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Size should matter: Distribution and genetic considerations for pest animal management. Peter B. S. Spencer[1] and Andrew P. Woolnough[2] ([1]School of Veterinary and Biomedical Sciences, Murdoch University, Western Australia, and [2]Vertebrate Pest Research Section, Department of Agriculture, 100 Bougainvillea Avenue, Forrestfield, Western Australia 6058, Austrlia. Email: P.Spencer@murdoch.edu.au).

Key words: *applied genetics, distribution and abundance, feral pig, GIS, Sus scrofa, vertebrate pest*.

Importance of understanding biological boundaries. Biological invasions by pest species constitute one of the leading threats to biodiversity and ecosystem health (Long 2003). However, in terms of reducing their abundance, and ultimately the restoration of damaged ecosystems, a species can not be effectively managed without understanding their demic structure or biological boundaries (Zenger *et al*. 2003). We consider that the ability to define biological boundaries of a population as an important ecological parameter for the effective control of feral and invasive species. This is particularly so where subpopulations may be acting as a source for re-invasion, and also in those areas that may act as net recipients of dispersing individuals.

Feral pigs: a 'triple threat species' (environment, agriculture and biosecurity). Feral pigs (*Sus scrofa*) are a significant vertebrate pest in Australia (Choquenot *et al*. 1996). There are estimated to be more than 23 million animals inhabiting approximately 40% of the continent, with numbers varying considerably depending on environmental conditions, and the level of control exerted (Hone 1990; Choquenot *et al*. 1996).

The south-west of Western Australia (WA) is under threat from a range of processes including vertebrate pests, changing fire regimes, logging and clearing. It also has been described as one of the 10 most biologically diverse regions in the world (Myers *et al*. 2000), so effective management of feral pig populations is essential. In this region, feral pigs occupy most suitable habitat from the Perth hills around to Albany in the lower south of the state. They are often associated with available water (e.g. dams, riparian ecosystems) and developing forest industries (Long 2003). Feral pigs are perceived as a major threat to the biodiversity (and agricultural) values of this region and present a biosecurity risk for endemic and exotic diseases (Choquenot *et al*. 1996). As such, they should be a high priority management issue for conservation and agricultural practitioners alike.

We suggest that utilizing a combination of genetic and distribution information will enhance our ability to define biological boundaries for feral pigs. This information is essential to develop and implement regional strategies necessary for the effective control of this highly destructive and invasive pest. Our approach combines GIS and genetic methodologies to estimate a minimum area occupied by feral pig populations at a landscape scale.

Location surveys and genetic sampling. Distribution and abundance information on feral pigs was obtained for every parcel of land (agricultural, conservation, forestry and unallocated crown land) greater than 10 ha in size using a detailed and robust survey process (see West & Saunders 2003; Woolnough *et al*. 2004). This survey process captured the detailed local knowledge of staff from the Departments of Agriculture ($n = 73$) and Conservation and Land Management ($n = 31$). Central to the survey process was a comprehensive two-part structured interview developed to minimize any perception bias. The first part of the interview was an interactive questionnaire specifically about pest animals. The second part of the interview was a mapping exercise which utilized specifically-developed maps (fine scale) for each local area to describe distributions of various pest animals and a set of standard definitions to describe the abundance of pest animals (see Woolnough *et al*. 2004). These key features of the survey process allow distribution and abundance data to be compared across local areas, regions and states (Woolnough *et al*. 2004). Moreover, we refer to distribution in terms of feral pigs being either present or absent from an area. This simplifies many of the assumptions that are associated with abundance and distribution estimates. Surveys were conducted from mid-2002 to mid-2003 with data incorporated into a Geographic Information System (GIS).

During the same period, we obtained samples for DNA analysis (at 14 microsatellite loci) from 276 adult feral pigs from the same areas. A Bayesian assignment approach of Pritchard *et al*. (2000) was used to identify genetic structure and, based on the sampling locations, feral pig populations were defined (see Hampton *et al*. 2004). The minimum polygon method (which is likely to overestimate total population area) was used to estimate the area occupied by each population and define the most likely biological boundaries of each population.

'Operational management unit' of feral pigs. Six genetically distinct populations have been defined for the south-west of WA and described by Hampton *et al*. (2004). These populations were found to be (significantly) genetically distinct, even between some populations that were only 25 km apart,

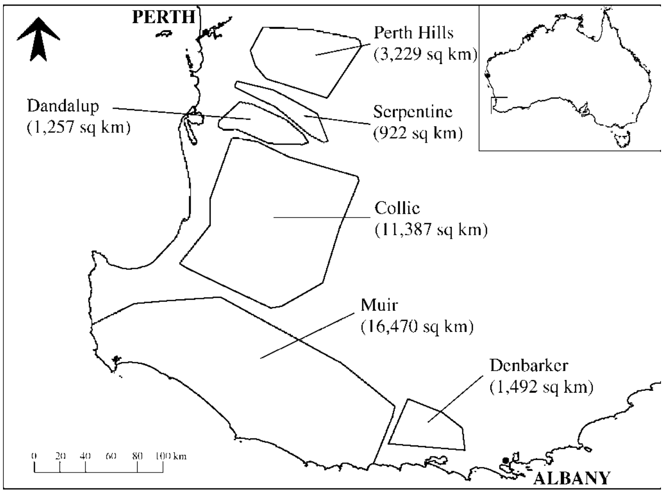

Figure 1. **Distribution of the six genetically-defined populations of feral pigs in the south-west of Western Australia. Areas, and hence operational management units, were estimated using minimum convex polygons.**

such as between the populations of Serpentine and Dandalup (Hampton *et al*. 2004). These results are consistent with the only other comparative data, which were obtained from Italian wild boars (Vernesi *et al*. 2003). Even though Hampton *et al*. (2004) defined the genetic structure of feral pig populations, they did not estimate the area occupied by of any of these populations and the addition of the distribution data adds extra value in terms of defining the actual population (biological) boundaries at a landscape scale.

Based on the genetic structure and distribution of the feral pigs, each population could be regarded as an 'operational management unit (OMU)'. OMU range in area from an estimated 922 km^2–16 470 km^2 (mean area, 5792 $km^2 \pm 2675$ SE; Fig. 1). The populations with the largest geographical ranges occur in the more southern areas (e.g. Collie and Muir) which most likely reflect the relatively recent invasion of these regions by feral pigs (Hampton *et al*. 2004).

Defining OMU will always be contentious depending on what the primary aim of pest management is viewed to be (e.g. prevent establishment, prevent expansion, prevent damage, etc.). Alternative definitions of OMU may, therefore, focus on where damage is occurring, artificial boundaries such as fences or manipulated buffers, availability of resources for control, or even areas of enthusiastic stakeholders. Many of the current control program for feral pigs in this area reflect this relatively variable way of defining OMU and responding to it. We suggest that the biological definition (i.e. known distribution combined with defined genetic structure) is perhaps a better way of defining an OMU at a landscape scale. Furthermore, failure to identify and manage these genetically defined populations as OMU will inevitably result in re-invasion of the controlled areas by pigs from elsewhere *within* the population. The result of this is that any control efforts at a local scale are likely to have little long-term effect in reducing the overall presence of feral pigs because of re-invasion. Only control at a population level (genetically defined) will achieve long-term results, particularly if the population can not be removed in a single exercise.

The management implications derived from our combined genetics-GIS approach gives a preliminary indication of the large size and scale necessary for the effective control and management of feral pigs in the south-west of WA. In an ideal world, genetically-defined OMU would be very useful, however, we acknowledge that the reality is that OMUs need to be a compromise of what is practicable at a landscape scale. Nonetheless, our approach should value-add to established doctrine about pest animal management (e.g. Olsen 1998; Braysher & Saunders 2003).

A need for integrated agency control operations. We suggest that feral pig control will probably be necessary at landscape scales, rather than be restricted to artificial boundaries (e.g. municipal boundaries) which currently define management areas. As such, these results also suggest that with a large OMU (> 1000 km^2), control operations need to be cooperative and strategic, and involve both government and non-government agencies. Moreover, an approach that engages both the community and government capabilities/interests would enable more efficient use of available resources, and ultimately provide a valuable contribution to control programs for feral pigs.

Overall, the management and restoration of fragile habitats may be extremely difficult to achieve and maintain unless a clear understanding of all key threatening processes is obtained. Our approach offers an important addition so as to better understand and control populations of various animal pests.

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20.10

FROM: Julien M. Flanagan, G. Heard, T. Hennecke, B. Paynter, and Q. C. Wilson. (2004) Research and Management of *Mimosa pigra*. Papers presented at the 3rd International Symposium on the Management of *Mimosa pigra* 23–25 September 2002, Darwin, Australia. CSIRO Entomology, Canberra.

20.10.1

Prevention and early intervention in the management of *Mimosa pigra*. pp. 80–84. I. L. Miller, Department of Business, Industry and Resource Devleopment (GPO Box 3000, Darwin, NT 0801, Australia. Email: ian.miller@nt.gov.au).

Key words: *contamination, controls, environmental weeds, quarantine, seed longevity, surveillance*.

Programs for prevention and early intervention in the management of Mimosa (*Mimosa pigra*) may be developed for a country, state, province, region, district, catchment or for an individual property. In establishing a program, knowledge of the climatic regions suitable for Mimosa, its favoured habitats, the vectors that enable spead, the long-term dormancy of seeds, growth rate, and reproductive pattern enables predictions to be made of the areas most at risk for invasion. Processes to prevent entry of Mimosa, and preparedness for early intervention, can then be targeted at areas of high risk, whilst maintaining some vigilance in areas of lower risk.

Preventing the movement of seed is imperative to avoid the devleopment of new infestations. Stopping the large-scale movement of seed on the floodwaters is difficult, but the transport of seed by people, vehicles, equipment, animals, fodder, soild and other vectors can be prevented. There needs to be a commitment to minise contamination by Mimosa seed in the first place, and vigilance to ensure that items are clean before transporting them to uninfested areas. When land is free of Mimosa, quarantine and surveillance provide the best means of preventing its entry and establishment. The success of quarantine and surveillance at all levels relies on public cooperation that, in turn, is dependent upon education. Upon detection of Mimosa, its successful management depends upon early intervention and knowledge of control options. Prompt action inmproves the prospects for effective eradication of the weed, provided that rebular monitorin and control are combined with a long-term commitment to the task.

20.10.2

Herbicides and their application for the control of *Mimosa pigra* in the Northern Territory, Australia. pp. 96–101. Steve Wingrave, Regional Weeds Officer, Fire and Weed Management Branch, NT Department of Infrastructure, Planning and Environment (P.O. Box 30, Palmerston, NT 0831, Australia).

Key words: *basal-bark application, cut-stump application, environmental weeds, foliar application, stem injection*.

There is a wide range of habits in which Mimosa (*Mimosa pigra*) can effectivly colonise, and the selection of a herbicide and application technique must be appropriate to the situation. There are several interacting factors that can influence the effectiveness of a herbicide and the application tehcnique including environmental, infestation characteristics, and human resourcing issues. There are effective herbicides that are currently not registered for use in the Northern Territory and this limits the availability of choices in some situations. The registration of these options should be a priority. (Note: this paper focuses soley on herbicides in respect of their application to Mimosa. While it is clear that some of the herbicides referred to in the paper are selective and may provide some protection to non-target species, herbicide selectivity and the potential impacts if the herbicides on native plants are not discussed.)

20.10.3

***Mimosa pigra* at Peter Faust Dam, Proserpine, Queensland, Australia.** pp. 102–105. Cassandra Chopping, Department of Natural Resources and Mines (Mackay, Queensland 4740, Australia).

Key words: *community involvement, early intervention, environmental weeds, survey*.

A small Mimosa (*Mimosa pigra*) infestation has been found at Peter Faust Dam, located approximately 25 km west of Proserpine, Queensland. Pater Faust Dam is at the head of the Proserpine Catchment system and is utilised as a recreational and water storage area. The initial infestation was identified in February 2001 and a control program was instigated immediately. Three detailed survey/control programs have occurred since, in September 2001, April 2002, and September 2002. Surveys during April 2002 identified substantial Mimosa germination within the south-western areas of the dam. Infestations existed between current high and low-water marks, generally dispersed in thick *Melaleuca* sp. Mechanical control was undertaken in this area of the dam by the removal of high priority *Melaleuca*/Mimosa areas and the construction of access tracks along the foreshore. New geminations were largely a result of receding water levels within the catchment. The dam water levels are predicted to drop futher and it is expected future germination will occur. September 2002 saw the initial control zone extended to approximately double its original size. Further access tracks and high priority areas within the control zone were bulldozed to eliminate *Melaleuca* stands currently hindering access and vision. Future plans include undertaking controlled burns and follow-up in these areas. To-date, all know plants have been or are being controlled. A key stakeholder group has been formed, and an extension and communication strategy is being developed and alternative high-risk areas of the State are being surveyed.

20.10.4

Caring for country: community-based management of *Mimosa pigra* on Aboriginal lands in the Northern Territory, Australia. Mark Ashley[1], Michael Storrs[1] and Matthew Brown[2] ([1]Northern Land Council, P.O. Box 42921, Casuarina, NT 0811 Australia; [2]Indigenous Land Corporation, GPO Box 652, Adelaide, SA 5001, Australia).

Key words: *community involvement, environmental weeds, indigenous land management*.

The community-based Mimosa (*Mimosa pigra*) management program on Aboriginal lands of the Top End of the Northern Territory emerged in 1998 and has been successful in controlling 7000 ha of Mimosa. The program, implemented and maintained by Aboriginal people and facilitated by the Northern Land Council's Caring for Country Unit, has established strong partnerships with an array of government and non-government organisations.

After operating strongly for 5 years, Aboriginal land management groups are broadening the focus of their Mimosa management programs to tackle other land management issues. Many Aboriginal groups are developing