Original Article

Effectiveness of a Bounty Program for Reducing Wild Pig Densities

STEPHEN S. DITCHKOFF,[1] *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA*

ROBERT W. HOLTFRETER, *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA*

BRIAN L. WILLIAMS, *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA*

ABSTRACT Bounty programs have been historically implemented as a means of controlling invasive or pest species. Although bounty programs are generally considered to be ineffective, they are still proposed as management tools in situations where other management strategies have been unsuccessful. The wild pig (*Sus scrofa*) is an invasive large mammal in North America and most management strategies have proven to be ineffective at reducing or eliminating its populations, resulting in population expansion in recent decades. Fort Benning Army Infantry Training Center, Georgia, USA, had been inhabited by wild pigs since the mid-1900s. In response to increasing negative impacts on flora, fauna, and military training activities and equipment, Fort Benning began offering a bounty on pigs in June 2007 to reduce the population and eventually eradicate wild pigs from the installation. To gauge the effectiveness of the program, we evaluated the population response of wild pigs within 2 study areas on the installation from June 2007 to February 2008. During the study, 1,138 pigs were harvested throughout the installation at a total cost (bounties paid and administration) of US$57,296. Surveys indicated that pig density and occupancy rates increased 23–130% and 12–19%, respectively, during the course of the bounty program. Additionally, sounder size and number of juveniles per adult female increased 144–233% and 191–219%, respectively. These data suggest that the wild pig population was increasing during the period when the bounty program was in effect. We hypothesize that this was due to increased food availability and reproduction associated with baiting wild pigs during the program, and because efforts of program participants were focused on eliminating the segment of the pig population that would maximize return on effort and "trophy" quality of animals rather than on the segment of the population that would most greatly influence population growth. © 2017 The Wildlife Society.

KEY WORDS bounty program, control, Fort Benning, Georgia, population density, repeated counts, *Sus scrofa*, wild pigs.

Controlling invasive species is perhaps one of the greatest challenges land managers and wildlife biologists face today (Allendorf and Lundquist 2003). Historically, some biologists and hunters have promoted bounty programs as a sensible means of controlling or reducing the abundance of invasive or pest species, often arguing that costs associated with controlling these species may be reduced by providing private citizens with an economic incentive to harvest the species of interest (Hassell and Associates Pty Ltd 1998). In practice, however, bounty programs usually have not achieved a significant or cost-effective reduction in the density of targeted species (Smith 1990). Failures are often attributed to the biology of the target species being poorly understood or the avaricious motivations of participants in such programs (Hassell and Associates Pty Ltd 1998, Bartel and Brunson 2003). For example, European rabbits (*Oryctolagus cuniculus*) and house mice (*Mus musculus*) reproduce at a faster rate than they can be removed from their respective populations, negating any benefit of control activities (Tisdell 1982, Smith 1990, Williams et al. 1995). However, even among species with slower rates of reproduction (e.g., dingos [*Canis lupus dingo*]; coyotes [*C. latrans*]), bounty programs have not been successful, often failing to elicit an increase in effort from participants when the incentive provided was perceived as too low. Further, these programs have often resulted in fraud, or farming for bounties, when the incentive provided was perceived as great enough to off-set the risk of punishment (Barry 1979, Smith 1990, Hassell and Associates Pty Ltd 1998, Bartel and Brunson 2003, Lelli et al. 2009). Despite these well-documented problems, bounty programs continue to be suggested, debated, and implemented as a solution for the control of invasive and pest species throughout the world (e.g., nutria [*Myocastor coypus*], Baker 2006, LDWF 2015; northern pikeminnow [*Ptychocheilus oregonensis*], PSMFC 2015; wild pigs, Hassell and Associates Pty Ltd 1998, WAPT News 16 2015).

In North America, wild pigs (*Sus scrofa*) are considered an invasive species because of their expansion into most of the 50 United States, Mexico, and parts of Canada in recent

decades (Ditchkoff and West 2007). With wild pig populations increasing in range and distribution, development of successful control programs has become critical to protect native ecosystems, agriculture, and domestic animals from negative effects associated with pig rooting and disease transmission (Hone and Pedersen 1980, Sterner and Barrett 1991, Anderson and Stone 1993, Katahira et al. 1993). Wild pigs are a concern on Fort Benning, Georgia, USA, because of their predation of federally listed herpetofauna species (e.g., gopher tortoises [*Gopherus polyphemus*] and spadefoot toads [*Scaphiopus holbrookii*]; Jolley et al. 2010), destruction of relict trillium (*Trillium reliquum*), and as a general nuisance to military training on the installation. However, despite control efforts, population levels of wild pigs on Fort Benning in recent years have been relatively stable (Hanson et al. 2008, Ditchkoff and Mitchell 2009).

Despite substantial costs (Williams et al. 2010*b*), contemporary techniques used to control pigs (e.g., trapping, night shooting, shooting from helicopters, poisoning, the Judas pig technique, and hunting with dogs; Choquenot et al. 1990, Jolley et al. 2010, Parkes et al. 2010) often result in negligible or short-lived reductions in local pig densities (Hone and Pedersen 1980, Jolley et al. 2010). To date, the effectiveness of a bounty program for controlling wild pigs has not been evaluated; however, some studies have indicated heavy hunting pressure can reduce the density of pig populations (Sweitzer et al. 2000) and frequency of pig damage (Mazzoni della Stella et al. 1995, Geisser and Reyer 2004) at little or no cost to management agencies. In June 2007, Fort Benning Army Infantry Training Center (hereafter, Fort Benning) in west-central Georgia, attempted to address what resource managers perceived to be an overabundance of wild pigs by implementing a bounty program wherein participants were paid for producing tails of wild pigs harvested on the installation. The stated goal of the program was the complete eradication of wild pigs from the installation, which they deemed feasible because of the popularity of wild pigs as a game species on the installation. As part of a larger research program designed to evaluate other control techniques for wild pigs, we were already monitoring wild pig populations on the installation; and so we had the opportunity to evaluate the effectiveness of the bounty program with respect to population density and other parameters. Although our sampling protocol was not originally designed for this purpose, these data did provide a unique opportunity to evaluate an historical management tool for which data are somewhat limited, especially with respect to wild pigs.

STUDY AREA

We conducted this study on the 737-km^2 Fort Benning Army Infantry Training Center located in west-central Georgia and east-central Alabama, USA. Fort Benning was characterized by rolling hills and bottomlands typical of the Fall Line Sandhill area of the East Gulf Coastal Plain (Dilustro et al. 2002). Vegetation on the hills and slopes was dominated by longleaf pine (*Pinus palustris*) interspersed with plantations of loblolly (*P. taeda*) and shortleaf pine (*P. echinata*; King et al. 1998). Oak (*Quercus* spp.) and

hickory (*Carya* spp.) were the dominant canopy species in the bottomlands (King et al. 1998).

Wild pigs had been present on Fort Benning since the mid-1900s and in recent decades had begun to pose significant problems with sensitive flora and fauna, as well as military training (Ditchkoff and Mitchell 2009). As a result, the natural resources program on the installation had identified wild pigs as a threat to installation objectives and focused on identifying strategies that could reduce or eliminate wild pigs. Wild pig harvest by white-tailed deer (*Odocoileus virginianus*) and wild pig hunters had averaged 939 pigs annually (Ditchkoff and Mitchell 2009); yet, despite this harvest, wild pig numbers remained relatively stable (Hanson et al. 2008, 2009). Ditchkoff and Mitchell (2009) provide a more thorough description of the history of wild pigs and their management on Fort Benning.

We conducted multiple camera surveys of wild pigs within 2 approximately 36-km^2 study areas located approximately 8 km apart and separated by a tributary of the Chattahoochee River (Fig. 1). These study areas were selected by personnel at the Fort Benning Conservation Branch prior to a wild pig research project conducted on the installation between 2004 and 2006. The Fort Benning Conservation Branch considered approximately 575 km^2 of the installation to be manageable, while the remaining approximately 161 km^2 were restricted from management because of military or civilian activity. Each study area was representative of the manageable portion of Fort Benning; however, the north study area was dominated by upland pine habitat while the south study area was dominated by bottomland hardwood habitat (Holtfreter et al. 2008). Trapping, night hunting, and baiting of wild pigs were prohibited in the north study area.

Approximately 2,600 licensed hunters had access to Fort Benning over the course of the study. Hunters were limited to active duty and retired military persons, as well as civilian personnel and their guests, and subject to the state laws of Georgia and Alabama pertaining to licensing, trapping, and use of bait. In general, trapping and bait usage were prohibited during the Alabama and Georgia white-tailed deer and turkey (*Meleagris gallopavo*) hunting seasons. With the exception of the north study area, bounty program participants were allowed to use up to 10 box or corral traps and allotted 20 trap sites throughout the manageable portion of the installation (i.e., the bounty program was base-wide). Traps were provided to participants in the program on a first-come, first-served basis. For use as bait, participants were provided with bagged whole-kernel corn and mess hall slop consisting of food waste products from the various cafeterias on the installation. Participants were allowed to shoot over bait; a select group of 60 hunters were allowed to shoot over bait at night after completing a required night shooting safety course. Hunting with dogs was not allowed on the installation.

Participants in the bounty program were required to provide the tails of wild pigs as proof of harvest, along with a report that detailed the sex, approximate mass, location, and method of harvest. At the onset of the program in June 2007, participants were paid US$25/tail; however, in January of 2008, Fort Benning officials increased the bounty
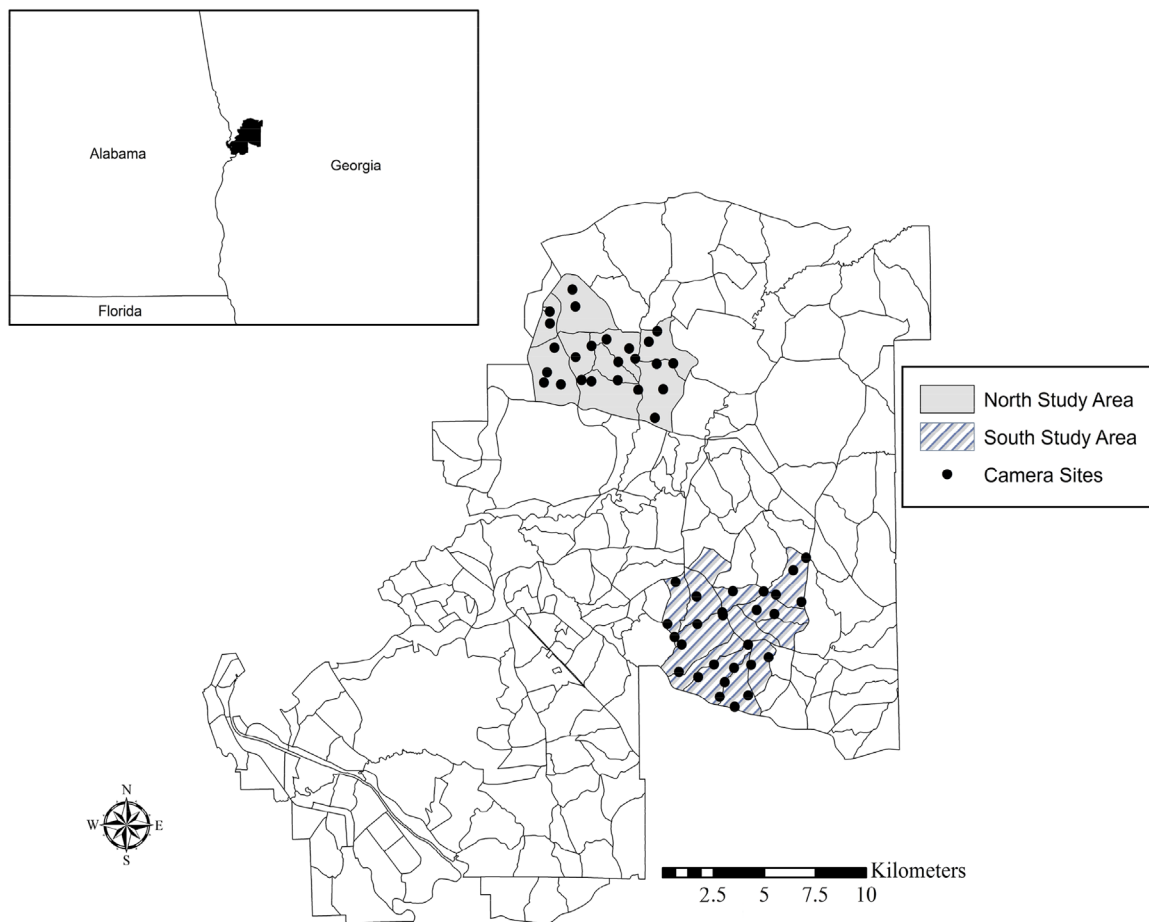
Figure 1. The 737-km^2 Fort Benning Military Reservation in west-central Georgia, USA, with the north and south study areas indicated as well as camera sites used for surveying wild pigs during 2007 and 2008. Bait usage, night hunting, and trapping were allowed throughout the installation with the exception of the north study area.

to US$40/tail in response to complaints from participants concerning high fuel costs. Throughout the bounty program, we recorded the total dollar amount paid to participants as well as costs associated with trapping equipment and bait purchased for the program.

METHODS

Camera Surveys

The bounty program officially began in June of 2007. By this time we were already conducting camera surveys as part of a larger research study on wild pigs. These surveys were designed to estimate the density of the wild pig population in each of our designated study areas. To this end we selected camera sites by randomly choosing cells from a 1-km^2 grid overlaid on both study areas using the Hawth's Tools extension in ArcGIS 9.1 (Beyer 2004). We selected 27 sites in the south study area (reduced to 24 after sampling period 2) and 24 sites in the north study area. We used a 1-km^2 grid to ensure adequate coverage of the study areas and following the spacing of live-traps used in a prior mark–recapture study of wild pigs on the installation (Hanson et al. 2009). Based upon previous camera-based mark–recapture data collected by Hanson et al. (2009) and the average sounder (matriarchal

family group) territory size determined by Sparklin et al. (2009), we felt that the cost:benefit of potential double-sampling of sounders relative to the assurance that each sounder had ≥1 camera site within its territory would be maximized. Additionally, Holtfreter et al. (2008) demonstrated that individual pigs and sounders in the Fort Benning population could be identified, allowing for documentation of sounders that visited >1 bait site during a sampling period. Within each selected cell, we chose a single site as described by Holtfreter et al. (2008) based on evidence of wild pig activity (e.g., rooting, tracks, scat, wallows, tree rubs), which we found in all selected cells. Selected sites were typically near creek bottoms within 250 m of an unpaved road or track.

We conducted camera surveys (8 in the north study area and 5 in the south study area) between 30 July 2007 and 27 February 2008 (Table 1), which provided an opportunistic data set for evaluation of the bounty program. We conducted surveys continuously throughout this period and rotated cameras between study areas and among camera sites within study areas because of limitations in the number of cameras available. We conducted surveys with PixController Digital Scout 3.2 megapixel game cameras (Penn's Woods Products, Export, PA, USA) and RECONYX Silent Image 1.8 megapixel game cameras (Model PM35M13; Reconyx LLP,

Table 1. Survey number and dates for camera surveys of wild pigs conducted at Fort Benning, Georgia, USA, between July 2007 and February 2008. The cumulative number of wild pigs harvested by the end of each survey is also provided.

	North study area				South study area		
Survey number	Camera group[a]	Survey dates	Cumulative pig harvest	Survey number	Camera group[a]	Survey dates	Cumulative pig harvest
1	A	5–9 Sep		1	A	30 Jul–3 Aug	
	B	12–16 Sep	1		B	6–10 Aug	
2	A	19–23 Sep			C	13–17 Aug	11
	B	26–30 Sep	1	2	A	20–24 Aug	
3	A	3–9 Oct			B	27–31 Aug	
	B	10–16 Oct	2		C	3–9 Sep	20
4	A	17–23 Oct		3	A	31 Oct–6 Nov	
	B	24–31 Oct	2		B	7–13 Nov	33
5	A	14–20 Nov		4	A	26 Dec–1 Jan	
	B	21–28 Nov	4		B	2–8 Jan	44
6	A	12–18 Dec		5	A	23–29 Jan	
	B	19–26 Dec	6		B	31 Jan–6 Feb	78
7	A	9–15 Jan					
	B	16–23 Jan	6				
8	A	13–19 Feb					
	B	20–27 Feb	12				

[a] We divided the north study area into 2 camera groups (i.e., A and B) with 12 camera sites in each group for all surveys. During the first 2 surveys in the north study area, we deployed cameras for a 5-day period in camera group A and then rotated cameras to camera group B for a second 5-day period with a 2-day gap in between sampling of camera groups. During the following 6 surveys, we deployed cameras for a 7-day period in camera group A and then rotated cameras to camera group B for a second 7-day period with a 1-day gap in between sampling of camera groups. We divided the south study area into 3 camera groups (i.e., A, B, and C) with 9 camera sites in each group for the first 2 camera surveys, and 2 camera groups (i.e., A and B), with 12 camera sites/group, for the remaining 3 surveys. During the first 2 surveys, camera groups were sampled for sequential 5-day periods, with a 2-day gap between groups. For the remaining surveys, camera groups were sampled for sequential 7-day periods, with a 1-day gap between groups.

Holmen, WI, USA). In the south study area, we initially divided our 27 camera sites into 3 groups of 9 sites, corresponding to the number of cameras at our disposal at the time. Following the second survey, we divided cameras sites in both study areas into 2 groups of 12 sites, and rotated cameras between groups. We kept each camera group active for one 5-day sampling period at 27 sites during the initial 2 surveys in each study area; however, we kept camera groups active for one 7-day sampling period at 24 sites during all subsequent surveys (Holtfreter et al. 2008). We prebaited sites with approximately 5.7 kg of shelled corn 5 and 3 days prior to camera placement and refreshed corn, as needed, on day 3 of each sampling period. We set all cameras to take time-lapse photographs, with 1 picture captured every 3 min throughout each sampling survey (Williams et al. 2010a).

Population Abundance

The distribution, social behavior, and spatial dynamics of wild pigs violate assumptions of most population models designed to estimate density, and as a result, it is very difficult to employ generally accepted statistical modelling techniques where wild pigs exhibit territoriality and strong sounder cohesiveness. For this reason, we chose to document a variety of population parameters that would provide insight into the direction of population growth or subsidence. We felt that the combination of these parameter assessments would be adequate to document the relative success, or failure, of the bounty program at Fort Benning. We considered a single photo-capture of a wild pig during a camera survey to be indicative of the presence of wild pigs within the effective sampling area for each respective camera site. For each survey, we additionally recorded a count of the maximum numbers of wild pigs detected in any one image during each 24-hr period (sunrise to sunrise) as a simple metric of pig abundance. We estimated average per site abundance (λ) and detection probability (p) using Royle repeated-count models (Royle and Nichols 2003) in Program PRESENCE (Hines 2006). We elected to use repeated counts to estimate abundance because approximately 40% of wild pigs on Fort Benning do not exhibit uniquely identifiable pelage characteristics (i.e., solid colored; S. S. Ditchkoff, Auburn University, AL, USA, unpublished data) and the method does not rely on the recapture of "marked" individuals.

For each survey, we estimated the density (pigs/km²) of the wild pig population in both study areas as the estimated average site abundance (λ) divided by the effective sampling area. We calculated the effective sampling area for each survey by plotting camera sites and summing the nonoverlapping area within 1.28-km² circular buffers around each site using ArcGis 9.1. We elected to use a buffer area of this size to more accurately represent the average territory size for wild pig sounders on Fort Benning reported by Sparklin et al. (2009). Sounder territories typically exceed the 1-km² cell size we used to establish survey sites, so we observed several sounders at adjacent camera sites during the study. Repeated-count models assume that sites are spaced far enough apart to preclude visitation by the same individual animals because this would inflate estimates of abundance resulting from animals being counted more than once per trap-night (Royle and Nichols 2003). In an effort to avoid this potential source of bias, we sought to differentiate sounders and track pig movement across sites by recording capture histories for individual pigs that could be uniquely identified by sex, approximate weight, age-class (juvenile or

adult), pelage markings and coloration, and sounder association (Sweitzer et al. 2000, Holtfreter et al. 2008). This approach allowed us to remove camera capture data where a sounder was identified at a second camera site during a sampling period, thus minimizing potential violations of model assumptions. We also identified pigs by ear-tag number because some pigs had been tagged as part of other research projects.

We calculated confidence intervals for density estimates by dividing lower and upper 95% confidence intervals for each abundance estimate by the effective sampling area. We calculated the average growth rate for each population between July 2007 and February 2008 by taking the square root of the density estimate from the last survey in each study area divided by the square root of the density estimate from the first survey in each study area (Williams et al. 2002). We considered sounder size to be the maximum number of adult females and juveniles observed in any one image during a survey. Individual sounders can be distinguished based on group composition (i.e., no. of adult females, shoats, piglets) in combination with their respective pelage or morphological characteristics (Sweitzer et al. 2000; Holtfreter et al. 2008; Hanson et al. 2009; Williams et al. 2010a,b); however, because sounders are territorial, typically only one sounder will be observed per site (Ilse and Hellgren 1995, Gabor et al. 1999, Sparklin et al. 2009). For each survey, we calculated recruitment for each site as the maximum number of juveniles observed in any one image divided by the maximum number of adult females observed in any one image.

RESULTS

Between 30 July 2007 and 27 February 2008, 29 and 7 participants in the bounty program harvested 78 (35 M and 43 F) and 12 (9 M and 3 F) wild pigs in the south and north study areas, respectively. In the south study area, participants harvested 95% (57/60; 18 did not indicate period) of pigs during the day, with 81% (63/78) killed while stand or stalk hunting as opposed to trapping or night hunting. Throughout the installation, participants reported harvesting 1,138 pigs at a cost of US$57,296, or US$50.35/pig. This estimate included the cost of paid bounties (US$35,950), traps (US$5,000), and bait (US$16,346) that were supplied by Fort Benning.

Between 30 July 2007 and 27 February 2008, we conducted 5 camera surveys consisting of 774 trap-nights in the south study area. Similarly, we conducted 8 camera surveys with 1,248 trap-nights in the north study area. We collected 307,475 images in the south study area, including 8,422 with pigs; and we collected 567,356 images, including 17,733 with pigs, in the north study area. Approximately 5% (1,257/26,155) of images with wild pigs were unusable because of obstructions of the view of the camera, poor light conditions, or inclement weather; we removed these unusable images from the data set. We estimated the effective sampling area for the first 2 surveys in the south study area to be 49.9 km^2, which was reduced slightly to 47.1 km^2 for all subsequent surveys in the area because access to 3 camera sites within the area became restricted because of military activities. We

estimated the effective sampling area for all surveys in the north study area to be 50.2 km^2.

Our initial estimates of wild pig density in the south study area (1.52 pigs/km^2; 95% CI = 1.19–1.93; Fig. 2) and north study area (1.58 pigs/km^2; 95% CI = 1.15–2.18; Fig. 3) were similar. Density estimates generally increased with each subsequent survey in the south study area, more than doubling to 3.52 pigs/km^2 (95% CI = 3.01–4.12) by the last survey. Density estimates also tended to increase in the north study area to 1.95 pigs/km^2 (95% CI = 1.49–2.54), but not to the degree that they did in the south.

The percentage of camera sites where wild pigs were detected remained relatively consistent throughout surveying in both study areas, increasing from 66.7% (18/27) during the first survey to 79.2% (19/24) during the final survey in the south study area and from 70.8% (17/24) to 79.2% (19/24) in the north study area. The maximum number of wild pigs observed in any one image generally increased in the north study area, starting with a mean of 2.59 pigs/site (95% CI = 1.74–3.44) in the first survey and ending with a mean of 4.53 pigs/survey (95% CI = 2.76–6.30). However, the maximum number of wild pigs observed in any one image nearly tripled in the south study area, increasing from a mean of 3.38 pigs/site (95% CI = 2.51–4.27) during the initial survey to a mean of 9.16 pigs/site (95% CI = 6.37–11.95) in the final survey (Fig. 4). The increase in estimated population density we observed in the south study area resulted in a mean λ of 1.52 (95% CI = 1.46–1.59) between July 2007 and February 2008; whereas, slightly increasing density estimates in the north study area resulted in a mean λ of 1.11 (95% CI = 1.08–1.14) during the same time period. Mean sounder size increased in the south study area from 4.0 (SE = 0.52) to 13.30 (SE = 1.78) pigs/sounder, and mean number of juvenile pigs per adult female increased from 1.06 (SE = 1.38) to 3.38 (SE = 2.12; Table 2) between the first and last surveys. Likewise, in the north study area, mean size of sounders increased from 5.60 (SE = 1.03) to 13.67 (SE = 2.73) pigs/sounder; mean number of juveniles per female increased from 1.00 (SE = 1.01) to 2.91 (SE = 4.02) from the first to last camera survey.
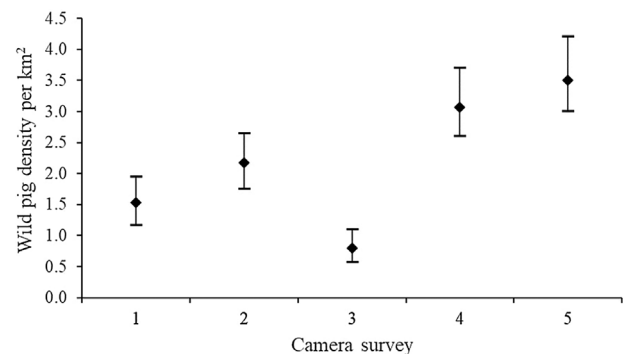

Figure 2. Density of wild pigs, with 95% confidence intervals, within the south study area (night hunting, trapping, and bait usage allowed) at Fort Benning, Georgia, USA, throughout camera surveys conducted between 30 July 2007 and 7 February 2008. Dates for each survey are provided in Table 1.
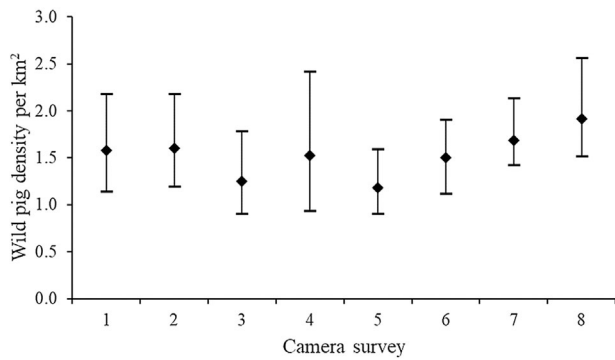
Figure 3. Density of wild pigs, with 95% confidence intervals, within the north study area (night hunting, trapping, and bait usage not allowed) at Fort Benning, Georgia, USA, throughout camera sight and resight surveys conducted between 5 September 2007 and 27 February 2008. Dates for each survey are provided in Table 1.

DISCUSSION

All population metrics that we estimated using camera surveys suggested that the wild pig population at Fort Benning was not declining during the duration of our assessment of the bounty program. Rather, estimates of density, sounder size, and juveniles:adult female ratios all increased during our study. These data suggest that the bounty program was ineffective at reducing the number of wild pigs on Fort Benning during the period that we were able to study the population. Other studies have suggested that sport hunting may be a reliable and cost-effective method for controlling wild pig populations (Sweitzer et al. 2000, Geisser and Reyer 2004); however, in a pest management program, a high level of mortality achieved with great effort and expense is seen as cost-effective only if mortality is additive (Sinclair and Pech 1996). On the surface, harvest of 1,138 pigs by participants in the bounty program appeared impressive. However, in relation to the size of Fort Benning, participants removed pigs at a rate of <1 pig/3.50 km² (i.e., the average home range size for sounders)/month for the duration of the study. Additionally, this harvest level was comparable to estimated annual rates of wild pig harvest by wild pig and deer hunters prior to implementation of the bounty program (Ditchkoff and Mitchell 2009). Hanson et al. (2009) suggested that this level of wild pig harvest was not capable of reducing density of wild pigs at Fort Benning.

At the time the bounty program started, the southeastern United States was experiencing a severe drought (Seager et al. 2009), which is generally associated with diminished body condition (Barrett 1978), decreased reproductive rates (Fernández-Llario and Carranza 2000), and increased mortality (Massei et al. 1997) in wild pigs. The dynamics of wild pig populations are affected by availability of pulse-resources, such as hard and soft mast (Bieber and Ruf 2005). Where pulse-resources are abundant, adult females may become sexually mature at an earlier age and produce larger or more frequent litters (Bieber and Ruf 2005, Ditchkoff et al. 2012). Likewise, wild pigs have been shown to exhibit greater reproductive performance when provided with pulse resources during periods of drought (Cahill et al. 2012); pulse resources in general tend to result in increased recruitment in pig populations (Náhlik and Sandor 2003). In the autumn of 2007, the southeastern United Stated experienced a
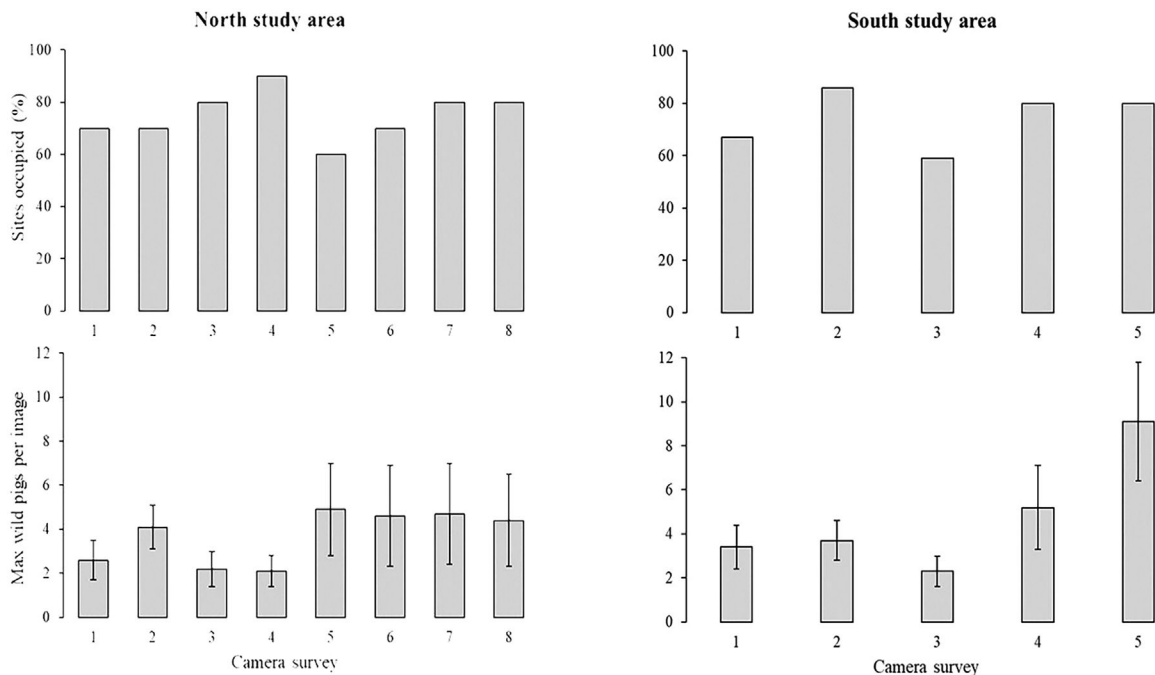

Figure 4. Percentage of sites occupied (i.e., ≥1 wild pig photo-captured) by wild pigs during camera surveys in the north and south study areas, respectively, and the mean (across sites, with 95% CIs) maximum number of wild pigs photo-captured in any one image at each site for each study area and camera survey at Fort Benning, Georgia, USA, between 5 September 2007 and 27 February 2008. Bait usage, night hunting, and trapping were allowed throughout the installation with the exception of the north study area.

Table 2. Mean sounder (matriarchal social group) size, adult sex ratio, and juvenile:adult female ratio of wild pigs observed during multiple camera surveys conducted at Fort Benning, Georgia, USA, between July 2007 and February 2008.

Surveys[a]	Sounders	Sounder size $\bar{x}$	SE	M/F $\bar{x}$	SE	Juv/F[b] $\bar{x}$	SE
North study area							
1[c]	5	5.60	1.03	1.79	0.57	1.00	1.01
2	5	6.60	2.16	1.78	0.89	0.89	1.17
3	4	4.50	0.29	1.93	0.71	0.43	0.63
4	4	4.00	0.41	2.31	0.93	0.23	0.62
5	3	9.00	5.00	1.91	0.73	1.45	3.91
6	3	11.00	4.04	2.30	0.70	2.30	3.76
7	5	8.40	2.73	1.35	0.70	1.41	3.14
8	3	13.67	2.73	1.45	0.45	2.91	4.02
South study area							
1	8	4.00	0.52	2.19	0.58	1.06	1.38
2	12	4.38	0.38	1.15	0.99	0.73	0.81
3	8	3.63	0.63	1.58	0.95	1.50	2.44
4	12	10.17	1.73	0.73	0.53	1.60	1.88
5	10	13.30	1.78	0.81	0.31	3.38	2.12

[a] Bait usage, night hunting, and trapping were allowed throughout the installation with the exception of the north study area.
[b] Juveniles included both subadults and piglets.
[c] See Table 1 for the dates for each survey.

well-above-average acorn crop associated with the severe drought (Seager et al. 2009). Additionally, with the exception of the north study area where baiting was restricted, participants in the bounty program dispersed 40 tons of corn and 30 tons of slop throughout the installation between June and October of 2007 and in February of 2008. Our initial density estimate in the north study area (1.58 pigs/km^2) was slightly less than an estimate from the same study area in 2006 (1.61 pigs/km^2), while our initial estimate from the south study area (1.53 pigs/km^2) was noticeably less than estimates from the previous 3 years (2.74 pigs/km^2 in 2006, 2.45 pigs/km^2 in 2005, 1.79 pigs/km^2 in 2004; Hanson et al. 2009). Similarly, the population growth rate we observed in the south study area was similar to growth rates for wild pigs in ideal habitat, while growth rates in the north study area more closely approximated growth rates for wild pigs in moderate habitat (Bieber and Ruf 2005). Likewise, the average number of juveniles per adult female we observed in our final survey in the south study area closely resembled that of adult females in a population provided with supplemental feed (Náhlik and Sandor 2003). We suggest the low initial population density at the beginning of the study combined with increasing water availability as the drought subsided and increased food availability due to abundant pulse resources and supplemental feed resulted in a set of ideal conditions for population growth.

Eradication programs are often hindered by decreased effort from participants once a number of individuals have been removed from the population and harvest becomes more difficult (Bomford and O'Brien 1995). In the south study area, where the density of pigs increased dramatically, 78 pigs were harvested during the study as compared with the north study area where population density remained constant and only 12 pigs were removed. This suggests that participants might have gravitated to areas with increased pig availability; however, the addition of several harvest techniques permitted in the south study area but not in the north area might also have led to increased hunter effort in the area. Past trapping efforts on Fort Benning resulted in reduced survival and decreased growth rates of pig populations, particularly where an effort was made to continue removals after trapping success waned (Hanson et al. 2009). However, participants in the bounty program were free to reduce their efforts or shift to more productive locations when their return on investment decreased. Likewise, participants in the bounty program either avoided trapping as a removal technique, or their attempts met with little success, which may affect future trapping efforts negatively (Morrison et al. 2007).

Hunter preference for animals perceived as trophies may also affect the success of control or eradication efforts because 45% of pigs harvested in the south study area were adult males, which have little bearing on the growth rate of polygynous species. Our data indicated that the prevalence of adult males relative to females in the south study area decreased as the study progressed. We hypothesize that this was due to selective harvest of adult males by some bounty participants. Hanson et al. (2009) reported that overall reductions in wild pig survival are critical for reducing population density, but recruitment must also be considered when attempting to lower populations. Females are ultimately responsible for production of the population and drive juvenile recruitment, so control efforts that focus on adult females will be more effective.

MANAGEMENT IMPLICATIONS

We believe that the original goal of the bounty program was unrealistic and a more appropriate goal would have been reduction of the population to a level that was more easily attained. If the program proved to be successful in the short term, the strategy could then be modified to continue population reduction. An adaptive approach such as this would theoretically allow for successful attainment of realistic short-term goals and modification of incentives throughout the program to increase probability of success. This case study suggests that incentive-based programs are more complex than many believe, and biology of the target species as well as social factors driving participation in the program should be carefully considered when predicting the potential success of a program.

ACKNOWLEDGMENTS

LITERATURE CITED

Allendorf, F. W., and L. L. Lundquist. 2003. Introduction: population biology, evolution, and control of invasive species. Conservation Biology 17:24–30.

Anderson, S. J., and C. P. Stone. 1993. Snaring to control feral pigs (*Sus scrofa*) in a remote Hawaiian rainforest. Biological Conservation 63:195–201.

Baker, S. J. 2006. The eradication of coypus (*Myocaster coypus*) from Britain: the elements required for a successful campaign. Pages 142–147 *in* F. Koike, M. N. Clout, M. Kawamichi, M. De Poorter, and K. Iwatsuki, editors. Assessment and control of biological invasion risks. Shoukadoh Book Sellers, Kyoto, Japan and International Union for the Conservation of Nature, Gland, Switzerland.

Barrett, R. H. 1978. The feral hog at Dye Creek Ranch, California. Hilgardia 46:283–355.

Barry, W. D. 1979. Bogus noses (with apologies to Andre). Maine Life. September 1979:51–58.

Bartel, R. A., and M. W. Brunson. 2003. Effects of Utah's coyote bounty program on harvester behavior. Wildlife Society Bulletin 31:738–743.

Beyer, H. L. 2004. Hawth's analysis tools for ArcGIS. Available at https://www.spatialecology.com/htools. Accessed 22 Aug 2013.

Bieber, C., and T. Ruf. 2005. Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. Journal of Applied Ecology 42:1203–1213.

Bomford, M., and P. O'Brien. 1995. Eradication or control for vertebrate pests. Wildlife Society Bulletin 3:249–255.

Cahill, S., F. Llimona, L. Cabaneros, and F. Calomardo. 2012. Characteristics of wild boar (*Sus scrofa*) habituation to urban areas in the Collserola Natural Park (Barcelona) and comparison with other locations. Animal Biodiversity and Conservation 35:221–233.

Choquenot, D., B. Kay, and B. Lukins. 1990. An evaluation of warfarin for the control of feral pigs. Journal of Wildlife Management 54:353–359.

Dilustro, J. J., B. S. Collins, L. K. Duncan, and R. R. Sharitz. 2002. Soil texture, land-use intensity, and vegetation of Fort Benning upland forest sites. Journal of the Torrey Botanical Society 129:289–297.

Ditchkoff, S. S., D. B. Jolley, B. D. Sparklin, L. B. Hanson, M. S. Mitchell, and J. B. Grand. 2012. Reproduction in a population of wild pigs (*Sus scrofa*) subjected to lethal control. Journal of Wildlife Management 76:1235–1240.

Ditchkoff, S. S., and M. S. Mitchell. 2009. Ft. Benning Military Reservation. Pages 357–364 *in* J. J. Mayer and I. L. Brisbin, Jr., editors. Wild pigs: biology, damage, control techniques, and management. Savannah River National Laboratory RP-2009-00869, Aiken, South Carolina, USA.

Ditchkoff, S. S., and B. C. West. 2007. Introduction to HWC's special topic: ecology and management of feral hogs. Human-Wildlife Conflicts 1:149–151.

Fernández-Llario, P., and J. Carranza. 2000. Reproductive performance of the wild boar in a Mediterranean ecosystem under drought conditions. Ethology Ecology and Evolution 12:335–343.

Gabor, T. M., E. C. Hellgren, R. A. Van Den Bussche, and N. J. Silvy. 1999. Demography, sociospatial behavior and genetics of feral pigs (*Sus scrofa*) in a semi-arid environment. Journal of the Zoological Society of London 247:311–322.

Geisser, H., and H. Reyer. 2004. Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. Journal of Wildlife Management 68:939–946.

Hanson, L. B., J. B. Grand, M. S. Mitchell, D. B. Jolley, B. D. Sparklin, and S. S. Ditchkoff. 2008. Change-in-ratio density estimator for feral pigs is less biased than closed mark-recapture estimates. Wildlife Research 35:695–699.

Hanson, L. B., M. S. Mitchell, J. B. Grand, D. B. Jolley, B. D. Sparklin, and S. S. Ditchkoff. 2009. Effect of experimental manipulation on survival and recruitment of feral pigs. Wildlife Research 36:185–191.

Hassell and Associates Pty Ltd. 1998. Economic evaluation of the role of bounties in pest management. Unpublished report for the Australian Bureau of Rural Sciences, Canberra, Australia.

Hines, J. E. 2006. PRESENCE2—software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.gov/software/presence.html. Accessed 28 Aug 2013.

Holtfreter, R. W., B. L. Williams, S. S. Ditchkoff, and J. B. Grand. 2008. Wild pig detectability with game cameras. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 62:17–21.

Hone, J., and H. Pedersen. 1980. Changes in a feral pig population after poisoning. Proceedings of the Vertebrate Pest Conference 9:176–182.

Ilse, L. M., and E. C. Hellgren. 1995. Resource partitioning in sympatric populations of collared peccaries and feral hogs in southern Texas. Journal of Mammalogy 76:784–799.

Jolley, D. B., S. S. Ditchkoff, B. D. Sparklin, L. B. Hanson, M. S. Mitchell, and J. B. Grand. 2010. An estimate of herpetofauna depredation by a population of wild pigs. Journal of Mammalogy 91:519–524.

Katahira, L. K., P. Finnegan, and C. P. Stone. 1993. Eradicating feral pigs in montane mesic habitat at Hawaii Volcanoes National Park. Wildlife Society Bulletin 21:269–274.

King, T. G., M. A. Howell, B. R. Chapman, K. V. Miller, and R. A. Schorr. 1998. Comparisons of wintering bird communities in mature pine stands managed by prescribed burning. Wilson Bulletin 110:570–574.

Lelli, B., D. E. Harris, and A. M. Aboueissa. 2009. Seal bounties in Maine and Massachusetts, 1888 to 1962. Northeastern Naturalist 16:239–254.

Louisiana Department of Wildlife and Fisheries [LDWF]. 2015. Nutria control program. www.nutria.com/site9.php. Accessed 8 Jan 2015.

Massei, G., P. V. Genov, B. W. Staines, and M. L. Gorman. 1997. Mortality of wild boar, *Sus scrofa*, in a Mediterranean area in relation to sex and age. Journal of Zoology, London 242:394–400.

Mazzoni della Stella, R., F. Calovi, and L. Burrini. 1995. The wild boar management in a province of the central Italy. Journal of Mountain Ecology 3:213–216.

Morrison, S. A., N. Macdonald, K. Walker, L. Lozier, and M. R. Shaw. 2007. Facing the dilemma at eradication's end: uncertainty of absence and the Lazarus effect. Frontiers in Ecology and the Environment 5:271–276.

Náhlik, A., and G. Sandor. 2003. Birth rate and offspring survival in free-ranging wild boar *Sus scrofa* population. Wildlife Biology 9:37–42.

Pacific States Marine Fisheries Commission [PSMFC]. 2015. 2014 Northern pikeminnow sport-reward program. <www.pikeminnow.org>. Accessed 8 Jan 2015.

Parkes, J. P., D. S. L. Ramsey, N. Macdonald, K. Walker, B. S. Cohen, and S. A. Morrison. 2010. Rapid eradication of feral pigs (*Sus scrofa*) from Santa Cruz Island, California. Biological Conservation 143:634–641.

Royle, J. A., and J. D. Nichols. 2003. Estimating abundance from repeated presence absence data or point counts. Ecology 84:777–790.

Seager, R., A. Tzanova, and J. Nakamura. 2009. Drought in the southeastern United States: causes, variability over the last millennium, and the potential for future hydroclimate change. Journal of Climate 22:5021–5045.

Sinclair, A. R. E., and R. P. Pech. 1996. Density dependence, stochasticity, compensation and predator regulation. Oikos 75:164–173.

Smith, M. J. 1990. The role of bounties in pest management with specific reference to state dingo control programs. Study project submitted to Charles Sturt University, Riverina, New South Wales, Australia.

Sparklin, B. D., M. S. Mitchell, L. B. Hanson, D. B. Jolley, and S. S. Ditchkoff. 2009. Territoriality of feral pigs in a highly persecuted population on Fort Benning, Georgia. Journal of Wildlife Management 73:497–502.

Sterner, J. D., and R. H. Barrett. 1991. Removing feral pigs from Santa Cruz Island, California. Transactions of the Western Section of The Wildlife Society 27:47–53.

Sweitzer, R. A., D. Van Vuren, I. A. Gardner, W. M. Boyce, and J. D. Waithman. 2000. Estimating sizes of wild pig populations in the north and central coast region of California. Journal of Wildlife Management 64:531–543.

Tisdell, C. A. 1982. Wild pigs: environmental pest or economic resource. Pergamon Press, Oxford, United Kingdom.

WAPT News 16. 2015. Mississippi lawmakers consider bounty on wild hogs. <http://www.wapt.com/news/mississippi/Mississippi-lawmakers-consider-bounty-on-wild-hogs/19207602>. Accessed 8 Jan 2015.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. Academic Press, San Diego, California, USA.

Williams, K., I. Parer, B. Coman, J. Burley, and M. Braysher. 1995. Managing vertebrate pests: rabbits, Australian Government Publishing Service, Canberra, Australia.

Williams, B. L., R. W. Holtfreter, S. S. Ditchkoff, and J. B. Grand. 2010*a*. Efficiency of time-lapse intervals and simple baits for camera surveys of wild pigs. Journal of Wildlife Management 75:655–659.

Williams, B. L., R. W. Holtfreter, S. S. Ditchkoff, and J. B. Grand. 2010*b*. Trap style influences wild pig behavior. Journal of Wildlife Management 75:432–436.

Associate Editor: Blackwell.