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Plant community shifts caused by feral swine rooting devalue Florida rangeland

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ABSTRACT

Invasive species threaten agriculture by changing agroecosystem structure and function, reducing habitat value, decreasing biodiversity and ecosystem services and increasing management costs. Grazing lands in south central Florida are a mosaic of sown pastures, native grasslands, wetlands and woodlands that provide a variety of ecosystem services. Disturbance of these pastures and native grasslands by invasive feral swine (*Sus scrofa*) can have negative consequences for both economic productivity and biodiversity. In this study, we show that the effect of rooting on plant diversity depends on ecosystem type and initial levels of plant species diversity. For example, in native grassland pasture, rooting was initially associated with declines in plant species richness, while in sown pastures, rooting was associated with more sustained increases in plant species richness. In both sown pastures and native grasslands, swine rooting altered plant community composition reducing agricultural productivity. Forage grasses were primarily associated with unrooted areas, whereas low quality forage species or nuisance species were found in rooted areas. We provide an example of monetary losses that cattle ranches can incur when feral swine are abundant on the landscape and control is minimal. Ranch managers and government agencies are encouraged to consider implementing more stringent feral swine management programs to minimize negative effects of feral swine rooting on ecological and economic value of grazing lands.

1. Introduction

Non-native vertebrates threaten agricultural systems (U.S. Congress, 1993) and the ecosystem services they provide (Kenis et al., 2009; Richardson and Van Wilgen, 2004). In North America, feral swine (*Sus scrofa*) are a non-native species that act as ecosystem engineers (Crooks, 2002; Cuevas et al., 2010; Hone, 2002). Rooting behavior—in which feral swine turn over soil in search of food items—causes soil disturbance and creates opportunistic habitats for disturbance-adapted plants to exploit. The new community composition of these habitat patches may form alternative, yet stable ecological states that are difficult to restore once established (Firn et al., 2013).

Rooting by feral swine has been shown to decrease plant cover (Singer et al., 1984), including forage grasses for cattle and livestock (Tisdell, 1982), and to alter plant communities (Siemann et al., 2009). The resulting opportunistic plant communities include undesirable plants of little value to agriculture, i.e., they are sometimes toxic to livestock, costly to manage or eliminate, and compete with economically important grasses (Baker, 1974). In the southeastern USA, feral swine facilitate the expansion of a native plant species, Carolina redroot (*Lachnanthes caroliniana*), that has been documented as a native invader in commercial cranberry (*Vaccinium* spp.) bogs in Louisiana (Robertson, 1976). In Florida, Carolina redroot has been shown to invade and dominate natural habitats after feral swine rooting, both in experimental plots (Boughton and Boughton, 2014) and in natural systems (C. Gates, pers. comm.).

Plant community responses to rooting by feral swine differ widely among ecosystems, and are in part determined by the life history of resident species as well as other natural and introduced disturbance regimes (Cushman et al., 2004; Kotanen, 1995). Reduced plant species richness has been documented after feral

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swine rooting in native gray beech (*Fagus grandifolia*) forest habitat in the Great Smoky Mountains National Park (Bratton, 1975), but an increase in plant species richness has been observed in California grasslands (Cushman et al., 2004; Kotanen, 1995) and Florida flood plain assemblages (Arrington et al., 1999). Cattle ranches in south central Florida contain a mosaic of high diversity native grassland and low diversity sown pastures and we expected these two communities to respond to disturbance differently.

Our objectives were to document if feral swine rooting caused changes to community composition in native grassland and sown pasture, to determine the resilience of these grassland habitats to rooting disturbance, and to calculate the annual economic cost of lost forage to ranchers. We hypothesized high quality forage would be reduced by rooting in the two dominant pasture types found in Florida, although the mechanisms driving the loss would be different. In native grassland pastures, plant diversity would decrease in areas disturbed by rooting due to invasion of Carolina redroot following disturbance (Boughton and Boughton, 2014). We hypothesized that the composition of communities would also change such that disturbance-adapted plants would be more abundant in rooted areas than in areas that had not been disturbed by feral swine. We predicted that both the decrease in species richness and change in community composition would decrease the abundance of forage grass in native grassland. In sown pastures, where plant diversity is low, we hypothesized that plant diversity would increase after rooting disturbance, as rooting has been shown to interrupt the competitive dominance of non-native grasses (Cushman et al., 2004).

The cost of feral swine damage and control in the United States exceeds $1.5B annually (USDA, 2013). In Florida, feral swine have been documented to damage imperiled ecosystems as well as agricultural ecosystems costing the state millions of dollars per year (Engeman et al., 2003, 2004, 2007). Florida rangeland provides extensive ecosystem services, has high conservation value and is a direct economic benefit to local and state economies. Based on our estimated loss of forage to rooting, we calculated a baseline estimate of economic losses to cattle ranchers both locally and regionally.

Table 1
List of plant species commonly encountered in this study.

Scientific name	Growth habit	Forage quality
Axonopus fissifolius	Graminoid	Low
Panicum longifolium Torrey	Graminoid	Low
Spartina bakeri	Graminoid	Low after burned
Andropogon virginicus L.	Graminoid	Medium
Panicum hemitomon	Graminoid	High
Paspalum notatum	Graminoid	High
Cynodon dactylon	Graminoid	High
Cirsium spp.	Forb	Unpalatable
Cyperus spp.	Forb	Unpalatable
Lachnanthes caroliniana	Forb	Unpalatable
Sporobolus indicus	Graminoid	Unpalatable
Eupatorium capillifolium	Woody dicot	Unpalatable
Rubus leucodermis	Woody dicot	Unpalatable
Bidens mitis	Forb	Unknown
Centella asiatica	Forb	Unknown
Diodia virginiana	Forb	Unknown
Hydrocotyle umbellata	Forb	Unknown
Justicia angusta	Forb	Unknown
Ludwigia octovalvis	Forb	Unknown
Ludwigia repens	Forb	Unknown
Phyla nodifloria	Forb	Unknown
Rhexia spp.	Forb	Unknown
Bacopa caroliniana	Forb	Unknown
Euthamia minor	Forb	Unknown
Proserpinaca palustris	Forb	Unknown
Eleocharis vivipara	Graminoid	Unknown
Rhynchospora spp.	Graminoid	Unknown
Euthamia graminifolia	Woody dicot	Unknown

2. Materials and methods

2.1. Study site

The MacArthur Agro-ecology Research Center (MAERC; a division of Archbold Biological Station) spans 4170-ha in Highlands County, Florida, and is one of the top 20 cattle producers in the state. Between 1950 and 1970, ranch owners converted most of the upland dry prairie to sown pasture (~1800 ha), planting Bahia grass (*Paspalum notatum*) to support cattle. Today, the vegetation in the low lying wet prairies of the ranch is generally native and used for winter cattle grazing (~2282 ha). Native grassland pastures primarily consist of medium-quality winter forage grasses including broomsedge (*Andropogon virginicus*), panic grass (*Panicum longifolium*), maidencane (*Panicum hemitomon*), and carpetgrass (*Axonopus fissifolius*). Common forbs include Carolina redroot, coinwort (*Centella asiatica*), thistle (*Cirsium* spp.), and sedges (*Cyperus* spp.). Dog-fennel (*Eupatorium capillifolium*) is a common and problematic woody dicot in these pastures that can cause dehydration in cattle if consumed in large quantities (Ferrell and MacDonald, 2005). In sown pastures, Bahia grass, a common high-quality forage grass in the southeastern United States, dominates; but small amounts of Bermudagrass (*Cynodon dactylon*), another high-quality forage grass, is also present. Forbs include thistle (*Cirsium* spp.) and dog fennel (*E. capillifolium*, Table 1) and other graminoids include sedges (*Cyperus* spp.).

Feral swine populations in the Kissimmee River Valley in south central Florida, where MAERC is located, have been documented since the 1840s, and populations were reinforced by escaped free-range domestic swine (Mayer and Brisbin, 2008). Feral swine provide income in this area today; many land managers offer guided hunts or trap feral swine to sell to other land managers for hunting opportunities. Feral swine are abundant on MAERC, with 200–400 individuals sold or hunted annually during 2007–2012 (Boughton and Boughton, 2014), generating approximately $12,000–$20,000 per year in revenue. Although feral swine generate income locally and provide food and sport, stakeholders are concerned about the adverse impacts feral swine can have on human, livestock, and wildlife health.

2.2. Experimental design and sampling

We compared plant community composition through time of rooted and unrooted pastures using a permanent paired subplot design. We began estimates of community composition one month after feral swine rooting in both native and sown pastures. Monthly sampling of plant community composition occurred in sown pastures for 13 consecutive months, April 2013–April 2014. In native grassland pastures sampling occurred from March to June 2013, and from October 2013 through April 2014 for a total of 11 sampling months. We were unable to complete sampling in July, August, and September of 2013 due to extensive flooding.

In order to define rooted and unrooted patches, we mapped rooted areas. In two native grassland pastures we established six 100 m transects per 30-ha pasture; in sown pastures, we established four 100 m transects in each of two 20 ha pastures. We mapped all freshly rooted patches that fell along transect lines that were 4 m^2 or greater in area using a Trimble GeoXT. Among the mapped rooted patches we randomly chose 24 rooted patches and established four subplots per patch for permanent vegetation sampling in native grassland pastures and eight rooted patches with four subplots per rooted patch in sown pastures. Each subplot within rooted areas was paired with a neighboring unrooted