Project proposal 5: A Disturbing Look at Northern Australia's Mammal Problem

Introduction and Background

Australia is among those select few nations whose Gross Domestic Product (GDP) exceeds the trillion-dollar threshold[1]. It is thus surprising to see a nation flush with flagship species struggle so mightily with maintaining mammal biodiversity. In short, 11% of Australia's native species have died out since 1788, and that number shows no apparent signs of decline in the coming years[2]. The culprits of this decline can be attributed to various factors in varying degrees. For example, the introduction of large herbivores such as cattle and horses by conservation reserves could play a role in reducing species richness. Based on data from North American and African Savannahs, increased grazing causes unfavorable soil compaction and reduced predator protection from vegetation for small mammals[2]. Additionally, many small mammals are threatened by the invasive cane toad, whose glands are toxic to native consumers, including the Northern Quoll. Diseases through invasive black rats and Devil Facial Tumor Disease have also seen increased prevalence in recent years[3].

However, the two biggest drivers of small mammal population decline in Australia are the changing fire regime and the feral cat/fox problem[4]. Over the last hundred years burning of Australia's vegetation has become much more frequent and widespread, including national parks with up to 50% burned per year[2]. This can be attributed in part to invasive "super grasses" introduced by pastoralists that burn at much more severe rates. The high degree of fire disturbance has led to myriad alterations in food availability and predation for native small mammals. For example, in high disturbance regimes annual, rather than perennial vegetation dominates the landscape that eliminates mammals that thrive on perennial seeds. Additionally, fire serves to clear protective vegetation, which makes small mammals more susceptible to predators[2].

The feral cat has been perhaps the most troubling addition to the small mammal problem in Australia. The cats are invasive generalist predators for small mammals in Australia and number between 15 and 23 million[3]. These feral cats have no local predators and are likely responsible for the extinction of the Paradise Parrot[2].

Reparative measures are being taken to limit the damage from some of these issues. For example, a Carbon Farming Initiative (CFI) is in place to encourage farmers to hold emissions and reduce the total area burned per year[5]. Additionally, biosecurity efforts have been augmented in islands that are less susceptible to feral cat predation[3]. However, it is important to study how these issues are interacting in order to focus biosecurity efforts and maximize reparative efforts. In the case of fire regimes and feral cats, increases in disturbance lead to less protective vegetation for small mammals and thus increased predation. However, at lower disturbance levels more predators may be present and predation would still be high.

Since neither high nor low levels of disturbance would limit feral cat predation, it follows that intermediate levels of disturbance (in either intensity or duration) would be ideal for maximizing species diversity, which is the central tenet of the Intermediate Disturbance Hypothesis[6].

Questions and Goals

The goal of this project is to determine the interaction between fire regimes and predation by the feral cat in controlling native species diversity. My hypothesis in this case is that the effect of predation by the feral cat is minimized under a temporal model of intermediate disturbance.

Methodological Approach

The methodology for this experiment includes developing a model for predator prey relationships

under increasing levels of disturbance. Therefore the workflow for developing the model will necessarily begin with a community in the absence of any fire regime. That is, an *n* species Lotka-Volterra predator-prey model with a generalist predator that consumes each species at the same rate[7].

Then increasing disturbance regimes would be simulated using a temporal model of the Intermediate Disturbance Hypothesis in the absence of the feral cat, which would generate an inverted parabola. The predator would then be added to this model, and changes in prey diversity under the various disturbance regimes would be determined. Note that analyses would consist of numerical simulations, and experimental data where available.

Note also that a functional response would need to be created for the model, since fire controls the interaction between predator and prey. This would be A = a*b, where *A* is the attack rate of the feral cat, *a* is an attack rate with no environmental impact, and *b* is the effect of the environment on the attack rate.

Expected Results and Implications

As mentioned above, I expect small mammal species diversity to be optimized under intermediate levels of disturbance in the presence of the feral cat. Traditionally the Intermediate Disturbance Hypothesis has been applied to community succession, and describes a system where early and late species can thrive[6]. However, in this scenario it is possible that intermediate disturbance would optimize habitat patches for prey to occupy[2]. For example, Black-Footed Tree-Rats are historically found in unburnt areas while Northern Quolls are found in more frequently burnt areas. This would reflect an optimal fire regime in which frequency and duration of disturbance is varied across the continent.

Feral Cats have been an established invasive species for the past hundred years, but they are recently having a heightened impact on native species richness[2]. It is possible that this is due to a cumulative assault from these various biodiversity detractors. In that case, minimizing the impact of interactions between these problems is the most effective strategy for preserving biodiversity in Australia.

References

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