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Evaluating Feral Pig Management Strategies at Tejon Ranch, California

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ABSTRACT: Feral swine are a serious management issue for natural resource managers, farmers, ranchers, and increasingly even suburban, private property owners. The 270,000-acre privately-owned Tejon Ranch in the Tehachapi Mountains of California, the subject of an historic conservation and land use agreement that conserved 90% of the property, supports a population of feral pigs that originally escaped from a private hunting ranch in the Tehachapi. Pigs now established on Tejon Ranch produce extensive ecological and economic damages, but are also a revenue source for the landowner's hunting program. The Tejon Ranch Conservancy serves as steward of the conserved lands and is evaluating management options to reduce feral pig damages, while respecting the landowner's right to maintain a hunting operation. To inform our management, we have modeled pig population responses to age- and sex-specific harvest scenarios. Consistent with previous studies, our models show that >70% of the population must be harvested annually to maintain or reduce the population, and that high harvest of adult females and juveniles is most effective at reducing abundance. Our analysis shows that population growth rates, which dictate harvest rates required for population control, are most sensitive to reproductive rates, and we have no site-specific data to estimate reproductive or mortality rates. As part of the National Feral Swine Damage Management Program, the Conservancy is partnering with the USDA Animal Plant Health Inspection Service on a research and monitoring project to estimate feral pig population size and demography; habitat use and home ranges; and damages at Tejon Ranch. The ultimate objective of the program is to evaluate techniques for reducing damages cause by feral swine.

KEY WORDS: abundance estimation, California, camera traps, damage estimation, hunting, management strategy, National Feral Swine Damage Management Program, population model, *Sus scrofa*, wild pigs

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INTRODUCTION

Feral swine (*Sus scrofa*) pose a serious management problem for natural resource managers, farmers, ranchers, and, increasingly, suburban private property owners. Tejon Ranch (270,000 acres) is the largest contiguous private property in California and supports a population of feral pigs. Located in the Tehachapi Mountains, Tejon Ranch lies at the confluence of four major ecological regions of California: Great Central Valley, Sierra Nevada, Mojave Desert, and South Coast. Thus, it supports a high level of biodiversity and has long been a focus of conservationists. Tejon Ranch also supports a diversified agribusiness with extensive acreage of vineyards, nut orchards, and row crops, as well rangelands for cattle. Feral pigs became established at Tejon Ranch in the early 1990s following an accidental release from a hunting ranch outside of Tehachapi, California.

The 2008 Tejon Ranch Conservation and Land Use Agreement (Agreement) between the Tejon Ranch Company, the property owner, and five environmental organizations (Audubon California, Endangered Habitats League, Natural Resources Defense Council, Planning and Conservation League, and Sierra Club) resulted in the conservation of 240,000 acres of the Ranch. Conservation at Tejon Ranch is via conservation easement, and under these easements the Tejon Ranch Company retains a number of land use rights in the conserved lands, including hunting and cattle ranching. The Agreement created the Tejon Ranch Conservancy and charged it with developing and implementing a management plan, known as the Ranch-Wide Management Plan (RWMP), for the conserved lands to "protect, enhance, and restore" their native biodiversity. The RWMP also allows the Conservancy to develop Best Management Practices (BMPs) for the Tejon Ranch Company's reserved rights under the conservation easements (e.g., hunting) to minimize any adverse effects of these reserved rights and to enhance conservation values. The RWMP identifies feral pigs as a significant threat to conservation values. Pigs also cause extensive agricultural and property damages at Tejon Ranch but provide hunting revenue to the landowner.

The Conservancy's challenge, therefore, is to develop effective conservation management strategies for feral pigs in the context of the private lands conservation agreement that maintains the landowner's right to operate a commercial hunting operation. Thus, we have focused our efforts on: 1) understanding what role hunting can play in feral pig population and damage management at Tejon Ranch, 2) quantifying pig abundance and habitat-specific damages, and 3) exploring approaches to protecting sensitive habitats and assessing associated changes in condition.

CAN HUNTING MANAGE PIGS AT TEJON RANCH?

As hunting is a reserved right of the Tejon Ranch Company under the conservation easements, and pigs are regulated as a big game species in California, we are evaluating whether hunting can help control the pig population at Tejon. For example, Bieber and Ruf (2005), Hanson et al. (2009), and others have found that very high harvest rates are necessary to control population growth of wild pigs, which may not be achievable with recreational hunting. However, the Tejon Ranch Company runs a commercial operation offering guided and unguided hunting opportunities, and BMPs could potentially improve the hunting program's ability to achieve pig management targets.

We first assembled harvest records for pigs at Tejon Ranch for 2001-2015 (Figure 1). Annual harvest varied from 600-800 animals from 2001-2011, but increased to 1,000-1,200 pigs per year between 2012 and 2015. While the total population of wild pigs at Tejon Ranch is unknown, densities of pigs in California range from 0.7-3.8/km^2 (Sweitzer et al. 2000). At these reported densities, Tejon Ranch would support from 764 to 4,150 pigs.

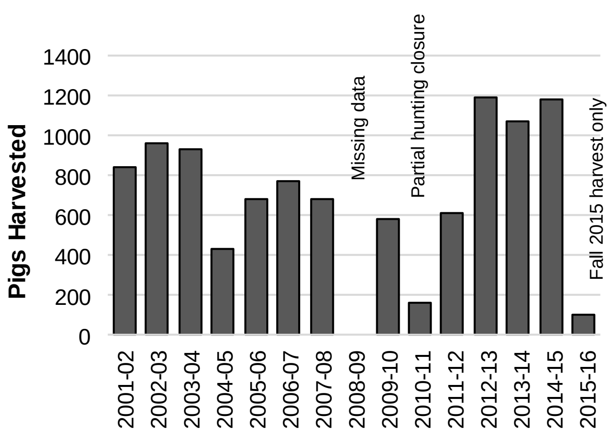

Figure 1. Annual harvest of pigs at Tejon Ranch, Years 2001-2015.

We explored the implications of pig hunting on population growth rates using the program VORTEX (Miller and Lacey 1999), which has been used to evaluate extinction processes in species of conservation concern (Manlik et al. 2016). VORTEX is a population viability model that allows the user to set parameters for starting population; age classes; sex and age-specific survival and fecundity; density-dependent reproduction; and immigration and emigration rates. As we had no site-specific data for Tejon Ranch, we explored model scenarios based on ranges of population parameters and vital rates from the literature. In these scenarios, our objective was to determine what population parameters are necessary for stable or negative pig population growth rates.

The results of the model runs show that male mortality is insignificant, high mortality of juveniles is most effective at controlling population growth, and immigration of pigs onto Tejon can be offset by high mortality rates. Of the parameters we tested, the percent females breeding had the highest impact on population growth rates (i.e., it was the most sensitive parameter). At realistic high reproductive rates (e.g., 80% of adult females breeding and 80% producing two litters; Hanson et al. 2009), only very high rates of mortality for both juveniles and adults (>80%) could reduce populations. At lower reproductive rates (60% adult females breeding and 80% producing two litters), moderate rates of harvest (70%; Hanson et al. 2009) for both juveniles and adults reduced population growth.

Under the high reproductive rates, increasing juvenile mortality rates had greater effect on population trends (was a more sensitive parameter) than increasing adult female mortality. Juvenile mortality rates of >50% are required to reduce population growth rates even at low reproductive rates. Lowering adult male mortality did not significantly change model outcomes versus the high adult male mortality model scenarios (i.e., the model was most sensitive to female mortality).

We used a high annual immigration rate of 1.5% (higher than the immigration rate in Hampton et al. 2004) from a second population adjacent to Tejon of similar size with slightly lower mortality rates than for the modeled Tejon population. The Tejon population declined at both high and low reproductive rates when the Tejon population was modeled with the highest mortality rates (>80%). Thus, high immigration rates onto Tejon did not completely offset high mortality in the Tejon population. When we added density-dependent reproduction to the model, with 90% females breeding at low densities versus 70% breeding at carrying capacity, we found no significant changes in model outcomes.

Based on modeling scenarios with the parameters we explored, pig populations do not decline unless there are high adult mortality rates (>80%) and juvenile mortality rates of >50%. At high rates of reproduction, very high rates of mortality are required to reduce the population; and even at lower rates of reproduction, relatively high mortality is needed to reduce the population. Our models show that low immigration rates from adjacent properties could be countered by high mortality rates on Tejon, and high mortality rates could also overcome density-dependent increases in reproductive rates.

We don't know population size, reproductive rates, or mortality rates for Tejon, which limits our ability to track pig population responses to hunting pressure and thus to evaluate hunting as a management tool. However, we obtained a sample of body size from pigs harvested at Tejon Ranch between 2007 and 2010 (Figure 2). Mean field dressed weights of harvested animals were 138 lbs for males and 118 lbs for females. At Tejon Ranch few if any juvenile animals are harvested, making it unlikely that recreational hunting will be an effective means to control populations.

MEASURING ABUNDANCE AND ECOLOGICAL DAMAGE

Summer 2013

In summer 2013, the Conservancy initiated a field pilot study of methods to quantify abundance of wild pigs

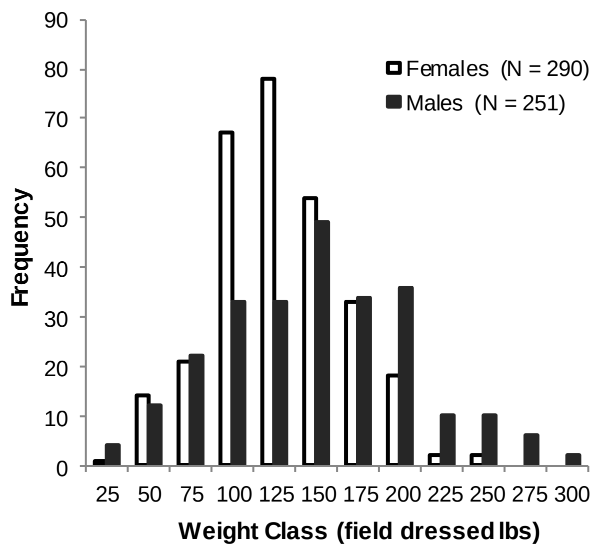

Figure 2. Weight classes of a sample of pigs harvested at Tejon Ranch, 200-2010.

and the rooting damage that they cause (Christie et al. 2014). We utilized remotely-triggered wildlife camera traps to develop an index of abundance of wild pigs (i.e., pigs detected/camera/night). Cameras were set to record videos, and we quantified the total number of pigs observable in each video clip. We estimated the effects of feral pigs on terrestrial plant and animal communities with a Fresh Damage Index similar to the one developed by Engeman et al. (2001). This method estimates the percentage of fresh rooting in five 10×10 m plots along 0.5 km transects located along roads in five different habitats: grassland, chaparral, oak savanna, oak woodland, and conifer. In riparian habitats we established 50 m transects along stream reaches and placed remotely triggered wildlife cameras along each stream reach to measure pig activity in that reach. We quantified riparian damage by measuring the width of the area disturbed by pigs at 5 m intervals along the arbitrarily selected "river right" side of the stream.

The results of the abundance and damage assessments are shown in Table 1. During these summer surveys, pig abundance was an order of magnitude higher in riparian habitats than in any upland habitat. Among upland habitat types, wild pigs were most abundant in chaparral but with a high standard deviation. Estimated damages were highest in riparian and oak vegetation types, and very low or non-existent in grassland, conifer, and chaparral vegetation types. Pig abundance and riparian damage showed a significant positive correlation; damage and abundance were not significantly correlated in other habitats.

Summer 2014

We modified our approach to measuring pig abundance and damages during summer 2014. We developed a density estimate for pigs using Line Transect Surveys (LTS) with a DISTANCE sampling approach (Thomas et al. 2010); developed concurrent camera indices of abundance; and estimated rooting damage along portions of lines used in the LTS (Teton et al. 2016).

Surveys were conducted within a grid comprising 101 4 km^2 cells and established a 4 km LTS route (generally square in shape) within each grid. In each cell sampled, the observer walked the transect line between two hours post-dawn or two hours pre-sunset for approximately a two hour period. We counted all pigs (and other wildlife species) and classified them as adult male, adult female, juvenile, or piglet; we also recorded the distance and bearing to the observed animal(s). Density was estimated from all LTS results using program DISTANCE (Thomas et al. 2010).

During the LTS, we also assessed pig damage (rooting) along eight 25 m segments of the 4 km transect (one 25-m segment for every 0.5 km walked), totaling 200 m; pig damage is expressed as the proportion of the total distance surveyed. In addition, we placed a single camera trap in each survey grid at a wallow or game trail. Cameras were set to collect 30-second videos with a 30-second lag between video captures.

During May through July, we made 28 observations

Table 1. Abundance index (pigs/camera/night) and damage (m^2) detected in the summer of 2013 (from Christie et al. 2014).

Vegetation Type	Mean Abundance Index ± SD	No. Detections	Mean Detected Group Size	Max Group Size	Mean Damage Detected (m^2) ± SD
Grassland	0.001 ± 0.018	1	1	1	0 ± 0.00
Conifer	0.093 ± 0.527	17	2.53	13	3 ± 6.00
Chaparral	0.217 ± 1.755	38	2.79	13	8.7 ± 10.08
Oak Woodland	0.042 ± 0.077	10	1	1	22.8 ± 15.37
Oak Savannah	0.013 ± 0.035	4	1.25	2	20.1 ± 11.78
Riparian	3.823 ± 6.460	223	2.86	18	75.3 ± 51.43

of pigs on 42 transects during the LTS. This yielded a mean density of 0.069/ha and a 95% CI of 0.034-0.139 (CV = 0.363). This density is equivalent to 6.9 pigs/km^2, which is higher than previous density estimates for wild pigs in California (0.7-3.8 pigs/km^2; Sweitzer et al. 2000). During our LTS, damage averaged 15% of transects surveyed (SD = 0.13, 95% CI of 0.12-0.19). We placed 61 cameras in 61 cells from March to September. Our mean pigs/camera night was 1.63. Damage estimates were not well correlated with abundance estimates.

Cameras vs. LTS

We found cameras to be superior at detecting pigs than LTS at Tejon Ranch. The rugged terrain and dense vegetation make conducting LTS extremely difficult, and we suspect that our density estimates from this approach are likely low and have a high degree of uncertainty. Cameras are good at detecting pigs in the complex landscape of Tejon Ranch, but they can only provide an index of abundance rather than a true density estimate. However, cameras also provide information on other wildlife, including information on demographics and reproduction, as well as images valuable for outreach and education.

We are currently modifying our abundance monitoring approach to incorporate mark-resight population estimation using naturally marked animals. Our preliminary estimates indicate that 15-20% of pigs at Tejon Ranch can be individually identified from unique pelage patterns. The mark-resight approach would allow development of pig density estimates using wildlife camera data.

We believe that LTS is a viable approach for measuring damage, at least visible damages associated with rooting and wallowing. Aging the damage (recent or old) can be problematic depending on the time of year and the age of the rooting. However, mapping the distribution of the damage along transects allows comparison of the damage present along different portions of the transects in different survey periods.

CONTINUING EFFORTS

In 2015, the Conservancy and the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) initiated a partnership as part of the National Feral Swine Damage Management Program (USDA APHIS 2016). The focus of the National Program is to increase our understanding of wild pig population ecology (e.g., population estimation, dispersal, habitat use, and diet); risk identification and analysis (e.g., disease prevalence and risks, potential for disease transmission to livestock and humans, and disease control); and damage assessment (e.g., agricultural damage assessment methods, economic analyses of damage, ecological damage assessment methods, and damage control approaches). The ultimate goal of the National Feral Swine Damage Manage Program is to reduce the spread of feral swine, as well as reduce their populations, damage, and associated disease risks. Tejon Ranch serves as a West Coast study site for the National Program to develop and explore new field techniques.

As part of this research effort, APHIS is currently trapping, marking, and putting GPS/vhf collars on wild pigs at Tejon Ranch to develop mark-resight population estimates and better understand their spatial use patterns and movements. The Tejon Ranch field study will provide information on population estimation approaches and the ability to detect changes in population size resulting from wild pig management actions. As discussed above, the Conservancy is using natural pelage markings to develop mark-resight population estimates within the APHIS study area, which will allow us to compare the costs, logistics, and efficacy of these methods for monitoring wild pig populations in large, complex landscapes such as Tejon Ranch. In addition, information developed on habitat use and movements will allow us to better plan wild pig management actions.

Through our pilot studies, we have realized the extensive damage that pigs cause in wetland and riparian habitats and we are currently exploring the effects of excluding pigs from these habitats. We have constructed pig-proof exclosures around small (<5 acres) spring systems and are tracking responses in vegetation community composition. We are also evaluating the relative effects of pigs and cattle by implementing seasonal cattle management in some stream reaches while excluding both cattle and pigs from other reaches. We are monitoring responses of vegetation, riparian birds, and herpetofauna to these management treatments (Ratcliff et al. 2015).

LITERATURE CITED

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. J. Appl. Ecol. 42:1203-1213.

Christie, J., E. DeMarco, E. Hiroyasu, A. Kreger, and M. Ludington. 2014. Wild pig management at Tejon Ranch. Group Masters Project, Bren School of Environmental Science and Management, University of California-Santa Barbara, Santa Barbara, CA. http://www.esm.ucsb.edu/research/2014Group_Projects/documents/Chanchos_Final Report_FINAL.pdf

Engeman, R. M., B. Constantine, M. Nelson, J. Woolard, and J. Bourassa. 2001. Monitoring changes in feral swine abundance and spatial distribution. Envir. Conserv. 28(3):235-240.

Hampton, J., B. Peter, L. Deryn, E. Laurie, P. Andrew, D. Jeff, H. Tony, and P. John. 2004. Molecular techniques, wildlife management and the importance of genetic population structure and dispersal: a case study with feral pigs. J. Appl. Ecol. 41:735-743.

Hanson, L. B., M. S. Mitchell, J. B. Grand., B. Jolley, B. Sparklin, and S. Ditchkoff. 2009. Effects of experimental manipulation on survival and recruitment of feral pigs. Wildl. Res. 36:185-191.

Miller, P. S., and R. C. Lacy. 1999. VORTEX: a stochastic simulation of the extinction process. Version 8 User's manual. Conservation Breeding Specialist Group (SSC/IUCN), Apple Valley, MN.

Manlik, O., J. A. McDonald, J. Mann, H. C. Raudino, L. Bejder, M. Krützen, R. C. Connor, M. R. Heithaus, R. C. Lacy, and W. B. Sherwin. 2016. The relative importance of reproduction and survival for the conservation of two dolphin populations. Ecol. Evol. (online version):1-17. http://onlinelibrary.wiley.com/doi/10.1002/ece3.2130/full

Ratcliff, F. P., J. W. Bartolome, M. Hammond, S. Spiegal, and M. White. 2015. Developing ecological site and state and transition models for grazed riparian pastures at Tejon Ranch, California. Pp. 209-218 *in*: R. B. Standiford and K. L. Purcell (Tech. Coords.), Proceedings of the Seventh California Oak Symposium: Managing Oak Woodlands in a Dynamic World. Gen. Tech. Rept. PSW-GTR-251. U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station, Berkeley, CA. 579 pp.

Sweitzer, R. A., D. Van Vuren, I. Gardner, W. Boyce, and J. Waithmann. 2000. Estimating sizes of wild pig populations in the north and central region of California. J. Wildl. Manage. 64:531-534.

Teton, B., K. Kunkel, and M. D. White. 2016. Grappling with wild pigs in California high country: wild pig population and disturbance research at Tejon Ranch. Proc. Vertebr. Pest Conf. 27:124-127.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. J. Appl. Ecol. 47:5-14.

USDA APHIS. 2016. APHIS National Feral Swine Damage Management Program. Website. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. https://www.aphis.usda.gov/aphis/resources/pests-diseases/feral-swine/feral-swine-program. Accessed May 10, 2016.