1. Case Study: Senescence of Kwongan Heath

The senescence of kwongan heath throughout the Wheatbelt is a useful example of how a range of stressors interact to shape the health and resilience of ecosystems.

Kwongan heath is an incredibly diverse vegetation association that supports a huge number of plant species, forms dense heathlands and produces a spectacular display of wildflowers in spring. Kwongan heath is associated with the lateritic uplands, often dominated by yellow sand plain, that exist throughout the extensively cleared areas of the Wheatbelt. Kwongan displays a high degree of diversity both within similar habitats and across habitats, environmental and geographical gradients, and supports approximately 2,500 plant species (Maher 2007). In addition to being extremely diverse, this vegetation association has a high degree of endemism, most likely due to the extreme poverty of the underlying soil type (Beard et al. 2000).

Senescence of Kwongan communities and subsequent invasion by *Allocasuarina huegeliana* (rock sheoak) has been observed over recent decades (Maher 2007). This dramatic shift in vegetation dominance is thought to be influenced by a combination of factors, including changes to fire regimes and the herbivore composition of ecosystems, precipitated by clearing of native vegetation and changes to pest management practice.

1.1 Decline of Native Mammals

At the time of European colonisation, native animals were by all accounts extremely abundant and were intensely harvested for food and skins and for bounty as agricultural pests. Hunting and the introduction of foxes in the 1920s caused a dramatic decline in many species, particularly amongst medium-sized (critical weight range) mammals (Short 1998).

A further decline in the native mammal population occurred in Southwest WA after 1970, coinciding with an increase in fox populations due to the phasing out of one-shot (1080 poison) oats for rabbit control. One-shot oats had previously killed foxes that preyed on poisoned rabbits (Christensen 1980). Extensive clearing of the Wheatbelt occurred between 1945 and 1970, significantly reducing native mammal habitat and increasing foxes' preferred habitat of open paddocks and isolated remnants (Short 2004).

Rabbits have replaced small browsing mammals in many Australian ecosystems and can restrict recruitment of woody perennials (Short 2004). Rabbit populations in the Wheatbelt began to decline in the 1950s due to the introduction of 1080 poisoning and myxomatosis. A further substantial decline in the population occurred in the 1970s after the introduction of the rabbit flea, which greatly increased the transmission efficiency of myxomatosis (Maher 2007).

1.2 A. huegeliana Invasion

Encroachment of *A. huegeliana* into kwongan heath has been observed throughout the central and southern Wheatbelt since the 1970s, coinciding with the decline in native mammal and rabbit populations (Maher 2007). *A. huegeliana* occurs throughout Southwest WA, typically in the 300–600 mm annual rainfall zone, and naturally occur in sandy loam soils at the base of granite rock outcrops. It is a moderate to fast-growing, nitrogen fixing tree well adapted to sandy, well-drained soils.

A. huegeliana is fire sensitive and produces a large quantity of seed, a feature of many coloniser species (Florabank 2012). Previous vegetation surveys indicate that *A. huegeliana* was sparsely populated and did not occur in kwongan heath prior to the 1970s (Muir 1978, Brown & Hopkins 1983).

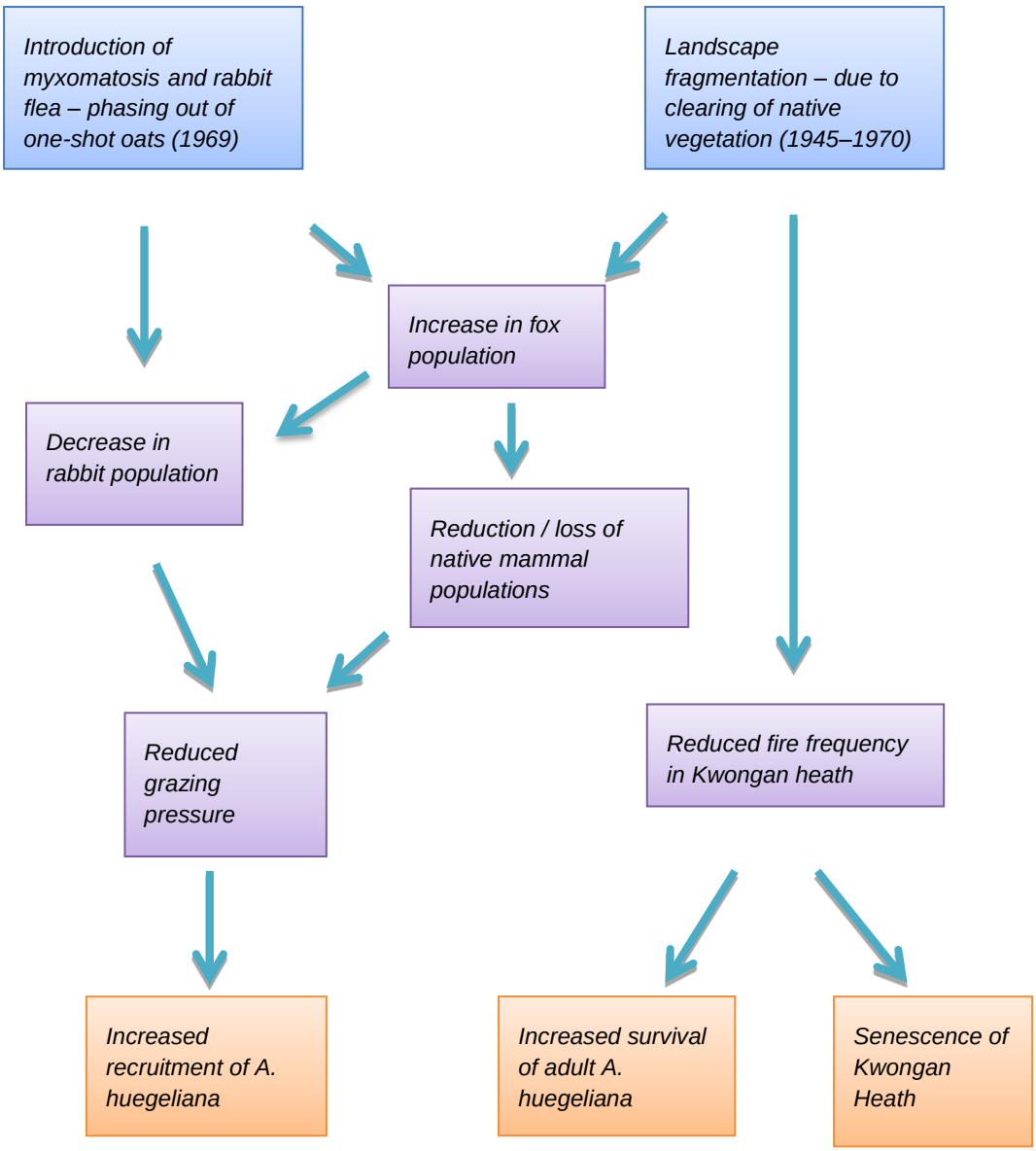
1.3 Changes to Fire Regimes

Although the decline in the numbers of small browsing mammals since the 1970s appears to have had a significant impact on recruitment of *A. huegeliana, it* is not considered to be sole driver for *A. huegeliana* encroachment within kwongan heath (Maher 2007).

In addition to changes in grazing pressure, many reserves within the Wheatbelt have not been burnt for more than 20–50 years. Kwongan heath requires fire to regenerate, and long periods without fire cause it to senesce. Long periods without fire also encourage the fire-sensitive *A. huegeliana* to develop mature stands, disbursing more seed into the underlying Kwongan heath (Maher 2007).

Kwongan heath is thought to have historically been subject to frequent fires set by Indigenous people or caused by lightning at intervals from 1-20 years (Pate & Beard 1984). The reduction in frequency of bush fire within reserves and private patches of remnant native vegetation within the Wheatbelt is a direct reflection of fragmentation caused by clearing of the landscape for agriculture, and reduced contribution from indigenous people.

Figure 1. Schematic Flow Diagram – Key Factors Influencing Senescence of Kwongan and Proliferation of *A. huegeliana*



1.4 Impact of Multiple Stressors

Ultimately the combination of stressors including landscape fragmentation, reduced fire regimes, and reduced browsing pressure of native animals and rabbits, fuelled by larger fox populations, have combined to change an otherwise relatively stable ecosystem.

The key factors influencing the senescence of kwongan and proliferation of *A. huegeliana* are presented in Figure 1. The combination of phasing out of one-shot oats, landscape fragmentation and reduced fire frequency have caused cascading ecosystem change resulting in reduced regeneration of Kwongan heath, and increased recruitment and establishment of mature stands of *A. huegeliana.*

More appropriate fire regimes and greater control of fox populations are essential in managing the proliferation of *A. huegeliana* within kwongan heath. However, this may only be an effective strategy if viable native mammal populations remain or are able to recolonise affected remnants, or where increased rabbit numbers are sufficient to provide effective grazing pressure to inhibit *A. huegeliana* recruitment.

1.5 States and Transitions

Two potential state and transition thresholds exist for the management of degraded kwongan heath. The first relates to the capacity of native mammals to recolonise impacted remnants in sufficient numbers to inhibit *A. huegeliana* recruitment. Existing research indicates that the size of the reserve and type of vegetation are the key factors influencing the presence of various mammals. Smaller patches of remnant vegetation are less likely to support viable populations of mammals; connectedness to larger remnant islands may enable the remnant or reserve to be repopulated.

The second threshold is that once senescence of kwongan reaches a critical point, then undertaking fox control and burning will no longer result in regeneration of kwongan but will likely remove or restrict *A. huegeliana* recruitment and density, essentially creating an open niche, potentially resulting in invasion by other coloniser species.

Insufficient information is available to effectively quantify these key thresholds for kwongan management.

1.6 Conclusion

Senescence of kwongan heath is one of numerous potential transitions in the structure and function of ecosystems within the region, and demonstrates some very important factors impacting biodiversity, which has important management implications.

- *Underlying ecosystems are complex and often behave in unpredictable and unintended ways in response to changes in land management practice, demanding the development and implementation of scientifically-based adaptive management systems.*
- *Threatening processes impacting biodiversity within the region are typically driven by a combination of stressors rather than individual or discrete threats. Integrated management responses to multiple stressors are required.*
- *There can be long temporal delays between when changes in land management practice occur and when responses within impacted ecosystems can be measured. As a result long-term management and monitoring programs linked to stable science-based decision-support systems are essential to ensure that we learn from management actions.*
- *Management thresholds are often difficult to determine due to the underlying complexity and dynamic responses of impacted ecosystems, demanding flexibility in management and a scientific approach underpinned by effective monitoring.*

- *Changes in ecosystems are often a response to landscape-scale changes in land management practice, demanding a landscape-scale response. This requires whole-of-community engagement in management, focusing on elements of the community (the farming community in particular) with land management responsibility and the skills and means to respond.*

1.7 References

Beard JS, Chapman AR, Gioia P 2000 Species Richness and Endemism in the Western Australian Flora. *Journal of Biogeography*, Volume 27, Issue 6, pp. 1257–1268.

Brown JM, Hopkins AJ 1983 The Kwongan (sclerophpyllous scrubland) of Tutanning Nature Reserve, Western Australia. *Australian Journal of Ecology* Volume 8, pp. 63–73.

Florabank 2012 *Allocasuarina huegeliana*. http://www.florabank.org.au/lucid/key/species%20navigator/media/html/Allocasuarina_huegeliana.htm

Muir BG 1978. *Introduction to Durolooppin and Kodi Kodjin Nature Reserves*. Records of Western Australia Museum supplement Volume 7, 9–14.

Maher 2007 *Encroachment of Sand Plain Heathland (Kwongan) by Allocasuarina huegeliana in the WA Wheatbelt: the role of Herbivores, Fire and other Factors.* Thesis for Doctorate of Philosophy, School of Environmental Science, Murdoch University.

Pate J, Beard J 1984 *Kwongan: plant life of the sandplain. Biology of South West Australian shrub land ecosystem*. University of Western Australia Press. ISBN (08) 5564 2289.

Short J 1998 The extinction of rat-kangaroos in New South Wales, Australia. *Biological Conservation* Volume 86, pp. 365–377.

Short J 2004 Conservation of mallee fowl: are there lessons from the successful conservation of native mammals by intensive fox control? *Proceedings from the National Mallee Fowl Forum*, Mildura, pp 54–68.

Short J, Smith A 1994 Mammal decline and recovery in Australia. *Journal of Mammalogy*, Volume 75, Number 2, (May 1994), pp 288–297.

Salmon J. Watson, Rick S. Taylor, Lisa Spence-Bailey, Dale G. Nimmo, Sally Kenny, Luke T. Kelly, Angie aslem, Peter Griffioen, Kate Callister, Lauren Brown, Sarah Avitabile, Michael F. Clarke and Andrew F. Bennett. An overview of Valley fire project biodiversity Project. Proceedings from the fourth National Mallee Fowl Forum 2011.