Project proposal 2: Robustness and Recovery of Ecological Networks

Introduction

Many influences, both natural and man-made, have direct impact on the stability of different types of ecological systems, including seed-dispersal networks, pollination networks, and food webs. Extinction of one or more species from the complex ecological network can destabilize the entire system by further propagating the extinction of other interacting species within the network or across the interdependent ecosystems. This is particularly important given the current rate of species' extinction, which can be attributed to anthropogenic activities or climate change, or combination, thereof. Hence, faster and efficient rehabilitation of perturbed system is crucial to minimize a) resources required for restoration and b) cascading impacts on interconnected ecosystems. While researchers in the past have advanced our understanding of topology, and fragility of the complex ecological systems, our understanding of recovery strategies for stressed ecological networks is limited (Pocock *et al.* 2012) and not easily generalizable across different types of systems.

Questions and Goals

While there is a progress in our understanding how extinction of one species may cause further extinction of other species, understanding the impact of conservation and restoration of one species on other interacting species is critical. Through this project, I will develop a network science based approach to quantatively understand the fragility and comparative evaluation of various recovery strategies for ecological networks. The proposed methodology would help in comparative analyses of recovery rates and resource requirement associated with different restoration strategies. This study would answer the question: Which one is the more efficient and better restoration strategy: strategy based on number of interactions of species or the one accounting for topological measures, including species betweenness, species proximity to the others, or species relative importance in the network based on its interactions?

Methodological Approach

As discussed by researchers in the past, network science based analysis help in understanding the topological features of the complex ecological systems at different scales: ranging from smaller communities (or modules) to food webs (Gilman *et al.* 2010). Hence, for present studies, methods and metrics adapted form network science would be used for understanding species' interactions within and across different networks to understand the relative importance of species in ecological systems. Systems will be modeled as directed network, if direction of flow of biomass is important, for example, in food webs; whereas undirected graph is an appropriate system representation if a) symbiotic relationships exist between interacting species, for example, in pollination networks, or b) maintaining biodiversity is prime objective.

Expectations and implications

The expected outcome of proposed research is a generalizable and quantified framework to assess resilience of different types of complex ecological systems under different restoration strategies. This framework will be useful to understand the impacts on organization structure (or compartmentalization) if whole or part of the ecosystem is subjected to external perturbation. One of the expected outcomes from this study is measure of recovery rates under different strategies obtained from this study. This measure would be of great interest for resilience analysis of fragile ecosystems, which are highly sensitive to even small changes in rainfall patterns or seasonal temperatures can have significant harmful impacts on these ecosystems and reduce their functional capacities. Hence, speedier restoration is critical for such systems. The insights and outcomes from this study can potentially help informing the ecologists and stakeholders in designing more efficient conversation (restoration) plans for endangered (extinct) ecological systems.

Key references:

1.
Gilman, S.E., Urban, M.C., Tewksbury, J., Gilchrist, G.W. & Holt, R.D. (2010). A framework for community interactions under climate change. *Trends Ecol. Evol.*, 25, 325–331.

2.
Pocock, M.J.O., Evans, D.M. & Memmott, J. (2012). The Robustness and Restoration of a Network of Ecological Networks. *Science*, 335, 973–977.