Appendix E Conceptual Model for Apacherian-Chihuahuan Mesquite Upland Scrub

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E.1 *Apacherian-Chihuahuan Mesquite Upland Scrub*

The Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem occurs as upland native woody increaser shrublands as a result of altered dynamics. During the last century, the area occupied by this desert thornscrub type has increased through conversion of semi-desert grasslands (Brown and Archer 1987) and oak woodlands (Turner et al. 2003). Although it is possible that this upland mesquite type may have occurred in minor amounts historically, mesquite was largely confined to mesic drainages until cattle distributed seeds upland from the bosques into grasslands and oak woodlands (Brown and Archer 1987, 1989).

For this assessment, it is considered a novel ecosystem because these *Prosopis* spp. dominated shrublands have replaced large areas of semi-desert grasslands, especially those formerly dominated by *Bouteloua eriopoda*, in Trans-Pecos Texas, southern New Mexico and southeastern Arizona (York and Dick-Peddie 1969, Hennessy et al. 1983). Studies on the Jornada Experimental Range suggest that combinations of drought, overgrazing by livestock, wind and water erosion, seed dispersal by livestock, fire suppression, shifting dunes, and changes in the seasonal distribution of precipitation have caused this recent, dramatic shift in vegetation physiognomy (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990, McPherson 1995).

For the MAR REA, there is a desire to understand: a) how invasion of mesquite into the uplands is degrading other, natural ecological systems; b) what are some of the factors managers need to be aware of when attempting to restore natural ecosystems that have been mesquite-invaded; and c) generally where might restoration efforts be worth exploring in on-the-ground surveys, given other constraints within the landscape (e.g. development, exotic plants, soils, and fire regimes).

E.1.1 Classification

The ecosystem types for the MAR REA were selected from NatureServe's classification of terrestrial ecological systems (Comer et al. 2003). Over three dozen ecological systems occur in the MAR, but only a select subset was chosen for the REA. This system is treated as an altered, non-natural concept in this conceptual model, and includes this NatureServe ecological system type:

- Apacherian-Chihuahuan Mesquite Upland Scrub (CES302.733)

There are other terrestrial ecological systems in the NatureServe classification that also occur in the MAR, or in adjacent ecoregions, which are similar to this CE concept but are not included in this concept. These are listed here to help the reader understand what is not included in this conceptual model; each of these other ecological systems has information that can be searched for and reviewed on NatureServe's on-line Explorer website. The first two ecological systems listed below occur peripherally in the MAR, on the eastern edges of the ecoregion, and are extensive further east in the Chihuahuan Desert. The other three ecological systems are grassland types, that when they are degraded, may be similar to mesquite scrub, but retain enough of the natural floristic composition and structure so as to be recognizable as degraded grasslands.

- Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub (CES302.737) (mesquite scrub)
- Chihuahuan Mixed Desert and Thornscrub (CES302.734) (might have scattered mesquite, but other desert scrub species such as *Larrea tridentata* are the dominants)
- Degraded Apacherian-Chihuahuan Semi-Desert Grassland and Steppe [CES302.735)
- Degraded Chihuahuan Loamy Plains Desert Grassland (CES302.061) (upland tobosa/blue grama)

- Degraded Chihuahuan Sandy Plains Semi-Desert Grassland [CES302.736) (black grama)

E.1.2 Summary

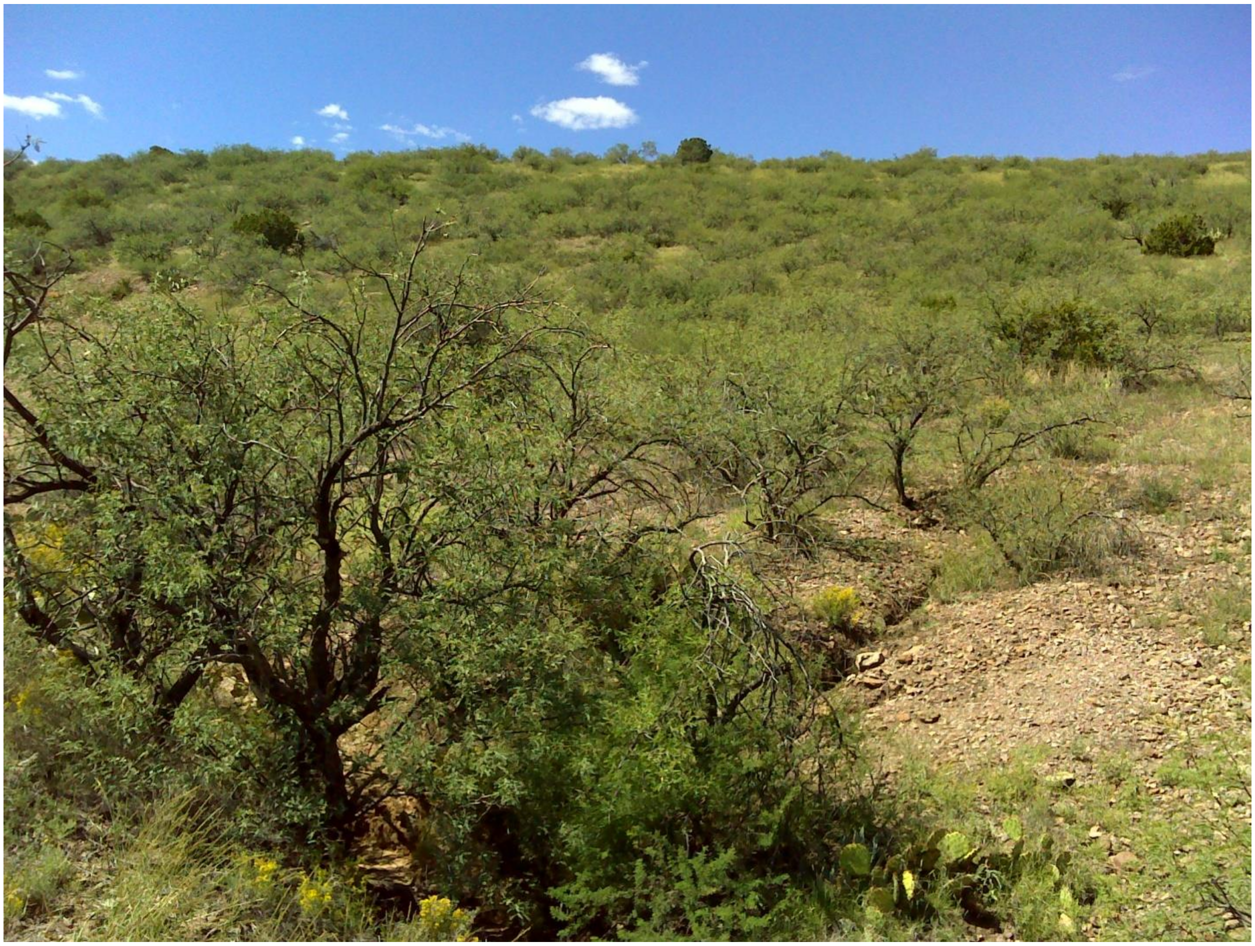
This ecological system occurs as upland native woody increaser shrublands that are concentrated in the extensive semi-desert grassland in foothills and piedmonts of the Chihuahuan Desert, extending into the Sky Island region to the west (Figure 1). Substrates are typically derived from alluvium, and are often gravelly without a well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers. *Prosopis* spp. and other deep-rooted shrubs exploit this deep-soil moisture that is unavailable to grasses and cacti.

Vegetation is typically dominated by *Prosopis glandulosa* or *Prosopis velutina* and succulents. Other desert scrub species that may codominate include *Acacia neovernicosa, Acacia constricta, Juniperus monosperma*, or *Juniperus coahuilensis*. *Larrea tridentata* is typically absent or has low cover. Grass cover is typically low and composed of desert grasses such as *Dasyochloa pulchella (= Erioneuron pulchellum), Muhlenbergia porteri, Muhlenbergia setifolia*, and *Pleuraphis mutica*. During the last century, the area occupied by this system has increased through conversion of semi-desert grasslands as a result of drought, overgrazing by livestock, and/or decreases in fire frequency. In the Madrean Encinal (oak-dominated woodlands and savannas) similar effects have occurred causing increases in woody species, changing the species composition in some areas from oak dominated woodlands or savanna to mesquite and/or juniper dominated woodlands (Turner et al. 2003).

The mesquite upland scrub is similar to Chihuahuan Mixed Desert and Thornscrub (CES302.734) but is generally found at higher elevations where *Larrea tridentata* and other desert scrub species are not codominant. It is also similar to Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub (CES302.737) but does not occur on aeolian-deposited substrates (sandsheets), although some stands may have evidence of wind erosion and deposition.

The description is based on several references, including Brown (1982b), Dick-Peddie (1993), Gibbens et al. (2005), MacMahon (1988), Muldavin et al. (2002), and NatureServe Explorer (2013).

Figure 1. Apacherian-Chihuahuan Mesquite Upland Scrub (http://www.azfirescape.org).



A crosswalk of this system to approved Ecological Site Descriptions (ESD) by Major Land Resource Areas (MLRA) is provided in Table 1. There are no approved State and Transition Models developed for approved ESDs in NM that are strongly related to this ecosystem type. However, of the 7 approved NM ESDs, two sites include mesquite in the plant community description and list it as an increaser species; those 2 NM sites are provided below. Altered states of these ESDs with higher densities of mesquite would be included in the Upland Mesquite Scrub ecosystem. The last ESD listed, F041XC310AZ, under the Historic Climax Plant Community (HCPC) is a large tree mesquite type (occurring in riparian bottomlands), but one altered state is the "mesquite, scrubland" which occurs when the water table is lowered via human development/water pumping. Some areas mapped as Mesquite Upland Scrub in the MAR may well be this altered state of the loamy bottom 12-16" ESD. (For a complete list of ESDs for MLRA 41 see https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD).

Table 1. Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem CE crosswalk with approved Ecological Site Descriptions.

MLRA	Ecological Site Description Name	Site ID
041-Southeastern Arizona Basin and Range	Loamy Upland 8-12" p.z. / *Prosopis glandulosa var. torreyana - Ephedra fasciculata / Pleuraphis mutica – Aristida (/* honey mesquite - desert Mormon tea / tobosa - Aristida)	R041XB210AZ

041-Southeastern Arizona Basin and Range	Sandy Loam Upland 8-12" p.z. / *Prosopis glandulosa / Yucca elata -Eephedra fasciculata / Muhlenbergia porteri - Bouteloua eriopoda* (/ honey mesquite / soaptree yucca - desert Mormon tea / bush muhly - black grama)	R041XB215AZ
041-Southeastern Arizona Basin and Range	Loamy Bottom 12-16" *Populus fremontii - Juglans nigra / Sporobolus wrightii - Panicum obtusum* (cottonwood - black walnut / giant sacaton - vine-mesquite)	R041XA006NM
041-Southeastern Arizona Basin and Range	Clay Loam Upland 12-16"	R041XA002NM
041-Southeastern Arizona Basin and Range	Loamy Bottom 12-16" p.z. *Prosopis glandulosa var. torreyana / / Sporobolus wrightii* (velvet mesquite - western honey mesquite / / big sacaton)	F041XC310AZ

E.1.3 Species and Mesquite

There are many common animal species that utilize mesquite upland scrub as habitat. Honey mesquite (*Prosopis glandulosa*) and velvet mesquite (*P. velutina*) seeds are nutritionally rich and are important food for a large number of wildlife species (Graham 1941, Tull 1987, Steinberg 2001). Honey mesquite seeds form an important part of the diet of mice, kangaroo rats, woodrats, chipmunks, ground squirrels, rock squirrels, cottontail, skunks, quail, doves, ravens, the black-tailed prairie dog, black-tailed jackrabbit, porcupine, raccoon, coyote, collared peccary, javelina, white-tailed deer, mule deer, wild turkey, and mallard (many citations in Steinberg 2001). On the Jornada Experimental Range species of small rodents frequently store whole beans of western honey mesquite in dens or caches, and honey mesquite beans formed the bulk of stored food (Wood 1969). Mesquite flowers are eaten by numerous bird species, and often comprise 10 to 25% of the Gambel's and scaled quails' diets (Davis et al. 1975, DeLoach et al. 1986). Different birds also nest in the tree's canopy. In a southwestern Texas study, honey mesquite fruit comprised 14.9% of the white-tailed deer summer diet, but deer use of any honey mesquite parts during the rest of the year was minimal (Varner and Blankenship 1987). It is an important "honey plant" and bees that forage its flowers produce excellent quality honey (Dayton 1931). It provides a good source of nectar and food for butterfly adults and larvae (Taylor et al. 1997).

Some species of conservation or management concern are associated with this ecological system, and may utilize it for some portions of their life cycle (nesting, foraging, cover, burrows). These species are of conservation or management concern due primarily to their relative vulnerability to extinction through alteration of other ecosystems but mesquite scrub may replace lost habitat in some cases. These vulnerabilities stem from their sensitivity to past or current land/water uses, natural rarity, or forecasted vulnerabilities to climate change effects. Although some of the species listed below may be assessed individually (see separate conceptual models for them), most are listed to make users aware of associated species that are of concern.

There is little information in the published literature about sensitive species utilization of upland mesquite scrub, outside of those found in riparian mesquite bosques. One can assume that less-dense mesquite shrublands, especially those with remaining native grasses, may support some species that are associated with healthy grasslands, especially if the mesquite patches are smaller and are in the vicinity of natural systems. Listed below are selected species of conservation or management concern that are associated with healthy grasslands from the BLM Gila District (USDI-BLM 2010). Ffolliott (1999b) mentioned neotropical birds in general and specifically listed game species important to mesquite ecosystems.

Birds: Ferruginous Hawk (*Buteo regalis*) (breeding population only), Mourning dove (*Zenaidura macroura),* Northern Aplomado Falcon (*Falco femoralis septentrionalis*), White-winged dove (*Zenaidura astiatica),* scaled quail (*Callipepla squamata*)

Mammals: Banner-tailed Kangaroo Rat (*Dipodomys spectabilis*), Black-tailed Prairie Dog (*Cynomys ludovicianus*), Collared Peccary (*Tayassu tajacu*), Mule deer (*Odocoileus hemionus),* White-tailed deer *(Odocoileus virginianus)*

Reptiles: Slevin's Bunchgrass Lizard (*Sceloporus slevini*)

E.1.4 Ecological System Dynamics

This section of the conceptual model presents a narrative description of the primary factors that have resulted in the expansion of mesquite into the uplands in the MAR. The section contains two sub-sections: (1) a description of the altered dynamics and how these may cause the continued decline or degradation of the other ecosystem CEs that have been [mostly] converted to mesquite scrub; 2) a list of the stressors that are the primary agents of these altered dynamics; and (3) state-and-transition models from two Ecological Site Descriptions (ESDs) developed by NRCS.

For description of this type before conversion to mesquite dominated shrubland refer to the Historic Climax Plant Community (HCPC) and the Reference State section of the below ESD models (Figure 2). Also refer to the conceptual models for the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe CE and the Madrean Encinal CE.

E.1.4.1 Upland Mesquite Dynamics

The Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem occurs as upland native woody increaser shrublands. During the last century, the area occupied by this system has increased through conversion of semi-desert grasslands as a result of drought, overgrazing and *Prosopis* spp. seed dispersion by livestock, and/or decreases in fire frequency (Buffington and Herbel 1965, Brown and Archer 1987). Season of precipitation is a key environmental variable with periods of strong summer precipitation promoting grasses and periods of summer drought favoring shrub dominance (Burgess 1995, Van Devender 1995). Shrubs such as mesquite and creosote bush have invaded semi-desert grasslands of this region three times in the last 4,000 years (Van Devender 1995). The first two cycles were driven by long-term drought, but the current shrub increase beginning in the 1880s was intensified by human disturbance and cattle (Bahre and Hutchinson 2001) during drought periods. Prior to the most recent invasion, mesquite dominated shrublands rarely occurred in uplands and were largely confined to mesic drainages until cattle distributed seeds upland from the bosques into grasslands (Brown and Archer 1987, 1989). Therefore Apacherian-Chihuahuan Mesquite Upland Scrub is considered a novel ecosystem.

Gori and Enquist (2003) estimate that 84% of the historical (pre-1880s) extent of semi-desert grasslands have some degree of shrub invasion, and 37% has been completely converted to a shrub-dominanted system (mesquite or creosote bush). This mesquite upland scrub type is currently estimated to occupy approximately 20% of the ecoregion, based on vegetation mapping by NatureServe (2013). Just east of the MAR on the Jornada Range, mesquite (*Prosopis* spp.), tarbush (*Flourensia cernua*) and creosote bush occupied approximately 42% of the Jornada Range in the 1850s; by the early 1960s, these shrub species were found through the entirety of the Range (Buffington and Herbel 1965).

Historical natural-ignition fires were relatively small, probably 10-15 acres in size. Repeated fire is thought to help maintain a general mosaic pattern between open grassland and shrub-dominated areas (Johnston 1963). Wright et al. (1976) found that *Prosopis glandulosa* is very fire-tolerant when only 3 years old. Most plants resprout after being top-killed by fire. Thus, prior to fire and/or drought influences reducing fire frequency, repeated grassland fires probably maintained lower stature of shrubs and prevented new establishment by killing seedlings.

Drought is a relatively common occurrence in this ecoregion, generally occurring every 10-15 years and lasting 2-3 years with occasional long-term drought periods (10-15 years duration). *Prosopis* spp. and other shrubs have extensive root systems that allow them to exploit deep-soil water that is unavailable to shallower rooted grasses and cacti (Burgess 1995). This strategy works well, especially during drought. However, on sites that have well-developed argillic or calcic soil horizons that limit infiltration and storage of winter moisture in the deeper soil layers, *Prosopis* spp. invasion can be limited to a few, small individuals (McAuliffe 1995). This has implications in plant geography and semi-desert grassland restoration work in the southwestern United States. For example, degraded grasslands on these sites with well-developed argillic or calcic soil horizons could be prioritized for restoration.

E.1.4.2 Stressors on Ecological Dynamics Causing Continued Degradation or Change

This novel mesquite dominated upland shrubland ecological system is the result of several interacting change agents which affected primarily the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe and Madrean Encinal CEs, resulting in degradation and conversion to the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem. Restoration of these upland mesquite-dominated scrublands will be directly affected by continuous heavy grazing by livestock, direct and indirect wildfire suppression, land development, and non-native plant species invasion. Changes in long-term climate regime or short-term weather patterns are also factors that will effect restoration potential, but are factors that cannot easily be controlled for in restoration efforts. Table 2 identifies the most likely impacts associated with each of these stressors on ecological dynamics and hence potential for restoration.

Table 2. Stressors that are likely to effect the successful restoration or management of Apacherian-Chihuahuan Mesquite Upland Scrub in the Madrean Archipelago ecoregion.

Stressor	Impacts on ecological dynamics and restoration potential
Land Use	
Livestock grazing	Grazing of native vegetation by livestock at inappropriate stocking rates, season of use, or duration can be detrimental to grass vigor resulting in decline of grass cover and shifts in species composition to more grazing tolerant or less palatable species (Milchunas 2006). Over time this often results in increased woody cover or bare ground and erosion. Livestock grazing can affect also soil structure and water infiltration, and species diversity (USDA-USFS 2009). Heavy grazing can indirectly decrease fire return intervals by removing fine fuels that carry fire (Swetnam and Baisan 1996). Livestock feed on *Prosopis* spp. seeds and are a major source of dispersal (Brown and Archer 1987).
Recreation	This mostly relates to off road vehicle use, which creates additional roads and trails that fragment natural ecosystem patches and contribute to increases in soil erosion and compaction and non-native species dispersal (USDA-USFS 2009).
Development	
Linear Features Transportation infrastructure Roadways/railways and transmission lines	Fragmentation from transportation infrastructure leads to disruptions in ecological processes such as fire, dispersal of invasive non-native species, and can alter hydrological processes by changing surface flows such as when excessive runoff from roads creates gullies that can lower water tables. Additionally, destruction of wildlife habitat and disruption of wildlife migration patterns can also occur (Bahre 1991, Bock and Bock 2002, Finch 2004, Heinz Center 2011, Marshall et al. 2004, McPherson 1997, Ockenfels et al. 1994, Schussman 2006b).

Stressor	Impacts on ecological dynamics and restoration potential
Site Suburban/Rural (include Military), Mines/Landfill, Energy (Renewable wind/solar), Oil/Gas	This stress contributes to altered fire regimes (e.g. fire suppression to protect infrastructure), increased erosion, direct habitat loss/conversion, increased groundwater pumping, fragmentation, invasive non-native species dispersal and disruption of wildlife migration patterns (Bahre 1991, Finch 2004, McPherson 1997).
Uncharacteristic Fire Regime	Fire suppression, both active and passive with livestock removing fine fuels that carry fire, has contributed to the expansion of mesquite dominated shrublands into former semi-desert grasslands and encinal woodlands (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, McLaughlin and Bowers 1982, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990, McPherson 1995). The Apacherian-Chihuahuan Mesquite Upland Scrub is also the result, in part, in a change in fire regime from frequent surface fires common in semi-desert grasslands (FRI of 2.5-10 years) (Brown and Archer 1999, Gori and Enquist 2003, McPherson 1995, Robinett 1994, Wright 1980); this results in increasing shrub cover and contributes to the conversion from perennial grasslands to this mesquite dominated desert scrub.
Invasive non-native Species	Replacement of native vegetation with non-native grass species such as *Eragrostis lehmanniana* and *Eragrostis curvula*. These species are better adapted to frequent fire and increase in relative abundance over native grasses after burning (Anable et al. 1992, Cable 1971, Gori and Enquist 2003, Schussman 2006a). The impact of invasive non-native species on community function of native vegetation is well documented (Anable et al. 1992, Cable 1971, Cox et al. 1988).
Soil Erosion	The condition of the soil/surface substrate directly affects the functioning of natural ecosystems. Studies on the Jornada Experimental Range suggest that wind and water erosion in combination with the other stressors listed here, have caused this recent, dramatic shift in vegetation physiognomy resulting in mesquite dominance (Buffington and Herbel 1965, Herbel et al. 1972, Humphrey 1974, Gibbens et al. 1983, Hennessy et al. 1983, Schlesinger et al. 1990). Loss of ground cover (both vascular and nonvascular plants), livestock trampling, recreational vehicles, and runoff from adjacent developed areas can directly affect soil properties by disturbing soil crusts, compacting pore space that reduces water infiltration and percolation, changing other structural characteristics, and can expose soils to increased erosional forces, leading to degradation of sites.
Climate change	Alteration of precipitation, evapotranspiration rates, and timing (season) of precipitation, may result in more frequent drought periods and higher intensity precipitation events, which following drought can cause significant erosion of topsoil. Predicted increases in temperatures and effective precipitation will impact restoration efforts.

E.1.4.3 Dynamics Models

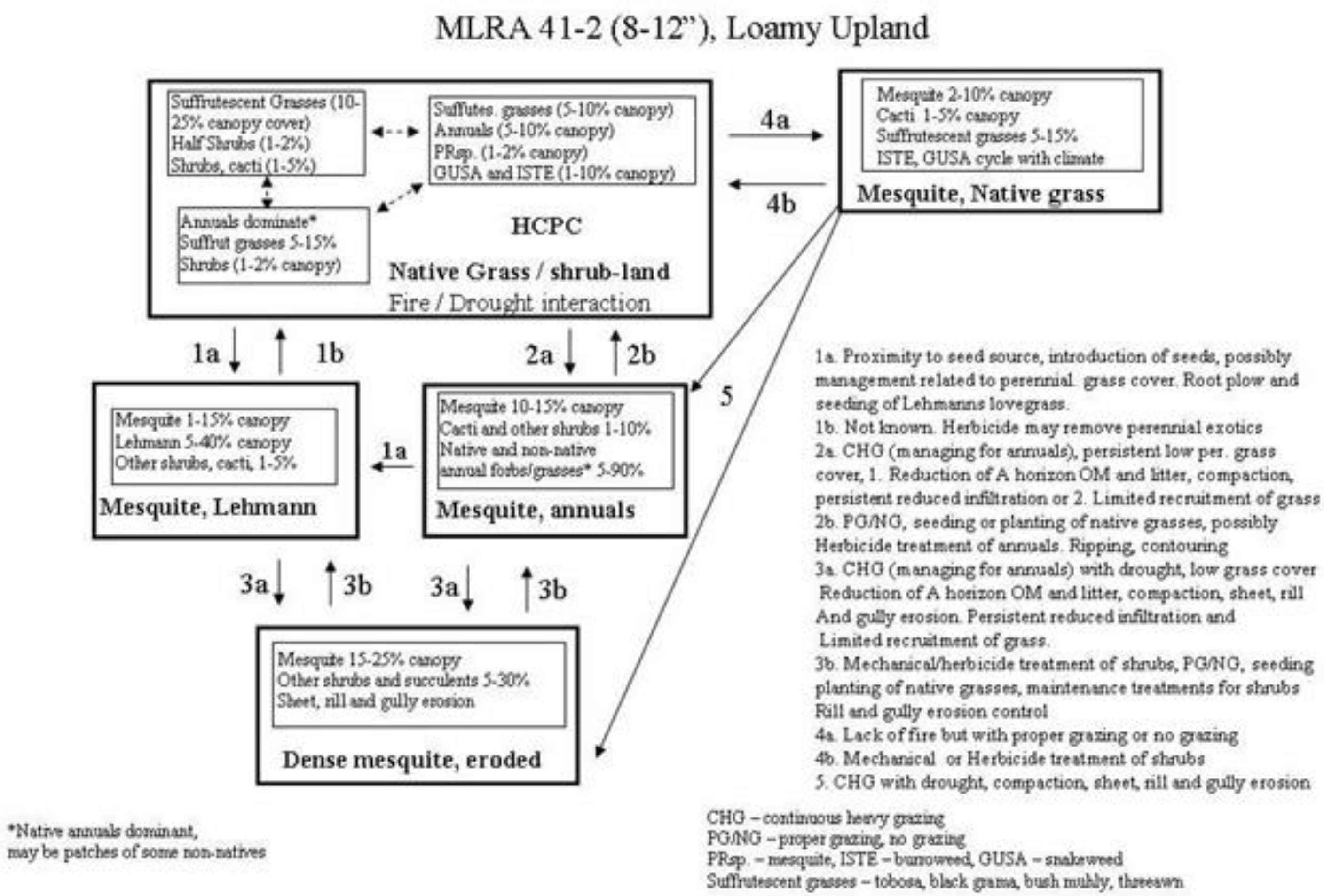
Below are two conceptual state and transition models that are representative of the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem CA. The model in Figure 2 (NRCS ESD R041XA210AZ) was developed by the NRCS for southeastern Arizona. This model has four disturbed states: Mesquite, Native grass; Mesquite, Lehmann; Mesquite, annuals; and Dense mesquite, eroded. The undisturbed Historic Climax Plant Community (HCPC) state or reference state that relates directly to the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe CE is part of the model.

The model in Figure 3 (NRCS ESD R041XA210AZ) was also developed by the NRCS for southeastern Arizona and is an alternative model that is representative of the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem, as an altered state of the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe CE. The model has three disturbed states: an Exotic Grasses, a Mesquite-Juniper Invaded, and an Eroded Surface. The shrub dominated state relates to the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem.

For each of these ESD models, the text describing the altered states is provided, along with the ESD state-and-transition models. In general, the transitions from one state to another are influenced by the amount and timing of grazing, the proximity to a seed source for mesquite, the cyclical occurrence of drought, and the fire regime. Mechanical treatments, herbicide applications, or other efforts to manage or control mesquite or invasive exotics can reverse mesquite invasion and degradation of the site, but compaction or disruption of soils by either livestock or equipment can lead to erosion and gullying, and loss of the native perennial grasses.

Additional work on Ecological Site Descriptions is being completed by NRCS and BLM in New Mexico, but are currently in draft form and not available to provide in this conceptual model.

Figure 2. Conceptual state and transition model of the Historic Climax Plant Community (HCPC) and altered dynamics for NRCS ESD R041XA210AZ. This model model is representative of the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem CE. This model is excerpted from the Ecological Site Description (ESD) for R041XA210AZ from the 041-Southeastern Arizona Basin and Range MLRA at: https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD.



From ESD R041XA210AZ (Figure 2):

Description of State and Transition Model

The HCPC portion of this model represents this ecosystem under natural dynamic conditions, a semi-desert grassland that lacks the upland mesquite, a native woody increaser. The Altered Dynamic portions of this community are shown with arrows indicating invasion by mesquite with native grass understory; invasion by mesquite with introduction of non-native forage grasses such as *Eragrostis Lehmanniana* or *Eragrostis curvula*; invasion by mesquite with dominance of non-native and native annual grasses; and an eroded surface with low grass cover (including reduction or loss of A soil horizon, reduced soil infiltration, soil organic material, ground cover, litter, and increased soil compaction, sheet and rill erosion). Descriptions of altered states are excerpted from Ecological Site Description (ESD) for Loamy Upland 8-12" p.z. / *Prosopis glandulosa var. torreyana - Ephedra fasciculata / Pleuraphis mutica – Aristida* below:

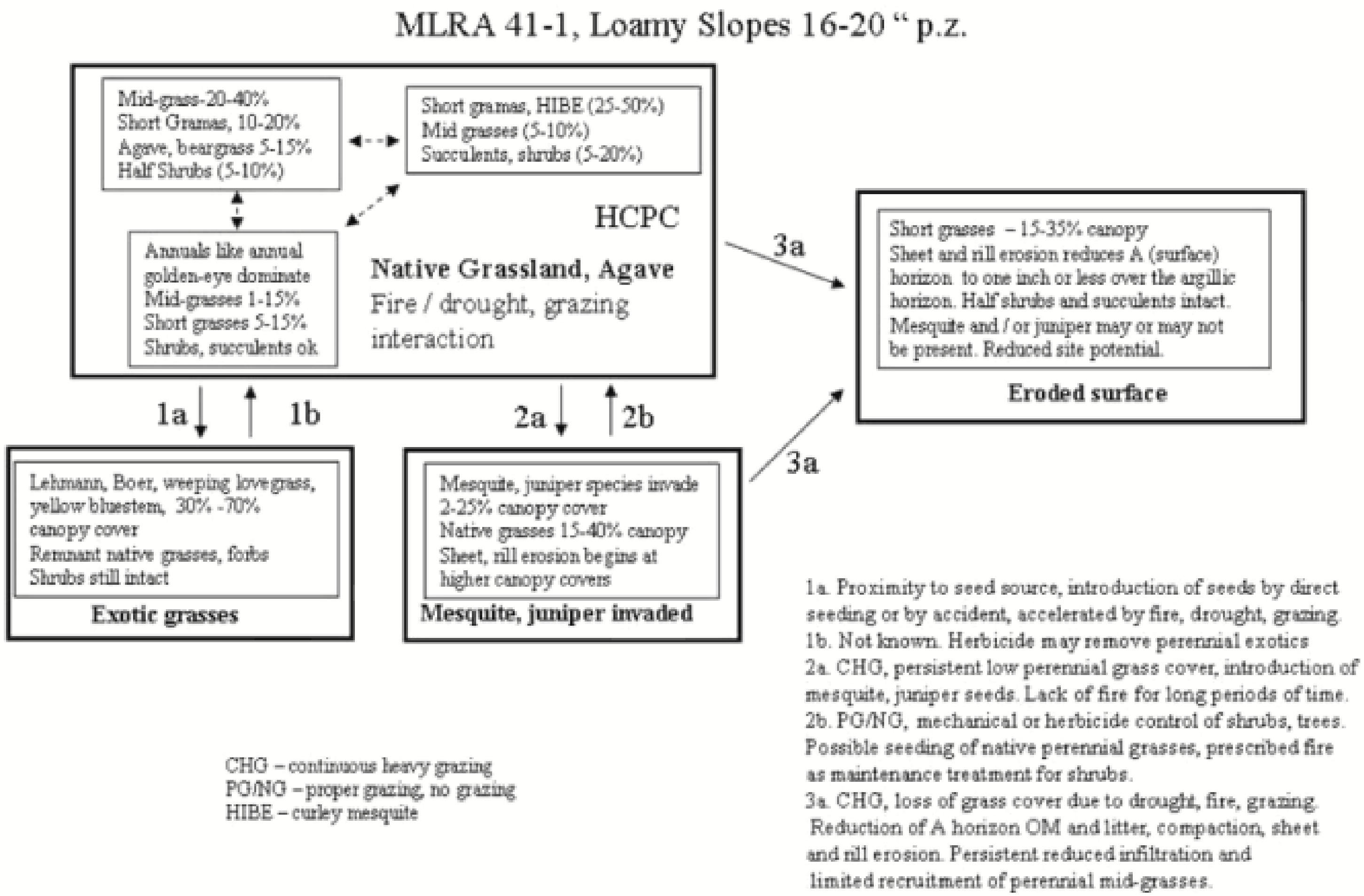
"Mesquite, natives
This state occurs where mesquite has increased from between 2 and 10% canopy cover and some cover of native perennial (suffrutescent) grasses and forbs remains. Other shrubs and succulents exist in minor amounts. Annual forbs and grasses (both native and non-native) are very important in their respective (wet) seasons.

Mesquite, Lehmann lovegrass
This state occurs where Lehmann, and in some cases Boers, lovegrass has been seeded; usually in combination with mechanical mesquite control. The cover of Lehmann lovegrass varies widely with climate, ranging from 1-5% canopy in dry years up to 20-40% canopy in years with wet summers. Lehmann never dominates the plant community on this site but does dominate the herbaceous layer of the plant community once established.

Mesquite, annuals
This state occurs where mesquite and other shrubs (creosotebush) and cacti dominate the plant community. Native perennial grasses and forbs have been removed from the plant community and native and non-native annual species dominate the herbaceous layer.

Mesquite, Erosion
This state occurs where mesquite canopy is heavy (15-25%) and the interaction of drought and continuous grazing has resulted in severe sheet, rill and, in some cases, gully erosion on the site. These areas are usually near historic watering locations and are characterized by soil compaction due to trailing and heavy livestock traffic."

Figure 3. Conceptual state and transition model of the Historic Climax Plant Community (HCPC) and altered dynamics for NRCS ESD R041XA107AZ. This model is representative of the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe CE or semi-desert mixed grassland vegetation type. It includes a shrub-invaded state, where either mesquite or juniper have become dominant. This model is excerpted from Ecological Site Description (ESD) for R041XA107AZ Loamy Slopes 16-20" p.z. / *Agave palmeri - Nolina microcarpa / Bouteloua curtipendula - Eragrostis intermedia* from the 041-Southeastern Arizona Basin and Range MLRA at: https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD.



From ESD R041XA107AZ (Figure 3):

Description of State and Transition Model

The HCPC portion of this model represents the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe CE ecosystem under natural dynamic conditions. The Altered Dynamics portions of this community are shown with arrows indicating introduction of non-native forage grasses such as *Eragrostis Lehmanniana* or *E. curvula*; invasion by shrubs and small trees (primarily species of *Prosopis* and *Juniperus*) resulting from extended periods of lack of fire; and an eroded surface with low grass cover (including reduction or loss of A soil horizon, reduced soil infiltration, soil organic material, ground cover, litter, and increased soil compaction, sheet and rill erosion).

Descriptions of altered states are excerpted from Ecological Site Description (ESD) for R041XA107AZ below:

"Exotic grasses

This state occurs where non-native lovegrass species or yellow bluestem, have invaded from adjacent areas or roads and ROWs with a seed source. As these species increase to dominate the plant community, native perennial grasses and forbs decrease to remnant amounts. Fire will usually act to increase species like Lehmann lovegrass. The native half shrubs seem to be able to stay in the plant community. It is not known how Agave Palmeri fares under this condition.

Shrub invaded

This state occurs where mesquite, wait a bit mimosa, one-seed juniper and / or alligator juniper have invaded or increased to dominate the plant community. This occurs in the absence of fire for long periods of time, with continuous grazing and in the presence of a seed source of these species. As canopy levels of trees and shrubs approach 30%, sheet and rill erosion can begin to accelerate.

Eroded surface

This state occurs where severe soil compaction and trailing has resulted in loss of plant cover and an increase in runoff. Sheet and rill erosion accelerates and the surface (A) horizon is removed faster than it can be replaced by down-slope soil movement and weathering of the ridgetops. When the subsurface argillic (clayey) horizons are exposed, the site has lost its potential productivity. The plant community will shift from warm season plants to cool season plants and the ratio of runoff to infiltration will increase.

With continuous, heavy grazing, mid-grasses are removed from the plant community and replaced by short grasses such as curly mesquite, slender grama and sprucetop grama. With severe deterioration, shrubby species such as wait-a-bit mimosa, one-seed and alligator juniper, and mesquite can increase to dominate the site. With good management, native mid-grasses will be able to regain their dominance in the plant community, unless soil erosion is severe enough to strip away the surface horizon. Mesquite and Lehmann lovegrass are at the upper limits of their elevation range, but can increase on the site, especially below 5000 feet elevation and on southern exposures. Climatic warming may allow these two species to push higher in elevation as time goes by. Naturally occurring fires in June-August were an important factor in shaping this plant community. Fire-free intervals range from 10-20 years. Without disturbance like grazing or fire, perennial mid-grasses can become decadent and forbs like annual goldeneye, cudweed and camphorweed can increase to dominate the plant community. This site is the principal habitat for the Agave Palmeri in southeastern Arizona, an important food source for the endangered lesser long-nosed bat in June, July, and August. Dense stands of this species occur scattered throughout areas of this site. Nectar production in these stands ranges from 6-10 gallons per acre.

Periodic drought can occur in this LRA and cause significant grass mortality. Droughts in the early 30s, mid 50s, 1975-1976, 88-89, 95-96 and 2002 resulted in the loss of much of the grass cover on this site. The site recovers rapidly, however, due to excellent covers of stone, cobbles and gravel and the favorable climate that prevails in this common resource area."

E.1.5 Key Factors Related to Restoration Potential

Several interacting factors will affect the ability of land managers to restore areas that have been degraded by mesquite invasion. The models presented above from the NRCS ESDs and the work done by Gori and Enquist (2003) and Gori et al. (2012) to document the historic range of variability of the semi-desert grasslands in this region both provide much useful information. McPherson and Weltzin (2000) provide an overview of the interactions of disturbance, both natural and human-caused, and climate change in the region containing the MAR, and how these have resulted in shifts in plant community composition and physiognomy (e.g. shifts from grasslands to shrublands). In their report, they suggest that prairie dogs probably historically had a role in keeping shrubs, such as mesquite, from dominating areas; they do acknowledge that current scientific understanding of this is poor, and suggest a fruitful area of research would be on the effects of native herbivores on establishment and persistence of woody plants.

Wilson et al. (2001) discuss the expansion of mesquite in this region within the context of the natural history of mesquite species, focusing on the attributes that allowed this expansion. They also provide a useful summary of research that has addressed this expansion, primarily from the decade prior to the report, and a summary of mesquite management practices (such as herbicide application, prescribed burning, and mechanical removal) in the context of several objectives.

Below the information is summarized (Table 3), and related to the potential for restoration at three levels (high, moderate, low or no potential). Thresholds were adapted from Apache Highland Grassland Assessment condition classes in the project area by Gori et al. (2012) and NRCS ESDs R041XA210AZ. These factors cannot be evaluated individually, since there are interacting effects; e.g., the surrounding landscape condition may be favorable to restoration, but the individual mesquite stand may be large, dense, and have a non-native grass understory, making restoration success more difficult without large investments in effort.

Table 3. Key factors for determining the potential for restoration of places dominated by the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem.

Factor	Key indicators of mesquite sites with <u>high potential</u> for restoration to semi-desert grassland	Key indicators of mesquite sites with <u>moderate potential</u> for restoration to semi-desert grassland	Key indicators of mesquite sites with <u>low or no potential</u> for restoration to semi-desert grassland
Site description	Open mesquite shrublands (generally <15% cover) with a moderately dense (10-25% cover) native grass layer.	Open to moderately dense (15% to 25% cover) mesquite shrublands with sparse (<10% cover) native grass layer.	Dense mesquite shrublands (>45%) or mesquite shrublands (>25%) with non-native grass layer or bare eroded substrate.
Landscape Context	Site is large, on public land; or in an area with private partnerships conducive to restoration activities. Fragmentation level (density of roads, transmission lines, urban and exurban development) is low	Site is relatively large, on mixture of public and privately owned land. Fragmentation level (density of roads, transmission lines, urban and exurban development) is low	Site is relatively small on mixture public and privately owned land. Fragmentation level (density of roads, transmission lines, urban and exurban development) is high.

Factor	Key indicators of mesquite sites with <u>high potential</u> for restoration to semi-desert grassland	Key indicators of mesquite sites with <u>moderate potential</u> for restoration to semi-desert grassland	Key indicators of mesquite sites with <u>low or no potential</u> for restoration to semi-desert grassland
Livestock Grazing	No livestock use or at low stocking rate so as not to impact restoration; livestock management allows adjustment of seasonality and stocking rate.	No livestock use or at low stocking rate so as not to impact restoration	Livestock use at moderate to high stocking rate
Vegetation Composition	Herbaceous layer has moderate to dense cover and is dominated by native perennial grasses. Invasive, non-native grasses like Lehmann lovegrass are absent or very low cover (<1%)	Herbaceous layer has low to moderate cover and dominated by native perennial grasses. Invasive, non-native grasses like Lehmann lovegrass are absent or have low cover (<3%)	Herbaceous layer is sparse and composed of native grasses or herbaceous layer has moderate to high cover of invasive, non-native grasses such as Lehmann lovegrass.
Vegetation Structure	Open mesquite shrublands with medium woody cover (10-35% total, with cover of mesquite or juniper <15%). Other shrubs can contribute to the total. Perennial native grass cover is >5%, preferably at least 10% cover.	Former grassland and savanna with high woody plant cover (15-25% cover mesquite and juniper combined or 35-45% total woody cover); perennial grass cover <10% but generally <5% and usually <3%).	Shrub cover is dense (>45% total, or with cover of mesquite or juniper >25%). Herbaceous layer is sparse – fine fuels are too low to carry fire; or if grass cover is high, composition is entirely non-natives.
Soil Condition	Soils well developed, often gravelly surface to limit erosion and with well-developed argillic or calcic soil horizon that would limit infiltration and storage of winter precipitation in deeper soil layers that *Prosopis* spp. and other deep-rooted shrubs can exploit.	Soils well developed enough to support moderately dense grasslands.	Soils shallow, poorly developed/skeletal, sand deposit or top soil is eroded to <10 cm deep.
Fire Regime	Fire regime restorable with prescribed fire; preferred return intervals of 2-5 yrs.	Fire regime restorable with prescribed fire	Fire regime is severely altered and not restorable

E.1.6 References

This section lists literature is listed that is relevant to the classification, distribution, floristic composition, ecological processes, threats, stressors, or management of the ecosystem, in some cases for portions of the range outside of the ecoregion. These are not exhaustive literature surveys, rather are an accumulation of known references. Some documents may be listed that are not cited in the narrative text.

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