MANAGEMENT OF WOODY WEEDS IN THE AUSTRALIAN RANGELANDS: A BIOECONOMIC APPROACH

By

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In dedication to my wife Claire and my two sons Anton and Callum

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ABSTRACT

The encroachment of woody weeds within Australian rangeland systems poses a significant threat to the 12 billion dollar Australian grazing industry. Woody weeds reduce stock carrying capacities, increase mustering effort, impede cattle from accessing waterways, and some species poison livestock.

Graziers are faced with the arduous task of weighing up the costs and benefits of weed management strategies in these vast, remote, heterogeneous landscapes with low economic returns and limited available resources. This is further complicated by the episodic recruitment of woody weeds in response to climate. Moreover, the decision making process is made even more difficult with the complexities of multispecies infestations. This analysis provides important information which can assist weed managers in deciding which strategies to adopt for woody weed infestations.

To date ecological population and economic optimisation models have not been combined to establish integrated weed management (IWM) policies for woody weeds within rangeland grazing systems. The woody-weed decision model presented in this research derives such polices while capturing key ecological processes and maintaining economic robustness.

Understanding the costs and benefits of controlling woody weeds requires knowledge of how these infestations change over time, their impacts on pasture production and their response to management. A single species density-dependent stage projection matrix (SPM) model is developed and applied to *Ziziphus mauritiana* (chinee apple), *Acacia nilotica* (prickly acacia), and *Parkinsonia aculeata* (parkinsonia) in upland and riparian zones. These species were chosen to represent a diversity of life-history parameters and response to weed control. Eigenvalue elasticity analysis is used to identify the life stages that should be targeted to have the greatest effect on these infestations. The single species model is then expanded into a multispecies density-dependent population model to investigate the complex relationships between species, their effect on pasture production, and response to weed control. This analysis highlighted the need for IWM policies when managing multispecies infestations.

Woody weed management policies must also consider the impact climate has on episodic recruitment. The northern rangelands tend to have hot-wet summers and warm-dry winters. The wet season results in the germination of seeds but many of the seedlings will perish in the following dry season. Occasionally, climatic conditions will allow for the establishment of many woody weed cohorts. An episodic recruitment model is established for chinee apple based on the historical rainfalls of Charters Towers in northern Queensland. The model considered both the increased germination and survival rates of woody weed seedlings cohorts in high rainfall years, after which they become drought tolerant. This episodic event driver is later incorporated into an optimisation bioeconomic model.

A bioeconomic optimisation model, based on stochastic dynamic programming (SDP) was developed to derive IWM policies for woody weeds within rangeland grazing systems. The model captures the stochasticity of the system as well as the population dynamics of the plant. The dimensionality of the problem was reduced by aggregating the life stages into three sub-groups: seeds, seedlings and adults, while maintaining the transitions of the population within the full matrix model. The model provides clear weed management thresholds and decision rules. The benefits of combining biocontrol with other control methods are also investigated.

Results of this modelling framework established the optimal weed control decisions and management threshold frontier for various combinations of weed control costs and grazing gross margins. Assuming current weed control costs and efficacies with available grazing gross margins, the control of chinee apple by private landholders within the northern Australian rangelands will not result in net profits. However, this research does provide insight into the degree to which gross margins must increase and weed control costs decrease to warrant control. Moreover, with this information, it is possible for other stakeholders to determine the amount of compensation that would be required by graziers to undertake weed control for environmental reasons. An alternative stance is that graziers may undertake weed control for land stewardship purposes.

CERTIFICATION

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

[redacted]

Signature

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