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Impacts from Control Operations on a Recreationally Hunted Feral Swine Population at a Large Military Installation in Florida

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RESEARCH ARTICLE

Impacts from control operations on a recreationally hunted feral swine population at a large military installation in Florida

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Abstract Feral swine were targeted for control at Avon Park Air Force Range in south-central Florida to avert damage to sensitive wetland habitats on the 40,000-ha base. We conducted a 5-year study to assess impacts from control to this population that had been recreationally hunted for many years. Control was initiated in early 2009. The feral swine population was monitored from 2008 to 2012 using a passive tracking index (PTI) during the dry and wet seasons and using recreational hunter take rates from the dry season. All three indices showed substantial feral swine declines after implementing control, with indices leveling for the final two study years. Military missions and recreational hunting seasons impacted temporal and spatial consistency of control application, thereby limiting further impacts of control efforts on the feral swine population. The PTI was also able to monitor coyotes, another invasive species on the base, and detect Florida black bear and Florida panther, species of particular concern.

Keywords Animal damage · Conservation · Coyote · Feral hog · Hunter take · Invasive species · Passive track index · Population monitoring · *Sus scrofa*

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Introduction

Feral swine (*Sus scrofa*) are highly destructive exotic animals that degrade habitats and archeological sites, prey on native species, and compete with native species (Choquenot et al. 1996; Engeman et al. 2013a; Seward et al. 2004; Taft 1999; U.S. Department of Agriculture 1999). They also harbor a number of diseases transmittable to wildlife, livestock, or humans (e.g., Conger et al. 1999; Corn et al. 2005; Romero and Meade 1999; Taft 1999). Swine were one of the first invasive exotic species to establish in Florida after being introduced to Florida by DeSoto in 1539 (Towne and Wentworth 1950). Feral swine possesses the highest reproductive potential of any large mammal in North America (Wood and Barrett 1979; Hellgren 1999) and, with subsequent introductions, the range in the USA continues to expand (Corn et al. 2005; Gipson et al. 1997). Feral swine currently inhabit many areas in such large numbers that they adversely impact wild land and agricultural ecosystems. They have been implicated by some as the single greatest vertebrate modifier of natural plant communities (Bratton 1977; Wood and Barrett 1979). Feral swine-rooting behavior, which can overturn or dislodge soils and native vegetation, has been shown to alter plant populations and ultimately change plant species composition (Bratton 1977).

Habitat damage by feral swine is most pronounced in wet environments (e.g., Choquenot et al. 1996). In Florida, many unique wetland habitats are rapidly disappearing (Florida

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Natural Areas Inventory 2010). For example, only 1 % of the original extent of seepage slopes in Florida remains (Florida Natural Areas Inventory 2010). Avon Park Air Force Range (APAFR) contains globally rare wetlands, plants, and plant communities, some of which are endemic to peninsular Florida (i.e., cutthroat grass and *Panicum abscissum*-dominated wetlands) (Bridges and Orzell 1999; Orzell 1997), and feral swine rooting consistently damages some of these ecologically sensitive habitats. Moreover, APAFR also holds dozens of archeological sites eligible for inclusion in the National Register of Historic Places, with 42 % having had some level of feral swine disturbance (Engeman et al. 2013a). Considerable recreational hunting takes place on the base and is popular with the public, but feral swine damage to those plant communities prompted further efforts to reduce the feral swine population through implementation of a control program. Thus, monitoring population changes and trends is a key performance metric for evaluating the need for and efficacy of management actions (Engeman et al. 2013b), control operations in this case. We carried out and report here on a multiyear investigation to evaluate the impacts of control on feral swine population trends at this large base.

Methods

Avon Park Air Force Range

APAFR is a 42,430-ha military installation in south-central Florida (27°35′N, 81°16′W), that was established during World War II for air-to-ground training and related military missions. It contains 23,600 ha of intact natural habitats (Orzell 1997) and experiences a seasonal subtropical climate, conventionally divided into a winter dry and summer wet season (Chen and Gerber 1990; Slocum et al 2010). Over 33,000 ha are open to the public on a regular basis for various recreational activities, including hunting. The Air Force is federally mandated to manage the natural resources of APAFR in support of both the military readiness mission and the preservation of the area's natural and cultural heritage. This latter component is significant because APAFR has numerous US-federally listed species, many state and globally imperiled plants, and is recognized as a significant conservation area (Orzell 1997; Stein et al 2008).

The geologic backbone of APAFR is the Bombing Range Ridge (BRR), a Plio-Pleistocene sand ridge running north-south across the base. The topographic relief of this unique geologic feature accounts for the presence and location of many of the sensitive wetland plant communities. The APAFR landscape varies from a low-lying elevation of 9.1 m in long-hydroperiod marshes along the Kissimmee River to pine savanna-grasslands with embedded short-hydroperiod marshes, to herbaceous seepage slopes and forested seepage bays on the side slopes of the Bombing Range Ridge, to xeric uplands on the ridge top. The ridge acts as an unconsolidated aquifer, storing water which percolates slowly downward until it meets an impervious layer on the side slopes causing it to seep out on the side slopes to create seepage slopes. These seepage slopes are found north-south along the length of the ridge through the base, while wet pinelands and prairies (i.e., wet prairies and flatwoods) characterize much of the low-lying flatland adjacent to the BRR. Many of the plant community types at APAFR are globally imperiled and are dominated by endemic plant associations found only in peninsular Florida (Bridges and Orzell 1999; Orzell 1997).

The wet season lasts, on average, 133 days from May 21 to October 1, while the dry season, despite being almost twice as long, from October 2 to May 20, has only half the rainfall (Slocum et al 2010), thereby drying soil moisture and lowering water levels especially in seasonal low-elevation wetlands. A variety of seasonal wetland plant communities found on the base are highly sensitive to ground disturbance (e.g., seepage slopes, wet flatwoods, wet prairies, and peaty marshes) and harbor many rare and endemic plants (Bridges and Orzell 1999; Florida Natural Areas Inventory 2010; Harper et al. 1998; Orzell 1997). The climate's seasonality coupled with the pronounced elevation gradient from wet to xeric plant communities and the resultant fluctuations in soil moisture causes wetland plant communities to be seasonally vulnerable to feral swine rooting. The impact of feral swine on these natural resources is an ecological management issue, and this concern led to implementation of control activities to further constrain and reduce feral swine populations beyond the benefits obtained from recreational hunting (USDA 2009).

Passive tracking index methodology

We applied passive tracking index (PTI) methodology similar in principle to the methods successfully used by Engeman et al. (2007) to monitor feral swine in another large natural area in Florida with the methodology customized for the logistics and landscape at APAFR. Data collection for an index is most efficient if observation stations can be placed to intercept predicted daily activity of the animals (Engeman 2005; Engeman et al. 2013b). Roads and tracks through native terrain offer many species of animals convenient travel routes making them prime locations to place observation stations. This often has proven to be the case for monitoring feral swine in various places in the world including Florida (e.g., Elledge 2011; Engeman et al. 2001, 2007; Jiang et al. 2006; Theuerkauf and Rouys 2008). Tracking plots were 0.8 km in length and located randomly along roads throughout APAFR (Fig. 1) as an efficient design for sampling on a large scale (Pearson and Ruggiero 2003; Engeman et al. 2007).

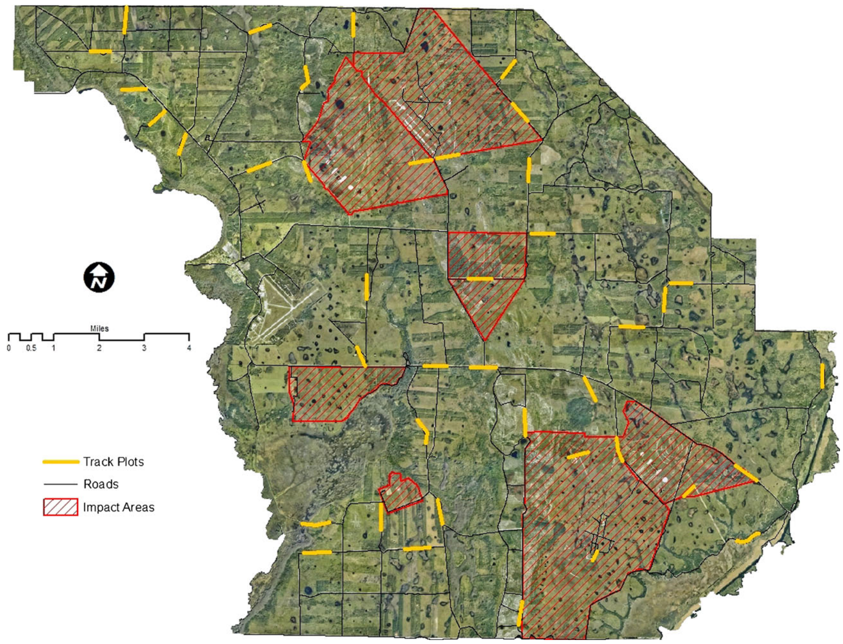

Fig. 1 Location of tracking plots for calculating a passive tracking index to monitor feral swine and sympatric species at Avon Park Air Force Range in south-central Florida. *Shaded areas* indicate impact areas, ranges with restricted access during military missions and are closed to all public access

The surfaces of the plots were smoothed for reading tracks, and the number of track intrusions by feral swine and other wildlife were counted and recorded at each plot the following day (Engeman et al. 2001, 2007). Track plot counts obtained for analysis were "passive" because they did not involve the use of attractants or drives to bring feral swine to the plots. Daily counts of tracking plot intrusions were produced when feral swine and other animals intercepted the plots during their normal daily activity. To prepare the track plots, we used an all-terrain vehicle (ATV) to tow a drag device or mechanical rake to smooth the track plot surface (Fig. 2). Feral swine and other animal tracks were easily detected in the freshly smoothed, typically sandy, soil.

We used the same plot locations, recorded by GPS, on each sampling occasion (e.g., Ryan and Heywood 2003; Engeman 2005). Tracking data were collected from 40 permanent plot locations during two seasons—dry season (late fall/early winter, December/January) and wet season (late spring/early summer, late May/early July). It is appropriate to only compare index values across years using data obtained from the same season (Engeman 2005; Engeman et al. 2013b). We collected the initial track data in December 2008 prior to implementation of feral swine control operations, and subsequently twice per year from those same plots for wet season and dry season from 2009 through 2012. Feral swine control operations concluded just prior to the final dry season observations in 2012.

Much of the perimeter of the base did not pose a barrier to feral swine movement, i.e., there were no natural barriers or wildlife-proof fences that would deter immigration. Of particular interest for feral swine management at APAFR is a private hunting club on its north border where feral swine are sporadically released to be hunted. Such releases represent an artificially increased prospect for immigration to the base beyond what would occur naturally among the feral swine living in the vicinity. We used seven tracking plots near the northern border to see if their index values were higher relative to trends observed for the base as a whole, which might indicate an immigration pulse from the neighboring property

Fig. 2 Preparation of tracking plots using a drag device (*left photo*) and mechanical rake (*right photo*) to smooth the track plot surface

prior to their diffusion throughout the base. This subset of north perimeter plots seems a relatively small number, but considering they each were 0.8 km in length, additional plots could not be included from the larger set or created and still be considered as representing the perimeter area. Further, subsets of tracking plots have been successfully used in other applications to look at immigration and contrast with results from a larger overall area (e.g., Engeman et al. 2003a, b).

One of the benefits from using passive tracking plots to intercept the daily activities of animals without an attractant is it offers the opportunity to simultaneously monitor a variety of animal species (e.g., Engeman 2005). Thus, we took advantage of the possibility for monitoring other invasive species, and even rare species (although for very uncommon species, the method serves primarily as an efficient means to detect presence in a large area, rather than to monitor population trends). While our focus was to monitor feral swine, we felt it important to document the broader utility of the PTI method and to obtain and report information on other invasive or rare species that would be of broad management interest in the general geographic area. In particular, coyotes (*Canis latrans*) are invasive in Florida (Schmitz and Brown 1994) and have been increasing their populations and expanding ranges in Florida (Coates et al. 2002; Wooding and Hardisky 1990). Coyotes could pose a threat to livestock grazing on the base, game species such as deer (*Odocoileus virginianus*) and wild turkeys (*Meleagris gallopavo*), threatened and endangered species, and other species of concern (e.g., Mastro et al. 2012). Besides feral swine, we were most interested in ancillary monitoring of coyotes as potentially significant invasive predators, as well as any rare species detected by the tracking plots.

We calculated PTI for feral swine for dry season during 2008–2012 and for wet season during 2009–2012 by applying the indexing paradigm of Engeman (2005), specifically applied to tracking plots for feral swine (Engeman et al. 2001, 2007). The mean measurement across plots was calculated for each day, and the index values were the means of the daily means (Engeman 2005):

$$\mathrm{PTI} = \frac{1}{d}\sum_{j=1}^{d}\frac{1}{s_j}\sum_{i=1}^{s_j}x_{ij}$$

where x_{ij} represents the number of feral swine intrusions at the ith tracking plot on the jth day, d is the number of days of observation, and s_j is the number of plots contributing data on the jth day. SAS PROC VARCOMP, using restricted maximum likelihood estimation (REML) (SAS Institute 2004), was used to calculate the variance components (Searle et al. 1992) needed in the variance estimation formula (Engeman 2005). Independence among plots or among days is not required for these calculations (Engeman 2005). Variance estimates were incorporated in Z tests for assessing differences between PTI values (Engeman 2005).

Hunter take rates

Hunter take (catch per effort) is a widely applied method for assessing relative abundance of wildlife, including wild swine (Boitani et al. 1994; Fernandez-Llario et al. 2003). Catch per effort is often formulated as pigs per hunter-day or pigs per 100 hunter-days. Large sampling areas and sample sizes help reduce bias in hunt indices (Siren et al. 2004). Fortunately, APAFR is a large controlled area with a history of considerable public hunting in designated areas. The bombing ranges are off limits to the public.

Recreational hunters entering APAFR must check in at the gate, and then again upon leaving when take is recorded. Thus, reliable data were available on hunter take and the corresponding number of hunter-days for each hunting season each year. A take-per-effort index was calculated for each season and standardized as take per 100 hunter-days.

Recreational hunting at APAFR is carried out during various hunting seasons through the year. Many are short special seasons that can be designated at any time during the year with no temporal regularity from year to year. Three hunting seasons, one each for three hunting methods, archery, muzzle loader guns, and standard guns (rifles), occur in the same timeframes each year. This temporal regularity across years is crucial, because, as with the PTI data, index values for a particular measurement method are appropriately examined across years when measurements are made in the same timeframe each year in the same manner (Engeman et al. 2013b). Archery and muzzle loader gun seasons are short and involve far fewer hunters specializing in these firearms than partake in the lengthy (7–8 weeks) standard gun season. Consequently, we used only the data from the annual standard gun season to calculate a hunter take index each year because only that season was at the same time each year and involved a sufficient number of hunter-days each year (~5,000–6,500 hunter-days) to be considered reliable for indicating population trends (see Siren et al. 2004).

Feral swine removal during control operations

The initial PTI data collection began in the dry season (December) in 2008 and served as the precontrol baseline for the dry season time frame. There was no corresponding baseline for the wet season time periods. Operational removal of feral swine (in contrast with recreational hunting) was initiated in January 2009 and continued through September 2012. Feral swine were removed by agreement with U.S. Department of Agriculture/Wildlife Services (WS), the federal agency responsible for managing conflicts with wildlife (U.S.

Department of Agriculture/Animal and Plant Health Inspection Service, U.S. Department of Agriculture/Forest Service and Department of Interior/Bureau of Land Management 1997), using only approved and humane methods to euthanize animals, which conform to guidelines in the 2013 Report of the American Veterinary Medical Association Panel on Euthanasia (2013) and set forth as agency policy in USDA/APHIS/WS Directive 2.505.

Swine were primarily removed by capture in pen traps and sharpshooting. After identification of the most favorable locations to carry out control activities, baiting with soured corn was initiated to condition the feral swine to feeding at bait sites. Once feral swine were consistently feeding at a bait site, traps were set up and the feral swine conditioned to feeding in and around the open trap. After feral swine consistently were entering the pen trap to feed, the trap would be set. These custom-designed traps were collapsible for portability, but exhibiting extreme durability, and able to capture groups of feral swine, including the largest individuals (Engeman et al. 2010). Feral swine were also removed by sharpshooting opportunistically, especially in bombing range areas, which are unavailable to public access. Feral swine trapping was not permitted in public hunting areas during hunting seasons, although trapping was allowed on bombing ranges during these times if the ranges were not active.

Results

Feral swine

The monitoring results using the PTI and hunter take are summarized in Table 1, with the PTI summarized for the base as a whole, and also for the tracking plots near the north perimeter where pulse immigrations from feral swine releases adjacent to the base were suspected to occur. Hunter take rates are also given in Table 1 and are part of the dry season period observations.

By the conclusion of 2010, the dry season and hunter take observations represented two full years of control activities (all of 2009 and 2010) and the wet season observations represented 1.5 years of control activities (all of 2009 and half of 2010). By 2010, the dry season PTI and hunter take indices had each shown successive sharp decreases (Table 1) from the 2008 precontrol values ($Z>3.13$, $p<0.0017$, across both indices), and, similarly, the wet season PTI values had declined sharply in 2010 from 2009, the initial year for wet season measurements ($Z=3.94$, $p=0.0001$). Since 2010, all PTI values remained on average less than one intrusion observed per 0.8 km tracking plot per day for both the dry season and wet season seasons. During this time, both the wet season and dry season PTI values for the north perimeter followed suit and were always lower than the base-wide values, except in 2009 when the north perimeter values for wet season and dry season both spiked well above the values for the base as a whole. For the precontrol observation in 2008, the dry season PTI for the north perimeter was 18 % less than that for the base as a whole. However, for 2009, it was 48 % higher. In all subsequent years, it was again lower than for the base as a whole: 27, 68, and 18 % less than the base-wide PTI, respectively, for years 2010–2012. This discrepancy in pattern between the dry season PTI values for the base as a whole and the north perimeter plots suggests an immigration pulse may have occurred in 2009. Although precontrol observations were not available for the wet season, a similar pattern emerged, with the base-wide PTI dropping precipitously from 2009 (after a half year of control activities) to 2010 (after 1.5 years of control activities). Again, only in 2009 was the wet season PTI value from the north perimeter plots higher than the value from the base as a whole. Relative to the base-wide index values, the wet season index values from the north perimeter tracking plots were 38 % higher in 2009, and then 14, 34, and 34 % lower, respectively, for the years 2010–2012. Considering the feral swine habitat near the north border is not as optimal as further south on the base

Table 1 Passive tracking index (PTI) and hunter take results for feral swine at Avon Park Air Force Range for the dry season (late fall–early winter) and wet season (late spring–early summer) observation periods from 2008 to 2012. The 2008 dry season results form a baseline prior to implementation of operational swine control

Year	Feral swine passive track index (PTI) (study initiated in dry season 2008)				Take/100 hunter-days (gun season)
	Wet season		Dry season		
	Whole base	N perim	Whole base	N perim	Whole base
2008*	–	–	2.38	1.94	3.15
2009	2.58	3.57	1.63	2.42	2.53
2010	0.43	0.37	0.92	0.67	1.59
2011	0.64	0.42	0.60	0.19	2.23
2012	0.73	0.48	0.91	0.75	2.18

where most of the wetlands occur, and considering the north perimeter PTI values were uniformly less than the base-wide PTI value in every year for both seasons except 2009, the data suggest a possible immigration pulse along the north border in 2009.

The PTI for the dry season period reached a minimum in 2011, 75 % less than the precontrol value (Z=4.31, p<0.0001). In 2012, the dry season PTI increased to a value nearly identical (Z=0.0.02, p=0.98) to that in 2010 (still 62 % less than for precontrol). Feral swine control was discontinued at the end of September 2012, meaning this final dry season PTI was obtained a quarter year after the end of control operations. While not detectable statistically, the wet season PTI had also increased from 2011 to 2012 while control was ongoing (Z=0.32, p=0.75). The wet season PTI and hunter take indices each reached their minimums in 2010. For all three indices, there was a slight rebound/leveling off in the last year or two of the study, with the concluding index values still well lower than during the first 2 years (2008 and 2009).

Coyotes

The PTI indexing results for coyotes are summarized in Table 2 where the tracking plot data suggest coyotes increased to a somewhat level population on the base. Substantial differences in PTI values between seasons for wild canids were expected due to potential differences in activity between seasons and illustrate why it would be inappropriate to compare index values from dry and wet seasons (e.g., Allen et al. 2011; Allen et al. 2013; Engeman 2005). However, it is fitting to examine the trends indicated among the two seasons (Engeman 2005). The dry season index value for the initial year (2008) was considerably less than all subsequent years' PTI values, with each of those being at least 59 % higher than for 2008. From 2009 through 2012, the dry season PTI fluctuated without showing an increasing or decreasing trend. The same was true for all wet season values which were obtained in this same span of years from 2009 to 2012.

Table 2 Passive tracking index (PTI) results for coyotes at Avon Park Air Force Range for the dry season (late fall–early winter) and wet season (late spring–early summer) observation periods from 2008 to 2012

Year	Coyote passive track index (PTI)	
	Wet season	Dry season
2008[a]	–	0.80
2009	0.70	1.29
2010	0.49	1.27
2011	0.56	1.48
2012	0.69	1.36

[a] The study was initiated in early dry season 2008

Rare wildlife species

The track plot observations in June 2010 included one occurrence of Florida black bear (*Ursus americanus floridanus*) tracks, while the track plot observations in June 2011 included an observation of Florida panther (*Puma concolor coryi*) tracks. The Florida panther is federally listed as an endangered species, while the Florida black bear was recently removed from state listing as threatened. However, the subpopulation in which APAFR lies is at or below the "minimum subpopulation objective" for state bear management, and APAFR is particularly important for this subpopulation (Florida Fish and Wildlife Conservation Commission 2012). While one set of tracks on one plot during one sampling occasion does not present an indexing opportunity for either species, these observations along with previous occasional sightings of bears and panthers at APAFR document at least temporary presence and could provide information to consider in managing natural resources.

Discussion

While recreational hunting can impose a source of mortality on a feral swine population, hunters typically do not target all population segments equally, potentially limiting the severity of population reduction (Braga et al. 2010; Festa-Bianchet 2007; Keuling et al. 2013; Plhal et al. 2011). In contrast, operational control targets all demographics and typically is cost-effective (Engeman et al. 2003a, b; 2004; 2007, 2010), yet it requires consistent application to be effective. In Florida, feral swine are ubiquitous and pose a constant threat from immigration into an area in which their populations have been reduced by control efforts. That, coupled with feral swine having the highest reproductive potential of any large mammal in North America (Wood and Barrett 1979; Hellgren 1999), means the beneficial effects of feral swine population reduction can be quickly undone. Here, we have documented feral swine population declines after implementing control over a large area that had been receiving consistent hunting pressure for many years. Although having an ecologically similar nearby 40,000-ha site without feral swine control to use for comparison was impossible, there could be no other rational explanation for the parallel decreases among the three population indices. That is, there were no significant disease outbreaks, climatic events, or any other potentially population decimating factors that occurred during the course of the study. Importantly, we also were able to identify factors that deterred maximal feral swine population reductions, in particular anthropogenic induced immigration and limitations on the consistency with which control could be applied.

Our study provides strong evidence that sporadic immigration pulses of feral swine can occur from the hunting club property bordering APAFR on the north. As this study was concluding, a feral swine-proof fence was being installed along the base's northeast border to deter some such immigration (Fig. 1). A feral swine-proof fence was also constructed specifically to protect an archeological site of significant importance on the base (Engeman et al. 2013a). The consideration of fencing raises an interesting dilemma for managing feral swine to protect sensitive wetland plant communities. In some circumstances, it may be possible to use feral swine-proof fencing to prevent immigration, while eradicating all feral swine existing on the interior. Conducted iteratively, this approach in conjunction with the necessary control operations to eliminate feral swine inside fenced areas could result in relatively permanent, large feral swine-free areas. However, the upfront cost for fencing and concomitant control to remove feral swine inside the fences may represent the equivalent of many years of control operations. Additionally, fences constructed in sandy substrates in a region regularly subjected to hurricanes might require considerable maintenance. Moreover, fence lines are problematic to maintain in fire-frequented ecosystems such as in Florida, where fire lanes needed to protect fences further disrupt ecosystem function at a landscape level comparable to hog rooting ecosystem damage (Hutchison and Roberts 2009). This would be especially true if fencing were used to protect specific, relatively small plant community sites. A careful economic evaluation would be in order for determining optimal strategies for keeping feral swine populations from affecting vulnerable resources.

While the index values for feral swine remained considerably lower from 2010 through 2012 than in 2008 (for dry season and hunter take) and in 2009 (all three indices), the minimum values for all three indices occurred in 2010 or 2011, and increased from 2011 to 2012 for dry season and successively from 2010 to 2012 for the wet season index values. Various factors could account for these observations. To achieve and maintain maximal efficacy, control should not only be maintained over years, but it should also be consistently applied within each year. Otherwise, the rapidity with which feral swine can immigrate and/or reproduce can reduce the efficacy and efficiency of the control program. In the day-to-day efforts of removing feral swine at APAFR, a challenge existed to manage trapping schedules within periods of active military missions where access to substantial areas within APAFR are prohibited or restricted due to safety and risk management concerns (Fig. 1). Moreover, during hunting seasons, trapping was restricted to areas of APAFR closed to hunting, which primarily were the impact areas where military operations are focused. This resulted in frequent periods when and areas where control could not be exercised. Baiting and trapping efforts require revisiting sites at timed intervals to monitor activity, replenish baits, set/reset traps, and remove trapped animals. If conflicts between the planned baiting/trapping and range schedules or hunting seasons occurred, the feral swine removal effort had to be modified or curtailed.

Military training activity at APAFR increased during the study, as did the number of special hunting seasons each year. A partial solution to constraints on feral swine trapping involved the use of automated bucket feeders at potential trap sites within impact areas to maintain attracting feral swine without needing human presence. Automated bucket feeders needed to be checked once a week compared to traditional baiting which involves daily visits. This approach helped alleviate some of the logistical access issues to impact areas, but not for carrying out control within the much larger public access portion of the base during hunting seasons where such activities would have been in direct conflict with hunting (Fig. 1).

Besides protecting endangered plant species and rare plant communities, the reduction of feral swine populations at APAFR may help protect the Florida panthers and Florida black bears that reside on or pass through the base, as detected by the PTI observations. Pseudorabies (PRV), a density-dependent disease, is carried by feral swine in many areas and is usually fatal in secondary species, including felids and bears (Dow and McFerran 1963; Glass et al. 1994; Schultze et al. 1986; Zanin et al. 1997). Moreover, 42 of 60 feral swine (70 %) from APAFR tested from 2009 to 2011 were seropositive for pseudorabies (M. Milleson, personal communication). While this percent does not translate directly to active infection, it does indicate a high likelihood that active infection is present at any given time in the feral swine population at APAFR. Feral swine are a common prey item for Florida panthers (Maehr et al. 1990) and lethality to Florida panthers from preying upon an infected feral swine has long been suspected (Roelke et al. 1993) and demonstrated (Glass et al. 1994). Similarly, bears are also highly susceptible to PRV-induced mortality (Schultze et al. 1986; Zanin et al. 1997), and could face similar risks as the panthers.

There are many ecological and economically valid concerns for reducing feral swine populations at APAFR including the protection of sensitive plant communities, archeological sites, native grass seed sources, livestock grazing pastureland, and a variety of rare plant and animal species. We saw in this study that a control program can reduce a feral swine population that already had been annually subjected recreational hunting pressure for many years. We suspect from the leveling of the three population indices during the final 2 years of the study that the effects of control were not fully realized due to the inconsistencies with which it was applied each year. A limited degree of fencing is now in place on the base as barriers to feral swine, but only the area encompassed by fencing to protect a significant archeological site, if diligently maintained, is fully protected (Engeman et al. 2013a). This fencing was installed at an approximate cost of $18,000 USD (Engeman et al. 2013a) indicating the level of financial commitment that would be needed to exclude feral swine from larger areas of the base with fencing. The optimal application of resources for protecting the natural treasures on this large base will undoubtedly pose management resource allocation dilemmas.

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