Destabilizing effects of controlling ecosystem behavior

M2 student project supervised by: Yuval Zelnik and Michel Loreau

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Objectives

Understanding how and when human intervention to stabilize an ecosystem's dynamics may actually lead to a more fragile ecosystem. In particular, exploring whether minimizing commonly used stability measures, such as temporal variability, can lead to higher chance of extreme events, such as an ecosystem collapse.

Summary

The influence of human activities on ecosystems has been growing dramatically in the past decades. The purpose of such anthropogenic disturbances is varied, but in many cases the overall goal is to protect and stabilize the ecosystem and the services it provides. Nonetheless, our understanding of the long term affects of common managing practices with this goal in mind, such as pest removal or fire prevention, is quite limited. In particular, it is not well understood in what conditions might controlling the ecosystem's behavior to stabilize one aspect of its dynamics might lead to a significant destabilization of another aspect. We wish to explore this issue by focusing on a specific example of managing a forest to protect it from fire damage. In what conditions will decreasing the frequency of wildfires lead to less frequent but more damaging fire events? Starting from a conceptual model that demonstrates this scenario, we will try to answer several questions: In what conditions does inhibiting variability lead to higher collapse probability? What are the physical conditions where this may occur? Can other common managing practices lead to similar dynamics? Can similar parallels be drawn between other stability and integrity measures, such as biodiversity and resistance? By answering these questions we can gain theoretical insight into the feedbacks between ecosystems' dynamics and human activities, and better inform management practices in a wide range of ecosystems.

Profile

This project focuses on a theoretical approach to ecology. Therefore the student should have a strong interest in theoretical research, and in using analytical and numerical tools for it. In particular, the following list of skills and knowledge would be helpful:

1. Programming skills (e.g. Matlab, Python, R), and using these for numerical analysis.
2. Mathematical tools, especially calculus, differential equations and probability theory.
3. Proficiency in English, especially for reading scientific articles.

Relevant References

[1] Holling, CS (1973), 'Resilience and stability of ecological systems', Annu. Rev. Ecol. Syst. 4, 1-23.

[2] Perrings, C & Walker, B (1997), 'Biodiversity, resilience and the control of ecological-economic systems: the case of fire-driven rangelands'. Ecological Economics, 22(1), 73-83.

[3] Van Langevelde, F, Van De Vijver, CA, Kumar, L, et. al. (2003), 'Effects of fire and herbivory on the stability of savanna ecosystems', Ecology, 84(2), 337-350.

[4] Turner, MG (2010), 'Disturbance and landscape dynamics in a changing world', Ecology 91, 2833-2849.

[5] Donohue, I, Hillebrand, H, Montoya, JM, et. al. (2016), 'Navigating the complexity of ecological stability', Ecology Letters 19(9), 1172-1185.

[6] Arnoldi, JF, Loreau, M & Haegeman, B, (2016), 'Resilience, reactivity and variability: A mathematical comparison of ecological stability measures', Journal of Theoretical Biology 389, 47-59.