Changes in key mule deer habitat during the second half of the 20th century.

A combined landscape and community level assessment of vegetation in semi-arid communities of western Colorado.

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1 Executive Summary

Increased stand age and forest cover resulting from wildfire suppression is believed to cause fundamental changes in ecosystem processes by altering habitat across landscapes throughout the Rocky Mountains. In addition, it is widely believed that the introduction of domestic herbivores has modified landscapes in western North America. Domestic and wild ungulates have grazed extensively across the mountainous and inter-mountain steppe communities of this region influencing the structure of herbaceous and shrub vegetation, which also affects fire regimes and inter-specific competition. Landscape level dynamics of woody species cover and vegetation community dynamics in critical shrub land habitats were both considered in this synecological assessment of change in forest, range and associated habitats.

We investigated changes in composition of landscapes in western Colorado using current and historical aerial photography. Aerial photographs from 1937, 1965-7, and 1994 were sampled at exact locations within overlapping photographs. We studied two sites on the eastern edge of the Colorado Plateau in western Colorado; (1) the Uncompahgre Plateau (GMU 62,63) and the surrounding mesas and valleys south of Grand Junction and west of Montrose, and (2) Piceance Basin (GMU 22, 23, 24) north of Rifle and west of Meeker. We modeled change across the landscapes and found a small, net decrease in forest canopy cover. These trends were not uniform in their distribution across the landscape. We described a region of predominant canopy decline between 2250 - 2600m (7400 – 8500 feet); a region of predominantly increased cover occurred between 1800 - 2300m (5900 - 7500 feet); this zone is where pinon-juniper woodland meets sagebrush steppe. Mean conifer cover decreased in coniferous forests, which counteracted a trend of increased conifer cover in mixed forests, savanna-like pinon pine and juniper woodlands, and the shrub steppe. Anthropogenic disturbance had a stronger counteractive effect on canopy growth than wildfire, but this did not entirely explain the canopy decline. Forest cover increased in undisturbed areas, whereas forest cover declined in areas with significant anthropogenic disturbance. Our analyses revealed that human induced disturbances were extensive, but not uniform across these landscapes. Anthropogenic disturbance partially counteracted the net effect of succession of shrublands to forests. Across the landscape, natural dynamics in this region resulted in diverse changes rather than a simple progression towards increased forest cover.

At the community level, we investigated the roles that grazing, browsing, and protection from grazing and browsing had on changes in the structure and composition of 16 semi-arid shrub communities in western Colorado over a period of 40-50 years. We sampled the vegetation cover within and adjacent to the historic (established between 1949 and 1959) domestic and wild ungulate grazer exclusions. Distributed among several shrub-grassland steppe communities these fenced exclosures are located within important winter habitats for Colorado's mule deer populations. We compare the current vegetation condition to the past using data collected in the 1950s by Colorado Fish and Game. We identified significant increases in shrub cover in areas where grazing intensity was limited, but a significant decrease in shrub cover in unprotected areas. Graminoids declined, while non-graminoid, herbaceous species increased significantly irrespective of treatment. Tree invasion (pinon pine and juniper) was evident across all treatments, but it

did not occur at all locations. Bare ground cover increased significantly across treatments over the 40-50 year period; grazing pressure significantly increased this effect. Study site was a stronger predictor of current species richness ($F = 16.98$, $p < 0.0001$) than the grazing treatments, however treatment effects are also a significant predictor ($F = 2.49$, $p = 0.078$) identifying both extensive variation in composition within the sagebrush community types and the effects of grazing on plant species composition as important determinants of vegetation structure. We conclude that there were important compositional changes in these communities over the past 40-50 years, and the level of domestic and wild ungulate grazing was one important determinant of current sagebrush community structure and range condition.

We assessed the quantity and quality of the standing herbaceous crop relative to grazing pressure at six of the treatment sites. We estimated herbaceous production within six vegetation classes, and compared quality of forage using carbon and nitrogen content of the dry biomass as an indicator of protein content. We found neither compelling nor statistical differences in the carbon and nitrogen contents of similar vegetation types between grazing treatments. Patterns of production varied between sampling years (one near normal precipitation and one drought year), grazing treatment, and vegetation type. Productivity of all types and both years is highest in the spring before the end of May, dropping to near zero during early summer, followed by limited late growth by some types in some grazing regimes. Bunch grasses across treatments and cattle-protected tall, broad-leaved grasses in the wet year. Herbaceous dicots (rosettes and cauline types) managed a late season growth pulse when they were openly grazed all season. Rosette and caespitose species were also productive late in the wetter year when full protected from ungulates. Anticipating cumulative effects of nutrient redistribution by herbivores, we compared the nitrogen mineralization potential of soils, which is an indicator of nitrogen availability for plant uptake. Nitrogen mineralization was used as a surrogate for soil quality to compare treatments and vegetation associations. Our results suggested minimal biochemical effects of rest from herbivore activities.

Thus, while some differences in composition and effects on cover patterns were observed in comparisons between grazing treatments, productivity and nutrient cycling are not currently limited by grazing. However, because these plant communities persist in a harsh, semi-arid environment, growth rates and net production are low, therefore so is natural change. Increased bare ground over time, a pattern that was magnified by ungulate presence, represents a physical change that could lead to permanent degradation if soil erosion follows. Evidence of the resilience of the community was provided from its continuing persistence despite an extensive, recent grazing history.