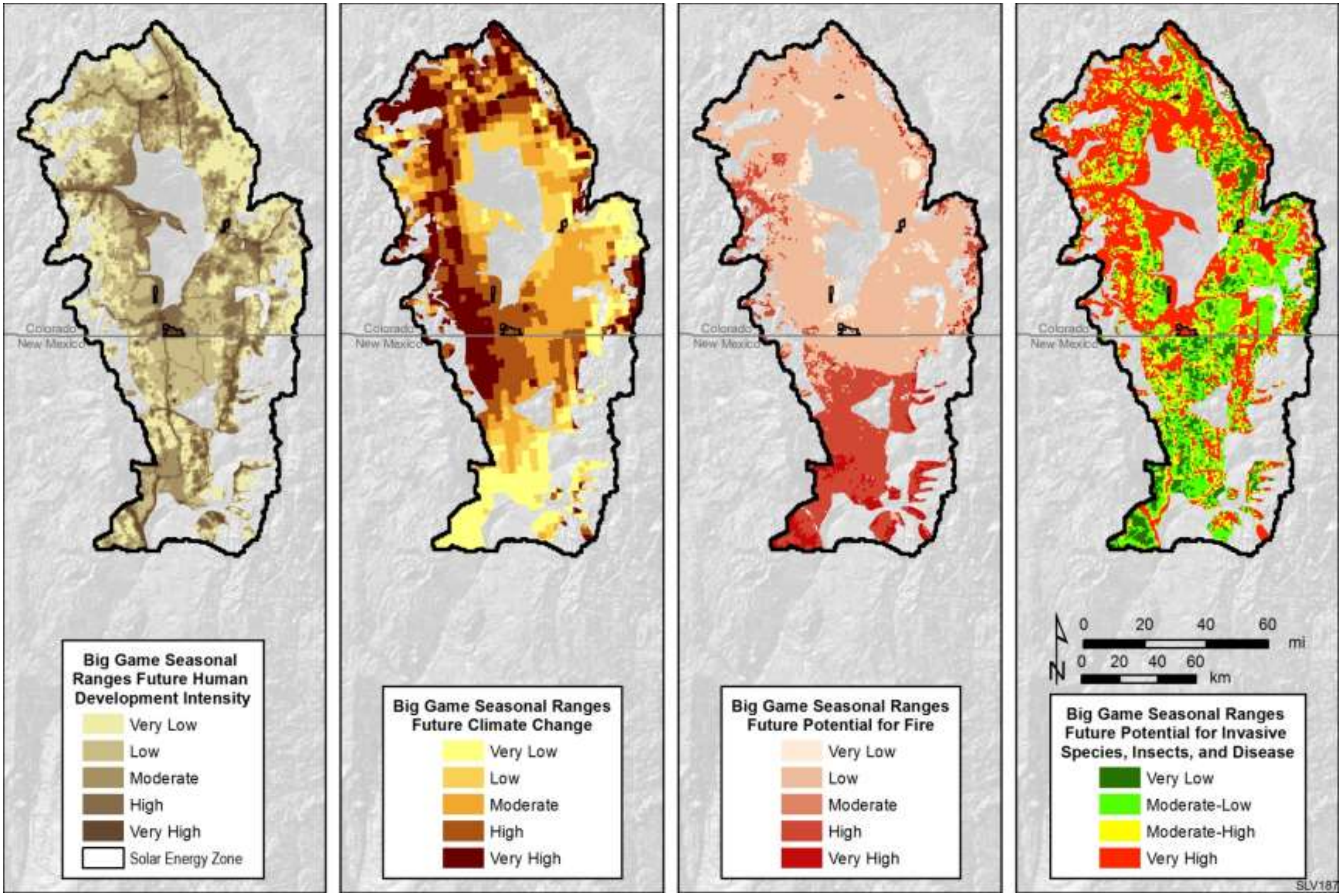


Figure A.4.3-5. Illustration for MQD3: Where are Big Game Seasonal Ranges vulnerable to change agents in the future? Data Sources: Argonne 2014, data received from BLM and CPW 2012.

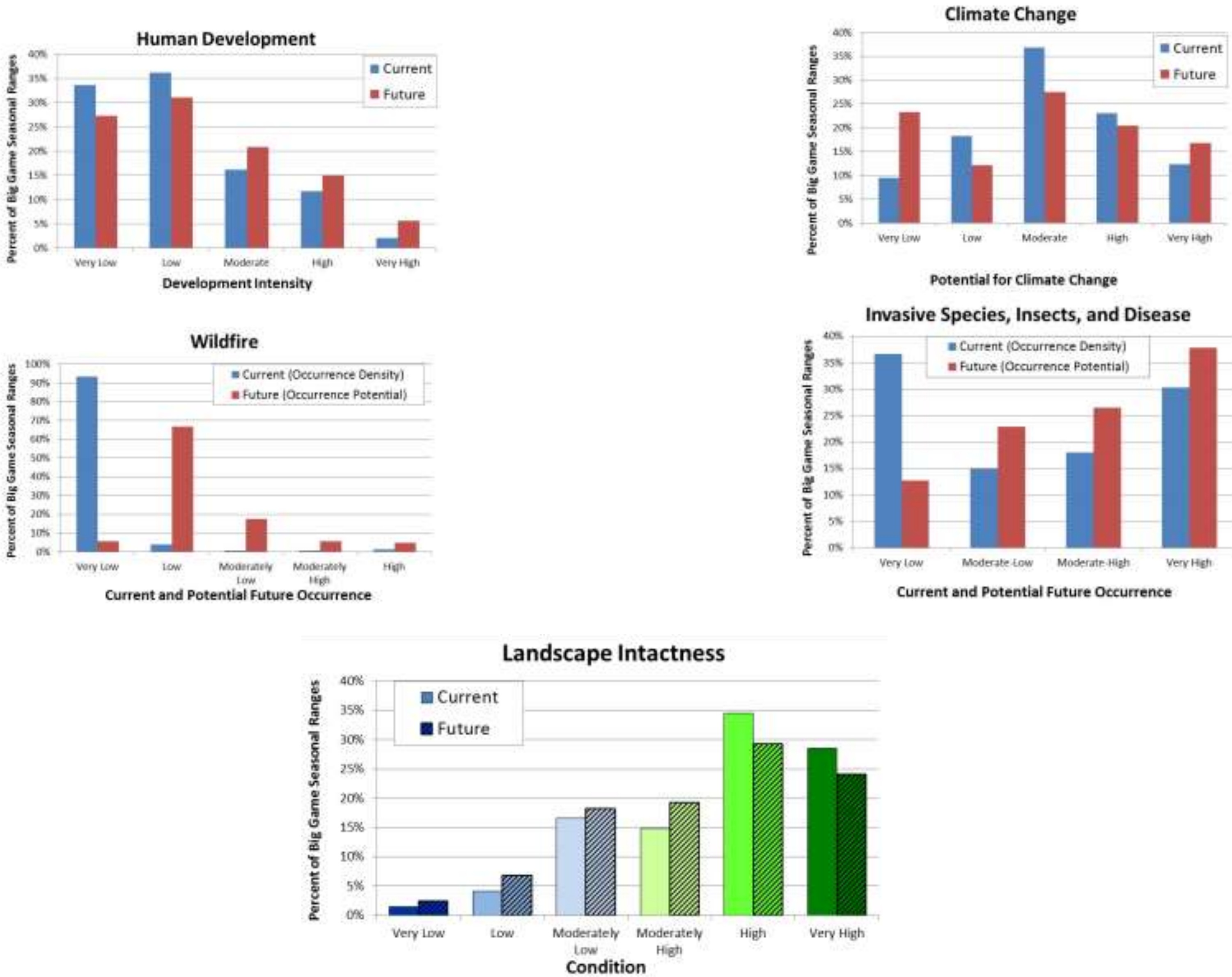
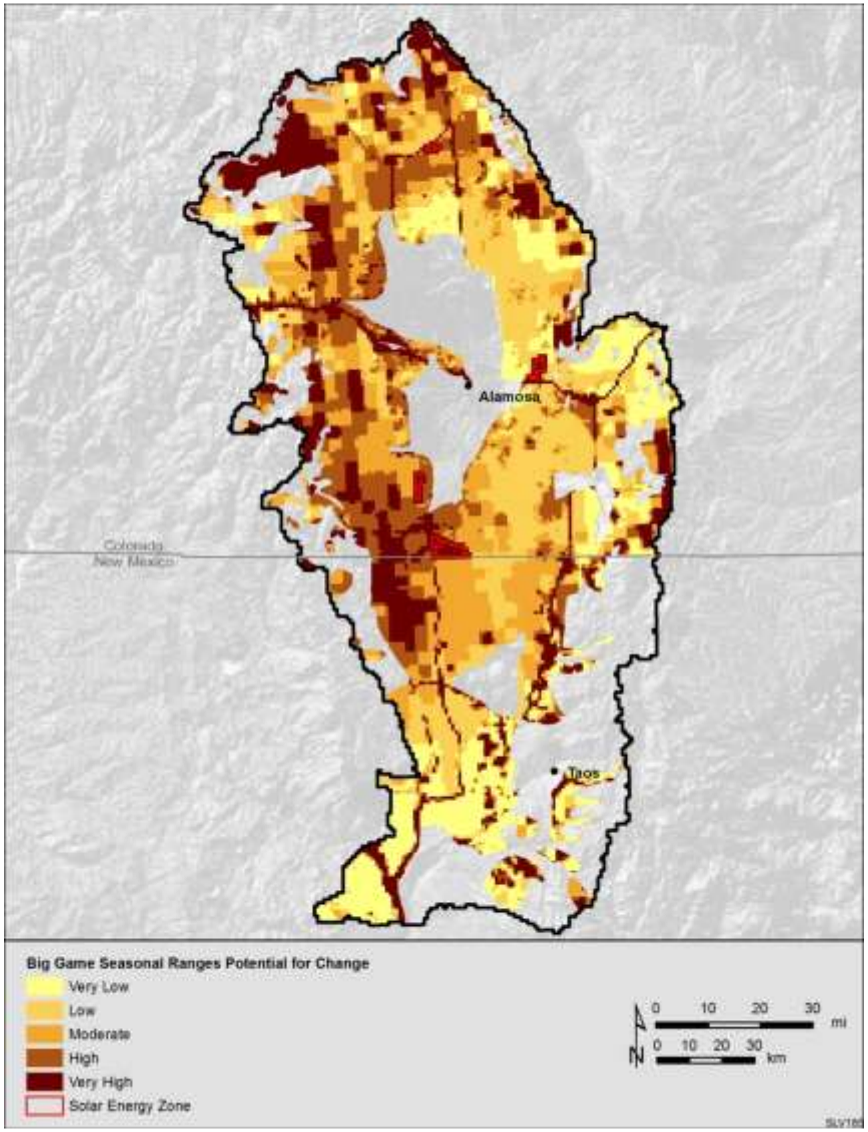


Figure A.4.3-6. Predicted Trends in Big Game Seasonal Ranges within the Study Area.



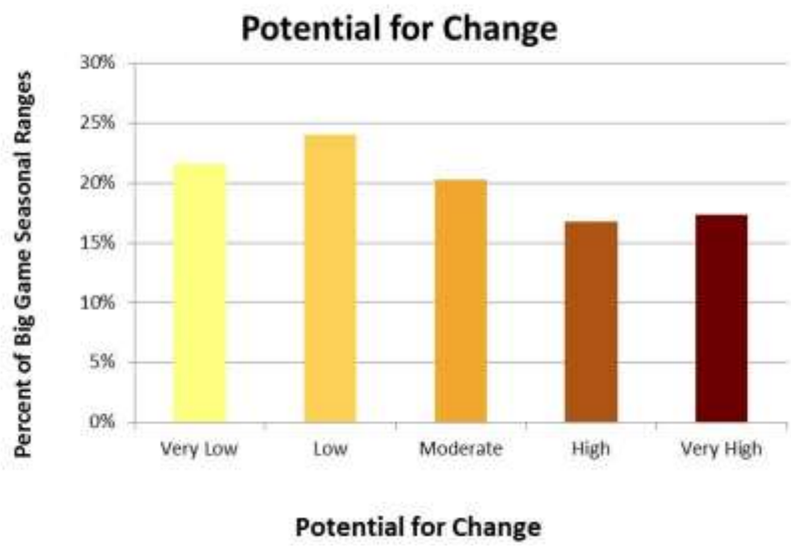


Figure A.4.3-7. Big Game Seasonal Ranges Aggregate Potential for Change (combines potential future change model output for human development, climate change, fire, and invasive species change agents). Data Sources: Argonne 2014, data received from BLM and CPW 2012.

A.4.3.2 Big Game Migration Corridors

Big Game Migration Corridors were provided by the BLM San Luis Valley Field Office. The dataset was developed in part from data provided by Colorado Parks and Wildlife (http://cpw.state.co.us/). This dataset represents big game migratory corridors as determined from state natural resource agencies. Species include bighorn sheep, elk, mule deer, and pronghorn antelope. Migration corridors were clipped to the study area boundary and merged and dissolved across species.

Figures A.4.3-8 through **A.4.3-14** show, respectively: **Figure A.4.3-8** – big game migration corridors in the study area; **Figure A.4.3-9** – current vegetation departure within big game migration corridors; **Figure A.4.3-10** – current and future landscape intactness within big game migration corridors; **Figure A.4.3-11** – status of big game migration corridors with respect to change agents; **Figure A.4.3-12** – areas of predicted future change within big game migration corridors; **Figure A.4.3-13** – predicted trends in big game migration corridors within the study area; and **Figure A.4.3-14** - the aggregate potential for change in big game migration corridors.

The majority (46%) of vegetation within the big game migration corridors has a moderate degree of departure from historic reference vegetation conditions (**Figure A.4.3-13**). Most of the vegetation departure that has occurred within the big game migration corridors is located in rural and shrubland areas of the Taos Plateau in northern New Mexico (**Figure A.4.3-9**).

The majority (41%) of the big game migration corridors are located within areas of high current landscape intactness (**Figure A.4.3-10; Figure A.4.3-13**). Future trends in landscape intactness indicate a decrease in landscape intactness within big game migration corridors. The amount of big game migration corridors occurring within areas of high and very high landscape intactness is expected to decrease by approximately 8% in the near-term (i.e., by 2030) (**Figure A.4.3-13**).

The majority (76%) of the big game migration corridors are located within areas of very low and low current human development intensity (**Figure A.4.3-11; Figure A.4.3-13**). Future trends in human development indicate an increase in human development intensity within big game migration corridors. The amount of big game migration corridors occurring within areas high and very high human development intensity is expected to increase by approximately 6% in the near-term (i.e., by 2030) (**Figure A.4.3-12; Figure A.4.3-13**).

The majority of the big game migration corridors are within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (**Figure A.4.3-11; Figure A.4.3-13**). Future trends in climate change indicate portions of big game migration corridors with high or very high potential for climate change in the long-term future (i.e., by 2069) (**Figure A.4.3-12; Figure A.4.3-13**). Approximately 53% of the big game migration corridors are located in areas with high or very high potential for future climate change (**Figure A.4.3-12; Figure A.4.3-13**). The greatest potential for future climate change within big game migration corridors occurs in the western portion of the migration corridors in the study area (**Figure A.4.3-12**).

The majority of the big game migration corridors are within areas of very low current fire occurrence density (**Figure A.4.3-11; Figure A.4.3-13**). Future trends in wildfire indicate an increase in wildfire potential in some portions of the big game migration corridors in the study area. The greatest potential for future wildfire occurs in the southern portion of the habitat distribution in New Mexico (**Figure A.4.3-12**).

The majority of big game migration corridors are within areas of either very low or very high current density of invasive species, insects, and disease (**Figure A.4.3-11; Figure A.4.3-13**). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of big game migration corridors in the study area (**Figure A.4.3-13**). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, and spread of forest insects and disease (**Figure A.4.3-12**).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 47% of the big game migration corridors have the potential for high or very high future change among the change agents (**Figure A.4.3-14**). Areas with greatest potential for change within big game migration corridors include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (**Figure A.4.3-14**).

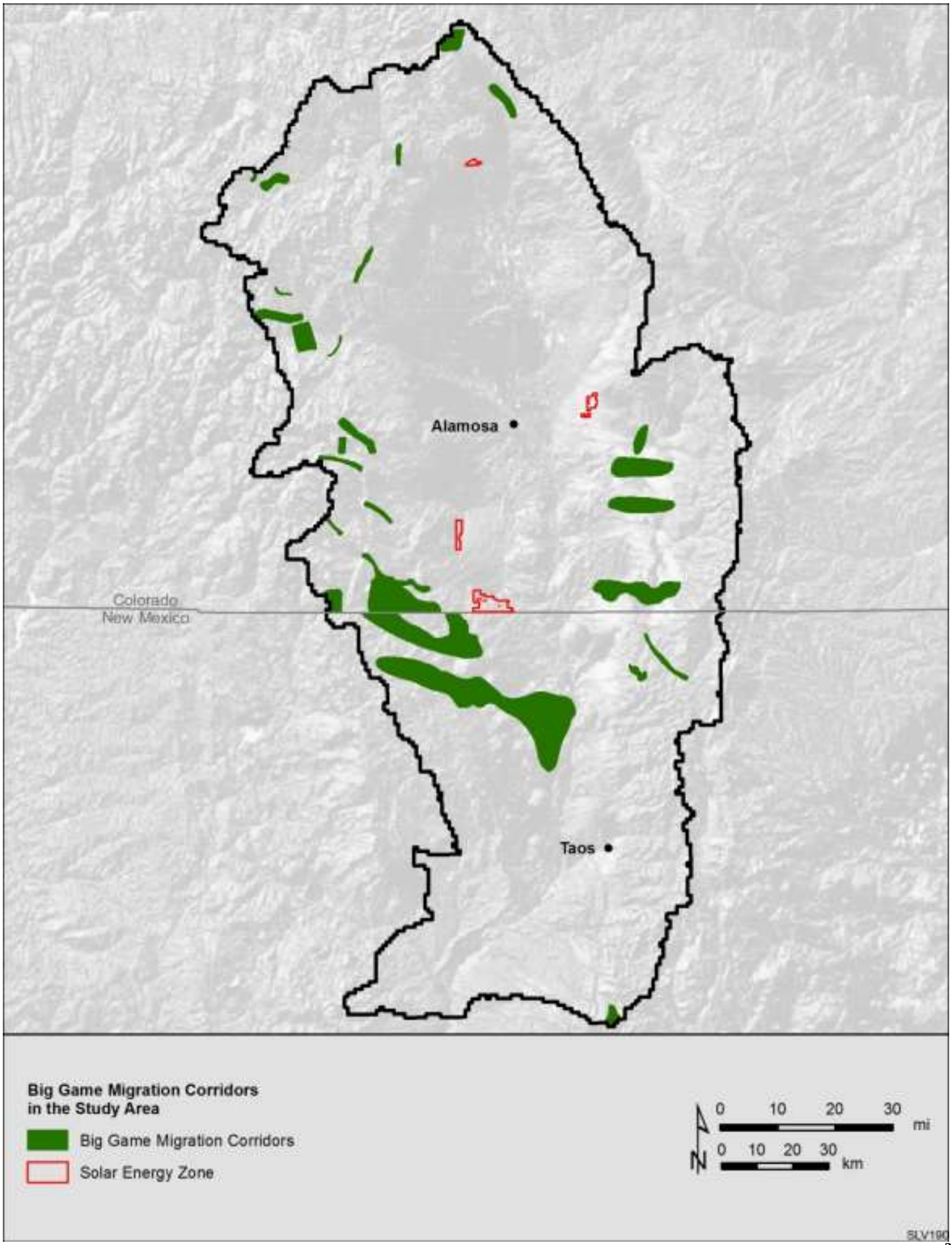


Figure A.4.3-8. Current Distribution of Big Game Migration Corridors, Summarized to 1km^2 Reporting Units. Data Source: data received from BLM.

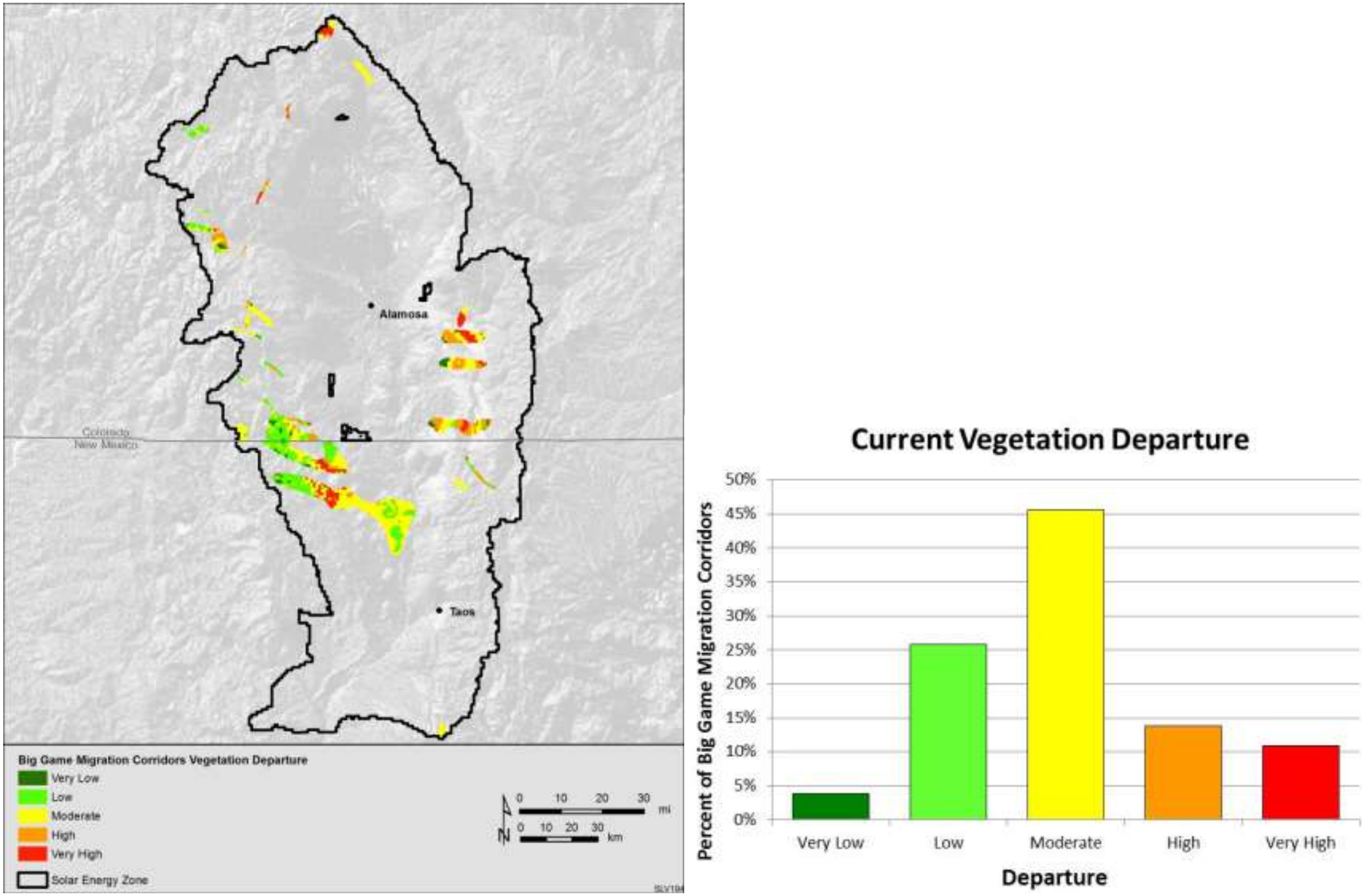


Figure A.4.3-9. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Big Game Migration Corridors. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a) and data received from BLM. Data were Summarized to 1 km^2 Reporting Units.

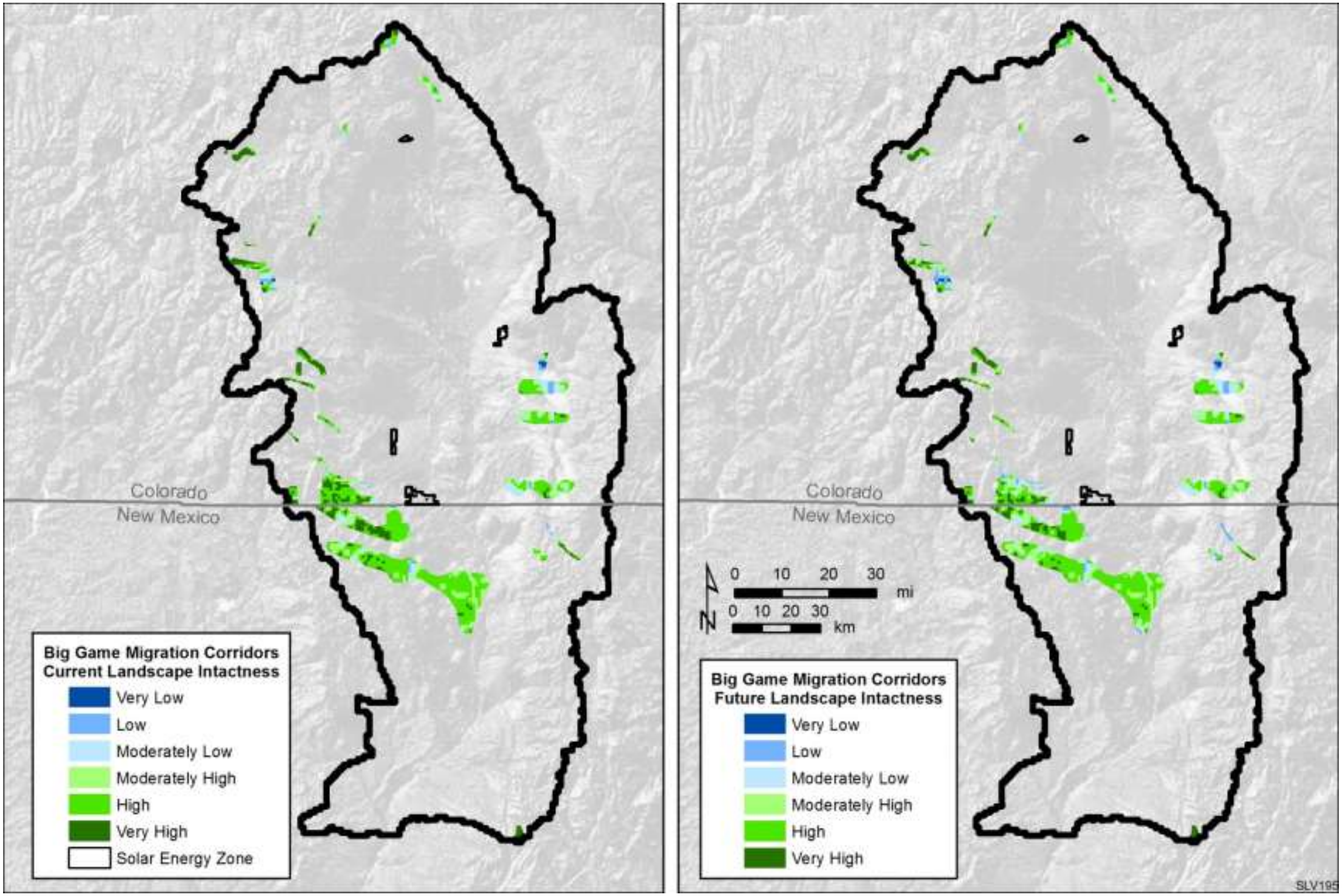


Figure A.4.3-10. Current and Future Landscape Intactness of Big Game Migration Corridors. Data Sources: Argonne 2014 and data received from BLM.

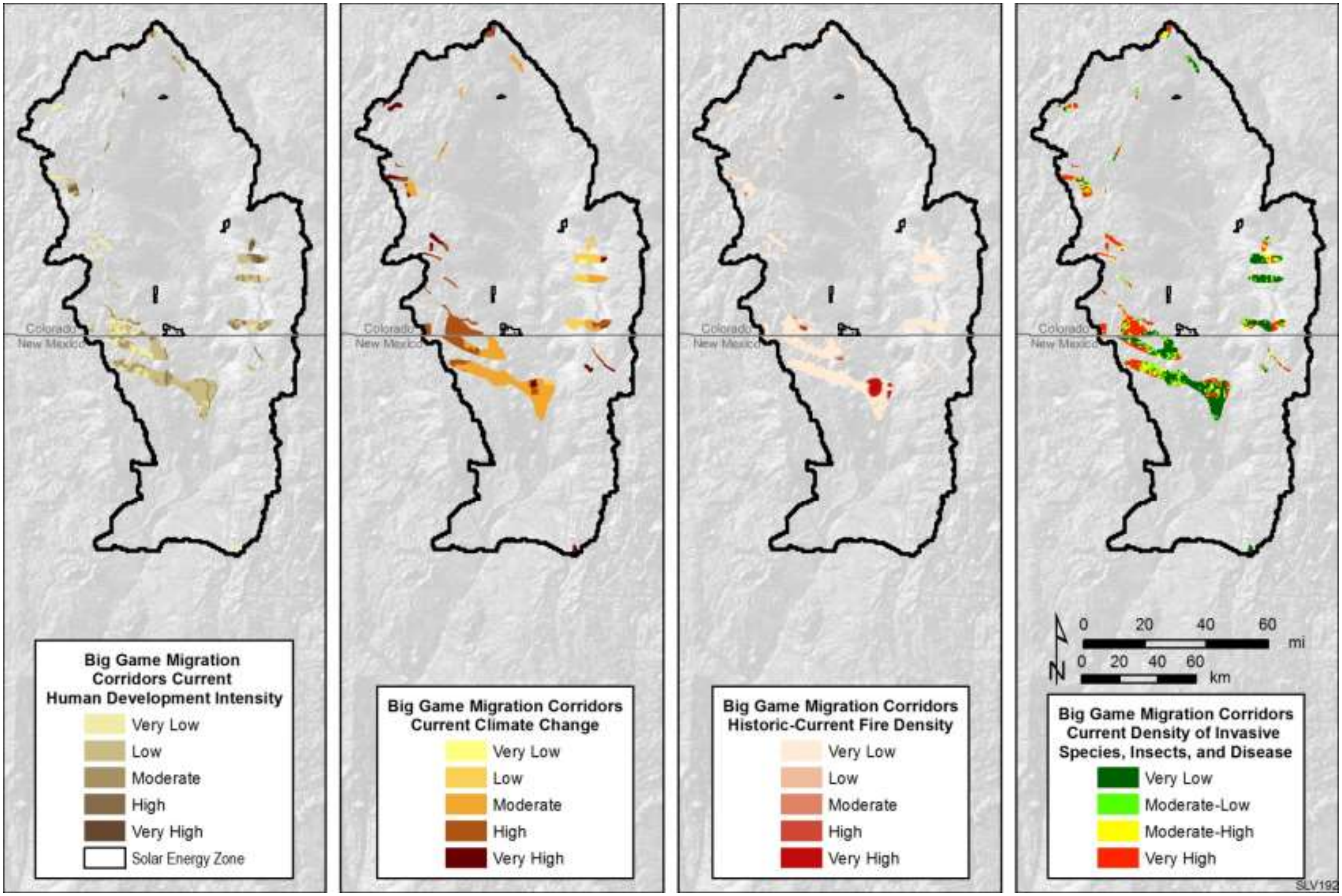


Figure A.4.3-11. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for Big Game Migration Corridors? Data Sources: Argonne 2014 and data received from BLM.

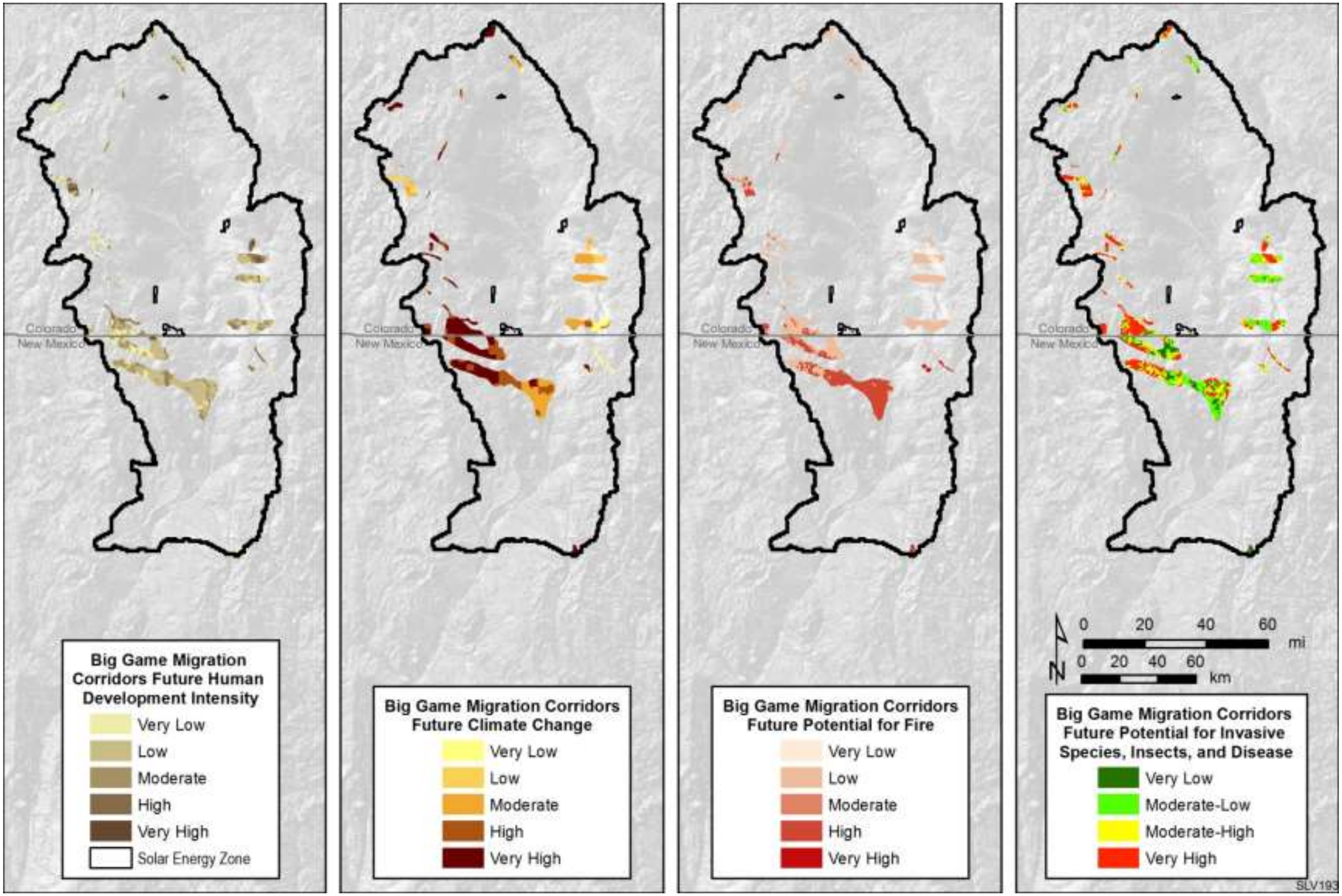


Figure A.4.3-12. Illustration for MQD3: Where are big game migration corridors vulnerable to change agents in the future? Data Sources: Argonne 2014 and data received from BLM.

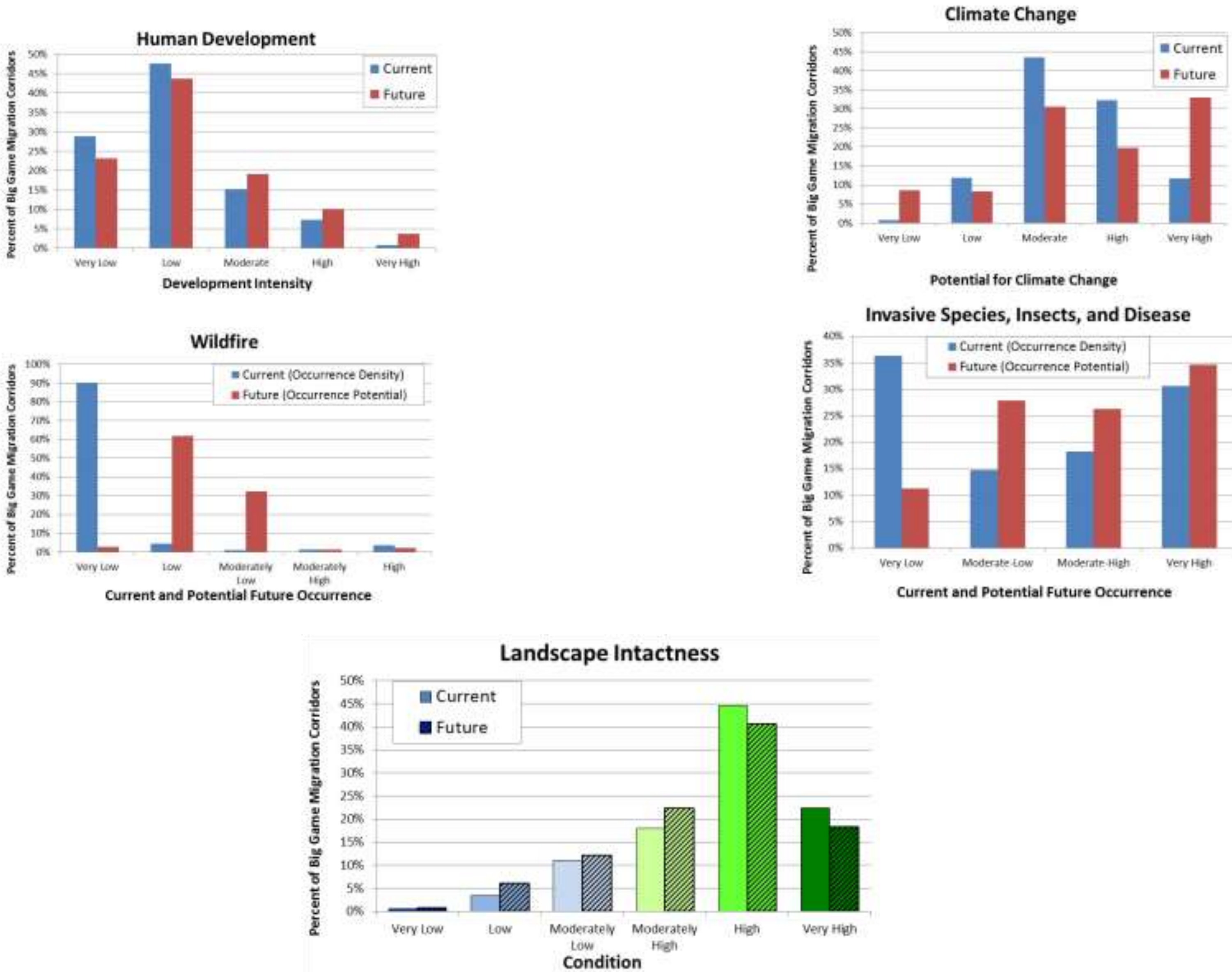


Figure A.4.3-13. Predicted Trends in Big Game Migration Corridors within the Study Area

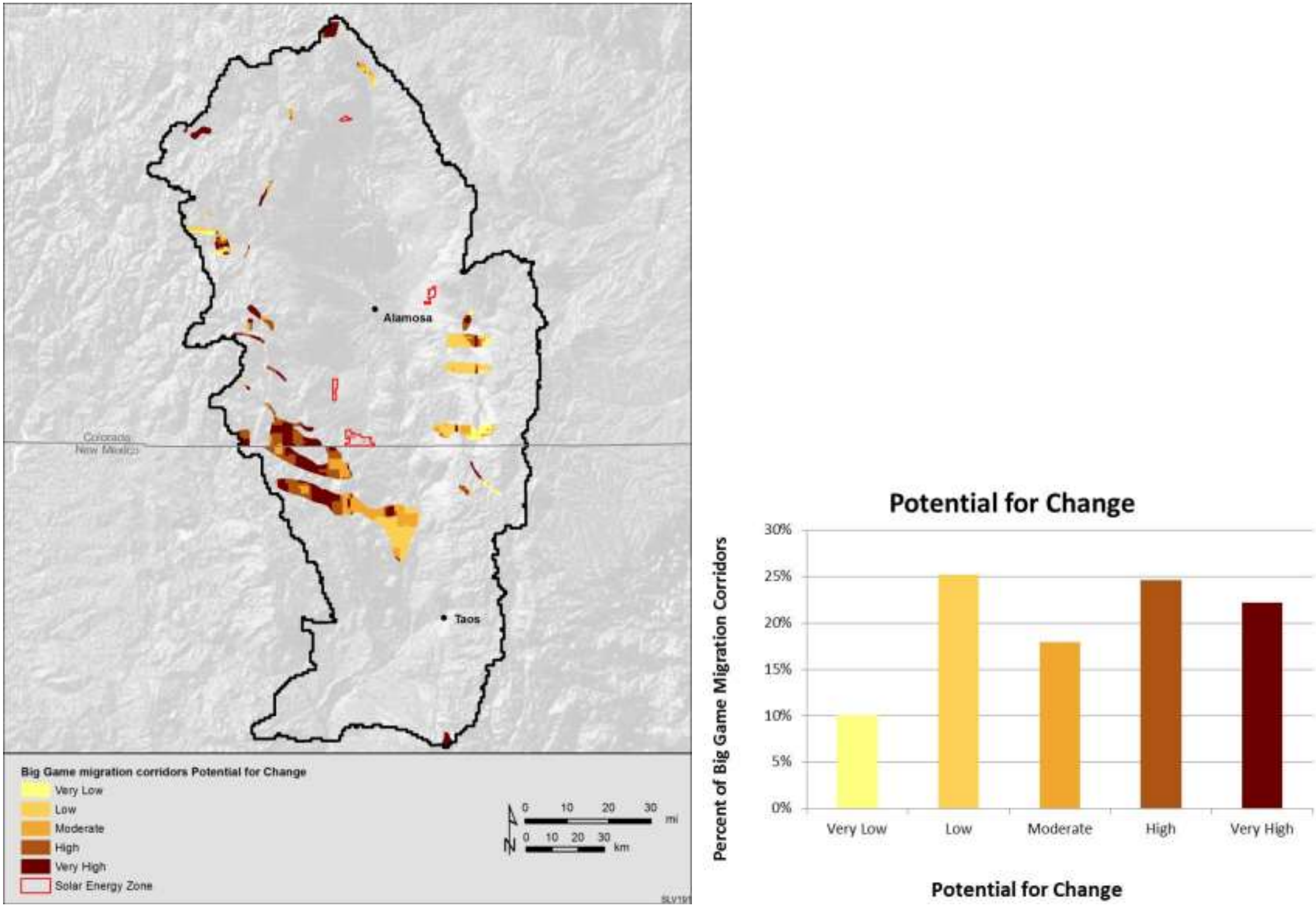


Figure A.4.3-14. Big Game Migration Corridors Aggregate Potential for Change. Data Sources: Argonne 2014 and data received from BLM.

A.5 Management Questions for Wildfire

E. Wildfire	
MQE1	Where has wildfire occurred in the past 20 years? **See Below.**
MQE2	Where are the Fire Regime Condition Classes? **See Below.**
MQE3	Where is fire adverse to ecological communities, features, and resources of concern? **See Below.**
MQE4	Where are the areas with potential to change from wildfire in the future? **See Below.**
MQE5	Where is fire likely to change in relation to climate change? **See Below.**
MQE6	Where might fire interfere with future human development (e.g., development risk)? **See Below.**

A.5.1 MQE1: Where Has Wildfire Occurred in the Past 20 Years?

The model developed to characterize the historical-current distribution of wildlife was presented in the text (Section 3.2.7). Input datasets characterized the location and size of historic fires in the study area and were obtained from several sources (**Table A.5.1-1**). Historic fire occurrence data were obtained from a number of sources including GEOMAC, BLM, and USGS (LANDFIRE). The process model to characterize the historic-current distribution of wildfires is shown in **Figure A.5.1-1**. The input datasets were summarized to 1 km^2 reporting units and normalized along a scale of -1 to 1, where values closer to -1 indicated areas of low fire density and values closer to 1 indicated areas of high fire density. The resulting datasets were combined and the minimum normalized density value was calculated for each 1 km^2 reporting unit to determine the historic-current distribution of wildfire in the study area. Model results were then classified into one of five categories to describe fire density: Very Low, Low, Moderate, High, and Very High. The mapped model results for historic-current fire density is shown in **Figure A.5.1-2**.

Table A.5.1-1. Input datasets used to characterize the historic-current distribution of wildfire in the study area.

Source	Description
BLM	Fire locations in the study area (points)
GEOMAC	Fire locations in the study area (points)
USGS (LANDFIRE)	LANDFIRE Disturbances (raster)
GEOMAC	Fire perimeters in the study area (polygons)

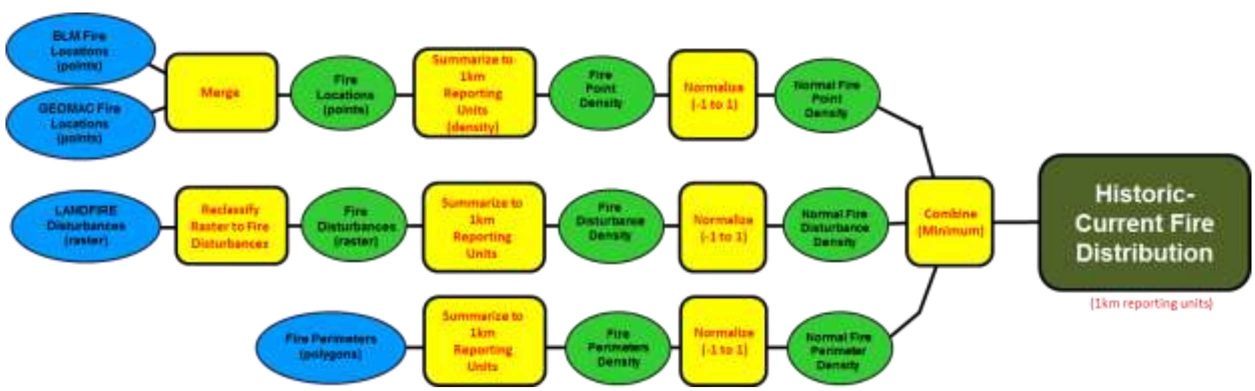


Figure A.5.1-1. Process model to characterize historic-current distribution of wildfire.

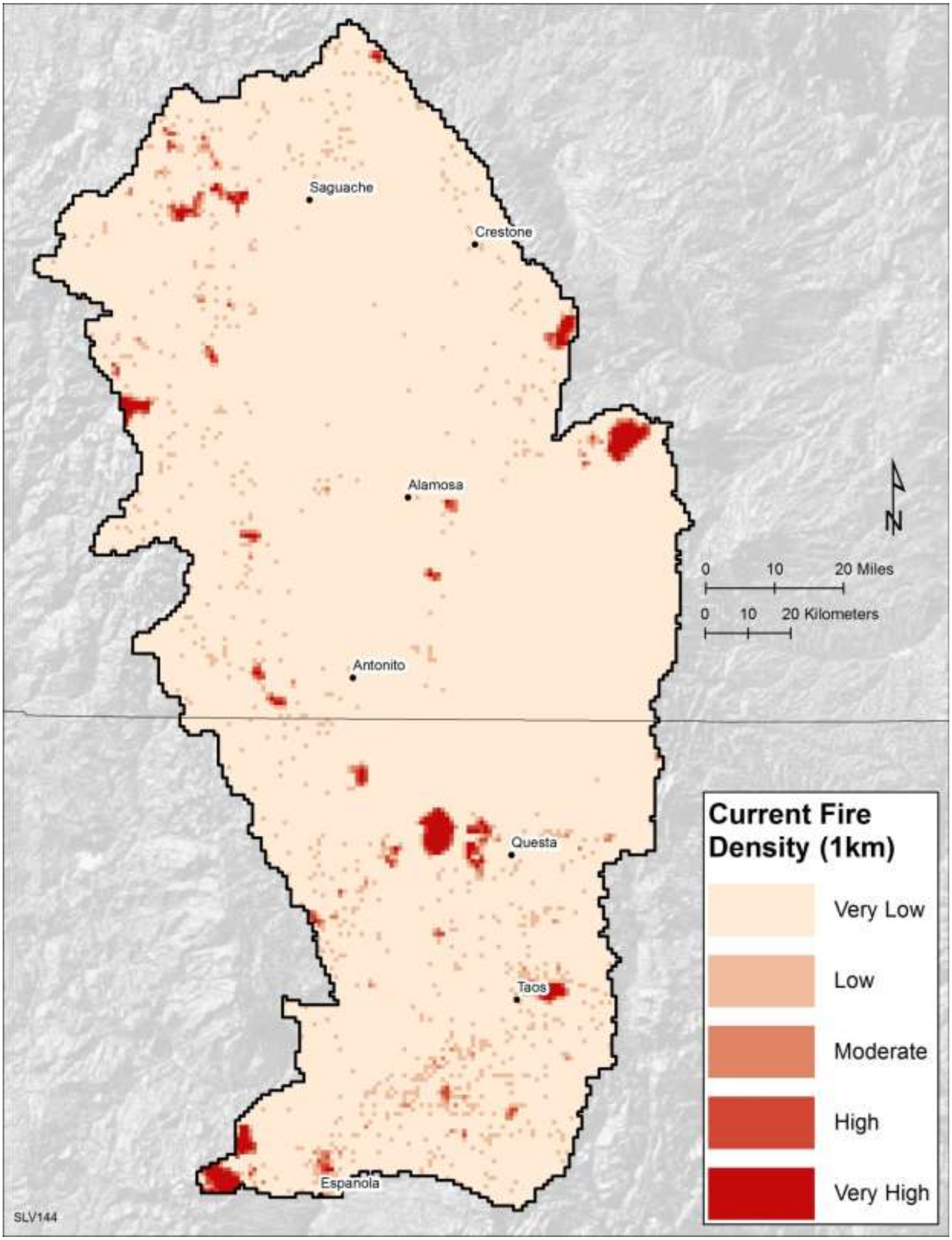


Figure A5.1-2. Historic-current distribution of wildfire modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

A.5.2 MQE2: Where are the Fire Regime Condition Classes?

Data sources:

- USGS LANDFIRE Fire Regime Groups (http://www.landfire.gov/NationalProductDescriptions12.php)
- USGS LANDFIRE Vegetation Condition Class and Vegetation Departure (http://www.landfire.gov/notifications33.php)

The Fire Regime Groups (FRG) were intended to characterize the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context. FRG definitions have been altered from previous applications to best approximate the definitions outlined in the Interagency Fire Regime Condition Class Guidebook. These definitions were refined to create discrete, mutually exclusive criteria appropriate for use with LANDFIRE's fire frequency and severity data products. A map characterizing Fire Regime Groups in the study area is provided in **Figure A.5.2-1**.

Previously, Fire Regime Condition Class (FRCC) mapped by LANDFIRE included both classed and continuous metrics of departure for vegetation and were called FRCC and FRCC Departure Index. These products have now been referred to as Vegetation Condition Class (VCC) and Vegetation Departure (VDEP). According to the FRCC Guidebook, FRCC is a combination of vegetation departure and fire frequency and severity departure. The map of VCC is provided in **Figure A.5.2-2**. The Vegetation Condition Class (VCC) layer quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions. Three condition classes describe low departure (VCC 1), moderate departure (VCC 2), and high departure (VCC 3).

VCC is calculated based on changes to species composition, structural stage, and canopy closure using methods described in the Interagency Fire Regime Condition Class Guidebook. LANDFIRE VCC is based on departure of current vegetation conditions from reference vegetation conditions only, whereas the Guidebook approach includes departure of current fire regimes from those of the reference period. LANDFIRE simulates historical vegetation reference conditions using the vegetation and disturbance dynamics model VDDT (Vegetation Dynamics Development Tool) (LANDSUM for LF_1.0.0 only). Current vegetation conditions are derived from a classification of existing vegetation type, cover, and height.

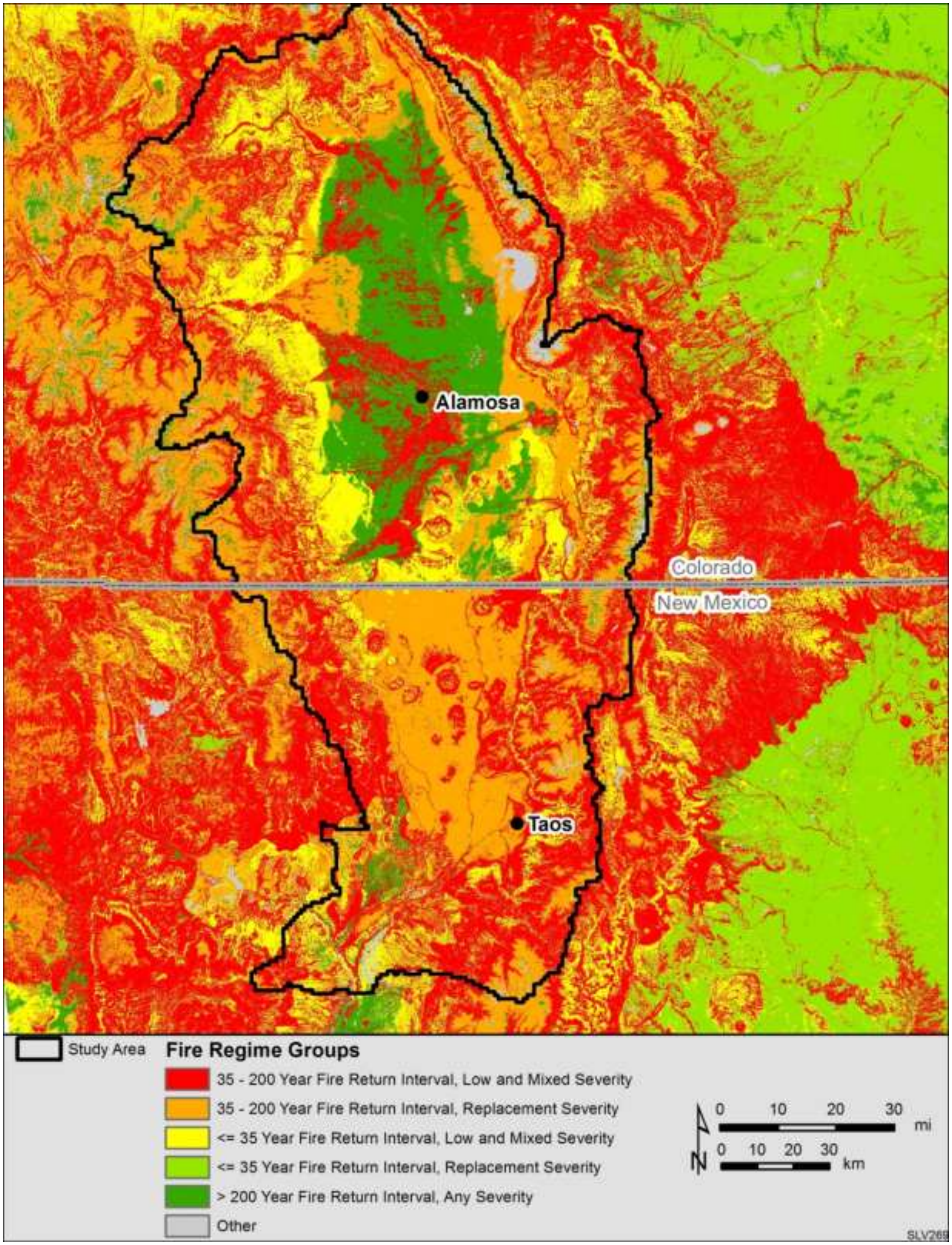


Figure A.5.2-1. LANDFIRE Fire Regime Groups in the Study Area. Data Source: Fire Regime Groups (FRG) (LANDFIRE v 1.1; USGS, 2008b).

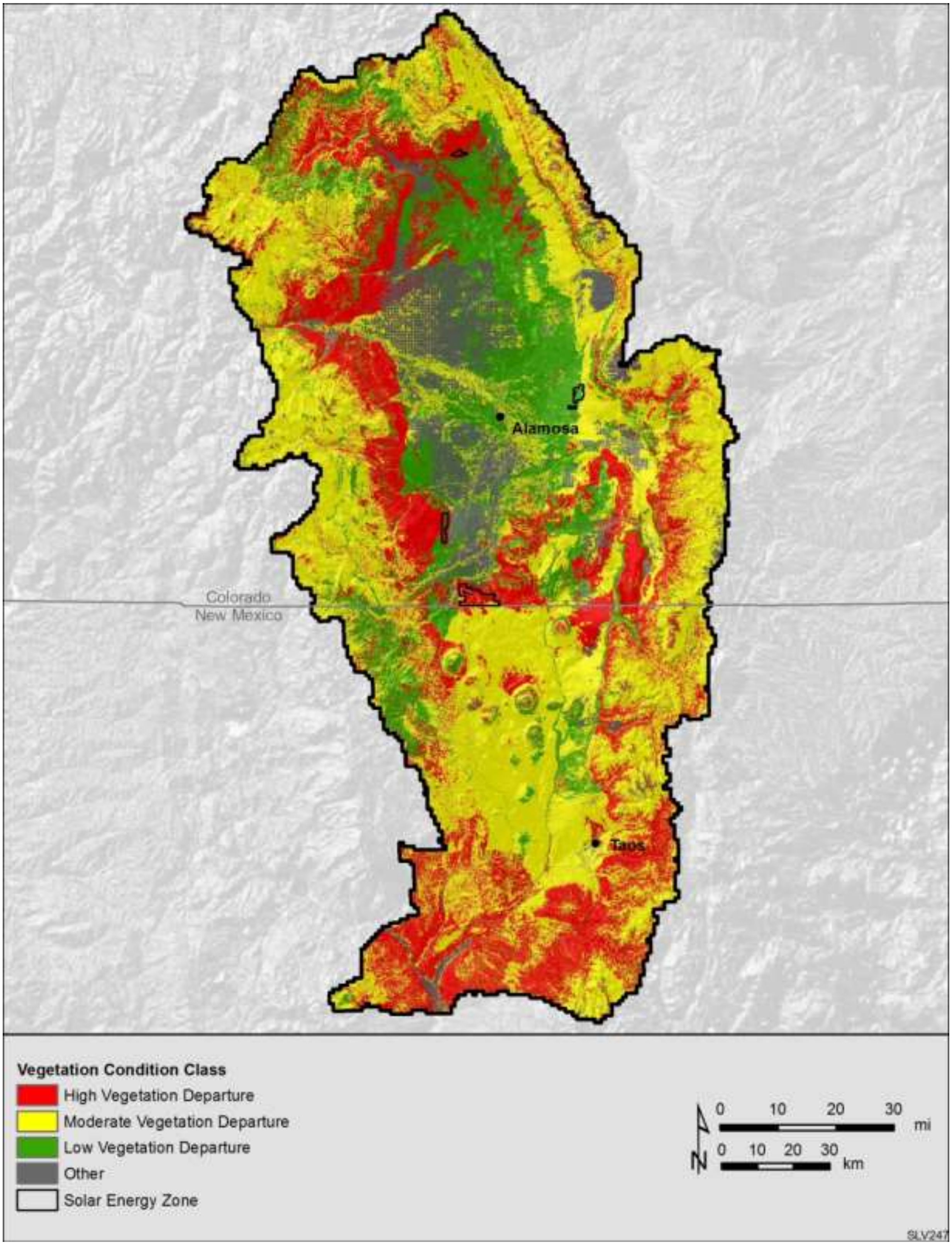


Figure A.5.2-2. LANDFIRE Vegetation Condition Classes in the Study Area. Data Source: Vegetation Condition Class (VCC) (LANDFIRE v 1.1; USGS, 2008c).

A.5.3 MQE3: Where is Fire Adverse to Ecological Communities, Features, and Resources of Concern?

Datasets:

- LANDFIRE Fire Regime Groups (FRG) (http://www.landfire.gov/NationalProductDescriptions12.php)
- LANDFIRE Existing Vegetation Type (EVT) (http://www.landfire.gov/NationalProductDescriptions21.php)
- LANDFIRE Succession Class (http://www.landfire.gov/NationalProductDescriptions17.php)
- SWReGAP Landcover Types (http://swregap.nmsu.edu/)

The process model for identifying areas where fire may be adverse to ecological communities, features, and resources of concern is provided in **Figure A.5.3-1**. Results of the model are shown in **Figure A.5.3-2**.

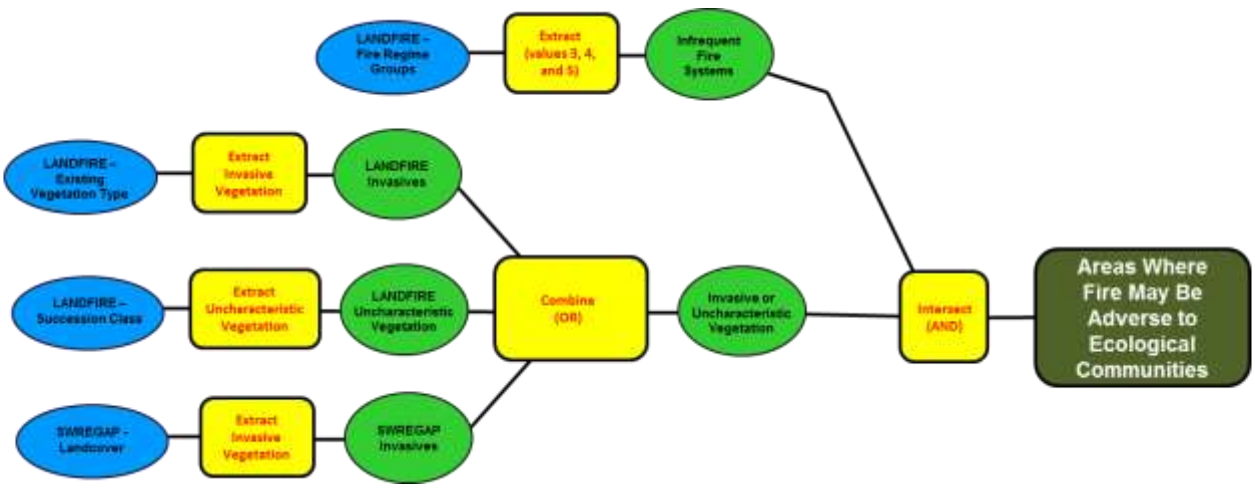


Figure A.5.3-1. Process model to characterize where fire may be adverse to ecological communities.

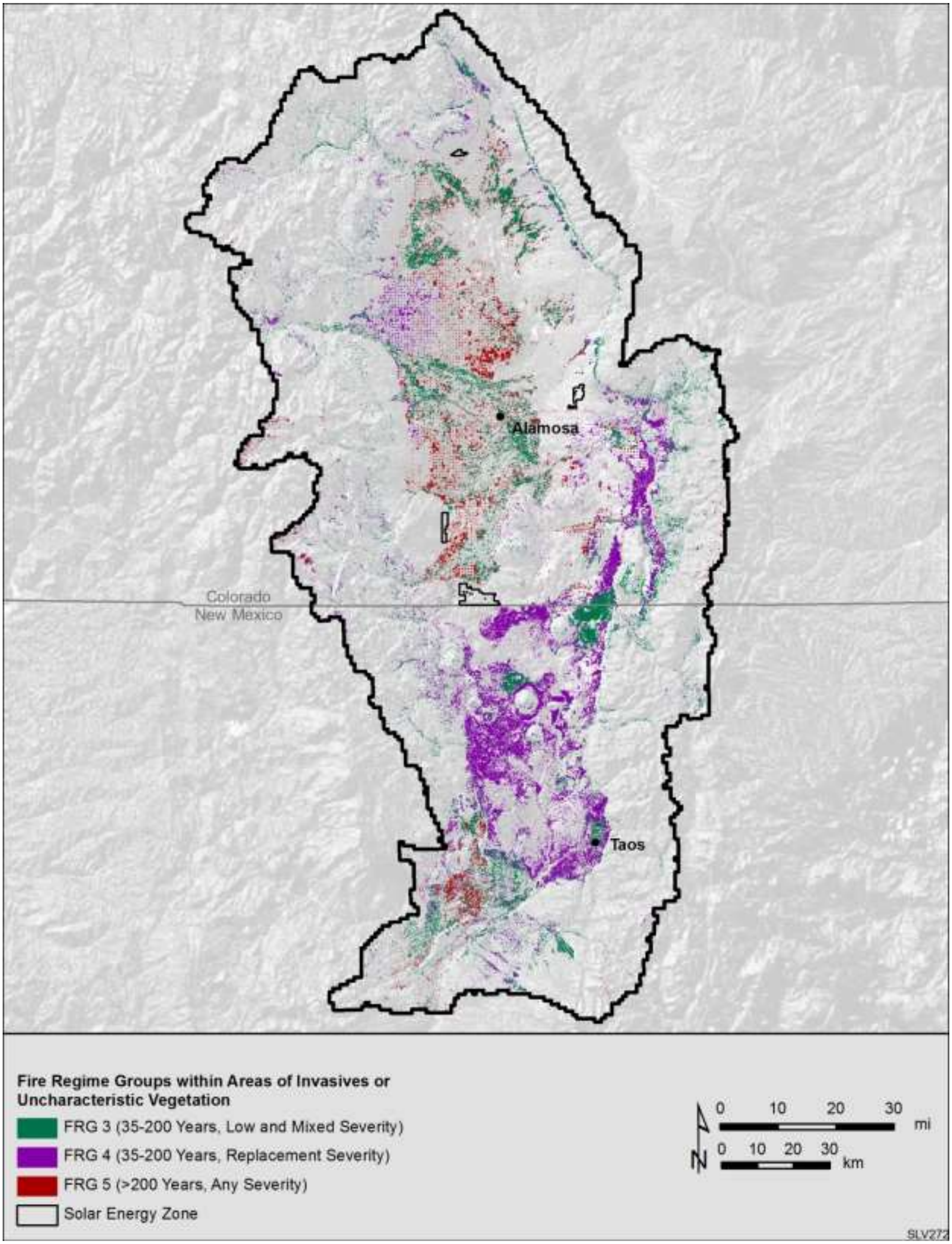


Figure A.5.3-2. Areas Where Fire May Be Adverse To Ecological Communities, Features, and Resources of Concern. Data Sources: USGS 2010a, USGS 2008 b,d and USGS 2004.

A.5.4 MQE4: Where are Areas with Potential to Change from Wildfire in the Future?

The wildland fire potential (WFP) dataset (USFS 2013) was used to characterize near-term future (2015-2030) potential for wildfire throughout the study area. The WFP dataset is a raster geospatial product produced by the USDA Forest Service, Fire Modeling Institute that is intended to be used in analyses of wildfire risk or hazardous fuels prioritization at regional or national scales. The WFP map builds upon, and integrates, estimates of burn probability (BP) and conditional probabilities of fire intensity levels (FILs) generated for the national interagency Fire Program Analysis system (FPA) using a simulation modeling system called the Large Fire Simulator (FSim; Finney et al. 2011). The specific objective of the 2012 WFP map is to depict the relative potential for wildfire that would be difficult for suppression resources to contain, based on past fire occurrence, 2008 fuels data from LANDFIRE, and 2012 estimates of wildfire likelihood and intensity from FSim. Areas with higher WFP values, therefore, represent fuels with a higher probability of experiencing high-intensity fire with torching, crowning, and other forms of extreme fire behavior under conducive weather conditions.

To model near-term future wildfire potential, the WFP raster values were summarized to 1 km2 reporting units and normalized along a scale ranging between -1 and 1, where values closer to -1 indicate non-burnable areas or areas with very low potential for future wildfire. Normalized values closer to 1 indicate areas with very high potential for future wildfire. Normalized values were then classified into one of five categories to map near-term future wildfire potential: Very Low, Low, Moderate, High, and Very High. The mapped model results for near-term future wildfire potential shown in **Figure A.5.4-1**.

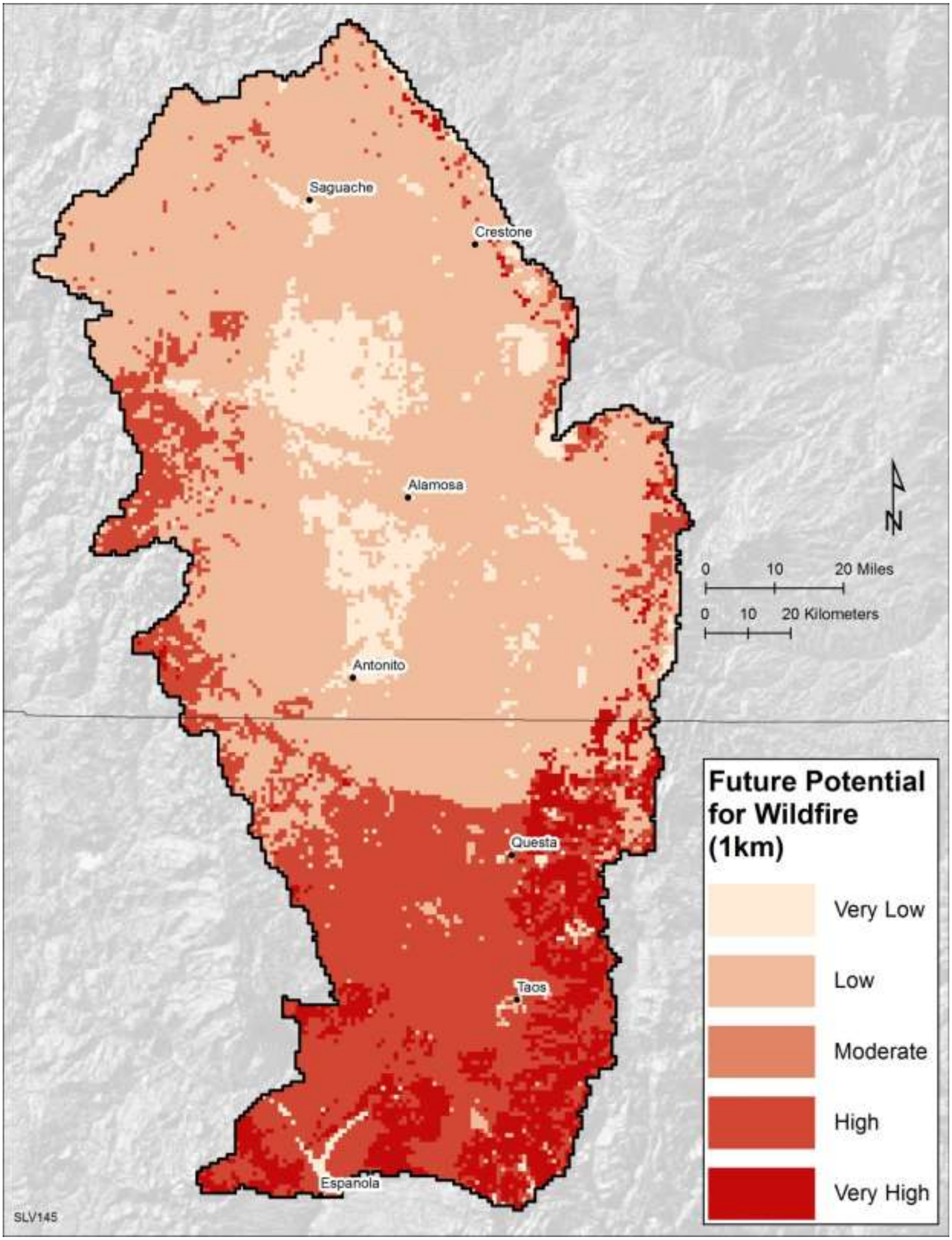


Figure A.5.4-1. Near-term future potential for wildfire in the Study Area (Argonne 2014).

A.5.5 MQE5: Where is Fire Likely to Change in Relation to Climate Change?

The approach to evaluate where fire potential is likely to change in relation to climate change included an intersection of near-term future fire risk within areas of high long-term future potential for climate change. The map results of future wildfire risk within areas of high potential future climate change are shown in **Figure A.5.5-1**. These results may not necessarily reflect an association between climate change and wildfire potential. Additional study is needed to determine site-specific responses (e.g., vegetation structure and soil moisture) to climate change that may influence future wildfire potential.

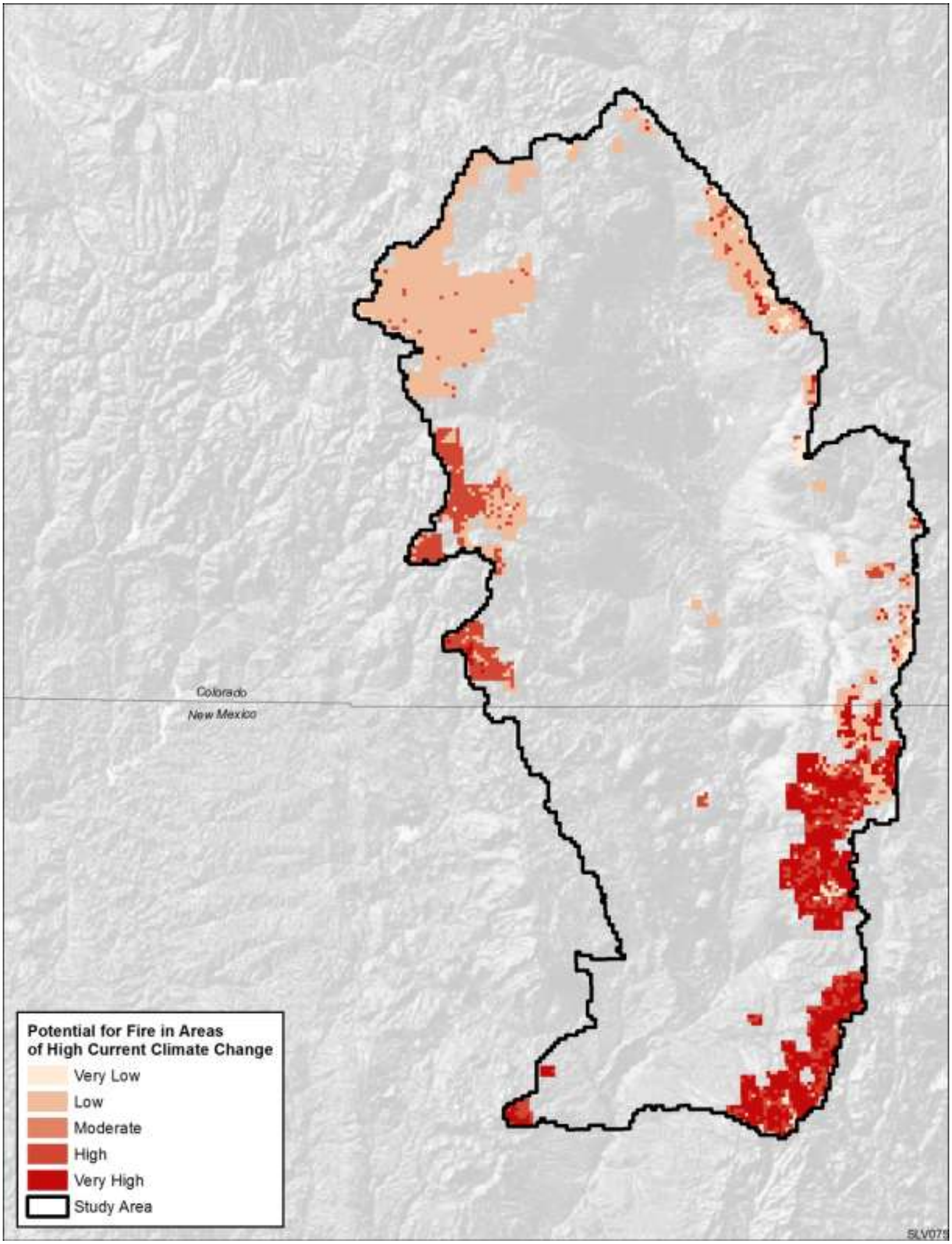


Figure 5.5-1. Coincidence of fire potential and areas with high potential for climate change (Argonne 2014).

A.5.6 MQE6: Where Might Fire Interfere with Future Human Development?

The approach to evaluate where fire is likely to affect with human development included an intersection of near-term future fire risk within areas of high potential for near-term future human development. The map results of future wildfire risk within areas of high potential future human development are shown in **Figure A.5.6-1**. These results may not necessarily reflect an association between human development and wildfire potential. Additional study is needed to determine site-specific responses (e.g., vegetation structure and soil moisture) to human development that may influence future wildfire potential.

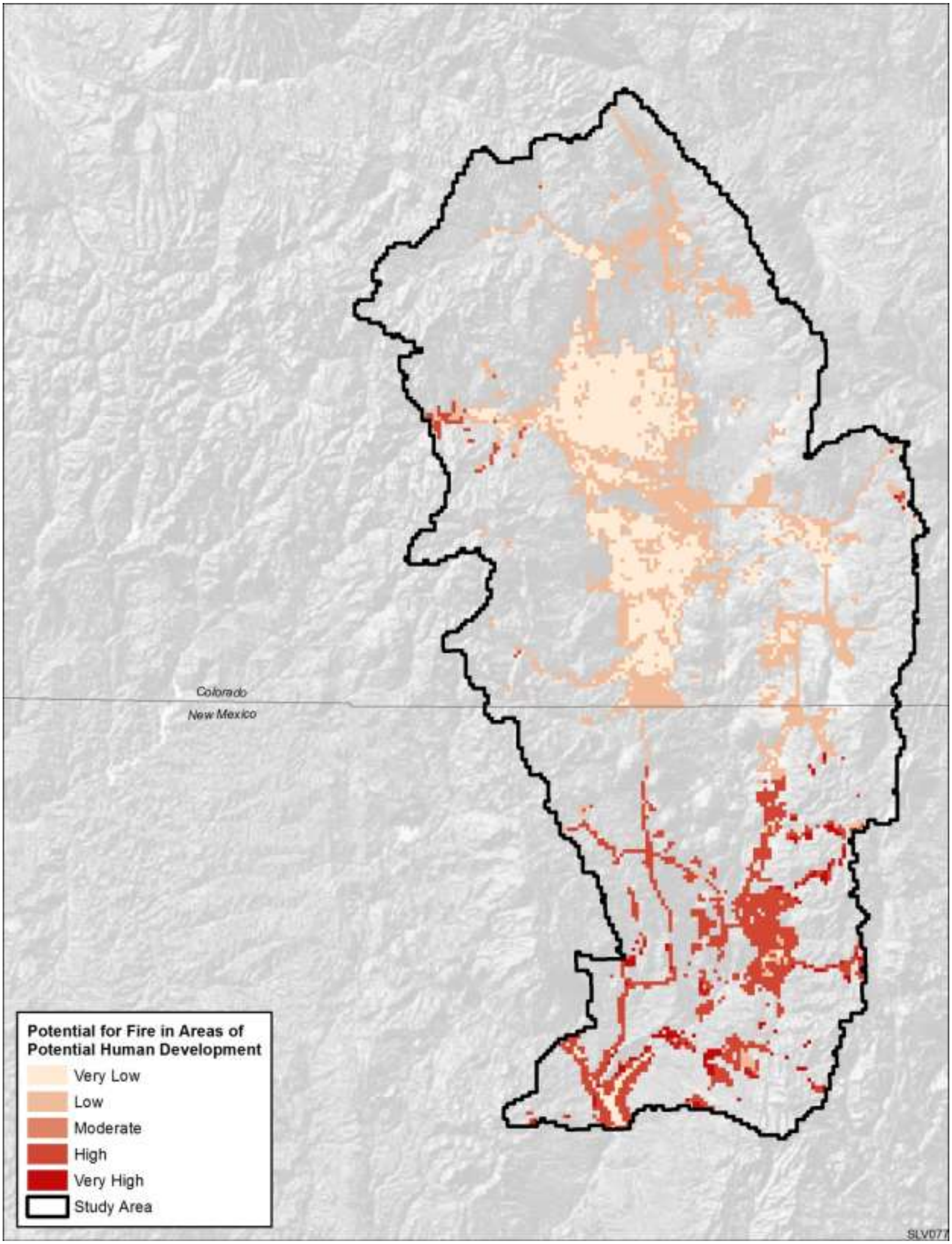


Figure 5.6-1. Potential for fire within areas of high potential for human development (Argonne 2014).

A.6 Management Questions for Invasive Species, Insects, and Disease

F. Invasive Species	
MQF1	Where are areas that invasive species occur or could potentially occur (e.g. tamarisk, Russian Olive, cheatgrass)? **See Below.**

A.6.1 MQF1: Where are Areas That Invasive Species Occur or Could Potentially Occur?

Multiple exotic and invasive species have become established in the San Luis Valley – Taos Plateau study area. Priority invasive species in the study area include the following (from USFS 2008):

- Yellow toadflax
- Russian knapweed
- Black henbane
- Cheatgrass (downy brome)
- Leafy spurge
- Oxeye daisy
- Tall and short white top
- Canada thistle
- Musk thistle
- Tamarisk
- Russian olive
- Leafy spurge
- Eurasian milfoil

Several of these species, such as cheatgrass and tamarisk, are known to alter ecosystem processes, such as fire regimes and hydrologic processes; they have the potential to expand their distribution in spite of human and natural disturbances and to adapt and shift their range in response to climate change. Invasive vegetation often out-competes native species by using soil nutrients and water at a greater rate or earlier in the season and regularly producing greater biomass (DeFalco et al. 2007).

In addition to invasive species, forest communities in the study area may become plagued by the presence of insect pests and diseases. Through the U.S. Forest Service National Forest Health Monitoring Program (USDA 2014), data have been collected on the presence of insects and disease within the National Forests. In the study area, the most common insect pests recorded within the Carson and Rio Grande National Forests include spruce beetle (*Dendroctonus rufipennis*), western spruce budworm (*Choristoneura occidentalis*), Douglas-fir beetle (*Dendroctonus pseudotsugae*), tent caterpillar (*Malacosoma spp.*), and western balsam bark beetle (*Dryocoetes confusus*). The spruce beetle has become an increasingly dominant threat to spruce communities throughout North America by causing significant high mortality in mature high-elevation spruce forests.

Accurately mapping the full distribution of major invasive vegetation species and areas of forest insect and disease infestations is challenging due to the lack of survey effort across broad regions and the difficulty in using remote sensing to develop accurate land cover classifications.
In addition, Invasive species, insects, and diseases may be difficult to detect where they are co-dominants, present in the understory, or if vegetation have not shown symptoms of insects or disease.

Invasive species, insects, and disease (IID) change agent models were developed to (1) characterize the currently-known distribution of IIDs and (2) model the near-term future potential distribution of IIDs within the San Luis Valley – Taos Plateau study area. Based on available spatial data, modeling was focused on exotic and invasive vegetation and USFS Forest Health survey locations within the Carson and Rio Grande National Forests.

A.6.1.1 Current Invasive Species, Insects, and Disease Distribution

Available spatial datasets on current invasive species, insects, and disease distributions were used to characterize the current spatial distribution of IIDs in the study area. The following five datasets were used: LANDFIRE Existing Vegetation Type (v1.2), LANDFIRE Successional Class (v1.1), SWReGAP Landcover types, vector polygons from the San Luis Valley Public Lands weed infestation inventories, and USFS Forest Health survey locations that documented the presence of forest insects and disease. To create the current distribution map, invasive vegetation classes were extracted from remote sensing datasets (e.g., LANDFIRE Existing Vegetation Types, LANDFIRE Succession Classes, and SWReGAP Landcover types). The results of remotely sensed exotic/invasive vegetation were then merged with the distribution of San Luis Valley Public Lands weed infestation inventories and the USFS Forest Health survey locations to represent the distribution of IIDs throughout the study area. These datasets likely underestimate the total distribution of IIDs, because the methodology used to create the input datasets relied mostly on remotely-sensed imagery or aerial survey and required dominance of a site by IIDs to be detectable. Where these IIDs occur as less dominant components of the vegetation community, they may expand and dominate quickly due to disturbance, land use, and climate change. The process diagram for the current invasive species distribution is shown in **Figure A.6.1.1-1**.

The result of the current invasive species, insects, and disease distribution model is shown in **Figure A.6.1.1-2**. Model results were summarized to the 1 km reporting units, where current invasive species distribution is represented by a measure of density within the reporting units symbolized along a scale from very low IID density (green) to very high IID density (red).

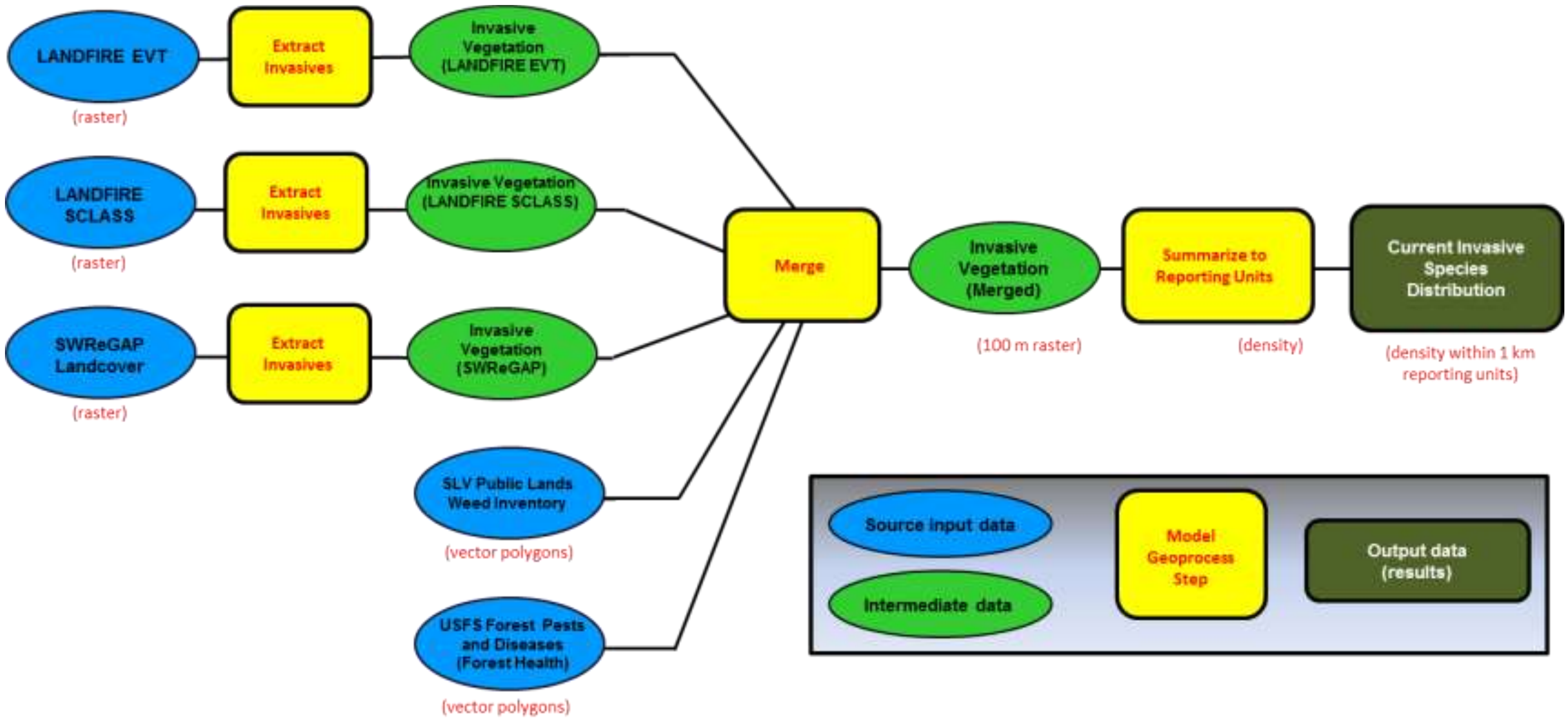


Figure A.6.1.1-1. Process model to characterize current distribution of invasive species, insects, and disease.

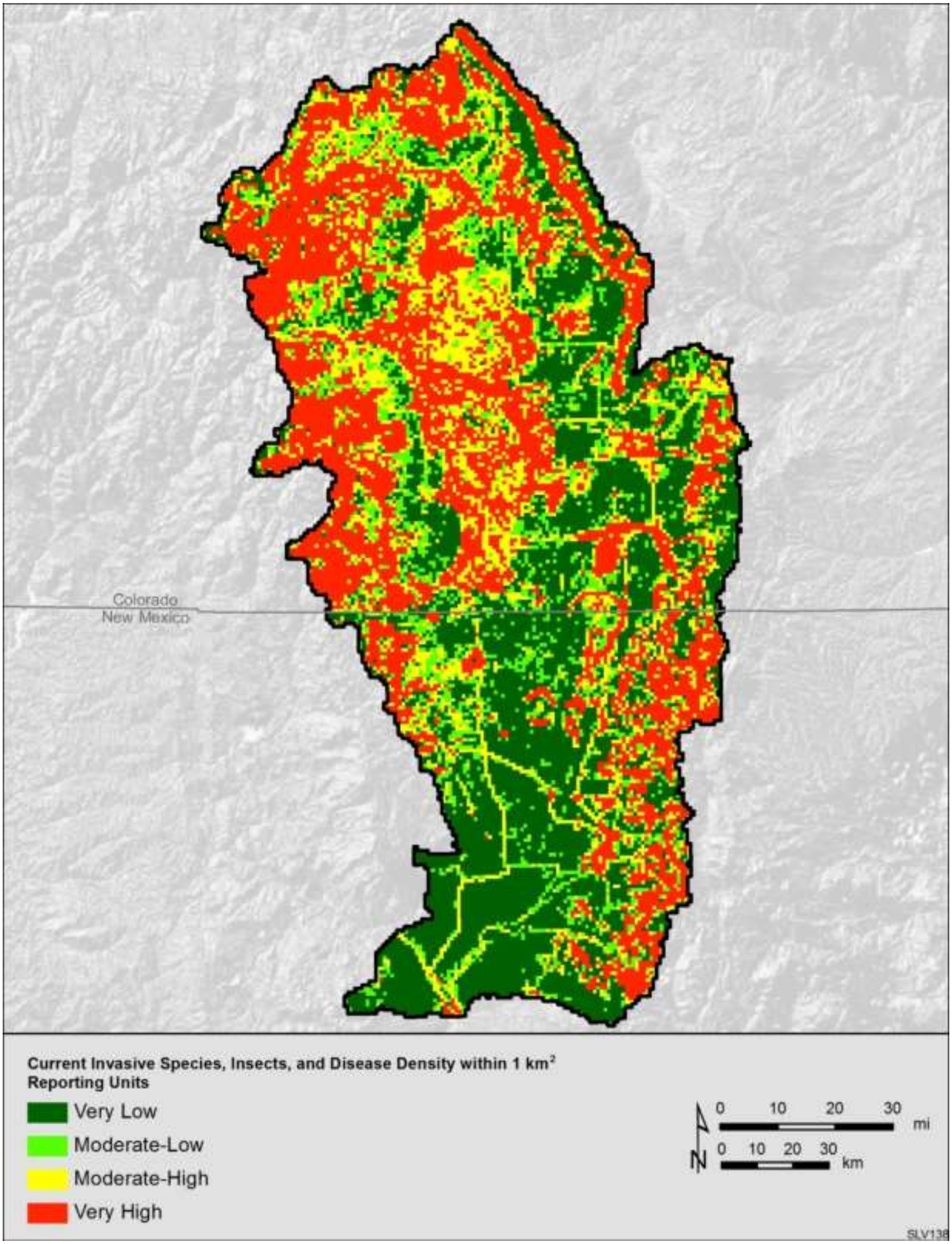


Figure A.6.1.1-2. Current distribution of invasive species, insects, and disease (IID) modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

A.6.1.2 Near-Term Future Invasive Species, Insects, and Disease Potential

The model of future risk of exotic species invasion and insect and disease infestation to forest communities followed the methodology of previous landscape modeling efforts (e.g., Leu et al. 2008). A general model was first developed to predict the potential spread of exotic species as related to proximity to anthropogenic features. For example, roads may directly promote exotic plant establishment via vehicle dispersal (Gelbard and Belnap 2003). In Californian serpentine soil ecosystems several exotic plant species were found up to 1 km from the nearest road (Gelbard and Harrison 2003), and Russian thistle (*Salsola kali*), an exotic forb growing along roads, was wind-dispersed over distances >4 km (Stallings et al. 1995). Roads may also indirectly promote exotic plant establishment via seeding along road verges or in disturbed areas near roads as a management strategy to control the establishment of less desirable exotic grass species (Evans and Young 1978). Last, human populated areas and agricultural areas (Vitousek et al. 1996) act as conduits of exotic plant invasion.

The exotic species invasion model was adopted from previous invasive species modeling approaches (e.g., Leu et al. 2008) and follows the approach used in developing the landscape intactness model. The model integrates data on the existing distribution of invasive vegetation in the study area along with data on anthropogenic features and human land uses that may facilitate the spread of invasive species. The result of the current invasive species distribution (**Figure A.6.1.1-2**) was used as input to this model.

The exotic species invasion risk model consists of a risk value along a continuum between -1 and 1, reflecting the risk of invasion. Values close to 1 imply a relatively high risk of exotic species invasion, whereas values close to -1 imply a low risk. The exotic species invasion risk model included 21 datasets from three human land use categories (transportation, urban and industrial development, and modified land cover types) (**Table A.6.1.2-1**). Each dataset was assigned to either a moderate or high exotic plant invasion risk class. Areas of greater human activity were assigned to the high risk class and areas of lower human activity were assigned to the moderate risk class. For example, urban areas and major roadways were assigned to the high risk class and unpaved roads and agricultural areas were assigned to the moderate risk class. Human land-use input data for the invasive probability model are listed in **Table A.6.1.2-1**.

Similar to the landscape intactness model, a distance decay function was applied to the input data for the exotic species invasive model to model the effect of distance away from the mapped human land-use datasets. This process involves the use of Euclidean Distance mapping tools and other geoprocesses (e.g., raster calculator) to spatially represent the functional relationship between exotic species invasion risk and distance away from human land uses. For purposes of modeling the exotic species invasion risk, two different linear distance decay functions were applied: one for land-uses with high risk of invasion and one for land-uses with moderate risk of invasion (**Figure A.6.1.2-1**). A maximum distance of 1.5 km was applied as the maximum distance at which human land-uses influence the risk of invasion.

Integrating the mapped distance decay results for all human land uses, the resulting exotic species invasion risk model is a map surface indicating relative risk of invasion across the study area.

It was assumed that the current distribution of forest insects and diseases would also be a suitable predictor of their future distribution. Therefore, the USFS Forest Health survey areas were integrated into the final future exotic species invasion risk model to illustrate the predicted future distribution of invasive species, insects, and disease (**Figure A.6.1.2-2**). The current and potential future distributions of invasive species, insects, and disease were characterized by categorizing current densities and future risk of invasion into 4 ordinal classes (very low, moderate-low, moderate-high, very high).

Table A.6.1.2-1. Future Exotic Species Invasion Risk Model Input Human Land-Use Data and Risk Classes for the San Luis Valley – Taos Plateau Landscape Assessment.[1]

Human Land Use or Impact Factor	Risk Class[2]	Risk Value[3]
Transportation		
Dirt roads, OHV trails	Moderate	0.6
Local roads	High	0.95
Primary highways	High	0.95
Urban and Industrial Development		
Low density development (including rural development)	Moderate	0.6
Medium density development	High	0.95
High density development	High	0.95
Communication Towers	Moderate	0.6
Powerlines / transmission lines	Moderate	0.6
Mines and oil/gas well pad locations	Moderate	0.6
Urban Polygons (BLM and U.S. Census Bureau)	High	0.95
High Impervious Surfaces (NLCD Imperv > 40)	High	0.95
Urban Lights (NASA Night Lights > 200)	High	0.95
Wildland-Urban Interface (WUI)	High	0.95
Urban Development Risk – High and Moderate Risk	High	0.95
Urban Development Risk – Low Risk	Moderate	0.6
Potential for Solar Development (SEZs)	High	0.95
Managed and Modified Land Cover		
Low agriculture and invasives (ruderal forest, recently burned, recently logged, etc)	Moderate	0.6
Pasture (landcover)	Moderate	0.6
Grazing allotments with degraded habitat quality	Moderate	0.6
Introduced vegetation	High	0.95
Cultivated agriculture	Moderate	0.6

1 Modeling approach adopted from Leu et al. (2008).

2 Two risk classes considered (moderate and high). Risk was considered “high” in areas of more intense human activity. Risk was considered “moderate” in areas of lower human activity.

3 The risk value was determined based on risk class (“high” = 0.95, “moderate” = 0.6). These risk values were used to parameterize the model.

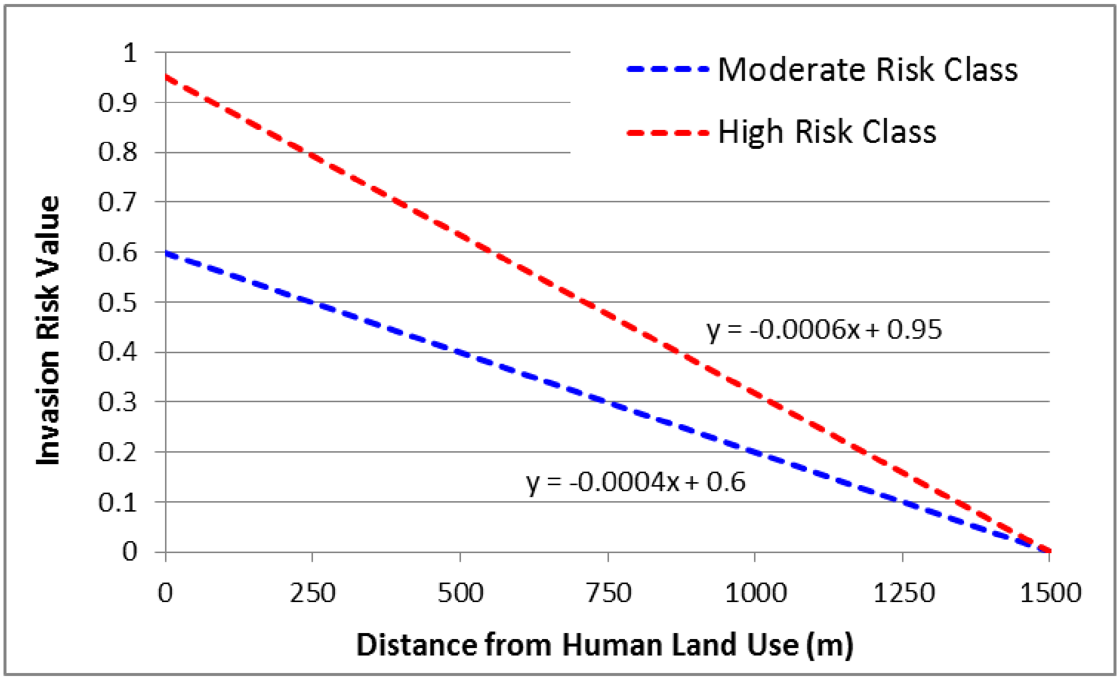


Figure A.6.1.2-1. Distance decay functions for human land use datasets categorized by moderate risk classes and high risk classes to develop the future exotic species invasion risk model.

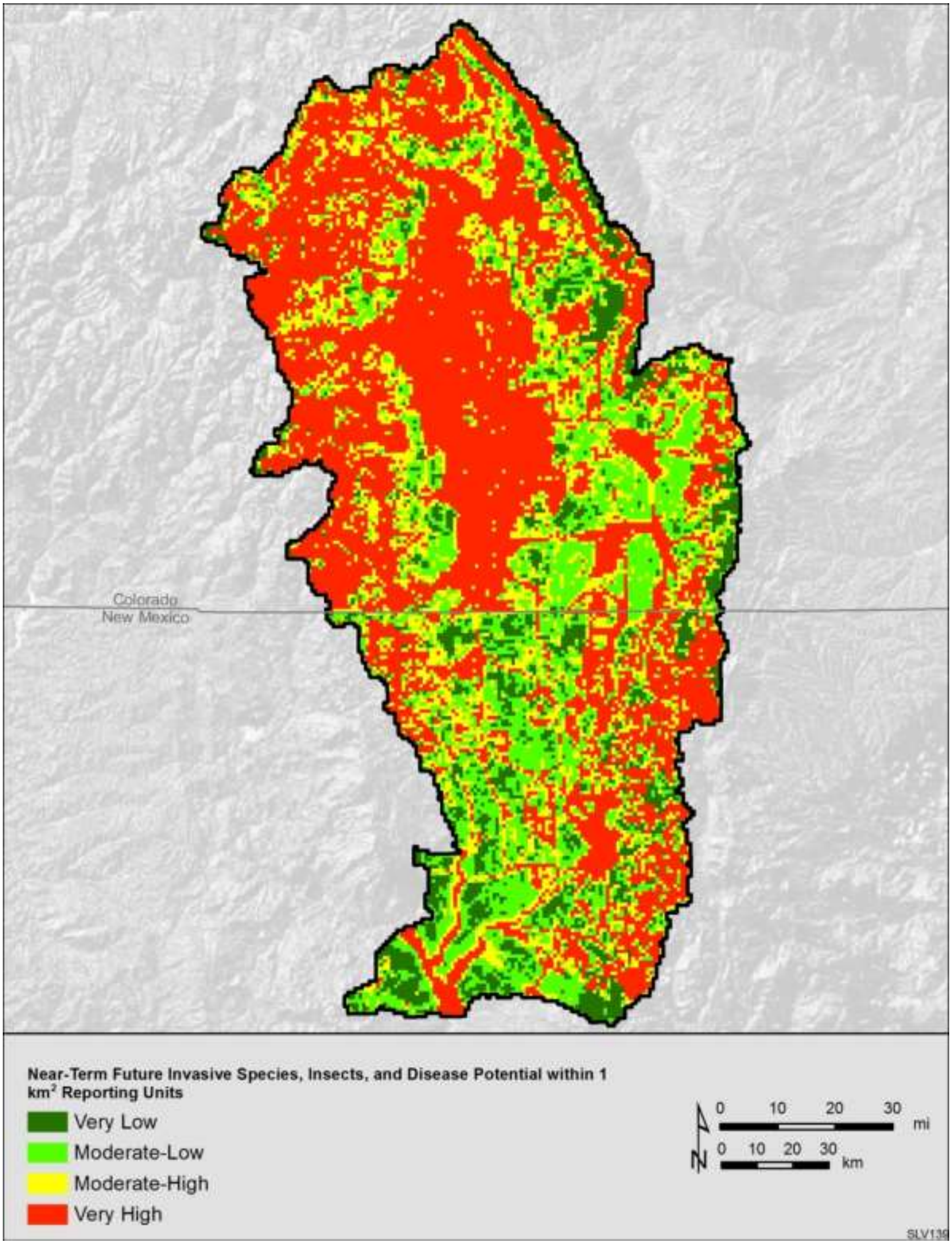


Figure A.6.1.2-2. Near-term future distribution of invasive species, insects, and disease (IID) modeled for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

A.7 Management Questions for Human Development and Resource Use

G. Human Development and Resource Use	
MQG1	Where are linear recreation features such as OHV roads and trails? **See Below.**
MQG2	Where are Special Recreation Permits (SRPs) and permitted uses such as grazing and wood gathering? **See Below.**
MQG3	Where are the locations of irrigated lands **See Below.**
MQG4	Where are high-use recreation areas, (High Intensity Recreation Areas (HIRA's) SRMAs, National Parks, etc)? **See Below.**
MQG5	Where are areas of current and planned development (e.g., plans of operation, urban growth, wildland-urban interface, energy development, mining, transmission corridors, governmental planning)? **See Below.**
MQG6	Where are federally owned water rights that are adjudicated for wildlife and irrigation? **See Below.**
MQG7	Where are areas of potential future development (e.g., under lease), including renewable energy sites and transmission corridors? **See Below.**
MQG8	Where are areas of potential human land use change (e.g., agricultural fallowing)? **Data not available at time of assessment.** **This MQ has been identified as a potential information gap for future study.**
MQG9	What are the conditions and locations of surface and groundwater rights? **See Below.**
MQG10	Where are current conservation efforts prohibiting human development? **See Below.**
MQG11	Where is the acoustic environment affected by human development? **Data not available at time of assessment. This MQ has been identified as a potential information gap for future study.**

A.7.1 MQG1: Where are Linear Recreation Features Such as OHV Roads and Trails?

Roads datasets provided by BLM and the U.S. Census Bureau (http://www.census.gov/) were merged together and queried for attributes such as vehicular trails, walkways, pedestrian trails, ATV, authorized use, foot only, foot/horse, motorized single track, mechanized trail, basic custodial care, and high clearance vehicles (**Figure A.7.1-1**).

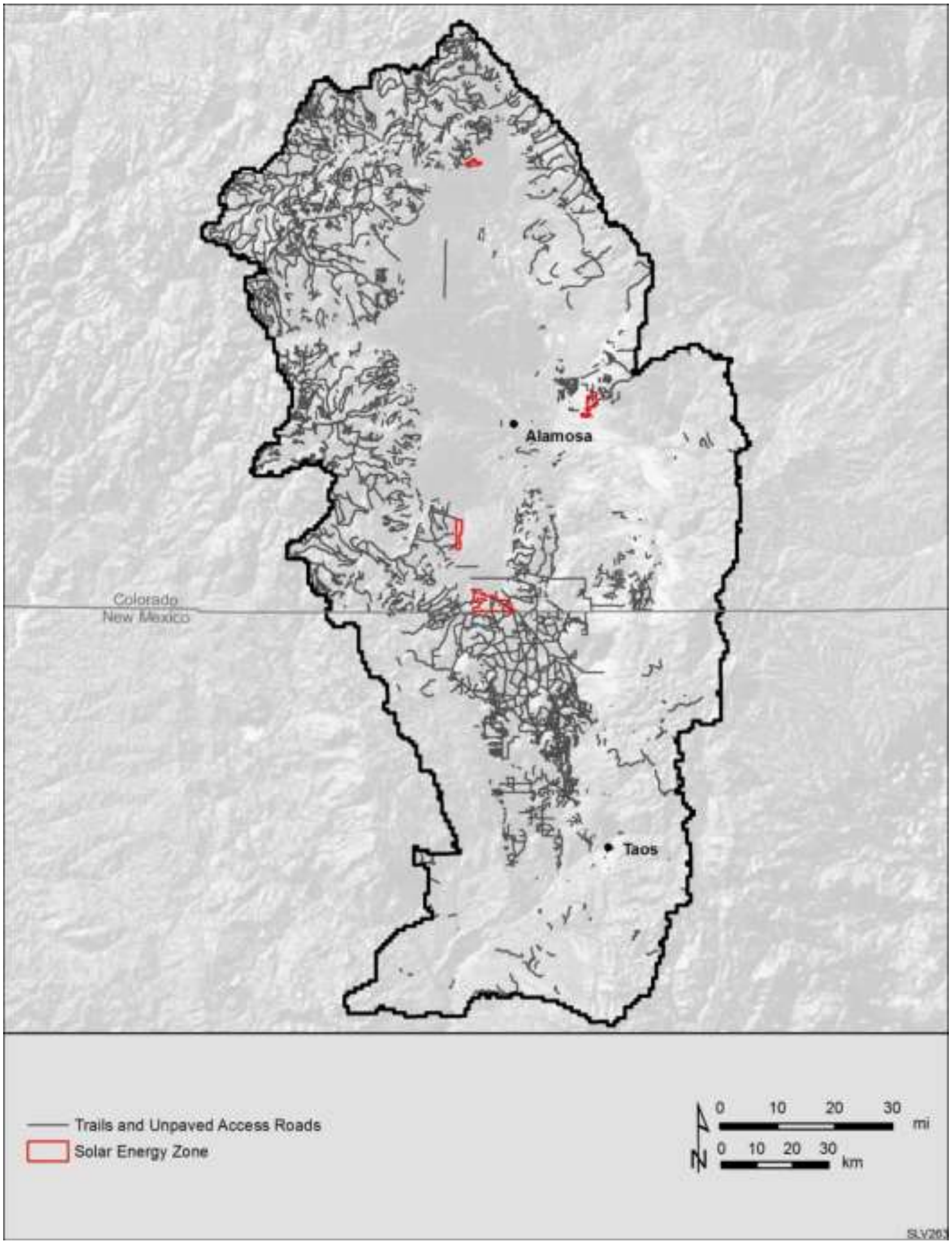


Figure A.7.1-1. Trails and Unpaved Access Roads. Data Sources: data received from BLM and USCB 2013.

A.7.2 MQG2: Where are Special Recreation Permits (SRPs) and permitted uses such as grazing and wood gathering?

Permitted uses in the study area such as grazing allotments and wood processors and users locations are displayed in **Figure A.7.2-1**.

Wood Processors and Users (NM only) - This map was developed by Forest Guild in coordination with ForestERA (www.forestera.nau.edu) for use in landscape-level planning and prioritization of forest management across a 3.4 million-acre study area in the North-central New Mexico LA area. This map is intended to help develop the small-wood based industry generated from forest restoration or hazardous fuels reduction projects by increasing the knowledge and awareness of where these business are located and what production capabilities or specialties they have in relation to forest resources.

These data depict point locations of wood related businesses that currently or potentially use wood from public and private forested land within 60 miles of the North-Central New Mexico LA boundary [ForestERA (www.forestera.nau.edu)]. This map is based on a source map developed by USDA FS Region 3 titled "Infrastructure Interest in the Southwestern Region, May 2005". Forest Guild took the source map data and implemented a search for additional businesses that utilize or process local wood. This work was acquired by the Forest Ecosystem Restoration Analysis (ForestERA) project for use in the North-central New Mexico Landscape Assessment. The study area for this project encompasses approximately 3.4 million acres. The area is a diverse landscape that includes grassland and sagebrush, ponderosa pine, mixed conifer, spruce-fir, and tundra vegetation types. The study area includes the southern Sangre de Cristo Mountains and elevations ranging from 5,000 - 13,000 feet. Land managers include eight northern Pueblos, the Carson and Santa Fe National Forests, private land owners, state lands departments, and the Bureau of Land Management. The area also includes portions of six counties and extends from the Colorado-New Mexico border south to Interstate 25.

BLM Grazing Allotments - This feature class contains BLM Grazing Allotments for the States of Colorado and New Mexico. Data were compiled from grazing allotment information maintained at the field office level.

USFS Grazing Allotments - This dataset was created by merging together the regional range allotment dataset for USFS Region 2 and the range pastures and exclosures on Carson National Forest.

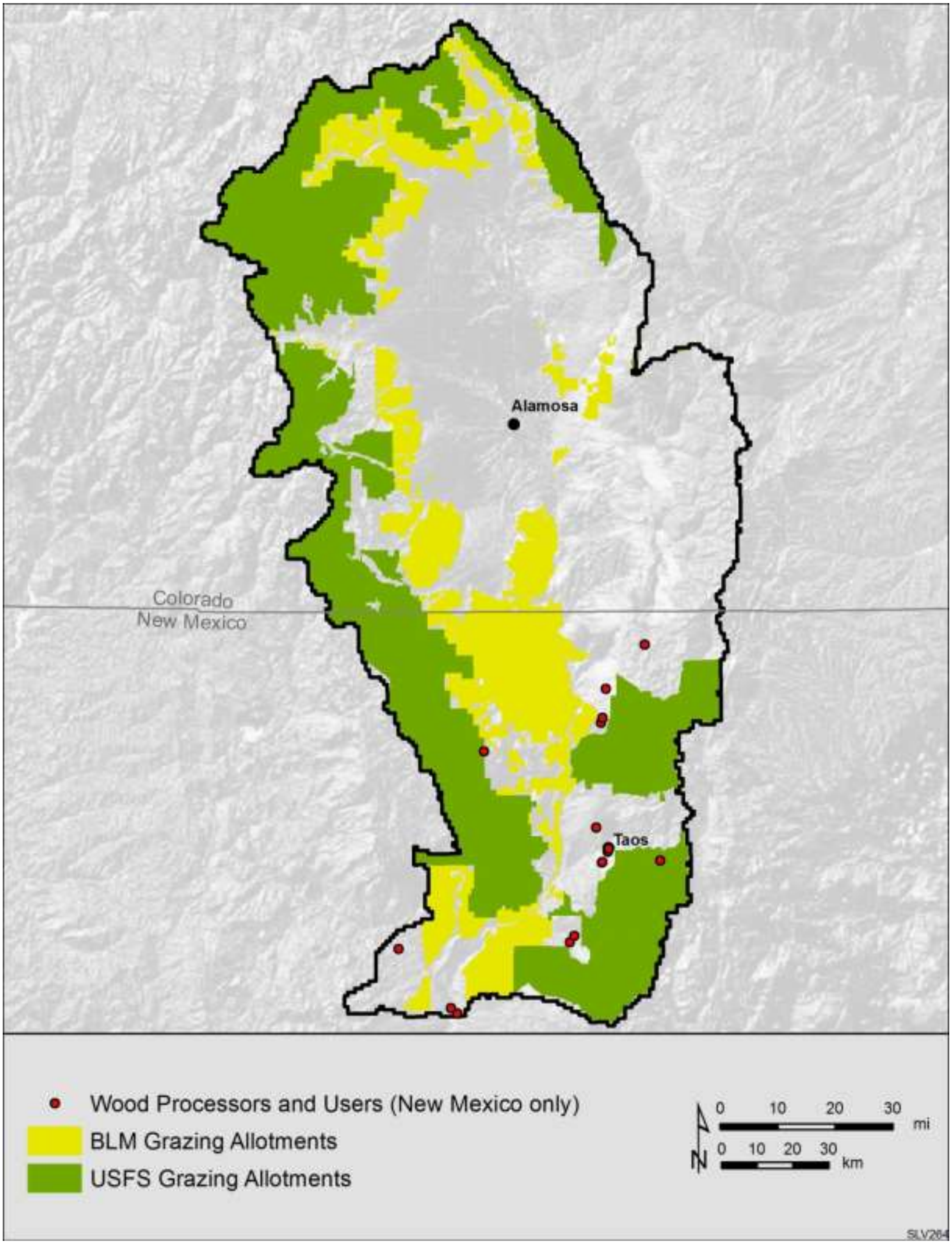


Figure A.7.2-1. Permitted Uses. Data Sources: Krasilovsky and Melton 2006, data received from BLM, and USFS 2006, 2008.

A.7.3 MQG3: Where are the locations of irrigated lands?

Irrigated lands were determined by querying LANDFIRE Existing Vegetation Type for 'Agriculture' and combining it with Colorado DWR's Irrigated Parcels from 2010 (**Figure A.7.3-1**). The Colorado DWR Irrigated Parcels were provided by BLM.

LANDFIRE Existing Vegetation Type - The LANDFIRE existing vegetation layers describe the following elements of existing vegetation for each LANDFIRE mapping zone: existing vegetation type, existing vegetation canopy cover, and existing vegetation height.

Irrigated Parcels (Colorado DWR) – A spatial and informational database of irrigated parcels in the San Luis Valley during the 2010 growing season in support of the Rio Grande DSS.

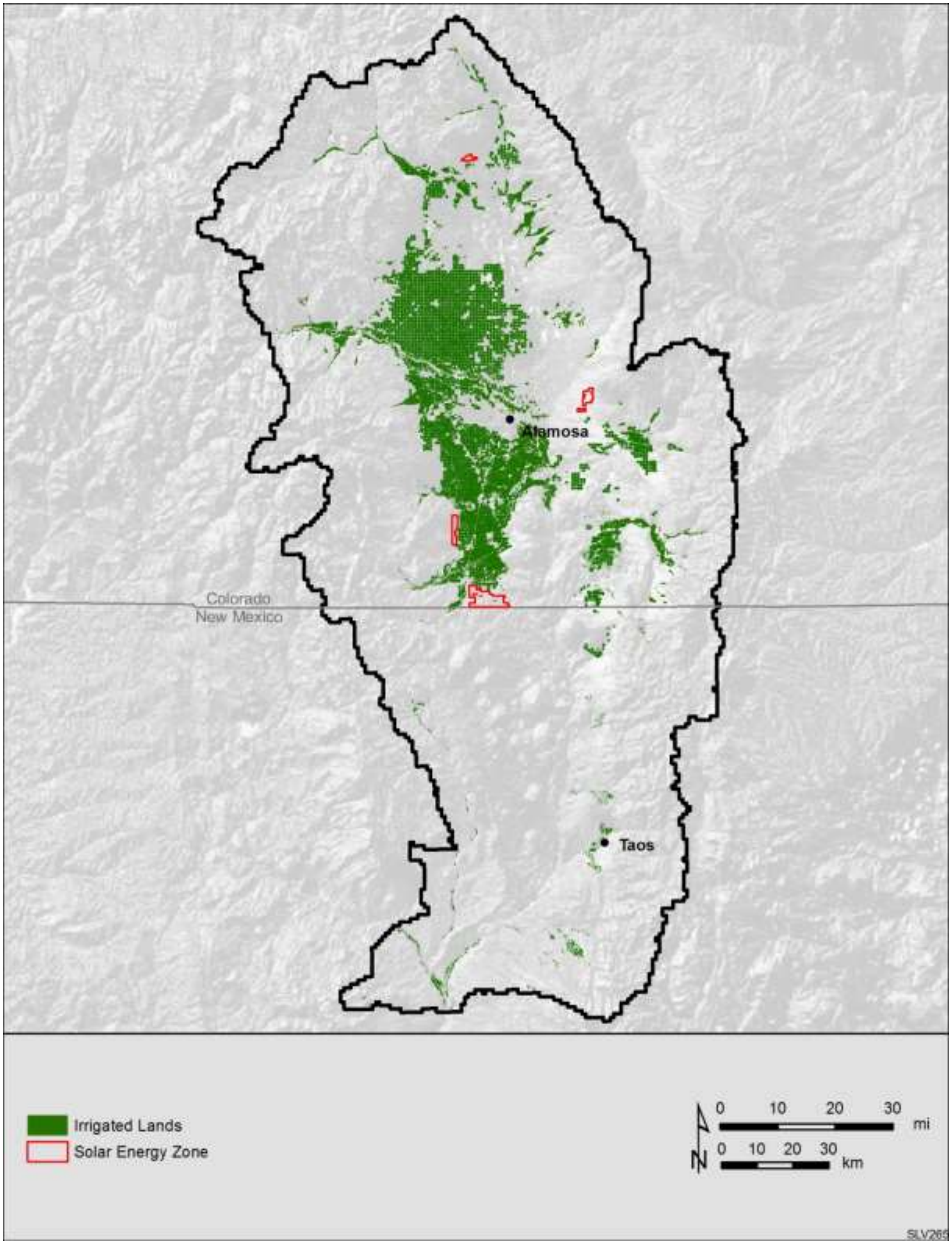


Figure A.7.3-1. Irrigated Lands. Data Sources: CDWR 2010 and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).

A.7.4 MQG4: Where are high-use recreation areas, (High Intensity Recreation Areas (HIRA's) SRMAs, National Parks, etc)?

High-use recreation areas were determined from Special Recreation Management Areas (SRMAs), national parks, and recreation areas on the Rio Grande National Forest (**Figure A.7.4-1**).

SRMAs (BLM) - This dataset represents the official agency record of the boundaries of the Special Recreation Management Areas. Data were manually compiled onto 7.5' quads by the GSFO Resource Specialist from field maps. Data was generated from existing digital sources. Boundaries were snapped to Land Status and GCDB and, where applicable, major rivers. All data were verified for positional accuracy and labeled by a data steward.

Great Sand Dunes National Park – The boundary of the Great Sand Dunes National Park was extracted from the Surface Management Agency dataset (maintained by NOC, BLM, DOI). This "Surface Management Agency" data layer portrays tracts of federal land for the United States and classifies these holdings by administrative agency. Multiple federal agencies have contributed to the contents of this layer and it is in a continuous state of update. This feature class contains BLM Grazing Allotments for the States of Colorado and New Mexico. Data were compiled from grazing allotment information maintained at the field office level.

Recreation areas on the Rio Grande National Forest (USFS) - This dataset is a polygon layer of developed recreation areas on the Rio Grande National Forest.

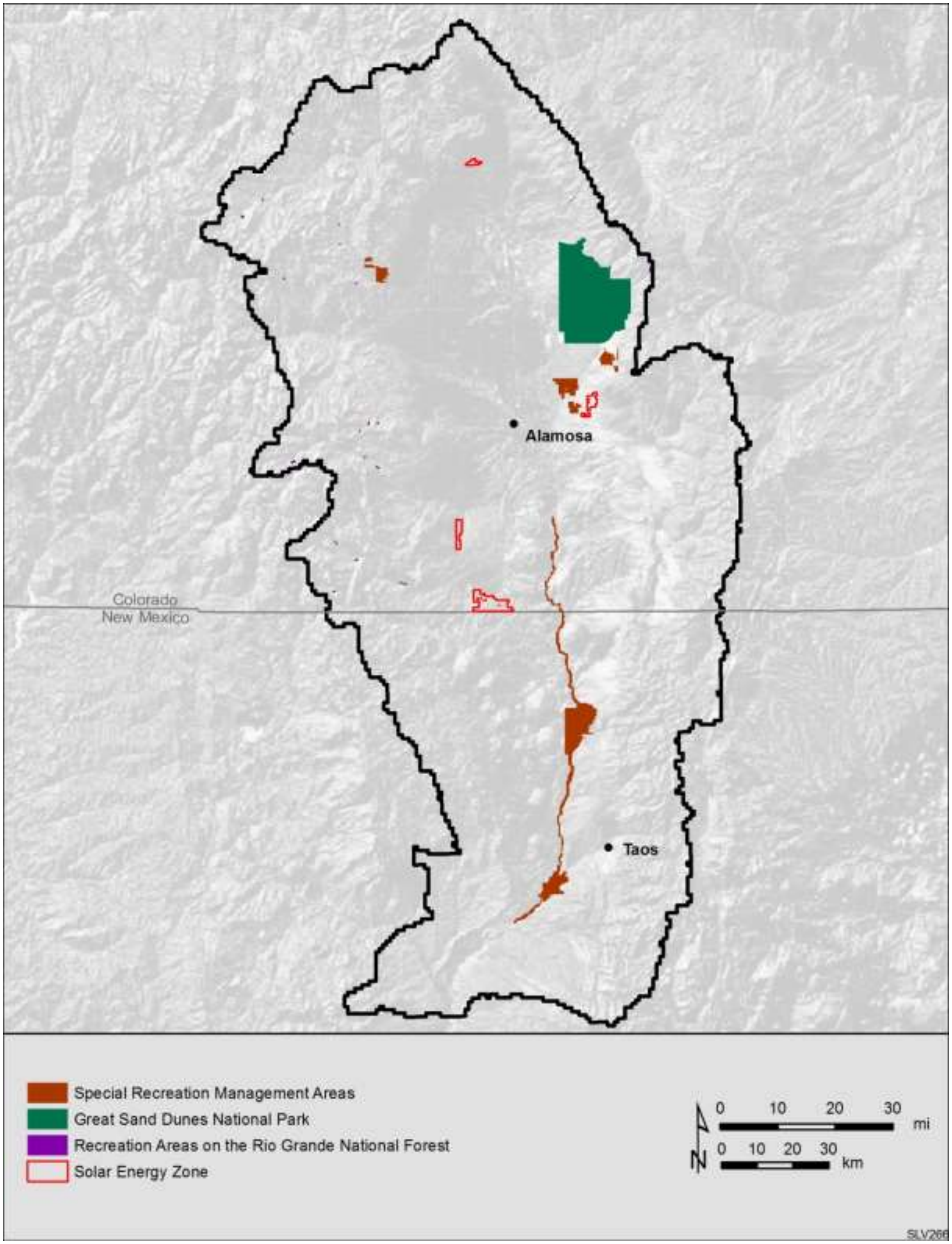


Figure A.7.4-1. High-Use Recreation Areas. Data Sources: BLM 2009, 2013 and USFS 2005.

A.7.5 MQG5: Where are areas of current and planned development (e.g., plans of operation, urban growth, wildland-urban interface, energy development, mining, transmission corridors, governmental planning)?

This dataset provides an estimate of human development intensity in the San Luis Valley - Taos Plateau study area (**Figure A.7.5-1**). It is the result of a fuzzy model that integrates numerous human land use datasets along an intensity index. Input datatsets include roads, urban areas, agriculture, grazing, NASA city lights, and NLCD impervious surfaces. The attribute **DEV_C_FZ** is used to symbolize current human development intensity. This model is identical to the current ecological landscape intactness model. Please refer to landscape intactness model documentation for details on model development.

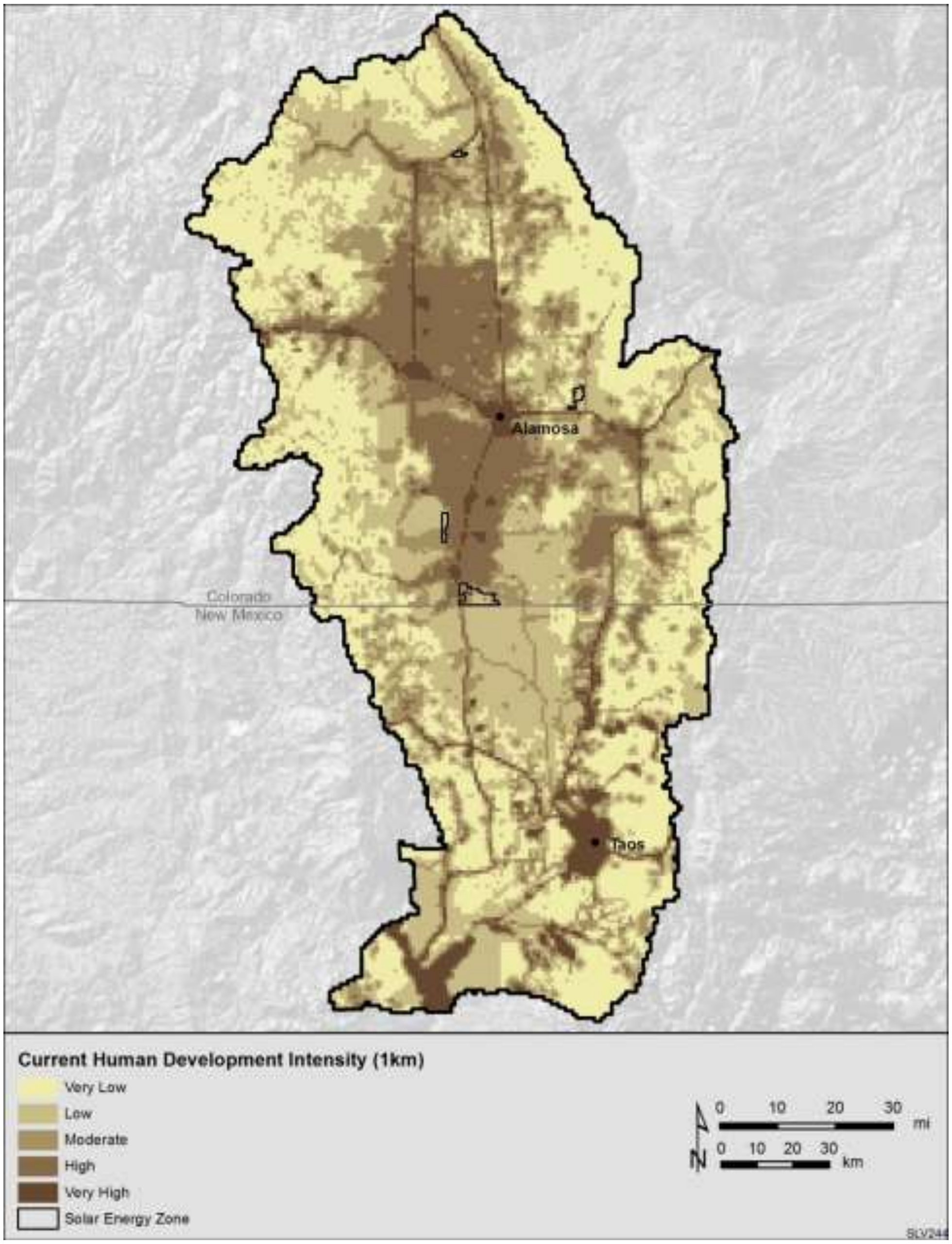


Figure A.7.5-1. Current Human Development Intensity (Argonne 2014).

A.7.6 MQG6: Where are federally owned water rights that are adjudicated for wildlife and irrigation?

Datasets:

- **Well Permits (CDWR)-** Well permits in Colorado as of 11/5/13 (http://water.state.co.us/Home/Pages/default.aspx).
- **NM Wells (Forest Ecosystem Restoration Analysis Project)-** These data depict wells in New Mexico. These data are a subset of well information provided by the Office of the State Engineer from their internet Waters Administration Technicial Engineering Resource System (iW.A.T.E.R.S.) database. More information can be found online http://www.ose.state.nm.us/waters_db_index.html.

Water rights that are adjudicated for wildlife and irrigation were mapped by merging together CDWR well permits and Forest Ecosystem Restoration Analysis Project New Mexico wells and querying for use (Irrigation, stock, or wildlife) (**Figure A.7.6-1**). Based upon inconsistencies in the data across states, it was not possible to identify federally-owned water rights in both states.

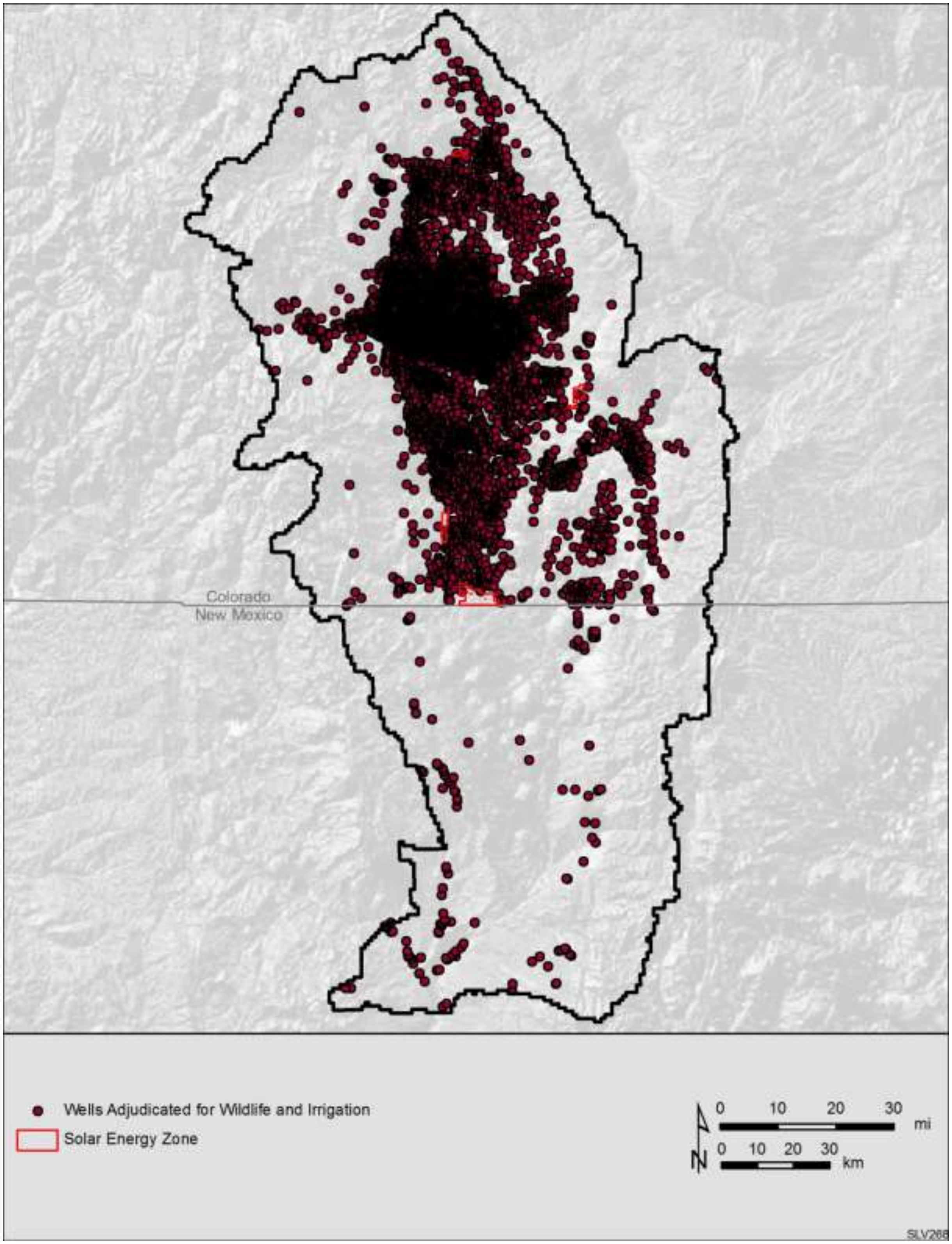


Figure A.7.6-1. Wells adjudicated for Wildlife and Irrigation. Data Sources: data received from BLM and ForestERA 2006.

A.7.7 MQG7: Where are areas of potential future development (e.g., under lease), including renewable energy sites and transmission corridors?

Areas of Potential Future Development (**Figure A.7.7-1**) were determined from the Solar Energy Zones boundaries, querying the Wild Urban Interface dataset for 'WUIFLAG10 = 1 or 2', querying the Development Risk dataset for Value = 1, 2, or 3, and querying the oil and gas potential dataset for Value>15.

Solar Energy Zones (Argonne National Laboratory) - This dataset identifies areas available for utility-scale solar energy development under the Record of Decision (ROD) for the Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States (Solar PEIS) (BLM 2012). Spatial data for the SEZs were obtained from the BLM's Solar Energy Program website (http://solareis.anl.gov/maps/index.cfm).

Wild Urban Interface (USDA Forest Service Northern Research Station) - Provides a spatially detailed national assessment of the Wildland Urban Interface (WUI) across the coterminous U.S. to support wildland fire research, policy and management, and inquiries into the effects of housing growth on the environment. The WUI is the area where houses meet or intermingle with undeveloped wildland vegetation. This makes the WUI a focal area for human-environment conflicts such as wildland fires, habitat fragmentation, invasive species, and biodiversity decline. Using geographic information systems (GIS), we integrated U.S. Census and USGS National Land Cover Data, to map the Federal Register definition of WUI (Federal Register 66:751, 2001). These data are useful within a GIS for mapping and analysis at national, state, and local levels. Community Wildfire Protection Plans (CWPPs) also have defined boundaries that could be different than the mapped WUIs provided by the U.S. Forest Service.

Development Risk (from Theobald [2007])- The development risk data layer is intended to emphasize areas that are projected to experience increased housing development in the next 30 years. This raster dataset is the result of a modeling process to depict housing density for the coterminous US in 2000 and 2030, based on 2000 US Census Bureau block (SF1) datasets. Housing density values are on a scale of 0-10 with values near zero representing little development risk and values near 10 representing greater development risk.

Oil and Gas Potential (Copeland, H., K. Doherty, D. Naugle, A. Pocewicz, J. Kiesecker, 2010) - Estimates landscape scale relative oil and gas potential in the Intermountain West from Copeland et al. (2010). This is the dataset for oil and gas potential in the US Intermountain West.

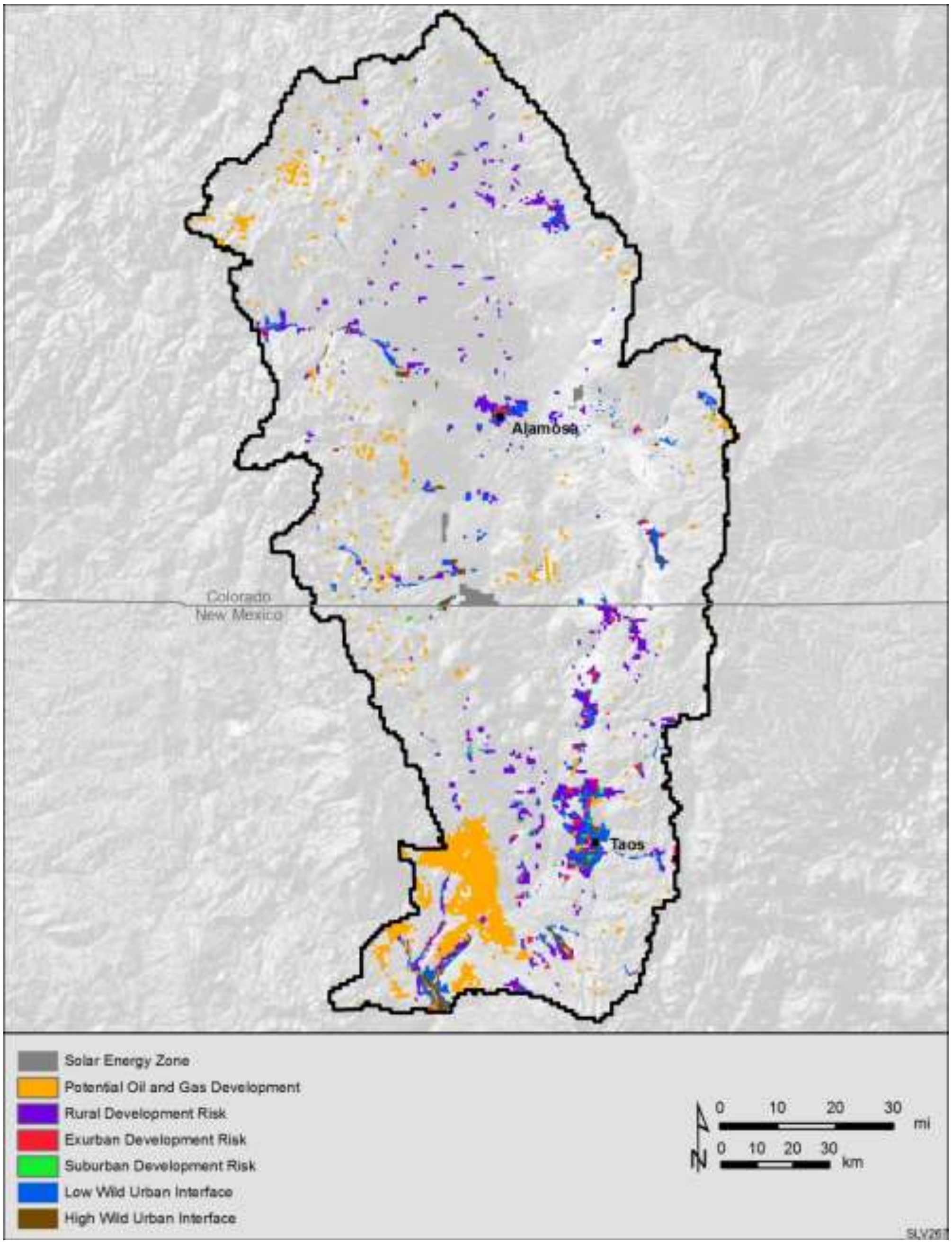


Figure A.7.7-1. Areas of Potential Future Development. Data Sources: BLM 2012, USFS 2010, Theobald (2007), and Copeland et al. (2010).

A.7.8 MQG9: What are the conditions and locations of surface and groundwater rights?

<u>Datasets:</u>

- **Well Permits (CDWR)-** Well permits in Colorado as of 11/5/13 (http://water.state.co.us/Home/Pages/default.aspx).
- **NM Wells (Forest Ecosystem Restoration Analysis Project)-** These data depict wells in New Mexico. These data are a subset of well information provided by the Office of the State Engineer from their internet Waters Administration Technicial Engineering Resource System (iW.A.T.E.R.S.) database. More information can be found online http://www.ose.state.nm.us/waters_db_index.html.

Well locations were mapped by merging together CDWR well permits and Forest Ecosystem Restoration Analysis Project New Mexico wells (**Figure A.7.8-1**). Due to inconsistencies in data across states, it was not possible to identify groundwater rights for all locations.

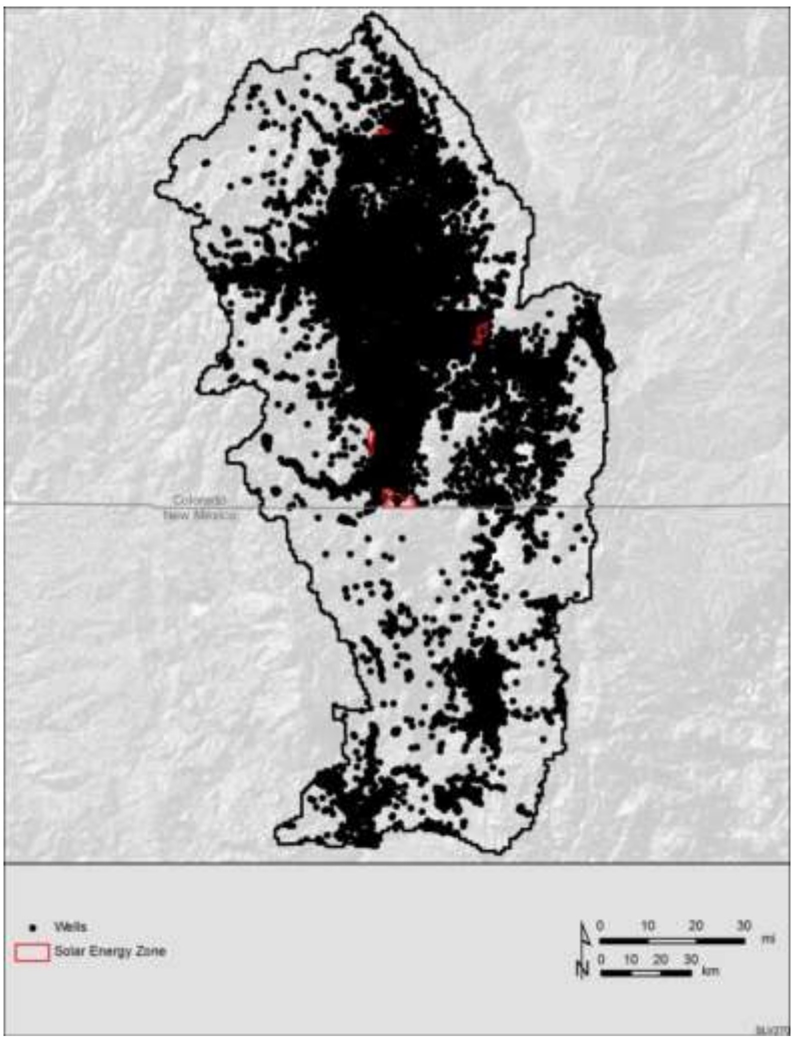


Figure A.7.8-1. Locations of Groundwater Rights. Data Sources: data received from BLM and ForestERA 2006.

A.7.9 MQG10: Where are current conservation efforts prohibiting human development?

Datasets:

- **National Conservation Easement Database (www.http://conservationeasement.us/).**

- **Data provided by BLM:** (1) Trinchera Easement, (2) Blanca Easement, (3) Sangre de Cristo Conservation Area, (4) Easements on private land, (5) and other conservation easements not found in the National Conservation Easement Database.

Current conservation efforts prohibiting human development were mapped by merging together the National Conservation Easement Database (NCED), Trinchera Easement, Blanca Easement, Sangre DeCristo Conservation Area, Easements on private land, and other conservation easements (not found in NCED) (**Figure A.7.9-1**).

NCED - NCED shows a comprehensive picture of privately owned conservation easement lands in the U.S. The NCED will allow better strategic planning for conservation and development by merging data on land protection with biodiversity and resources, improving ecological and economic plans and investments. State and regional planners and managers will appreciate this dataset as it provides critical contextual information for their work. Institutions responsible for national and international reporting will find this database full of reliable, accurate information for their purposes. The scientific and conservation community will similarly benefit from having this standardized base map to carry out their research and planning objectives.

Easements on Private Land (CSU)- Colorado Ownership, Management and Protection is a comprehensive dataset of land ownership and management. This version contains data from Federal agencies, State agencies, The Nature Conservancy, city and county sources and land trust sources. Data was collected from multiple sources and processed into one complete layer.

Provided by BLM: Trinchera Easement, Blanca Easement, Sangre De Cristo Conservation Area, and Easements (not found in NCED).

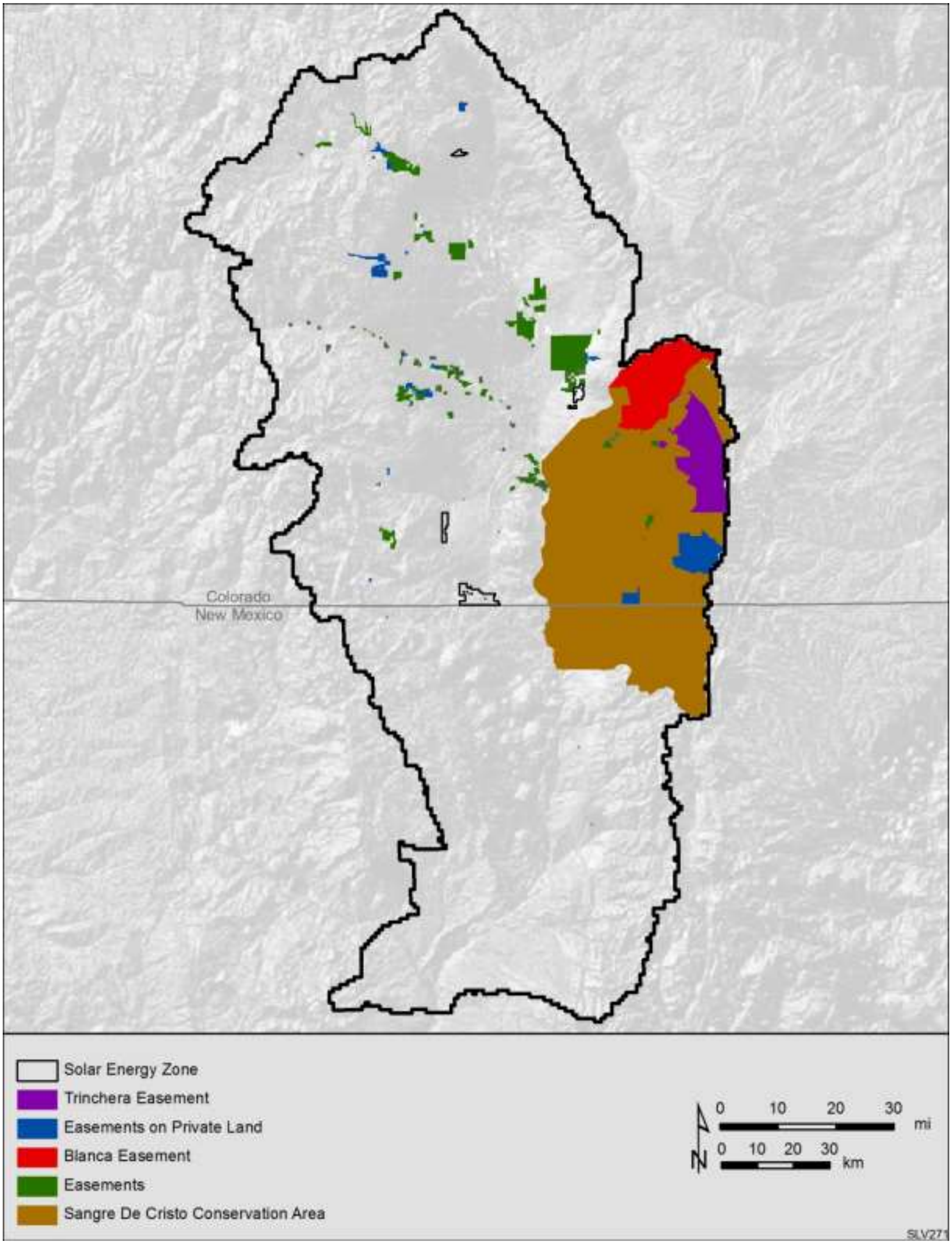


Figure A.7.9-1. Current Conservation Efforts Prohibiting Human Development. Data Sources: data received from BLM and NCED 2013.

A.8 Management Questions Related to Climate Change

H. Climate Change	
MQH1	Where are areas with greatest long-term potential for climate change? **See Below.**
MQH2	Where have conservation elements experienced climate change and where are conservation elements vulnerable to future climate change? **Refer to Appendix B.**

A.8.1 MQH1: Where are Areas with Greatest Long-term Potential for Climate Change?

There has been unequivocal warming of the Earth's climate since the 1950s, as observed in the warming of the Earth's atmosphere and oceans, diminishing snow and ice, and sea level rise. In the Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (IPPC 2014) concluded that it is extremely likely that most of the observed changes in the Earth's climate since 1950 was caused by human activities (e.g., increases in greenhouse gas emissions). There have been several studies that have examined bioclimatic effects of climate change in predicting landscape-level changes in the distribution of vegetation communities and animal species in response to climate change (e.g., USFS 2012; van Riper et al. 2014). For example, the U.S. Forest Service (2012) estimated that, by the end of this century, approximately 55% of future landscapes in the western U.S. will likely have climates that are incompatible with current vegetation types on those landscapes.

Warming trends have been observed in the states of Colorado and New Mexico over the past 50 years. For example, annual average temperatures in the state of Colorado have increased by 2.0°F over the past 30 years and 2.5°F over the past 50 years (Lukas et al. 2014). Climate model projections indicate that these temperature increases are likely to continue into the future. This projected future warming trend is expected to result in more frequent heat waves, droughts and wildfires will increase in frequency and severity in Colorado by the mid-21st century. State-wide in Colorado, average annual temperatures are projected to warm by +2.5°F to +5°F by 2050 relative to a 1971–2000 baseline under a medium-low emissions scenario (RCP 4.5). Summer temperatures are projected to warm slightly more than winter temperatures by 2050 (Lukas et al. 2014).

Climate change models used in various assessments and applications involve the downscaling of mathematical atmospheric general circulation models (GCMs) coupled with simulations of local/regional climate characteristics. Such climate models have been developed for the western United States (including this LA study area) to predict the implications of future climate change, including but not limited to:

- The role of climate change in the future range of reptiles and bird species (van Riper et al. 2014).
- The role of climate change in mountain snowmelt timing and volume with implications for water demand and availability in the Upper Rio Grande Basin (Lukas et al. 2014; Elias et al. 2015).

Current departure from historic climate conditions (referred to as "current climate change") and potential for future climate change were based on an evaluation of seasonal changes in precipitation and temperature. Data from the PRISM Climate Group (http://www.prism.oregonstate.edu/) were used to characterize the historic and current climate of the Western United States (historic period: 1905-1934; current period: 1981-2010). Current climate change was evaluated by calculating the absolute difference between current and historic seasonal temperature and precipitation values. PRISM mean monthly precipitation and temperature values correspond to mean monthly values provided in the IPCC (International

Panel on Climate Change) AR4 GCM simulation results. Therefore, an ensemble average of IPCC A1B emission scenarios was to characterize long-term future climatic conditions (2040–2069). Results of the IPCC A1B scenarios were statistically downscaled to a 2.5-minute grid (approximately 4-km grid), as described by Garfin and others (2010). PRISM data were obtained from the PRISM Climate Group at Oregon State University (http://prism.oregonstate.edu/). Results for the A1B scenario were obtained from The National Center for Atmospheric Research Community Climate System Model (https://gisclimatechange.ucar.edu/). The approach to characterize current and future climate change in this assessment provides a framework to evaluate regional climate trajectories in the future as climate models are reviewed and updated.

The process models describing the geospatial characterization of current and future climate change are shown in **Figures A.8.1-1 and A.8.1-2**, respectively. The process involves the calculation of absolute differences in seasonal precipitation and temperature. The resulting absolute differences were then summarized to 1 km^2 reporting units (average) and normalized along a scale of -1 to 1 based on minimum and maximum thresholds. Values closest to -1 correspond to areas with relatively less change in temperature or precipitation, whereas values closest to 1 correspond to areas with relatively greater change in temperature or precipitation. A single operation was then applied to determine the minimum of all normalized values at each 1 km^2 reporting unit, which resulted in a single overall measure of current climate change. For final map reporting, results were categorized based on equal intervals of normalized climate change values within reporting units within five categories ranging from very low climate change potential to very high climate change potential. The future climate change model was developed in a similar manner using 30-year period average IPCC A1B estimates for the period 2040-2069 compared to PRISM estimates for the current period (1981-2010). The histogram of summarized normalized climate change values with quantile breakpoints used to determine categories is shown in **Figure A.8.1-3**. The resulting current climate change model, summarized to 1 km^2 reporting units, is shown in **Figure A.8.1-4**. The long-term future (e.g., 2040-2069) potential climate change model, summarized to 1 km^2 reporting units, is shown in **Figure A.8.1-5**.

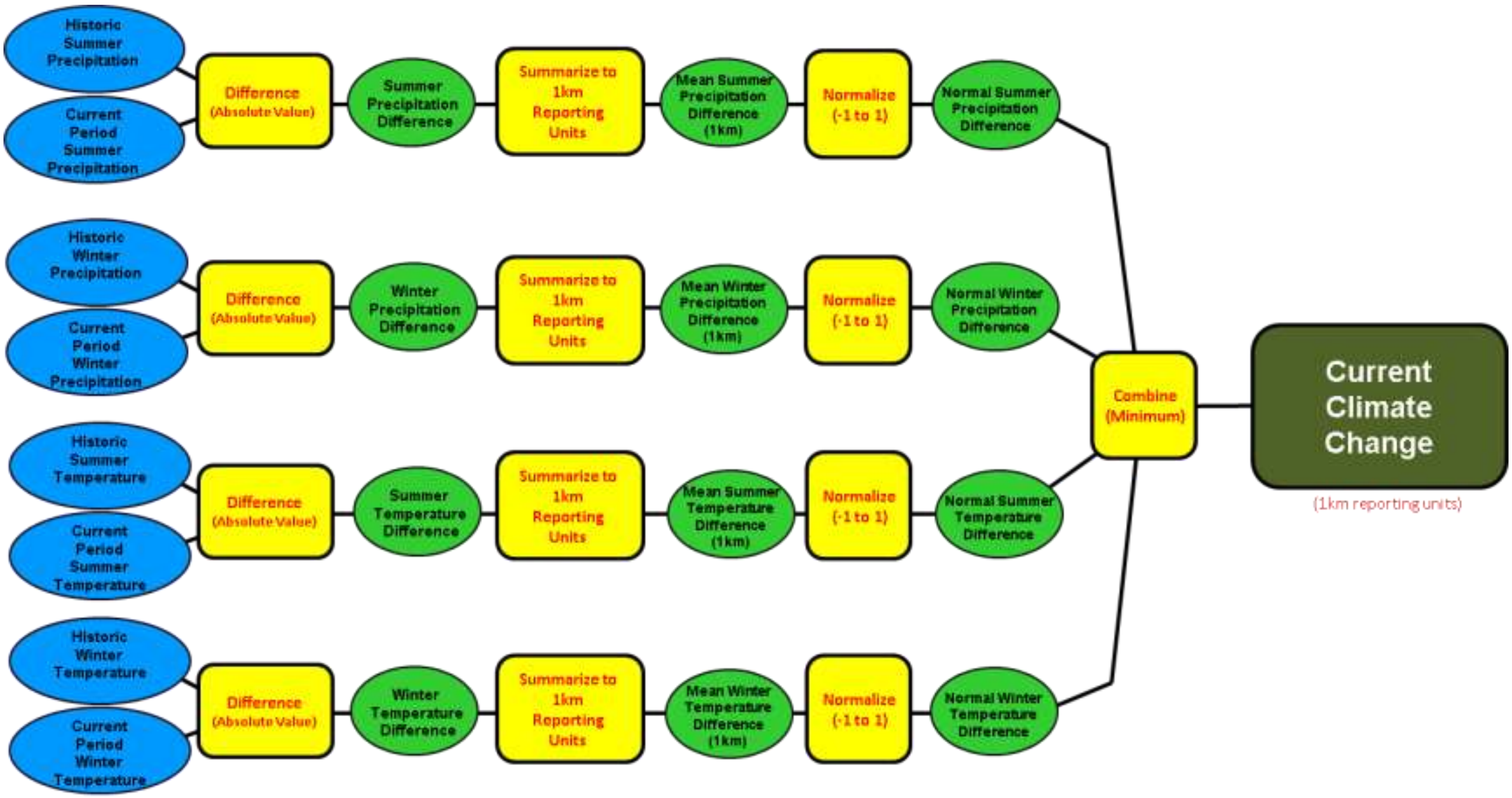


Figure A.8.1-1. Process model for the characterization of current climate change. The current climate change model was developed using PRISM monthly averages in precipitation and temperature over a 30-year current period (1981-2010) compared to a historic reference period (1905-1934).

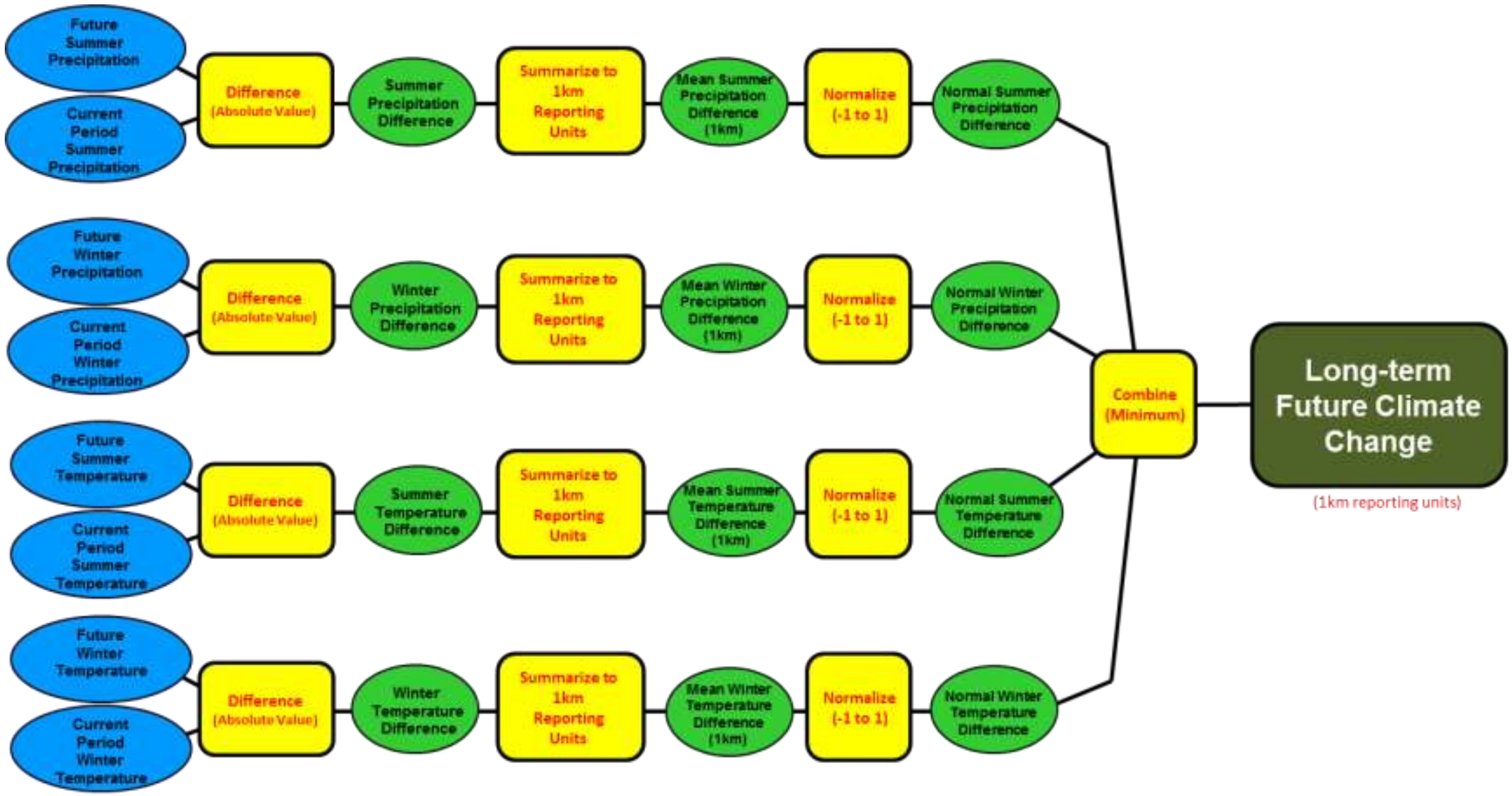
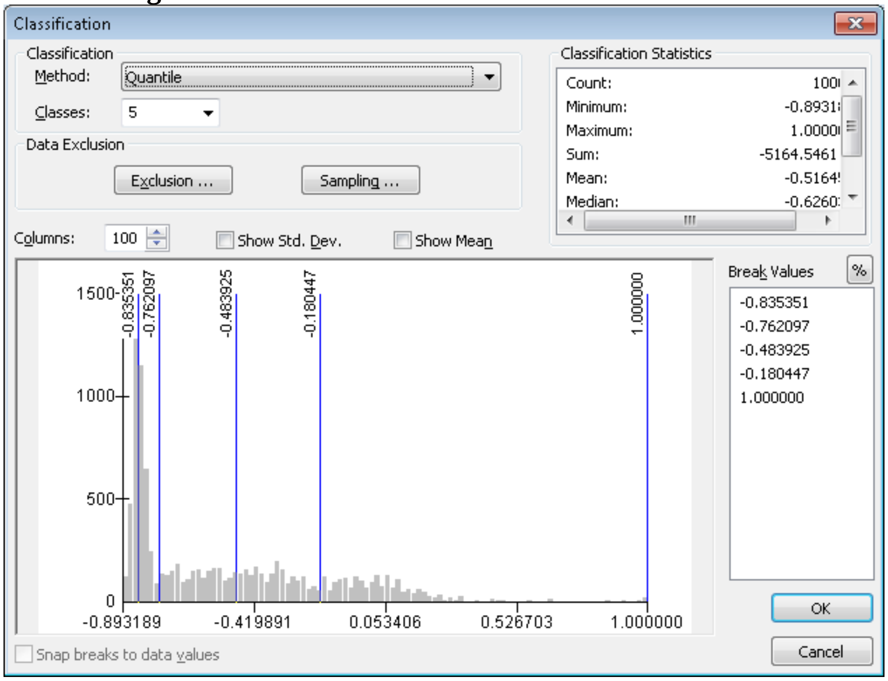


Figure A.8.1-2. Process model for the characterization of long-term future climate change. The future climate change model was developed using 30-year period average IPCC A1B estimates for the period 2040-2069 compared to PRISM estimates for the current period (1981-2010).

(a) Current Climate Change



(b) Long-term Future Climate Change

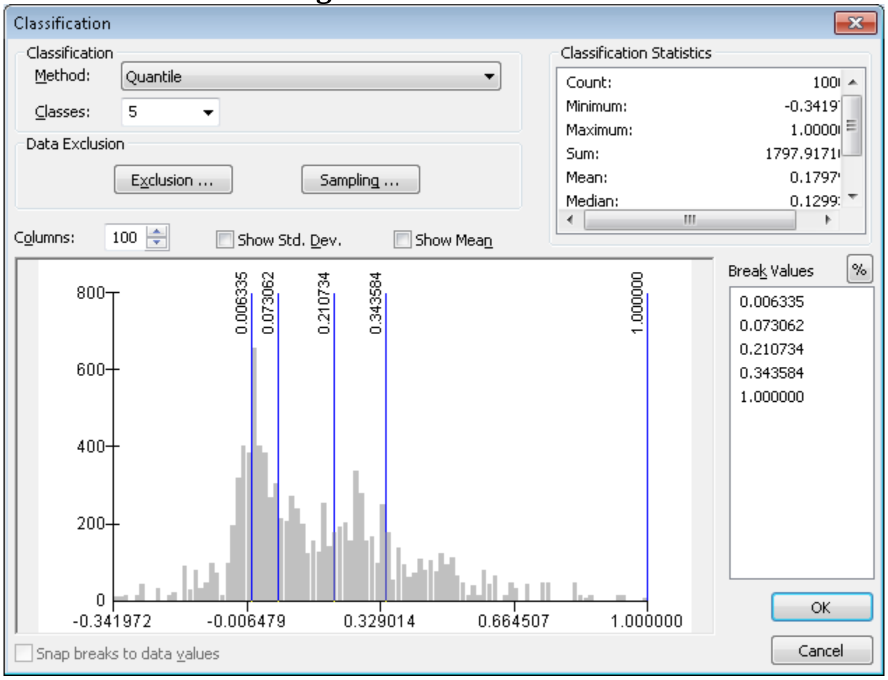


Figure A.8.1-3. Histogram and breakpoints used to assign categories (a) current climate change and (b) long-term future climate change. Breakpoints correspond to the following categories used to describe potential for climate change: Very Low, Low, Moderate, High, and Very High.

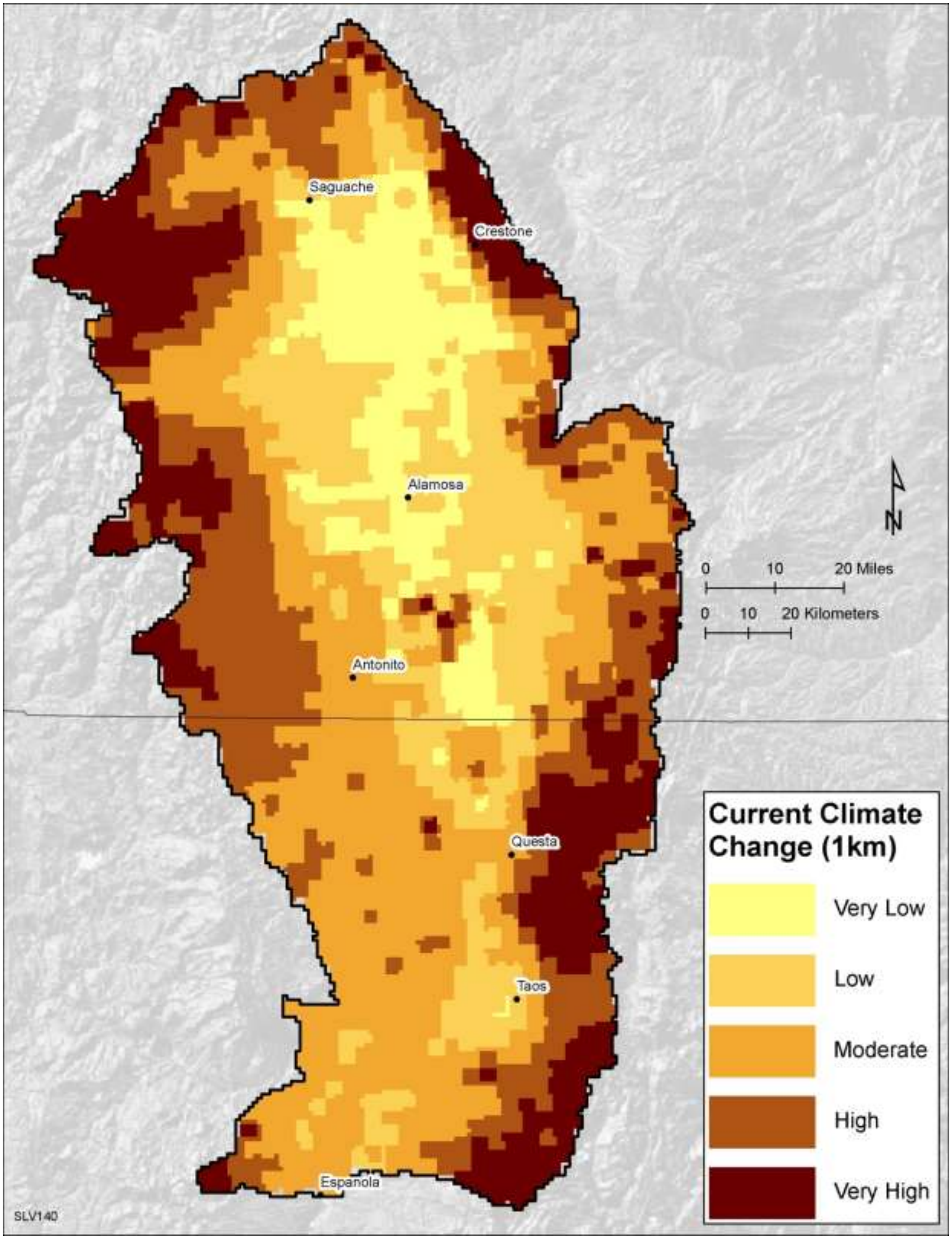


Figure A.8.1-4. Current climate change (relative to historic period conditions) for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

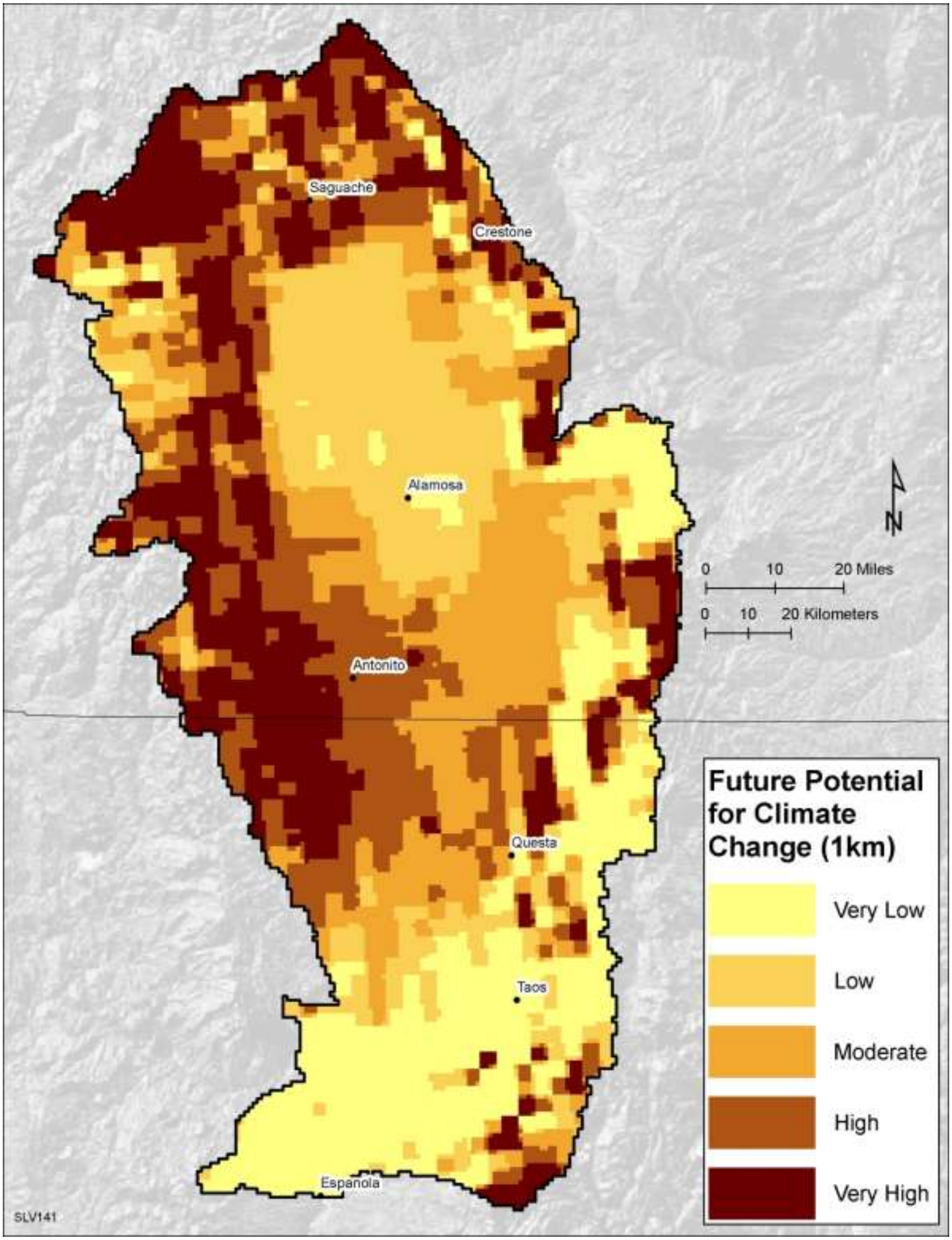


Figure A.8.1-5. Long-term future (2040-2069) climate change potential for the San Luis Valley-Taos Plateau Level IV Landscape Assessment (Argonne 2014).

A.9 Management Questions for Human and Cultural Elements

The six MQs pertaining to human and cultural elements highlighted in yellow below were addressed in a *Landscape-Level Cultural Heritage Values and Risk Assessment* (Wescott et al. 2016). One MQ (MQI7) was not addressed in this LA or in the *Landscape-Level Cultural Heritage Values and Risk Assessment* and represents a question for future research.

I. Human and Cultural Elements	
MQI1	Where do areas of cultural resource management and protection occur (National Monuments, ACECs, National Historic Landmarks, World Heritage Areas, Los Caminos Scenic and Historic Byway, etc)?
MQI2	Where are known historic properties, traditional cultural properties, and sacred sites and landscapes?
MQI3	What are the traditional cultural land use patterns?
MQI4	Where are known historic properties, traditional cultural properties, and sacred sites vulnerable to change agents
MQI5	Where are high potential areas or high density areas for historic properties that address the highest priority research goals?
MQI6	Where is cultural landscape connectivity vulnerable to change agents (human development, fire, invasive species, climate change)
MQI7	Where are sensitive socioeconomic populations and how are they affected by change agents? **This MQ was not addressed in either this Landscape Assessment or the *Landscape-Level Cultural Heritage Values and Risk Assessment* (Wescott et al. 2016) and represents an area of potential future research.**

A.10 Management Questions Pertaining to Landscape Intactness

J. Landscape Intactness	
MQL1	What is current and future predicted landscape intactness? **See Below.**

A.10.1 MQL1: What is Current and Future Predicted Landscape Intactness?

One important model that will be developed to assist in the evaluation of Conservation Element status and trends is the Landscape Intactness Model. This model builds on a growing body of existing methods that aim to characterize the relative landscape intactness of landscapes (Theobald 2001, 2010, 2013; Leu et al. 2008; Comer and Hak 2012). This model uses regionally available spatial data to characterize landscape intactness in the landscape as a function of the system's ability to support and maintain diverse and functional ecosystems and habitats expressed by the influence of human land uses in the landscape (Parrish et al. 2003). This model utilizes indicators of human modification (or absence thereof), which provide a measurable way to characterize the state of the environment.

General landscape modeling approaches involve the parameterization of indicators used to score the level of human influence in the ecosystem. This scoring system is quantified as a degree of human modification, *h*, which is often represented as a function of human modification intensity and the spatial influence of the human activity (Brown and Vivas 2005; Woolmer et al. 2008; Theobald 2013), but it is also regarded as a site impact score. The goal of these modeling efforts is to spatially characterize landscape intactness along a relative continuum ranging from low human modification to high human modification.

Indicators and their scores were selected for the Landscape Intactness Model based upon knowledge of their amount and distribution in the study area and understood level of impact to natural systems. Estimates of the degree of human modification, *h*, from previous modeling efforts (e.g., Brown and Vivas 2005; Woolmer et al. 2008; Theobald 2013) were used to parameterize the site impact scores for each indicator in this model. The Landscape Intactness Model for this LA consists of a site impact score of human land uses (ranging from 0.015 to 0.95), reflecting the presumed level of ecological stress or impact. Values close to 1.0 imply relatively little ecological impact from the land use. For example, recently logged areas are given a relatively high site impact score (0.7) compared to cultivated agriculture (0.35) or high-density urban development (0.015). This range of values (0 to 1) is similar to the range of landscape intactness values modelled in previous landscape modeling efforts (e.g., Brown and Vivas 2005; Woolmer et al. 2008; Comer and Hak 2012; Theobald 2013).

Proximity to human modifications also affects landscape intactness and can be spatially estimated in the landscape. Habitat quality and use by wildlife generally decreases with proximity to human developments. For example, Rowland et al. (2000) found there was a measurable decline in elk habitat use up to 1.8 km (1.1 mi) away from roadways. Other example effects of proximity to human development on wildlife and habitat are provided in

Table A.10.1-1. Most reported effects to wildlife have been observed within 4 km (2.5 mi) from human development, although there are fewer reports of effects occurring at greater distances. For this reason, the current Landscape Intactness Model was parameterized with a maximum distance of influence of 4 km (**Table A.10.1-2**).

Table A.10.1-1. Example effects of proximity to human developments on wildlife and habitat.

Ecological Attribute	Indicator	Distance (km)	Measured Response	Citation
Elk habitat	Distance to roads	1.8	Elk habitat use decreased up to 1.8 km from roadways	Rowland et al. (2000)
Elk habitat	Distance to human disturbances	3	Elk may avoid habitats within 3 km from human disturbances	Preisler et al. (2006), Naylor et al. (2009)
Elk habitat	Distance to roads	>4	Elk habitat use is greatest at distances >4 km away from roads	Montgomery et al. (2013)
Mule deer habitat	Distance from natural gas wells	3.7	Lower predicted probability of habitat use up to 3.7 km away from natural gas well developments	Sawyer et al. (2006)
Bighorn sheep observations	Distance to roads	>0.5	Bighorn sheep observations greatest at distances >500 m away from roads	Papouchis et al. (2001)
Elk habitat	Distance to human recreation	NA	Elk habitat use increases with increasing distance from human recreational areas	Zeigenfuss et al. (2011)
Sage grouse	Distance to energy development	3.2	Negative effects of energy development on sage grouse lek attendance and persistence within 3.2 km	Walker et al. (2007)

Table A.10.1-2. Landscape Intactness Model impacting factors, site impact scores, and distance decay scores for the San Luis Valley – Taos Plateau Landscape Assessment.[1]

Human Land Use or Impact Factor	Site Impact Score[2]	Presumed Relative Stress[3]	Distance of Influence (m)[4]	Function[5]
Transportation				
Dirt roads, OHV trails	0.75	Low	500	linear
Local roads	0.3	Medium	1000	logistic
Primary highways	0.015	High	4000	logistic
Urban and Industrial Development				
Low density development (including rural development)	0.6	Medium	1000	logistic
Medium density development	0.35	Medium	2000	logistic
High density development	0.015	High	4000	logistic
Communication Towers	0.6	Low	200	linear
Powerlines / transmission lines	0.6	Low	200	linear
Mines and oil/gas well pad locations	0.2	High	1000	logistic
Urban Polygons (BLM and U.S. Census Bureau)	0.015	High	4000	logistic
High Impervious Surfaces (NLCD Imperv > 40)	0.3	Medium	500	logistic
Urban Lights (NASA Night Lights > 200)	0.05	High	4000	logistic
Managed and Modified Land Cover				
Low agriculture and invasives (ruderal forest, recently burned, recently logged, etc)	0.7	Low	500	linear
Pasture (landcover)	0.7	Low	500	linear
Grazing allotment polygons	0.7	Low	500	linear
Introduced vegetation	0.6	Medium	500	linear
Cultivated agriculture	0.35	Medium	2000	linear

1 Modeling approach and parameters are adopted from the Landscape Condition Model prepared for the Mojave Basin and Range Rapid Ecoregional Assessment (BLM 2013).

2 Site Impact Score ranges between 0 and 1 and provides an indication of presumed ecological stress or impact. Lower values (closer to 0) indicate a greater site impact. Values adopted from previous modeling efforts by Brown and Vivas (2005), Woolmer et al. (2008), Comer and Hak (2012), and Theobald (2013).

3 Presume relative stress indicates the level of influence the impacting factor has relative to other impacting factors. For example, high-density developments such as urban areas have the highest relative stress scores.

4 Distance of influence is the minimum distance at which intactness values approach 1.0. Values adopted from previous modeling efforts by Comer and Hak (2012), which described the methodology for completing the Landscape Condition Model for the BLM Mojave Basin and Range REA.

5 Distance decay functions for impacting factors with low or medium relative levels of stress were evaluated with linear or logistic functions. Distance decay functions for impacting factors with high relative levels of stress were evaluated with logistic functions.

To characterize the influence of proximity to human modifications on landscape intactness, each input data layer for the landscape intactness model was parameterized with a distance decay function that expressed a decreasing ecological impact with distance away from the mapped location of the feature (**Table A.10.1-2**). This process involved the use of Euclidean Distance mapping tools and other geoprocesses (e.g., raster calculator) to spatially represent the functional relationship between intactness value and distance away from the human land use indicator. Those features with a smaller distance of influence result in a map surface where the impact dissipates within a relatively short distance. Values for each layer approach 1.0 at the distance of influence, symbolizing an area of negligible impact. An example logistic functional relationship for major roadways is provided in **Figure A.10.1-1**.

For comparability with results of other change agent models, landscapes intactness model results were normalized along a scale ranging between -1 and 1, where modeled values of 0 correspond to normalized values of -1 and modeled values of 1 correspond to normalized values of 1. All values between -1 and 1 were estimated based on the linear relationship between the minimum and maximum values. For this LA, the landscape intactness model was developed using datasets for existing development (i.e., "current landscape intactness model") and for a near-term (i.e., 2015-2030) future timeframe using spatial data that project potential future human development. Data and parameters for the near-term future landscape intactness model are provided in **Table A.10.1-3**. For purposes of this LA, the normalized condition values were summarized to 1 km^2 reporting units by calculating the average continuous condition value within reporting units. For final map reporting, results were categorized based on equal intervals of condition values within reporting units within six categories ranging from very low condition to very high condition. The histogram of summarized condition values with equal interval breakpoints used to determine categories is shown in **Figure A.10.1-2**. The resulting current and near-term future (e.g., 2015-2030) Landscape intactness Models, summarized to 1 km^2 reporting units, are shown in **Figure A.10.1-3.**

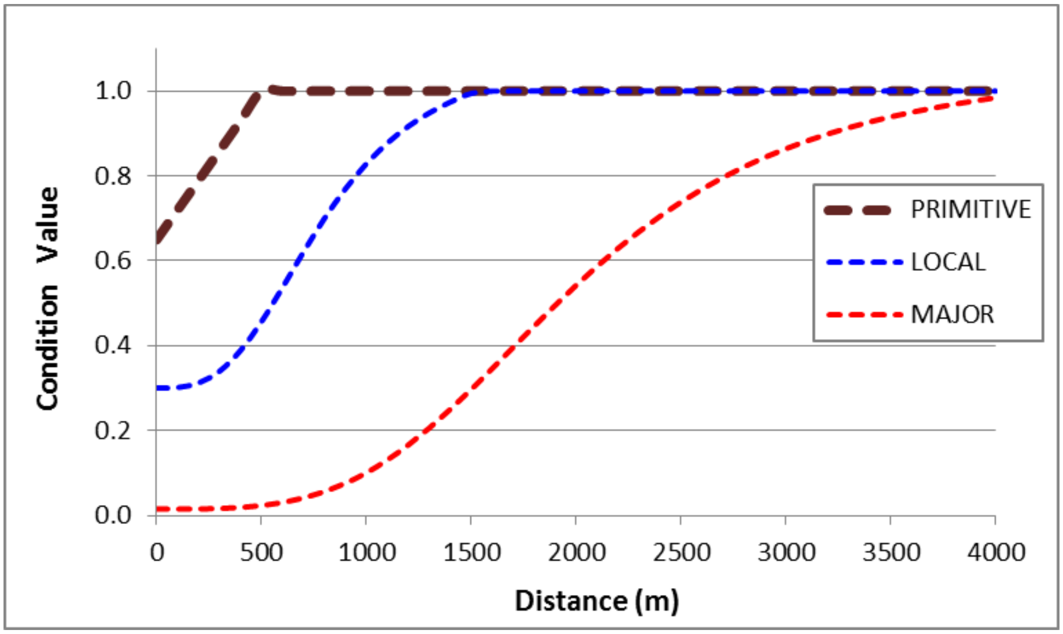


Figure A.10.1-1. Distance decay functions for the three types of roadways (primitive, local, and major) evaluated in the development of the Landscape intactness Model.

Table A.10.1-3. Near-term future Landscape intactness Model impacting factors, site impact scores, and distance decay scores[1]

Human Land Use or Impact Factor	Site Impact Score[2]	Presumed Relative Stress[3]	Distance of Influence (m)[4]	Function[5]
Urban Development Potential				
Wildland-Urban Interface – Low Risk (WUIFLAG10 = 1)	0.3	Low	1000	Linear
Wildland-Urban Interface – High Risk (WUIFLAG10 = 2)	0.2	High	4000	Logistic
Urban Development Risk (Theobald 2007) – Low Risk (VALUE = 1)	0.3	Low	1000	Linear
Urban Development Risk (Theobald 2007) – Moderate Risk (VALUE = 2)	0.3	Medium	2000	Logistic
Urban Development Risk (Theobald 2007) – High Risk (VALUE = 3)	0.2	High	4000	Logistic
Energy Development				
Potential For Renewable Energy Development (Solar Energy Zones)	0.2	High	2000	Logistic
Potential for Oil & Gas Development (Copeland et al. 2009)[6]	0.5	Medium	1000	Linear

1 The near-term future landscape intactness model also incorporated the current landscape intactness model as input. See Figure A.10.1-2 for conceptual process model that includes the current landscape intactness model.

2 Site Impact Score ranges between 0 and 1 and provides an indication of presumed ecological stress or impact. Lower values (closer to 0) indicate a greater site impact. Values adopted from previous modeling efforts by Brown and Vivas (2005), Woolmer et al. (2008), Comer and Hak (2012), and Theobald (2013).

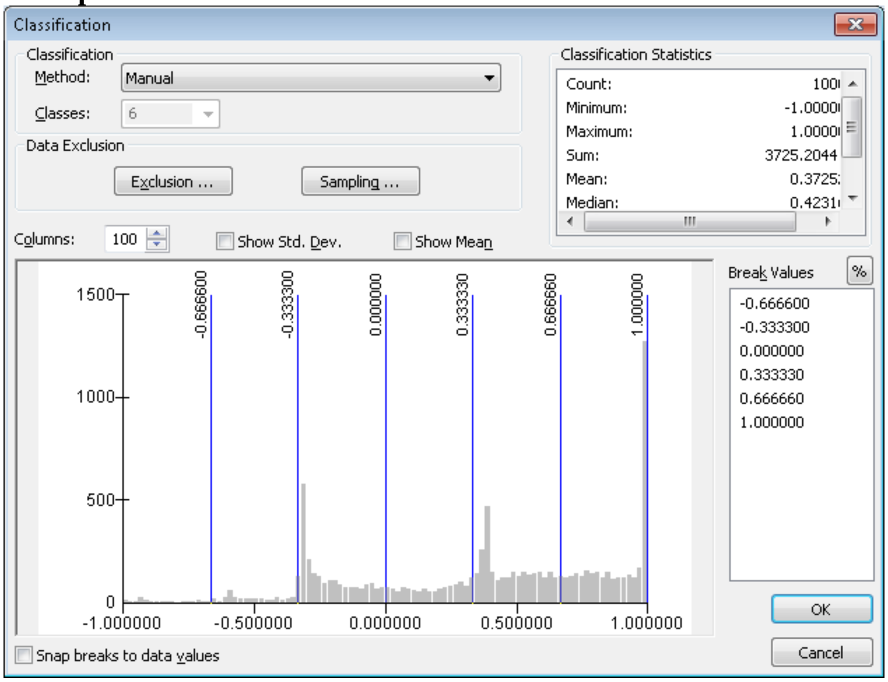
3 Presume relative stress indicates the level of influence the impacting factor has relative to other impacting factors. For example, high-density developments such as urban areas have the highest relative stress scores.

4 Distance of influence is the minimum distance at which condition values approach 1.0. Values adopted from previous modeling efforts by Comer and Hak (2012), which described the methodology for completing the Landscape Condition Model for the BLM Mojave Basin and Range REA.

5 Distance decay functions for impacting factors with low or medium relative levels of stress were evaluated with linear or logistic functions. Distance decay functions for impacting factors with high relative levels of stress were evaluated with logistic functions.

6 Due to greater uncertainty in input data (Copeland et al. 2009) to characterize potential for future oil and gas development in the study area, this input dataset was parameterized with a higher site impact score.

(a) Current Landscape intactness



(b) Near-term Future Landscape intactness

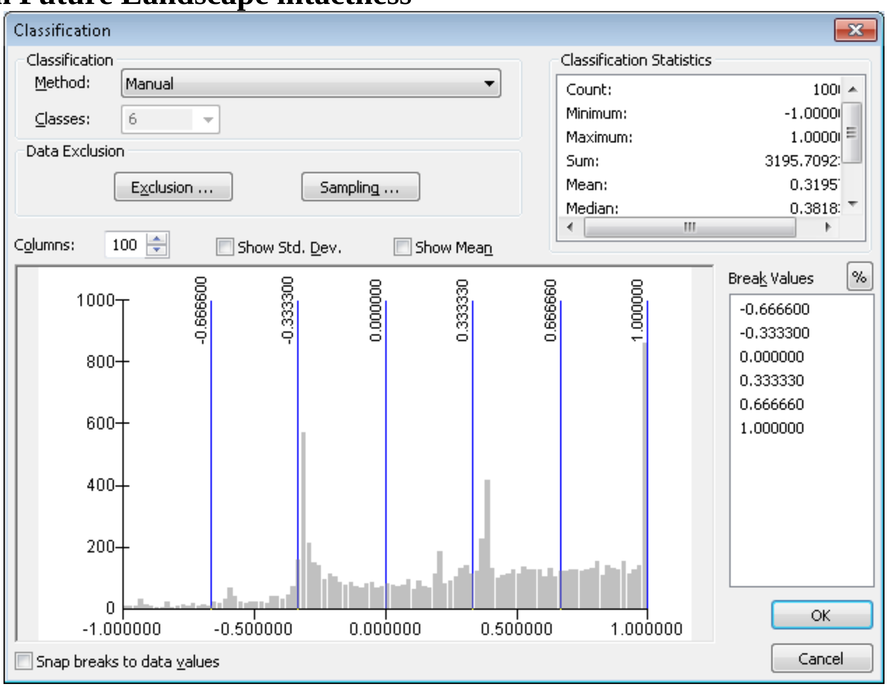


Figure A.10.1-2. Histogram and breakpoints used to assign condition categories for the (a) current landscape intactness model and (b) near-term future landscape intactness model. Breakpoints correspond to the following condition categories: Very Low (<-0.666), Low (-0.666 – -0.333), Moderately Low (-0.333 – 0), Moderately High (0 – 0.333), High (0.333 – 0.666), and Very High (>0.666).

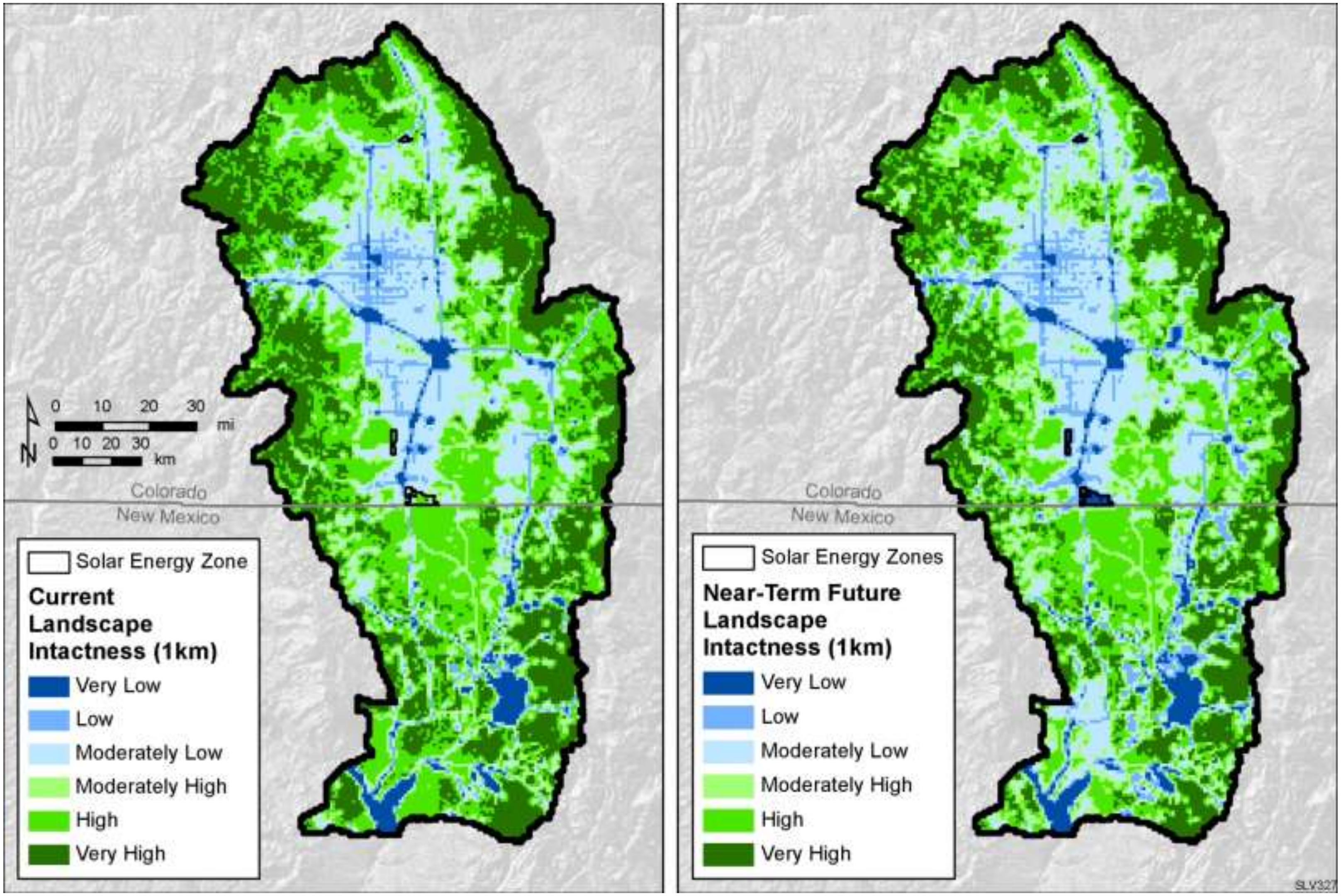


Figure A.10.1-3. Current and near-term future Landscape Intactness Model for the San Luis Valley-Taos Plateau Level IV Landscape Assessment. Landscape intactness is summarized to 1 km^2 reporting units and categorized from very low intactness (dark blue) to very high intactness (dark green) (Argonne 2014).

A.11 Management Questions for Visual Resources

Management Questions for visual resources are addressed below. Some of the visual MQs were addressed in a separate Visual Resource Assessment (Sullivan et al. 2016) prepared for the BLM solar energy zones in the study area.

K. Visual Resources	
MQK1	Where are specially designated/managed areas with associated visual resource considerations/mandates/prescriptions? **See Below.**
MQK2	Where are visual resource inventoried areas with high scenic quality, public sensitivity for scenic quality, and distance zones where people commonly view the landscape? **Please refer to the Visual Resource Assessment study (Sullivan et al. 2016).**
MQK3	Where are the highest quality night skies and where are they vulnerable to change agents (NPS inventory)? **See Below.**
MQK4	Where are high scenic quality values within the region and where are they vulnerable to change agents? **See Below.**
MQK5	Where are areas of high relative visual values (based on Visual Resource Inventory (VRI) classes) and where are they vulnerable to change agents? **See Below.**
MQK6	Where are current Visual Resource Management (VRM) classes that specify retention or partial retention of existing landscape character and where are they vulnerable to change agents? **See Below.**

A.11.1 MQK1: Where are Specially Designated/Managed Areas with Associated Visual Resource Considerations, Mandates, or Prescriptions?

Datasets:

- BLM ACECs (http://www.geocommunicator.gov/GeoComm/)
- National Historic Trails
- National Parks (Great Sand Dunes NP)
- National Wildlife Refuges
- Scenic Highways/Byways (National Scenic Byways Program - http://www.fhwa.dot.gov/hep/scenic_byways/)
- Scenic Railways (Federal Railroad Administration - http://www.fra.dot.gov/Page/P0001)
- Wilderness Areas and Wilderness Study Areas (Provided by BLM)

A map of designated or managed areas with visual resource considerations is shown in **Figure A.11.1-1.**

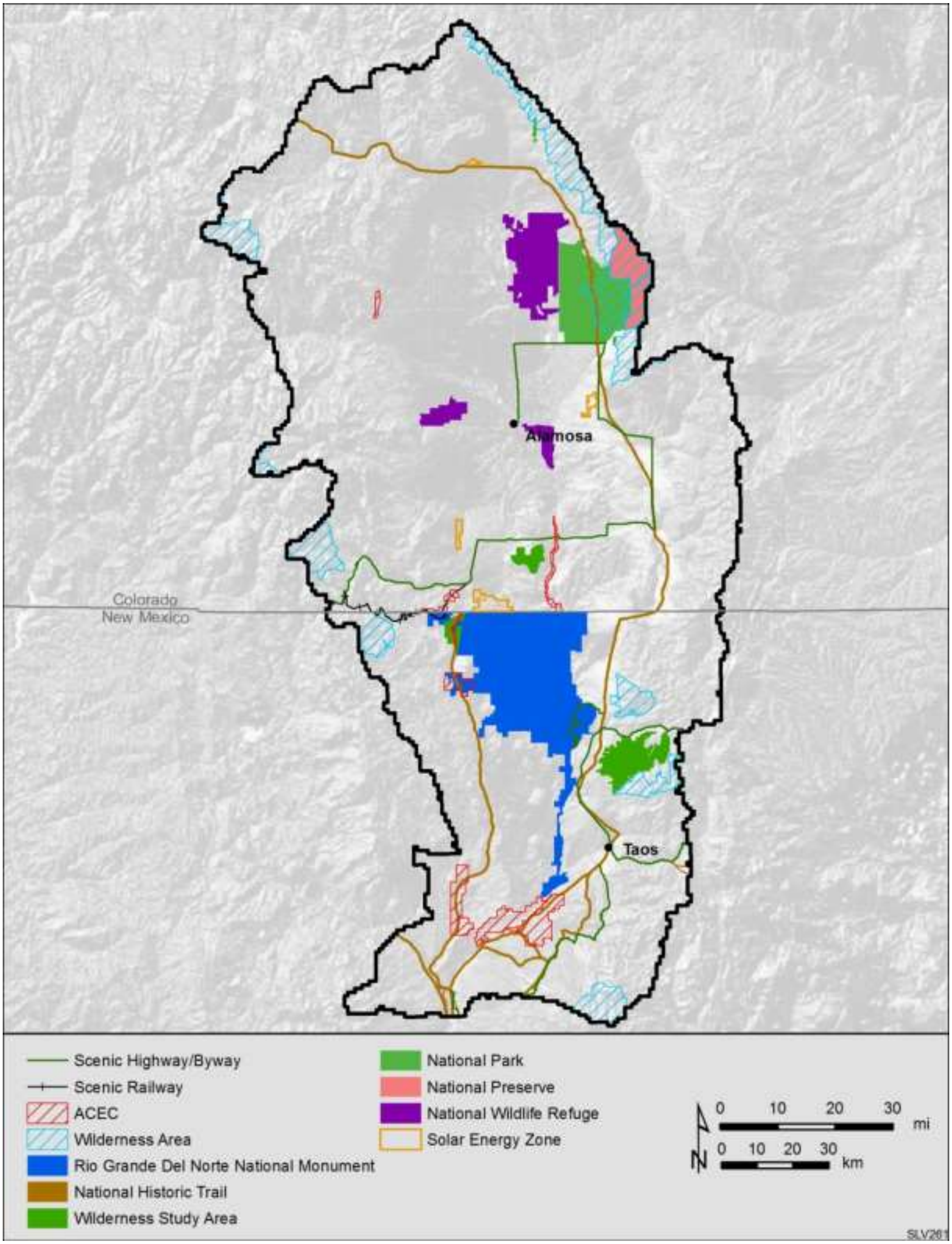


Figure A.11.1-1. Specially Designated Areas and Managed Areas with Visual Resource Considerations. Data Sources: BLM 2009,2014, NSBP 2005, FRA 2008, Wilderness.net 2014, and data received from BLM.

A.11.2 MQK2: Where are visual resource inventoried areas with high scenic quality, public sensitivity for scenic quality, and distance zones where people commonly view the landscape?

Please refer to the Visual Resource Assessment study (Sullivan et al. 2016).

A.11.3 MQK3: Where are the highest quality night skies and where are they vulnerable to change agents (NPS inventory)?

Datasets:

- NASA City Lights of the United States (2012)

The NASA night light data of the United States of America is a composite assembled from data acquired by the Suomi NPP satellite in April and October 2012. The image was made possible by the new satellite's "day-night band" of the Visible Infrared Imaging Radiometer Suite (VIIRS), which detects light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe dim signals such as city lights, gas flares, auroras, wildfires, and reflected moonlight. **Figure A.11.3-1** illustrates NASA City Lights of the United States within the study area. This map shows areas of greater light intensity near urban and developed areas and areas of less light intensity (and presumably greater night sky values). No assessment of night sky vulnerability to change agents was possible for this LA. The dataset of city lights at night represents one indicator of night sky visual resource value and was used as a preliminary evaluation of potential night sky impacts in the study area. Additional study would be needed to understand the magnitude of night sky impacts and relationship of these impacts with viewsheds of areas of regional importance.

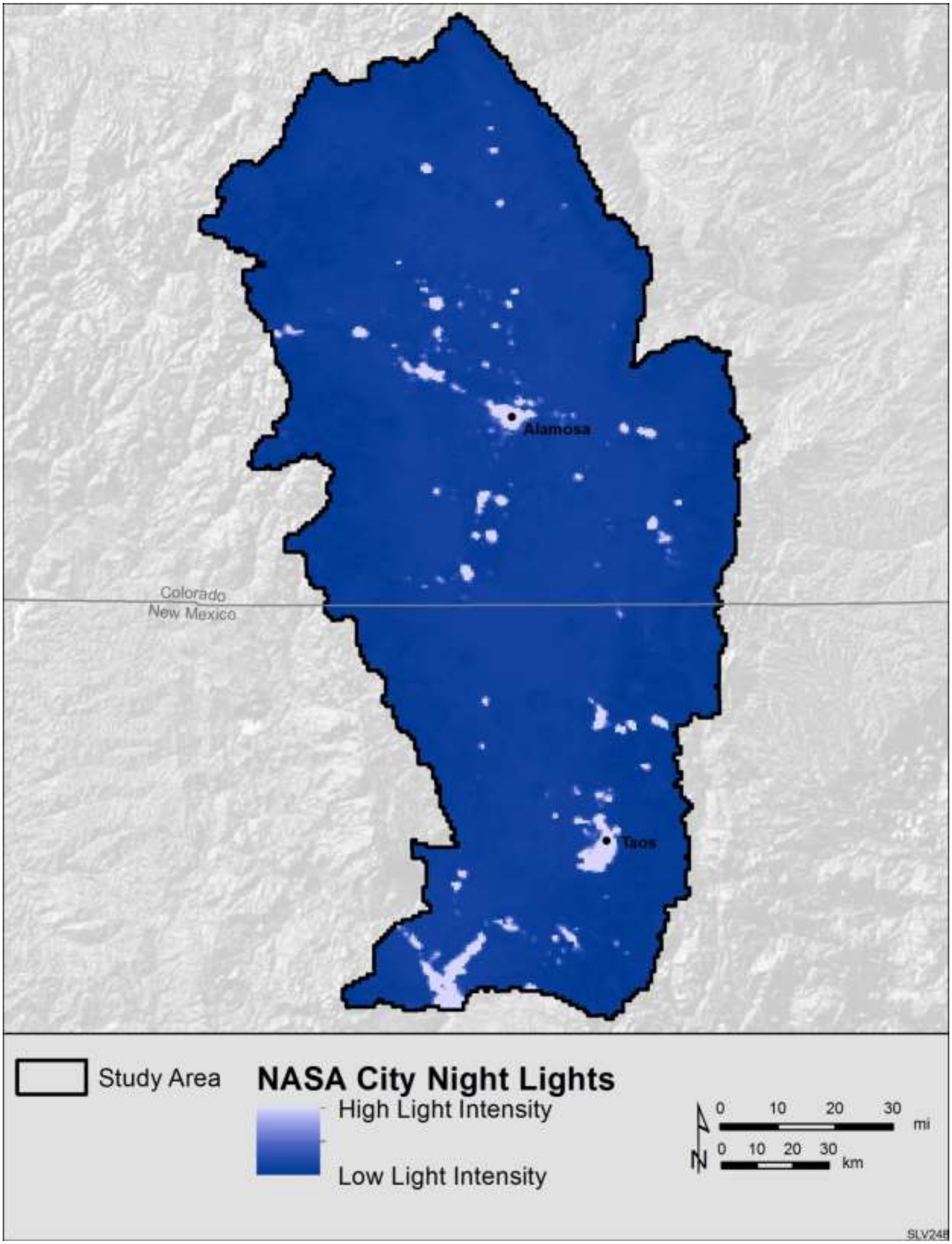


Figure A.11.3-1. NASA City Night Lights, an Indicator of Night Sky Values (NASA 2012).

A.11.4 MQK4: Where are high scenic quality values scarce within the region and where are they vulnerable to change agents?

Please refer to the Visual Resource Assessment (Sullivan et al. 2015). Note that the Visual Resource Assessment evaluated areas of scenic quality within viewsheds of the Solar Energy Zones. They were not evaluated with respect to the change agents evaluated in this Landscape Assessment.

A.11.5 MQK5: Where are areas of high relative visual values (based on Visual Resource Inventory (VRI) classes) and where are they vulnerable to change agents?

Datasets:

- Visual Resource Inventory for Colorado and New Mexico (data provided by BLM)

Figure A.11.5-1 shows distribution of visual resource inventory classes in the study area. These VRI areas were intersected with Change Agent models to evaluate current and potentially future conditions in **Figures A.11.5-2** through **A.11.5-7**.

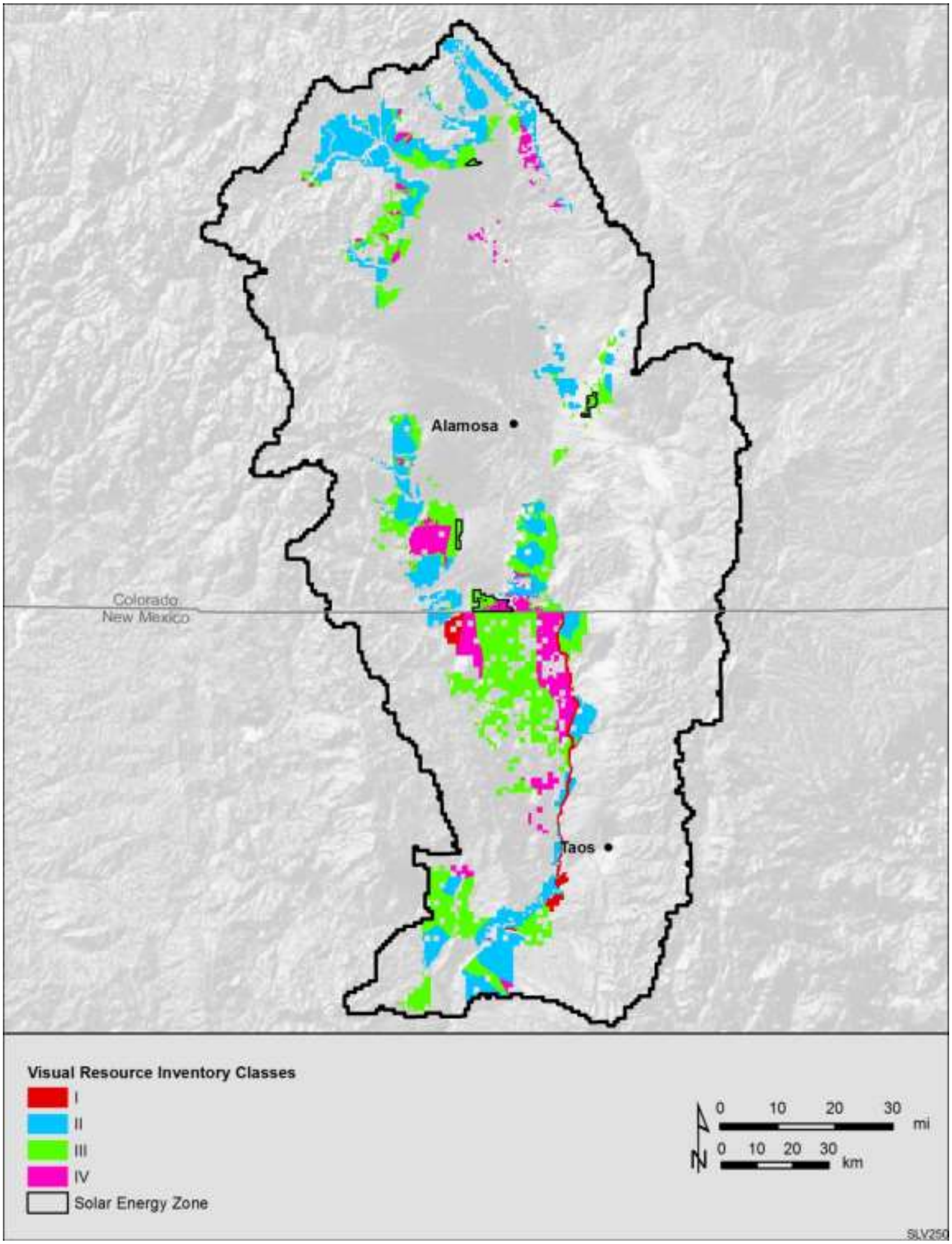


Figure A.11.5-1. Visual Resource Inventory Classes (BLM 2010).

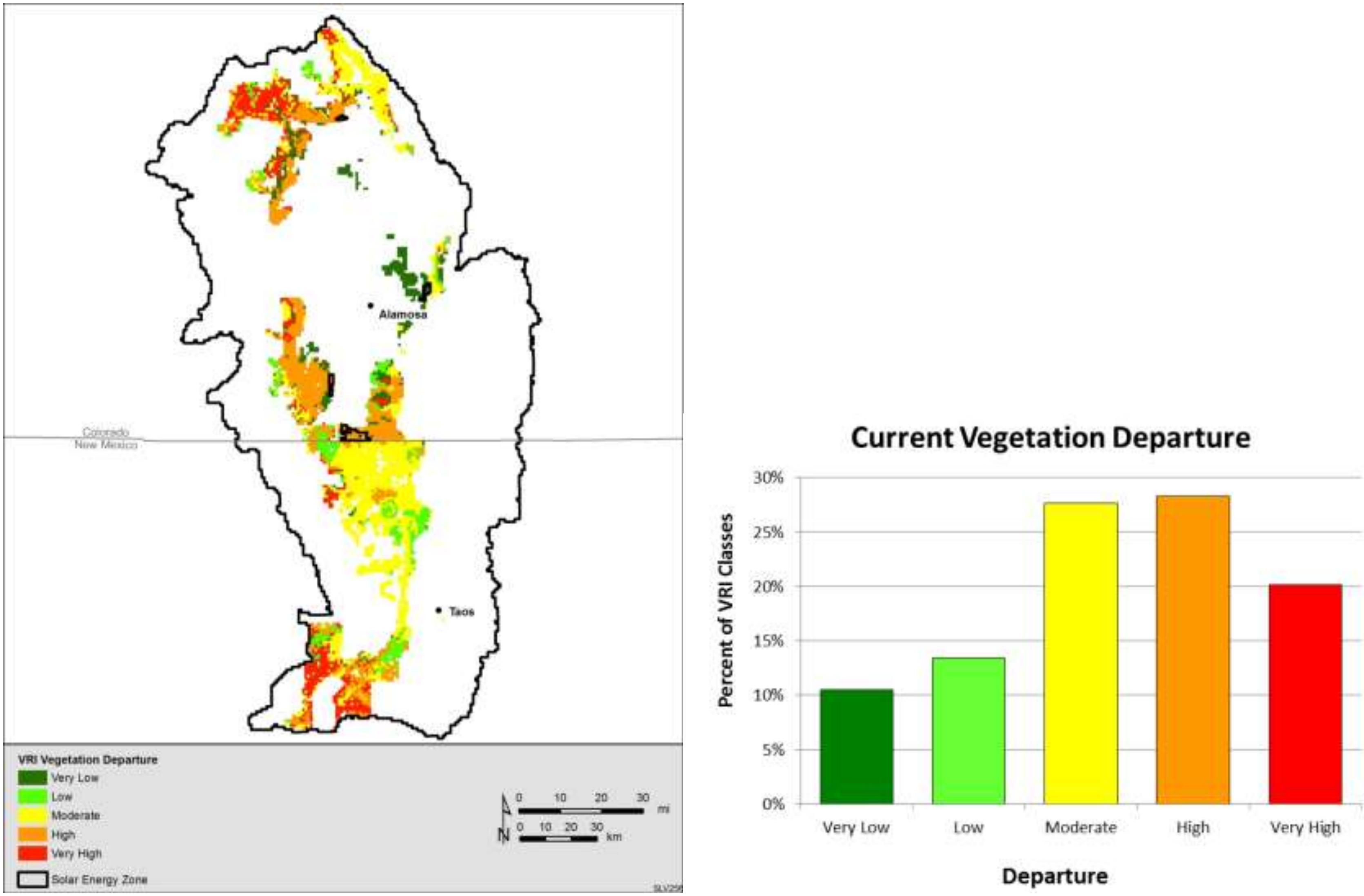


Figure A.11.5-2. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Visual Resource Inventory Areas. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a) and BLM 2010. Data were Summarized to 1 km^2 Reporting Units.

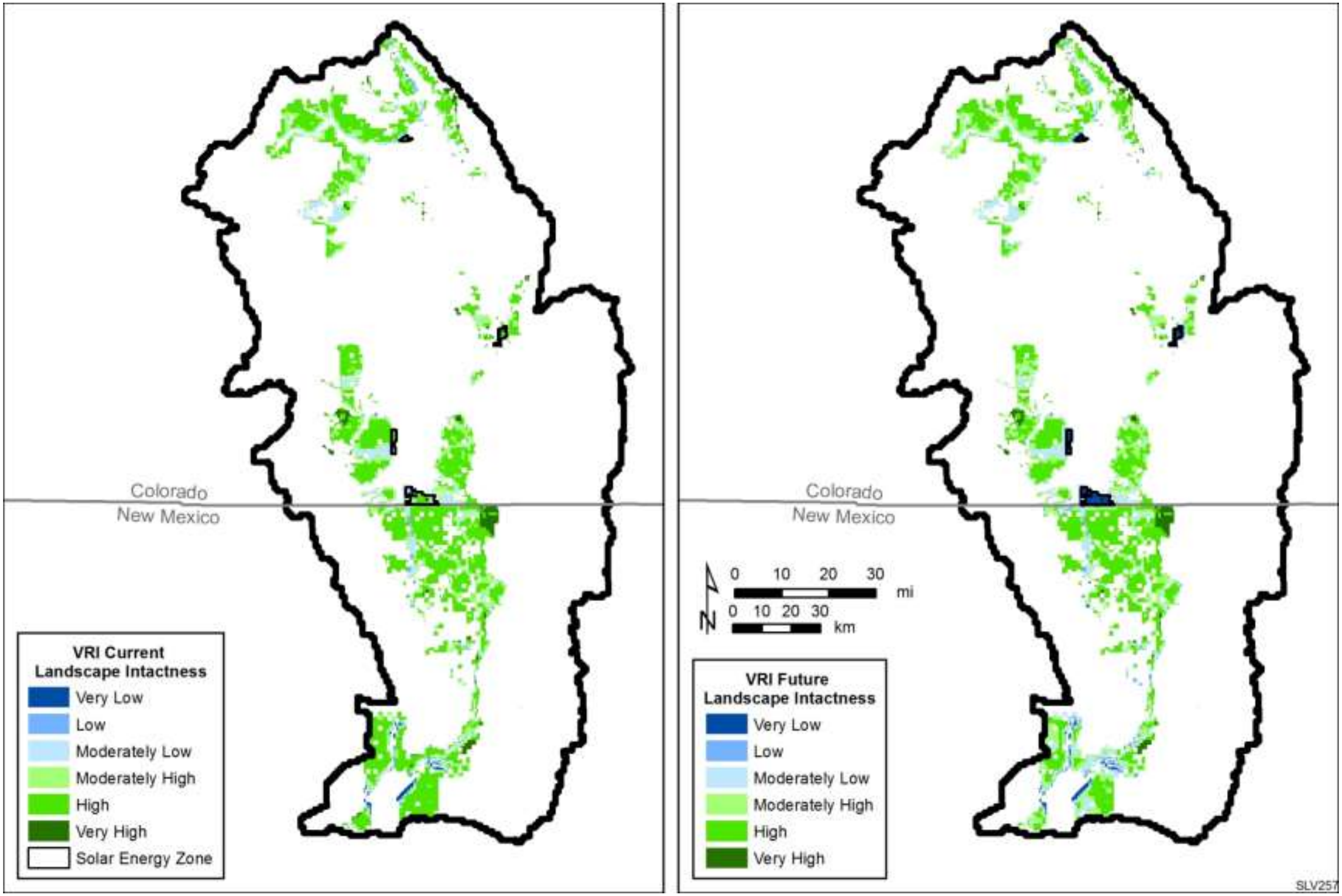


Figure A.11.5-3. Current and Future Landscape Intactness of Visual Resource Inventory Areas. Data Sources: Argonne 2014 and BLM 2010.

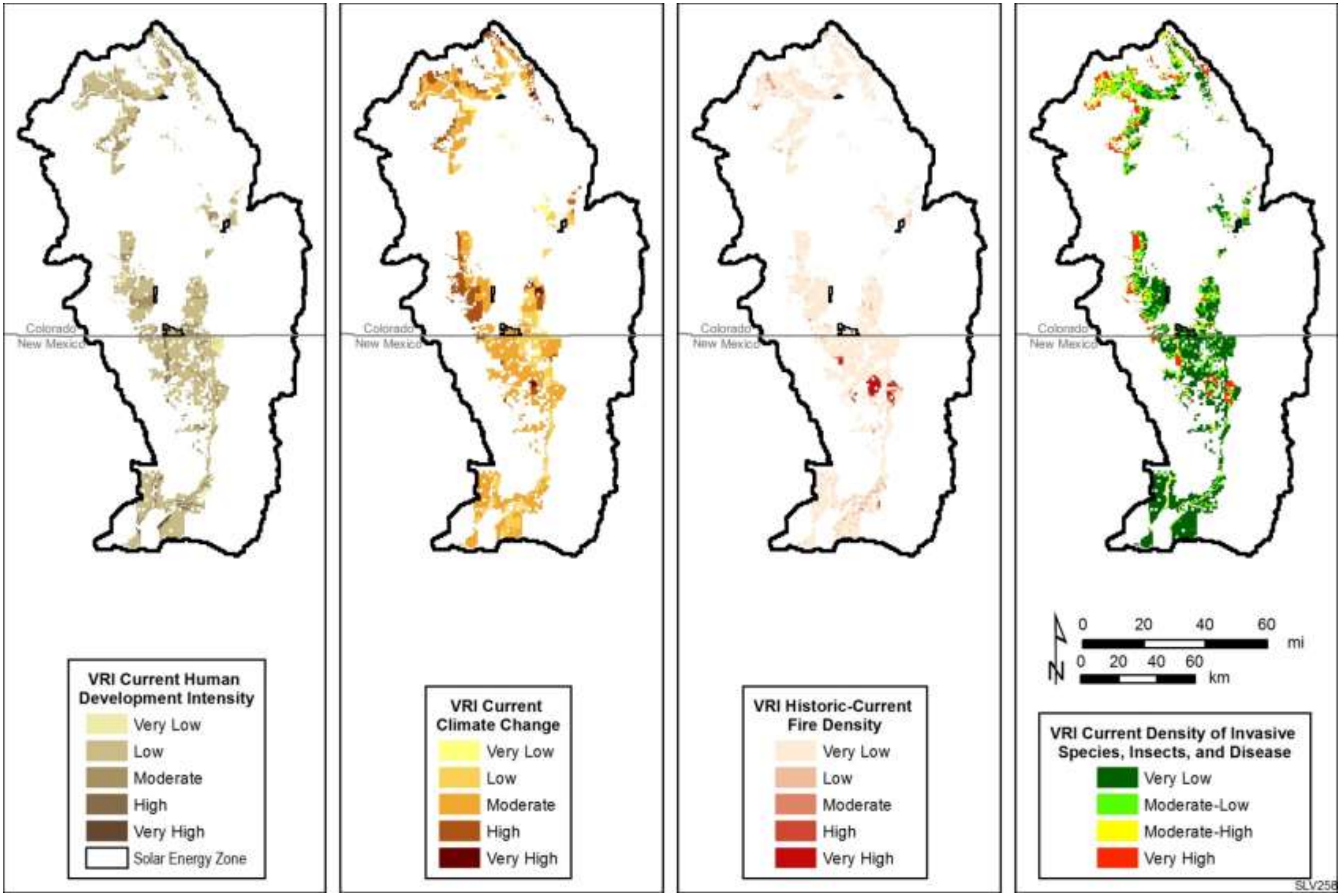


Figure A.11.5-4. Current distribution and intersection of Visual Resource Inventory Areas with change agents. Data Sources: Argonne 2014 and BLM 2010.

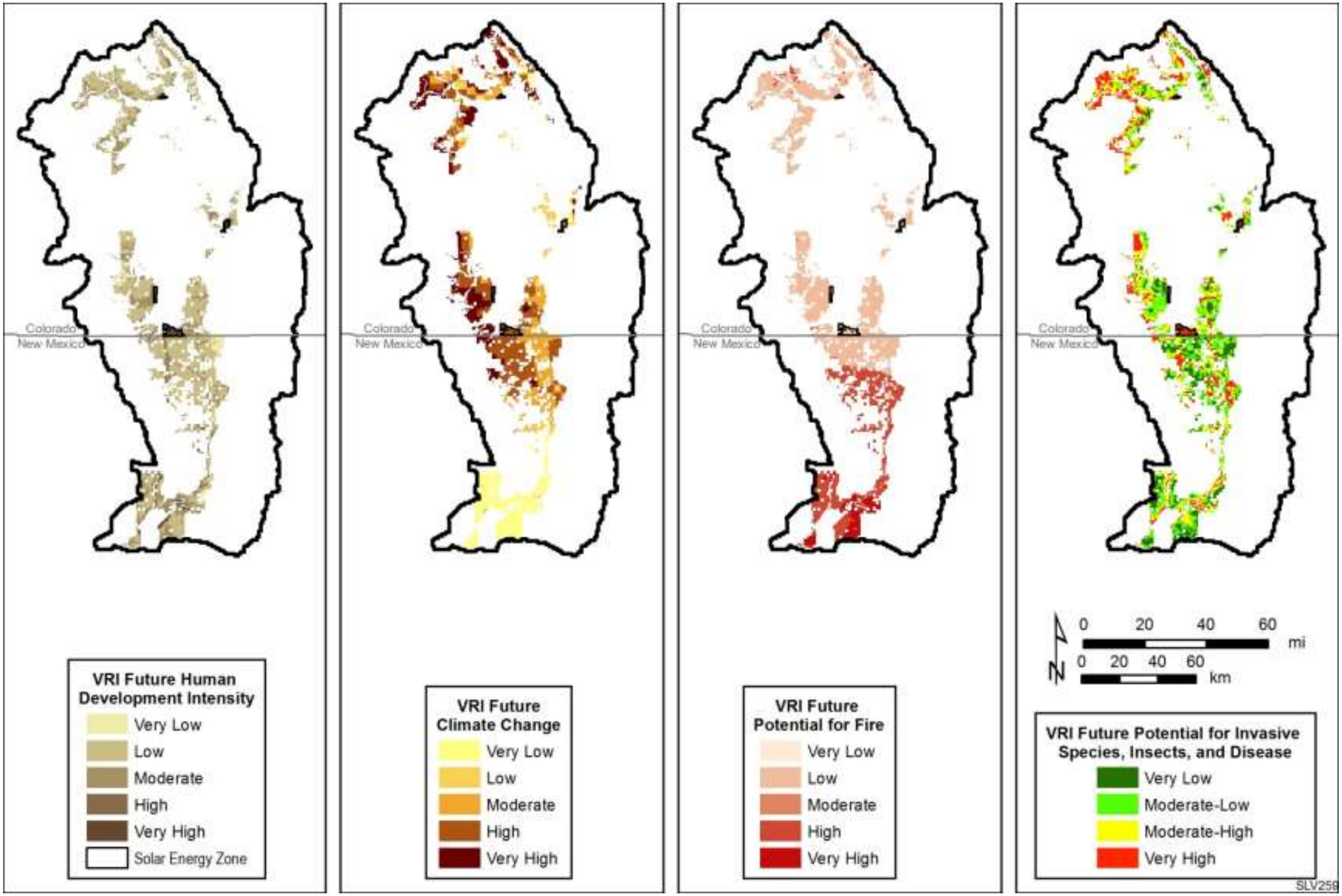


Figure A.11.5-5. Intersection of Visual Resource Inventory Areas with future change agent models to evaluate where Visual Resource Inventory Areas may be vulnerable to change agents in the future. Data Sources: Argonne 2014 and BLM 2010.

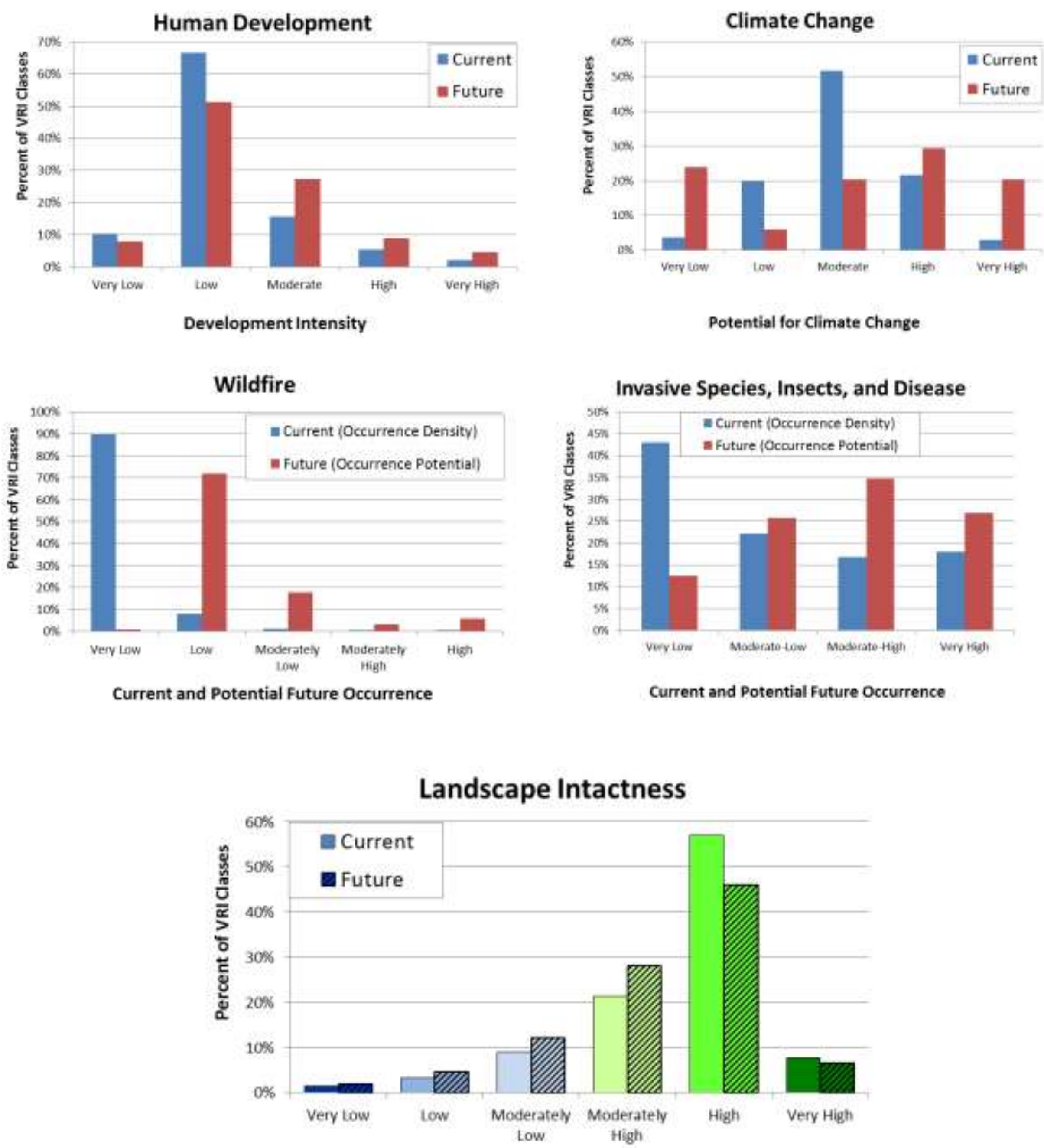
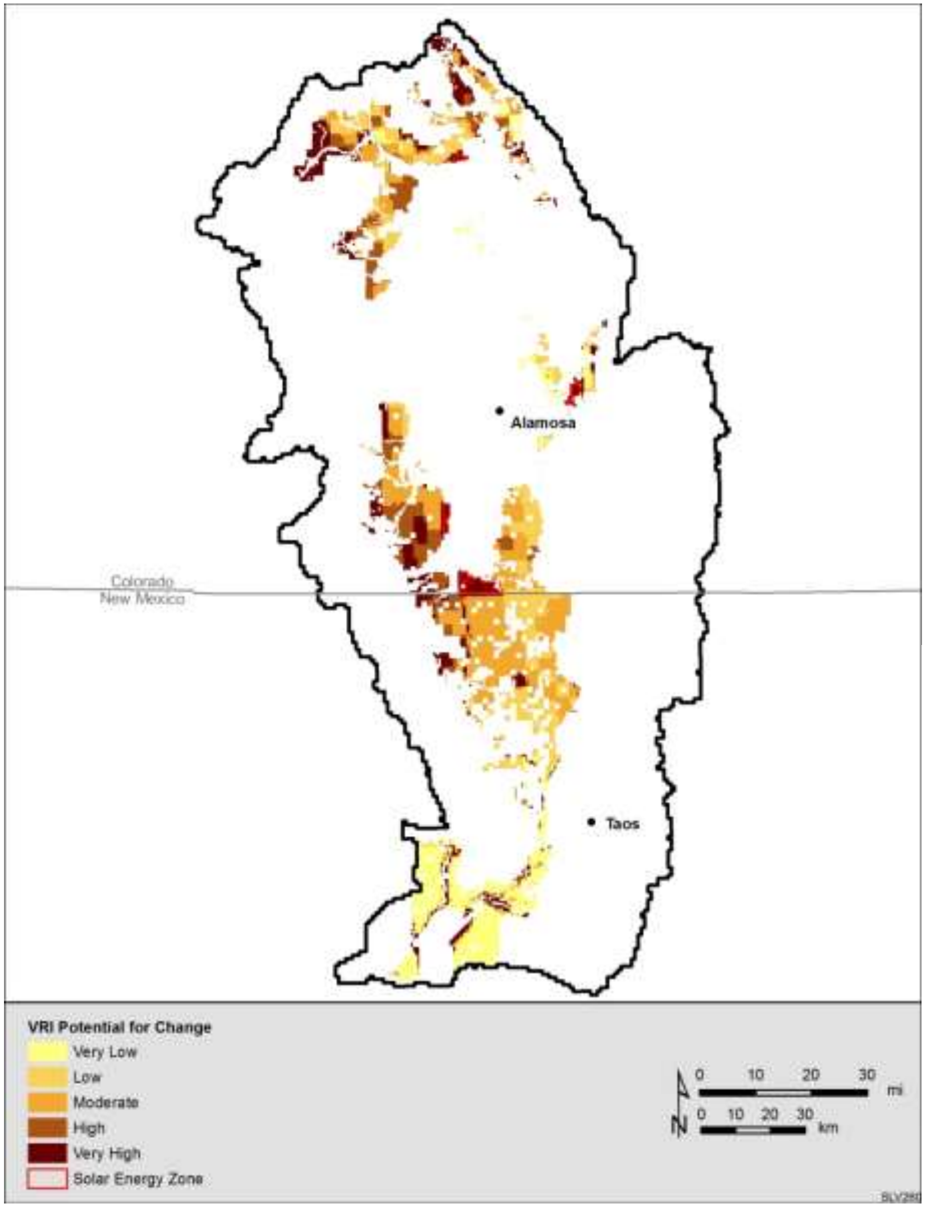


Figure A.11.5-6. Predicted Trends in Visual Resource Inventory areas within the Study Area



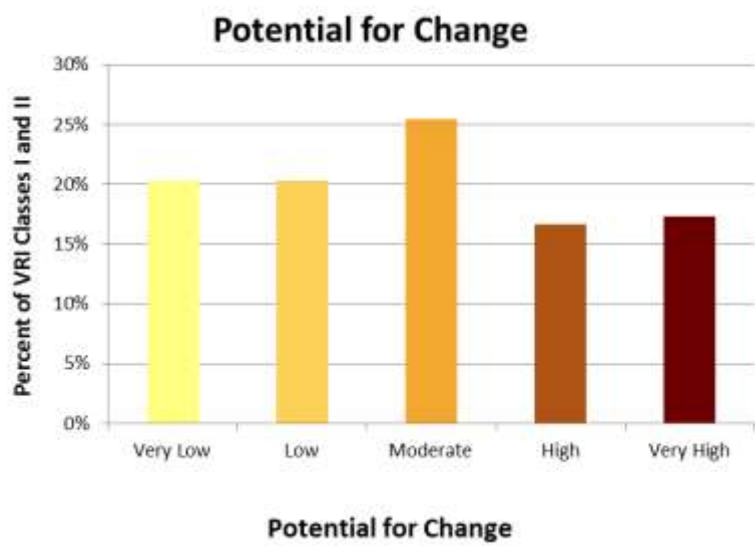


Figure A.11.5-7. Visual Resource Inventory Aggregate Potential for Change. Data Sources: Argonne 2014 and BLM 2010.

A.11.6 MQK6: Where are current Visual Resource Management (VRM) classes that specify retention or partial retention of existing landscape character and where are they vulnerable to change agents?

Datasets:

- Visual Resource Management Classes for Colorado and New Mexico (data provided by BLM)

Figure A.11.6-1 shows the distribution of visual resource management (VRM) classes in the study area. These VRM areas were intersected with Change Agent models to evaluate current and potentially future conditions in **Figures A.11.6-2** through **A.11.6-7**.

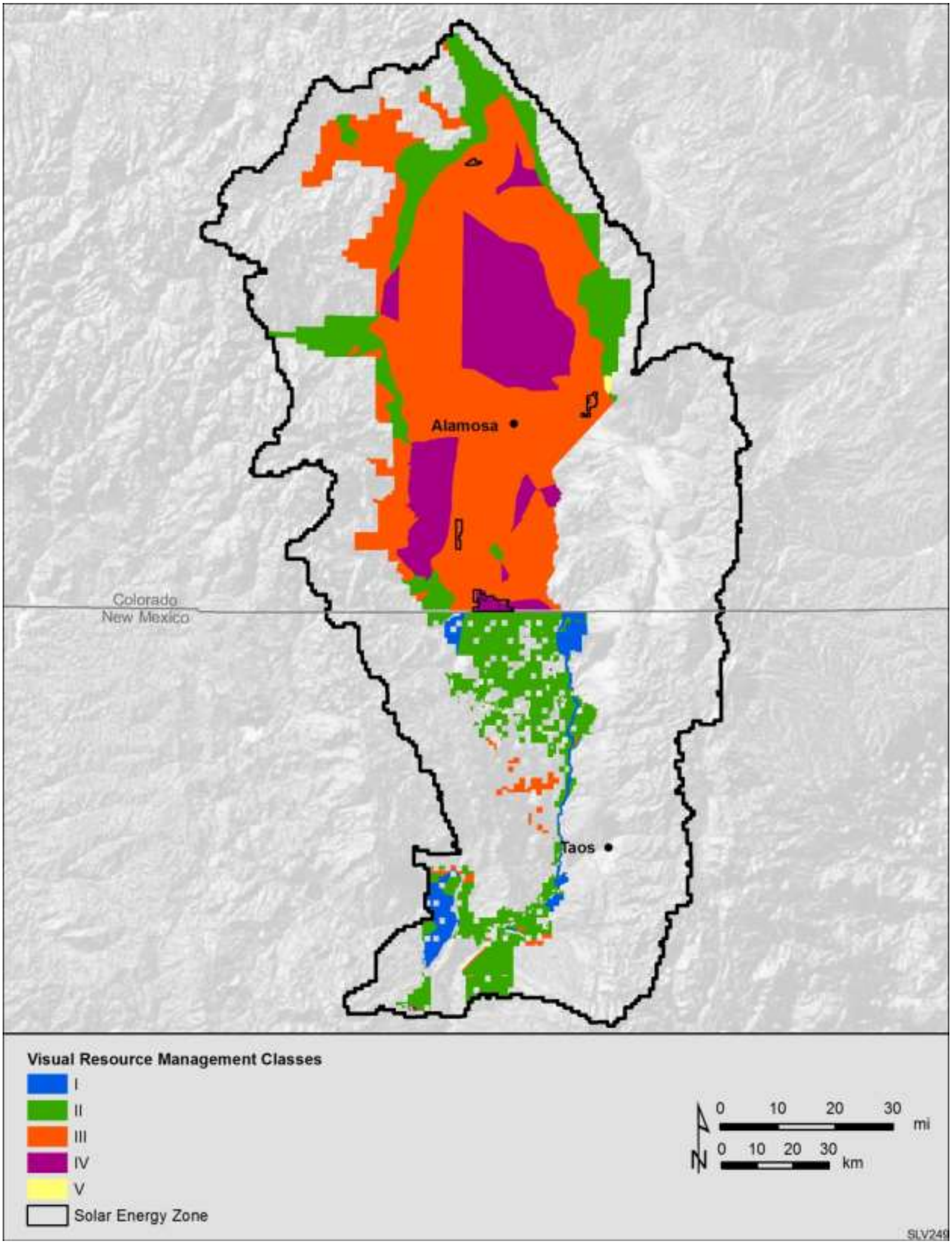


Figure A.11.6-1. Visual Resource Management Classes (data received from BLM).

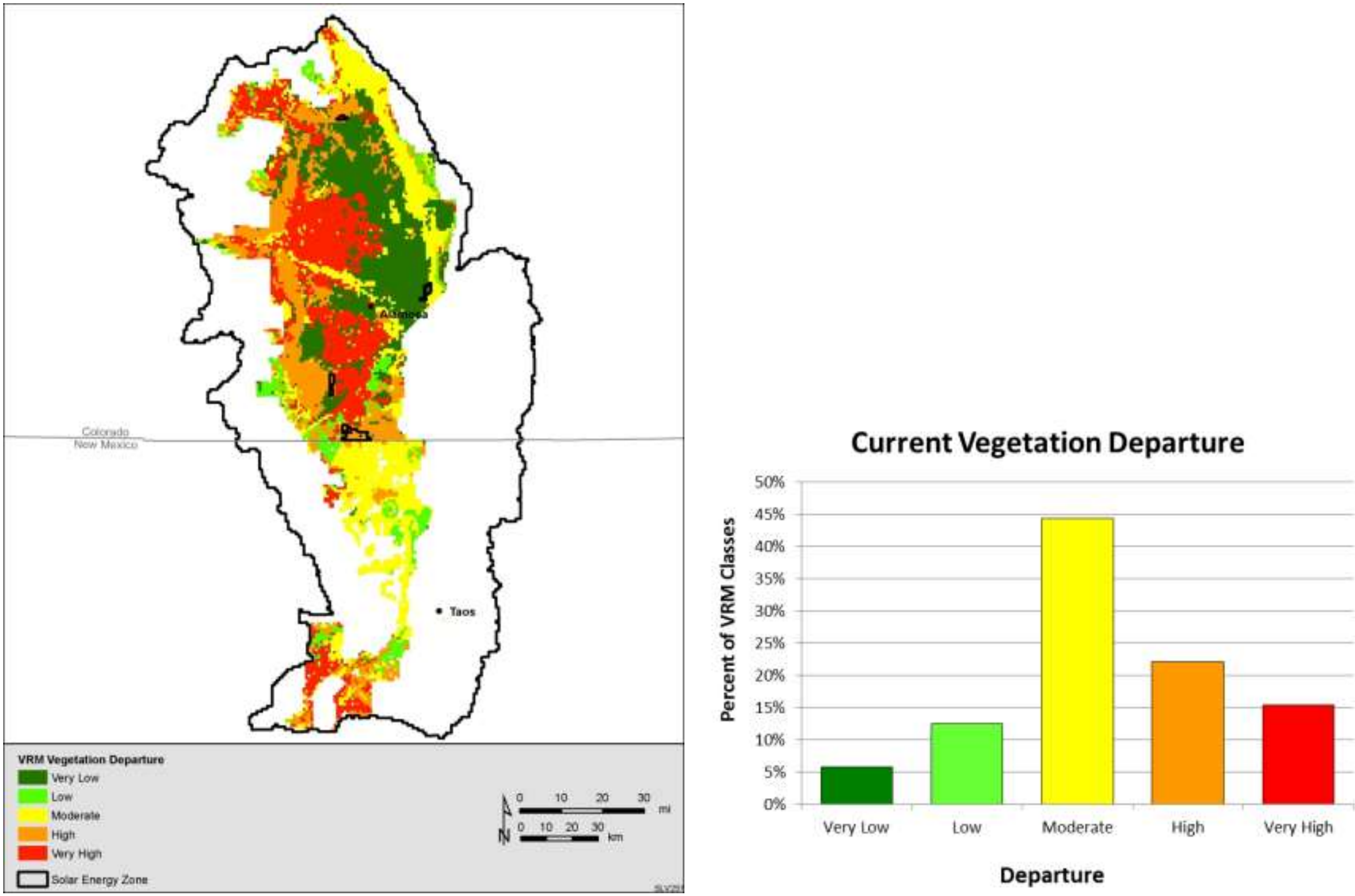


Figure A.11.6-2. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Visual Resource Management Areas. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008a) and data received from BLM. Data were Summarized to 1 km^2 Reporting Units.

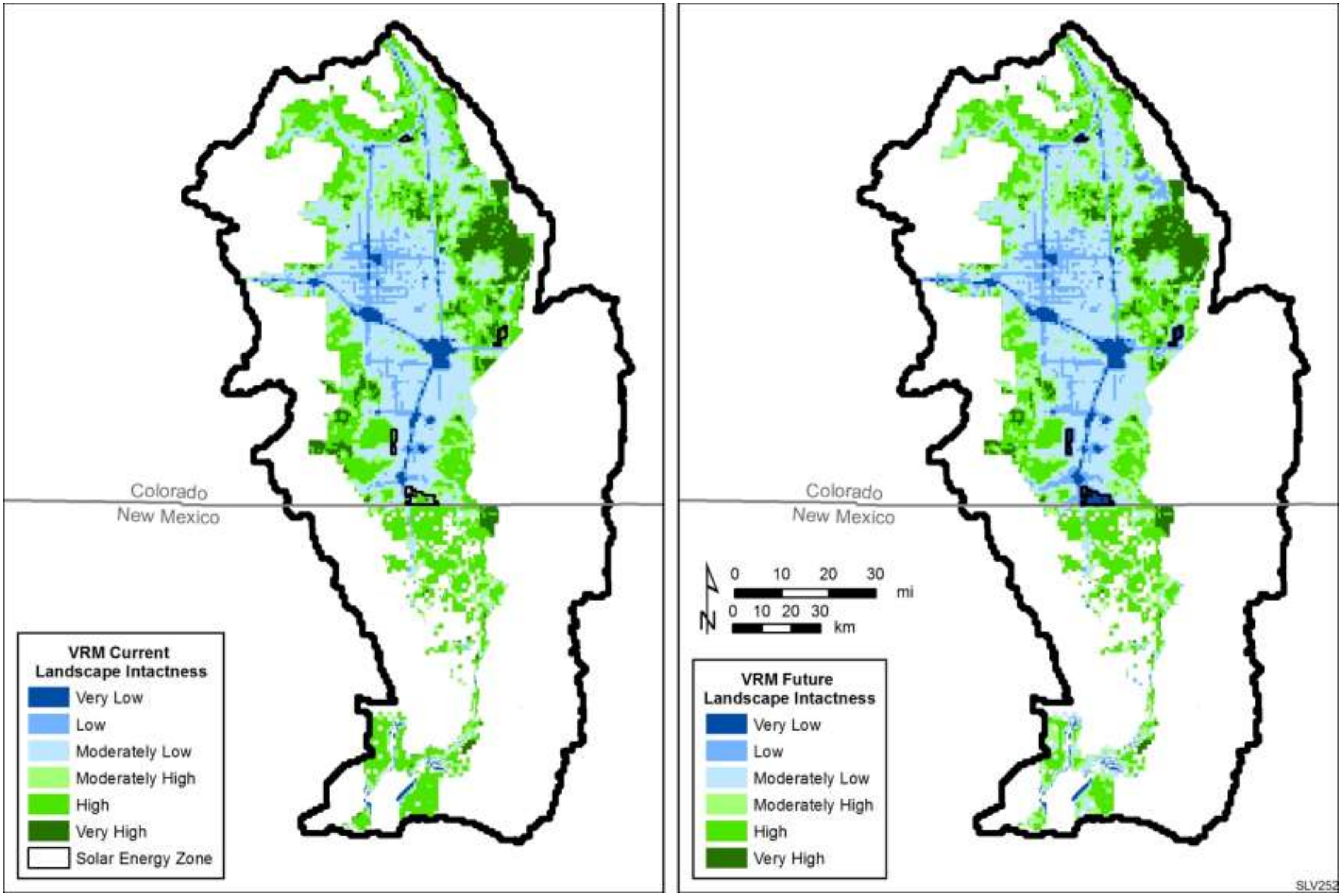


Figure A.11.6-3. Current and Future Landscape Intactness of Visual Resource Management Areas. Data Sources: Argonne 2014 and data received from BLM.

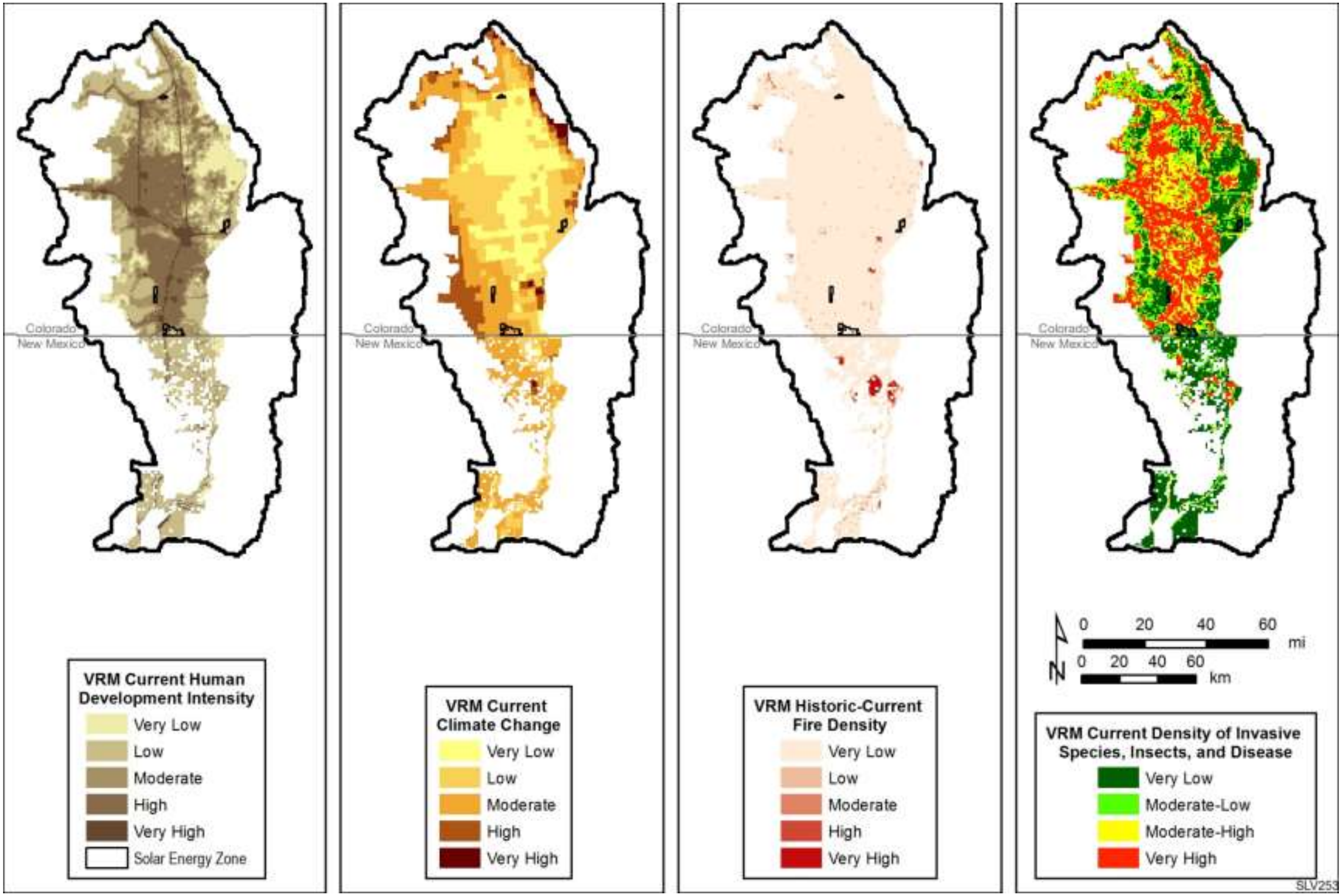


Figure A.11.6-4. Current distribution and intersection of Visual Resource Management Areas with change agents. Data Sources: Argonne 2014 and data received from BLM.

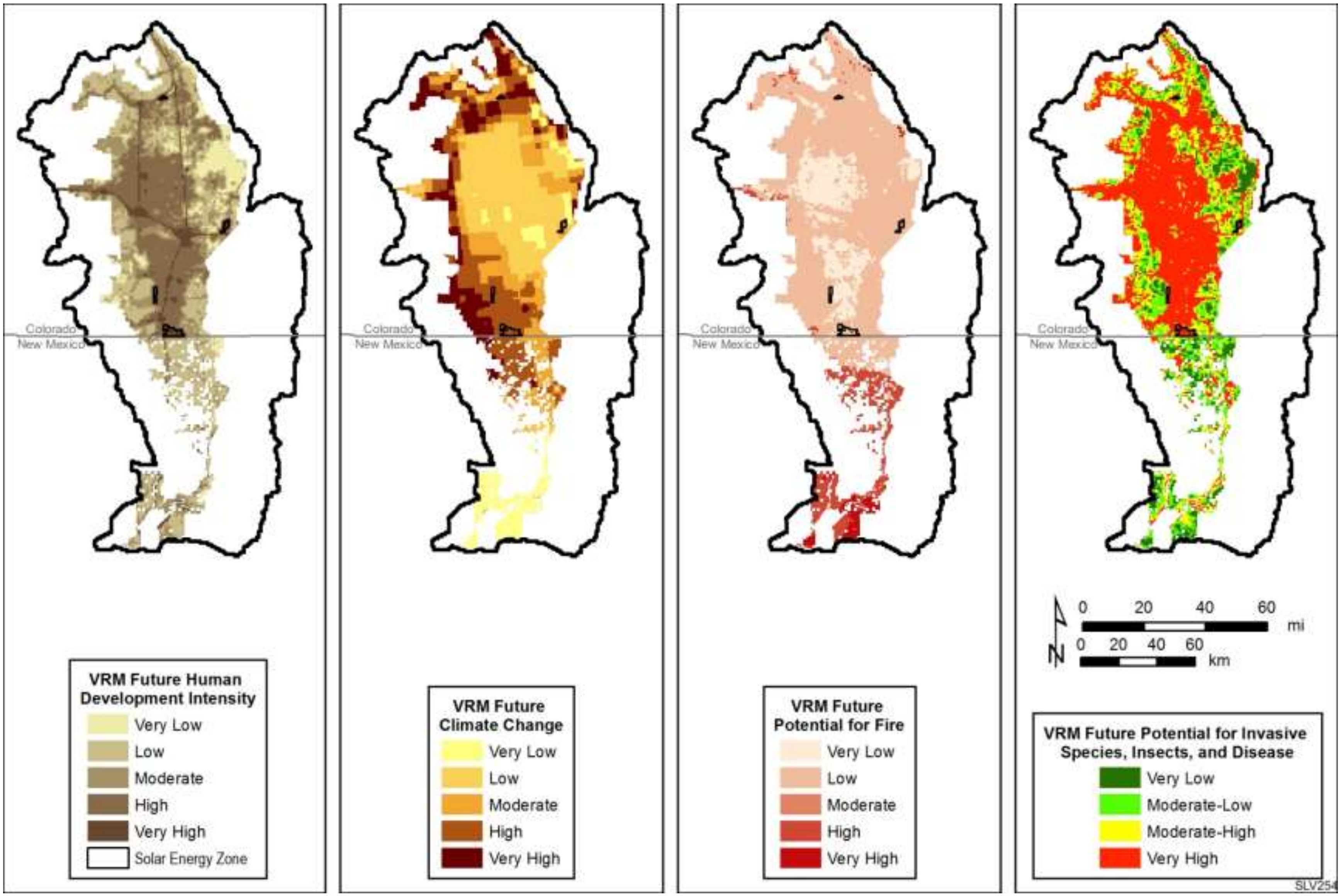


Figure A.11.6-5. Intersection of Visual Resource Management Areas with future change agent models to evaluate where Visual Resource Management Areas may be vulnerable to change agents in the future. Data Sources: Argonne 2014 and data received from BLM.

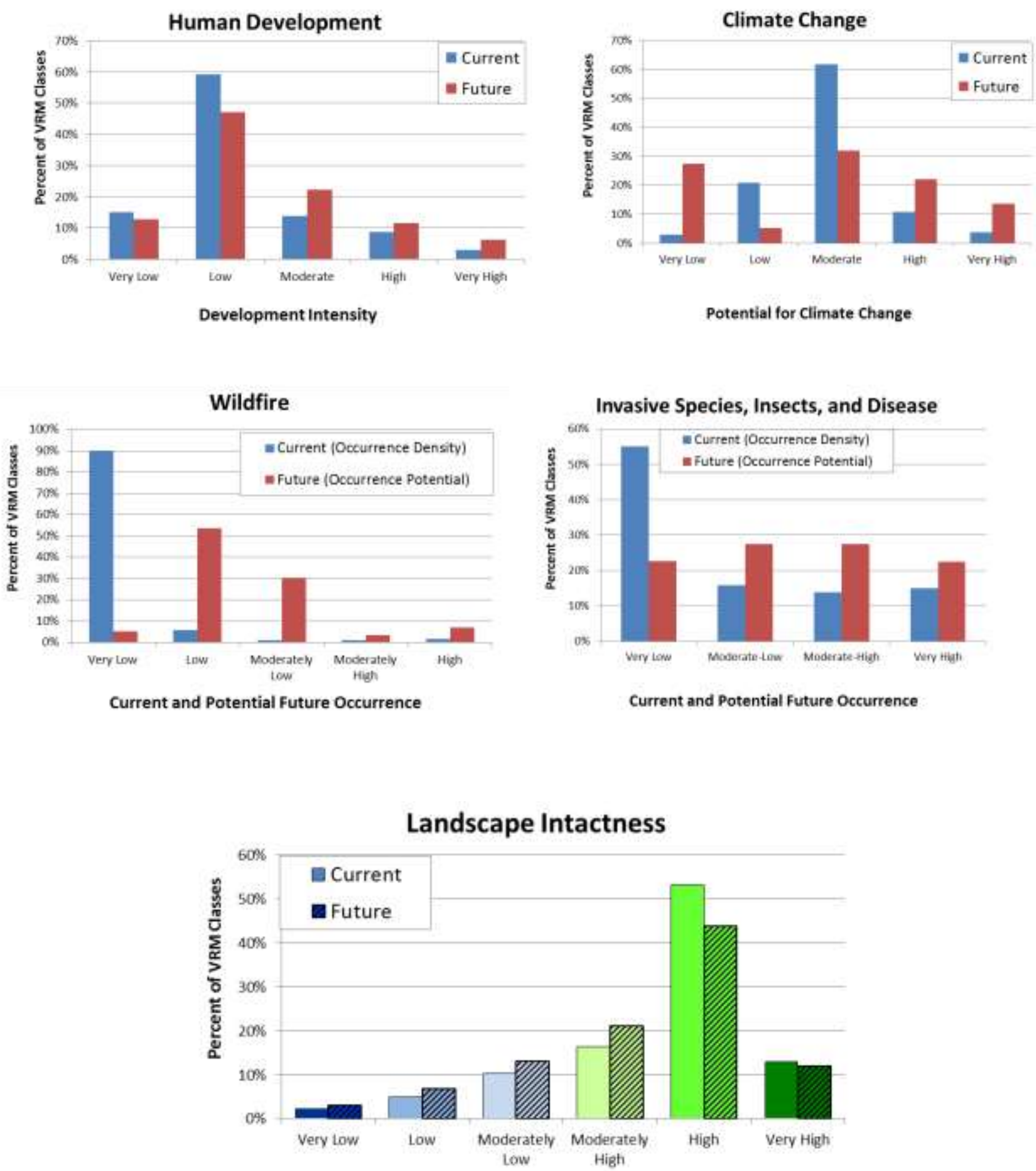


Figure A.11.6-6. Predicted Trends in Visual Resource Management areas within the Study Area

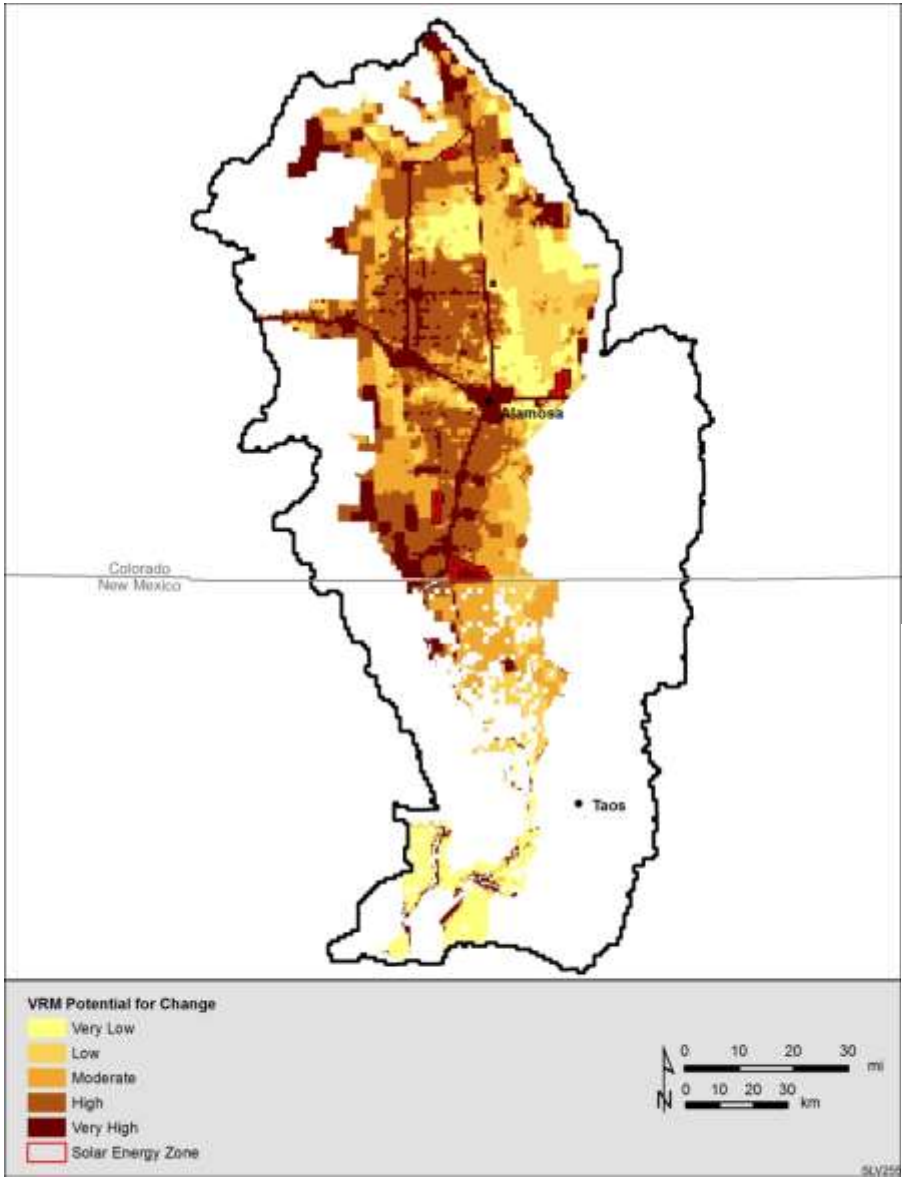


Figure A.11.6-7. Visual Resource Management (VRM) Aggregate Potential for Change. Data Sources: Argonne 2014 and data received from BLM.

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APPENDIX B:

EVALUATION OF CONSERVATION ELEMENTS

A total of 30 Conservation Elements (CEs) were included for assessment in this Landscape Assessment (**Table B-1**). These CEs are summarized as follows:

- 4 Ecological Systems CEs;
- 12 Focal Species CEs;
- 1 Aggregate Sites of Conservation Concern CEs;
- 6 Ecosystem Functions CEs; and
- 7 Cultural and Historic CEs (evaluated in the Cultural Landscape Assessment).

The process for identifying, screening, and selecting CEs for this Landscape Assessment is described in the Phase I Report (Argonne National Laboratory 2014).

Table B-2 summarizes the current and future conditions of Conservation Elements with respect to their intersections with Change Agents.

The spatial distributions and current and future conditions of these CEs are presented in the sections below. Conceptual models are also provided for ecological systems and focal species to illustrate the interactions between the CEs, the physical environment, and change agents.
A separate References Section is provided for all references cited in this Appendix.

Table B-1. Conservation Elements Evaluated in this Landscape Assessment

A. Ecological Systems[1]		
	Ecological System Macrogroup	**Percent of Ecoregion**
A.1	Montane and Subalpine Conifer Forest	35.2%
A.2	Basin Grassland and Shrubland	27.6%
A.3	Piñon-Juniper Woodland	10.2%
A.4	Riparian and Wetland Systems (playa, marsh, open water, wetland)	8.6%
B. Focal Species		
B.1	Native fish assemblage (Rio Grande chub, Rio Grande cutthroat trout, and Rio Grande sucker)	
B.2	Brewer's sparrow (representative migratory bird species)	
B.3	Ferruginous hawk	
B.4	Northern goshawk (representative montane species)	
B.5	Gunnison sage-grouse	
B.6	Waterfowl/shorebird assemblage	
B.7	Mexican free-tailed bat (representative bat species)	
B.8	Bighorn sheep	
B.9	Grassland fauna assemblage (burrowing owl, mountain plover, and Gunnison's prairie dog)	
B.10	Mountain lion	
B.11	Pronghorn	
B.12	Elk-mule deer assemblage	
C. Sites of Conservation Concern		
C.1	Sites of Conservation Concern Assemblage	
D. Ecosystem Functions		
D.1	Soils with potential for erosion	
D.2	Aquatic systems (including streams, lake, ponds, reservoirs, wetlands/playas, ponds livestock and wildlife watering tanks, springs, wells, diversions, ditches, canals and other artificial water bodies)	
D.3	Riparian areas (includes data from various sources and scales, such as CPW, NWI, and species-specific data on willow and cottonwood, if available)	
D.4	Hydrologic systems (includes snowpack level, runoff [timing], rainfall patterns, high quality waters, impaired waters, ephemeral drainages, groundwater and aquifers related to quantity (recharge and discharge) and quality (contaminant transport and groundwater pollution)	
D.5	Species Richness / Biodiversity Assemblage (rare/at risk species summed by Natural Resources Conservation Service (NRCS) HUC10 hydrologic reporting unit)	
D.6	Big game ranges (including summer & winter range, fawning, lambing, and calving areas, and migration corridors)	
E. Cultural and Historic Conservation Elements		
	A total of 7 cultural historic CEs were identified through a separate Cultural Landscape Assessment effort.	

[1] Macrogroups determined from LandFire EVT associations and compliant with BLM vegetation mapping standards (IM 2013-111 [BLM 2013b] : http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2013/im_2013-111_the_national.html)

Table B-2. Summary of Conservation Element Current and Future Potential Conditions.[6]

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
A. Ecological Systems											
Montane and Subalpine Conifer Forest	**Moderate** Very Low: 3.3% Low: 28.6% Mod: 46.8% High: 19.9% Very High: 1.3%	**Very high** Very Low: 0.3% Low: 1.5% Mod Low: 3.5% Mod High: 7.9% High: 27.8% Very High: 59.0%	**Very high** Very Low: 0.5% Low: 2.7% Mod Low: 5.3% Mod High: 14.7% High: 25.5% Very High: 51.3%	**High** Very Low: 0.1% Low: 0.1% Mod: 13.9% High: 43.9% Very High: 42.0%	**High** Very Low: 26.8% Low: 7.5% Mod: 16.4% High: 21.2% Very High: 28.3%	**Very Low** Very Low: 90.8% Low: 5.8% Mod: 0.9% High: 1.0% Very High: 1.6%	**Low** Very Low: 0.2% Low: 52.7% Mod: 19.3% High: 10.3% Very High: 17.5%	**Very High** Very Low: 18.6% Mod Low: 11.1% Mod high: 14.5% Very High: 55.9%	**Very High** Very Low: 10.4% Mod Low: 13.0% Mod high: 19.3% Very High: 57.3%	**Low** Very Low: 28.3% Low: 14.9% Mod: 17.9% High: 17.8% Very High: 21.2%	Current and predicted future human development in this system is relatively low, as evidenced by relatively high landscape intactness values. Most of the current vegetation departure within this system (as measured by LANDFIRE VDEP) has occurred in New Mexico south of the state line and along the Sangre de Cristo mountains as well as the mountains south and west of Tres Piedras, within the Carson National Forest and is collocated in areas of high to very high future wildfire risk. Areas of greatest potential exposure to future climate change within this system are in the western portion of the study area in the eastern San Juan mountains and La Garita mountains. There is high potential for invasive species, insects, and disease prevalence within this system where outbreaks of spruce beetles have been recorded, and may continue to infest new areas as a result of climate change. The overall potential for change within this system centers on Saguache Park northeast along the continental divide to Poncha Pass and then south along the Sangre de Cristo mountains to the Crestone area, the eastern San Juan mountains from the Alamosa River drainage to San Antonio mountain.
Basin Grassland and Shrubland	**Moderate** Very Low: 11.4% Low: 3.0% Mod: 48.7% High: 27.2% Very High: 9.7%	**Moderately High** Very Low: 2.4% Low: 4.6% Mod Low: 12.8% Mod High: 20.1% High: 46.4% Very High: 13.7%	**Moderately High** Very Low: 4.3% Low: 7.7% Mod Low: 15.8% Mod High: 24.2% High: 37.2% Very High: 10.9%	**Moderate** Very Low: 9.1% Low: 30.9% Mod: 53.1% High: 6.2% Very High: 0.8%	**Moderate** Very Low: 25.9% Low: 10.6% Mod: 37.4% High: 19.1% Very High: 7.0%	**Very Low** Very Low: 97.3% Low: 2.4% Mod: 0.3% High: 0.0% Very High: 0.0%	**Low** Very Low: 0.3% Low: 69.3% Mod: 28.2% High: 1.8% Very High: 0.3%	**Very Low** Very Low: 60.7% Mod Low: 19.1% Mod high: 15.4% Very High: 4.9%	**Moderately Low** Very Low: 17.4% Mod Low: 37.7% Mod high: 30.4% Very High: 14.6%	**Low** Very Low: 21.5% Low: 34.8% Mod: 20.4% High: 11.1% Very High: 12.3%	Much of the historic distribution of this ecological system has been converted to agriculture and other human developments throughout the study area. Most of the vegetation departure within its current distribution is located in the western portion of the study area in Colorado, in proximity to the foothills of the Rio Grande National Forest (e.g., west of La Jara and in the Poncha Pass regions of Colorado). These areas are also the most vulnerable to experience future climate change.

[6] Conservation Element current and potential future conditions were based on the intersections between Conservation Element distributions and Change Agent models in the study area. Overall categorical determinations (in bold) are based on averages of modeled values. Percentages represent the relative proportion of each category. Cell colors also correspond to Change Agent model categories. Refer to individual Change Agent models (Appendix A) and Conservation Element assessments (Appendix B, below) for additional information.

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
Piñon-Juniper Woodland	**Low** Very Low: 7.5% Low: 33.2% Mod: 17.5% High: 21.5% Very High: 20.3%	**High** Very Low: 1.1% Low: 4.7% Mod Low: 8.1% Mod High: 17.5% High: 42.0% Very High: 26.5%	**High** Very Low: 1.6% Low: 10.4% Mod Low: 16.6% Mod High: 21.7% High: 32.0% Very High: 17.6%	**Moderate** Very Low: 0.4% Low: 10.1% Mod: 72.0% High: 15.0% Very High: 2.5%	**Low** Very Low: 48.1% Low: 10.1% Mod: 24.2% High: 12.9% Very High: 4.7%	**Very Low** Very Low: 87.9% Low: 8.0% Mod: 1.7% High: 0.7% Very High: 1.7%	**Moderate** Very Low: 0.0% Low: 32.4% Mod: 35.7% High: 11.4% Very High: 20.5%	**Very Low** Very Low: 68.6% Mod Low: 14.3% Mod high: 10.5% Very High: 6.6%	**Moderately Low** Very Low: 22.7% Mod Low: 38.4% Mod high: 25.2% Very High: 13.8%	**Very Low** Very Low: 38.3% Low: 26.5% Mod: 14.2% High: 10.1% Very High: 10.9%	The majority of vegetation within piñon-juniper woodland system has a low degree of departure from historic reference vegetation conditions and most of that is in New Mexico. According to the Colorado Natural Heritage Program, this threat status for the pinon-juniper system in the study area is "fair". Climate change since the 1930's has been most pronounced along the flanks of the northern Sangre de Cristos from Blanca Peak to Wild Cherry Creek. Future trends in climate change indicate portions of piñon-juniper woodland system with high or very high potential for climate change in the long-term future, primarily due to lack of disturbances and over stocking. Future potential for climate change in this system is greatest in Colorado along the foothills of the San Luis Valley within BLM lands, notably in the La Garita foothills and upland catchments of Alamosa River, but also in New Mexico in stands in the Taos Plateau and the Sangres foothills north of Questa. Drought stress and subsequent insect outbreaks have been causing widespread mortality of piñon pine throughout much of its range, especially on soil types that are more prone to moisture loss (Mueller et al. 2005). Close attention to climate change projections may be particularly important in defining where this community type can occur in the future.
Riparian and Wetland Systems	**Moderate** Very Low: 16.5% Low: 13.6% Mod: 33.6% High: 20.0% Very High: 16.2%	**High** Very Low: 3.2% Low: 5.9% Mod Low: 23.5% Mod High: 14.3% High: 28.0% Very High: 24.9%	**Moderately Low** Very Low: 4.1% Low: 9.1% Mod Low: 24.8% Mod High: 17.6% High: 23.6% Very High: 20.8%	**Moderate** Very Low: 13.9% Low: 23.1% Mod: 29.8% High: 18.8% Very High: 14.4%	**Moderate** Very Low: 29.1% Low: 14.6% Mod: 24.7% High: 17.8% Very High: 13.9%	**Very Low** Very Low: 94.1% Low: 3.8% Mod: 0.7% High: 0.6% Very High: 0.8%	**Low** Very Low: 11.2% Low: 59.4% Mod: 16.8% High: 5.4% Very High: 7.1%	**Moderately High** Very Low: 31.0% Mod Low: 14.0% Mod high: 20.5% Very High: 34.5%	**Very High** Very Low: 9.8% Mod Low: 19.5% Mod high: 24.9% Very High: 45.8%	**Moderate** Very Low: 21.2% Low: 20.9% Mod: 18.5% High: 20.9% Very High: 18.5%	Currently, agriculture represents about 86% of Colorado's water use and the Rio Grande Basin faces continued water shortages associated with existing agricultural demands. This modelling effort suggests that riparian areas in the montane and foothill regions of the study area are more likely to experience future climate change than lower elevation areas. However, indirect effects of climate change, e.g., less precipitation in higher elevations resulting in lower streamflows feeding lower elevation systems and providing less groundwater recharge to aquifers underlying the valley floor, are not reflected in this model. Groundwater declines in the San Luis Valley resulting from both extreme drought conditions and

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
											agriculture pumping have been documented, and have resulted in decreases in wetlands habitat in the San Luis Valley. This should be expected to be exacerbated by climate change impacts. Invasive species have the potential to become established along all riparian areas and in wetland basins. Invasive plants such as tamarisk often successfully out-compete native species such as willows, because of their higher reproductive capacity and tolerance to drought and flooding events. The greatest potential for change in riparian-wetland systems as a result of all change agents is located near urban and agricultural areas such as Alamosa and Antonito, Colorado.
<u>B. Focal Species</u>											
Native fish assemblage	**<u>Moderate</u>** Very Low: 4.4% Low: 28.0% Mod: 43.9% High: 18.0% Very High: 5.7%	**<u>High</u>** Very Low: 0.4% Low: 1.8% Mod Low: 5.0% Mod High: 11.7% High: 29.5% Very High: 51.7%	**<u>High</u>** Very Low: 0.6% Low: 2.9% Mod Low: 7.0% Mod High: 20.5% High: 25.1% Very High: 43.8%	**<u>High</u>** Very Low: 0.0% Low: 0.0% Mod: 16.4% High: 31.4% Very High: 52.2%	**<u>Moderate</u>** Very Low: 33.8% Low: 7.0% Mod: 14.6% High: 22.9% Very High: 21.8%	**<u>Very Low</u>** Very Low: 91.2% Low: 4.2% Mod: 1.4% High: 1.1% Very High: 2.0%	**<u>Moderate</u>** Very Low: 1.9% Low: 60.3% Mod: 11.7% High: 6.8% Very High: 19.3%	**<u>Moderately High</u>** Very Low: 16.7% Mod Low: 11.0% Mod high: 20.5% Very High: 51.8%	**<u>Moderately High</u>** Very Low: 8.5% Mod Low: 11.8% Mod high: 24.3% Very High: 55.5%	**<u>Moderate</u>** Very Low: 34.8% Low: 14.5% Mod: 17.2% High: 15.9% Very High: 17.6%	The native fish assemblage (Rio Grande cutthroat trout, Rio Grande sucker, and Rio Grande chub) face threats from human alteration of the hydrology where these species are found. Changes to hydrology include decreased flows from water diversions and changes in stream hydrograph as a result of dam operations. These species also face tremendous threats from competition and predation from introduced species, habitat fragmentation, and habitat loss and degradation due to climate change and other anthropogenic factors such as land-use practices that increase stream sedimentation, reduce streamside vegetation, or impact water quality. Relatively little vegetation departure has occurred in the areas inhabited by the native fish assemblage and these areas are expected to have relatively high future landscape intactness. However, the models evaluated in this LA suggest that these habitats have moderate to high potential to experience climate change in the future, which could alter habitats by influencing hydrologic patterns and promote establishment of invasive species. According to models prepared for this LA, native fish habitats in the study area also have a moderately high potential for future encroachment of invasive species.

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
Brewer's sparrow	**Moderate** Very Low: 4.4% Low: 3.9% Mod: 68.0% High: 14.1% Very High: 9.6%	**Moderately High** Very Low: 3.6% Low: 7.5% Mod Low: 13.1% Mod High: 21.9% High: 39.5% Very High: 14.4%	**Moderately High** Very Low: 4.3% Low: 12.0% Mod Low: 15.0% Mod High: 23.8% High: 33.3% Very High: 11.5%	**Moderate** Very Low: 3.0% Low: 27.8% Mod: 61.3% High: 6.4% Very High: 1.5%	**Low** Very Low: 37.6% Low: 10.9% Mod: 41.3% High: 8.2% Very High: 1.9%	**Very Low** Very Low: 94.3% Low: 3.2% Mod: 0.7% High: 0.7% Very High: 1.0%	**Moderate** Very Low: 0.3% Low: 47.7% Mod: 50.2% High: 1.5% Very High: 0.3%	**Very Low** Very Low: 61.5% Mod Low: 15.3% Mod high: 14.9% Very High: 8.2%	**Moderately High** Very Low: 13.7% Mod Low: 38.5% Mod high: 27.7% Very High: 20.1%	**Low** Very Low: 26.5% Low: 38.0% Mod: 14.7% High: 7.0% Very High: 13.8%	Breeding habitat for the Brewer's sparrow is composed of shrublands and is closely associated with sagebrush-dominated landscapes. The majority of vegetation within Brewer's sparrow potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions with areas of high departure notable at Poncha Pass, Trinchera, and San Luis in Colorado and in uplands at the confluence of the Rio's Chama and Ojo Caliente north of Española, New Mexico. Intactness of the Brewer's sparrow's habitat is not expected to change much in the near-term (moderately high intactness). Climate change since the 1930's has been highest in the Poncha Pass area and moderate in Brewer's sparrow habitat that extends from the Taos Plateau to the Trinchera Creek. Future climate change models evaluated for the study area indicate a moderate potential for the majority of Brewer's sparrow habitat, except in the Poncha Pass area, where habitat is projected to be highly and very highly impacted by future climate change. Climate change in other portions of the study area could influence Brewer's sparrow habitat. According to the change agent models evaluated in the LA, the greatest potential for change in Brewer's sparrow habitat in the study area is associated with the expansion of human activities in shrubland systems and spread of invasive species in suitable habitats. The greatest potential for Brewer's sparrow habitat to experience these change agents is in New Mexico.

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Ferruginous hawk	**Moderate** Very Low: 26.0% Low: 2.0% Mod: 32.6% High: 9.7% Very High: 29.8%	**Moderately Low** Very Low: 5.7% Low: 9.8% Mod Low: 43.5% Mod High: 14.9% High: 18.0% Very High: 8.0%	**Moderately Low** Very Low: 6.3% Low: 14.1% Mod Low: 41.6% Mod High: 14.7% High: 16.1% Very High: 7.1%	**Low** Very Low: 27.9% Low: 39.3% Mod: 29.2% High: 3.1% Very High: 0.5%	**Low** Very Low: 32.6% Low: 25.9% Mod: 30.2% High: 10.1% Very High: 1.3%	**Very Low** Very Low: 97.5% Low: 1.7% Mod: 0.4% High: 0.4% Very High: 0.4%	**Low** Very Low: 27.4% Low: 53.7% Mod: 18.2% High: 0.6% Very High: 0.0%	**Moderately Low** Very Low: 28.0% Mod Low: 10.7% Mod high: 24.8% Very High: 36.5%	**Moderately High** Very Low: 6.4% Mod Low: 16.8% Mod high: 21.3% Very High: 55.5%	**Moderate** Very Low: 18.6% Low: 22.4% Mod: 16.3% High: 26.2% Very High: 16.7%	The ferruginous hawk is a BLM sensitive species in both Colorado and New Mexico and could occur in open grasslands and shrublands throughout the study area. The majority of vegetation within ferruginous hawk potentially suitable habitat has a moderate to very high degree of departure from historic reference vegetation conditions. Habitat conversion represents one of the primary threats to this species in the study area. Specifically, conversion of shrubland-grasslands to intensive agricultural cultivation has reduced the amount of preferred habitat in the Conejos, Alamosa, and Rio Grande River Basins, and Closed Basin in Colorado's San Luis Valley from Saguache south to Antonito. Intactness of the ferruginous hawk's habitat was modified historically, and future models do not predict high additional change. Climate change in Ferruginous Hawk habitat since the 1930's has been moderate to high in the Taos Plateau and along the Sangre de Cristo range in Costilla County Colorado. The future climate change model (2040-2065) predict highest exposure to change within Ferruginous hawk habitat at Poncha Pass, in agricultural and residential lands east of Saguache, along the Rio Grande at Del Norte, along the Conejos River in Colorado with low to moderate exposure through the rest of its range in the study area.

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Northern goshawk	**Moderate** Very Low: 3.6% Low: 27.7% Mod: 44.0% High: 19.7% Very High: 5.0%	**High** Very Low: 0.5% Low: 1.5% Mod Low: 3.3% Mod High: 8.2% High: 29.2% Very High: 57.2%	**High** Very Low: 0.7% Low: 2.6% Mod Low: 5.0% Mod High: 15.4% High: 26.6% Very High: 49.6%	**High** Very Low: 0.0% Low: 0.9% Mod: 15.8% High: 42.6% Very High: 40.6%	**Moderate** Very Low: 27.1% Low: 7.2% Mod: 16.8% High: 20.5% Very High: 28.5%	**Very Low** Very Low: 90.7% Low: 5.8% Mod: 0.9% High: 1.0% Very High: 1.6%	**Moderate** Very Low: 0.7% Low: 54.3% Mod: 18.1% High: 9.7% Very High: 17.1%	**Moderately High** Very Low: 19.5% Mod Low: 11.8% Mod high: 15.7% Very High: 52.9%	**Moderately High** Very Low: 10.6% Mod Low: 13.1% Mod high: 21.0% Very High: 55.3%	**Moderate** Very Low: 28.7% Low: 14.9% Mod: 17.9% High: 17.0% Very High: 21.5%	The northern goshawk is a BLM sensitive species in both Colorado and New Mexico and could occur as a permanent resident of the montane coniferous forests in the study area. Relatively little vegetation departure has occurred in the areas inhabited by the northern goshawk and these areas are expected to have relatively high future landscape intactness. However, the models evaluated in this LA suggest that northern goshawk habitats have moderate to high potential to experience climate change in the future, which could alter habitats in a number of ways, including promoting establishment of invasive species that may affect forest health. According to models prepared for this LA, northern goshawk habitats in the study area also have a moderately high potential for future encroachment of invasive species. Most of the future potential for change in northern goshawk habitat occurs in the western portion of the study area in the Rio Grande National Forest.
Gunnison sage-grouse	**Moderate** Very Low: 0.0% Low: 1.3% Mod: 83.0% High: 0.0% Very High: 15.7%	**Moderately High** Very Low: 0.0% Low: 8.3% Mod Low: 20.0% Mod High: 20.4% High: 39.1% Very High: 12.2%	**Moderately High** Very Low: 0.4% Low: 8.7% Mod Low: 19.6% Mod High: 21.7% High: 37.8% Very High: 11.7%	**Moderate** Very Low: 0.0% Low: 14.8% Mod: 50.0% High: 23.0% Very High: 12.2%	**High** Very Low: 0.0% Low: 5.7% Mod: 18.3% High: 23.0% Very High: 53.0%	**Very Low** Very Low: 94.3% Low: 5.7% Mod: 0.0% High: 0.0% Very High: 0.0%	**Low** Very Low: 0.4% Low: 95.2% Mod: 3.0% High: 0.9% Very High: 0.4%	**Moderately High** Very Low: 22.6% Mod Low: 17.4% Mod high: 24.8% Very High: 35.2%	**Moderately High** Very Low: 7.4% Mod Low: 20.4% Mod high: 31.3% Very High: 40.9%	**High** Very Low: 0.0% Low: 18.3% Mod: 13.9% High: 30.4% Very High: 37.4%	The Poncha Pass population of Gunnison sage-grouse is a small population known to occur at the north end of the San Luis Valley. Current and future direct and functional loss of habitat due to human development is the principal threat to all remaining populations of Gunnison sage-grouse. There is also concern that other change agents such as climate change will continue to affect sagebrush habitats in the future. Relatively little vegetation departure has occurred in the occupied and potential habitat by the Poncha Pass population. Even though these areas are expected to have moderately high future landscape intactness, anthropogenic affects would impact Gunnison sage-grouse throughout Poncha Pass. Gunnison sage-grouse require large contiguous patches of sagebrush habitat and to be relatively isolated from anthropogenic stressors like highways, transmission lines, and other development that increases noise and the presence of corvids, which depredate nests. Highway 285 bisects the suitable habitat for the Poncha Pass population, which may affect Gunnison sage-grouse several miles away.

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											Additionally, there are transmission lines on the west side of the habitat, and which provide raptors and corvids numerous perch sites in and gain a large competitive advantage over Gunnison sage-grouse. The models evaluated in this LA suggest that habitat for the Gunnison sage-grouse will have moderate to high potential to experience climate change in the future, which could alter habitats in a number of ways, including altering soil-moisture dynamics and promoting establishment of invasive species that may affect sagebrush systems. With climate change, Gunnison sage-grouse brood rearing success would be negatively impacted by a likely decrease in chick survival, because there would less forbs and insects to forage in summer near the drier riparian corridors. According to models prepared for this LA, northern Gunnison sage-grouse habitat in the study area also has a moderately high potential for future encroachment of invasive species. Recent telemetry data of Gunnison sage-grouse in Poncha Pass indicates almost exclusive use the habitat east of Highway 285 in the northern half of modeled habitat.
Waterfowl/shorebird assemblage	**Moderate** Very Low: 21.4% Low: 12.8% Mod: 28.6% High: 17.9% Very High: 19.2%	**Moderately High** Very Low: 4.7% Low: 7.7% Mod Low: 31.5% Mod High: 15.7% High: 22.5% Very High: 17.9%	**Moderately High** Very Low: 5.6% Low: 11.1% Mod Low: 30.9% Mod High: 17.6% High: 19.5% Very High: 15.3%	**Moderate** Very Low: 19.1% Low: 23.9% Mod: 27.9% High: 18.5% Very High: 10.5%	**Moderate** Very Low: 27.2% Low: 16.7% Mod: 22.6% High: 18.8% Very High: 14.7%	**Very Low** Very Low: 94.3% Low: 4.0% Mod: 0.8% High: 0.5% Very High: 0.4%	**Low** Very Low: 13.8% Low: 61.9% Mod: 15.8% High: 3.8% Very High: 4.7%	**Moderately High** Very Low: 21.3% Mod Low: 14.0% Mod high: 24.6% Very High: 40.0%	**Moderately High** Very Low: 5.8% Mod Low: 14.1% Mod high: 25.8% Very High: 54.3%	**Moderate** Very Low: 16.8% Low: 18.1% Mod: 19.7% High: 23.6% Very High: 21.8%	The majority of vegetation within shorebird-waterfowl potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions. Most of the vegetation departure that has occurred within shorebird-waterfowl habitat is located in agricultural and rural areas of the San Luis Valley in Colorado, near the center of the study area. Although the model predicts only moderate vegetation departure, the model does not capture the degree of impact that occurs to this species group from farming practices in native grass habitats. Even though vegetation may remain within historic types, farming practices including haying and grazing can vastly limit the utility of these habitats for shorebirds and waterfowl. Modelling suggests higher elevation habitats are less likely to be affected by human development. This modelling effort also suggests that suitable habitat for the shorebird-waterfowl group in the montane and foothill regions of the study area are

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											more likely to experience future climate change than lower elevation areas. However, indirect effects of climate change, e.g., less precipitation in higher elevations resulting in lower streamflows feeding lower elevation systems and providing less groundwater recharge to aquifers underlying the valley floor, are not reflected in this model. Groundwater declines in the San Luis Valley resulting from both extreme drought conditions and agriculture pumping have been documented, and have resulted in decreases in wetlands habitat supporting the shorebird-waterfowl group in the San Luis Valley. This should be expected to be exacerbated by climate change impacts. Invasive species have the potential to become established in wetland basins. Invasive plants such as tamarisk often successfully out-compete native species such as willows, because of their higher reproductive capacity and tolerance to drought and flooding events.
Mexican free-tailed bat	**Moderate** Very Low: 15.5% Low: 13.2% Mod: 29.2% High: 23.4% Very High: 18.8%	**Moderately High** Very Low: 3.2% Low: 5.8% Mod Low: 22.6% Mod High: 15.7% High: 33.9% Very High: 18.8%	**Moderately High** Very Low: 4.2% Low: 9.0% Mod Low: 24.4% Mod High: 19.4% High: 27.9% Very High: 15.0%	**Moderate** Very Low: 13.5% Low: 23.3% Mod: 39.2% High: 18.1% Very High: 5.9%	**Moderate** Very Low: 31.3% Low: 14.6% Mod: 26.5% High: 16.6% Very High: 11.0%	**Very Low** Very Low: 93.1% Low: 4.2% Mod: 0.8% High: 0.7% Very High: 1.1%	**Low** Very Low: 10.1% Low: 58.6% Mod: 20.2% High: 4.8% Very High: 6.3%	**Moderately Low** Very Low: 37.2% Mod Low: 15.3% Mod high: 20.3% Very High: 27.1%	**Moderately High** Very Low: 11.4% Mod Low: 23.6% Mod high: 26.4% Very High: 38.5%	**Moderate** Very Low: 23.6% Low: 22.8% Mod: 18.1% High: 19.3% Very High: 16.2%	Threats to the Mexican free-tailed bat include loss of roosting habitat, pesticide poisoning, and climate change. This species consumes large numbers of insects nightly, a large proportion of which are agricultural pests. As a result, pesticides have been implicated as important causes of mortality. This species relies on very high densities of prey insects. Temperature and rainfall patterns associated with climate change may cause insect populations to shift, but the cave roosts of the Mexican free-tailed bats cannot shift. Therefore, climate change poses a threat to this species by shifting the distribution and availability of prey resources. The majority of vegetation within Mexican free-tailed bat potentially suitable habitat has a moderate to very low degree of departure from historic reference vegetation conditions. Most of the highest vegetation departure that has occurred within this habitat is located in agricultural and rural areas of the San Luis Valley in Colorado, near the center of the study area. Notable non-agricultural lands with very high degrees of vegetation departure in Mexican free-tailed bat habitat are in upper Saguache Creek, La Garita hills, Limekiln-Greenie foothills in

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											Colorado and uplands at the confluence of Rios Chama and Ojo Caliente in New Mexico. Human activities will continue to pose a threat to roosting and foraging habitats in the future. Additionally, according to models prepared for this LA, habitat for the Mexican free-tailed bat has the greatest potential to experience climate change in the northern and western portion of the study area in Colorado, including Poncha Pass and Northern Sangre de Cristos, Middle and Upper Saguache Creek, Tracy Mountain and extending to the South San Juans from Fox Creek to the Rio los Pinos and Rio San Antonio drainages in northern New Mexico.
Bighorn sheep	**Moderate** Very Low: 5.2% Low: 26.8% Mod: 26.4% High: 30.5% Very High: 11.2%	**High** Very Low: 0.8% Low: 2.5% Mod Low: 5.0% Mod High: 11.6% High: 38.1% Very High: 42.1%	**High** Very Low: 1.1% Low: 4.4% Mod Low: 7.4% Mod High: 18.4% High: 32.8% Very High: 35.8%	**High** Very Low: 0.6% Low: 4.1% Mod: 31.2% High: 41.7% Very High: 22.4%	**Moderate** Very Low: 34.2% Low: 6.7% Mod: 18.2% High: 19.9% Very High: 20.9%	**Very Low** Very Low: 90.2% Low: 7.4% Mod: 1.2% High: 1.2% Very High: 2.3%	**Moderate** Very Low: 0.3% Low: 28.8% Mod: 8.4% High: 4.4% Very High: 8.2%	**Moderately High** Very Low: 26.8% Mod Low: 16.0% Mod high: 18.2% Very High: 39.1%	**Moderately High** Very Low: 10.2% Mod Low: 18.6% Mod high: 27.3% Very High: 43.8%	**Moderate** Very Low: 31.7% Low: 17.3% Mod: 18.4% High: 15.8% Very High: 16.8%	Bighorn sheep habitat is limited and fragmented, thus making the species vulnerable to several threats such as disease and competition. Relatively moderate vegetation departure has occurred in the areas inhabited by the bighorn sheep and these areas are expected to have relatively high future landscape intactness. However, the models evaluated in this LA suggest that these habitats have moderate to high potential to experience climate change in the future, which could affect populations by altering vegetation and increasing the likelihood of disease transmission. The Trickle Mountain area has a small bighorn sheep population in an area with high potential for climate change, and has previously had documented cases of pneumonia. There are several bighorn core herd home ranges on the eastern portion of the San Juan Mountains of the study area and sheep in this region have tested positive for *Mycoplasma ovipneumoniae* and *Mannheimia haemolytica*. Given the current history of disease in the LA area, if future conditions increase the risk of disease, then recruitment and survival of lambs would decline from current levels, which are very low. According to models prepared for this LA, bighorn sheep habitat in the study area also has a moderately high potential for future encroachment of invasive species. The greatest potential for future climate change within bighorn sheep habitat is within the Rio Grande National Forest in Colorado in the northwestern portion of the study area.

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Grassland fauna assemblage	**Moderate** Very Low: 19.6% Low: 6.7% Mod: 31.8% High: 19.9% Very High: 22.0%	**Moderately High** Very Low: 4.0% Low: 6.9% Mod Low: 28.2% Mod High: 16.5% High: 32.2% Very High: 12.2%	**Moderately High** Very Low: 5.2% Low: 10.6% Mod Low: 29.8% Mod High: 19.1% High: 26.0% Very High: 9.3%	**Low** Very Low: 18.2% Low: 31.0% Mod: 42.4% High: 7.4% Very High: 1.0%	**Moderate** Very Low: 30.5% Low: 17.1% Mod: 30.1% High: 16.3% Very High: 6.0%	**Very Low** Very Low: 95.6% Low: 2.9% Mod: 0.6% High: 0.4% Very High: 0.5%	**Low** Very Low: 13.5% Low: 60.2% Mod: 19.9% High: 2.9% Very High: 3.6%	**Moderately Low** Very Low: 42.4% Mod Low: 14.9% Mod high: 20.4% Very High: 22.3%	**Moderately High** Very Low: 12.3% Mod Low: 25.8% Mod high: 25.9% Very High: 36.0%	**Moderate** Very Low: 20.8% Low: 25.6% Mod: 18.6% High: 20.0% Very High: 14.9%	Much of the historic habitat for the grassland fauna assemblage has been converted to agriculture and other human developments throughout the study area. Most of the vegetation departure within its current distribution is located in the western portion of the study area in Colorado, in proximity to the foothills of the Rio Grande National Forest (e.g., west of La Jara and in the Poncha Pass regions of Colorado), and in the southwestern portion of New Mexico from Pilar to Espanola within the Carson National Forest. In Colorado these areas are also the most vulnerable to experience future climate change, while in New Mexico northwest of Tres Piedras near and around San Antonio mountain is the most vulnerable.
Mountain lion	**Moderate** Very Low: 7.4% Low: 19.3% Mod: 42.6% High: 22.1% Very High: 8.7%	**High** Very Low: 1.0% Low: 3.2% Mod Low: 8.8% Mod High: 14.1% High: 37.1% Very High: 35.8%	**High** Very Low: 1.9% Low: 5.7% Mod Low: 11.7% Mod High: 19.7% High: 31.1% Very High: 30.0%	**Moderate** Very Low: 3.6% Low: 12.8% Mod: 36.4% High: 27.0% Very High: 20.1%	**Moderate** Very Low: 27.6% Low: 8.7% Mod: 25.3% High: 19.4% Very High: 19.0%	**Very Low** Very Low: 92.6% Low: 4.6% Mod: 0.8% High: 0.8% Very High: 1.2%	**Moderate** Very Low: 0.8% Low: 59.1% Mod: 23.4% High: 6.8% Very High: 10.0%	**Moderately Low** Very Low: 38.8% Mod Low: 15.1% Mod high: 16.2% Very High: 29.9%	**Moderately High** Very Low: 14.0% Mod Low: 24.6% Mod high: 26.1% Very High: 35.3%	**Moderate** Very Low: 25.6% Low: 23.2% Mod: 18.7% High: 15.1% Very High: 17.4%	Within their large home ranges, mountain lion populations may be affected by direct mortality and habitat loss associated with human interactions (e.g., hunting, vehicle collisions). The most important threat to mountain lions is overall habitat degradation due to human activities such as residential development, recreational development, and road building. Responses of prey populations to other change agents such as climate change can also affect mountain lions. The majority of the vegetation within mountain lion potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions. According to the models evaluated in this LA, mountain lion habitats are expected to have relatively high future landscape intactness. However, human activities (e.g., agriculture, residential, and recreational activities) will continue to pose a threat to mountain lion populations. In addition, change agent models suggest that the greatest potential for the species to experience climate change is located in the western portion of the study area in the Rio Grande National Forest.

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
Pronghorn	**Moderate** Very Low: 20.8% Low: 4.4% Mod: 33.6% High: 18.4% Very High: 22.7%	**Moderately High** Very Low: 4.2% Low: 6.9% Mod Low: 30.0% Mod High: 16.3% High: 32.2% Very High: 10.3%	**Moderately High** Very Low: 5.5% Low: 10.0% Mod Low: 30.2% Mod High: 18.9% High: 27.0% Very High: 8.5%	**Low** Very Low: 20.3% Low: 33.0% Mod: 36.0% High: 8.3% Very High: 2.4%	**Moderate** Very Low: 25.1% Low: 17.3% Mod: 30.5% High: 17.8% Very High: 9.3%	**Very Low** Very Low: 97.0% Low: 2.2% Mod: 0.5% High: 0.4% Very High: 0.4%	**Low** Very Low: 14.6% Low: 67.5% Mod: 17.5% High: 0.3% Very High: 0.1%	**Moderately Low** Very Low: 36.3% Mod Low: 15.6% Mod high: 23.0% Very High: 25.1%	**Moderately High** Very Low: 10.0% Mod Low: 23.0% Mod high: 27.4% Very High: 39.6%	**Moderate** Very Low: 16.4% Low: 24.6% Mod: 20.0% High: 22.2% Very High: 16.8%	Much of the historic habitat for the pronghorn has been converted to agriculture and other human developments throughout the study area. Most of the vegetation departure within pronghorn current distribution is located in the western portion of the study area in Colorado, in proximity to the foothills of the Rio Grande National Forest and east central region from San Luis to Antonito. Human activities (e.g., urban and agricultural developments) will continue to pose a threat to pronghorn populations, mostly in areas of the San Luis Valley in Colorado. In addition, change agent models suggest that the greatest potential for the species to experience climate change is located in the western portion of the study area including potions of the Carson National Forest northwest of Tres Piedras, around San Antonio mountain, and west of the Rio Grande between Taos and Espanola.
Elk-mule deer assemblage	**Moderate** Very Low: 13.4% Low: 16.0% Mod: 34.0% High: 20.7% Very High: 16.1%	**Moderately High** Very Low: 2.8% Low: 5.0% Mod Low: 19.4% Mod High: 13.9% High: 31.5% Very High: 27.4%	**Moderately High** Very Low: 3.6% Low: 7.8% Mod Low: 21.1% Mod High: 18.3% High: 26.4% Very High: 22.8%	**Moderate** Very Low: 11.3% Low: 19.6% Mod: 33.5% High: 21.6% Very High: 14.0%	**Moderate** Very Low: 29.1% Low: 13.4% Mod: 24.8% High: 18.2% Very High: 14.6%	**Very Low** Very Low: 93.3% Low: 4.1% Mod: 0.8% High: 0.7% Very High: 1.1%	**Low** Very Low: 4.2% Low: 29.3% Mod: 9.7% High: 2.7% Very High: 4.0%	**Moderately High** Very Low: 33.8% Mod Low: 14.1% Mod high: 19.3% Very High: 32.8%	**Moderately High** Very Low: 11.5% Mod Low: 21.2% Mod high: 24.6% Very High: 42.6%	**Moderate** Very Low: 23.2% Low: 21.3% Mod: 18.7% High: 19.2% Very High: 17.7%	The majority of vegetation within the elk-mule deer potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions. According to the models evaluated in this LA, these habitats are expected to have relatively high future landscape intactness. However, human activities (e.g., agriculture, residential, and recreational activities) will continue to pose a threat to elk and mule deer populations, primarily in areas throughout the study area where agricultural and energy developments are expected to occur. In addition, change agent models suggest that the greatest potential for these species to experience climate change is located in the western portion of the study area in the Rio Grande National Forest, including potions of the Carson National Forest northwest of Tres Piedras, around San Antonio mountain.

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
C. Sites of Conservation Concern											
Sites of Conservation Concern Assemblage	**Moderate** Very Low: 14.3% Low: 17.4% Mod: 38.4% High: 18.5% Very High: 11.4%	**High** Very Low: 2.2% Low: 3.9% Mod Low: 14.2% Mod High: 13.7% High: 32.8% Very High: 33.3%	**Moderately High** Very Low: 3.1% Low: 6.2% Mod Low: 16.3% Mod High: 18.5% High: 28.0% Very High: 28.0%	**Moderate** Very Low: 9.9% Low: 14.9% Mod: 32.2% High: 23.1% Very High: 19.9%	**Moderate** Very Low: 27.0% Low: 11.4% Mod: 23.2% High: 20.0% Very High: 18.3%	**Very Low** Very Low: 92.8% Low: 4.3% Mod: 0.9% High: 0.8% Very High: 1.2%	**Low** Very Low: 2.6% Low: 31.5% Mod: 9.5% High: 2.6% Very High: 3.8%	**Moderately High** Very Low: 34.3% Mod Low: 14.3% Mod high: 17.7% Very High: 33.7%	**Moderately High** Very Low: 13.6% Mod Low: 20.4% Mod high: 24.7% Very High: 41.3%	**Moderate** Very Low: 23.9% Low: 21.9% Mod: 18.8% High: 16.4% Very High: 19.0%	The majority of vegetation within the aggregated sites of conservation concern CE has a moderate degree of departure from historic reference vegetation conditions. According to the models evaluated in this LA, these sites are expected to have relatively high future landscape intactness. However, future human activities (e.g., agriculture, residential, and recreational activities) will continue to pose a threat to these sites in areas along the Rio Grande in Colorado and Espanola in New Mexico. In addition, although change agent models suggest that the greatest potential for these sites to experience climate change is located in the western portion of the study area in the Rio Grande National Forest, the model does not reflect indirect effects from climate change at lower elevations. Because less precipitation in higher elevations will result in lower streamflows feeding lower elevation systems and less groundwater recharge to aquifers underlying the valley floor, there would likely be climate change impacts observed at lower elevations that are not captured in this model, posing a threat to lower elevation sites of conservation concern as well.
D. Ecosystem Functions											
Soils with potential for erosion	**Moderate** Very Low: 17.3% Low: 13.7% Mod: 35.4% High: 16.1% Very High: 17.7%	**Moderately High** Very Low: 3.1% Low: 4.8% Mod Low: 21.5% Mod High: 12.3% High: 26.4% Very High: 31.9%	**Moderately High** Very Low: 3.6% Low: 7.5% Mod Low: 23.5% Mod High: 16.5% High: 22.1% Very High: 26.9%	**Moderate** Very Low: 14.2% Low: 22.5% Mod: 27.4% High: 18.4% Very High: 17.5%	**Moderate** Very Low: 31.4% Low: 15.3% Mod: 26.6% High: 14.0% Very High: 12.7%	**Very Low** Very Low: 93.6% Low: 3.8% Mod: 0.7% High: 0.7% Very High: 1.2%	**Low** Very Low: 12.8% Low: 55.5% Mod: 16.9% High: 5.4% Very High: 9.3%	**Moderately High** Very Low: 34.8% Mod Low: 11.7% Mod high: 18.6% Very High: 35.0%	**Moderately High** Very Low: 13.6% Mod Low: 20.5% Mod high: 21.1% Very High: 44.7%	**Moderate** Very Low: 25.4% Low: 22.7% Mod: 16.6% High: 18.1% Very High: 17.2%	The majority of vegetation overlapping the distribution of soils with potential for erosion has a moderate degree of departure from historic reference vegetation conditions. However, areas east of Del Norte and west of Hwy 17; south of Alamosa along HWY 285 (in Colorado), around San Juan Indian Reservation, along Rio Chama and Rio Grande (located at the south end of the analysis area in New Mexico) has a very high degree of departure from historic reference vegetation conditions. Most of the areas east of HWY 17 along San Luis Creek have a very low degree of departure from historic reference vegetation conditions. According to the models evaluated in this LA, these sites are expected to have a moderately high future landscape

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
											intactness. Most areas along Sangre De Cristo mountain (in New Mexico) and around Saguache Creek and the Great Sand Dunes (in Colorado) have very high future landscape intactness. However, future human activities (e.g., agriculture, residential, and recreational activities) will continue to pose a threat to soil stability in agricultural areas in the San Luis Valley in Colorado and near Espanola in New Mexico. Climate change will also pose a risk to soil stability in higher elevation sites, some low elevation sites (especially around Antonito, Saguache, Del Norte, and Poncha Pass areas along San Luis Creek in Colorado) and those sites along riparian areas and other hydrologic features. The majority of the areas with greatest future wildfire potential are mainly located in most part of New Mexico portion of the study area, which will also continue to pose a threat to soil stability.
Hydrologic systems	**Moderate** Very Low: 14.6% Low: 15.9% Mod: 19.6% High: 26.3% Very High: 23.5%	**Moderately Low** Very Low: 25.9% Low: 22.9% Mod Low: 19.0% Mod High: 14.0% High: 12.7% Very High: 5.4%	**Moderately Low** Very Low: 25.1% Low: 22.4% Mod Low: 18.9% Mod High: 14.4% High: 14.5% Very High: 4.8%	**Low** Very Low: 34.8% Low: 23.9% Mod: 19.4% High: 13.9% Very High: 8.1%	**Moderate** Very Low: 19.8% Low: 23.3% Mod: 22.3% High: 20.2% Very High: 14.4%	**Very Low** Very Low: 83.3% Low: 10.4% Mod: 4.0% High: 2.3% Very High: 0.1%	**Moderate** Very Low: 28.9% Low: 19.9% Mod: 18.8% High: 16.6% Very High: 15.8%	**Moderately Low** Very Low: 22.0% Mod Low: 28.6% Mod high: 28.8% Very High: 20.6%	**Moderately High** Very Low: 9.6% Mod Low: 26.5% Mod high: 29.9% Very High: 33.9%	**Moderate** Very Low: 8.0% Low: 21.3% Mod: 27.1% High: 26.3% Very High: 17.3%	Vegetation distribution in most of the analysis area has a moderate degree of departure from historic reference vegetation conditions. However, along Conejos River above San Antonio SEZ (in Colorado) and around San Juan Pueblo Indian Reservation located at the southern tip of the analysis area (in New Mexico) have a very high degree of departure from historic reference vegetation conditions. In addition, areas around Del Norte, Trickle Mountain, La Jara Creek, Alamosa River, around Los Mogotes/Antonito SE SEZs, and some of the southern tip of the analysis area have a high degree of vegetation departure. Most of high elevation areas have high and very high future landscape intactness, while most of the lowlands have very low to moderately low future landscape intactness. Most of south San Juan Mountain areas located west of Antonito SE and Los Mogotes SEZs, Saguache Creek, Trickle Mountain, East Poncha Pass area (along San Luis Creek), and some of the areas along the Sangre De Cristo mountains have high and very high future climate change threats on hydrologic systems; while most of the lowland areas have very low to moderate future climate change impact on hydrologic systems. However, climate change impacts on high

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
											elevation areas are hydrologically or indirectly connected to low elevation areas and the lowlands would also have high future climatic threats on hydrologic systems, although the model did not show this connection. Most of New Mexico portion of the analysis area have high and very high future wildfire potential impact on hydrologic systems, while future wildfire impact is low to moderate on hydrologic systems in all of the Colorado portion of the analysis area, except for the areas around Trujillo Meadows in the west and North Fork Trinchera Creek in the east. Overall impact due to all change agent groups on hydrologic systems is low and intermediate in most of the areas, except some areas [around Los Mogotes/ Antonito SE SEZs, between Del Norte and Alamosa along the Rio Grande, Raspberry Canyon in the east, Poncha Pass, Saguache Creek area, around Cuelebra Creek (in Colorado), north and west of San Antonio Mountain, around Taos Mountain, San Juan Pueblo Indian reservation, Raton canyon, Angostura Ridge (in New Mexico)] that have high and very high overall potential for change. Summarized to 5th-level watersheds, the primary threats to hydrologic systems in the study area are related to future human activities and climate change. Increased future human activities are expected to increase water demands in areas of the San Luis Valley in Colorado, and near Taos and Espanola in New Mexico. In addition, models evaluated for this LA suggest that the potential for future climate change will be greatest along the higher-elevation regions in the western portion of the study area. Climate change is expected to alter hydrologic processes in these regions, and may also have hydrologic implications at downstream locations.

Conservation Element	Current Vegetation Departure	Current Ecological Intactness (inverse of human development)	Future Ecological Intactness (inverse of human development)	Current Climate Change (Relative to Historic)	Potential for Future Climate Change	Current Fire Density	Future Potential for Fire	Current Invasive Species, Insects, and Disease Density	Future Potential Invasive Species, Insects, and Disease	Potential for Change	Interpretation Summary
Big game seasonal ranges	**Moderate** Very Low: 14.7% Low: 15.2% Mod: 35.8% High: 21.3% Very High: 13.0%	**High** Very Low: 1.5% Low: 4.1% Mod Low: 16.5% Mod High: 14.8% High: 34.6% Very High: 28.5%	**Moderately High** Very Low: 2.5% Low: 6.8% Mod Low: 18.2% Mod High: 19.3% High: 29.2% Very High: 24.0%	**Moderate** Very Low: 9.5% Low: 18.2% Mod: 36.9% High: 23.0% Very High: 12.3%	**Moderate** Very Low: 23.3% Low: 12.2% Mod: 27.4% High: 20.4% Very High: 16.7%	**Very Low** Very Low: 93.4% Low: 3.9% Mod: 0.7% High: 0.8% Very High: 1.2%	**Low** Very Low: 5.6% Low: 66.6% Mod: 17.5% High: 5.6% Very High: 4.7%	**Moderately Low** Very Low: 36.7% Mod Low: 15.0% Mod high: 18.1% Very High: 30.3%	**Moderately High** Very Low: 12.8% Mod Low: 22.9% Mod high: 26.5% Very High: 37.8%	**Moderate** Very Low: 21.6% Low: 24.0% Mod: 20.2% High: 16.8% Very High: 17.3%	The majority of vegetation within big game seasonal ranges and migration corridors has a moderate degree of departure from historic reference vegetation conditions. According to the models evaluated in this LA, these areas are expected to have relatively high future landscape intactness. However, future human activities (e.g., agriculture, residential, and recreational activities) will continue to pose a threat to big game habitat and movements. The greatest potential for change in big game seasonal ranges and migration corridors exists in the western portion of the study area where the potential for future climate change and human activities are also greatest. The big game migration corridors near the Colorado and New Mexico border are predicted to experience a high degree of climate change that could result in a reduction of net primary plant production yielding less forage. High quality and quantity forage in migration corridors ameliorate utilization in seasonal ranges because migration of big game occurs at a slower rate since they have the opportunities to forage and find suitable cover. Without quality habitat within migration corridors, seasonal ranges will tend be more heavily utilized and degrade over time.
Big game migration corridors	**Moderate** Very Low: 3.9% Low: 25.7% Mod: 45.7% High: 13.9% Very High: 10.8%	**High** Very Low: 0.6% Low: 3.4% Mod Low: 11.1% Mod High: 17.9% High: 44.6% Very High: 22.5%	**High** Very Low: 0.8% Low: 6.0% Mod Low: 12.0% Mod High: 22.3% High: 40.6% Very High: 18.3%	**Moderate** Very Low: 0.7% Low: 11.8% Mod: 43.5% High: 32.3% Very High: 11.7%	**High** Very Low: 8.6% Low: 8.3% Mod: 30.5% High: 19.7% Very High: 33.0%	**Very Low** Very Low: 89.8% Low: 4.4% Mod: 1.0% High: 1.1% Very High: 3.6%	**Low** Very Low: 2.8% Low: 61.7% Mod: 32.1% High: 1.2% Very High: 2.2%	**Moderately Low** Very Low: 36.4% Mod Low: 14.8% Mod high: 18.2% Very High: 30.6%	**Moderately High** Very Low: 11.2% Mod Low: 27.9% Mod high: 26.3% Very High: 34.7%	**Moderate** Very Low: 10.1% Low: 25.2% Mod: 18.0% High: 24.6% Very High: 22.2%	

B.1 Ecological Systems Conservation Elements

B.1.1 Montane and Subalpine Conifer Forest Systems

At the highest elevations is the subalpine life zone, characterized by cooler temperatures and heavier snows; annual precipitation can be relatively high for this semi-arid region, from 30 to 35 inches a year. Much of the precipitation comes in the form of snow during the cooler months, but a significant portion falls as heavy rains during the summer monsoon season, especially along the southern margin of the Colorado Plateau. Where snowpack keeps the forest floor moist for a large part of the year, subalpine conifer forests occur as small, isolated mountaintop stands. Only the hardiest trees such as Engelmann spruce (*Picea engelmannii)* and subalpine fir (*Abies lasiocarpa)* survive in this zone. Spruce-fir forests grade into bristlecone pine stands on some treeline sites, particularly on limestone substrates and drier south-facing slopes, and into mixed-conifer forests at lower elevations. Significant stands of quaking aspen occur in subalpine forests, particularly after fires (Grahame and Sisk 2002; USFWS 2013).

The vast majority of land at the higher elevations in the study area is under the management of the USFS, except for areas of Costilla County, where it is largely part of a handful of large private ranches. Several bird species are found in these forests, including olive-sided flycatcher, yellow warbler, and mountain chickadee. These higher elevation forests also provide habitat and migration corridors for important large mammals such as elk, black bear, and the threatened Canada lynx (USFWS 2012).

Natural fires are infrequent in subalpine conifer forests, but when they occur, they are usually severe and replace the stand (Kipfmueller and Baker 2000). Some spruce-fir stands experience mixed fire regimes, with stand-replacing fires occurring about every 300-400 years, and more frequent surface fires occurring every 15 to 30 years. Subalpine forests have probably been less altered by modern fire suppression and livestock grazing than the lower elevation forests (Grahame and Sisk 2002; Wyoming Game and Fish Department 2010).

Subalpine conifers are adapted to the strong winds and frigid temperatures atop the high peaks and tablelands of the region. Nevertheless, the uprooting and blowdown of subalpine trees by wind (windthrow) is a major natural disturbance factor. Windthrow is exacerbated where partial cutting of spruce-fir forest exposes remaining old trees to new wind stresses. Windthrow as well as accumulation of debris from logging operations contribute to outbreaks of spruce beetles, since these insects prefer downed trees (Veblen et al. 1991). Fire, windthrow, and insect infestation in coniferous forests create mosaic forests of varying structure and composition (Veblen et al. 1991). Projected climate changes might increase beetle infestations and the frequency of forest fires which could result in the elimination of some subalpine forests from isolated mountain ranges (Grahame and Sisk 2002).

Lack of aspen regeneration has been a consequence of modern fire suppression, and conifer understories are now widely overtopping aspen stands. Elk herbivory on aspen sprouts also retards regeneration on small burns or clear-cuts. Between 1962 and 1986, the area of aspen stands declined by 46% in Arizona and New Mexico. Many aspen forests in the Southwest are now composed of trees more than 100 years old which are particularly susceptible to increased insect and disease problems. Without major fires, aspen stands will continue to decline. However, the high probability of intense fires in southwestern conifer forests in the coming decades suggests that new aspen stands will develop again soon, changing their status from declining to increasing (Grahame and Sisk 2002; Wyoming Game and Fish Department 2010).

The information discussed in this CE assessment was used in the development of a conceptual model illustrating status and the mechanisms by which montane and subalpine coniferous forest systems may be affected within the San Luis Valley – Taos Plateau study area (Figure B.1.1-1). Figures B.1.1-2 through

B.1.1-8 show, respectively: Figure B.1.1-2 - the current distribution of montane and subalpine coniferous forest systems in the study area based on the aggregation of LANDFIRE Existing Vegetation Types; Figure B.1.1-3 – distribution with respect to current vegetation departure; Figure B.1.1-4 - distribution with respect to current and future landscape intactness in the study area; Figure B.1.1-5 - distribution and status with respect to the current status of change agents; Figure B.1.1-6 - distribution with respect to predicted areas of change; Figure B.1.1-7 - predicted trends in montane and subalpine coniferous forest systems within the study area; and Figure B.1.1-8 - the aggregate potential for change in montane and subalpine coniferous forest systems.

The majority (47%) of vegetation within montane and subalpine coniferous forest systems has a moderate degree of departure from historic reference vegetation conditions (Figure B.1.1-3).

The majority (59%) of montane and subalpine coniferous forest systems are within areas of very high current landscape intactness (Figure B.1.1-4; Figure B.1.1-7). Future trends in landscape intactness indicate a decrease in landscape intactness within montane and subalpine coniferous forest systems. The amount of these systems occurring within areas of high and very high landscape intactness is expected to decrease by approximately 10% in the near-term (i.e., by 2030) (Figure B.1.1-7).

The majority (66%) of montane and subalpine coniferous forest systems are within areas of very low current human development intensity (Figure B.1.1-5; Figure B.1.1-7). Future trends in human development indicate an increase in human development intensity within these systems. The amount of montane and subalpine coniferous forest systems occurring within areas high and very high human development intensity is expected to increase by approximately 4% in the near-term (i.e., by 2030) (Figure B.1.1-6; Figure B.1.1-7).

The majority of montane and subalpine coniferous forest systems are within areas of high and very high current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.1.1-5; Figure B.1.1-7). Future trends in climate change indicate portions of montane and subalpine coniferous forest systems with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.1.1-6; Figure B.1.1-7). Approximately 50% of these systems are located in areas with high or very high potential for future climate change (Figure B.1.1-6; Figure B.1.1-7).

The majority of montane and subalpine coniferous forest systems are within areas of very low current fire occurrence density (Figure B.1.1-5; Figure B.1.1-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of these systems in the study area. Over 70% of montane and subalpine coniferous forest systems have low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.1.1-7). The greatest potential for future wildfire occurs in the southern portion of the distribution of these systems in New Mexico (Figure B.1.1-6).

The majority of montane and subalpine coniferous forest systems are within areas of very high current density of invasive species, insects, and disease (Figure B.1.1-5; Figure B.1.1-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of these systems in the study area (Figure B.1.1-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of potential energy development and spread of forest insects and disease (Figure B.1.1-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 39% of the montane and subalpine coniferous forest systems have the potential for high or very high future change among the change agents (Figure B.1.1-8). Areas with greatest potential for change within these systems include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.1.1-8).

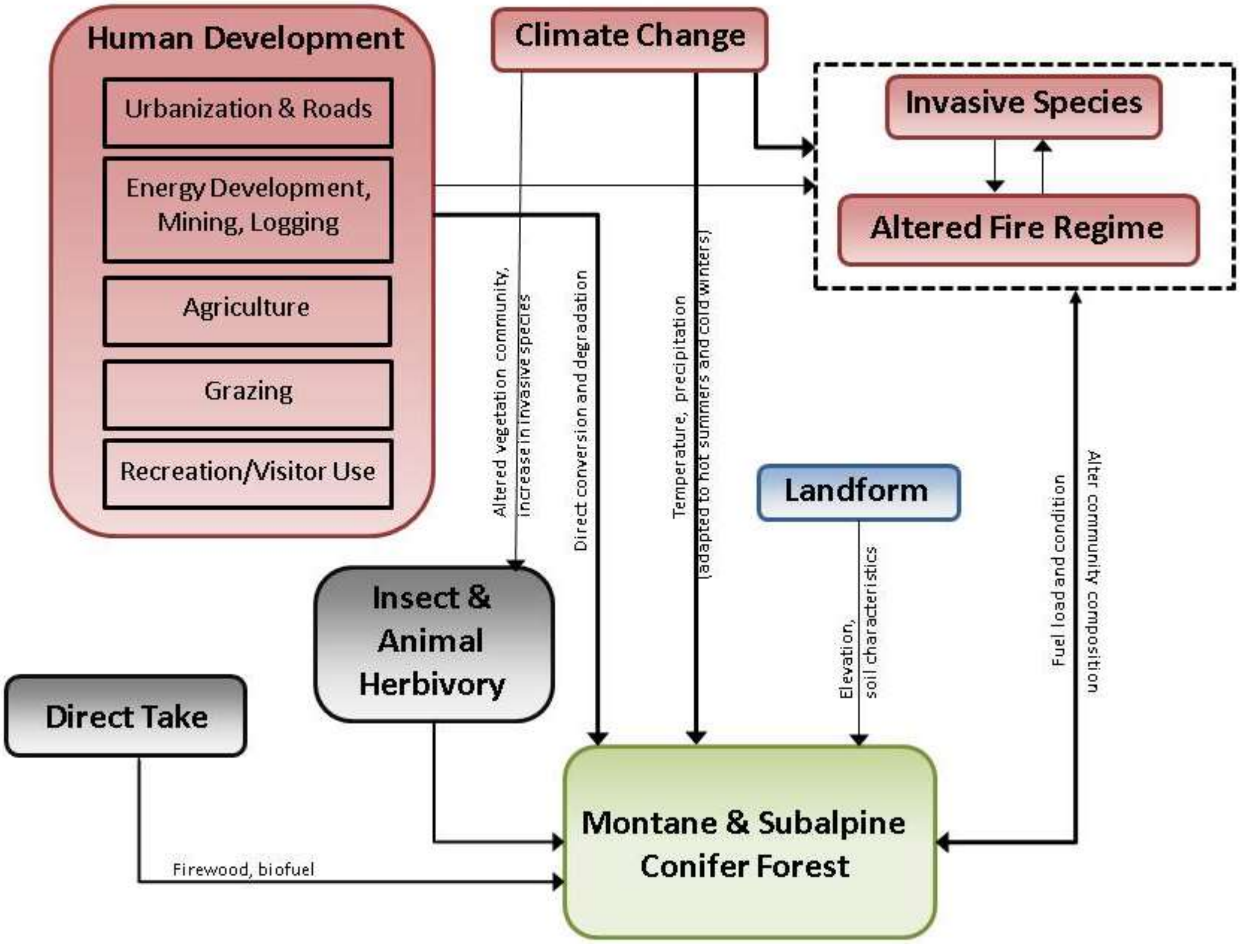


Figure B.1.1-1. Montane and Subalpine Conifer Forest Conceptual Model.

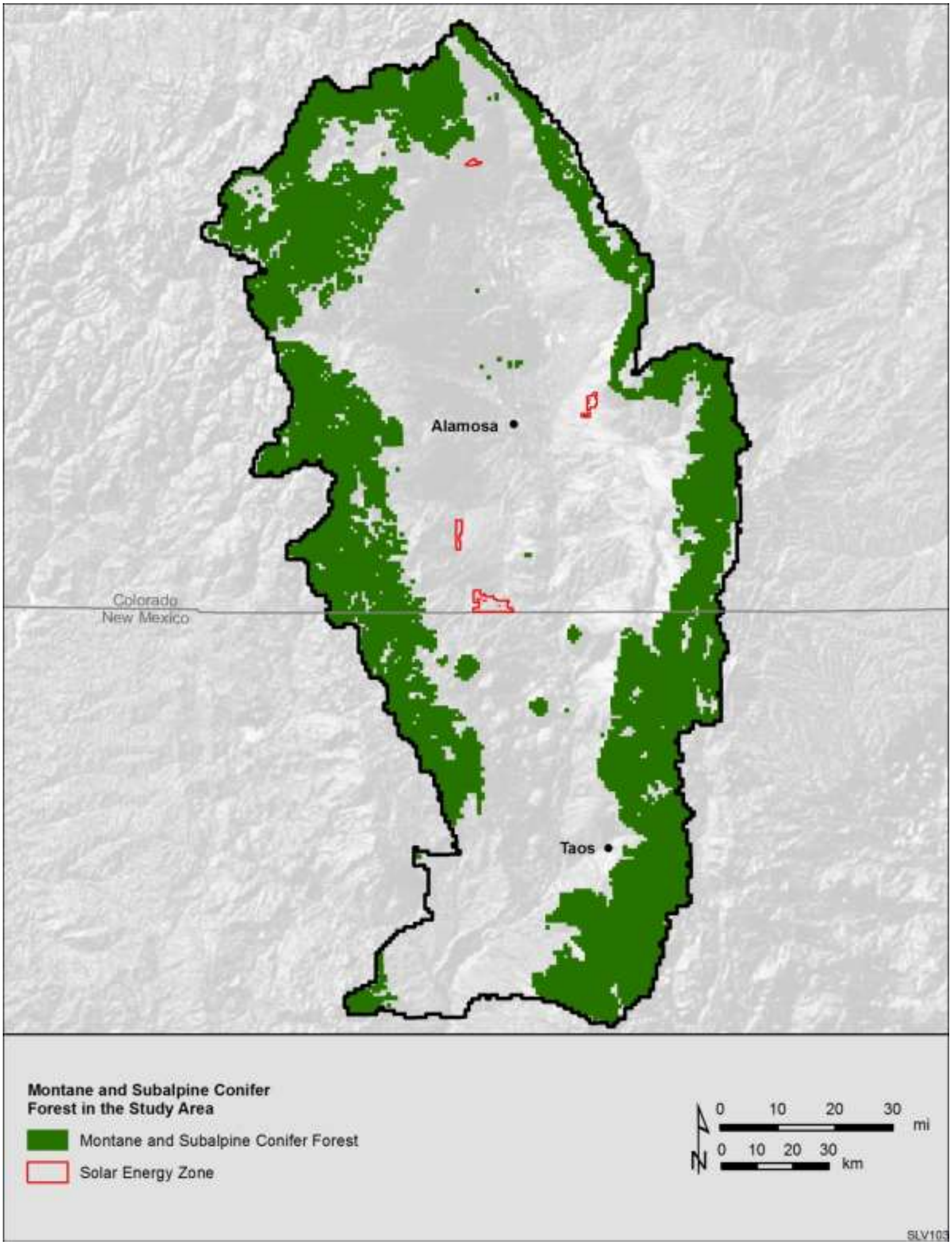


Figure B.1.1-2. Current Distribution of Montane and Subalpine Conifer Forests. Data Source: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).

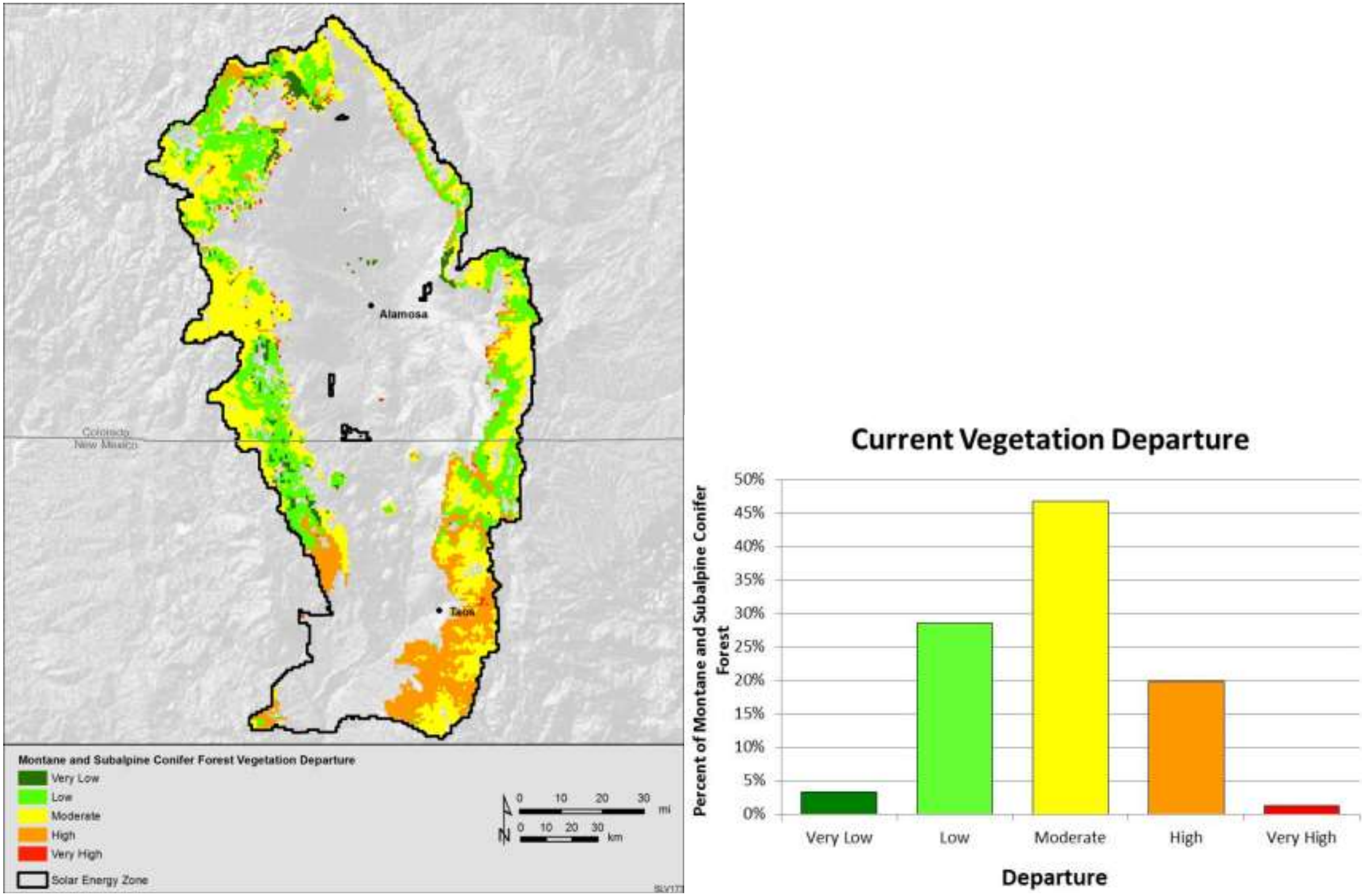


Figure B.1.1-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Montane and Subalpine Conifer Forest Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010). Data were Summarized to 1 km^2 Reporting Units.

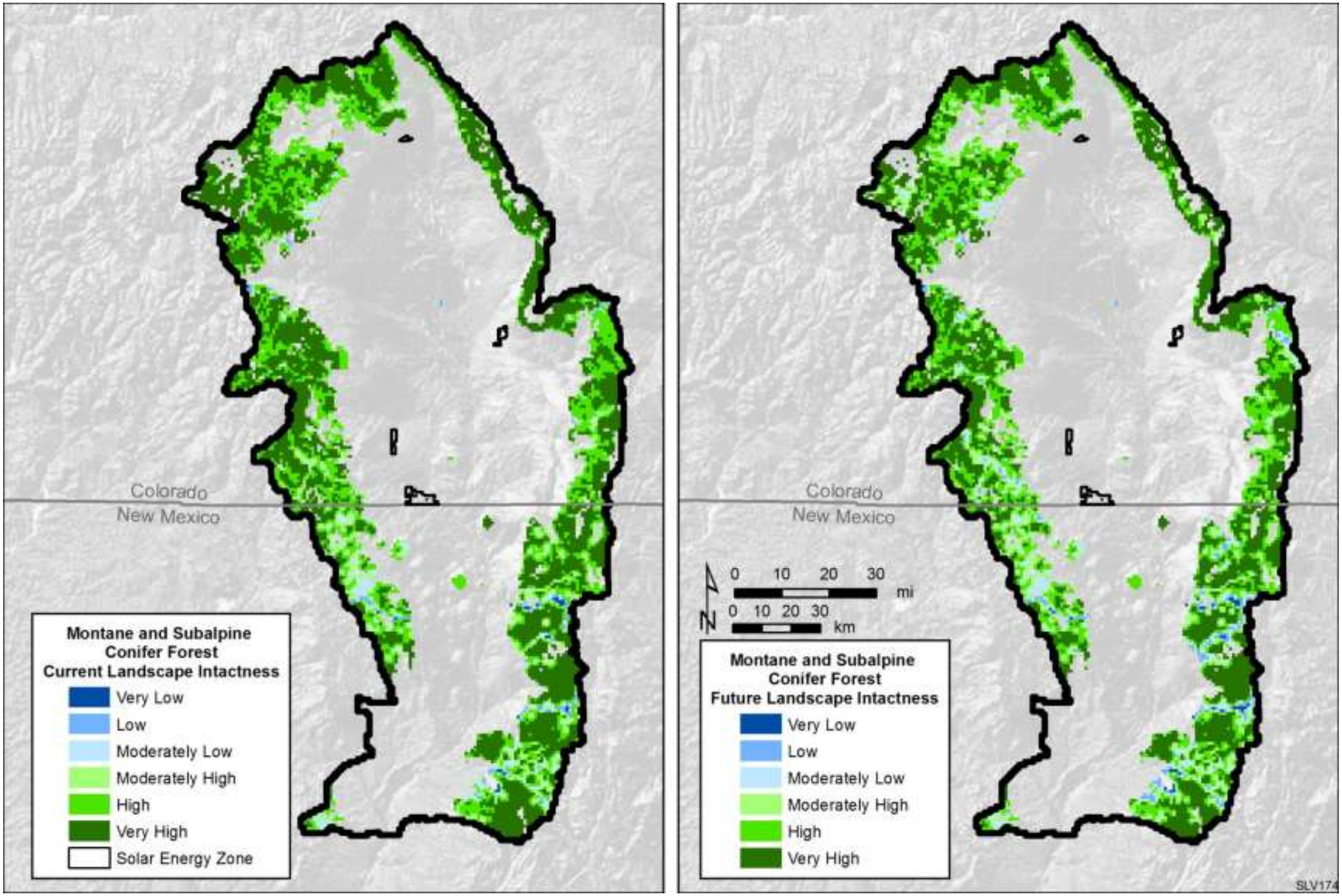


Figure B.1.1-4. Current and Future Landscape Intactness of Montane and Subalpine Conifer Forest. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

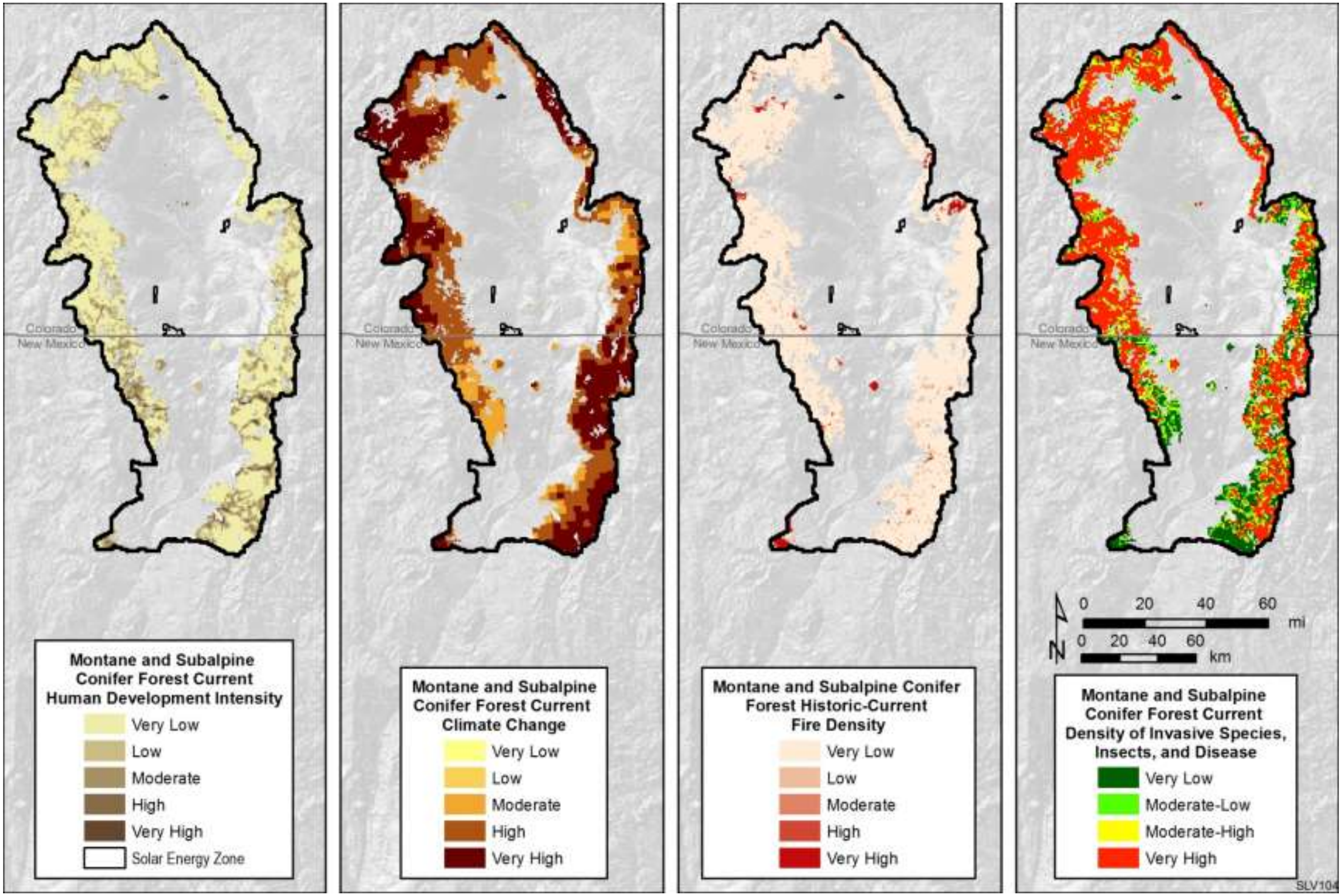


Figure B.1.1-5. Illustration for MQD1: What is the current distribution and status of montane and subalpine conifer forest? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

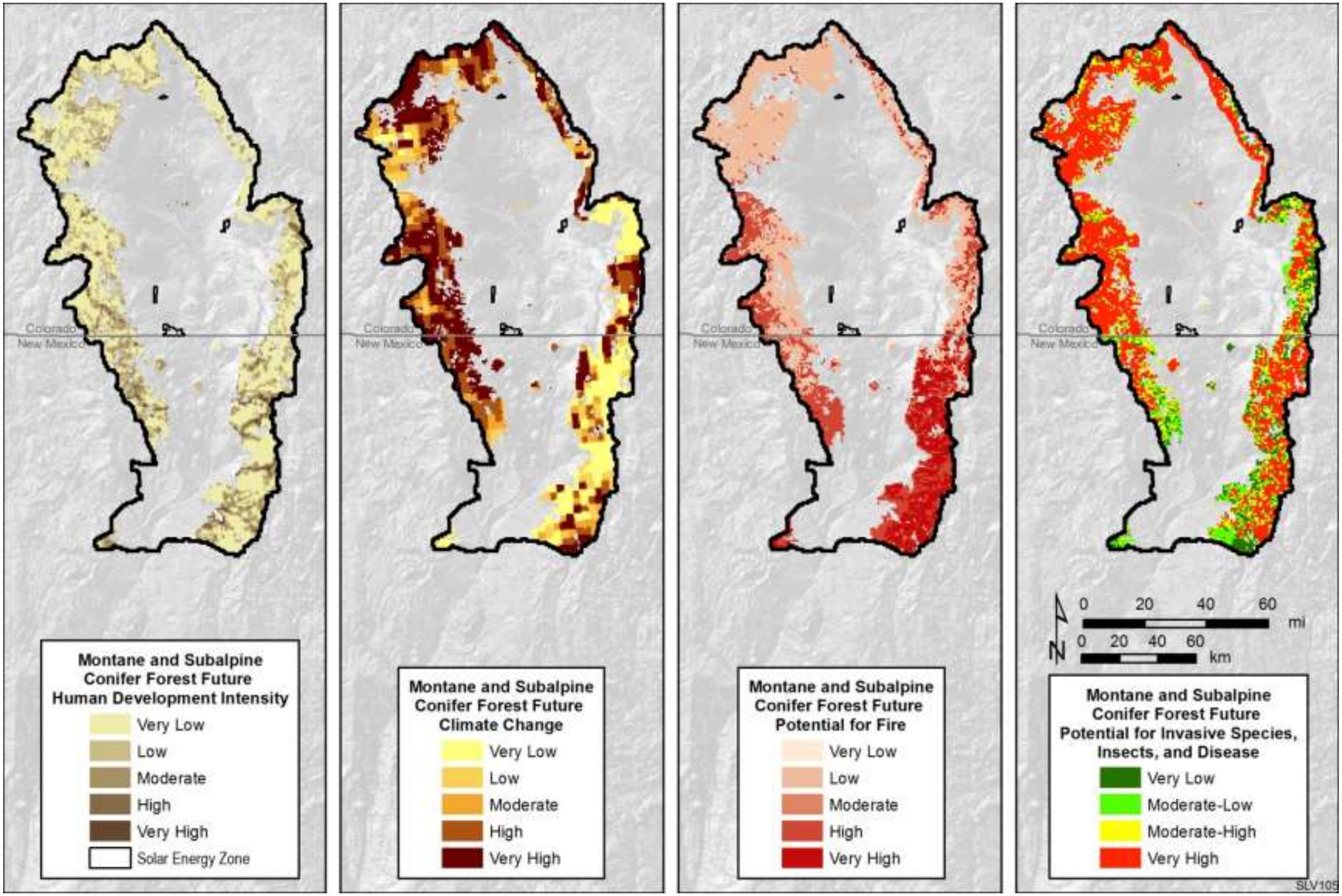


Figure B.1.1-6. Illustration for MQD3: Where is Montane and Subalpine Conifer Forest vulnerable to change agents in the future? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

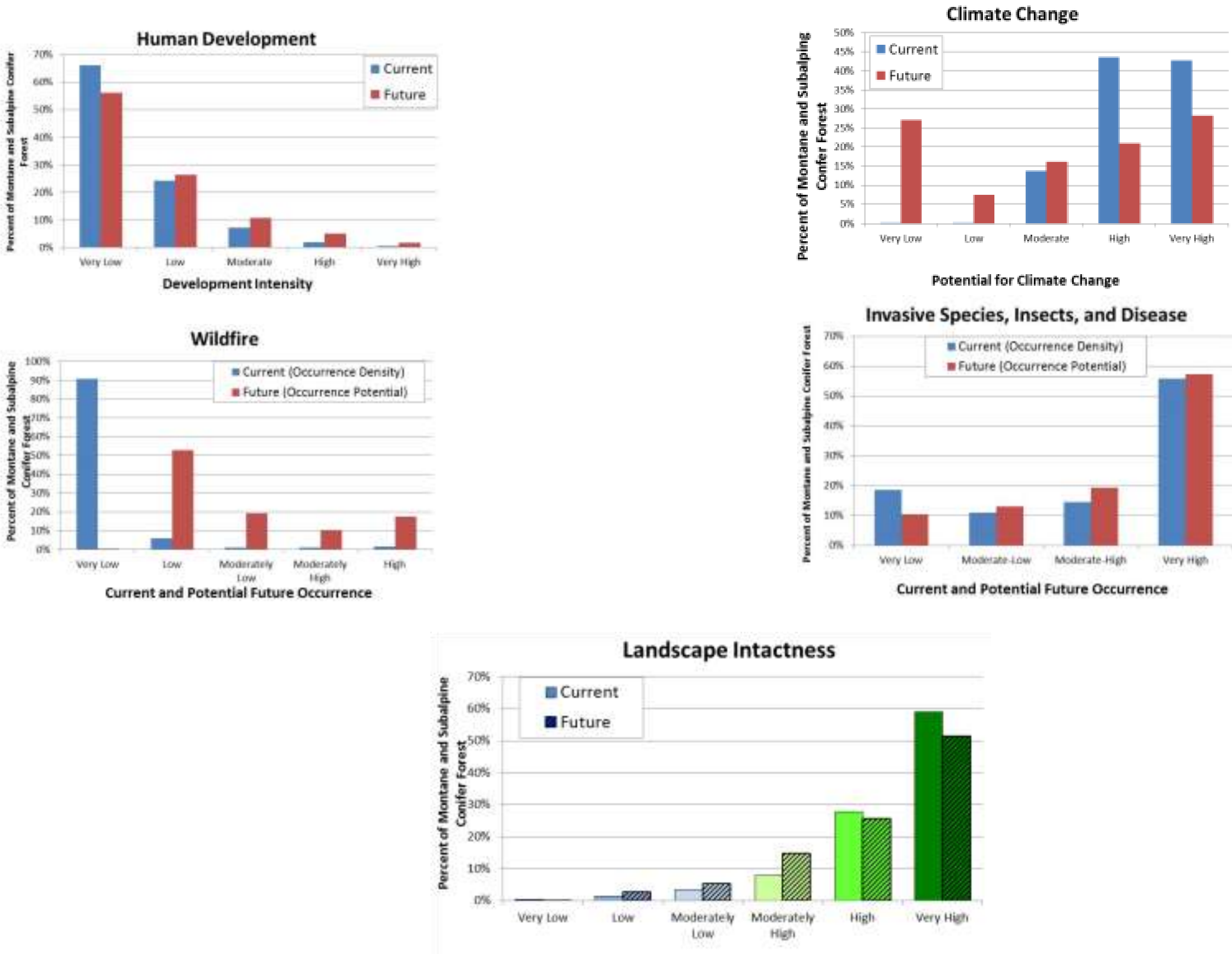


Figure B.1.1-7. Predicted Trends in Montane and Subalpine Conifer Forest Habitat within the Study Area

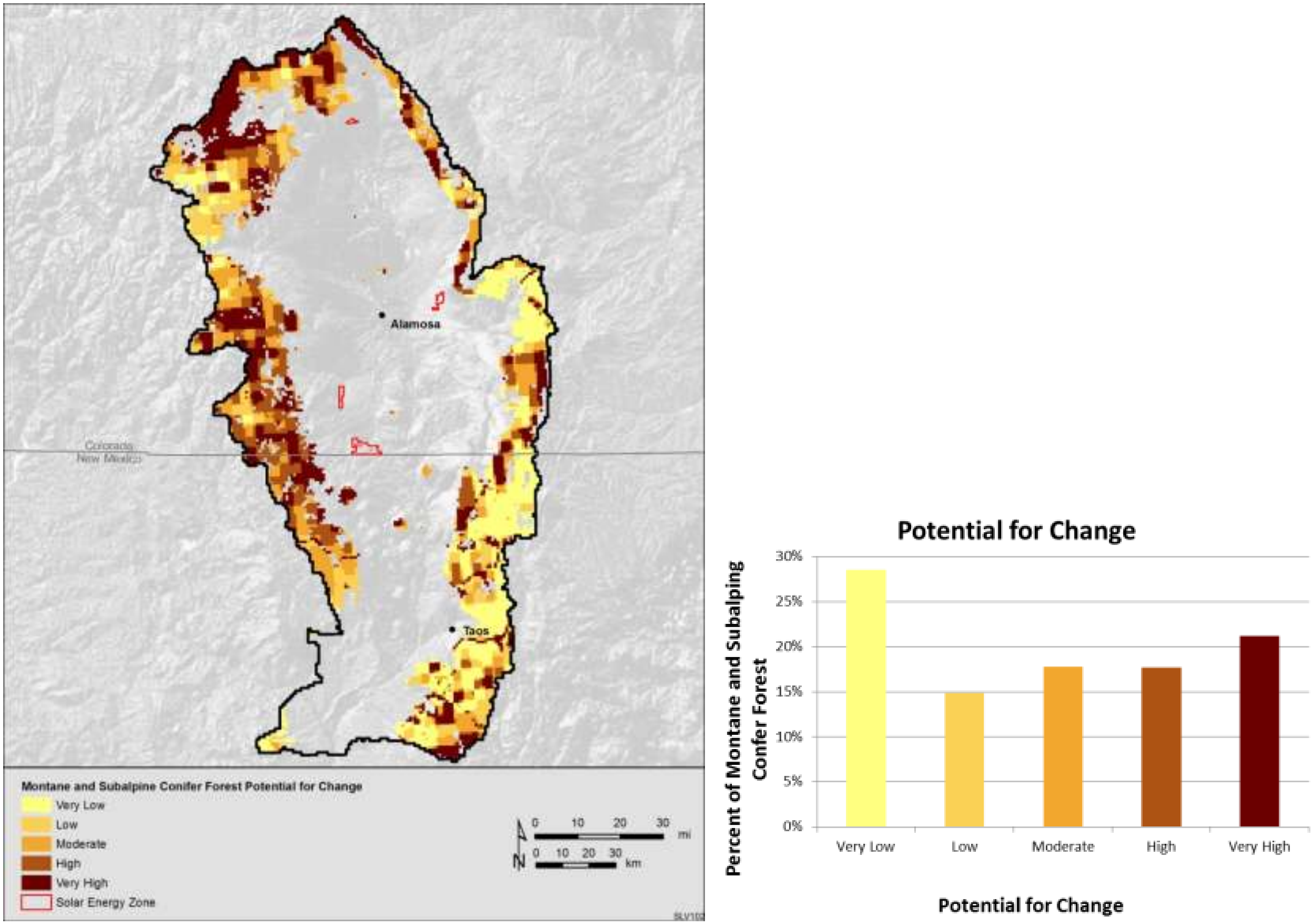


Figure B.1.1-8. Montane and Subalpine Conifer Forest Aggregate Potential for Change. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

B.1.2 Basin Grassland and Shrubland Systems

The San Luis Valley floor contains primarily grassland and shrubland, while the hills surrounding the valley are forested. Sagebrush shrubland and steppe are not widespread, but are found in a ring above the desert scrubland and below the piñon-juniper woodland in the far northern, southeast, and southwest portions of the valley. Many of the plants within these communities are drought resistant and tolerant of high soil salinity. These shrublands are characterized by an open to moderately dense assemblage of species including rubber rabbitbrush, greasewood, fourwing saltbush, shadscale, and winterfat. Also present in these communities are yucca, cactus, and various grasses. Slightly higher elevations contain desert scrub and shrub-steppe habitats that have a significant cover of big sagebrush and/or sand sage-brush. Grasses in these areas include Indian ricegrass, alkali sacaton, western wheat grass, and blue grama (USFWS 2012). Typically, short grass and short-emergent species such as sedges (*Carex* spp.), Baltic rush (*Juncus balticus*), and western wheat grass (*Pascopyrum smithii*) are also found.

Collectively, grasslands, and shrublands account for most of the land cover in the San Luis Valley. Much of this land is managed by the BLM. The largest areas of this vegetation in the region are in Costilla County, Colorado, and these areas are almost entirely privately owned and not under conservation easements. Colorado Parks and Wildlife has identified this area as potential but unoccupied habitat for the Gunnison sage-grouse, a threatened species under the Endangered Species Act. This area provides habitat to other sagebrush obligate species, which are particularly sensitive to disturbance (USFWS 2012).

Bird diversity and density tend to be relatively low in semi-desert shrublands due to structural and floristic simplicity (Wiens and Rotenberry 1981). Nesting species typical of this habitat include the horned lark, mourning dove, western meadowlark, and loggerhead shrike. Upland grassland habitats have the potential to support grassland-dependent species such as burrowing owl, long-billed curlew, and a variety of sparrows. Semi-desert grasslands are important to golden eagles, ferruginous hawks, and prairie falcons that prey on the prairie dogs inhabiting this habitat (Colorado Partners in Flight 2000). The sagebrush-dominated habitats are also home to the declining sage thrasher and the Gunnison sage-grouse (USFWS 2012).

Inter-mountain basins big sagebrush shrubland is a drier system and more restricted in its environmental setting than sagebrush steppe ecosystems. Big sagebrush (*Artemsia tridentate ssp. wyomingensis*) is the signature species for this ecosystem and it is affected by a number of factors. Climatic events such as periods of excessive moisture (Sturges and Nelson 1986) as well as long droughts impact this and related species (Anderson and Inouye 2001). Climate change may represent one of the greatest future risks to the sagebrush system by influencing moisture levels and decreasing the habitat for sagebrush-obligate species such as the sage grouse (Homer et al. 2015). The Aroga moth (*Aroga websteri*) and leaf beetles (*Trirhabda pilosa*) can cause significant sagebrush mortality (Pringle 1960, Gates 1964). Mechanical removal/burning of this community to improve grazing can promote invasive grasses altering the system even further (Bryce et al. 2012). Heavy grazing can increase soil water losses and reduce the biomass of deep roots (CNHP 2005).

Fire frequency and seasonality are important. Sagebrush generally responds favorably to spring fires, but fall fires tend to cause significant mortality in sagebrush. Recovery of big sagebrush after fire is slow. Fire suppression and livestock grazing has significantly degraded this ecological system (NatureServe 2009). Fire suppression in grasslands can lead to conversion to shrub lands (CNHP 2005).

Grazing continues to be widespread in these grasslands, causing cheatgrass and other species to expand into areas where native grasses die out (Colorado Partners In Flight 2000). Extensive amounts of land are also being converted to agricultural production. Once these ecosystems are converted, there is only limited potential for reconversion to native grasslands, either mechanically or by removal of livestock (Grahame and Sisk 2002).

The information discussed in this CE assessment was used in the development of a conceptual model illustrating status and the mechanisms by which basin grassland and shrubland systems may be affected within the San Luis Valley – Taos Plateau study area (Figure B.1.2-1). Figures B.1.2-2 through B.1.2-8 show, respectively: Figure B.1.2-2 - the current distribution of basin grassland and shrubland systems in the study area based on the aggregation of LANDFIRE Existing Vegetation Types; Figure B.1.2-3 – distribution with respect to current vegetation departure; Figure B.1.2-4 - distribution with respect to current and future landscape intactness in the study area; Figure B.1.2-5 - distribution and status with respect to the current status of change agents; Figure B.1.2-6 - distribution with respect to predicted areas of change; Figure B.1.2-7 - predicted trends in basin grassland and shrubland systems within the study area; and Figure B.1.2-8 - the aggregate potential for change in basin grassland and shrubland systems.

The majority (49%) of vegetation within basin grassland and shrubland systems has a moderate degree of departure from historic reference vegetation conditions (Figure B.1.2-3).

The majority of basin grassland and shrubland systems are within areas of high current landscape intactness. Approximately 46% of these systems occur in areas of high current landscape intactness (Figure B.1.2-4; Figure B.1.2-7). Future trends in landscape intactness indicate a decrease in landscape intactness within basin grassland and shrubland systems. The amount of these systems occurring within areas of high and very high landscape intactness is expected to decrease by approximately 12% in the near-term (i.e., by 2030) (Figure B.1.2-7).

The majority (51%) of basin grassland and shrubland systems are within areas of low current human development intensity (Figure B.1.2-5; Figure B.1.2-7). Future trends in human development indicate an increase in human development intensity within these systems. The amount of basin grassland and shrubland systems occurring within areas of high and very high human development intensity is expected to increase by approximately 10% in the near-term (i.e., by 2030) (Figure B.1.2-6; Figure B.1.2-7).

The majority of basin grassland and shrubland systems are within areas of low to moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.1.2-5; Figure B.1.2-7). Future trends in climate change indicate portions of basin grassland and shrubland systems with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.1.2-6; Figure B.1.2-7). Approximately 26% of these systems are located in areas with high or very high potential for future climate change (Figure B.1.2-6; Figure B.1.2-7).

The majority of basin grassland and shrubland systems are within areas of very low current fire occurrence density (Figure B.1.2-5; Figure B.1.2-7). Future trends in wildfire indicate little change in wildfire potential in these systems. Over 90% of basin grassland and shrubland systems have low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.1.2-7). The greatest potential for future wildfire occurs in the southern portion of the distribution of these systems in New Mexico (Figure B.1.2-6).

The majority of basin grassland and shrubland systems are within areas of very low current density of invasive species, insects, and disease (Figure B.1.2-5; Figure B.1.2-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of these systems in the study area (Figure B.1.2-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural human expansion and potential energy development (Figure B.1.2-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 23% of the basin grassland and shrubland systems have the potential for high or very high future change among the change agents (Figure B.1.2-8). Areas with greatest potential for change within these systems include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.1.2-8).

Although not addressed as a separate CE, ground and above ground nesting pollinators are widespread throughout the ecoregion and may be impacted by change agents within this system. Pollinators, such as honey bees, native bees, birds, bats, and butterflies, have been in decline over the last few decades (Presidential Memorandum 2014). Insect pollinators are important in maintaining biologically diverse plant and animal communities in all types of rangelands. Similarly, a heterogeneous rangeland landscape, including a variety of native grasses and forbs within a grassland, contributes to the diversity of insect pollinators (Gilgert and Vaughan 2011; Black et al. 2009). The most common grassland pollinators are solitary ground nesting bees, but flies, beetles, and butterflies are also found in grasslands. Shrubland and scrub habitat provide nesting sites for bees in twigs and holes in shrubs and trees. Some of the threats facing grassland pollinators include habitat loss and fragmentation, invasive species reducing floral diversity, overgrazing, mowing, burning, and pesticide use. Some threats facing shrubland and scrub pollinators include commercial livestock grazing, habitat fragmentation, burning, mowing, and pesticides (Black et al. 2009).

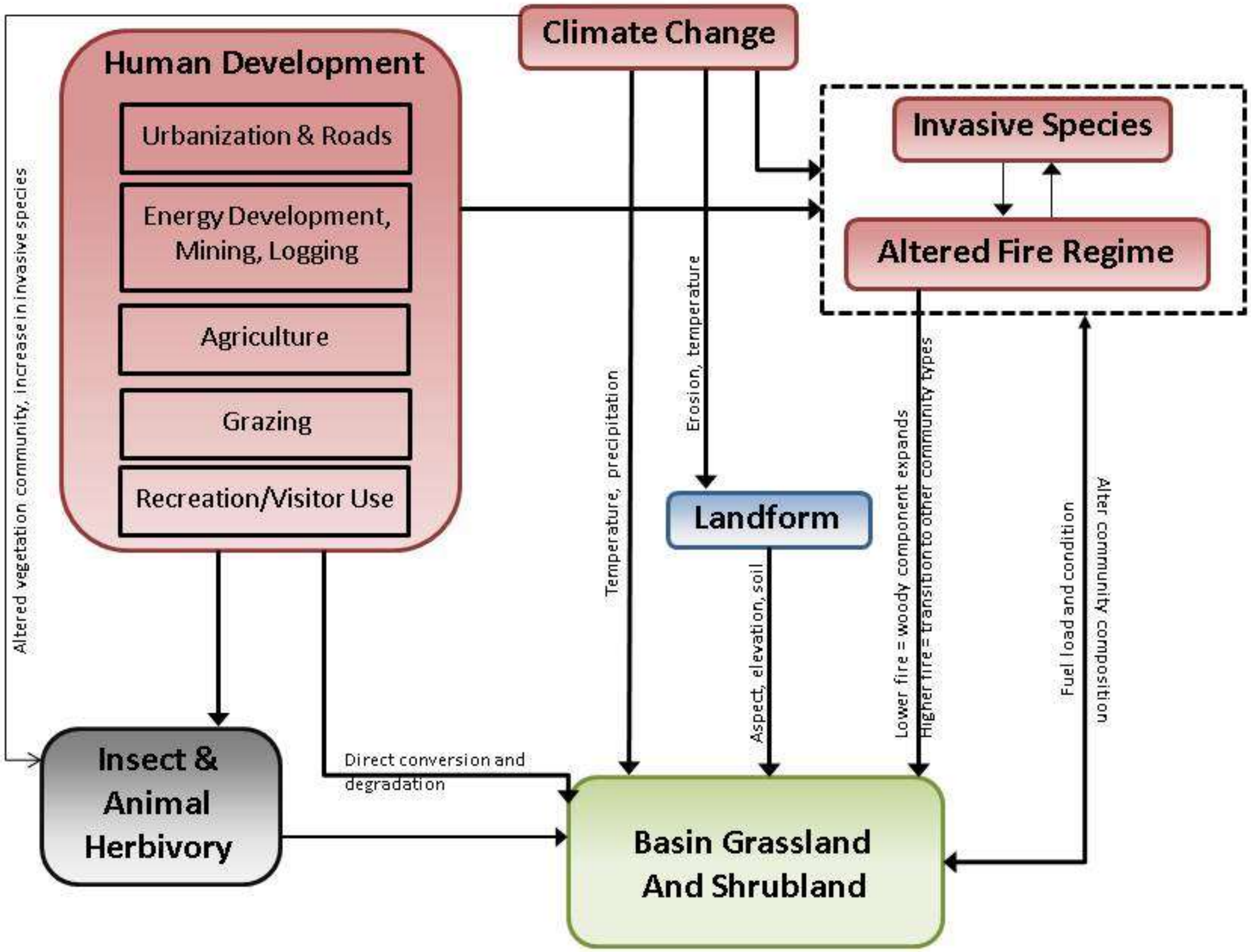


Figure B.1.2-1. Basin Grassland and Shrubland Conceptual Model.

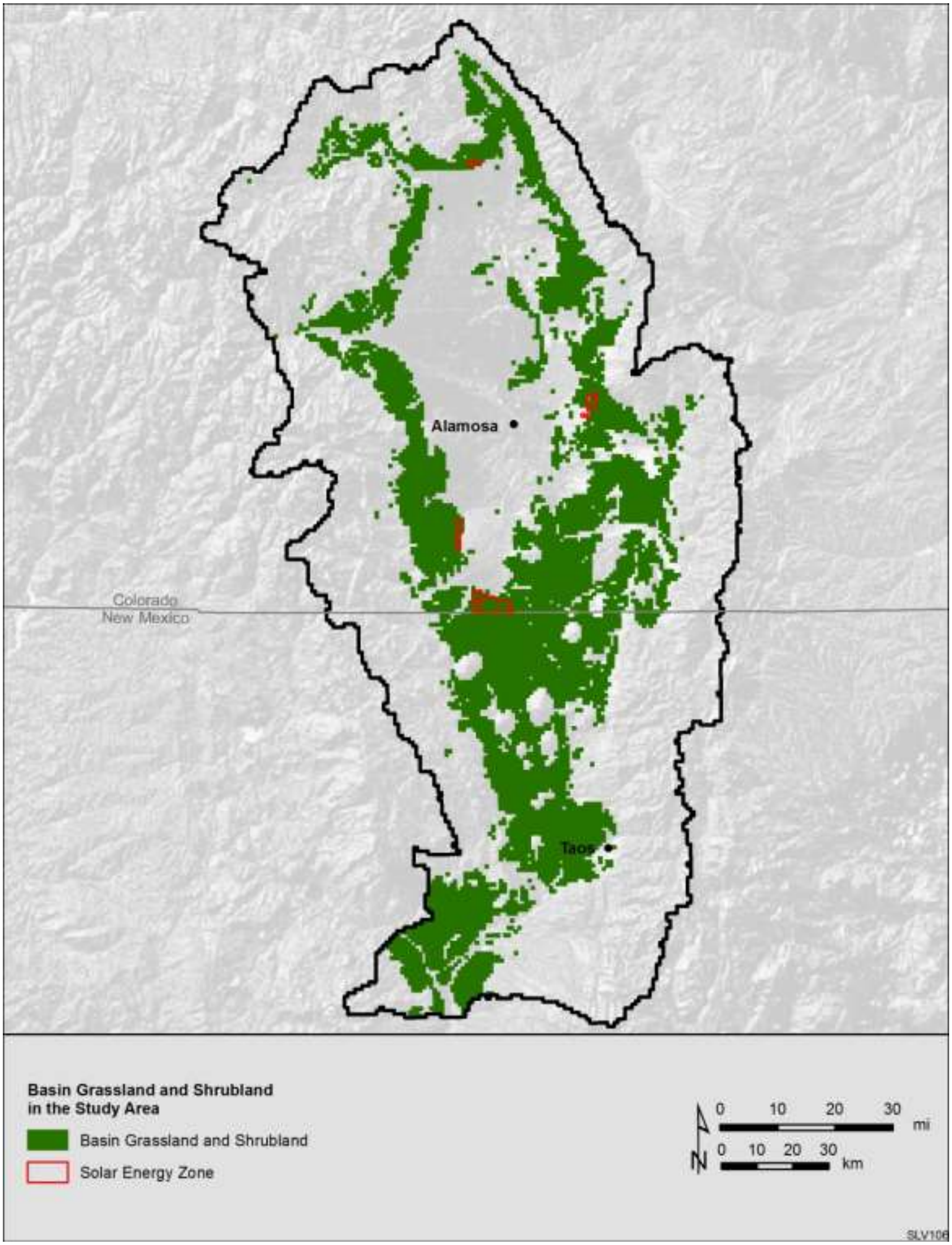
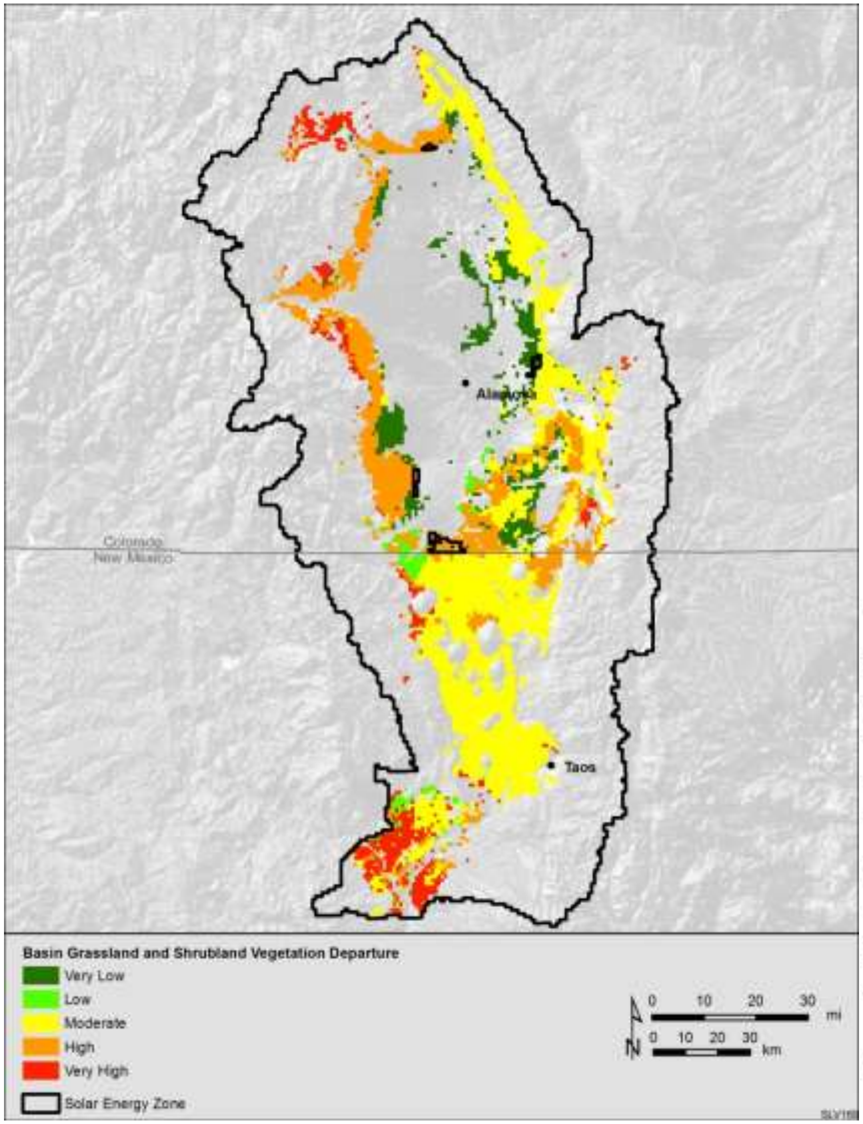


Figure B.1.2-2. Current Distribution of Basin Grasslands and Shrublands. Data Source: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).



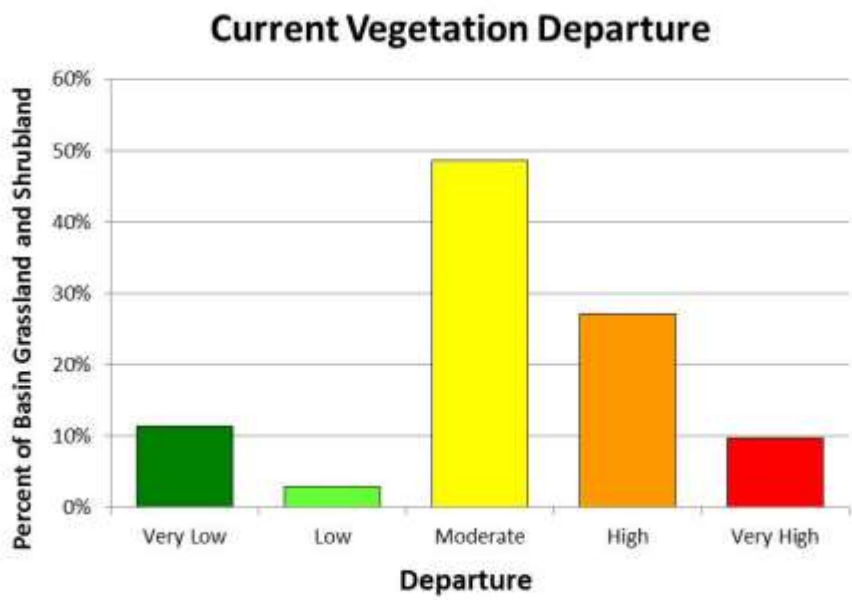


Figure B.1.2-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Basin Grassland and Shrubland Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010). Data were Summarized to 1 km2 Reporting Units.

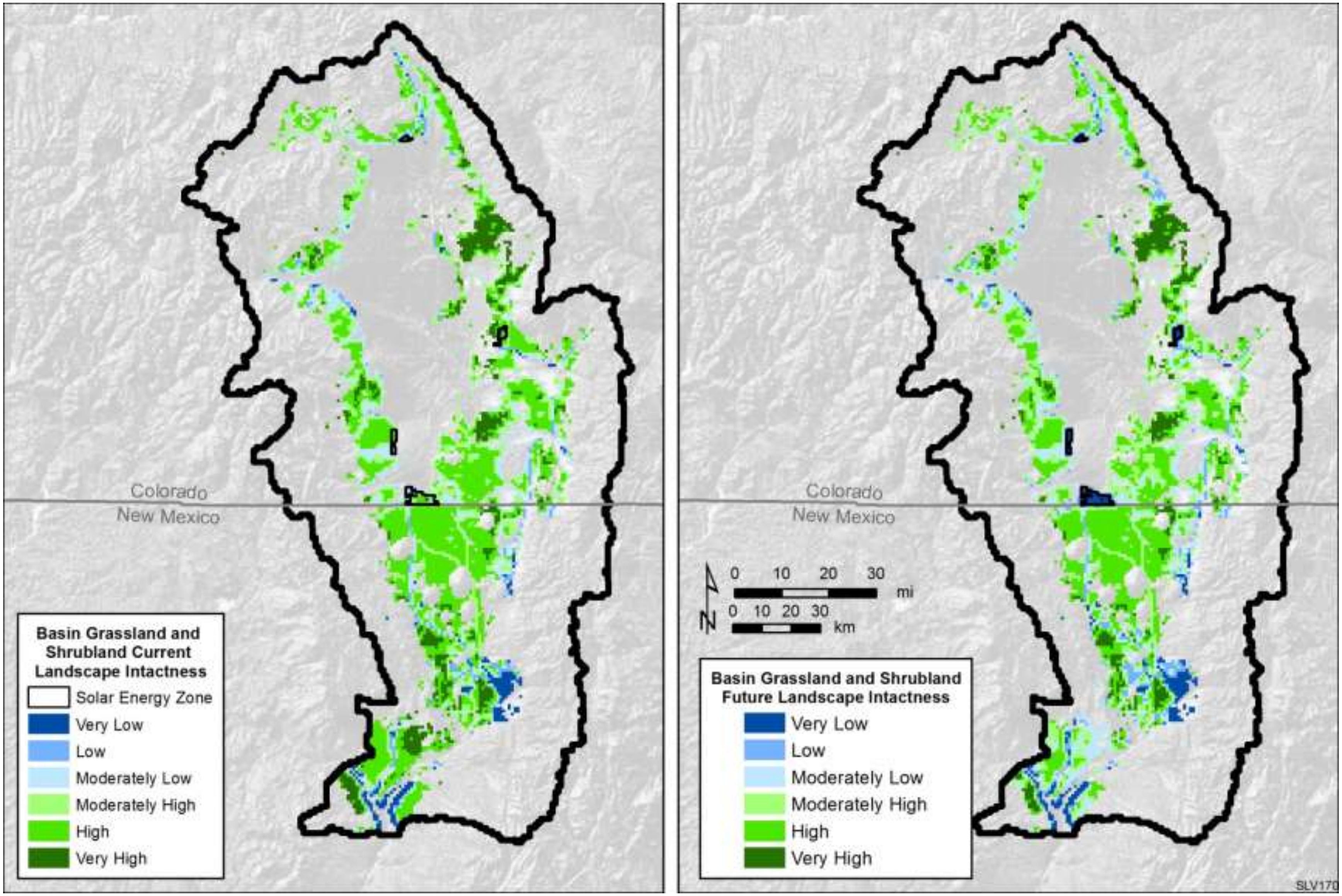


Figure B.1.2-4. Current and Future Landscape Intactness of Basin Grasslands and Shrublands. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

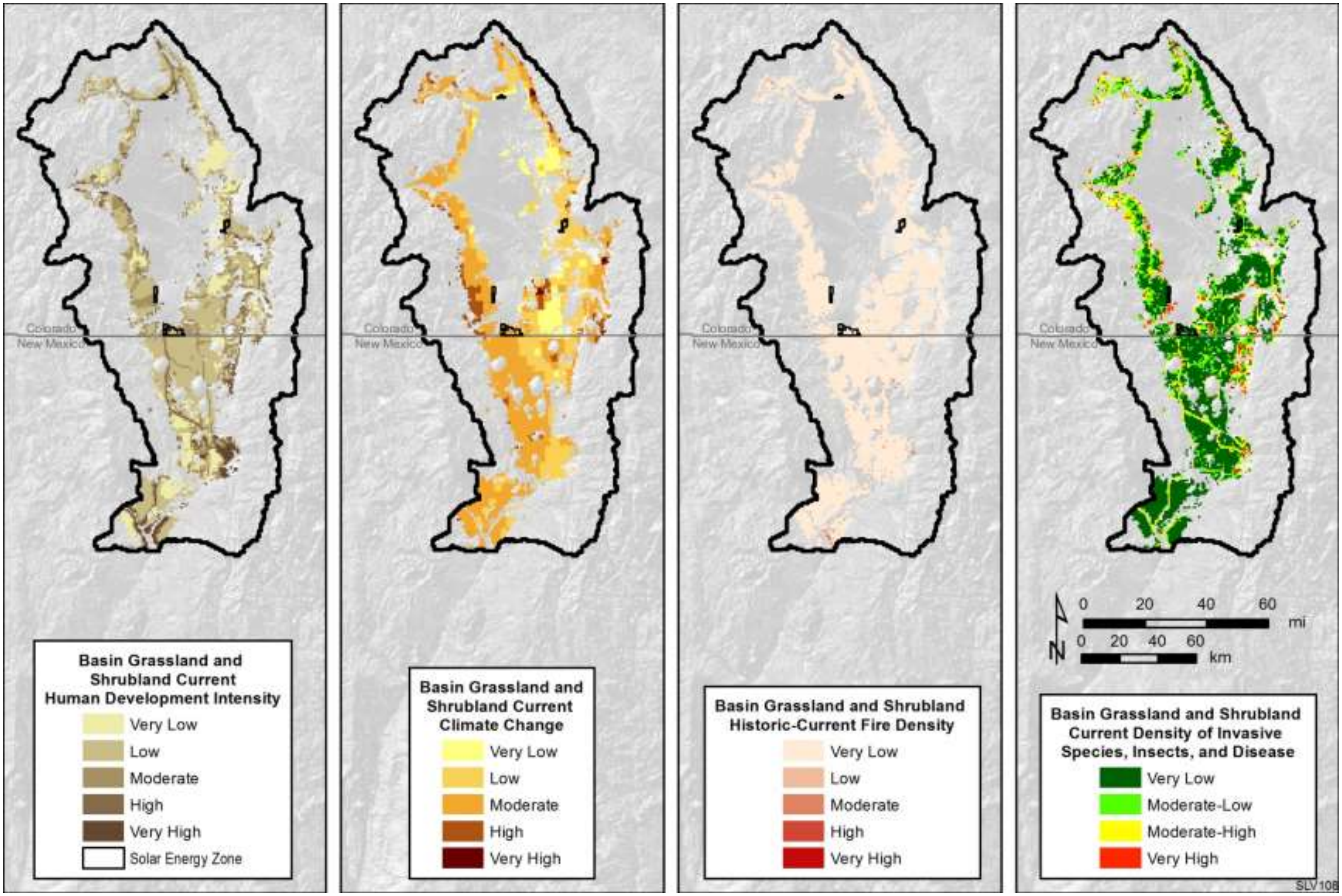


Figure B.1.2-5. Illustration for MQD1: What is the current distribution and status of basin grasslands and shrublands? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

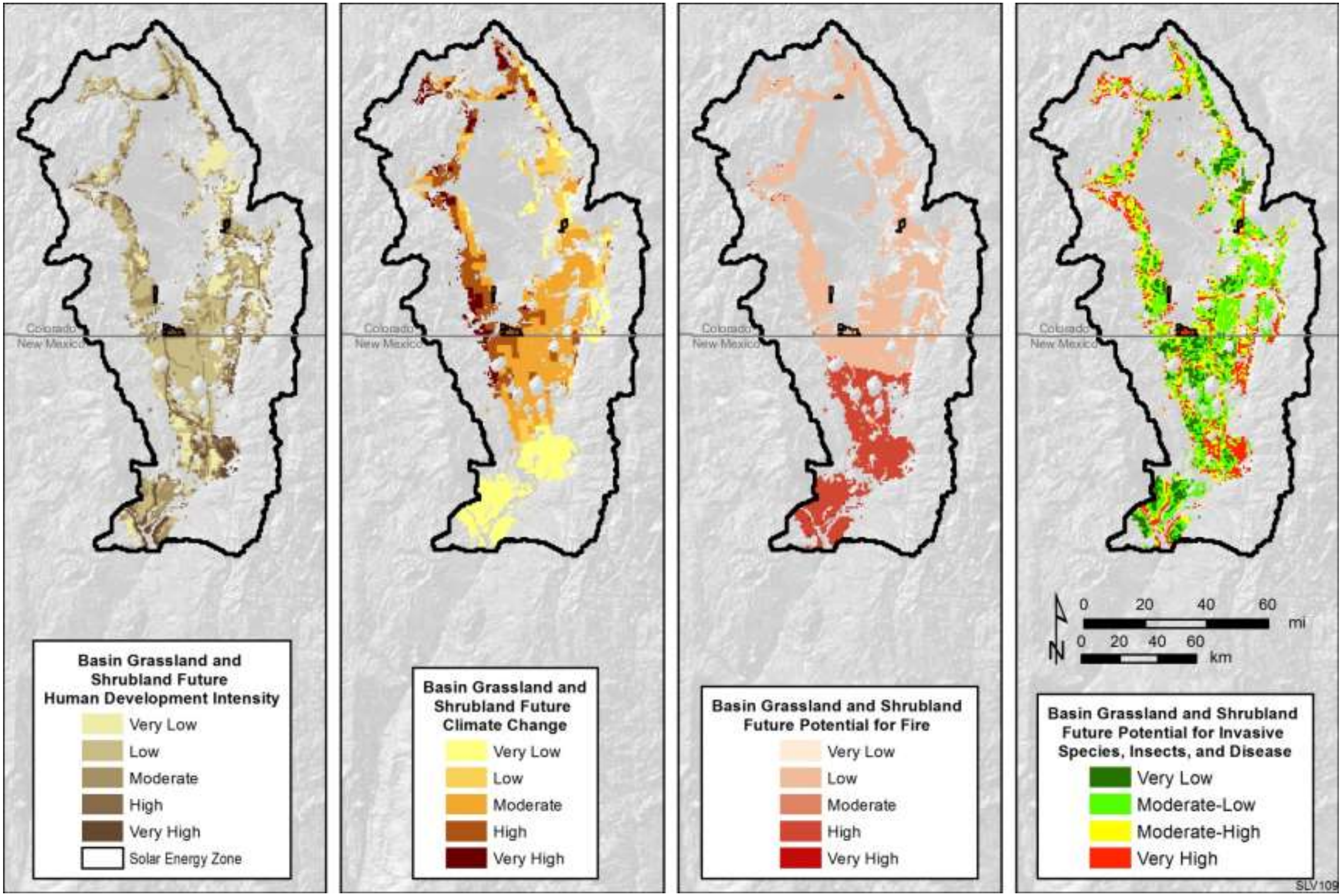


Figure B.1.2-6. Illustration for MQD3: Where are Basin Grassland and Shrubland vulnerable to change agents in the future? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

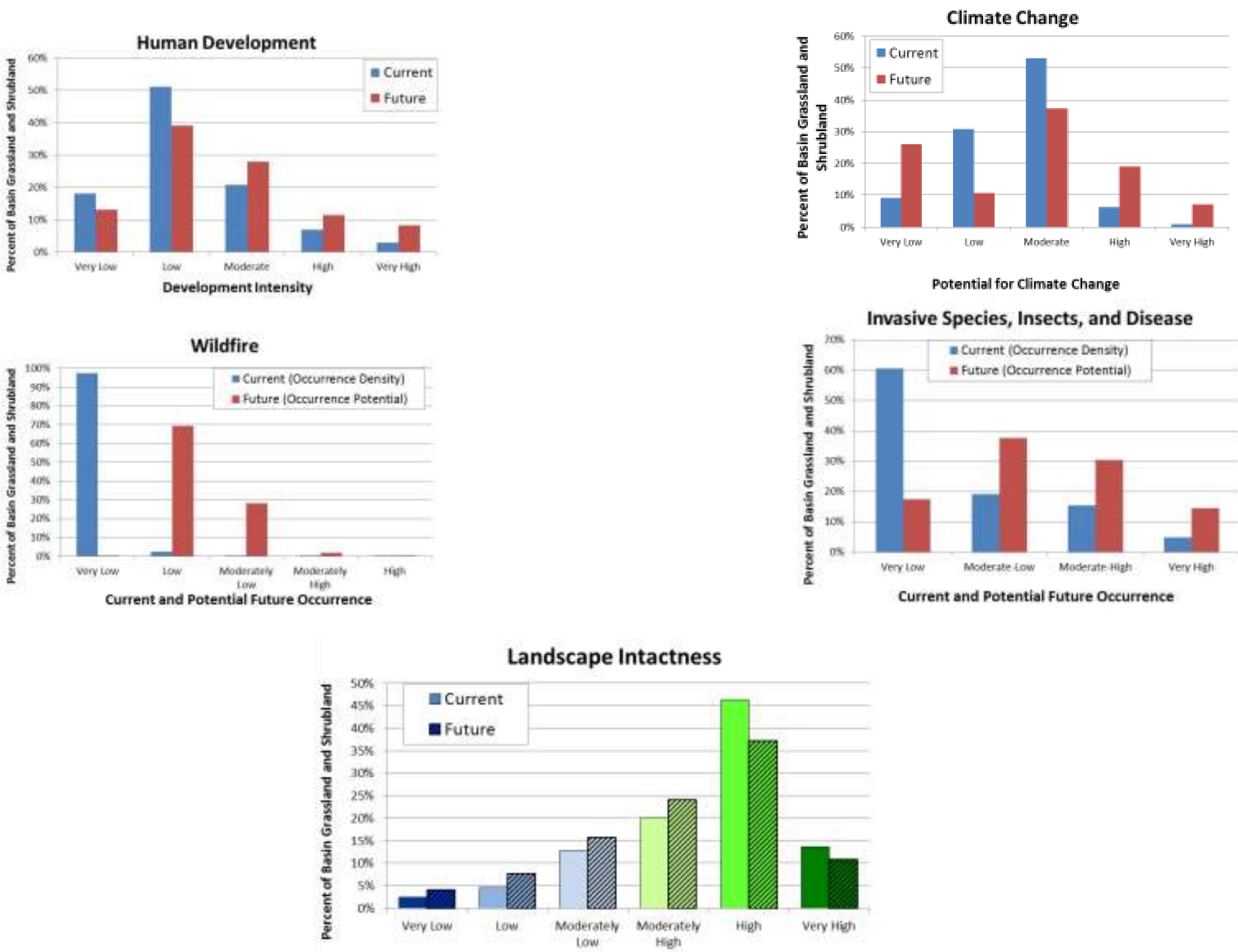
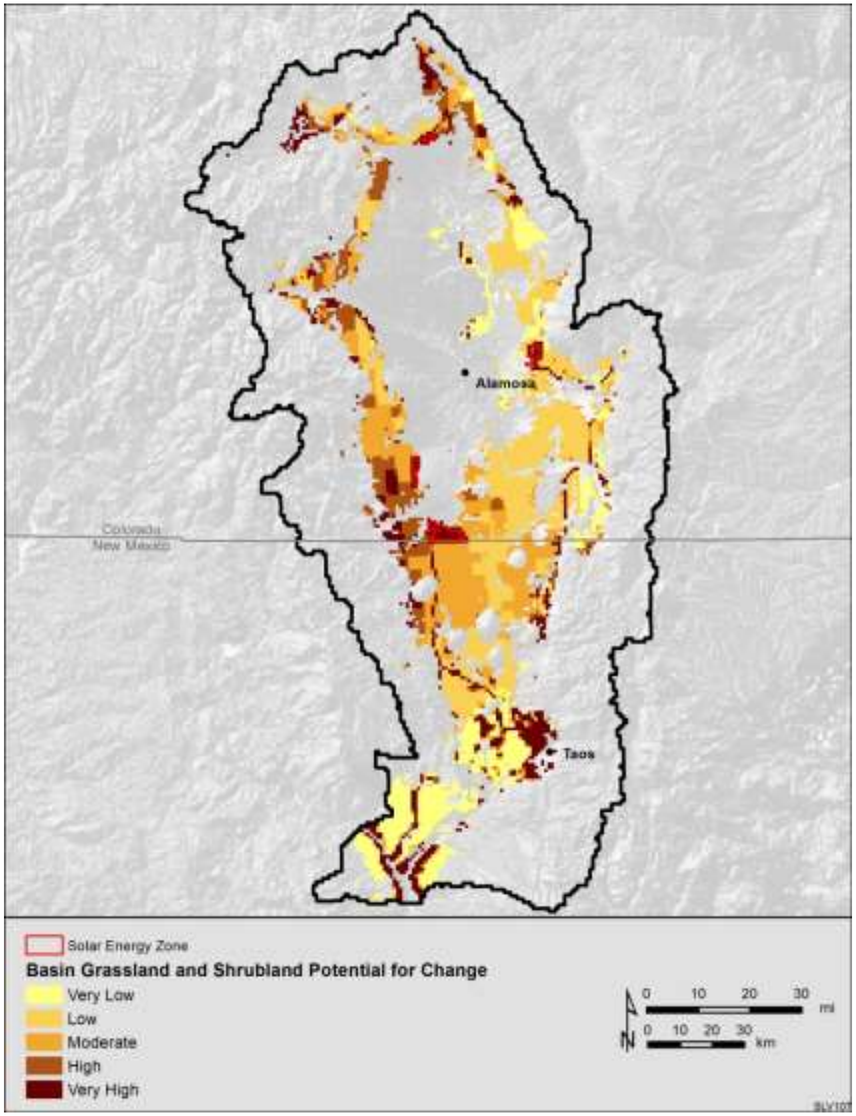


Figure B.1.2-7. Predicted Trends in Basin Grassland and Shrubland Habitat within the Study Area



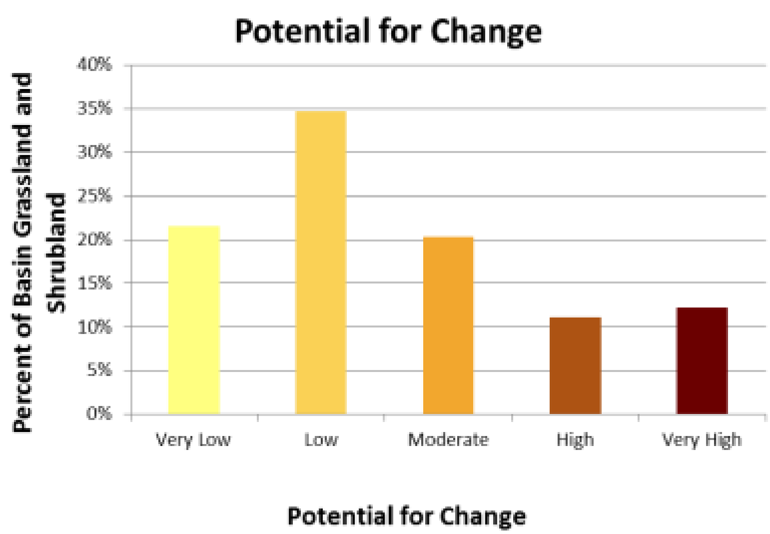


Figure B.1.2-8. Basin Grassland and Shrubland Aggregate Potential for Change. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

B.1.3 Piñon-Juniper Woodland Systems

The piñon-juniper woodland is an open-canopy forest dominated by piñon pines and junipers, with an understory consisting of shrubs and grasses. Upper and intermediate elevations are usually dominated by piñon, while lower elevations contain more juniper (USFS). Annual precipitation is typically from 10 to about 15 inches in piñon-juniper woodlands, and tree species in these communities have evolved both drought and cold resistance. There are relatively few vertebrates endemic to piñon-juniper woodlands, but there are significant levels of biodiversity in less prominent organisms such as herbaceous vegetation and soil organisms (Grahame and Sisk 2002). Piñon-juniper woodland supports the most nesting bird species of all upland vegetation types found in the West. Piñon jays are obligate nesters in the piñon-juniper woodlands; although their population is stable in Colorado, they are effective indicators of forest health and are therefore a priority species for Partners in Flight throughout the intermountain west (Colorado Partners in Flight 2000). Other piñon-juniper associated species include black-throated gray warbler and juniper titmouse (USFWS 2012). Much of the existing piñon-juniper woodland in the San Luis Valley is managed by BLM, though there are extensive stands on private lands in Costilla County.

According to the Colorado Natural Heritage Program, this woodland's threat status is "fair" and its protection status is "poor-fair." There are natural periods of range expansion of this ecological system followed by contraction due to climate stress and insect/disease vectors, especially where there are closed stands (Landfire 2007). Drought stress and subsequent insect outbreaks have been causing widespread mortality of piñon pine throughout much of its range, especially on soil types that are more prone to moisture loss (Mueller et al. 2005). Close attention to climate change projections may be particularly important in defining where this community type can occur in the future.

The long history of livestock grazing in many piñon-juniper woodlands on the Colorado Plateau has both diminished and altered herbaceous vegetation, leading to widespread desertification of understory conditions. For many years, large areas of piñon-juniper woodlands have been converted to rangeland through mechanical disruption known as chaining. Although not as common as it once was, conversion of this woodland type for agricultural purposes still occurs. Mechanical removal and development also directly convert or degrade this system. Mechanical removal or disturbance of this community can promote invasive grasses altering the system in significant ways (Bryce et al. 2012).

Despite these human induced changes, human activity as a whole has increased piñon-juniper coverage. Since approximately 1860, the area and density of trees has increased from three- to ten-fold due to fire exclusion, over-grazing, favorable climate, and recovery from settlement-era harvesting (USFS). Fire suppression in particular has caused the woodland to advance (Colorado Partners in Flight 2000). The fire regime is characterized by somewhat mixed severity mosaics (mean fire return interval of 150–200 years) with infrequent replacement fires (every 200–500 years, Rondeau 2001). Lower fire frequency, due to fire suppression results in an expansion of woody vegetation. This expansion increases the risk of larger and more severe wildfires (USFS).

The information discussed in this CE assessment was used in the development of a conceptual model illustrating status and the mechanisms by which piñon-juniper woodland system may be affected within the San Luis Valley – Taos Plateau study area (Figure B.1.3-1). Figures B.1.3-2 through B.1.3-8 show, respectively: Figure B.1.3-2 - the current distribution of piñon-juniper woodland system in the study area based on the aggregation of LANDFIRE Existing Vegetation Types; Figure B.1.3-3 – distribution with respect to current vegetation departure; Figure B.1.3-4 - distribution with respect to current and future landscape intactness in the study area; Figure B.1.3-5 - distribution and status with respect to the current status of change agents; Figure B.1.3-6 - distribution with respect to predicted areas of change; Figure B.1.3-7 - predicted trends in piñon-juniper woodland system within the study area; and Figure B.1.3-8 - the aggregate potential for change in piñon-juniper woodland system.

The majority of vegetation within piñon-juniper woodland system has a low degree of departure from historic reference vegetation conditions. Approximately 33% of the piñon-juniper woodland system within the study area has a moderate degree of vegetation departure (Figure B.1.3-3).

The majority (42%) of the piñon-juniper woodland system is within areas of high current landscape intactness (Figure B.1.3-4; Figure B.1.3-7). Future trends in landscape intactness indicate a decrease in landscape intactness within the piñon-juniper woodland system. The amount of this system occurring within areas of high and very high landscape intactness is expected to decrease by approximately 19% in the near-term (i.e., by 2030) (Figure B.1.3-7).

The majority (44%) of the piñon-juniper woodland system is within areas of low current human development intensity (Figure B.1.3-5; Figure B.1.3-7). Future trends in human development indicate an increase in human development intensity within this system. The amount of piñon-juniper woodland system occurring within areas high and very high human development intensity is expected to increase by approximately 14% in the near-term (i.e., by 2030) (Figure B.1.3-6; Figure B.1.3-7).

The majority of the piñon-juniper woodland system is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.1.3-5; Figure B.1.3-7). Future trends in climate change indicate portions of piñon-juniper woodland system with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.1.3-6; Figure B.1.3-7). Approximately 17% of this system is located in areas with high or very high potential for future climate change (Figure B.1.3-6; Figure B.1.3-7).

Like all other CEs, the response of the piñon-juniper system to climate change may not be closely related to the potential magnitude of the change in future precipitation or temperature, as evaluated in this LA. Even relatively small changes in future climate could result in different CE-specific response. Previous assessments regarding the response piñon-juniper systems to climate change have indicated a range-wide decrease in the distribution of this system. For example, a recent model produced by the USGS for the pinyon jay (*Gymnorhinus cyanocephalus*), a nonmigratory mutualist with piñon forests of the western U.S. (including the LA study area), indicated a loss of 25-31 percent in available piñon-juniper habitat by 2099 due to climate change, primarily as a function of the change in mean winter precipitation (van Riper et al. 2014).

The majority of the piñon-juniper woodland system is within areas of very low current fire occurrence density (Figure B.1.3-5; Figure B.1.3-7). Future trends in wildfire indicate an increase in wildfire potential in this system. Approximately 36% of the piñon-juniper woodland system has a moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.1.3-7). The greatest potential for future wildfire occurs in the southern portion of the distribution of this system in New Mexico (Figure B.1.3-6).

The majority of the piñon-juniper woodland system is within areas of very low current density of invasive species, insects, and disease (Figure B.1.3-5; Figure B.1.3-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of this system in the study area (Figure B.1.3-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural human expansion, potential energy development, and spread of forest insects and disease (Figure B.1.3-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 20% of the piñon-juniper woodland system has the potential for high or very high future change among the change agents (Figure B.1.3-8). Areas with greatest potential for change within this system include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.1.3-8).

Although not addressed as a separate CE, ground and above ground nesting pollinators are widespread throughout the ecoregion and may be impacted by change agents within this system. Pollinators, such as honey bees, native bees, birds, bats, and butterflies, have been in decline over the last few decades (Presidential Memorandum 2014). Insect pollinators are important in maintaining biologically diverse plant and animal communities in all types of rangelands, including the understory of Piñon-Juniper Woodlands (Gilgert and Vaughan 2011; Nyoka 2010). Similarly, a heterogeneous rangeland landscape contributes to the diversity of insect pollinators (Gilgert and Vaughan 2011). The understory of woodlands provide habitat for a variety of native bees. Some of the threats facing woodland pollinators include habitat fragmentation from agriculture and urban developments, fire, and overgrazing in the understory (Black et al. 2009).

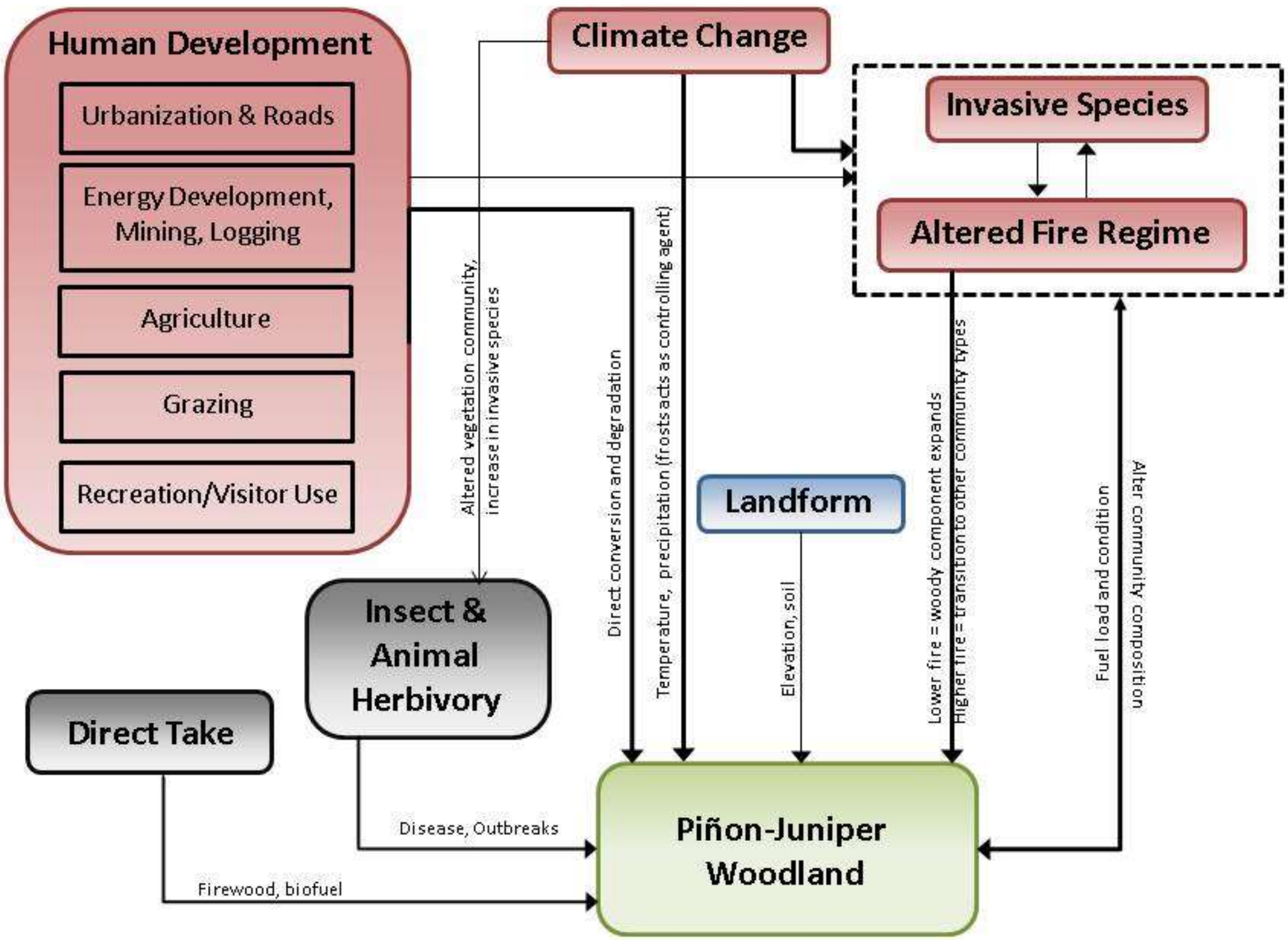


Figure B.1.3-1. Piñon-Juniper Conceptual Model.

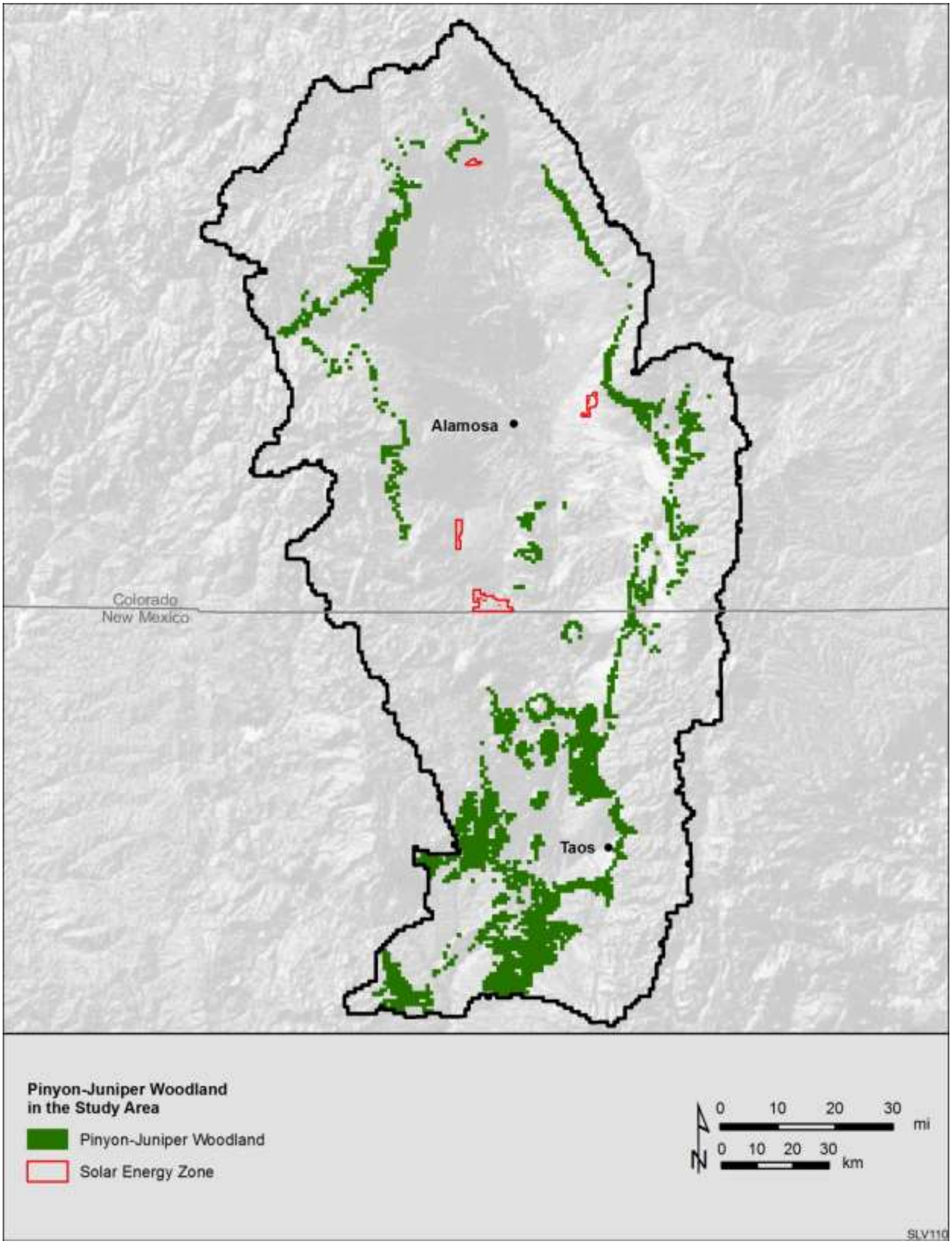


Figure B.1.3-2. Current Distribution of Piñon-Juniper Woodlands. Data Source: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).

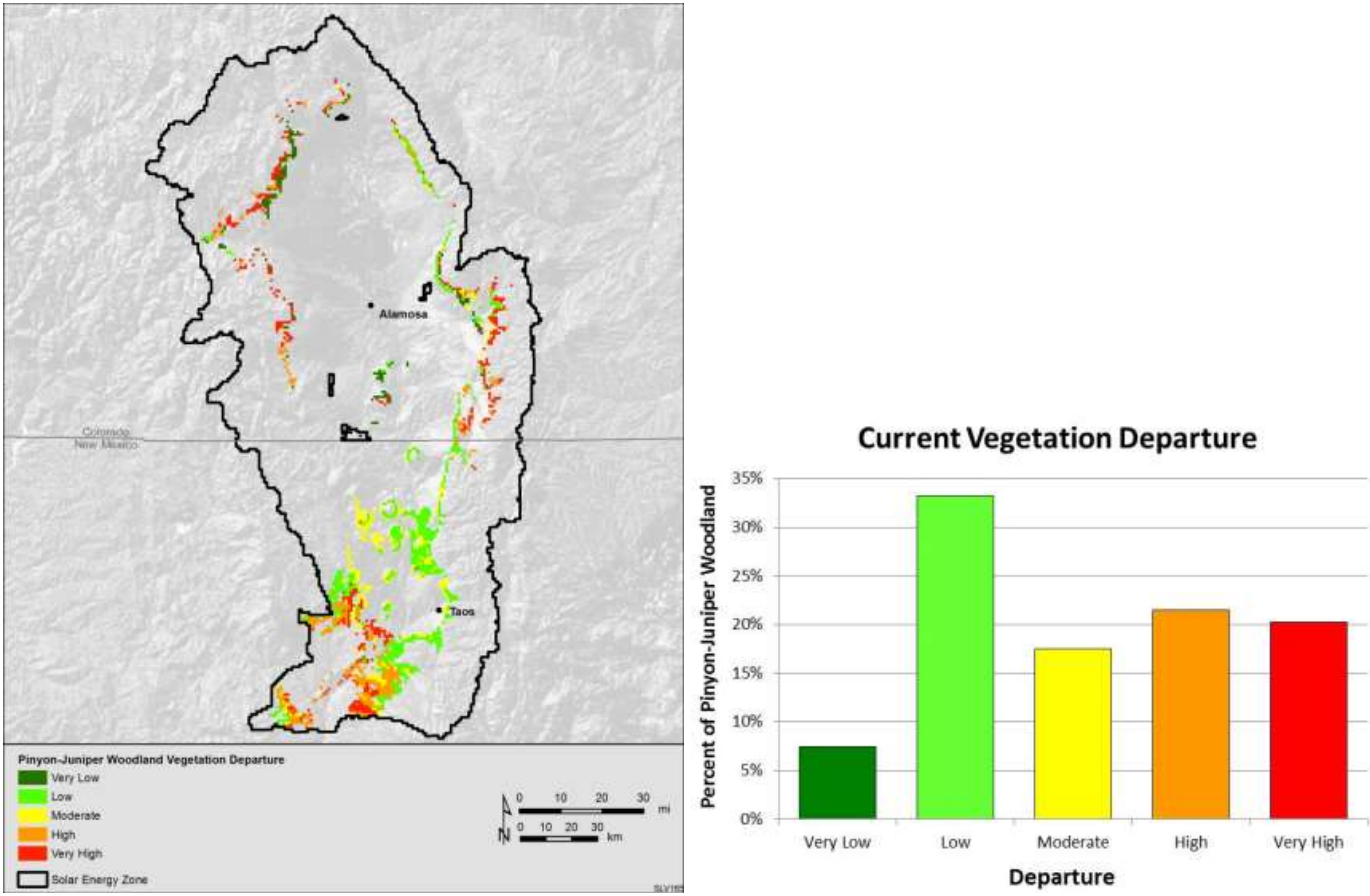


Figure B.1.3-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Piñon-Juniper Woodland Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010). Data were Summarized to 1 km^2 Reporting Units.

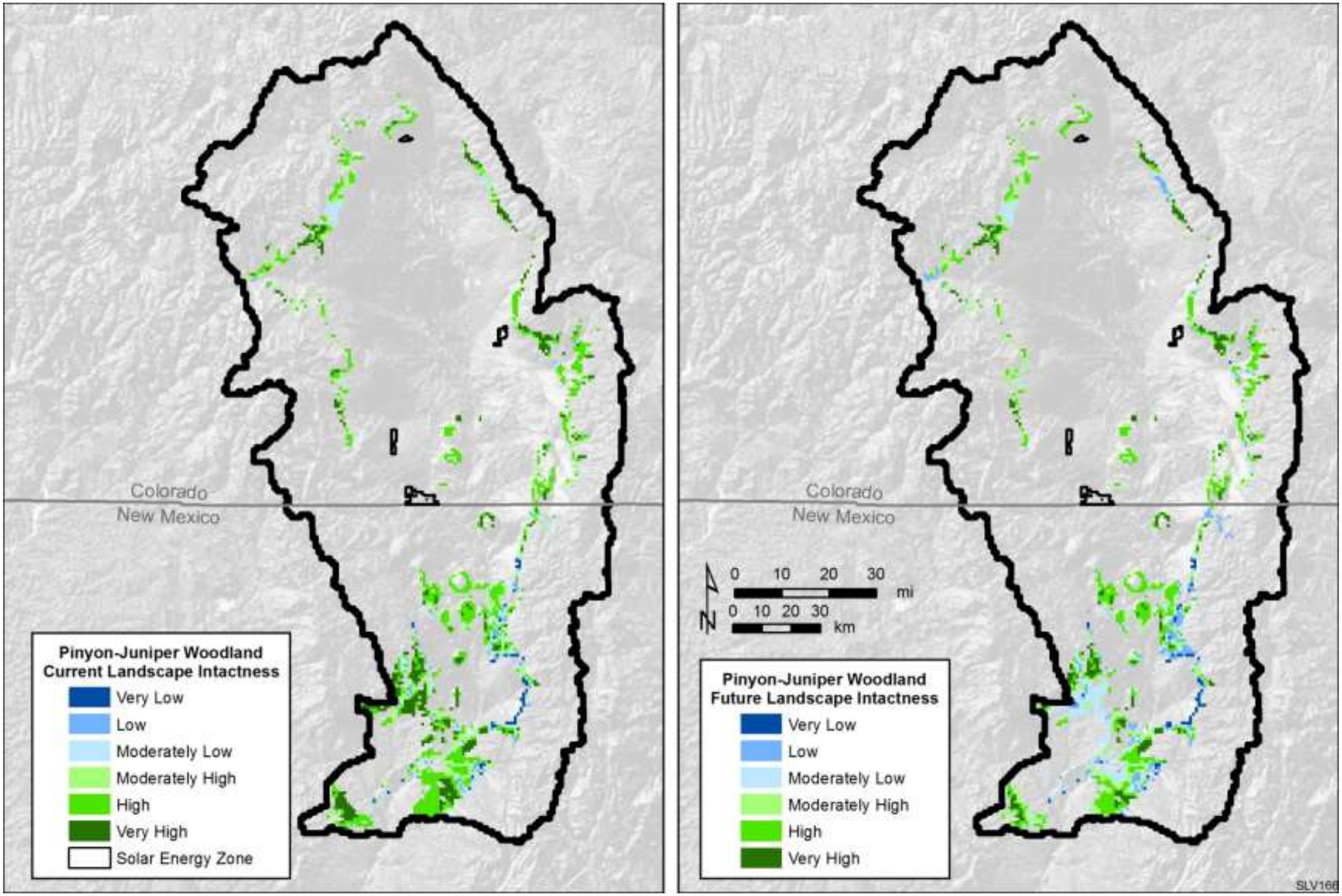


Figure B.1.3-4. Current and Future Landscape Intactness of Piñon-Juniper Woodland. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

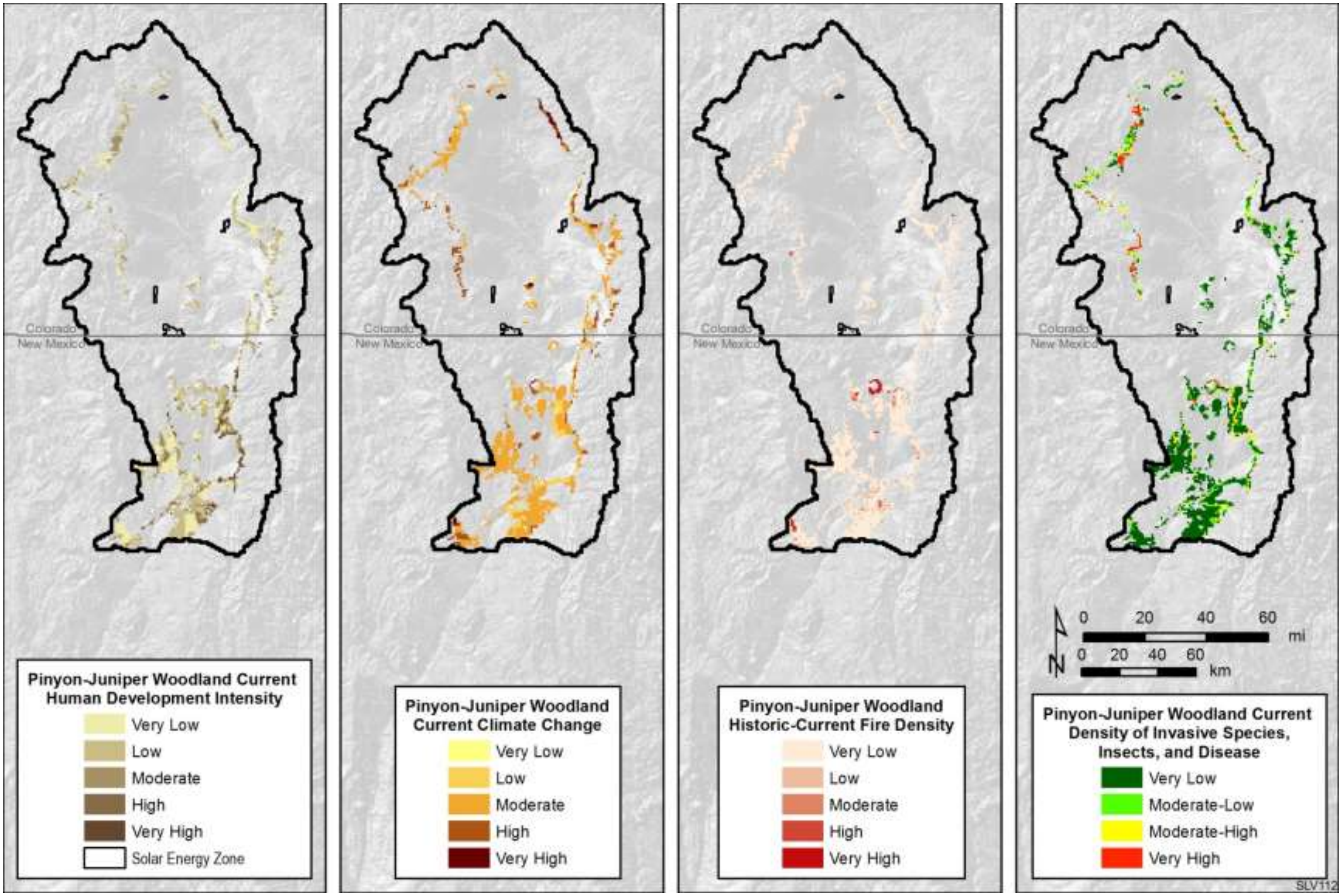


Figure B.1.3-5. Illustration for MQD1: What is the current distribution and status of piñon-juniper woodland systems? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

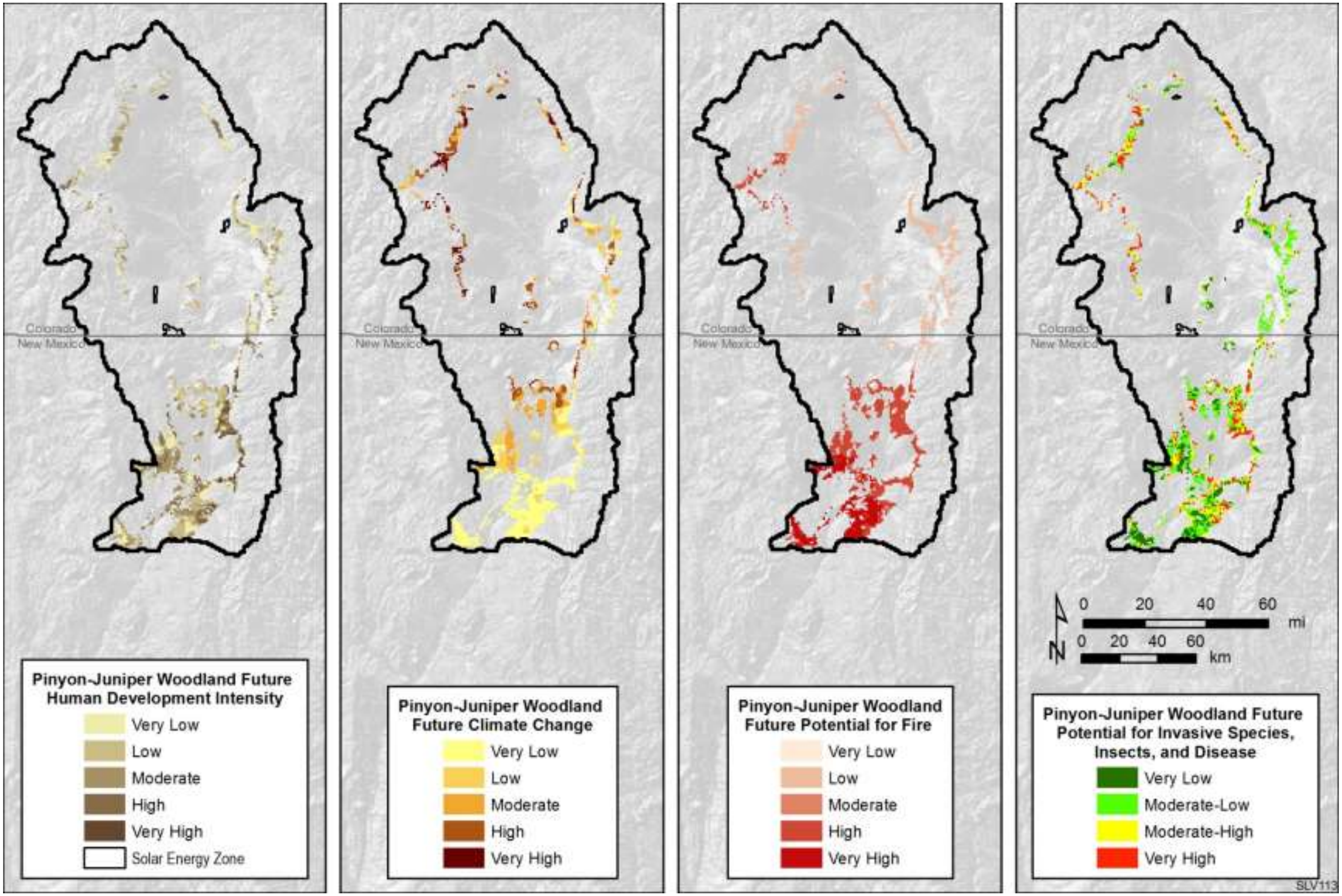


Figure B.1.3-6. Illustration for MQD3: Where is piñon-juniper woodland vulnerable to change agents in the future? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

Predicted Trends in Piñon-Juniper Woodland Habitat within the Study Area

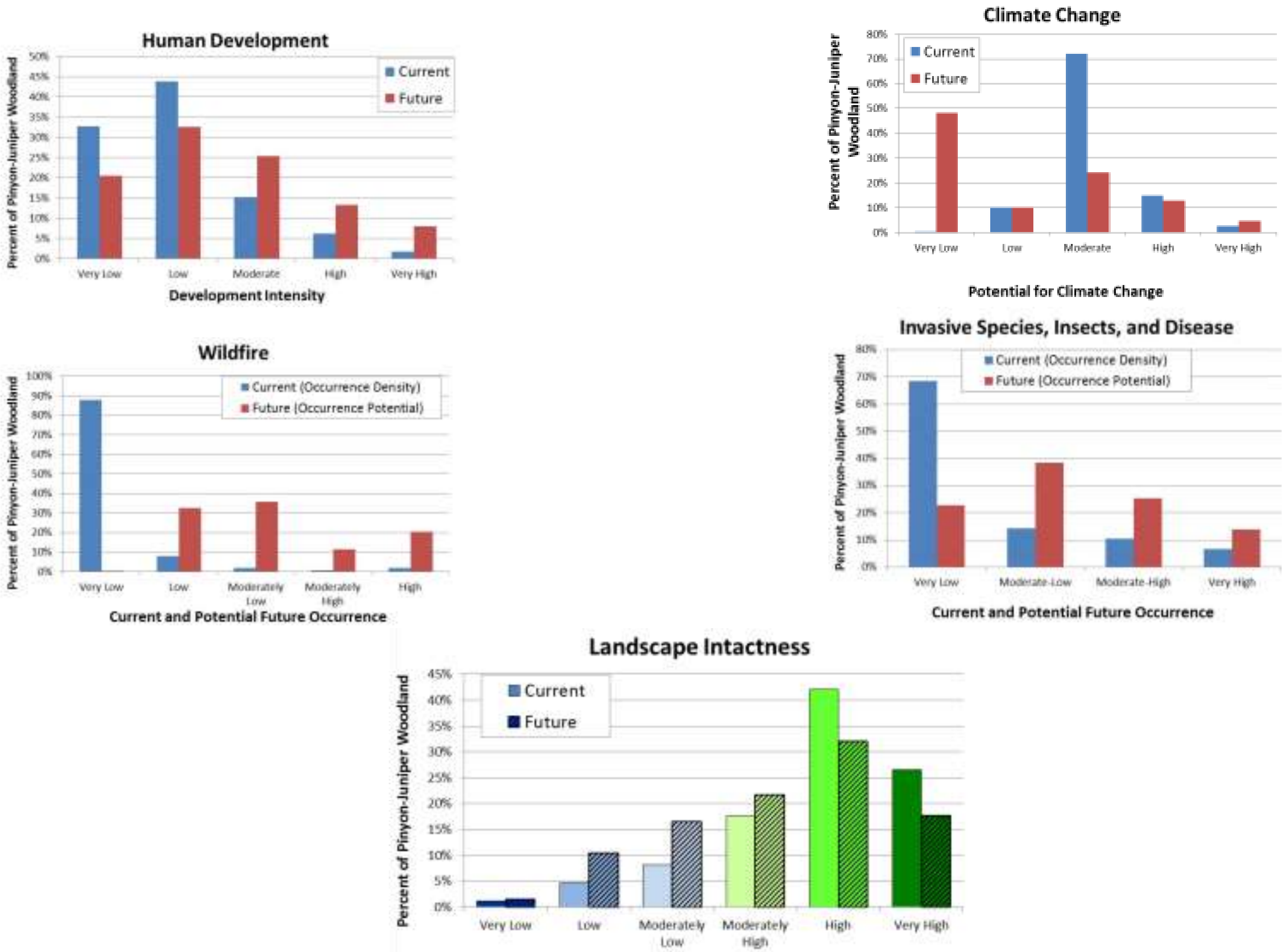


Figure B.1.3-7. Predicted Trends in Piñon-Juniper Woodland within the Study Area

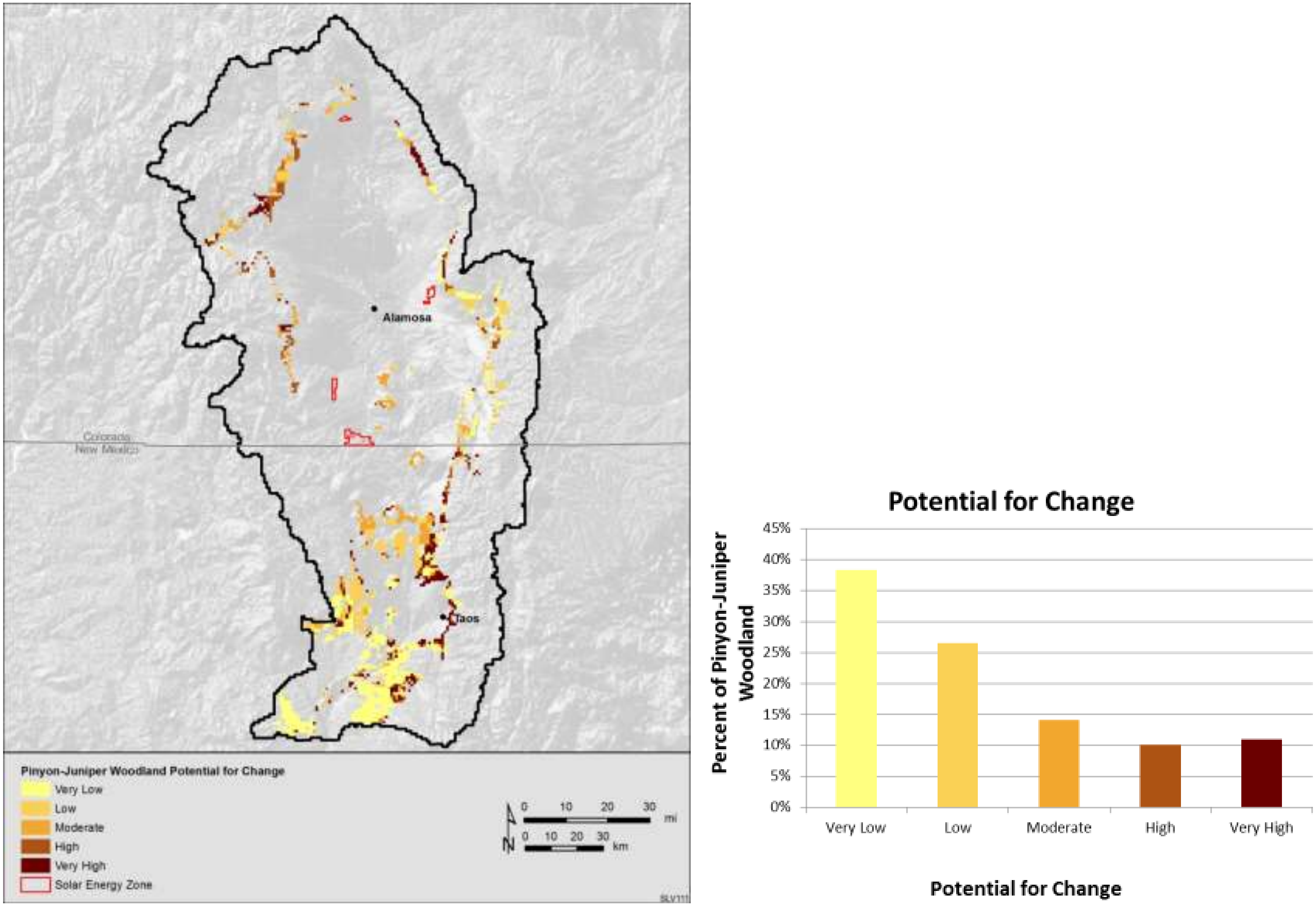


Figure B.1.3-8. Piñon-Juniper Woodland Aggregate Potential for Change. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

B.1.4 Riparian and Wetland Systems

The San Luis Valley in south-central Colorado is in an ancient lake bed approximately 100 miles long and 50 miles wide. The northern portion of the valley is a closed basin with no surface drainage outlet. This closed basin contains wetlands that support large concentrations of resident and migratory water birds. The Rio Grande River flows through the valley, separated from the closed basin by a low ridge. Surface waters in the valley include rivers, creeks, lakes, reservoirs, wetlands, and inter-basin diversions. Agriculture, greasewood flats, wetlands, and riparian communities dominate the landscape (USFWS 2014a; San Luis Valley Wetlands Focus Area Committee 2000). The climate regime (precipitation and temperature) regulates the water quantity and delivery to the system. Moisture tends to be seasonal and flashy, and any significant departure from this pattern can degrade riparian ecosystems (Bryce et al. 2012).

In San Luis Valley palustrine wetlands are seasonally flooded and support short, emergent herbaceous species. In areas with shallow water tables, many wetlands are also supported by groundwater. The San Luis Valley is the most important duck breeding area in Colorado. It also provides important foraging, migration, molting, staging, and wintering habitat for many species of waterfowl, shorebirds, and waterbirds (San Luis Valley Wetlands Focus Area Committee 2000).

Riparian habitats account for less than 3 percent of Colorado's landscape, but they support about 75 percent of the State's plant and animal species (EPA 2014). A wide array of birds use riparian habitats in the San Luis Valley during migration and for nesting. Riaprian habitat is also important to native fish such as the Rio Grande cutthroat trout, Rio Grande chub, and Rio Grande sucker (USFWS 2014b).

Development of resources including water, real estate, and agriculture are the primary threats to fish and wildlife resources in the San Luis Valley (USFWS 2014a). Riparian ecological systems have undergone significant physical and biological changes throughout the Colorado Plateau ecoregion due to numerous factors, including: human diversion or impoundment of free-flowing water, overgrazing by domestic livestock, competition with invasive species, bank erosion due to road building, logging, and other human development (LUHNM 2014). Livestock grazing has damaged approximately 80% of stream and riparian ecosystems in the western U.S. (Belsky et al. 1999). Invasive plants such as tamarisk often successfully out-compete native species such as willows, because of their higher reproductive capacity and tolerance to drought and flooding events (Stevens and Waring 1985, Glenn et al. 1998, Stromberg et al. 2007).

The establishment of tamarisk introduces a regime of episodic fire, which researchers believe is uncommon in most native riparian woodlands (LUHNM 2014). Fire regime is influenced by a complex interaction of factors—fuel load and condition, grazing, invasive species, and fire frequency. Riparian vegetation is affected by fire in two ways. There is the outright burning of the vegetation and, more broadly, there are changes in water retention and runoff over the larger burn area outside the riparian zone resulting in alterations in the amount of water and sediment that reaches the riparian zone (Bryce et al. 2012).

Riparian and wetland areas were characterized through the aggregation of several datasets including the U.S. National Atlas water features, National Wetlands Inventory, National Hydrography Dataset waterbodies, SWReGAP landcover types, and LANDFIRE Existing Vegetation Types. Specific sources of data are discussed below.

Stream Centerlines: U.S. National Atlas (http://nationalmap.gov/small_scale/). Water Feature Lines represents the linear water features (e.g., aqueducts, canals, intercoastal waterways, and streams) of the United States.

Wetlands: U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory (http://www.fws.gov/wetlands/). This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the conterminous United States. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979). Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and near shore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery. By policy, the FWS also excludes certain types of "farmed wetlands" as may be defined by the Food Security Act or that do not coincide with the Cowardin et al. definition.

Waterbodies: National Hydrography Dataset (http://nhd.usgs.gov/). The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. The waterbodies included in this dataset represent playas, lakes/ponds, reservoirs, and swamps/marshes.

Riparian Landcover Types: SWReGAP (http://earth.gis.usu.edu/swgap/). 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, etc.) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 acre. 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, etc.) 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 mosaicked to create the regional dataset. An internal validation for modeled classes was performed on a withheld 20% of the sample data.

Riparian Existing Vegetation Types: LANDFIRE Existing Vegetation Types (EVT) (http://www.landfire.gov/NationalProductDescriptions21.php). The EVT layer represents the species composition currently present at a given site. Vegetation map units are primarily derived from NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units. Additional units are derived from NLCD, National Vegetation Classification Standard (NVCS) Alliances, and LANDFIRE specific types.

EVTs are mapped using decision tree models, field data, Landsat imagery, elevation, and biophysical gradient data. Decision tree models are developed separately for each of the three lifeforms - tree, shrub, and herbaceous, and are then used to generate lifeform-specific EVT layers.

The information discussed in this CE assessment was used in the development of a conceptual model illustrating status and the mechanisms by which riparian and wetland systems may be affected within the San Luis Valley – Taos Plateau study area (Figure B.1.4-1). Through the process of evaluating Change Agents, the availability and distribution of surface water and groundwater through hydrologic processes was suggested as a fifth Change Agent that could influence the distribution, status, and trends of the riparian and wetland systems CE. Although water was not evaluated as a Change Agent in this LA, it is identified as a data gap for this and several other CEs.

The assessment of riparian and wetland condition and trend incorporated generalized indicators of landscape intactness and measures of change agents. While this approach provides a standard baseline to evaluate all CEs, not all species and ecological systems respond similarly to change agents. For example, some CEs may experience greater impacts from relatively small changes in climate (e.g., areas with low potential for future climate change). In addition, CE condition may be a function of other factors that could not be measured for this LA. For example, the condition of aquatic and hydrologic systems is related to the amount of human surface and groundwater use, which could not be adequately quantified and spatially represented in this LA. Assessment of CE-specific responses to disturbance factors and integration of other factors that may influence CE condition have been identified as data gaps for future study.

Figures B.1.4-2 through B.1.4-8 show, respectively: Figure B.1.4-2 - the current distribution of riparian and wetland systems in the study area; Figure B.1.4-3 – distribution with respect to current vegetation departure; Figure B.1.4-4 - distribution with respect to current and future landscape intactness in the study area; Figure B.1.4-5 - distribution and status with respect to the current status of change agents; Figure B.1.4-6 - distribution with respect to predicted areas of change; Figure B.1.4-7 - predicted trends in riparian and wetland systems within the study area; and Figure B.1.4-8 - the aggregate potential for change in riparian and wetland systems.

The majority (33.6%) of vegetation within riparian and wetland systems has a moderate degree of departure from historic reference vegetation conditions (Figure B.1.4-3).

The majority (53%) of riparian and wetland systems are within areas of high and very high current landscape intactness (Figure B.1.4-4; Figure B.1.4-7). Future trends in landscape intactness indicate a decrease in landscape intactness within riparian and wetland systems. The amount of these systems occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (Figure B.1.4-7).

The majority (59%) of riparian and wetland systems are within areas of very low to low current human development intensity (Figure B.1.4-5; Figure B.1.4-7). Future trends in human development indicate an increase in human development intensity within these systems. The amount of riparian and wetland systems occurring within areas of high and very high human development intensity is expected to increase by approximately 7% in the near-term (i.e., by 2030) (Figure B.1.4-6; Figure B.1.4-7).

The majority of riparian and wetland systems are within areas of very low current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.1.4-5; Figure B.1.4-7). Future trends in climate change indicate portions of riparian and wetland systems with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.1.4-6; Figure B.1.4-7). Approximately 13% of these systems are located in areas with high or very high potential for future climate change (Figure B.1.4-6; Figure B.1.4-7).

Like other CEs, the future potential for climate change in the study area is expected to influence the distribution and quality of riparian and wetland systems. Although the extent of warming likely to occur is not known with certainty at this time, the Intergovernmental Panel on Climate Change (IPCC) (2014) has concluded that warming of the climate is unequivocal and continued greenhouse gas emissions at or above current rates would cause further warming. The IPCC (2014) also projected that there will very likely be an increase in the frequency of hot extremes, heat waves, and heavy precipitation. Future warming in the southwest is expected to result in decreased length of snow season, decreased snow depth, and earlier snowmelt.

The majority of riparian and wetland systems are within areas of very low current fire occurrence density (Figure B.1.4-5; Figure B.1.4-7). Future trends in wildfire indicate a slight increase in wildfire potential for these systems. Approximately 71% of riparian and wetland systems have very low to low near-term future (i.e. by 2030) potential for wildfire (Figure B.1.4-6; Figure B.1.4-7).

The majority of riparian and wetland systems are within areas of very low or very high current density of invasive species, insects, and disease (Figure B.1.4-5; Figure B.1.4-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of these systems in the study area (Figure B.1.4-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, potential energy development, and spread of forest insects and disease (Figure B.1.4-6).

In addition to the four change agents modeled in this Landscape Assessment, the distribution and availability of water through natural and human-altered hydrologic processes can also be considered a unique change agent that could influence the distribution and status of several CEs, including riparian and wetland systems. As one outcome of this Landscape Assessment, the role of water as a change agent has been identified as a knowledge gap where future research efforts may be directed. Future research to characterize spatio-temporal patterns of water availability and how these processes influence CEs is needed to adequately address the role of water availability on riparian and wetland systems.

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 39% of the riparian and wetland systems have the potential for high or very high future change among the change agents (Figure B.1.4-8). Areas with greatest potential for change within these systems include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.1.4-8).

Although not addressed as a separate CE, ground and above ground nesting pollinators are widespread throughout the ecoregion and may be impacted by change agents within this system. Pollinators, such as honey bees, native bees, birds, bats, and butterflies, have been in decline over the last few decades (Presidential Memorandum 2014). Insect pollinators are important in maintaining biologically diverse plant and animal communities in all types of rangelands. Similarly, a heterogeneous rangeland landscape, including plant diversity in riparian corridors, contributes to the diversity and quantity of insect pollinators (Gilgert and Vaughan 2011; NRCS 2008). Riparian areas offer important nesting sites for bees during the spring and nectar and pollen for native bees during the summer and fall (NRCS 2008). Some of the threats facing riparian pollinators include habitat loss, grazing, pesticide use, and invasive exotic plants (Black et al. 2009).

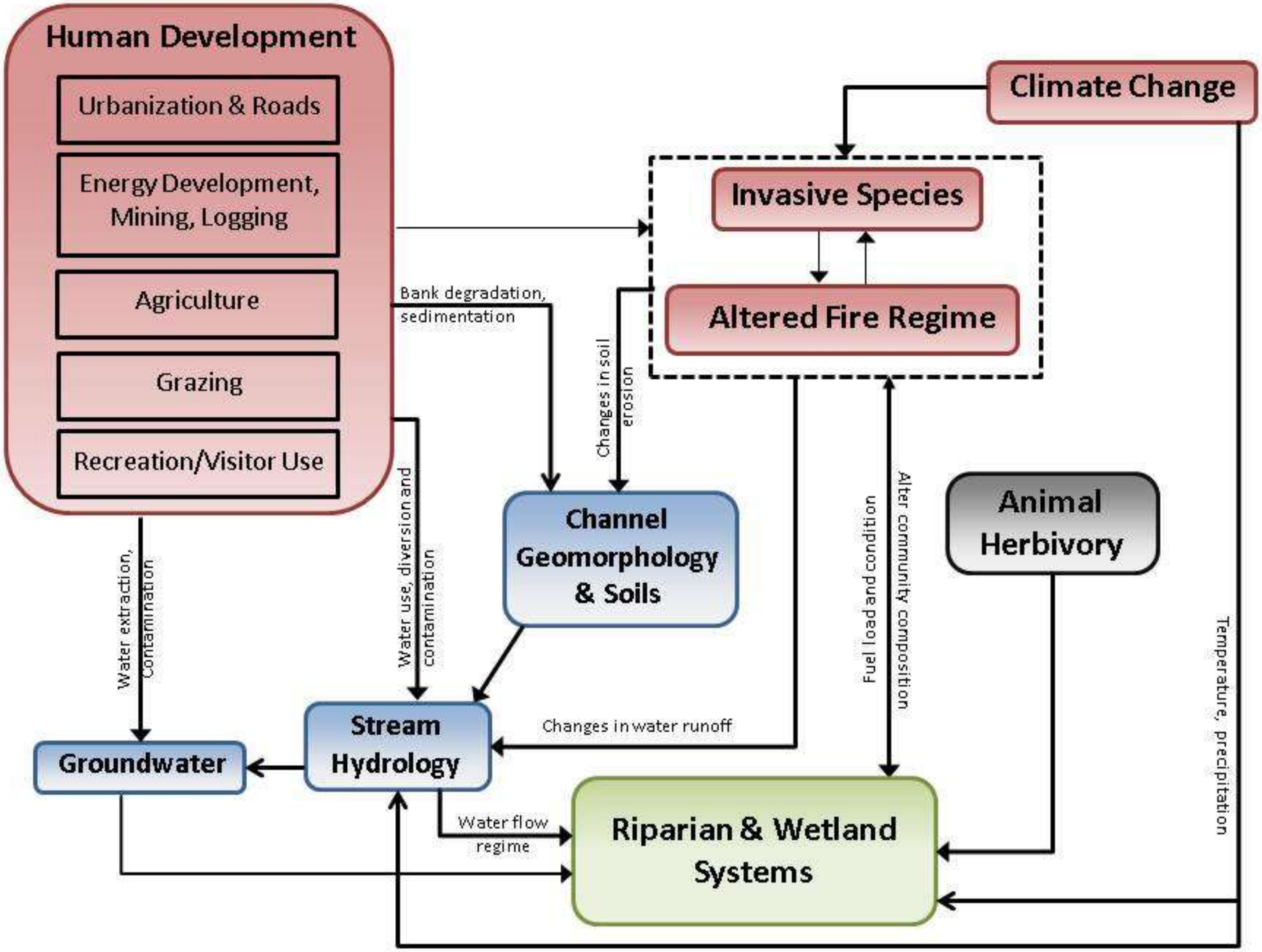


Figure B.1.4-1. Riparian and Wetland Conceptual Model.

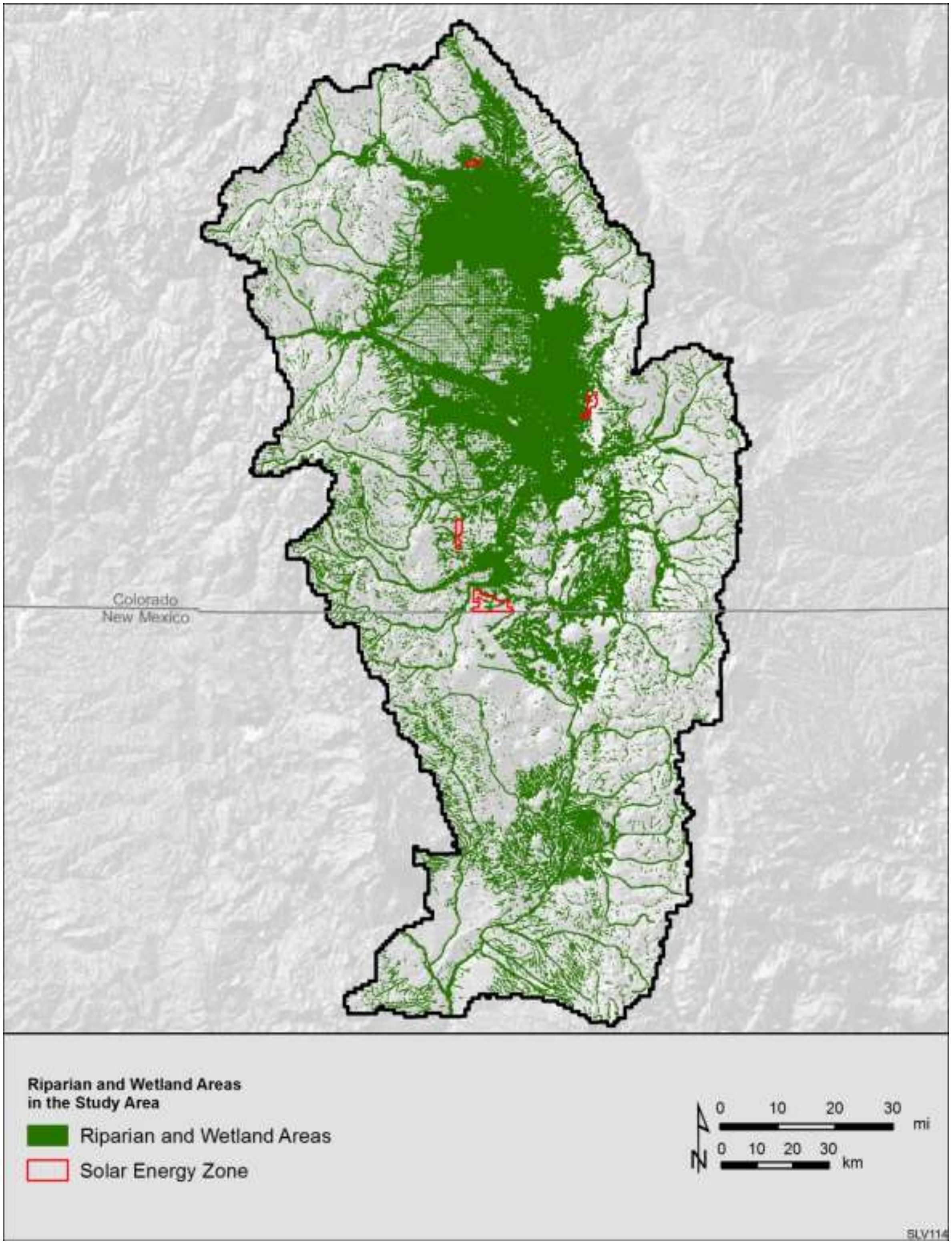


Figure B.1.4-2. Current Distribution Riparian and Wetland Systems. Data Sources: U.S. National Atlas water features, National Wetlands Inventory, National Hydrography Dataset waterbodies, SWReGAP landcover types, and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).

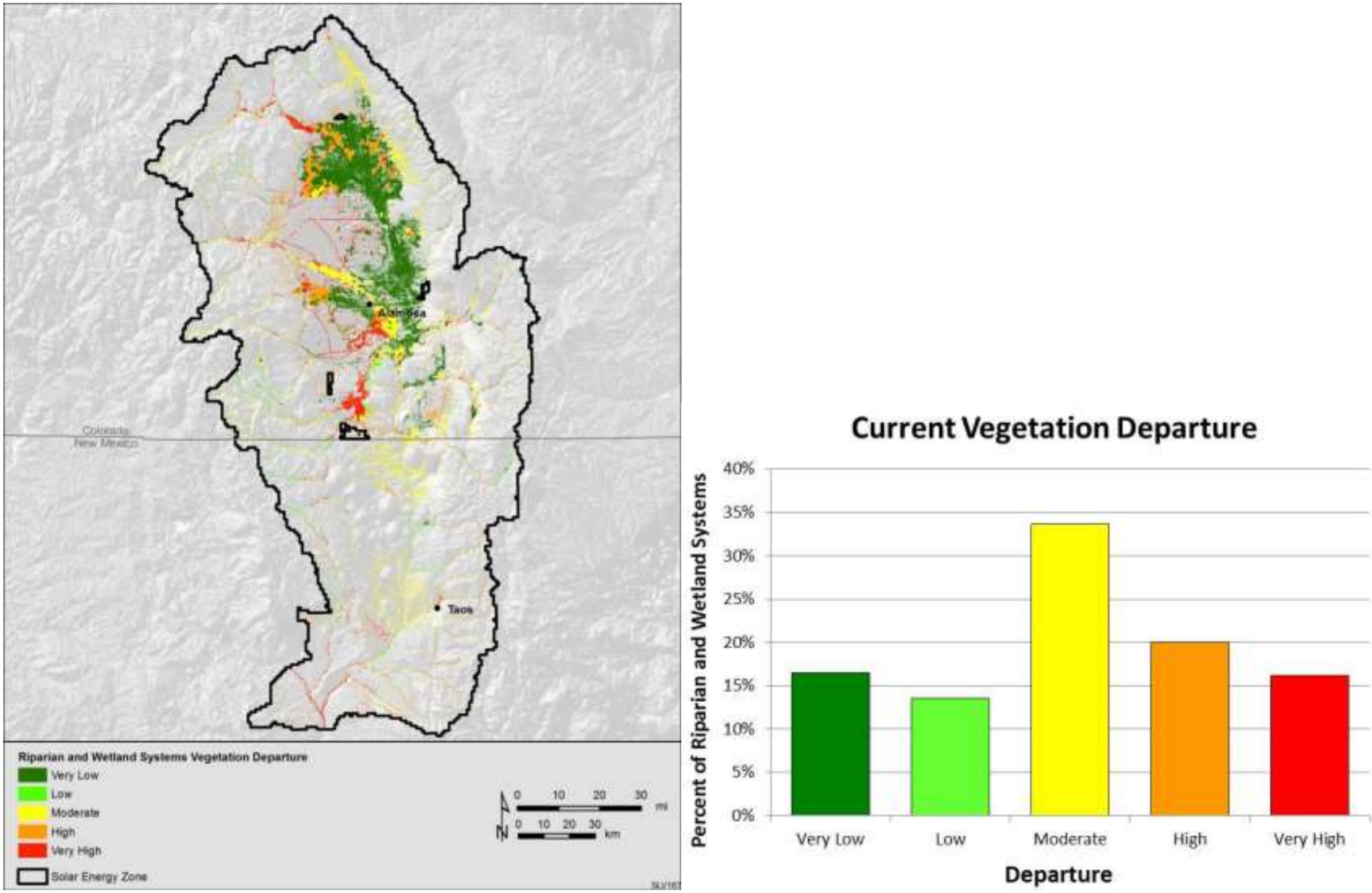


Figure B.1.4-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Riparian and Wetland Systems Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008), U.S. National Atlas water features, National Wetlands Inventory, National Hydrography Dataset waterbodies, SWReGAP landcover types, and Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010).

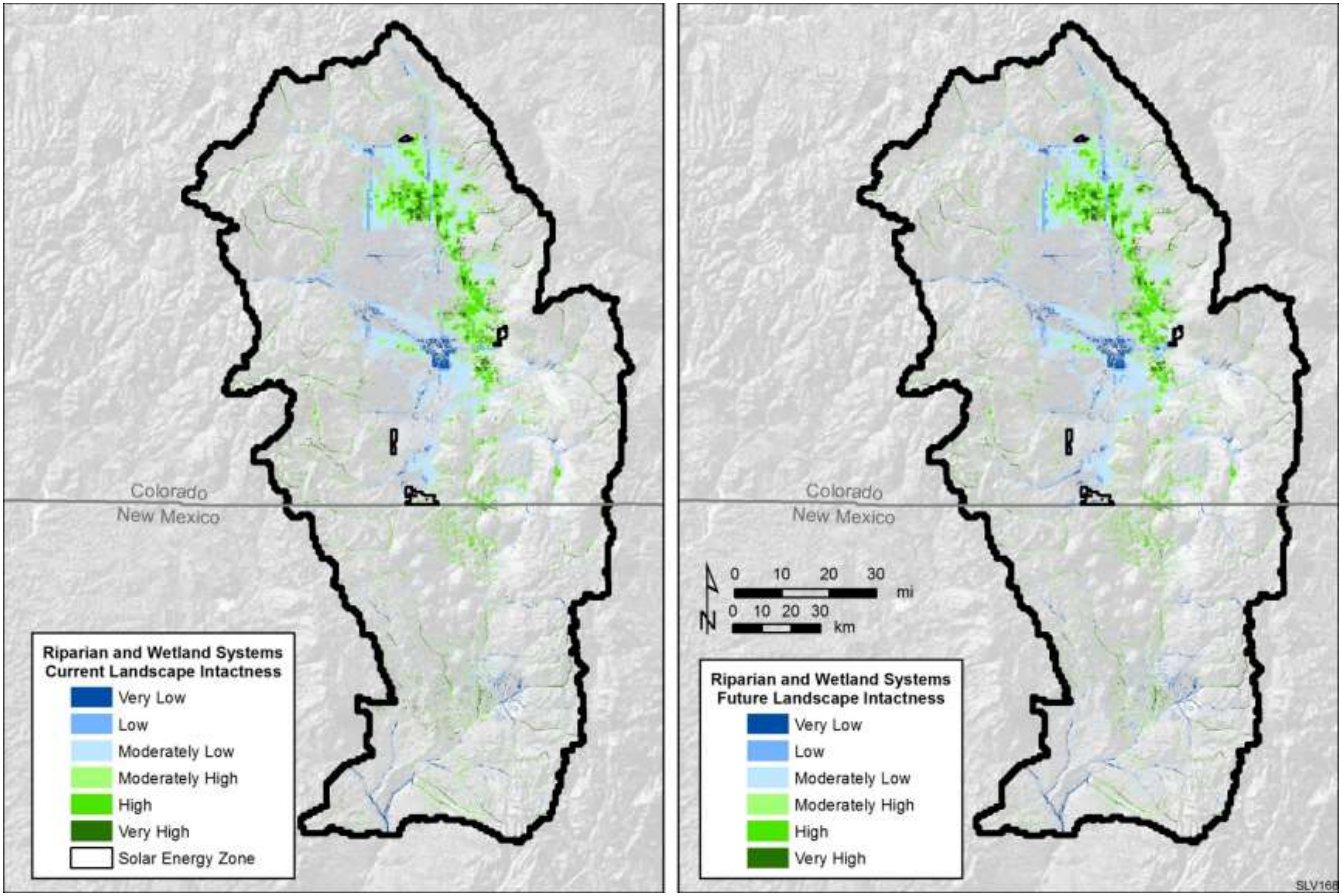


Figure B.1.4-4. Current and Future Landscape intactness of Riparian and Wetland Systems. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

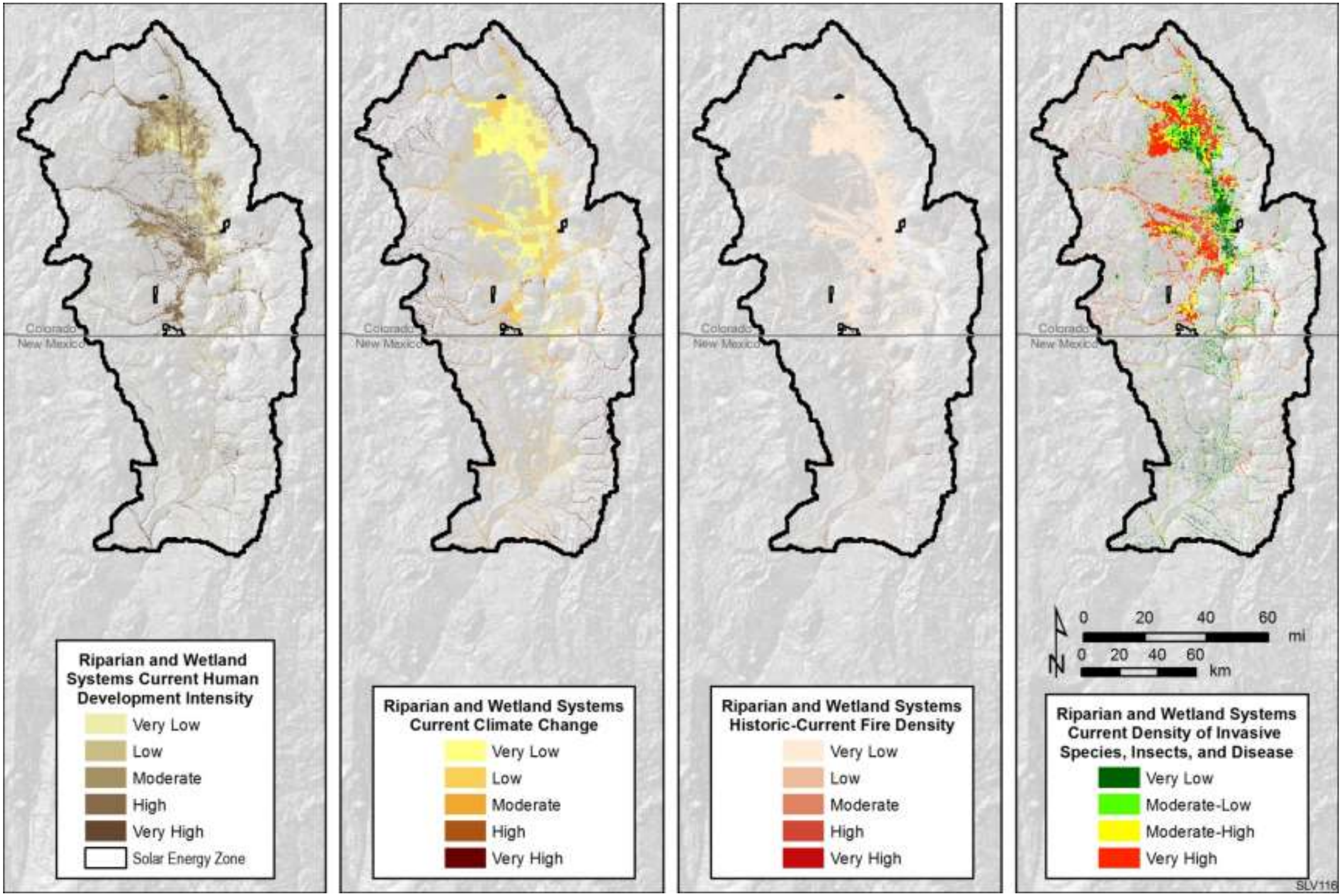


Figure B.1.4-5. Illustration for MQD1: What is the current distribution and status of riparian and wetland systems? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

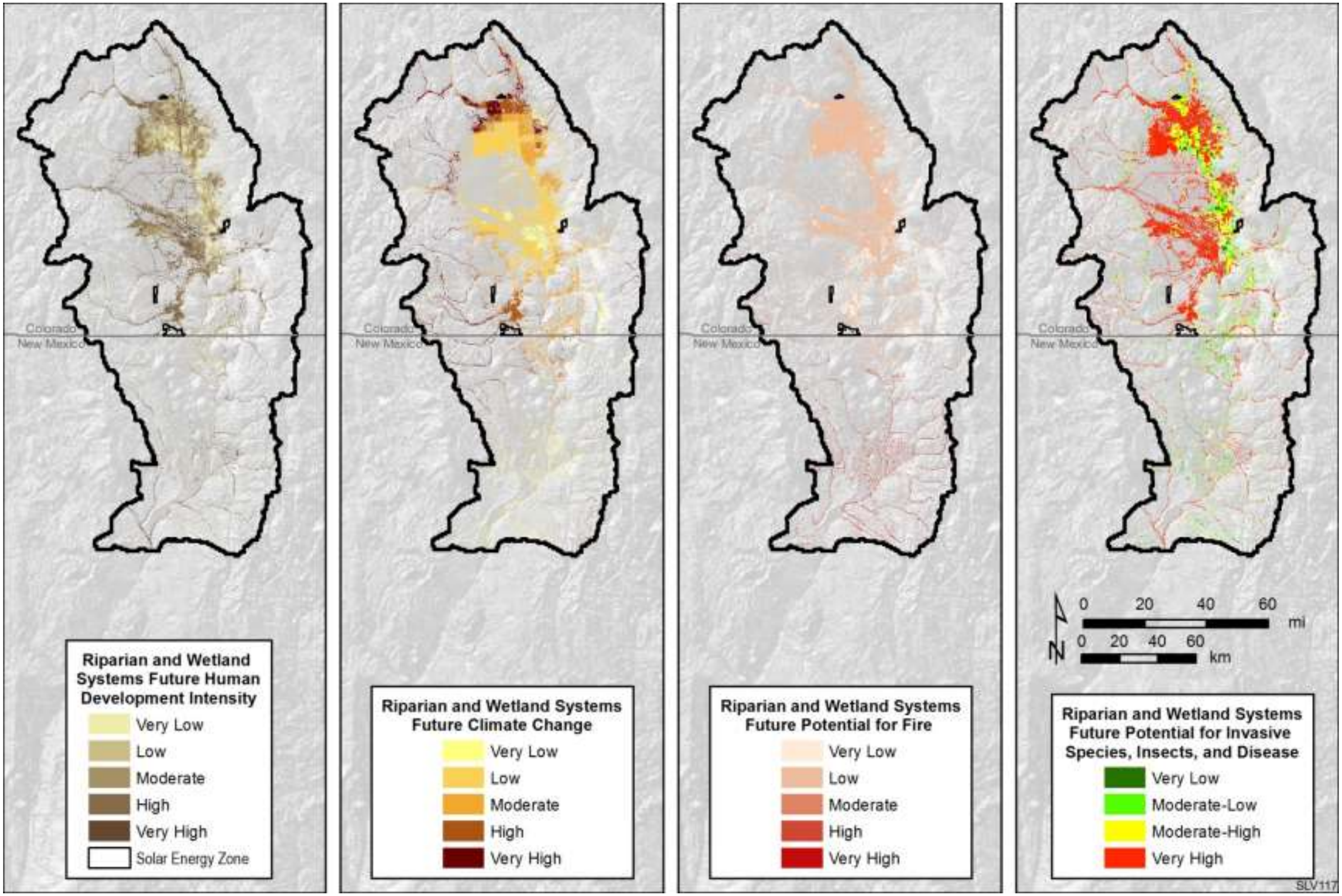


Figure B.1.4-6. Illustration for MQD3: Where are riparian and wetland systems vulnerable to change agents in the future? Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

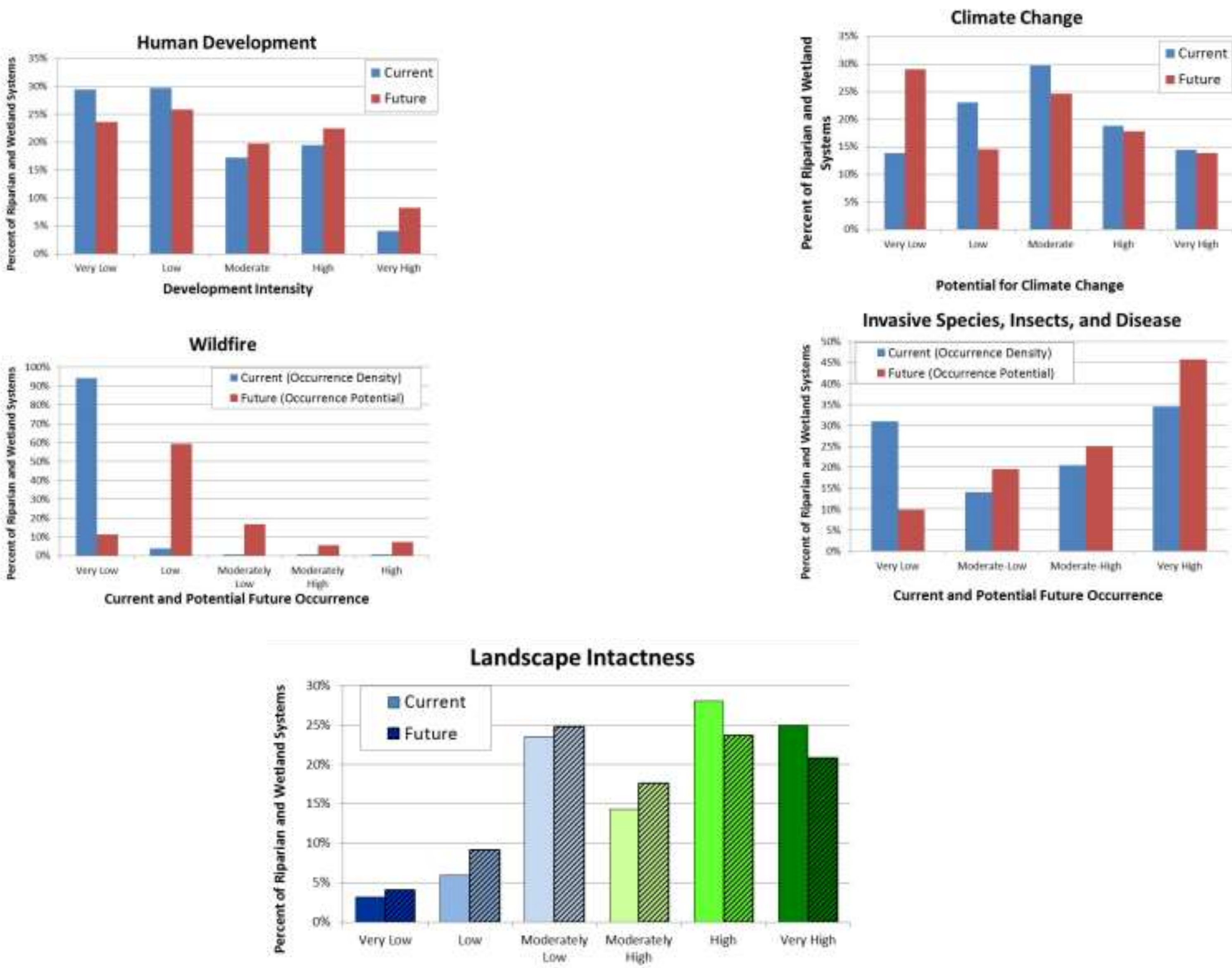


Figure B.1.4-7. Predicted Trends in Riparian and Wetland Systems within the Study Area

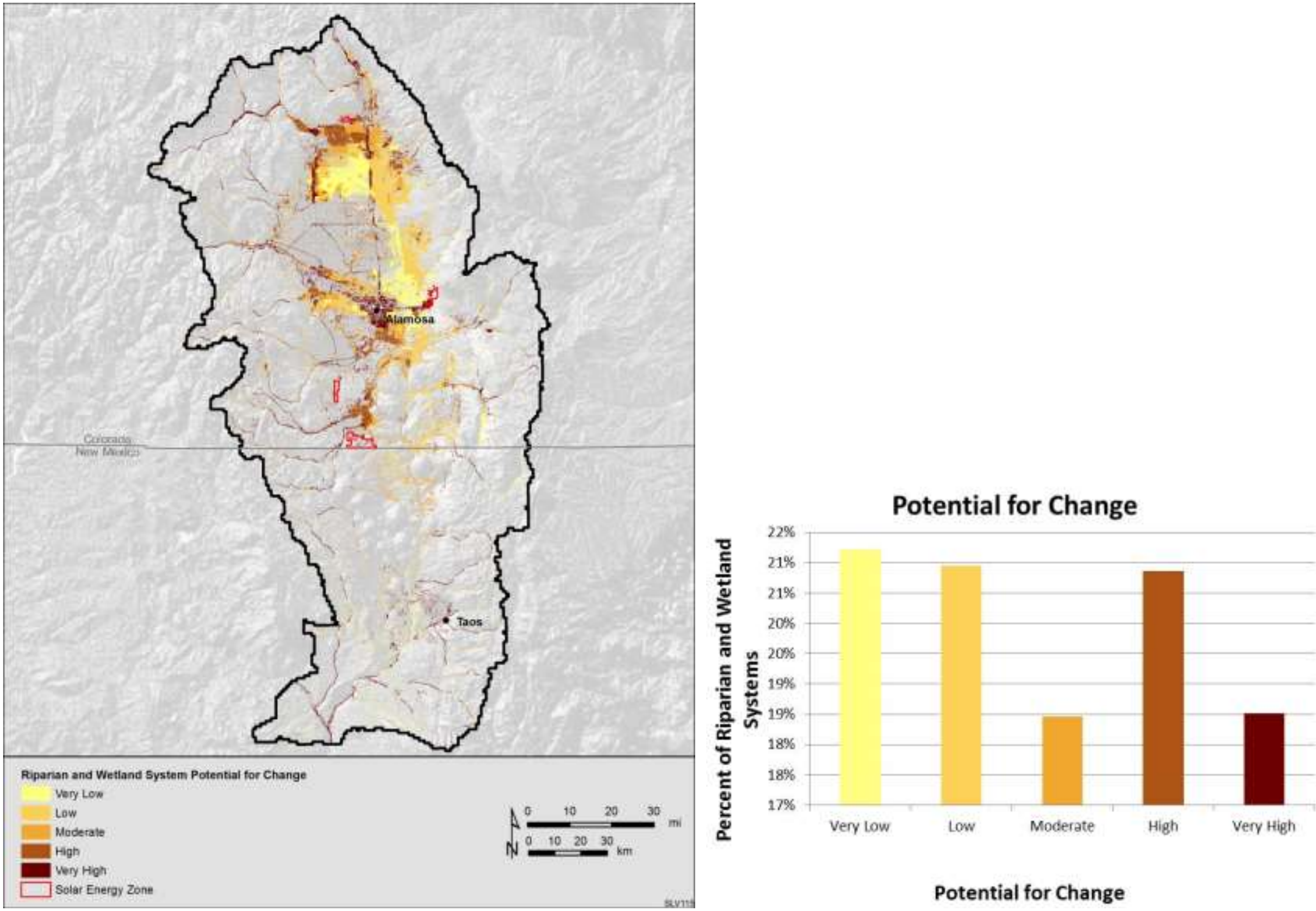


Figure B.1.4-8. Riparian and Wetland Systems Aggregate Potential for Change. Data Sources: Existing Vegetation Type (EVT) (LANDFIRE v 1.2; USGS, 2010) and Argonne 2014.

B.2 Focal Species Conservation Elements

B.2.1 Native Fish Assemblage (Rio Grande cutthroat trout, Rio Grande sucker, and Rio Grande chub)

The native fish assemblage CE includes the following species: Rio Grande cutthroat trout, Rio Grande sucker, and Rio Grande chub. Distribution data for these species were provided by BLM and CDOW (http://cpw.state.co.us/). These species face challenges due to human alteration of the hydrology where they are found (USFWS 2012). Changes to hydrology include decreased flows from water diversions and changes in stream hydrograph as a result of dam operations. These species also face threats from competition and predation from introduced species, habitat fragmentation, and habitat loss and degradation due to climate change and other anthropogenic factors such as land-use practices that increase stream sedimentation, reduce streamside vegetation, or impact water quality.

The Rio Grande sucker (*Catostomus plebeius*) occurs exclusively in the Rio Grande basin from Colorado to Mexico (Rees and Miller 2005, Woodling 1985). It prefers backwaters and pools near rapidly flowing water. Once abundant throughout the Rio Grande basin in Colorado, it was thought to have been extirpated from all but one location in Hot Creek (USFWS 2012; Rees and Miller 2005, Swift-Miller et al. 1999). Recently, a second historic population was found on the newly established Baca National Wildlife Refuge in Crestone Creek (Scott Miller, personal communication). It is considered a State endangered fish in Colorado (Rees and Miller 2005). Recovery efforts have included reintroducing Rio Grande sucker to several streams in the San Luis Valley. It is a BLM Sensitive Species in Colorado and New Mexico, is considered critically imperiled by the Colorado Natural Heritage Program, and considered imperiled in New Mexico (NatureServe). Rio Grande sucker was petitioned for listing as endangered under the Endangered Species Act on September 30, 2014.

Degradation of riparian vegetation along suitable and occupied streams, specifically the loss of a willow overstory along streambanks, may alter thermal regimes, which could affect the species. Changes in temperature could negatively influence the timing of the Rio Grande sucker spawning period (typically from February to April and sometimes a second time in late summer) (Woodling 1985). Additionally, the lack of streambank vegetation could reduce hiding cover for fish and result in increased bank erosion and subsequent increases in stream sedimentation. Deposition of fine sediments has also been found to negatively affect the abundance and condition of Rio Grande suckers (Swift-Miller et al. 1999). Interactions with non-native species may also have detrimental effects on Rio Grande sucker, including potential competition and hybridization with white suckers (Swift-Miller et al. 1999).

The Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*) lives in high elevation, coldwater streams in New Mexico and southern Colorado. It is the only native trout to occur in the Rio Grande basin. It is a subspecies that was made a candidate for listing by the U. S. FWS under the Endangered Species Act of 1973, as amended (Act) in 2008 (73 FR 27900, December 6, 2007). It was recently determined to be “not warranted” for listing under the Endangered Species Act (October 1, 2014, Ferderal Register). This species had been petitioned for listing because of its dramatically reduced range, and multiple threats facing its continued existence. It is a BLM Sensitive Species in both Colorado and New Mexico. It occupies high-elevation streams covering about 10 percent of its historic range (USFWS 2012). The Rio Grande cutthroat trout’s habitat is fragmented and gene flow among populations is virtually nonexistent (Rinne 1995).

Habitat of the Rio Grande cutthroat trout has been degraded by overgrazing by livestock (reduces streambank cover and increases sedimentation). Other threats include competition and hybridization with, and predation by, introduced trout; loss of streamside cover resulting from timber harvest; habitat loss or degradation resulting from wildfires; and changes in stream temperature and quality due to human alteration of hydrology and climate change (Sublette et al. 1990; USFWS 2012; Rinne 1995).

The Rio Grande chub (*Gila pandora*) was historically widespread in creeks of the upper Rio Grande and Pecos watersheds in New Mexico and the Rio Grande and San Luis Valley basin in southern Colorado, with an isolated population in the Davis Mountains, Texas (Little Aguja Creek [Nations Canyon Creek], Pecos River system, Jeff Davis County) (Sublette et al. 1990, Zuckerman and Langlois 1990, Calamusso and Rinne 1996, Bestgen et al. 2003, Rees et al. 2005, Hubbs et al. 2008). Now the range is reduced in the Pecos system, and likely the species has been extirpated from the mainstem Rio Grande and is now only found in tributary streams (Rees et al. 2005). A population in the headwaters of the Canadian River (Red River drainage), New Mexico, may be introduced or possibly native (Sublette et al. 1990). It is considered critically imperiled by the Colorado Natural Heritage Program, and considered a vulnerable species in New Mexico (NatureServe). It is also a BLM Sensitive Species in Colorado and New Mexico. This species can be found in both riverine and lacustrine habitats. Stream populations spawn in riffle habitat between March and June and may have an additional spawning period in the fall (Rees et al. 2005). Main threats to the Rio Grande chub include anthropogenic events such as habitat fragmentation by impoundments for diversions, habitat destruction due to poor land use practices, and predation by, and competition with, introduced fish species (USFWS 2012; Rees et al. 2005). In addition, natural hybridization between *Rhinichthys cataractae* and *Gila pandora* (Rio Grande chub) has been reported (Cross and Minckley 1960; Suttkus and Cashner 1981). Ecological attributes and indicators for the native fish assemblage are provided in Table B.2.1-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the native fish assemblage may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.1-1). In addition to the four change agents modeled in this Landscape Assessment, the distribution and availability of water through natural and human-altered hydrologic processes can also be considered a unique change agent that could influence the distribution and status of several CEs, including the native fish assemblage. As one outcome of this Landscape Assessment, the role of water as a change agent has been identified as a knowledge gap where future research efforts may be directed. Future research to characterize spatio-temporal patterns of water availability and how these processes influence CEs is needed to adequately address the role of water availability on the native fish assemblage.

The assessment of condition and trends for the native fish assemblage incorporated generalized indicators of landscape intactness and measures of change agents. While this approach provides a standard baseline to evaluate all CEs, not all species and ecological systems respond similarly to change agents. For example, some CEs may experience greater impacts from relatively small changes in climate (e.g., areas with low potential for future climate change). In addition, CE condition may be a function of other factors that could not be measured for this LA. For example, the condition of aquatic and hydrologic systems is related to the amount of human surface and groundwater use, which could not be adequately quantified and spatially represented in this LA. Assessment of CE-specific responses to disturbance factors and integration of other factors that may influence CE condition have been identified as a data gaps for future study.

Figures B.2.1-2 through B.2.1-8 show, respectively: Figure B.2.1-2 - the current distribution of potentially suitable habitat for the native fish assemblage in the study area; Figure B.2.1-3 – habitat distribution with respect to current vegetation departure; Figure B.2.1-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.1-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.1-6 - habitat distribution with respect to predicted areas of change; Figure B.2.1-7 - predicted trends in habitat for the native fish assemblage within the study area; and Figure B.2.1-8 - the aggregate potential for change in habitat for the native fish assemblage.

The majority (44%) of vegetation within potentially suitable habitat native fish assemblage has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.1-3).

The majority (80%) of potentially suitable habitat for the native fish assemblage is within areas of high and very high current landscape intactness (Figure B.2.1-4; Figure B.2.1-7). Future trends in landscape intactness indicate a decrease in landscape intactness within native fish assemblage potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 12% in the near-term (i.e., by 2030) (Figure B.2.1-7).

The majority (85%) of potentially suitable habitat for the native fish assemblage is within areas of very low and low current human development intensity (Figure B.2.1-5; Figure B.2.1-7). Future trends in human development indicate an increase in human development intensity within native fish assemblage potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 3% in the near-term (i.e., by 2030) (Figure B.2.1-6; Figure B.2.1-7).

The majority of potentially suitable habitat for the native fish assemblage is within areas of high and very high current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.1-5; Figure B.2.1-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.1-6; Figure B.2.1-7). Approximately 45% of native fish assemblage suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.1-6; Figure B.2.1-7). Like other CEs, the future potential for climate change in the study area is expected to influence the distribution and habitat quality of the native fish assemblage. Although the extent of warming likely to occur is not known with certainty at this time, the Intergovernmental Panel on Climate Change (IPCC) (2014) has concluded that warming of the climate is unequivocal and continued greenhouse gas emissions at or above current rates would cause further warming. The IPCC (2014) also projected that there will very likely be an increase in the frequency of hot extremes, heat waves, and heavy precipitation. Future warming in the southwest is expected to result in decreased length of snow season, decreased snow depth, and earlier snowmelt. These changes are expected to have future effects on aquatic habitats for the native fish assemblage by altering water temperature, water depth, changes in stream flow, and increasing intensity and frequency of other disturbances (Williams et al. 2009).

The majority of potentially suitable habitat for the native fish assemblage is within areas of very low current fire occurrence density (Figure B.2.1-5; Figure B.2.1-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Approximately 73% of native fish assemblage habitat has low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.2.1-6; Figure B.2.1-7).

The majority of potentially suitable habitat for the native fish assemblage is within areas of very high current density of invasive species, insects, and disease (Figure B.2.1-5; Figure B.2.1-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of native fish assemblage potentially suitable habitat in the study area (Figure B.2.1-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include spread of forest insects and disease (Figure B.2.1-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 33% of the native fish assemblage suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.1-8). Areas with greatest potential for change within native fish assemblage suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.1-8).

Table B.2.1-1. Native Fish Assemblage Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat (Rio Grande cutthroat Trout)	Temperature	Low temperatures			>7.8 °C	Pritchard and Cowley 2006
Habitat (Rio Grande cutthroat trout)	Slope	>20%			10%	Pritchard and Cowley 2006
Habitat (Rio Grande sucker)	Velocity	>113 cm/s			<20 cm/s	Rees and Miller 2005
Habitat (Rio Grande sucker)	Slope	>3.2%			Low gradient habitat	Rees and Miller 2005
Habitat (Rio Grande chub)	Slope				<2%	Rees et al. 2005
Habitat	Presence of non-native species	Present			Not Present	

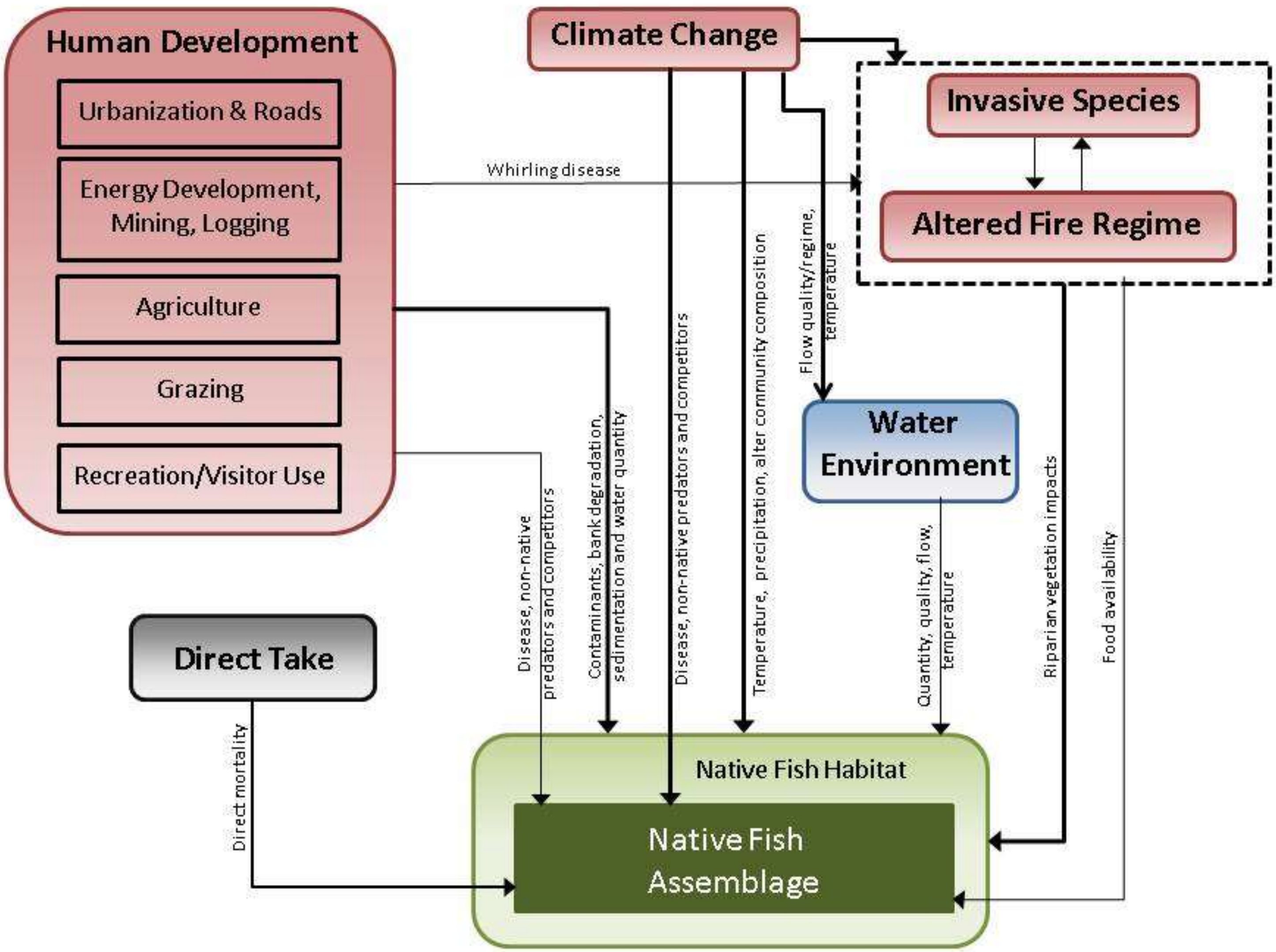


Figure B.2.1-1. Native Fish Assemblage Conceptual Model.

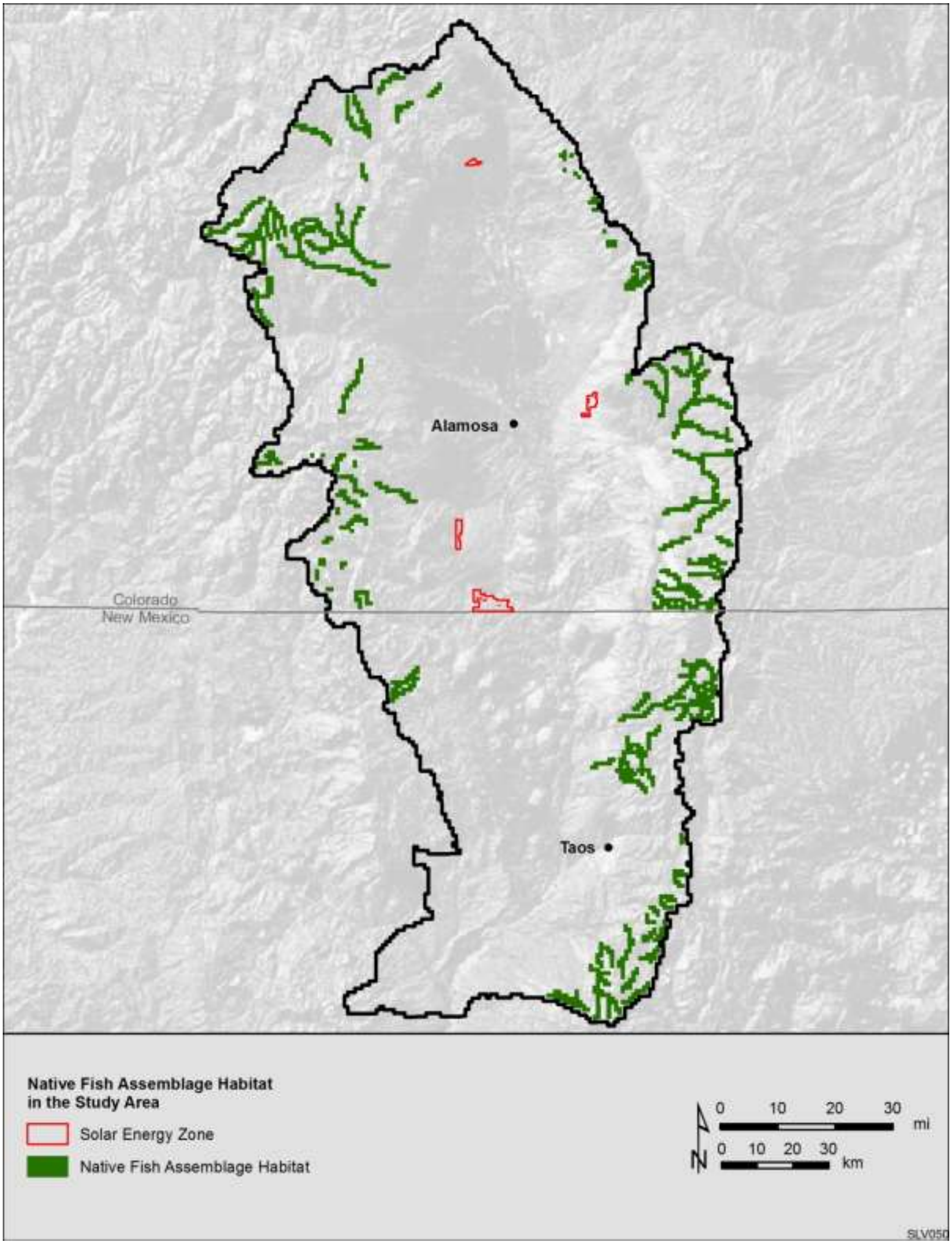


Figure B.2.1-2. Current Distribution of Potentially Suitable Habitat for the Native Fish Assemblage. Data Sources: data received from BLM.

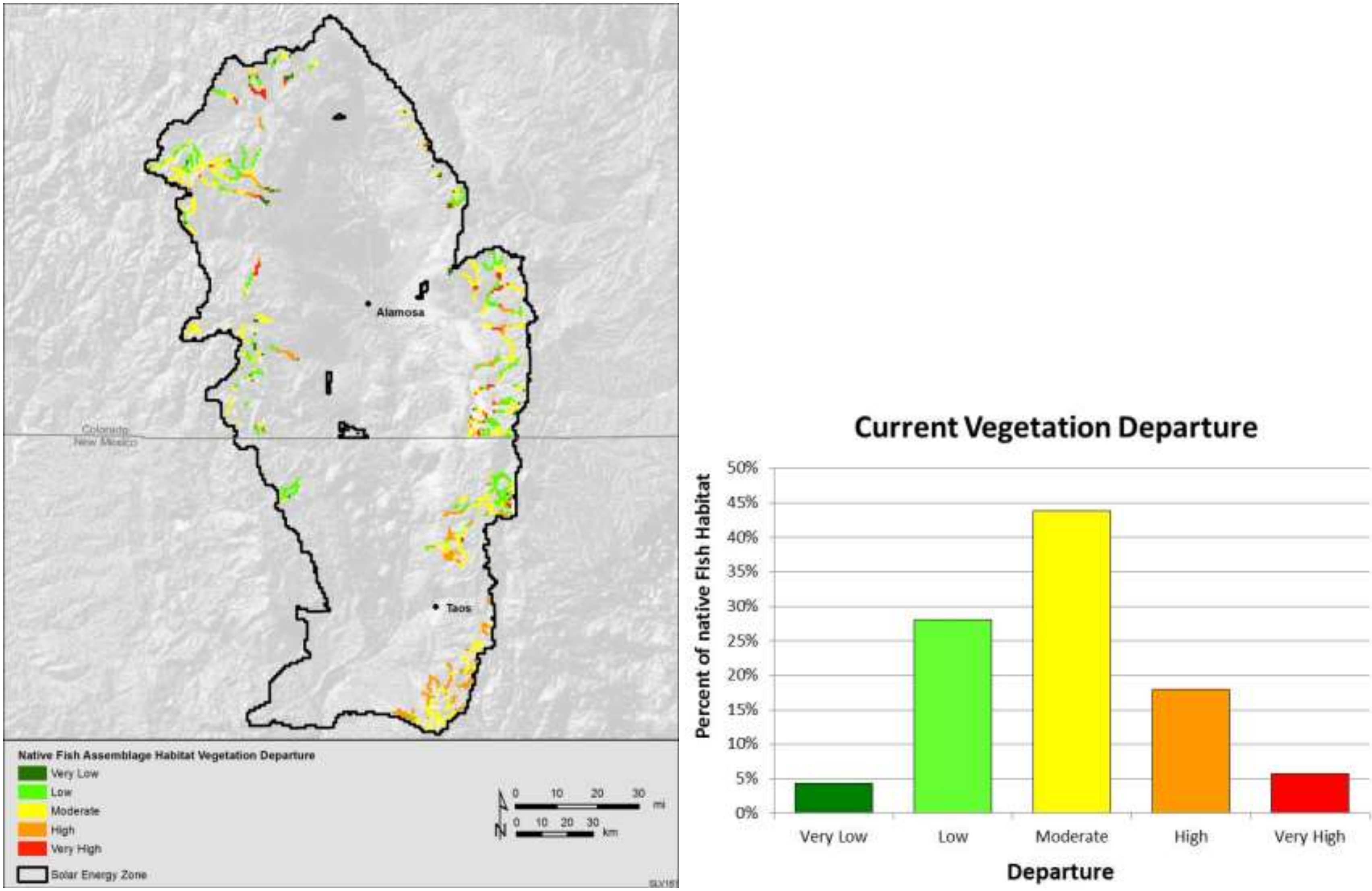


Figure B.2.1-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Native Fish Assemblage Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and data received from BLM. Data were Summarized to 1 km^2 Reporting Units.

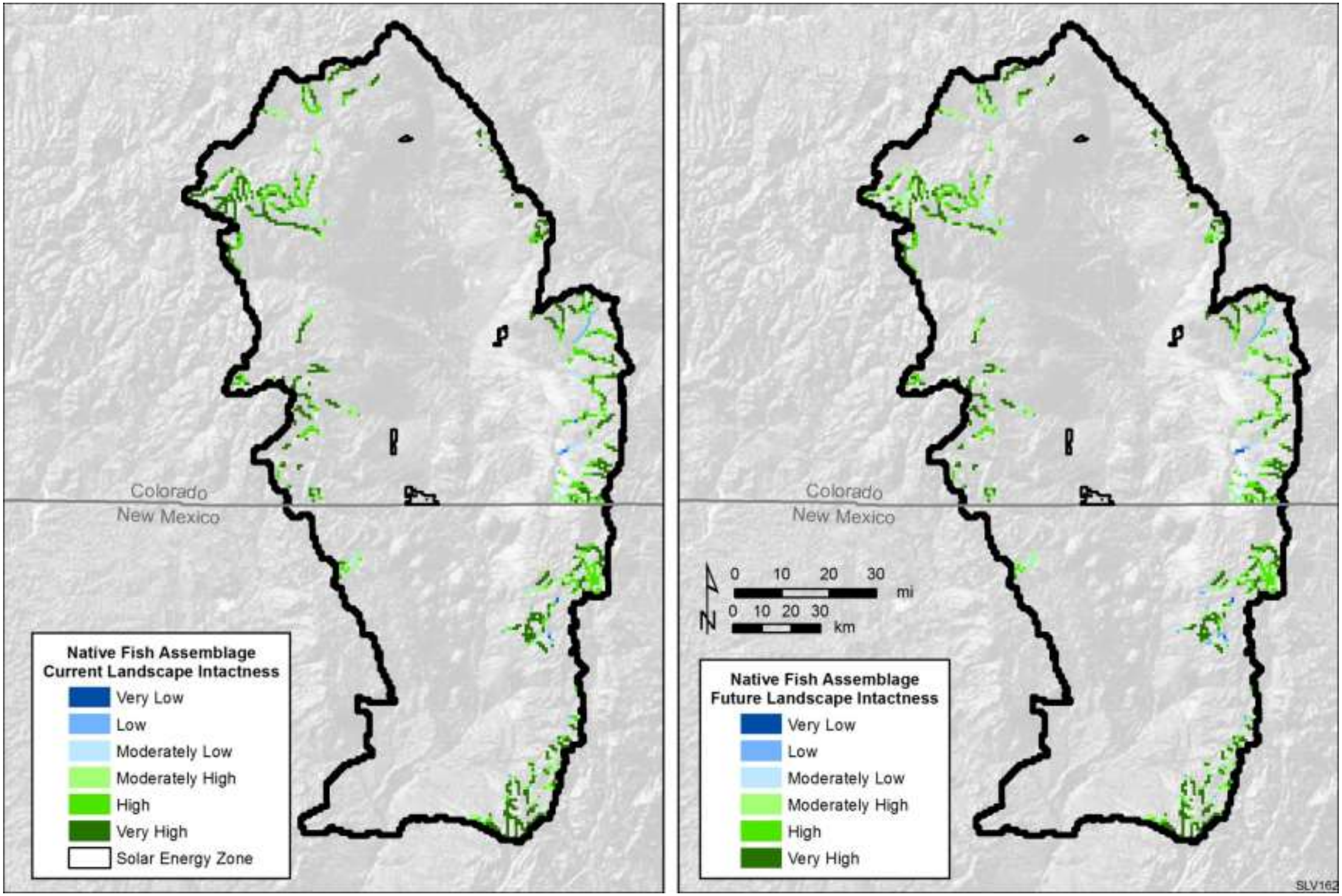


Figure B.2.1-4. Current and Future Landscape Intactness of Potentially Suitable Native Fish Habitat. Data Sources: Argonne 2014 and data received from BLM.

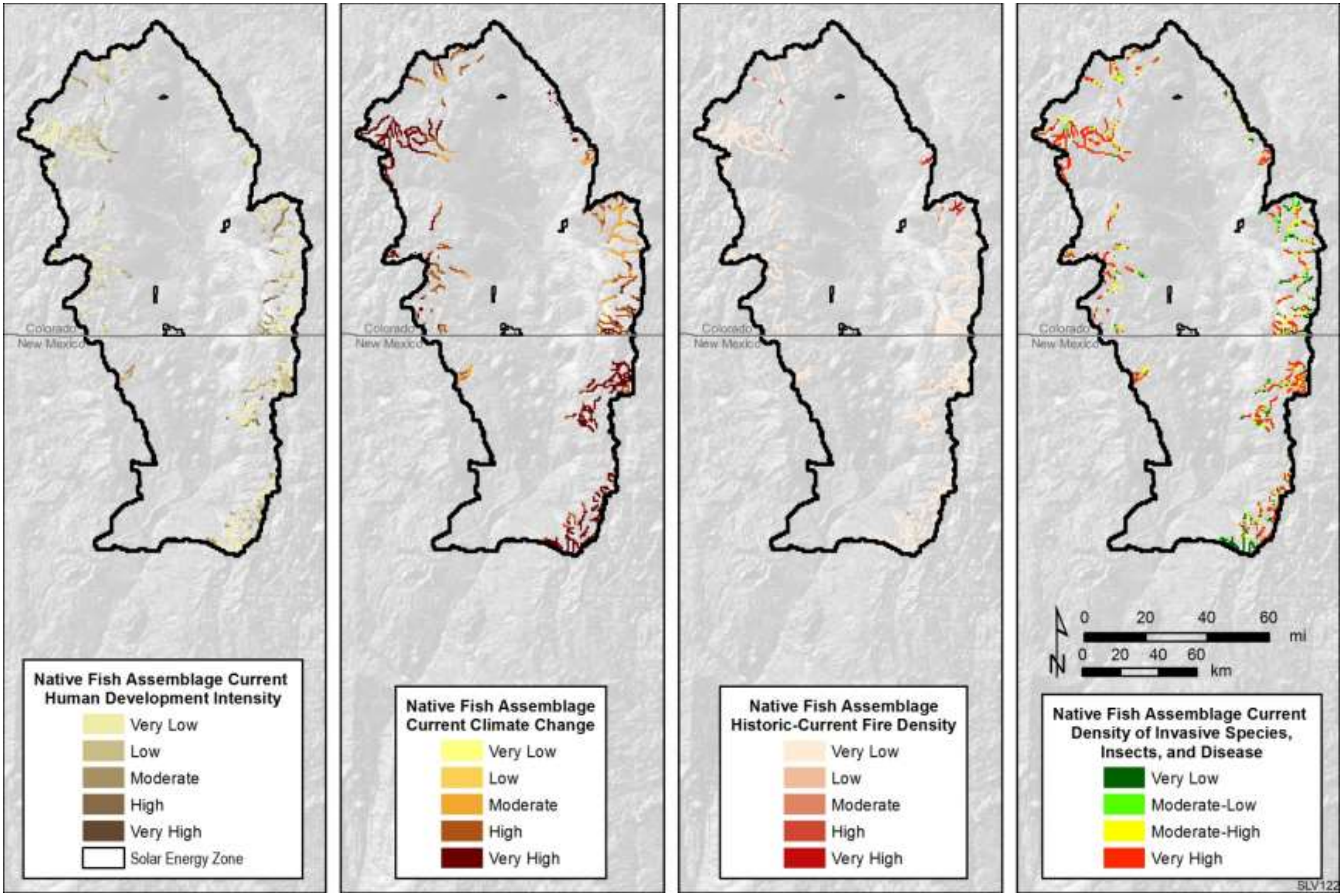


Figure B.2.1-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat for the native fish assemblage? Data Sources: Data Sources: Argonne 2014 and data received from BLM.

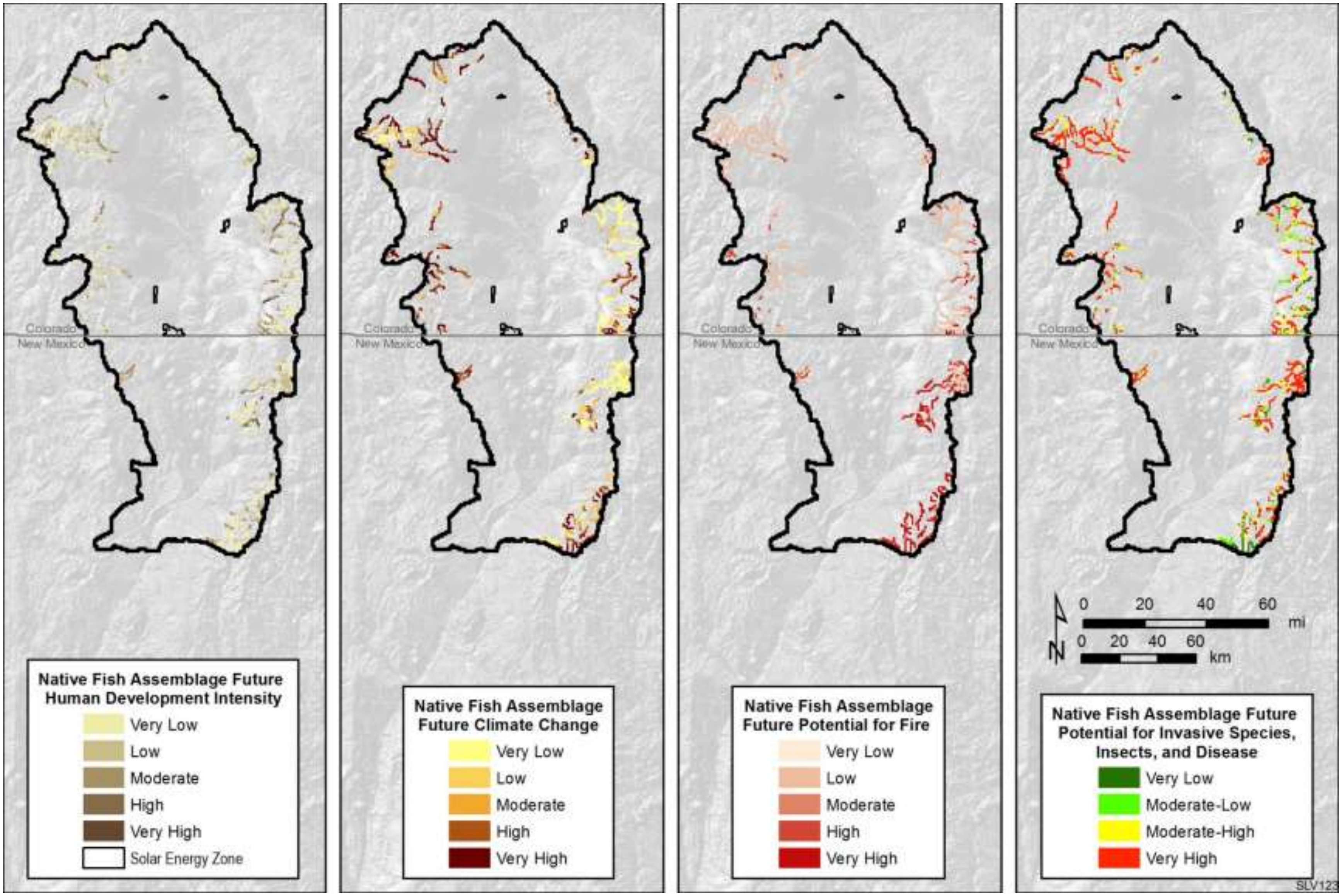


Figure B.2.1-6. Illustration for MQD3: Where are native fish vulnerable to change agents in the future? Data Sources: Argonne 2014 and data received from BLM.

Predicted Trends in Native Fish Habitat within the Study Area

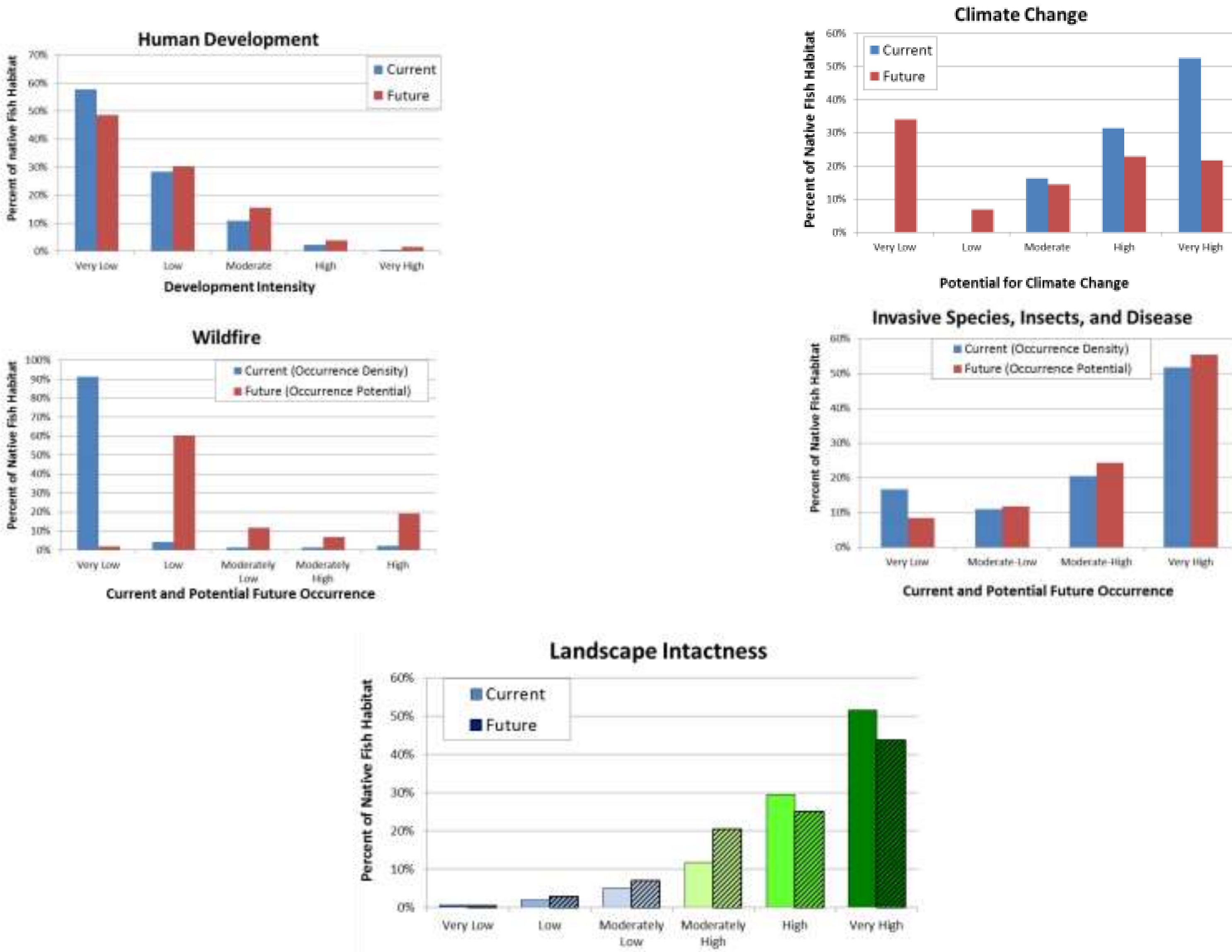
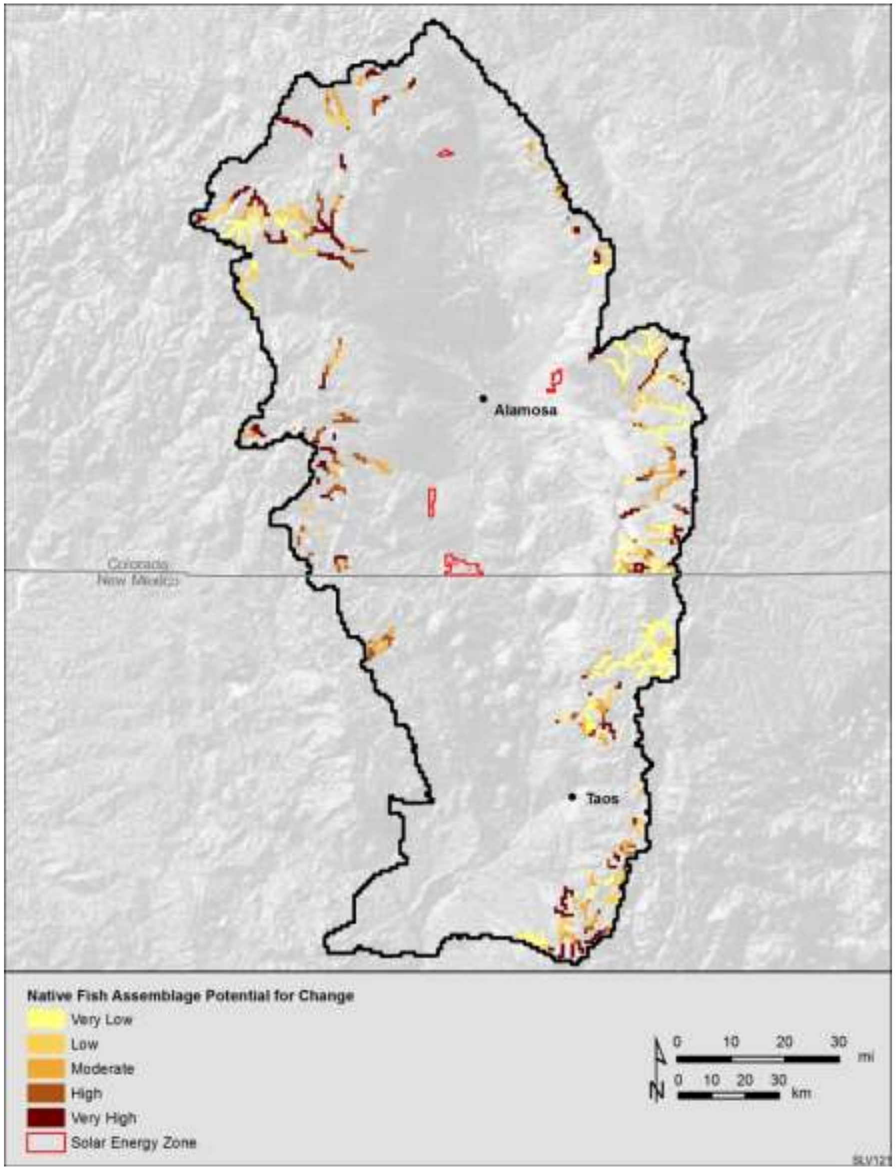


Figure B.2.1-7. Predicted Trends in Native Fish Habitat within the Study Area



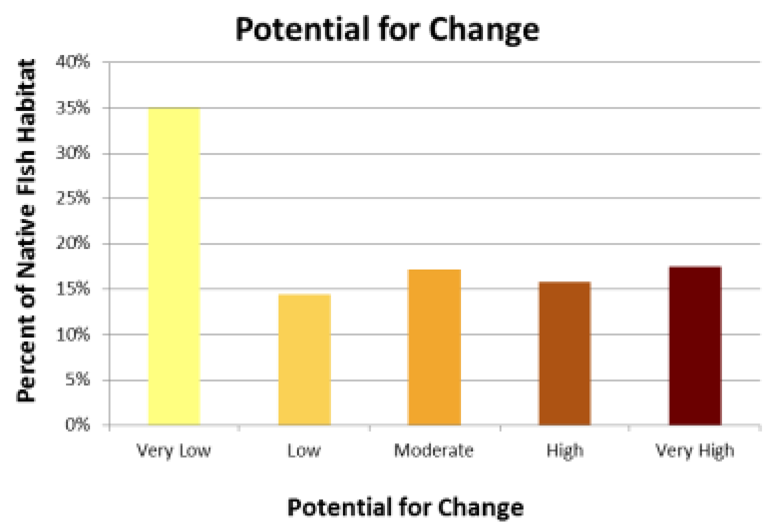


Figure B.2.1-8. Native Fish Assemblage Aggregate Potential for Change. Data Sources: Argonne 2014 and data received from BLM.

B.2.2 Brewer’s Sparrow

Brewer’s sparrow (*Spizella breweri*) is a small (12-15 cm) migratory bird species that occurs throughout western North America. It is a BLM sensitive species in Colorado. The breeding region is primarily found in the Great Basin region ranging from eastern California, Oregon and Washington to the Rocky Mountains. The breeding region includes most of Colorado and northwestern New Mexico. The wintering range, which includes southern New Mexico, extends from southeastern California, to southeast Texas, and into the northern regions of Mexico (Cornell Lab of Ornithology 2015; Rotenberry et al. 1999). Spring migration occurs from mid-March to late May, with peak migration occurring in April. Fall migration occurs from mid-August through October (USFWS 2014c).

Breeding habitat for the Brewer’s sparrow is composed of shrublands and is closely associated with sagebrush-dominated landscapes (Knopf 1994). Populations may occur in piñon-juniper woodlands or in large tracts of coniferous forests (Sedgwick 1987). The preferred habitat for Brewer’s sparrow in the winter range is composed of sagebrush shrublands and desert dominated by saltbrush vegetation and creosote (Rotenberry et al. 1999; USFWS 2014c).

The start of the breeding season for Brewer’s sparrow varies from mid-May to early June, depending on the geographic location of the population’s breeding grounds (Best and Petersen 1985; NatureServe 2014). Nests are often located in sagebrush that is significantly taller and denser than the surrounding vegetation, and are constructed from small sagebrush twigs, dry grasses, weed stems, rootlets, and lined with fine grasses, small strips of bark, and hair (Harrison 1978, Rich 1980, Petersen and Best 1985). Frequently there are three to four eggs in a clutch and two broods produced in a single breeding season, though the proportion of double-brooding individuals has not been reported. It has been found that an increase in clutch size is strongly correlated to a higher occurrence of precipitation in the prior winter season (Rotenberry and Wiens 1991; NatureServe 2014).

The diet of the Brewer’s sparrow consists of grains and insects. Individuals will drink free water where it is available, although the species is adapted to arid environments and can survive on metabolic water (Rotenberry et al. 1999).

Although often the most abundant songbird in sagebrush habitats, it is declining across its range, threatened by large scale reduction and fragmentation of sagebrush habitats occurring due to a number of activities, including land conversion to tilled agriculture, urban and suburban development, and road and power-line rights of way (NatureServe 2014). Brewer’s sparrow can likely persist with moderate grazing and other land management activities that maintain sagebrush cover and the quality and integrity of native vegetation. Sagebrush habitats may be very difficult to restore where non-native grasses and other invasive species are pervasive. Fire cycles that permanently convert sagebrush habitats to annual grassland can lead to an escalation of habitat loss. Ecological attributes and indicators for the Brewer’s sparrow are provided in Table B.2.2-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the Brewer’s sparrow may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.2-1). Figures B.2.2-2 through B.2.2-8 show, respectively: Figure B.2.2-2 - the current distribution of potentially suitable Brewer’s sparrow habitat in the study area; Figure B.2.2-3 – habitat distribution with respect to current vegetation departure; Figure B.2.2-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.2-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.2-6 - habitat distribution with respect to predicted areas of change; Figure B.2.2-7 - predicted trends in Brewer’s sparrow habitat within the study area; and Figure B.2.2-8 - the aggregate potential for change in Brewer’s sparrow habitat.

The majority (68%) of vegetation within Brewer's sparrow potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.2-3). Areas of potentially suitable habitat with the greatest vegetation departure are located in agricultural and shrubland areas in southern portion of the study area in New Mexico (Figure B.2.2-3).

The majority (52%) of Brewer's sparrow potentially suitable habitat is within areas of moderately high and high current landscape intactness (Figure B.2.2-4; Figure B.2.2-7). Future trends in landscape intactness indicate a decrease in landscape intactness within Brewer's sparrow potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 9% in the near-term (i.e., by 2030) (Figure B.2.2-7).

The majority (43%) of Brewer's sparrow potentially suitable habitat is within areas of low current human development intensity (Figure B.2.2-5; Figure B.2.2-7). Future trends in human development indicate an increase in human development intensity within Brewer's sparrow potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 11% in the near-term (i.e., by 2030) (Figure B.2.2-6; Figure B.2.2-7).

The majority of Brewer's sparrow potentially suitable habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.2-5; Figure B.2.2-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure X-6; Figure B.2.2-7). Approximately 10% of the Brewer's sparrow suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.2-7). The greatest potential for future climate change within Brewer's sparrow potentially suitable habitat occurs in isolated habitat areas in the western and northwestern portion of the study area (Figure B.2.2-6).

The majority of Brewer's sparrow potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.2-5; Figure B.2.2-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Over 90% of Brewer's sparrow habitat has low or moderately low near-term future (i.e. by 2030) potential for wildfire (Figure B.2.2-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.2-6).

The majority of Brewer's sparrow potentially suitable habitat is within areas of very low current density of invasive species, insects, and disease (Figure B.2.2-5; Figure B.2.2-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of Brewer's sparrow potentially suitable habitat in the study area (Figure B.2.2-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion and spread of forest insects and disease in the southern portion of the study area (Figure B.2.2-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 21% of the Brewer's sparrow suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.2-8). Areas with greatest potential for change within Brewer's sparrow suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.2-8).

Table B.2.2-1. Brewer's Sparrow Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Nest success	Habitat fragmentation	Highly fragmented	Moderate fragmentation	Minimally fragmented	Low fragmentation	Vander Haegen (2007)
Population abundance	Natural gas well density within 1 km^2	High well density (>8 wells)	Moderate well density (4-7 wells)	Low well density (1-3 wells)	No wells	Gilbert and Chalfoun (2011)

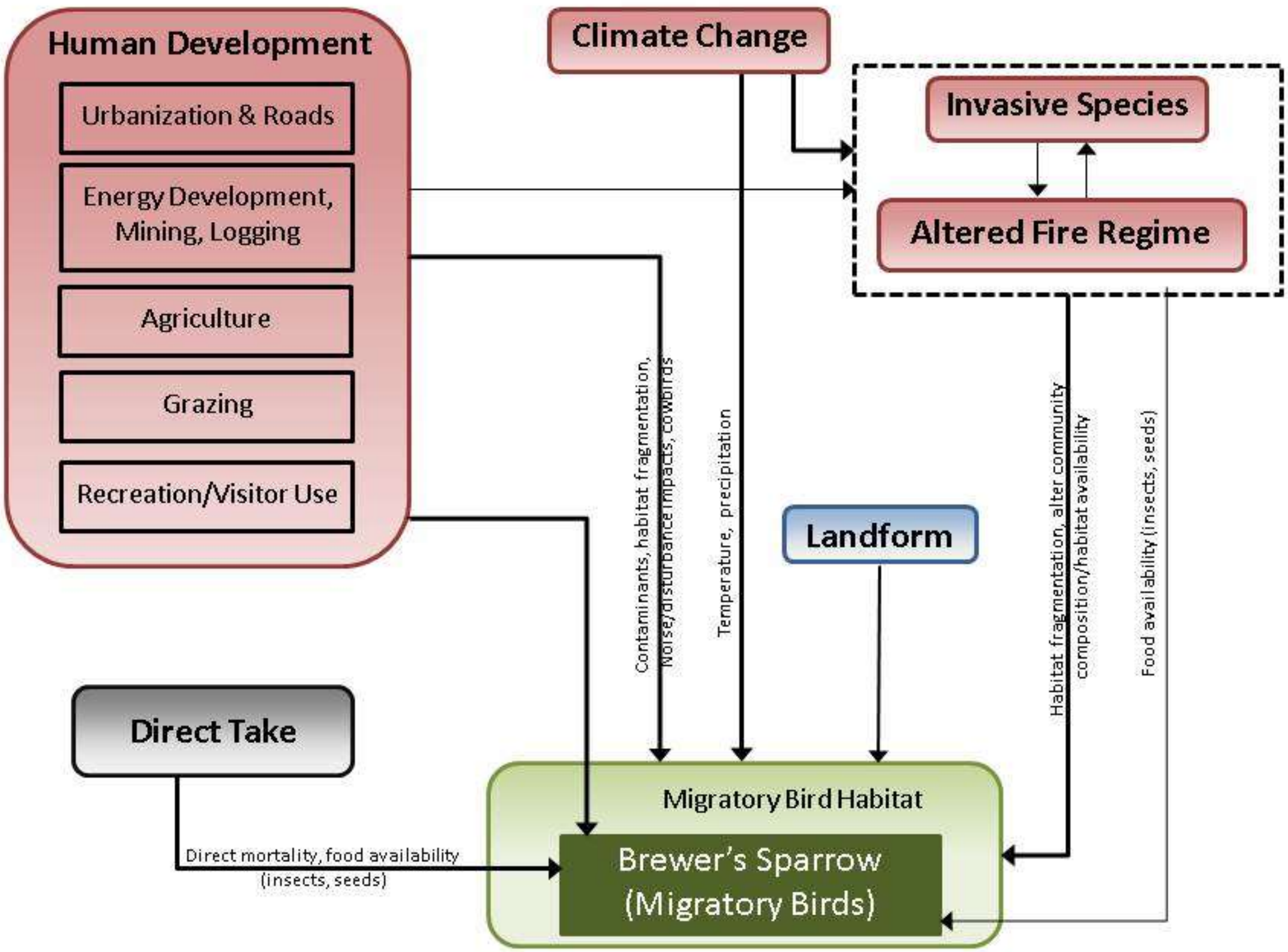


Figure B.2.2-1. Brewer's Sparrow Conceptual Model.

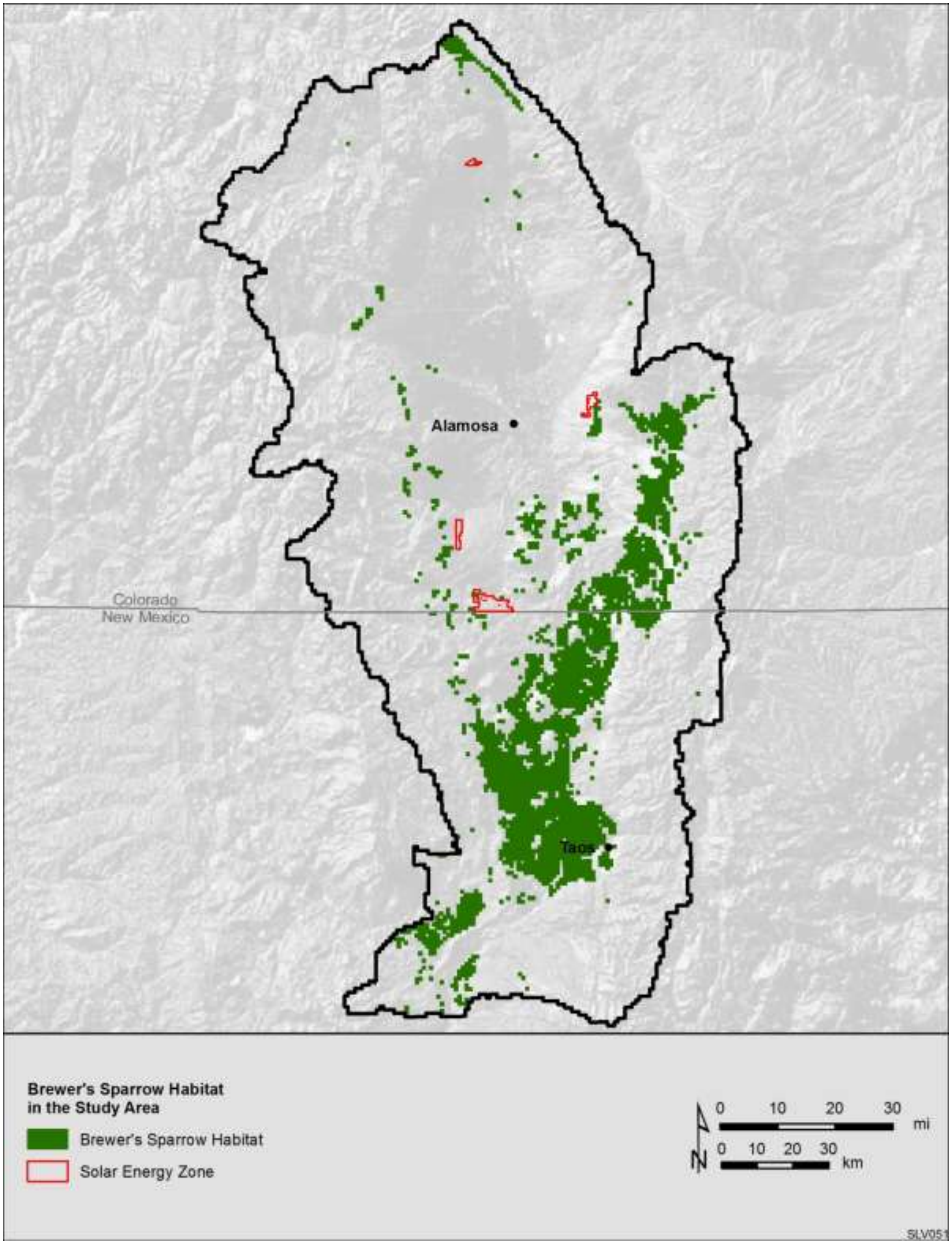


Figure B.2.2-2. Current Distribution of Potentially Suitable Habitat for the Brewer's Sparrow. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

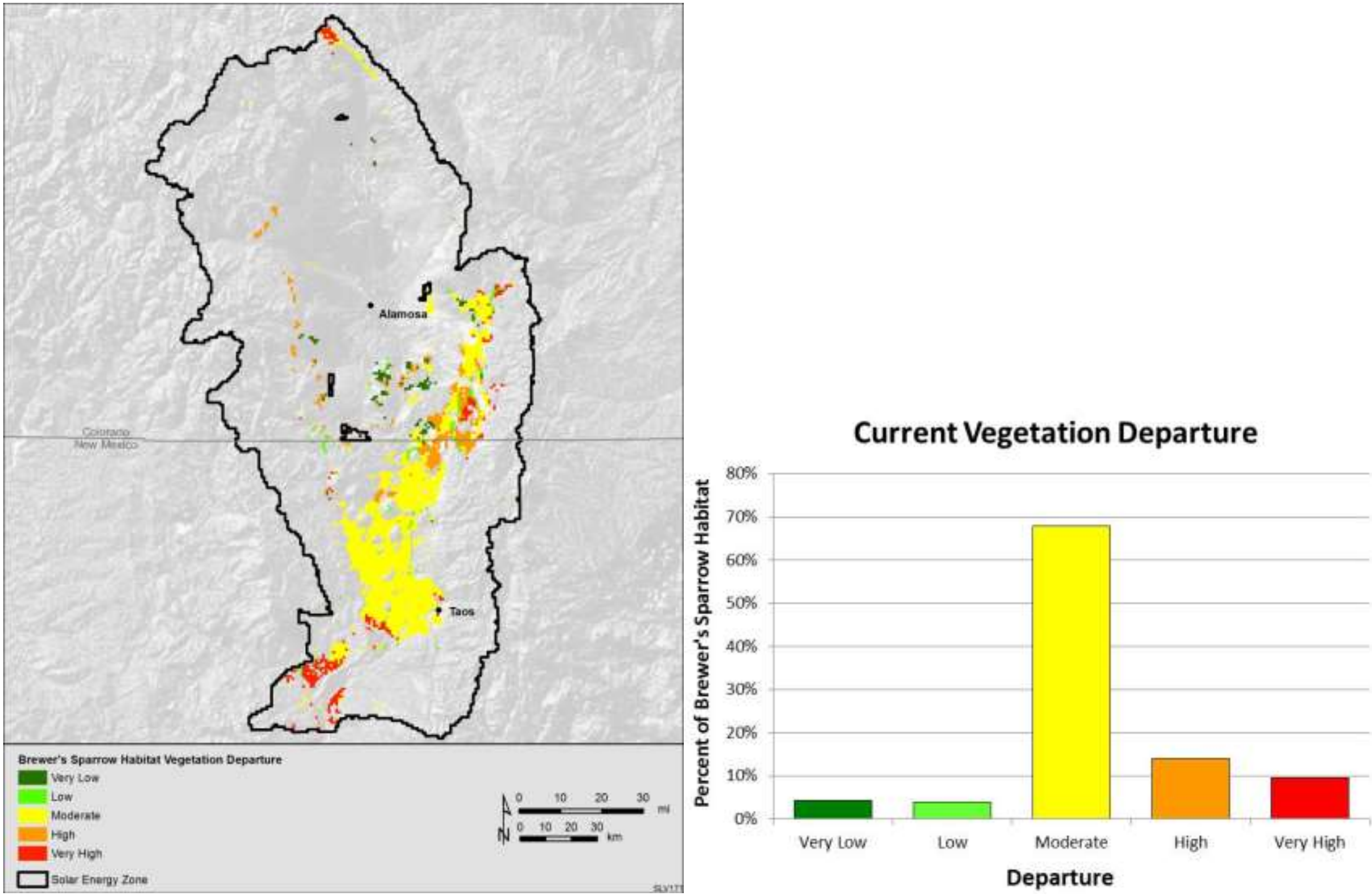


Figure B.2.2-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Brewer's Sparrow Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

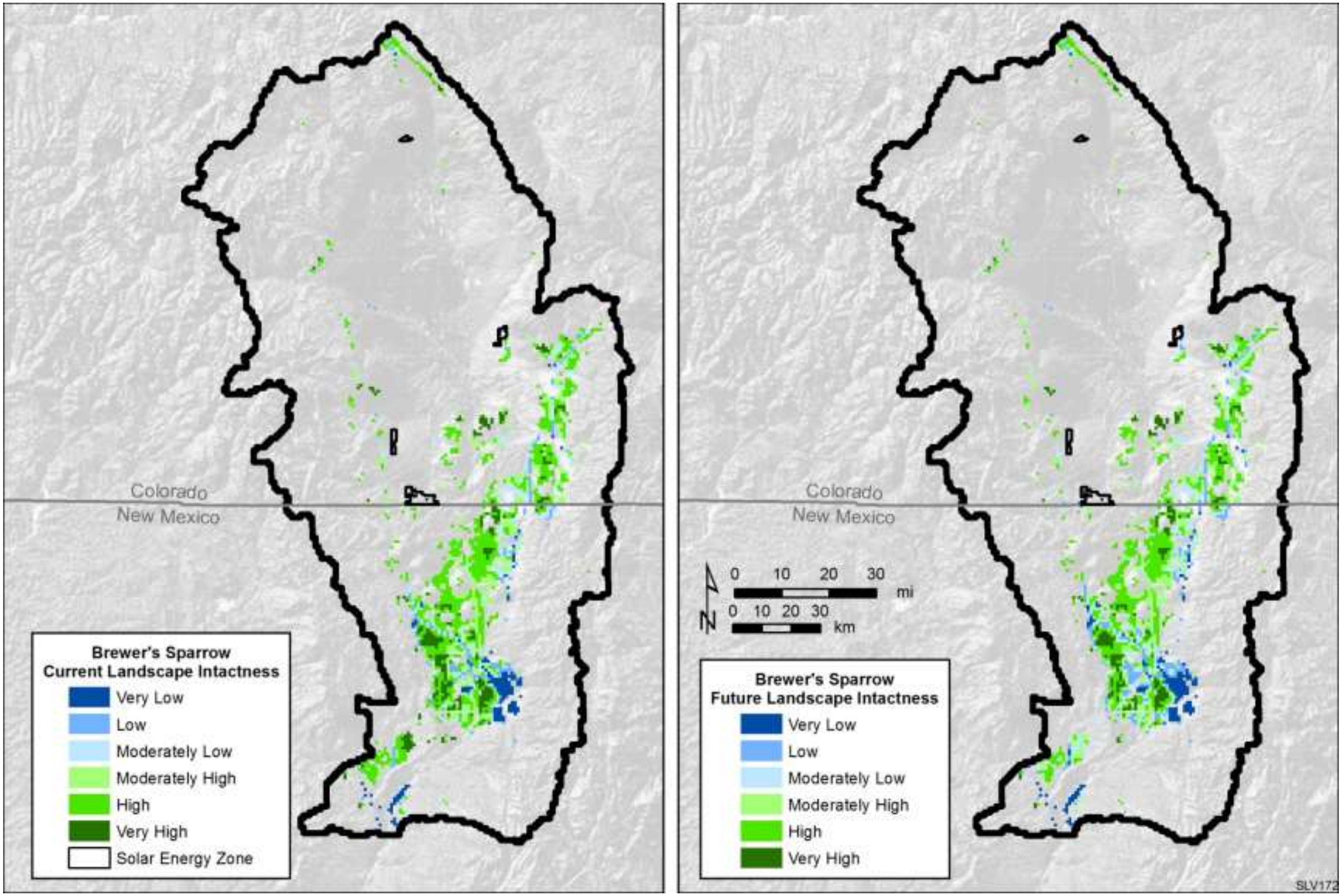


Figure B.2.2-4. Current and Future Landscape Intactness of Potentially Suitable Brewer's Sparrow Habitat. Data Sources: Argonne 2014 and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

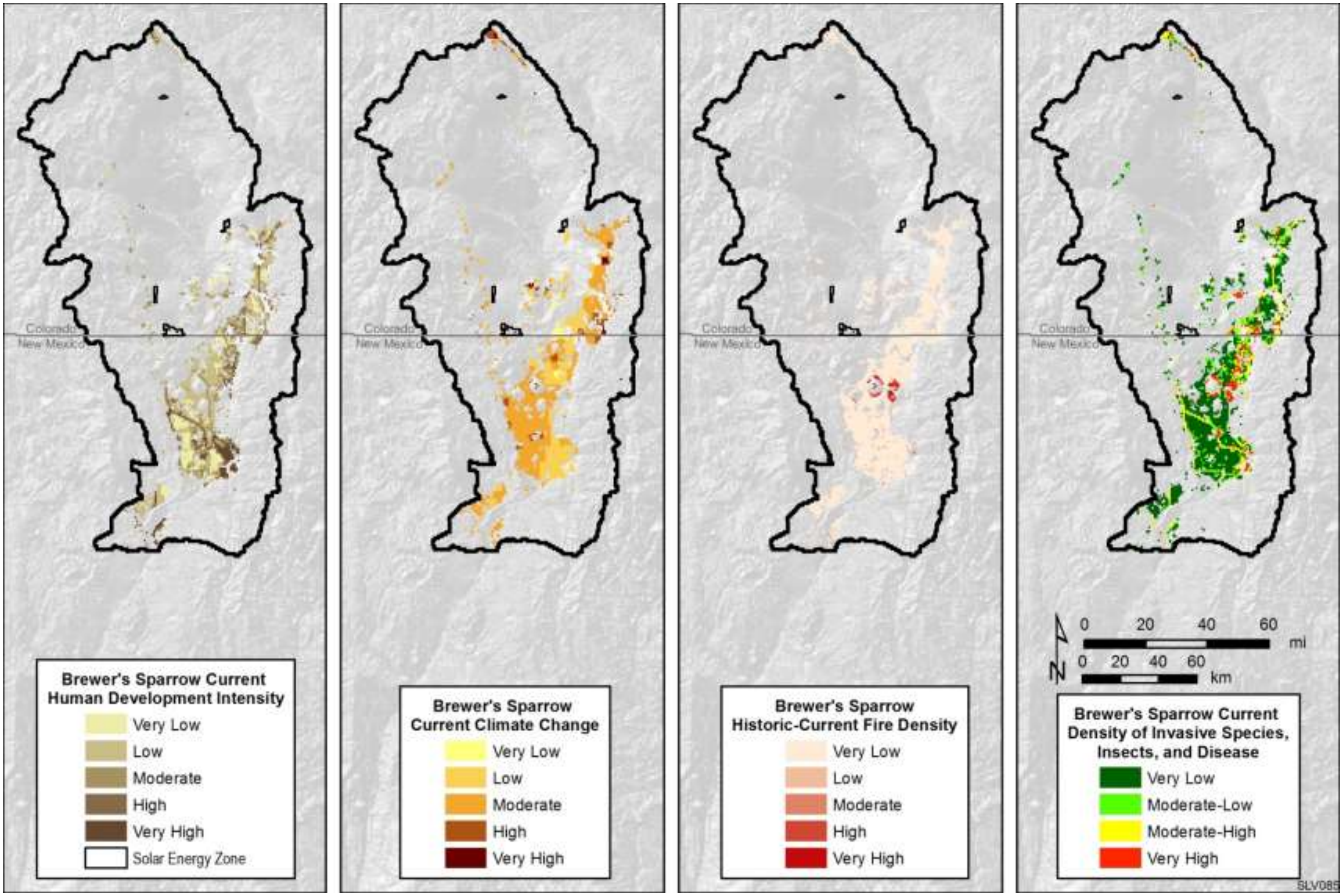


Figure B.2.2-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for Brewer's Sparrow? Data Sources: Argonne 2014 and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

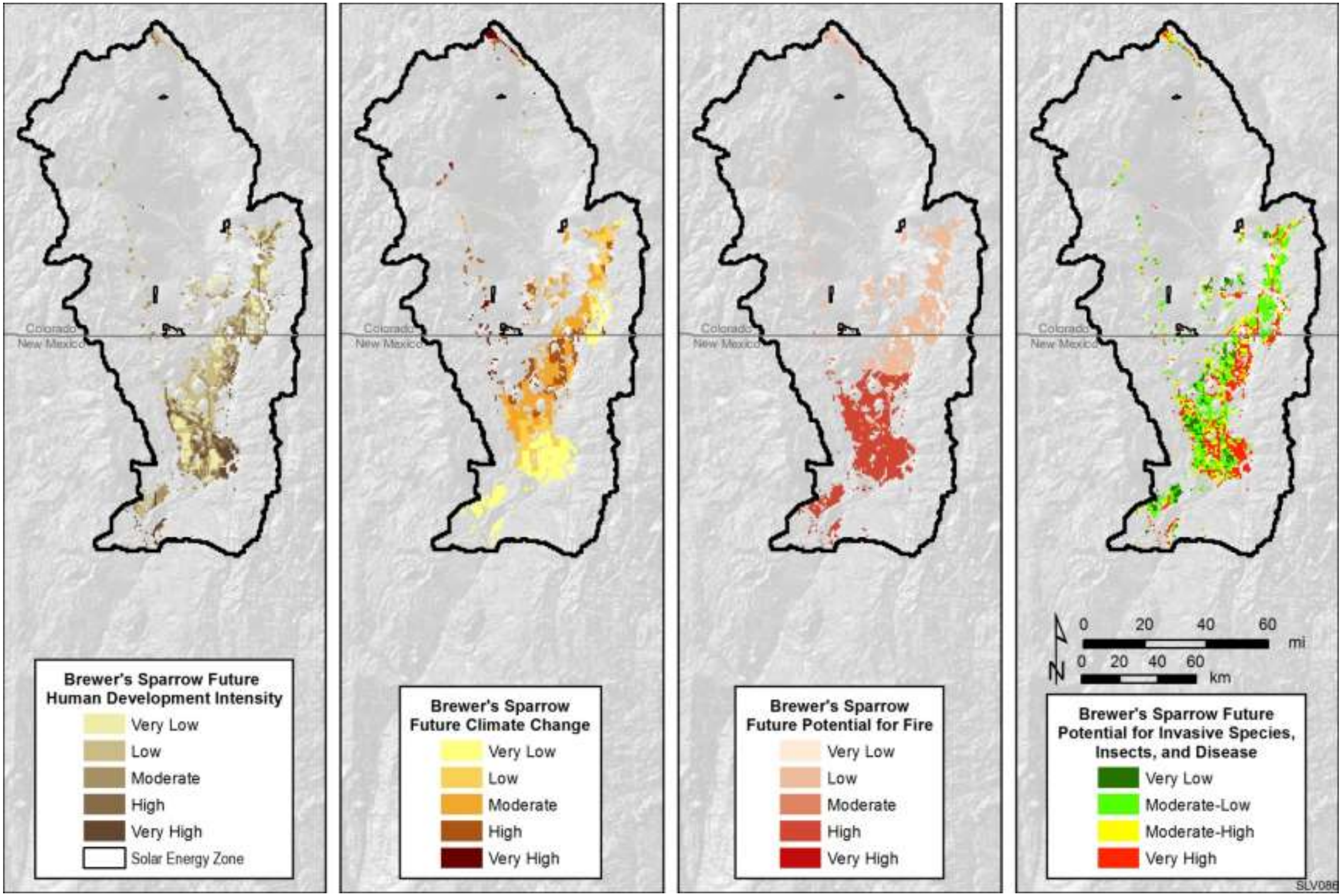


Figure B.2.2-6. Illustration for MQD3: Where is Brewer's sparrow vulnerable to change agents in the future? Data Sources: Argonne 2014 and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

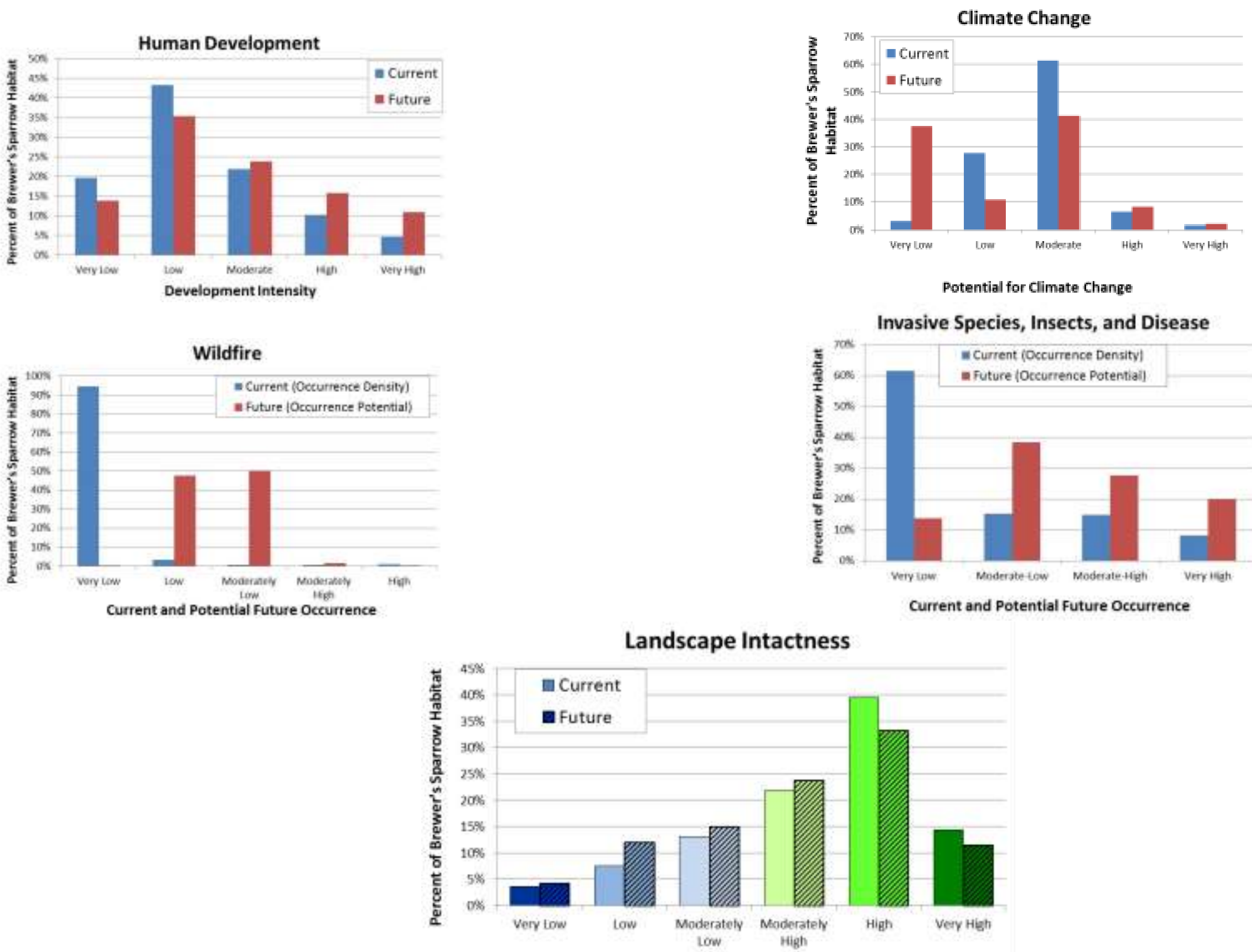


Figure B.2.2-7. Predicted Trends in Brewer's Sparrow Habitat within the Study Area

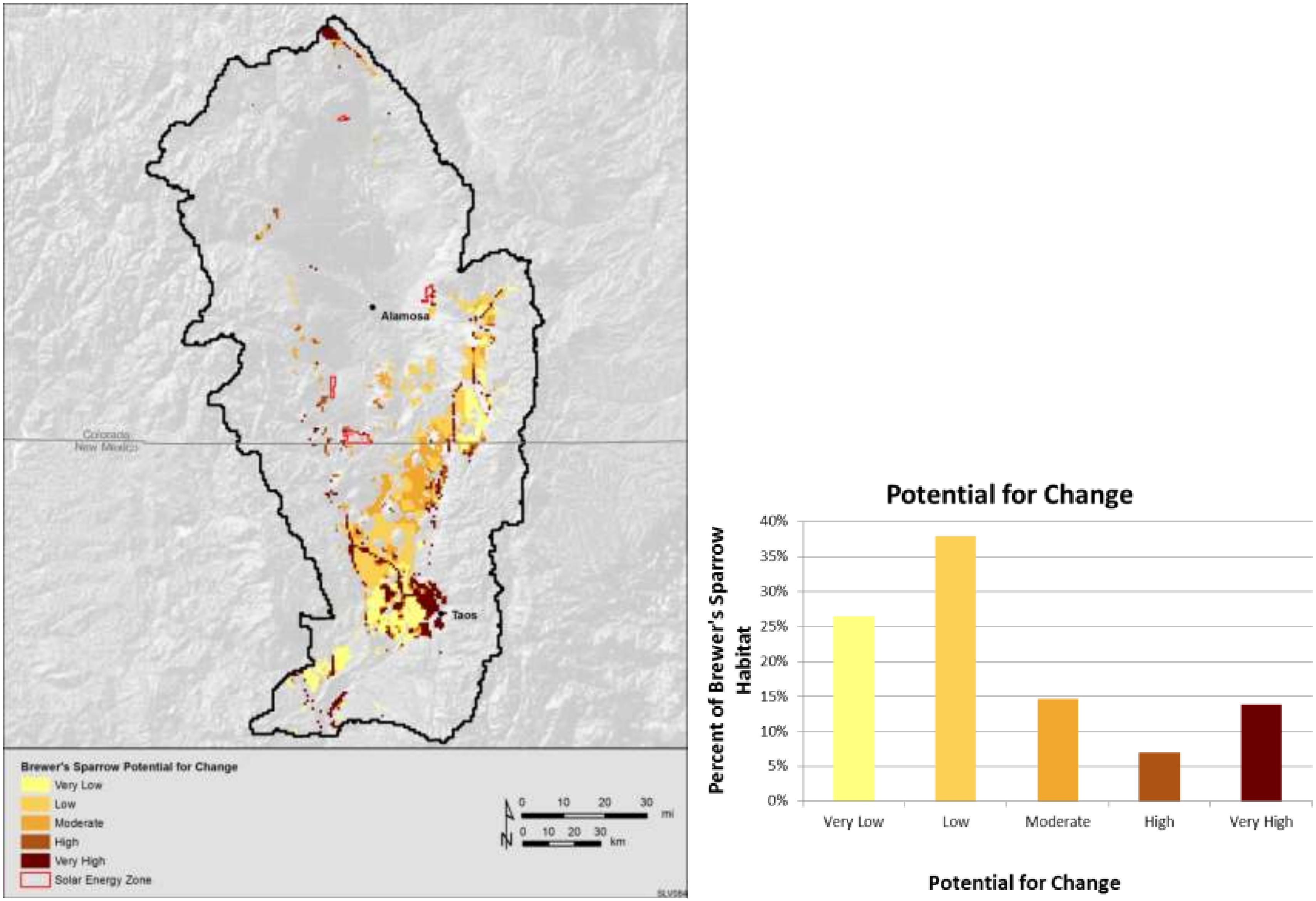


Figure B.2.2-8. Brewer's Sparrow Aggregate Potential for Change. Data Sources: Argonne 2014 and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

B.2.3 Ferruginous Hawk

The ferruginous hawk was selected as a wildlife species CE because it is a BLM sensitive species in both Colorado and New Mexico and a species that could occur in open grasslands and shrublands that may be affected by solar energy development within the Landscape Assessment study area. The species occurs throughout most of the San Luis Valley – Taos Plateau Level IV ecoregion. It is a state Species of Concern in both Colorado and New Mexico. The U.S. Forest Service listed the ferruginous hawk as a Management Indicator Species, defined as a "species selected because its welfare is presumed to be an indicator of the welfare of other species sharing similar habitat requirements", and "a species which reflects ecological changes caused by land management activities" (Collins and Reynolds 2005). Ferruginous hawks are very sensitive to disturbance during the nesting season (White and Thurow 1985). Entry into nesting areas is not advised for 99 days from egg laying and 68 days after hatching (Olendorff 1993). Avoidance setback buffers as large as 1 mi (1.6 km) around nest sites have been suggested to minimize disturbance to nesting individuals (Olendorff and Zeedyk 1978; Suter and Joness 1981).

This species forages over open country and typically nests in trees near streams and grassy knolls, but may also nest in piñon-juniper woodlands (Johnsgard 1990, Kingery 1998). In Colorado, nesting can begin as early as mid-March and last through July (Kingery 1998). The ferruginous hawk is known as a consummate open-country specialist, and known to nest on a diverse array of natural substrates, including the ground, small rock piles, larger rock outcroppings and cliffs, stout shrubs, low-growing trees, and a variety of erosional formations (Olendorff 1993, Bechard and Schmutz 1995, Neal 2007). Ferruginous hawks have also nested on a variety of manmade substrates, including chimneys or roofs of abandoned buildings, windmills, haystacks, shelterbelts, and power-line towers (Gaines 1985, Olendorff 1993).

Considered to be perch hunters, ferruginous hawks spend more time foraging on the ground than any other large raptor, and hover hunt from heights up to 300 ft (91.5 m) (Wakely, 1974; Bechard and Schmutz, 1995). In winter ferruginous hawks typically aggregate where ground squirrels and prairie dogs are numerous. They are "sit-and-wait" hunters, and groups of 5 to 10 birds will often perch in and around prairie-dog towns (Bechard and Schmutz, 1995).

Conversion of grasslands to intensive agricultural cultivation has reduced the amount of preferred habitat and is implicated as one of the greatest threats to this species (Schmutz 1984). Other threats to this species include collisions with vehicles and power lines, especially in the dry habitat these birds inhabit where trees are scarce and power poles can provide a good hunting perch. Poisonings are also a major threat to these hawks where ranchers have used rodenticides to kill prairie dogs or other ground-dwelling mammals whose burrows are deemed a hazard to livestock (Cascade Raptor Center 2013). Ecological attributes and indicators for the ferruginous hawk are provided in Table B.2.3-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the ferruginous hawk may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.3-1). Figures B.2.3-2 through B.2.3-8 show, respectively: Figure B.2.3-2 - the current distribution of potentially suitable ferruginous hawk habitat in the study area; Figure B.2.3-3 – habitat distribution with respect to current vegetation departure; Figure B.2.3-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.3-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.3-6 - habitat distribution with respect to predicted areas of change; Figure B.2.3-7 - predicted trends in ferruginous hawk habitat within the study area; and Figure B.2.3-8 - the aggregate potential for change in ferruginous hawk habitat.

The majority (33%) of vegetation within ferruginous hawk potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.3-3). Areas of potentially suitable habitat with greatest vegetation departure are located in agricultural and shrubland areas of the San Luis Valley near the center of the study area (Figure B.2.3-3).

The majority (44%) of ferruginous hawk potentially suitable habitat is within areas of moderately low current landscape intactness (Figure B.2.3-4; Figure B.2.3-7). Future trends in landscape intactness indicate a decrease in landscape intactness within ferruginous hawk potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 3% in the near-term (i.e., by 2030) (Figure B.2.3-7).

The majority (41%) of ferruginous hawk potentially suitable habitat is within areas of high current human development intensity (Figure B.2.3-5; Figure B.2.3-7). Future trends in human development indicate an increase in human development intensity within ferruginous hawk potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 7% in the near-term (i.e., by 2030) (Figure B.2.3-6; Figure B.2.3-7).

The majority of ferruginous hawk potentially suitable habitat is within areas ranging from very low to moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.3-5; Figure B.2.3-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.3-6; Figure B.2.3-7). Approximately 11% of the ferruginous hawk suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.3-7). The greatest potential for future climate change within ferruginous hawk potentially suitable habitat occurs in habitat areas in the northern portion of the study area (Figure B.2.3-6).

The majority of ferruginous hawk potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.3-5; Figure B.2.3-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Over 80% of ferruginous hawk habitat has very low or low near-term future (i.e. by 2030) potential for wildfire (Figure B.2.3-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.3-6).

The majority of ferruginous hawk potentially suitable habitat is within areas of moderately high to very high current density of invasive species, insects, and disease (Figure B.2.3-5; Figure B.2.3-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of ferruginous hawk potentially suitable habitat in the study area (Figure B.2.3-7). Approximately 55% of the suitable habitat has a very high potential for near-term future (i.e., by 2030) spread of invasive species, insects, and diseases. Areas of potential near-term future spread of invasive species, insects, and disease include areas of urban and rural expansion and energy development in the San Luis Valley (Figure B.2.3-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 43% of the ferruginous hawk suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.3-8). Areas with greatest potential for change within ferruginous hawk suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.3-8).

Table B.2.3-1. Ferruginous Hawk Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Abundance of main prey	Jackrabbit density	<10 per sq km	10-30 per sq km	30-50 per sq km	>50 per sq km	Howard and Wolfe (1976)
Habitat suitability	Size of contiguous cropland	>16 ha	8-16 ha	1-8 ha	none	Jasikoff (1982)
Habitat loss and degradation	Livestock density	present in large number	present in moderate numbers	present in small numbers	absent	Olendorff (1993)
Nesting habitat suitability	Distance to human activity			>1 mi (1.6 km)		Olendorff and Zeedyk (1978); Suter and Joness (1981)

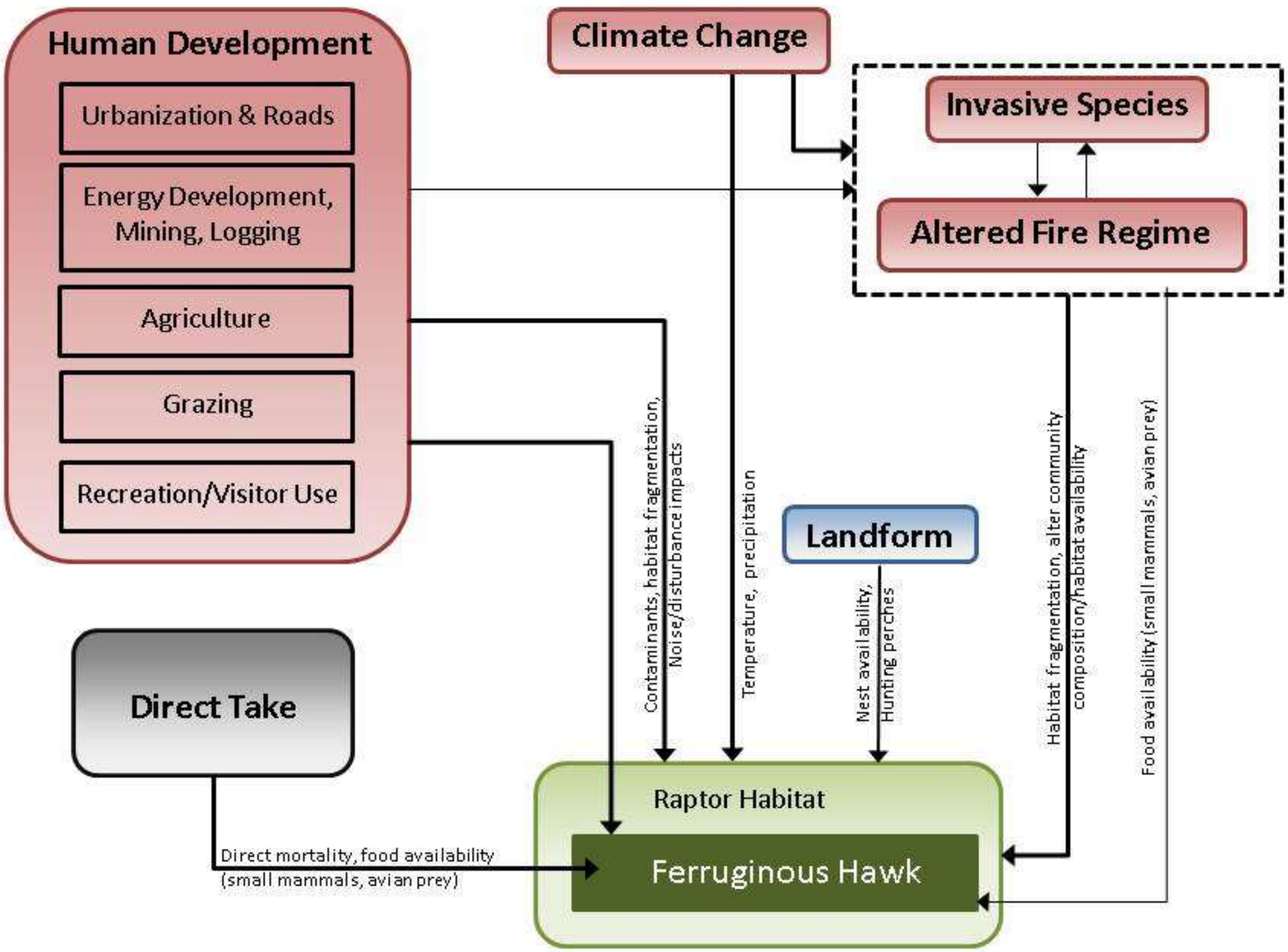


Figure B.2.3-1. Ferruginous Hawk Conceptual Model.

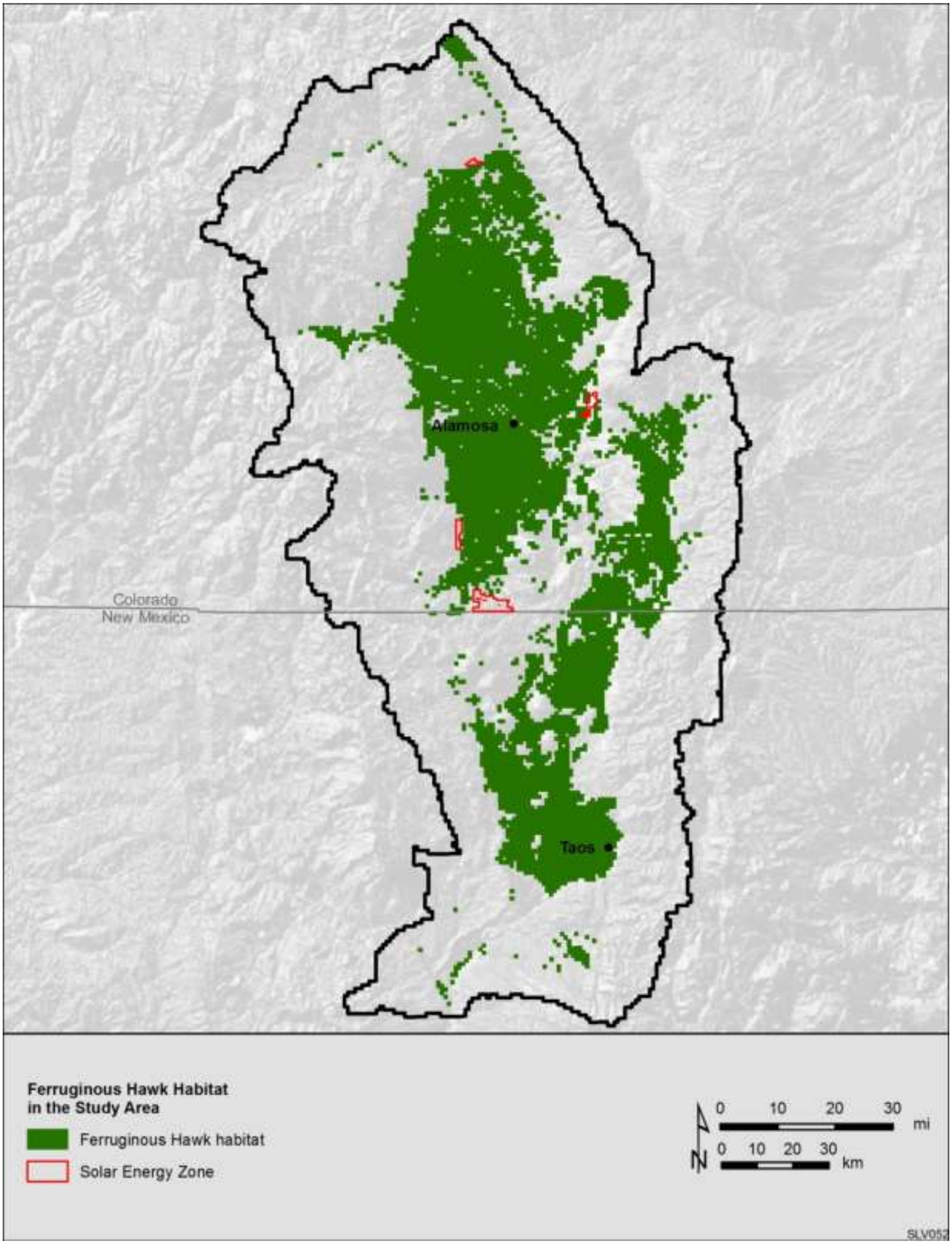


Figure B.2.3-2. Current Distribution of Potentially Suitable Habitat for the Ferruginous Hawk. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

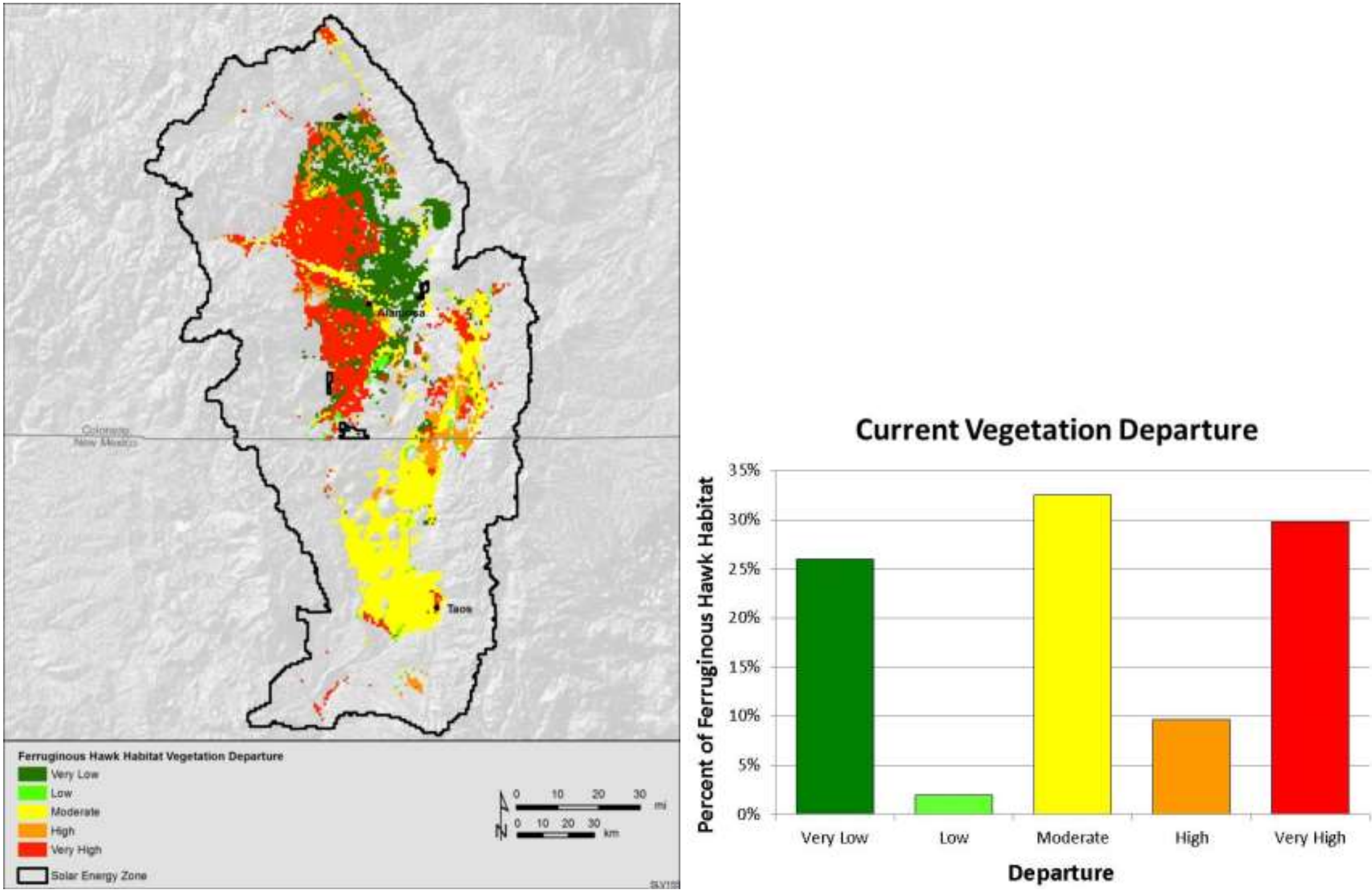


Figure B.2.3-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Ferruginous Hawk Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

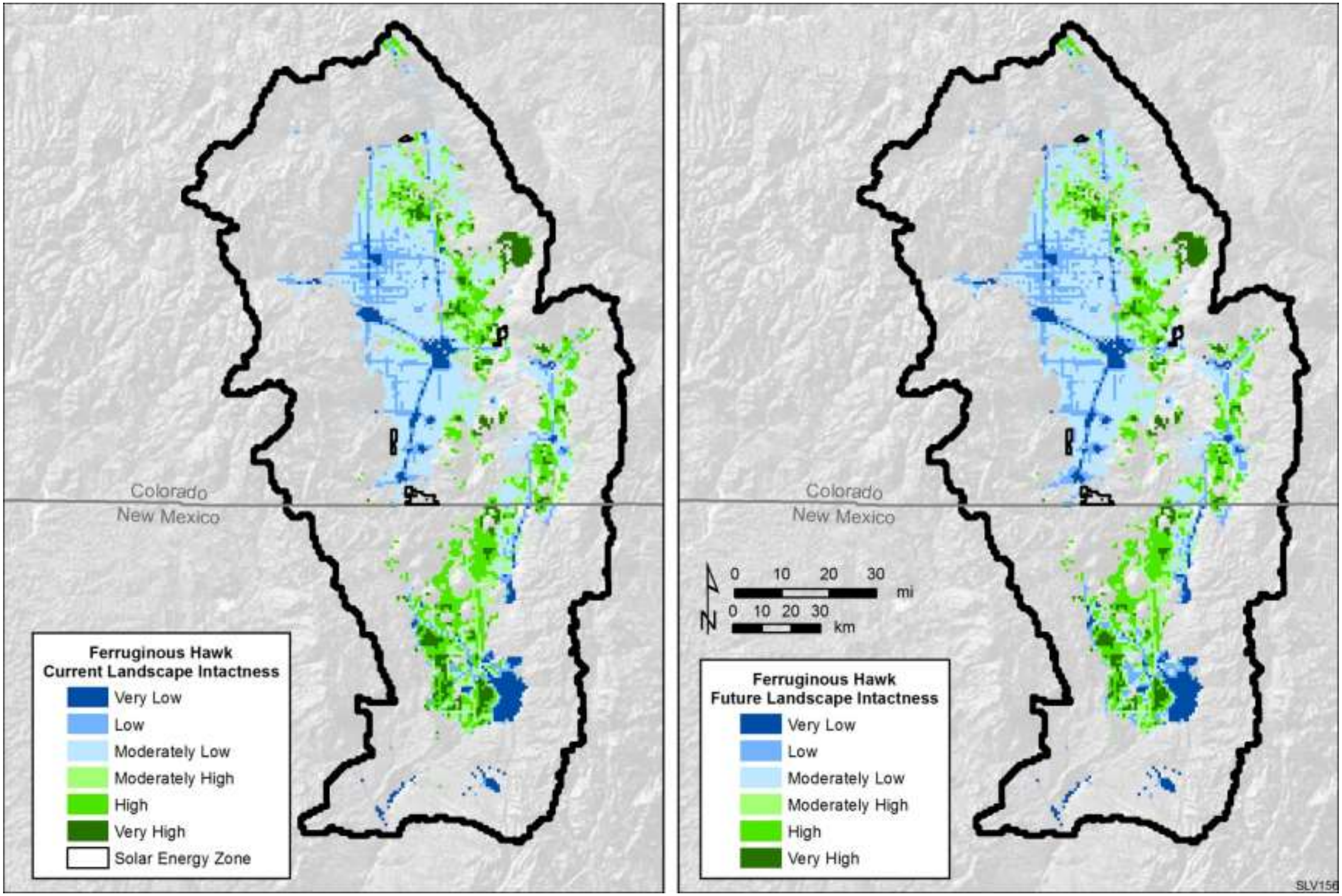


Figure B.2.3-4. Current and Future Landscape Intactness of Potentially Suitable Ferruginous Hawk Habitat. Data Sources: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

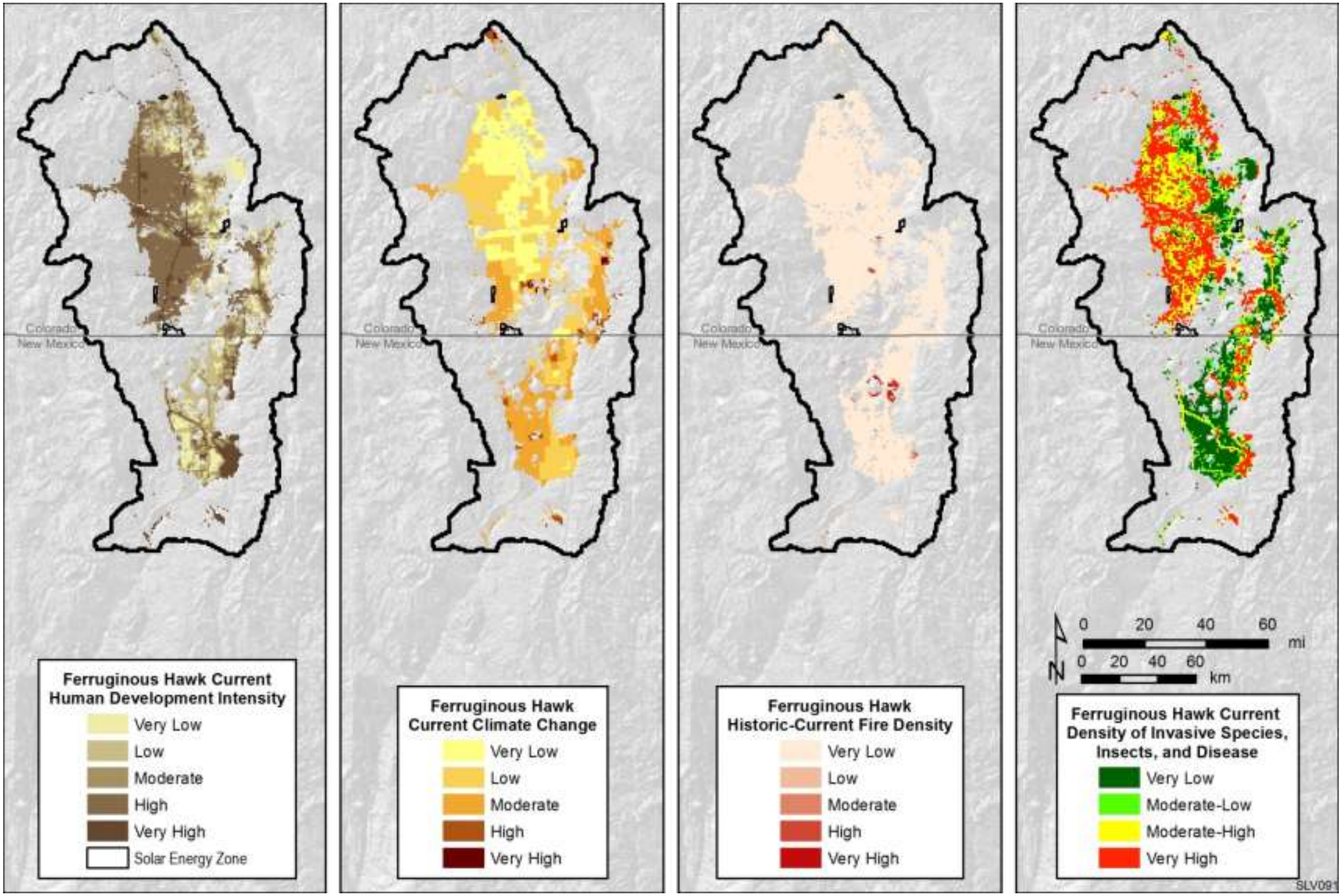


Figure B.2.3-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for ferruginous hawk? Data Sources: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

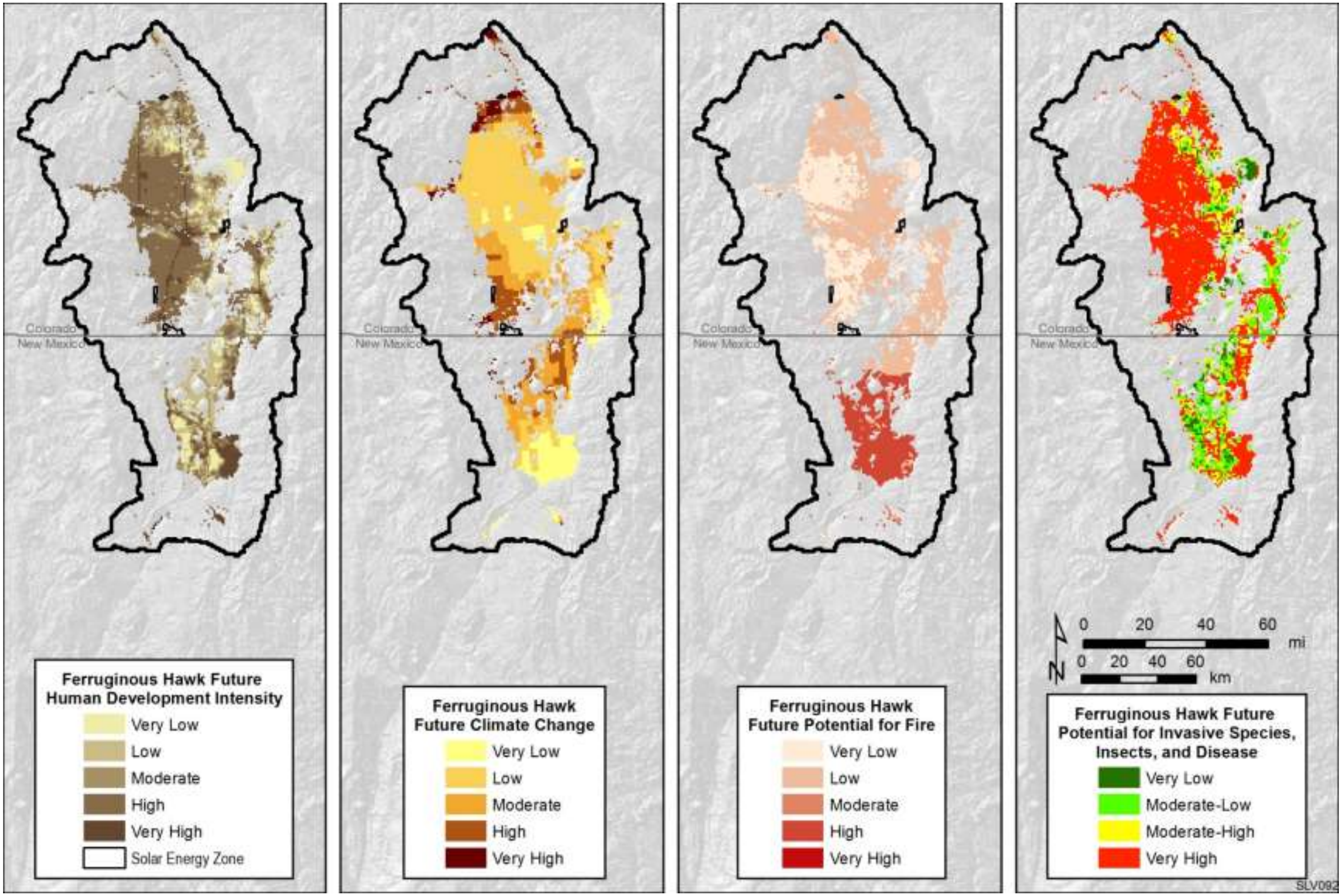


Figure B.2.3-6. Illustration for MQD3: Where is ferruginous hawk vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

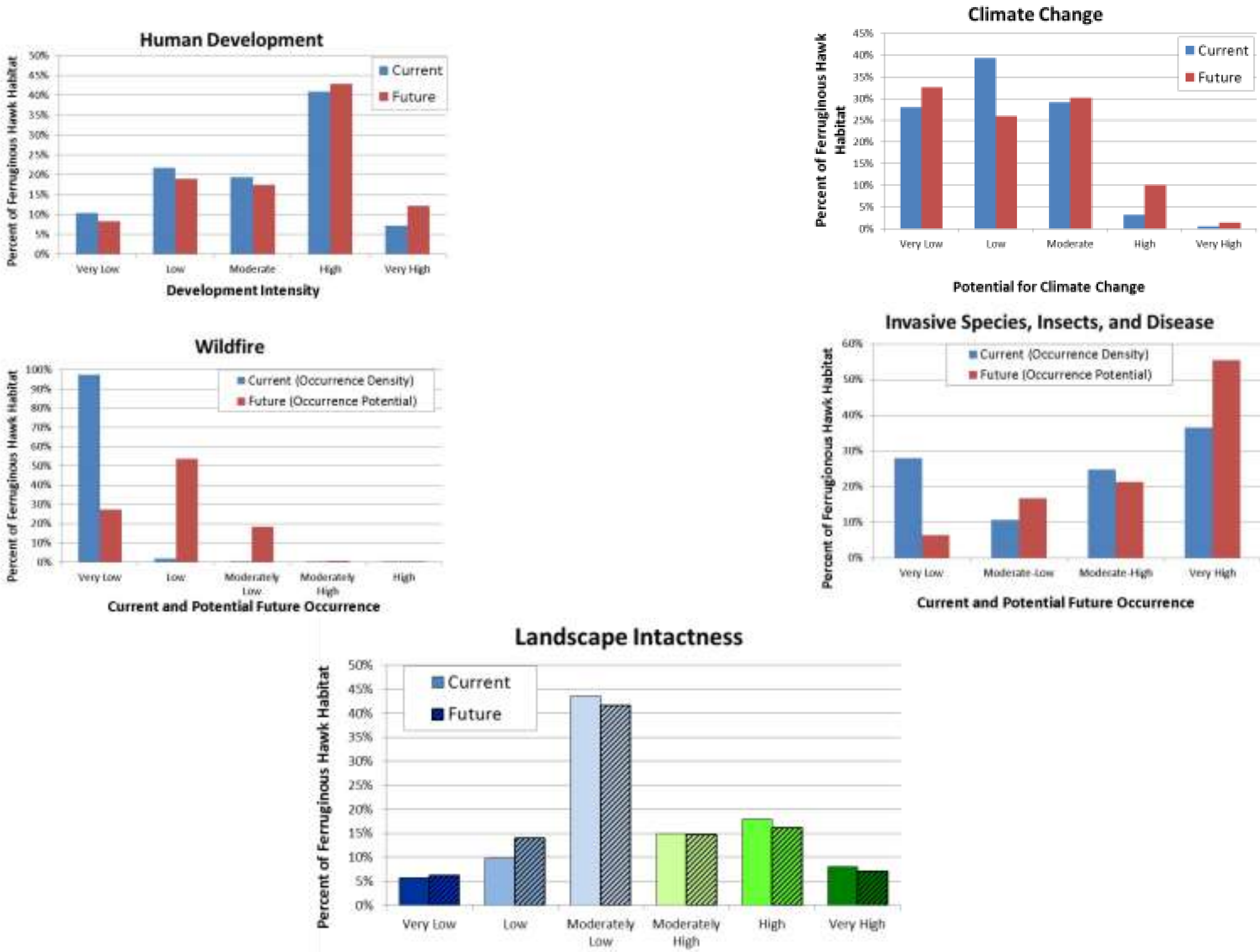


Figure B.2.3-7. Predicted Trends in Ferruginous Hawk Habitat within the Study Area

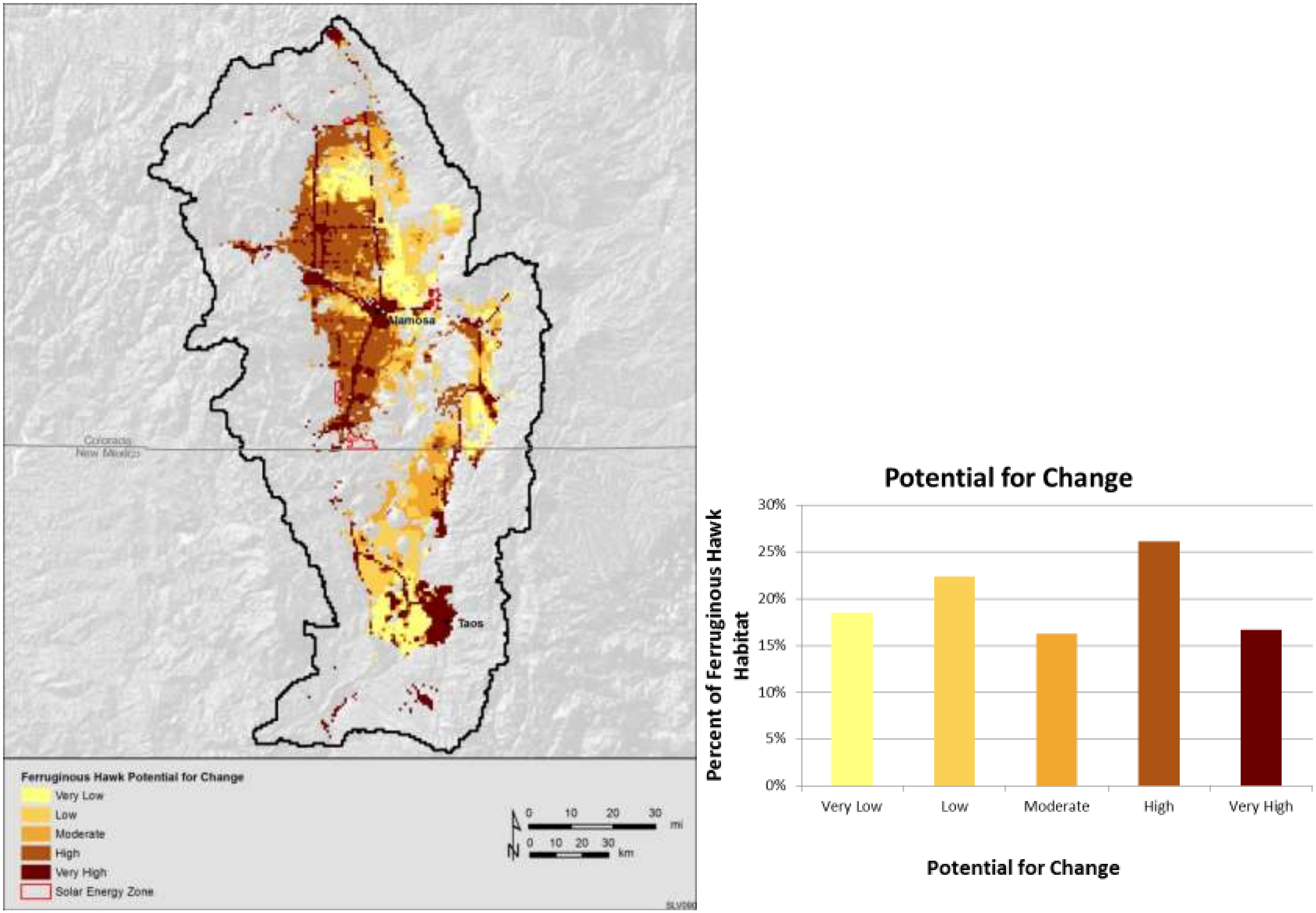


Figure B.2.3-8. Ferruginous Hawk Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.4 Northern Goshawk

The northern goshawk is a large hawk of about 55-61 cm in length, the largest of all the accipiters. Females are up to one-third larger than males (USFWS 2014d; Speas 2005). A generalist predator of rodents and birds, the species inhabits the montane forests of the mountains surrounding the San Luis Valley (USFWS 2012). The northern goshawk is a BLM sensitive species in both Colorado and New Mexico. The range of this species includes the boreal forests in Alaska, Canada, and Newfoundland, south to the montane forests of the west, and into the mountains of western and northwestern Mexico (Speas 2005). This species is a permanent resident in western Colorado and New Mexico and a nonbreeding resident in the eastern part of both states (Cornell Lab of Ornithology 2015). The species forages in a stop-and-go manner using short flights to reposition for brief prey searches from perches, and also hunts by flying rapidly along forest edges, across openings, and through dense vegetation. An opportunistic hunter, the northern goshawk preys on a wide variety of vertebrates and, occasionally, insects (Kennedy and Ward 2003; NatureServe 2014). Despite their larger size, females do not capture larger or heavier prey than males (Boal and Mannan 1996). Some northern goshawks migrate relatively short distances (less than 500 km) while others remain on home ranges year round. Migration may depend on availability of prey (Speas 2005).

Breeding usually occurs mid-February through April with nestlings fledging in early August or September (Speas 2005). Northern goshawks nest in both deciduous and coniferous trees (Shuster 1980; NatureServe 2014). Nesting densities of most western U.S. populations range from 6.6 - 10.7 pairs per 100 km^2 (Squires and Reynolds 1997). Home ranges during nesting vary from 95-3500 hectares depending on sex and habitat characteristics (Squires and Reynolds 1997). Home ranges of males are typically larger than those of females (Hargis et al. 1994, Keane and Morrison 1994). Individuals typically enlarge or sometimes shift location of home ranges after breeding (Hargis et al. 1994, Keane and Morrison 1994).

Home ranges of non-breeders are poorly known, but may be larger than those of breeders (Squires and Reynolds 1997; Kennedy 2003). In North America, winter home ranges are unknown (USFWS 2014d).

The northern goshawk is currently not listed under the Engendered Species Act, but the species has been proposed for listing several times (Kennedy 2003). The main threat to the northern goshawk is loss of habitat from timber management. Timber management can degrade habitat by reducing stand density and canopy cover and can cause nest failure due to abandonment (Kennedy 2003; Boal and Mannan 1994; West 1998). Fire suppression, razing, and insect and tree disease outbreaks can also impact nesting habitat (Graham et al. 1999). Presently, pesticides do not appear to be a major threat, presumably since agricultural landscapes are seldom used.

The incursion of great horned owls is especially significant as they prey on both adult and nestling goshawks (Boal and Mannan 1994). Other known or suspected predators include martens (*Martes Americana*), fishers (*martes pennanti*), and wolverines (*Gulo Gulo)* (Doyle 1995, Graham et al. 1999, Paragi and Wholecheese 1994). Ecological attributes and indicators for the northern goshawk are provided in Table B.2.4-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the northern goshawk may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.4-1). Figures B.2.4-2 through B.2.4-8 show, respectively: Figure B.2.4-2 - the current distribution of potentially suitable northern goshawk habitat in the study area; Figure B.2.4-3 – habitat distribution with respect to current vegetation departure; Figure B.2.4-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.4-5 - habitat distribution and status with respect to the current status of change agents;

Figure B.2.4-6 - habitat distribution with respect to predicted areas of change; Figure B.2.4-7 - predicted trends in northern goshawk habitat within the study area; and Figure B.2.4-8 - the aggregate potential for change in northern goshawk habitat.

The majority (44%) of vegetation within northern goshawk potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.4-3). Areas of potentially suitable habitat with the greatest vegetation departure are located in the Rio Grande National Forest in the northwestern portion of the study area (Figure B.2.4-3).

The majority (85%) of northern goshawk potentially suitable habitat is within areas of high and very high current landscape intactness (Figure B.2.4-4; Figure B.2.4-7). Future trends in landscape intactness indicate a decrease in landscape intactness within northern goshawk potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 10% in the near-term (i.e., by 2030) (Figure B.2.4-7).

The majority (90%) of northern goshawk potentially suitable habitat is within areas of very low and low current human development intensity (Figure B.2.4-5; Figure B.2.4-7). Future trends in human development indicate an increase in human development intensity within northern goshawk potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 4% in the near-term (i.e., by 2030) (Figure B.2.4-6; Figure B.2.4-7).

The majority of northern goshawk potentially suitable habitat is within areas of high and very high current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.4-5; Figure B.2.4-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.4-6; Figure B.2.4-7). Approximately 50% of northern goshawk suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.4-7). The greatest potential for future climate change within northern goshawk potentially suitable habitat occurs in in the western and northwestern portion of the study area (Figure B.2.4-6).

The majority of northern goshawk potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.4-5; Figure B.2.4-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Approximately 75% of northern goshawk habitat has low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.2.4-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.4-6).

The majority of northern goshawk potentially suitable habitat is within areas of very high current density of invasive species, insects, and disease (Figure B.2.4-5; Figure B.2.4-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of northern goshawk potentially suitable habitat in the study area (Figure B.2.4-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of potential energy development and spread of forest insects and disease (Figure B.2.4-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 38% of the northern goshawk suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.4-8). Areas with greatest potential for change within northern goshawk suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.4-8).

Table B.2.4-1. Northern Goshawk Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat (nesting)	Forest structure				Late successional forest with >40% canopy closure	Greenwald et al. 2005
Habitat	fire	High-severity fire			Low-severity and moderate-severity fires	Reynolds et al. 2008
Habitat (nesting)	Mesic sites	>1/2 mi from drainages/mesic sites		Within ¼ - ½ mi of drainages/mesic sites	<1/4 mi from drainages/mesic sites	Speas 2005

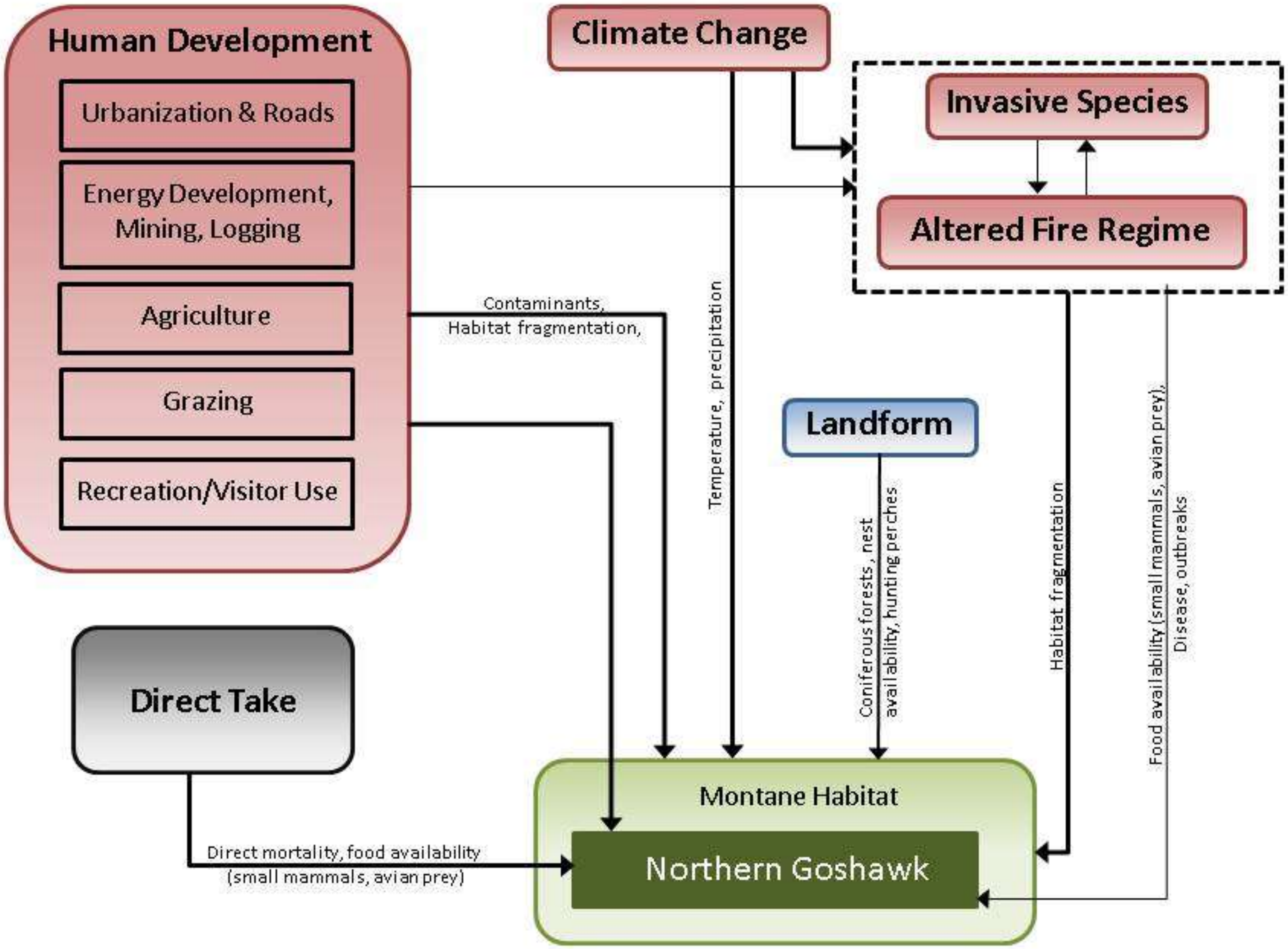


Figure B.2.4-1. Northern Goshawk Conceptual Model.

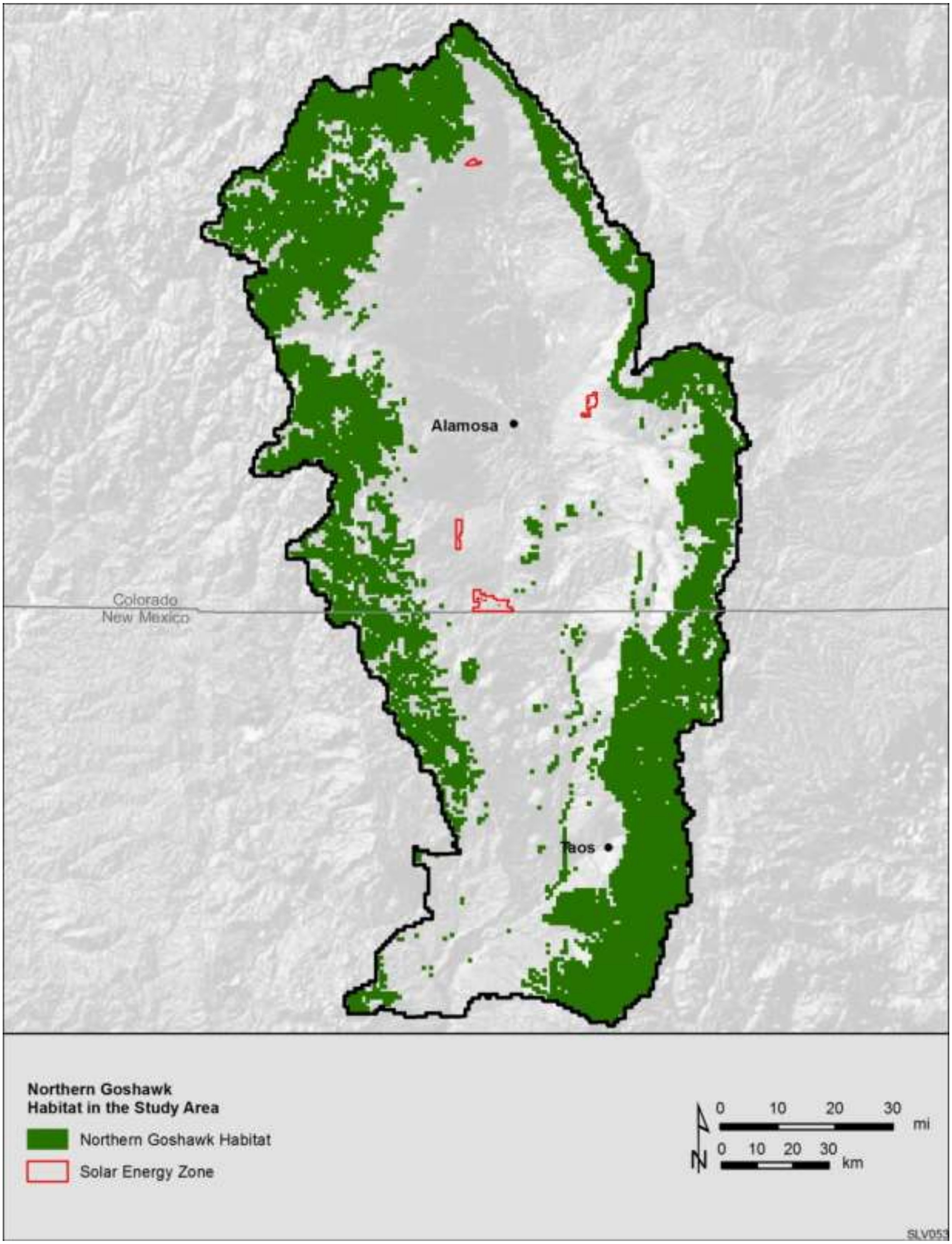
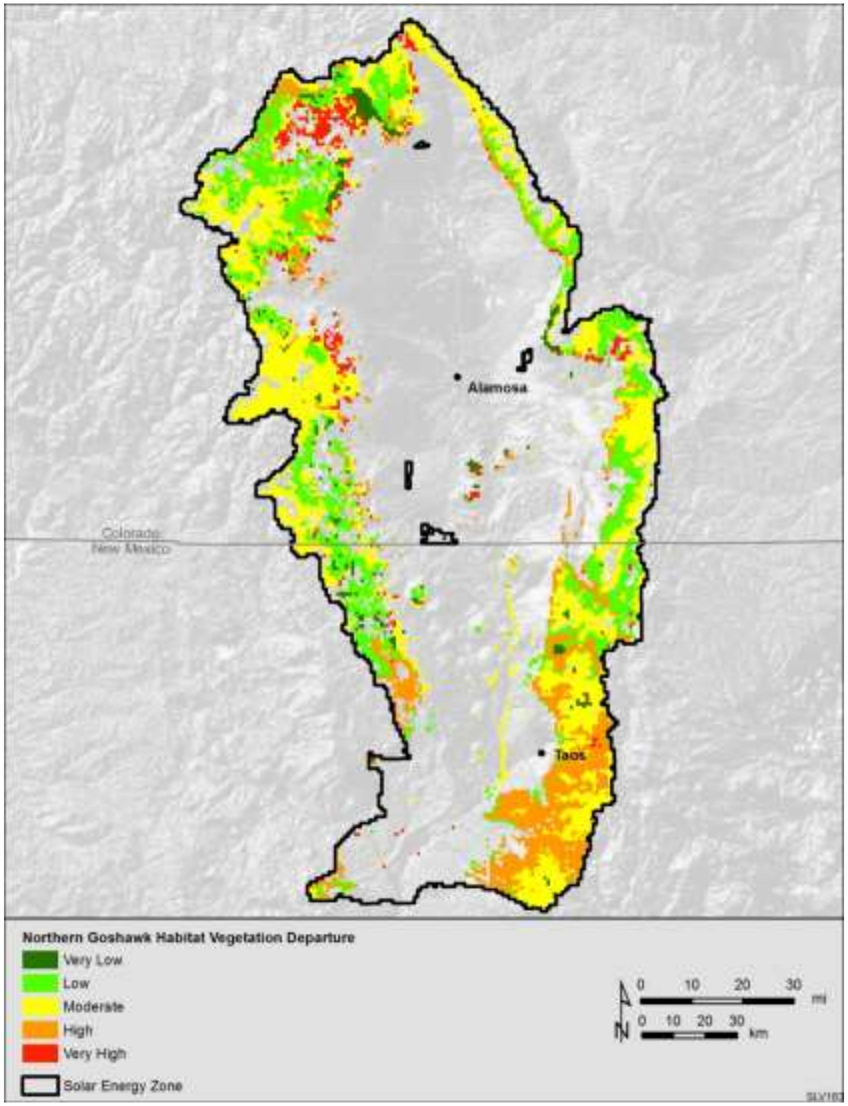


Figure B.2.4-2. Current Distribution of Potentially Suitable Habitat for the Northern Goshawk. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).



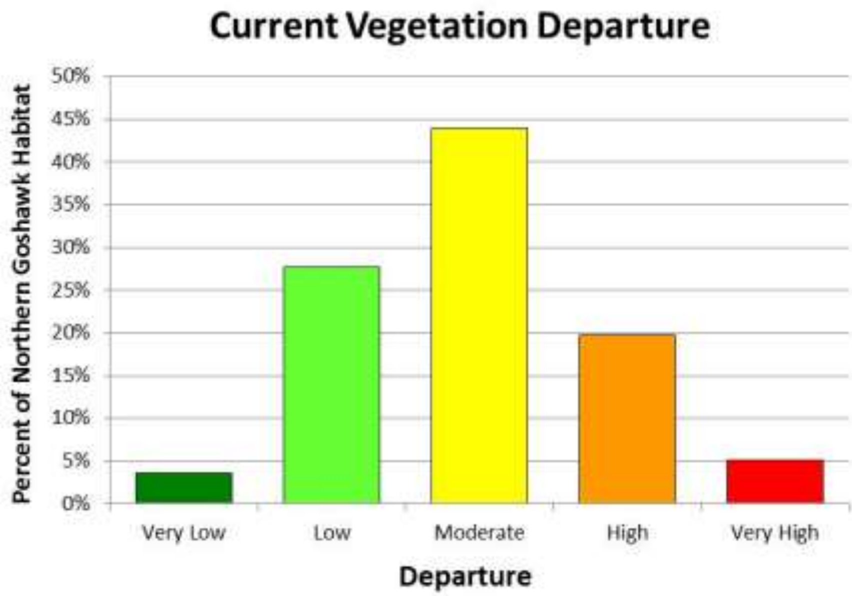


Figure B.2.4-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Northern Goshawk Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

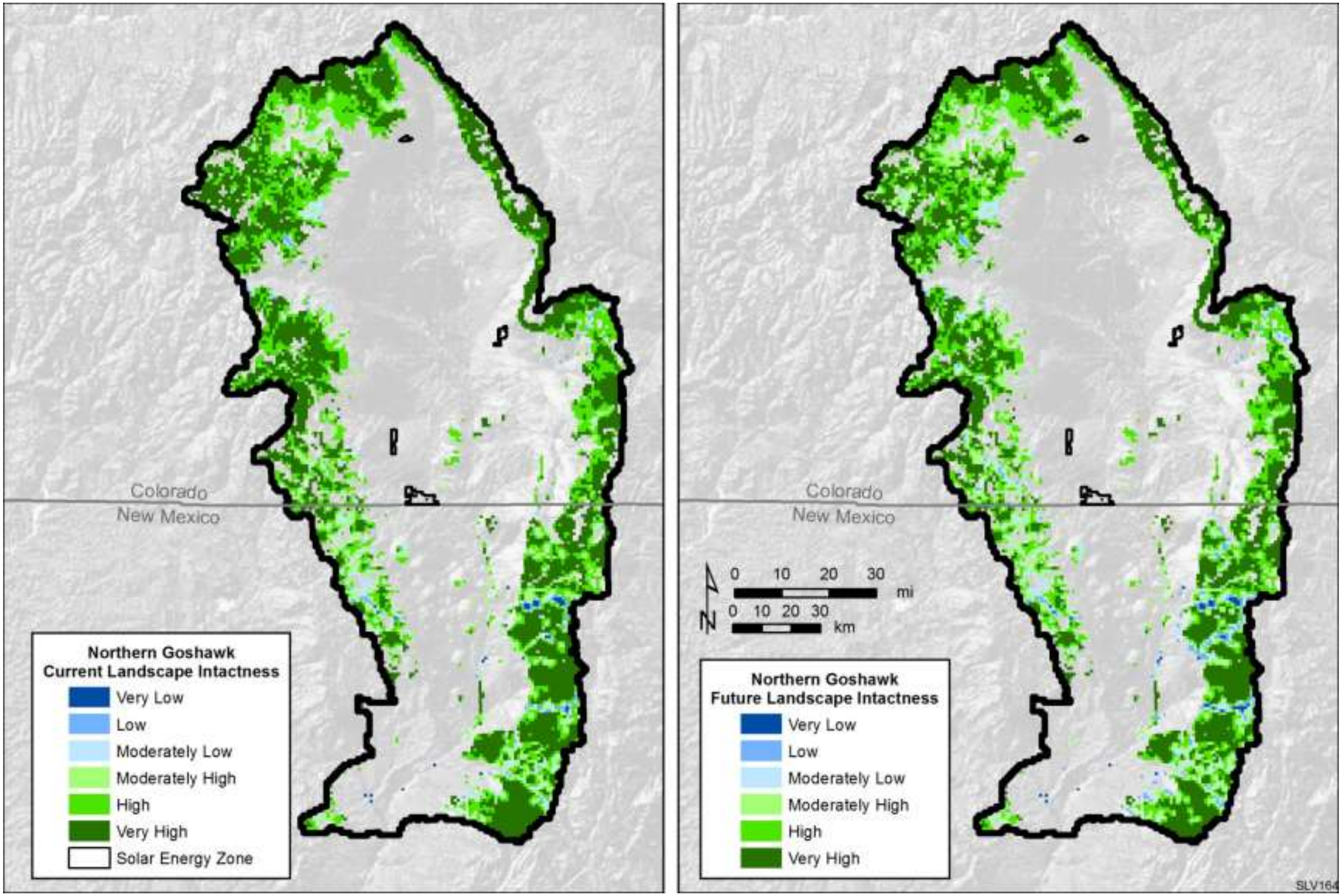


Figure B.2.4-4. Current and Future Landscape intactness of Potentially Suitable Northern Goshawk Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

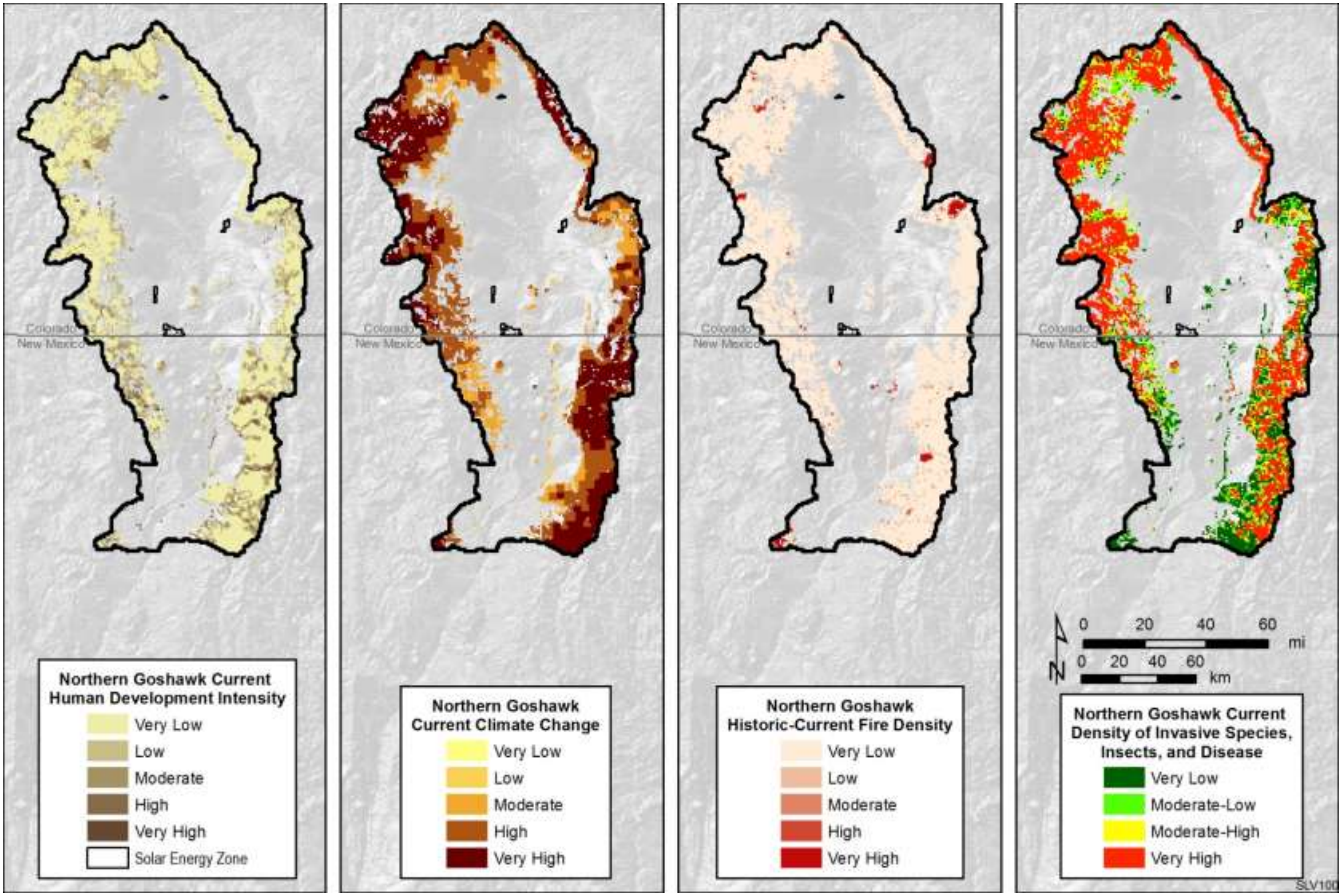


Figure B.2.4-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for northern goshawk? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

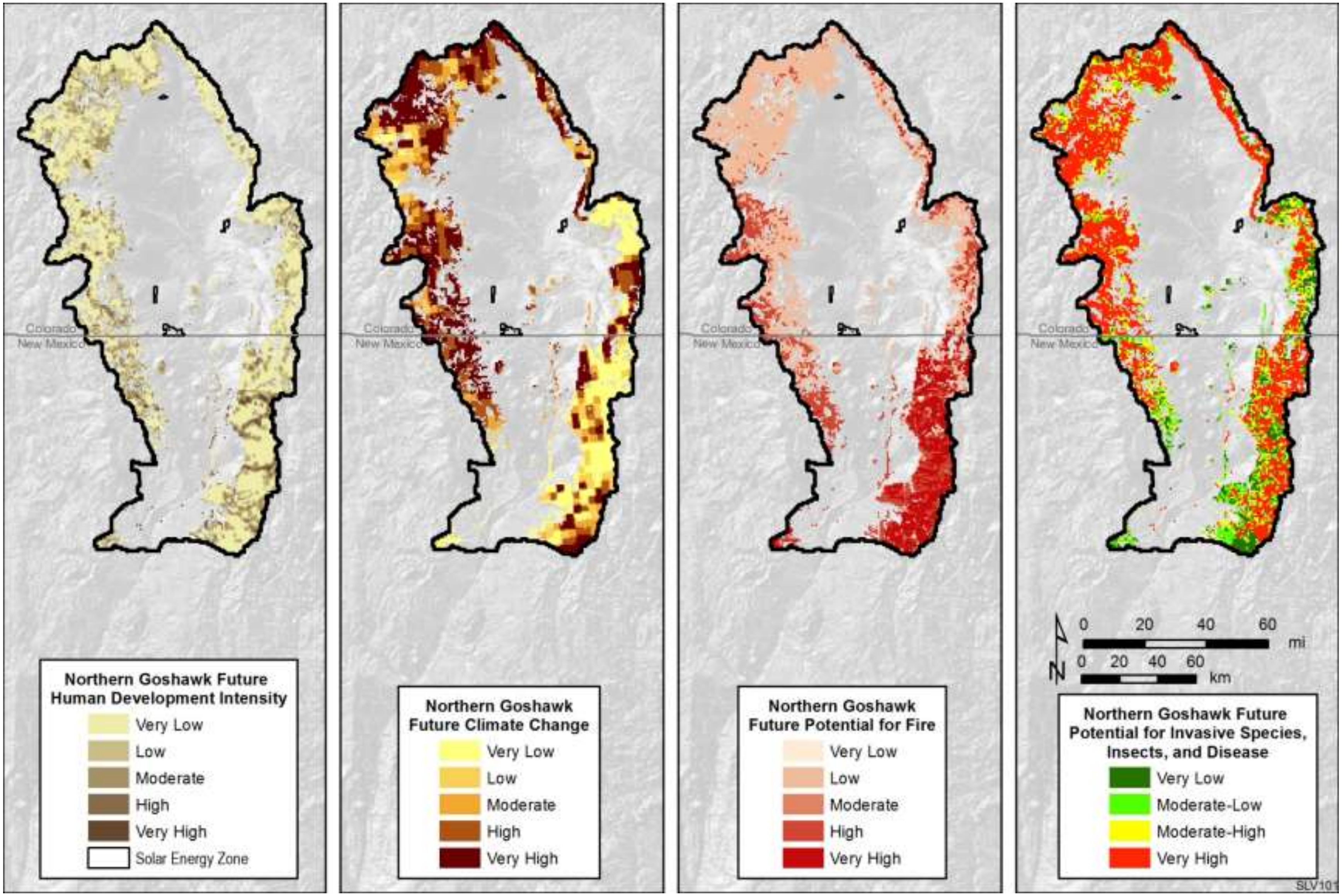


Figure B.2.4-6. Illustration for MQD3: Where is northern goshawk vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

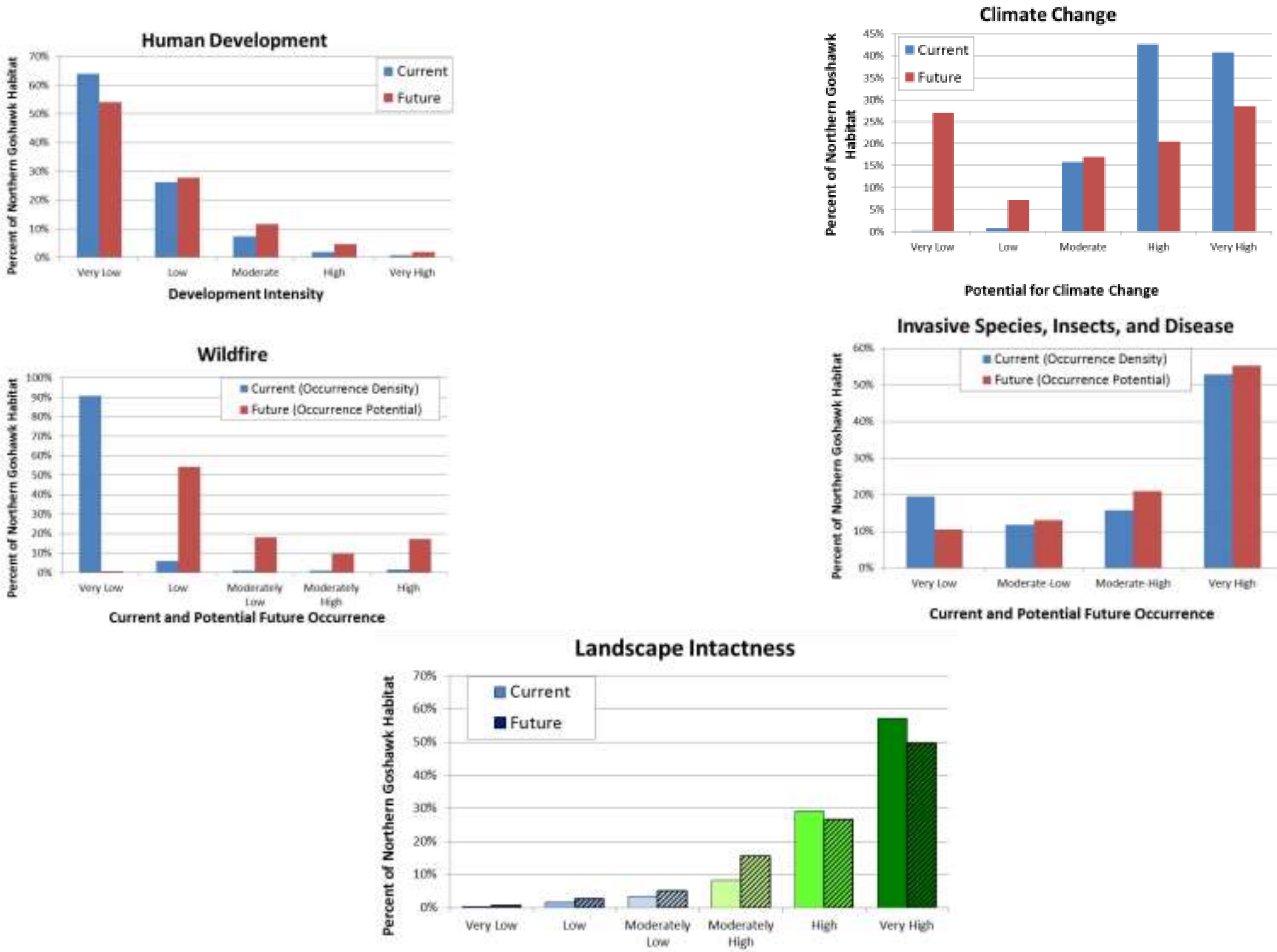


Figure B.2.4-7. Predicted Trends in Northern Goshawk Habitat within the Study Area

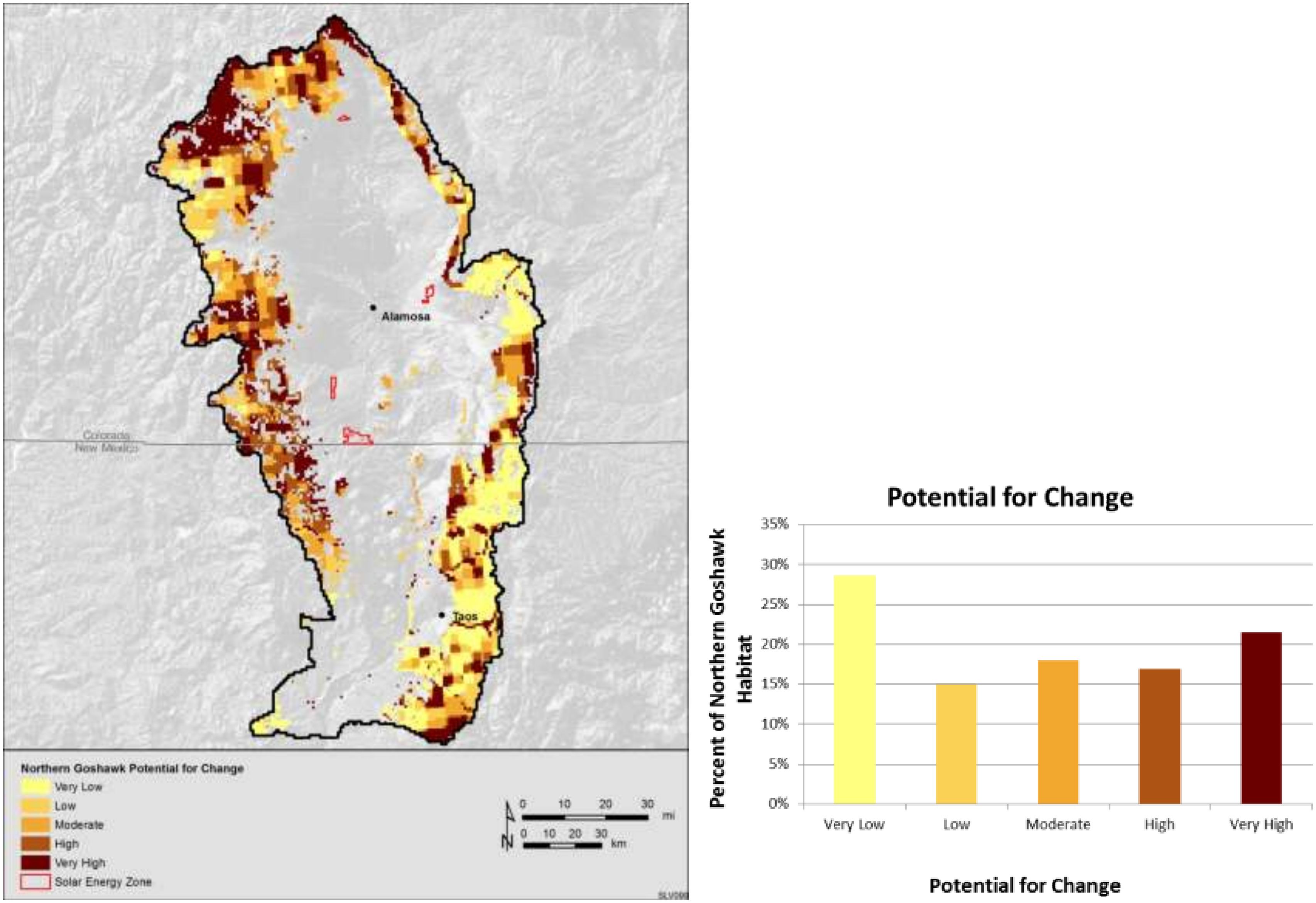


Figure B.2.4-8. Northern Goshawk Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.5 Gunnison Sage-Grouse

The Gunnison sage-grouse (*Centrocercus minimus*) is a species of sage-grouse found south of the Colorado River in Colorado and Utah. They are about one-third smaller than the greater sage-grouse. The species require a variety of habitats such as large expanses of sagebrush with a diversity of grasses and forbs and healthy wetland and riparian ecosystems. Sagebrush is used for shelter and thermal cover as well as for food in the winter (Hupp and Braun 1989; Braun et al. 2014). Sage-grouse are strong fliers but tend to travel slowly on foot unless threatened, in which case the grouse tend to hide or fly (less likely to run long distances) (Patterson 1952, Schroeder et al. 1999).

The San Luis Valley is in the eastern corner of the sagebrush region of the Intermountain West (Pitkin and Quattrini 2010) and, as such, has some sagebrush-associated or sagebrush-obligate bird species including the Gunnison sage-grouse. Southwest Colorado contains six of the seven remaining Gunnison sage-grouse populations (USFWS 2014e) and a small population (Poncha Pass population) is known to occur at the north end of the San Luis Valley (USFWS 2013). This species is currently listed as threatened under the Federal Endangered Species Act, is a species of special concern in Colorado, and is a BLM sensitive species in Colorado. Gunnison sage-grouse previously had a much broader distribution than they do at present (Schroeder et al. 2004), and the Colorado Parks and Wildlife has identified that some of this former range is still potential habitat for the species (Gunnison Sage-Grouse Rangewide Steering Committee 2005).

In Colorado, males display on leks from mid-March through late May, depending on elevation and conditions (Rogers 1964). Females visit leks, mate with one or more males, then depart to begin nesting. Clutch size averages around 6-7 (Young 1994, USFWS 2010). Incubation, by the female alone, lasts about 4 weeks. Hatching begins around mid-May and may extend into July; the peak usually is in mid-June (Gunnison Sage-grouse Rangewide Steering Committee 2005). Chicks leave the nest with the female shortly after hatching. Females infrequently re-nest if they lose their first nest.

Current and future direct and functional loss of habitat due to human development is the principal threat to all remaining populations of Gunnison sage-grouse. Current human development exacerbates the fragmentation of habitat that has already occurred from past agricultural conversion and residential development. Gunnison sage-grouse are sensitive to these forms of habitat fragmentation because they require large areas of contiguous, suitable habitat. Given the increasing human population trends in Gunnison sage-grouse habitat, human development and associated roads and infrastructure are expected to continue to expand. Likewise, the direct and indirect effects from these activities, including habitat loss, degradation and fragmentation, are expected to increase in sage-grouse habitats (USFWS 2013; NatureServe 2014).

Invasive species, fire, and climate change may not individually threaten the Gunnison sage-grouse; however, the documented synergy among these factors result in a high likelihood that they will threaten the species in the future (USFWS 2013). Noxious and invasive plant incursions into sagebrush ecosystems, which are facilitated by human activities and fragmentation, are likely to increase wildfire frequencies, further contributing to direct loss of habitat and fragmentation. Climate change may alter the range of invasive plants, intensifying the proliferation of invasive plants to the point that they become a threat to the species. Sagebrush habitats are highly fragmented due to anthropogenic impacts, and in most cases are not resilient enough to return to native vegetative states following disturbance from fire, invasive species, and the effects of climate change. These threats are expected to continue and potentially increase in magnitude in the future (USFWS 2013).

Using a spatial model predicting Gunnison sage-grouse nesting probability, Aldridge et al. (2012) found that Gunnison sage-grouse nests decreased within 2.5 km (1.6 mi) away from residential developments. Gunnison sage-grouse may also avoid road areas because of noise, visual disturbance, pollutants, and predators, which further reduces the amount of habitat available to them. Holloran (2005) found that male lek site attendance of greater sage-grouse (*C. urophasianus*) declined within 3 km (1.9 mi) of a methane well or roads with traffic volume exceeding one vehicle per day.

Historically, all sage-grouse were classified as a game species and subject to hunting under state wildlife laws. Colorado and Utah have eliminated hunting for sage-grouse in areas occupied by Gunnison sage-grouse (Nature Serve 2014). Ecological attributes and indicators for the Gunnison sage-grouse are provided in Table B.2.5-1.

The dataset used for this analysis represents Gunnison sage-grouse occupied and potential habitat that was considered as proposed critical habitat from the Gunnison Sage-grouse Rangewide Steering Committee (http://cpw.state.co.us/Documents/WildlifeSpecies/SpeciesOfConcern/GunnisonSageGrouse/ConsPlan/0RCPCover06.pdf). The data set was created in 2005 and was updated as recently as 2009. The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the Gunnison sage-grouse may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.5-1). Figures B.2.5-2 through B.2.5-8 show, respectively: Figure B.2.5-2 - the distribution of Gunnison sage-grouse proposed critical habitat in the study area; Figure B.2.5-3 – habitat distribution with respect to current vegetation departure; Figure B.2.5-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.5-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.5-6 - habitat distribution with respect to predicted areas of change; Figure B.2.5-7 - predicted trends in Gunnison sage-grouse habitat within the study area; and Figure B.2.5-8 - the aggregate potential for change in Gunnison sage-grouse habitat.

The majority (83%) of vegetation within Gunnison sage-grouse occupied and potential habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.5-3).

The largest percentage (39%) of Gunnison sage-grouse occupied and potential habitat is within areas of high current landscape intactness (Figure B.2.5-4; Figure B.2.5-7). Future trends in landscape intactness indicate a decrease in landscape intactness within Gunnison sage-grouse habitat. The amount of habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 2% in the near-term (i.e., by 2030) (Figure B.2.5-7).

The largest percentage (49%) of Gunnison sage-grouse occupied and potential habitat is within areas of low current human development intensity (Figure B.2.5-5; Figure B.2.5-7). Future trends in human development indicate an increase in human development intensity within Gunnison sage-grouse habitat. The amount of habitat occurring within areas high and very high human development intensity is expected to increase by approximately 6% in the near-term (i.e., by 2030) (Figure B.2.5-6; Figure B.2.5-7).

The majority of Gunnison sage-grouse occupied and potential habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.5-5; Figure B.2.5-7). Future trends in climate change indicate portions of the species' habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.5-6; Figure B.2.5-7). Approximately 76% of Gunnison sage-grouse habitat is located in areas with high or very high potential for future climate change (Figure B.2.5-7).

The majority of Gunnison sage-grouse occupied and potential habitat is within areas of very low current fire occurrence density (Figure B.2.5-5; Figure B.2.5-7). Future trends in wildfire indicate a small increase in wildfire potential in some portions of the species' habitat distribution in the study area. However, approximately 96% of Gunnison sage-grouse habitat has very low or low near-term future (i.e. by 2030) potential for wildfire (Figure B.2.5-6; Figure B.2.5-7).

The majority of Gunnison sage-grouse occupied and potential habitat is within areas of very high or moderate-high current density of invasive species, insects, and disease (Figure B.2.5-5; Figure B.2.5-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of Gunnison sage-grouse habitat in the study area (Figure B.2.5-6; Figure B.2.5-7).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 68% of the Gunnison sage-grouse occupied and potential habitat has the potential for high or very high future change among the change agents (Figure B.2.5-8). Areas with greatest potential for change within Gunnison sage-grouse habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.5-8).

Table B.2.5-1. Gunnison Sage-Grouse Attributes and Indicators

Attribute	**Indicator**	**Indicator Rating**				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat	Distance to residential development	<1.5 km	1.5 km	2.5 km	>4 km	Aldridge et al. (2012)
Habitat	Distance to roads	<1.5 km	1.5 km	3 km	>4 km	Holloran (2005)

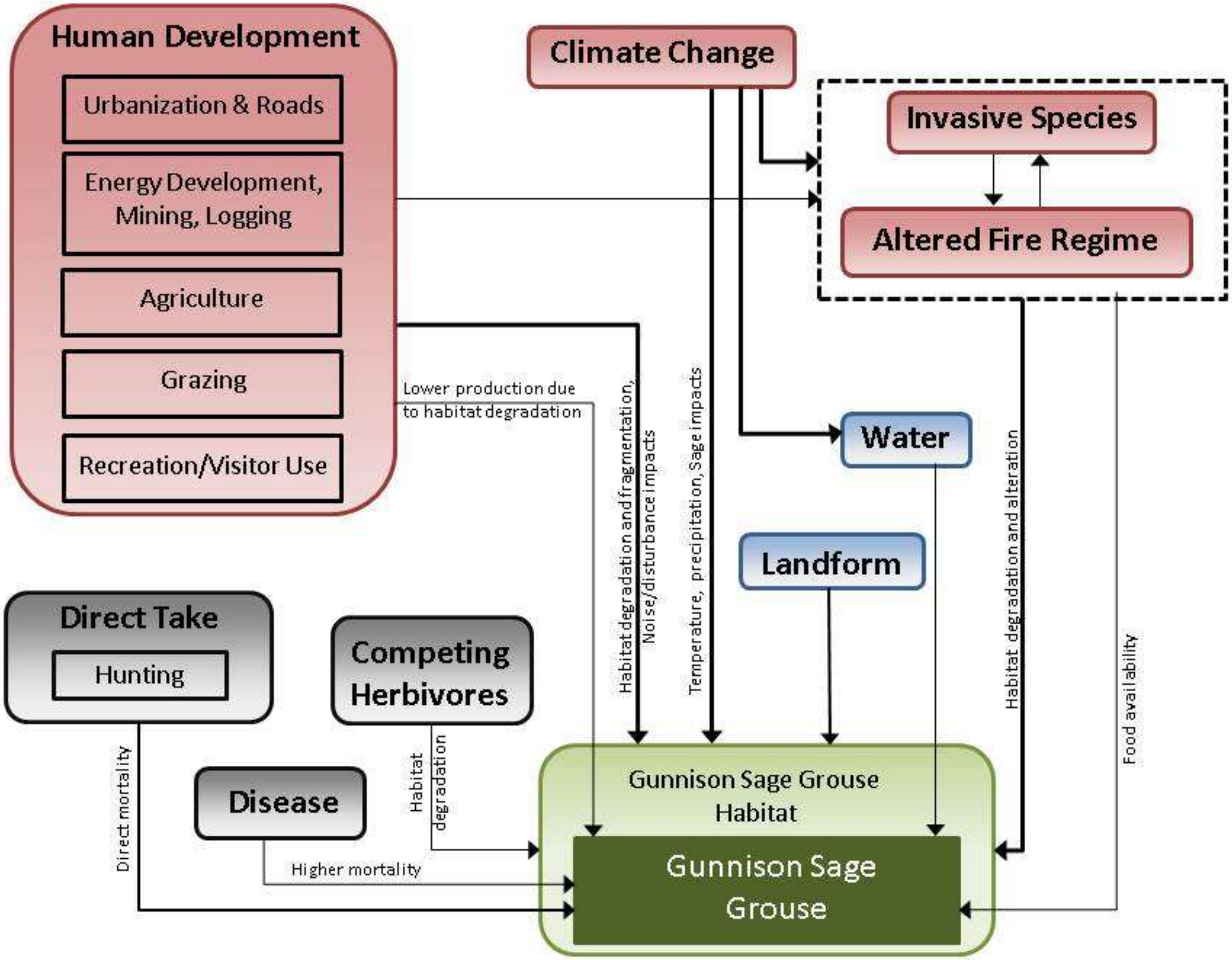


Figure B.2.5-1. Gunnison Sage-Grouse Conceptual Model.

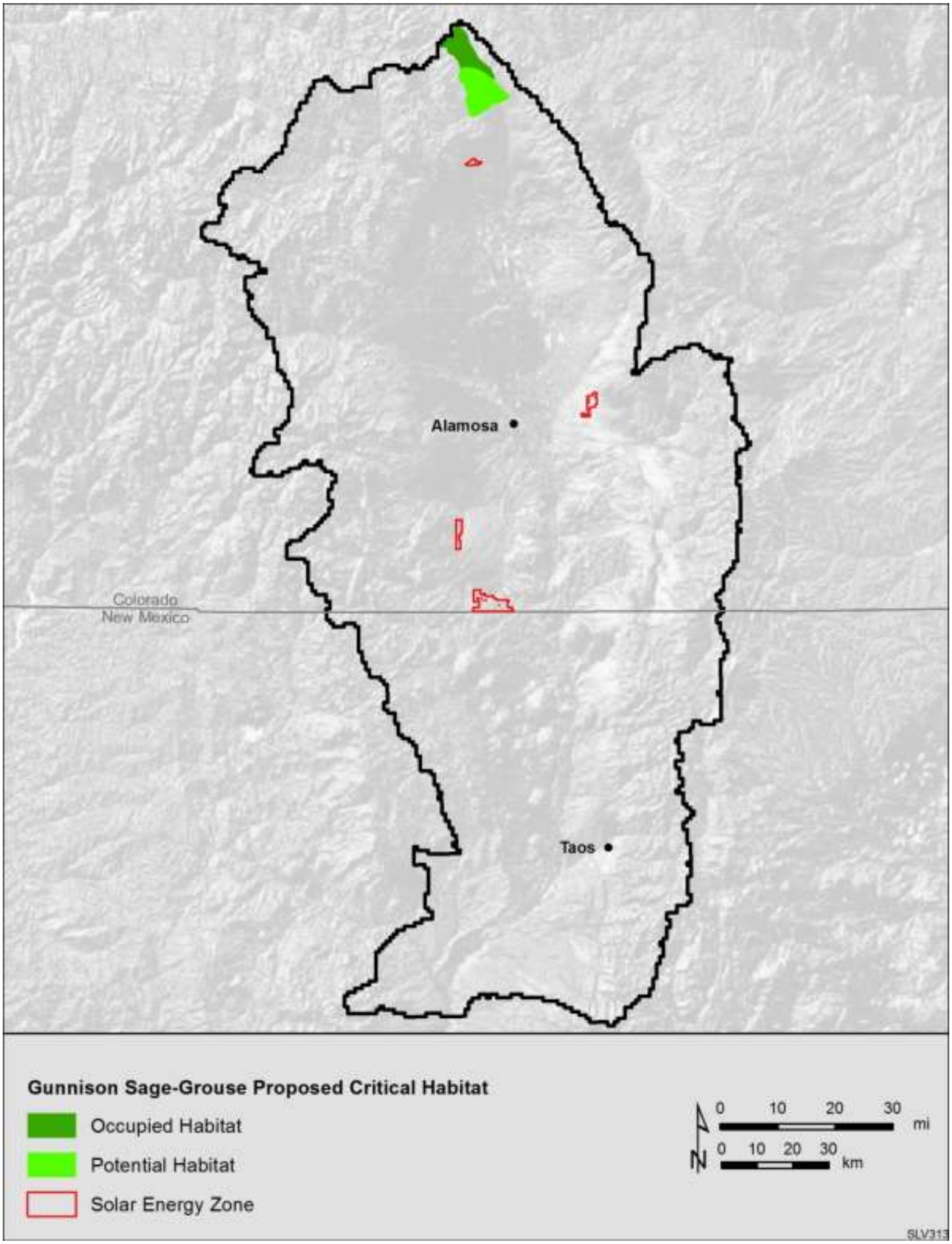


Figure B.2.5-2. Distribution of Proposed Critical Habitat for the Gunnison Sage-Grouse. Data Source: Gunnison Sage-grouse Rangewide Steering Committee, 2005.

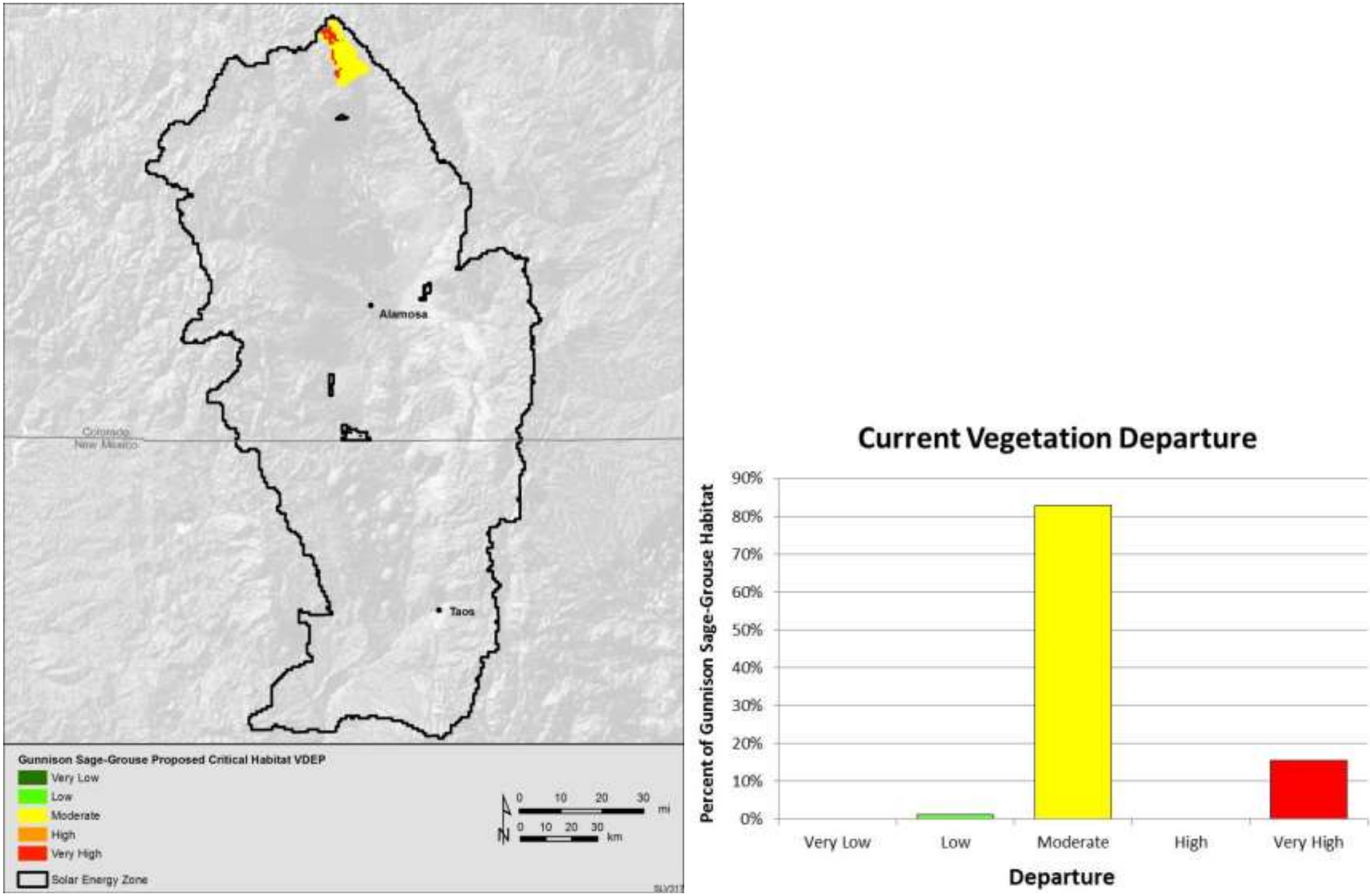


Figure B.2.5-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Gunnison Sage-Grouse Proposed Critical Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Gunnison Sage-grouse Rangewide Steering Committee, 2005. Data were Summarized to 1 km^2 Reporting Units.

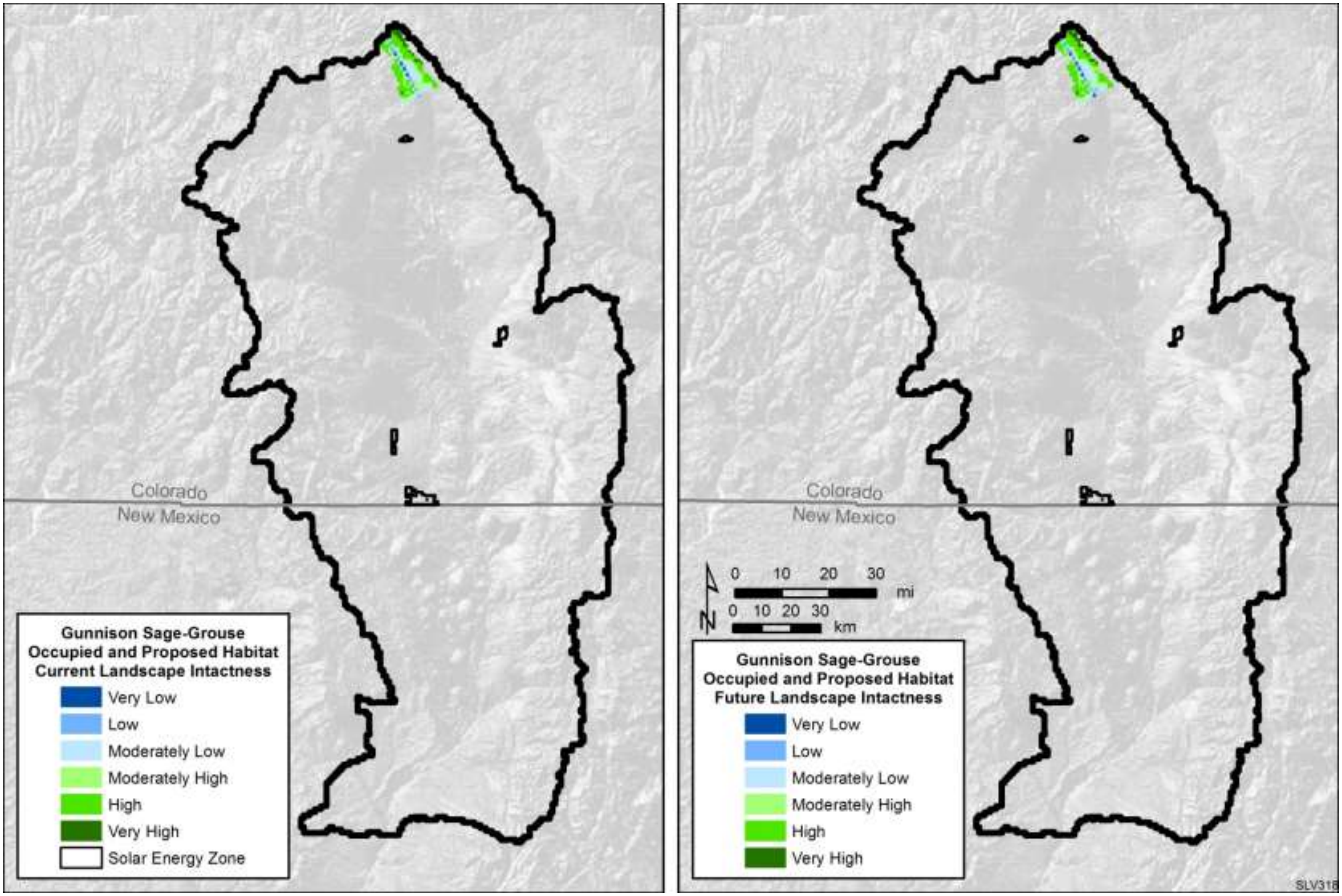


Figure B.2.5-4. Current and Future Landscape Intactness of Gunnison Sage-Grouse Occupied and Potential Habitat. This landscape intactness model does not include LANDFIRE Vegetation Departure (VDEP). Data Sources: Argonne 2014 and Gunnison Sage-grouse Rangewide Steering Committee (2005).

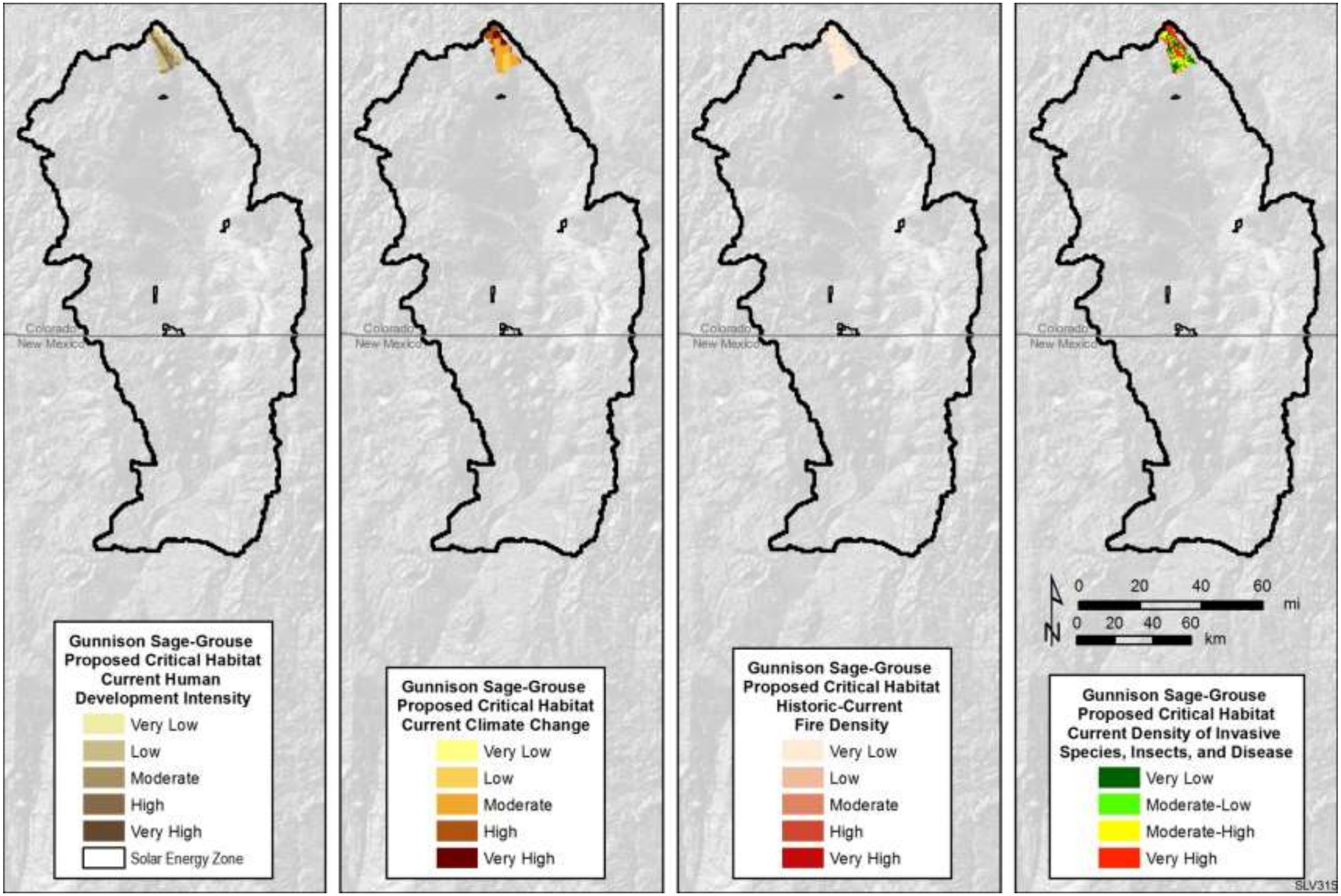


Figure B.2.5-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for Gunnison sage-grouse? Data Sources: Argonne 2014 and Gunnison Sage-grouse Rangewide Steering Committee, 2005.

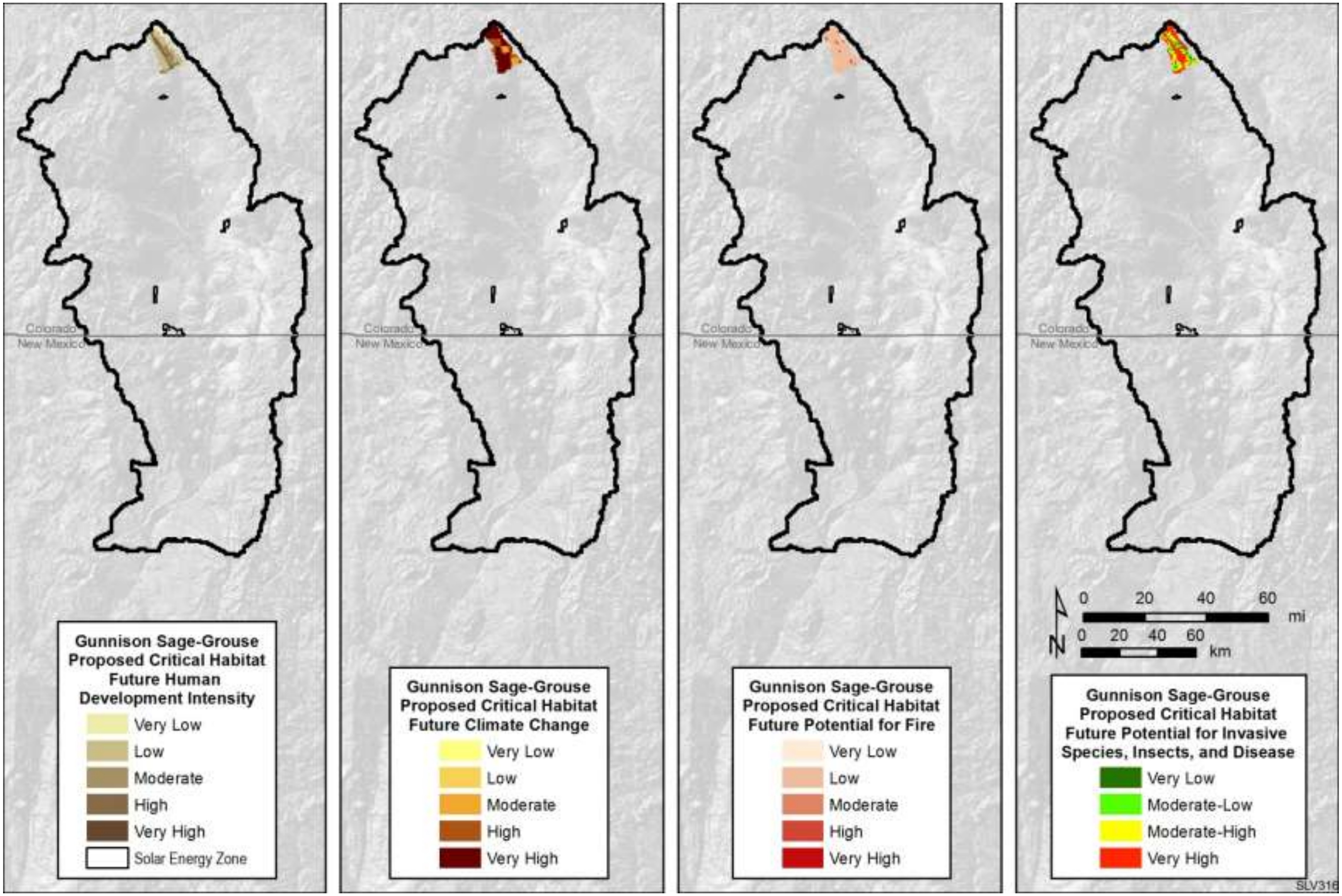


Figure B.2.5-6. Illustration for MQD3: Where is the Gunnison sage-grouse vulnerable to change agents in the future? Data Sources: Argonne 2014 and Gunnison Sage-grouse Rangewide Steering Committee, 2005.

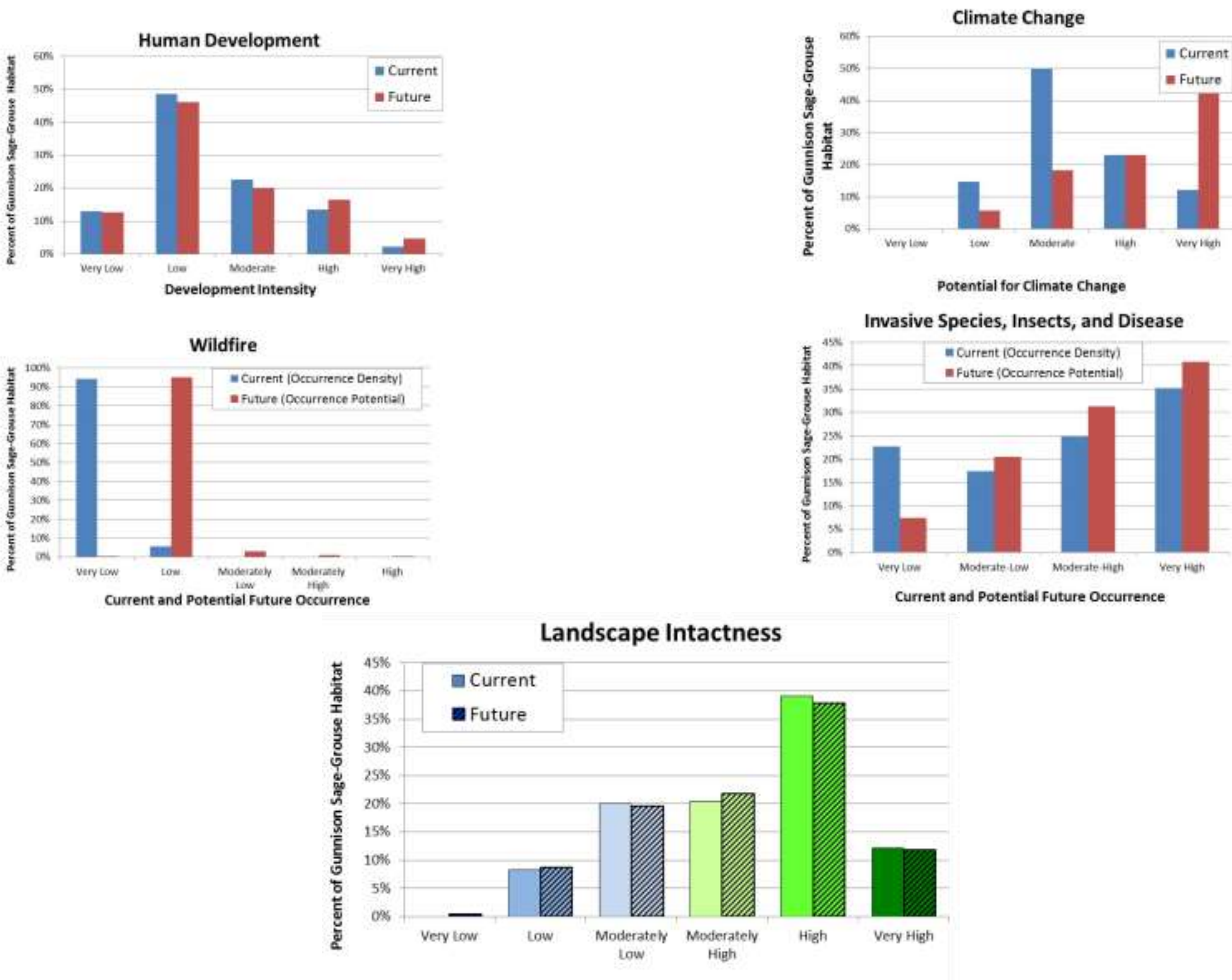


Figure B.2.5-7. Predicted Trends in Gunnison Sage-Grouse Habitat within the Study Area

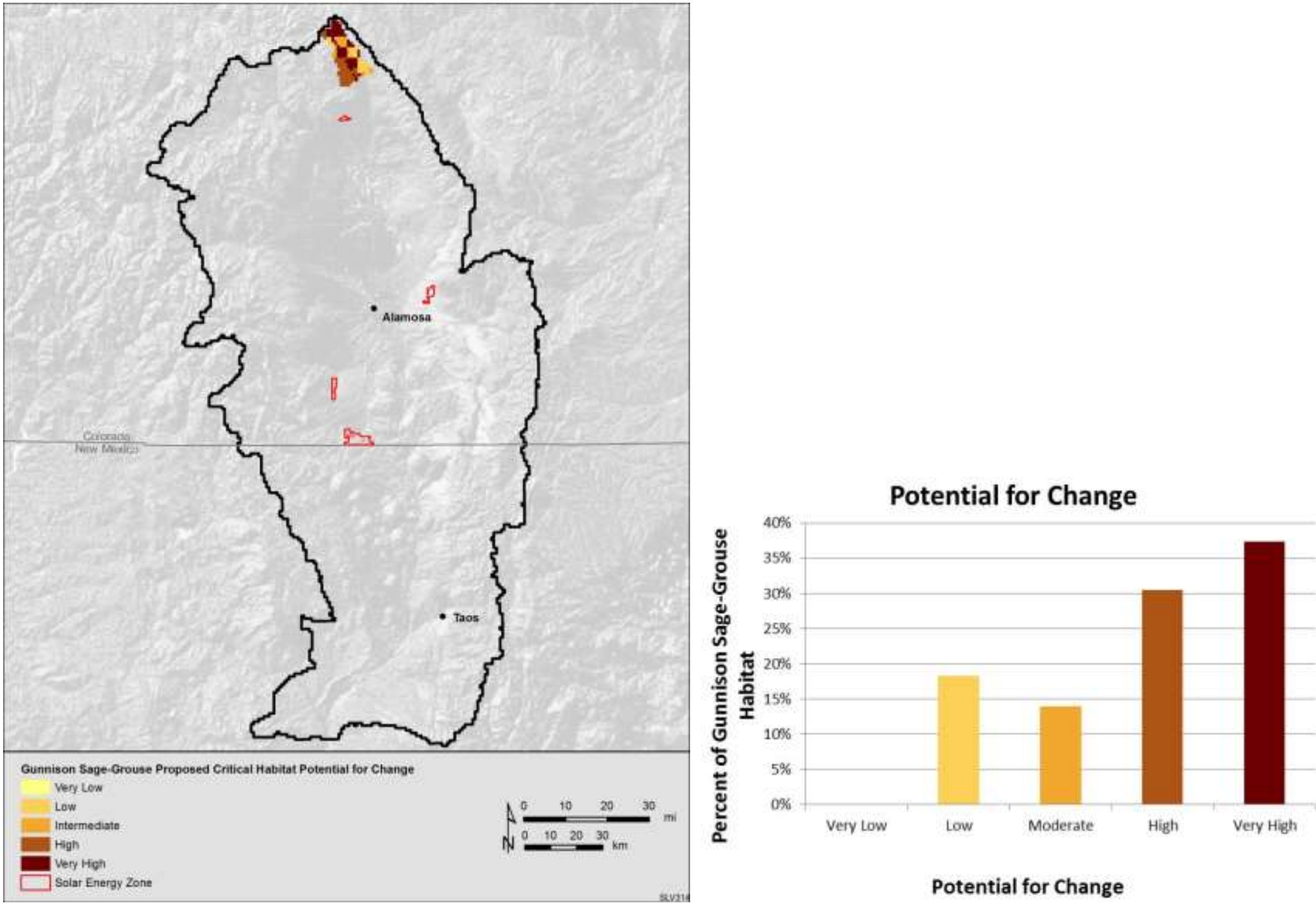


Figure B.2.5-8. Gunnison Sage-Grouse Aggregate Potential for Change. Data Sources: Argonne 2014 and Gunnison Sage-grouse Rangewide Steering Committee, 2005.

B.2.6 Waterfowl-Shorebird Assemblage

The waterfowl-shorebird assemblage was created by combining NWI wetlands polygons (http://www.fws.gov/wetlands/), water bodies (ForestERA Project), riparian areas, Canada goose ranges (CPW)(http://cpw.state.co.us/), white pelican ranges (CPW)(http://cpw.state.co.us/), and US National Atlas stream centerlines (buffered by 250 m) (http://nationalmap.gov/small_scale/). The wetlands of the San Luis Valley provide habitat for many species of birds. Some of these birds are year-round residents, but many migrate through the valley on their way to and from wintering and breeding grounds while others come to the valley to breed or spend the winter. At least 35 species of shorebirds and waterfowl are known to use the wetlands in the study area as either stopover or breeding habitat (Table B.2.6-1). Six of these shorebirds, including the snowy plover, which breeds in the playa wetlands of the Closed Basin, are either focal species for the USFWS Migratory Bird Program and/or are USFWS Region 6 Birds of Conservation Concern (USFWS 2012). Several of these species breed in the wetlands, marshes, wet meadows, and riparian areas and make extensive use of natural and agricultural habitats in the study area. Many migratory species use the study area as stopover habitat, particularly on and around the Alamosa and Monte Vista National Wildlife Refuges and Blanca Wetlands.

Wet meadow habitat is naturally present in the San Luis Valley in areas that have shallow water tables and areas that are periodically shallowly inundated early in the growing season. Wet meadows are the most widespread wetland type in the San Luis Valley. The combination of plant structure and density coupled with water depth and duration creates rich habitat diversity within each large area of wet meadow. This richness of habitat creates tremendous foraging and nesting opportunities for a variety of bird species (Gammonley and Laubhan 2002; USFWS 2012).

Playa wetlands in the study area are primarily found in the Closed Basin (on and near the Baca National Wildlife Refuge) and in and around the Blanca Wetlands, which are managed by BLM. These wetlands are ephemeral or temporary, and since the water regime of the valley has been altered by human activity, they may remain dry in years of below average precipitation (USFWS 2012). The ephemeral nature of these wetlands adds to their uniqueness and their high productivity when inundated. The dynamic flooding and drying cycles within these wetlands provides for the nutrient cycling conditions ideal for invertebrates and other prey for migratory shorebirds. Greasewood and rabbitbrush vegetation communities typically surround these wetlands, which are also important to foraging and nesting shorebirds (USFWS 2012).

Seasonal and semi-permanent wetlands have hydrologic regimes that allow for the persistence of water throughout the growing season. These semi-permanent wetlands may have substantial areas of open water with aquatic vegetation beds, and are often fringed by tall emergent vegetation. Swimming birds, including grebes, coots, and waterfowl, use open water areas of these wetlands for foraging. Emergent vegetation provides breeding habitat for diving and dabbling ducks, American bitterns, snowy and cattle egrets, black-crowned night herons, and white-faced ibis, among other species of shorebirds and waterfowl (Laubhan and Gammonley 2000; USFWS 2012). Ecological attributes and indicators for the shorebird – waterfowl assemblage are provided in Table B.2.6-2.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the shorebird-waterfowl assemblage may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.6-1). Figures B.2.6-2 through B.2.6-8 show, respectively: Figure B.2.6-2 - the current distribution of potentially suitable shorebird-waterfowl habitat in the study area; Figure B.2.6-3 – habitat distribution with respect to current vegetation departure; Figure B.2.6-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.6-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.6-6 - habitat distribution with respect to predicted areas of change; Figure B.2.6-7 - predicted trends in shorebird-waterfowl habitat within the study area; and Figure B.2.6-8 - the aggregate potential for change in shorebird-waterfowl habitat.

The majority (29%) of vegetation within shorebird-waterfowl potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.6-3). Most of the vegetation departure that has occurred within potentially suitable habitat is located in agricultural and rural areas of the San Luis Valley near the center of the study area (Figure B.2.6-3).

The majority (47%) of shorebird-waterfowl potentially suitable habitat is within areas of moderately low and moderately high current landscape intactness (Figure B.2.6-4; Figure B.2.6-7). Approximately 40% of the suitable habitat occurs in areas of high and very high current landscape intactness. Future trends in landscape intactness indicate a decrease in landscape intactness within shorebird-waterfowl potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 6% in the near-term (i.e., by 2030); whereas the amount of potential habitat occurring within areas of very low and low near-term future landscape intactness is expected to increase by approximately 5% (Figure B.2.6-7).

The majority (26%) of shorebird-waterfowl potentially suitable habitat is within areas of either low or high current human development intensity (Figure B.2.6-5; Figure B.2.6-7). Future trends in human development indicate an increase in human development intensity within shorebird-waterfowl potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 7% in the near-term (i.e., by 2030) (Figure B.2.6-6; Figure B.2.6-7).

The majority of shorebird-waterfowl potentially suitable habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.6-5; Figure B.2.6-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.6-6; Figure B.2.6-7). Approximately 33% of the shorebird-waterfowl suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.6-7). The greatest potential for future climate change within shorebird-waterfowl potentially suitable habitat occurs in the western and northwestern portion of the habitat distribution in the study area (Figure B.2.6-6).

The majority of shorebird-waterfowl potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.6-5; Figure B.2.6-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.6-6).

The majority of shorebird-waterfowl potentially suitable habitat is within areas of very high current density of invasive species, insects, and disease (Figure B.2.6-5; Figure B.2.6-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of shorebird-waterfowl potentially suitable habitat in the study area (Figure B.2.6-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (Figure B.2.6-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 45% of the shorebird-waterfowl suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.6-8). Areas with greatest potential for change within shorebird-waterfowl suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.6-8).

In addition to the four change agents modeled in this Landscape Assessment, the distribution and availability of water through natural and human-altered hydrologic processes can also be considered a unique change agent that could influence the distribution and status of several CEs, including waterfowl and shorebirds. As one outcome of this Landscape Assessment, the role of water as a change agent has been identified as a knowledge gap where future research efforts may be directed. Future research to characterize spatio-temporal patterns of water availability and how these processes influence CEs is needed to adequately address the role of water availability on waterfowl and shorebirds.

Table B.2.6-1. Shorebird and Waterfowl Species of the San Luis Valley –Taos Plateau Study Area[1]

American avocet (*Recurvirostra Americana*)
American bittern (*Botaurus lentiginosus*)
American coot (*Fulica americana*)
American white pelican (*Pelecanus erythrorhynchos*)
American wigeon (*Anas americana*)
Black tern (*Chlidonias niger*)
Black-crowned night heron (*Nycticorax nycticorax*)
Black-necked stilt (*Himantopus mexicanus*)
Blue-winged teal (*Anas discors*)
Canada goose (*Branta canadensis*)
Canvasback (*Aythya valisineria*)
Cattle egret (*Bubulcus ibis*)
Cinnamon teal (*Anas cyanoptera*)
Common goldeneye (*Bucephala clangula*)
Common loon (*Gavia immer*)
Common merganser (*Mergus merganser*)
Double-crested cormorant (*Phalacrocorax auritus*)
Eared grebe (*Podiceps nigricollis*)
Forster's tern (*Sterna forsteri*)
Gadwall (*Anas strepera*)
Great blue heron (*Ardea herodias*)
Great egret (*Ardea alba*)
Snow goose (*Chen caerulescens*)
Sora (*Porzana carolina*)
Greater scaup (*Aythya marila*)
Green-winged teal (*Anas crecca*)
Least bittern (*Ixobrychus exilis*)
Lesser scaup (*Aythya affinis*)
Long-billed curlew (*Numenius americanus*)
Mallard (*Anas platyrhynchos*)
Northern pintail (*Anas acuta*)
Northern shoveler (*Anas clypeata*)
Pied-billed grebe (*Podilymbus podiceps*)
Redhead (*Aythya americana*)
Ring-necked duck (*Aythya collaris*)
Ruddy duck (*Oxyura jamaicensis*)
Snowy egret (*Egretta thula*)
Snowy plover (*Charadrius nivosus*)
Sandhill crane (*Grus canadensis*)
Virginia rail (*Rallus limicola*)
Western grebe (*Aechmophorus occidentalis*)
White-faced ibis (*Plegadis chihi*)
Wilson's phalarope (*Phalaropus tricolor)*
Wilson's snipe (*Gallinago delicata*)
Wood duck (*Aix sponsa*)

[1] Sources: USFWS (2012); USGS (2013). Note: this list is not a comprehensive or exhaustive list of all shorebirds or waterfowl that may be observed in the study area.

Table B.2.6-2. Shorebird-Waterfowl Assemblage Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat suitability	Amount of anthropogenic disturbance	Greater anthropogenic disturbance	Moderate anthropogenic disturbance		No anthropogenic disturbance	Fredrickson and Reid (1988); Aarif et al. (2014)
Habitat suitability	Distance to human activity	<80 m				Klein et al. (1995)
Habitat suitability	Distance to human activity	<50 m		>300 m		Pease et al. (2005)

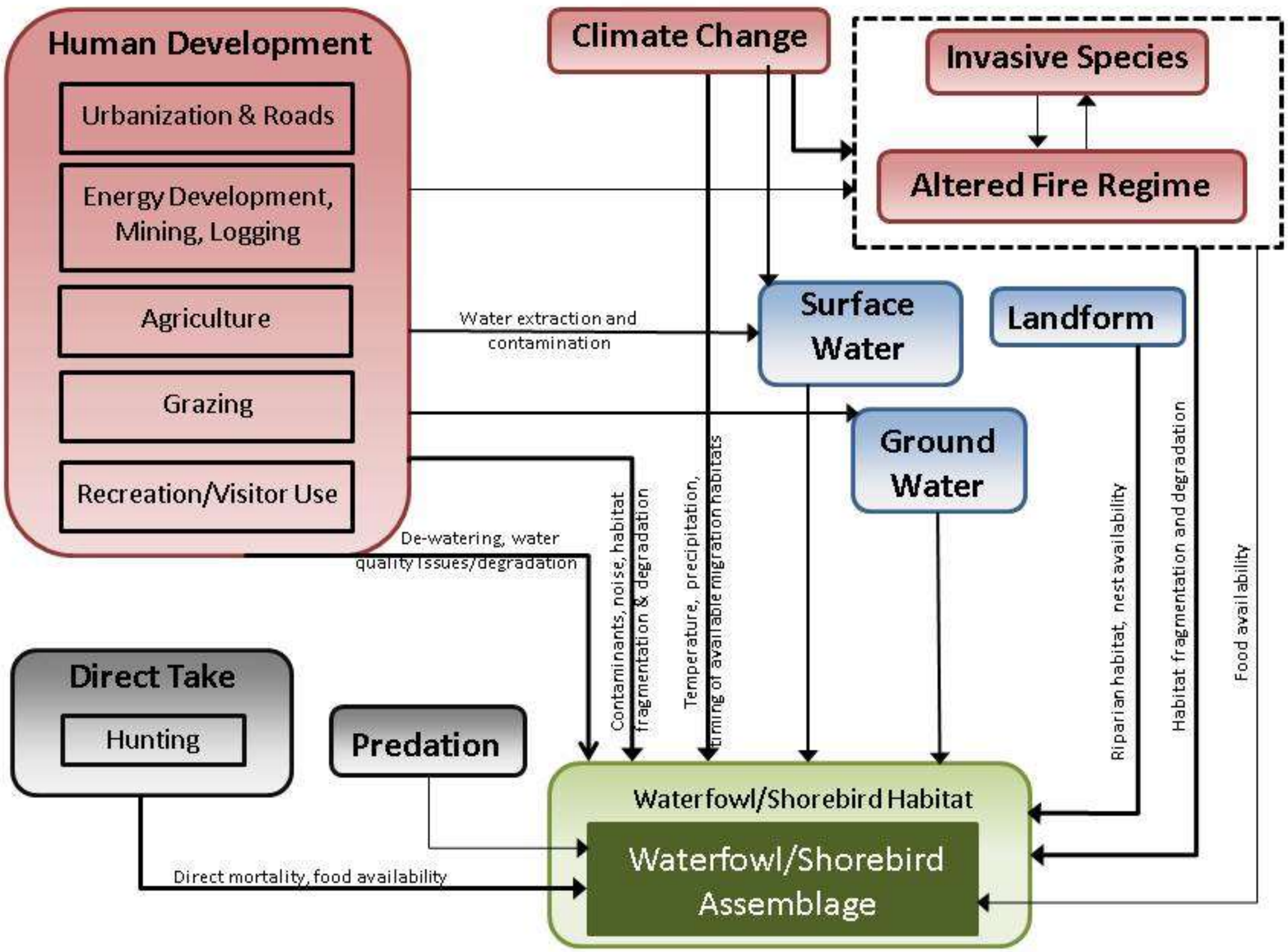


Figure B.2.6-1. Waterfowl/Shorebird Assemblage Conceptual Model.

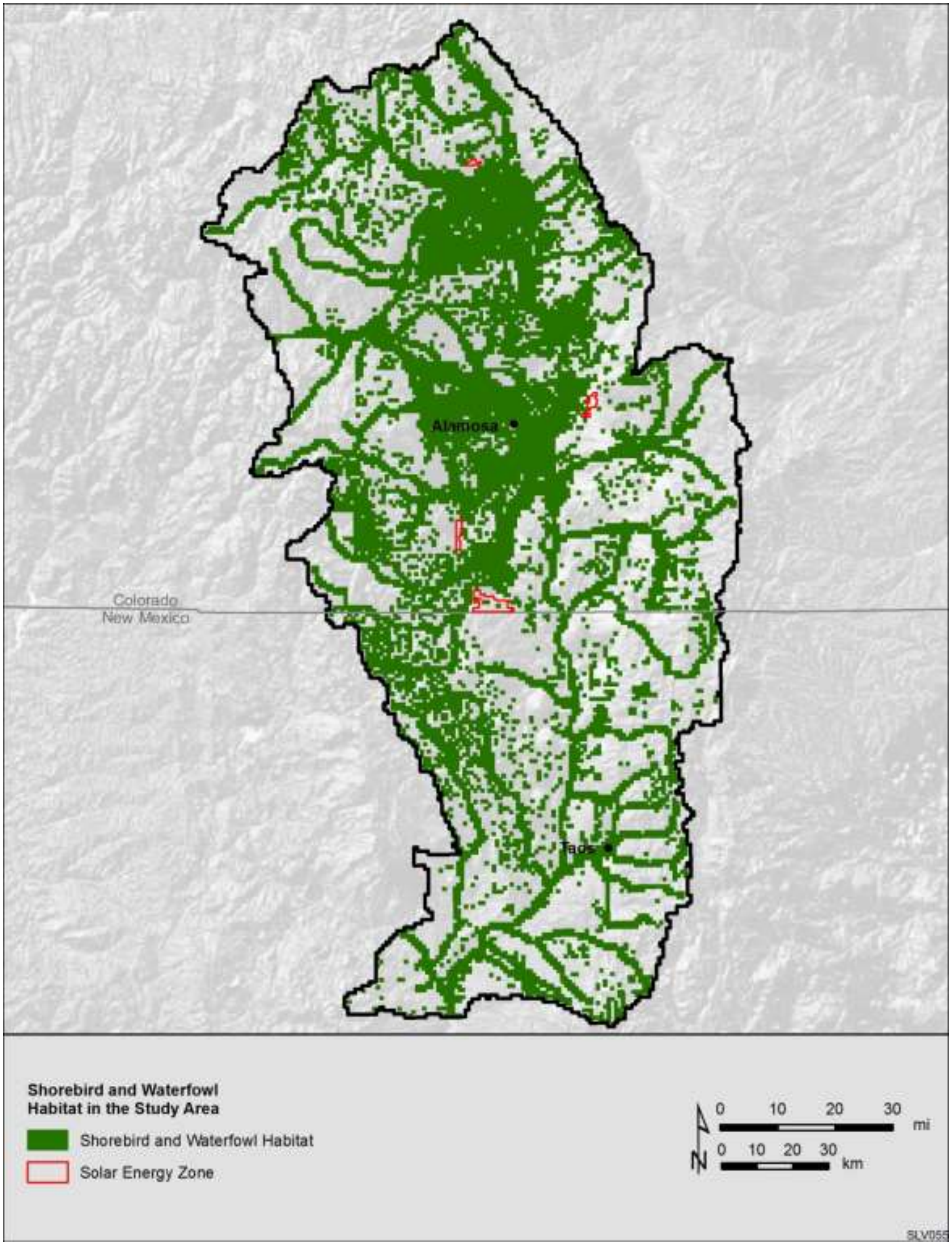
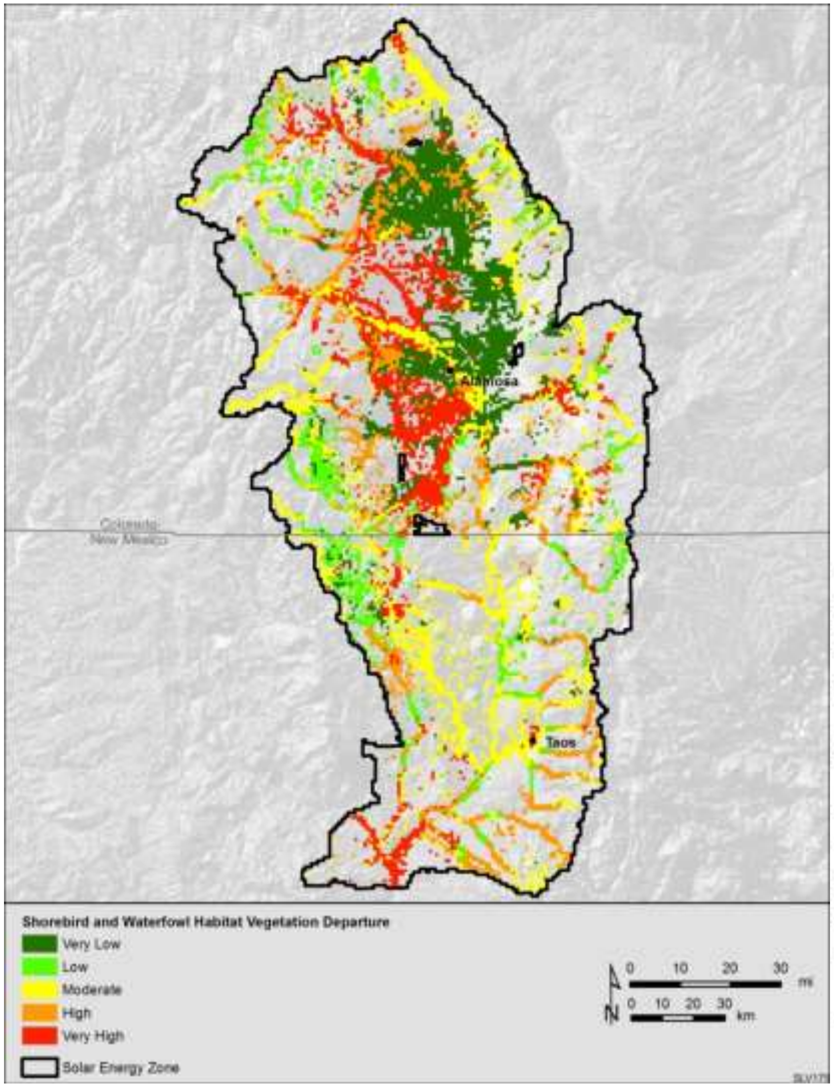


Figure B.2.6-2. Current Distribution of Potentially Suitable Habitat for the Waterfowl/Shorebird Assemblage, Summarized to 1km^2 Reporting Units. Data Sources: USFWS 2014g, ForestERA 2006, CPW 2012.



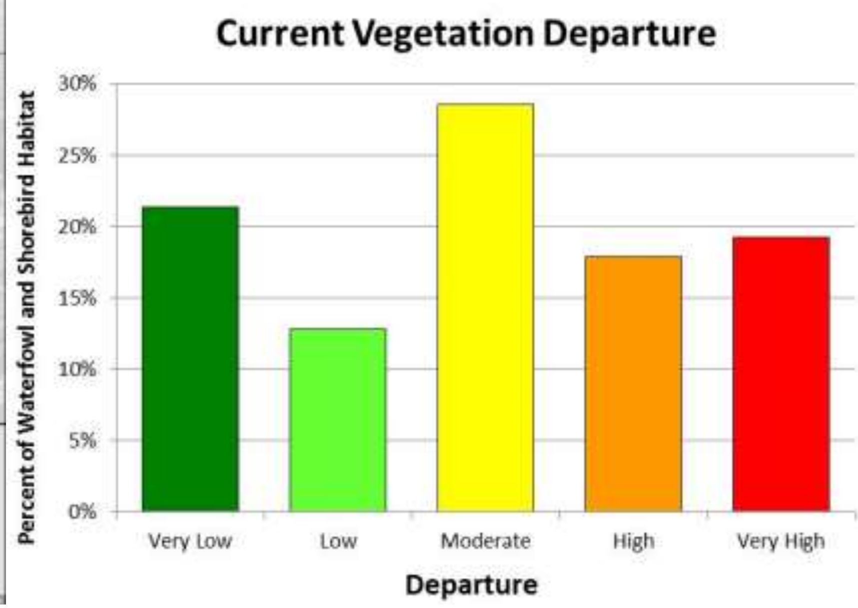


Figure B.2.6-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Waterfowl and Shorebird Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008), USFWS 2014g, ForestERA 2006, CPW 2012..

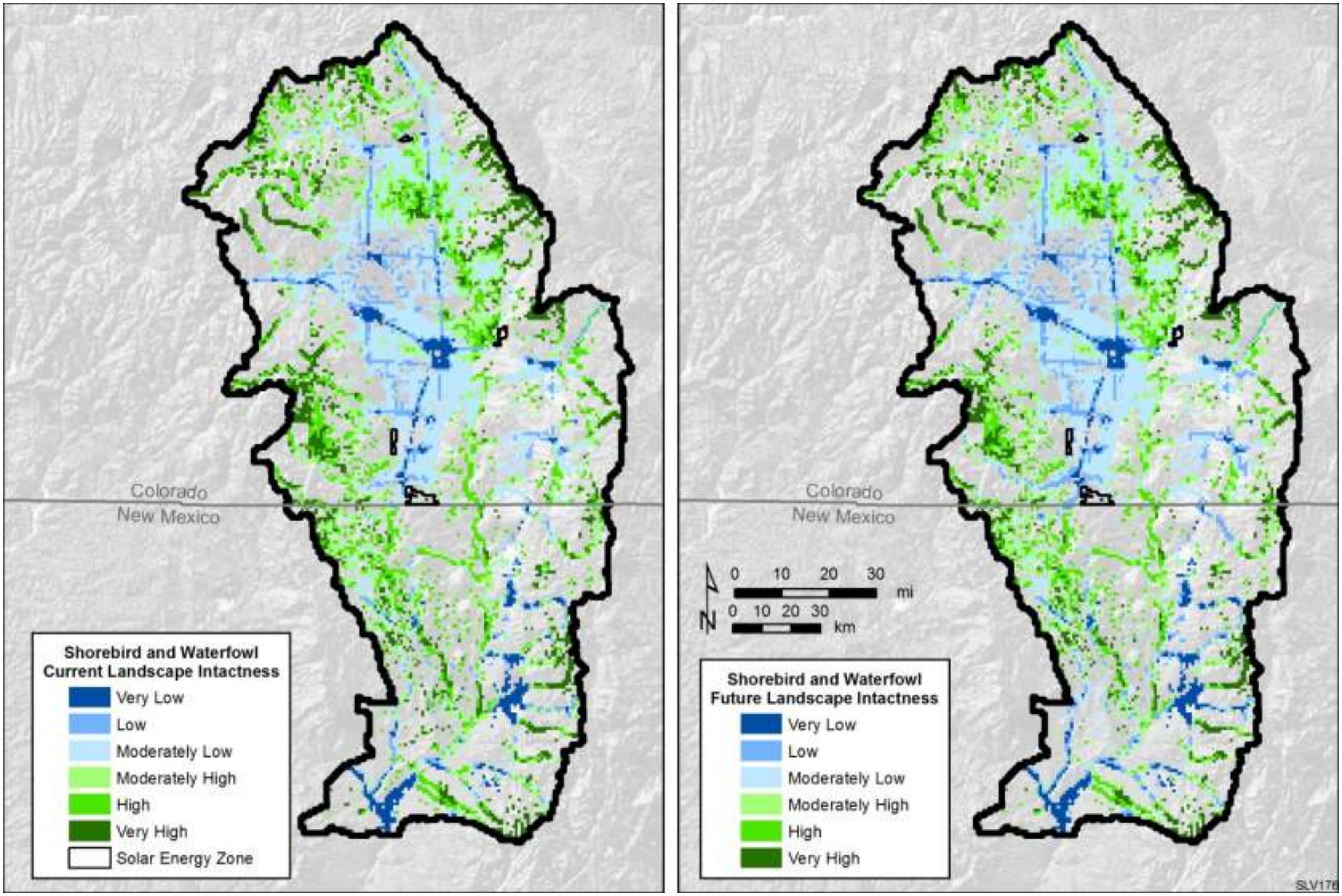


Figure B.2.6-4. Current and Future Landscape Intactness of Potentially Suitable Shorebird and Waterfowl Habitat. Data Sources: Argonne 2014, USFWS 2014g, ForestERA 2006, CPW 2012.

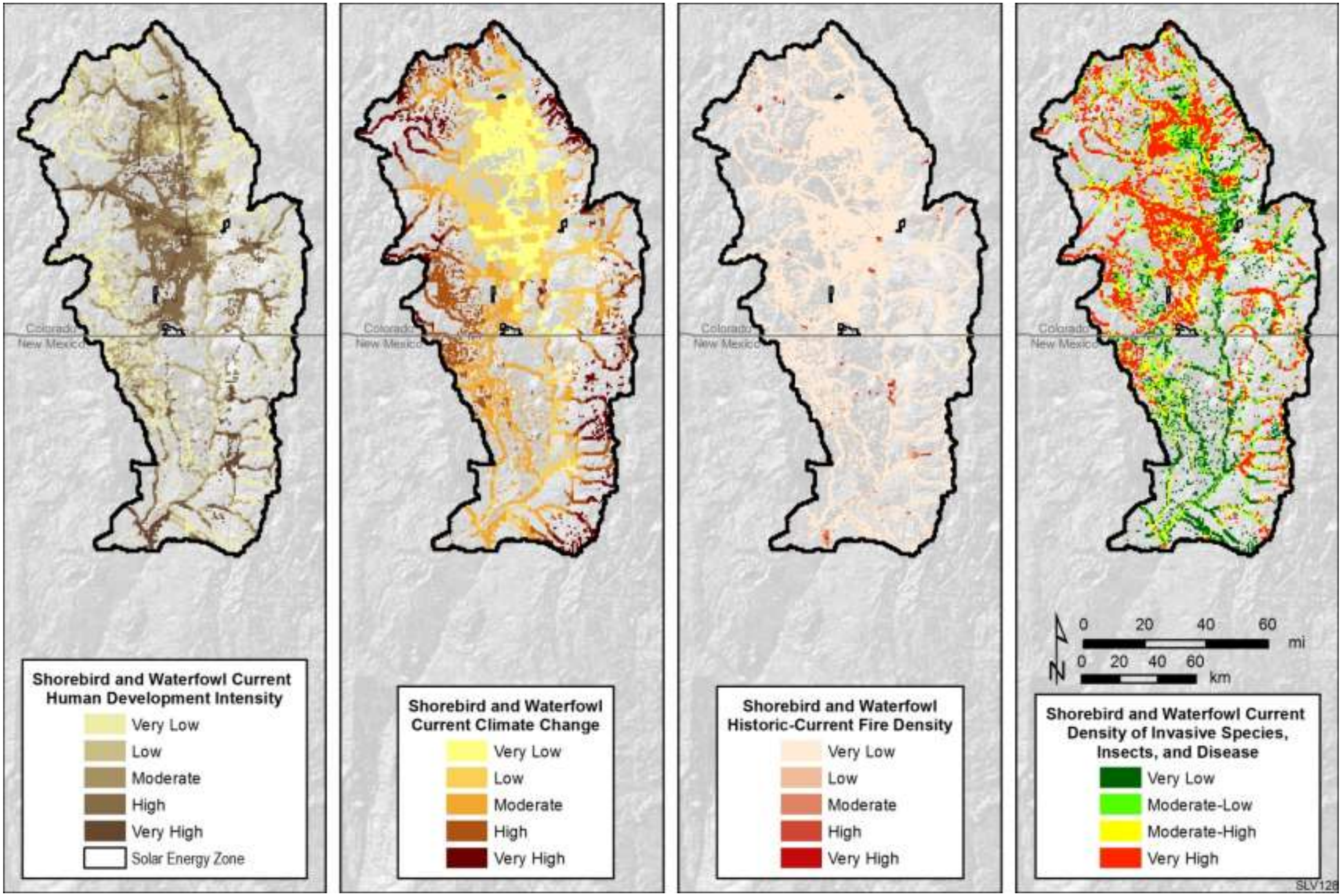


Figure B.2.6-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for waterfowl/shorebird assemblages? Data Sources: Argonne 2014, USFWS 2014g, ForestERA 2006, CPW 2012.

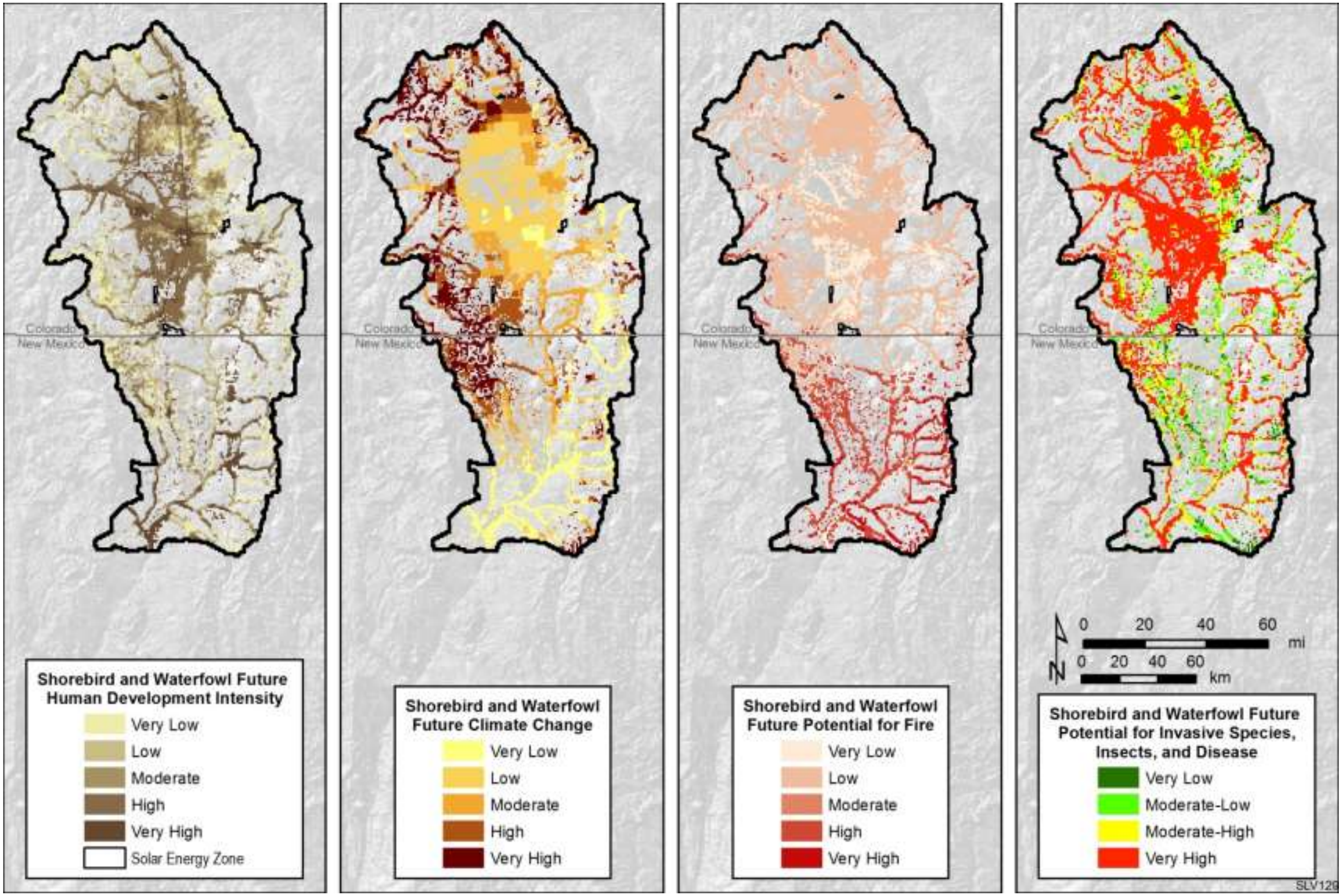


Figure B.2.6-6. Illustration for MQD3: Where are waterfowl/shorebird assemblages vulnerable to change agents in the future? Data Sources: Argonne 2014, USFWS 2014g, ForestERA 2006, CPW 2012.

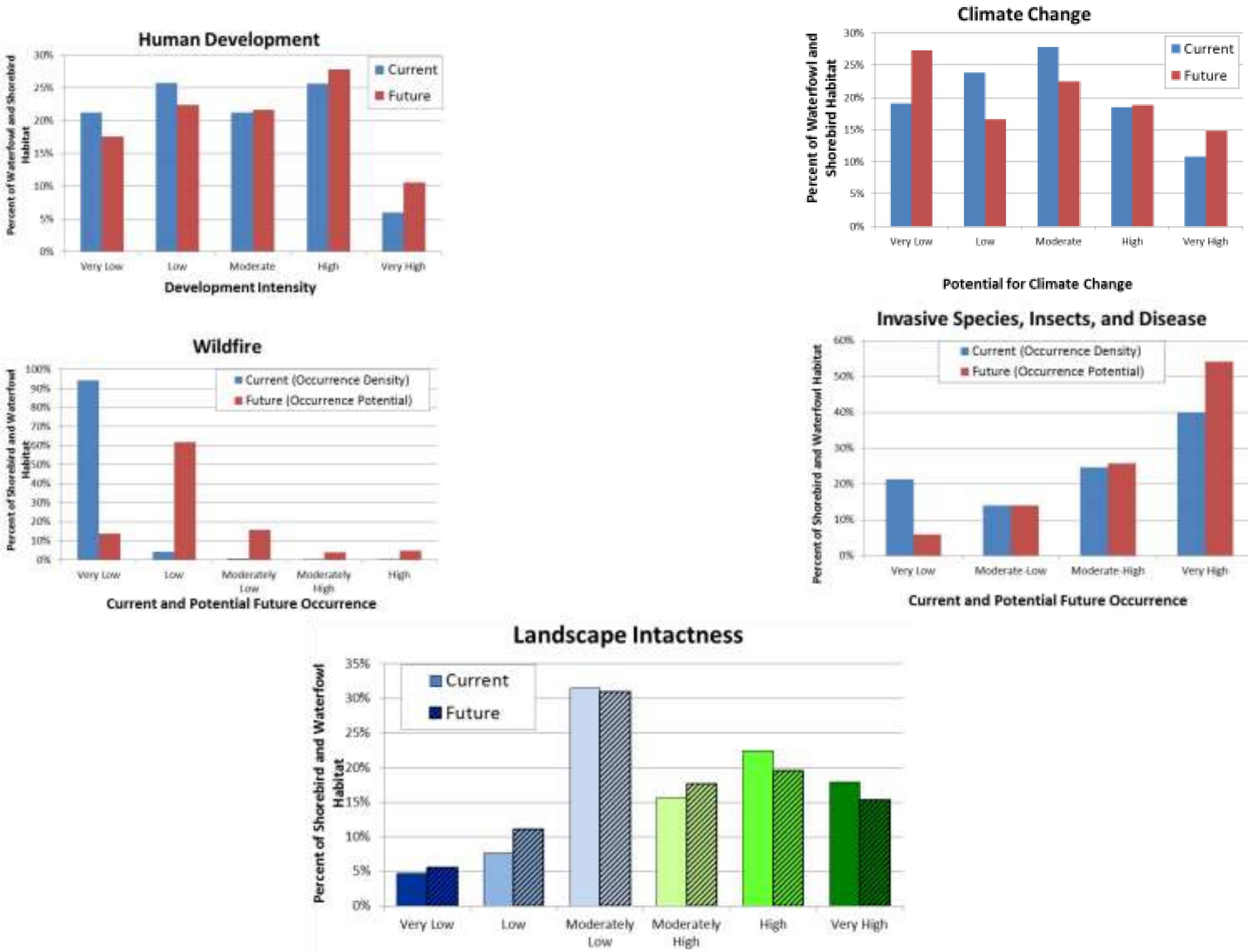
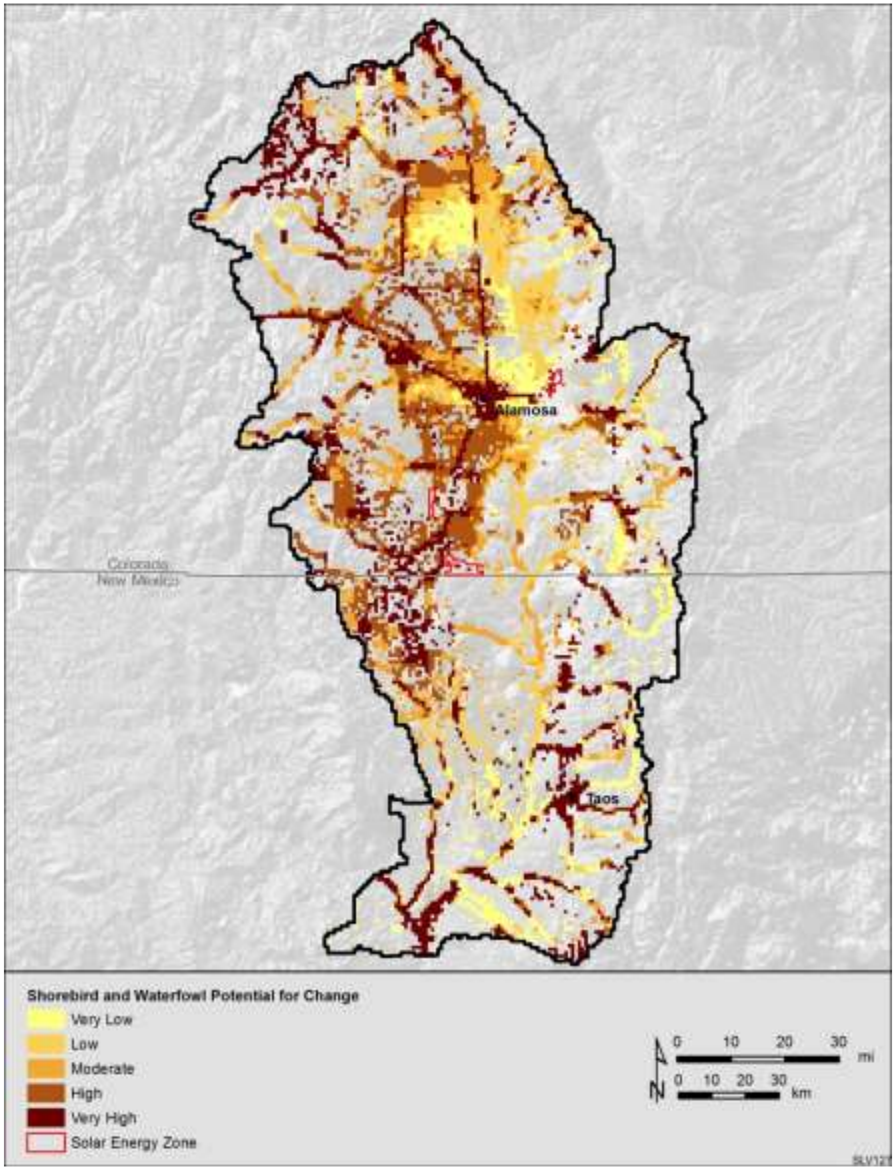


Figure B.2.6-7. Predicted Trends in Waterfowl/Shorebird Assemblage Habitat within the Study Area



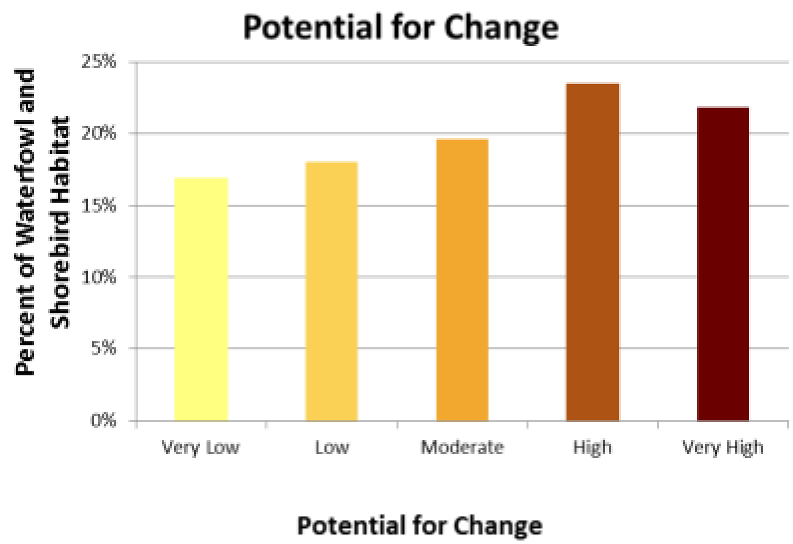


Figure B.2.6-8. Waterfowl/Shorebird Assemblage Aggregate Potential for Change. Data Sources: Argonne 2014, USFWS 2014g, ForestERA 2006, CPW 2012.

B.2.7 Mexican Free-Tailed Bat

The Mexican free-tailed bat is a small, gray-brown bat with long, narrow wings and a tail that extends well beyond the membrane between the legs. Individuals weigh 8-12 g, have a wingspan of approximately 300 mm, and a total length of 90 to 105 mm (Colorado Bat Working Group 2014).

Mexican free-tailed bats occupy a wide variety of habitats including desert communities, pinion-juniper woodland, and pine-oak forests at elevations from sea level to 9,000 feet (BLM 2013). They are found throughout Mexico, the western United States, and northern South America (Wiederholt et al 2014). Maternity colonies are formed in caves, abandoned mines, old wells, hollow trees, under bridges, and in buildings (Texas Parks and Wildlife 2014).

Males generally form small colonies farther north, although a colony in Colorado has an estimated population of as many as 250,000 individuals. This species seems confined to the southern half of Colorado. Previously the Brazilian free-tailed bat was considered only a wanderer in Colorado, but it is now known to be a summer resident. This bat does not hibernate in Colorado (Colorado Bat Working Group 2014). The species winters in central and southern Mexico and migrates north in spring to the southwestern U.S. and northern Mexico (Wiederholt et al. 2014). There may be distinct migratory pathways. Some apparently live to be 15 years old, but most have a considerably shorter life span. Predators include owls, kestrels, various hawks, raccoons, skunks and snakes (Colorado Bat Working Group 2014).

The species roosts in tightly packed groups with winter congregations usually being much smaller than summer colonies. In North America the species breeds in late February-March or early April and births mainly in June-July (NatureServe 2014). Sexes generally segregate during the summer when males form small colonies (but sometimes up to 100,000) at higher elevations and females form nursery colonies in warmer areas of the species' northern range (Genoways et al. 2000; Freeman and Wunder 1988).

Mexican free-tailed bats are primarily insectivores. They hunt their prey using echolocation and typically feed within a 50-mile radius of day roost, but up to 150 miles away (Whitaker 1980). Diet includes moths, flying ants, beetles, bugs, and other insects; the bat often preys on densely swarming insects (NatureServe 2014). Bats usually catch flying prey in flight (McWilliams 2005).

Threats to the Mexican free-tailed bat in the U.S. and Mexico include guano mining, loss of roosting habitat as old buildings are destroyed, human disturbance and vandalism of key roosting sites, intentional destruction of colonies due to an exaggerated fear of rabies, and pesticide poisoning (Wiederholt et al. 2014; Texas Parks & Wildlife 2014). The Mexican free-tailed bat consumes staggering numbers of insects nightly, a large proportion of which are agricultural pests. As a result, organochlorine pesticides have been implicated as important causes of mortality. A population decline in Eagle Creek Cave was documented from over 25 million in 1963 to just 30,000 six years later, and the famous Carlsbad Caverns population, estimated to contain 8.7 million in 1936, had fallen as low as 218,000 by 1973 (Texas Parks & Wildlife 2014). The declining populations in Carlsbad have been linked to pesticide poisoning (Freeman and Wunder 1988; Wiederholt et al. 2014).

The Mexican free-tailed bat was selected as a climate change impact representative for cave-dwelling bats. This species relies on very high densities of prey insects. Temperature and rainfall patterns associated with climate change may cause insect populations to shift, but the cave roosts of the Mexican free-tailed bats cannot shift along with that prey resource (Newson et al. 2009). Ecological attributes and indicators for the Mexican free-tailed bat are provided in Table B.2.7-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the Mexican free-tailed bat may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.7-1). Figures B.2.7-2 through B.2.7-8 show, respectively: Figure B.2.7-2 - the current distribution of potentially suitable Mexican free-tailed bat habitat in the study area; Figure B.2.7-3 – habitat distribution with respect to current vegetation departure; Figure B.2.7-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.7-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.7-6 - habitat distribution with respect to predicted areas of change; Figure B.2.7-7 - predicted trends in Mexican free-tailed bat habitat within the study area; and Figure B.2.7-8 - the aggregate potential for change in Mexican free-tailed bat habitat.

The majority (29%) of vegetation within Mexican free-tailed bat potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.7-3). Areas of potentially suitable habitat with the greatest vegetation departure are located in agricultural and shrubland areas in the San Luis Valley in the center of the study area (Figure B.2.7-3).

The majority (34%) of Mexican free-tailed bat potentially suitable habitat is within areas of high current landscape intactness (Figure B.2.7-4; Figure B.2.7-7). Future trends in landscape intactness indicate a decrease in landscape intactness within Mexican free-tailed bat potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 8% in the near-term (i.e., by 2030) (Figure B.2.7-7).

The majority (60%) of Mexican free-tailed bat potentially suitable habitat is within areas of very low and low current human development intensity (Figure B.2.7-5; Figure B.2.7-7). Future trends in human development indicate an increase in human development intensity within Mexican free-tailed bat potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 8% in the near-term (i.e., by 2030) (Figure B.2.7-6; Figure B.2.7-7).

The majority of Mexican free-tailed bat potentially suitable habitat is within areas of low to moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.7-5; Figure B.2.7-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.7-6; Figure B.2.7-7). Approximately 27% of Mexican free-tailed bat suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.7-7). The greatest potential for future climate change within Mexican free-tailed bat potentially suitable habitat occurs in in the western and northwestern portion of the study area (Figure B.2.7-6).

The majority of Mexican free-tailed bat potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.7-5; Figure B.2.7-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Approximately 85% of Mexican free-tailed bat habitat has low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.2.7-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.7-6).

The majority of Mexican free-tailed bat potentially suitable habitat is within areas of very high current density of invasive species, insects, and disease (Figure B.2.7-5; Figure B.2.7-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of Mexican free-tailed bat potentially suitable habitat in the study area (Figure B.2.7-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, potential energy development, and spread of forest insects and disease (Figure B.2.7-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 36% of the Mexican free-tailed bat suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.7-8). Areas with greatest potential for change within Mexican free-tailed bat suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.7-8).

Table B.2.7-1. Mexican Free-tailed Bat Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Foraging Habitat	Distance to roads	<300m	>300m			Kitzes and Merenlender 2014

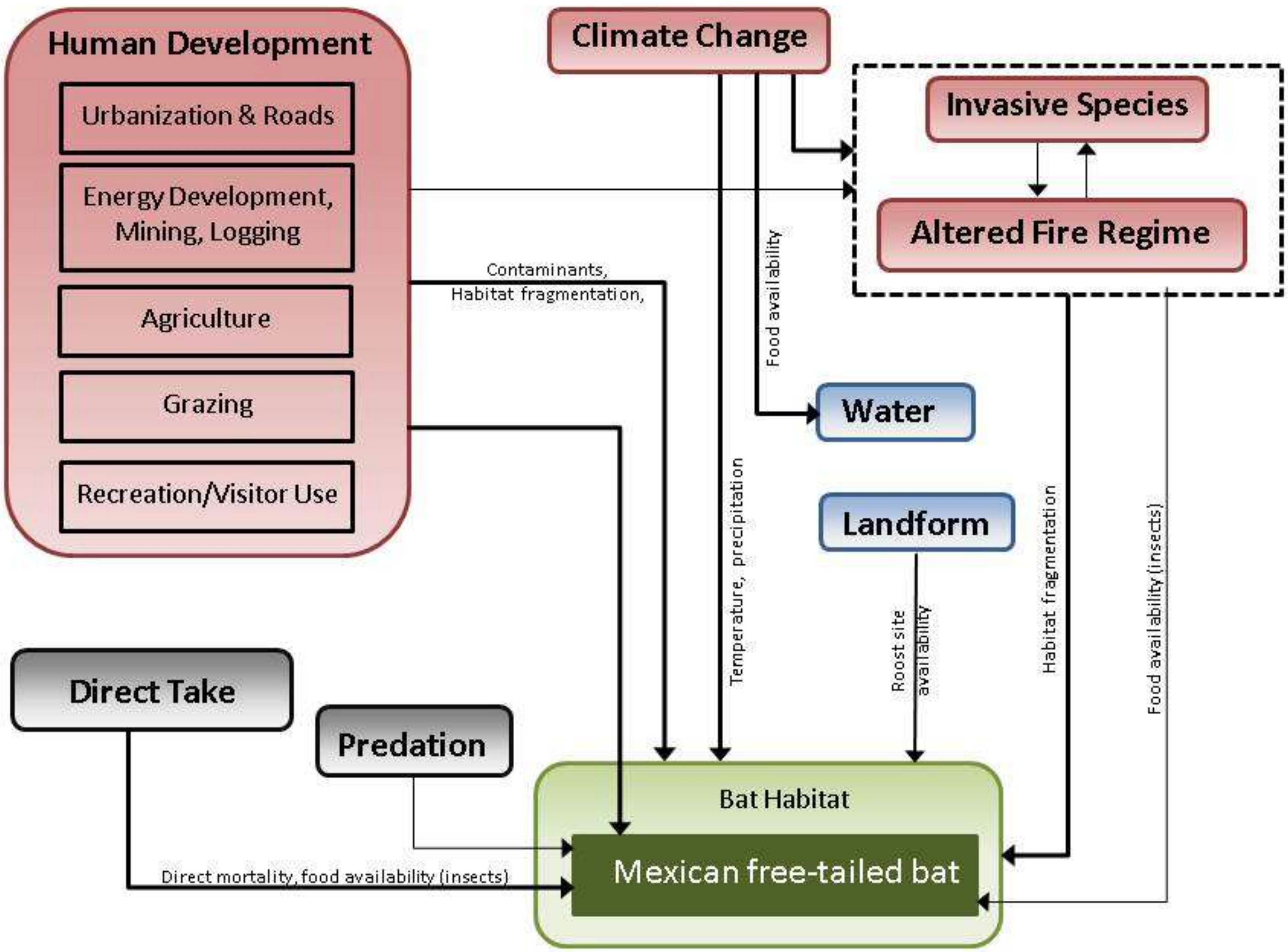


Figure B.2.7-1. Mexican free-tailed bat Conceptual Model.

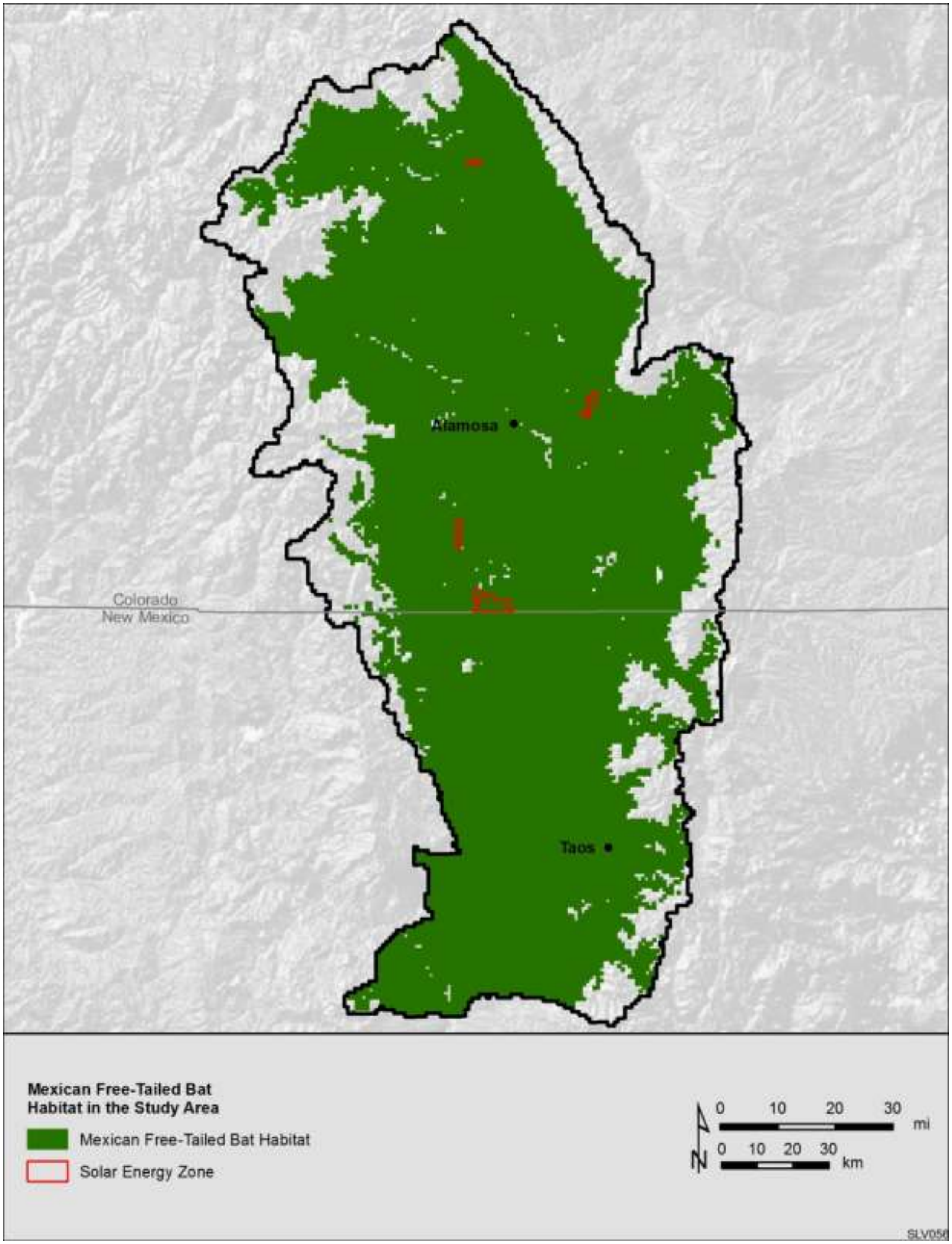


Figure B.2.7-2. Current Distribution of Potentially Suitable Habitat for the Mexican Free-tailed Bat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

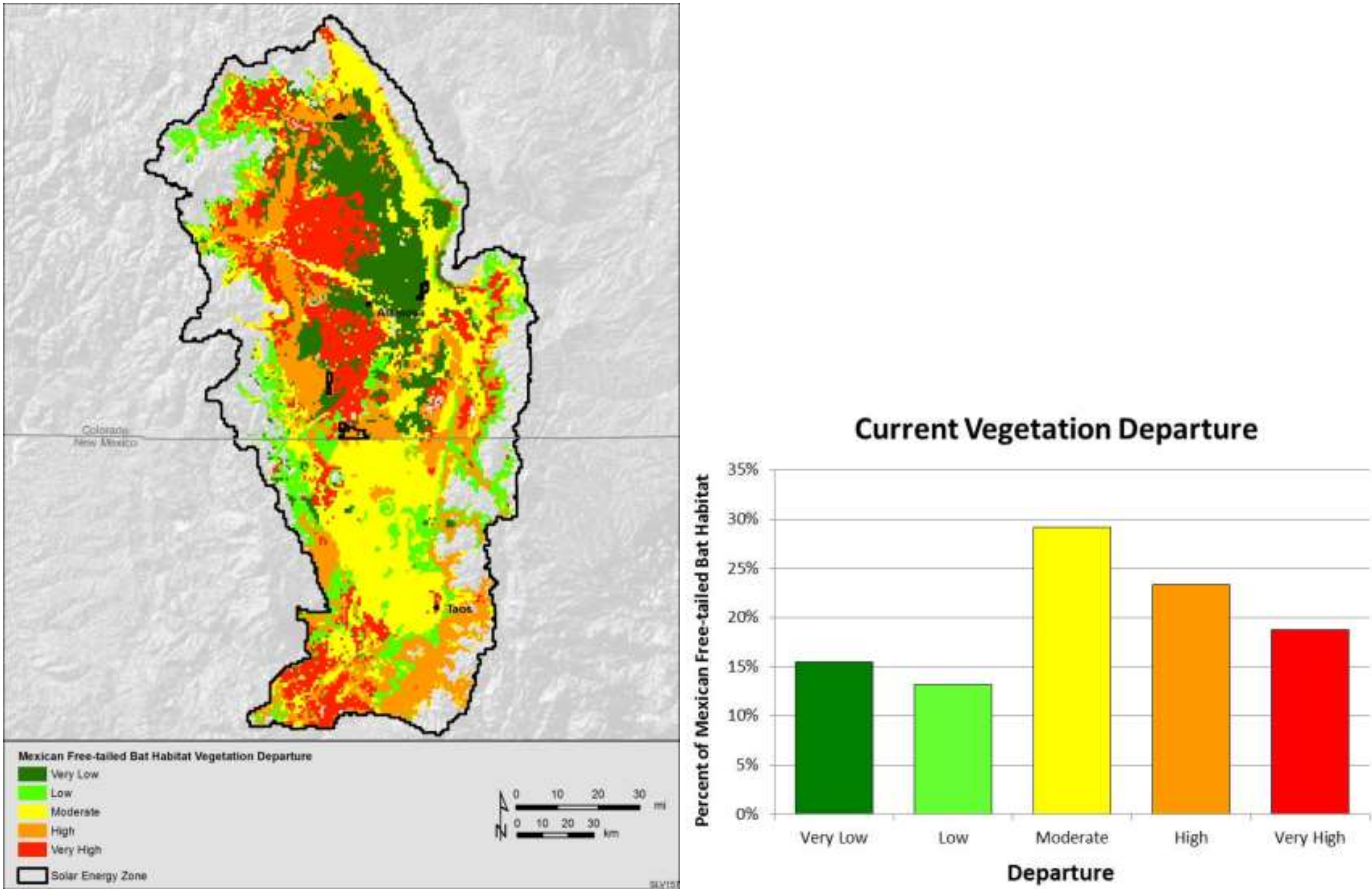


Figure B.2.7-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Mexican Free-tailed Bat Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

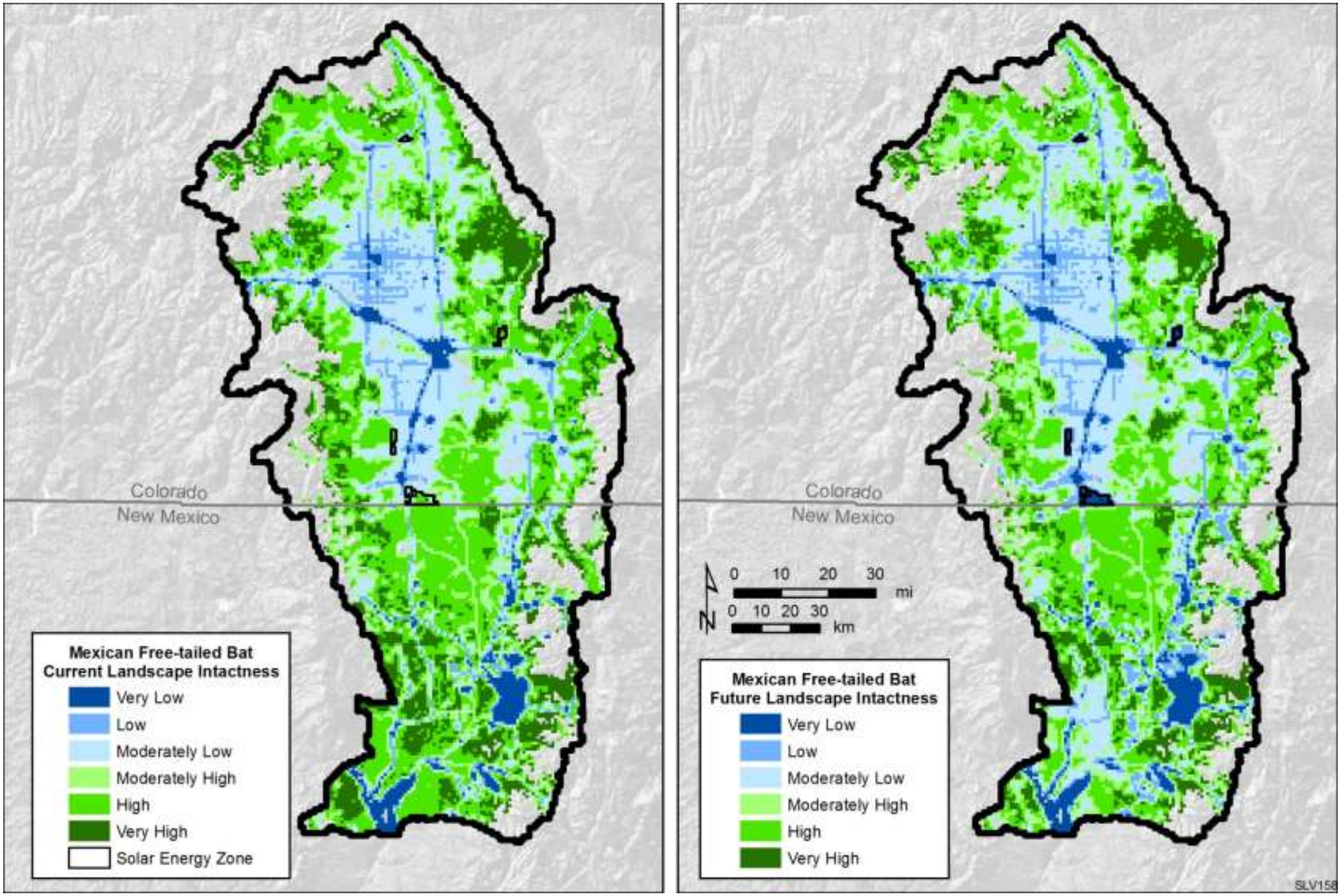


Figure B.2.7-4. Current and Future Landscape Intactness of Potentially Suitable Mexican Free-tailed Bat Habitat. NOTE: This landscape intactness model does not include LANDFIRE Vegetation Departure (VDEP). Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

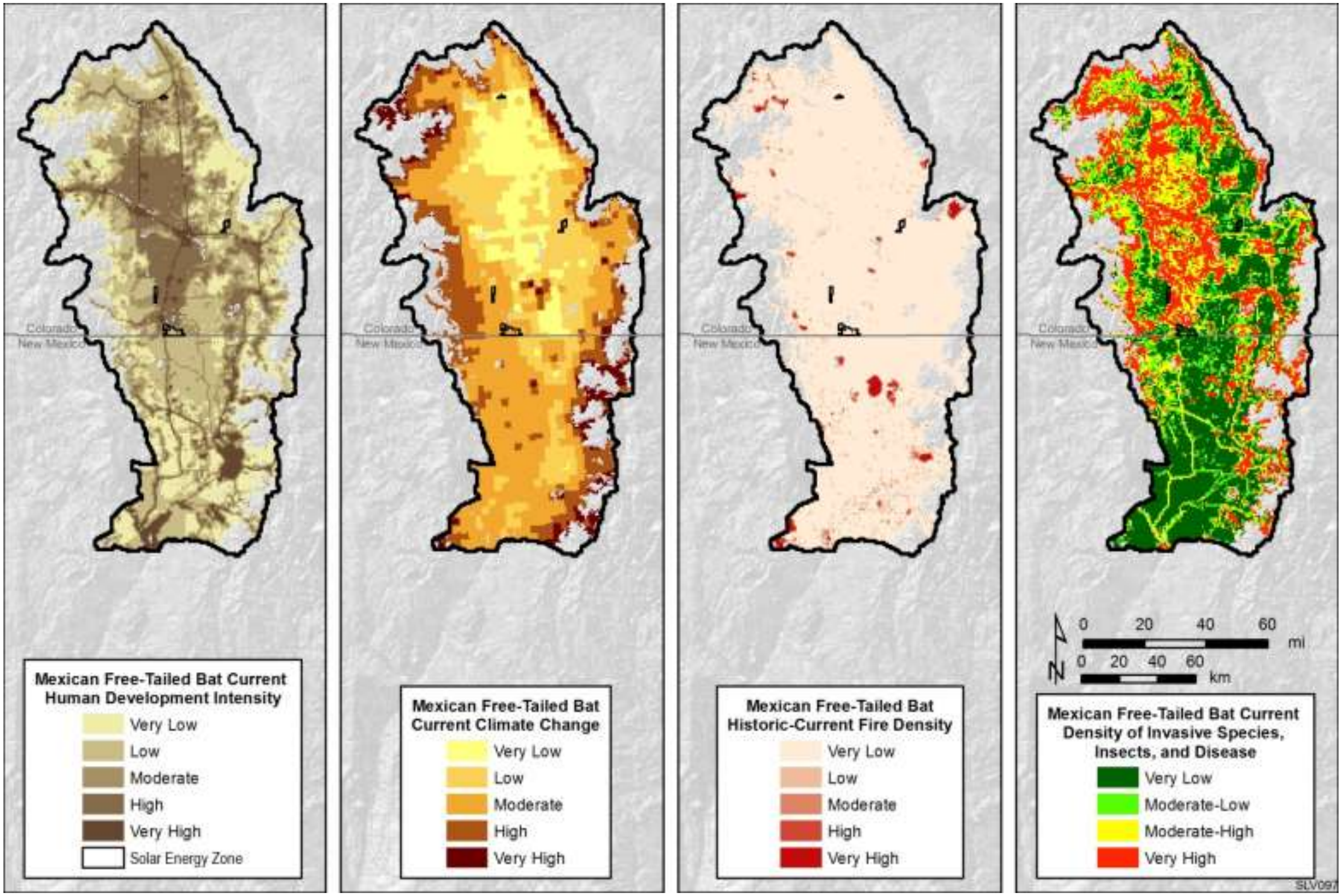


Figure B.2.7-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for Mexican free-tailed bat? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

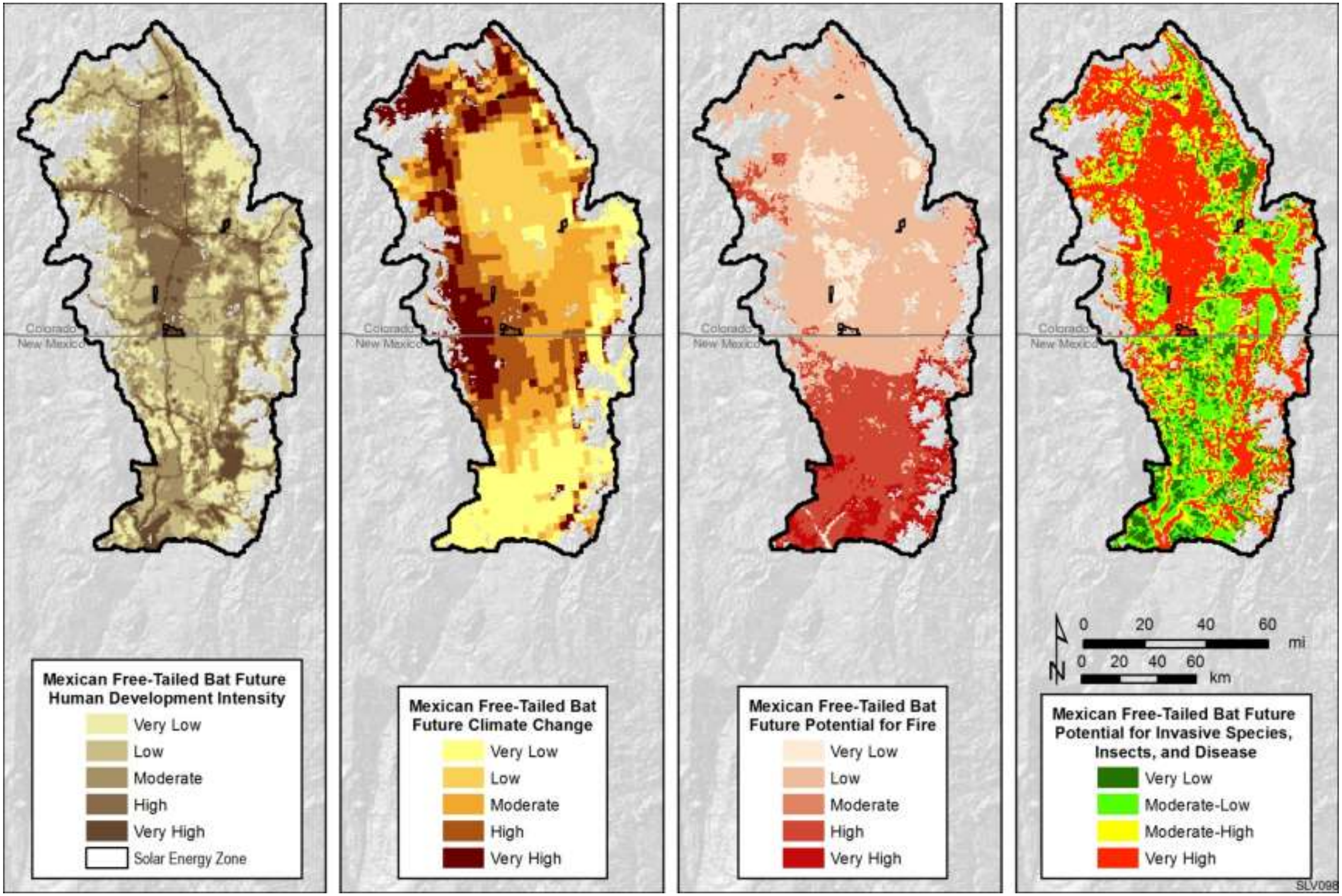


Figure B.2.7-6. Illustration for MQD3: Where is Mexican free-tailed bat vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

Predicted Trends in Mexican Free-Tailed Bat Habitat within the Study Area

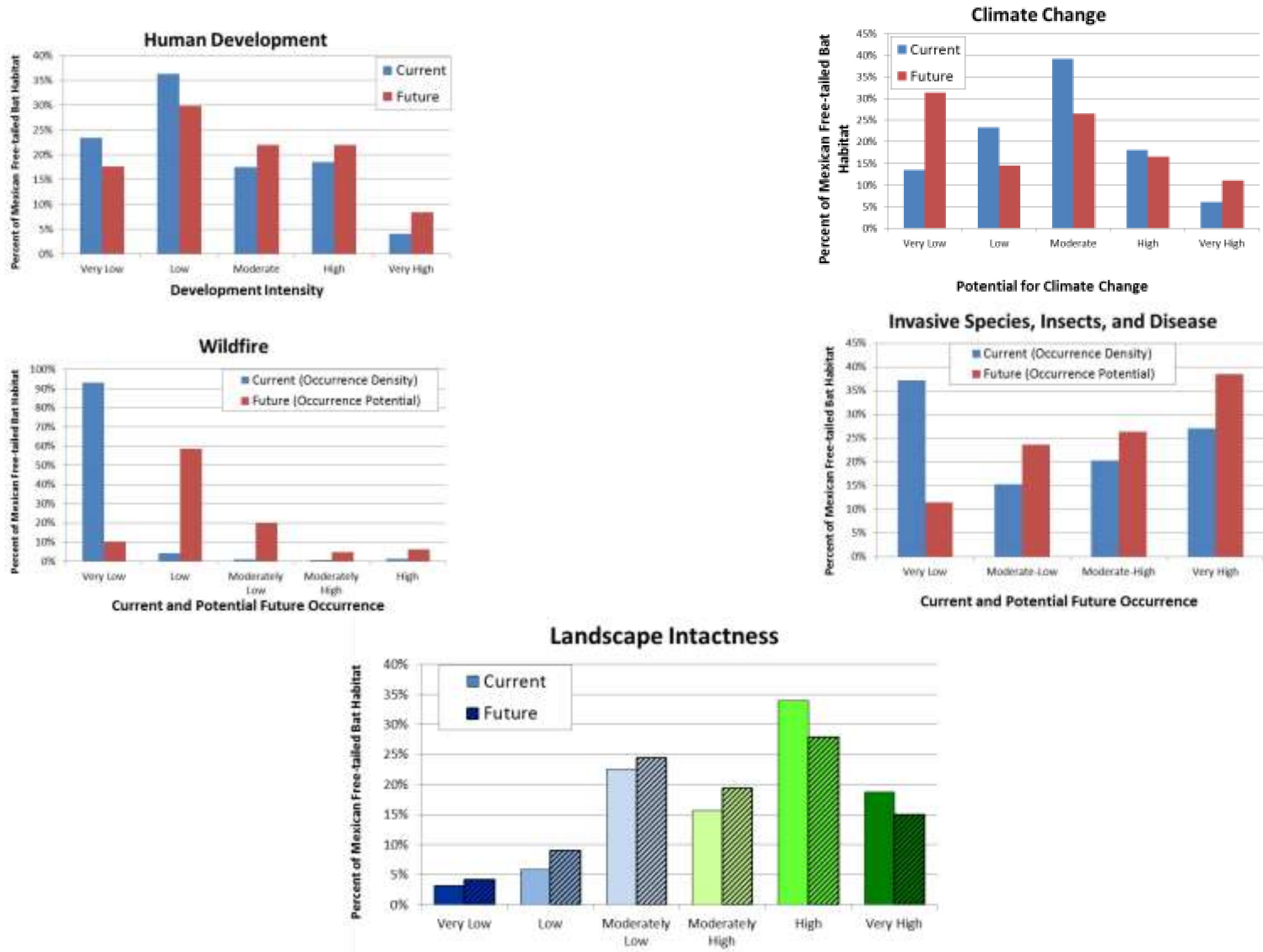


Figure B.2.7-7. Predicted Trends in Mexican Free-tailed Bat Habitat within the Study Area

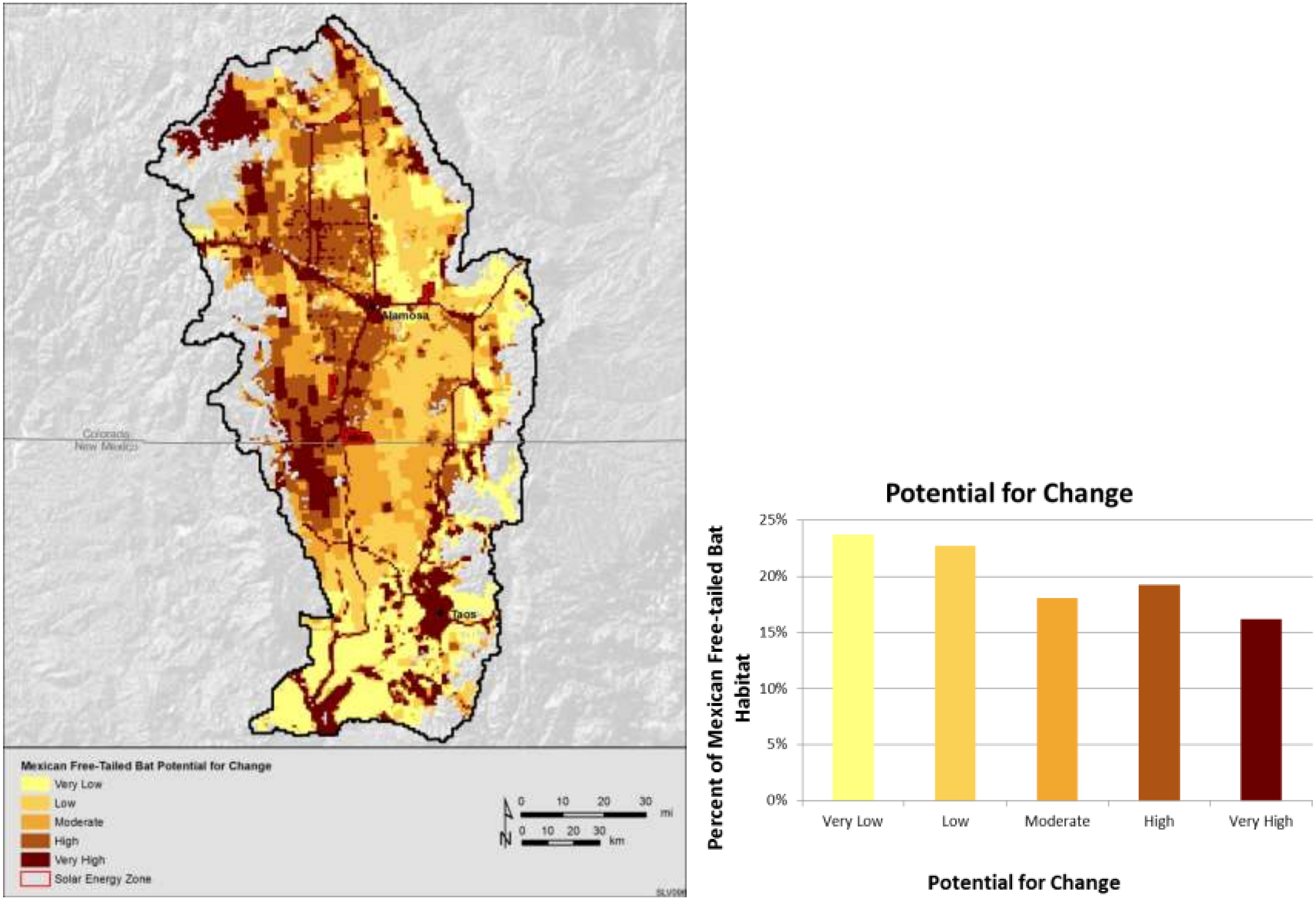


Figure B.2.7-8. Mexican Free-tailed Bat Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.8 Bighorn Sheep

The Rocky Mountain Bighorn Sheep is the largest wild sheep in North America. Rams can weigh over 300 pounds and ewes typically weigh 125-150 pounds. Rams have massive horns tightly curled close to the face. Ewes have smaller horns that curve slightly. The bighorn sheep's keen eyesight, hearing, and sense of smell help it detect and avoid predators. Bighorn sheep are well-equipped for climbing the steep terrain that keeps their predators at bay (National Wildlife Federation 2014; National Bighorn Sheep Center 2014).

Rocky Mountain bighorn sheep are distributed throughout the mountainous regions of western North America from British Columbia and Alberta south to northern New Mexico and central Arizona. Colorado has the largest number of bighorn sheep in the United States. Bighorn sheep are primarily found in open habitats, such as alpine meadows, open grasslands, shrub-steppe, talus slopes, rock outcrops, and cliffs; in some places, however, they may use areas of deciduous and conifer forests, especially where openings may have been created by clear-cuts or fire. Open, steep terrain is an important habitat feature to allow escape from wolves, coyotes, and cougars (Dunn 1996). Bighorn sheep usually stay within 800 meters of escape terrain throughout the year (Pallister 1974). Winter ranges of northern populations are relatively snow-free and bighorns generally avoid snow deeper than 30 centimeters (Stelfox 1975). Many populations migrate seasonally, some moving a few hundred meters up or down a mountainside and others going 10-20 km from one mountain range to another. Some males make much longer migrations. Males and females live apart except during the mating season (Whiting et al. 2010). Ewes usually give birth to one lamb, in May.

As ruminants, grass-eating bighorn sheep have a complex four-part stomach that enables them to eat large portions rapidly before retreating to cliffs or ledges where they can thoroughly re-chew and digest their food, safe from predators. The sheep also absorb moisture during this digestive process, enabling them to go for long periods without water (National Wildlife Federation 2014). Diet changes seasonally. Access to mineral licks may be important for Rocky Mountain and desert bighorns, especially in spring (Shackleton et al. 1999, Krausman et al. 1999).

From the late 1800's through the mid-1900's, bighorn sheep populations experienced significant declines across their range and many herds were extirpated as a result of diseases introduced from domestic livestock, unregulated and market hunting, habitat loss, and competition from domestic livestock (Beecham et al. 2007; Dunn 1996; Valdez and Krausman 1999). Reintroductions and transplants helped reestablish populations where bighorn sheep were extirpated (Smith et al. 2014). Bighorn sheep are currently at 10 percent of historic numbers, but they are considered somewhat secure throughout much of their range. Bighorn sheep populations in Colorado, Wyoming, and South Dakota are considered secure (Beecham et al. 2007). The estimated 2007 Colorado statewide, post hunt Rocky Mountain bighorn sheep population was 7,040 in 79 herds (Colorado Division of Wildlife 2009).

Bighorn sheep are ecologically fragile because their habitat is limited and fragmented (Valdez and Krausman 1999; Whiting 2010). This makes bighorn sheep vulnerable to the effects of unregulated hunting and the transmission of disease (such as pneumonia and scabies) from domestic sheep introduced in the mid-19th century. Competition can also occur between bighorn sheep and other wild ungulates, such as mountain goats, mule deer, and elk. This competition can result from dietary overlap and can cause bighorn sheep to be displaced from preferred habitat (Colorado Division of Wildlife 2009). Plant community succession and forestation of native ranges, and increasing human development of winter ranges have also been identified as contributing to bighorn sheep declines. Bighorn sheep managers generally agree that bacterial pneumonia (also called "pasteurellosis") is the main reason for Rocky Mountain bighorn sheep population declines across much of the west in recent decades (Colorado

Division of Wildlife 2009). Ecological attributes and indicators for the bighorn sheep are provided in Table B.2.8-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the bighorn sheep may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.8-1). Figures B.2.8-2 through B.2.8-8 show, respectively: Figure B.2.8-2 - the current distribution of potentially suitable bighorn sheep habitat in the study area; Figure B.2.8-3 – habitat distribution with respect to current vegetation departure; Figure B.2.8-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.8-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.8-6 - habitat distribution with respect to predicted areas of change; Figure B.2.8-7 - predicted trends in bighorn sheep habitat within the study area; and Figure B.2.8-8 - the aggregate potential for change in bighorn sheep habitat.

The majority (30%) of vegetation within bighorn sheep potentially suitable habitat has a high degree of departure from historic reference vegetation conditions (Figure B.2.8-3). Areas of potentially suitable habitat with the greatest vegetation departure are located in the Rio Grande National Forest in the northern portion of the study area (Figure B.2.8-3).

The majority (80%) of bighorn sheep potentially suitable habitat is within areas of high and very high current landscape intactness (Figure B.2.8-4; Figure B.2.8-7). Future trends in landscape intactness indicate a decrease in landscape intactness within bighorn sheep potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 12% in the near-term (i.e., by 2030) (Figure B.2.8-7).

The majority (85%) of bighorn sheep potentially suitable habitat is within areas of very low and low current human development intensity (Figure B.2.8-5; Figure B.2.8-7). Future trends in human development indicate an increase in human development intensity within bighorn sheep potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 6% in the near-term (i.e., by 2030) (Figure B.2.8-6; Figure B.2.8-7).

The majority of bighorn sheep potentially suitable habitat is within areas of moderate and high current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.8-5; Figure B.2.8-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.8-6; Figure B.2.8-7). Approximately 40% of bighorn sheep suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.8-7). The greatest potential for future climate change within bighorn sheep potentially suitable habitat occurs in in the western and northwestern portion of the study area (Figure B.2.8-6).

The majority of bighorn sheep potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.8-5; Figure B.2.8-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Over 75% of bighorn sheep habitat has low or moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.2.8-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.8-6).

The majority of bighorn sheep potentially suitable habitat is within areas of very high current density of invasive species, insects, and disease (Figure B.2.8-5; Figure B.2.8-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of bighorn sheep potentially suitable habitat in the study area (Figure B.2.8-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of potential energy development and spread of forest insects and disease (Figure B.2.8-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 32% of the bighorn sheep suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.8-8). Areas with greatest potential for change within bighorn sheep suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.8-8).

Table B.2.8-1. Rocky Mountain Bighorn Sheep Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat quality	Cover & terrain	Forest/thick brush; lack of precipitous escape terrain			Visually open with steep, rocky slopes	Sierra Nevada Bighorn Sheep Foundation; Beecham et al. 2007
Disease	Proximity to domestic livestock				A minimum of 13.5 km between sheep & domestic livestock	Beecham et al, 2007; Singer et al, 2001
Habitat quality	Habitat fragmentation	Increased human disturbance			Little to no human disturbance	Beecham et al, 2007; King and Workman 1985
Climate	Effect on vegetation	Higher temperatures - decreased precipitation			Normal to higher levels of rainfall	Beecham et al, 2007

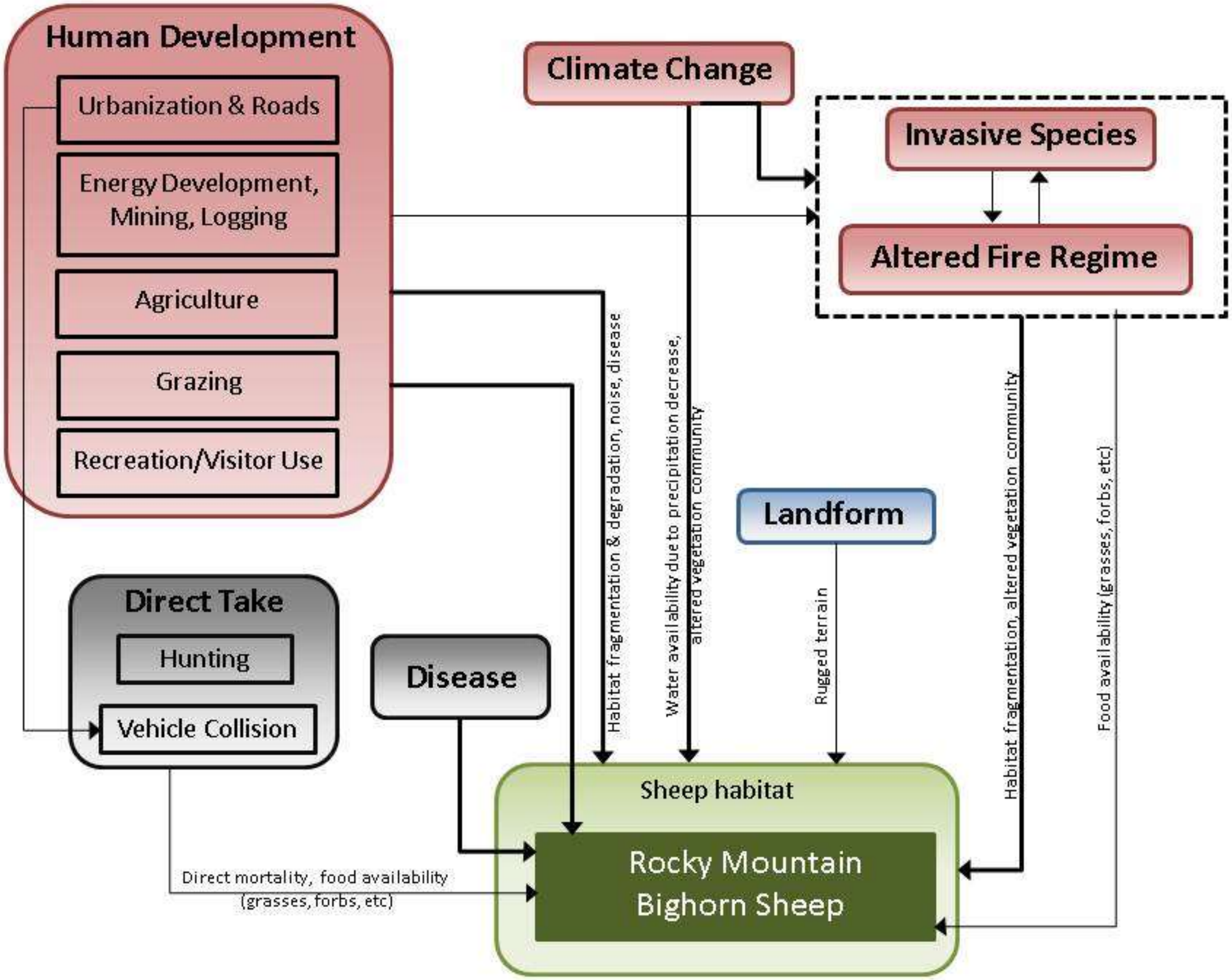


Figure B.2.8-1. Rocky Mountain Bighorn Sheep Conceptual Model.

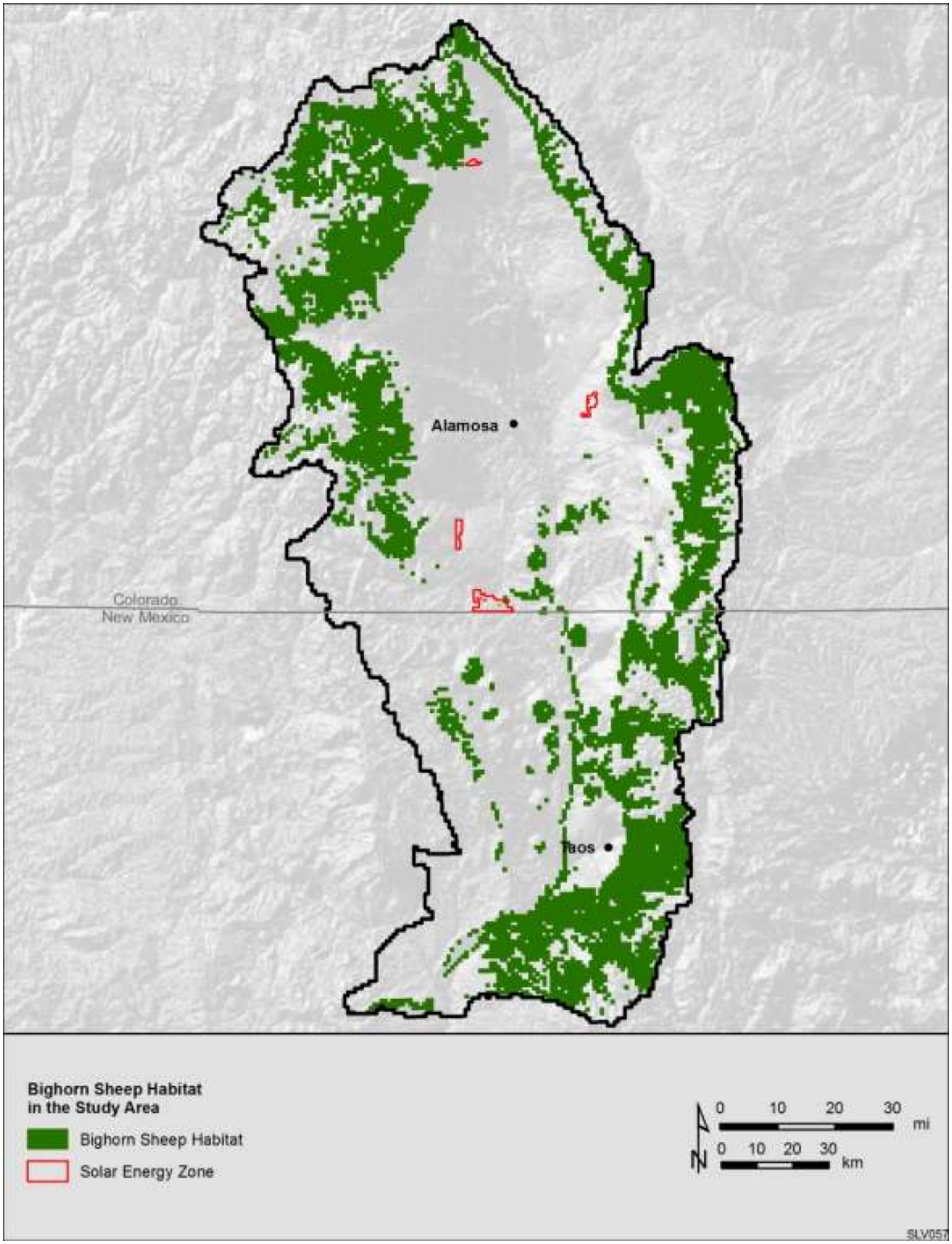


Figure B.2.8-2. Current Distribution of Potentially Suitable Habitat for the Bighorn Sheep. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Note: Data include only potentially suitable habitat and do not directly represent movement corridors and seasonal ranges, which are evaluated separately.

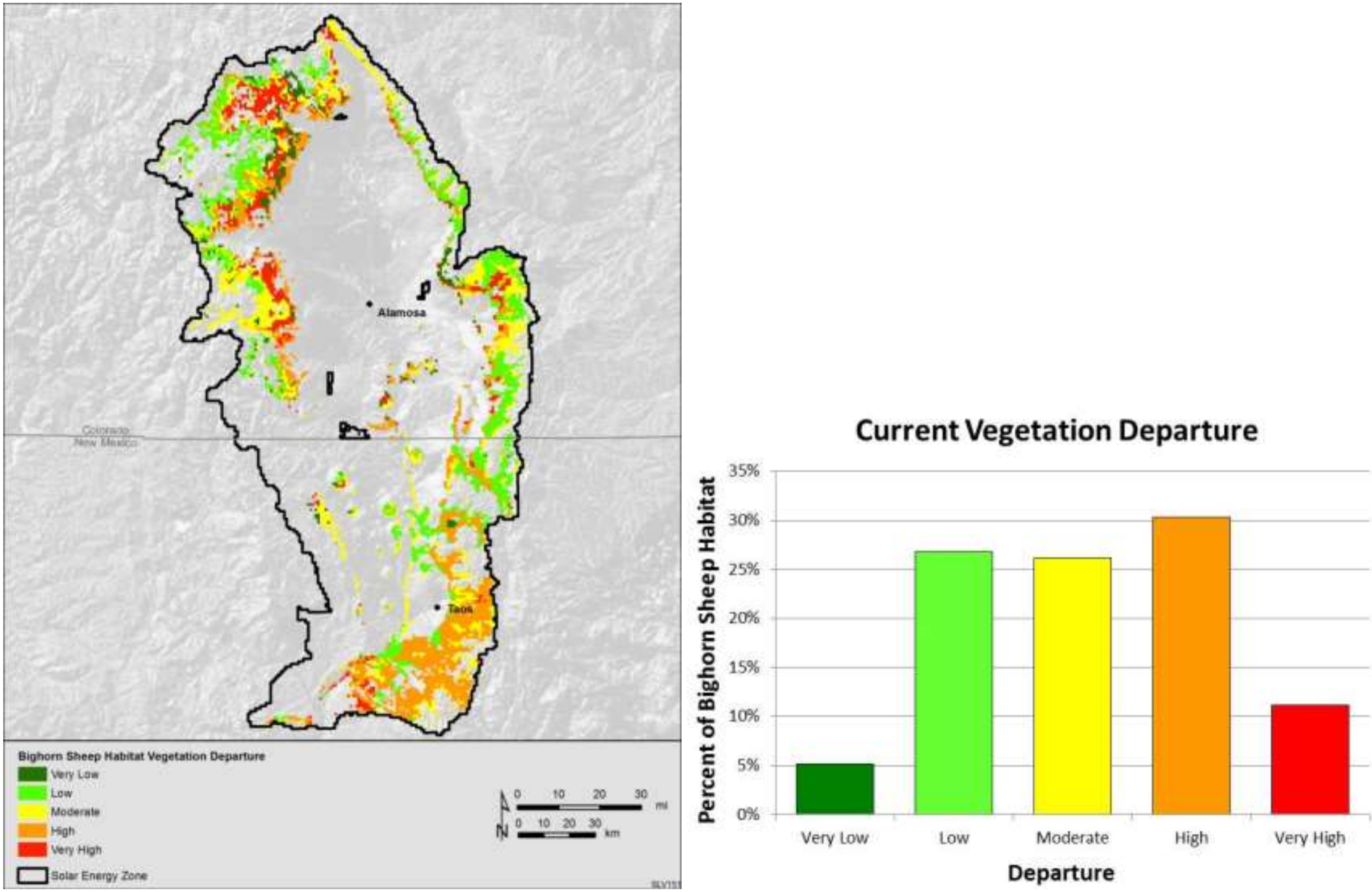


Figure B.2.8-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Bighorn Sheep Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

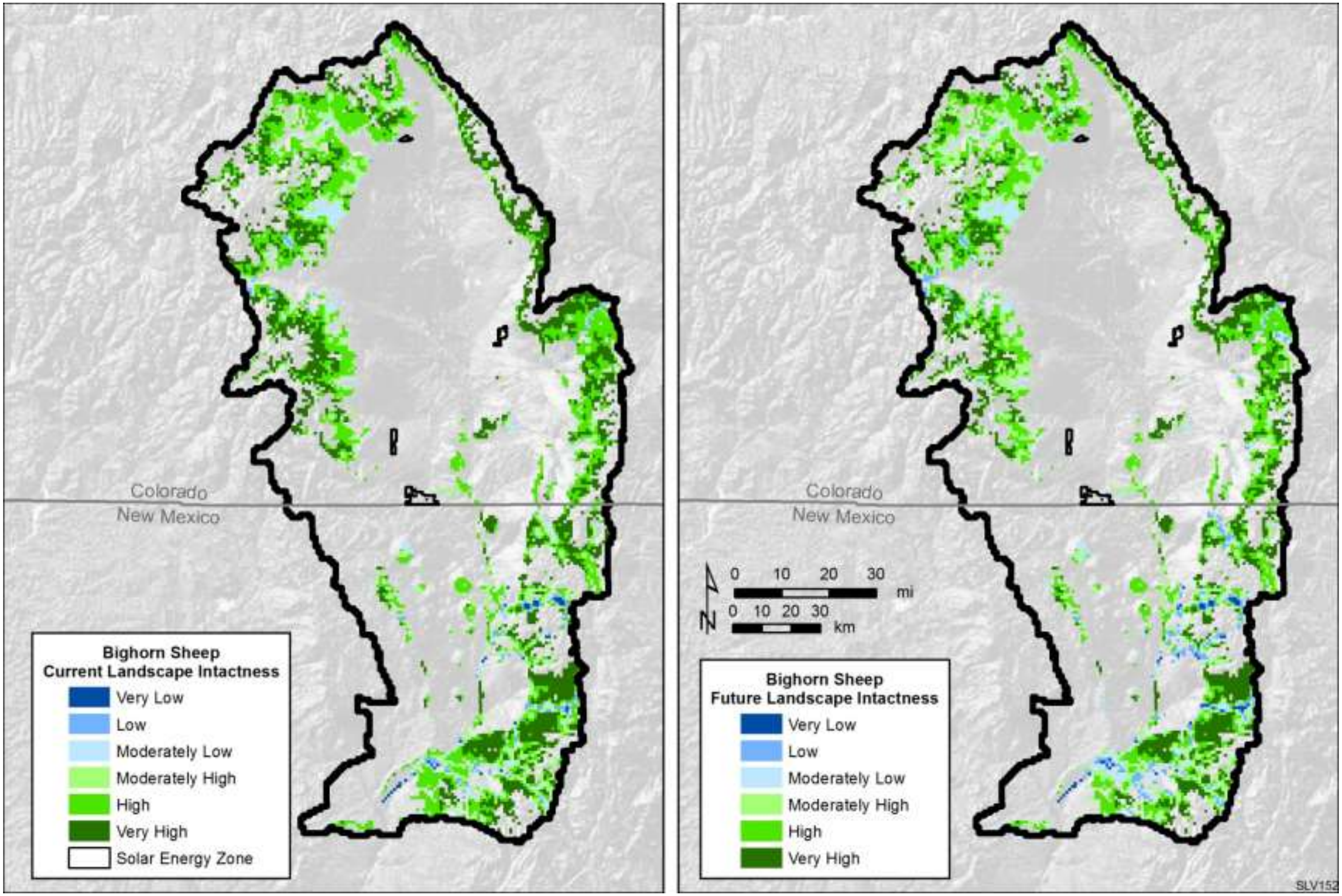


Figure B.2.8-4. Current and Future Landscape Intactness of Potentially Suitable Bighorn Sheep Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

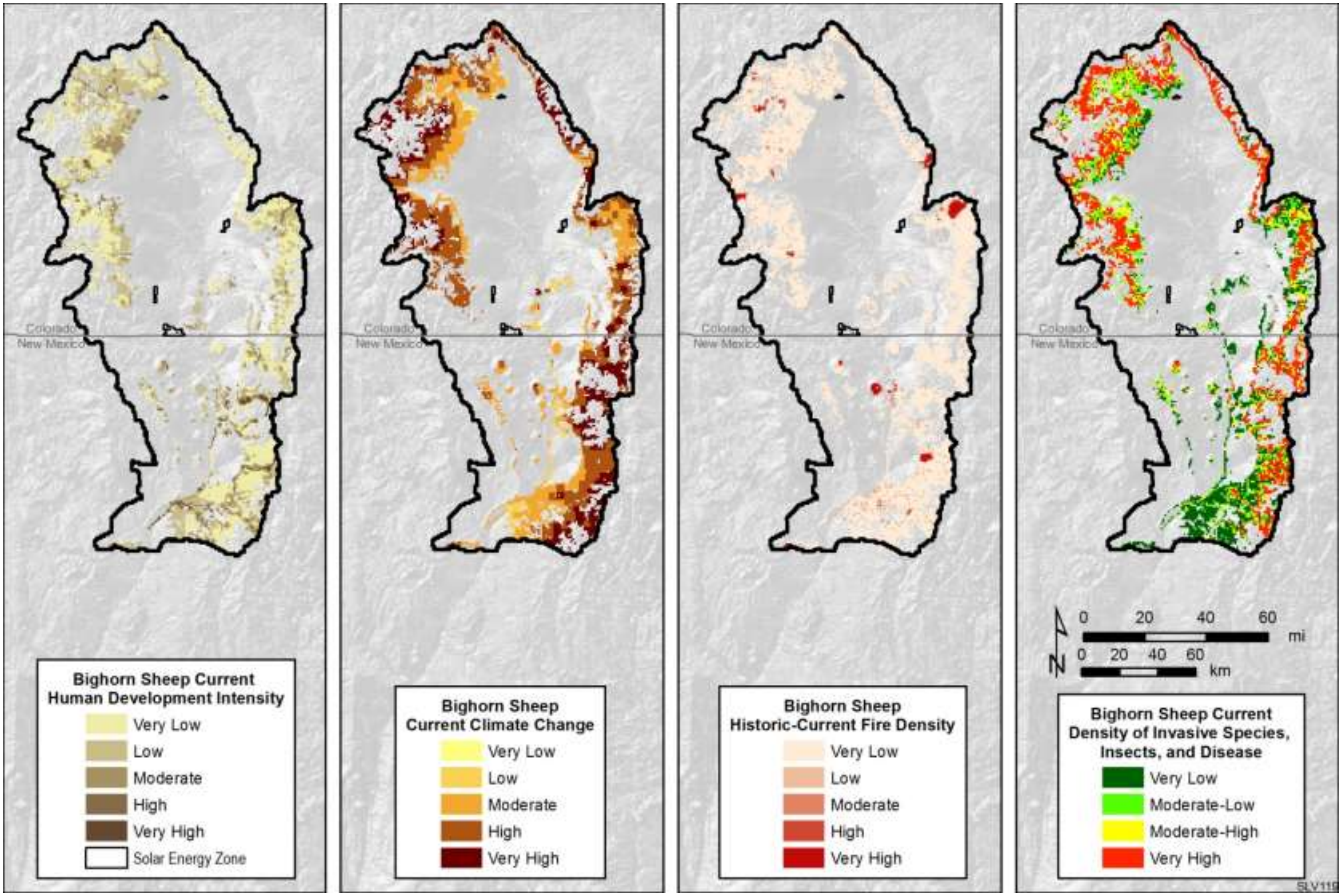


Figure B.2.8-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for bighorn sheep? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

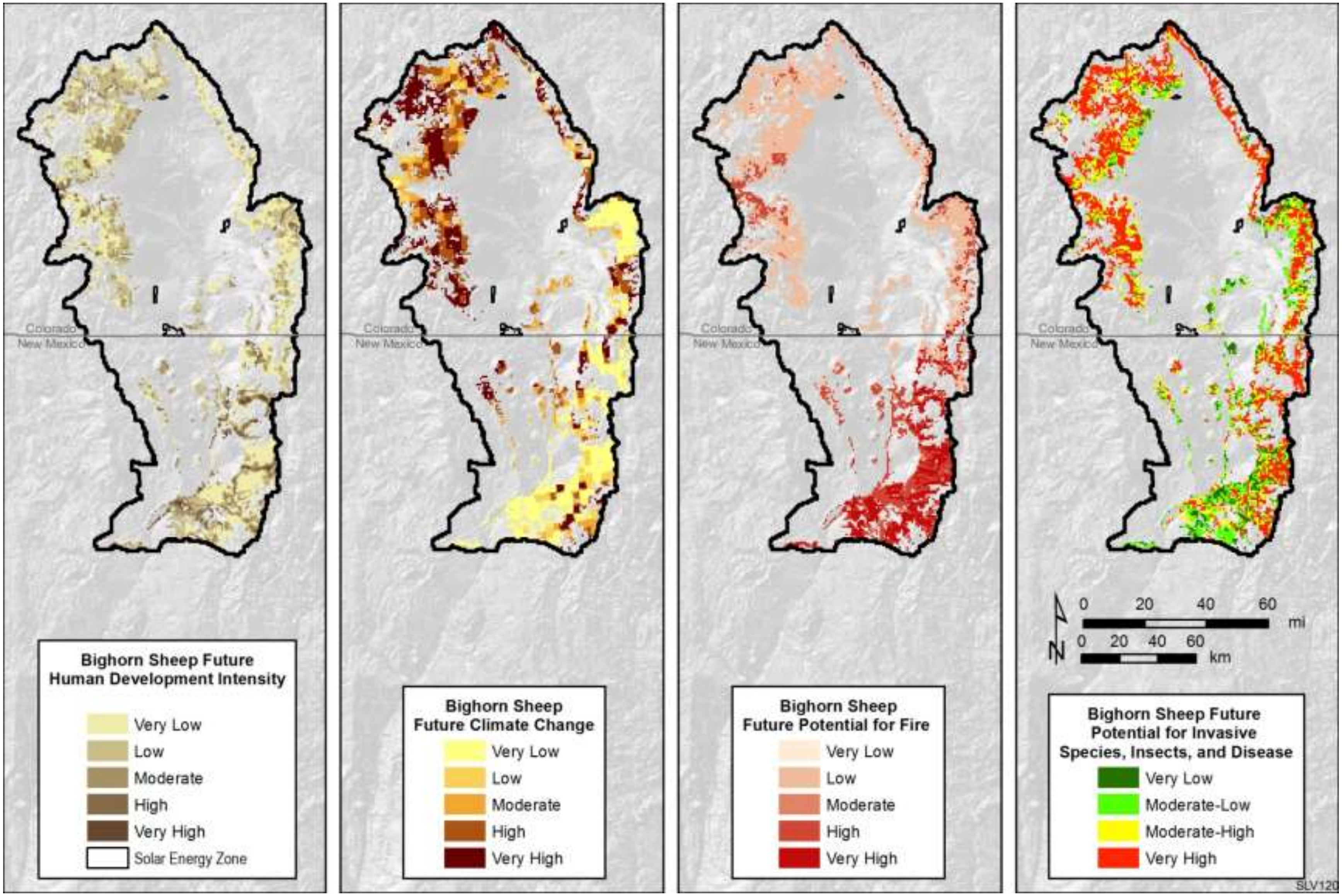


Figure B.2.8-6. Illustration for MQD3: Where are bighorn sheep vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

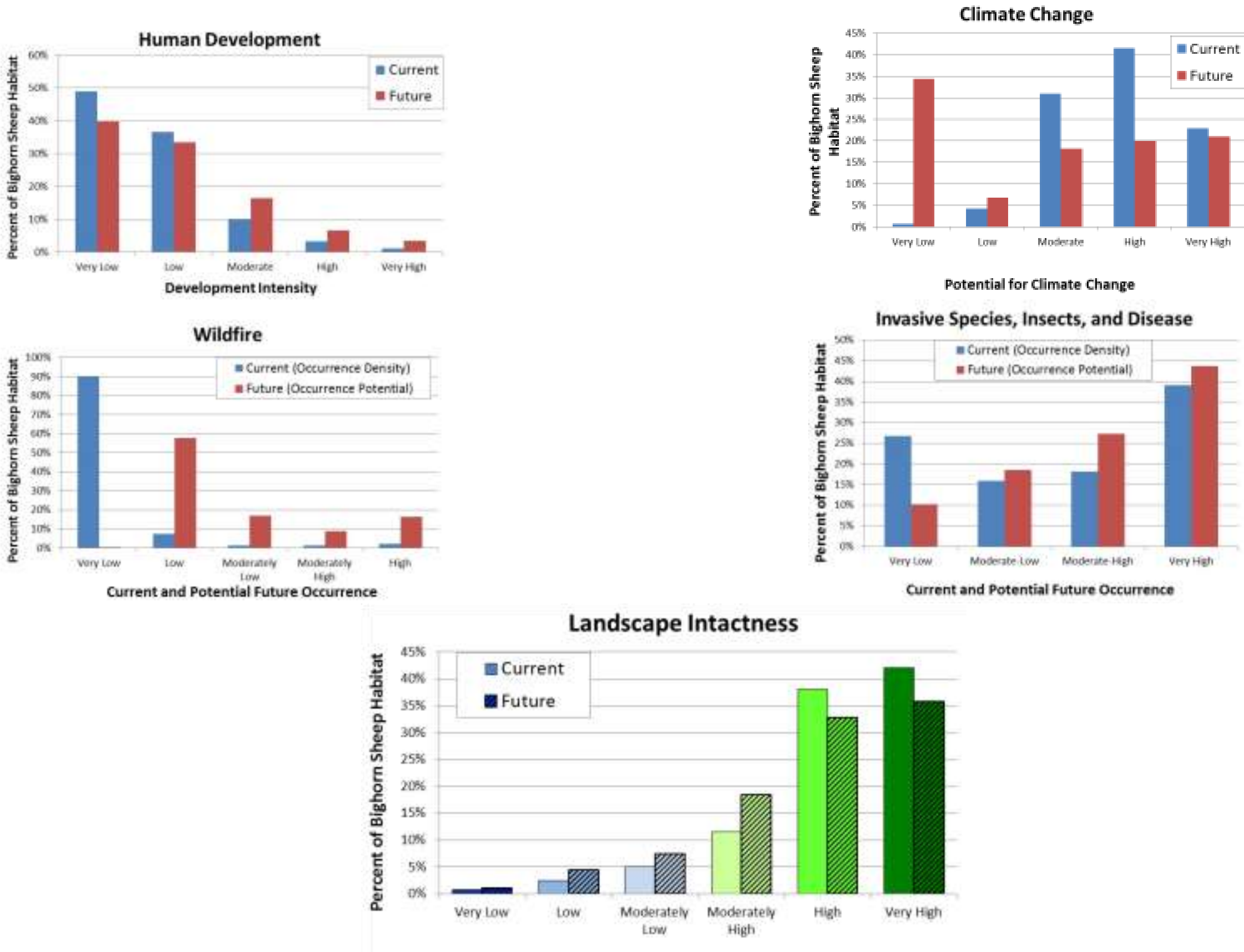
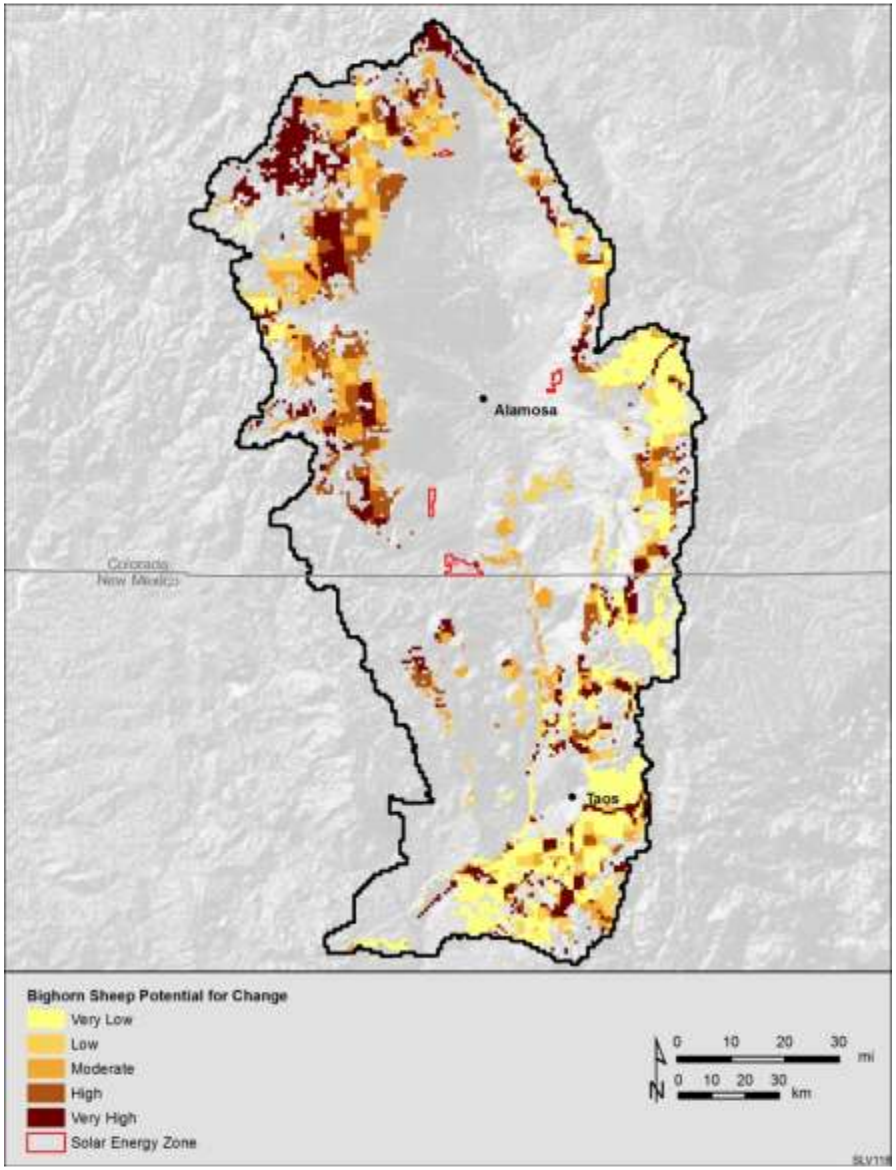


Figure B.2.8-7. Predicted Trends in Bighorn Sheep Habitat within the Study Area



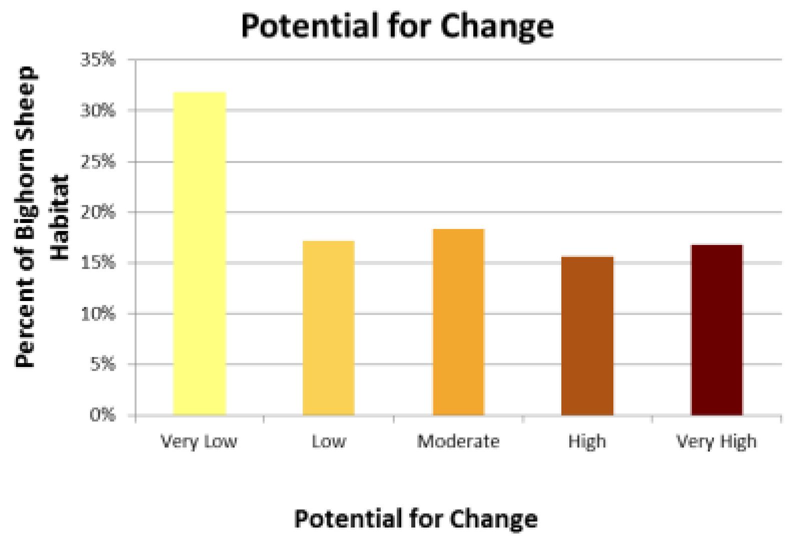


Figure B.2.8-8. Bighorn Sheep Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.9 Grassland Fauna Assemblage

The grassland fauna assemblage considered for this Landscape Assessment includes species that predominantly inhabit the grassland and shrubland communities within the study area. Species included in this assemblage are the burrowing owl, mountain plover, Gunnison's prairie dog, and swift fox. The burrowing owl (*Athene cunicularia*) is a BLM Sensitive Species in Colorado and New Mexico. The species is typically associated with prairie dog colonies and heavily grazed mixed-grass prairie. The burrowing owl is a permanent resident in the southern half of New Mexico and a breeding resident in northern New Mexico as well as the entire state of Colorado (Cornell Lab of Ornithology 2015). In Colorado, the species occurs on the eastern plains, intermountain parks and valleys, and western portions of the State in the vicinity of Cortez and Grand Junction (Kingery 1998). Habitat typically consists of desert shrublands and grasslands with sparse vegetation and abundant burrows (Kingery 1998). The species arrives in Colorado in late March or early April and begins nesting by late April (Kingery 1998). The breeding season is typically from March 15 through August 15. Burrowing owls nest in rodent burrows in areas with sparse vegetation. Several nesting records have been recorded in the San Luis Valley (Kingery 1998). Nests are in abandoned burrows, such as those dug by prairie dogs. Burrowing owl habitat use in the vicinity of the BLM solar energy zones (SEZs) in the San Luis Valley is shown in Table B.2.9-1.

The mountain plover (*Charadrius montanus*) is a BLM Sensitive Species in Colorado. The species inhabits short-grass prairies and shrub-steppe areas in the western Great Plains and the Colorado Plateau (Knopf 1996). Prime breeding habitat consists of short grasses and shrub vegetation <8 cm tall with a substantial portion of bareground (Graul 1975, Knopf and Miller 1994, Knopf 1996, Manning and White 2001). Because grazing helps maintain short vegetation structure, mountain plover breeding areas are often associated with prairie dog colonies (Knowles et al. 1982, Dinsmore et al. 2003) and livestock (Knopf and Miller 1994, Knopf 1996). The mountain plover breeding range includes the eastern half of Colorado and northern New Mexico (Cornell Lab of Ornithology 2015). In Colorado, mountain plovers are found on the eastern plains and intermountain parks and valleys including North Park, South Park, and the San Luis Valley (Kingery 1998). Breeding habitat in the San Luis Valley is semi-desert shrublands that are flat and sparsely vegetated with stunted shrubs and widely spaced dwarf rabbitbrush (Kingery 1998). This species generally arrives on breeding grounds from mid-March through mid-April and nests typically are in a slight depression on bare or open ground (Kingery 1998). An average clutch of three eggs is typically laid in May. Mountain plovers typically migrate from their breeding grounds to wintering grounds, which range from Texas to southern California, from early August to late September (Kingery 1998). Mountain plover habitat use in the vicinity of the BLM SEZs in the San Luis Valley is shown in Table B.2.9-1.

The Gunnison's prairie dog (*Cynomys gunnisoni*) is a BLM Sensitive Species in New Mexico and Colorado. The species occupies a small range in Colorado and New Mexico. The montane portion of the range is generally described as the San Luis Valley, Gunnison Basin, and South Park in Colorado, extending south into north-central New Mexico (Seglund and Schnurr 2010). The montane habitat of Gunnison's prairie dog in central and south-central Colorado and north-central New Mexico consists primarily of grass/forb/shrub (sagebrush, rabbitbrush, and/or greasewood) habitats, including abandoned cultivated land, on valley floors and in stream valleys and mountain meadows, on high-elevation plateaus and benches, and in intermountain valleys (NatureServe 2014, USFWS 2008). The species typically burrows on slopes or in hummocks and prefers elevations of 1,550–3,660 meters (Longhurst 1944, Pizzimenti and Hoffman 1973, Linzey et al. 2008). They require well drained, deep soils for burrow construction and, because the species hibernates, they rely on placement of hibernacula below the frost line (Linzey et al. 2008). Grasses are the species' most important food item but the species also consumes forbs, insects, and shrubs (Shalaway and Slobodchikoff 1988, Linzey et al. 2008). Gunnison's prairie dog habitat use in the vicinity of the BLM SEZs in the San Luis Valley is shown in Table B.2.9-1.

The swift fox (*Vulpes velox*) is a BLM Sensitive Species in Colorado. The species inhabits grasslands and shrublands in southern and eastern Colorado. In northeastern Colorado, it is most numerous in areas with relatively flat to gently rolling topography. However, habitat for the species in the southeastern portion of the state is more diverse (CPW 2014). The species also inhabits areas of mixed agricultural use where there are low human population densities. Prairie dog towns have been noted as preferred habitat for swift fox (USFWS 2014e). The swift fox spends a large portion of its time underground in dens, which may be excavated by the swift fox or may be old badger holes or prairie dog burrows. The swift fox was not previously known to inhabit the San Luis Valley – Taos Plateau study area until 2012 when several swift fox were observed in Colorado near the Antonito Southeast SEZ (CPW 2013a; Harvey 2012). Since that time, swift fox have been observed to utilize shrubland habitats in the vicinity of the Antonito Southeast and Los Mogotes East SEZs (Table B.2.9-1).

Primary threats to these four species that comprise the grassland fauna assemblage relate to habitat loss and fragmentation associated with human activities. Range-wide, burrowing owl populations are suspected of declining and its range has been contracting southward and westward for at least 30 years (Klute et al. 2003; Poulin et al. 2011). A threat to colonies of Gunnison's prairie dog is their high susceptibility to outbreaks of plague (USFWS 2008). Specifically, sylvatic plague is a bacterial disease transferred by fleas and is a serious mortality threat to the prairie dog (Rocke 2011). The sylvatic plague is not native to North America and prairie dogs seem to be particularly susceptible to the disease and suffer very high mortality rates, up to 90% during outbreaks (Rocke 2011, Linzey et al. 2008). Although poisoning of Gunnison's prairie dogs and the effects of climate change in the montane portion of the range were regarded as issues important to monitor, USFWS (2008) concluded that aside from plague "no other natural or manmade factors are a significant threat to this species, at this time, throughout all or a significant portion of its range". Like other carnivorous mammals, swift foxes face threats from human trapping, hunting, and poisoning (USFWS 2014e). Although the swift fox is not federally listed as threatened or endangered, it is currently found in less than 40% of its historic range (USFWS 2014e).

Prairie dog towns are important to many vertebrate species of concern (e.g. black-footed ferrets, bald eagles, ferruginous hawks, and burrowing owls) and influence mammal, herptile, and avian community structure (Lomolino and Smith, 2003; Smith and Lomolino, 2004). This is of conservation concern because the diversity of animals at the base of the food web has the potential for a bottom-up contribution to ecosystem function, and the diversity of taxa at higher levels may be mediated by prairie dog engineering. As such, it has been previously recommended that actions to conserve burrowing owls and mountain plovers should incorporate land management to benefit prairie dogs (Tipton et al. 2008). Mountain plovers and burrowing owls highly depend on prairie dog colonies for nesting and breeding habitat. Mountain plovers also benefit from the shorter vegetation which allows them to spot predators more easily while foraging for insects which are also made more plentiful by the presence of the prairie dogs. Burrowing owls use their burrows for nesting and shelter. Ecological attributes and indicators for the grassland fauna assemblage are provided in Table B.2.9-2.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the grassland fauna assemblage may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.9-1). Figures B.2.9-2 through B.2.9-8 show, respectively: Figure B.2.9-2 - the current distribution of potentially suitable habitat in the study area based on the aggregation of SWReGAP habitat suitability models for three species (burrowing owl, mountain plover, and Gunnison's prairie dog) [note: the SWReGAP habitat suitability model for the swift fox does not occur in the study area]; Figure B.2.9-3 – habitat distribution with respect to current vegetation departure; Figure B.2.9-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.9-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.9-6 - habitat distribution with respect to predicted areas of change; Figure B.2.9-7 -

predicted trends in grassland fauna assemblage habitat within the study area; and Figure B.2.9-8 - the aggregate potential for change in grassland fauna assemblage habitat.

The majority (32%) of vegetation within grassland fauna assemblage suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.9-3). Areas of potentially suitable habitat with the greatest vegetation departure are located in agricultural and rural areas of the San Luis Valley in the center of the study area (Figure B.2.9-3).

The majority (77%) of grassland fauna assemblage potentially suitable habitat is within areas of moderately low to high current landscape intactness (Figure B.2.9-4; Figure B.2.9-7). Future trends in landscape intactness indicate a decrease in landscape intactness within grassland fauna assemblage potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 8% in the near-term (i.e., by 2030) (Figure B.2.9-7).

The majority (79%) of grassland fauna assemblage potentially suitable habitat is within areas of low to high current human development intensity (Figure B.2.9-5; Figure B.2.9-7). Future trends in human development indicate an increase in human development intensity within grassland fauna assemblage potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 8% in the near-term (i.e., by 2030) (Figure B.2.9-6; Figure B.2.9-7).

The majority of grassland fauna assemblage potentially suitable habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.9-5; Figure B.2.9-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.9-6; Figure B.2.9-7). Approximately 22% of grassland fauna assemblage suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.9-7). The greatest potential for future climate change within grassland fauna assemblage potentially suitable habitat occurs in in the western and northwestern portion of the study area (Figure B.2.9-6).

The majority of grassland fauna assemblage potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.9-5; Figure B.2.9-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. Approximately 94% of grassland fauna assemblage habitat has very low to moderate near-term future (i.e. by 2030) potential for wildfire (Figure B.2.9-7). The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.9-6).

The majority of grassland fauna assemblage potentially suitable habitat is within areas of very low current density of invasive species, insects, and disease (Figure B.2.9-5; Figure B.2.9-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of grassland fauna assemblage potentially suitable habitat in the study area (Figure B.2.9-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, potential energy development, and spread of forest insects and disease (Figure B.2.9-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 35% of the grassland fauna assemblage suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.9-8). Areas with greatest potential for change within grassland fauna assemblage suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.9-8).

Table B.2.9-1. Grassland Fauna Assemblage Use of the BLM Solar Energy Zones in the San Luis Valley.

Solar Energy Zone	Burrowing Owl	Mountain Plover	Gunnison's Prairie Dog	Swift Fox
Antonito Southeast	No activity noted on the SEZ during 2011 surveys; however, a burrowing owl was seen on the ground 5 mi (8 km) east of the SEZ (SLVPLC 2011). Activity is also noted in the vicinity of the SEZ in New Mexico.	Known to occur within 5 miles of the SEZ in Colorado and New Mexico.	Activity was noted in the western and northern portion of the SEZ during 2011 surveys (SLVPLC 2011). Acitivity is also noted in the vicinity of the SEZ in New Mexico.	An active den was located on the SEZ during 2012 surveys (CPW 2013a; Harvey 2012).
DeTilla Gulch	No activity noted in any portion of the SEZ during 2011 surveys. However, areas around the SEZ remain unsurveyed (SLVPLC 2011).	Activity is not known to occur on or near the SEZ.	Activity was noted in the western portion of the SEZ during 2011 surveys (SLVPLC 2011).	Activity is not known to occur on or near the SEZ.
Fourmile East	No activity noted in any portion of the SEZ during 2011 surveys. However, areas around the SEZ remain unsurveyed (SLVPLC 2011).	Known to occur within 5 miles of the SEZ.	No activity noted in any portion of the SEZ during 2011 surveys. Established colonies are 10 mi (16 km) north of the SEZ (SLVPLC 2011).	Activity is not known to occur on or near the SEZ.
Los Mogotes East	No activity noted on the SEZ during 2011 surveys; however, a burrowing owl nest was found 1.8 mi (2.9 km) north of the SEZ in a Gunnison's prairie dog colony (SLVPLC 2011).	Known to occur within 5 miles of the SEZ.	No activity noted in any portion of the SEZ during 2011 surveys. Established colony occurs 1.8 mi (2.9 km) north of the SEZ (SLVPLC 2011).	Activity near the SEZ was observed during 2012 surveys (CPW 2013a; Harvey 2012).

Table B.2.9-2. Grassland Fauna Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat quality	Elevation	<4,500 ft or >11,000 ft	4,500–5,000 ft or 10,000–11,000 ft	5,000–6,000 ft or 8,500–10,000 ft	6,000–8,500 ft	Longhurst (1944), Pizzimenti and Hoffman (1973)
Disease (Prairie dog)	Sylvatic plague	exposed			No exposure	Linzey et al. (2008)
Habitat quality	Slope	>15%	5–15%	2–5%	0–2%	Fitzgerald and Lechleitner (1974)
Mortality (Burrowing owl)	Distance to roads	<1 km	1 – 2 km	2 – 2.5 km	>2.5 km	Haug et al. (1993)

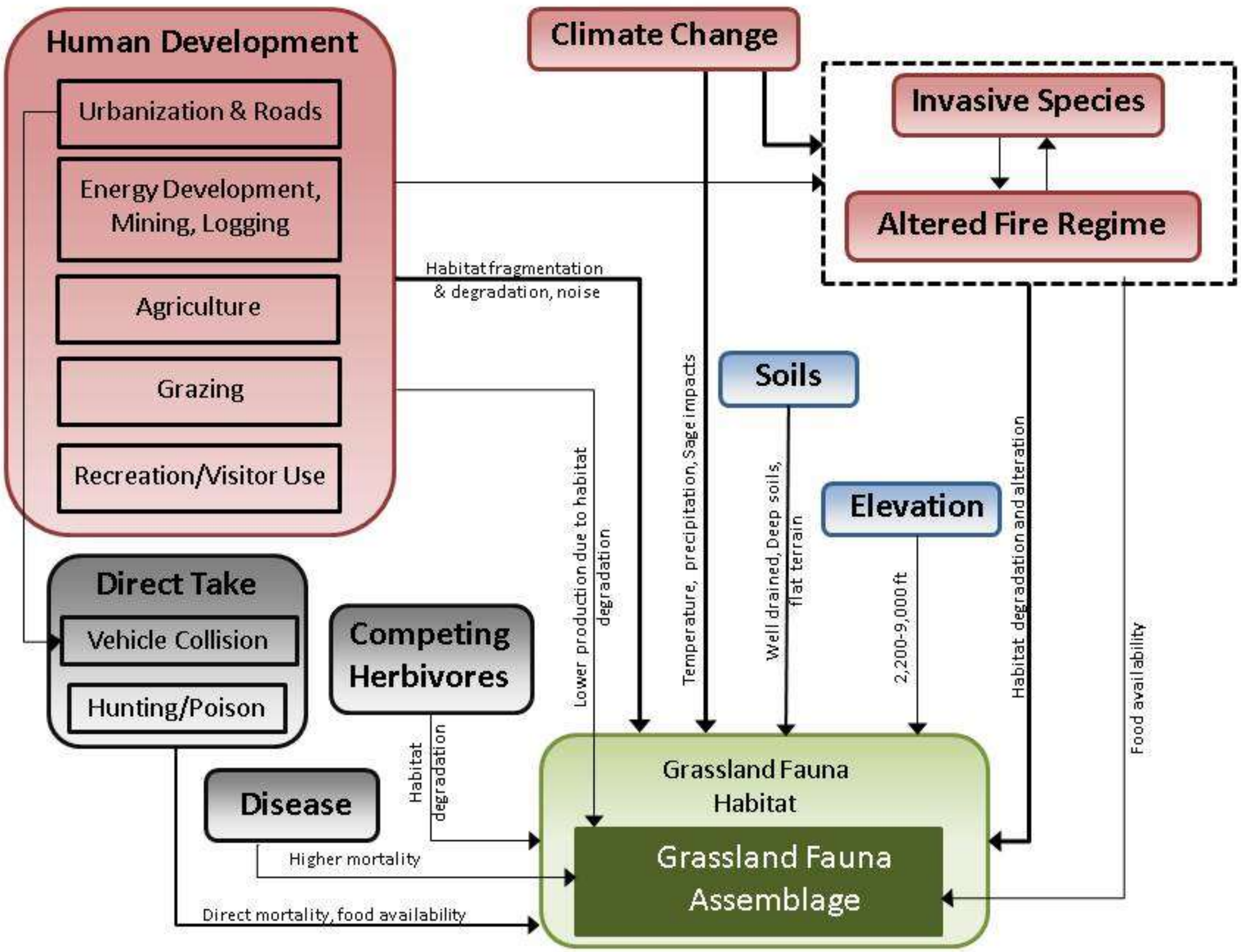


Figure B.2.9-1. Grassland Fauna Assemblage Conceptual Model.

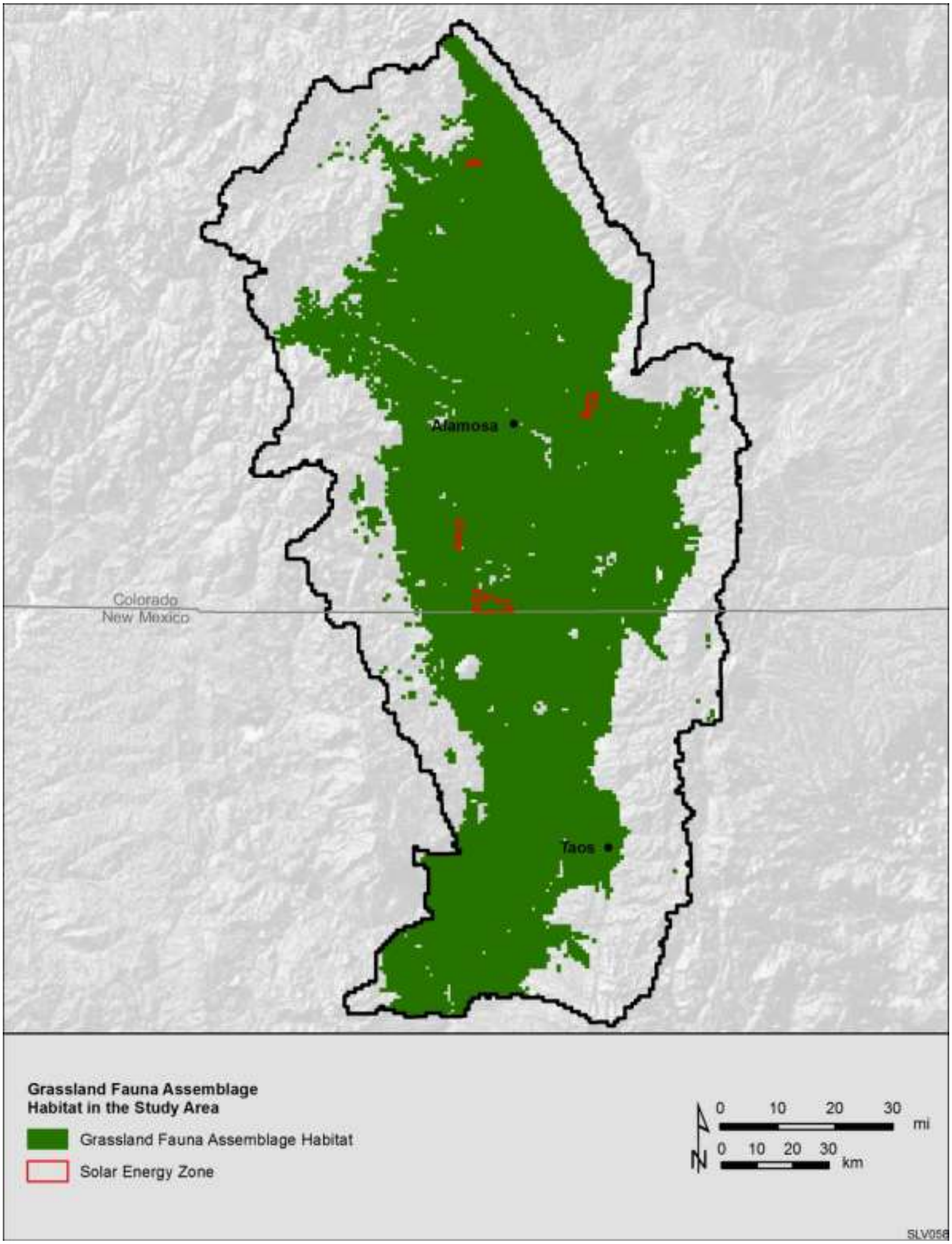


Figure B.2.9-2. Current Distribution of Potentially Suitable Habitat for the Grassland Fauna Assemblage. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

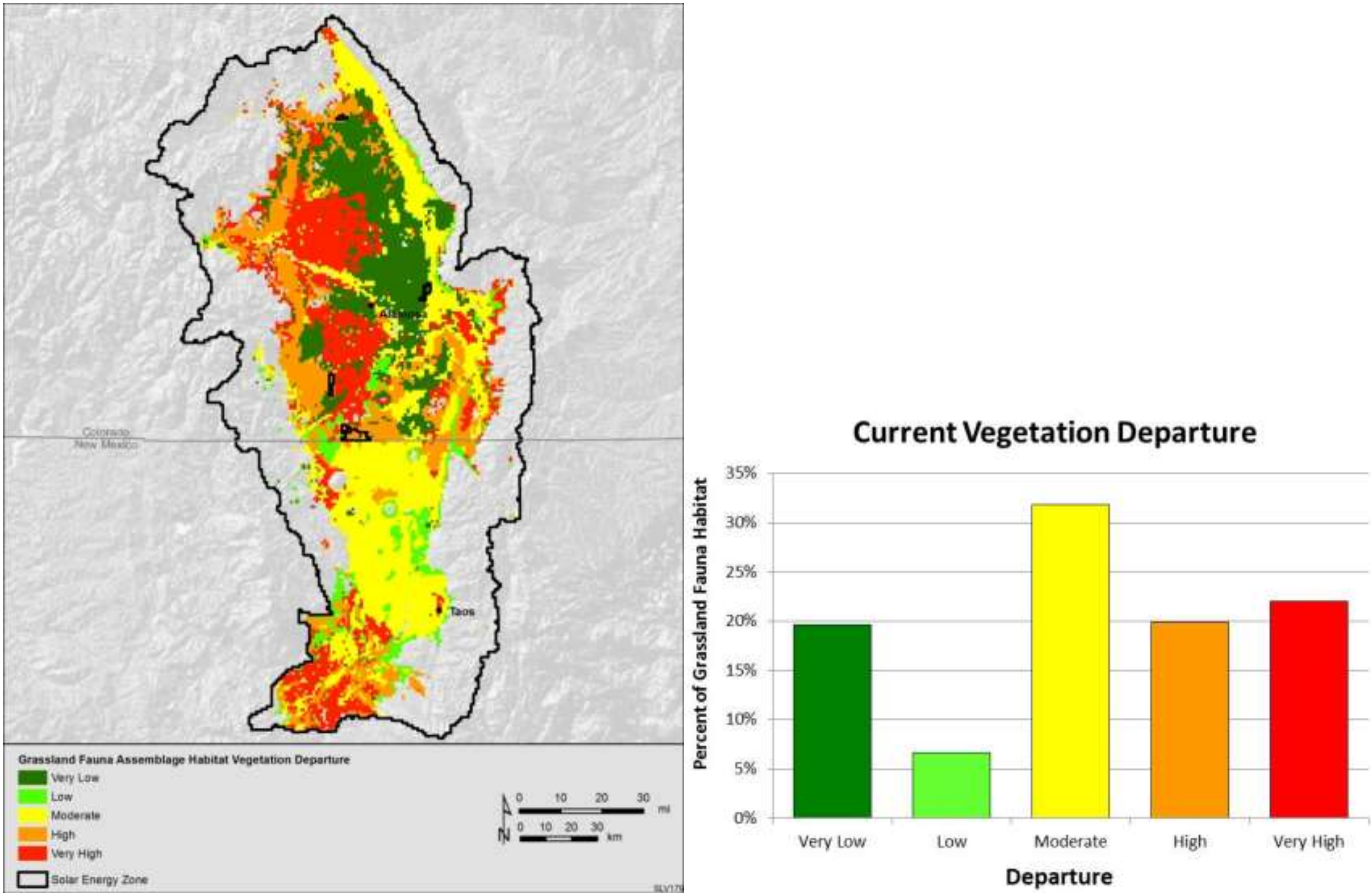


Figure B.2.9-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Grassland Fauna Assemblage Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

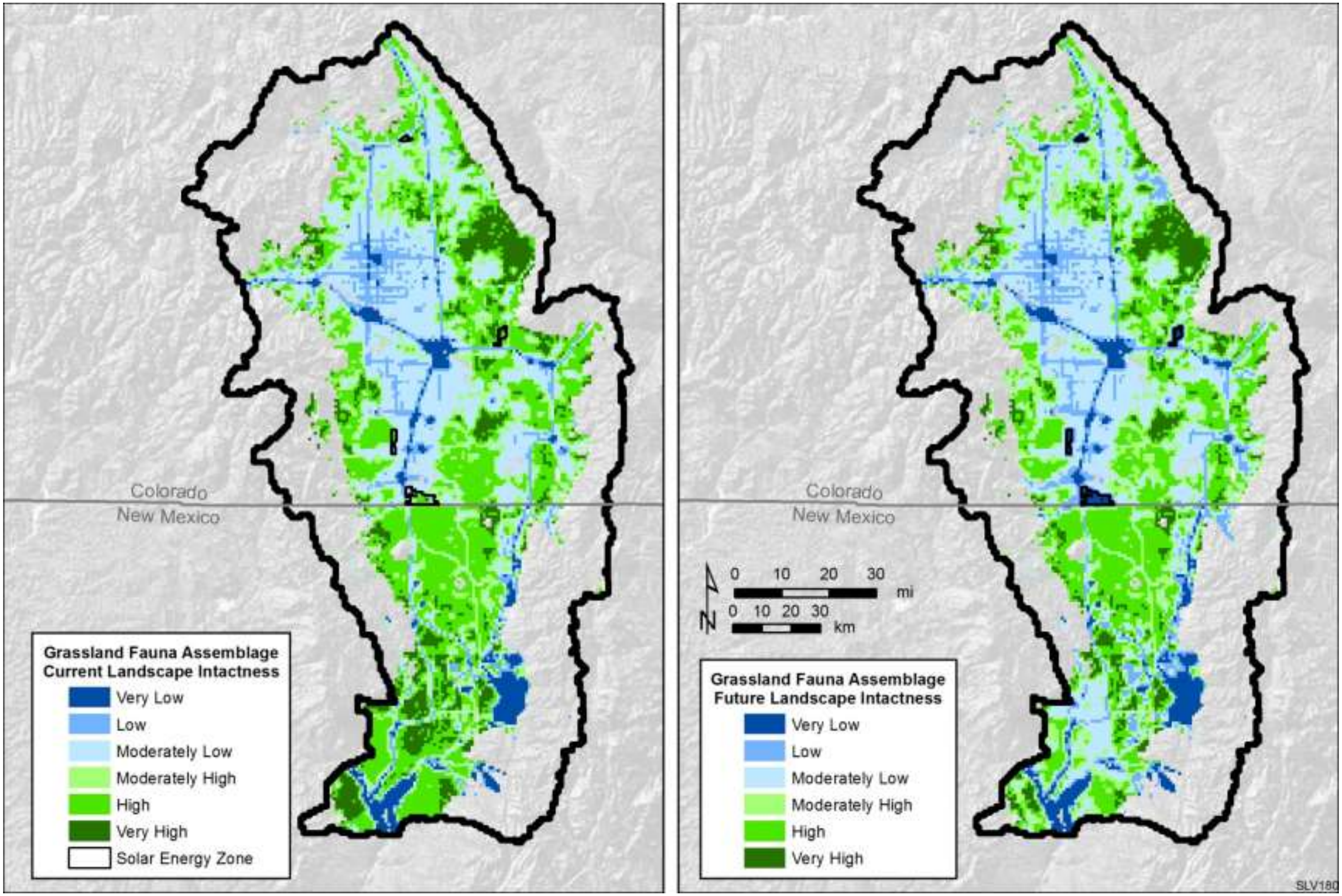


Figure B.2.9-4. Current and Future Landscape Intactness of Potentially Suitable Grassland Fauna Assemblage Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

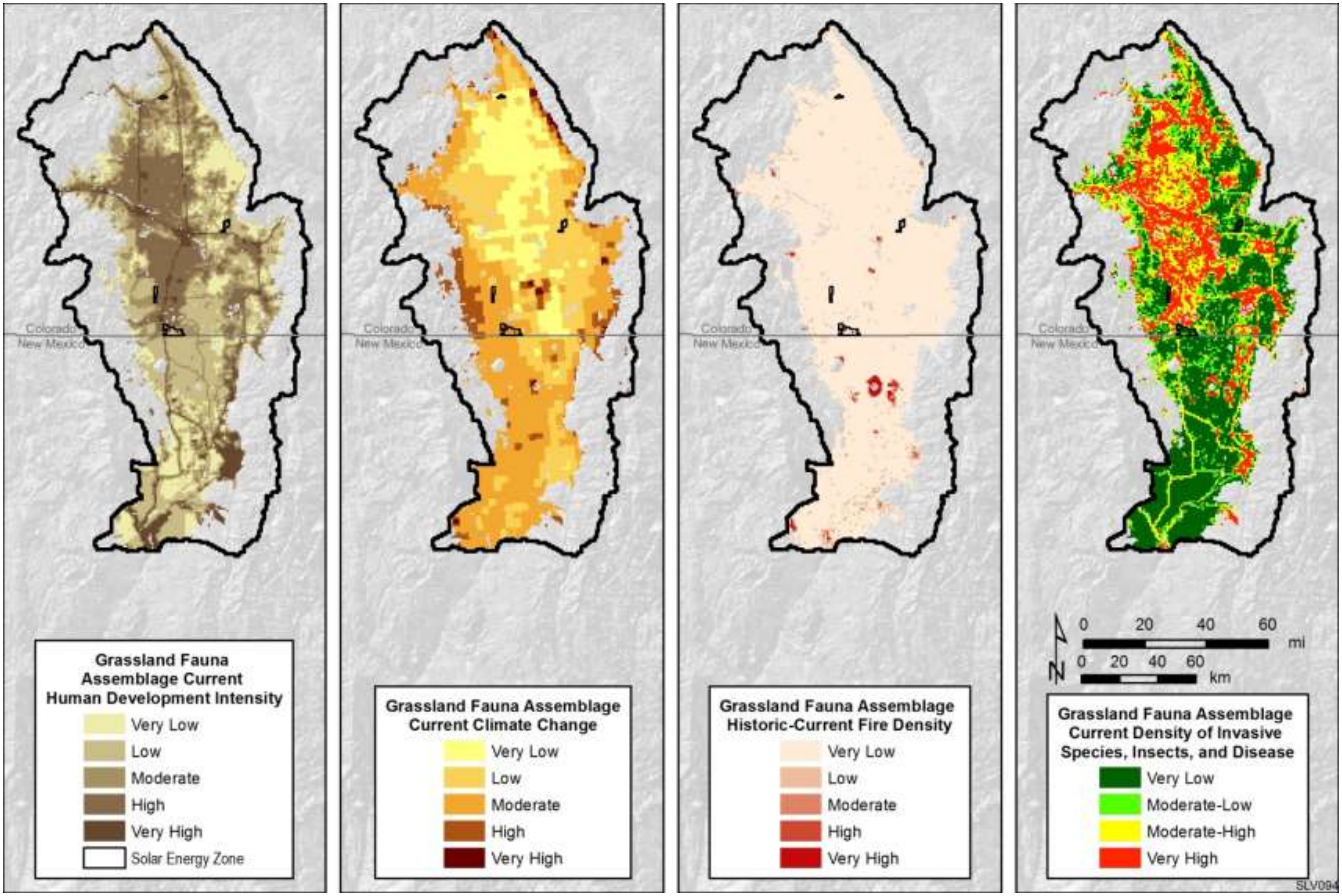


Figure B.2.9-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for grassland fauna? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

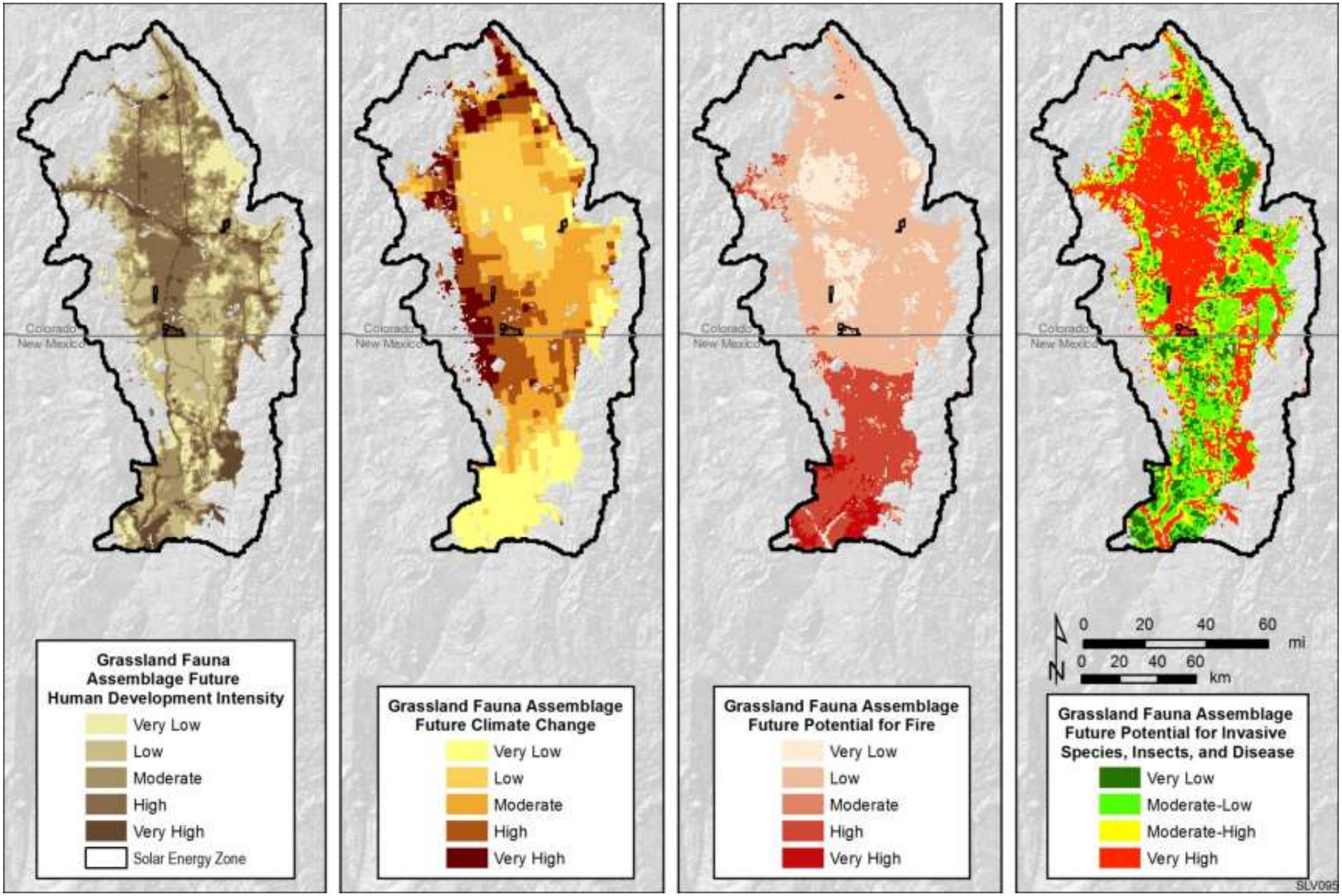


Figure B.2.9-6. Illustration for MQD3: Where are grassland fauna vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

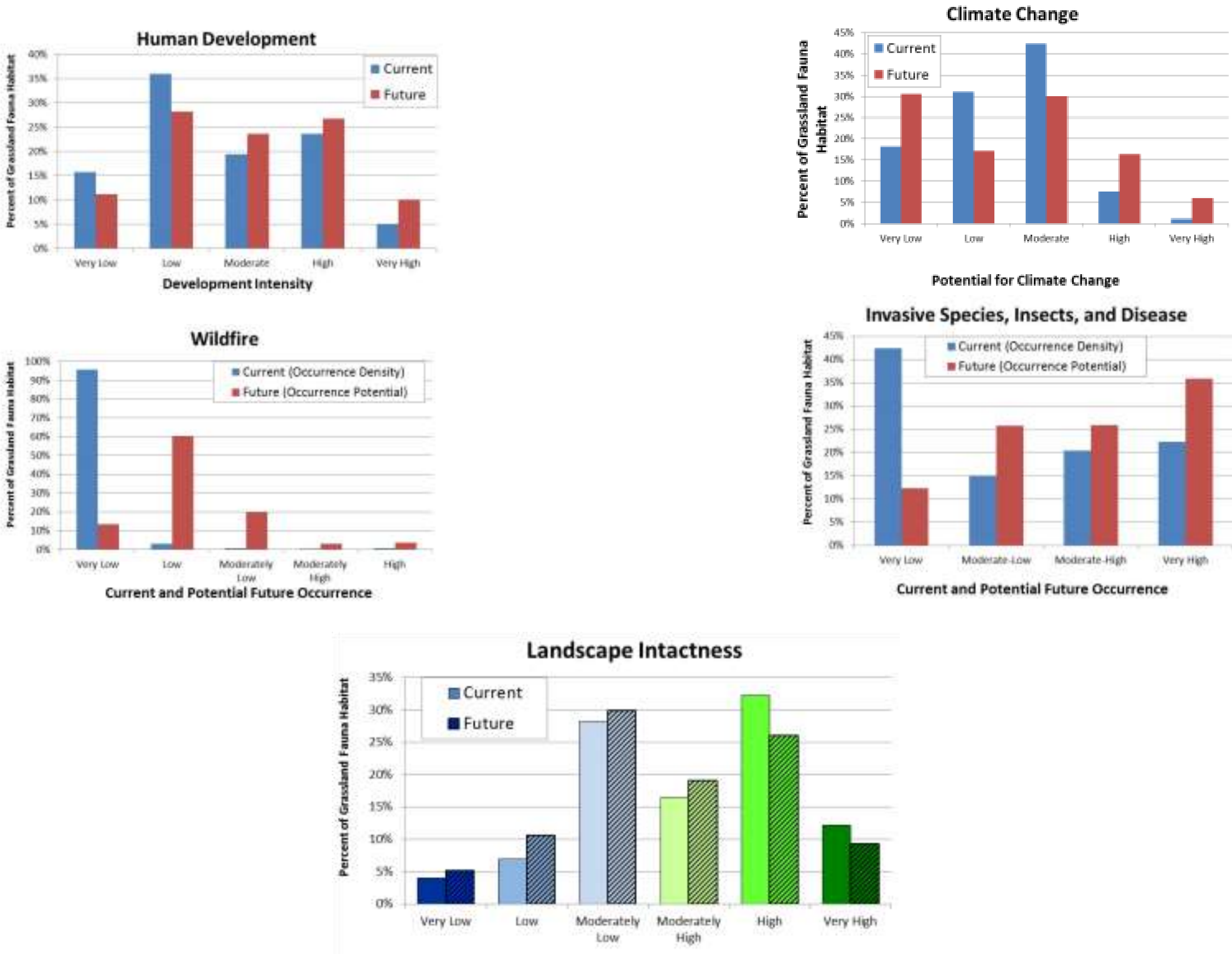


Figure B.2.9-7. Predicted Trends in Grassland Fauna Assemblage Habitat within the Study Area

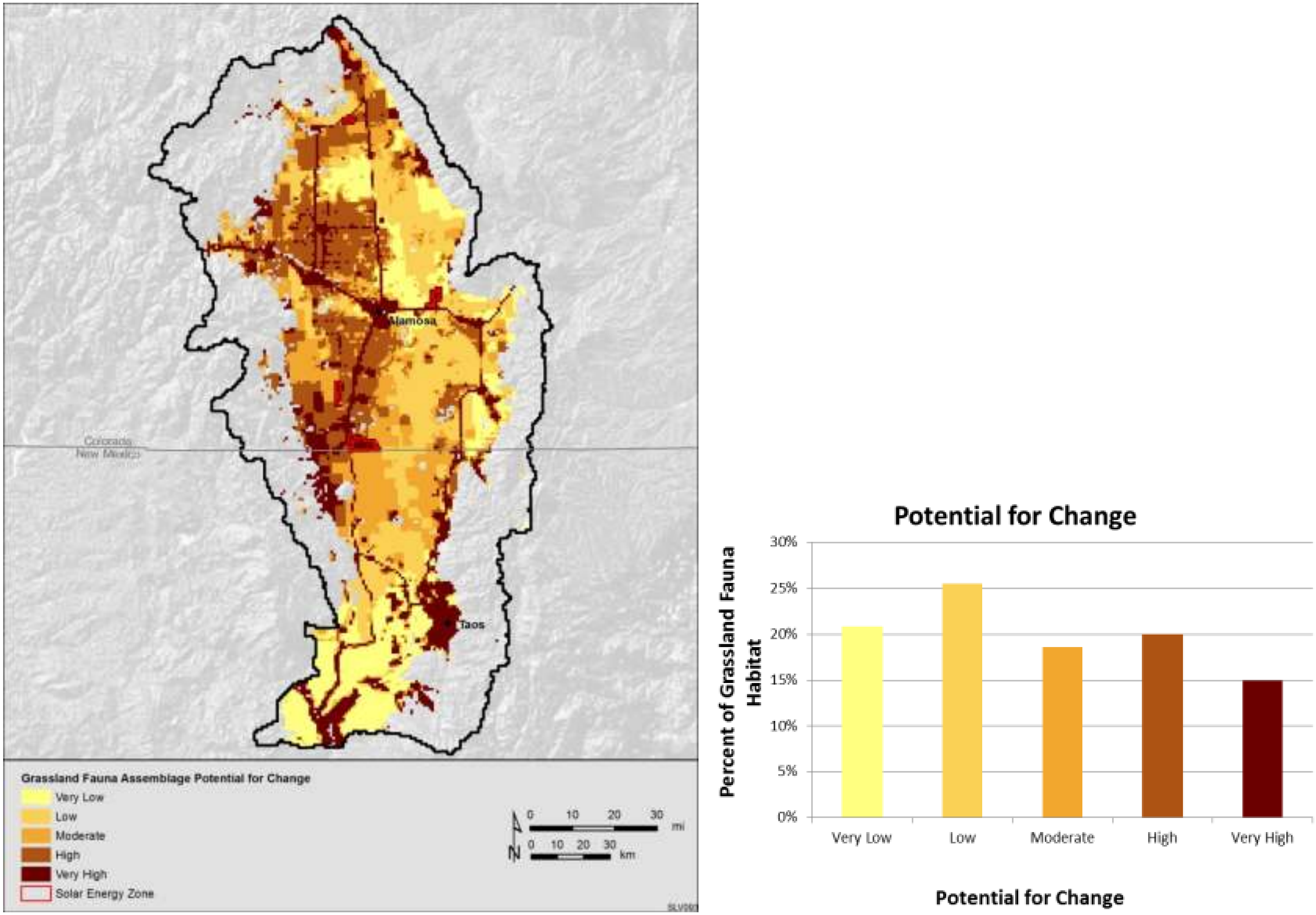


Figure B.2.9-8. Grassland Fauna Assemblage Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.10 Mountain Lion

Mountain lions are habitat generalists that have adapted to a wide range of environmental conditions (Weaver et al. 1996). The three main components defining high quality mountain lion habitat are abundance of prey species (e.g., mule deer, elk, and bighorn sheep), steep, rugged terrain, and vegetative cover to allow for the successful stalking of prey (Hornocker 1970, Koehler and Hornocker 1991). Mountain lions can inhabit all elevations, but they prefer open mixed hardwood and coniferous forest vegetation zones below timberline. Although terrain ruggedness is a strong predictor of habitat availability in some landscapes, availability of abundant prey (especially in winter) is the most important factor in supporting a strong lion population. Mountain lions are highly territorial, solitary predators that display a wide variability in home range sizes (between 10 and >1,000 km^2), with males generally having larger home range sizes than females (Kitchener 1991; Pierce et al. 1999). Territory size, which often shifts seasonally, is determined by a number of ecological and allometric factors including abundance of prey—higher prey densities often result in smaller home ranges (Grigione et al. 2002). Hemker et al. (1984) reported some of the largest known home range sizes for mountain lions in southern Utah with males occupying up to 513 sq mi and females up to 426 sq mi. A typical mountain lion population consists of resident males and females in occupied territories, transient males and females moving across the landscape looking to establish their own territories, and dependent kittens of resident females (Lynch 1989). Mountain lion density in the landscape is generally no greater than 3-4 adults per 100 km^2 (Kitchener 1991).

At the ecoregion level, mountain lions require fairly large home ranges with ample food and cover (provided by vegetation cover and/or rugged terrain). They also require the ability to disperse widely in search of prey and new territories as this is important component of their life history. Mountain lions can tolerate significant human disturbance (Weaver et al. 1996); however, they do avoid developed and semi-developed areas unless dispersing to new territories, which is normally conducted at night when under more stressful circumstances (Beier 1995). Mountain lion populations may be affected by direct mortality and habitat loss associated with human interactions. For example, hunting may reduce the number of individuals in the population and affect the habitat use and spatial ecology of surviving lions (Maletzke et al. 2014). The most important threat to mountain lions in the ecoregion is overall habitat degradation due to human activities such as residential development, recreational development, and road building. For example, Van Dyke et al. (1986) reported areas with road densities > 0.6 km/sq km as poor habitat for mountain lion due to avoidance behavior and direct mortality through increased conflict with humans. Mountain lion ecological attributes and indicators are provided in Table B.2.10-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the mountain lion may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.10-1). Figures B.2.10-2 through B.2.10-8 show, respectively: Figure B.2.10-2 - the current distribution of potentially suitable mountain lion habitat in the study area; Figure B.2.10-3 – habitat distribution with respect to current vegetation departure; Figure B.2.10-4 - habitat distribution with respect to current and future landscape intactness in the study area; Figure B.2.10-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.10-6 - habitat distribution with respect to predicted areas of change; Figure B.2.10-7 - predicted trends in mountain lion habitat within the study area; and Figure B.2.10-8 - the aggregate potential for change in mountain lion habitat.

The majority (43%) of vegetation within mountain lion potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.10-7). Most of the vegetation departure that has occurred within potentially suitable habitat is located in rural areas of the Taos Plateau in northern New Mexico (Figure B.2.10-3).

The majority (73%) of mountain lion potentially suitable habitat is within areas of high or very high current landscape intactness (Figure B.2.10-4; Figure B.2.10-7). Future trends in landscape intactness indicate a decrease in landscape intactness within mountain lion potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 11% in the near-term (i.e., by 2030) (Figure B.2.10-7).

The majority (80%) of mountain lion potentially suitable habitat is within areas of very low or low current human development intensity (Figure B.2.10-5; Figure B.2.10-7). Future trends in human development indicate an increase in human development intensity within mountain lion potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 8% in the near-term (i.e., by 2030) (Figure B.2.10-6; Figure B.2.10-7).

The majority of mountain lion potentially suitable habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.10-5; Figure B.2.10-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.10-6; Figure B.2.10-7). Approximately 38% of the mountain lion suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.10-7). The greatest potential for future climate change within mountain lion potentially suitable habitat occurs in the western and northwestern portion of the habitat distribution in the study area (Figure B.2.10-6).

The majority of mountain lion potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.10-5; Figure B.2.10-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.10-6).

The majority of mountain lion potentially suitable habitat is within areas of very low and moderately low current density of invasive species, insects, and disease (Figure B.2.10-5; Figure B.2.10-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of mountain lion potentially suitable habitat in the study area (Figure B.2.10-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (Figure B.2.10-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 33% of the mountain lion suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.10-8). Areas with greatest potential for change within mountain lion suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.10-8).

Table B.2.10-1. Mountain Lion Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Prey	Ungulate density	Low	Medium	High	Very high	Julander and Jeffrey (1964)
Habitat degradation	Road density	.6 km/sq km	0.4	0.2	0	Van Dyke et al. (1986)
Habitat	Cover & terrain	Very dense or open cover	-	-	Rugged terrain with mixed cover	Riley (1998)
Habitat degradation	Human development	Highly developed	Moderately developed	Minimally developed	No development	Van Dyke et al. (1986)

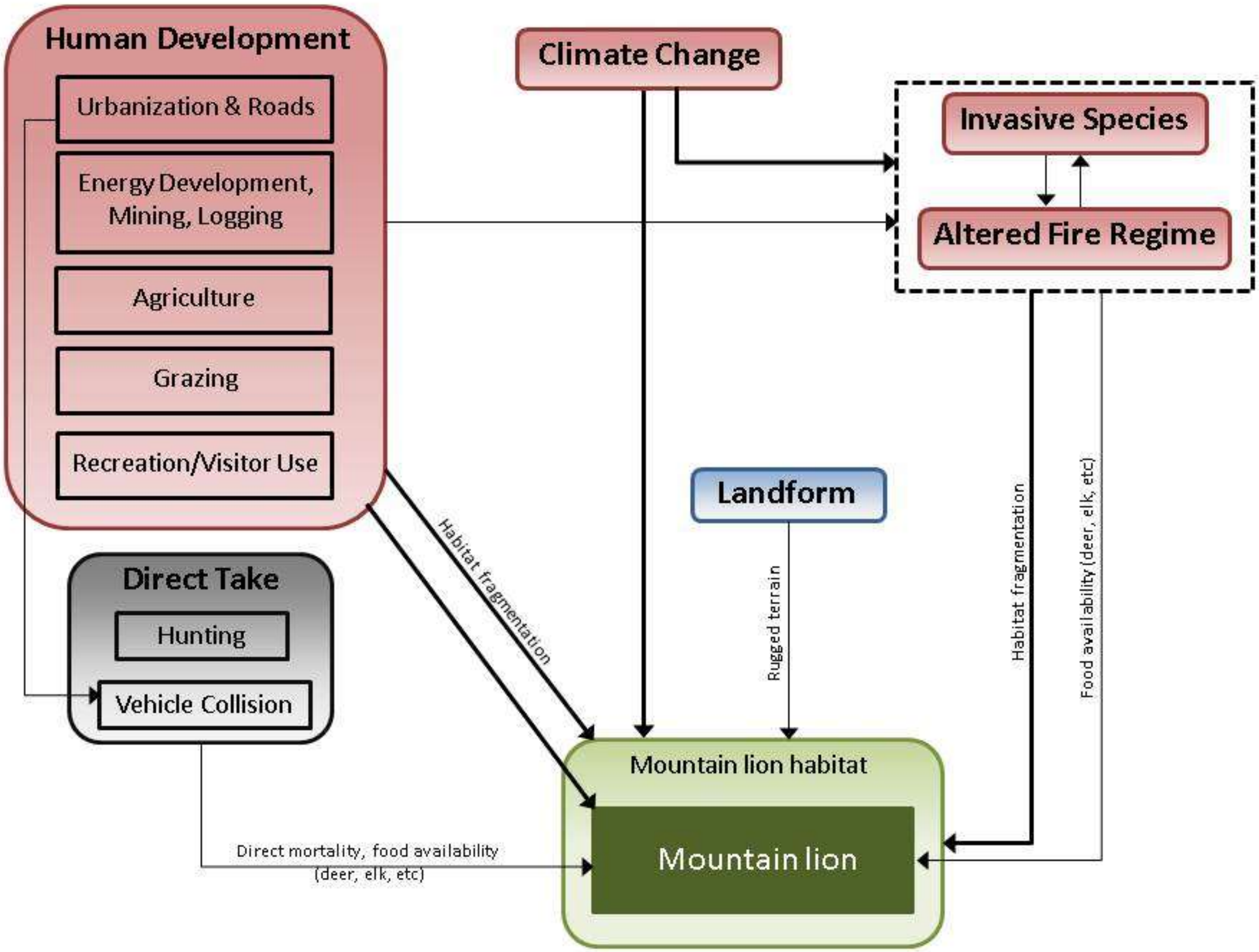


Figure B.2.10-1. Mountain Lion Conceptual Model.

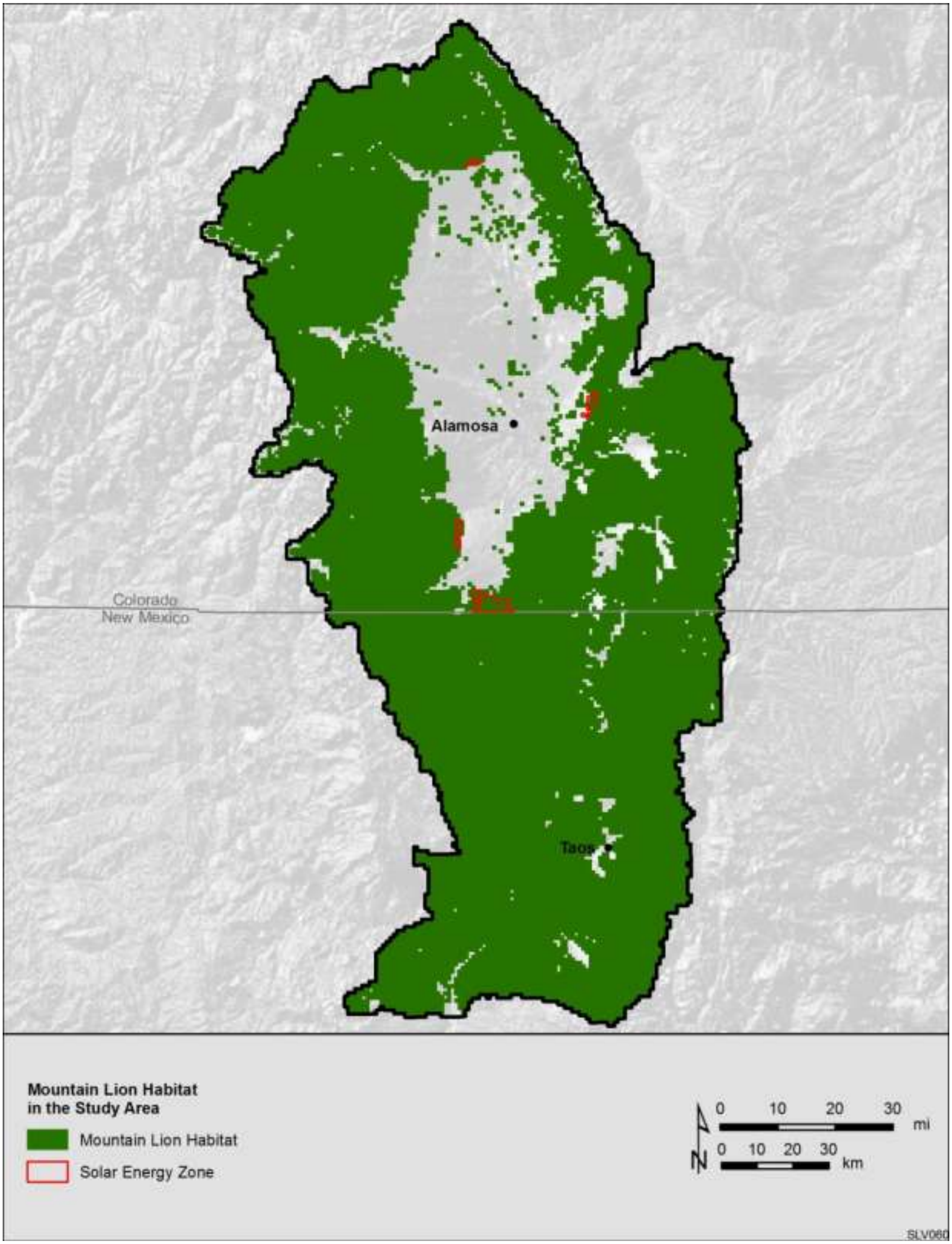


Figure B.2.10-2. Current Distribution of Potentially Suitable Habitat for the Mountain Lion. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007).

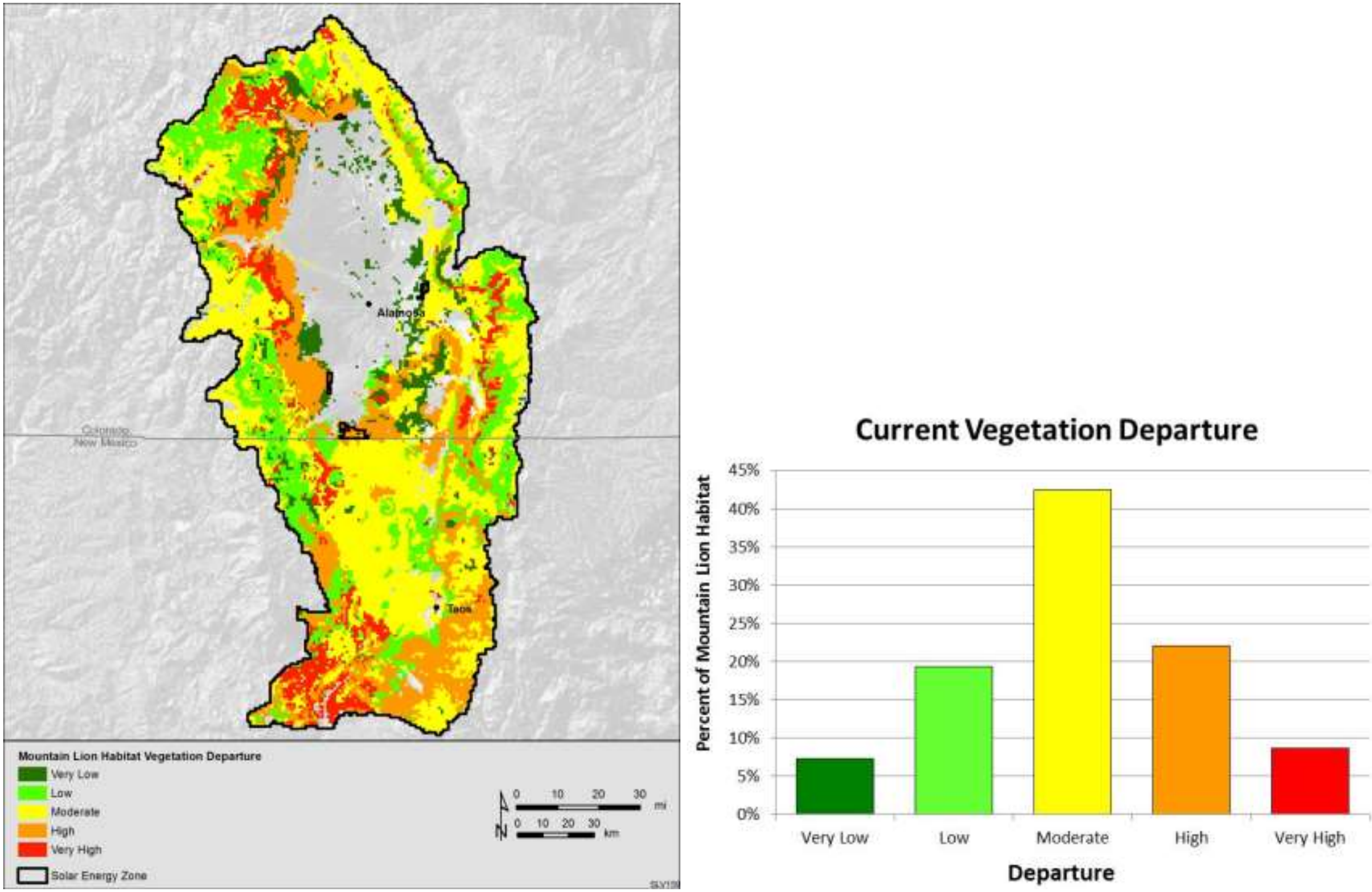


Figure B.2.10-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Mountain Lion Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

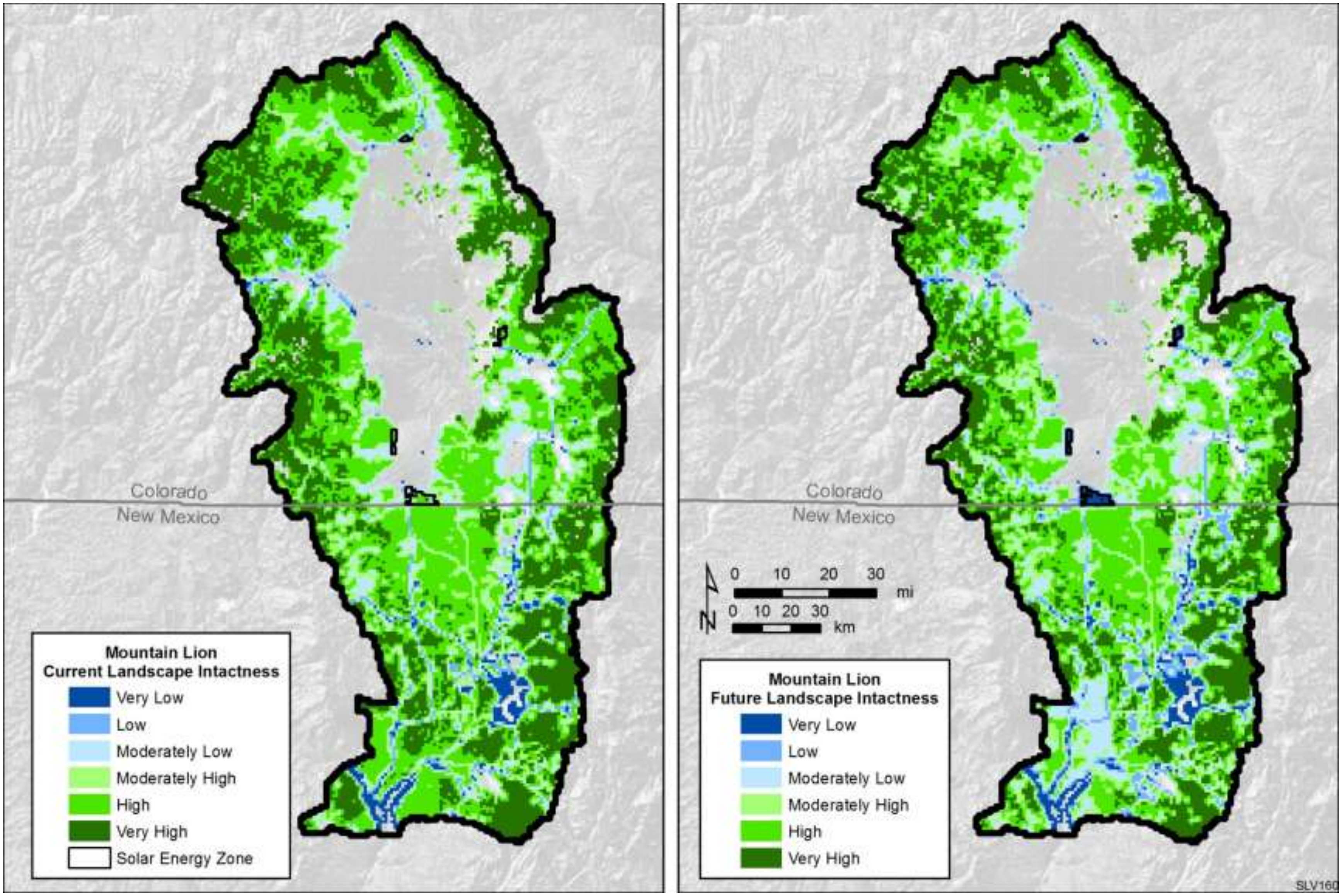


Figure B.2.10-4. Current and Future Landscape intactness of Potentially Suitable Mountain Lion Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

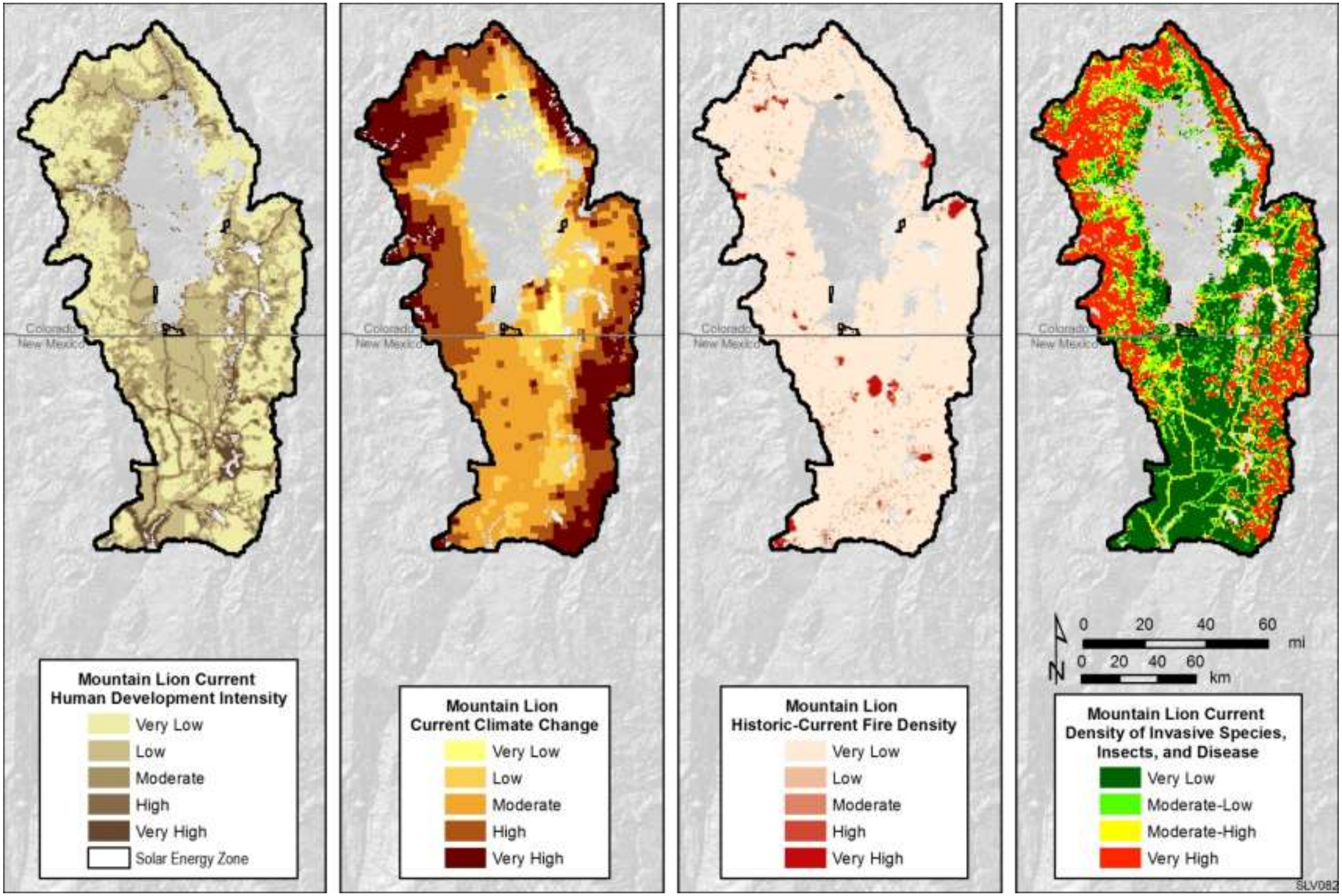


Figure B.2.10-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for mountain lion? Data Source: Southwest Regional Gap Analysis Project (SWReGAP)

(USGS National Gap Analysis Program, 2007) and Argonne 2014.

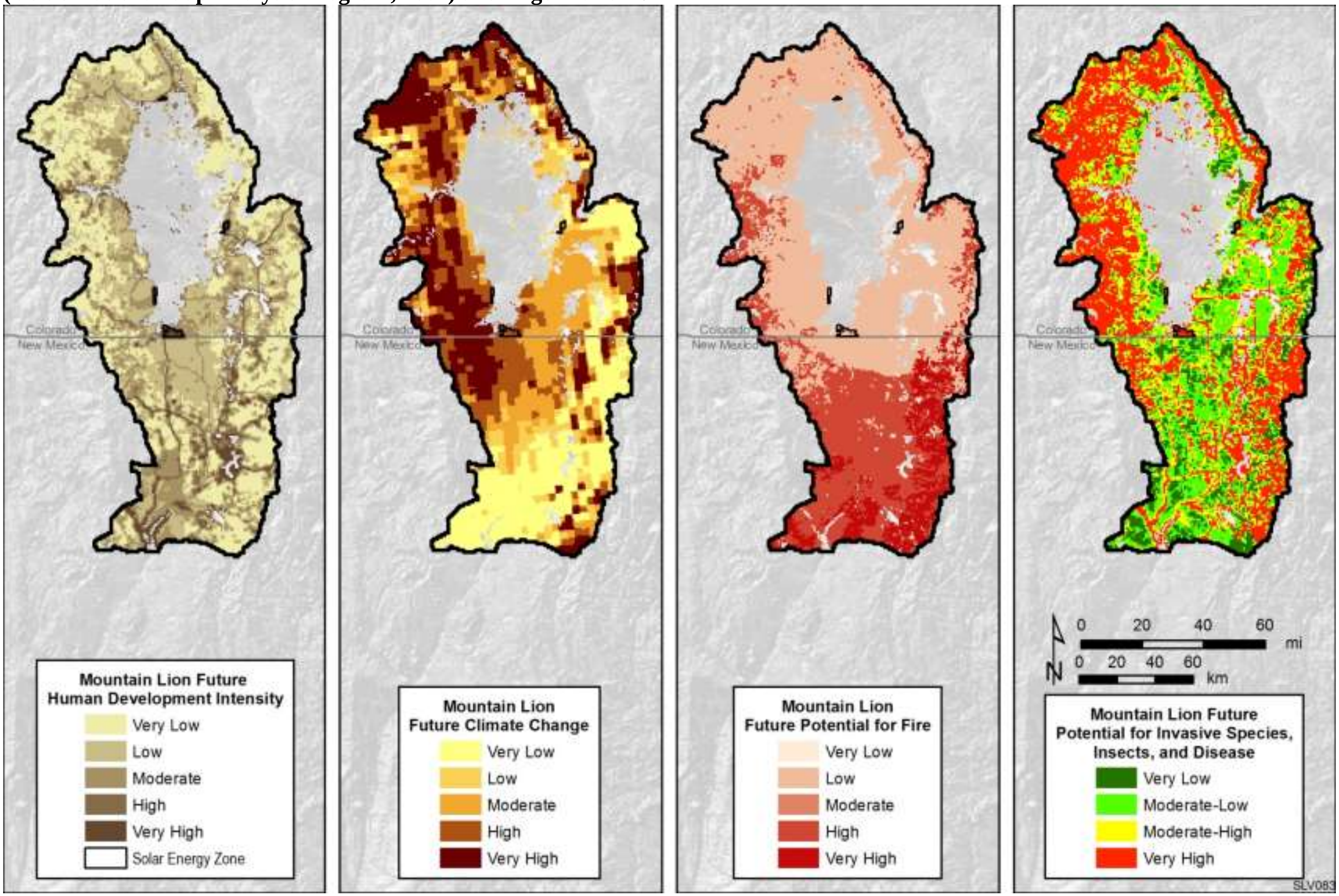


Figure B.2.10-6. Illustration for MQD3: Where is mountain lion vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

Predicted Trends in Mountain Lion Habitat within the Study Area

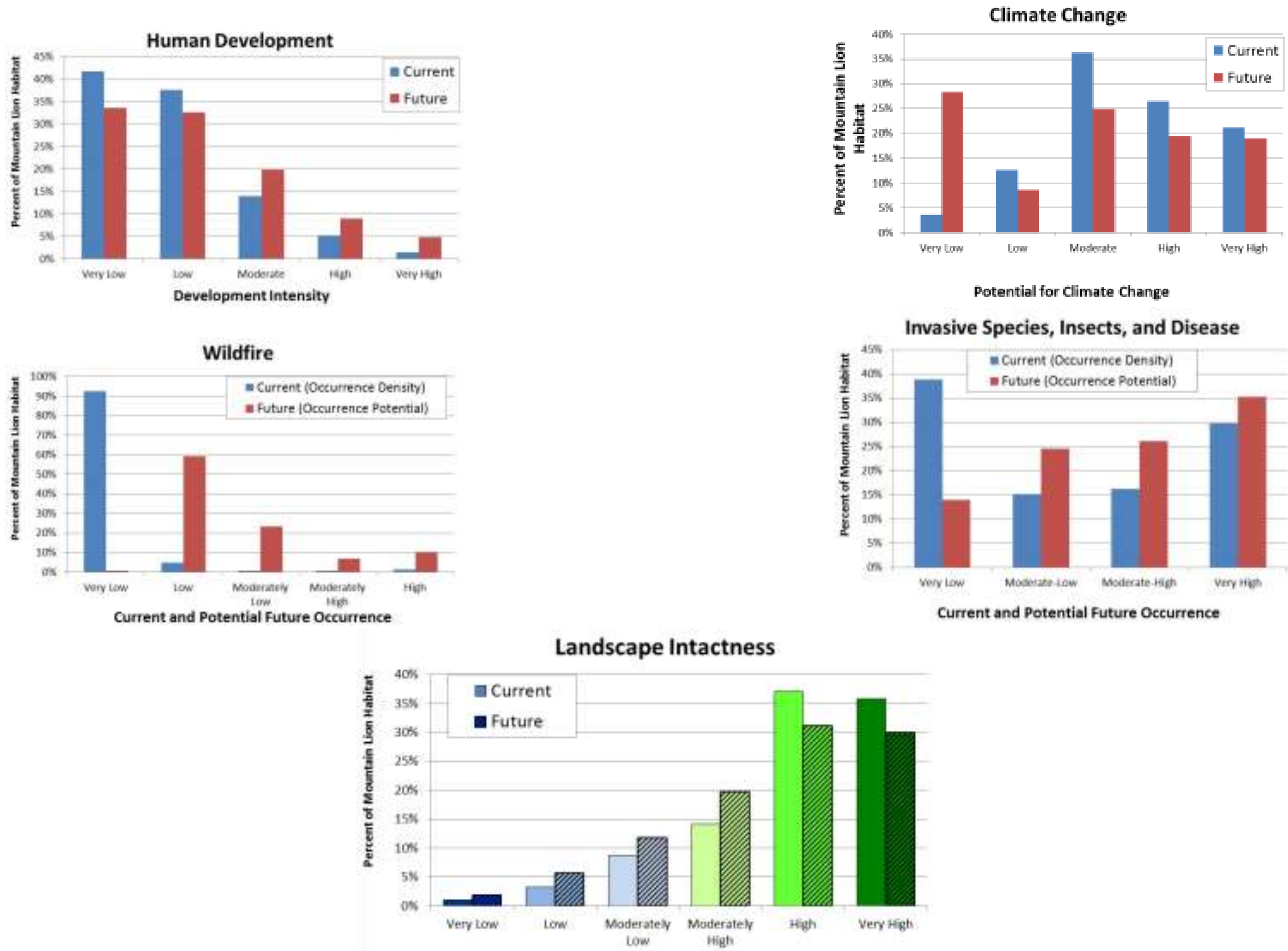


Figure B.2.10-7. Predicted Trends in Mountain Lion Habitat within the Study Area

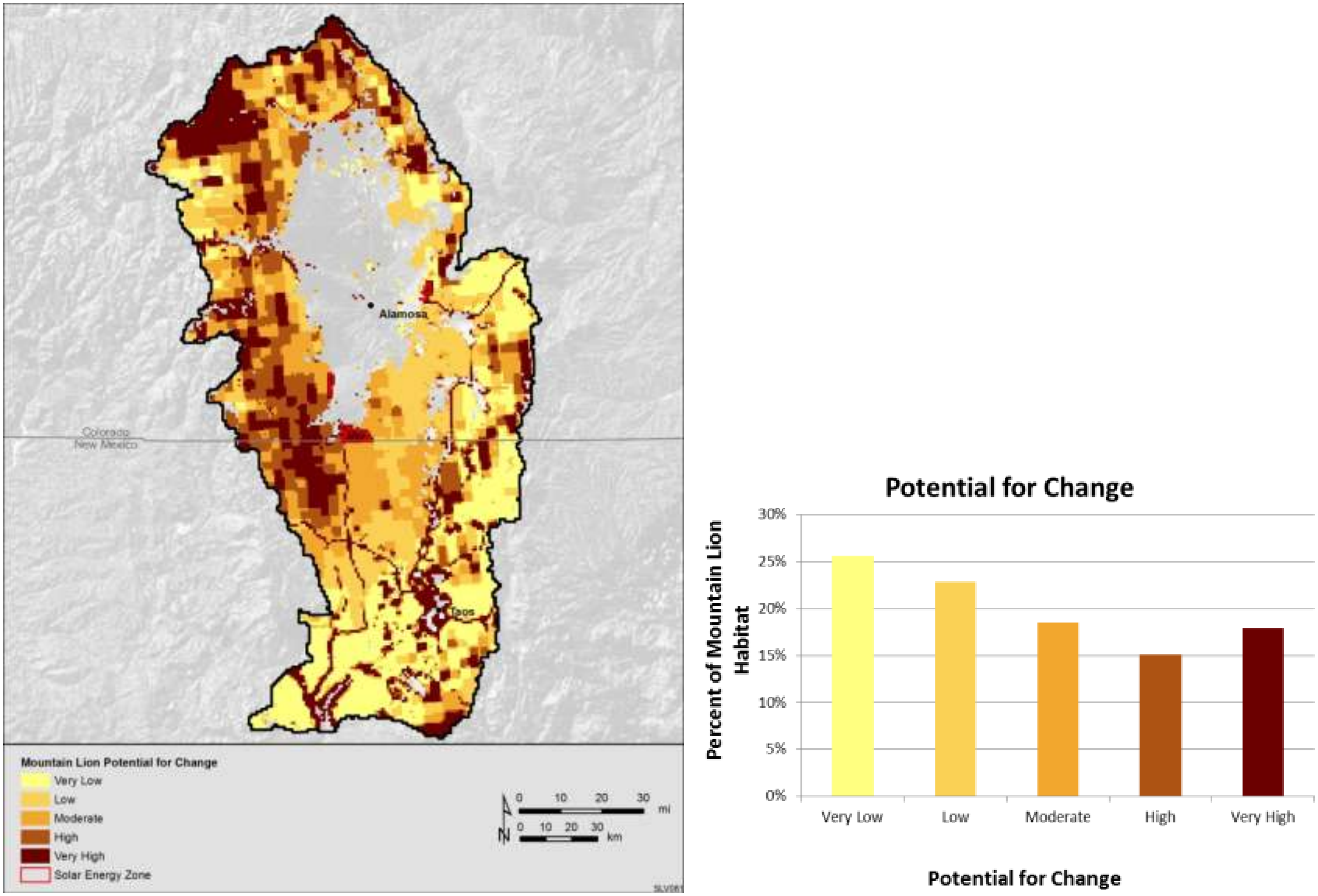


Figure B.2.10-8. Mountain Lion Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.11 Pronghorn

The pronghorn antelope, an open-country grassland and shrub-steppe obligate, has specific habitat requirements necessary for the species to persist and thrive (Gates et al. 2012). Yoakum et al. (1996) and Jaeger and Fahrig (2004) defined the optimal habitat parameters for the North American pronghorn including elevation, terrain, connectivity of habitat, distance from water, and vegetation. Peak concentrations of herds are located between 1,200 and 1,850 meters above sea level in open shrubland (Yoakum et al. 1996). In addition, for predator detection and escape, pronghorns require flat, open habitat, with rolling hills and slopes less than 30% to detect approaching predators (Yoakum et al. 1996). The pronghorn is the fastest land mammal in North America with speeds reaching 60 mph (Gates et al. 2012). The Pronghorn lives alone or in small bands in summer and forms large herds in winter. Being highly mobile, the Pronghorn may cover a large area during the year. Pronghorn can survive a temperature range of 180 degrees, from 130 in the deserts to 50 below zero (Royo 2014).

Some pronghorn populations migrate long distances between summer and winter feeding grounds. They do not consistently return to the same wintering areas because they only migrate as far as necessary to find suitable habitat (Gates et al. 2012). Long-distance migrations by ungulates are declining globally mostly due to anthropogenic factors (Poor et al. 2012). Fences form an especially significant barrier to pronghorn movement, as the species is averse to jumping fences and will typically choose to go under a fence (Yoakum et al. 1996, Jaeger and Fahrig 2004). Other barriers to pronghorn migration include roads, railroads, urban sprawl, rivers, and gas fields (Gates et al. 2012; Sawyer et al. 2006). Additionally, pronghorns require ready access to water and they are usually found within 1.5 – 6.5 km of a water source (Yoakum et al. 1996). Pronghorn also need a variety of vegetation for foraging; they select, in order of preference, forbs, shrubs, and grasses (Yoakum et al. 1996).

It is estimated that in the mid-1800s, Pronghorn numbered in the many million, but by the 1920s, the U.S. population had been reduced to about 20,000 (Royo 2014). The northern San Luis Valley herd reached a peak population size of 4,200 (estimated) in 1993, but had declined to an estimated population of between 2,100 and 2,500 individuals by 2008 (Colorado Division of Wildlife 2008). In New Mexico, it is estimated that the current population of pronghorn between the Rio Grande and San Antonio Mountain area (Antelope Management Unit 52) is between 900 and 1,200 animals (BLM 2012). The two biggest factors limiting the northern San Luis Valley population are limited water availability throughout the range and winter habitat. Areas with available water and succulent vegetation, such as areas along San Luis Creek and irrigated alfalfa fields provide better habitat for pronghorn. The availability of winter range continues to decline with increased number of homes on private land and competition with domestic livestock (Colorado Division of Wildlife 2008). In 2012, it was estimated that 64% of the pronghorn range had been lost (Poor et al. 2012). Their habitat continues to be altered by human development such as cultivation, irrigation, roads, oil and gas development, mining, water development, urban expansion, and fences (Gates et al. 2012). Oil and gas development in the Colorado Plateau is a major change agent affecting the future sustainability of pronghorn, particularly related to area needs for foraging and maintenance of seasonal migration routes. Heavy habitat fragmentation and migration blockages and bottlenecks from oil and gas development have been documented in western Wyoming (Sawyer et al. 2002, Berger 2003). Pronghorn antelope ecological attributes and indicators are provided in Table B.2.11-1.

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the pronghorn antelope population may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.11-1). Figures B.2.11-2 through B.2.11-8 show, respectively: Figure B.2.11-2 - the current distribution of potentially suitable pronghorn habitat in the study area; Figure B.2.11-3 - habitat distribution with respect to current vegetation departure; Figure B.2.11-4 - habitat distribution with respect to current and future landscape intactness in the study area;

Figure B.2.11-5 - habitat distribution and status with respect to the current status of change agents; Figure B.2.11-6 – habitat distribution with respect to predicted areas of change; Figure B.2.11-7 - predicted trends in pronghorn antelope habitat within the study area; and Figure B.2.11-8 - the aggregate potential for change in pronghorn habitat.

The majority (34%) of vegetation within the pronghorn potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.11-7). Most of the vegetation departure that has occurred within the potentially suitable habitat is located in areas of agricultural and urban development in the San Luis Valley (Figure B.2.11-3).

The majority (80%) of the pronghorn potentially suitable habitat is within areas ranging from moderately low to moderately high current landscape intactness (Figure B.2.11-4; Figure B.2.11-7). Future trends in landscape intactness indicate a decrease in landscape intactness within pronghorn potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 7% in the near-term (i.e., by 2030) (Figure B.2.11-7).

The majority (56%) of the pronghorn potentially suitable habitat is within areas of low or moderate current human development intensity (Figure B.2.11-5; Figure B.2.11-7). Future trends in human development indicate an increase in human development intensity within pronghorn potential habitat. The amount of potential habitat occurring within areas high and very high human development intensity is expected to increase by approximately 4% in the near-term (i.e., by 2030) (Figure B.2.11-6; Figure B.2.11-7).

The majority of the pronghorn potentially suitable habitat is within areas of low and moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.2.11-5; Figure B.2.11-7). Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.2.11-6; Figure B.2.11-7). Approximately 27% of the pronghorn suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.11-7). The greatest potential for future climate change within pronghorn potentially suitable habitat occurs in the western and northwestern portion of the habitat distribution in the study area (Figure B.2.11-6). Recent studies have examined the role of climate change in future pronghorn population dynamics in the western United States. For example, in a study of 18 pronghorn populations, Gedir et al. (2015) found that all populations were expected to experience increased temperatures, resulting in changes in surface water availability and leading to the extirpation of half of the studied populations by 2090.

The majority of the pronghorn potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.11-5; Figure B.2.11-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. The greatest potential for future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.11-6).

The majority of the pronghorn potentially suitable habitat is within areas of very low current density of invasive species, insects, and disease (Figure B.2.11-5; Figure B.2.11-7). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of pronghorn potentially suitable habitat in the study area (Figure B.2.11-7). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (Figure B.2.11-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 39% of the pronghorn suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.11-8). Areas with greatest potential for change within pronghorn suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.11-8).

In addition to the four change agents modeled in this Landscape Assessment, the distribution and availability of water through natural and human-altered hydrologic processes can also be considered a unique change agent that could influence the distribution and status of several CEs, including pronghorn antelope. As one outcome of this Landscape Assessment, the role of water as a change agent has been identified as a knowledge gap where future research efforts may be directed. Future research to characterize spatio-temporal patterns of water availability and how these processes influence CEs is needed to adequately address the role of water availability on pronghorn antelope.

Table B.2.11-1. Pronghorn Attributes and Indicators

Attribute	**Indicator**	**Indicator Rating**				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat	Distance to water	>6.5 km	4.5-6.5 km	4.5-1.5 km	<1.5 km	Yoakum et al. (1996)
Habitat	Fragmentation	<242 ha			large patch	Berger et al. 2006
Movement	Barriers	abundant	common	few	none	Jaeger and Fahrig (2004)
Habitat	Diet	woody vegetation	single food	somewhat mixed food	well-mixed food - forbs, grass, and shrubs	Yoakum et al. (1996), Martinka (1967)

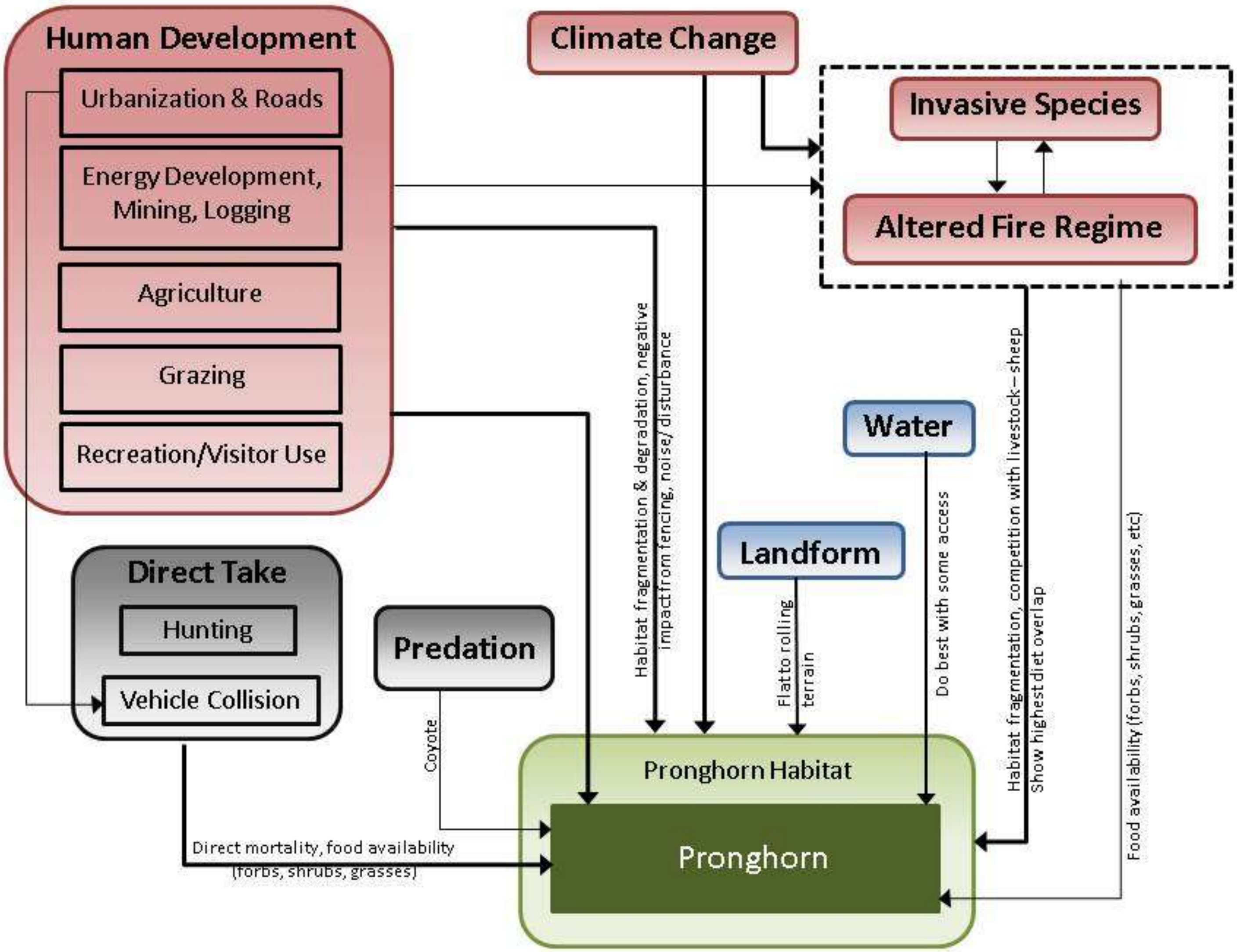


Figure B.2.11-1. Pronghorn Antelope Conceptual Model.

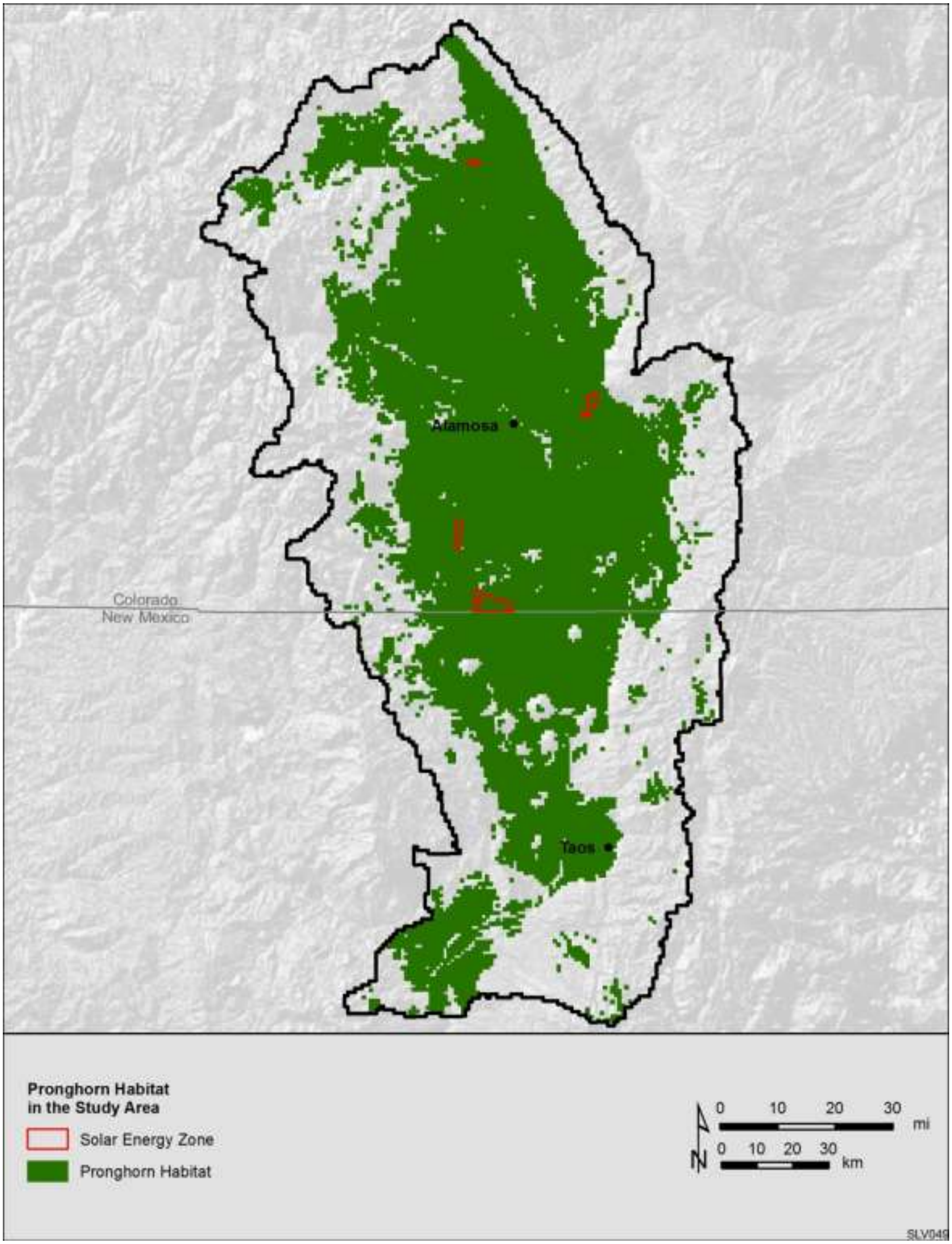


Figure B.2.11-2. Current Distribution of Potentially Suitable Habitat for the Pronghorn Antelope. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Note: Data include only potentially suitable habitat and do not directly represent movement corridors and seasonal ranges, which are evaluated separately.

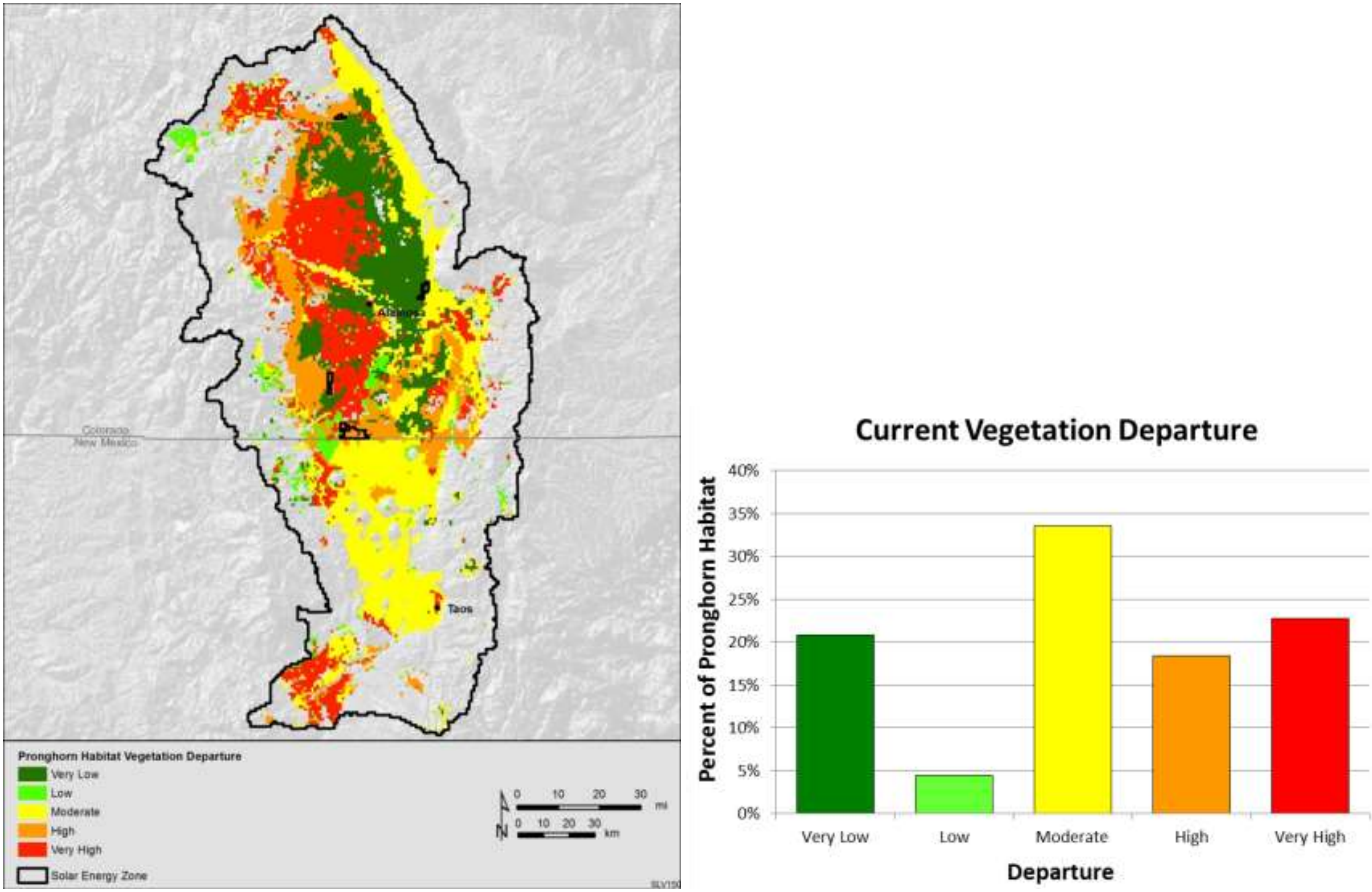


Figure B.2.11-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Pronghorn Antelope Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

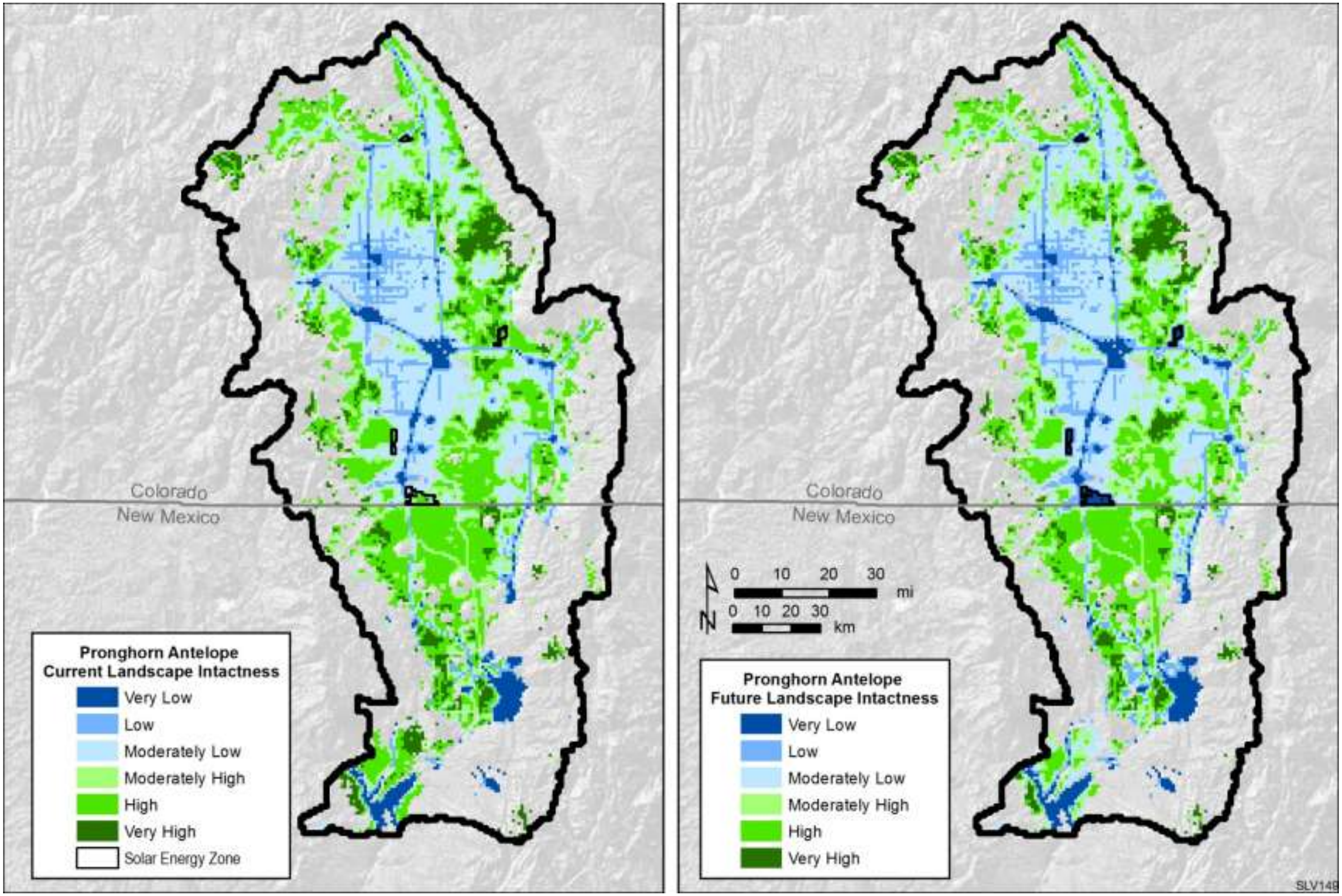


Figure B.2.11-4. Current and Future Landscape Intactness of Potentially Suitable Pronghorn Antelope Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

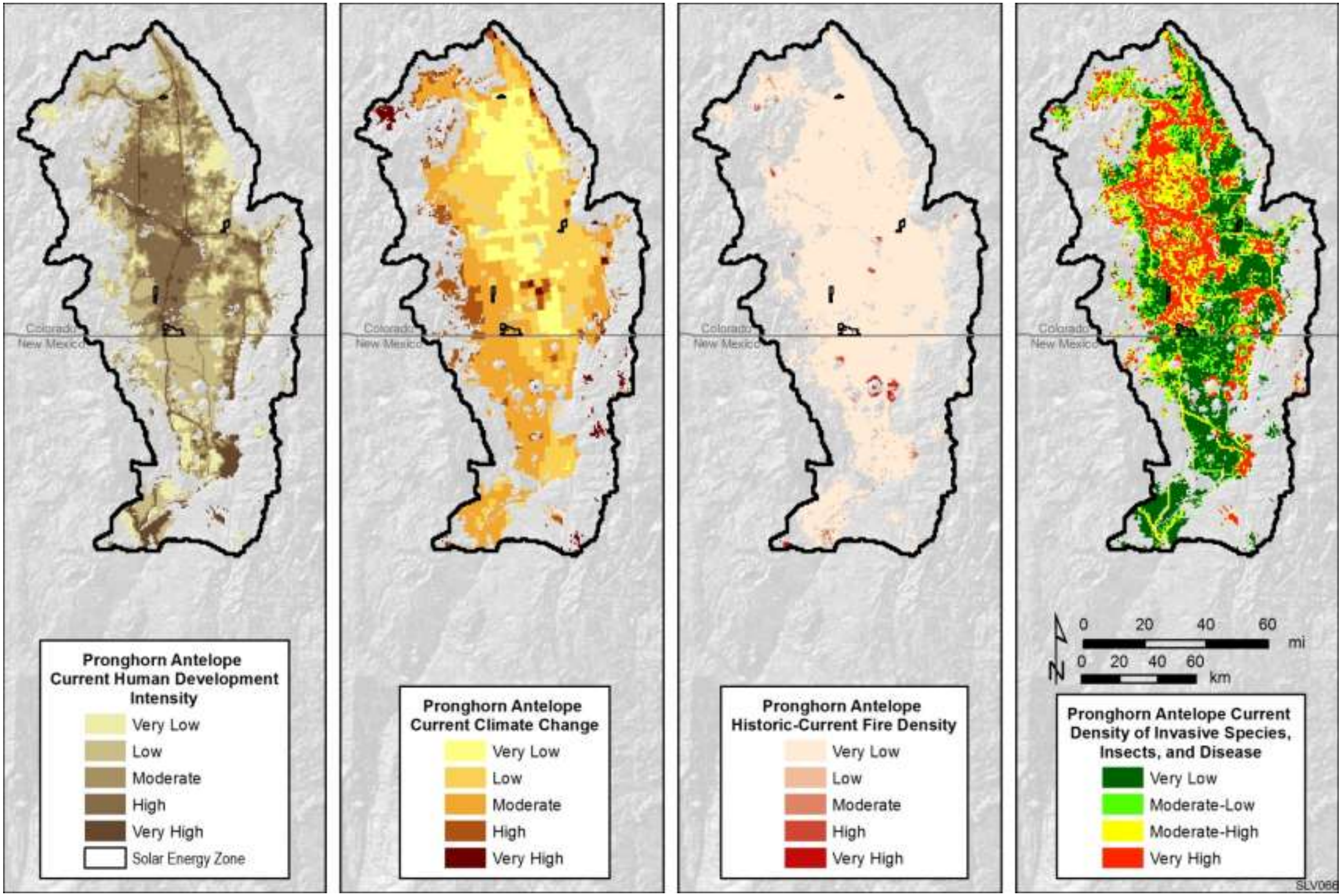


Figure B.2.11-5. Illustration for MQD1: What is the current distribution and status of available and suitable habitat, seasonal and breeding habitat, and movement corridors for pronghorn antelope? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

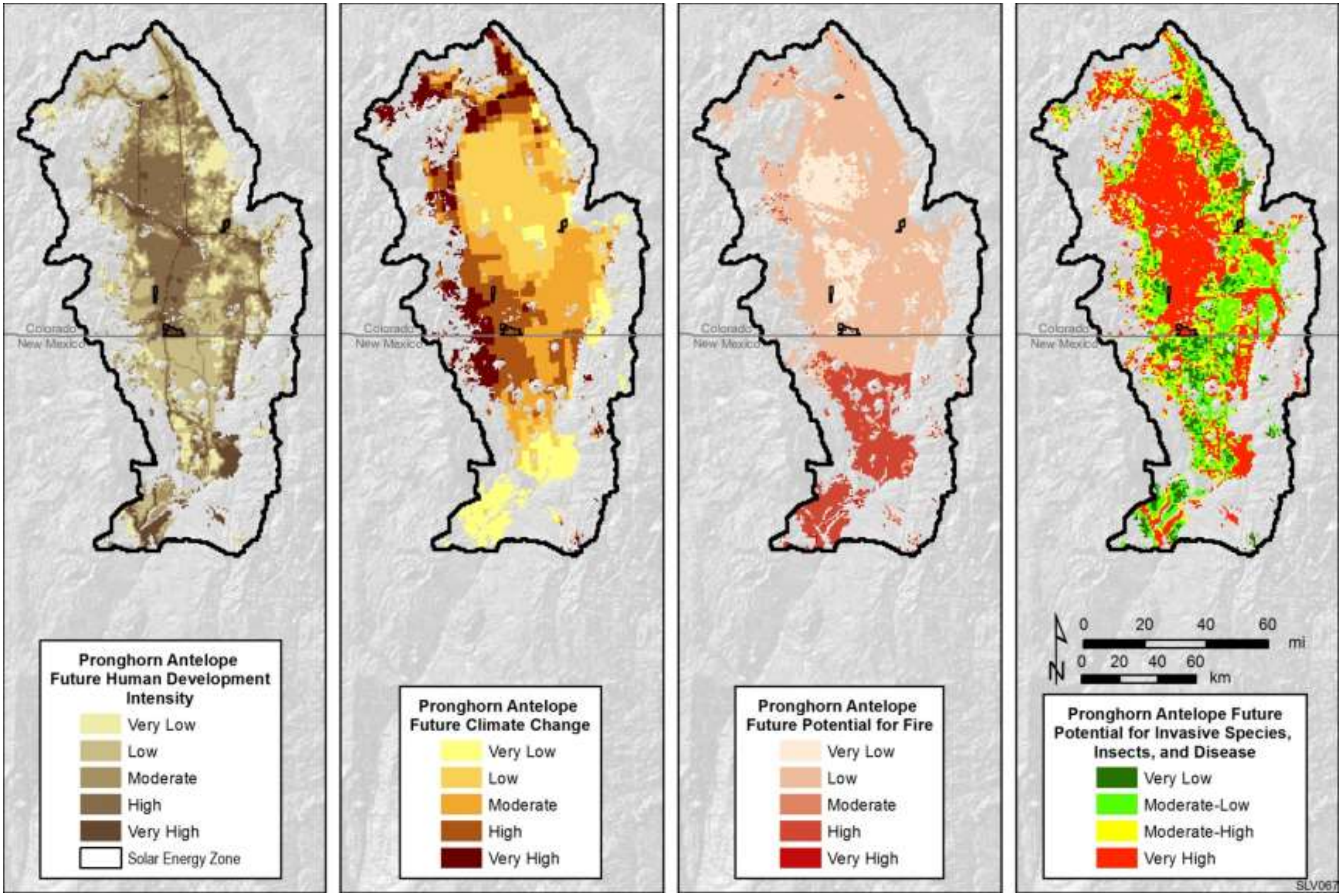


Figure B.2.11-6. Illustration for MQD3: Where is pronghorn antelope vulnerable to change agents in the future? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

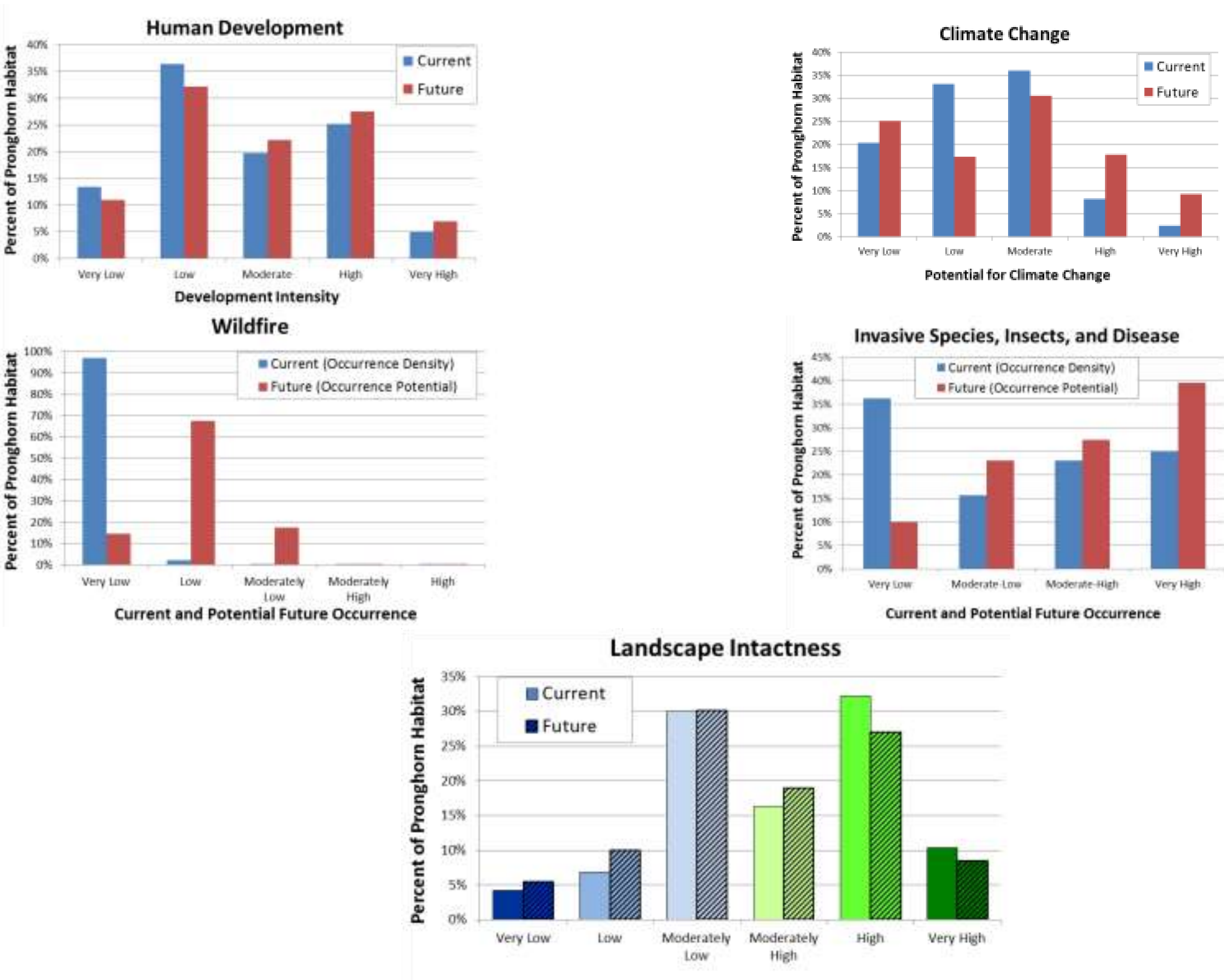


Figure B.2.11-7. Predicted Trends in Pronghorn Antelope Habitat within the Study Area

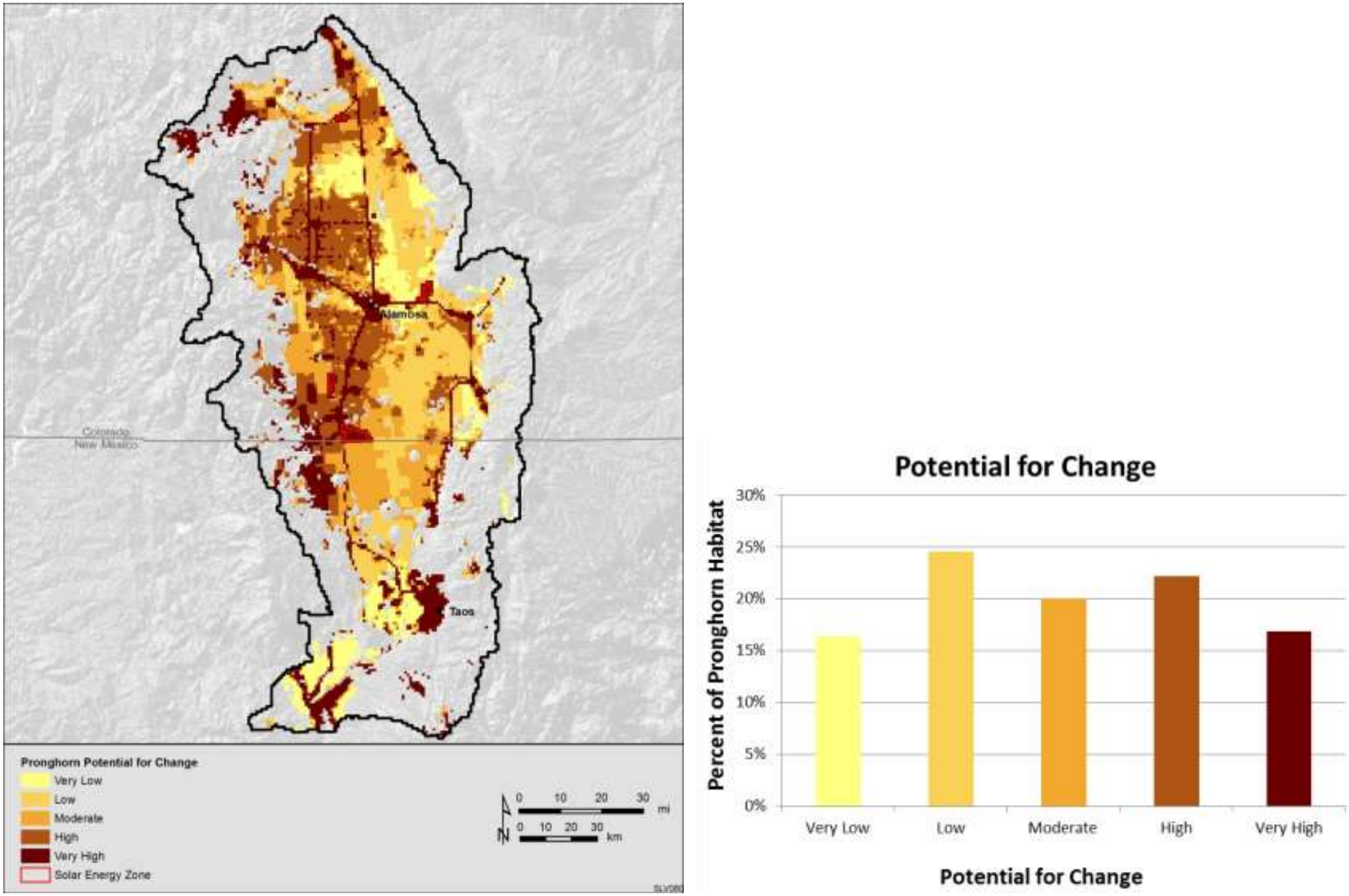


Figure B.2.11-8. Pronghorn Antelope Aggregate Potential for Change. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.2.12 Elk-Mule Deer Assemblage

In mountainous regions elk spend summers in alpine meadows and winters in valleys. The species is active at night, but most active at dusk and dawn. There is much geographic and seasonal variation in elk diet; it is primarily a grazer but also consumes forbs and may browse on willow, aspen, oak, etc., where grasses are unavailable. Diurnal feeding is more common in summer than in winter. Feeding periods are more prolonged in winter, concentrated in morning and evening. Herds may bed down in meadows in afternoon and again after midnight to chew cud (Nature Serve 2014).

Mule deer have the ability to occupy a diverse set of habitats as well, but are most commonly associated with sagebrush communities (Mule Deer Working Group 2003, Theodore Roosevelt Conservation Partnership 2011). Shrub communities are important to mule deer for food and shelter, and the connectivity of such seasonal habitats is critical to the survival of mule deer populations (Theodore Roosevelt Conservation Partnership 2011). Like most deer, mule deer are browsers that rely on a diverse range of plants for their nutrition. In late spring to early fall, mule deer eat mostly forbs and grasses, while in late fall they eat the leaves and stems of brush species, and in winter to early spring they must survive on just twigs and branches (Theodore Roosevelt Conservation Partnership 2011).

While elk and mule deer forage on a wide variety of plant species, they also have very specific seasonal foraging requirements, and variety and high nutritional content across seasons is imperative to the survival of populations (Watkins et al. 2007). Mountain lions are the top predators in the ecoregion. Despite their adaptability, mule deer populations have been decreasing in numbers since the latter third of the 20th century. There are a myriad of stressors on mule deer, but the most significant threats involve habitat fragmentation and conversion (Theodore Roosevelt Conservation Partnership 2011). The vegetative species composition has been modified extensively with the invasion of non-native plants such as cheatgrass (Watkins et al. 2007). Cheatgrass out-competes most native plant species in a moisture-limited environment and changes the site-specific fire ecology, resulting in a loss of important shrub communities (Watkins et al. 2007). Plant species composition has also changed due to livestock grazing, successional changes caused by fire suppression, and the disturbance and conversion of habitat (Watkins et al. 2007). In addition to the change in plant species composition, active fire suppression has changed the vegetation structure to result in the accumulation of unnaturally high fuel loads that can lead to more extensive fires (Watkins et al. 2007, Mule Deer Working Group 2011). Other factors that contribute to the decline of mule deer populations include habitat fragmentation due to gas, mineral, and oil exploration and increased competition with elk when habitat is poor or limited (Mule Deer Working Group 2011).

Elk responses to highways and roads vary by a number of factors, such as topography, vegetation, traffic volumes, how the highway is designed, and whether or not elk are hunted. Elk have been shown to use habitat adjacent to roads less frequently than similar habitat that is not affected by roads (Johnson et al. 2000, Ager et al. 2003, Perry and Overly 1977, Lyon 1979, Ruediger et al. 2006). Generally, elk use of habitat decreases as the proximity of that habitat to roads and highways increases. Rowland et al. (2000) found there was a measurable decline in elk use up to 1.8 kilometers (5,500 ft) from roads. Ecological attributes and indicators for the elk-mule deer assemblage are provided in Table B.2.12-1.

Energy development results in direct loss of habitat, disturbance and displacement from foraging areas and migration routes, resulting loss of connectivity between seasonal habitats, contamination of water supplies, spread of invasive non-native vegetation, and stress-related energy expenditures, particularly in the winter months (Tessman et al. 2004).

Since the 1980s, the Great Sand Dunes Elk Herd in the northeastern portion of the San Luis Valley has increased in size to over 5,000 individuals by 2010 (CPW 2010). This elk herd has grown to significant numbers, making control of the population through harvest nearly impossible (due to the amount of private and federal land where hunting is not allowed or is on a limited basis). Management issues for the Great Sand Dunes Elk herd include the habitat loss and fragmentation associated with oil and gas development and solar energy development, as well as the spread of invasive species and insect pests (such as the spruce pine beetle) in the coniferous forests in which this population inhabits (CPW 2010).

The information discussed in this species account was used in the development of a conceptual model illustrating status and the mechanisms by which the elk-mule deer populations may be affected within the San Luis Valley – Taos Plateau study area (Figure B.2.12-1). Figures B.2.12-2 through B.2.12-8 show, respectively: Figure B.2.12-2 - the current distribution of potentially suitable elk-mule deer habitat in the study area; Figure B.2.12-3 - the distribution with respect to current vegetation departure; Figure B.2.12-4 - the distribution of potentially suitable habitat with respect to current and future landscape intactness in the study area; Figure B.2.12-5 - the distribution and status with respect to the current status of change agents; Figure B.2.12-6 - the distribution with respect to predicted areas of change; Figure B.2.12-7 - predicted trends within the study area; and Figure B.2.12-8 - the aggregate potential for change in potentially suitable elk-mule deer habitat.

The majority (34%) of vegetation within the elk-mule deer potentially suitable habitat has a moderate degree of departure from historic reference vegetation conditions (Figure B.2.12-7). Most of the vegetation departure that has occurred within the potentially suitable habitat is located in areas of agricultural and urban development in the San Luis Valley (Figure B.2.12-3).

The majority (60%) of the elk-mule deer potentially suitable habitat is within areas of high and very high landscape intactness (Figure B.2.12-7). Future trends in landscape intactness indicate a decrease in landscape intactness within elk-mule deer potential habitat. The amount of potential habitat occurring within areas of high and very high landscape intactness is expected to decrease by approximately 10% in the near-term (i.e., by 2030) (Figure B.2.12-7).

The majority (65%) of the elk-mule deer potentially suitable habitat is within areas of low or very low human development intensity (Figure B.2.12-7). Future trends in human development indicate an increase in human development intensity within elk-mule deer potential habitat. The amount of potential habitat occurring within areas of high and very high human development intensity is expected to increase by approximately 7.5% in the near-term (i.e., by 2030) (Figure B.2.12-7).

The majority of the elk-mule deer potentially suitable habitat is within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature. Future trends in climate change indicate portions of the potential habitat distribution with high or very high potential for climate change in the future (i.e., by 2069) (Figure B.2.12-6). Approximately 33% of the elk-mule deer suitable habitat is located in areas with high or very high potential for future climate change (Figure B.2.12-7). The greatest potential for future climate change within elk-mule deer potentially suitable habitat occurs in the western and northwestern portion of the study area (Figure B.2.12-6). Although the overall impact of climate change on the elk-mule deer assemblage and their habitat is currently unknown (e.g., CPW 2010), studies suggest that future habitat quality may be reduced with changes in temperature suitability for forest insect pests (e.g., Bentz et al. 2010).

The majority of the elk-mule deer potentially suitable habitat is within areas of very low current fire occurrence density (Figure B.2.12-7). Future trends in wildfire indicate an increase in wildfire potential in some portions of the potential habitat distribution in the study area. The greatest potential for near-term future wildfire occurs in the southern portion of the potential habitat distribution in New Mexico (Figure B.2.12-6).

The majority of the elk-mule deer potentially suitable habitat is within areas of either very low or very high current density of invasive species, insects, and disease (Figure B.2.12-7). Future trends indicate an increase in invasive species, insects, and disease potential in some portions of elk-mule deer potentially suitable habitat in the study area. Areas of potential future spread of invasive species, insects, and disease include areas of urban and rural expansion, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (Figure B.2.12-6).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 35% of the elk-mule deer suitable habitat has the potential for high or very high future change among the change agents (Figure B.2.12-8). Areas where greatest potential for change occur within elk-mule deer suitable habitat include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.2.12-8).

Table B.2.12-1. Elk-Mule Deer Assemblage Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	**Fair**	**Good**	**Very Good**	**Citation**
Habitat quality (elk)	Distance to roads	<2 km		>2 km		Rowland et al. (2000)
Habitat quality (mule deer)	Distance from oil wells	<2.7 km			>3.7 km	Sawyer et al. (2006)
Habitat quality (mule deer)	Fire suppression	Large, hot fires			Small, infrequent fires (early successional plants)	Mule Deer Working Group (2003)

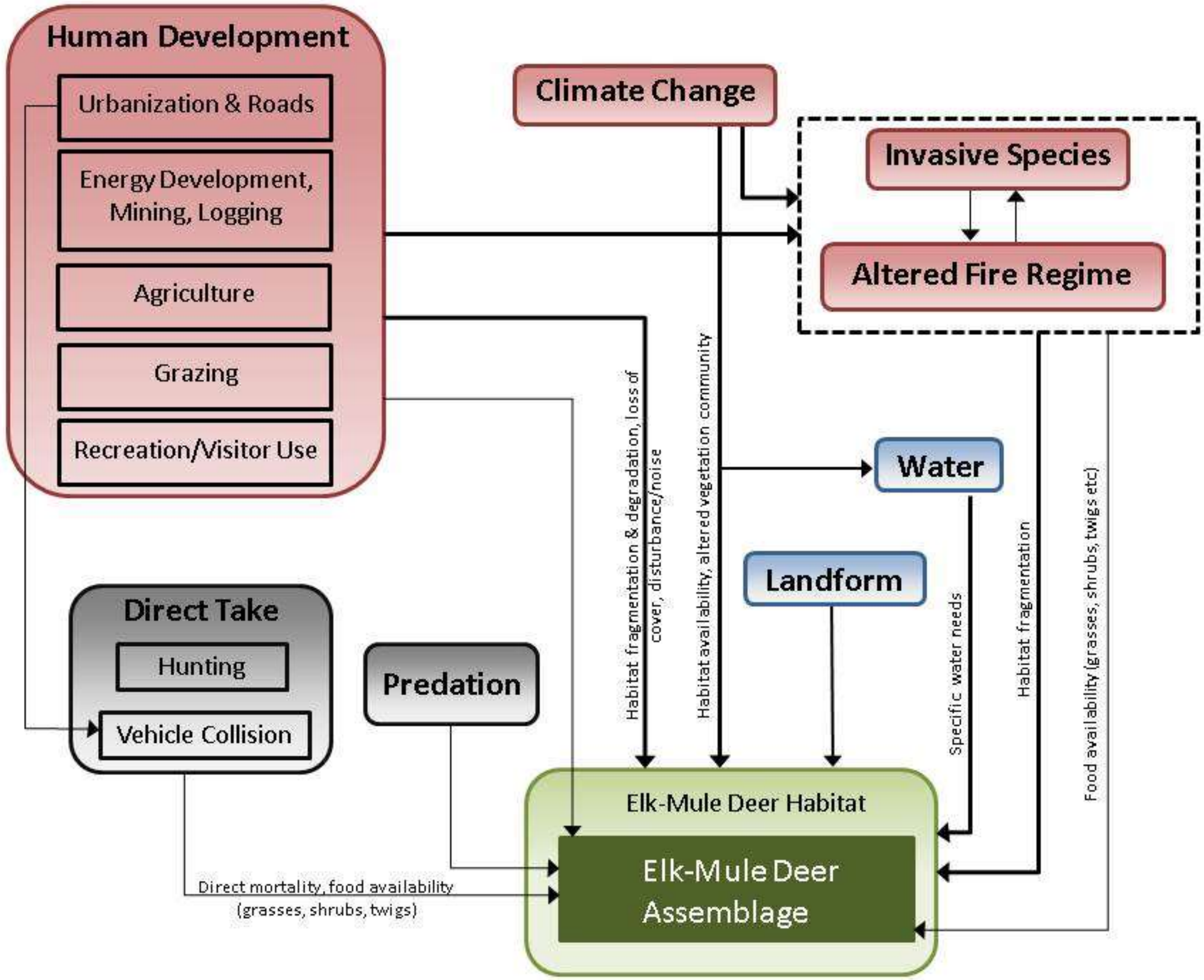


Figure B.2.12-1. Elk-Mule Deer Assemblage Conceptual Model.

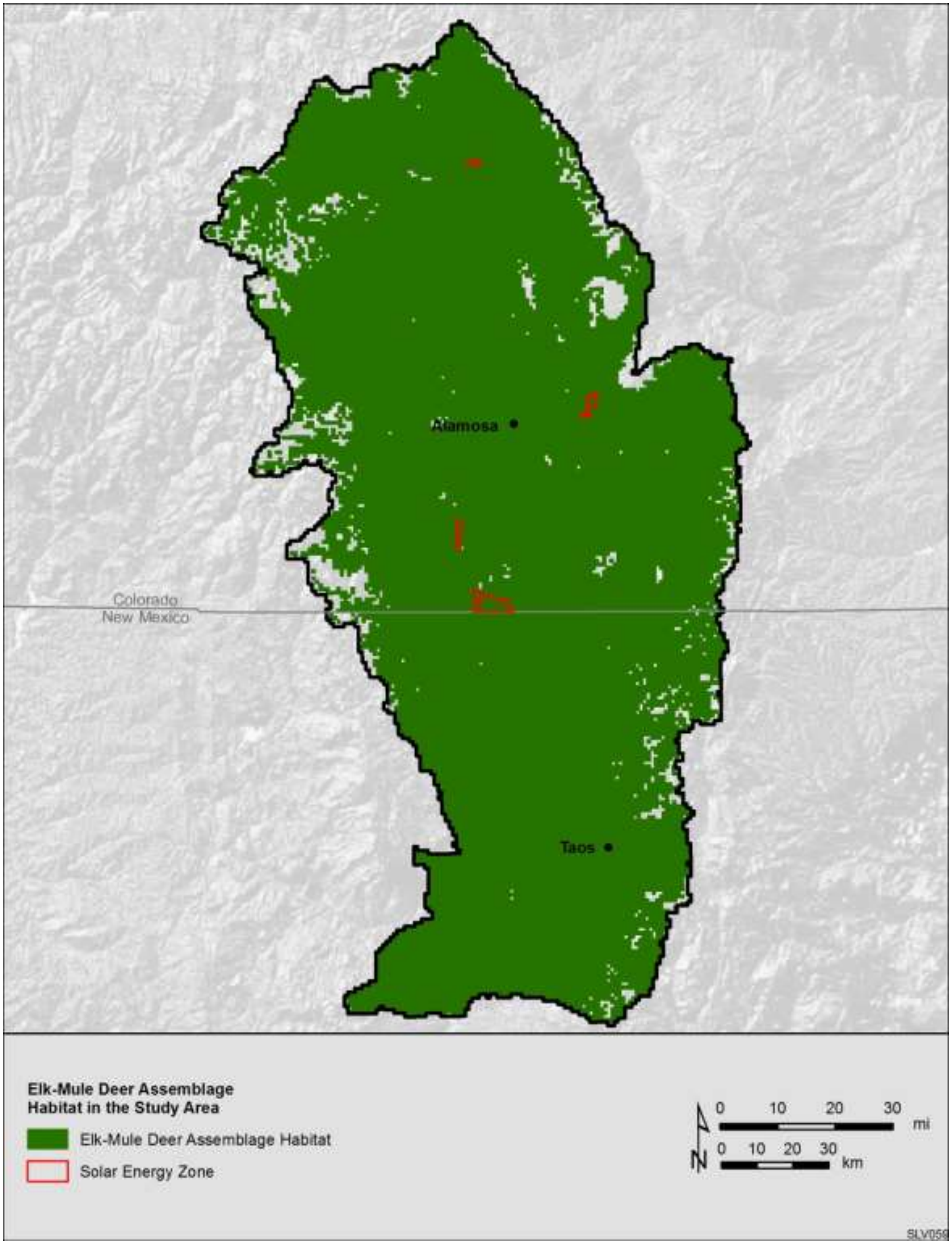


Figure B.2.12-2. Current Distribution of Potentially Suitable Habitat for the Elk-Mule Deer Assemblage. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Note: Data include only potentially suitable habitat and do not directly represent movement corridors and seasonal ranges, which are evaluated separately.

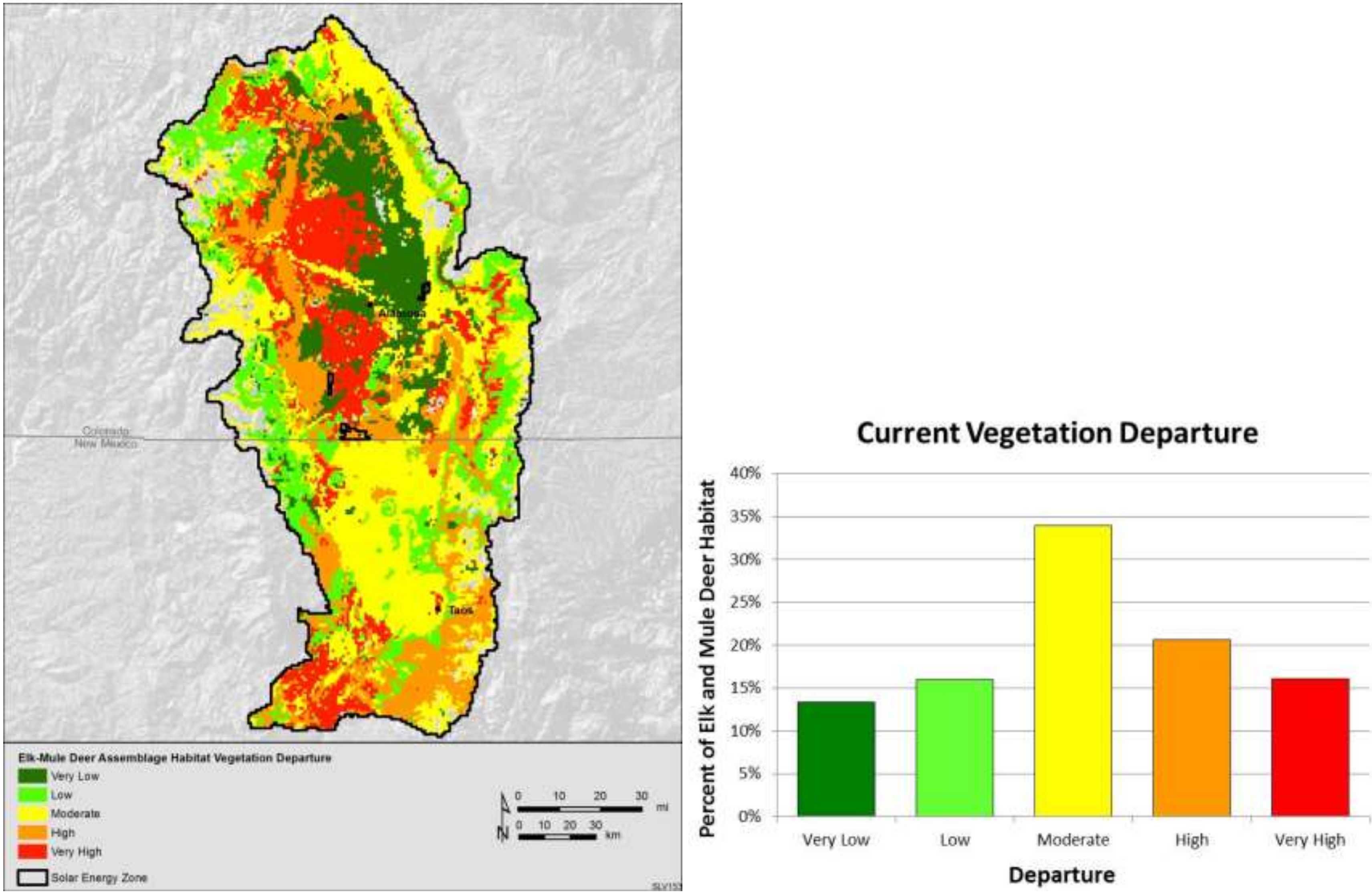


Figure B.2.12-3. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Current Elk-Mule Deer Assemblage Potentially Suitable Habitat. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008) and Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007). Data were Summarized to 1 km^2 Reporting Units.

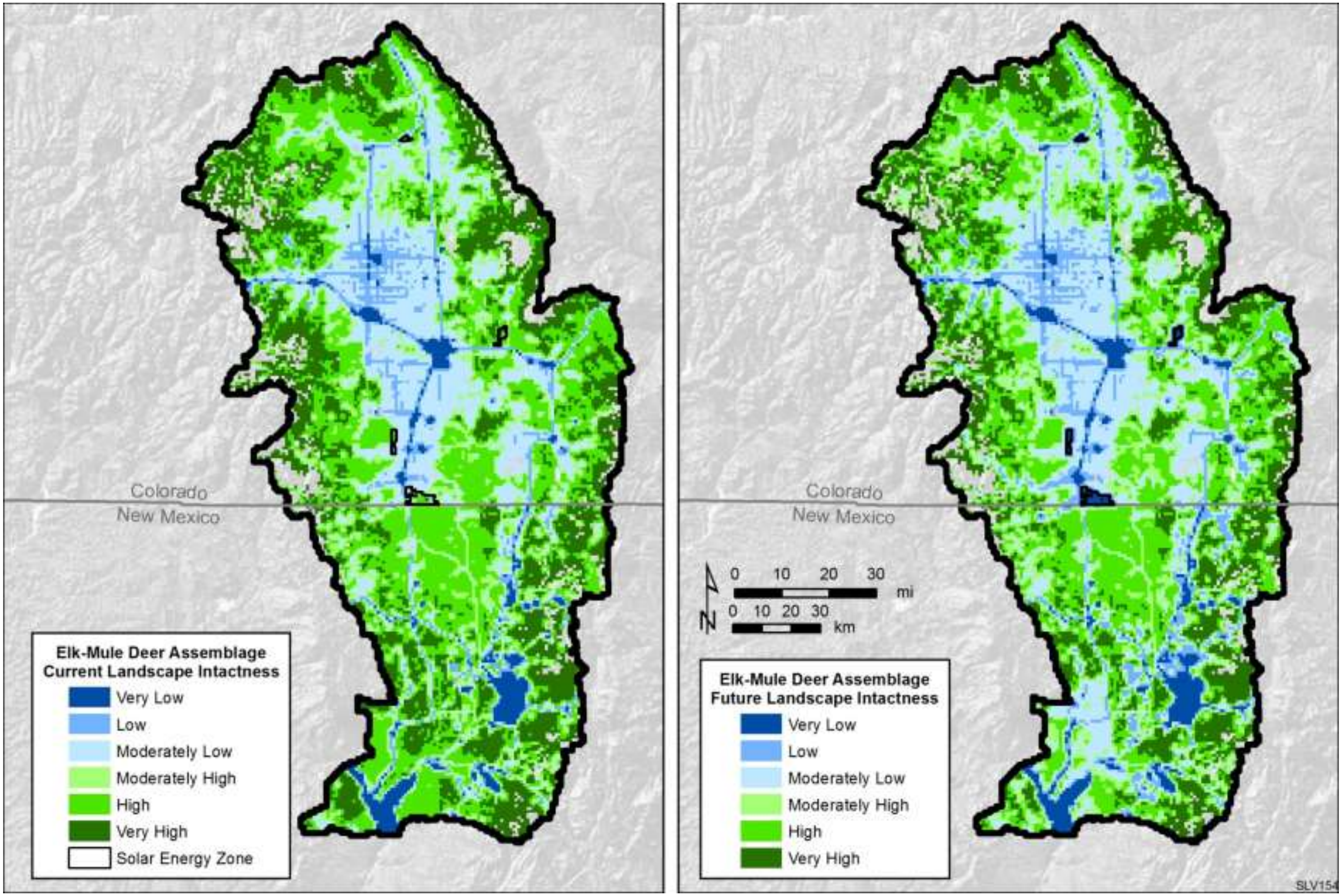


Figure B.2.12-4. Current and Future Landscape Intactness of Potentially Suitable Elk-Mule Deer Assemblage Habitat. Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

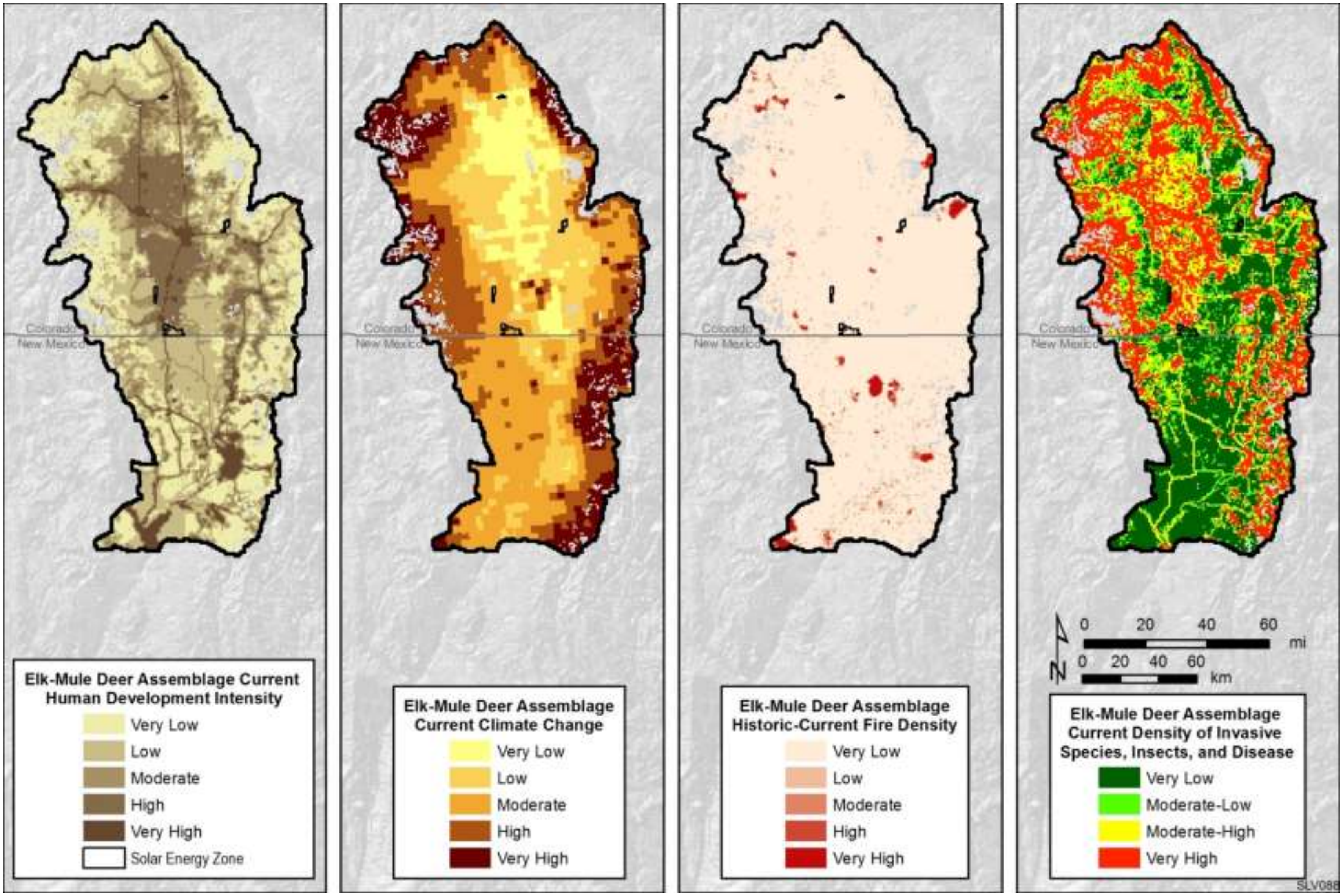


Figure B.2.12-5. Illustration for MQD1: What is the current distribution and status of suitable habitat for the Elk-Mule Deer Assemblage? Data Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

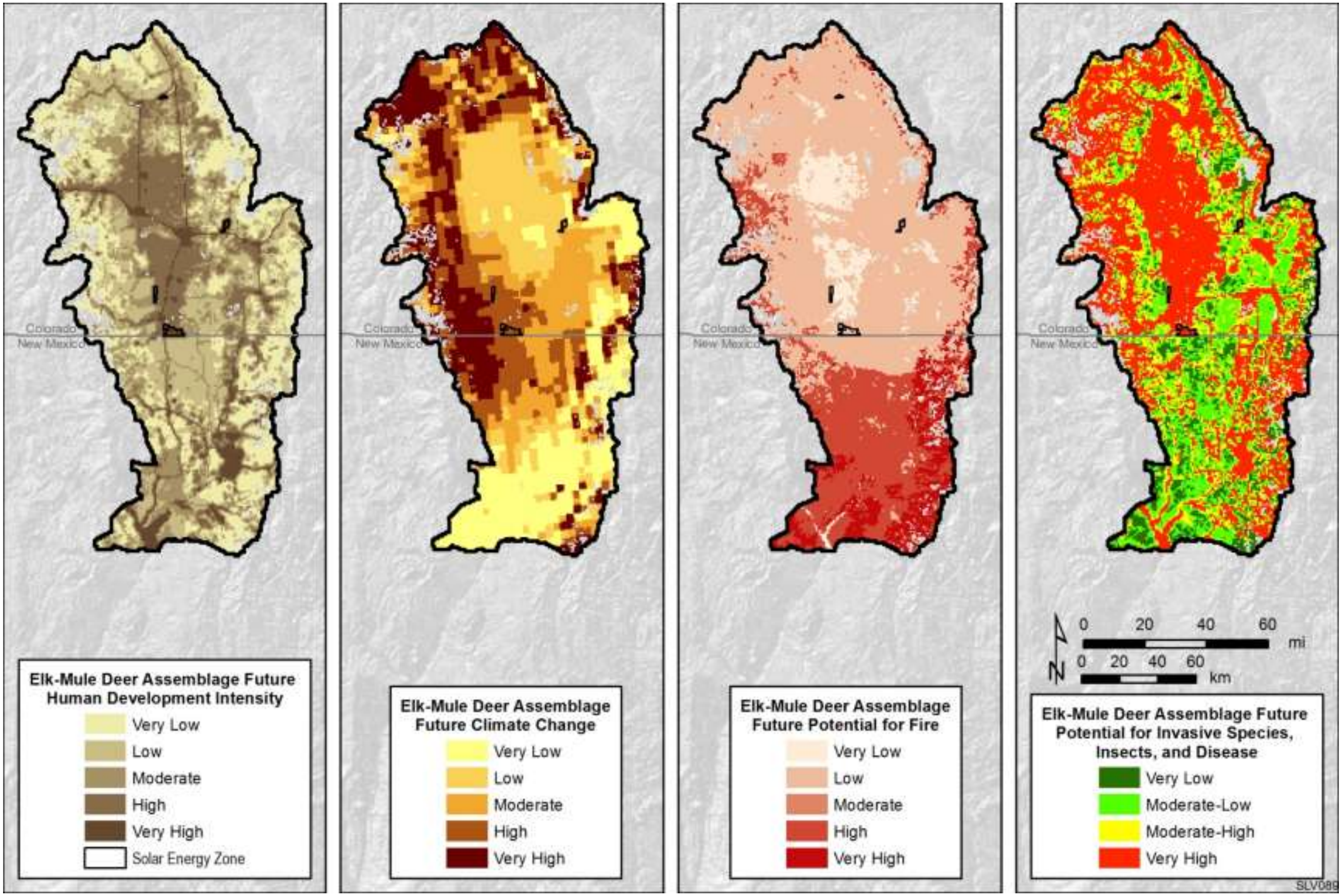


Figure B.2.12-6. Illustration for MQD3: Where is the Elk-Mule Deer Assemblage vulnerable to change agents in the future? Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

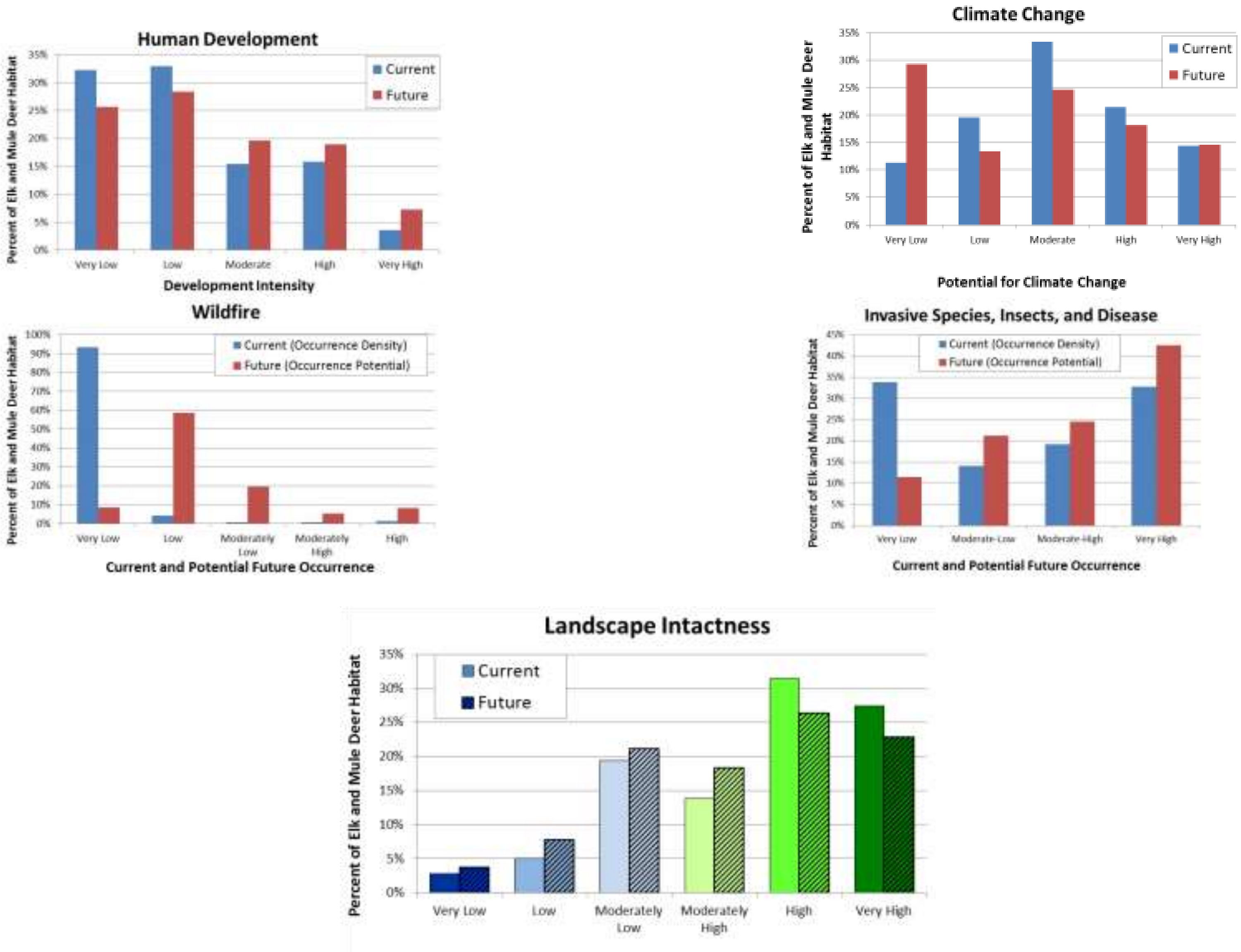


Figure B.2.12-7. Predicted Trends in Elk-Mule Deer Assemblage Habitat within the Study Area

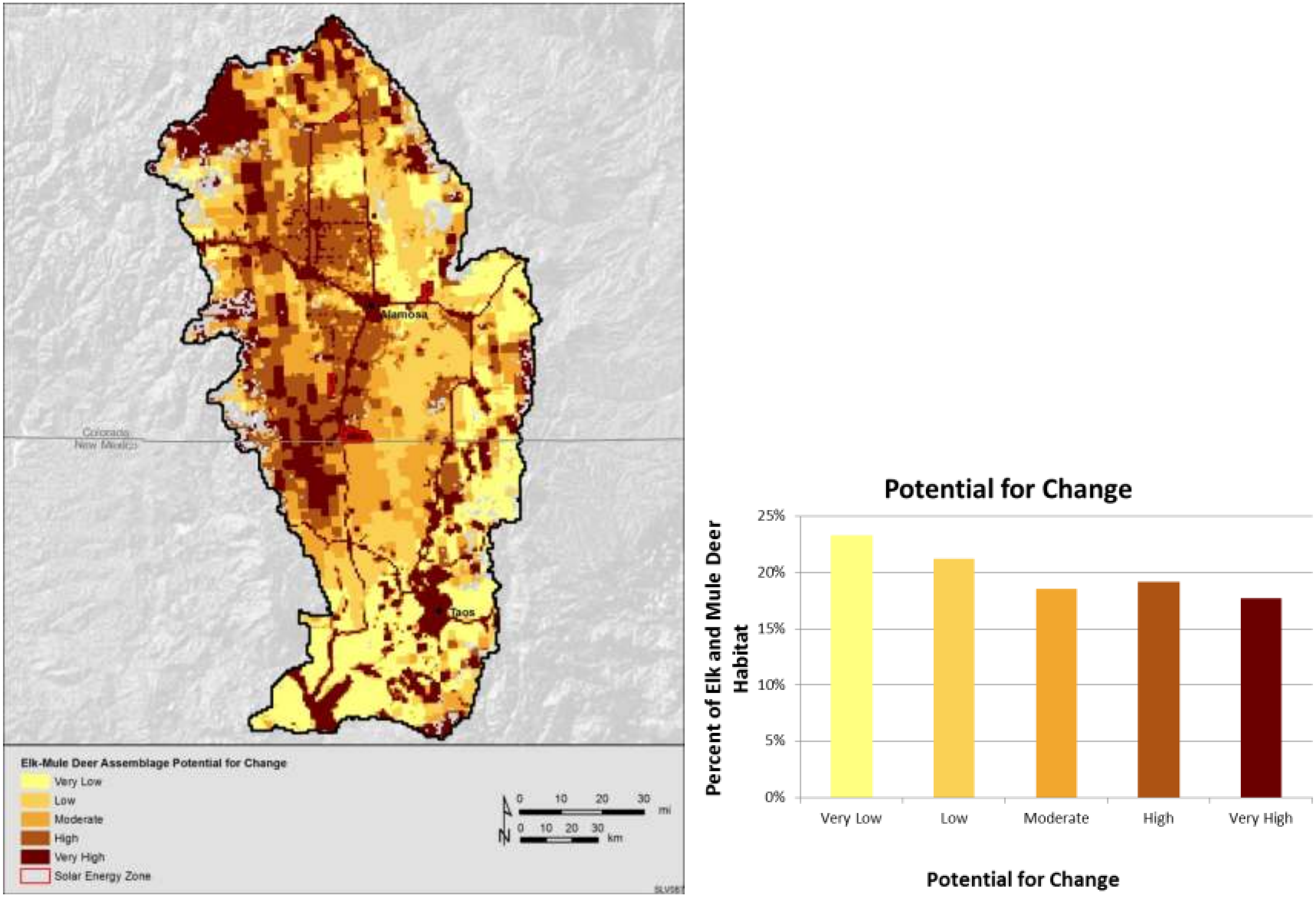


Figure B.2.12-8. Elk-Mule Deer Assemblage Aggregate Potential for Change. Source: Southwest Regional Gap Analysis Project (SWReGAP) (USGS National Gap Analysis Program, 2007) and Argonne 2014.

B.3 Sites of Conservation Concern Conservation Element

B.3.1 Sites of Conservation Concern Assemblage

Geospatial datasets were compiled to represent sites of conservation concern for ecological value. Sites were considered to be "protected" or "unprotected". Protected sites were those that have special designations and are managed for ecological value where human activities on the sites are controlled. Unprotected areas are those that do not have a specific designation or management policy but have been identified as having ecological value that may warrant conservation. Table B.3.1-1 lists the types of datasets used to characterize sites of conservation concern within the study area.

Figures B.3.1-1 through B.3.1-7 show, respectively: Figure B.3.1-1 – "protected" sites of conservation concern; Figure B.3.1-2 – "unprotected" sites of conservation concern; Figure B.3.1-3 – aggregate distribution of sites of conservation concern in the study area; Figure B.3.1-4 – sites of conservation concern with respect to current vegetation departure; Figure B.3.1-5 – sites of conservation concern with respect to current and future landscape intactness in the study area; Figure B.3.1-6 – status of sites of conservation concern with respect to the current status of change agents; Figure B.3.1-7 – spatial trends in sites of conservation concern; Figure B.3.1-8 – graphical predicted trends in sites of conservation concern; and Figure B.3.1-9 - the aggregate potential for change in sites of conservation concern.

The majority (40%) of vegetation within sites of conservation concern has a moderate degree of departure from historic reference vegetation conditions (Figure B.3.1-4; Figure B.3.1-8). Most of the vegetation departure that has occurred within sites of conservation concern is located in rural and shrubland areas of the Taos Plateau in northern New Mexico (Figure B.3.1-4).

The majority (65%) of the sites of conservation concern are within areas of high and very high current landscape intactness (Figure B.3.1-5; Figure B.3.1-8). Future trends in landscape intactness indicate a decrease in landscape intactness within sites of conservation concern. The amount of sites of conservation concern occurring within areas of high and very high landscape intactness is expected to decrease by approximately 10% in the near-term (i.e., by 2030) (Figure B.3.1-8).

The majority (72%) of the sites of conservation concern are within areas of very low and low current human development intensity (Figure B.3.1-6; Figure B.3.1-8). Future trends in human development indicate an increase in human development intensity within sites of conservation concern. The amount of sites of conservation concern occurring within areas of high and very high human development intensity is expected to increase by approximately 6% in the near-term (i.e., by 2030) (Figure B.3.1-7; Figure B.3.1-8).

The majority of the sites of conservation concern are within areas of moderate current climate change, as measured by the relative change in current precipitation and temperature from historic baseline period precipitation and temperature (Figure B.3.1-6; Figure B.3.1-8). Future trends in climate change indicate portions of the sites of conservation concern with high or very high potential for climate change in the long-term future (i.e., by 2069) (Figure B.3.1-7; Figure B.3.1-8). Approximately 38% of the sites of conservation concern are located in areas with high or very high potential for future climate change (Figure B.3.1-8). The greatest potential for future climate change within sites of conservation concern occurs in the western and northwestern sites in the study area (Figure B.3.1-7).

The majority of the sites of conservation concern are within areas of very low current fire occurrence density (Figure B.3.1-6; Figure B.3.1-8). Future trends in wildfire indicate an increase in wildfire potential in some portions of the sites of conservation concern in the study area. The greatest potential for future wildfire occurs in the southern portion of the habitat distribution in New Mexico (Figure B.3.1-7).

The majority of sites of conservation concern are within areas of either very low or very high current density of invasive species, insects, and disease (Figure B.3.1-6; Figure B.3.1-8). Future trends indicate an increase in potential spread of invasive species, insects, and disease in some portions of sites of conservation concern in the study area (Figure B.3.1-8). Areas of potential near-term future (i.e., by 2030) spread of invasive species, insects, and disease include areas of urban and rural expansion, energy development, spread of forest insects and disease, and spread of tamarisk along the Rio Grande in the southern portion of the study area (Figure B.3.1-7).

Results of future change agent models were combined to represent an aggregate potential for change map. Overall, approximately 35% of the sites of conservation concern have the potential for high or very high future change among the change agents (Figure B.3.1-9). Areas with greatest potential for change within sites of conservation concern include areas of high future human development intensity, high potential for future climate change, high potential spread of invasive species, insects, and disease, and high potential for wildfire (Figure B.3.1-9).

Table B.3.1-1. Sites of Conservation Concern Datasets

Site of Conservation Concern[1]	Currently Protected Area?[2]	Source
BLM Areas of Critical Environmental Concern (ACECs)	Yes	http://www.geocommunicator.gov/GeoComm/
Designated Critical Habitat (USFWS)	Yes	http://ecos.fws.gov/crithab/
USFWS Occupied and Unoccupied Habitat for the Gunnison Sage-Grouse	Yes	http://www.fws.gov/coloradoes/gusg/
Wilderness Study Areas	Yes	Received from BLM
USGS Protected Areas Database (Areas managed for biodiversity)	Yes	http://gapanalysis.usgs.gov/padus/
State Wildlife Areas	Yes	Received from BLM
Rio Grande Wild and Scenic River	Yes	Received from BLM
Rio Grande del Norte National Monument	Yes	Received from BLM
Rio Grande Natural Area	Yes	Received from BLM
Conservation Easements	Yes	http://conservationeasment.us/ and received from BLM
Rio Grande corridor (1 km buffer)	No	Generated by Argonne National Laboratory
Audubon Important Bird Areas (IBAs)	No	http://web4.audubon.org/bird/iba/
The Nature Conservancy's (TNC's) Conservation Portfolio Sites	No	http://www.nature.org/
Colorado Natural Heritage Program Potential Conservation Areas	No	http://www.cnhp.colostate.edu/download/gis.asp

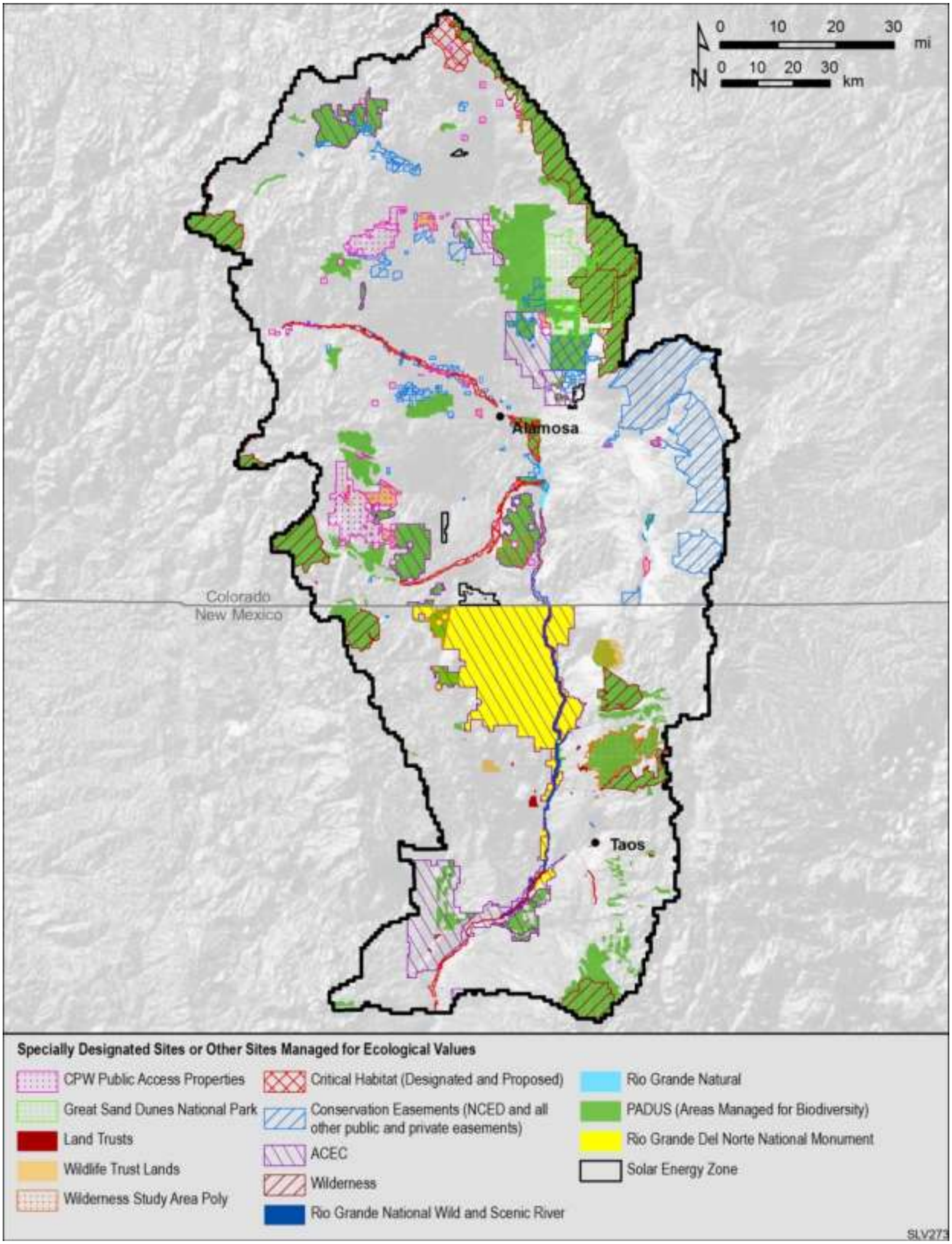


Figure B.3.1-1. Specially Designated Sites or Other Sites Managed for Ecological Value. Data Sources: data received from BLM, CPW 2013b, NCED 2013, USFWS 2014g, and USGS 2012.

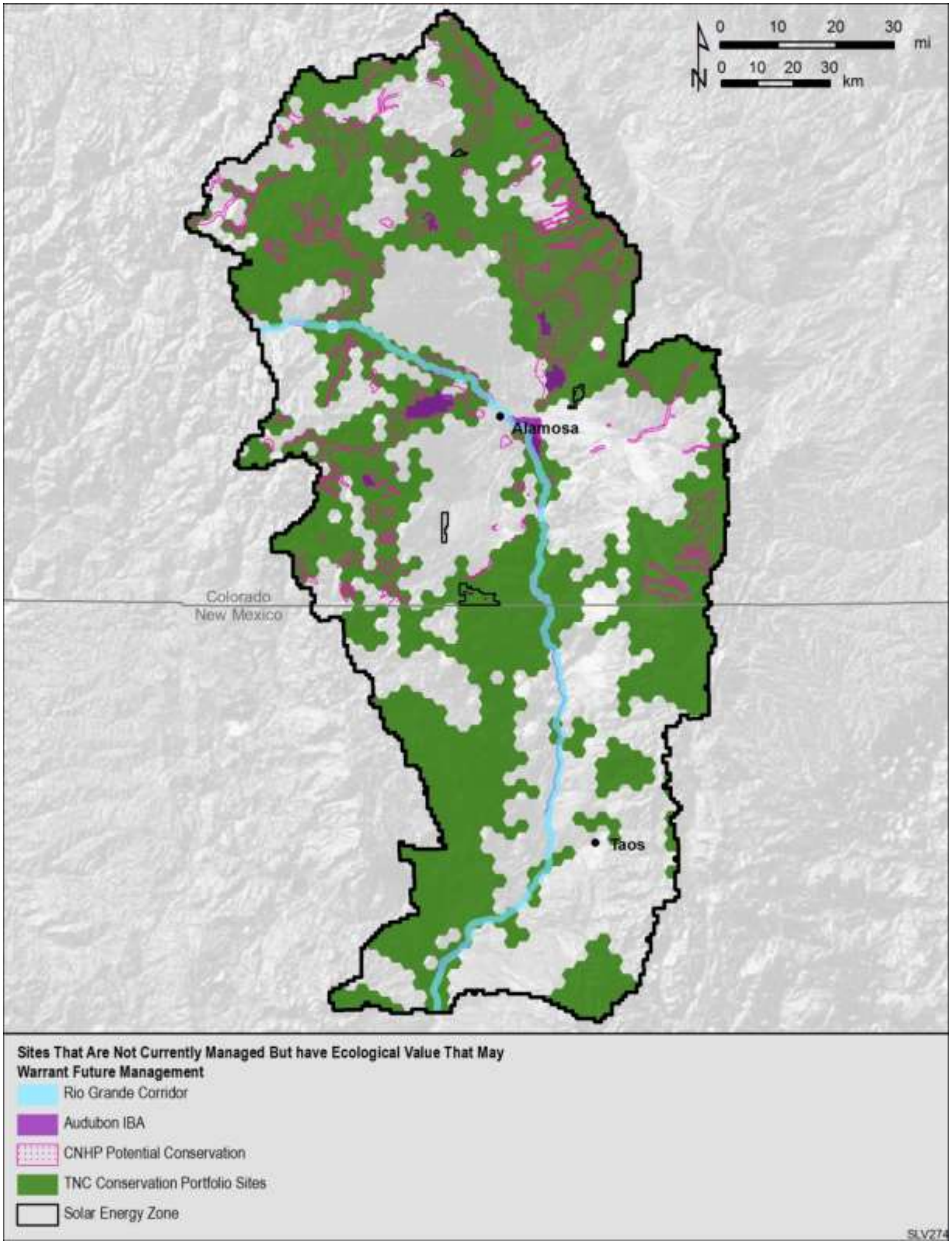


Figure B.3.1-2. Sites That Are Not Currently Managed But Have Ecological Value That May Warrant Future Management. Data Sources: Audubon 2014, data received from BLM, CNHP 2014, TNC 2011.

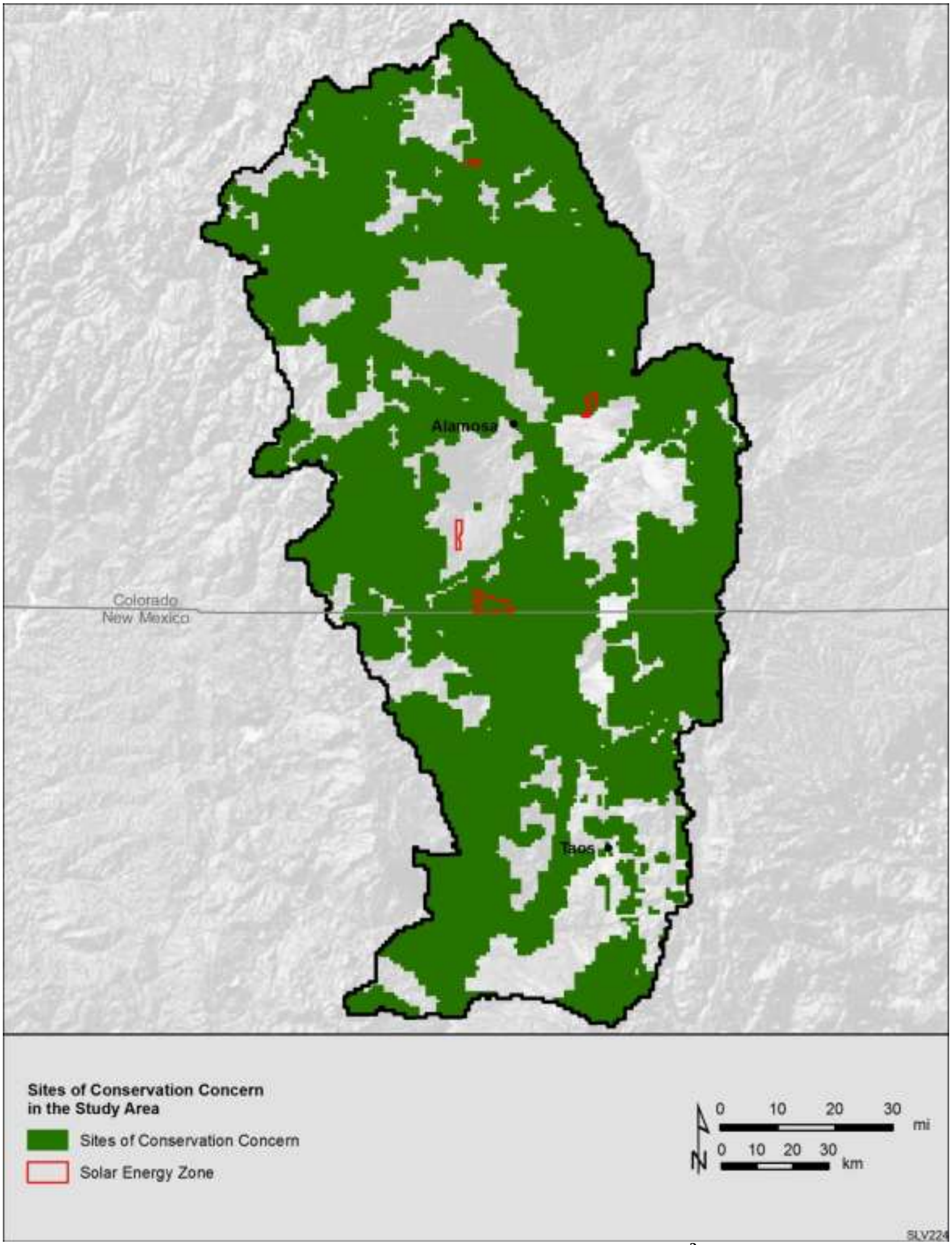
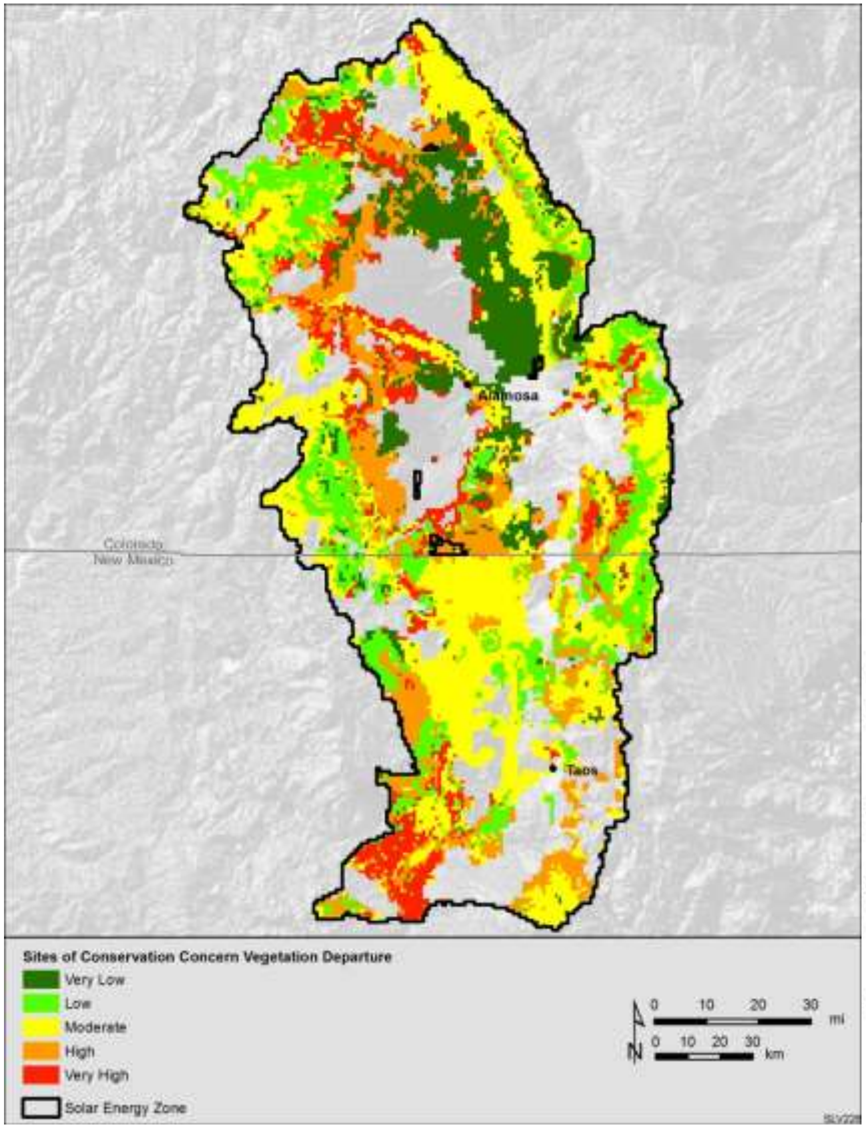


Figure B.3.1-3. Sites of Conservation Concern, Summarized to 1km^2 Reporting Units. Data Sources: data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012.



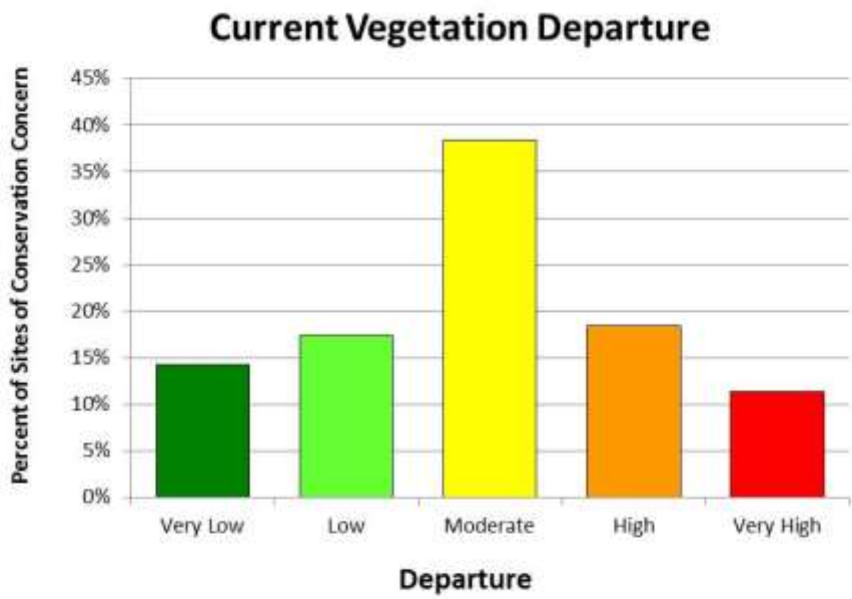


Figure B.3.1-4. Departure of Current Vegetation Conditions from Historic Vegetation Conditions within Sites of Conservation Concern. Data Sources: Current Vegetation Departure (VDEP) (LANDFIRE v 1.1; USGS, 2008), data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012. Data were Summarized to 1 km^2 Reporting Units.

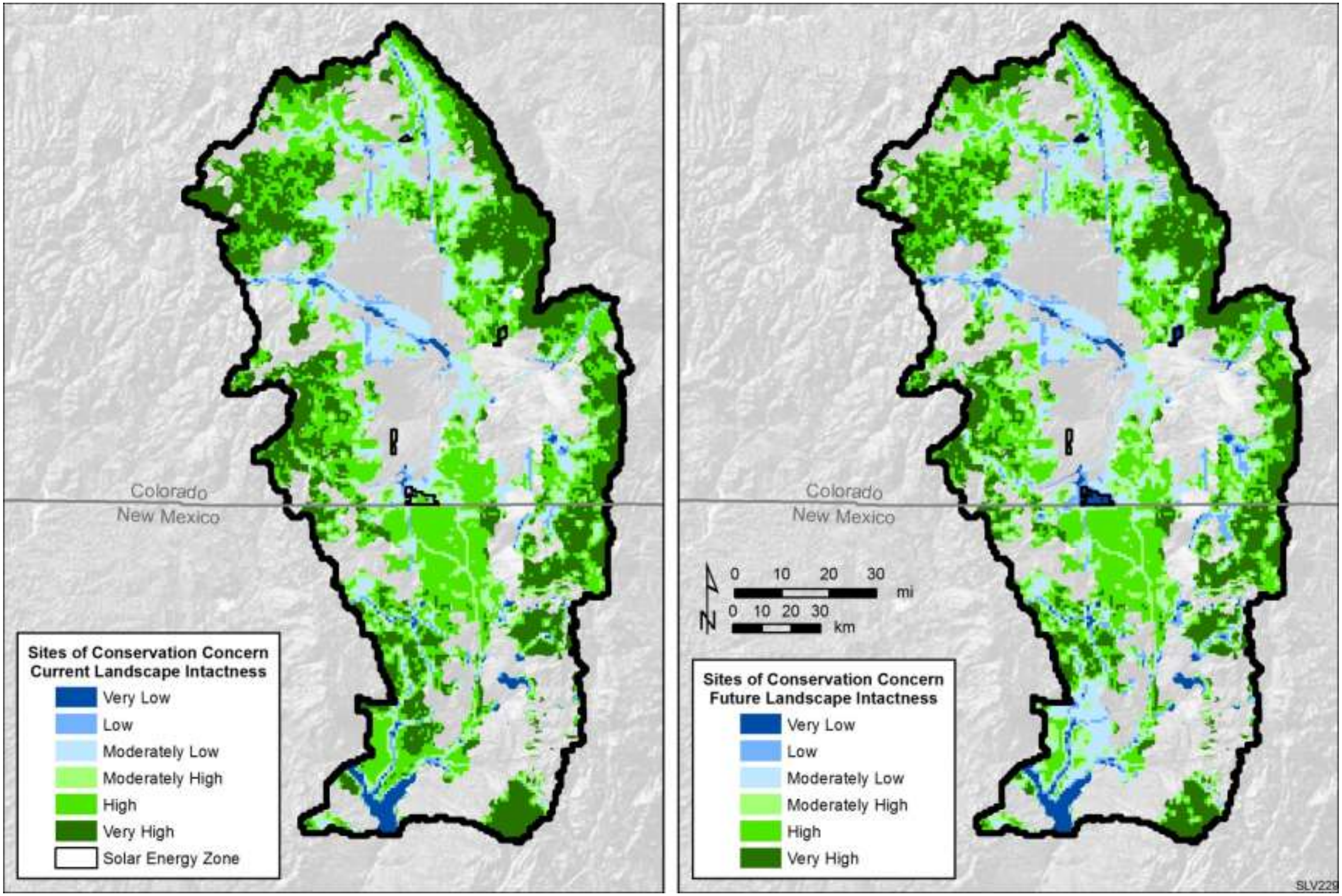


Figure B.3.1-5. Current and Future Landscape intactness of Sites of Conservation Concern. Data Sources: Argonne 2014, data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012.

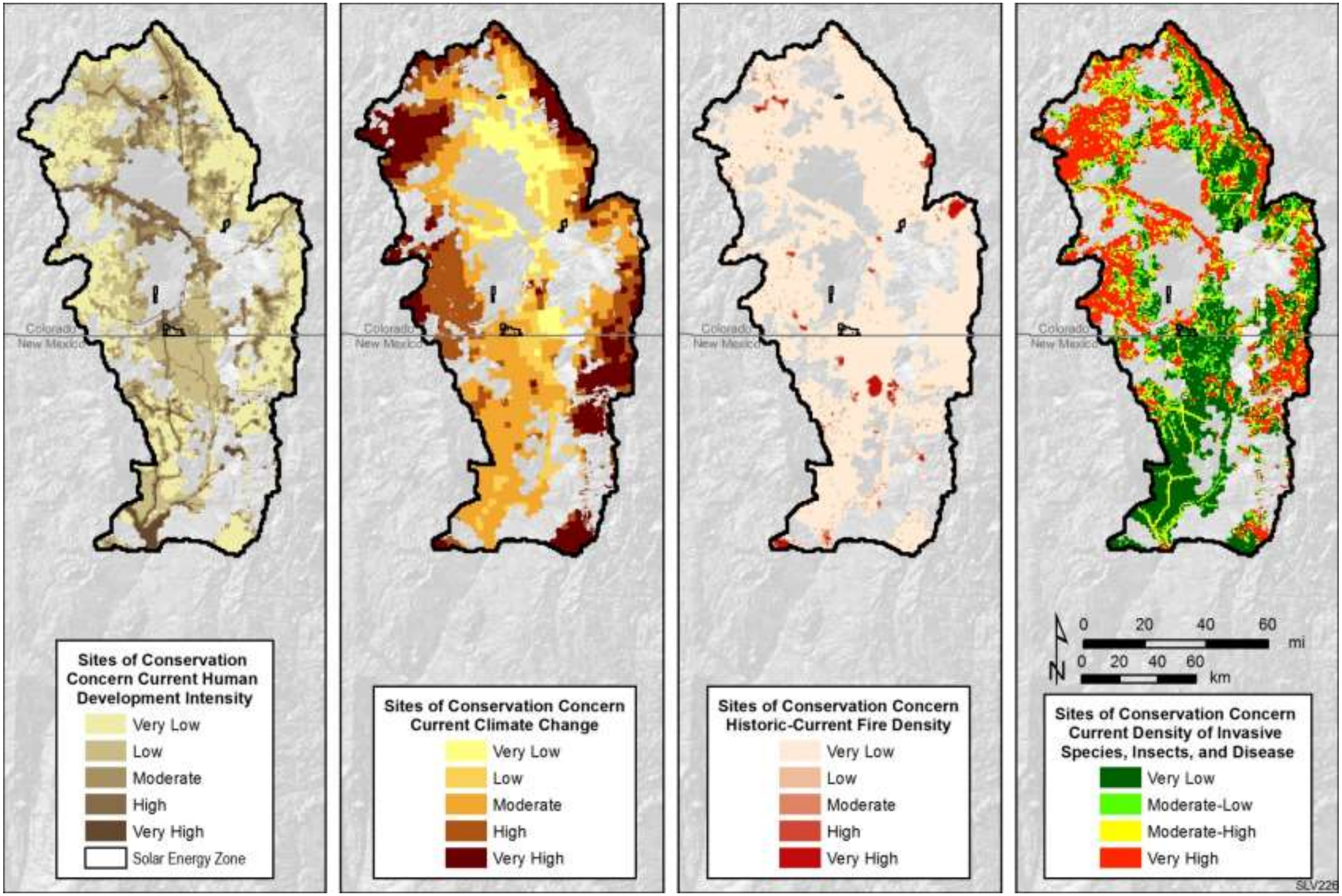


Figure B.3.1-6. Illustration for MQD1: What is the current distribution and status of Sites of Conservation Concern? Data Sources: Argonne 2014, data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012.

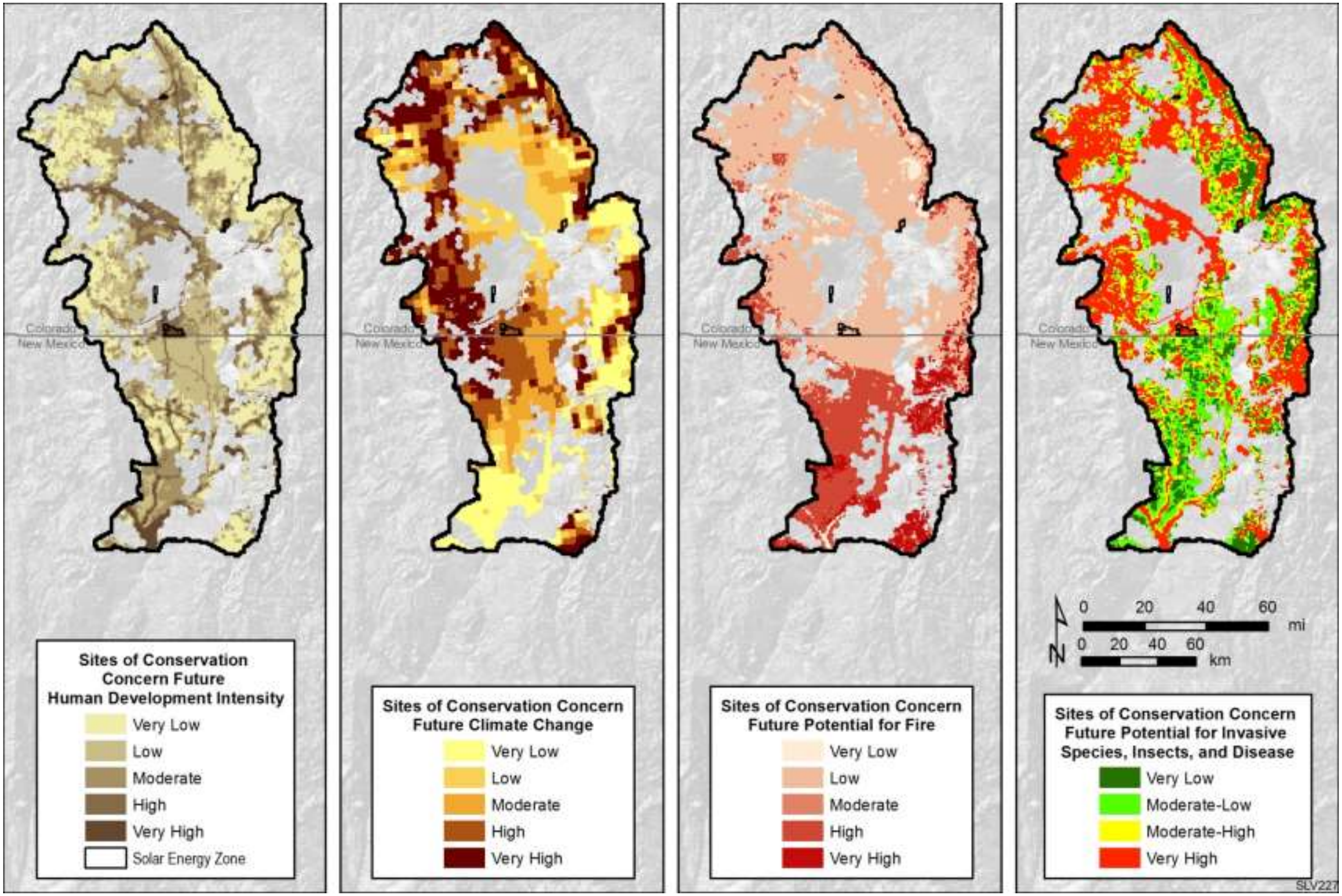


Figure B.3.1-7. Illustration for MQD3: Where are Sites of Conservation Concern vulnerable to change agents in the future? Data Sources: Argonne 2014, data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012.

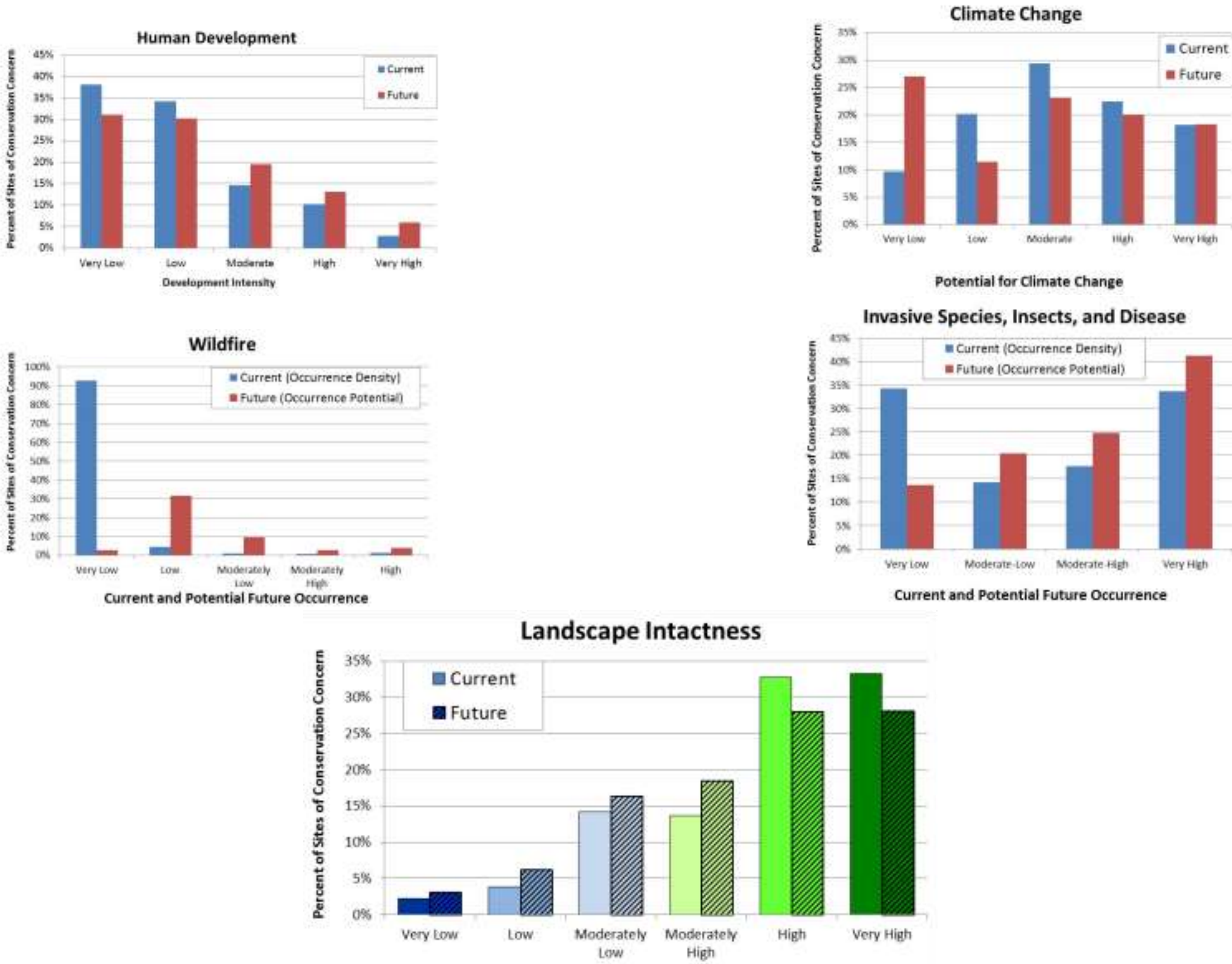
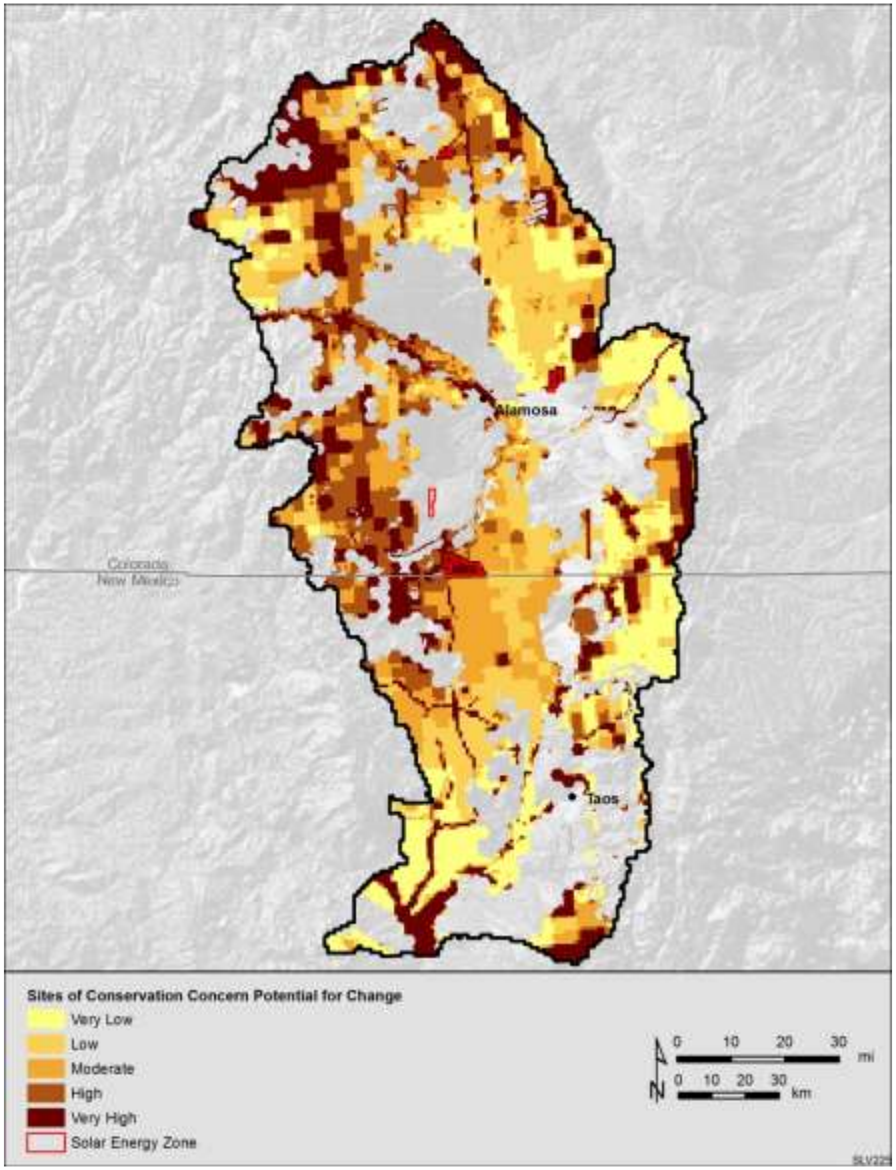


Figure B.3.1-8. Predicted Trends in Sites of Conservation Concern within the Study Area



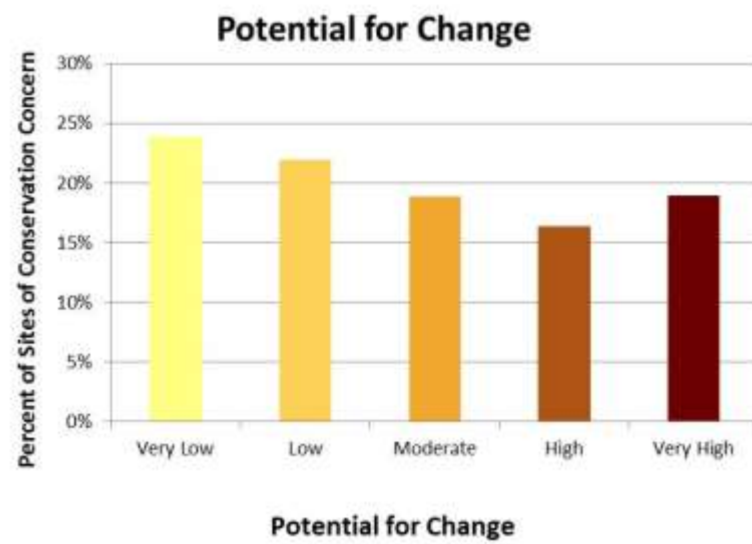


Figure B.3.1-9. Sites of Conservation Concern Aggregate Potential for Change. Data Sources: Argonne 2014, data received from BLM, Audubon 2014, CNHP 2014, CPW 2013, NCED 2013, TNC 2011, USFWS 2014, and USGS 2012.

B.4 Ecosystem Function Conservation Elements

B.4.1 Soils with Potential for Erosion

See Appendix A (Section A.1.2) - MQA2 – Where are Soils with Potential for Erosion?

B.4.2 Aquatic Systems

See Appendix A (Section A.2) for Management Questions pertaining to hydrology

B.4.3 Riparian Areas

See Section B.1.4 above for assessment of riparian and wetland ecological systems Conservation Elements

B.4.4 Hydrologic Systems

See Appendix A (Section A.2) for Management Questions pertaining to hydrology

B.4.5 Species Richness-Biodiversity Assemblage

See Appendix A (Section A.4) for Management Questions pertaining to species richness and biodiversity

B.4.6 Big Game Ranges

See Appendix A (Section A.4) for Management Questions pertaining to big game crucial habitat and movement corridors

B.5 Cultural and Historic Conservation Elements

A total of seven cultural and historic CEs have been identified as important human elements for evaluation:

- Places of Traditional Cultural Importance (Tribes)
- Traditional Resource Collection Areas
- Trails, Passes, and Travel Corridors
- Hispano Land Grants and Communal Use Patterns (Hispano Places of Traditional Cultural Importance)
- Eligible Prehistoric Properties
- Eligible Historic Properties
- Paleontology

These CEs are being evaluated as part of a Cultural Landscape Assessment (BLM and Argonne 2015). Please refer to that CLA for characterization of these CEs and assessment with respect to change agents.

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APPENDIX C:

DATA INVENTORY

Table C-1. Spatial Data Inventory for the San Luis Valley – Taos Plateau Landscape Assessment.

ID	Category	File Name(s)	Full Data Path	Description	Source
1	Agriculture	SLV_Allotments_BLM_Poly	SLV_Data.gdb\	BLM grazing allotments	BLM
2	Agriculture	SLV_Allotments_USFS_Poly	SLV_Data.gdb\	USFS grazing allotments	USFS
3	Agriculture	SLV_NM_Wood_ProcessAndUsers_pt	SLV_Data.gdb\	Wood process user locations in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
4	Air Quality	SLV_Veg_Carbon_C_1km_Poly	SLV_Data.gdb	Current status of areas with high carbon biomass	CBI
5	Air Quality	SLV_Veg_Carbon_N_1km_Poly	SLV_Data.gdb	Near-term future status of areas with high carbon biomass	CBI
6	Air Quality	carbon	SLV_Data.gdb	Vegetation with high carbon biomass	CBI
7	Aviation	SLV_Airspace_Poly	SLV_Data.gdb\	Military and commercial airspace data	BLM
8	Big Game	SLV_Big_Game_Seasonal_Ranges_Poly	SLV_Data.gdb	Big game seasonal ranges.	Colorado Parks and Wildlife and BLM
9	Big Game	SLV_Big_Game_Migration_Corridors_PFC_1km_Poly	SLV_Data.gdb	Distribution of big game migration corridors summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	CDOW migration corridors for bighorn sheep, elk, mule deer, and pronghorn.
10	Big Game	SLV_BigGame_PFC_1km_Poly	SLV_Data.gdb	Distribution of big game seasonal ranges and migration corridors summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	CDOW, Colorado Parks and Wildlife, and BLM

ID	Category	File Name(s)	Full Data Path	Description	Source
11	Big Game	SLV_Big_Game_Seasonal_Ranges_PFC_1km_Poly	SLV_Data.gdb	Distribution of big game seasonal ranges summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	Colorado Parks and Wildlife and BLM
12	Big Game	SLV_C_Big_Game_Winter_Range_1km_Poly	SLV_Data.gdb	Distribution of big game winter ranges summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	Colorado Parks and Wildlife and BLM
13	Biodiversity	NM_StateWildlifeAreas	SLV_Data.gdb	A current delineation of the surface ownership and/or surface management in the state of New Mexico.	BLM
14	Biodiversity	SLV_Biodiversity_Poly	SLV_Data.gdb	Areas managed for biodiversity	USGS, BLM, FWS, Audubon
15	Biodiversity	SLV_NatureServe_Species_HUC10_Poly	SLV_Data.gdb\	Conservation species by watershed	NatureServe, CO and NM natural heritage offices
16	Biodiversity	SLV_Biodiversity_PFC_1km_Poly	SLV_Data.gdb	Distribution of areas managed for biodiversity summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	USGS, BLM, FWS, Audubon
17	Biodiversity	SLV_PADUS_Poly	SLV_Data.gdb\	Protected Areas Database	USGS - PADUS
18	Biodiversity	SLV_SWREGAP_SpeciesRichness_240m.img	Raster\Conservation_Elements\Terrestrial\Species\	SWReGAP Species Richness	SWReGAP habitat distribution models

ID	Category	File Name(s)	Full Data Path	Description	Source
19	Biodiversity	SLV_Biodiversity_eo_quad_poly	SLV_Data.gdb	the sum of threatened, endangered, and rare species tracked by state natural heritage programs within USGS 1:24,000 (7.5 minute) quadrangles within the study area	Natural Heritage New Mexico; Colorado Natural Heritage Program
20	Biodiversity	slv_nm_vert	Raster\Existing_Source_Datasets\biota\Species\	Vertebrate species richness in New Mexico (30m)	BLM (Northern New Mexico Assessment)
21	Biodiversity	SLV_TNC_Portfolio_Poly	SLV_Data.gdb\	Terrestrial Biodiversity Sites	TNC Ecoregional Portfolio
22	Biodiversity	SLV_Easements_Poly	SLV_Data.gdb\	Terrestrial Biodiversity Sites	NCED
23	Biota	MANY	Raster\Existing_Source_Datasets\biota\Habitat\SWREGAP	SWReGAP Habitat Distribution Models for 136 species	SWReGAP
24	Boundary	ru_poly1km	SLV_Data.gdb	1km reporting units used in the assessment	Argonne National Laboratory
25	Boundary	ru_poly1km_empty	SLV_Data.gdb	1km reporting units used in the assessment	Argonne National Laboratory
26	Boundary	ru_raster	SLV_Data.gdb	1km reporting units used in the assessment	Argonne National Laboratory
27	Boundary	SLV_States_Poly	SLV_Data.gdb	CO and NM state boundaries	U.S. Census Bureau
28	Boundary	SLV_Study_Area	SLV_Data.gdb	Study area boundary	Argonne National Laboratory
29	Boundary	Jurisdiction_County_Area	SLV_Data.gdb	U.S. Counties represents the counties of the United States in the states of Arizona, California, Colorado, New Mexico, Nevada, and Utah.	U.S. Census Bureau
30	Cadastre (ownership)	SLV_SMA_CO	SLV_Data.gdb\	Surface Management Ownership	BLM
31	Cadastre (ownership)	SLV_SMA_NM	SLV_Data.gdb\	Surface Management Ownership	BLM (Doug Simon)

ID	Category	File Name(s)	Full Data Path	Description	Source
32	Climate	slv_ppt_long_annual_avg.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2069	Average Annual Precipitation (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios.	National Center for Atmospheric Research
33	Climate	slv_tmp_long_annual_avg.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2072	Average annual Temperature (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios.	National Center for Atmospheric Research
34	Climate	slv_ppt_long_summer.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2070	Average Summer Precipitation (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios.	National Center for Atmospheric Research
35	Climate	slv_tmp_long_summer.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2073	Average Summer Temperature (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios	National Center for Atmospheric Research
36	Climate	slv_ppt_long_winter.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2071	Average Winter Precipitation (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios.	National Center for Atmospheric Research
37	Climate	slv_tmp_long_winter.img	Raster\Change_Agents\Climate\clm_long\A1B_2040_2074	Average Winter Temperature (2040-2069) simulated by the NCAR Community Climate System Model (CCSM), using AR4 A1B emissions scenarios	National Center for Atmospheric Research

ID	Category	File Name(s)	Full Data Path	Description	Source
38	Climate	slv_ppt_c_annual_avg.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM annual average precipitation (ppt) for the current period (1981-2010).	PRISM
39	Climate	slv_tmp_c_annual_avg.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM annual average temperature (Celsius) for the current period (1981-2010).	PRISM
40	Climate	slv_ppt_c_summer.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM average monthly summer precipitation (ppt) for the current period (1981-2010).	PRISM
41	Climate	slv_ppt_historic_summer.img	Raster\Change_Agents\Climate\clm_historic	PRISM average monthly summer precipitation (ppt) for the historic period (1905-1934)	PRISM
42	Climate	slv_tmp_c_summer.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM average monthly summer temperature (Celsius) for the current period (1981-2010).	PRISM
43	Climate	slv_tmp_historic_summer.img	Raster\Change_Agents\Climate\clm_historic	PRISM average monthly summer temperature (Celsius) for the historic period (1905-1934)	PRISM
44	Climate	slv_ppt_c_winter.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM average monthly winter precipitation (ppt) for the current period (1981-2010).	PRISM
45	Climate	slv_ppt_historic_winter.img	Raster\Change_Agents\Climate\clm_historic	PRISM average monthly winter precipitation (ppt) for the historic period (1905-1934)	PRISM
46	Climate	slv_tmp_c_winter.img	Raster\Change_Agents\Climate\clm_current\PRISM\	PRISM average monthly winter temperature (Celsius) for the current period (1981-2010).	PRISM
47	Climate	slv_tmp_historic_winter.img	Raster\Change_Agents\Climate\clm_historic	PRISM average monthly winter temperature (Celsius) for the historic period (1905-1934)	PRISM

ID	Category	File Name(s)	Full Data Path	Description	Source
48	Climate	slv_veg_carbon_biomass.img	Raster\Existing_Source_Datasets\climatology\	Vegetation carbon biomass (indicator of carbon sequestration)	ORNL - model developed by ORNL but provided through DataBasin by CBI
49	Climate Chage	SLV_CL_L_Fire_Potential	SLV_Data.gdb	Areas of potetial future climate change with greater potential for fire	
50	Climate Change	SLV_CL_C_Fire_Potential	SLV_Data.gdb	Areas of current climate change with greater potential for fire	
51	Climate Change	SLV_CL_C_Potential_For_Change_1km_Poly	SLV_Data.gdb\	Current climate change model - 1km RU polygons	PRISM current & historic precipitation and temperature
52	Climate Change	SLV_CL_L_Potential_For_Change_1km_Poly	SLV_Data.gdb\	Long-term future potential for climate change - 1km RU polygons	PRISM and IPCC scenario predictions for precipitation and temperature
53	Development	SLV_C_DEV.img	Raster\Change_Agents\Development\dev_current	Current human development intensity model - 100m raster	
54	Development	SLV_N_DEV_1km_Poly	SLV_Data.gdb	Near-term future (i.e., 2025-2030) human development intensity within 1 km reporting units	Multiple
55	Development	SLV_N_DEV.img	Raster\Change_Agents\Development\dev_near	Near-term future human development intensity model - 100m raster	
56	Ecological Systems	SLV_Basin_Grassland_Shrubland_PFC_1km_Poly	SLV_Data.gdb	Distribution of Basin Grassland and Shrubland summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	LANDFIRE existing vegetation

ID	Category	File Name(s)	Full Data Path	Description	Source
57	Ecological Systems	SLV_Montane_Subalpine_Forest_PFC_1km_Poly	SLV_Data.gdb	Distribution of montane and subalpine conifer forest summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	LANDFIRE existing vegetation
58	Ecological Systems	SLV_Piñon_Juniper_PFC_1km_Poly	SLV_Data.gdb	Distribution of piñon-juniper woodland system summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	LANDFIRE existing vegetation
59	Ecological Systems	SLV_Riparian_Wetland_PFC	SLV_Data.gdb	Distribution of riparian and wetland system intersected with Change Agent models to assess status and potential for change (PFC)	LANDFIRE existing vegetation, NHD Waterbodies, and SWReGAP riparian landcover types
60	Energy	SLV_Wells_Geothermal_Point	SLV_Data.gdb\	Geothermal well locations	Geothermal wells in Colorado and New Mexico (digitized from Idaho National Engineering and Environmental Laboratory)
61	Energy	SLV_OilGas_Pot.img	Raster\Existing_Source_Datasets\economy\	Oil and gas density	Intermountain West Oil and Gas Potential - Anticipated Oil Wells (Copeland et al. 2009)
62	Energy	SLV_BLM_Oil_Gas_Lease_Poly	SLV_Data.gdb\	Potential oil and gas development	BLM - oil and gas leases

ID	Category	File Name(s)	Full Data Path	Description	Source
63	Energy	SLV_COGCC_Oil_Gas_Field_Poly	SLV_Data.gdb\	Potential oil and gas development	USDOI and DOE - Oil and gas fields
64	Energy	SLV_DV_N_Solar_SEZ_Poly	SLV_Data.gdb\	Potential solar energy development	BLM Solar SEZs
65	Energy	SLV_NREL_Wind_Potential_poly	SLV_Data.gdb	Potential wind energy development	NREL Wind power density classes at 50 m above ground
66	Fire	SLV_Fire_Perimeters_Historic_1km_Poly	SLV_Data.gdb	Density of historic fire perimeters summarized to 1km reporting units	GEOMAC
67	Fire	SLV_Fire_Historic_Density_1km_Poly	SLV_Data.gdb	Density of historic-current fire occurrences summarized to 1km reporting units	BLM, GEOMAC
68	Fire	SLV_Fire_History_CO	SLV_Data.gdb	Federal fire history reports in CO	DOI, USFWS, and USFS
69	Fire	slv_dist_2010.img	Raster\Existing_Source_Datasets\imagery \Existing_Vegetation\Landfire	Fire disturbance	LANDFIRE
70	Fire	SLV_LANDFIRE_Events_Poly	SLV_Data.gdb\	Fire perimeters as of 2010	LANDFIRE (v1.2.0)
71	Fire	SLV_BLM_FirePerim_poly	SLV_Data.gdb	Fire Perimeters	BLM
72	Fire	SLV_Fire_History_NM	SLV_Data.gdb	Historic fire occurrences in NM	BLM
73	Fire	SLV_Fire_Perimeters_Historic_Poly	SLV_Data.gdb\	Historic fire perimeters	GEOMAC
74	Fire	SLV_C_Fire_1km_Poly	SLV_Data.gdb\	Landscape Assessment model for historic-current fire occurrences in the study area.	BLM and Geomac fire perimeters, LANDFIRE fire disturbances
75	Fire	slv_mfri	Raster\Existing_Source_Datasets\imagery \Fire\Disturbance	Mean fire return interval for the region	LANDFIRE

ID	Category	File Name(s)	Full Data Path	Description	Source
76	Fire	SLV_N_Fire_1km_Poly	SLV_Data.gdb\	Near-term future potential for fire (fire risk)	USFS FireLab Fire risk model
77	Fire	slv_prs	Raster\Existing_Source_Datasets\imagery \Fire\Disturbance	Percent replacement severity for the region	LANDFIRE
78	Fire	slv_n_fire_potential.img	Raster\Change_Agents\Fire\fire_near	Wildland fire potential (WFP)	USDA Forest Service
79	Fire - Human Development	SLV_N_Fire_human_dev	SLV_Data.gdb	Intersection of areas with high fire potential with areas of high human development	Derived from assessment geoprocess model
80	Grazing	SLV_Allotments_BLM_NotMeet_LHS_Poly	SLV_Data.gdb\	BLM grazing allotments with degreated habitat quality - not meeting Land Health Standards (LHS) - from the BLM NOC in support of sage grouse planning efforts	BLM
81	Human Development	SLV_C_DEV_1km_Poly	SLV_Data.gdb	Current human development intensity within 1 km reporting units	Multiple
82	Hydrology	SLV_Active_Well_Level_Point	SLV_Data.gdb	Active Groundwater Level Network	USGS Office of Groundwater
83	Hydrology	SLV_CO_Alluvial_Aquifer_Poly	SLV_Data.gdb\	Alluvial aquifers in Colorado	CDSS
84	Hydrology	SLV_Hydrology_PFC_HUC10_Poly	SLV_Data.gdb	Change agent models summarized to HUC10 boundaries	NHD
85	Hydrology	SLV_Hydrology_PFC_HUC12_Poly	SLV_Data.gdb	Change agent models summarized to HUC12 boundaries	NHD
86	Hydrology	SLV_CO_Closed_Basin_Boundary_Line	SLV_Data.gdb\	Closed Basin Boundary (line)	BLM / BOR
87	Hydrology	SLV_CO_Diversions	SLV_Data.gdb	Colorado Diversions	CDSS
88	Hydrology	SLV_CO_Wetlands_NWI_Poly	SLV_Data.gdb\	Colorado Wetlands (NWI)	FWS - NWI

ID	Category	File Name(s)	Full Data Path	Description	Source
89	Hydrology	SLV_EPA_303d_ln	SLV_Data.gdb\	Degraded waterbodies	EPA 303(d) waterbodies
90	Hydrology	SLV_EPA_303d_Poly	SLV_Data.gdb\	Degraded waterbodies	EPA 303(d) waterbodies
91	Hydrology	SLV_Watershed_HUC10_Poly	SLV_Data.gdb\	HUC 10 Watersheds	USGS
92	Hydrology	SLV_NHD_Point	SLV_Data.gdb\	Hydro points - including springs/seeps throughout the study area	USGS - NHD
93	Hydrology	SLV_NM_Wetlands_NWI_Poly	SLV_Data.gdb\	New Mexico Wetlands (NWI)	FWS - NWI
94	Hydrology	SLV_CO_Waterbodies_Poly	SLV_Data.gdb	NHD Waterbodies in CO	NHD
95	Hydrology	SLV_NHD_Waterbody	SLV_Data.gdb\	NHD waterbodies in CO and NM	NHD
96	Hydrology	SLV_Wells_Point	SLV_Data.gdb\	Permitted wells (points)	BLM (from CDWR and NAU NM Assessment)
97	Hydrology	SLV_NHD_Flowlines_Line	SLV_Data.gdb\	Rivers and streams	NHD flowlines
98	Hydrology	SLV_NM_Springs_pt	SLV_Data.gdb\	Spring locations in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
99	Hydrology	SLV_USGS_Stream_Gage_pt	SLV_Data.gdb\	USGS Gage Station Data	USGS
100	Hydrology	SLV_USGS_Stream_Gage_Discharge_pt	SLV_Data.gdb	USGS stream gages and seasonal discharge	USGS
101	Hydrology	SLV_Surface_Water_Course_Line	SLV_Data.gdb	Water feature lines	US National Atlas
102	Hydrology	Surface_Water_Course_Centerline	SLV_Data.gdb	Water feature lines	US National Atlas

ID	Category	File Name(s)	Full Data Path	Description	Source
103	Hydrology	SLV_NM_Water_Tanks_pt	SLV_Data.gdb\	Water tank locations in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
104	Hydrology	SLV_NM_Waterbodies_Poly	SLV_Data.gdb\	Waterbodies in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
105	Invasive Species, Insects, and Disease	SLV_NM_ForestHealth_Poly	SLV_Data.gdb	Compilation of forest insect and disease activity mapped from aerial detection surveys in the state of New Mexico during 2012	US Forest Service
106	Invasive Species, Insects, and Disease	SLV_CO_ForestHealth_Poly	SLV_Data.gdb	Compilation of insect and disease affected trees on the Rio Grande National Forest from 1995-2012	US Forest Service
107	Invasive Species, Insects, and Disease (IID)	SLV_C_IID_1km_Poly	SLV_Data.gdb\	Current Invasives, Insects, and Disease (IID) Density - 1km RU polygons	EVT, SCLASS, SWREGAP, SLV Weed Management Areas, USFS Forest Health Survey Areas
108	Invasive Species, Insects, and Disease (IID)	SLV_N_IID_1km_Poly	SLV_Data.gdb\	Near-term Future Invasives, Insects, and Disease (IID) Density - 1km RU polygons	EVT, SCLASS, SWREGAP, SLV Weed Management Areas, USFS Forest Health Survey Areas
109	Invasive species, insects, disease	SLV_Forest_Health_Density_1km_Poly	SLV_Data.gdb	Density of forest insects, pests, and disease summarized to 1km2 reporting units	US Forest Service
110	Invasives	SLV_INV_C_100m.img	Raster\Change_Agents\Invasives\inv_current\	Current Invasives Occurrence - 100m raster	EVT, SCLASS, SWREGAP
111	Invasives	SLV_Tamarisk_Point	SLV_Data.gdb\	Tamarisk Points	CSU

ID	Category	File Name(s)	Full Data Path	Description	Source
112	Invasives	SLV_Tamarisk_Pot_USGS.img	Raster\Existing_Source_Datasets\biota\Invasives\	Tamarisk probability model	USGS
113	Invasives	SLV_Weeds_SLVPLC_Poly	SLV_Data.gdb\	Weed areas (SLV)	BLM
114	Landform	slv_dem_30m.img	Raster\Existing_Source_Datasets\elevation\DEM\	Digital Elevation Model for the region	USGS
115	Landform	slv_dem_100mi_buffer.img	Raster\Existing_Source_Datasets\elevation\DEM	Digital Elevation Model for the region and a 100mi buffer around the region	USGS
116	Landform	slv_hlsd_500m	Raster\Existing_Source_Datasets\elevation\DEM	Hillshade of the region	
117	Landscape Condition Model - Human Development	SLV_LCM_C_100m.img	Raster\Attributes_Indicators\Terrestrial\Ecosystem\	Current Landscape Condition Model - 100m raster	Multiple
118	Landscape Condition Model - Human Development	SLV_LCM_C_1km_Poly	SLV_Data.gdb\	Current Landscape Condition Model - 1km RU polygons	Multiple
119	Landscape Condition Model - Human Development	SLV_LCM_N_100m.img	Raster\Attributes_Indicators\Terrestrial\Ecosystem\	Near-Term Landscape Condition Model - 100m raster	Multiple
120	Landscape Condition Model - Human Development	SLV_LCM_N_1km_Poly	SLV_Data.gdb\	Near-Term Landscape Condition Model - 1km RU polygons	Multiple

ID	Category	File Name(s)	Full Data Path	Description	Source
121	Mining	SLV_Mines_Point	SLV_Data.gdb\	Mining count	Colorado and New Mexico Mines (Colorado Division of Reclamation, Mining, and Safety and New Mexico GIS Resource Program)
122	Places	SLV_Cities_Point	SLV_Data.gdb	Cities and towns in the US	US National Atlas
123	Potential for Change	SLV_N_PFC_1km_Poly	SLV_Data.gdb	Current and future change agent models and combined future potential for climate change (PFC).	Multiple
124	Recreation	SLV_USFS_RecSites_pt	SLV_Data.gdb\	Recreation sites (points and/or polygons)	USFS
125	Recreation	SLV_NM_RecTrails_ln	SLV_Data.gdb\	Recreation trails in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
126	Recreation	SLV_Rec_WaterTravelCorridors_ln	SLV_Data.gdb\	Recreation travel corridor density	NHD Plus
127	Riparian	SLV_CO_RipVeg_ln	SLV_Data.gdb\SLV_CO_RipVeg_ln	CPW Riparian lines and polygons	CPW
128	Roadless Area	SLV_IRA_Poly	SLV_Data.gdb\	USFS Inventoried Roadless Area (IRA)	USFS
129	Sensitive Data - OUO	SLV_Blanca_Easement_SENSITIVE	SLV_Data.gdb	Blanca Conservation Easement within the Sangre de Cristo Conservation Area (SDC)	BLM

ID	Category	File Name(s)	Full Data Path	Description	Source
130	Sites of Conservation Concern	SLV_ACEC_BlancaWetlands_Poly	SLV_Data.gdb	Blanca Wetlands ACEC	BLM
131	Sites of Conservation Concern	SLV_BLM_ACEC_Poly	SLV_Data.gdb\	BLM ACECs	BLM
132	Sites of Conservation Concern	SLV_SRMA_Poly	SLV_Data.gdb\	BLM Special Recreation Management Area	BLM
133	Sites of Conservation Concern	SLV_ClassI_PSD_Areas_Poly	SLV_Data.gdb	Class I PSD Areas	USG PADUS
134	Sites of Conservation Concern	SLV_CNHP_Potential_Conservation_Areas_Poly	SLV_Data.gdb	CNHP Potential Conservation Areas	CNHP
135	Sites of Conservation Concern	SLV_CO_CPW_Public_Access_Properties	SLV_Data.gdb	CO CPW Public Access Properties	CPW
136	Sites of Conservation Concern	SLV_NCED_Poly	SLV_Data.gdb	Conservation easements and land trusts	NCED
137	Sites of Conservation Concern	SLV_Trinchera_Easement_SENSITIVE	SLV_Data.gdb	Conservation easements and land trusts	USFWS
138	Sites of Conservation Concern	SLV_Easements_NotNCED_Poly	SLV_Data.gdb\	Conservation easements not listed in NCED	BLM (Doug Simon)
139	Sites of Conservation Concern	SLV_IBA_Poly	SLV_Data.gdb	Important Bird Areas (IBAs)	Audubon Society

ID	Category	File Name(s)	Full Data Path	Description	Source
140	Sites of Conservation Concern	SLV_NM_Land_Trust_Poly	SLV_Data.gdb\	Land Trusts (New Mexico)	BLM (Doug Simon)
141	Sites of Conservation Concern	SLV_Easement_Private_Land_Poly	SLV_Data.gdb\	Private lands that are protected (private land easements)	BLM (Doug Simon)
142	Sites of Conservation Concern	SLV_YBC_Proposed_Critical_Habitat_Poly	SLV_Data.gdb	Proposed critical habitat	BLM
143	Sites of Conservation Concern	SLV_SCC_Protected_Poly	SLV_Data.gdb	Protected Sites of Conservation Concern	Several sources, including BLM, CPW, USGS Protected Areas Database (PADUS), NCED
144	Sites of Conservation Concern	SLV_Recreation_Areas_RGNF_Poly	SLV_Data.gdb\	Recreation Areas - RGNF	USFS
145	Sites of Conservation Concern	SLV_Rio_Grande_Corridor_Poly	SLV_Data.gdb\	Rio Grande Corridor	U.S. National Atlas (buffered lines)
146	Sites of Conservation Concern	SLV_Rio_Grande_Del_Norte_National_Monument_Poly	SLV_Data.gdb\	Rio Grande del Norte National Monument	BLM
147	Sites of Conservation Concern	SLV_Rio_Grande_National_Wild_and_Scenic_River_Poly	SLV_Data.gdb\	Rio Grande National Wild and Scenic River Polygon	BLM
148	Sites of Conservation Concern	SLV_Rio_Grande_Natural_Area_Poly	SLV_Data.gdb\	Rio Grande Natural Area	BLM

ID	Category	File Name(s)	Full Data Path	Description	Source
149	Sites of Conservation Concern	SLV_Sangre_DeCristo_Conservation_Area_Poly	SLV_Data.gdb\	Sangre de Cristo Conservation Area	USFWS
150	Sites of Conservation Concern	SLV_SCC_Poly	SLV_Data.gdb	Sites of Conservation Concern, including protected and unprotected sites	Several sources, including BLM, CPW, USGS Protected Areas Database (PADUS), NCED
151	Sites of Conservation Concern	SLV_CO_Wildlife_Trust_Lands_Poly	SLV_Data.gdb\	State wildlife areas and state trust lands	BLM
152	Sites of Conservation Concern	SLV_NM_Wildlife_Trust_Lands_Poly	SLV_Data.gdb\	State wildlife areas and state trust lands	BLM
153	Sites of Conservation Concern	SLV_SCC_Unprotected_Poly	SLV_Data.gdb	Unprotected Sites of Conservation Concern	Audubon Society, BLM, TNC (TNC Conservation Portfolio Sites)
154	Sites of Conservation Concern	SLV_Critical_Habitat_Poly	SLV_Data.gdb\	USFWS Critical Habitat Polygons	USFWS
155	Sites of Conservation Concern	SLV_Wilderness_Study_Area_Poly	SLV_Data.gdb\	Wilderness Study Areas	BLM
156	Sites of Conservation Concern (SCC)	SLV_SCC_Protected_PFC_1km_Poly	SLV_Data.gdb	Distribution of Protected SCC summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	CPW

ID	Category	File Name(s)	Full Data Path	Description	Source
157	Sites of Conservation Concern (SCC)	SLV_SCC_PFC_1km_Poly	SLV_Data.gdb	Distribution of SCC summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	several
158	Sites of Conservation Concern (SCC)	SLV_SCC_Unprotected_PFC_1km_Poly	SLV_Data.gdb	Distribution of Unprotected SCC summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	Audubon Society, BLM, TNC
159	Snow	SLV_CO_Snotel_pt	SLV_Data.gdb	NRCS snow telemetry monitoring sites	NRCS
160	Soils	SLV_TES_Soils_Pot_for_Erosion_PFC_1km_Poly	SLV_Data.gdb	Distribution of soils with potential for erosion summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SSURGO, STATSGO
161	Soils	SLV_SSURGO_Poly	SLV_Data.gdb\	NRCS SSURGO soils for the region	NRCS
162	Soils	SLV_STATSGO_Poly	SLV_Data.gdb\	NRCS STATSGO soils for the region	NRCS
163	Soils	SLV_TES_C_RunoffPotential_Poly	SLV_Data.gdb\	Runoff potential	SSURGO, STATSGO
164	Soils	SLV_TES_C_WindErodibility_Poly	SLV_Data.gdb\	Soils susceptible to wind erosion (WEG)	SSURGO, STATSGO
165	Soils	SLV_TES_C_Soils_Pot_for_Erosion_Poly	SLV_Data.gdb\	Soils with Potential for Erosion	SSURGO, STATSGO
166	Soils	SLV_TES_C_KFact_Poly	SLV_Data.gdb	Water erosion potential	SSURGO, STATSGO
167	Soils	slv_at_dstsno	Raster\Attributes_Indicators\Terrestrial\Ecosystem		CHECK THE DUST MODEL TO DETERMINE WHETHER DATA ARE STILL VALID

ID	Category	File Name(s)	Full Data Path	Description	Source
168	Soils	slv_at_dust	Raster\Attributes_Indicators\Terrestrial\Ecosystem		CHECK THE DUST MODEL TO DETERMINE WHETHER DATA ARE STILL VALID
169	Transportation	slv_roads_census_line	SLV_Data.gdb\	Census Bureau - 2013 census roads	Census Bureau
170	Transportation	Major_Road_Centerline	SLV_Data.gdb	Nation's highways comprised of Rural Arterials, Urban Principal Arterials and all National Highway System routes.	NHPN
171	Transportation	slv_roads_primary_line	SLV_Data.gdb\	Primary / major highways	CDOT, NMDOT, NM RGIS
172	Transportation	slv_roads_secondary_line	SLV_Data.gdb\	Secondary / local roads	BLM, CDOT, NMDOT, NM RGIS
173	Urban Development	SLV_Urban_Areas_CB_Poly	SLV_Data.gdb\	Census Bureau Urban Areas	US Census Bureau
174	Urban Development	slv_nlcd_imperv2011.img	Raster\Existing_Source_Datasets\imagery\Imperviousness\	Current urban development	NLCD 2011 Impervious Surfaces
175	Urban Development	slv_urban_growth.img	Raster\Existing_Source_Datasets\society\	Future urban development	Development risk in the contiguous US (Theobald 2010)
176	Urban Development	slv_night_light.img	Raster\Existing_Source_Datasets\society\	NASA night light data (light use at night)	NASA
177	Urban Development	SLV_Urban_Areas_Taos.img	Raster\Existing_Source_Datasets\society\	Urban and rural developed areas in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
178	Urban Development	SLV_Urban_Areas_BLM_Poly	SLV_Data.gdb\	Urban areas in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)
179	Urban Development	SLV_HumanFootprint.img	Raster\Existing_Source_Datasets\society\	USGS Human Footprint in the West	USGS

ID	Category	File Name(s)	Full Data Path	Description	Source
180	Urban Development	SLV_WUI_Poly	SLV_Data.gdb\	Wildland-urban interface	WUI
181	Utilities	slv_utility_lines	SLV_Data.gdb\	Utility lines - includes overhead transmission lines, powerlines, cable lines, and gas pipelines	Aggregate of multiple datasets from different sources (BLM, USGS powerlines)
182	Vegetation	SLV_Basin_Grassland_Shrubland.img	Raster\Conservation_Elements\Terrestrial\Ecosystem\	Basin grassland and shrubland ecological system CE	extracted from LANDFIRE
183	Vegetation	SLV_BPS_V110.img	Raster\Existing_Source_Datasets\imagery\Fire\Biophysical_Settings\	Biophysical settings for the region	LANDFIRE
184	Vegetation	slv_evc_v120.img	Raster\Existing_Source_Datasets\imagery\Existing_Vegetation\Landfire\	Existing Vegetation Class	LANDFIRE
185	Vegetation	slv_esp_v120.img	Raster\Existing_Source_Datasets\environment\Fire	LANDFIRE Environmental Site Potential (ESP)	LANDFIRE
186	Vegetation	slv_evt_v120.img	Raster\Existing_Source_Datasets\imagery\Existing_Vegetation\Landfire\	LANDFIRE Existing Vegetation Type (EVT) - version 1.2	LANDFIRE
187	Vegetation	SLV_Montane_Subalpine_Forest.img	Raster\Conservation_Elements\Terrestrial\Ecosystem\	Montane and subalpine coniferous forest ecological system CE	extracted from LANDFIRE
188	Vegetation	SLV_NatureServe_Veg.img	Raster\Existing_Source_Datasets\biota\Invasives\	NatureServe National Landcover (v2.7)	NatureServe
189	Vegetation	SLV_Piñon_Juniper_Woodland.img	Raster\Conservation_Elements\Terrestrial\Ecosystem\	Pinon-juniper woodland ecological system CE	extracted from LANDFIRE
190	Vegetation	SLV_Riparian_Wetland.img	Raster\Conservation_Elements\Terrestrial\Ecosystem\	Riparian and wetland ecological system CE	extracted from LANDFIRE
191	Vegetation	SLV_SCLASS_V110.img	Raster\Existing_Source_Datasets\imagery\Fire\Succession\	Succession class for the region	LANDFIRE
192	Vegetation	SLV_SWREGAP.img	Raster\Existing_Source_Datasets\imagery\Landcover\SWReGAP\	SWREGAP Landcover Types	SWREGAP

ID	Category	File Name(s)	Full Data Path	Description	Source
193	Vegetation	slv_vcc_v110	Raster\Existing_Source_Datasets\environment\Fire	Vegetation Condition Class	LANDFIRE
194	Vegetation	slv_vdep	Raster\Existing_Source_Datasets\environment\VDEP	Vegetation departure (same as Fire regime condition class departure index)	LANDFIRE
195	Vegetation Departure	SLV_VDEP_1km_Poly	SLV_Data.gdb	LANDFIRE Vegetation Departure (VDEP) summarized to 1km reporting units	LANDFIRE VDEP
196	Wildlife	SLV_Big_Game_Migration_Corridors_Poly	SLV_Data.gdb\	Big game migration corridors - combined across species and states	BLM
197	Wildlife	SLV_Big_Game_Winter_Range_Poly	SLV_Data.gdb\	Big game winter ranges - combined across species and states	BLM
198	Wildlife	SLV_CO_Bighorn_Production_Area_Poly	SLV_Data.gdb\	Bighorn sheep production areas in Colorado	Colorado Natural Diversity Information Source
199	Wildlife	SLV_BighornSheep_PFC_1km_Poly	SLV_Data.gdb	Distribution of bighorn sheep summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
200	Wildlife	SLV_BrewersSparrow_PFC_1km_Poly	SLV_Data.gdb	Distribution of brewers sparrow to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
201	Wildlife	SLV_CHAT_PFC_1km_Poly	SLV_Data.gdb	Distribution of CHAT areas ranked 1 or 2 summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	CHAT

ID	Category	File Name(s)	Full Data Path	Description	Source
202	Wildlife	SLV_ElkMuleDeer_PFC_1km_Poly	SLV_Data.gdb	Distribution of elk-mule deer assemblage summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
203	Wildlife	SLV_FerruginousHawk_PFC_1km_Poly	SLV_Data.gdb	Distribution of ferruginous hawk summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
204	Wildlife	SLV_Grassland_PFC_1km_Poly	SLV_Data.gdb	Distribution of grassland fauna summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
205	Wildlife	SLV_SageGrouse_PFC_1km_Poly	SLV_Data.gdb	Distribution of gunnsion sage-grouse summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP Vertebrate Habitat Distribution Model for the Gunnison sage-grouse combined with the USFWS proposed critical habitat and clipped to the historic habitat boundary.

ID	Category	File Name(s)	Full Data Path	Description	Source
206	Wildlife	SLV_MexicanFreeTailedBat_PFC_1km_Poly	SLV_Data.gdb	Distribution of Mexican free-tailed bats summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
207	Wildlife	SLV_MountainLion_PFC_1km_Poly	SLV_Data.gdb	Distribution of mountain lions summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
208	Wildlife	SLV_NativeFish_PFC_1km_Poly	SLV_Data.gdb	Distribution of native fish summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	BLM and CDOW
209	Wildlife	SLV_NorthernGoshawk_PFC_1km_Poly	SLV_Data.gdb	Distribution of Northern goshawk summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
210	Wildlife	SLV_Pronghorn_PFC_1km_Poly	SLV_Data.gdb	Distribution of pronghorn antelope summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	SWReGAP habitat distribution models
211	Wildlife	SLV_ShorebirdWaterfowl_PFC_1km_Poly	SLV_Data.gdb	Distribution of Shorebird/Waterfowl Assemblage summarized to 1km reporting units and intersected with Change Agent models to assess status and potential for change (PFC)	NWI, CPW

ID	Category	File Name(s)	Full Data Path	Description	Source
212	Wildlife	SLV_CO_Elk_Migration_Corridor_Poly	SLV_Data.gdb\	Elk migration corridors in Colorado	Colorado Natural Diversity Information Source
213	Wildlife	SLV_CO_Elk_Production_Area_Poly	SLV_Data.gdb\	Elk production areas in Colorado	Colorado Natural Diversity Information Source
214	Wildlife	SLV_CO_Elk_Severe_Winter_Range_Poly	SLV_Data.gdb\	Elk severe winter range in Colorado	Colorado Natural Diversity Information Source
215	Wildlife	SLV_CO_Elk_Summer_Concentration_Area_Poly	SLV_Data.gdb\	Elk summer concentration area in Colorado	Colorado Natural Diversity Information Source
216	Wildlife	SLV_CO_Elk_Winter_Range_Poly	SLV_Data.gdb\	Elk winter range in Colorado	Colorado Natural Diversity Information Source
217	Wildlife	SLV_CO_Great_Blue_Heron_Foraging_Area_Poly	SLV_Data.gdb\	Great blue heron foraging area in Colorado	Colorado Natural Diversity Information Source
218	Wildlife	SLV_GunnisonSageGrouse_Habitat_Poly	SLV_Data.gdb	Gunnison sage-grouse habitat	SWReGAP and CPW
219	Wildlife	SLV_Gunnison_SageGrouse_Historic_Poly	SLV_Data.gdb\	Gunnison sage-grouse historic habitat (CO & NM)	Data Basin
220	Wildlife	SLV_CO_Gunnison_Sage_Grouse_Historic_Habitat_Poly	SLV_Data.gdb\	Gunnison's sage-grouse historical habitat in Colorado	Colorado Natural Diversity Information Source
221	Wildlife	SLV_CO_MuleDeer_Concentration_Area_Poly	SLV_Data.gdb\	Mule deer concentration areas in Colorado	Colorado Natural Diversity Information Source
222	Wildlife	SLV_CO_MuleDeer_Migration_Corridor_Poly	SLV_Data.gdb\	Mule deer migration corridors in Colorado	Colorado Natural Diversity Information Source

ID	Category	File Name(s)	Full Data Path	Description	Source
223	Wildlife	SLV_CO_MuleDeer_Severe_Winter_Range_Poly	SLV_Data.gdb\	Mule deer severe winter range in Colorado	Colorado Natural Diversity Information Source
224	Wildlife	SLV_CO_MuleDeer_Summer_Range_Poly	SLV_Data.gdb\	Mule deer summer range in Colorado	Colorado Natural Diversity Information Source
225	Wildlife	SLV_CO_MuleDeer_Winter_Range_Poly	SLV_Data.gdb\	Mule deer winter range in Colorado	Colorado Natural Diversity Information Source
226	Wildlife	SLV_CO_Pronghorn_Migration_Corridor_Poly	SLV_Data.gdb\	Pronghorn migration corridors in Colorado	Colorado Natural Diversity Information Source
227	Wildlife	SLV_CO_Pronghorn_Severe_Winter_Range_Poly	SLV_Data.gdb\	Pronghorn severe winter range in Colorado	Colorado Natural Diversity Information Source
228	Wildlife	SLV_CO_Pronghorn_Winter_Range_Poly	SLV_Data.gdb\	Pronghorn winter range in Colorado	Colorado Natural Diversity Information Source
229	Wildlife	SLV_CO_GunnisonSageGrouse_ProposedCH_Poly	SLV_Data.gdb\	Proposed critical habitat for Gunnison's sage-grouse	BLM
230	Wildlife	SLV_Fish_Dist_ln	SLV_Data.gdb\	Rio Grande cutthroat trout and native fish distributions	BLM
231	Wildlife	SLV_CO_Fish_Dist_Poly	SLV_Data.gdb\	Rio Grande cutthroat trout and native fish distributions	BLM
232	Wildlife	SLV_Shorebird_Waterfowl_Assemblage	SLV_Data.gdb\	Shorebird - Waterfowl Assemblage	Multiple - aggregate of NWI, riparian, stream lines, and species-specific data (Canada goose, white pelican)

ID	Category	File Name(s)	Full Data Path	Description	Source
233	Wildlife	SLV_Grassland_Fauna_Assemblage.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for grassland fauna	SWReGAP
234	Wildlife	SLV_Bighorn_Sheep_180711.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the bighorn sheep	SWReGAP
235	Wildlife	SLV_Brewers_Sparrow_179440.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the brewer's sparrow	SWReGAP
236	Wildlife	SLV_Elk_Mule_Deer_Assemblage.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the elk and mule deer	SWReGAP
237	Wildlife	SLV_Ferruginous_Hawk_175377.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the ferruginous hawk	SWReGAP
238	Wildlife	SLV_GUSG.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the Gunnison sage-grouse	SWReGAP
239	Wildlife	SLV_Mexican_FreeTailed_Bat_180088.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the Mexican free-tailed bat	SWReGAP
240	Wildlife	SLV_Mountain_Lion_552479.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the mountain lion	SWReGAP
241	Wildlife	SLV_Northern_Goshawk_175300.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the northern goshawk	SWReGAP
242	Wildlife	SLV_Pronghorn_180717.img	Raster\Conservation_Elements\Terrestrial\Species	SWReGAP Vertebrate Habitat Distribution Model for the pronghorn antelope	SWReGAP

ID	Category	File Name(s)	Full Data Path	Description	Source
243	Wildlife	SLV_CHAT	SLV_Data.gdb	Western Governor's Association (WGA) Crucial Habitat Assessment Tool (CHAT) - Wildlife crucial habitat	WGA
244	Wildlife	White_Pelican_Overall_Range	SLV_Data.gdb	White pelican overall range in Colorado	CPW

Table C-2. Input Data Inventory for the Current and Future Invasive Species, Insects, and Disease Models.

N	CATEGORY	INPUT LABEL	SOURCE	DATA TYPE	DATA PATH	MODEL
1	Energy	Potential oil and gas development	BLM - oil and gas leases	vector polygons	data\SLV_Data.gdb\SLV_BLM_Oil_Gas_Lease_Poly	Future IID model
2	Energy	Potential oil and gas development	USDOI and DOE - Oil and gas fields	vector polygons	data\SLV_Data.gdb\SLV_COGCC_Oil_Gas_Field_Poly	Future IID model
3	Energy	Potential solar energy development	BLM Solar SEZs	Vector polygons	data\SLV_Data.gdb\SLV_DV_N_Solar_SEZ_Poly	Future IID model
4	Grazing	BLM grazing allotments	BLM	Vector polygons	data\SLV_Data.gdb\SLV_BLM_Allotments_Poly	Future IID model
5	Grazing	BLM grazing allotments with degreated habitat quality - not meeting Land Health Standards (LHS) - from the BLM NOC in support of sage grouse planning efforts	BLM	Vector polygons	data\SLV_Data.gdb\SLV_Allotments_BLM_NotMeet_LHS_Poly	Future IID model
6	Invasives	Tamarisk probability model	USGS	raster (integer)	data\Raster\Existing_Source_Datasets\biota\Invasives\SLV_Tamarisk_Pot_USGS.img	Future IID model
7	Invasives	Weed areas (SLV)	BLM	Vector polygons	data\SLV_Data.gdb\SLV_Weeds_SLVPLC_Poly	Both - current and future IID models
8	Mining	Mining count	Colorado and New Mexico Mines (Colorado Division of Reclamation, Mining, and Safety and New Mexico GIS Resource Program)		data\SLV_Data.gdb\SLV_Mines_Point	Future IID model
9	Transportation	Census Bureau - 2013 census roads	Census Bureau	vector lines	data\SLV_Data.gdb\slv_roads_census_line	Future IID model
10	Transportation	Primary / major highways	CDOT, NMDOT, NM RGIS	vector lines	data\SLV_Data.gdb\slv_roads_primary_line	Future IID model
11	Transportation	Secondary / local roads	BLM, CDOT, NMDOT, NM RGIS	vector lines	data\SLV_Data.gdb\slv_roads_secondary_line	Future IID model

N	CATEGORY	INPUT LABEL	SOURCE	DATA TYPE	DATA PATH	MODEL
12	Urban Development	Census Bureau Urban Areas	US Census Bureau	Vector polygons	data\SLV_Data.gdb\SLV_Urban_Areas_CB_Poly	Future IID model
13	Urban Development	Current urban development	NLCD 2011 Impervious Surfaces	raster (integer)	data\Raster\Existing_Source_Datasets\imagery\Imperviousness\slv_nlcd_imperv2011.img	Future IID model
14	Urban Development	Future urban development	Development risk in the contiguous US (Theobald 2010)	raster (integer)	data\Raster\Existing_Source_Datasets\society\slv_urban_growth.img	Future IID model
15	Urban Development	NASA night light data (light use at night)	NASA	raster (integer)	data\Raster\Existing_Source_Datasets\society\slv_night_light.img	Future IID model
16	Urban Development	Urban and rural developed areas in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)	raster (integer)	data\Raster\Existing_Source_Datasets\society\SLV_Urban_Areas_Taos.img	Future IID model
17	Urban Development	Urban areas in New Mexico	BLM (from the NAU Assessment of Northern New Mexico)	Vector polygons	data\SLV_Data.gdb\SLV_Urban_Areas_BLM_Poly	Future IID model
18	Urban Development	Wildland-urban interface	WUI	Vector polygons	data\SLV_Data.gdb\slv_wui	Future IID model
19	Utilities	Utility lines - includes overhead transmission lines, powerlines, cable lines, and gas pipelines	Aggregate of multiple datasets from different sources (BLM, USGS powerlines)	vector lines	data\SLV_Data.gdb\slv_utility_lines	Future IID model
20	Vegetation	LANDFIRE Existing Vegetation Type (EVT) - version 1.2	LANDFIRE	raster (integer)	data\Raster\Existing_Source_Datasets\imagery\Existing_Vegetation\Landfire\slv_evt_v120.img	Both - current and future IID models
21	Vegetation	Succession class for the region	LANDFIRE	raster (integer)	data\Raster\Existing_Source_Datasets\imagery\Fire\Succession\SLV_SCLASS_V110.img	Both - current and future IID models
22	Vegetation	SWREGAP Landcover Types	SWREGAP	raster (integer)	data\Raster\Existing_Source_Datasets\imagery\Landcover\SWReGAP\SLV_SWREGAP.img	Both - current and future IID models
23	Insects & Disease	USFS Forest Health Survey Areas in Colorado and New Mexico	U.S. Forest Service	Vector polygons	data\SLV_Data.gdb\SLV_CO_ForestHealth_Poly data\SLV_Data.gdb\SLV_NM_ForestHealth_Poly	Both - current and future IID models

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APPENDIX D:

GLOSSARY

Adaptive Management – a system of management practices based on clearly identified outcomes and monitoring to determine whether management actions are meeting desired outcomes; and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated. Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain.

Areas of Critical Environmental Concern (ACEC) – Areas within the public lands where special management attention is required to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes.

Assessment Management Team (AMT) – A group of BLM managers that provides overall direction and guidance to the REA and makes decisions regarding ecoregional goals, resources of concern, conservation elements, change agents, management questions, tools, methodologies, models, and output work products.

Change Agent – An environmental phenomenon or human activity that either currently influence or could influence Conservation Elements. The four change agents evaluated in this LA include climate change, human development, invasive species, and wildfire.

Conceptual models – Illustrative depictions of the interactions between Conservation Elements, the biophysical properties of the environment, and Change Agents. Conceptual Models show the relationships and mechanisms of their interactions. Conceptual models are also supported and referenced by scientific literature.

Conservation Element – A limited number of resources with regional conservation importance. Resources addressed through Conservation Elements in this LA include species, species assemblages, ecological systems, habitats, physical resources (e.g., air, soils, hydrology), and cultural and visual resources.

Development – A type of change agent resulting from human activities such as urbanization, industrialization, transportation, mineral extraction, or water development.

Ecoregion – An ecological region or ecoregion is defined as an area with relative homogeneity in ecosystems. Ecoregions depict areas within which the mosaic of ecosystem components (biotic and abiotic as well as terrestrial and aquatic) differs from those of adjacent regions.

Geographic Information System (GIS) – A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data and associated attributes.

Habitat – A place where an animal or plant normally lives for a substantial part of its life, often characterized by dominant plant forms and/or physical characteristics.

Hydrologic Unit – An identified area of surface drainage within the U.S. system for cataloging drainage areas. The drainage areas are delineated to nest in a multilevel, hierarchical arrangement.

Landscape – A geographic area encompassing an interacting mosaic of ecosystems and human systems that is characterized by a set of common management concerns. The landscape is not defined by the size of the area, but rather by the interacting elements that are relevant and meaningful in a management context.

Landscape Assessment – A synthesis of existing information on the condition and trends of natural resources for a particular region. Landscape Assessments are fundamentally similar to the BLM's Rapid Ecoregional Assessments (REAs) but are conducted a smaller scale and may thus have a different scope of management questions. Landscape Assessments and REAs are used by the BLM to address key management questions for resources of concern, which provides the fundamental knowledge base for devising regional resource goals and priorities.

Landscape Intactness – A quantifiable estimate of naturalness across a region with respect to the level human disturbance. Intactness considers an assemblage of spatially explicit indicators that helps define the condition of the natural landscape.

Invasive Species – Species that are not part of (if exotic non-natives) or are a minor component of (if native), an original community that have the potential to become a dominant or co-dominant species if their future establishment and growth are not actively controlled by management interventions, or that are classified as exotic or noxious under state or federal law.

Management Questions – Questions about important resources and their attributes for addressing land management responsibilities. Management Questions guide the selection and evaluation of Conservation Elements.

Model – A representation of an object, process, or phenomenon. Models may be verbal, illustrative, or mathematical. Natural resource models typically characterize resource systems in terms of their components, interactions, and change through time.

Process Models – Process models are diagrams that map out data sources, GIS analyses, and workflow. Process models present the spatial analysis details and allow for repeatability of the same or similar model in the future.

Rapid Ecoregional Assessment (REA) – A broad-scale synthesis of existing information for a particular ecoregion. REAs are used by the BLM to address key management questions for resources of concern, which provides the fundamental knowledge base for devising regional resource goals and priorities.

Southwest Regional Gap Analysis Project (SWReGAP) – The Southwest Regional Gap Analysis Project is an update of the Gap Analysis Program's (GAP) mapping and assessment of biodiversity for the five-state region encompassing Arizona, Colorado, Nevada, New Mexico, and Utah. Available at: http://swregap.nmsu.edu/ (accessed June 10, 2015).

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