How social changes affect community robustness more than resource depletion

Understanding human-environmental interactions and feedbacks is a key challenge in today fast pacing world where climate is dramatically changing and profound socio-economic transformations are ongoing. While these changes affect the humankind, they have more severe effects on those communities that combine market-based activities with subsistence activities (i.e. hunting, fishing, and gathering). These communities are characterized by strong human-environment interdependencies (i.e., social-ecological networks) which play a key role in improving food security and health, as well as in increase group cohesion. These distinctive characteristics augment the flexibility in resource access via redistribution, especially in times of scarcity and change.

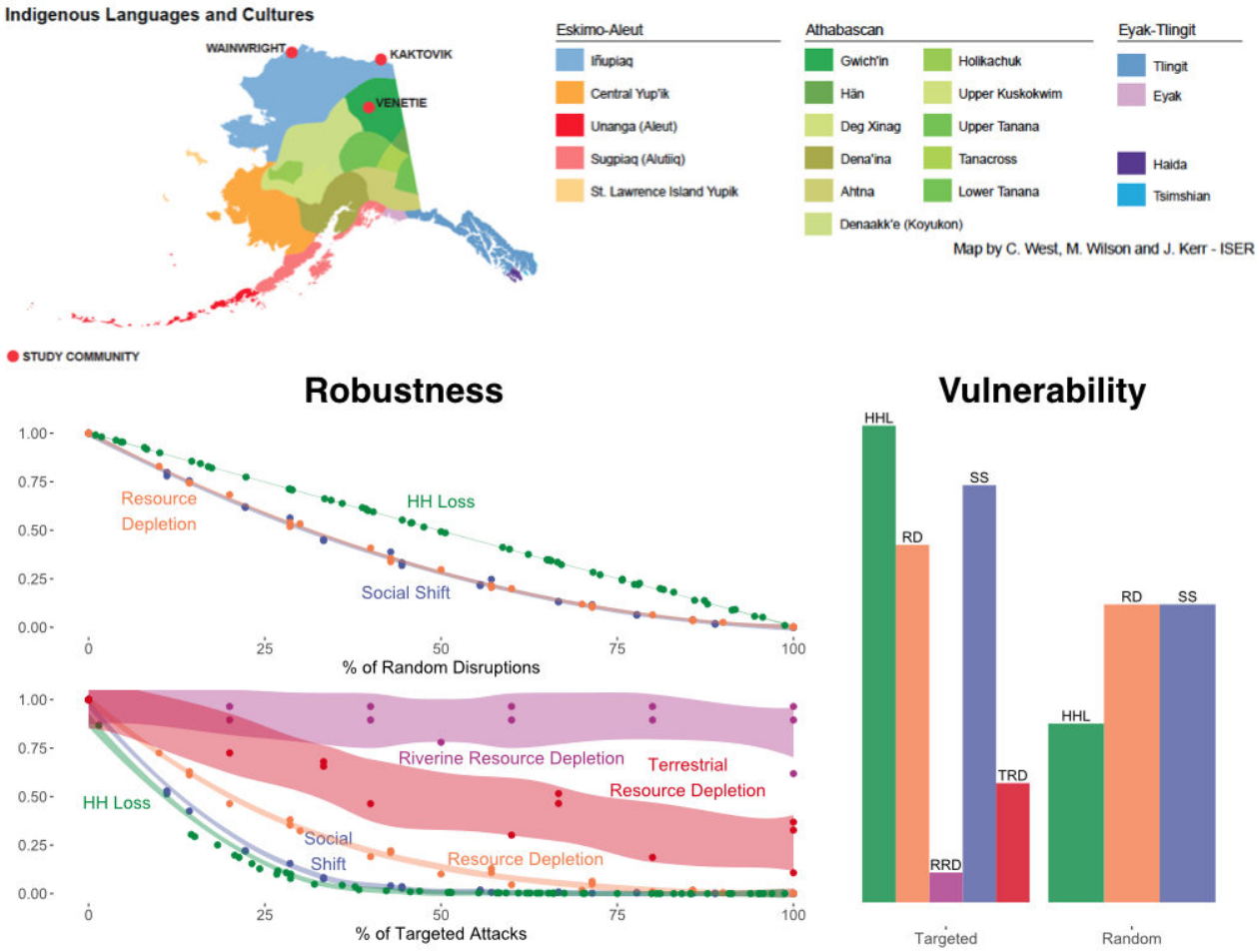

Fig. 1. Robustness and vulnerability of multilayer social-ecological networks to plausible scenarios of change. Top left: study areas in northern Alaska. Bottom Left: Robustness of the multilayer network of the three communities (band) to random and targeted perturbations. Targeted perturbation hit the most important HH or layers, while random perturbation are averaged over

1000 different random removal of HH or layers. Bottom right: Vulnerability of the three community (on average) to the targeted and random removal of layers and nodes. Nodes are removed in case of the HHL (house hold loss scenario), while layers are removed in case of the SS (social shift), RD (resource depletion), TRD (terrestrial resource depletion) and RRD (riverine resource depletion). Social Shift and Household Loss are the most impactful perturbations independent from the community under study.

However, characterizing and analyzing social-ecological network is not an easy task. The lack of data and methodological tools has slowed down our understanding of these networks and how they affect community robustness in face of change.

Recent methodological advances, grounded on multilayer network science, allow for a better representation of empirical networks, from biological to socio-technical systems, including social-ecological networks. This novel mathematical framework accounts for the multiple types of interactions (or relationships) among real-world entities, such as humans and species. Each distinct set of relationships is encoded by a “layer” and represented as a network. The set of all layers provides a multilayer network representation of the intricate web of interdependencies that exist within and between the social and the ecological domain.

Our research capitalizes on these methodological advances and high quality data – collected in three different northern Alaska villages characterized by mixed subsistence-cash economy – to assess the robustness of social-ecological networks to future plausible scenarios. For example, is community connectedness affected by climatic changes affecting influencing species abundance and distribution? How is community connectedness affected by shifts in cultural practices related to sharing and cooperation due to increased access to the job market or due to migration of key households and natural demographic changes?

To answer these questions, we build three different multilayer networks in which each node represents a household and edges represent specific social relation paired with specific species. More precisely, household can cooperate, share or contribute food and non-food resources to other households. Cooperation, sharing or contributions can be limited to specific species (i.e. whaling, caribou, salmon, moose etc.) or encompass multiple species. Each unique combination of social relation and resource (represents a layer of the multilayer network: cooperatively hunting caribou, sharing caribou, sharing moose are all different layers of a community's multilayer network. The resulting network representation is weighted by the intensity of such interactions and accounts for non-reciprocal relationships. In fact, the data encode the actual flow of resources in lbs of meat from one household to another.

This resulting social-ecological multilayer network allows us to assess how plausible future scenarios of change may affect the robustness of the three Alaskian communities studied.

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Publication

Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion.
Baggio JA, BurnSilver SB, Arenas A, Magdanz JS, Kofinas GP, De Domenico M
Proc Natl Acad Sci U S A. 2016 Nov 29