What next? Developing new quantitative tools to address conflicting evidence in temporal ecology

Bahlai CAREER Proposal 2020

Background Why is our understanding of the trajectory of ecological systems so poor? The era of synthetic and big data ecology has enabled ecologists to examine problems at scale, but tools for synthesizing and scaling temporal data has lagged behind those developed for spatial problems. The recent controversy surrounding the global insect decline phenomenon exemplifies this problem. Insect decline is a widely publicized, potentially catastrophic occurrence, but insect ecologists lack a comprehensive framework to handle insect population data at regional or global scales. A lively scientific discourse surrounding the phenomenon has ensued, with many authors calling for more transparent approaches to synthesizing data, better measurement and modelling approaches, and guidance for temporal scaling of results The current research paradigm does not have adequate tools for integrating multi-modal information in syntheses of this type, but moreover does not have an explicit framework for integrating and reconciling apparently contradictory information. Thus, to date, understanding and managing complex ecological problems like insect decline has not fully capitalized on the vast existing body of data. Furthermore, a lack of critical discussion around data and quantitative methods leads to inappropriate synthesis of findings, incorrect application of analytics, and has the potential to contribute to public distrust in science. The proposed program will use an adapted information science approach to develop and evaluate quantitative tools and frameworks for examining population and community time series data, with a focus on the insect decline controversy. I will use this approach to develop theoretical frameworks for interpreting temporal processes in ecological systems, build new computational tools to support the scientific community in their interpretation, and support an education and outreach program targeted at developing critical quantitative and numeracy skills in both trainees and the broader community.

Intellectual merit This program will develop novel approaches to data integration and tools for evaluating misleading trends in ecological data. It will be applied to several facets of the insect decline phenomenon but has applications across applied data science and systems modelling. Field and data synthesis experiments will evaluate information quality in data produced by common methods of insect surveillance, allowing legacy data to be integrated into population models. I will also develop on two foundational tools for examining trends and patterns in time series data. The first tool is based on the concept of trajectory and forecasting. I will develop a computational approach which will allow a broad array of nonlinear and linear processes to model the trajectory of a system. I will use this tool to evaluate existing insect surveys to characterize which data show genuine trends and which trends are spurious, biased or contain insufficient information. Because ecological systems often have non-linear behavior, understanding process changepoints in dynamical systems is a key aspect in describing their future behavior. Although tools for understanding shifts in these processes exist, few simultaneously consider change point uncertainty, magnitude of change, and fit specific mechanistic processes. I will develop a suite of tools for examining changepoints in dynamical systems providing outputs that allow a user to assess changepoints while accounting for underlying processes. Understanding and identifying changepoints in insect dynamics have key applications in conservation and management.

Broader impacts This program will create new tools that will support data integration and synthesis and incorporates an education and outreach plan to improve numerical literacy with direct feedbacks into the proposed research program, which will support training and public understanding of science. In addition to training undergraduates, graduate students and postdoctoral scholars, I will develop a new graduate quantitative methods course which integrates critical numeracy, historical context, more varied statistical approaches through a modular, case-study driven format. For broader outreach I will create a podcast that takes a multi-faceted view of the data to knowledge pipeline across fields. Through this podcast, in collaboration with sociologists and education specialists we will call upon diverse experts across disciplines advance societal understanding of data and information, and to highlight the work of early-career scientists, particularly minoritized individuals, to both give diverse context to issues of ‘knowing’, but also increase the visibility of underrepresented groups in science. Finally, curriculum materials will be developed to support use of the podcast for high school and college classrooms.

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