Appendix B – Ecological Systems Conservation Elements

Organization of Appendix B

The following sources and results are provided for each Ecological System (vegetation community) conservation element: a Conceptual Model; a description of the analytical process (including source data) and/or a Process Model for each management question, and results in the form of maps and other supporting graphics. Access to a data portal to examine the results in greater detail is available at the BLM website http://www.blm.gov/wo/st/en/prog/more/climatechange.html.

Ecological Systems Conceptual Models

Conceptual models used in the Colorado Plateau REA organize and articulate the relationship between the various change agents and natural drivers for a particular conservation element. Not all of the relationships identified lend themselves well to measurement or monitoring, but they are still important to include as it aids in our overall understanding of complex interactions.

All ecological systems (and biological crust) conceptual models include a series of change agents (depicted with yellow boxes) and natural drivers (cyan boxes). Specifics regarding some of the factors are presented in blue text. Within each ecological system, one or more dominant species are included in the model. Arrows represent relationships between the various change agents and natural drivers with the community overall and, where appropriate, with the dominant species more directly. More specific information is provided by the orange text. Thicknesses of the arrows **DO NOT** represent degree of importance. Rather, bold lines represent those factors that are tracked or modeled to varying degrees of certainty throughout the REA analysis.

Fire regime is influenced by a complex interaction of factors: fuel load and condition, grazing, invasive species, and fire frequency (both natural—a function of climate—and human-caused—a function of development). Fire suppression is another influencing factor on the fire regime. Climate change and development affects the entire complex and all of its components. Natural ecological systems are shaped by a natural fire regime and altered by a different regime. Native ecosystems can also be directly affected by invasive species and grazing.

No natural system is fixed in time or space, and it is the individual species that respond to environmental change, not the community. Evaluating natural ecological systems within the Colorado Plateau is particularly challenging for monitoring change as many of the more dominant natural communities are ecotonal and therefore demonstrate a high level of mobility on the landscape. Natural or human-caused change can drive one ecological system to another over a relatively short period of time in a given location. For example, pinyon-juniper woodlands can be driven towards a pinyon-juniper shrublands community or invasive grassland from an altered fire regime. When reviewing the different ecological systems conceptual models and resulting distribution maps, it is important to keep these dynamics in mind.

Finally, biological crust occurs as part of many of the other natural ecological systems reviewed for this REA. As part of these other systems, biological crusts inhibit invasive seed germination (Larsen 1995), help retain soil moisture (Belnap and Gardner 1993), stabilize soils (Belnap and Warren 1998), and serve as an important source of carbon and nitrogen fixation (Beymer and Klopatek 1991, Belnap 1995). Management questions (MQ A4 and MQ A5) and results maps for biological crust may be found in Appendix A.

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Beymer, R.J., and J.M. Klopatek. 1991. Potential contribution of carbon by microphytic crusts in pinyon-juniper woodlands. *Arid Soil Research and Rehabilitation* 5: 187–198.

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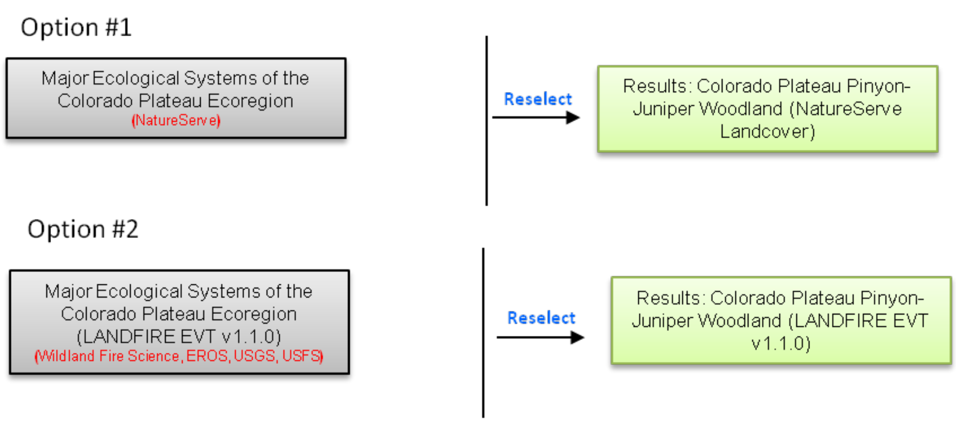
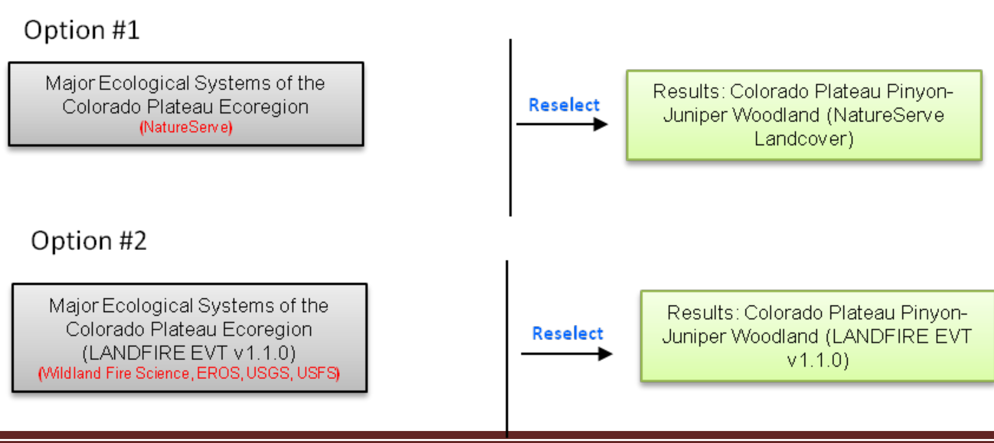
Process Models

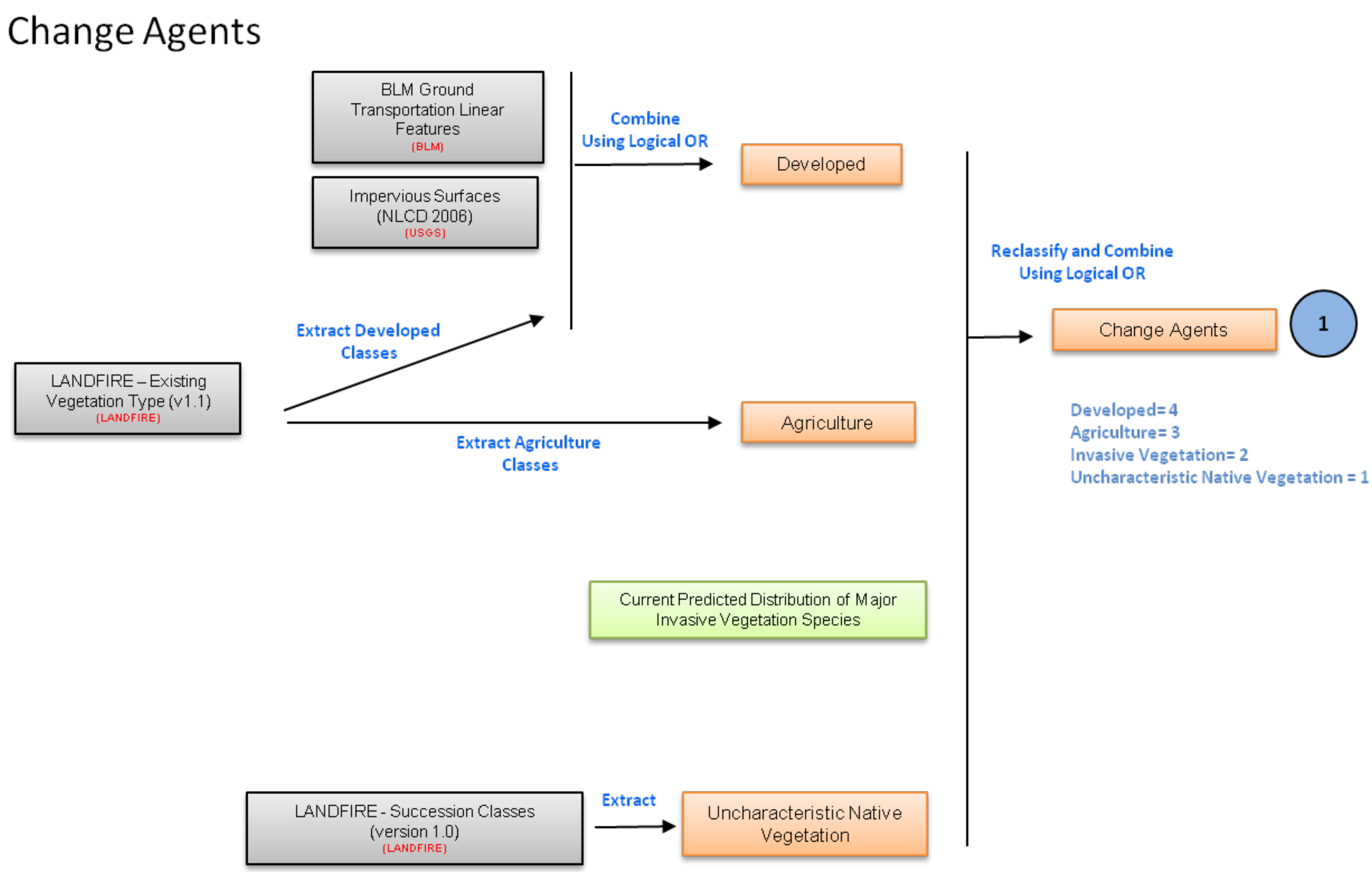
MQ C1. Where are existing vegetation communities of interest present and what is their current status?



MQ C2. Where are vegetative communities vulnerable to change agents in the future?



MQC3. What change agents have affected existing vegetative communities? Part 1



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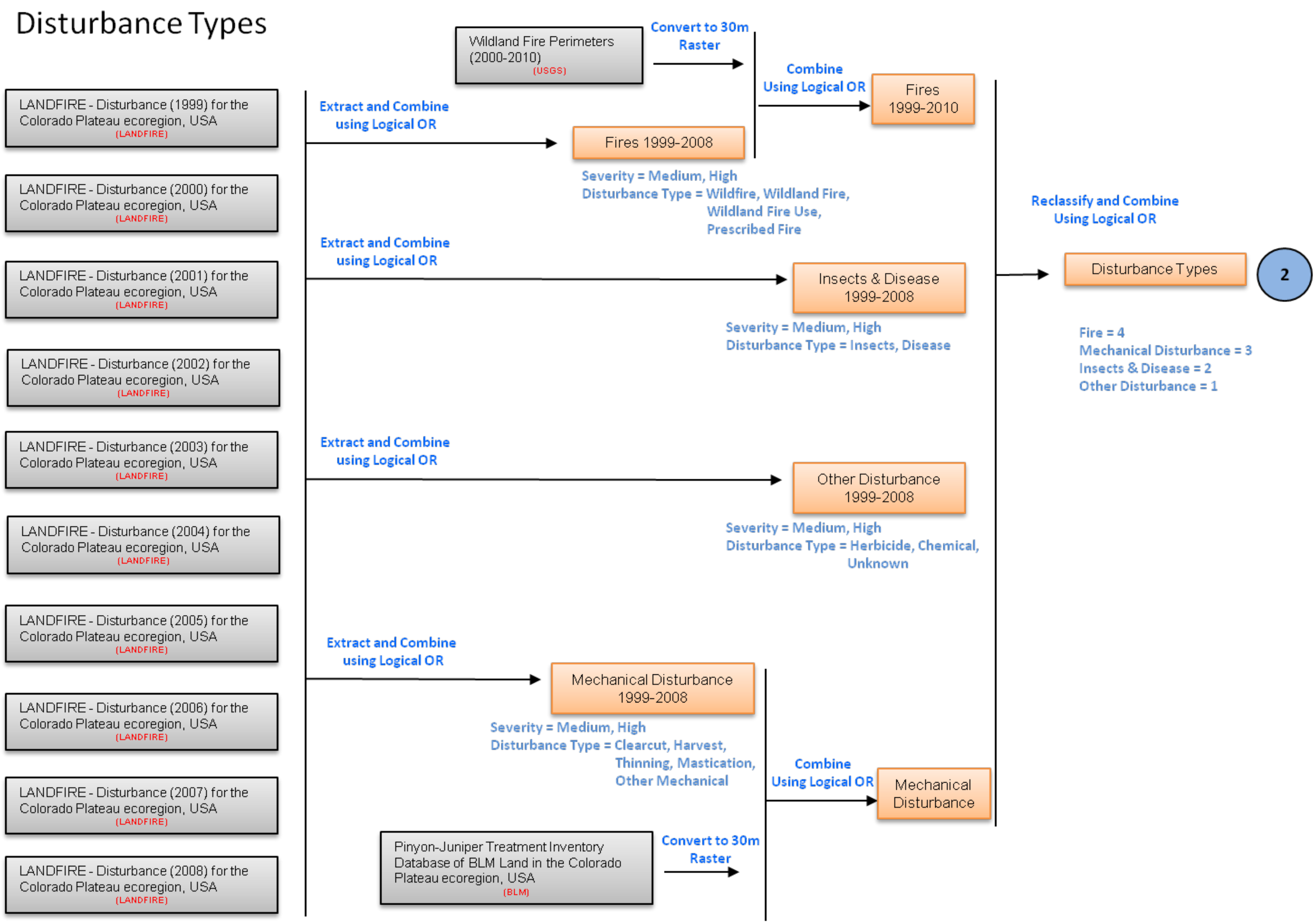
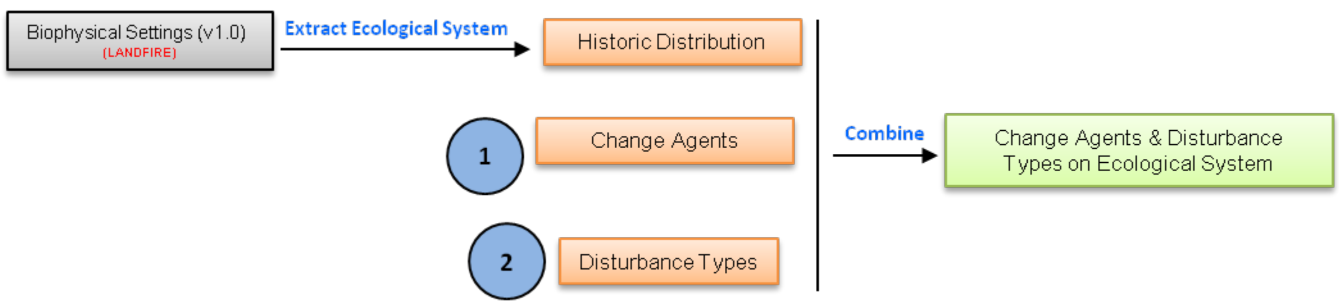


MQC3. What change agents have affected existing vegetative communities? Part 3



Colorado Plateau Pinyon-Juniper Woodland

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009). The important role jays and nutcrackers play in the life history of pinyon pine (*Pinus edulis*) is a natural driver specific for that dominant species.

Climatic events (droughts and frosts) are believed to limit the distribution of this community to a relatively narrow altitudinal band in the ecoregion. 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). Close attention to climate change projections may be particularly important in defining where this community type can occur in the future.

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). Scale of fire disturbance is typically small, but under certain conditions, stand replacing over 1000s of acres can occur. Mixed severity fires are on the order of 10–100s of acres in size. Lower fire frequency, which has been more common over the last decades due to fire suppression, results in an expansion of woody vegetation. Higher than normal fire frequency and severity results in a reduction of woody vegetation and a transition towards more shrubs and grasses. Livestock grazing and invasive grasses have altered the understory vegetation and, where fire has removed the tree cover, invasive grasses have become dominant eliminating woodland vegetation altogether. Where long-term grazing has occurred, there are significantly fewer grasses and cacti and more forbs and shrubs present (Harris et al. 2003).

Drought stress and subsequent insect outbreaks have been causing widespread mortality of pinyon pine throughout much of its range, especially on soil types that are more prone to moisture loss (Breshears et al. 2005, Mueller et al. 2005). Soils in regions of very high pinyon pine mortality are generally coarse, sandy, skeletal, with low fertility but rich in calcium (desert caliche layers). They have a torric moisture regime (hot and dry soils) and very little horizon development. The soils have large pores with little capillary forces that promote rapid water evaporation or drainage rather than conservation leading to tree mortality.

For many years, large areas of pinyon-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 (urban and energy) also directly convert or degrade this system. Mechanical removal or disturbance of this community can promote invasive grasses altering the system in significant ways. Direct harvest of the tree dominants in this community are also important change agents but more difficult to track with the data available.

Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Removal, Fires, and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where existing pinyon-juniper woodlands may be under significant climate stress.

References Cited

Breshears, D.D., N.S. Cobb, P.M. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer. 2005. Regional vegetation die-off in response to global change-type-drought. *Proceedings of the National Academy of Sciences* 102: 15144–15148.

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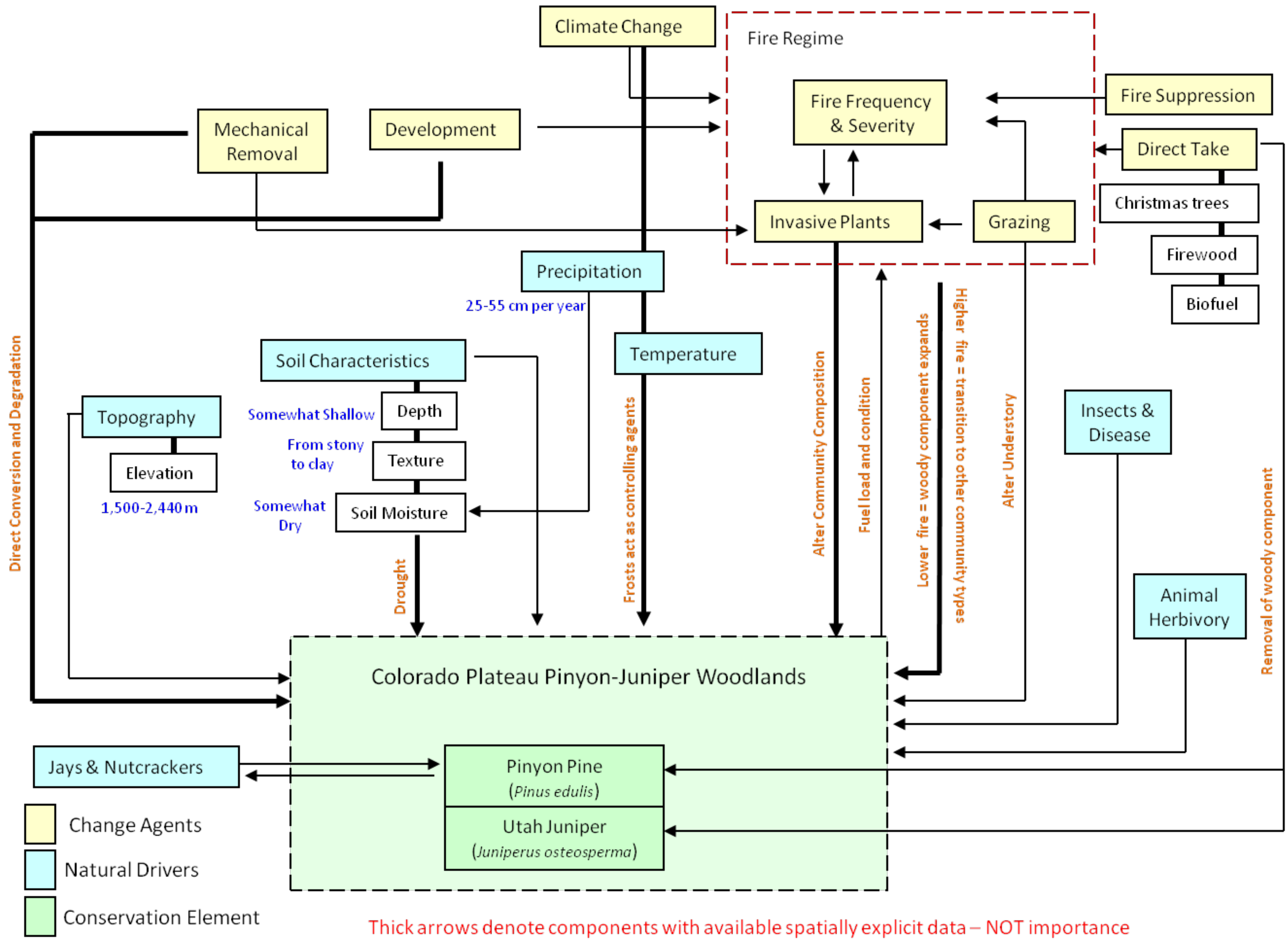
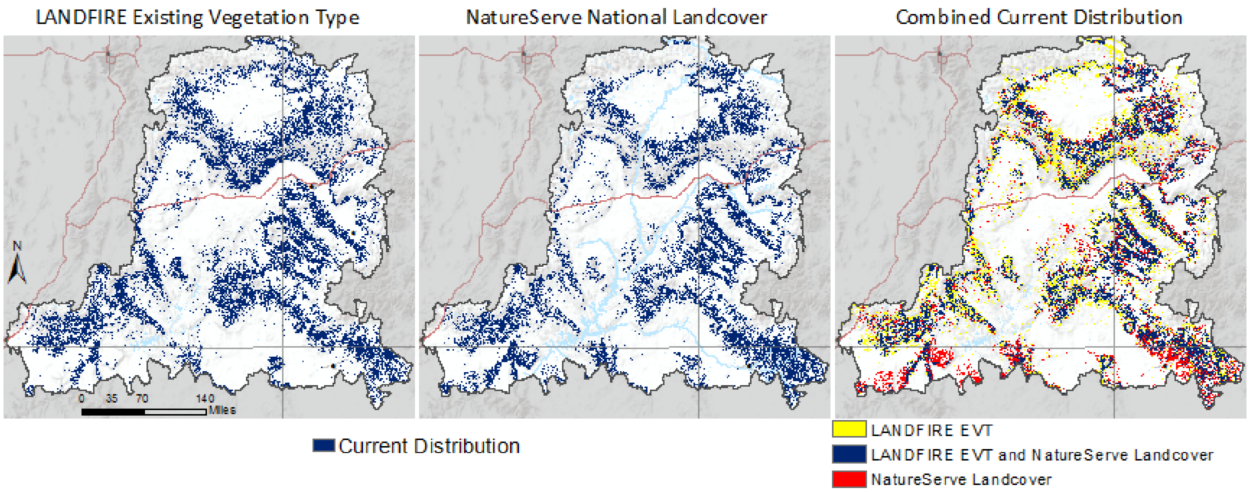

Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Mechanical Removal
Development
Direct Take
Christmas trees
Firewood
Biofuel
Invasive Plants
Grazing
Precipitation
25-55 cm per year
Soil Characteristics
Temperature
Topography
Elevation
1,500-2,440 m
Somewhat Shallow
Depth
From stony to clay
Texture
Somewhat Dry
Soil Moisture
Direct Conversion and Degradation
Drought
Frosts act as controlling agents
Alter Community Composition
Fuel load and condition
Lower fire = woody component expands
Higher fire = transition to other community types
Alter Understory
Insects & Disease
Animal Herbivory
Removal of woody component
Colorado Plateau Pinyon-Juniper Woodlands
Jays & Nutcrackers
Pinyon Pine (Pinus edulis)
Utah Juniper (Juniperus osteosperma)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is the current Colorado Plateau Pinyon-Juniper Woodlands community and what is its status?

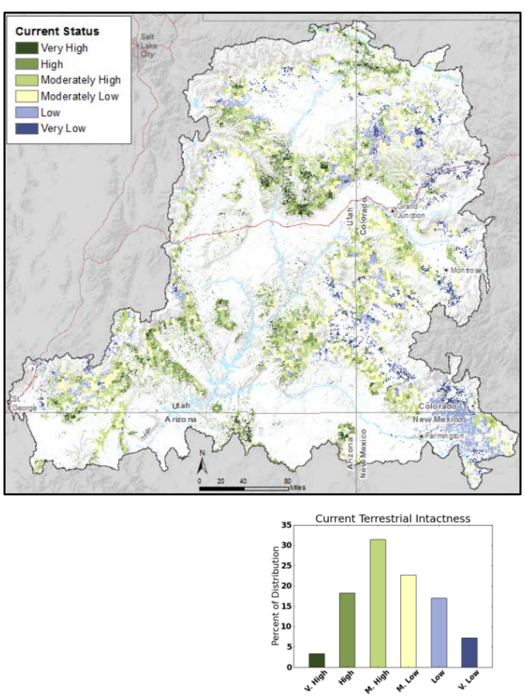
Distribution



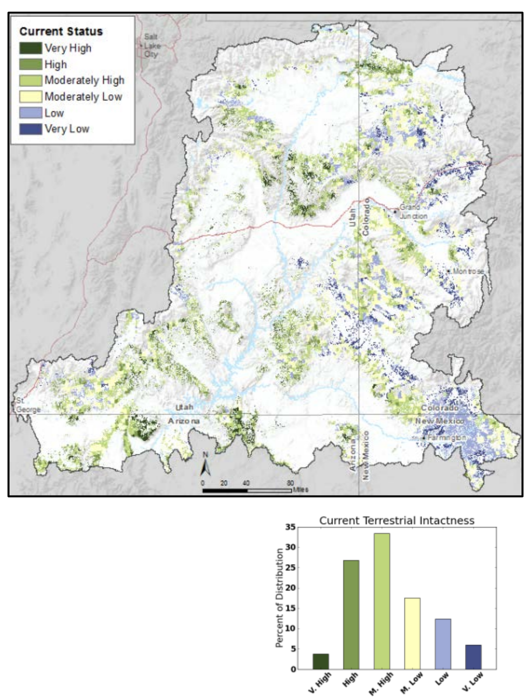
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Colorado Plateau Pinyon-Juniper Woodland	3,664,596	3,664,596	6,078,616	49.27

Status

LANDFIRE

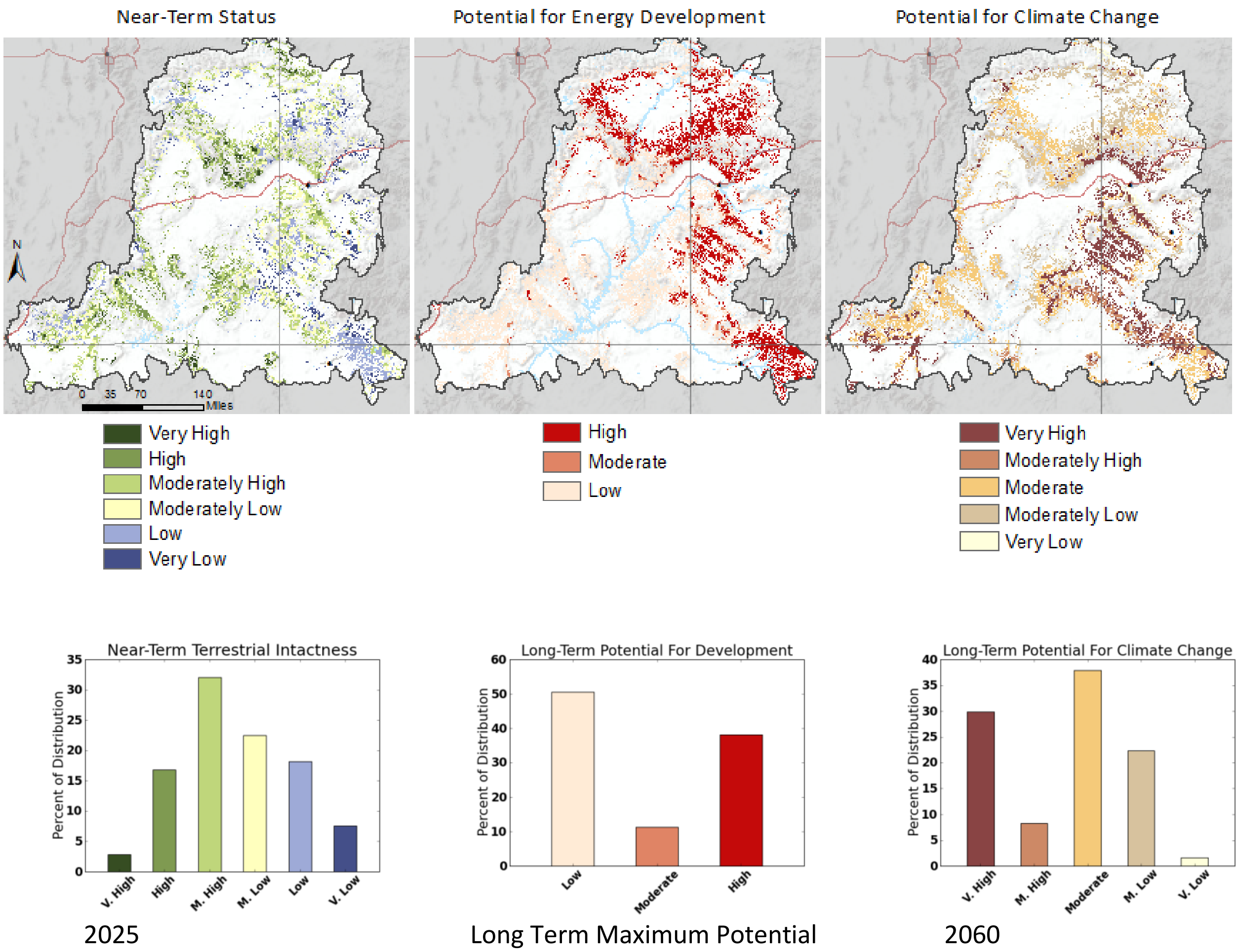


NatureServe



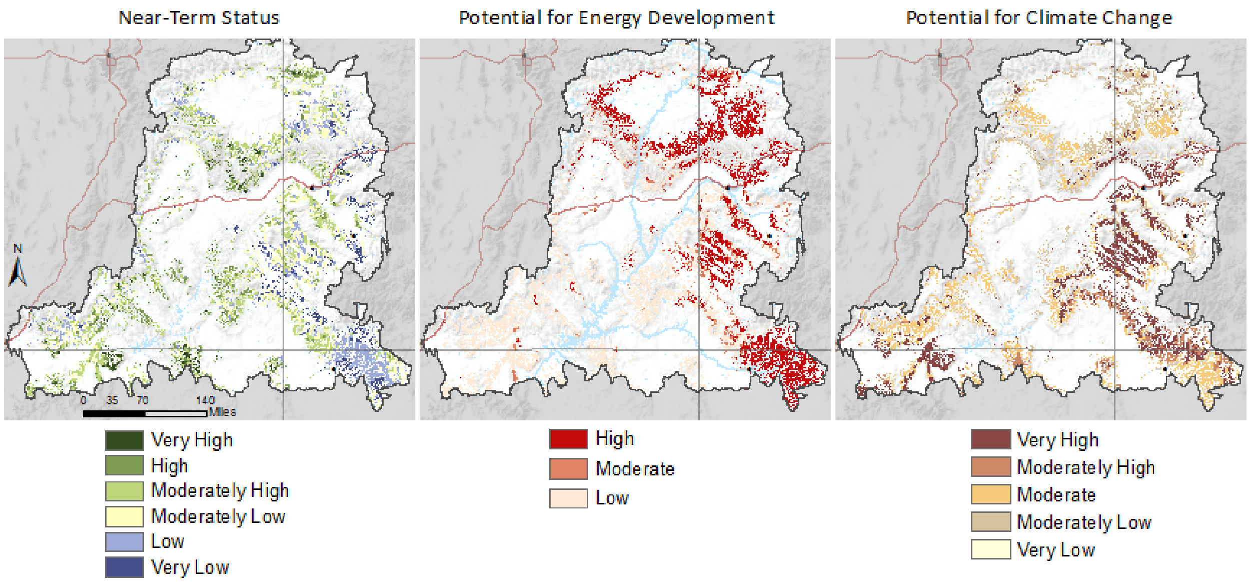
MQ C2. Where are Colorado Plateau Pinyon-Juniper Woodlands vulnerable to change agents in the future?

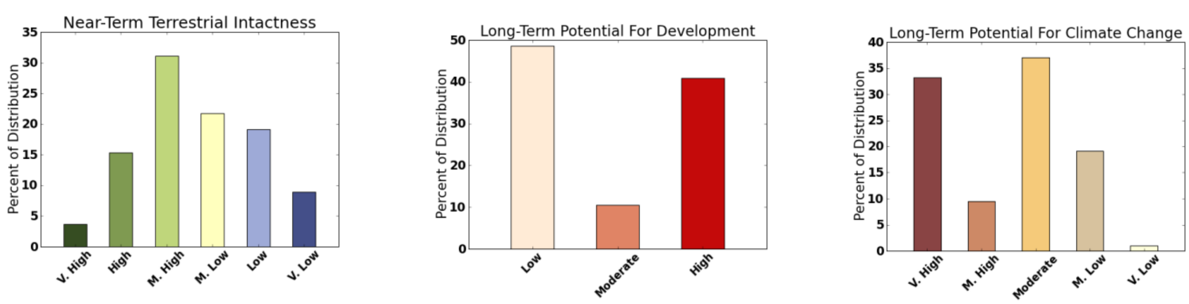
LANDFIRE Dataset



MQ C2. Where are Colorado Plateau Pinyon-Juniper Woodlands vulnerable to change agents in the future?

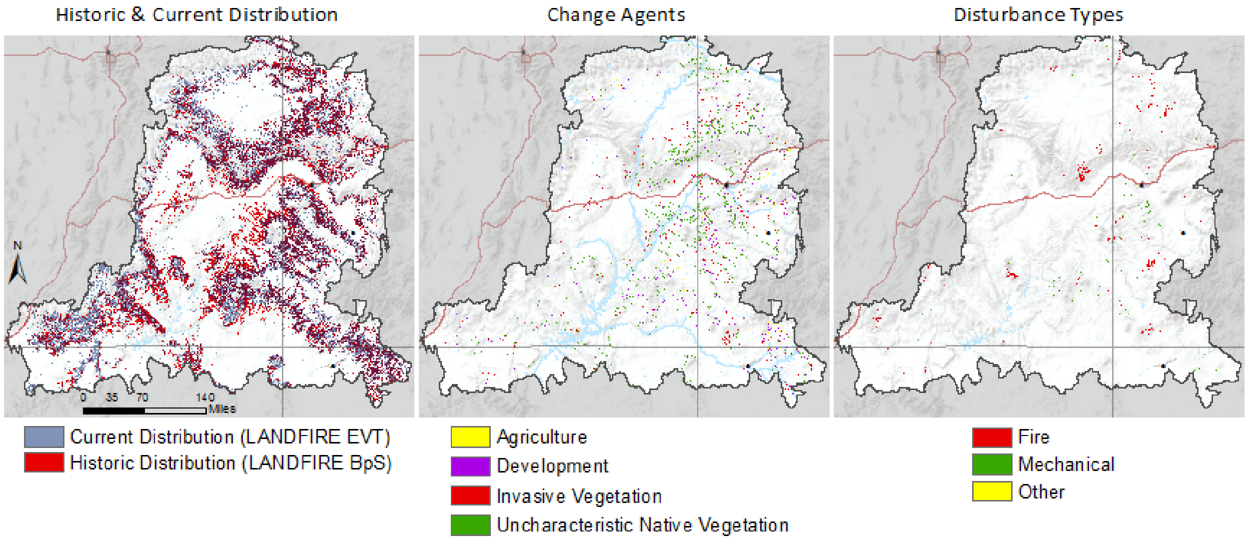
NatureServe Dataset





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Colorado Plateau Pinyon-Juniper Woodlands?



Historic Change Agents (change from modeled reference condition [LANDFIRE BpS dataset]

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
7,515,040	229,091	45,740	273,361	634,736	1,182,928	15.74%

Recent Disturbance (1999–2008)

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
7,515,040	194,113	71,692	763	266,568	3.55%

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009). The important role jays and nutcrackers play in the life history of pinyon pine (*Pinus edulis*) is natural driver specific for that dominant species.

Climatic events (droughts and frosts) are believed to limit the distribution of this community. Pinyon-juniper shrublands occur at lower elevations than pinyon-juniper woodlands but these two communities largely overlap. The defining factor for woodlands versus shrublands is moisture – shrublands occur under drier conditions. As observed in pinyon-juniper woodlands, 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). Close attention to climate change projections may be particularly important in defining where this community type can occur in the future.

Fire frequency is common but rarely burns more than a small area. Replacement fires are uncommon averaging a fire return interval of 100–500 years. Mixed severity fire, which occurs at the same fire return interval, is characterized as a mosaic of replacement and surface fires that occur over relatively small areas. Surface fires are more commonly where grasses are abundant (LANDFIRE 2007).

Livestock grazing and invasive grasses have altered the understory vegetation and, where fire has removed the woody cover, invasive grasses have been known to take hold eliminating woody vegetation altogether. Where long-term grazing has occurred, there are significantly fewer grasses and cacti and more forbs and shrubs present (Harris et al. 2003).

Drought stress and subsequent insect outbreaks have caused widespread mortality of pinyon pine throughout much of its range, especially on soil types that are more prone to moisture loss (Breshears et al. 2005, Mueller et al. 2005). Soils in regions of very high pinyon pine mortality are generally coarse, sandy, skeletal, with low fertility while rich in calcium (desert caliche layers). They have a torric moisture regime (hot and dry soils) and very little horizon development. Their large pores with little capillary forces promote rapid water evaporation or drainage rather than conservation leading to tree mortality.

For many years, large areas of pinyon-juniper shrublands 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 (urban and energy) directly convert or degrade this system. Mechanical removal or disturbance of this community can also promote invasive grasses altering the system in significant ways. Direct harvest of the tree dominants in this community are also important change agents but more difficult to track with the data available.

Change agents impacting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Removal, Fires, and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where existing pinyon-juniper shrublands may be under significant climate stress.

References Cited

Breshears, D.D., N.S. Cobb, P.M. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer. 2005. Regional vegetation die-off in response to global change-type-drought. Proceedings of the National Academy of Sciences, USA. 102: 15144-15148.

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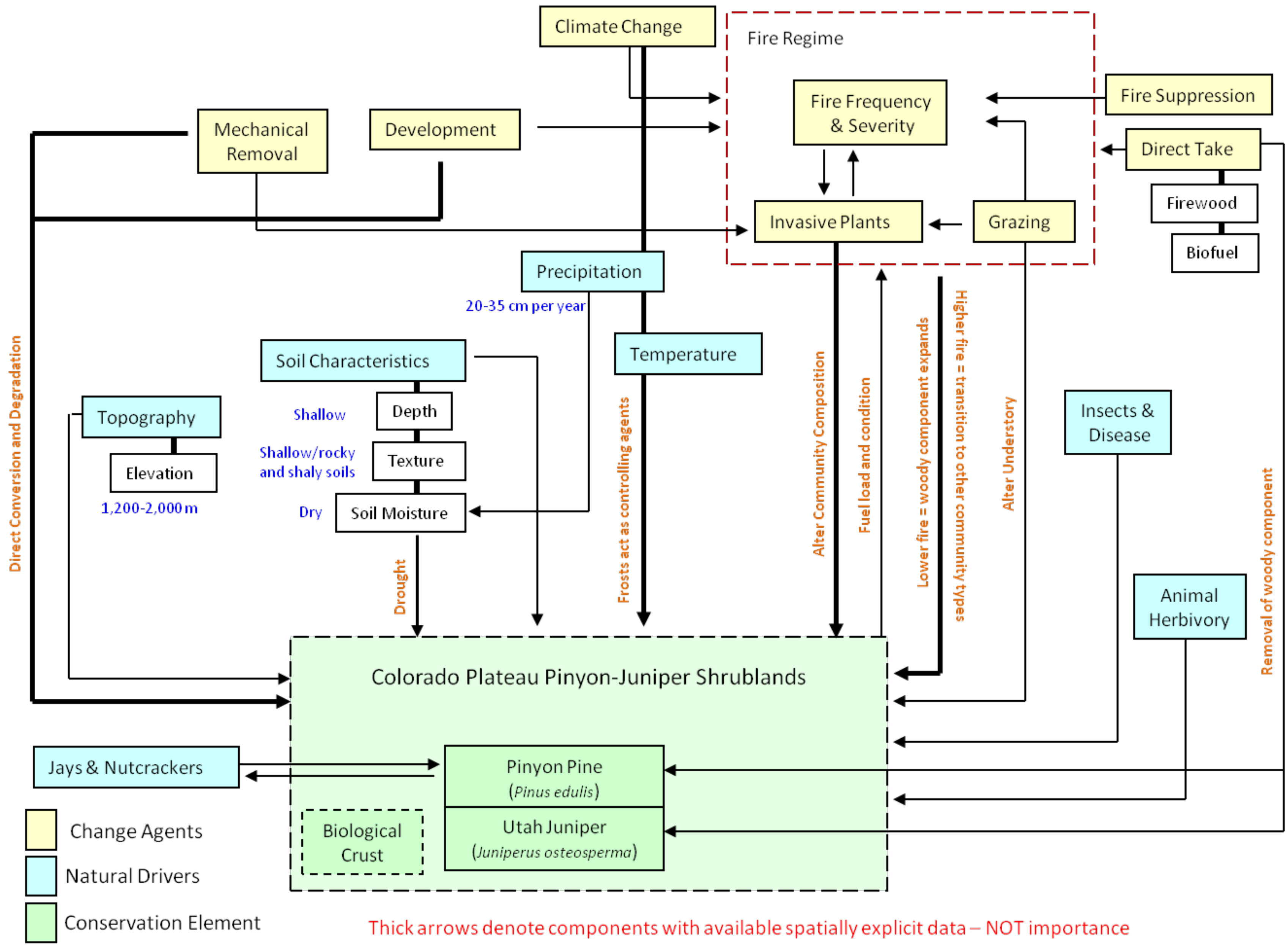
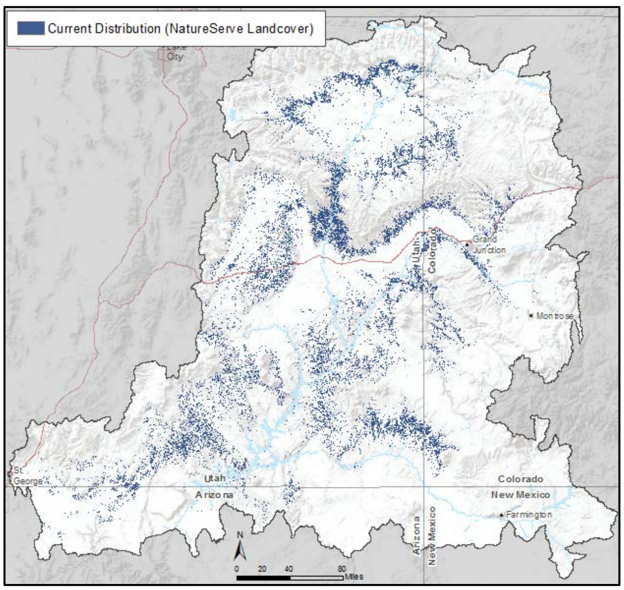

Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Direct Take
Firewood
Biofuel
Mechanical Removal
Development
Invasive Plants
Grazing
Precipitation
20-35 cm per year
Temperature
Soil Characteristics
Depth
Shallow
Texture
Shallow/rocky and shaly soils
Soil Moisture
Dry
Topography
Elevation
1,200-2,000 m
Direct Conversion and Degradation
Drought
Frosts act as controlling agents
Alter Community Composition
Fuel load and condition
Lower fire = woody component expands
Higher fire = transition to other community types
Alter Understory
Insects & Disease
Animal Herbivory
Removal of woody component
Colorado Plateau Pinyon-Juniper Shrublands
Jays & Nutcrackers
Pinyon Pine (Pinus edulis)
Utah Juniper (Juniperus osteosperma)
Biological Crust
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

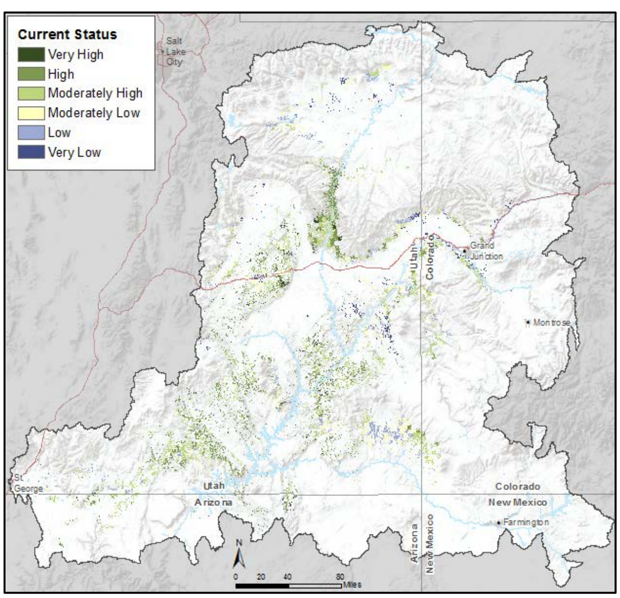
MQ C1. Where is the current Colorado Plateau Pinyon-Juniper Shrublands community and what is its status?

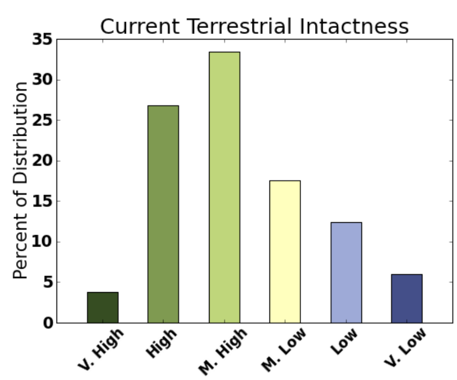
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Colorado Plateau Pinyon-Juniper Shrubland	In PJ Woodlands	2,694,089	0	0.00

Distribution



Status

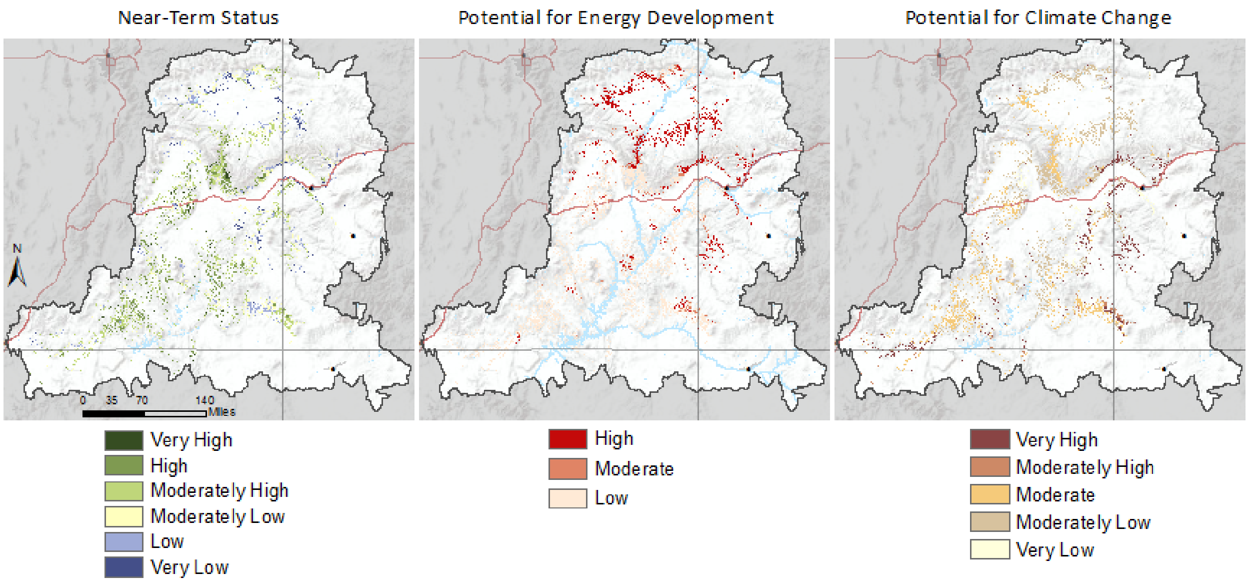


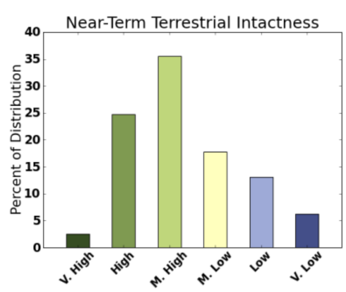


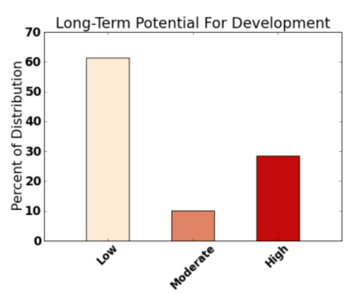
MQ C2. Where are Colorado Plateau Pinyon-Juniper Shrublands vulnerable to change agents in the future?

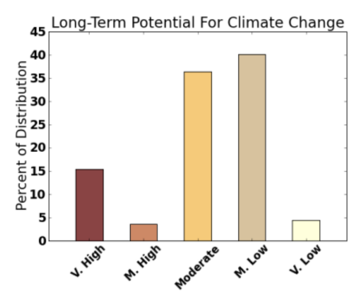
No LANDFIRE data for Pinyon-Juniper Shrublands

NatureServe Dataset



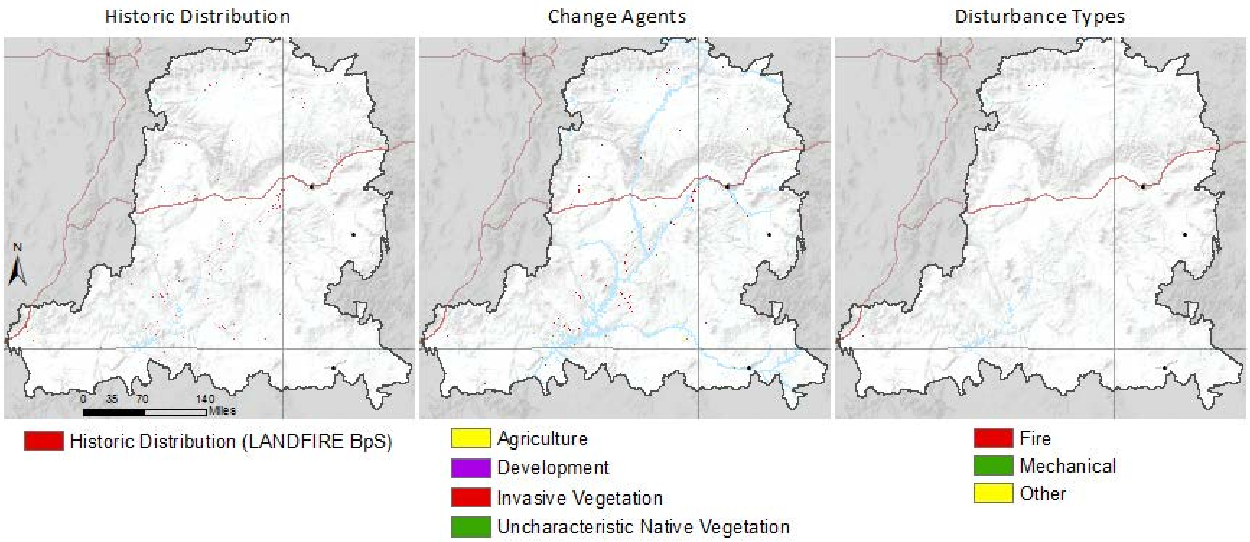






2025 | Long Term Maximum Potential | 2060

MQC3. What change agents have affected Colorado Plateau Pinyon-Juniper Shrublands?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
94,447	5,076	2,269	21,091	9,736	38,172	40.42%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
94,447	819	834	0	1,653	1.75%

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Also called Wyoming big sagebrush semi-desert, 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 et al. 1984) as well as long droughts impact this and related species (Anderson and Inouye 2001). The Aroga moth (*Aroga websteri*) and leaf beetles *(Trirhabda pilosa*) can cause significant sagebrush mortality (Pringle 1960, Gates 1964). Mechanical removal or burning of this community to improve grazing conditions has numerous negative ecological consequences (Hormay 1992; Blaisdell et al. 1982; Harniss and Murray 1973). Mechanical removal/burning of this community can also promote invasive grasses altering the system even further.

Stand replacement fires can occur at mid- and late-developmental stages of this shrubland community with a mean fire return interval (FRI) of 500 years. Surface fires are generally uncommon (mean FRI of 200 years), especially where shrub density is low. Where woody encroachment is evident, fire return interval shortens to every 100–125 years. Scale of fire disturbance historically ranged from <10 acres to >1,000 acres with an average disturbance patch size of 250 acres (LANDFIRE 2007). Besides fire frequency, seasonality of fire is also 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 throughout the Colorado Plateau (NatureServe 2009). In locations were fire suppression has been successful, woody encroachment (e.g. juniper and pine) has been significant. Due to the dynamic nature and interaction of many Colorado Plateau natural ecological systems and the challenge of accurately mapping vegetation using remote sensing, it is extremely difficult to track woody encroachment into this community over large geographic areas. Likewise, having more detailed data on grazing history and intensity would greatly improve the assessment of the overall condition of this community type. Both of these factors are reported to be extremely important for this community, but data do not exist to reliably assess and map their impacts.

Change agents impacting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Removal, Fires, and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where current inter-mountain basins big sagebrush shrubland may be under significant climate stress.

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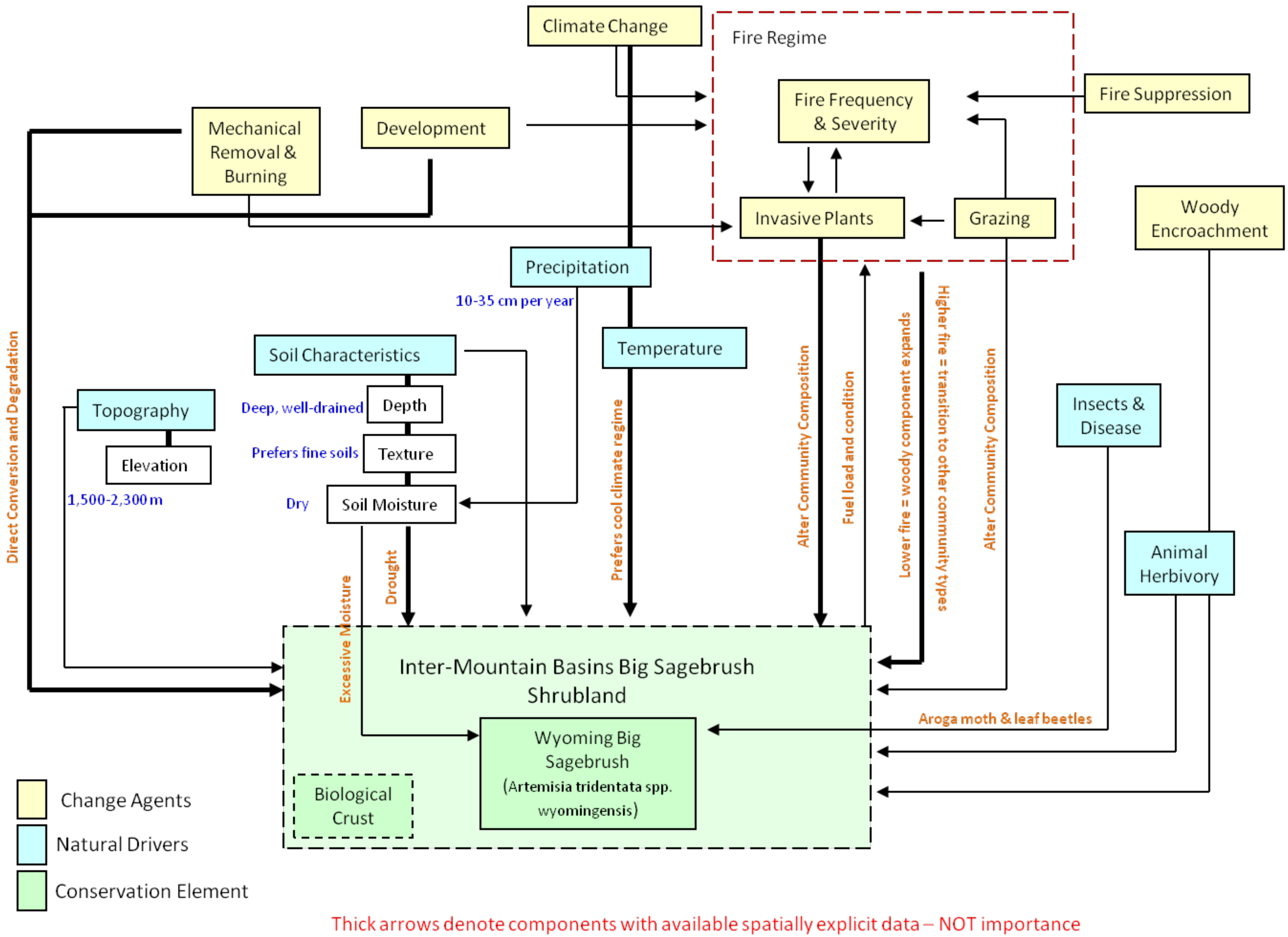
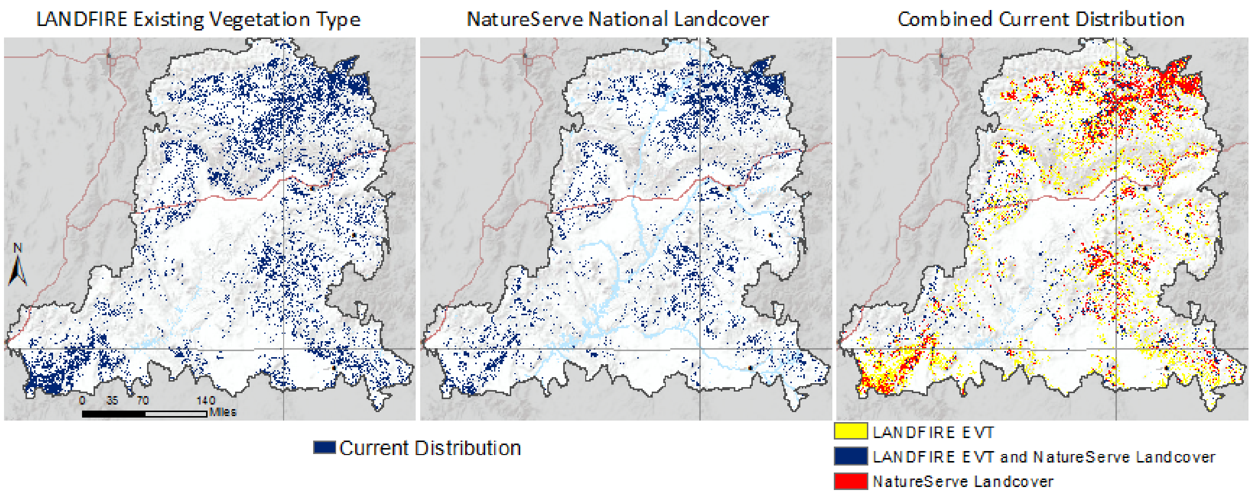

Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Mechanical Removal & Burning
Development
Invasive Plants
Grazing
Woody Encroachment
Precipitation
10-35 cm per year
Temperature
Soil Characteristics
Depth
Texture
Soil Moisture
Deep, well-drained
Prefers fine soils
Dry
Topography
Elevation
1,500-2,300 m
Insects & Disease
Animal Herbivory
Direct Conversion and Degradation
Excessive Moisture
Drought
Prefers cool climate regime
Alter Community Composition
Fuel load and condition
Lower fire = woody component expands
Higher fire = transition to other community types
Alter Community Composition
Aroga moth & leaf beetles
Inter-Mountain Basins Big Sagebrush Shrubland
Wyoming Big Sagebrush (Artemisia tridentata spp. wyomingensis)
Biological Crust
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Inter-Mountain Basins Big Sagebrush Shrubland and what is its status?

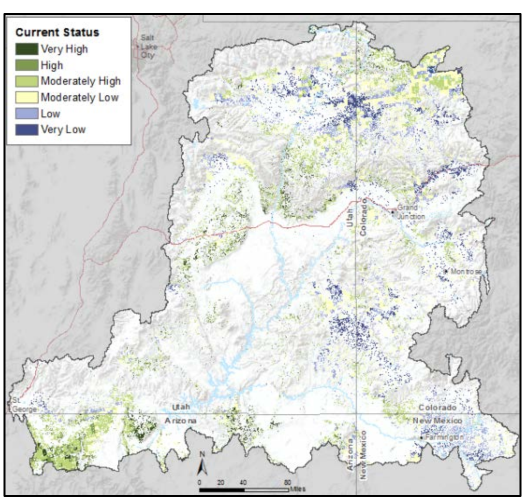
Distribution

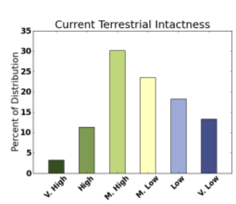


Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Inter-Mountains Basins Big Sagebrush Shrubland	3,970,331	1,542,766	2,370,353	30.07

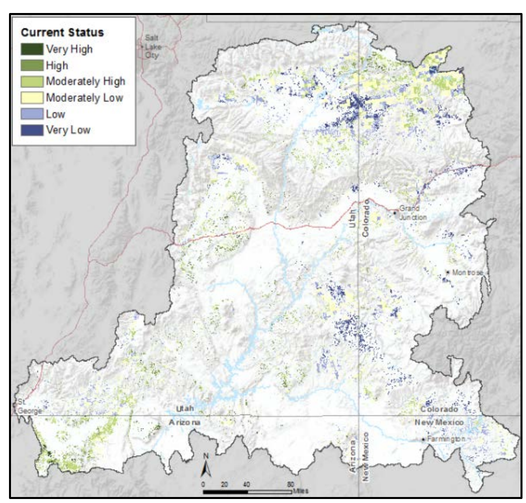
Status

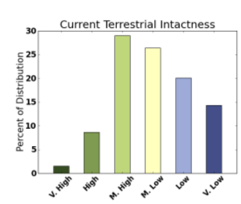
LANDFIRE





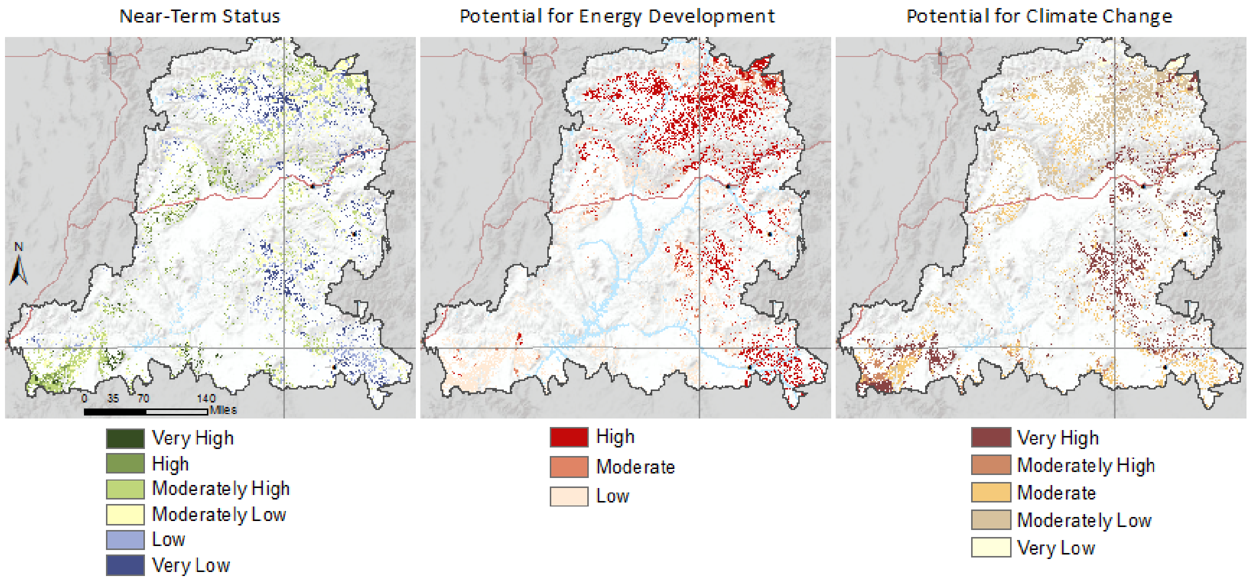
NatureServe

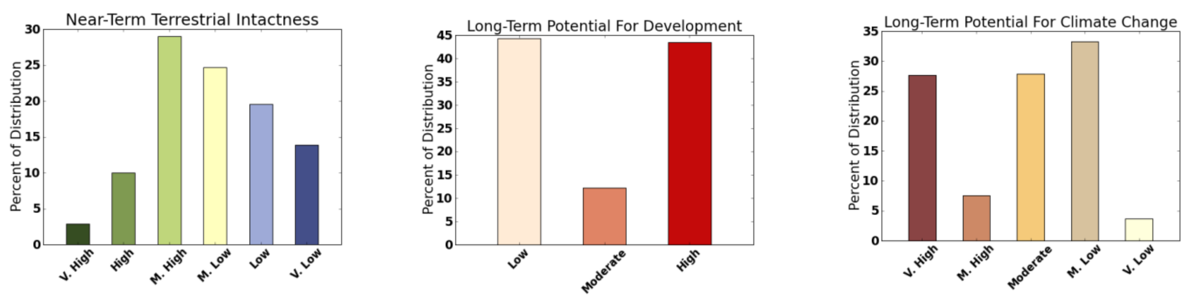




MQ C2. Where are Inter-Mountain Basins Big Sagebrush Shrublands vulnerable to change agents in the future?

LANDFIRE

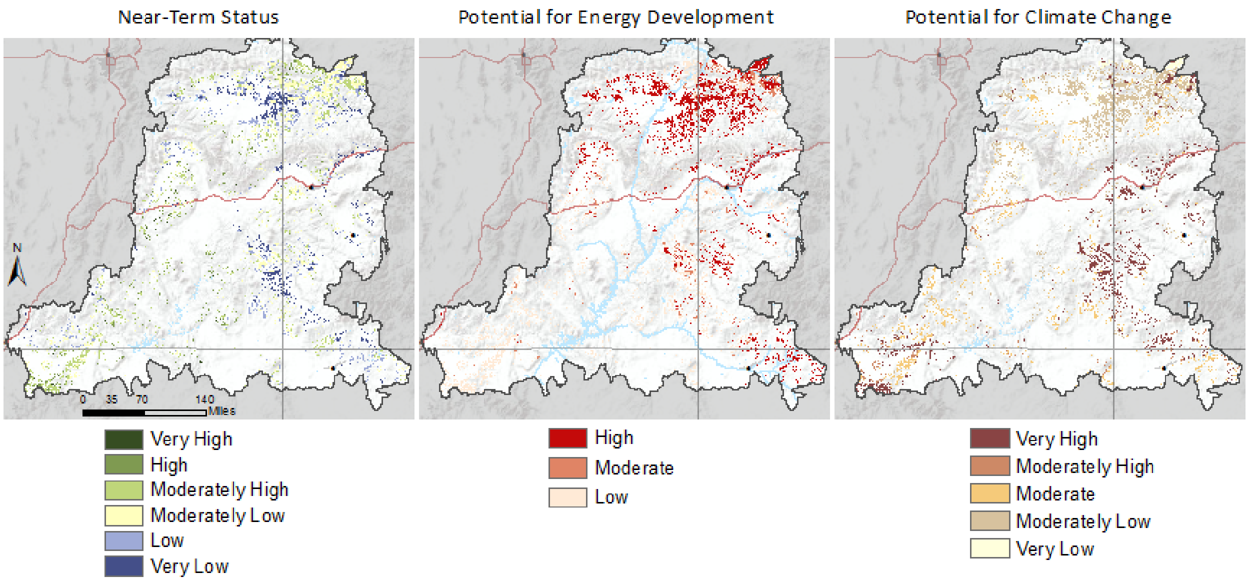


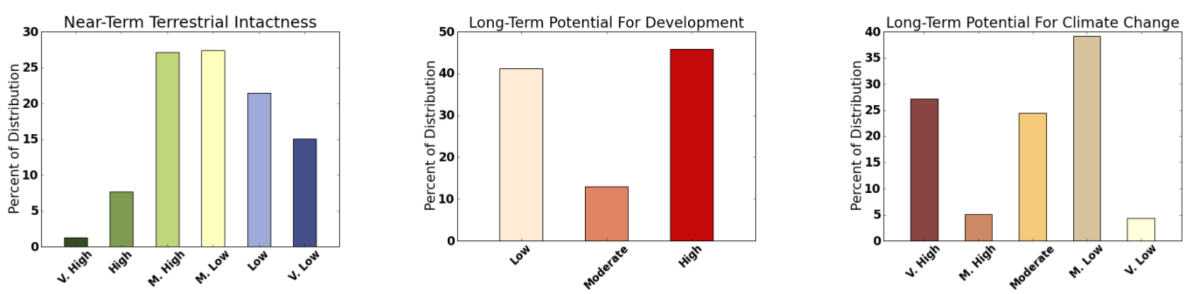


2025 Long Term Maximum Potential 2060

MQ C2. Where are Inter-Mountain Basins Big Sagebrush Shrublands vulnerable to change agents in the future?

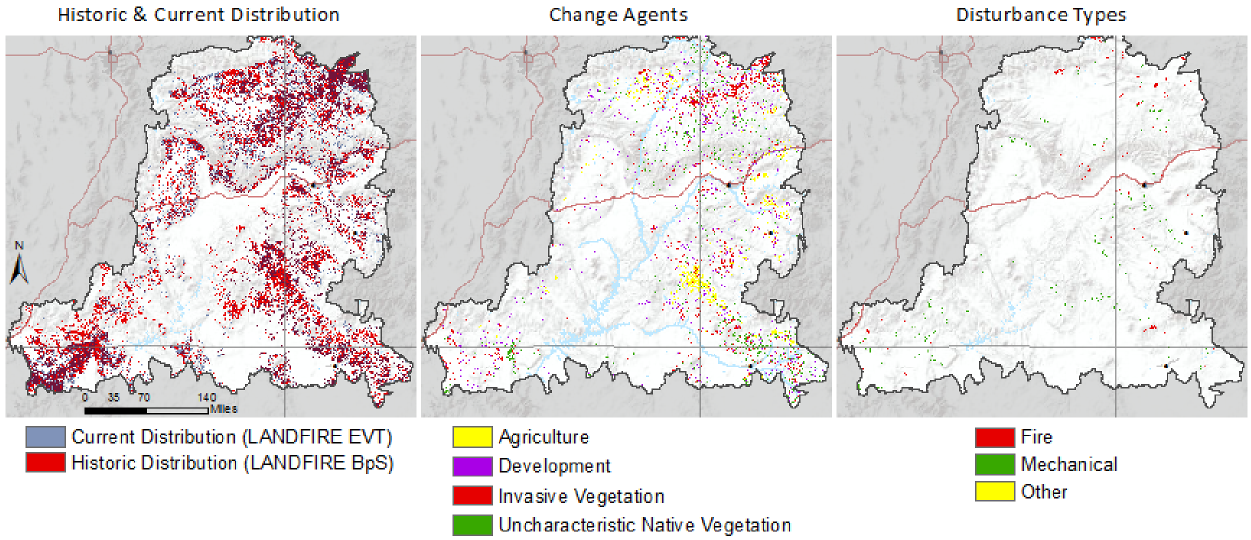
NatureServe





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Inter-Mountain Basins Big Sagebrush Shrublands?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
8,228,472	565,083	494,772	845,638	571,744	2,477,237	30.11%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
8,228,472	138,909	231,435	128	370,472	4.50%

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009), Tart (1996), and LANDFIRE (2007).

Mountain sagebrush (*Artemsia tridentata ssp. vaseyana*) 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 et al. 1984) as well as droughts impact this and related species (Anderson and Inouye 2001). The Aroga moth (*Aroga websteri*) and leaf beetles *(Trirhabda pilosa*) can cause significant sagebrush mortality (Pringle 1960, Gates 1964). Mechanical removal or burning of this community to improve grazing conditions has numerous negative ecological consequences (Hormay 1992, Blaisdell et al. 1982, Harniss and Murray 1973). Mechanical removal/burning of this community can also promote invasive grasses altering the system even further.

Because it occupies many different kinds of physical zones, the natural fire regime for this community is complex to describe. Mountain big sagebrush historically experienced stand replacing fire with a mean of 10 years at the ponderosa pine ecotone, 40 or more years at the Wyoming big sagebrush ecotone, and up to 80 years where low sagebrush makes up a high proportion of the landscape. LANDFIRE (2007) reported a replacement fire return interval for this community at 40–80 years with a mean of 50 years with the scale of fire disturbance historically ranging from <10 acres to >1,000 acres. Besides fire frequency, seasonality of fire is also important. Sagebrush generally responds favorably to spring fires, but fall fires tend to cause significant mortality. Fire suppression and livestock grazing has significantly degraded this ecological system throughout the Colorado Plateau (NatureServe 2009). In locations were fire suppression has been successful, woody encroachment (e.g. juniper and pinyon pine) has been significant. Due to the dynamic nature and interaction of many Colorado Plateau natural ecological systems and the challenge of accurately mapping vegetation using remote sensing, it is extremely difficult to track woody encroachment into this community over large geographic areas. Likewise, having more detailed data on grazing history and intensity would greatly improve assessing the overall condition of this community type. Both of these factors are reported to be extremely important for this community, but data do not exist to reliably assess and map their impacts.

Change agents affecting this ecological system covered in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Removal, Fires, and Insects and Disease. Mechanical removal or disturbance of this community can also promote invasive grasses that can alter the system significantly. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where current inter-mountain basins montane sagebrush steppe may be under significant climate stress.

References Cited

Anderson, J.E., and R.S. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of sagebrush steppe over 45 years*. Ecological Monographs* 71:531–556.

Blaisdell, J. P. 1953. Ecological effects of planned burning sagebrush-grass range on the upper Snake River Plains. Technical Bulletin #1075, U.S. Department of Agriculture, Washington, D.C. 34 pp.

Gates, D. H. 1964. Sagebrush infested by leaf defoliating moth. *Journal of Range Management* 17:209–210.

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Hormay, A.L. 1970. Principles of rest-rotation grazing and multiple-use land management. USDI/USDA Handbook. 25 pp.

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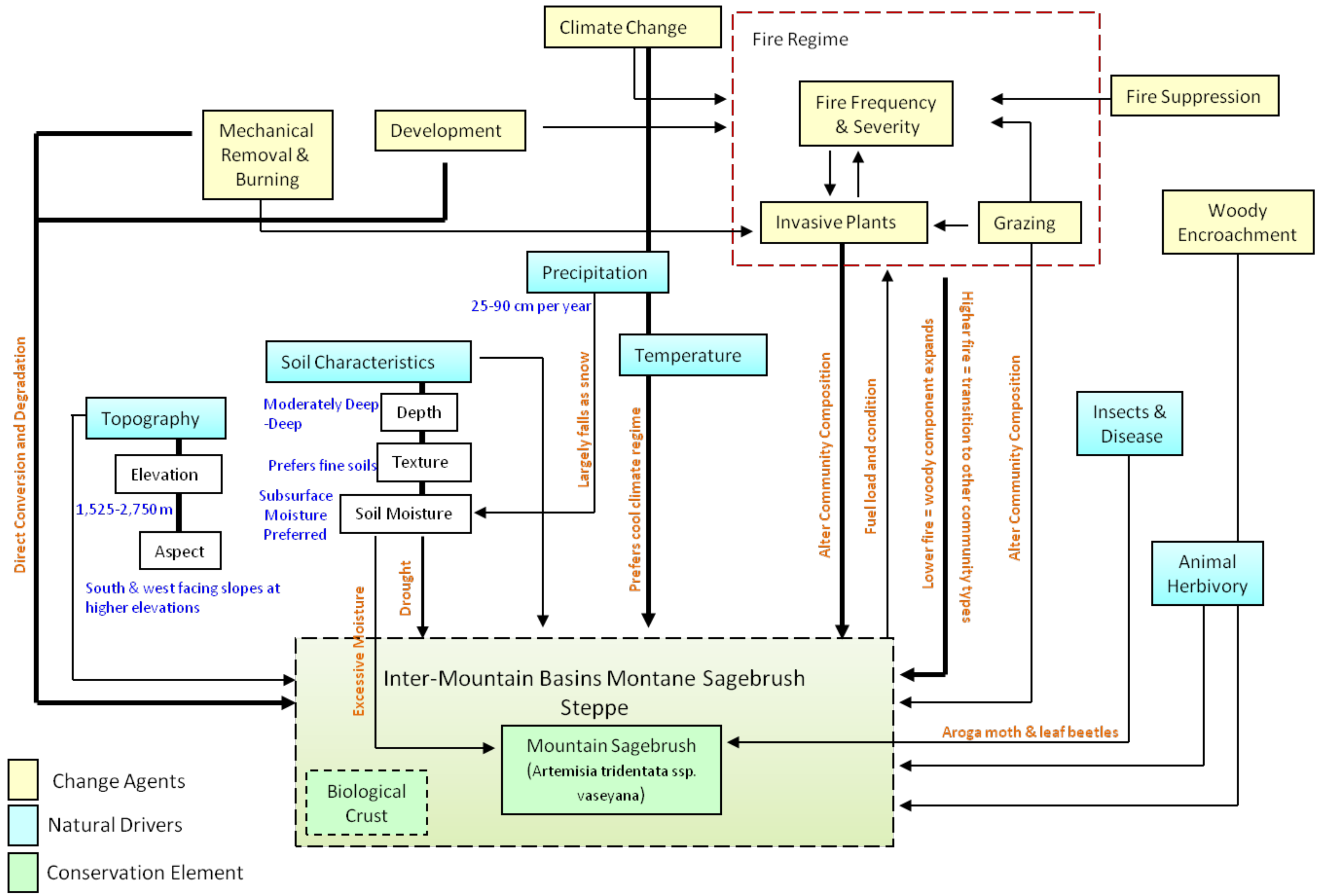
NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, VA.

Pringle, W.L. 1960. The effect of a leaf feeding beetle on big sagebrush in British Columbia. *Journal of Range Management* 13:139–142.

Sturges, D.L., and D.L. Nelson. 1986. Snow depth and incidence of a snowmold disease on mountain big sage. Symposium on the Biology of *Artemisia* and *Chrysothamnus*. July 9–13, 1984, Provo, Utah. General Technical Report INT-200, 1986, Intermountain Forestry and Range Experimental Station, Ogden, Utah.

Tart, D.L. 1996. Big sagebrush plant associations of the Pinedale Ranger District, Pinedale, Wyoming. U.S. Forest Service, Bridger-Teton National Forest, Jackson, Wyoming. 97 pp.

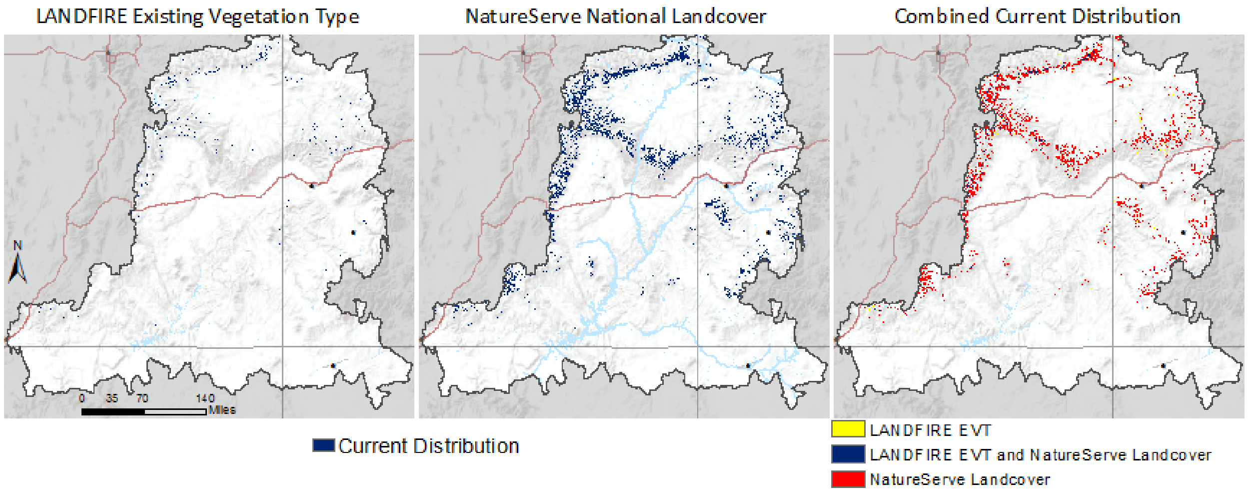


Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Inter-Mountain Basins Montane Sagebrush Steppe and what is its status?

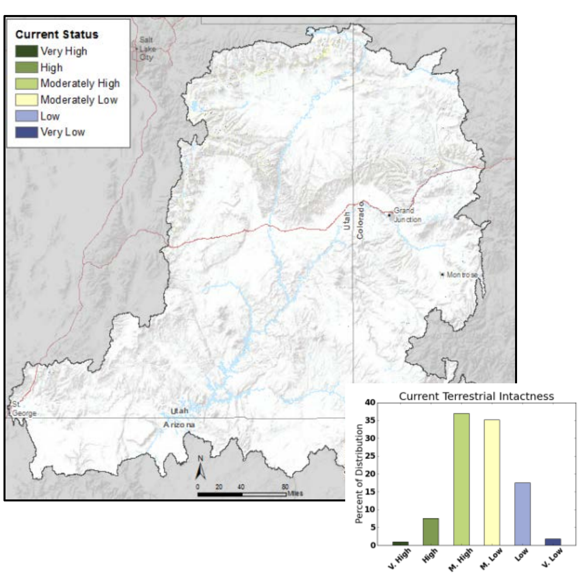
Distribution



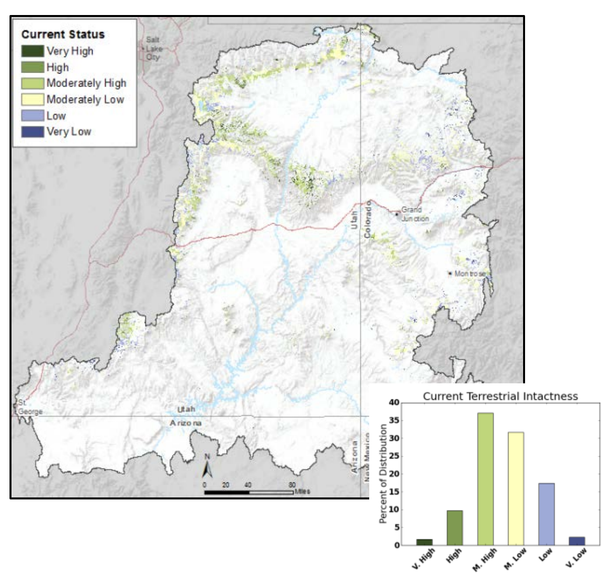
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Inter-Mountain Basins Montane Sagebrush Steppe	61,215	1,550,837	115,313	6.68

Status

LANDFIRE

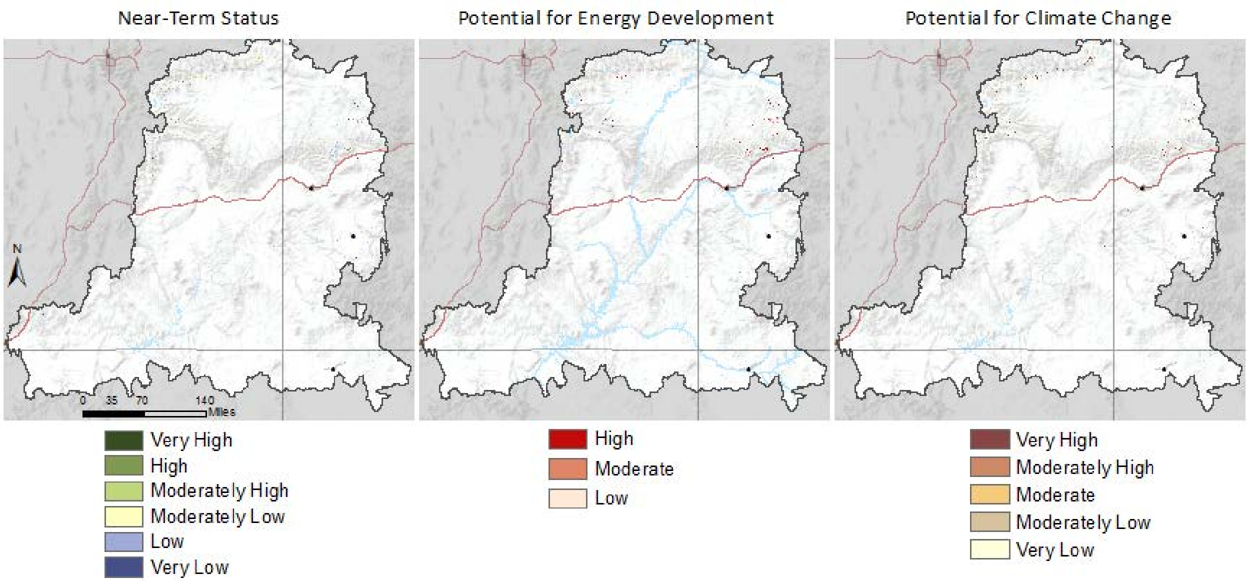


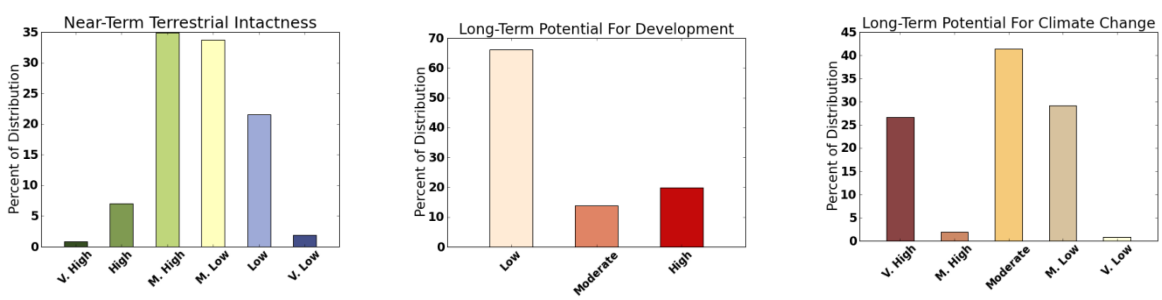
NatureServe



MQ C2. Where is Inter-Mountain Basins Montane Sagebrush Steppe vulnerable to change agents in the future?

LANDFIRE

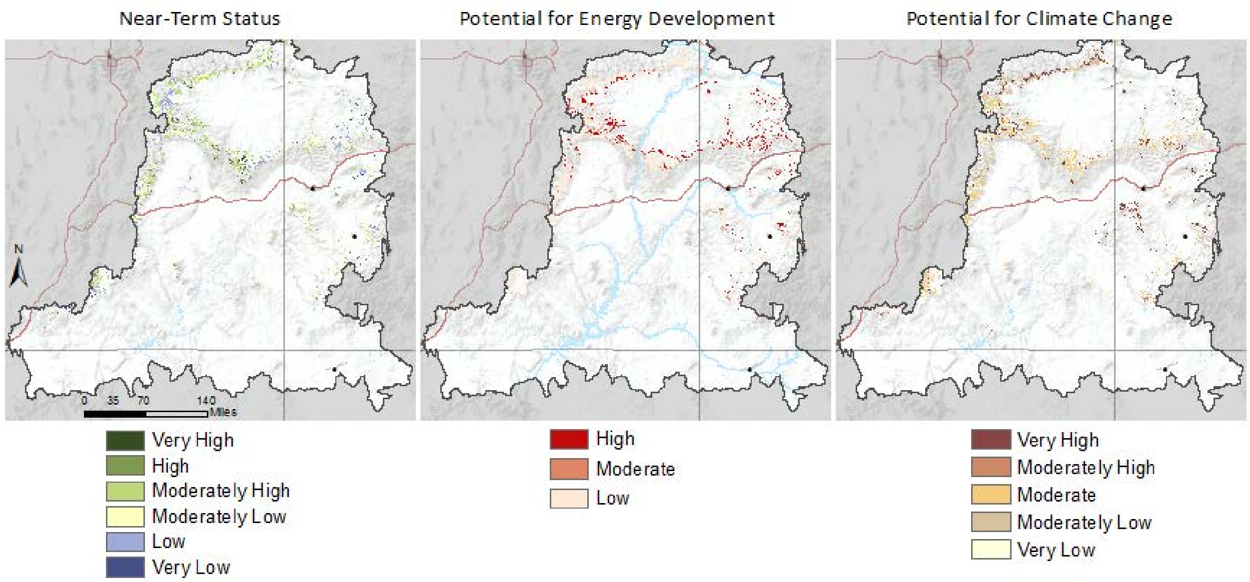


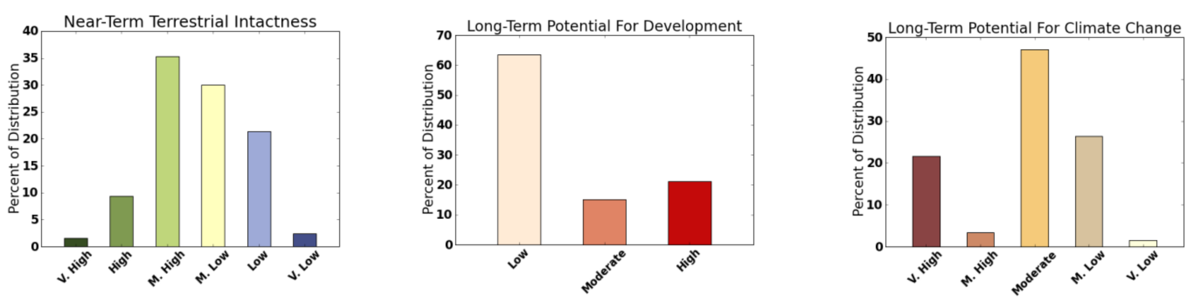


2025 Long Term Maximum Potential 2060

MQ C2. Where is Inter-Mountain Basins Montane Sagebrush Steppe vulnerable to change agents in the future?

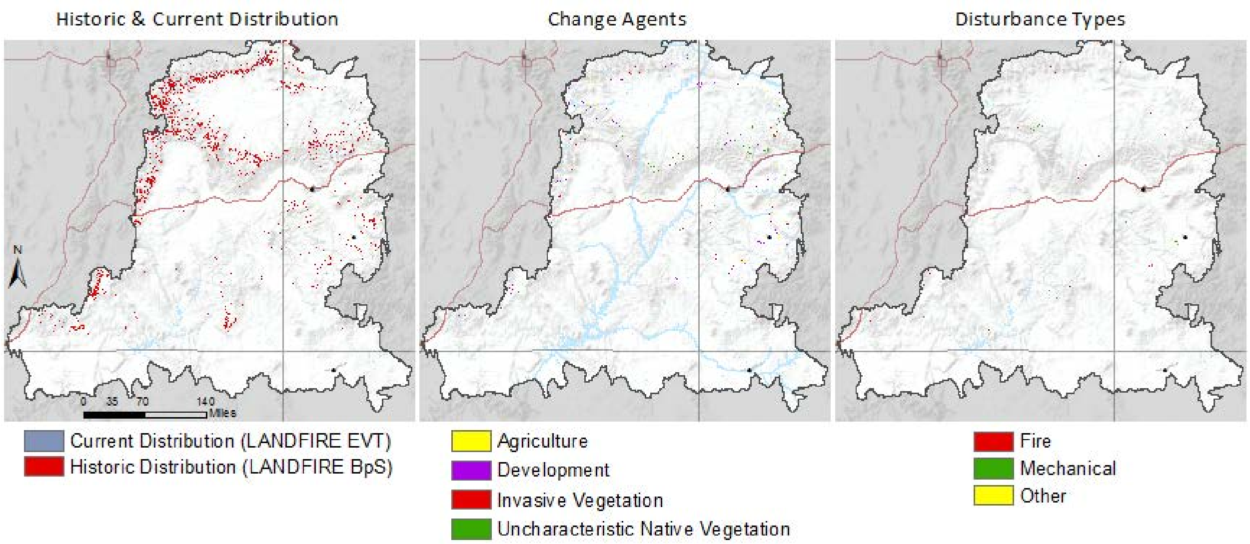
NatureServe





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Inter-Mountain Basins Montane Sagebrush Steppe?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
1,029,623	77,252	17,870	26,342	38,314	159,778	15.52%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
1,029,623	28,507	13,877	235	42,619	4.14%

Rocky Mountain Gambel Oak-Mixed Montane Shrubland

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Rocky Mountain Gambel Oak-Mixed Montane Shrubland is a large patch shrubland community occurring along the foothills of the southern Rocky Mountains and the Colorado Plateau. Gambel oak (*Quercus gambelii*) is the signature species forming a broadleaved canopy, sometimes forming dense thickets. Numerous other shrubs and grasses comprise the plant community with an herbaceous layer covering as much as 40% of the area. In this semi-arid system, moisture is usually delivered as winter snow or late fall rains. Plants are adapted to extreme summer and winter temperatures.

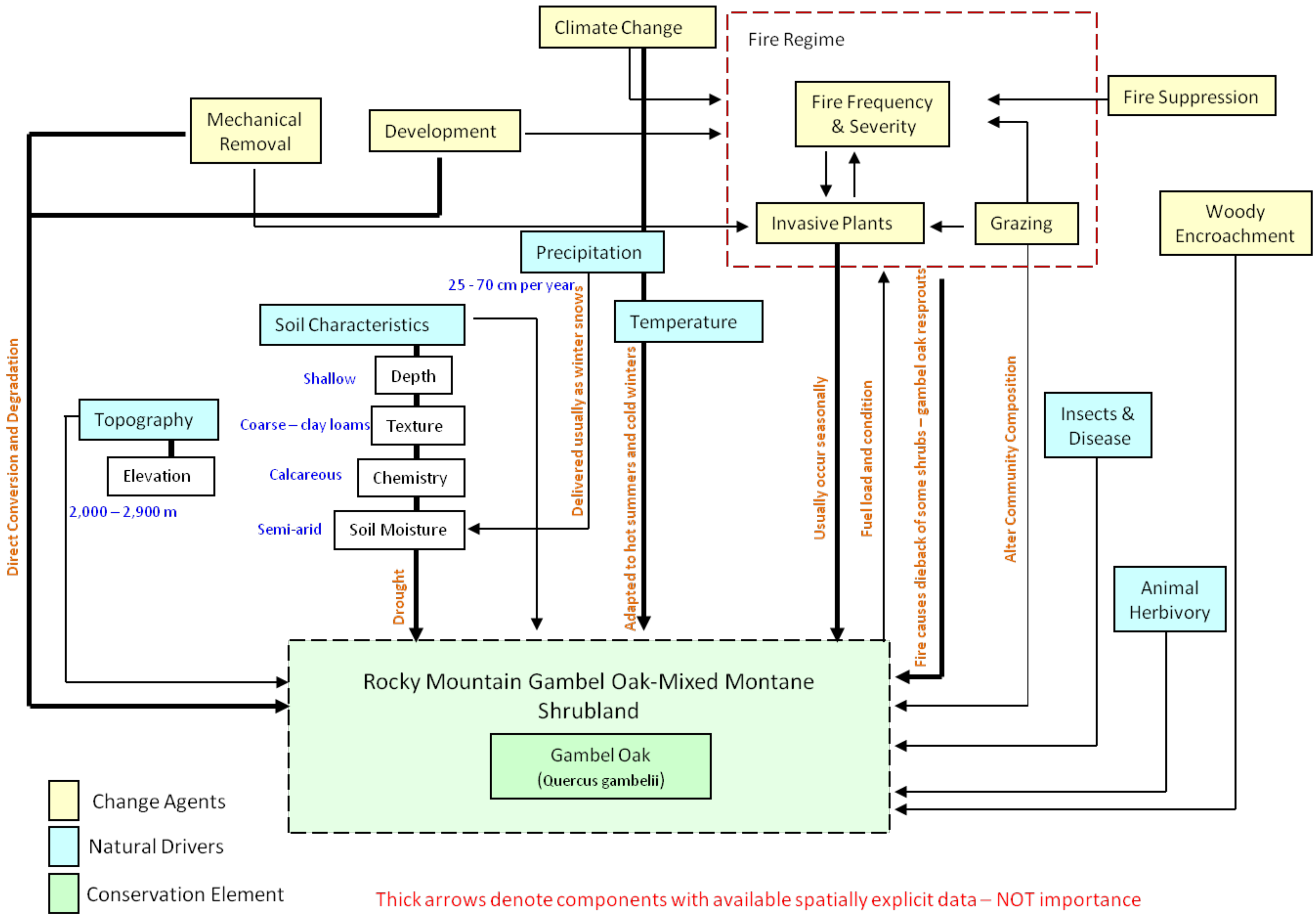
The primary natural disturbance agent is replacement fire, which often results in >75% top kill. Gambel oak responds with extensive sprouting after fire and larger individuals often survive the burn. Mean fire interval for replacement or mixed severity is 35–100 years. Non-native invasive grasses can follow fire, but they are sometimes only expressed seasonally, partially due to the remaining, post-fire resilient woody vegetation. Scale of fire events ranges from 10s to 1,000s of acres (LANDFIRE 2007). More widespread disturbance covering many thousands of acres is the result of periodic, prolonged drought. Livestock grazing occurs in this ecosystem type and management has been used to increase forage for livestock through mechanical treatment followed by goat grazing (Davis et al. 1975). In some areas where disturbance has been absent for long periods, this ecological system can be viewed as a seral stage to more forest species such as Ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor,* NatureServe 2009). Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Mechanical Treatment, Fires, and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS model outputs) were also used to predict where this community may be under significant future climate stress.

References Cited

Davis, G.G., L.E. Bartel, and C.W. Cook. 1975. Control of gambel oak sprouts by goats. Journal of Rangeland Management 28(3): 216-218.

LANDFIRE Biophysical Setting Model. September 2007.

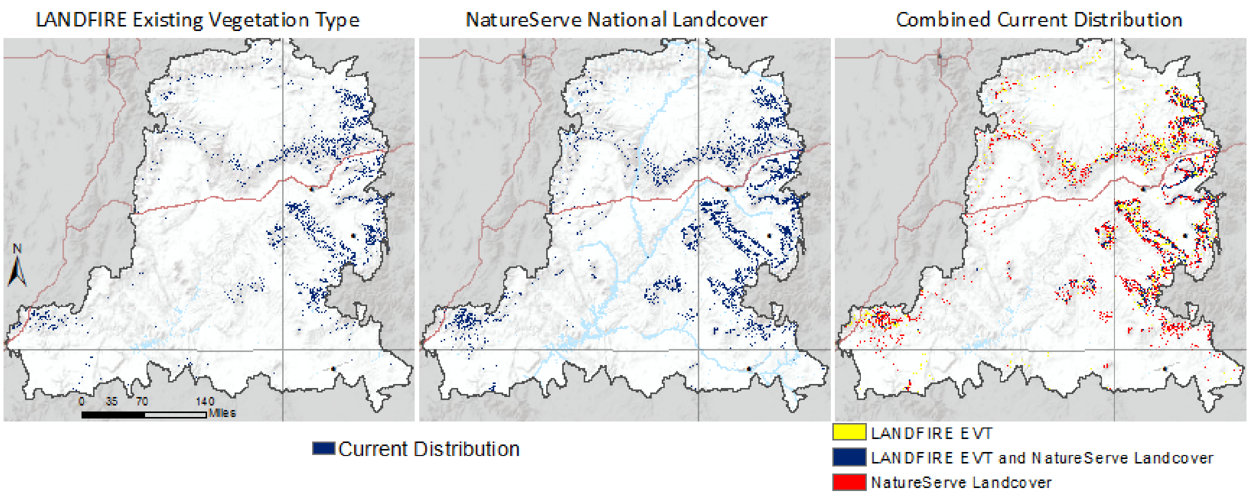
NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, VA.


Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Mechanical Removal
Development
Invasive Plants
Grazing
Woody Encroachment
Precipitation
25 - 70 cm per year
Temperature
Soil Characteristics
Shallow
Depth
Coarse – clay loams
Texture
Calcareous
Chemistry
Semi-arid
Soil Moisture
Topography
Elevation
2,000 – 2,900 m
Direct Conversion and Degradation
Delivered usually as winter snows
Adapted to hot summers and cold winters
Drought
Usually occur seasonally
Fuel load and condition
Fire causes dieback of some shrubs – gambel oak resprouts
Alter Community Composition
Insects & Disease
Animal Herbivory
Rocky Mountain Gambel Oak-Mixed Montane Shrubland
Gambel Oak
(Quercus gambelii)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Rocky Mountain Gambel Oak-Mixed Montane Shrubland and what is its status?

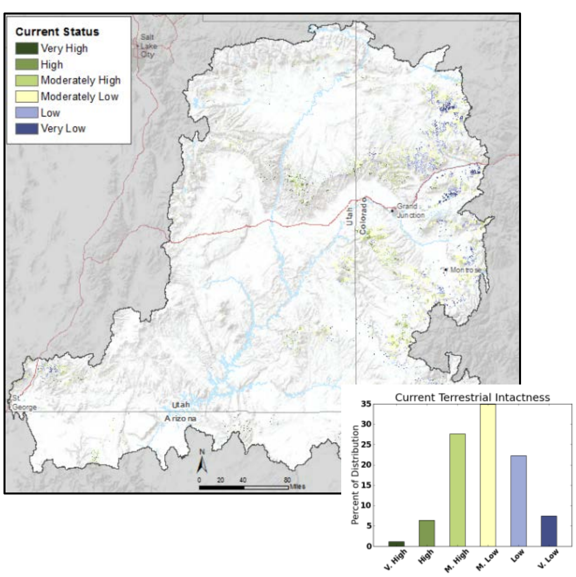
Distribution



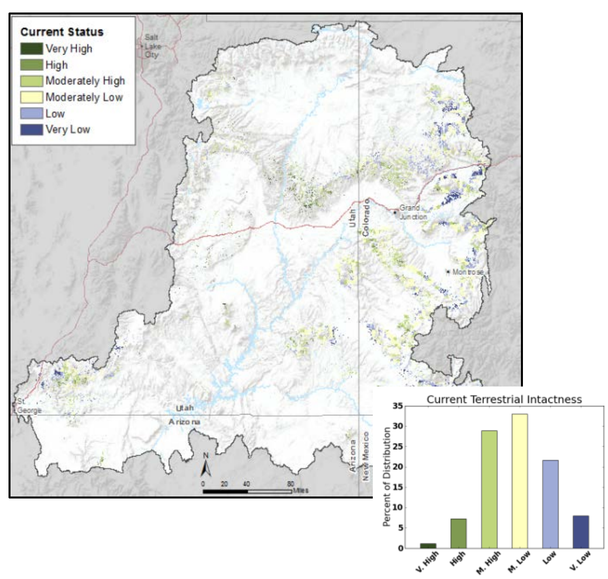
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	633,644	1,423,998	659,513	24.27

Status

LANDFIRE

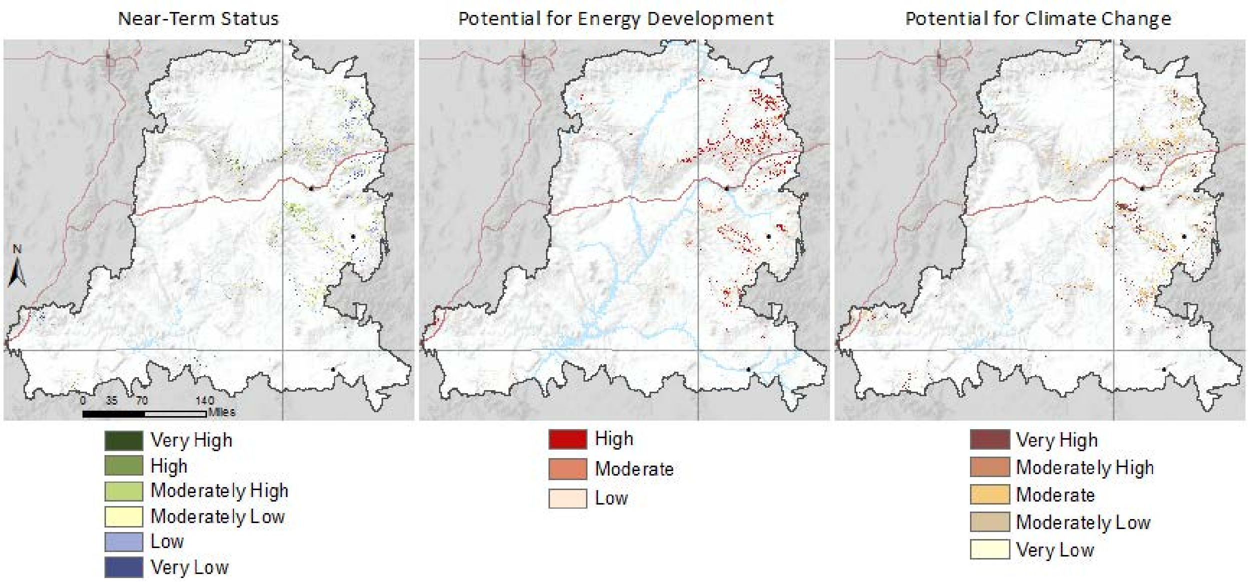


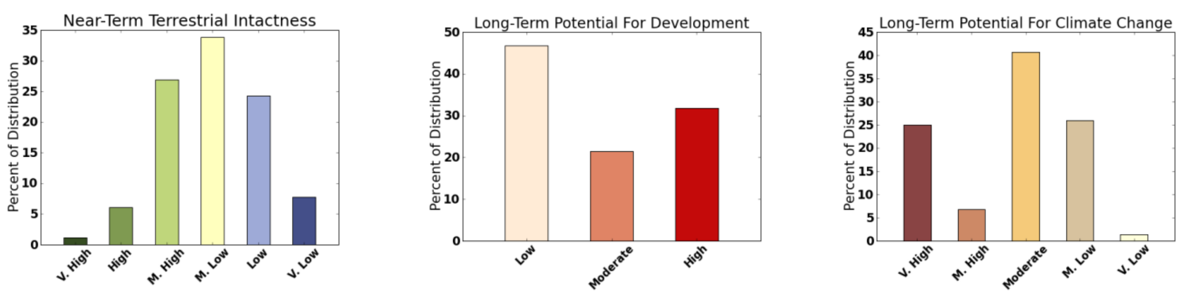
NatureServe



MQ C2. Where is Rocky Mountain Gambel Oak-Mixed Montane Shrubland vulnerable to change agents in the future?

LANDFIRE

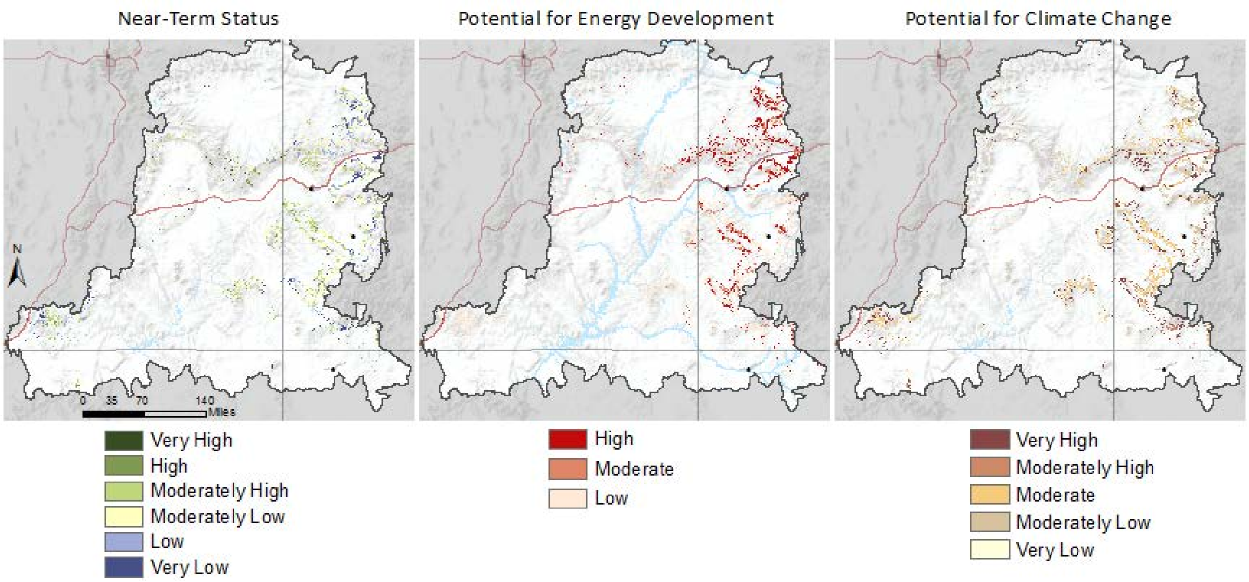


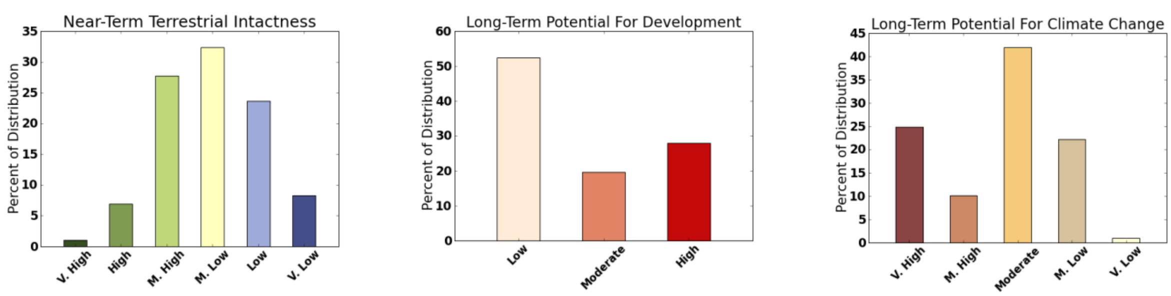


2025 Long Term Maximum Potential 2060

MQ C2. Where is Rocky Mountain Gambel Oak-Mixed Montane Shrubland vulnerable to change agents in the future?

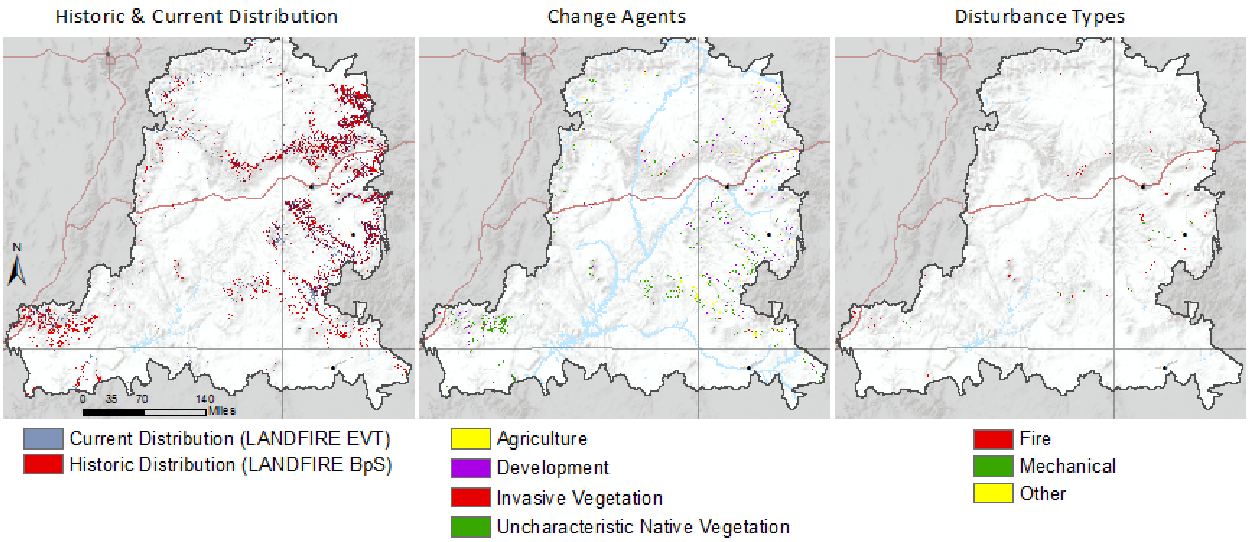
NatureServe





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Rocky Mountain Gambel Oak-Mixed Montane Shrubland?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
2,038,543	130,616	89,257	29,209	335,467	584,549	28.67%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
2,038,543	75,484	31,272	1,233	107,989	5.30%

Conceptual Model

There are six primary natural drivers (cyan boxes) for this ecological system including topography, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Colorado Plateau Blackbrush-Mormon-Tea Shrubland is an extensive dry, open shrubland found at lower elevations and usually dominated by blackbrush (*Coleogyne ramosissima*). An herbaceous layer is sparse covering <15% of the surface area. Topographic breaks dissect the landscape separating vegetated areas from rocky outcrops and steep canyon walls. Moisture is usually delivered in winter and summer storm events and prolonged droughts are common. Plants are adapted to extreme summer and winter temperatures.

Mean fire interval is approximately 75 years with high variability due to weather extremes. High fire years are correlated with high spring moisture when ground fuels build up. Blackbrush is fire intolerant and is extremely slow to recover after fire. Native species richness and cover typically decreases after fire throughout this ecosystem (Brooks and Matchett 2003). Non-native invasive grasses often follow fire throughout this ecosystem and change the fire regime significantly. Scale of fire events ranges from 10s to 100s of acres (LANDFIRE 2007).

More widespread disturbance covering many thousands of acres is the result of periodic, prolonged drought. Livestock grazing occurs in this ecosystem type, but with marginal forage value, especially in dry periods, grazing is not a major factor.

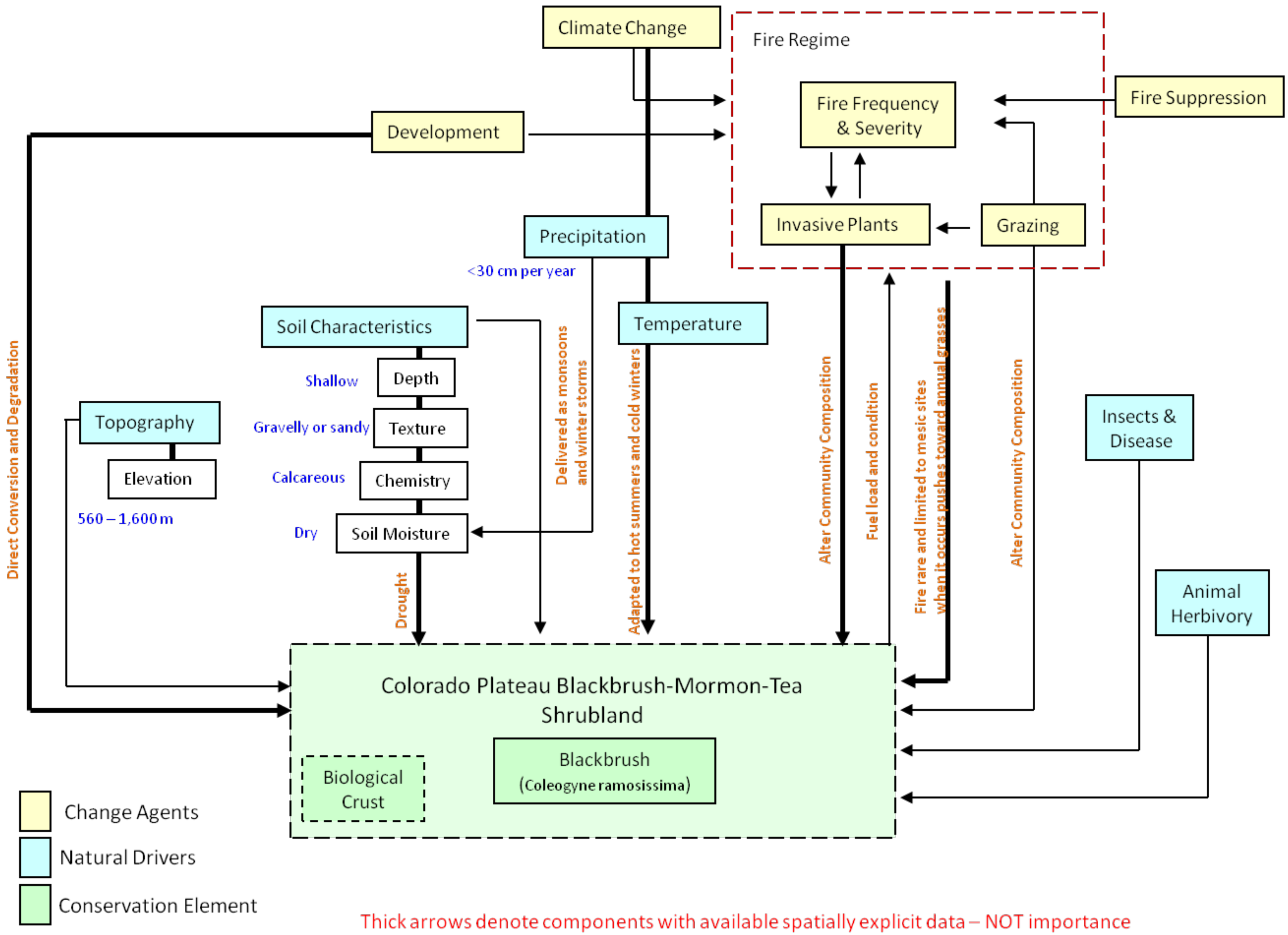
Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Fires and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where current Colorado Plateau Blackbrush-Mormon-Tea Shrubland may be under significant climate stress.

References Cited

Brooks, M.L., and J.R. Matchett. 2003. Plant community patterns in unburned and burned blackbrush (*Coleogyne ramosissima*) shrublands in the Mojave Desert. *Western North American Naturalist* 63(3): 283–298.

LANDFIRE Biophysical Setting Model. September 2007.

NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, VA.

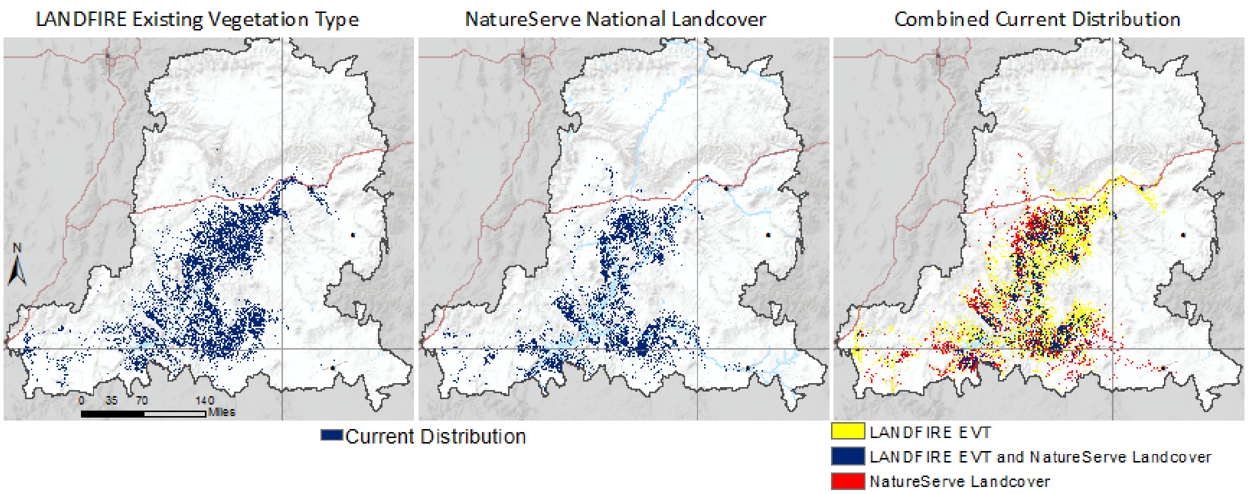


Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Development
Invasive Plants
Grazing
Precipitation
<30 cm per year
Soil Characteristics
Temperature
Shallow
Depth
Gravelly or sandy
Texture
Calcareous
Chemistry
Dry
Soil Moisture
Topography
Elevation
560 – 1,600 m
Direct Conversion and Degradation
Delivered as monsoons and winter storms
Adapted to hot summers and cold winters
Alter Community Composition
Fuel load and condition
Fire rare and limited to mesic sites when it occurs pushes toward annual grasses
Alter Community Composition
Insects & Disease
Animal Herbivory
Drought
Colorado Plateau Blackbrush-Mormon-Tea Shrubland
Biological Crust
Blackbrush (Coleogyne ramosissima)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Colorado Plateau Blackbrush-Mormon-Tea Shrubland and what is its status?

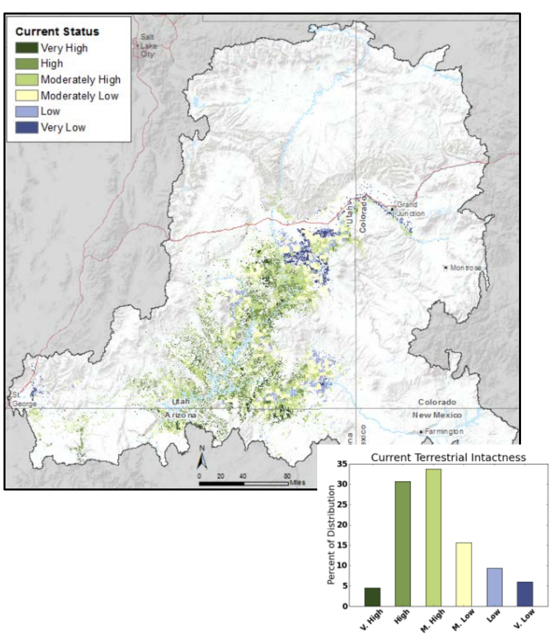
Distribution



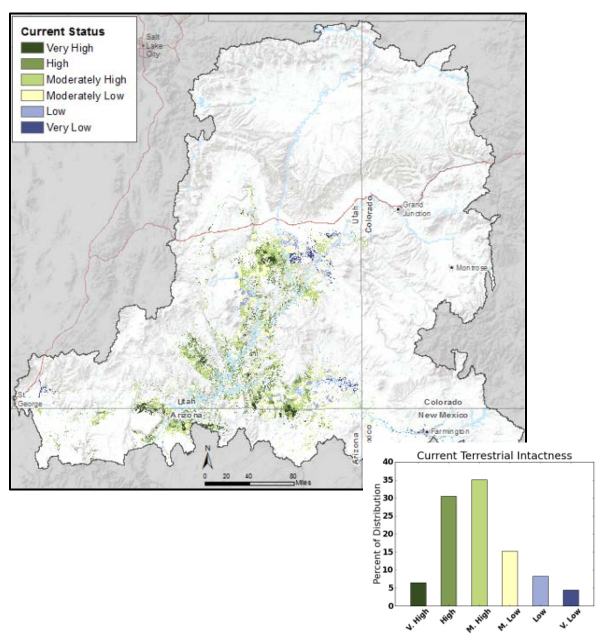
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Colorado Plateau Blackbrush-Mormon-Tea Shrubland	2,568,289	1,293,367	1,459,961	27.43

Status

LANDFIRE

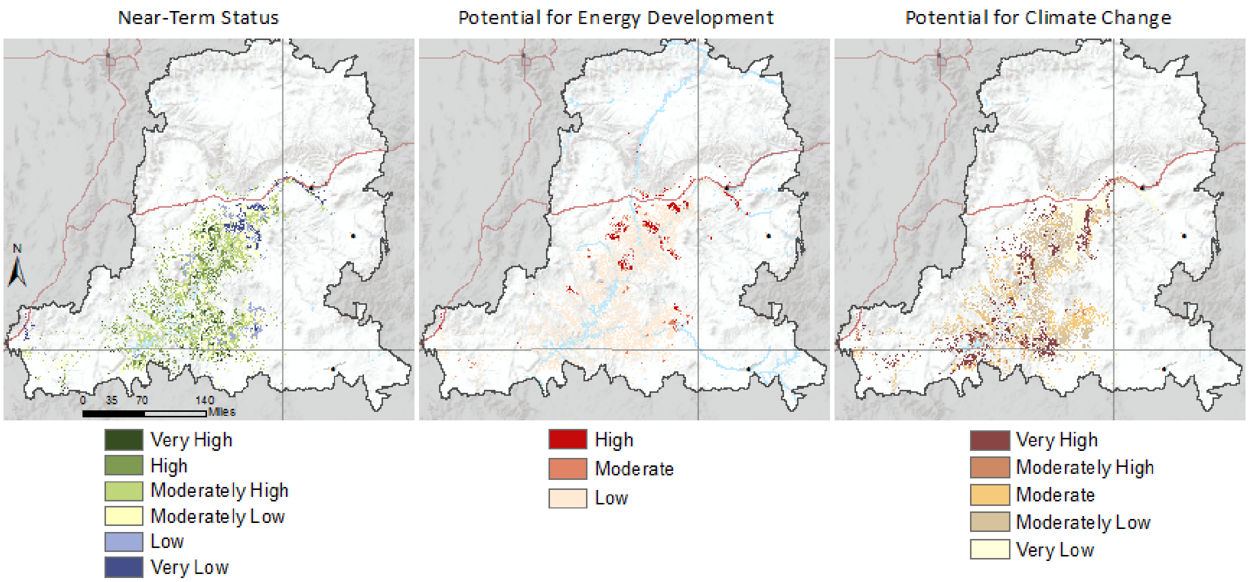


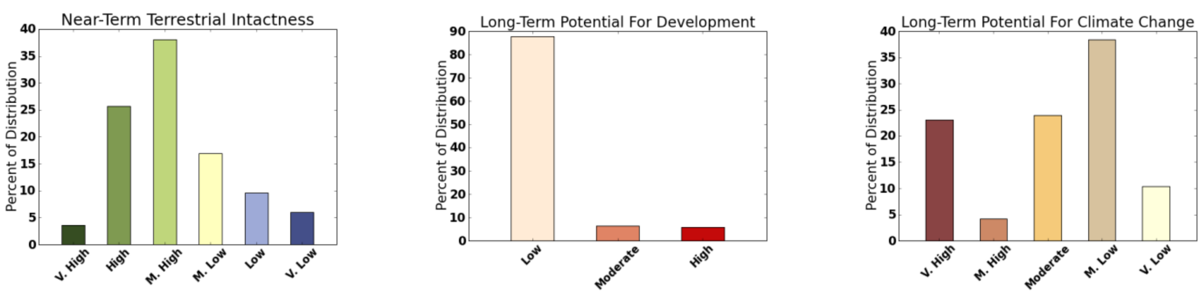
NatureServe



MQ C2. Where are Colorado Plateau Blackbrush-Mormon-Tea Shrublands vulnerable to change agents in the future?

LANDFIRE

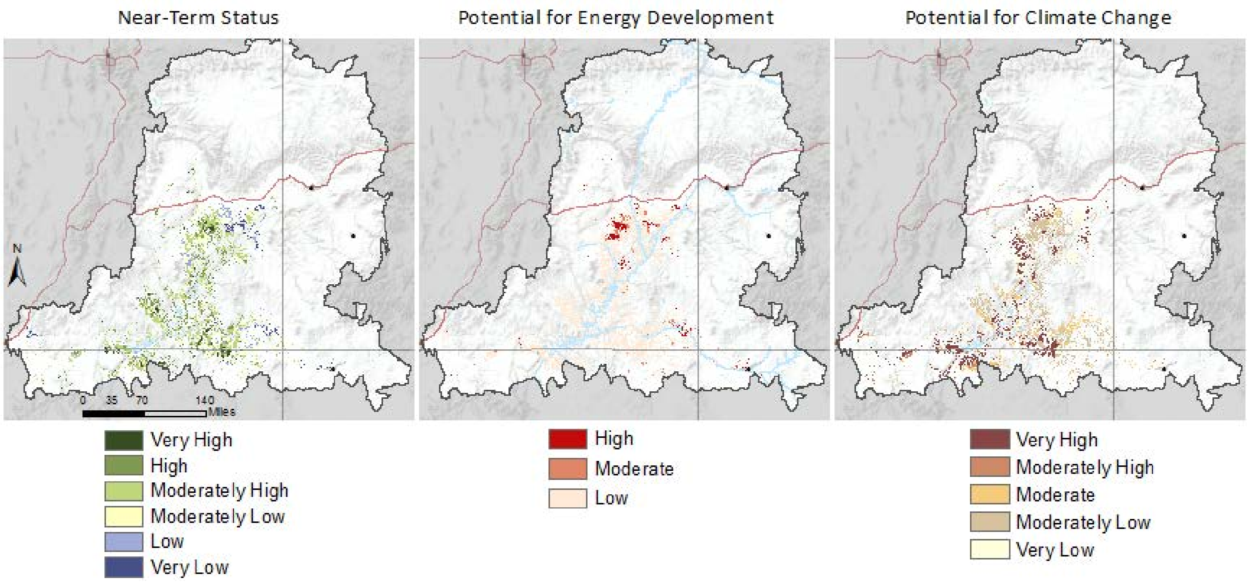


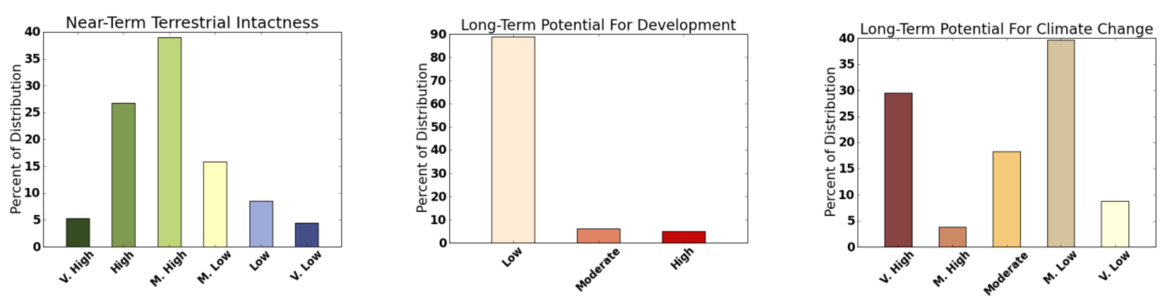


2025 Long Term Maximum Potential 2060

MQ C2. Where are Colorado Plateau Blackbrush-Mormon-Tea Shrublands vulnerable to change agents in the future?

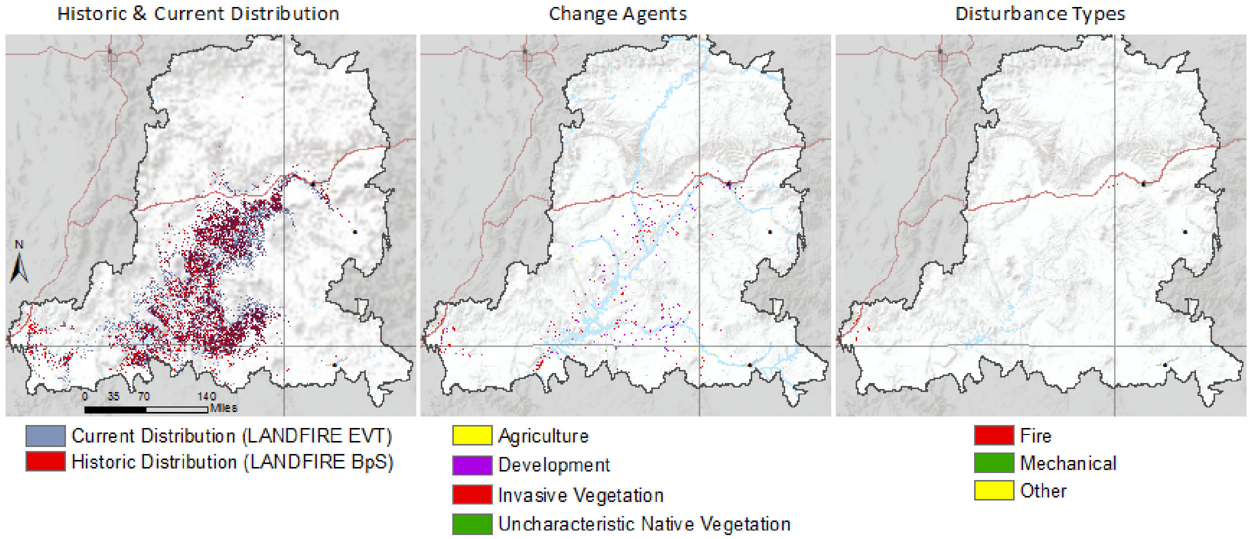
NatureServe





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Colorado Plateau Blackbrush-Mormon-Tea Shrublands?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
3,123,911	132,459	3,624	176,205	6,511	318,799	10.21%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
3,123,911	9,396	1,716	0	11,112	0.36%

Conceptual Model

There are seven primary natural drivers (cyan boxes) for this ecological system including topography, erosion, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Inter-Mountain Basins Mixed Salt Desert Scrub is a compositionally dynamic desert community that occurs at lower elevations throughout the Colorado Plateau. Depending on recent environmental conditions, the species composition and vegetation structure can change from year-to-year and from season-to-season. Some areas will be dominated by a single species (e.g. shadscale [*Atriplex confertifolia*]) while others contain higher species richness.

Vegetation is generally sparse with large open spaces between plants (Blaisdell and Holmgren 1984). Open spaces are typically covered with a biological crust (West 1982). While it is a desert community, wetter periods (usual occurring in the winter in the form of snow) will favor grass species the following spring and drier periods will favor shrubs. Excessive and prolonged drought will create declines in most plant species.

Fires are not a common disturbance agent in this community because of the low vegetative biomass. Only on more mesic sites can biomass accumulate enough to carry a fire; in these areas, mixed severity fire occurs every 500–1,000 years (LANDFIRE 2007). A more regular fire regime can get established in locations where invasive grasses have become established from disturbance and favorable growing conditions.

More common disturbance agents include periodic flooding from extreme weather events, erosion from wind and water to create badlands, and insect outbreaks such as Mormon cricket/grasshopper outbreaks. Scale of disturbance ranges from local to large geographic extents. Livestock grazing occurs in this ecosystem type, but with its marginal forage value, especially in dry periods, grazing is not a major factor.

Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover) and recent disturbance (1999–2008) from Fires and Insects and Disease. Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where current inter-mountain basins mixed salt desert scrub may be under significant climate stress.

References Cited

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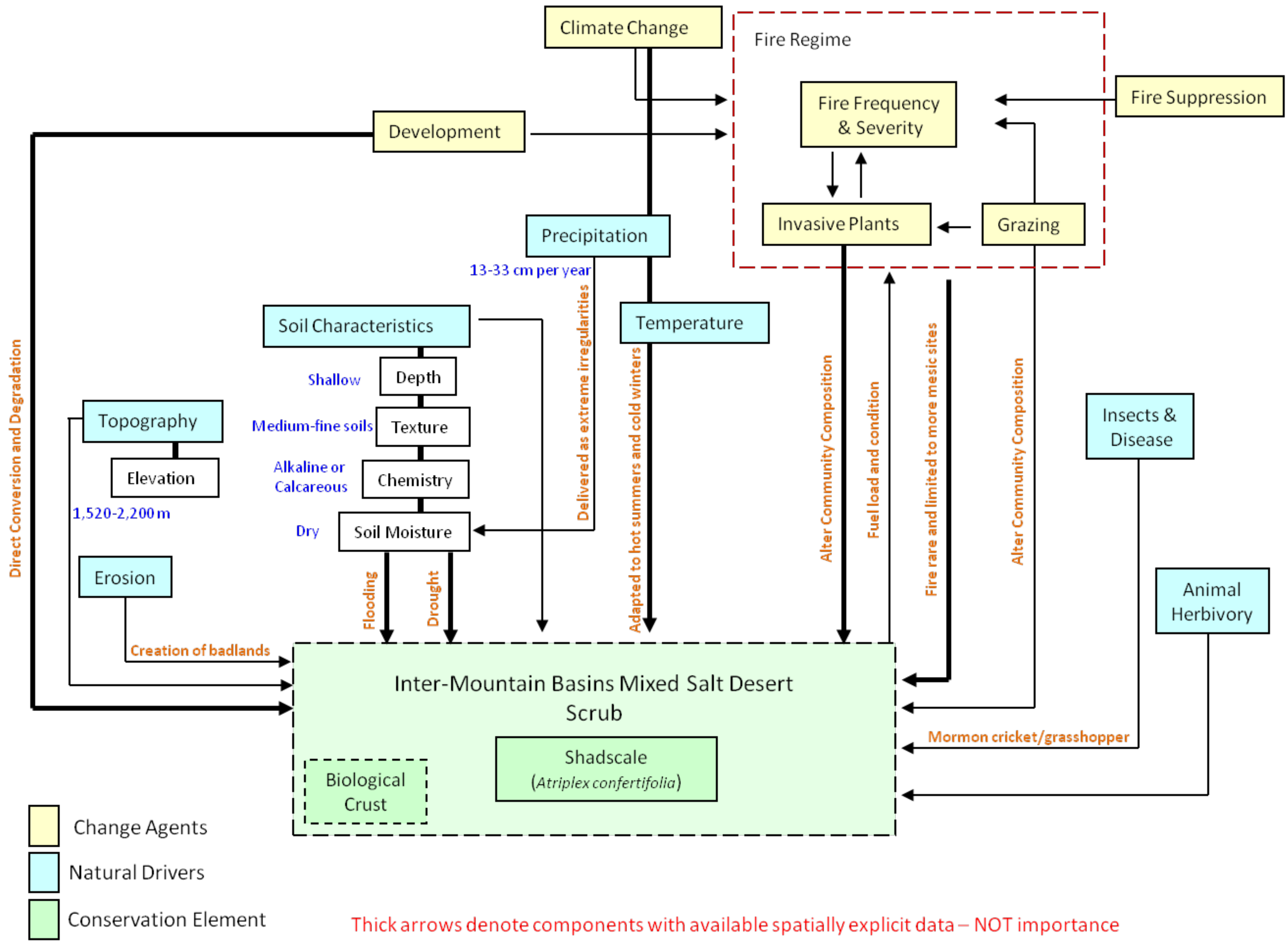
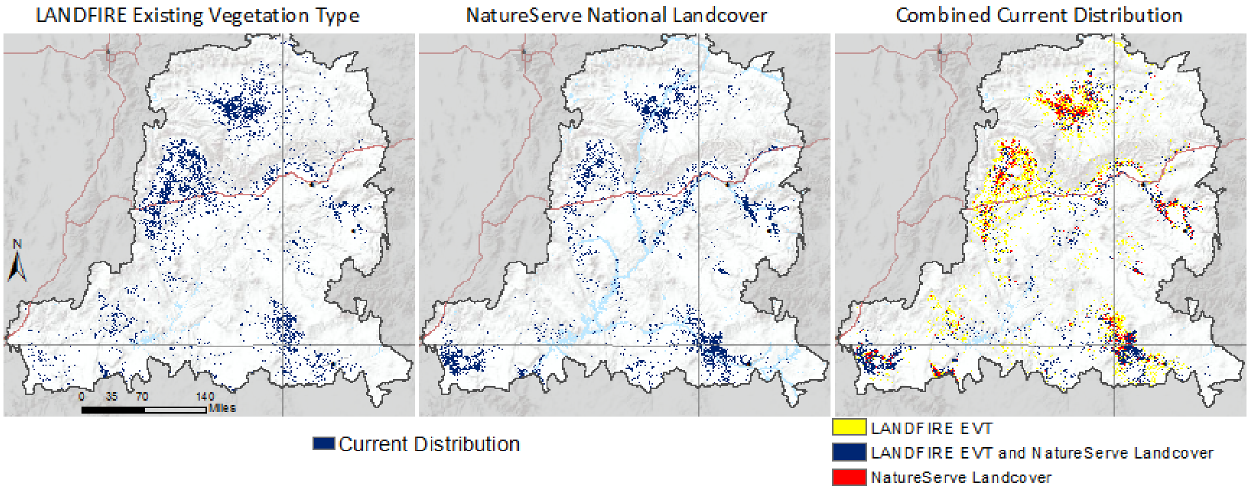
Photo: Head of Sinbad, San Rafael Swell. Bureau of Land Management.


Climate Change
Fire Regime
Fire Frequency & Severity
Fire Suppression
Development
Invasive Plants
Grazing
Precipitation
13-33 cm per year
Soil Characteristics
Temperature
Delivered as extreme irregularities
Adapted to hot summers and cold winters
Alter Community Composition
Fuel load and condition
Fire rare and limited to more mesic sites
Alter Community Composition
Shallow
Depth
Medium-fine soils
Texture
Alkaline or Calcareous
Chemistry
Dry
Soil Moisture
Topography
Elevation
1,520-2,200 m
Erosion
Direct Conversion and Degradation
Insects & Disease
Animal Herbivory
Flooding
Drought
Creation of badlands
Inter-Mountain Basins Mixed Salt Desert Scrub
Biological Crust
Shadscale (*Atriplex confertifolia*)
Mormon cricket/grasshopper
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

Results

MQ C1. Where is existing Inter-Mountain Basins Mixed Salt Desert Scrub and what is its status?

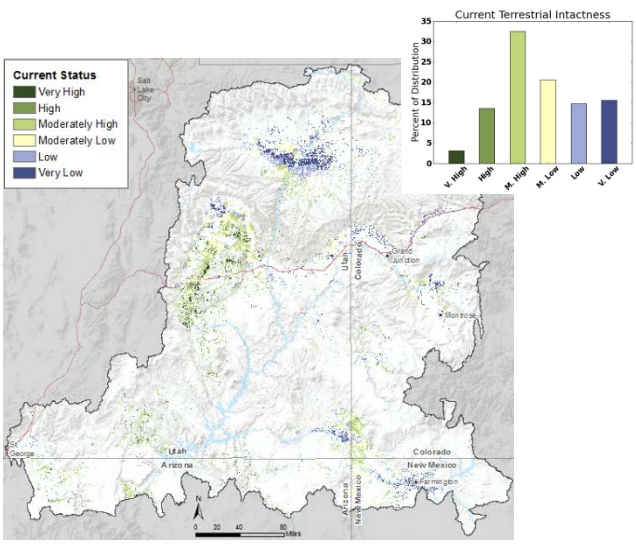
Distribution



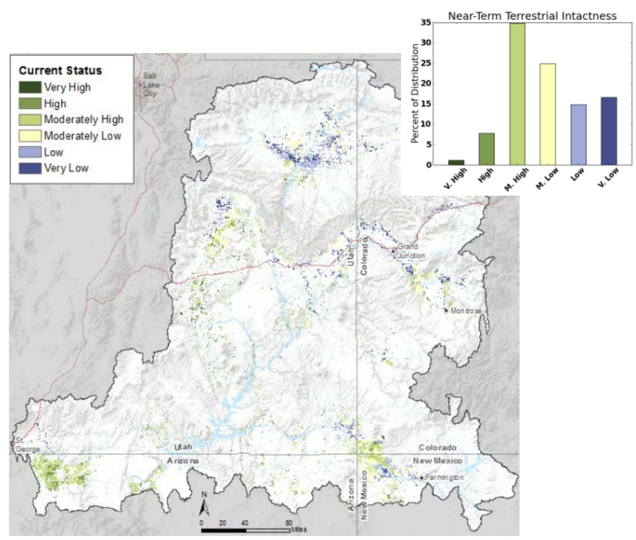
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Inter-Mountains Basins Mixed Salt Desert Scrub	1,964,350	1,645,308	680,837	15.87

Status

LANDFIRE

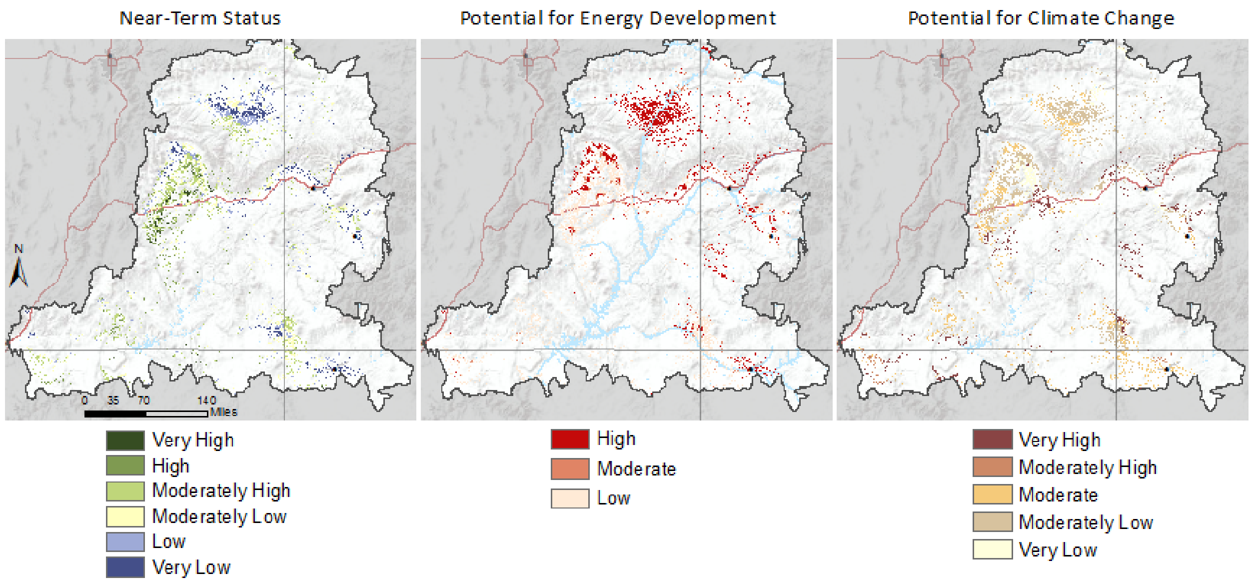


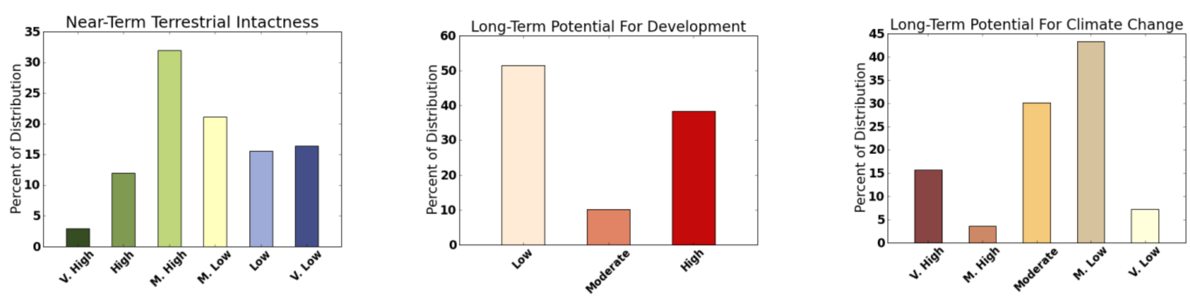
NatureServe



MQ C2. Where is Inter-Mountain Basins Mixed Salt Desert Scrub vulnerable to change agents in the future?

LANDFIRE





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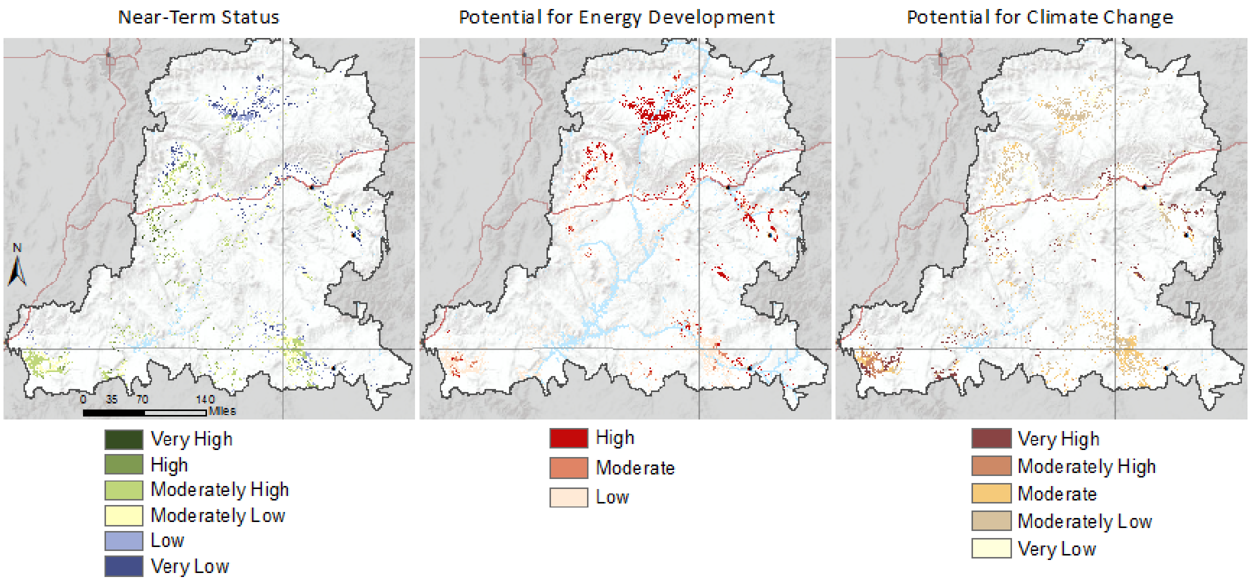
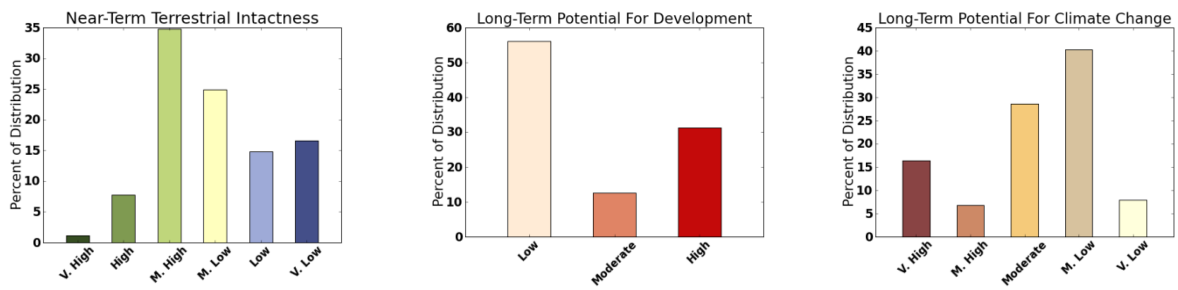
MQ C2. Where is Inter-Mountain Basins Mixed Salt Desert Scrub vulnerable to change agents in the future?

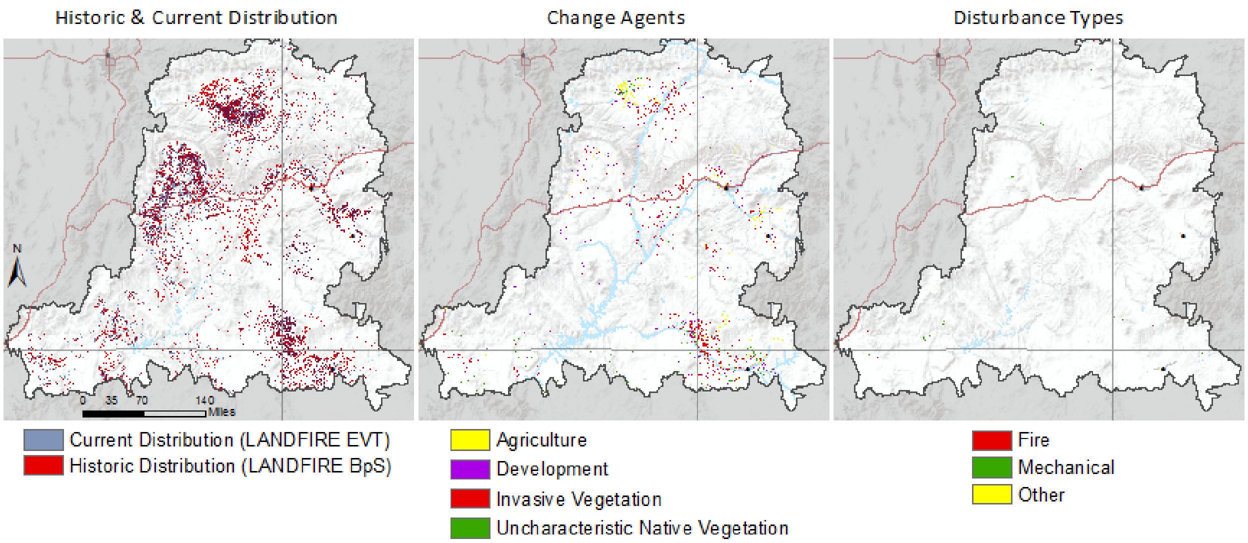
NatureServe





2025 Long Term Maximum Potential 2060

MQC3. What change agents have affected Inter-Mountain Basins Mixed Salt Desert Scrub?



Historic Change Agents

Total BpS Area	Urban & Roads	Agriculture	Invasives	Unchar Native Veg	Total Changed	Percent
3,155,282	178,112	109,125	402,992	117,076	807,305	25.59%

Recent Disturbance

Total BpS Area	Fire	Mechanical	Other	Total Disturbed	Percent
3,155,282	5,694	15,176	9	20,879	0.66%

Colorado Plateau Mixed Bedrock Canyon and Tablelands

Conceptual Model

There are seven primary natural drivers (cyan boxes) for this ecological system including topography, erosion, soil characteristics, precipitation, temperature, insects and disease, and animal herbivory. Specific details on the various environmental conditions characterizing this system (blue text) are provided by NatureServe (2009) and LANDFIRE (2007).

Colorado Plateau Mixed Bedrock Canyon and Tableland is a matrix community of the Colorado Plateau that is sparsely vegetated (<10% cover). Littleleaf Mountain Mahogany (*Cercocarpus intricatus*) is the signature species growing in scattered crevices across the dominating rocky substrate. When shrub and herbaceous layers exist at all, they are comprised of drought tolerant species that cover very limited areas. Classified as a semi-arid system, the canyonlands and tablelands receive moisture usually as winter snow. Plants are adapted to extreme summer and winter temperatures. Because of the harsh environment and geographic isolation, this ecological system is noted for its high levels of species endemism, especially in the forbs class (NatureServe 2009).

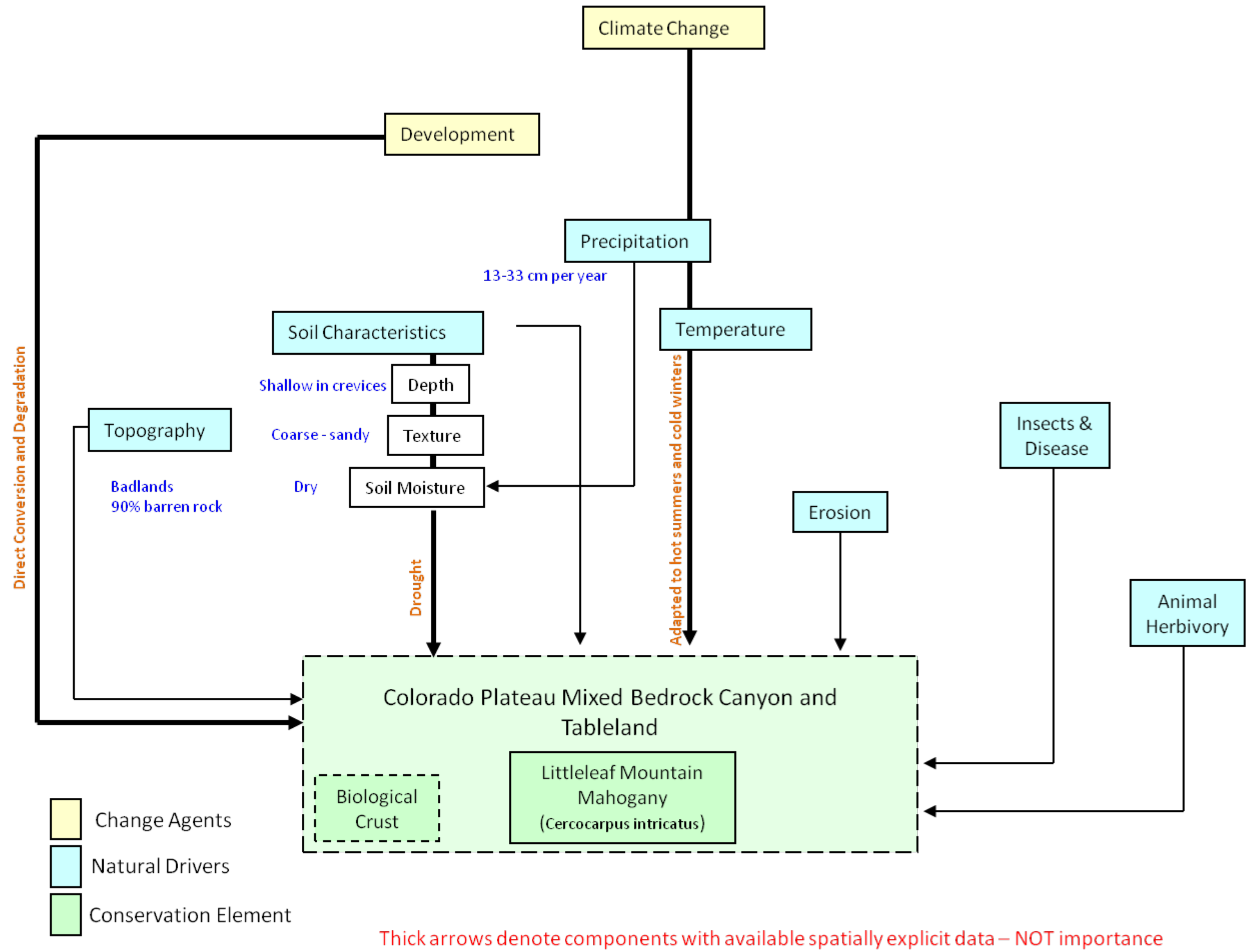
This ecological system is most frequently disturbed by erosion and freeze-thaw cycles on south-facing slopes. Fires are infrequent and do not play an important role.

Change agents affecting this ecological system accounted for in the REA process include Development (based on current and projected future extent of urban land cover). Overall landscape intactness, which includes development from all sources (urban, agriculture, energy, and roads), invasive species, and habitat fragmentation, is used to describe the regional environment that contains this ecosystem type. Climate change projections (including precipitation and temperature changes as well as MAPSS modeling outputs) are also used to predict where the current Colorado Plateau Mixed Bedrock Canyon and Tableland may be under significant climate stress.

References Cited

LANDFIRE Biophysical Setting Model. September 2007.

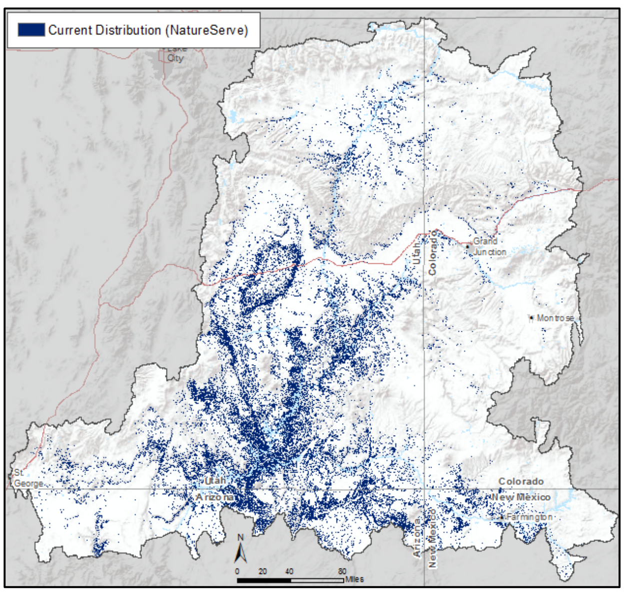
NatureServe. 2009. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Database. Arlington, VA.


Climate Change
Development
Precipitation
13-33 cm per year
Temperature
Soil Characteristics
Shallow in crevices
Depth
Coarse - sandy
Texture
Dry
Soil Moisture
Topography
Badlands
90% barren rock
Direct Conversion and Degradation
Drought
Adapted to hot summers and cold winters
Insects & Disease
Erosion
Animal Herbivory
Colorado Plateau Mixed Bedrock Canyon and Tableland
Biological Crust
Littleleaf Mountain Mahogany
(Cercocarpus intricatus)
Change Agents
Natural Drivers
Conservation Element
Thick arrows denote components with available spatially explicit data – NOT importance

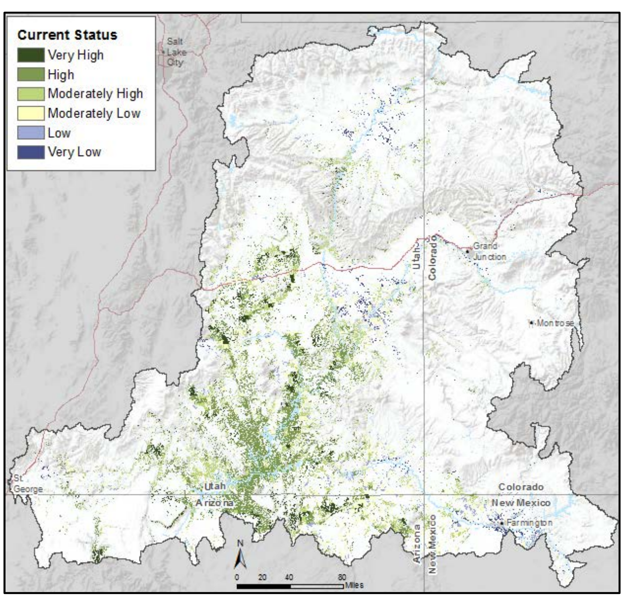
Results

MQ C1. Where is existing Colorado Plateau Mixed Bedrock Canyon and Tableland and what is its status?

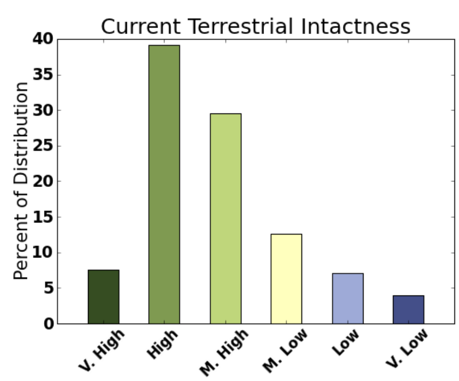
Vegetation Community	LANDFIRE Only (ac)	NatureServe Only (ac)	Both (ac)	Percent Overlap
Colorado Plateau Mixed Bedrock Canyon and Tableland	Not mapped	4,598,445	0	0.00



Distribution



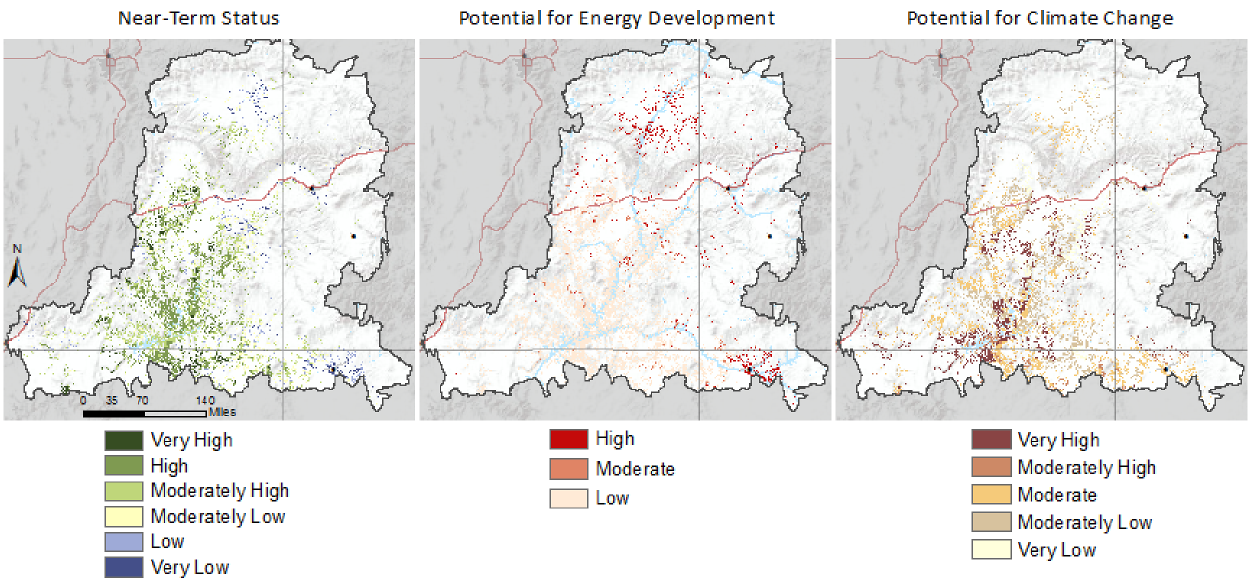
Status

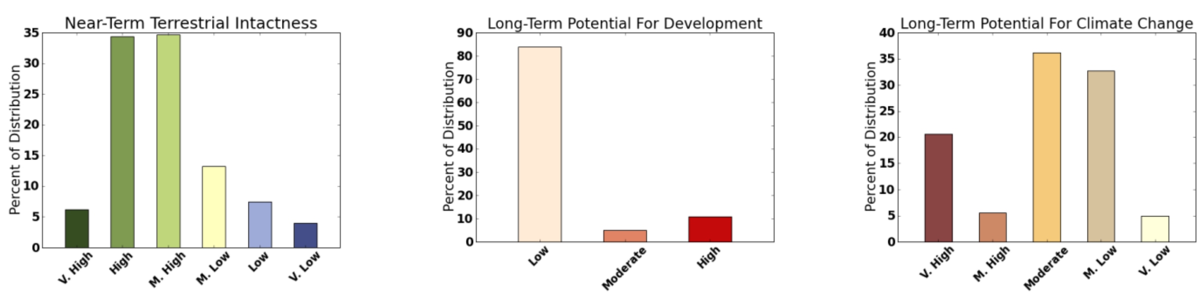


MQ C2. Where are Colorado Plateau Mixed Bedrock Canyon and Tableland vulnerable to change agents in the future?

No LANDFIRE data

NatureServe





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MQC3. What change agents have affected Colorado Plateau Mixed Bedrock Canyon and Tableland?

Not Applicable – BpS data does not exist for this community type

Conceptual Model

Riparian ecological systems have undergone significant physical and biological changes throughout the ecoregion due to numerous factors, including: conversion to other uses; changes in the natural flow regimes and suppression of fluvial processes (Stromberg 2001, Stromberg et al. 2007); livestock grazing (Armour et al. 1994); and invasive species dominance (tamarisk, Horton 1977, Graf 1978, Friedman et al. 2005, Merritt and Poff 2010). As much as 90% of pre-settlement riparian ecosystems have been lost (LUHNA 2011).

There are six primary natural drivers highlighted in the conceptual diagram: groundwater, channel geomorphology and soils, precipitation, temperature, stream hydrology, and animal herbivory. Together these shape the composition, structure, and function of riparian ecosystems.

The yellow boxes in the diagram, which denote the major change agents, impact these drivers in a number of ways. Some development directly converts riparian vegetation to other land uses, especially irrigated agricultural lands in this arid or semi-arid region. Development also affects riparian ecosystems in other ways including drawdown of groundwater lowering the water table, water use and contamination of surface water, and diversion from dams and various water management practices.

The climate regime (precipitation and temperature) regulates the water quantity and delivery to the system. In this ecoregion, moisture tends to be seasonal and flashy, and any significant departure from this pattern can degrade riparian ecosystems.

Fire regime is influenced by a complex interaction of factors—fuel load and condition, grazing, invasive species, and fire frequency (natural, a function of climate, and human-caused, a function of development). In the case of riparian vegetation, the fuel load and condition of surrounding vegetation is as much or more of a factor than the condition of the riparian vegetation itself, which is obviously wetter than surrounding conditions. Fire suppression is another influencing factor on the fire regime. 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.

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 such as willows, because of its reproductive capacity and its tolerance to drought and flooding events (Stevens and Waring 1985, Glenn et al. 1998, Stromberg et al. 2007).

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. The most recent landcover edited by NatureServe was used for the REA assessment to assess current distribution. There was ample data for development, fire, tamarisk, and dams and diversions to assess current and future condition and to address the management questions related to this topic. An aquatic intactness model was also developed to describe the upland impacts to aquatic environments more accurately: the aquatic intactness model can be overlaid against the existing riparian habitat data throughout the ecoregion.

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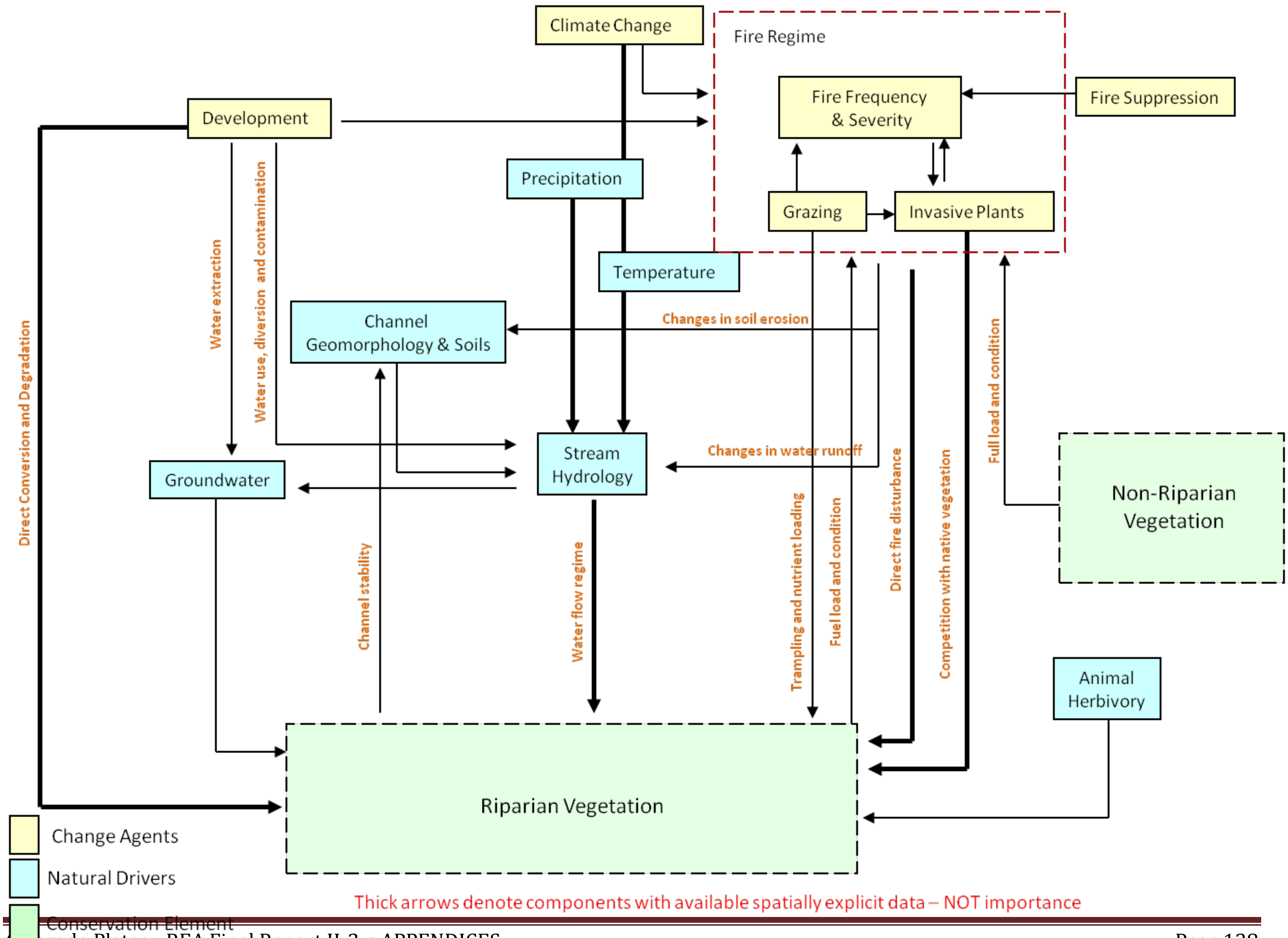
Stevens, L.E., and G.W. Waring. 1985. The effects of prolonged flooding on the riparian plant community in Grand Canyon. Pages 81–86 *in* Johnson, R.R., C.D. Ziebell, D.R. Patten, P.F. Ffolliot, and R.H. Hamre (eds.), Riparian ecosystems and their management: Reconciling conflicting uses. General Technical Report RM-120, U.S. Forest Service, Tucson, Arizona. 523 pp.

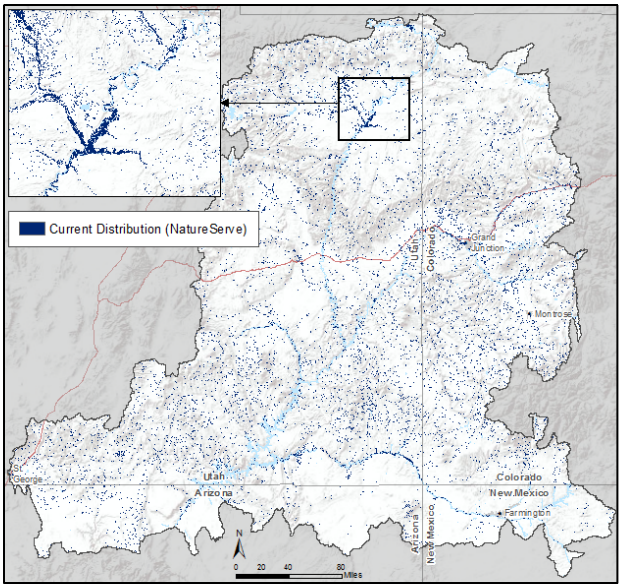


Thick arrows denote components with available spatially explicit data – NOT importance

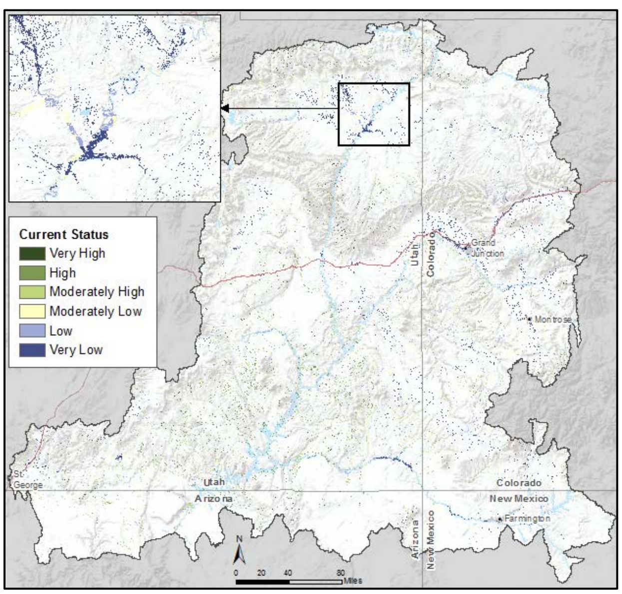
Results

MQ C1. Where is existing Riparian Vegetation and what is its status?

NatureServe



Distribution



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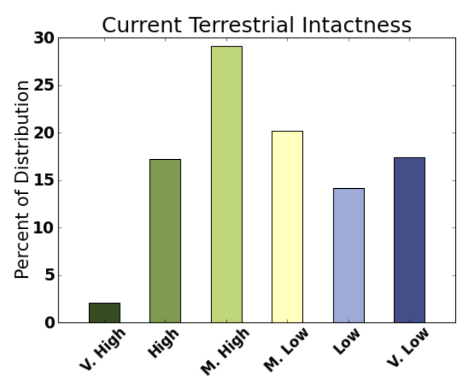
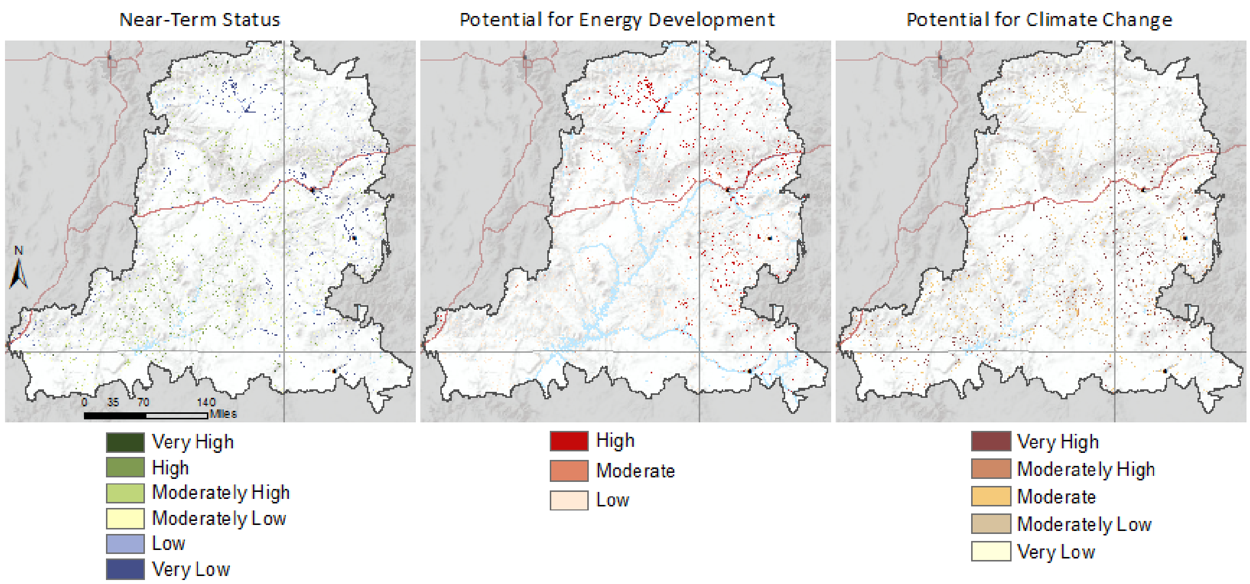
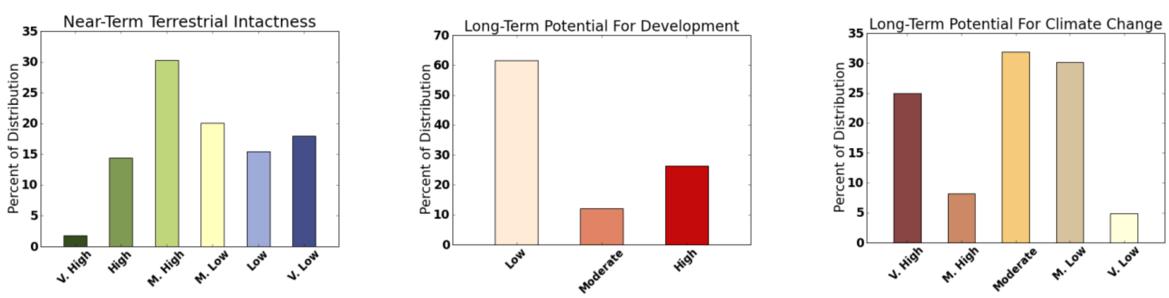


MQ C2. Where is Riparian Vegetation vulnerable to change agents in the future?

No LANDFIRE data

NatureServe





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MQC3. What change agents have affected Riparian Vegetation?

Not Applicable – BpS data does not exist for this community type