



The amount and economic cost of feral swine damage to the last remnant of a basin marsh system in Florida

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Summary

Swine (*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 swine. We estimated the amount of swine 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 swine 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 swine damaged 19% of the exposed portion of the basin marsh in our study area. Seventy percent of the sample sites showed swine damage at the shoreline and 58% showed damage at the interface with the upland vegetation of the adjacent mesic flatwoods. 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 swine impact 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 swine inhabiting SPSP as a reservoir for transmission of diseases to domestic livestock.

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Introduction

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

Feral swine often are the single greatest vertebrate modifier of natural plant communities (Bratton, 1977; Wood & Barrett, 1979). Rooting may damage population structures of plants, set back succession, and change species composition (Bratton, 1977). In addition, mounting evidence indicates that swine help spread rootrot fungus (*Phytophthora cinnamomi*), which causes dieback disease in native vegetation (Kliejunas & Ko, 1976). Habitat damage by swine is most pronounced in wet environments (e.g., Choquenot et al., 1996). Basin marshes are large, irregular, wet basins with outlets only during high water. Their shallow waters and exposed portions are dominated by herbs and shrubs (Florida Natural Areas Inventory, 1990), making them very attractive for foraging by swine. 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 swine and restore habitat is finite and must be carefully managed to optimise 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 swine 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 swine 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.

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 in most basin marshes (Florida Department of Environmental Protection, unpublished data). The basin marsh in SPSP occurs in the form of a band about 0.6–1.3 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 area, and sawgrass stands (*Cladium jamaicense*) cover the remaining 25%. Because of its ephemeral nature, the SPSP basin marsh aquatic 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 swine 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 US 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

Damage was sampled on transects spaced 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 water's edge to the interface between the marsh and upland vegetation of the surrounding mesic flatwoods community (Hartman,

1978; Kautz, 1987). Both of these limits to 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 swine. 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. Swine 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 swine damage by examining tracks and whether the ground was overturned, or dug by forefeet. The other two damage measures were binary and aimed at evaluating the damage precisely at the two habitat interfaces at the extremities of the transects. 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 vegetation.

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 length of the transect. 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 transect length across the sample sites multiplied by the 5.9 km of shoreline. The damage rate along the shoreline was calculated as the percent of sample sites with damage at the water's edge. The damage rate at the upland interface 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 habitat interfaces.

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 swine damage. Engeman, Shwiff, Smith, and Constantin (2002) discuss 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., 2002), 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. 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, and to a degree elected governments, 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 habitat from our study 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 & Dively, 1994) were \$247,742/ha and \$807,226/ha, respectively. The cost of the total area in our study site damaged by swine was calculated by multiplying the above values by the estimated area of swine damage.

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 swine was 19.0%, producing an estimated 5.0 ha of exposed basin marsh damaged by swine. 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, versus 58% at the upland shrub interface. However, this difference in damage rates was not detectable statistically (χ^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 swine. In estimating the monetary values of the swine 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. These values are substantially underestimated if the potential economic spillover effects of feral swine management are extended to incorporate endangered and threatened species, water quality impacts, suburban development areas (swine leave the park and damage sod in neighboring developments), agricultural lands, domestic livestock, and the transmission of diseases. These spillover effects, or secondary multiplier effects, represent the indirect benefits to society of feral swine management through additional benefits of management that were not necessarily intended directly as an outcome of the project (Boardman, Greenberg, Vining, & Weimer, 1996).

To expand on the above effects, consider that SPSP is home to dozens of threatened and endangered plant (and animal) species, as well as their unique habitats (e.g., Hartman, 1978; Gann, Bradley, & Woodmansee, 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., 2002). In fact, consider that values of endangered or threatened species have been deemed “incalculable” in US 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.”

The magnitude of potential damage costs by swine is further magnified if the definition of damage is broadened to include the potential for transmission of diseases to domestic livestock. Feral swine can harbor a number of diseases transmissible to livestock and/or humans (e.g., Becker et al., 1978; Choquenot et al., 1996; Romero & Meade, 1999; Taft, 1999), and SPSP is situated at interfaces with rural lands, native habitats, and suburban development. In particular, the swine industry in the USA has nearly eradicated swine brucellosis and pseudorabies, but feral swine serve as a potential reservoir from which these diseases can be transmitted back to domestic stock (Taft, 1999). The swine 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 swine 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 US Department of Agriculture/ Wildlife Services for intensive swine removal throughout the park. The cost of this contract was \$7500, and represents only a minor fraction of the value of the swine damage to an average single ha of the exposed basin marsh, let alone to the additional costs of the swine damage. Continued monitoring for swine damage along the marsh is planned for future years and will determine the sufficiency of the applied level of swine management for slowing damage and promoting habitat recovery.

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