REMOVING FERAL PIGS FROM ANNADEL STATE PARK

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Abstract: A project to study the feasibility of eradicating feral pigs (*Sus scrofa*) from a 2000-ha state park was initiated by the California Department of Parks and Recreation through a cooperative agreement established in 1985 with the University of California. Trapping and hunting with trained dogs were used to remove pigs. A fence to preclude future immigration was constructed. Transect surveys of pig sign have been conducted annually to monitor success of the project. As of January 1988 no sign of pigs has been observed. Costs to date include $90,000 for 11 km of fence and $75,000 for pig removal.

In 1957 the California Fish and Game Commission assumed the power to regulate the take of wild pigs (*Sus scrofa*) in the state by making them a big game mammal (Section 3950, California Fish and Game Code). Wild pigs include introduced European wild boar, feral pigs, and their hybrids (Wood and Barrett 1979). Despite liberal hunting regulations the population has increased as evidenced by an increase in the estimated legal kill from 3,600 in 1959 (from 4 counties), to approximately 40,000 in 1987 (from 33 counties) (California Department of Fish and Game Hunter Survey, unpublished data). This increase has been received favorably by hunters, some of whom have assisted in dispersing wild pigs throughout the state.

The expanding population of wild pigs has been noted with less enthusiasm by those concerned with preserving examples of native ecosystems. State legislation (Section 5003, California Public Resources Code) and California Department of Parks and Recreation (CDPR) policy (CDPR Resource Management Directives 24 and 36) clearly direct state park managers to do all within their power to rid state parks of exotic flora and fauna. At Annadel State Park (ASP), the wild pigs are strictly feral stock, resulting from illegal releases of domestic pigs at least two decades and possibly as much as four decades ago by previous landowners. In 1981, the senior author surveyed ASP and advised park rangers on pig control methods. He estimated a population of about 35 pigs at that time. Park rangers and private contractors had little success in controlling the population, which was estimated to be 150 head in July 1985. At that time a four-year project to investigate the feasibility and cost of eradicating feral pigs from one or more state parks was proposed. It was agreed that ASP was the logical place to start as it is a relatively isolated island of about 20 km^2 of wild land in a sea of developed country on the southeastern outskirts of Santa Rosa, Sonoma County, California. This report describes the results of the first three years of the proposed four-year project. We acknowledge the assistance of personnel of the CDPR, particularly Valerie Gizinski and William Krumbein. CDPR funded the project. Various personnel of the California Department of Fish and Game (CDFG) were also helpful, as were a number of volunteers.

OBJECTIVES

The objectives of the project were: 1) to document the impact of feral pigs on the park ecosystem, 2) relate the abundance of pig sign to pig density, 3) develop an efficient control strategy, and 4) gather basic biological data on the pig population. These objectives were designed to assist the CDPR in meeting its management goal of eliminating, or at least minimizing the influence of, feral pigs on lands under its control.

METHODS

Pig Sign In Relation To Pig Density

The distribution of pig sign (rooting, trails, scats, tracks, beds, wallows, carcasses) was surveyed annually during the dry season by walking transects along nine predetermined compass bearings. The transect lines were arranged in a random-start, systematic design (Myers and Shelton 1980). A hip-chain was used to monitor distance walked. The presence of pig sign (fresh or old) was recorded for each 10x10-m plot along a transect. Observ-

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ers periodically calibrated their ability to visually estimate a 5-m belt either side of the transect against a tape rule. Each survey required about seven person-days of field work. Results are reported as frequency of occurrence of each type of sign by habitat type. It was assumed that the extent of rooting was an adequate measure of the impact of pigs on park resources. The Fisher Exact Randomization Test (Sokal and Rohlf 1981:740) was used to detect statistically significant differences in sign frequency.

Pig Census And Control

Pigs were censused by the population reconstruction method (McCullough 1979). Trapping was carried out during the summer-fall dry season when pigs responded well to bait. A commercially available, pelleted, pig grower feed was used as bait (Pig Grower Pellets, 16 percent crude protein). Bait was distributed in 100-pound sacks. The sacks could be opened by adult pigs, and if not detected in a reasonable period, sacks could be retrieved and used at a new location. Prebaiting included sprinkling a handful of bait atop each sack so pigs could sample it before opening the sack.

Two box traps (1x1x2 m) fitted with drop doors (Williamson and Pelton 1971) and seven corral traps fitted with swing-down doors (Belden and Frankenberger 1977) were used. The corral traps were made by securing four to six 2.5-m lengths of 1.5-m high heavy steel mesh to 2-m fence posts. Doors were triggered by pigs tripping a light rope tied to a stick supporting the door. The rope, running the length of the trap and about 2 dm above the bait, was tripped when a pig's legs moved it. Multiple captures were the goal with corral traps.

Pigs were also hunted with dogs trained to avoid non-target species (Tortora 1982). These were primarily of the Catahoula Leopard Stockdog breed. Individual dogs were screened for olfactory capability using a testing procedure modified from that of Myers and Pugh (1985). Hunting was generally done at night to avoid park visitors, in areas where trapping was no longer effective (Birmingham 1983). It involved a crew of one hunter plus one or two assistants, three to six dogs and one or occasionally two Honda all-terrain vehicles fitted with small trailers to haul out carcasses. Hunters systematically scoured the park on foot, canyon by canyon. Areas in which fresh pig sign was located were searched intensively with the dogs until pigs were struck. Pigs struck by the dogs ran a few meters to several kilometers but rarely escaped. All pigs captured were humanely dispatched by a high powered bullet to the brain. Records were kept of the effort (sacks of bait, trap nights, hours of hunting) expended and of the pigs removed.

By the second year of the project it was clear that by using a power line right-of-way, pigs were able to move between ASP and Jack London State Historical Park, 7 km to the southeast. Therefore it was necessary to construct 11 km of pig-proof fence around the southeastern border of Annadel. The fence design consisted of 1-m high hog mesh topped with 2 strands of barbed wire strung on 1.5-m steel posts set every 2.5 m. A small deadman was cabled to the bottom wire between each post to insure that pigs could not squeeze under the fence.

Table 1. Summary of feral pig sign frequency in 10x10-m plots at Annadel State Park. Values in parentheses are 95% confidence intervals.

Sign Type	1985	1986	1987
Trails	15.6 (14.2-17.2)	1.3 (0.9-1.8)	0.9 (0.6-1.5)
Rooting	13.5 (12.2-15.0)	7.7 (6.6-8.6)	1.8 (1.3-2.3)
Scats	6.0 (5.1-7.1)	0.2 (0.1-0.4)	0.1 (0.0-0.4)
Tracks	2.1 (1.6-2.8)	0.2 (0.1-0.4)	0.4 (0.2-0.7)
Beds	1.0 (0.7-1.5)	0.1 (0.0-0.3)	0.2 (0.1-0.5)
Wallows	0.2 (0.1-0.5)	0.1 (0.0-0.3)	0.1 (0.0-0.3)
Carcasses	0.1 (0.0-0.3)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
All types	25.0 (23.3-26.8)	8.5 (7.3-9.4)	2.8 (2.2-3.6)
Plots sampled	2334	2764	2485

Biological Data From Necropsies

All pigs killed were given a complete necropsy at the time of death (Runnells et al. 1967). All carcasses were then turned over to the local Fish and Game Warden or delivered to a location approved by the CDFG. Detailed findings from necropsies will be reported in a separate paper.

RESULTS

Pig Sign In Relation To Pig Density

A survey of 23.34 km of transects during September and October 1985 found that pig sign of some type was evident on 25 percent of the plots (Table 1). Sign was distributed throughout the park but was somewhat more concentrated in the central and northern regions. Rooting was relatively common, especially in moist areas around lakes, marshes, springs and water courses. Extensive, heavy rooting was observed around Ledson Marsh where a decade ago the rare plant, *Navarretia plieantha*, was found; it is no longer present. The shores of Lake Ilsanjo were also heavily rooted with much emergent aquatic vegetation destroyed. Accelerated erosion in most wet areas was obvious, especially around springs. There was evidence of rooting throughout the park for bulbed plants such as *Brodaea* spp. and the rare *Fritillaria liliacea*. Much amphibian habitat had been disrupted.

A second transect survey was accomplished in June and July, 1986. A total of 27.64 km was walked. All types of pig sign declined between 1985 and 1986 (Table 1). The frequency of all types of sign dropped from 25 to 8.5 percent (66 percent decline), but the occurrence of rooting only dropped from 13.5 to 7.7 percent (43 percent decline). One sounder was seen during the survey in 1985 while 3 were seen in 1986. Pig sign was again seen throughout the park, but it was more concentrated in the central region in 1986.

In the 1986 survey pig sign was correlated with the cover type (Wainwright and Barbour 1984) of each 10x10 m plot. Sign was most commonly found in marshland, chamise chaparral, black oak woodland, and laurel woodland (Table 2). In turn, these habitats were being impacted by pigs more than others.

A third transect survey was accomplished in July and August 1987. There was a further decline in the frequency of pig sign to 2.8 percent (67 percent decline from 1986, Table 1). The sign was concentrated in the southeastern end of the park. One sounder was seen during this survey. As of January 1989, no fresh pig sign had been seen in the park.

Pig Census And Control

Only two control techniques were acceptable to park managers: trapping and hunting. Both were attempted throughout the year, but trapping was successful only during the dry season (May - October) prior to acorn drop. A full trapping program could not be instituted before acorn drop in 1985. Nevertheless, 32 pigs were captured in a six-week period using five traps and 2.0 tons of bait. However, in 1986, a ten-week trapping session was accomplished using nine traps and 4.5 tons of bait. Sixty-six pigs were captured. In 1987, a 13-week trapping session was carried out using seven traps and 1.9 tons of bait. Only one pig was captured (Table 3).

Although hunting with the aid of dogs was successful in all seasons, when pig density was high, trapping tended to be more efficient. In three years, 99 pigs (69 percent) were removed by trapping and 45 (31 percent) by hunting.

By recording the sex and age of all pigs removed it was possible to reconstruct the population existing prior

Table 2. Availability and use by feral pigs of 14 cover types at Annadel State Park based on a line transect survey, Summer 1986.

Cover Type	Percent of Park	Frequency of Pig Sign (%)
Marshland	0.2	66.7
Chamise	0.9	28.0
Black Oak	16.9	11.3
Laurel	12.3	10.4
Manzanita	10.1	9.8
Douglas Fir	21.6	8.7
Madrone	1.6	7.0
Grassland	15.3	6.7
Live Oak	10.1	6.5
White Oak	2.5	4.5
Baccharis	0.8	4.3
Barren, water	3.8	2.9
Buckeye	1.9	0.0
Redwood	2.0	0.0

Table 3. Catch-per-unit-effort results for trapping and hunting of feral pigs in Annadel State Park, 1985-1987. A trap night (TN) is one trap run for one night. A typical night's hunting bout lasted 8 hours (8H).

Catch per Unit Effort	1985	1986	1987
Trapping			
Trap nights (TN)	20	295	455
Pigs	32	66	1
Pigs/TN	1.600	0.223	0.002
Hunting			
Hours	120	548	317
Pigs	12	26	5
P/8H	0.800	0.380	0.126

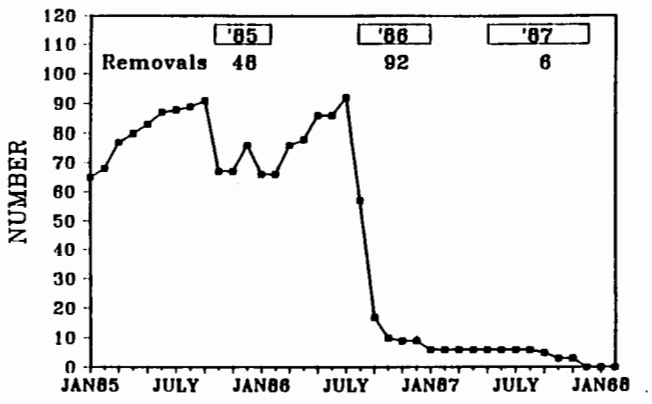

Fig. 1. Reconstruction of the feral pig population known to be alive in Annadel State Park based on the ages of 144 pigs removed from 1985 through 1987.

to removal. We believe 10 to 15 pigs of unknown sex and age were fenced out of the park in November 1987. However, the 144 animals removed as of that time provide a substantial sample for estimating minimum population size and composition. At least 89 pigs were alive in September 1985 when control began (Figure 1). The removal of 46 pigs that fall had only a short-term effect. At least 92 pigs were alive in July 1986. Ninety-two pigs were removed in 1986, but at least five were alive in July 1987. Those five pigs were removed by December 1987 (Figure 1).

Wildlife biologists commonly look at population sex and age composition when judging population trends. Unfortunately, this has many pitfalls (Caughley 1974). The mean age of the pig population at ASP increased slightly in 1986 and increased considerably in 1987 (Table 4). In general, the sex-age structure of the reconstructed population is typical of feral pigs, with few individuals reaching more than four years of age (Barrett 1978).

The selectivity for sex-age class by each control technique is of interest. If selectivity occurs in a control program it is desirable for it to be towards adult females. We noted no selection for sex, but trapping appeared to be more effective than hunting in removing young pigs (Table 5).

CONCLUSIONS AND RECOMMENDATIONS

Parks should provide a baseline with which to compare lands modified by more disruptive land uses. There was little argument over the need to eliminate feral pigs from ASP. This goal was directed by the public interest as spelled out in current laws and policies. Feral pigs have clearly disrupted the ASP ecosystem and thereby affected ecological and evolutionary processes.

The following effects of feral pigs on ASP were listed by Michael Garguilo in a 1984 proposal by CDPR to remove pigs from the park: accelerated erosion, fouled water supplies, altered natural patterns of vegetation succession, reduced forage production for native wildlife, destruction of rare native lilies, competition with native wildlife for acorns, destruction of habitat of native herpetofauna, degradation of the aesthetic quality of the landscape, increased trail maintenance costs, frightening of park visitors, and transmission of diseases. We found qualitative evidence for all of these impacts.

Feral pigs have been eradicated elsewhere in North America (Brown 1985). However, our effort is the first time total eradication of feral pigs has been attempted in a California park of this size. Thus, it is a test case, deserving careful monitoring. If successful eradication cannot be demonstrated, there should be a change in management policy, since if eradication is not feasible at ASP, it is unlikely to be so at other parks, except very small ones. As of January 1988, it appears that total eradication has been accomplished. A permanent, pig-proof fence will be maintained to prohibit immigration, and wet sites will be regularly monitored for pig sign.

Suggestions were made by various individuals to

Table 4. Sex-age structure of the feral pig population at Annadel State Park, 1985-1987.

Age Class	July 1985		July 1986		July 1987	
	Male(%)	Female(%)	Male(%)	Female(%)	Male(%)	Female(%)
5	0	0	0	1	0	0
4	0	2	0	7	0	17
3	2	8	2	2	17	0
2	2	7	10	6	17	0
1	18	17	11	5	3	20
0	30	14	30	26	17	0
Total Pigs	88		94		6	

Table 5. Selectivity of trapping versus hunting for sex and age classes of feral pigs at Annadel State Park, 1985-1987.

	Number (%) Removed	
Sex-age Class	Trapping	Hunting
Males (0-12 mo)	36 (84%)	7 (16%)
Females (0-12 mo)	26 (87%)	4 (13%)
Males (21+ mo)	17 (52%)	16 (48%)
Females (12+ mo)	19 (51%)	18 (49%)

remove pigs alive rather than kill them, and to transplant them to other lands. Both of these alternatives are inadvisable. Transplanting wild pigs is illegal without a permit from CDFG. Wild pigs will cause problems on any land. Public policy restricts introduction of exotics on public lands, and private landowners typically are not interested in releasing a known pest on their property (Barrett and Pine 1980). To date, fencing costs have totaled $90,000 and removal efforts have totaled $75,000. Removing pigs live from ASP only to take them to a slaughter house would have significantly increased the cost of removal, probably by a factor of two or three. We believe that removal costs could be substantially reduced, by as much as half, by dispensing with the requirement for retrieving carcasses and transporting them out of the area. We estimate the meat provided to charity by this project cost the taxpayer over $5.00 a pound, roughly twice the cost of purchasing pork at a supermarket. We recommend two techniques for eradicating a pig population at high density (over 5 per km^2). Initial efforts should involve trapping around water sources, later switching to hunting with dogs after the majority of pigs have been removed by trapping.

The cost of pig eradication is high, but it is technically possible. Control is also possible, but in the long run it is always more expensive than eradication unless it can be accomplished via sport hunting (Tisdell 1980). However, sport hunting is not an option in California's state parks.

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