METHODOLOGY: Developing Regional Models to Inform the SRMS

One model developed in BLM Rapid Ecoregional Assessments (REAs) to provide a generalized indicator of ecological quality across a landscape is a Landscape Intactness Model (LIM)[1]. These models inform REAs by assisting in the evaluation of regional status and trends of conservation elements such as managed wildlife and their habitats. The LIM 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; BLM and Argonne National Laboratory 2016). These approaches use 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 LIM 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 intactness to high intactness.

Indicators and their scores selected for the LIM are 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) can be used to parameterize the site impact scores for each indicator in this model. The index used for most landscape intactness models ranges between 0 and 1.0. 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. For this reason, LIMs typically include parameters to account for the influence of distance from human modification on modeled intactness values.

For the current and near-term future landscape intactness models prepared for the Afton SRMS, the list of input spatial datasets for human modification and landscape change is provided in **Tables 1 & 2**, respectively. Maps for each of these input datasets are shown in **Appendix A**. 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 1**). 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.

[1] Also referred to as a Landscape Condition Model in some BLM Rapid Ecoregional Assessments.

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 1**. The current and near-term future intactness models were created within the regional boundary for the Afton SEZ (the Rio Grande – Mimbres HUC4 watershed). Landscape intactness model results for the this region are shown in Figures 2 & 3.

APPLICATION: Example Use of LIM in the SRMS

The table below summarizes the average intactness results modeled for the HUC 4 watershed. Within the HUC 4 watershed, intactness is expected to decline by 2.9% in the near-term future.

Summary of Landscape Intactness Models Developed for the LCDO and HUC 4 Regional Boundaries.

Regional Boundary	Average Current Intactness	Average Future Intactness	Figures
HUC 4 Watershed	0.584	0.567	Figures 2 & 3

Table 1. Draft Current Landscape Intactness Model Factors, Impact Scores, and Distance Decay Functions

Human Land Use or Impact Factor	Source	Site Impact Score	Presumed Relative Stress[1]	Distance of Influence (m)	F(x)[2]
Transportation					
Primitive roads (Dirt roads, OHV trails)	U.S. Census Bureau	0.6	Low	200	Linear
Secondary roads	NM RGIS; U.S. Census Bureau	0.3	Medium	1000	Logistic
Primary highways (Highways and Interstates)	NM RGIS; U.S. Census Bureau	0.015	High	2000	Logistic
Urban and Industrial Development					
Low density development (including rural development)	SWReGAP; LANDFIRE	0.6	Medium	1000	Logistic
Medium density development	SWReGAP; LANDFIRE	0.35	Medium	2000	Logistic
High density development & urban polygons	SWReGAP;LANDFIRE; U.S. Census Bureau	0.015	High	2000	Logistic
Powerlines / transmission lines / ROWs	Data Basin – ICEBMP existing utility corridors; Also data provided by BLM	0.6	Low	200	Linear
Mines and wells	New Mexico Energy, Minerals and Natural Resources Department; BLM LCDO; BLM NM	0.3	High	1000	Logistic
High Impervious Surfaces	NLCD > 40% developed imperviousness	0.3	Medium	1000	Logistic
Low Impervious Surfaces	NLCD 5 – 40% developed imperviousness	0.75	Low	500	Linear
Urban Lights	NASA Night Lights > 200	0.35	Medium	2000	Logistic
DOD Lands & McGregor Range	Surface Management Agency dataset	0.7	Low	500	Linear
Managed and Modified Land Cover					

Low agriculture and invasive species (includes invasives, grazing allotments, and pastures)	SWReGAP; LANDFIRE BLM LCDO; BLM NM	0.7	Low	500	Linear
Allotments not meeting the Land Health Standard	BLM	0.5	Low	1000	Linear
Cultivated agriculture	LANDFIRE	0.35	Medium	2000	Linear
Vegetation Departure	ILAP & LANDFIRE VDEP (merged)	0.5 – 1.0	None	None	None

[1] Impacts with low stress levels were modeled with linear functions; impacts with medium or high stress levels were modeled with logistic functions.

[2] Numbers correspond to the equations listed in the following pages.

Table 2. Draft Near-Term Future (e.g., 2030) Landscape Intactness Model Factors, Impact Scores, and Distance Decay Functions (to be included with the draft current landscape intactness model).

Future Landscape Intactness Model				
Factor	Score	Presumed Stress	Distance (m)	F(x)
Suburban Development Risk (Theobald), Value = 3	0.2	High	2000	Logistic
High Urban WUI (WUI = 2)	0.2	High	2000	Logistic
Exurban Development Risk (Theobald), Value = 2	0.3	Medium-High	2000	Logistic
Rural Development Risk (Theobald), Value = 1	0.3	Low	1000	Linear
Low WUI (WUI = 1)	0.3	Low	1000	Linear
Afton Solar Energy Zone	0.2	High	2000	Logistic
Oil & gas lease polygons	0.3	Medium	1000	Linear
368 Corridor and BLM Designated Corridors	0.5	Low	1000	logistic

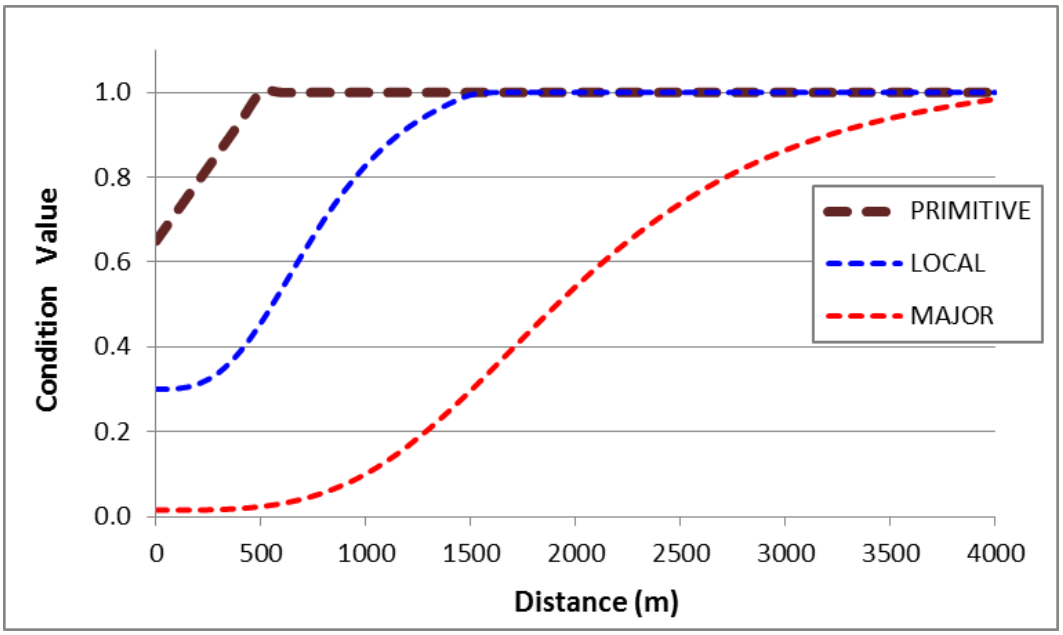

Figure 1. Example distance decay functions for the three types of roadways (primitive, local, and major) evaluated in the development of the Draft Landscape Intactness Model. Refer to Table 2 for model parameterization.

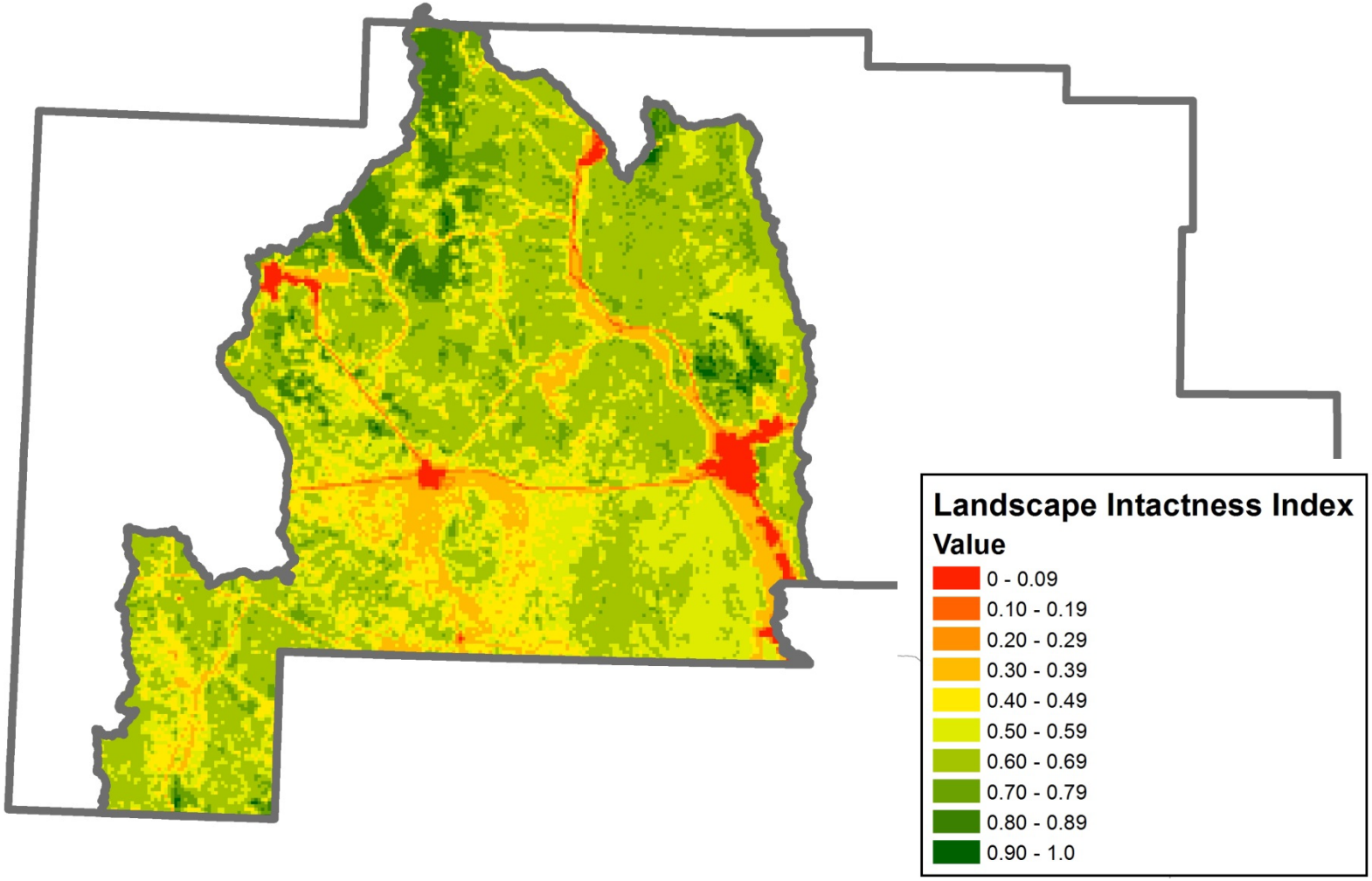

Figure 2 Current Landscape Intactness Model for the HUC4 watershed.

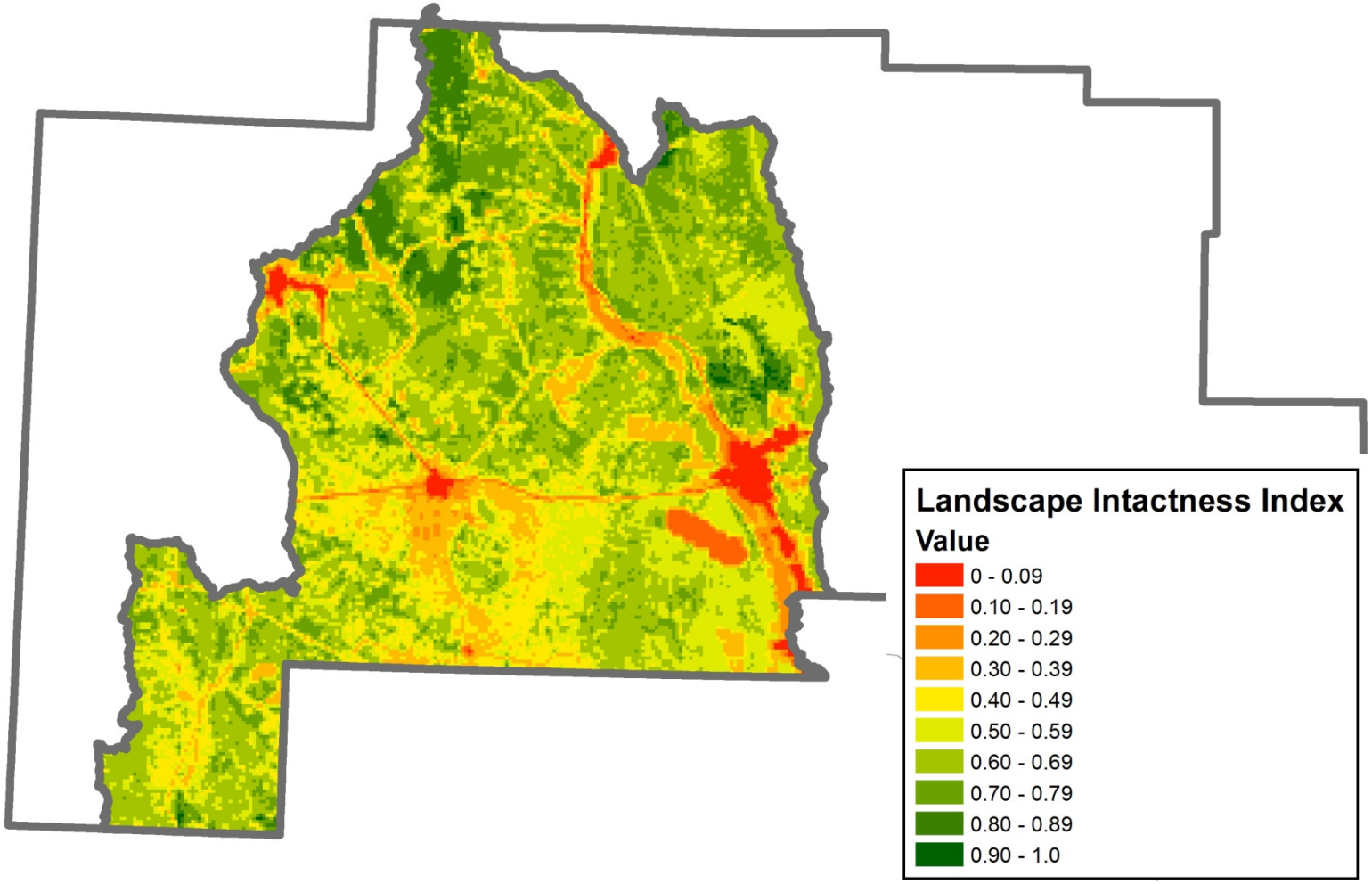

Figure 3 Future Landscape Intactness Model for the HUC4 watershed.

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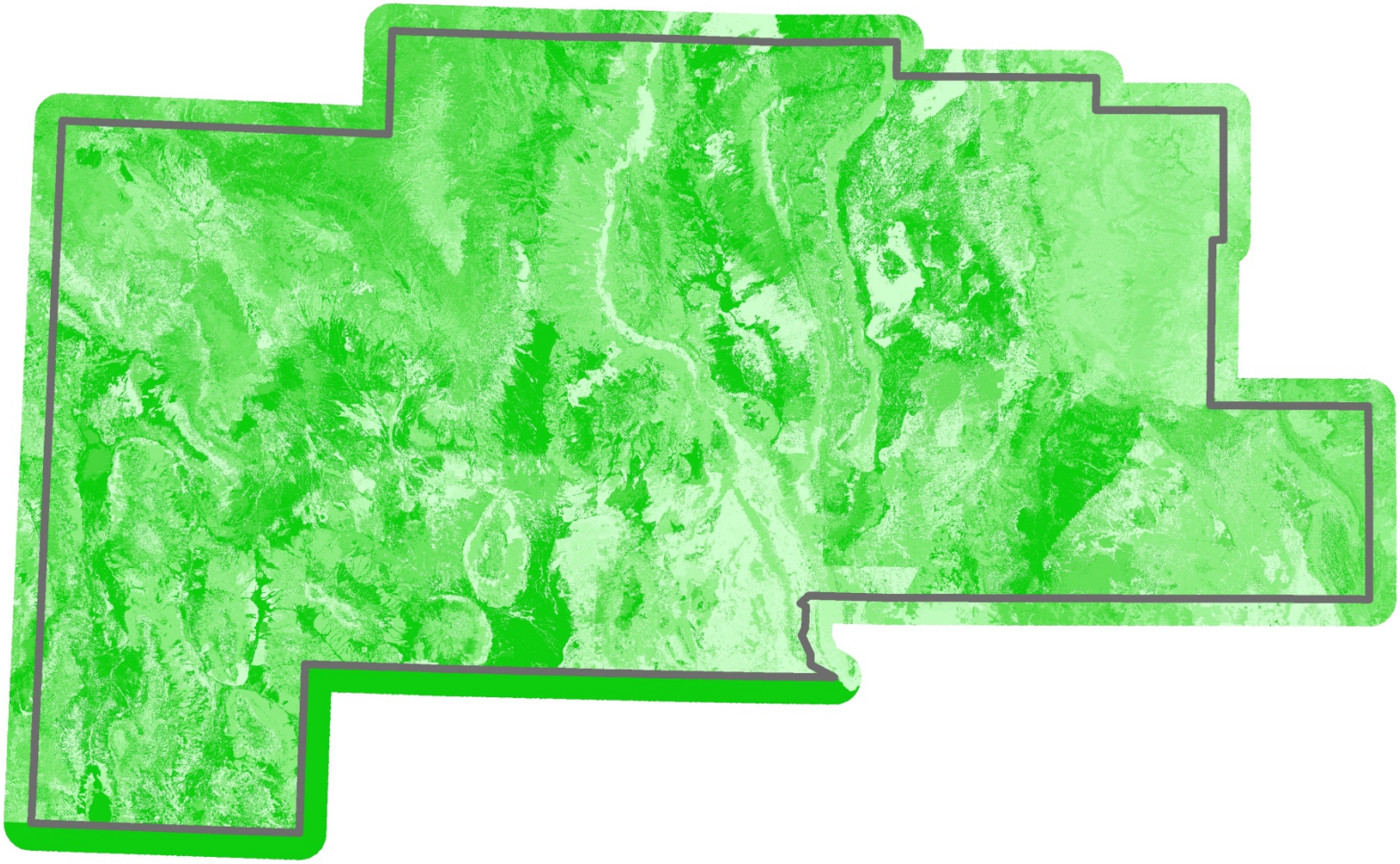
APPENDIX A:

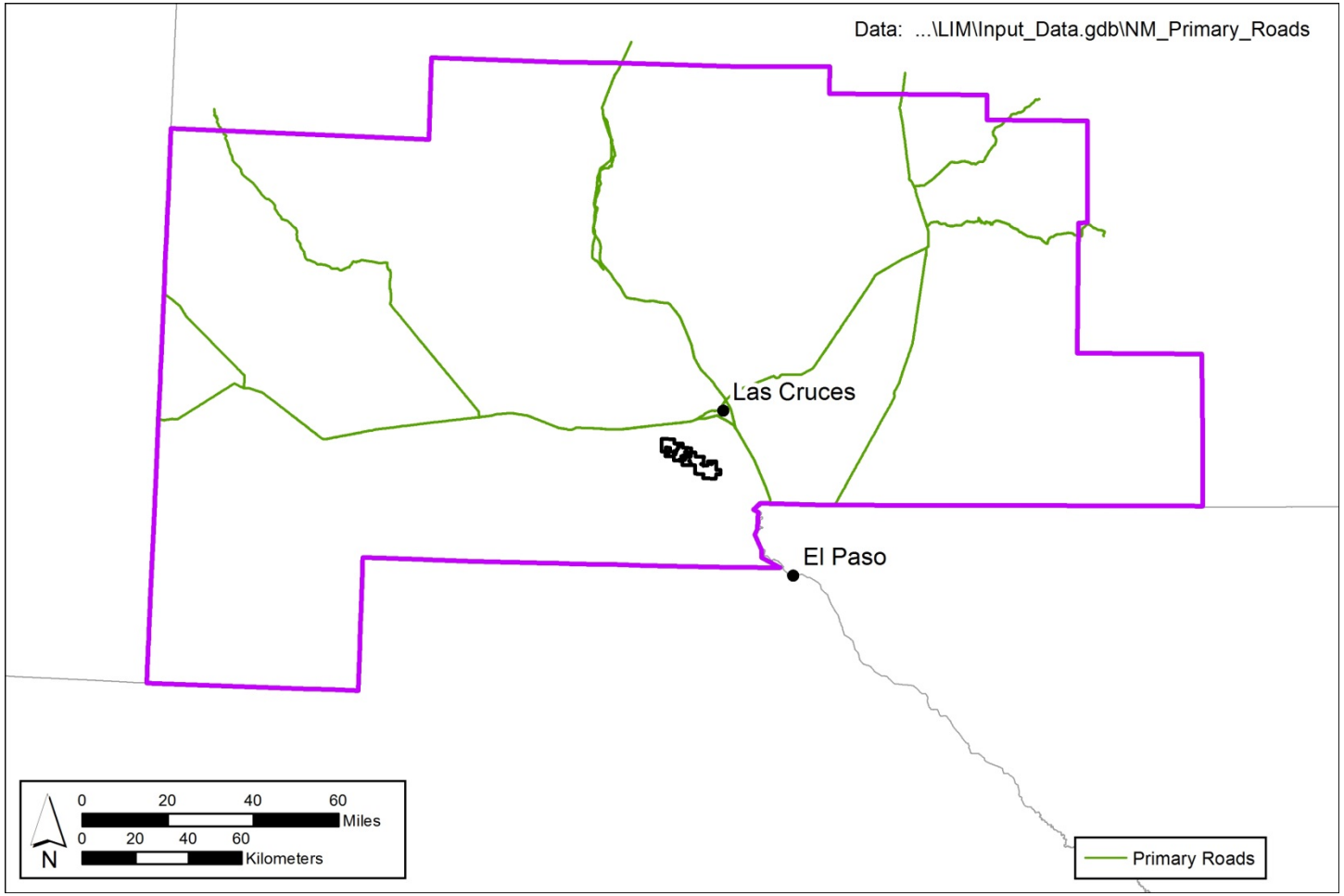
INPUT DATA MAPS

Vegetation Departure (merged ILAP & LANDFIRE VDEP)



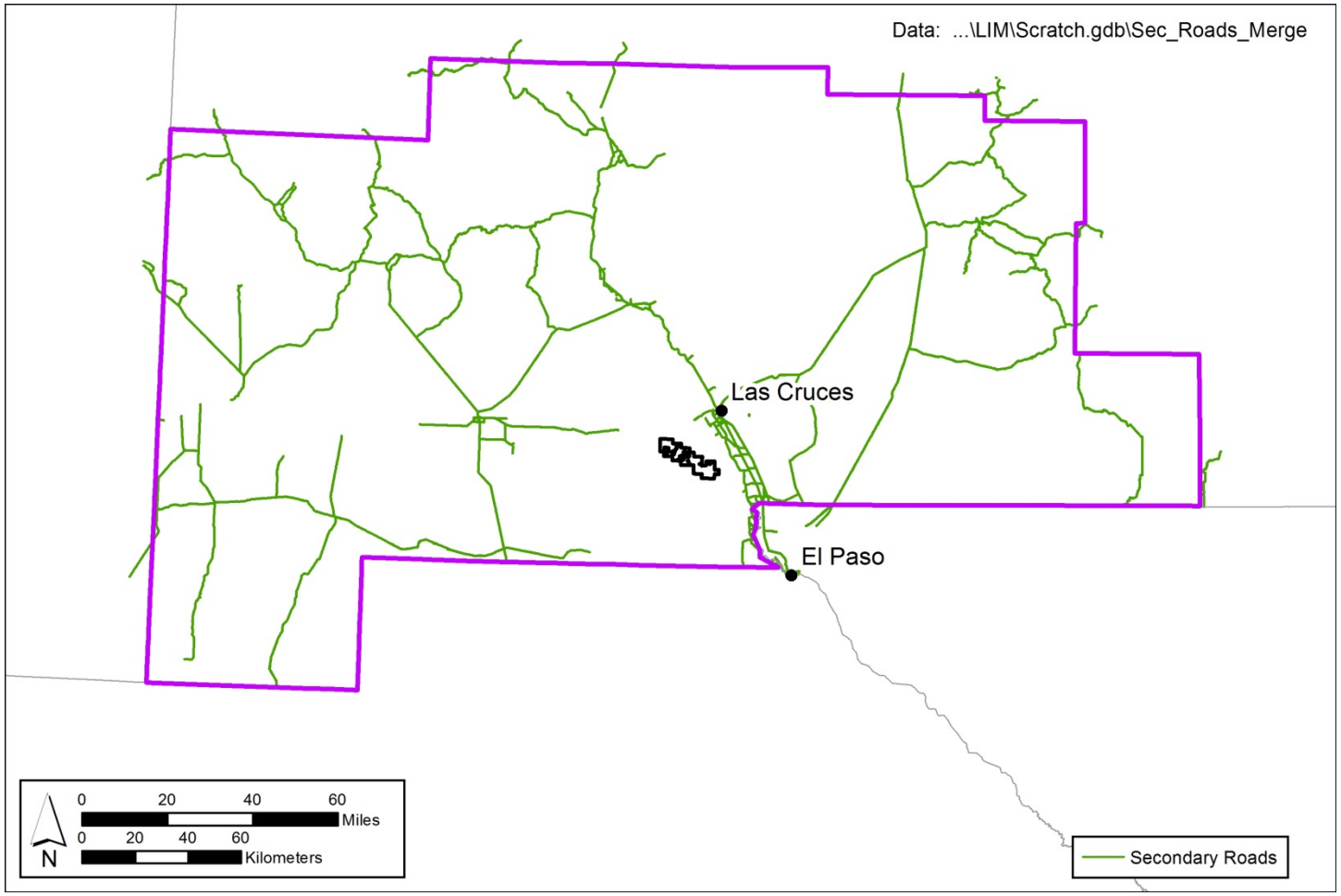
Vegetation departure estimated from ILAP. LANDFIRE VDEP was used in areas where ILAP data were absent. Lighter areas indicate areas of greater vegetation departure; darker areas indicate areas of low vegetation departure.

Primary Roads



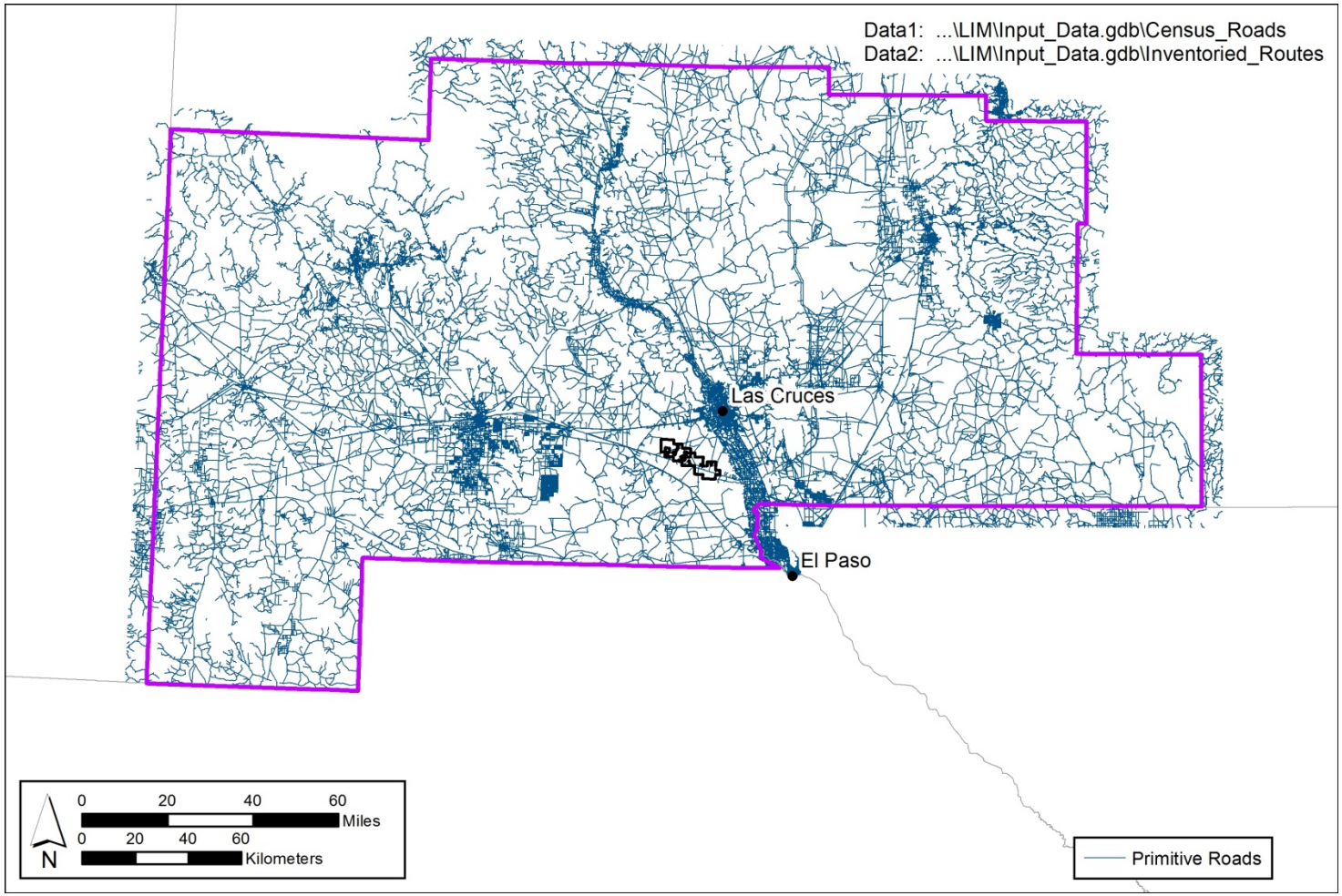
U.S. Census Bureau: TIGER Roads (queried for MTFCC = 'S1100') – 2015
BLM NM: TIGER Roads (queried for RTTYP = 'I' OR RTTYP = 'U') – 2010
The TIGER/Line Files are shapefiles and related database files (.dbf) that are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB).

Secondary Roads



U.S. Census Bureau: TIGER Roads (queried for MTFCC = 'S1200') – 2015
BLM NM: TIGER Roads (queried for RTTYP <> 'I' AND RTTYP <> 'U') – 2010
The TIGER/Line Files are shapefiles and related database files (.dbf) that are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB).

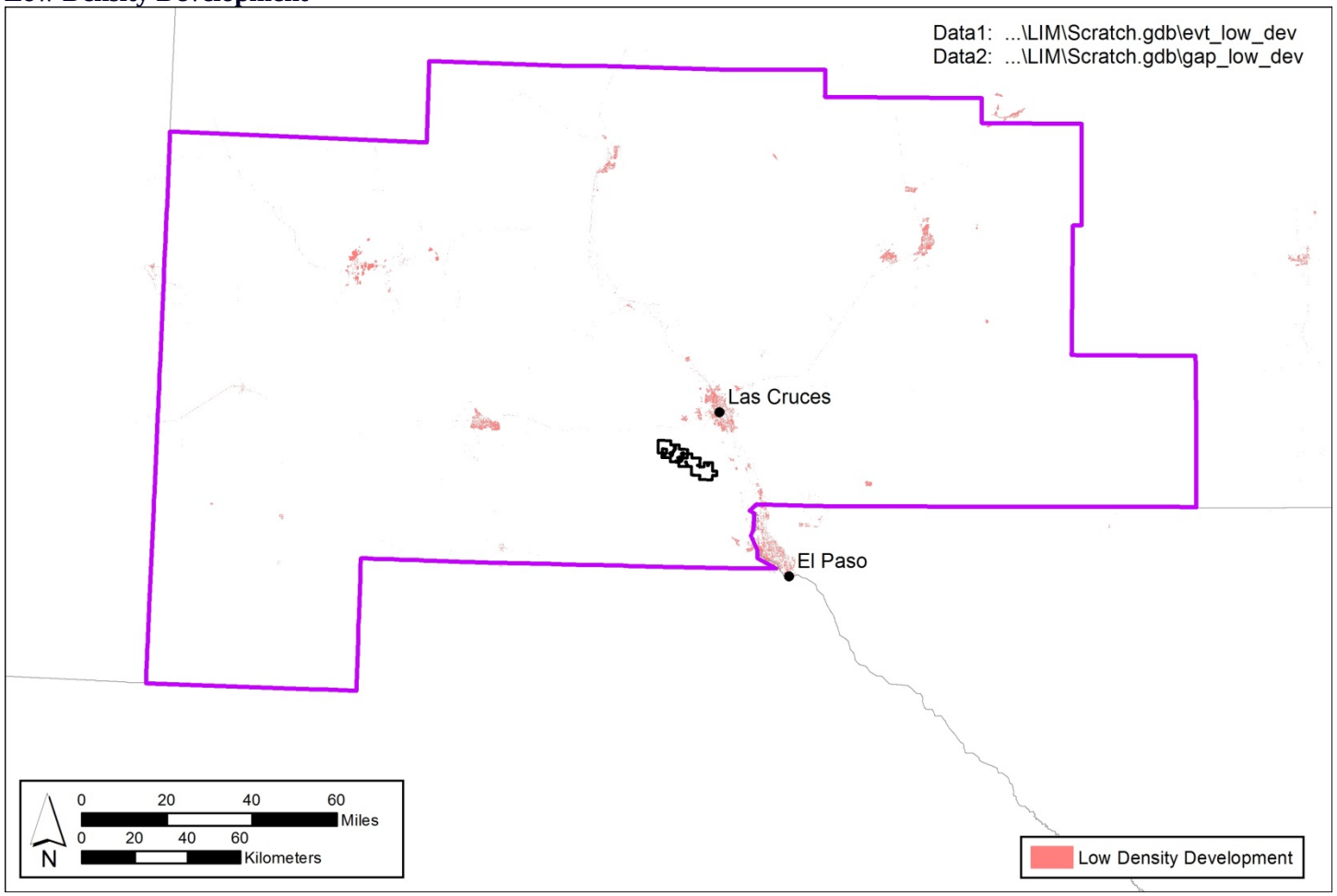
Primitive Roads



U.S. Census Bureau: TIGER Roads – 2015

The TIGER/Line Files are shapefiles and related database files (.dbf) that are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB).

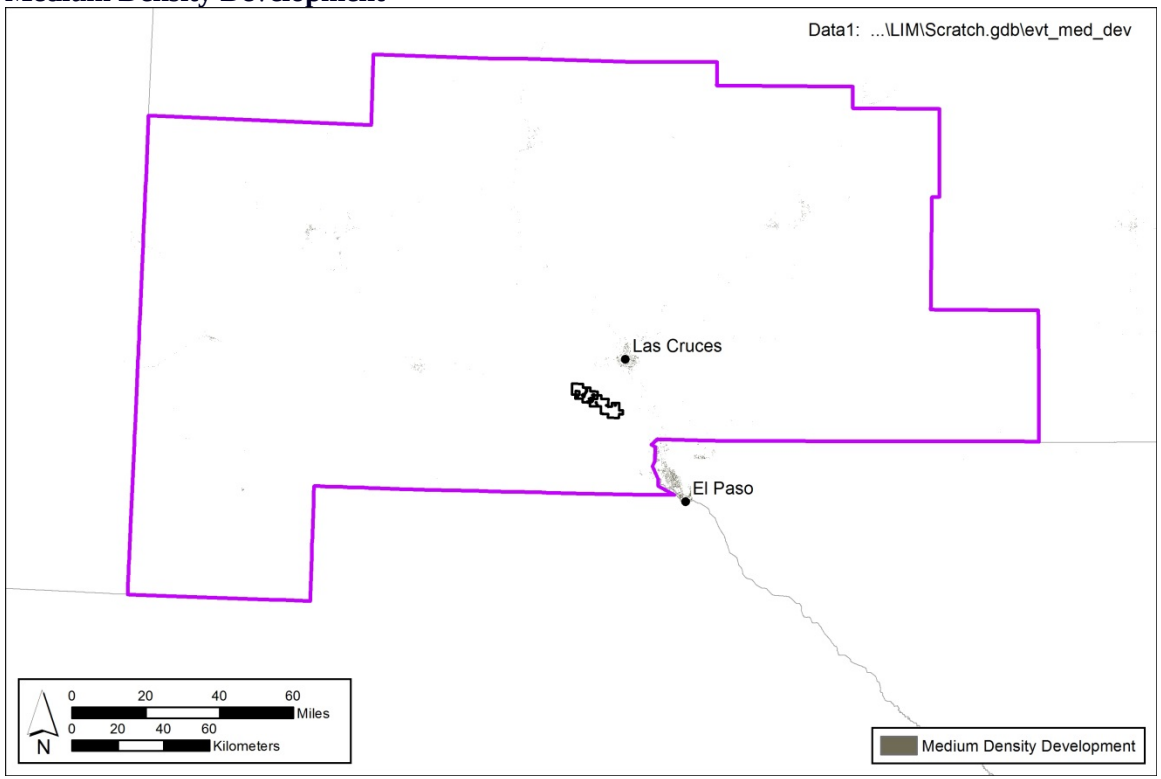
Low Density Development



USGS: SWReGAP (queried for Developed, Open Space - Low Intensity) – 2004
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. 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.

LANDFIRE: EVT (queried for Developed – Low Intensity) – 2012
The existing vegetation type (EVT) data layer represents the current distribution of the terrestrial ecological systems classification developed by NatureServe for the western Hemisphere (http://www.natureserve.org/publications/usEcologicalsystems.jsp). EVTs are mapped in LANDFIRE using decision tree models, field reference data, Landsat imagery, digital elevation model data, and biophysical gradient data.

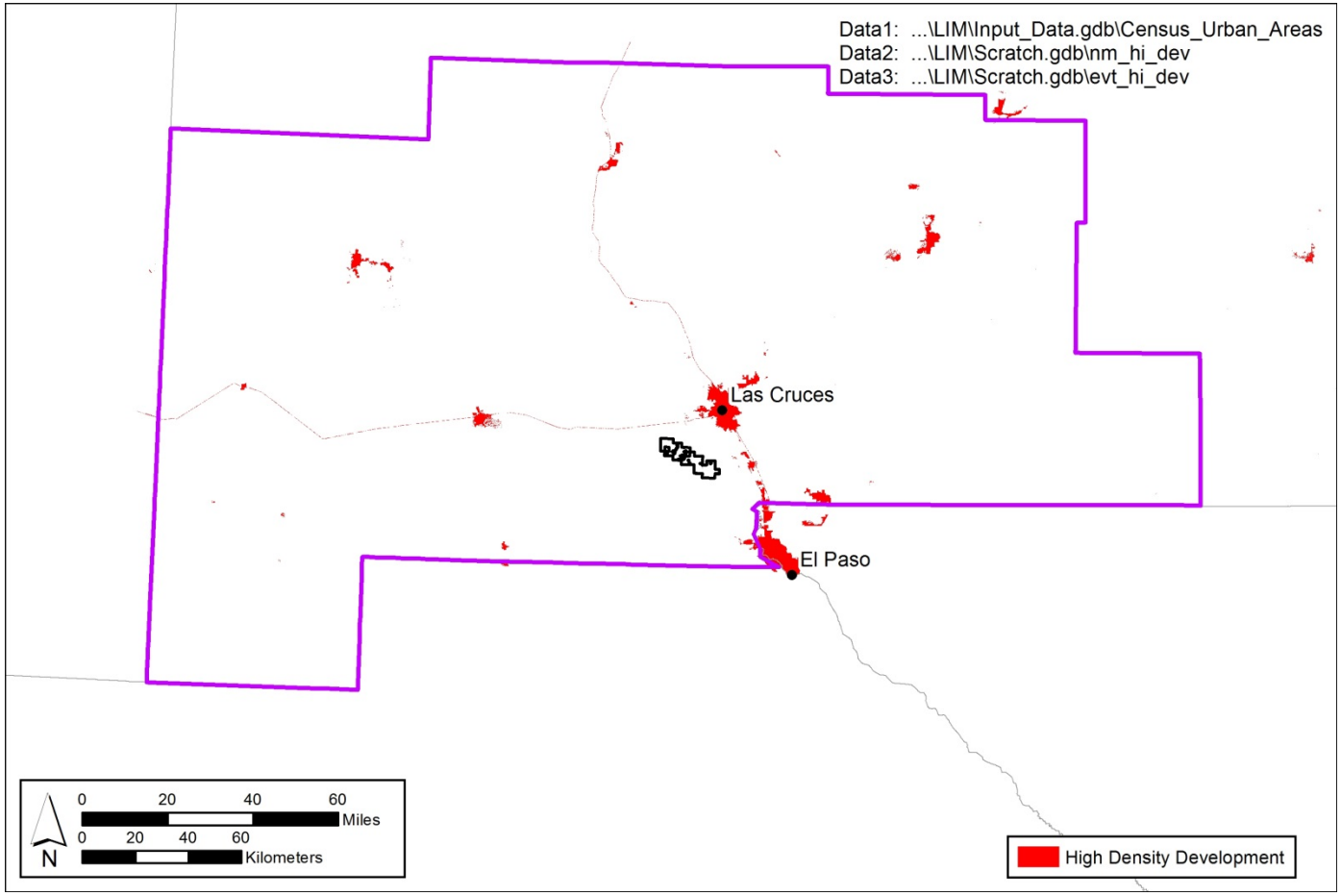
Medium Density Development



LANDFIRE: EVT (queried for Developed – Medium Intensity) – 2012

The existing vegetation type (EVT) data layer represents the current distribution of the terrestrial ecological systems classification developed by NatureServe for the western Hemisphere (http://www.natureserve.org/publications/usEcologicalsystems.jsp). A terrestrial ecological system is defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. EVTs are mapped in LANDFIRE using decision tree models, field reference data, Landsat imagery, digital elevation model data, and biophysical gradient data. Go to http://www.landfire.gov/participate_acknowledgements.php for more information regarding contributors of field plot data. Decision tree models are developed separately for each of the three life-forms -tree, shrub, and herbaceous - using C5 software. Life-form specific cross validation error matrices are generated during this process to assess levels of accuracy of the models. Decision tree relationships are then used to generate life-form specific EVT spatial data layers. The final EVT and Environemtanl Site Potential (ESP) layers are compared and rectified through a series of QA/QC measures. Values of one or more of these data layers are adjusted based on a hierarchical decision tree ruleset in order to align the respective life-forms and life-zone of each ESP and EVT category.

High Density Development and Urban Areas

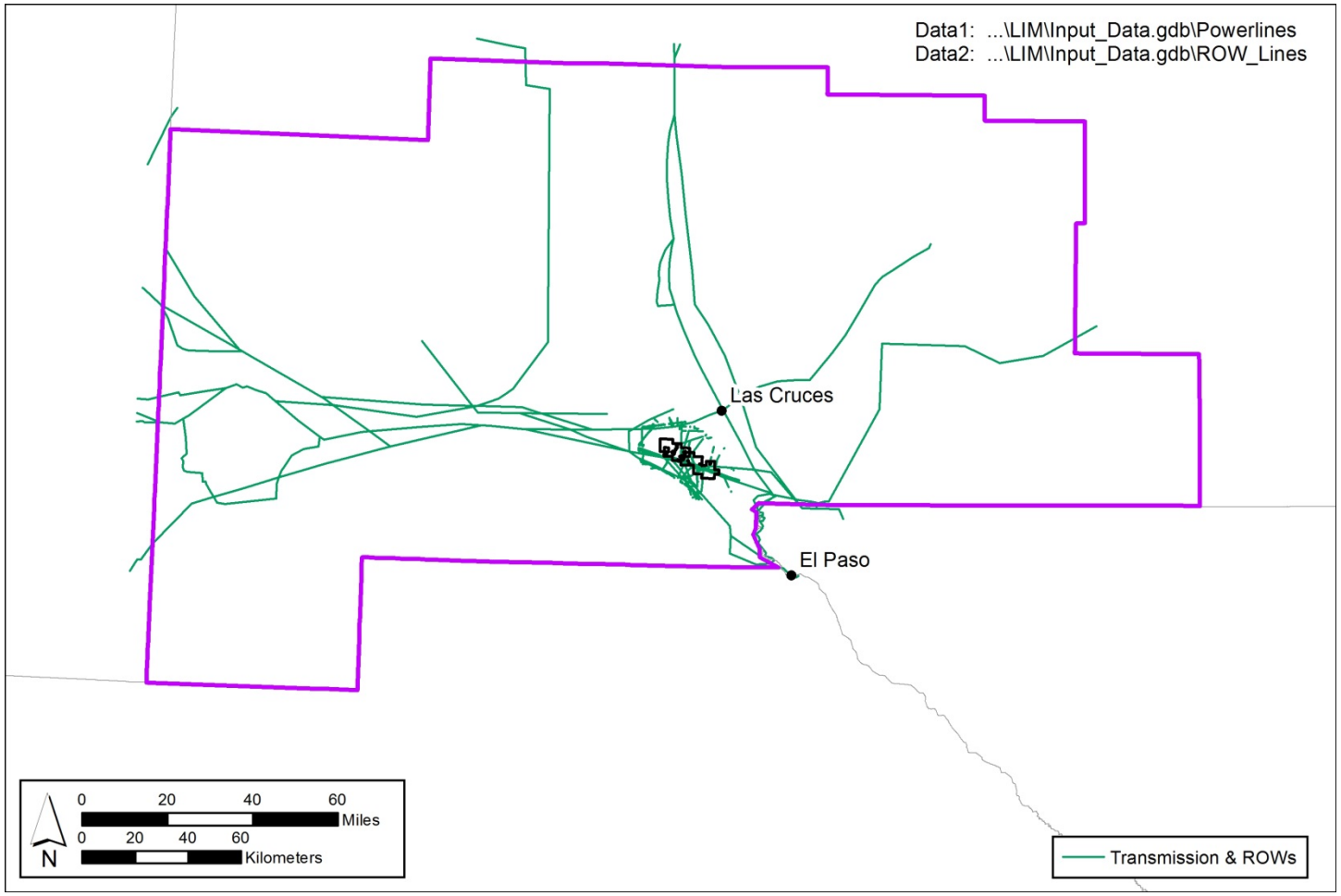


USGS: SWReGAP (queried for Developed, Medium – High Intensity) – 2004

LANDFIRE: EVT (queried for Developed – High Intensity) – 2012

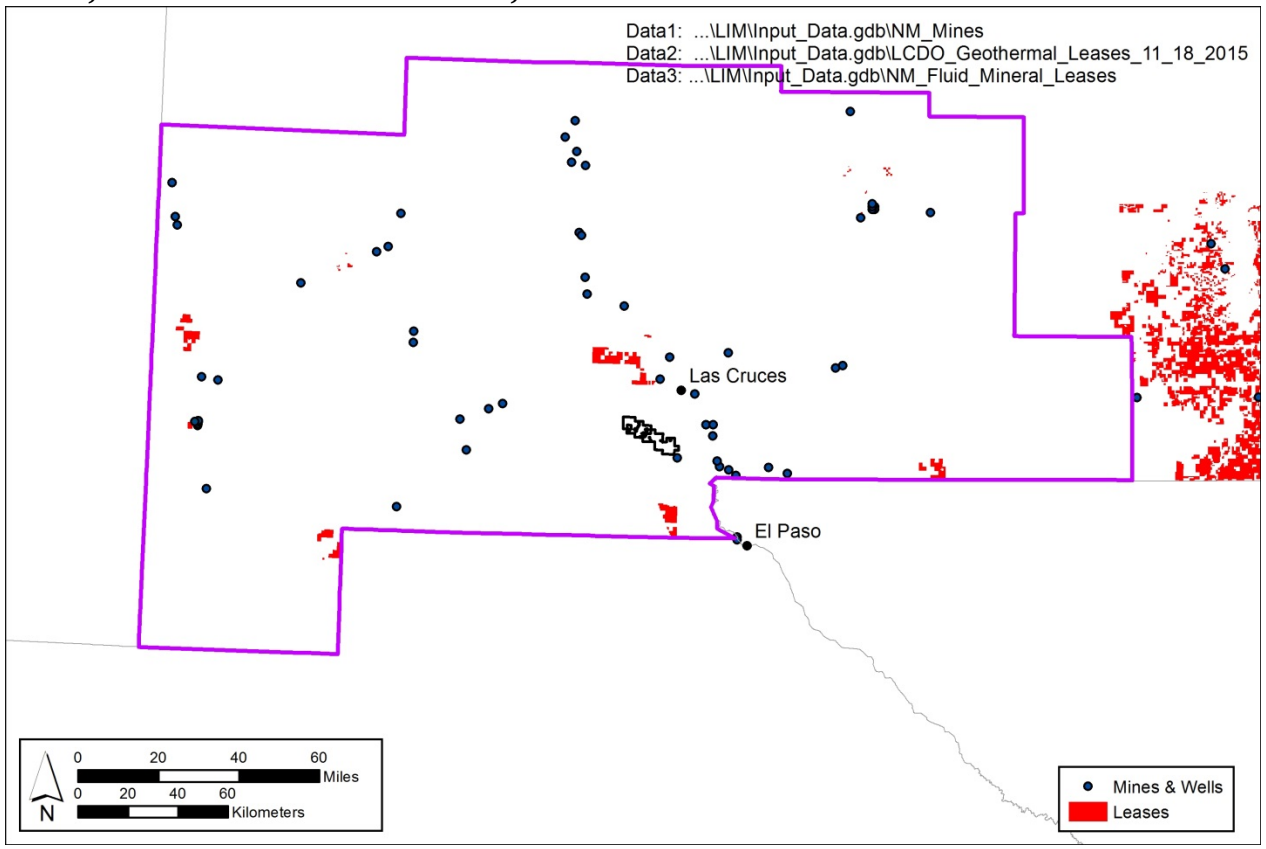
U.S. Census Bureau: Urban Areas – 2010
The Census Bureau delineates urban areas that represent densely developed territory, encompassing residential, commercial, and other nonresidential urban land uses.

Transmission Lines and ROWs



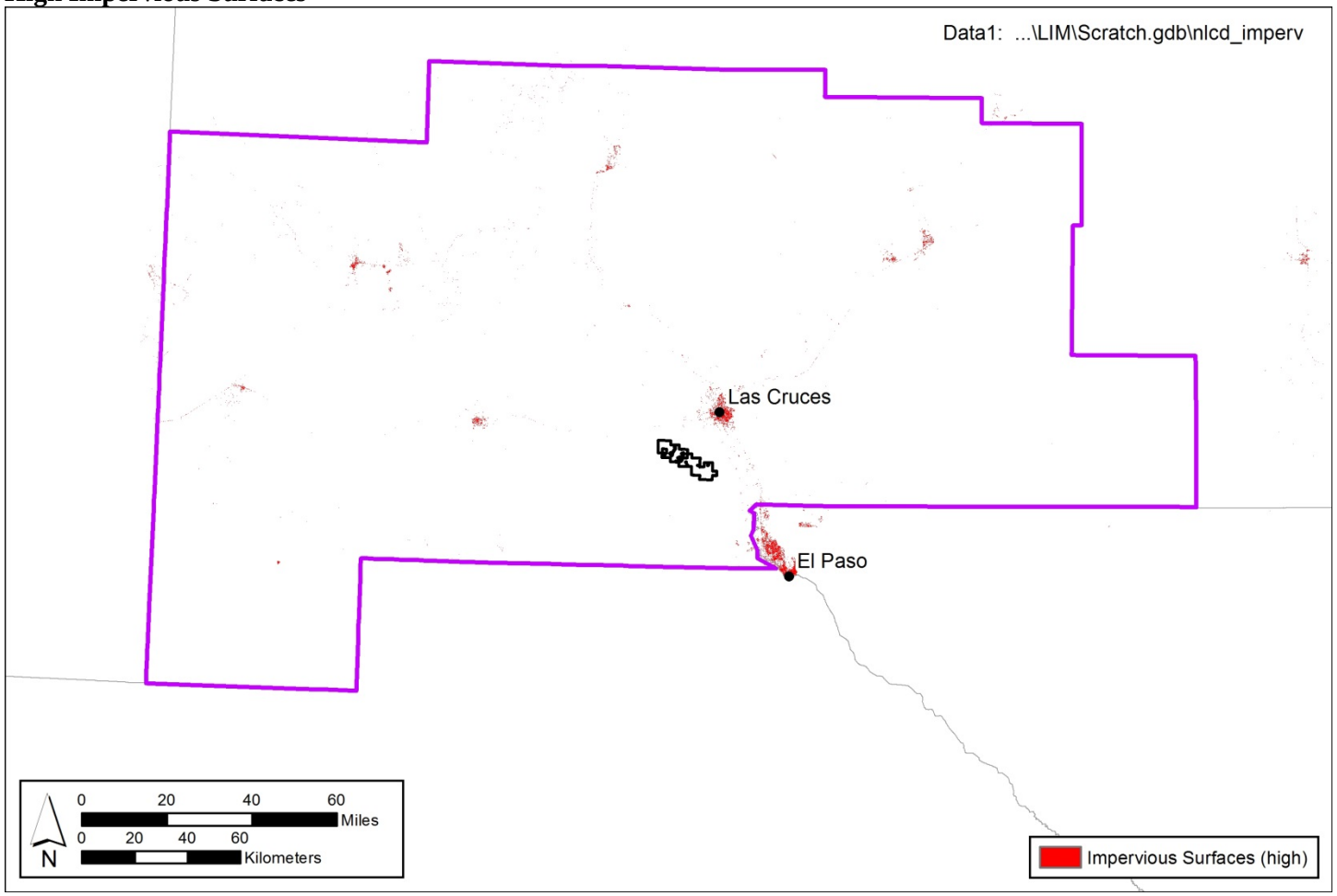
BLM Rights of Way – LCDO submission
Powerlines - Data Basin – downloaded November 2015
Powerlines in the western United States. Data was obtained from the ICEBMP existing utility corridors data set.

Mines, Geothermal Wells and Leases, and Fluid Mineral Leases



New Mexico Energy, Minerals and Natural Resources Department: New Mexico Active Mines – August 2013
The mining operation information in this document was collected under the authority of NMSA, 1978, Chapter 69, by the Mine Registration, Reporting and Safeguarding (MRRS) Program of the Mining and Minerals Division (MMD). It is the sole responsibility of mine operators to register any mine, mill, smelter, pit, quarry or other mining facility with MRRS prior to the start of operations; to notify MRRS of operational changes; and to accurately and periodically report data as required under the statute and attendant regulation. Information in this portion of MMD's website is based on data that is reported to MMD by mine operators. While MMD reviews the reported data for completeness and accuracy, anyone using this information should be aware that it does not originate with MMD. Additionally, some of the information may not be current because of changes since the last reporting cycle.
BLM LCDO: Geothermal Leases and Geothermal Wells – downloaded November 2015
BLM NM: Oil and Gas Leases – downloaded November 2015

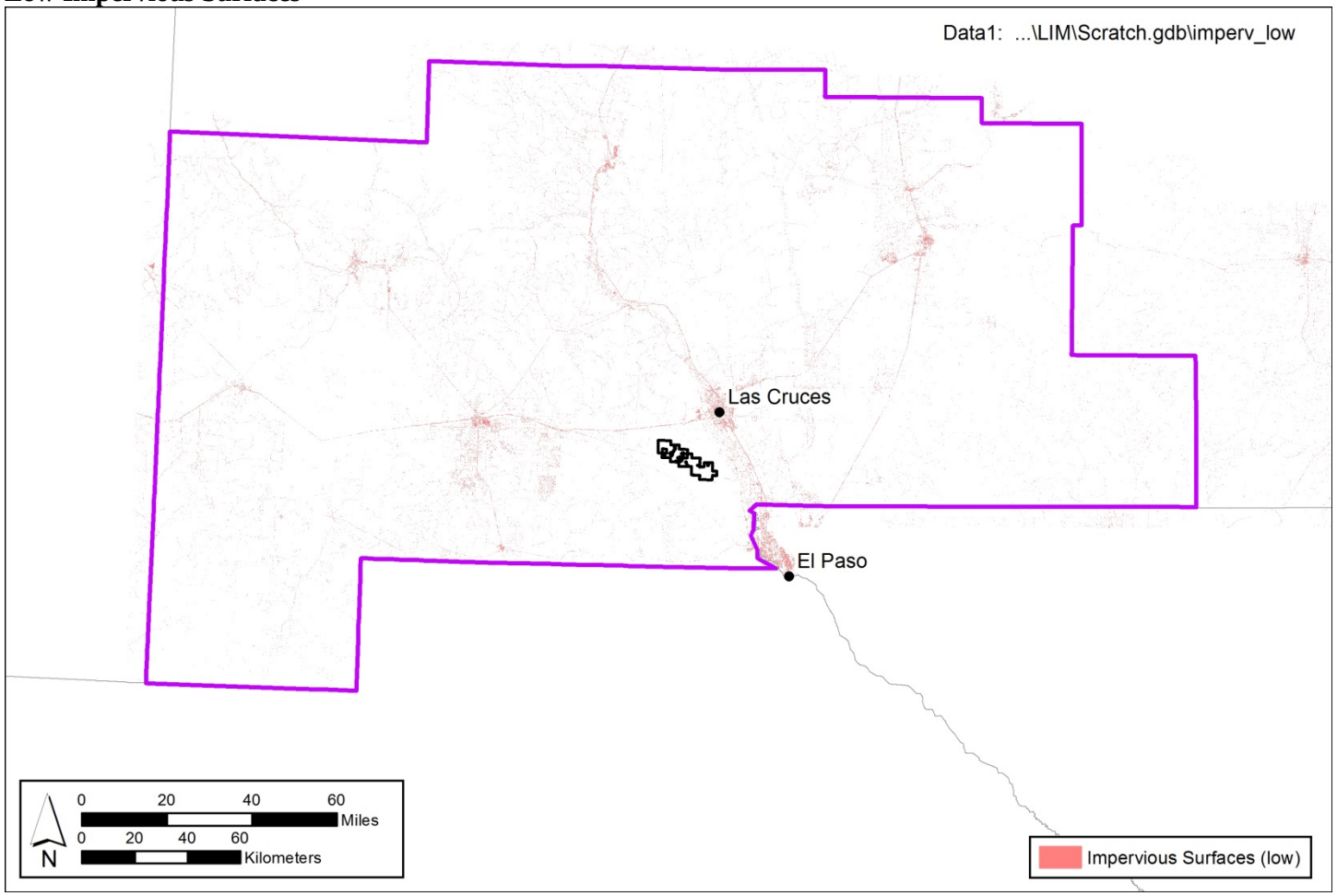
High Impervious Surfaces



NLCD: Percent Developed Imperviousness (queried for >40%) – 2011

For NLCD 2011, there are 5 primary data products: 1) NLCD 2011 Land Cover; 2) NLCD 2006/2011 Land Cover Change Pixels labeled with the 2011 land cover class; 3) NLCD 2011 Percent Developed Imperviousness; 4) NLCD 2006/2011 Percent Developed Imperviousness Change Pixels; and 5) NLCD 2011 Tree Canopy Cover provided by an MRLC partner - the USDA Forest Service Remote Sensing Applications Center.

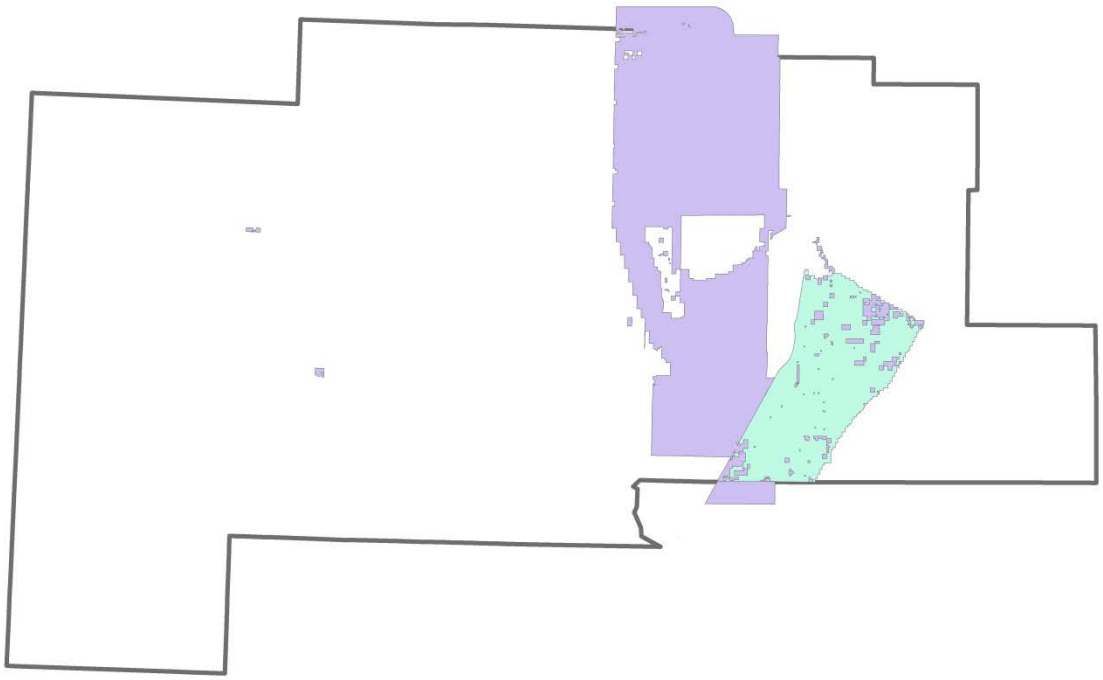
Low Impervious Surfaces



NLCD: Percent Developed Imperviousness (queried for 5-40%) – 2011

For NLCD 2011, there are 5 primary data products: 1) NLCD 2011 Land Cover; 2) NLCD 2006/2011 Land Cover Change Pixels labeled with the 2011 land cover class; 3) NLCD 2011 Percent Developed Imperviousness; 4) NLCD 2006/2011 Percent Developed Imperviousness Change Pixels; and 5) NLCD 2011 Tree Canopy Cover provided by an MRLC partner - the USDA Forest Service Remote Sensing Applications Center. Questions about the NLCD 2011 products can be directed to the NLCD 2011 land cover mapping team at the USGS/EROS, Sioux Falls, SD (605) 594-6151 or mrlc@usgs.gov.

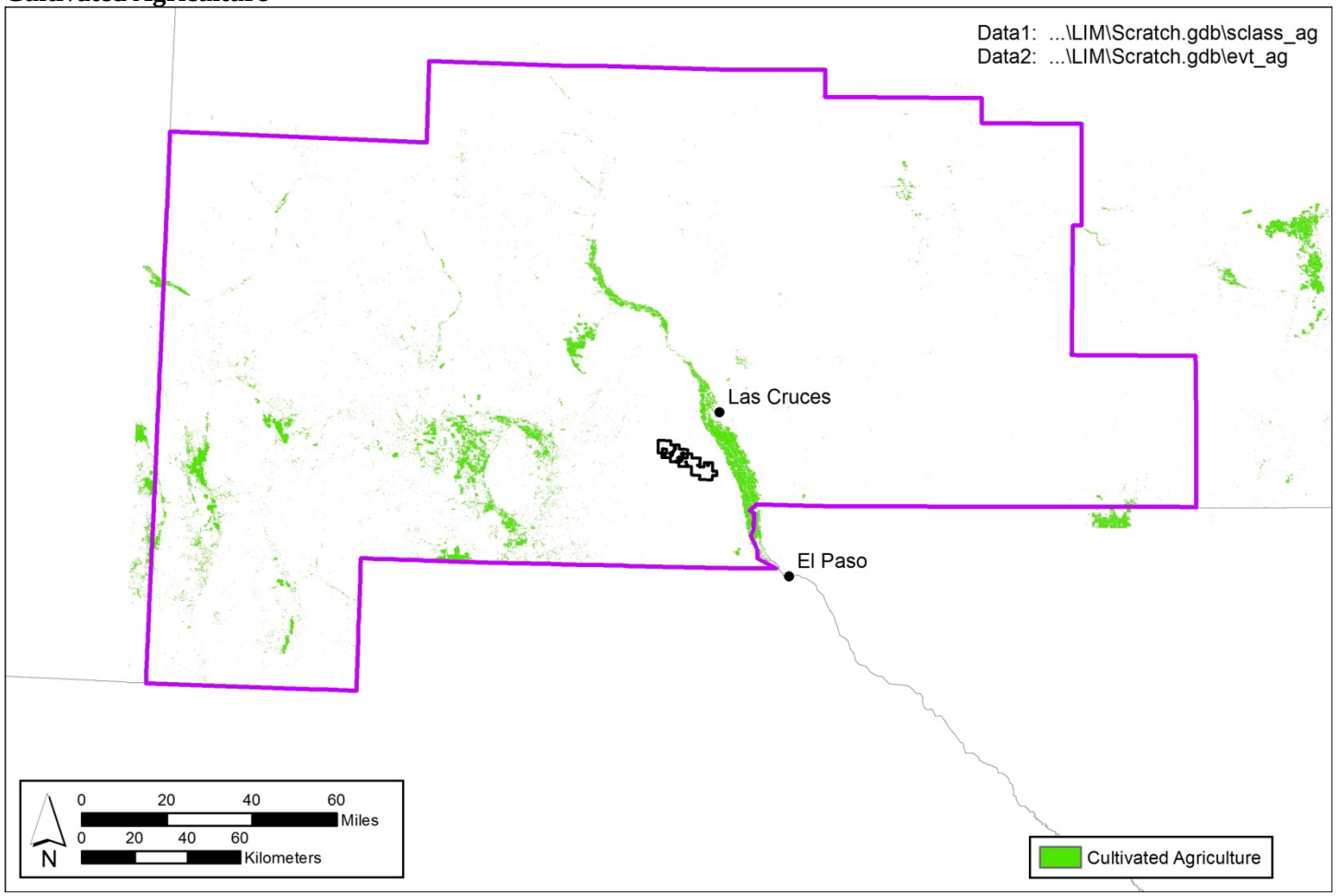
DOD Lands & McGregor Range



BLM: Surface Management Agency – 2015

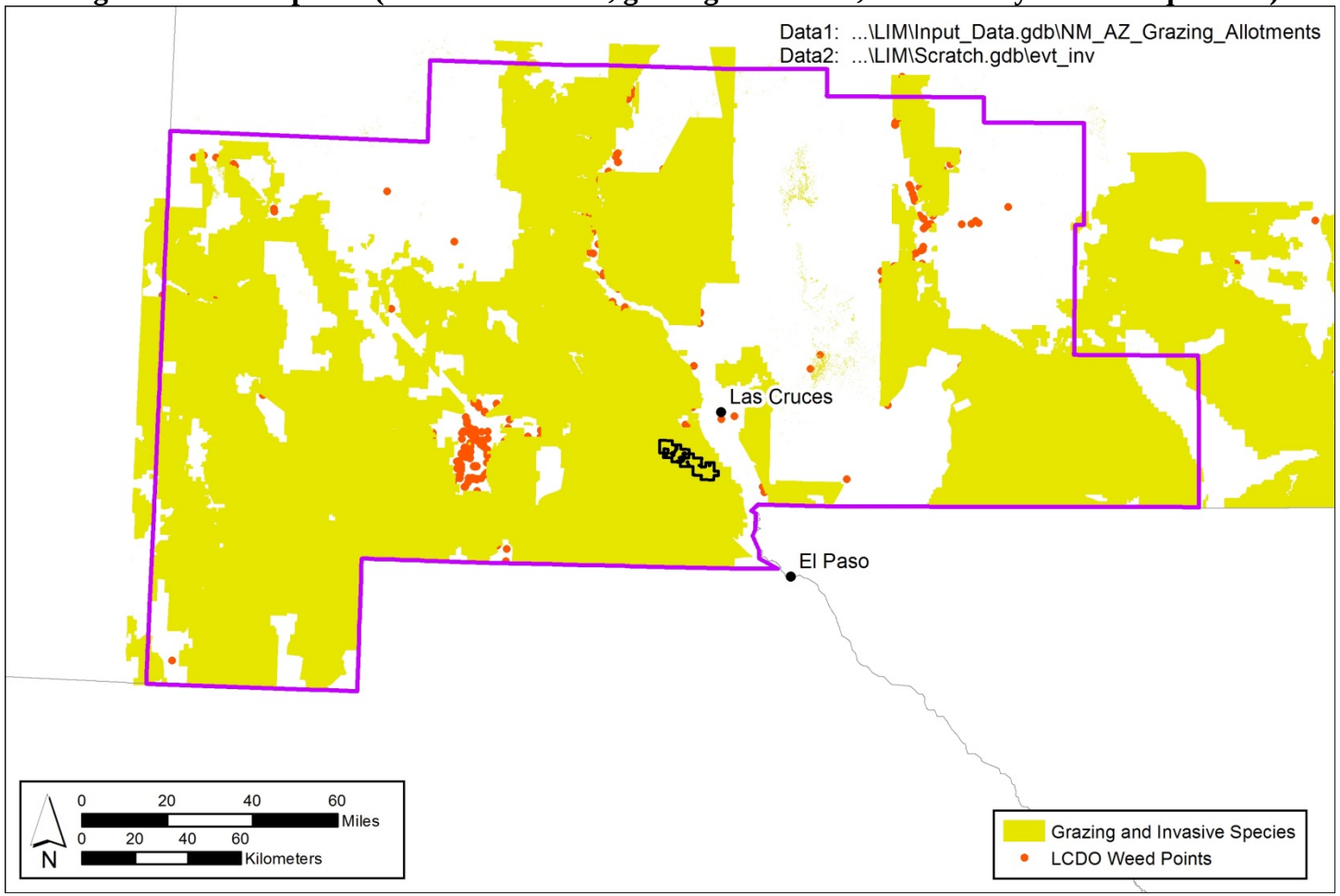
The Surface Management Agency (SMA) Geographic Information System (GIS) dataset depicts Federal land for the United States and classifies this land by its active Federal surface managing agency. The SMA feature class covers the continental United States, Alaska, Hawaii, Puerto Rico, Guam, American Samoa and the Virgin Islands. A Federal SMA agency refers to a Federal agency with administrative jurisdiction over the surface of Federal lands. Jurisdiction over the land is defined when the land is either: Withdrawn by some administrative or legislative action, or Acquired or Exchanged by a Federal Agency. This layer is a dynamic assembly of spatial data layers maintained at various federal and local government offices. The GIS data contained in this dataset represents the polygon features that show the boundaries for Surface Management Agency and the surface extent of each Federal agency's surface administrative jurisdiction. SMA data depicts current withdrawn areas for a particular agency and (when appropriate) includes land that was acquired or exchanged and is located outside of a withdrawal area for that agency. The SMA data do not illustrate land status ownership pattern boundaries or contain land ownership attribute details.

Cultivated Agriculture



LANDFIRE: EVT (queried for Agriculture) – 2012
LANDFIRE: SCLASS (queried for Non-burnable and Burnable Agriculture) – 2010
Succession Classes categorize current vegetation composition and structure into up to five successional states defined for each LANDFIRE Biophysical Settings (BpS) Model.

Grazing and invasive species (includes invasives, grazing allotments, and recently mined or quarried)



BLM NM: Grazing Allotment Boundaries – downloaded November 2015
LANDFIRE: EVT (queried for Introduced Vegetation) – 2012
LANDFIRE: SCLASS (queried for Uncharacteristic Exotic Vegetation) – 2010
BLM Las Cruces District Office: Weeds (points, lines, and polygons) – downloaded November 2015