Grazing Effects on Biodiversity and Ecosystem Function in California Vernal Pool Grasslands

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The purpose of this study was to examine the effects of grazing on vernal pool plant species diversity and aquatic invertebrate and vertebrate species diversity. Vernal pools occur throughout California in grassland areas underlain by a hardpan or claypan layer that restricts percolation of water through the soil. In short they are poorly drained depressional features. They are a conservation concern because less than twenty percent of the original habitat remains, and they contain a very high degree of diversity with more than 100 species of endemic plants and more than 30 species of endemic crustaceans. Vernal pools are defined by their seasonality. They are dry in the summer and fall. Water ponds in the pools each year with the onset of winter rain, creating aquatic habitat that supports the activity of aquatic vertebrates including such species as the California Tiger Salamander and the vernal pool tadpole shrimp. These unique species require rather long periods of inundation in order to complete their lifecycles. In spring as the pools begin to dry down they are ringed with wildflowers, and have become known as islands of native diversity in a sea of exotic annual grassland. Each pool displays a distinct moisture gradient from the pool, to the edge, and finally the upland. There is a significant correlation between the moisture gradient and the percent absolute cover of native and exotic species. The pool bottoms and edges are dominated by native species while the uplands surrounding the pools are dominated by non-native annual species. The study measured how disturbances such as grazing impact species composition along this moisture gradient. The study also investigated what level of grazing maintains the highest native diversity; how grazing impacts exotic species in and around the pools; whether exotic plant species impact vernal pool hydrology; and finally whether or not these effects differ by soil type.

The study was conducted on the 12,362-acre Howard Ranch property in Eastern Sacramento County. The ranch had been seasonally grazed by cattle for the past several decades. The ranch contains two distinct soil formations each providing the setting for unique vernal pools. The Northern portion of the ranch is underlain by the Valley springs formation which is defined by shallow soils underlain by bedrock and contains smaller and shallower vernal pools compared with the deeper pools found on the Southern portion of the ranch. These pools are associated with the Laguna Formation, defined by alluvial terraces overlying a hard pan and claypan at approximately three meters below the soil surface.

Three replicates of four grazing treatments were implemented on each formation for a total of six replicate treatment blocks. In each of these six blocks, the grazing treatments included: one left completely ungrazed, one grazed only during the wet season (when water was still in the pools), and one that allowed for grazing only during the dry season (when no water remained). The

control consisted of continuous grazing of vernal pools from October through June at an intensity of one animal unit per six acres.

The vegetation sampling scheme employed transects laid through the longest axis of each pool studied. Three locations were selected at random along the baseline transect to run perpendicular transects. Three 35 X 70 cm quadrats were placed along these perpendicular transects in the pool, on the edge, and in the upland. Within each quadrat researchers recorded species, cover class values, bare ground, litter, and anything else of interest.

The results demonstrated that the relative cover of native plant species remained highest in continuously grazed plots, while declining in those where grazing was removed. Grazing removal did not affect the cover of native vegetation in the pool quadrats but did negatively impact native cover in both the edge and upland zones. When the study began in 2001 the area was a forb-dominated system. After three years of grazing removal, the treatment areas quickly shifted to grass dominance. These treatment effects were most pronounced under the ungrazed treatment regime and less significant with the wet or dry season grazed treatments. The effects of the treatments were also more pronounced in the edge and upland zones compared to those in the pools. The effect of residual dry matter (RDM) values was also investigated, and it was found that there is a significant decline in species richness with higher RDM levels. The possibility of upper limits for RDM values being developed was pondered, but would prove challenging due to the significant variability in RDM values caused by changes in precipitation from year to year. It was also found that the change in native richness per quadrat over the first three years of the study was positive in grazed pools and negative in ungrazed pools. There was a decline in diversity with the removal of grazing after only three years, and this effect was most significant on the edge.

The study also looked at the effect of grazing on the hydrology and invertebrate/vertebrate community of the pools. Water quality measurements pertaining to temperature and clarity during invertebrate sampling were recorded. Water depth was recorded weekly, and the period of inundation was also determined. Sampling for invertebrates was performed twice a season and involved quite tedious separation and counting of each species in the lab. The change in hydrology as a result of the complete removal of grazing was quite significant resulting in an average maximum ponding period 50 days less in ungrazed pools compared with those left continuously grazed. This reduction in pool inundation is biologically very significant in that many species depend on extended periods of inundation to successfully complete their lifecycles. It was also observed that continuously-grazed pools dried completely fewer times than any of the grazing removal treatments. Soil compaction was also noted to be lowest in the ungrazed pools, leading to the possibility that in the case of vernal pools higher compaction may actually be a good thing. However the main cause of the observed hydrologic change was most likely a result of increased densities of grass resulting in increased rates of evapotranspiration essentially sucking the pools dry. As a result of shorter periods of inundation in the ungrazed plots invertebrate taxa richness was lowest in the ungrazed plots presumably because fewer species are allowed sufficient time to complete their lifecycles. Invertebrate taxa richness was observed to

remain constant in continuously grazed pools and declined in ungrazed pools throughout the season in 2003.

This study has several implications for management and restoration of vernal pool grasslands. First, if a site is grazed and demonstrates high diversity, then it should be left grazed unless there is a compelling, scientifically-based reason to change the management regime. Furthermore, if changes are made to the grazing regime the change should be monitored utilizing a control so that changes can be effectively observed and attributed to the grazing treatment rather than changes that may be simply due to climatic variability. Grazing too little should be considered as a threat to these systems as well as overgrazing. Finally, the removal of grazing may negatively impact vernal pool hydrology and species requiring longer periods of pool inundation.

Full results of this study can be found in the following article:

Marty, J. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. Conservation Biology **19**:1626-1632