4.2.2 Vegetation Communities: Distribution and Current Status

> Vegetation Communities
> Management Questions
>
> 1. Where are existing vegetative communities? What is their status?
> 2. What change agents have affected existing vegetation communities?

There were nine coarse filter vegetation communities evaluated for the Colorado plateau ecoregion—eight matrix vegetation communities plus riparian vegetation. For the specific vegetation communities, two different sources of data were compiled (LANDFIRE EVT v1.1 and NatureServe Landcover v2.7) to depict current distribution (Figure 4-21 A and B). All of the vegetation communities were distinct classes in the NatureServe Landcover dataset, but only six communities were mapped in LANDFIRE EVT—pinyon-juniper shrublands were not differentiated and the bedrock canyon and tableland class was combined with other barren lands in the LANDFIRE product.

Besides the differences in classes mapped, area covered for each vegetation community type according to the two classifications differed to varying degrees (Table 4-7**)**. While a visual inspection of maps of the two data sources presents each vegetation community in approximately the same general locations, the actual pixel-to-pixel agreement is generally poor, ranging in percent overlap from 0 to nearly 50 percent.

Comparison map results for the two classifications for each vegetation community for each data source are provided in Appendix B. Even though there are significant differences between the two classification systems, participants agreed that it is more appropriate to acknowledge the differences and choose the one most meaningful for a particular purpose than to attempt to hybridize the two into a single product.

Table 4-7. Comparison of area (in 1000s of acres) between NatureServe Landcover v2.7 and LANDFIRE EVT v1.1 for selected vegetation communities.

Vegetation Community	NatureServe Only	LANDFIRE Only	Both	Percent Overlap
Colorado Plateau Pinyon-Juniper Woodland	2,595	3,665	6,079	49.3
Colorado Plateau Pinyon-Juniper Shrubland	2,694	In PJ woodlands	0	0.00
Colorado Plateau Blackbrush-Mormon-tea Shrubland	1,293	2,568	1,460	27.4
Inter-Mountains Basins Big Sagebrush Shrubland	1,543	3,970	2,370	30.1
Inter-Mountains Basins Mixed Salt Desert Scrub	1,645	1,964	681	15.9
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	1,424	634	660	24.3
Inter-Mountain Basins Montane Sagebrush Steppe	1,551	61	115	6.7
Colorado Plateau Mixed Bedrock Canyon and Tableland	4,598	Not mapped	0	0.00

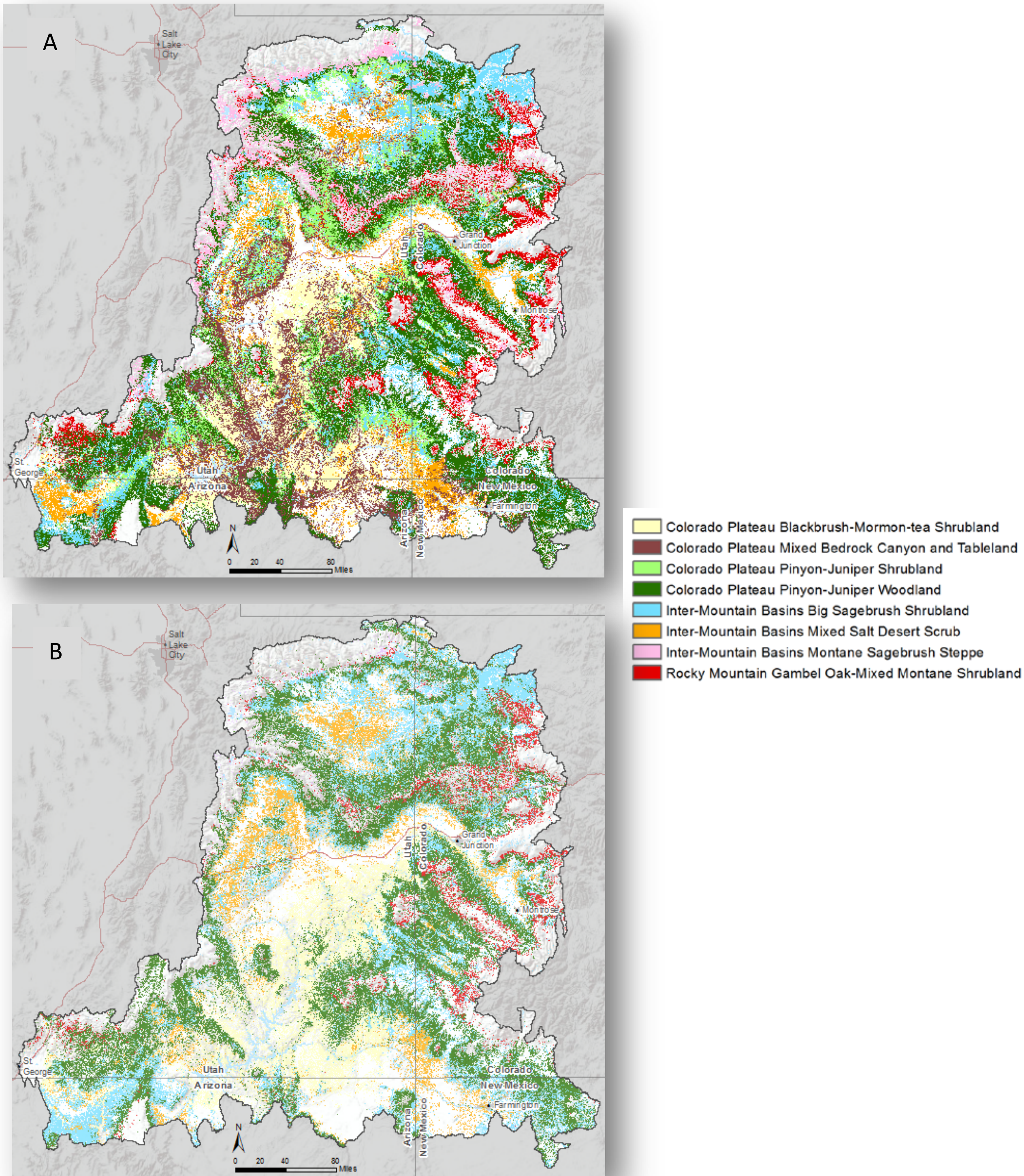

Figure 4-21. Maps show (A) NatureServe Landcover v2.7 and (B) LANDFIRE EVT v 1.1 for the matrix vegetation communities in the Colorado Plateau ecoregion. Eight vegetation communities were distinguished in the NatureServe Landcover dataset, but only six communities were mapped in LANDFIRE EVT. Pinyon-juniper shrublands were not differentiated and the bedrock canyons and tablelands class was combined with other barren lands in the LANDFIRE product.

Evaluating current status for each vegetation community is challenging in several ways. First, many of these vegetation communities are dynamic over time and space demonstrating a degree of fluidity, especially along ecotonal boundaries, driven by the pattern and timing of fire, climate, and human disturbance (Miller 2005, Miller et al. 2010). Specific plant communities are not fixed on the landscape; individual site histories and competition among species dictate what community is expressed at a particular time period. For example, some portions of a sagebrush community in the absence of periodic fire will transition into pinyon-juniper woodland or shrubland. Over time, these two communities can shift in distribution and abundance. Remotely sensed imagery, informed by physical environmental variables, limited training sites, and different levels of interpretation and expert opinion, produce different mapping outcomes such as those seen in Figure 4-21.

The LANDFIRE Biophysical Settings (BpS) data served as the reference condition to address questions of historic change. Biophysical settings provide a spatially explicit estimate of which vegetation communities would likely occur in a specific location based on physical conditions (e.g. soils, elevation, aspect, moisture, and natural fire regime). BpS is a model and a strict alignment with current distribution (i.e. LANDFIRE EVT) should not be expected. For example, the BpS and EVT maps for Inter-Mountain Basins Big Sagebrush Shrubland show considerable overlap but also some differences (Figure 4-22). It is reasonable to assume that some of these differences are the result of conversion of this community type to other land uses.

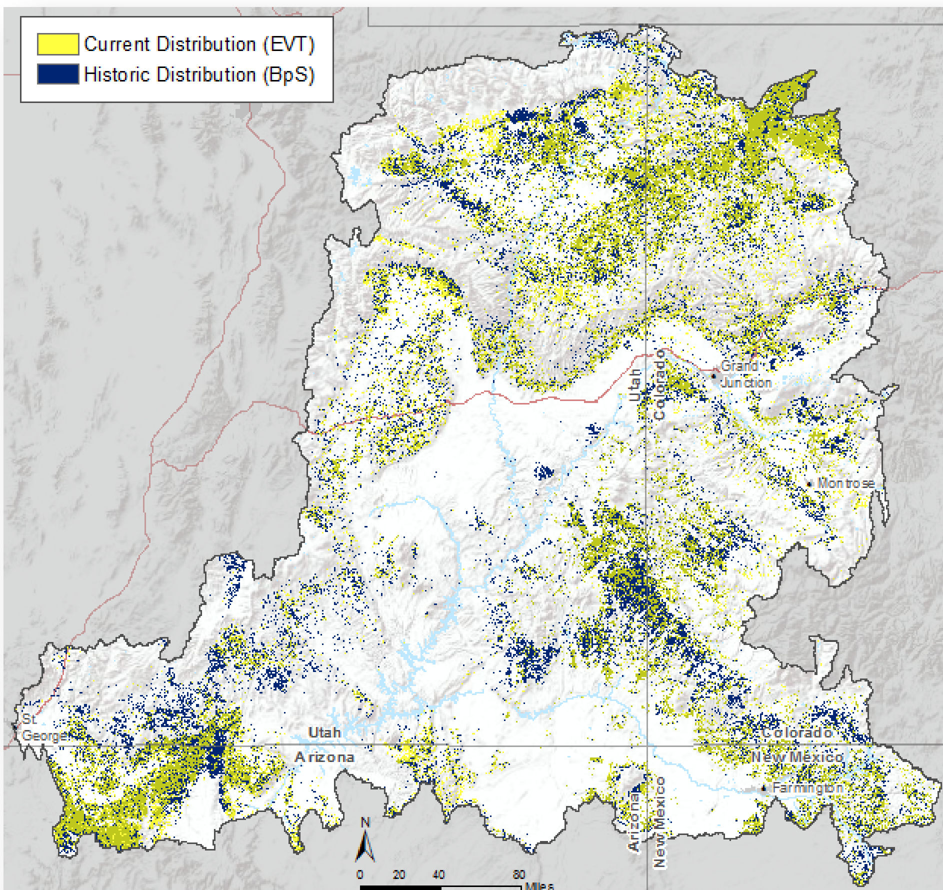

Figure 4-22. Comparison between LANDFIRE current distribution (EVT) and historic distribution (BpS) for Inter-Mountain Basins Big Sagebrush Shrublands. Differences between the two datasets represent conversion of this community type to other land uses.

Overlaying current urban and agriculture land uses, roads, invasive intrusion, and uncharacteristic native vegetation on the historic distribution of big sagebrush highlights areas of change from historic (reference) condition (Figure 4-23A). More recent disturbances (from the last 10–20 years) such as fire, mechanical treatment, and other disturbances were also obtained and overlaid in the same way (Figure 4-23B). Current distribution, historic change, and recent disturbance maps for each vegetation community are provided in Appendix B.

A total of 5.6 million acres (~22%) of the natural vegetation communities in the ecoregion as mapped by LANDFIRE BpS (representing reference condition) were affected by historic change (Table 4-8). Changes due to invasive species conversion and uncharacteristic native vegetation changes dominated the results for historic change, each affecting over 1.7 million acres (Table 4-8). Conversion from urbanization and roads altered over 1.3 million acres and intensive agriculture (excluding grazing) influenced over 760,000 acres. The greatest amount of total area changed (nearly 2.5 million acres or 30% of total BpS area) was for Inter-mountain Basins Big Sagebrush Shrubland, and this community led with maximum acres altered for urban and roads, agriculture, and invasives. Loss to invasive grasses was particularly noteworthy (~846,000 acres) for this community type. The large area of uncharacteristic native vegetation for Inter-mountain Basins Big Sagebrush Shrubland was mainly due to pinyon-juniper expansion.

Colorado Plateau Pinyon-Juniper Woodland, the second-largest vegetation community in the ecoregion, has also been affected by human land use conversion, but more significantly by invasive grasses (~273,000 acres) and uncharacteristic native vegetation conditions (~635,000 acres), which in this case is likely due to the uncharacteristic density of the pinyon-juniper trees from years of fire suppression.

Data for recent disturbance was acquired from datasets for fire perimeters for 2000–2010, LANDFIRE disturbance datasets (1999–2008), and BLM pinyon-juniper vegetation treatments (1958–2008). A total of about 822,000 acres (~3% of the combined area) were recently disturbed in the ecoregion (Table 4-9), mostly by fire (~453,000 acres) followed by mechanical treatment (~366,000 acres). As in the previous summary table, Inter-mountain Basins Big Sagebrush Shrubland was altered the most (>370,000 acres), followed by Colorado Plateau Pinyon-Juniper Woodland (>266,000 acres). One prominent figure is acres of Inter-mountain Basins Big Sagebrush Shrubland mechanically treated (~231,000 acres). Caution must be taken when interpreting this value as the purpose of the management action (e.g. removal of sagebrush to improve grazing or removal of woody intrusion to help restore sagebrush) are not differentiated in the dataset. The majority of approximately 72,000 acres of mechanical treatment in Colorado Plateau Pinyon-Juniper Woodland is likely from thinning operations.

In addition to evaluating historic and recent disturbance to the matrix vegetation communities, which provides some insight into loss and the types of recent disturbances, the existing setting in which these communities currently occur was also evaluated. For each community, the current LANDFIRE distribution was overlaid against the current terrestrial landscape intactness model results. The assumption is that each natural vegetation community is affected in various ways based on the overall intactness of its immediate neighborhood. Intactness maps and profiles for each matrix vegetation community are provided in Appendix B. The profile is a histogram of intactness versus percent of the total distribution. An example of current status for Inter-Mountain Basins Big Sagebrush Shrublands is provided in Figure 4-24A and B, with the results for NatureServe Landcover v2.7 represented in Figure 4-24A and LANDFIRE EVT v1.1 in Figure 4-24B.

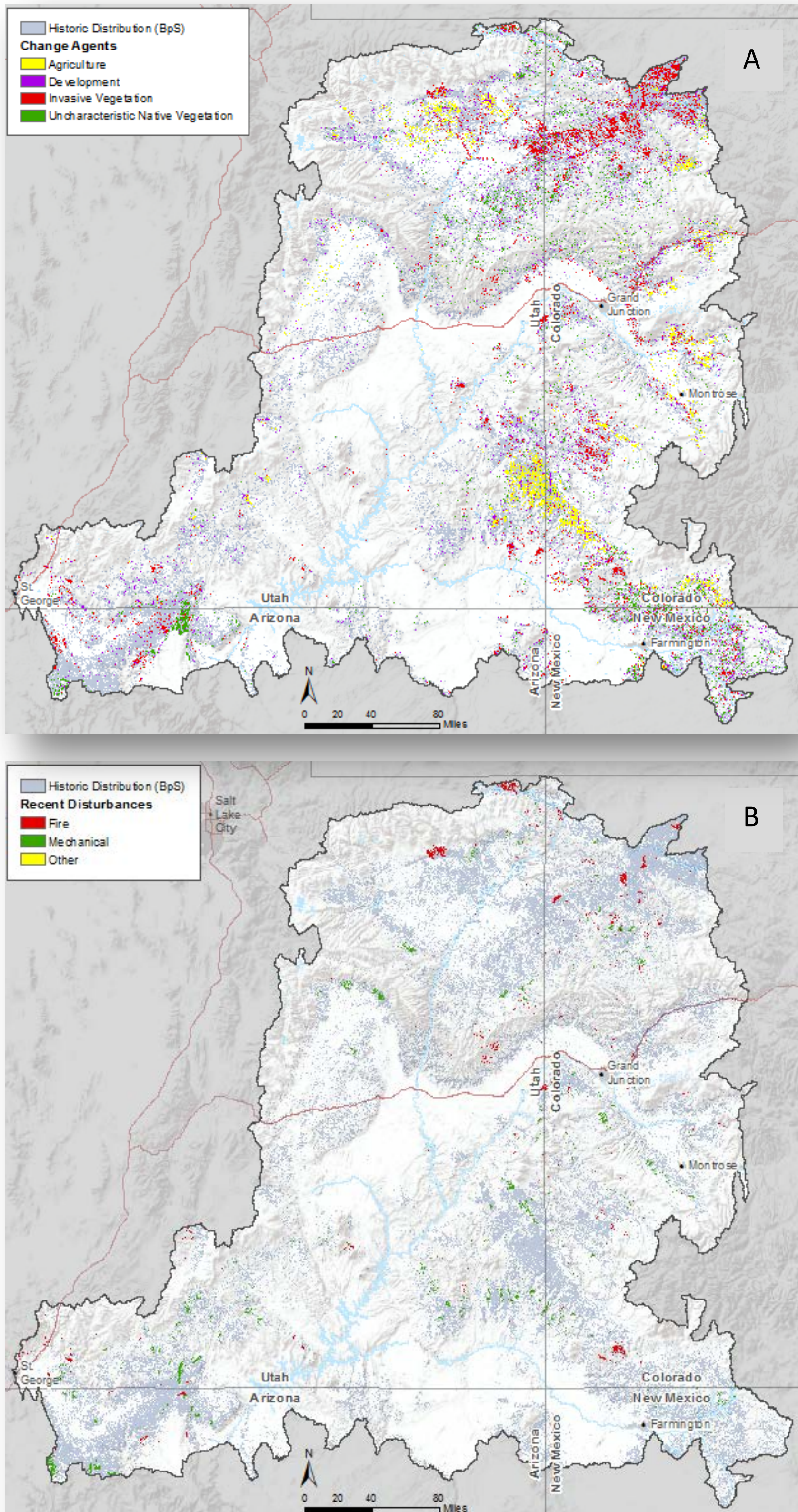

Figure 4-23. (A) Historic change and (B) recent disturbance of Inter-Mountain Basins Big Sagebrush Shrublands. See more detail by examining the live map on the data portal.

Table 4-8. Summary of area (in 1000s of acres) of historic change for each vegetation community, comparing existing vegetation to LANDFIRE BpS (representing reference condition).

Vegetation Community	Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
Colorado Plateau Blackbrush-Mormon-tea Shrubland	3,124	132	4	176	7	319	10.2%
Inter-Mountain Basins Big Sagebrush Shrubland	8,228	565	495	846	572	2,477	30.1%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	2,039	131	89	29	335	585	28.7%
Inter-Mountain Basins Montane Sagebrush Steppe	1,030	77	18	26	38	160	15.5%
Colorado Plateau Pinyon-Juniper Shrubland	94	5	2	21	10	38	40.4%
Colorado Plateau Pinyon-Juniper Woodland	7,515	229	46	273	635	1,183	15.7%
Inter-Mountain Basins Mixed Salt Desert Scrub	3,155	178	109	403	117	807	25.6%
Totals	**25,185**	**1,317**	**763**	**1,774**	**1,714**	**5,569**	

Table 4-9. Summary of area (in 1000s of acres) of recent disturbances (~10–20 years) for each matrix vegetation community.

Vegetation Community	Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
Colorado Plateau Blackbrush-Mormon-tea Shrubland	3,124	9	2	0	11	0.4%
Inter-Mountain Basins Big Sagebrush Shrubland	8,228	139	231	0.1	370	4.5%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	2,039	75	31	1	108	5.3%
Inter-Mountain Basins Montane Sagebrush Steppe	1,030	29	14	0.2	43	4.1%
Colorado Plateau Pinyon-Juniper Shrubland	94	0.8	0.8	0	2	1.8%
Colorado Plateau Pinyon-Juniper Woodland	7,515	194	72	0.8	267	3.6%
Inter-Mountain Basins Mixed Salt Desert Scrub	3,155	6	15	.01	21	0.7%
Totals	**25,185**	**453**	**366**	**2**	**822**	

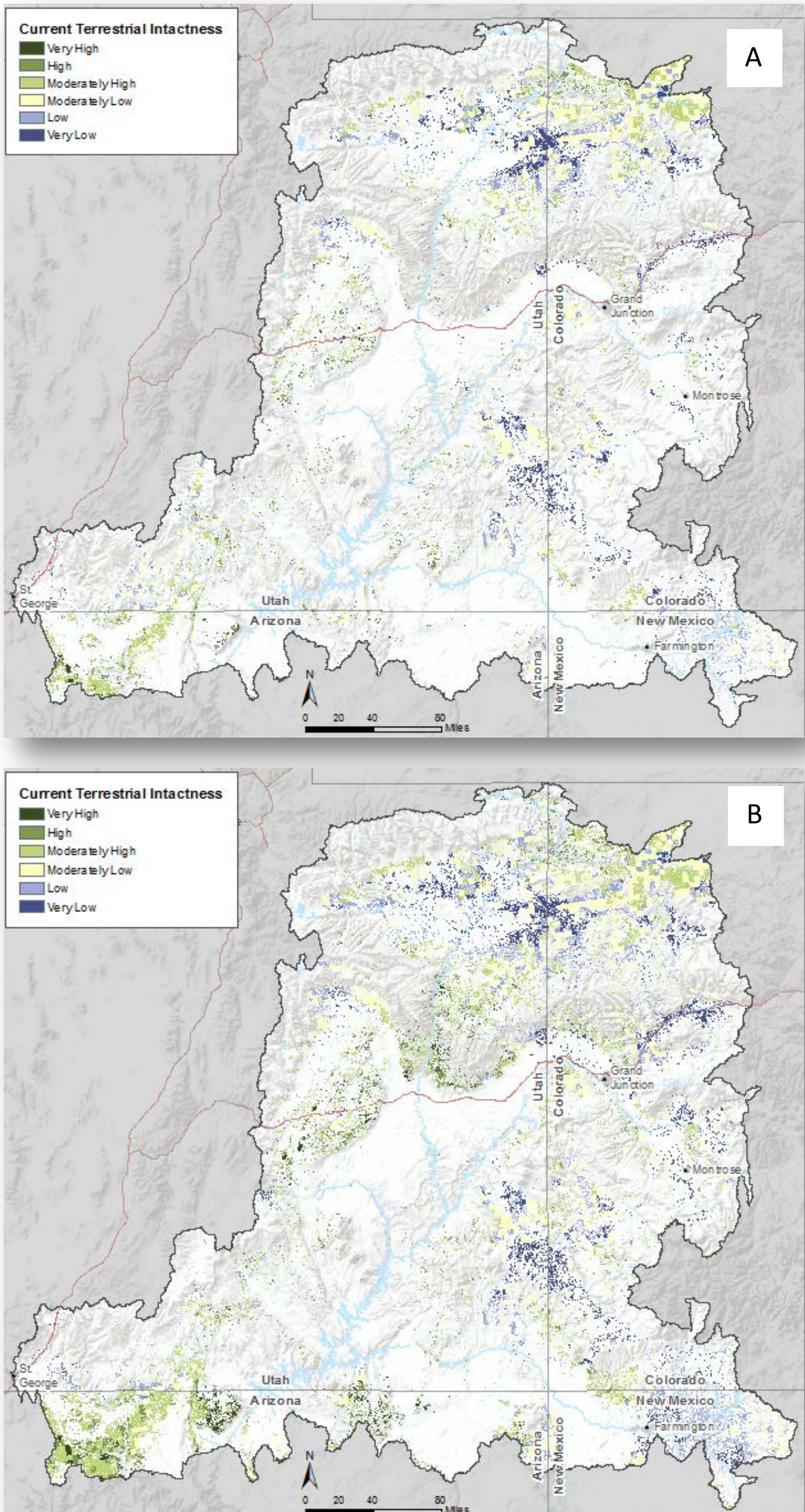

Figure 4-24. Current status for Inter-Mountain Basins Big Sagebrush for the Colorado Plateau ecoregion for A) NatureServe Landcover and B) LANDFIRE EVT from overlay of distribution with terrestrial intactness.

4.2.2.1 Riparian Vegetation

Riparian ecological systems have undergone significant physical and biological changes throughout the ecoregion because of direct conversion to other uses; changes in the natural flow regimes and suppression of fluvial processes (Busch and Smith 1995, Stromberg 2001, Stromberg et al. 2007a); livestock grazing (Armour et al. 1994); and alien species invasion, e.g., tamarisk (Horton 1977, Graf 1978, Stromberg et al. 2007b). As much as 90% of pre-settlement riparian ecosystems have been lost (LUHNA 2011). Livestock grazing has damaged approximately 80% of stream and riparian ecosystems in the western US (Belsky et al. 1999). Grazing alters streamside morphology, increases sedimentation, degrades riparian vegetation through trampling and consumption and causes nutrient loading to the system. Invasive plants such as tamarisk often successfully out-compete native species, because tamarisk produces seeds multiple times in a year; it is also more tolerant of drought and flow alterations than natives (Stromberg et al. 2007a, Merritt and Poff 2010). Riparian issues are covered in depth in the tamarisk case study insert.

Mapping riparian systems is difficult to do using satellite remote sensing. The narrow linear nature of the community makes it difficult to delineate with high levels of accuracy. NatureServe Landcover (v2.7) was used for the REA assessment to assess current distribution. Status was evaluated using the terrestrial landscape intactness results at 4km resolution. According to the NatureServe Landcover data, about 1,735,000 acres of riparian vegetation currently exist in the ecoregion. Status results, based on the terrestrial landscape intactness model, show that the dominant category is moderately high with the rest of the results skewed to the lower intactness classes (Figure 4-25). Although a 4 km X 4 km grid cell is an appropriate reporting unit for a region-wide assessment, it is less discriminating in characterizing linear communities.

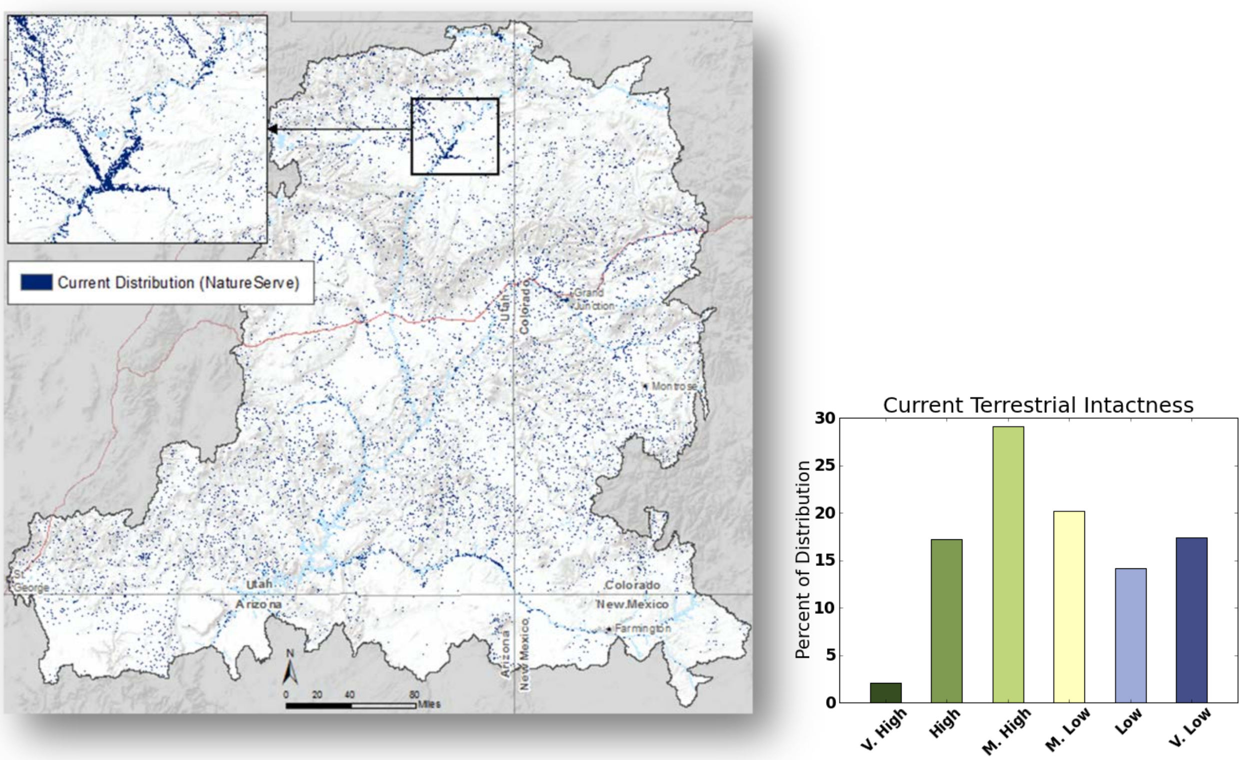

Figure 4-25. Detail of riparian vegetation distribution (in blue) based on NatureServe Landcover v2.7 for the Colorado Plateau ecoregion and general status histogram based on the terrestrial intactness model.

4.2.3 Evaluating Designated Sites: Distribution and Current Status

Approximately 28% (~12.4 million acres) of the Colorado Plateau ecoregion is currently under federal, state, local government or private conservation land designation, including conservation easements (Figure 4-26). These data are limited to designated protected lands and do not include other conservation lands under current land management plans by the various agencies. In some instances, these land designations are nested and ranked, in which case the more protective designation is displayed over the top of another (e.g. wilderness area above a national recreation area). Approximately 1,400 miles of wild and scenic rivers and national trails are also included in the map.

Status of these lands was evaluated by overlaying the designated lands polygons on terrestrial landscape intactness and summarizing the results (Figure 4-27, Table 4-10). Wilderness Study Areas made up the largest proportion of the protected areas. Other categories occupying over 1 million acres included Designated Roadless Areas, Other Protected Lands, National Monuments, National Recreation Areas, and Areas of Critical Environmental Concern. Wilderness Areas and National Parks accounted for somewhat less than 1 million acres each and all other classes combined (National Conservation Areas, State Wildlife Management Areas, State Parks, and National Wildlife Refuges) made up just less than 500,000 acres.

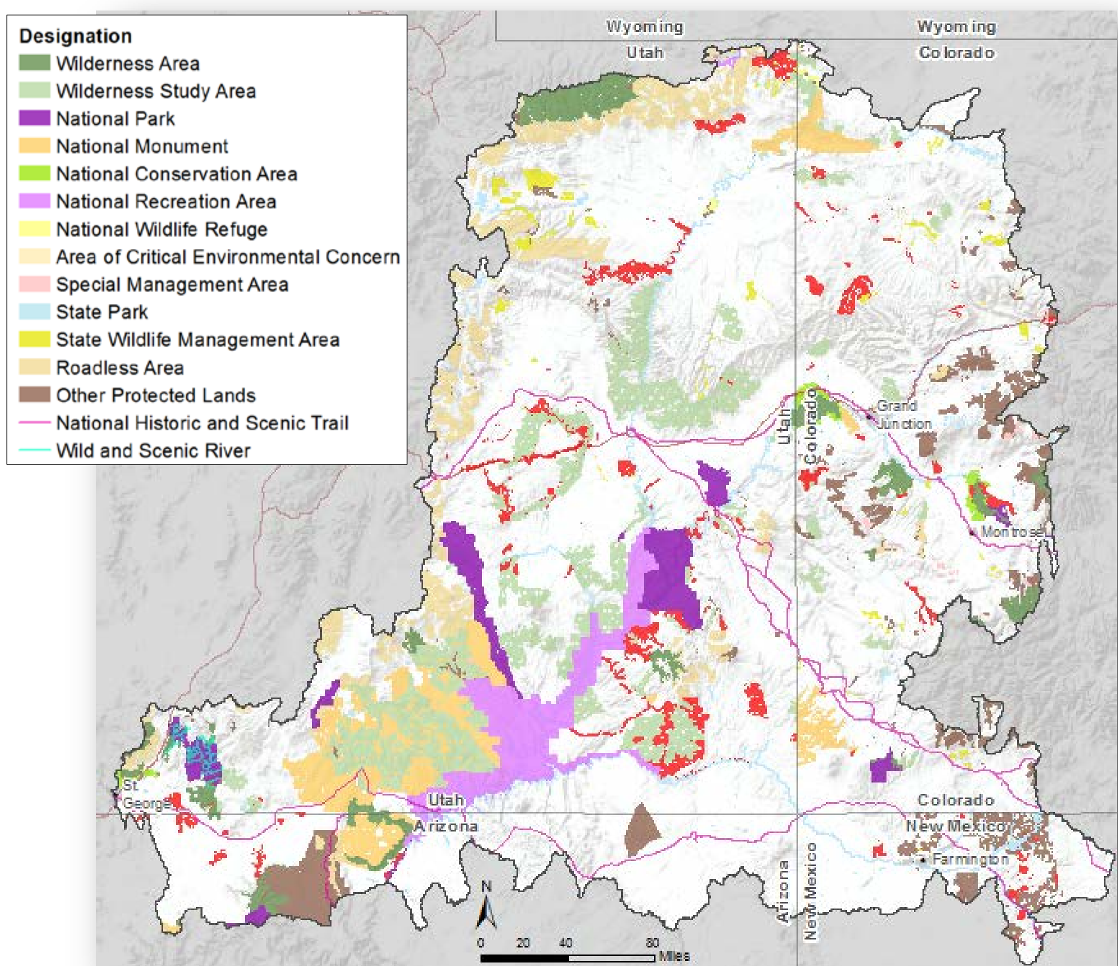

Figure 4-26. Map of designated lands in the Colorado Plateau ecoregion.

In general, terrestrial landscape intactness for special designated lands was heavily skewed (>75% of the area) towards more intact landscapes; however, not all designation classes scored equally (Figure 4-28). Wilderness Areas, Wilderness Study Areas, National Monuments, and National Recreation Areas showed the best intactness profiles. National Parks did well, but they had significant areas in low intactness classes, which may be surprising. However, several of the parks (e.g. Bryce Canyon and Arches) are not large and they are surrounded by various classes of development. Designations such as National Conservation Areas, State Parks, State Wildlife Management Units, and National Wildlife Refuges showed lower overall intactness.

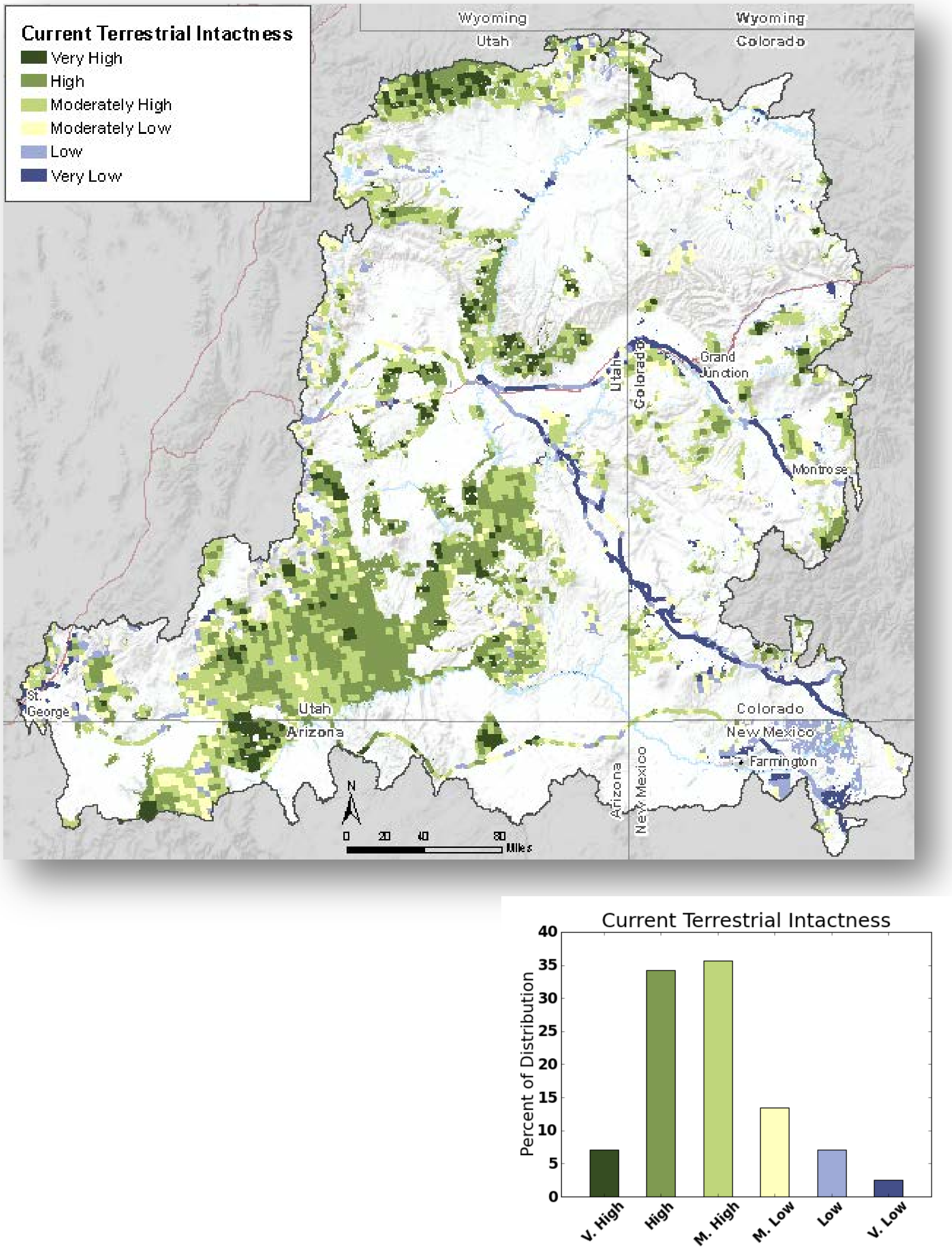

Figure 4-27. Status of designated lands in the Colorado Plateau ecoregion based on current terrestrial landscape intactness.

Table 4-10. Total area (in 1000s of acres) in each status category for all designated lands in the Colorado Plateau ecoregion.

Designation Category	Very High	High	Moderately High	Moderately Low	Low	Very Low	Total Area (acres)
Area of Critical Environmental Concern	38	195	336	258	151	50	1,028
National Conservation Area	0	0	36	17	5	48	106
National Monument	113	461	724	239	44	11	1592
National Park	65	347	304	147	50	27	940
National Recreation Area	11	874	313	48	8	2	1,256
National Wildlife Refuge	0	1	8	3	6	2	20
Other Protected Lands	78	216	564	327	329	99	1,613
Roadless Area	70	361	803	320	138	9	1,701
Special Management Area	0	4	21	16	6	1	48
State Park	0	5	10	11	21	6	53
State Wildlife Management Area	8	29	90	65	63	31	286
Wilderness Area	183	399	267	58	19	16	942
Wilderness Study Area	316	1,367	963	163	51	10	2,870
Total	**882**	**4,259**	**4,439**	**1,672**	**891**	**312**	**12,455**

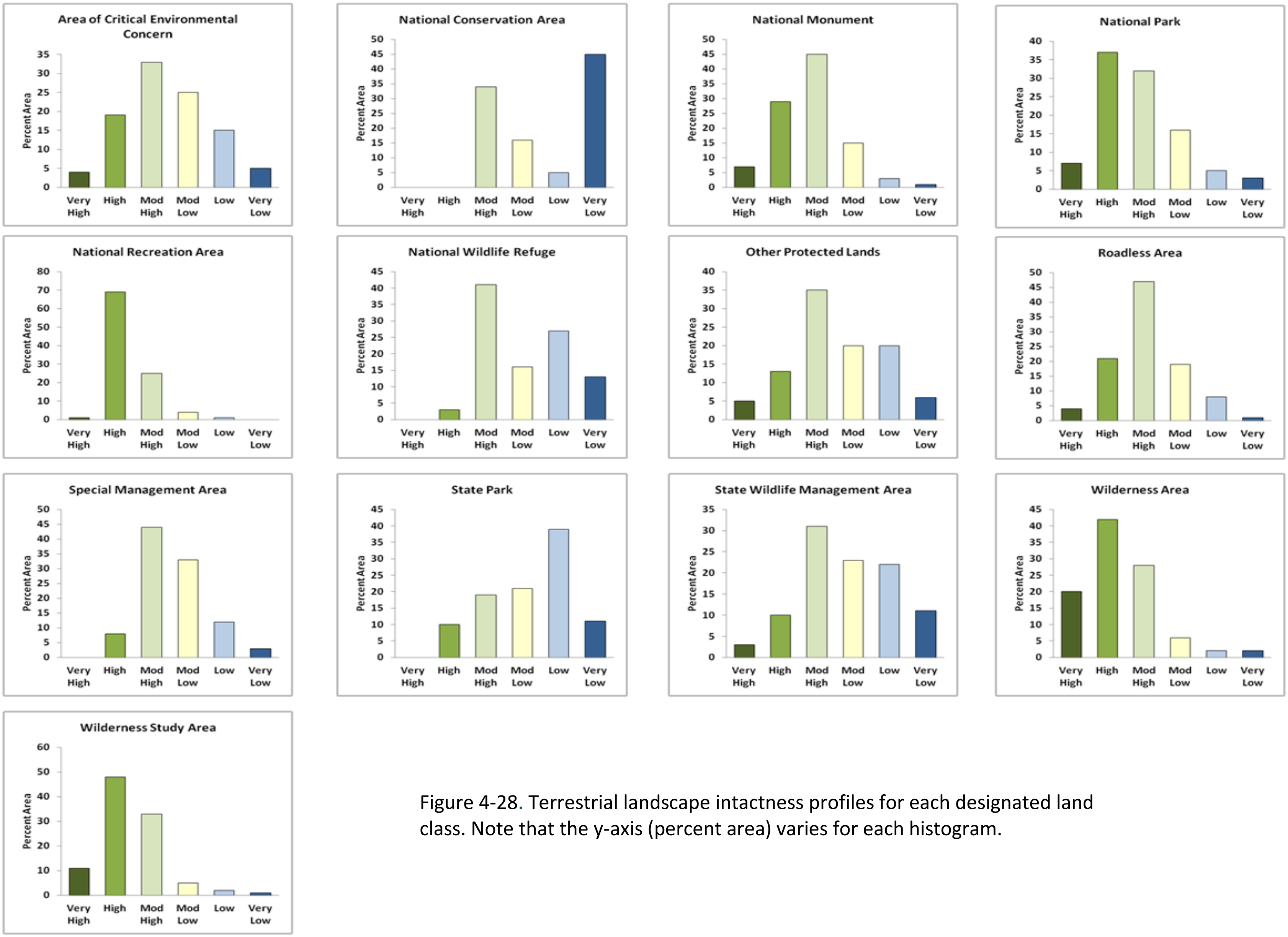

Figure 4-28. Terrestrial landscape intactness profiles for each designated land class. Note that the y-axis (percent area) varies for each histogram.

4.2.4 Connectivity

Least-cost path analysis for the Natural Landscape Blocks as described in the methods section (Chapter 3, Section 3.2.5) provided a number of key linkage zones for the ecoregion (Figure 4-29). Potential linkages were hand drawn between neighboring natural landscape blocks by connecting each one using a system of drawn sticks (centroid to centroid, as pictured in Section 3.2.5). Sticks identified the pairs of blocks to evaluate; the ArcGIS tools Cost Distance and Corridor determined the final least-cost corridors. Natural blocks included the designated lands. Most of the linkage corridors were concentrated in the eastern third of the study area where much of the human disturbance is located. Corridors do not exist where human disturbance is most heavily concentrated, e.g., in the central Uinta or San Juan basins.

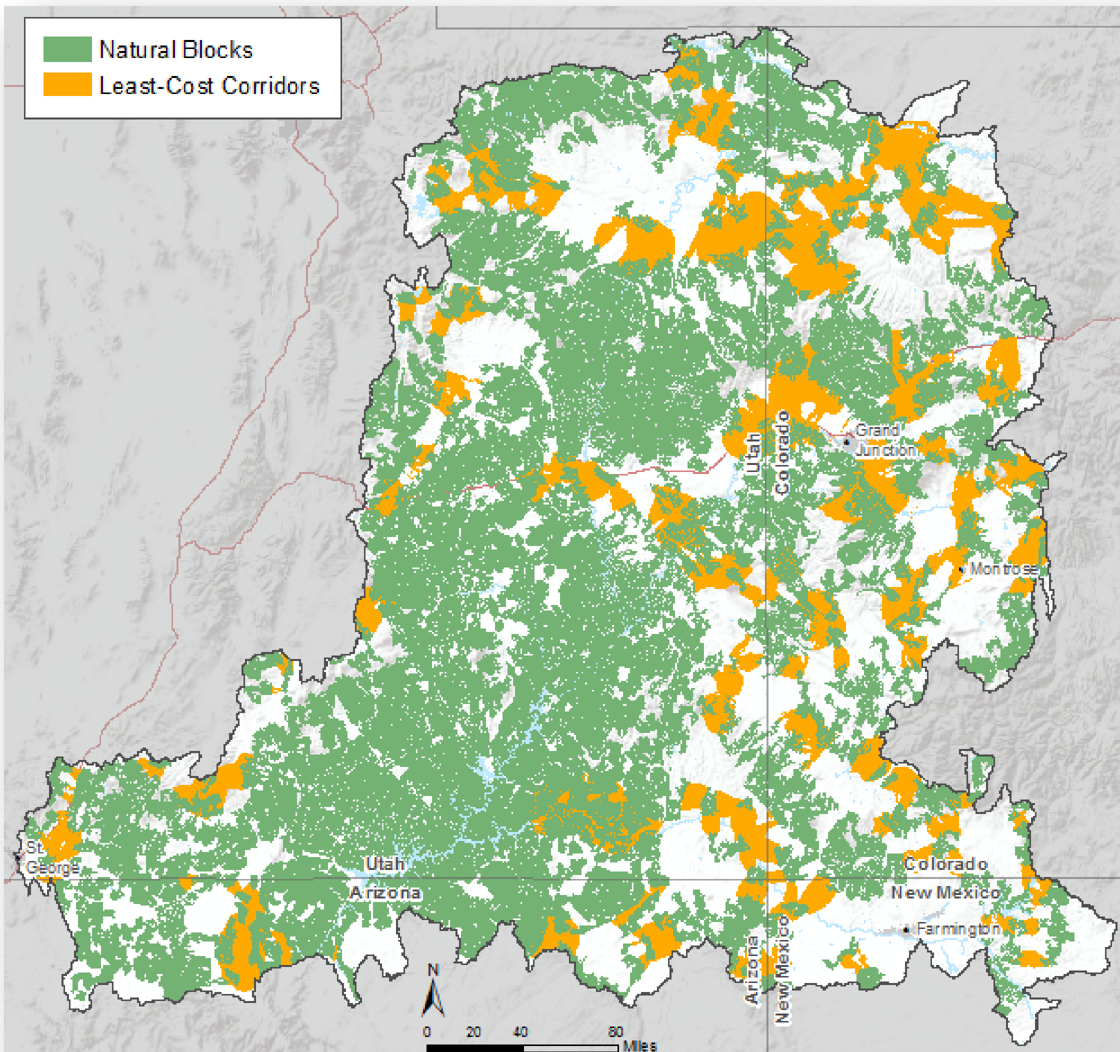

Figure 4-29. Landscape connectivity results based on generic (non-species specific) least-cost path analysis for the Colorado Plateau ecoregion.

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Photo: National Park Service, N. Herbert.

4.3 Change Agent Distribution and Intensity

Current Change Agent Management Questions

MQF1. Where are areas dominated by tamarisk and cheatgrass?

MQE1. Where are areas that have been changed by wildfire between 1999 and 2009?

MQE2. Where are areas with potential to change from wildfire?

MQE3. Where are the Fire Regime Condition Classes?

MQE4. Where is fire adverse to ecological communities, features, and resources of concern?

MQG1. Where are areas of planned development?

An assessment of the status of conservation elements must be conducted with reference to both natural and anthropogenic disturbance factors. Although the current distribution and status of REA conservation elements were presented together in Section 4.2 to economize on presentation space, the status or condition of various conservation elements should not be discussed without examining the risks that these resources experience from a collection of regional disturbances or change agents. The primary change agents affecting the region were introduced in Chapter II Introduction, Section 2.4.3 (Table 2-4). Those change agents related to current conditions are presented in this section: invasive vegetation, wildfire, and current development. Change agents associated with future conditions, near-term future (2025) development and intactness, potential energy development, and climate change, are presented in Chapter V Potential Future Conditions in the Colorado Plateau.

4.3.1 Invasive Vegetation

While there are multiple invasive species in the Colorado Plateau, two invasive plant species of concern, cheatgrass (*Bromus tectorum*) and tamarisk (*Tamarix* spp.), have been selected for the Colorado Plateau REA because they are considered significant change agents in the region. These species alter ecosystem processes, such as fire regimes; 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 annuals outcompete 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). As these species expand in distribution and dominance on the landscape, native species and communities become increasingly marginalized, which over time may seriously degrade the function of these ecosystems.

Cheatgrass (*Bromus tectorum*) is one of the key invasive species in the Colorado Plateau due to its strong potential to mediate a feedback cycle that can dramatically change the natural fire regime of ecologically significant vegetation communities, such as sagebrush. It is an annual grass native to Europe, northern Africa, and southwestern Asia that was accidentally introduced to North America in the mid- to late-1800s (Mack 1981, Young 2000, Novack and Mack 2001). It had occupied much of its present range by the early 1900s (Novack and Mack 2001, Mack 1981). It is particularly invasive in the western U.S. due, in part, to grazing (Mack 1981). Its ability to persist and dominate disturbed sites and to invade undisturbed habitat makes this species particularly problematic in the West, where it displaces native vegetation, outcompetes native species, alters fire and hydrological regimes, and encourages topsoil erosion (Boxell and Drohan 2009, Young 2000, Knapp 1996). It currently dominates shrublands in the Intermountain West (Pellant and Hall 1994), occupying at least 40,000 km^2 in Nevada and Utah alone (Bradley and Mustard 2005). Cheatgrass is most prevalent in sagebrush shrub and steppe communities; it also occurs in salt-desert scrub, blackbrush scrub, and pinyon-juniper shrublands and woodlands (Dukes and Mooney 2004, Zouhar 2003, Young 2000). Cheatgrass has replaced native cool- and warm-season grasses, such as Indian ricegrass (*Achnatherium* *hymenoides*), James galleta (*Pleuraphis jamesii*), blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), and needle-and-thread grass (*Hesperostipa comata*), which are not only important forage plants, but also essential to maintaining soil stability, wind and water erosion control, and natural fire regimes (USU Cooperative Extension 2011).

Another key invasive species in the region is tamarisk, with multiple species and hybrids present (e.g., *Tamarix chinensis, T. gallica,* and *T. ramosissima*). Tamarisk became widely distributed in the 1800s, when it was planted as an ornamental plant; it is now found throughout nearly all western and southwestern states (Lovich 2000). Tamarisk is of particular concern because its dense and rapid growth allows it to out-compete native plant species. In addition, it is extremely drought resistant, has high fecundity, and alters fire regimes (Busch and Smith 1995, Glenn et al. 1998). Tamarisk affects native wildlife by changing the composition of forage plants and the structure of native riparian systems. For more discussion about riparian ecosystems and tamarisk, see the Tamarisk Case Study Insert.

Accurately mapping the full distribution of major invasive vegetation species is quite difficult due to a general lack of systematically sampled occurrences, the difficulty in distinguishing low seasonal abundance within the satellite imagery often used to create land cover classifications, and the requirement of carefully calibrated satellite imagery time series to capture the particular phenology of the invasive species, such as early season green-up. Invasives may be difficult to detect where they are co-dominants, present in the understory, or not actively growing during the season of imagery. Results from multiple mapping efforts were combined to estimate the extent of major invasive vegetation species in the Colorado Plateau (Figure 4-30).

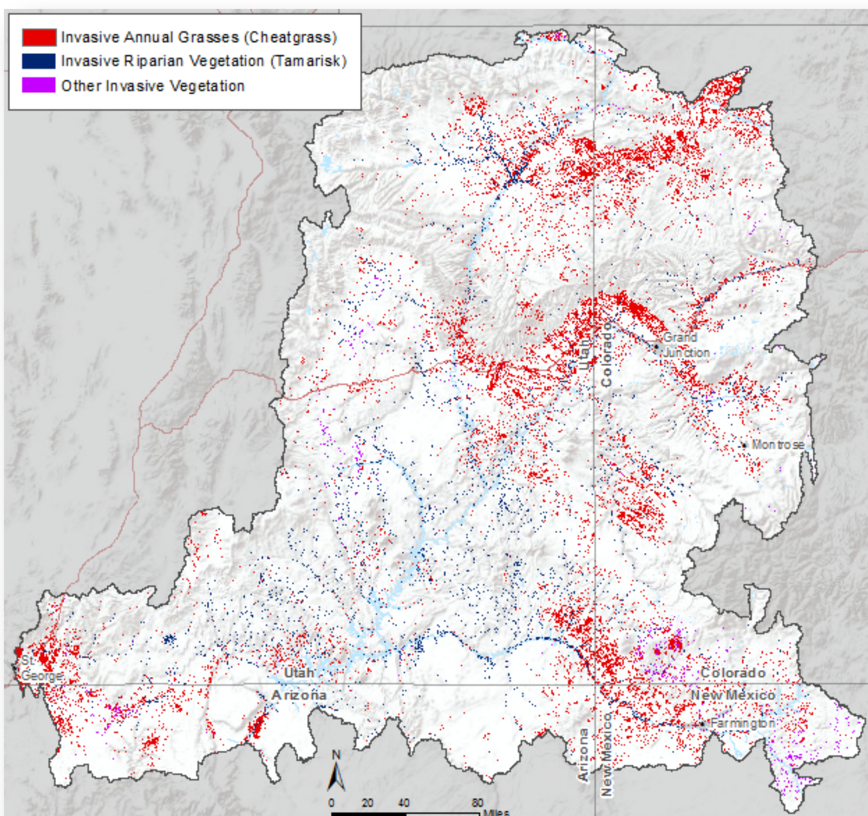

Figure 4-30. Distribution of major invasive vegetation species, including cheatgrass and tamarisk.

To create the map, invasive annual grass classes were extracted from LANDFIRE Existing Vegetation Type (EVT v1.1) and NatureServe Landcover (v2.7, classes include cheatgrass, red brome, and other species) and combined with the results of a modeled distribution of early season invasives (including cheatgrass, red brome, and Sahara mustard) for the Colorado Plateau (created by J. Hansen and T. Arundel of USGS). Similarly, invasive riparian vegetation classes were extracted from LANDFIRE and NatureServe (classes include tamarisk species [*Tamarix* spp.] and Russian olive [*Elaeagnus angustifolia*]) and combined with a tamarisk probability map (Jarnevich et al. 2011) and available tamarisk occurrence data. Other invasive vegetation classes mapped by LANDFIRE and NatureServe were also extracted. These data and models likely underestimate the total distribution of invasive vegetation, because most methods used remotely-sensed imagery and required dominance of a site by these species to be detectable. Where these species occur as less dominant components of the vegetation community, they may expand and dominate quickly due to disturbance, land use, and climate change.

4.3.2 Changes in Fire Regime

Fire is a natural ecosystem process in many regions, including the Colorado Plateau. In any given region, species are typically adapted to a particular fire regime, which can be characterized in terms of fire frequency, seasonality, severity, and size (Pausas and Keeley 2009). The degree to which fire may become an ecologically significant change agent is related to the extent to which the fire regime has been altered compared to reference conditions and the associated effects of the altered fire regime on the vegetation community. For example, certain vegetation communities adapted to frequent, low-intensity fire are threatened by the consequences of decades of effective fire suppression, which can increase the potential for large, high-severity fires (Schoennagel and Nelson 2010). In contrast, other communities adapted to very infrequent fire are now threatened by increases in fire frequency due to invasive plants and human ignitions.

Fire regimes have been altered in many Southwestern ecosystems compared to reference conditions that would have been present prior to Euro-American settlement. In recent decades, invasive species and human activities (e.g., grazing, urbanization, fire suppression), as well as other sources of human ignitions, have altered fire regimes in many fire-adapted ecosystems and introduced fire to other ecosystems that historically rarely experienced fire. Some widely-distributed invasive species, such as cheatgrass and red brome, increase fire frequency, size, and duration of the fire season by increasing fine fuel loads and continuity, thus allowing fires to spread into areas that were once fuel-limited (Hunter 1991, Brooks and Pyke 2001, Brooks et al. 2004). These alterations to fire regime can promote further species invasion and thus create a tight feedback loop of increasing fire frequency (Mack and D'Antonio 1998). In the western US, the source of invasions has been linked to various anthropogenic disturbances, including but not limited to grazing, transportation (roads and trains), logging, and residential development. Just as exotic species are likely to spread from these areas, human-caused ignitions are also likely to increase in areas with higher levels of human presence (Syphard et al. 2007, 2008).

In many ecosystems where fire historically served an important ecological function, several decades of effective fire suppression, combined with alterations to fuel load and pattern by anthropogenic land use and management practices, have led to conversions in vegetation type (e.g., shrub encroachment in semi-desert grasslands or pinyon-juniper woodland encroachment into sagebrush communities) or structure (e.g., increased canopy density as well as surface and canopy fuel loads, McPherson 1995, Van Auken 2000, Keane et al. 2002). Unless fuel loads are reduced, or unless fire occurs under non-severe weather conditions, fires in many of these communities may now become abnormally large and severe, which can result in dramatic reduction in aboveground live biomass, leading to cascading ecological impacts (DellaSala et al. 2004, Lehmkuhl et al. 2007, Hurteau and North 2009).

For the management question, *Where are the Fire Regime Condition Classes?,* current fire regime departure compared to reference conditions was estimated using a combination of existing measures of vegetation departure (LANDFIRE Fire Regime Condition Class Departure Index v1.0) and calculated departure of fire frequency and severity from expert estimates of current fire regime parameters (Figure 4-31). Vegetation departure describes the degree to which the proportions of various successional stages of a particular community are similar to the proportions that would be expected to occur over space and time under reference conditions. Vegetation departure increases with increasing abundance of invasive vegetation or in response to greater proportions of later or earlier successional vegetation than would have been expected under reference conditions.

Current estimates of fire regime (fire frequency and severity) were estimated for the 40 most abundant Biophysical Settings (from LANDFIRE Biophysical Settings v1.0) and applied to the full distribution of each system within the ecoregion (see Appendix A). Typically, estimates of fire regime are developed for smaller landscape reporting units tied to the reference condition fire regime characteristics of frequency and size (larger, infrequent fire regimes require larger reporting units); however, this was not feasible within the scope of this REA. It is very difficult to estimate both current and reference condition fire regimes with high confidence; this is due in large part to incomplete knowledge of fire history for each system within each unique landscape in the ecoregion and the relatively short period over which current estimates are drawn. Vegetation communities with historically frequent fires (Fire Regime Groups I and II; Table 4-11) can be described in terms of the number of fire cycles missed in recent decades, due in part to effective fire suppression.

Table 4-11. Fire Regime Group Characteristics

Fire Regime Group	Fire Return Intervals
I	≤ 35 year fire return interval, low and mixed severity
II	≤ 35 year fire return interval, replacement severity
III	35–200 year fire return interval, low and mixed severity
IV	35–200 year fire return interval, replacement severity
V	> 200 year fire return interval, any severity

In contrast, communities with historically infrequent fire are more difficult to estimate, because the period of analysis must be longer than is available for current estimates. Therefore, these estimates of current fire regimes should be treated with some degree of caution; while these are based on the best available information and expert understanding of the systems, they may under- or over-estimate actual fire regime departure. These estimates are also conflated due to necessity of summarizing results at the ecoregion scale because averaging across larger areas tends to drive estimates of departure toward the middle.

The analysis of reference condition fire regimes was extended to answer the management question, *Where is fire adverse to ecological communities, features, and resources of concern?* Systems were selected with historically longer fire return intervals (≥35 years, Fire Regime Groups III, IV, and V, Table 4-10) from the LANDFIRE Fire Regime Groups dataset where they intersected invasive vegetation mapped for this REA (Figure 4-29) and uncharacteristic exotics and uncharacteristic native vegetation classes from the LANDFIRE Succession Classes dataset (Figure 4-32). While fire may not always be adverse to these systems, the presence of invasives or uncharacteristic native vegetation increases the likelihood of negative post-fire vegetation response. In particular, fire may be particularly adverse to long fire return interval systems (Fire Regime Group V) occupied by invasives because native species may take longer to recover post-fire, whereas invasives may greatly expand in distribution and dominance.

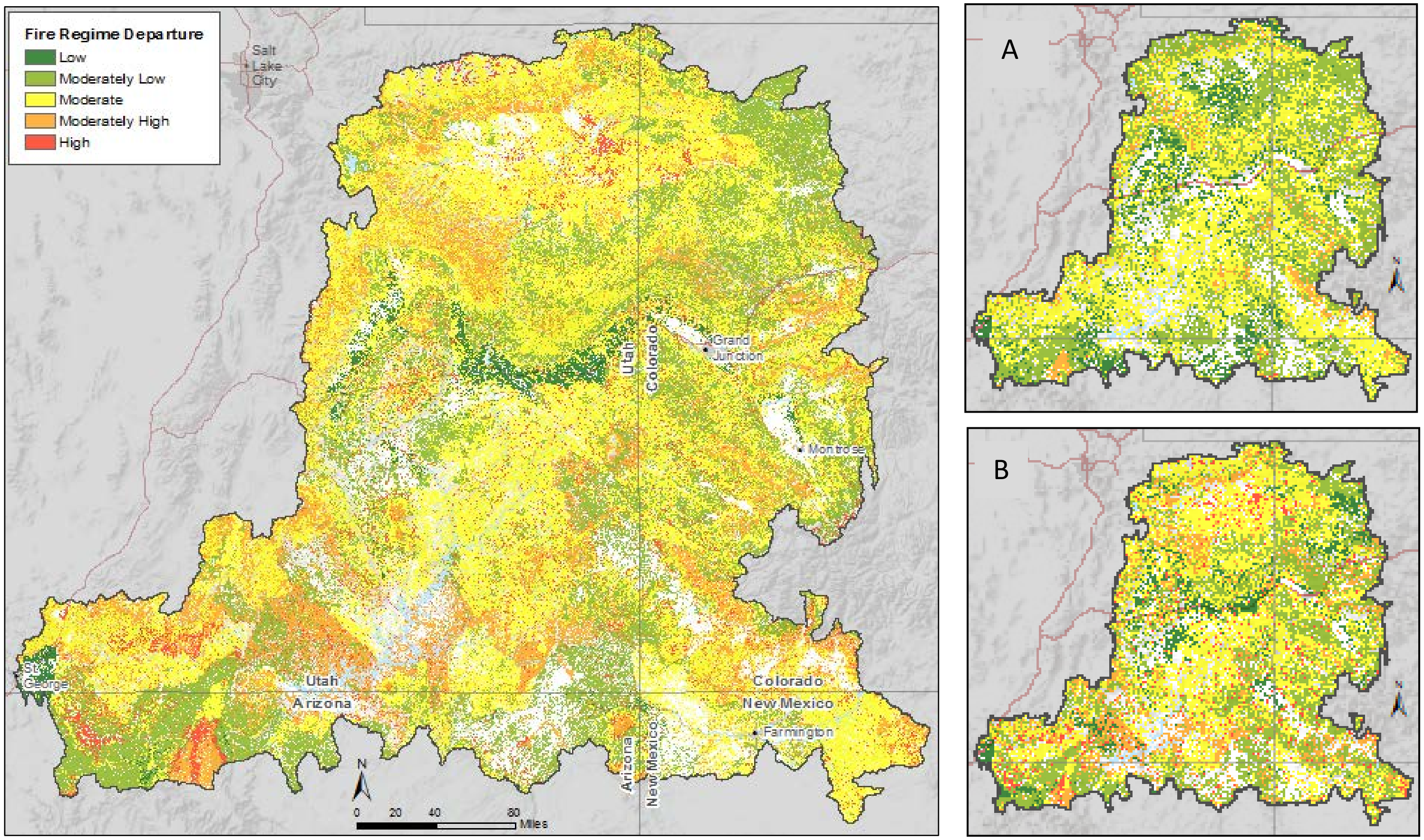

Figure 4-31**.** To answer the management question, *Where are the Fire Regime Condition Classes?,* map on the left depicts fire regime departure showing the maximum departure value between (A) existing measures of vegetation departure (LANDFIRE Fire Regime Condition Class Departure Index v1.0) and (B) calculated departure of fire frequency and severity from expert estimates of current fire regime parameters for the Colorado Plateau ecoregion.

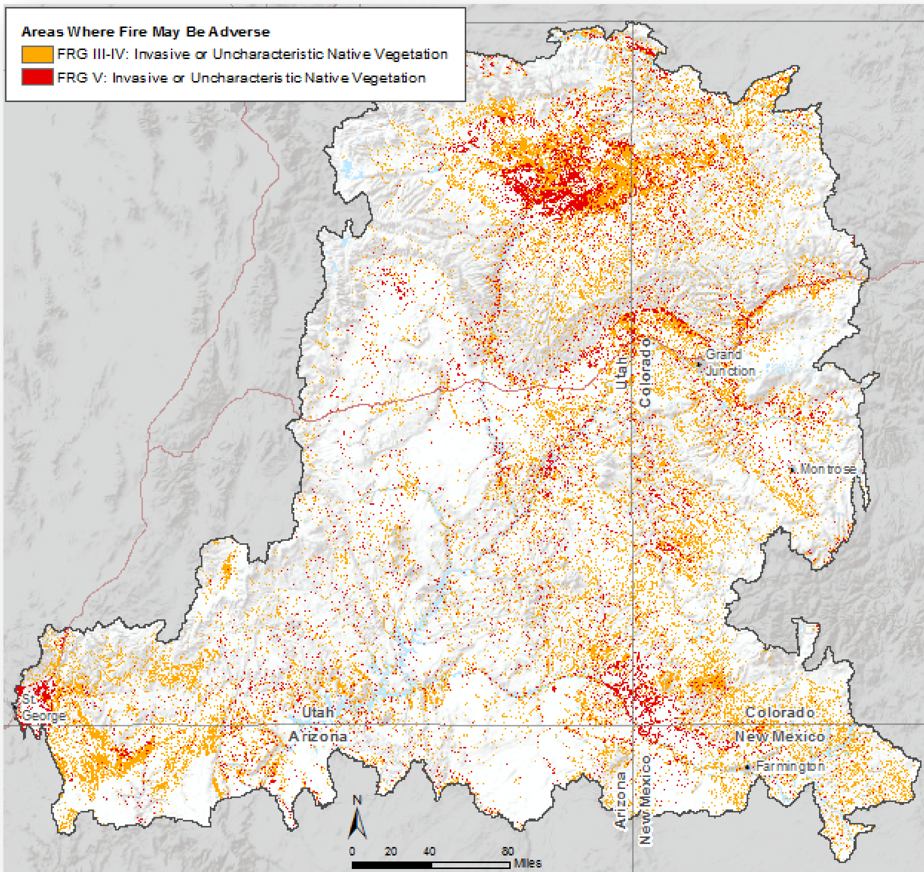

Figure 4-32. Areas where fire may be adverse to vegetation communities in the Colorado Plateau ecoregion. Systems were selected with historically longer fire return intervals (≥35 years, Fire Regime Groups III, IV, and V, Table 4-10) from the LANDFIRE Fire Regime Groups dataset where they intersected invasive vegetation mapped for this REA and uncharacteristic exotics and uncharacteristic native vegetation classes from the LANDFIRE Succession Classes dataset.

Areas changed by recent (1999–2010) wildfires were estimated using fire perimeters (GeoMAC 2000–2010, http://www.geomac.gov/index.shtml) supplemented with estimates of fire severity (LANDFIRE Disturbance datasets 1999–2008) where available (Figure 4-33). While efforts were made to compile the most complete dataset of fires during this period, some fires may be absent from both the fire perimeters dataset and the LANDFIRE disturbance dataset. LANDFIRE estimates of fire severity should be interpreted with caution in shrub and grassland systems because methods and definitions of fire severity were developed primarily for forested systems. Any area that has experienced fire has been changed by it to a degree that generally increases with increasing severity. High severity fires tend to result in early successional vegetation states followed by a recovery period during which characteristic species recolonize the site. However, areas with uncharacteristically high severity (due in part to fire suppression and fuel buildup) may transition to a different vegetation state, such as persistent invasive vegetation. It is not possible to evaluate the underlying change in vegetation resulting from fire because of the lack of accurate regional maps of pre- and post-fire vegetation. While the most recent version of LANDFIRE Existing Vegetation (v1.1) has been updated in areas of disturbance, the updates are not necessarily an accurate reclassification of the post-fire vegetation, but instead appear to be the result of applying a rule set based on pre-fire vegetation type and fire severity coupled with a systematic update of the entire product to correct areas of major inaccuracy.

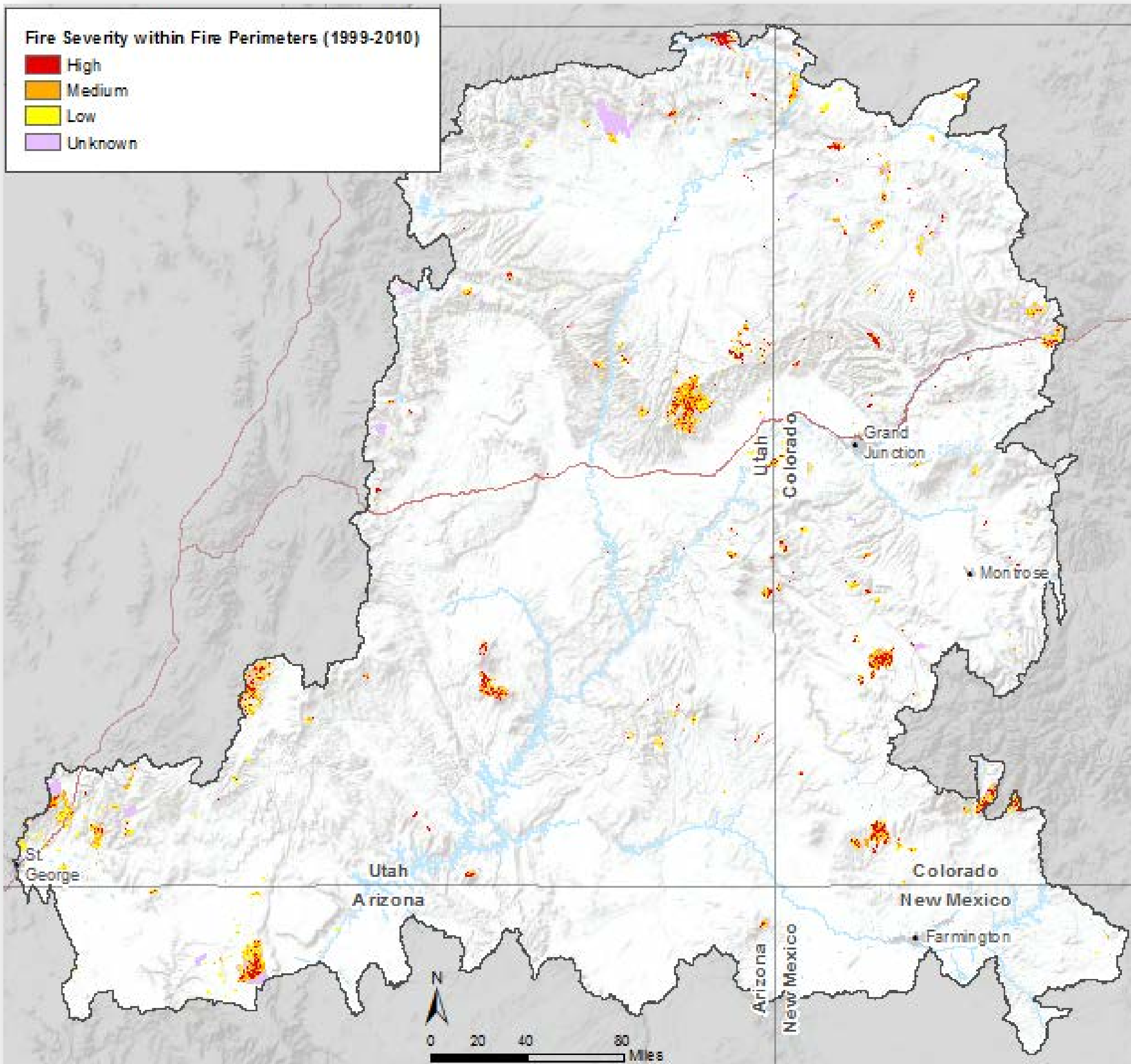

Figure 4-33**.** Map of fire perimeters annotated by severity (where available) answering the management question, *Where are the areas that have been changed by wildfire between 1999 and 2009*?

MaxEnt models of potential fire occurrence were developed to answer the final fire-related question (*Where are the areas with potential to change from wildfire?* Figure 4-34). In reality, fire has the potential to cause a greater or lesser magnitude of change due to fine scale fuel conditions, local fire behavior, fire weather, and pre-fire vegetation sensitivity to fire disturbance along with many other factors. It is not possible given existing data to evaluate these factors at the ecoregion scale. Instead, the focus was on predicting where fires are likely to occur based on the premise that this would provide a meaningful context for more detailed, local assessments of potential impacts due to fire.

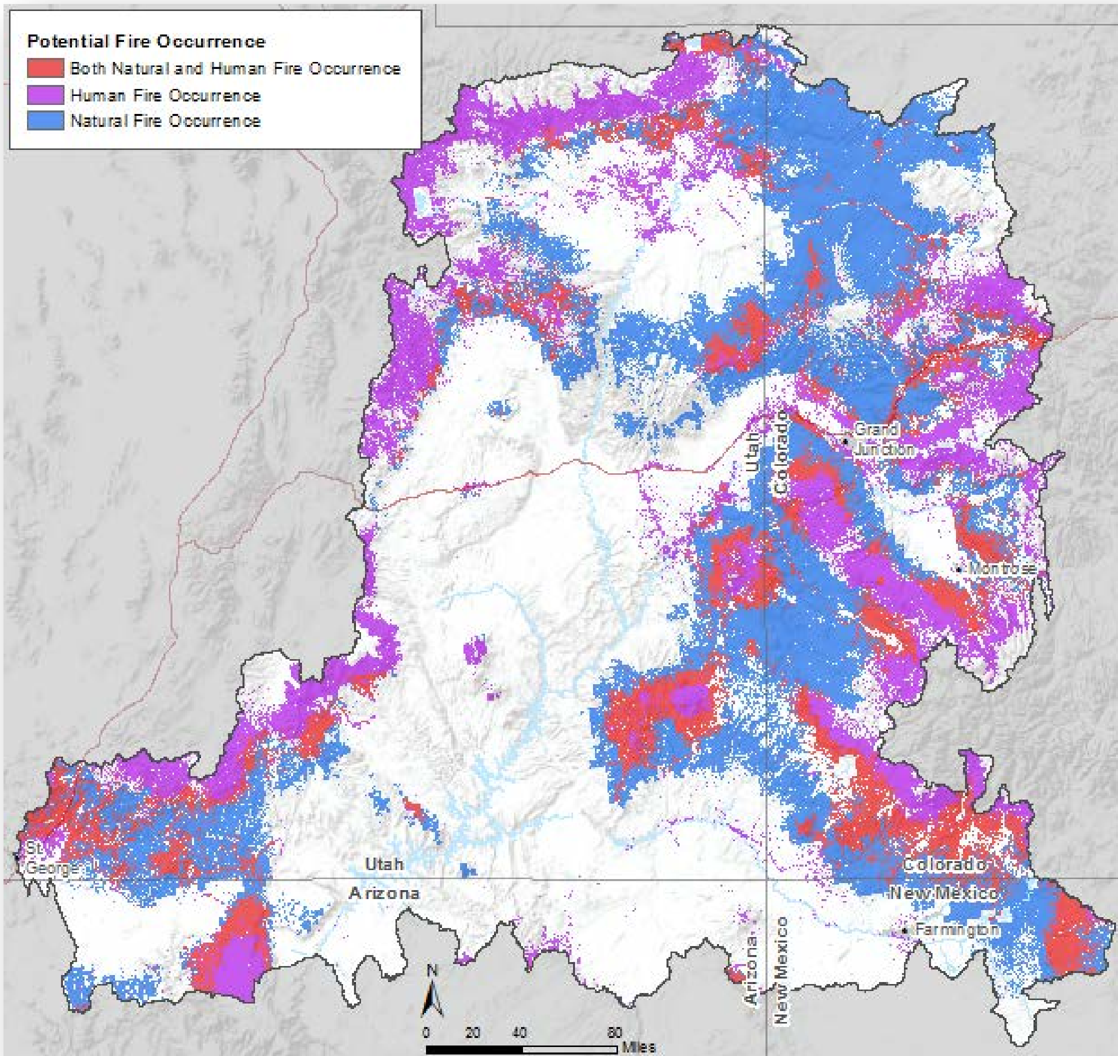

Figure 4-34**.** Potential fire occurrence map from combined human and natural fire occurrence MaxEnt models for the Colorado Plateau ecoregion answers the management question *Where are the areas with potential to change from wildfire?*

Thirty years of fire occurrence data were subdivided into human and naturally-caused fires (11,971 human caused fires and 23,716 naturally-caused fires) and a separate MaxEnt model was developed for each because of the very disparate relationship between fire cause and underlying geographic and environmental variables. Both models performed somewhat poorly (human model *Area Under Curve* or AUC: 0.678 and natural model AUC: 0.618). The results of these models should be interpreted with caution due to somewhat poor accuracy and because the models represent the likelihood of fire occurrence based on point-based fire occurrence data. Many ecologically significant fires may spread over large areas due to fuel and fire weather characteristics not captured by these models, and also may affect much larger areas than the occurrence points used to depict them. Thus, some fires shown in Figure 4-33 are not predicted as having high probability of fire occurrence in these models (Figure 4-34).

The most influential factors in the human model include: distance to recreation areas, distance to roads and highways, and annual and summer precipitation. The most influential factors in the natural model include: annual precipitation, summer temperature, and existing vegetation type. Even though the density of fire-season lightning events (1990–2009) was included in the natural model, it was the least important factor. In general, fire potential increases moving west to east at higher elevations, with the highest overall areas located in Colorado. Significant areas of overlap occur between the human and natural fire models, indicating that these areas may be at higher risk of fire occurrence in the future. It is important to note that fires may cause significant impacts to vegetation communities where they occur outside the areas of higher fire occurrence potential, because fires that do occur may be uncharacteristically severe, may occur in areas not generally adapted to fire disturbance, or may transition to invasive vegetation.

4.3.3 Current Development

Four major components of development were assessed for the ecoregion—energy, agriculture, urbanization (including roads), and recreational development. A dozen major inputs derived from multiple original datasets were compiled using a fuzzy logic model (Figure 4-35) to produce a single development footprint for the ecoregion. Reliable spatial data was available for all but the recreation input data, which proved to be very difficult to acquire. A subset of the recreation data that had been compiled and analyzed to address more specific recreation management questions was used for the composite model (see Appendix A for more details on recreation).

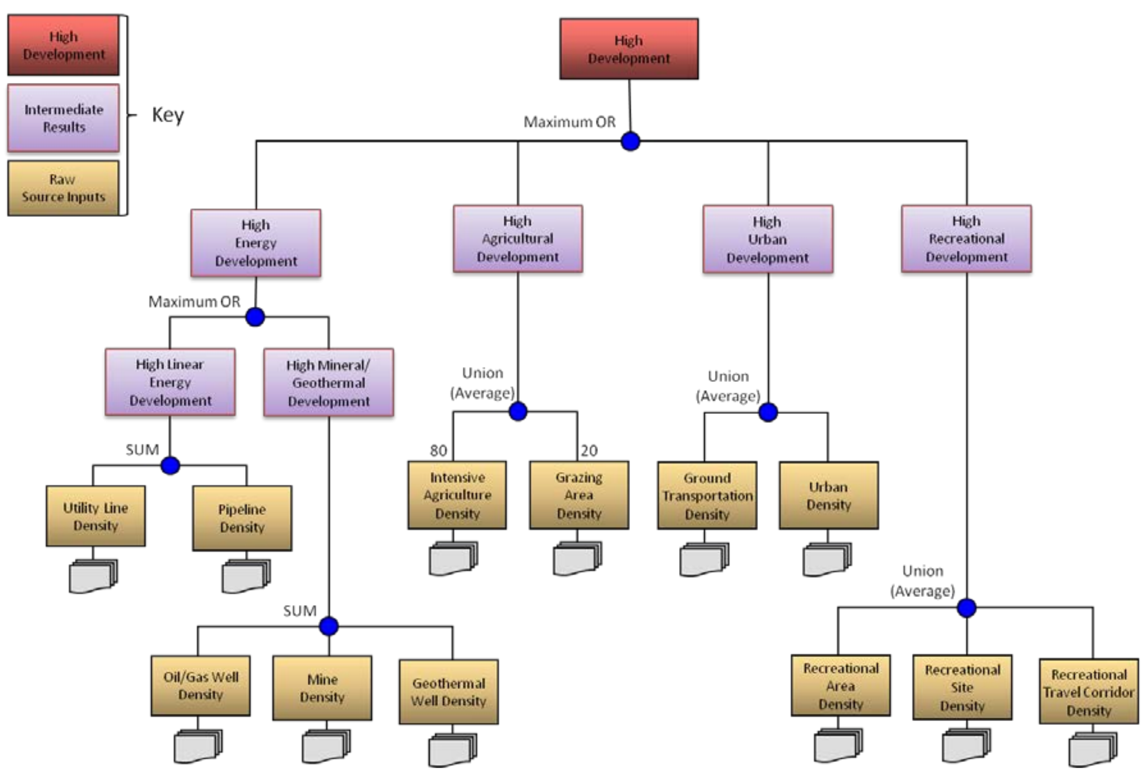

Figure 4-35. Current development fuzzy logic model for the Colorado Plateau ecoregion. Raw data inputs are in gold color, intermediate results for energy development, agriculture, urbanization, and recreation are in purple, and the final development footprint represented in red.

The recreation data used for the composite development model focused on land recreation only and included point, line, and polygon inputs (Figure 4-36D). Current energy development comprised spatial data on linear features (utility lines and pipelines) and point features (oil/gas wells, mines, and geothermal wells) and the data were aggregated using a *Maximum OR* logic operator (Figure 4-36A). The urban development component of the fuzzy logic model averaged urban landcover density and road density based on the ground transportation linear features dataset provided by BLM (Figure 4-36B). No weighting or special treatment of roads was conducted as the dataset was too inconsistently attributed (did not distinguish paved from unpaved) to allow for more detailed treatment of the road infrastructure, which ranged from OHV dirt paths to interstate highways.

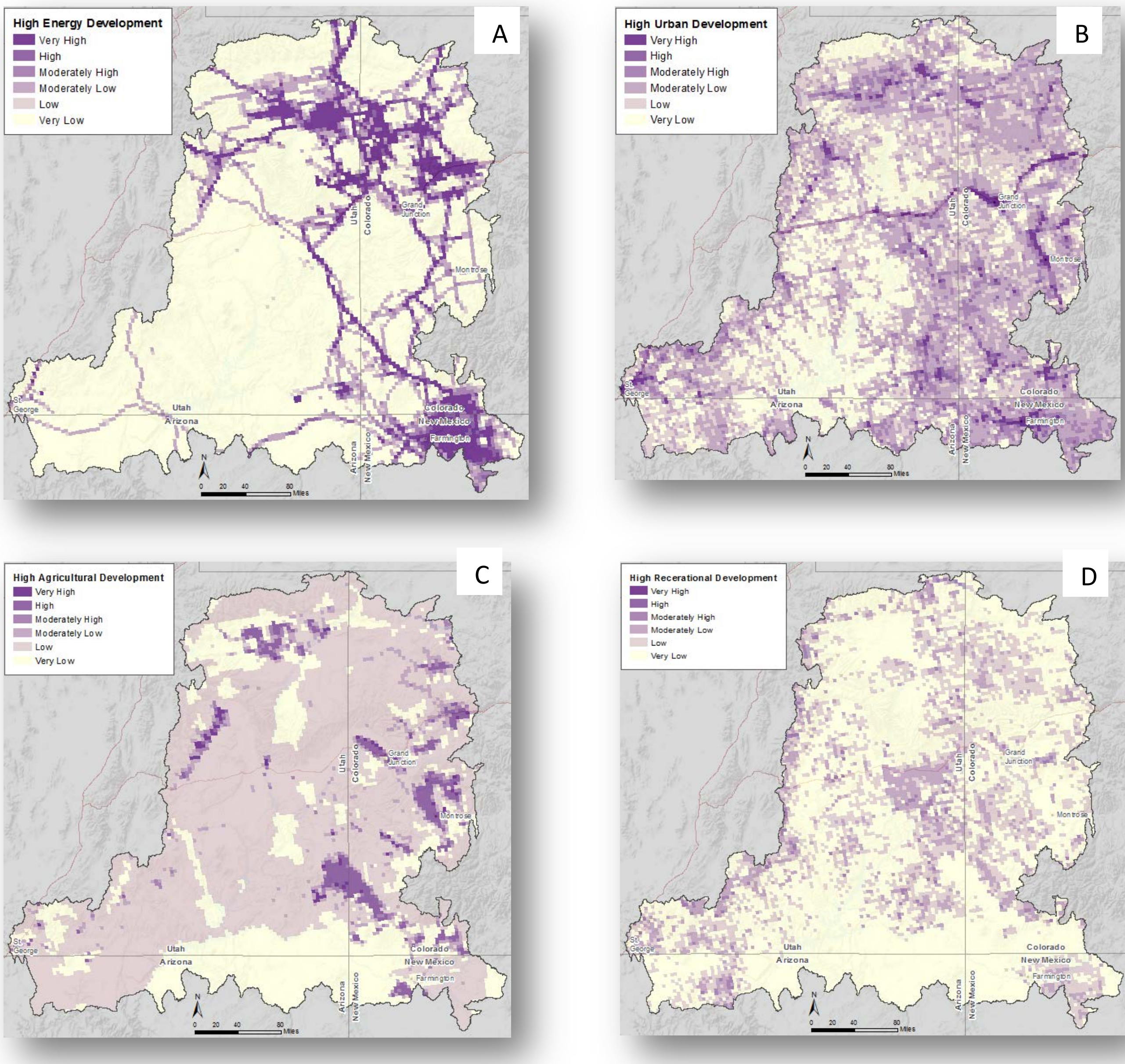

Figure 4-36. Intermediate results of the current development fuzzy logic model showing (A) current energy development, (B) urban development, (C) agriculture development, and (D) recreation development.

Agricultural development was derived from agriculture landcover data and grazing allotment data using an *Average* (or *Union*) logic operator and weighting converted agricultural land to grazing lands by 80/20 (Figure 4-36C). Agriculture contributes to the final map; however, lack of data on recent livestock density and overall range condition is a serious data gap in the model. In addition, there were no data for the large Navajo Nation in the southern portion of the ecoregion. Recreational development data is also substandard and the model would do a better job of incorporating recreation impacts with more detailed and complete data for the wide array of recreational activities (both active and passive). Filing these data gaps would enhance the development model as well as both the terrestrial and aquatic intactness models.

The full development footprint for the Colorado Plateau shows the highest development in the northern and eastern portions of the ecoregion where traditional energy development (oil and gas) and urbanization is concentrated (Figure 4-37). Future development scenarios are presented in Chapter V, Potential Future Conditions in the Colorado Plateau Ecoregion.

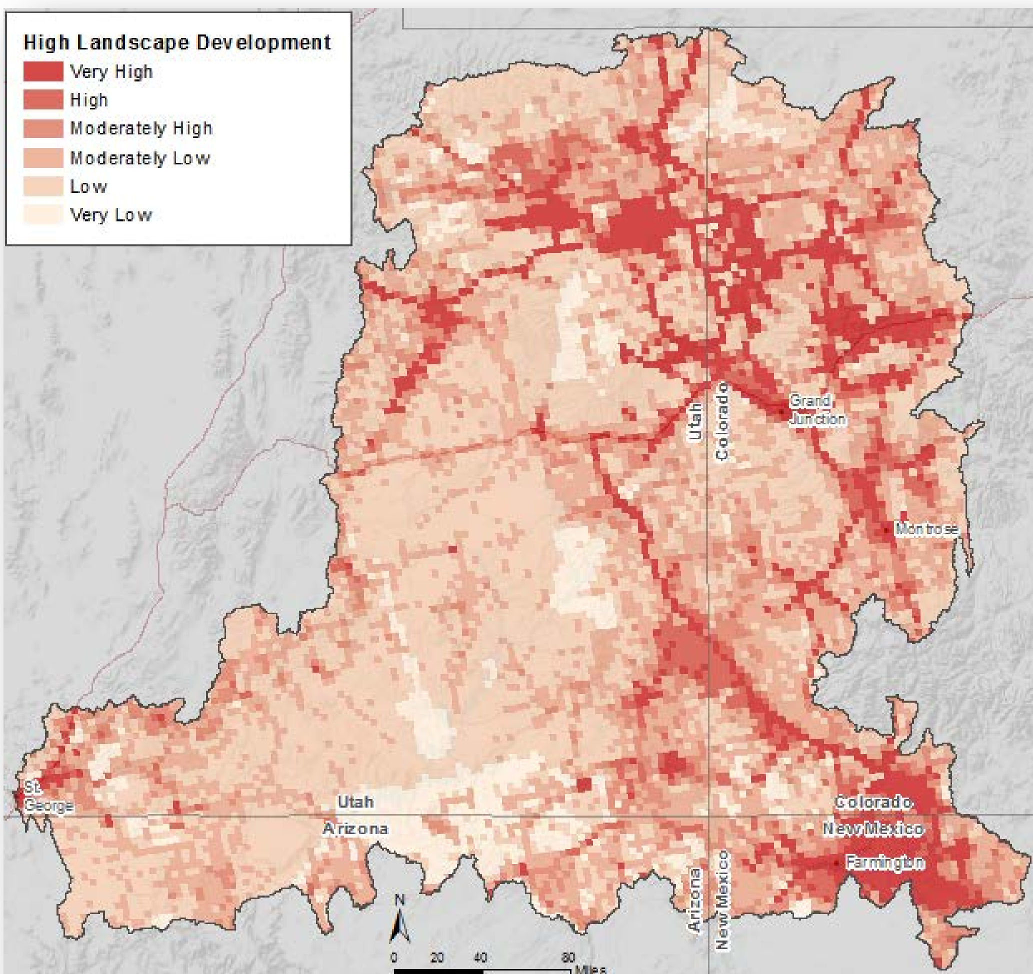

Figure 4-37. Composite map of current development in the Colorado Plateau ecoregion.

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