

Wetland biodiversity restoration in a former sugarcane cultivation site in Puerto Rico

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INTRODUCTION

- Native to tropical Asia, sugarcane (*Saccharum* spp.) was brought by Columbus to Hispaniola in 1493 as one of the earliest agricultural ventures in the Americas. In 1509 Juan Ponce de León established the first agriculture experiment station of the Western Hemisphere in the Río de la Plata valley of Puerto Rico to develop crop cultivation techniques, including sugarcane.
- Drainage of coastal wetlands for sugarcane cultivation in Puerto Rico increased into the early 1900s, then declined rapidly during the second half of the 20th century.
- Most coastal palustrine wetlands in Puerto Rico are established in abandoned sugarcane sites. Therefore, hydrology and plant community composition reflect past disturbance and modifications, often to the detriment of wetland wildlife.
- Abandoned sugarcane cultivation promotes establishment of deep water lagoons, vegetation surrounding lagoons is generally dominated by moist-soil habitats typified by dense herbaceous stands and low plant species diversity.
- Loss and deterioration of coastal wetlands has contributed to population declines of all native Caribbean waterfowl and other waterbirds in Puerto Rico, as well as other islands of the West Indies.



West Indian Whistling Duck
Dendrocygna arborea



White-cheeked Pintail
Anas bahamensis



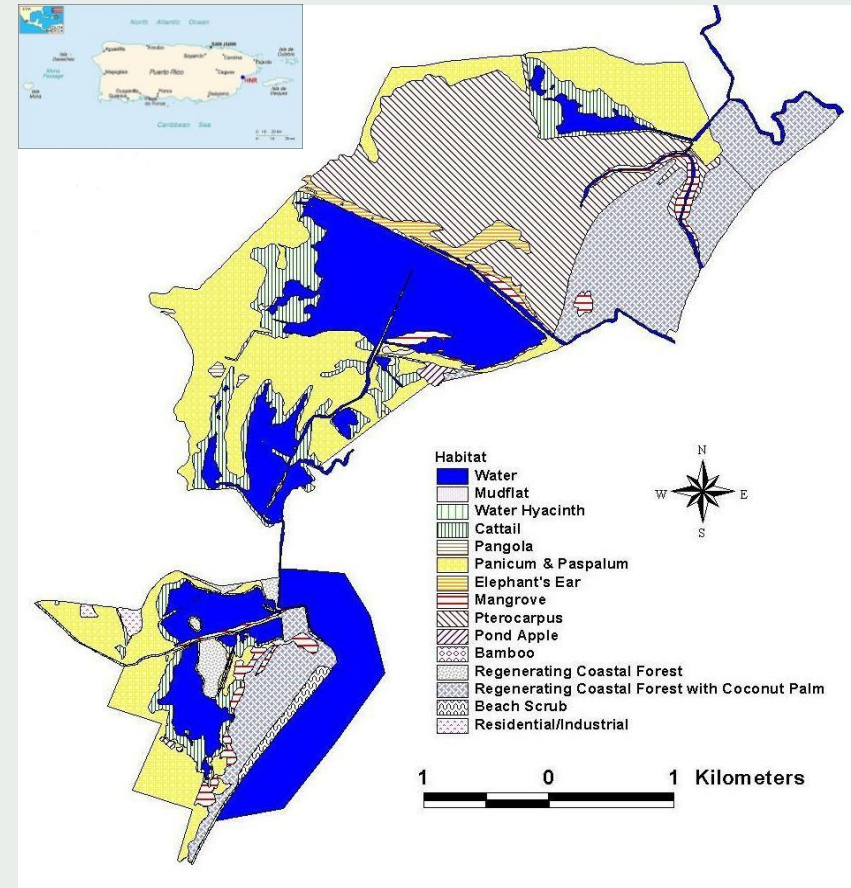
Caribbean Coot
Fulica caribaea



Caribbean Ruddy Duck
Oxyura jamaicensis jamaicensis

STUDY AREA

Humacao Nature Reserve (HNR), in southeastern Puerto Rico is a former sugarcane cultivation site. Rain events from hurricane David and tropical storm Frederick (1979) overtopped levees and flooded the area. Estuarine lagoons and emergent wetlands quickly became established in former sugarcane fields. HNR was established in 1986.

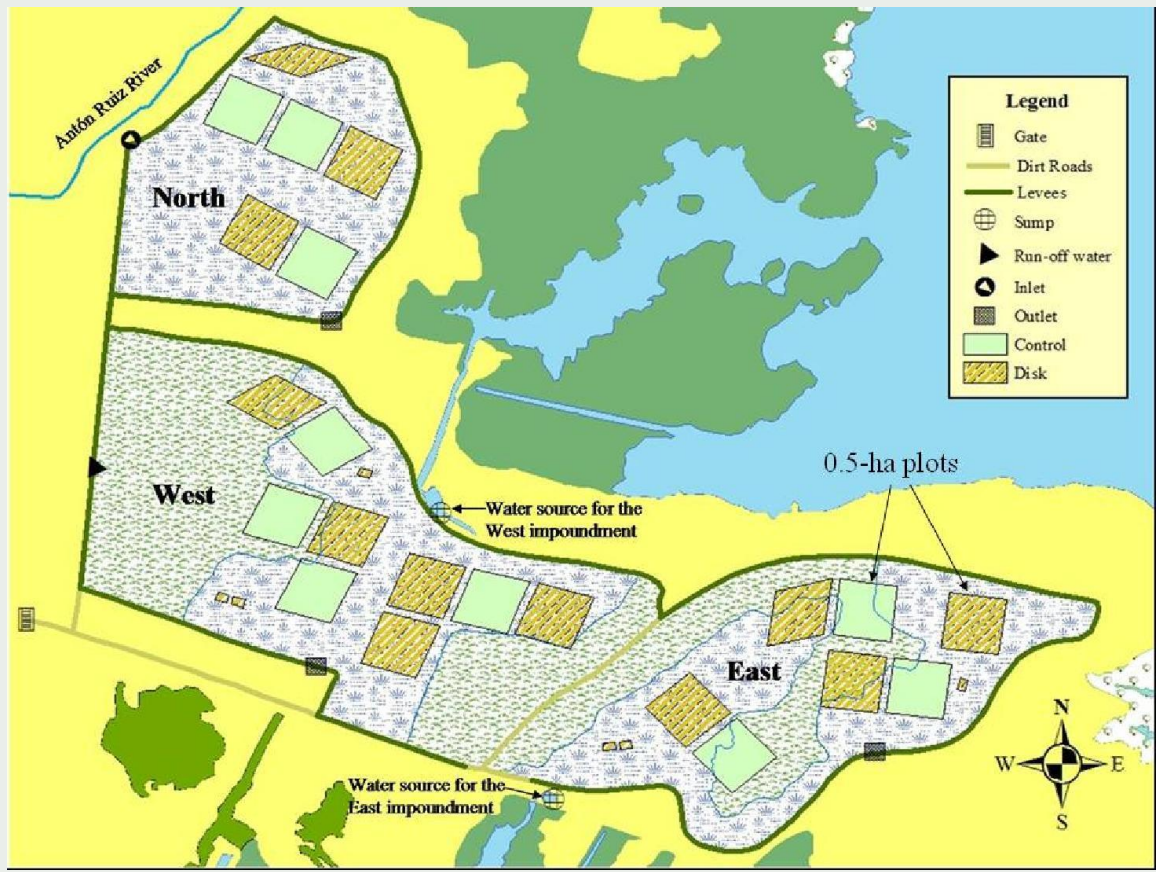


Humacao Nature Reserve Habitat Types (Total Area = 951 ha)



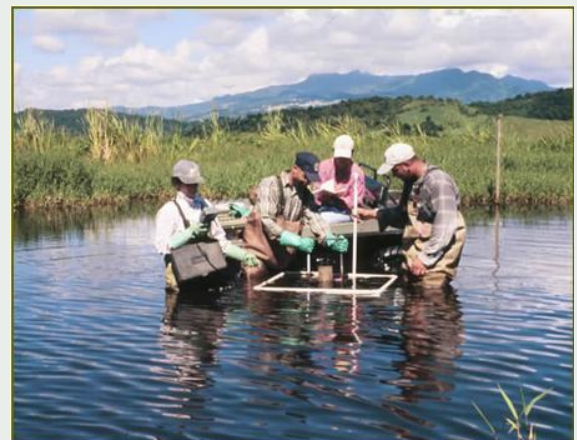
METHODS

- Three impoundments (north:10.2 ha, west:20.6 ha, east:14.7 ha) built on degraded emergent wetlands at HNR used as pasture for cattle grazing
- Randomized Complete Block Design: block = impoundment; experimental unit = 0.5 ha plot
- Treatment (disking) randomly assigned to plots within impoundments
- Treatment plots disked June-July in north, west, and east impoundments
- Flooded in early August, slow drawdown conducted between March and April
- Mixed model ANOVA with repeated statement; fixed effect = treatment; random effect = block



Waterbirds

- Familial diversity = Shannon-Weaver index (H)
- Species richness = number of bird species/plot
- Abundance = number of birds per species per plot
- Salinity, water depth, vegetation cover used as covariates
- Correlation analysis for bird and invertebrate associations



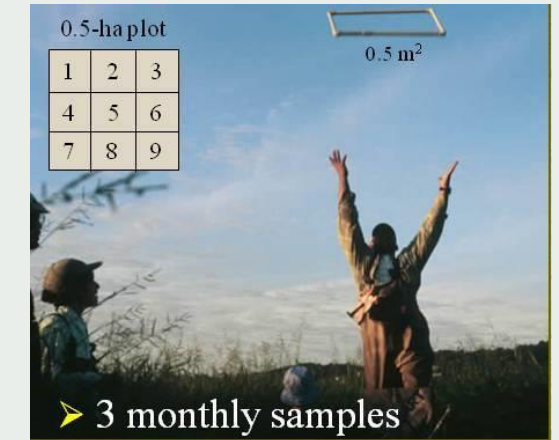
Macroinvertebrates

- Familial diversity = Shannon-Weaver index (H)
- Familial richness = number of invertebrate families per sample
- Density = individuals/m² (overall invertebrates and chironomids)
- Salinity, water depth, vegetation cover, and standing crop as covariates



Vegetation

- Plant species diversity = Shannon-Weaver index (H)
- Species richness = number of plant species/sample
- Biomass estimated (0.5 ha plot)
- Salinity & water depth covariates



RESULTS

- Bird species diversity was affected by treatment, species richness was not ($F_{1,28.4} = 2.95$, $P = 0.10$).
disked plots = 6.11 species \pm 0.77
control plots = 3.76 species \pm 1.07
- 67 bird species in six foraging guilds:
 - Upland = 6.76%
 - Above water surface = 5.44%
 - Dabblers (10-20 cm) = 16.21%
 - Divers (> 25 cm) = 4.11%
 - Waders (< 15 cm) = 65.35%
 - Variable = 2.21%
- Waterbird species nesting in restored wetlands increased over time (Fig. 1). This included 15 nests of the Yellow-breasted Crane (*Porzana flaviventer*), a species not reported in Puerto Rico since 1925.
- Chironomid larvae densities were influenced by salinity ($F_{1,46.5} = 8.54$, $P = 0.005$) and vegetation cover ($F_{1,142} = 22.46$, $P < 0.0001$). Vegetation standing crop was greater in control (251.86 ± 35.29 g) than treatment (118.38 ± 33.37 g) plots ($F_{1,24.1} = 29.63$, $P < 0.01$)



Wintering Blue-winged Teal (*Anas discors*) on restored wetlands at Humacao Nature Reserve



Yellow-breasted Crane (*Porzana flaviventer*) nesting in restored wetlands



RESULTS

Waterbird post-treatment response

Bird species:	1996	1999-2000	2001	2002
	16	53	65	67

Nests:	1996	2000	2001	2002
	N/A	N/A	55	213



Figure 1. Bird species and number of nests recorded before (1996-2000) and after restoration (2001-2002). No nests were found pre-restoration and most bird species observed were not wetland dependent species (e.g., Gray Kingbird *Tyrannus dominicensis*).

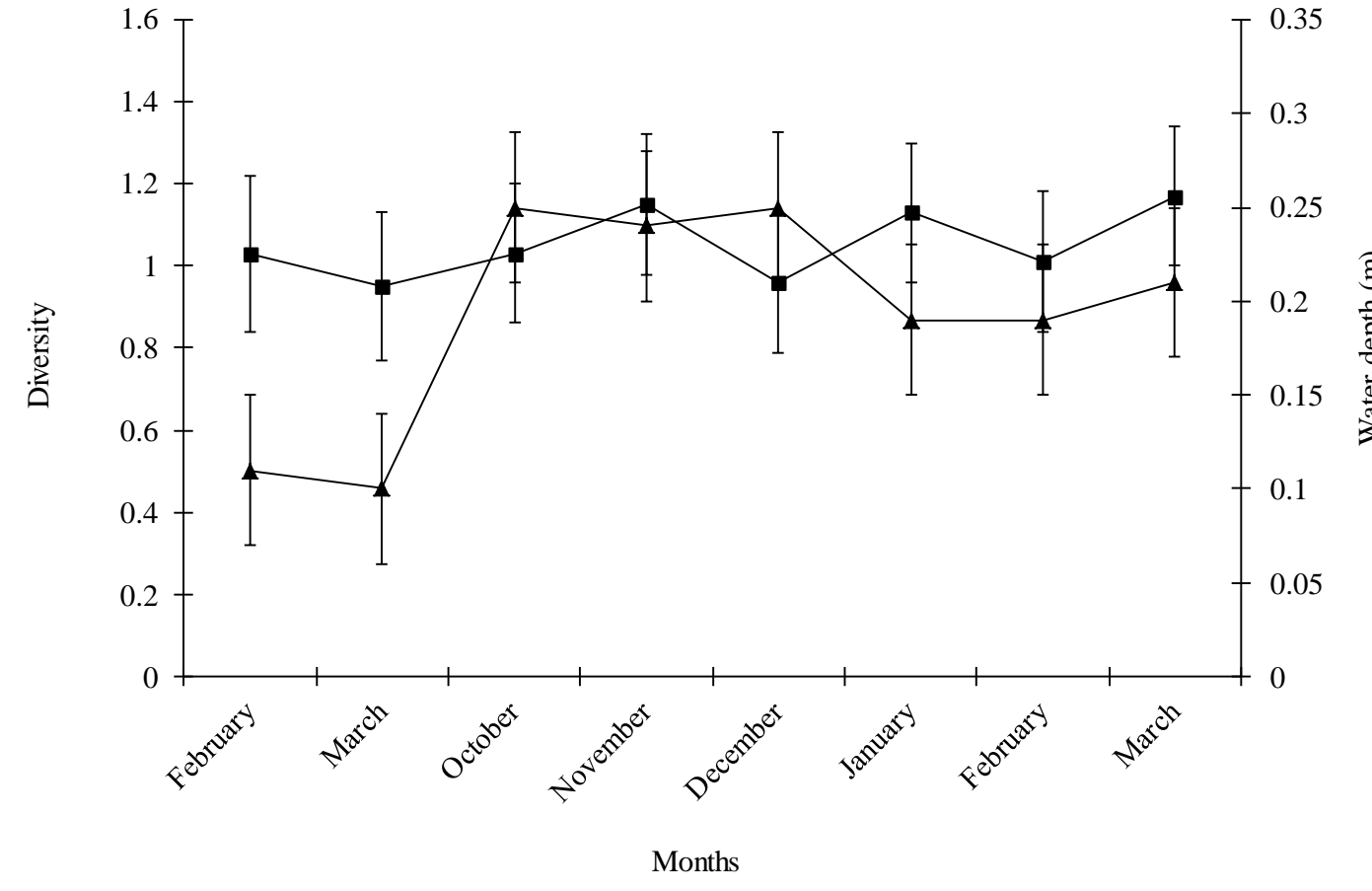


Figure 2. Water depth ($F_{1,138} = 10.80$, $P = 0.001$) and vegetation cover ($F_{1,190} = 16.60$, $P < 0.0001$) influenced bird diversity. Covariates: diversity \downarrow 1.75 units for each 1m \uparrow in water depth; diversity \downarrow 0.01 units for each 1% \uparrow in cover.

Invertebrate post-treatment response

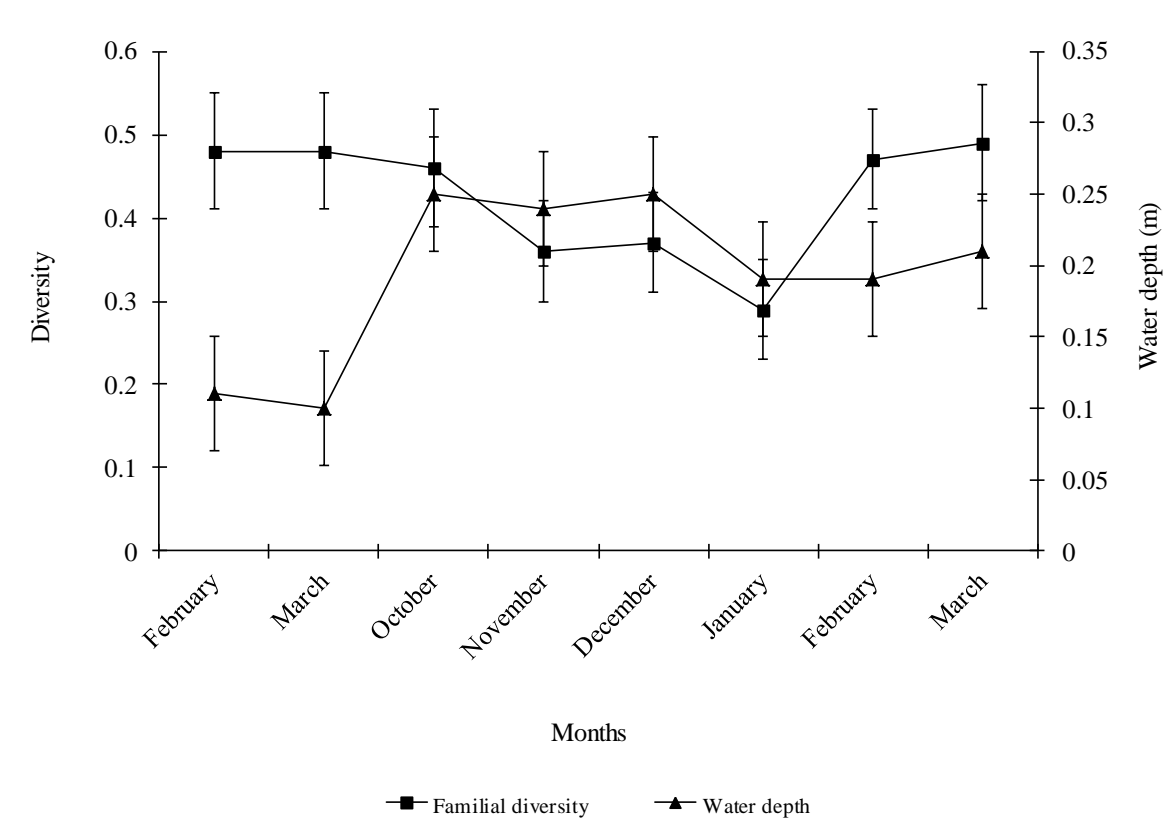


Figure 3. Water depth ($F_{1,156} = 11.46$, $P = 0.001$) and salinity ($F_{1,156} = 19.24$, $P < 0.0001$) influenced invertebrate diversity. Covariates: diversity \downarrow 0.70 units for each 1m \uparrow in water depth; diversity \downarrow 0.03 units for each 1 ppt \uparrow in salinity.

Vegetation post-treatment response

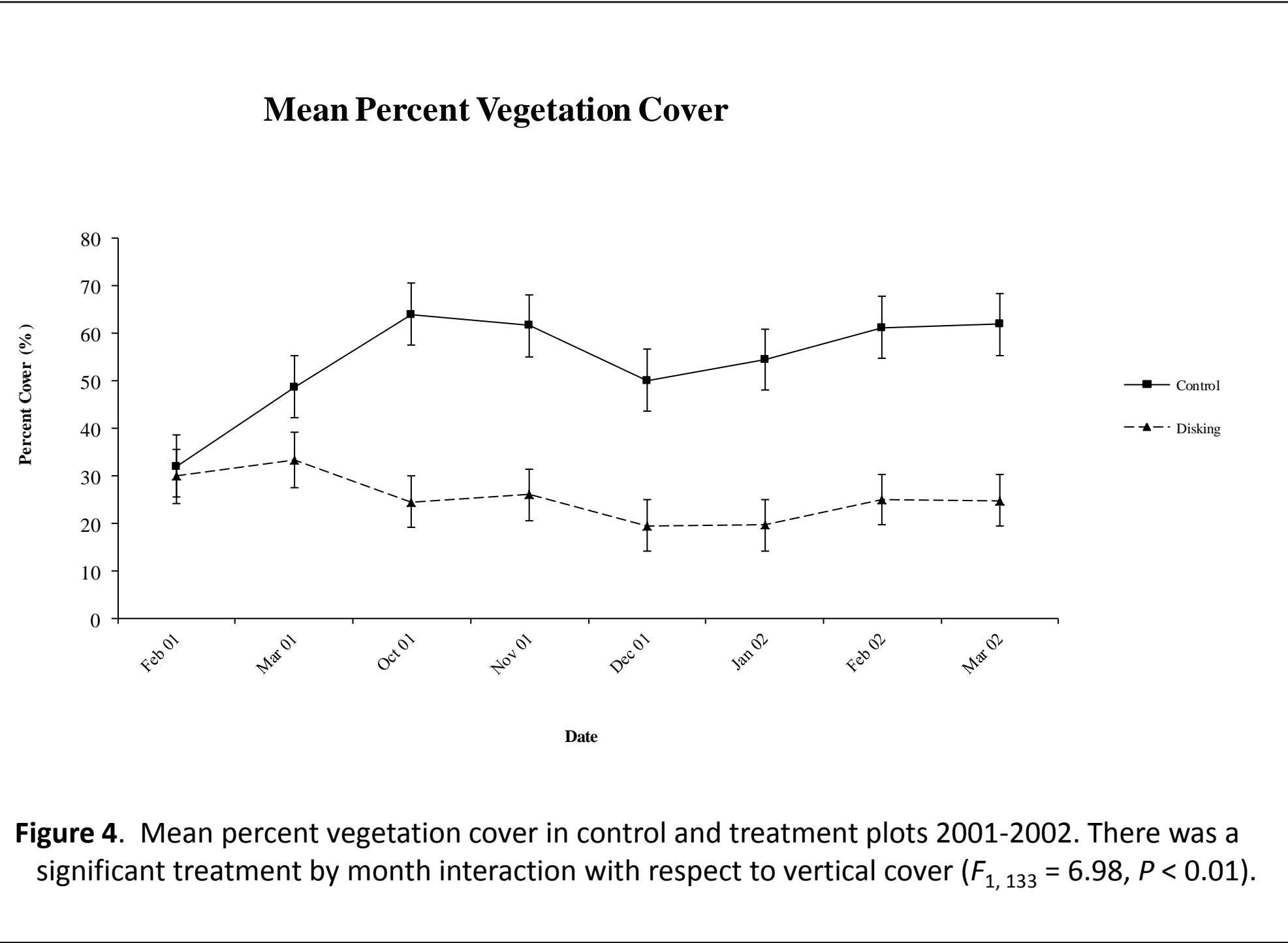


Figure 4. Mean percent vegetation cover in control and treatment plots 2001-2002. There was a significant treatment by month interaction with respect to vertical cover ($F_{1,133} = 6.98$, $P < 0.01$).

Vegetation temporal response to restoration



Figure 5. Chronosequence of plant community response to habitat restoration at the Humacao Nature Reserve impoundments from pasture (June 2000) to wetlands (May 2002).

DISCUSSION

- Soil disturbance promoted coexistence of plant species and maintained species richness.
- In some disked plots water depth may have inhibited seedlings plots by reducing transpiration and photosynthetic rates.
- The pantropical forage grass *Brachiaria mutica*, a perennial hydrophyte, dominated some experimental units and may have contributed to greater biomass in control plots.
- Absence of disturbance under year-round tropical growing conditions may also explain greater vegetation cover and biomass in control plots.
- Absence of treatment effect (disking) on invertebrates may reflect early succession of restored wetlands; water depth was the most significant factor affecting invertebrates.
- By the end of our study restored wetlands may still need to develop the structural features and resources (i.e., plant and invertebrate communities) required to support a more diverse wetland bird community.
- Water depth influenced bird diversity, richness and abundance; was greatest at 10-20 cm.
- Results indicated restored habitat conditions within impoundments provided improved wetlands for waterbirds. By end of study, avian community was dominated by wading birds.
- Established wetland conditions improved habitat by; reducing monotypic stands of vegetation, increasing fine particulate soil matter, and inducing managed levels of disturbance.
- A similar restoration approach implemented at other sites in Puerto Rico and other islands with a similar history of sugarcane cultivation and abandonment would greatly benefit wetland biodiversity in the Caribbean.

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