

Successional patterns in macrophytes in the Laguna Palo Verde one year following disturbance

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Abstract: According to the intermediate disturbance hypothesis, the highest levels of biodiversity occur at medium levels of disturbance. In the past year, Laguna Palo Verde has undergone several periods of disturbance by a tractor to clear invading cattails. We recorded the macrophytic vegetation of four sites disturbed at different times to determine levels of diversity in the period following disturbance. We found a gradient of succession that was distinguished by early-, mid-, and late successional macrophyte species. As predicted by the intermediate disturbance hypothesis, sites with a moderate time interval since disturbance showed highest plant diversity. Currently therefore, the anthropogenic alteration of this ecosystem appears to be enhancing biodiversity in the Palo Verde marsh.

Key Words: colonization, intermediate disturbance hypothesis, wetland vegetation

INTRODUCTION

Disturbance events influence species diversity and community succession. The intermediate disturbance hypothesis predicts that highest species diversity will occur at an intermediate level of disturbance. Disturbances can occur over a range of frequencies and intensities, and as the interval between disturbances increases, diversity will also increase, since more time is available for species colonization (Connell 1978). Patterns of species succession are observed after a disturbance because different species have different growth strategies. Early successional species are good colonizers that grow fast, whereas later successional species are active competitors that grow to maturity in the presence of early species but eventually out-compete them (Begon et al. 1990). Thus, without further disturbance, diversity will decline as the most efficient competitors displace other species.

The freshwater marsh in the Rio Tempisque floodplain of Palo Verde National Park, Costa Rica has undergone a variety of management techniques to open the wetland areas for migratory bird species. Abram et al. (1994) found that cattails (*Typha* spp.) in this area were able to out-compete other marsh species after cattle grazing was

prohibited in 1981. Starting early in 2002, a new attempt has been initiated to maintain wetland regions by compressing cattails with a tractor.

We hypothesized that anthropogenic disturbance would cause a change in plant diversity in the Palo Verde marsh. We predicted that plant species diversity would be low in areas where tractor disturbance was either very recent or had not occurred, and high in areas where tractor disturbance occurred between these extremes.

METHODS

We conducted this study on the Laguna Palo Verde marsh in Palo Verde National Park, Guanacaste Province, Costa Rica between 08:00 and 11:00 on 13 January 2003. We used four sites of varying disturbance histories. Study site 1, 100 m east of the observation tower, was disturbed one month prior to the experiment. Site 2, adjacent to the west end of the airstrip, was disturbed five months before the study. Site 3, directly surrounding the observation tower, was disturbed approximately 12 months before the study. Site 4, 500 m south of the observation tower, had not been disturbed.

We recorded plant species composition at each site using three east-west

transects varying in length from 25-60 m; adjacent transects were at least 20 m apart. Every 5 m, we counted macrophyte species within an area of one square meter, and converted these values to percent cover for plant type for each transect. We observed the following species: cattail (*Typha domingensis*), water hyacinth (*Eichhornia crassipes*), thalia (*Thalia geniculata*), sedge (*Oxycaryum cubense*), water lily (*Nymphaea ampla*), grass (Poaceae spp.), water lettuce (*Pistia stratiotes*), and fairy fern (*Salvinia auriculata*).

We used a one-way ANOVA to test for significant differences in vegetation patterns between sites. We used Tukey-Kramer HSD to identify which sites had differences in abundance for each macrophyte species.

RESULTS

We found that the occurrence and proportion of plant species varied across sites. Fairy fern was only found in the most recently disturbed site (Fig. 1; $F = 156.79$, $df = 3, 10$, $P < 0.001$), and Tukey-Kramer results indicated that abundance at site 1 was significantly different from all other sites. Several species occupied sites 2 and 3. Sedge

and water lily were present only in these sites, and differences in abundance were marginally significant (Fig. 1; $F = 3.74$, $df = 3, 10$, $P = 0.07$ and $F = 3.39$, $df = 3, 10$, $P = 0.08$, respectively). Grass and thalia were also only present in sites 2 and 3, but did not differ in abundance between those sites (Fig. 1; $F = 1.82$, $df = 3, 10$, $P = 0.23$ and $F = .85$, $df = 3, 10$, $P = 0.51$, respectively). Water lettuce was present in all disturbed sites and increased in abundance with increasing time since disturbance ($F = 4.41$, $df = 3, 10$, $P = 0.05$). Similarly, water hyacinth abundance increased significantly from sites 1 through 3 (Fig. 2; $F = 7.64$, $df = 3, 10$, $P = 0.01$), and Tukey-Kramer results identified significant differences in abundance of water hyacinth between sites 1 and 3 and sites 3 and 4. Cattail was the only species present in the undisturbed site, and was present at a low percentage at site 3 (Fig. 1; $F = 1833.58$, $df = 3, 10$, $P < 0.001$). Tukey-Kramer results identified significant differences in cattail cover between all sites.

The number of plant species differed significantly among the four sites. (Fig. 3; $F = 6.86$, $df = 3, 10$, $P = 0.02$). Tukey-Kramer identified significant differences in number of species present between sites 2 and 4.

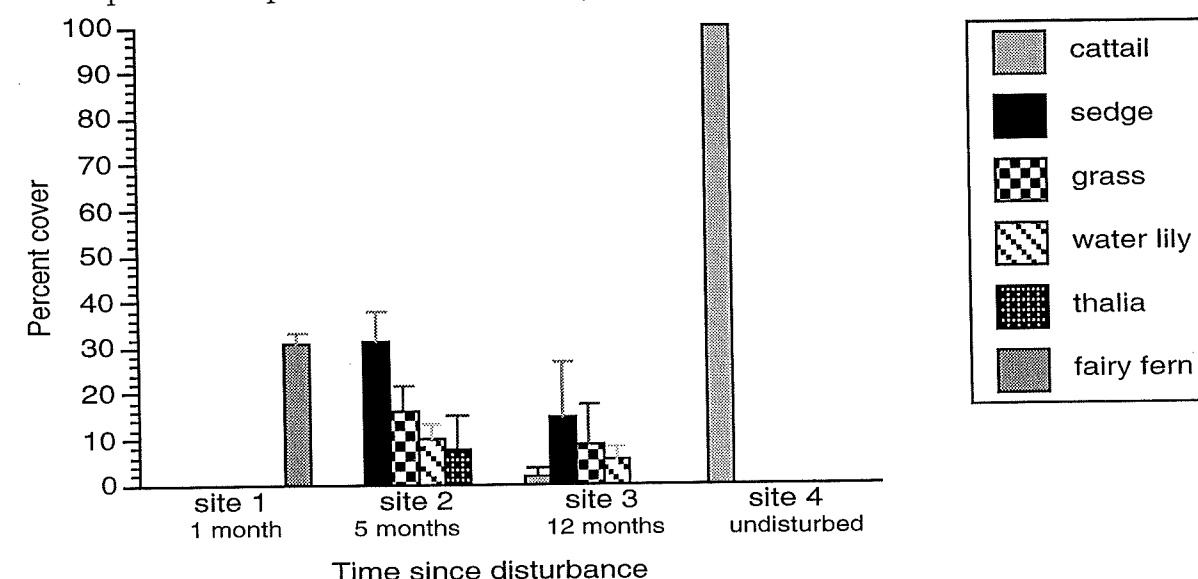


FIG. 1. Distribution of six plant species across sites of varying disturbance history at Laguna Palo Verde (mean \pm SE).

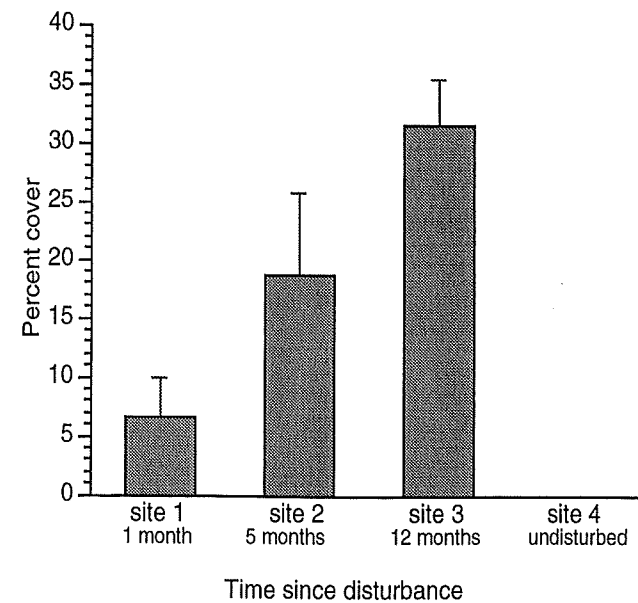


FIG. 2. Distribution of water hyacinth across sites of varying disturbance history (mean \pm SE). Abundance increased with time, but the species was eventually displaced by cattails.

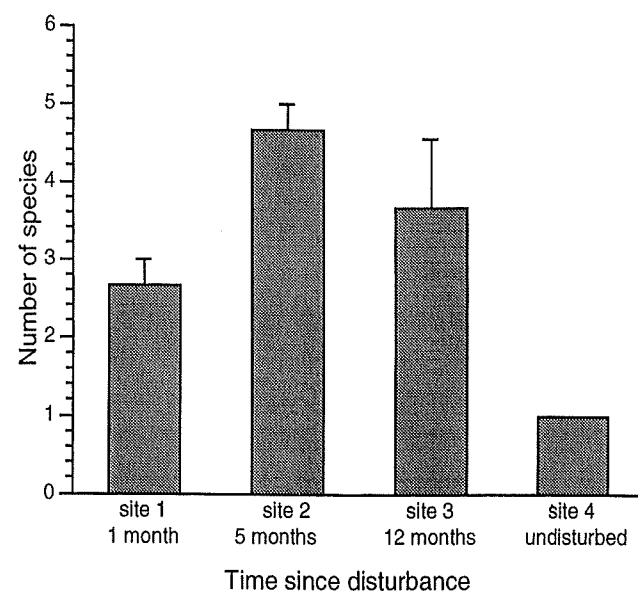


FIG. 3. The number of plant species present at each site in Laguna Palo Verde following disturbance by tractor (mean \pm SE).

DISCUSSION

We found clear successional changes among macrophyte species in Laguna Palo Verde. In addition, there were more plant species where disturbance had occurred within an intermediate time interval. Species diversity was notably lower in the most

recently disturbed area and lowest at the site where tractor disturbance had not occurred.

Laguna Palo Verde is in a non-equilibrium state, which, if left undisturbed, will probably develop into a low-diversity equilibrium community dominated by a monoculture of invasive cattails. Fairy fern was an early colonizer, while cattails dominated the undisturbed site (Fig. 1). Water hyacinth increased with time but was eventually replaced by cattails (Fig. 2). This demonstrates that early colonizers grow quickly but are eventually displaced. Our results agree with the conclusion of Abram et al. (1994), that cattails appear to displace all early successional species.

This study would have been improved by larger and more frequent transects. Because of the difficulty we had in moving around in the marsh, measuring transects of equal length proved difficult and some existing plant species may not have been recorded. Also, our time scale of disturbance was very short. Although we found successional patterns within a year of tractor disturbance, further research could investigate successional patterns of Laguna Palo Verde over a longer time period. Because the entire marsh experienced disturbance from cattle until 1981, the plant community in areas undisturbed by the tractor probably does not represent a late successional community. If left undisturbed, these wetland species could be displaced by even later successional species. As vegetation provides the basis for all other trophic levels, this successional change in plant community structure may greatly impact the species diversity of insect, avian, and mammalian communities in this ecosystem. At this time, biodiversity of this ecosystem is being enhanced through anthropogenic alteration. However, the role of successional patterns in the context of long-term species succession in anthropogenically disturbed wetlands remains to be seen.

LITERATURE CITED

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