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AMOUNT AND ECONOMIC VALUATION OF FERAL HOG DAMAGE TO A UNIQUE BASIN MARSH WETLAND IN FLORIDA

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Abstract. Feral hogs (*Sus scrofa*) have been introduced into many natural habitats throughout the world, and they have adversely affected the environment in most of those places. Basin marshes are unique, but dwindling ecosystems in Florida that are especially vulnerable to damage by feral hogs. We estimated the amount of hog damage to the last remnant of a basin marsh system in Savannas Preserve State Park (SPSP), and to ecotones within the marsh. We also applied an economic valuation method for the hog damage that was based on the dollar amounts that wetland regulators have allowed permit applicants to spend in mitigation attempts to replace lost wetland resources. We found that hogs damaged 19% of the exposed portion of the basin marsh in our study area. Seventy percent of the sample sites showed hog damage at the shoreline ecotone and 58% showed damage at the upland ecotone. The area damaged within our study site alone was valued between $1,238,760 and $4,036,290. These damage valuation estimates were considered conservative, because it was impossible to incorporate values for such contingencies as hog impacts to state and federally listed endangered plants in SPSP, some of which are found nowhere else in the world. We also could not extrapolate an economic quantity to describe the threat posed by the hogs inhabiting SPSP as a reservoir for transmission of diseases to livestock and wildlife.

Key words: damage estimation; economic value; exotic species; feral hogs; feral pigs, invasive species; wetland damage.

INTRODUCTION

Feral hogs (*Sus scrofa*) can be a particularly destructive exotic species in the places where they have been introduced (U.S. Department of Agriculture 1999). They impose a variety of negative environmental impacts through habitat degradation, predation on native species, and competition with native species (Chequenot et al. 1996, Taft 1999, Engeman et al. in press[a]). Florida, along with Hawaii, is one of the two states of the United States with the most severe invasive species problems (U.S. Congress 1993), and hogs were one of the first invasive exotic species to take hold in Florida. Florida is where hogs were first introduced to North America, by DeSoto in 1539 (Towne and Wentworth 1950). The species possesses the highest reproductive potential of any large mammal in North America (Wood and Barrett 1979, Hellgren 1999) and, with subsequent introductions, the range of feral hogs in the U.S. continues to expand (Gipson et al. 1997). Feral hogs currently inhabit many areas in such large numbers that they adversely impact wildland and agricultural ecosystems.

Feral hogs often are the single greatest vertebrate modifier of natural plant communities (Bratton 1977, Wood and Barrett 1979, Stone and Keith 1987, Engeman et al. in press[a]). Rooting may damage population structures of plants, set back succession, and change species composition (Bratton 1977). In addition, mounting evidence indicates that hogs help spread rootrot fungus (*Phytophthora cinnamomi*), which causes dieback disease in native vegetation (Kliejunas and Ko 1976). Habitat damage by hogs is most pronounced in wet environments (e.g., Chequenot et al. 1996, Engeman et al. in press[a]). The exposed portions of basin marshes are particularly susceptible, because they are large, irregular, wet basins with outlets only during high water. Their shallow waters are dominated by herbs and shrubs (Florida Natural Areas Inventory 1990), making them very attractive for

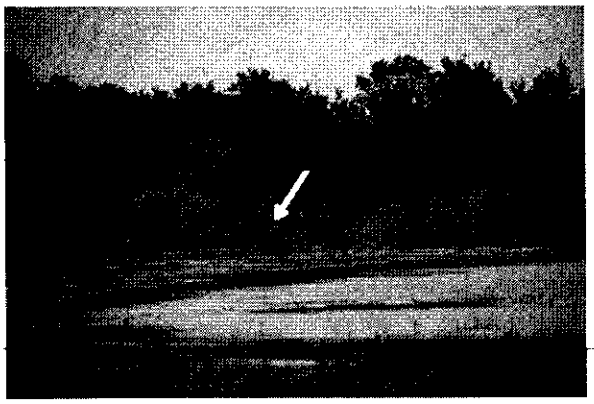

PLATE 1. Feral hogs "rooting" in basin marsh at Savannas Preserve State Park. Image by R.M. Engeman, NWRC.

foraging by hogs. Water generally stands in the basins for only about 200 days per year, and they are associated with and often grade into wet prairies or marsh lakes (Florida Natural Areas Inventory 1990).

Funding to manage feral hogs and restore habitat is finite and must be carefully managed to optimize the positive impact on the protected resources. Decisions on management actions towards destructive invasive species are based on economic constraints, but the metric for success of management actions is measured in resource quality. Therefore, a means to efficiently estimate feral hog damage to habitats, and to apply a monetary value to the damage, would permit economic analyses to help guide and evaluate management actions. Here, we quantify habitat damage by feral hogs to the exposed portions of the only significant basin marsh undisturbed by human habitat conversions in southeastern Florida. We also apply economic valuations to that damage (Engeman et al. in press[a]).

METHODS

The Basin Marsh

Savannas Preserve State Park (SPSP) protects the last remnant of extensive freshwater basin marsh systems that formerly extended for about 320 km along Florida's east coast. The SPSP basin marsh is unique in that water levels fluctuate dramatically from year to year, more so than most basin marshes (Florida Department of Environmental Protection, unpublished data). The basin marsh in SPSP occurs in the form of a band about 0.6 to 1.3 km wide immediately west of the Atlantic Coastal Ridge for the length of the property (approximately 15.5 km). Within the 570 ha of basin marsh, a mixture of grasses and sedges in shallow, open water dominates approximately 75% of the marsh, and sawgrass stands (*Cladium jamaicense*) cover the remaining 25%. Because of its ephemeral nature, the SPSP basin marsh aquatic

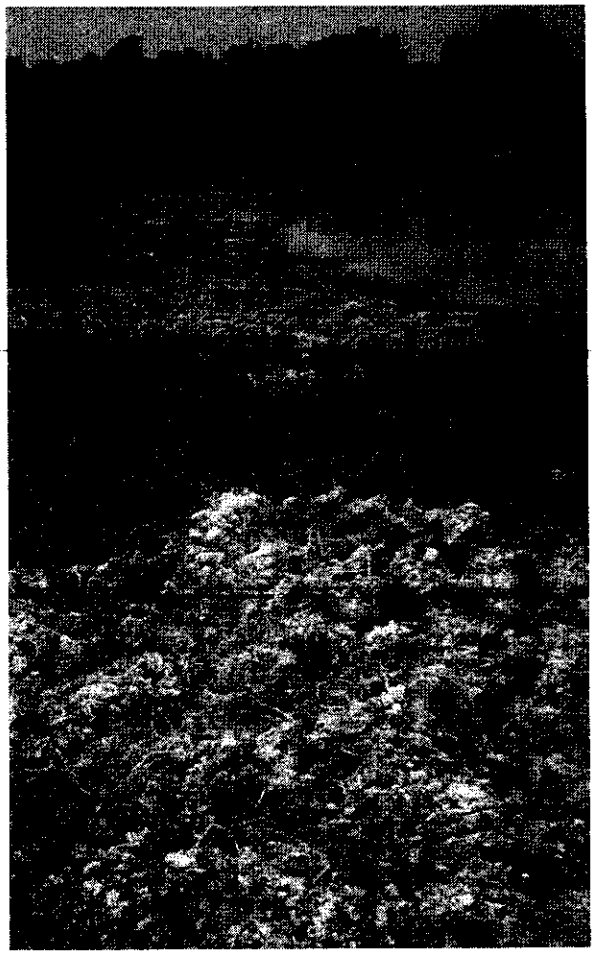

PLATE 2. Close-up of feral hog "rooting" damage in basin marsh at Savannas Preserve State Park. Image by R.M. Engeman, NWRC.

plant and animal communities are extremely sensitive to environmental disturbances. The fluctuating nature and gentle slope of the marsh also result in a wide, wet margin vegetated with forbs and grasses. This exposed zone is extremely attractive to hogs for foraging and it is highly vulnerable to damage.

SPSP supports at least 516 species of vascular plants, 192 species of vertebrates, and 300 species of aquatic invertebrates (Florida Department of Environmental Protection, unpublished data). Thirty-five of these species are listed by the U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission, or the Florida Department of Agriculture and Consumer Services as endangered, threatened, or of special concern (Florida Department of Environmental Protection 2003).

Study Site and Damage Measurements

During January 2003, damage was sampled at 100 m intervals for 5.9 km along the periphery of the basin

marsh. At each sample site, a tape measure transect was placed along the perpendicular distance from the ecotone defined by the water's edge to the ecotone between the marsh and upland vegetation of the surrounding mesic flatwoods community (Hartman 1978, Kautz 1987). Both ecotones that defined the limits of the exposed portion of basin marsh were abrupt and easy to define. After placing the tape measure, three damage measurements were made. The first was the total distance under the tape that was damaged by hogs. This amount could represent a single patch of damage or the combined distances under the tape of multiple patches. Damage not lying directly under the tape was not recorded. Hog damage was defined as ground overturned during foraging (rooting) activity. Tracks verified the species responsible. Armadillos (*Dasypus novemcinctus*) were the only other species in the park that could produce superficially similar (small) patches of damage, which were easily distinguished from hog damage by examining tracks and whether the ground was overturned, or dug by forefect. The other two damage measures were binary and aimed at evaluating the damage precisely at the two ecotones. The point at which the tape contacted the water's edge was recorded as damaged or undamaged, as was the point at which the tape contacted the upland ecotone.

Data Analyses

The percent damaged at each sample site was calculated as the ratio of the distance along the tape that damage patches comprised, divided by the total distance between the two ecotones. The percent damaged along the basin marsh was calculated as the mean percent damaged among the sample sites ($n = 60$). The total exposed area of the study area was calculated as the mean distance between ecotones across the sample sites multiplied by the 5.9 km of shoreline. The damage rate along the shoreline ecotone was calculated as the percent of sample sites with damage at the water's edge. The damage rate at the upland ecotone was calculated similarly. Cochran's Q test for single-factor repeated measures designs with dichotomous data (e.g., Winer 1971) was used to examine whether the rate of damage was different at the two ecotones.

Damage Valuation

Determination of monetary values for protected habitats is not a straight-forward nor precise process. A means of applying a monetary value on a unit-area basis to damaged native habitats was needed to estimate the unit (per ha) and total cost of hog damage (Engeman et al. in press[a]). Engeman et al. (in press[b]) also discussed a variety of ways to apply monetary values to threatened and endangered animal species. Analogies to these methodologies were considered for application to habitat values, as well as other avenues specific to habitat issues. One simplistic consideration for valuation of habitat is to appraise the land on the basis of market value. However, special habitats such as wetlands have limited "market value", and if such habitat is selectively protected, the market value diminishes even further (King 1998). The use of contingent valuation surveys for special habitats, analogous to those applied to endangered animals (Engeman et al. in press[b]), tend to be even more abstract appraisals of value (King 1998). Estimated costs for restoring habitat to pristine condition (replacement costs) frequently produce values well in excess of the public's "willingness-to-pay", and therefore also do not represent a realistic valuation. The most defensible, logical, and applicable valuation for the damaged habitat characteristic of our study site was to use expenditure data for permitted wetland mitigation projects in the United States (Engeman et al. in press[a]). Such data represent an empirical demonstration of willingness-to-pay value. King (1998) presented the dollar amounts per unit-area spent in efforts to restore a spectrum of wetland habitat types. The numbers represent the dollar amounts that environmental regulators have allowed permit applicants to spend in attempts to replace lost wetland services and values (King 1998). We identified the dollar value for the appropriate wetland habitat category from each of the two studies in King (1998). For these two studies, the habitats from our study areas would be classified as "freshwater emergent" or "open-water emergent", with respective 1997 empirical willingness-to-pay dollar values of $207,480/ha and $676,039/ha (King 1998). The 2003 values for each of these willingness-to-pay dollar amounts after adjusting for a 3% annual rate of inflation (Zerbe and Dively 1994) were $247,742/ha and $807,226/ha, respectively. The cost of the total area in our study site damaged by hogs was calculated by multiplying the above values by the estimated area of hog damage (Engeman et al. in press[a]).

RESULTS

Damage Estimates

The mean width of the exposed portion of the basin marsh was 44.7 m (SE = 4.9 m). Multiplying this value by the 5.9 km distance of marsh periphery sampled resulted in an estimated total area of exposed basin marsh in our study site of 26.4 ha. The mean percent width of exposed marsh that was damaged by feral hogs was 19.0%, producing an estimated 5.0 ha of exposed basin marsh damaged by hogs. The total value of the damaged area was $1,238,710 when using the "freshwater emergent" valuation and $4,036,130 when using the "open-water emergent" valuation.

Seventy percent of the sample sites showed damage at the water's edge ecotone, versus 58% at the upland shrub ecotone. However, this difference in damage rates was not detectable statistically (x^2, 1 df = 1.96, p = 0.16).

Discussion

In Florida, a premium is placed on sanctuaries for protection and preservation of habitats and species, especially because much of the natural habitat in Florida already has been lost to development. We found a substantial proportion (19%) of the exposed portion of the basin marsh to be damaged by feral hogs. In estimating the monetary values of the hog damage to the habitat we assumed standard costs for restoration. The total value of the damaged area just within our study site ranged from $1.2 million to $4.0 million for the two wetland valuation classifications. The periphery of the entire basin marsh would be about five times our study site. These values are substantially underestimated if the potential economic spillover effects of feral hog management are extended to incorporate endangered and threatened species, water quality impacts, suburban development areas, agricultural lands, and the transmission of diseases. These spillover effects, or secondary multiplier effects, represent the indirect benefits to society of feral hog management through additional benefits of management that were not necessarily intended directly as an outcome of the project (Boardman et al. 1996).

To expand on the above effects, consider that SPSP is home to a myriad of threatened and endangered plant (and animal) species, as well as their unique habitats (e.g., Hartman 1978, Gann et al. 2002), some of which are found nowhere else in the world (we do not identify the species or the specific areas in which these species are found to protect them from illegal collection). Damage to, or loss of, such a species is much more difficult to ascribe a monetary value to (Engeman et al. in press[b]). In fact, consider that values of endangered or threatened species have been deemed "incalculable" in U.S. Supreme Court case law (Tennessee Valley Authority vs. Hill, 1978). The opinion goes so far as to say "it would be difficult for a court to balance the loss of a sum certain - even $100 million - against a congressionally declared 'incalculable' value, even assuming we had the power to engage in such a weighing process, which we emphatically do not."

A further consideration of the magnitude of potential damage costs by hogs is that a further level of magnification occurs if the definition is broadened to include the potential for transmission of diseases to livestock and wildlife. Feral hogs can harbor a number of diseases transmissible to livestock and/or humans (e.g., Becker et al. 1978, Chequenot et al. 1996, Conger et al. 1999, Romero and Meade 1999, Taft 1999), and SPSP is situated at interfaces with rural lands, native habitats, and suburban development. In particular, the commercial hog industry in the USA has nearly eradicated swine brucellosis and pseudorabies, but feral hogs serve as a potential reservoir from which these diseases can be transmitted back to domestic stock (Taft 1999, Taylor 1999). The hogs damaging the SPSP basin marsh are geographically a potential reservoir for diseases that could be transmitted to domestic livestock in the area.

Thus, while we have provided monetary estimates on the value of hog damage to the exposed portion of the basin marsh, these values should be viewed as a lower bound on the value of potential ecological damage. As our study concluded, SPSP had commenced a contract with the U.S. Department of Agriculture/Wildlife Services for intensive hog removal throughout the park. The cost of this contract was $7,500, and represents only a minor fraction of the value of the hog damage to an average single ha of the exposed basin marsh, let alone to the synergistic value of the hog damage.

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