Baggio, J.A., BurnSilver, S.B., Arenas, A., Magdanz, J.S., Kofinas, G.P. and De Domenico, M., 2016. Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion. Proceedings of the National Academy of Sciences, 113(48), pp.13708-13713.

In the 2016 study "Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion," Baggio et al. apply multiplex network analysis to understand the robustness of three small indigenous communities in Arctic Alaska amid potential ecological and economic changes. Utilizing data on subsistence food flows, the authors construct a multiplex network to represent the complex interdependencies between ecological resources and social relations, measuring the flow of food and resources between households (Baggio et al., 2016, p. 13708). Each node in the network represents a household, and each layer corresponds to a unique resource–relation pair, such as caribou sharing. The authors hypothesize that the loss of key households or social relations could impact network robustness more significantly than the depletion of core subsistence species (Baggio et al., 2016, p. 13709).

Methods:

Each node in the network represents a household (or a whaling crew, stores, or other entities). Household engagement forms an edge in a network.

Social relationship types (i.e., contributing/sharing, providing service, buy/sell/trade, lending) are paired with a resource type (i.e., equipment, task, food, supplies such as fuel) to form a type of engagement. One type of engagement forms one sublayer network (i.e., contributing a specified food item, cooperating to acquire a specified food item, sharing gas). As I learned from setting up my objects for multivariate ERGMS, each engagement type can also be represented as different *edge attributes* for the multiplex network object (a community).

With one multiplex network for each community, multiplex networks are evaluated by engagement flow type. Engagement flow is the direction of the edge: receiving, giving, reciprocating, and overall. Receiving is operationalized as the weighted in-degree; giving as the weighted out-degree; reciprocating is, of course, both receiving and giving; and overall is the overall engagement and operationalized as the total weighted degree. Therefore, outflow engagement distribution is the value of the outdegree distribution of each resource–relation sublayer network. Weights are calculated by the number of interactions per year or, in the case of food, pounds per year scaled by averaging it with contributions of the given household.

How do they evaluate all subnetworks together?

Tensor: a matrix is a rank-2 tensor. 3 adjacency matrices form a rank-4 tensor. Matricization flattens higher-ranked matrices to a rank-2 supra-adjacency matrix. Centrality measures are calculated from the supra-adjacency matrix, considering intra- and inter-layer connectivity.

Inter-Layer correlation is calculated using Spearman. They display correlation figures for each engagement flow type. Each sublayer is found on the x and y axis. The color of the box indicates correlation values with higher values indicating an increased likelihood that a household will [engagement type] to another. The figures also include dendrograms.

R2 Stuff: They compare the engagement type (a sublayer network) with the engagement flow types (receiving, giving, reciprocating, and overall). In other words, they compare in-degree and out-degree for a sub-layer network. [<- I’m not sure if that is right.] Shapley decomposition on a two-part model on in-flows (receiving) and out-flows (giving). R2 is the result, the variance explained by N factors. R2 is the aggregation measure, denoting the relationship between N factors Fi with i = 1, 2...n and receiving or giving patterns. Factors represent specific resources, specific social-relation or, in aggregate, all resources and all social-relations. “In other words, the contribution of a single resource (species) or social relation, can be assessed as the difference between the overall R2 of the underlying two-part model and the R2 that is observed when that specific species or social-relation is removed from the overall set of factors determining the R2.” [I stopped trying to figure it out because I’m not going to use this method it in my work.]

[What most interests me in this study’s methods is how they explain correlations. In LOVE chapter, I don’t use Spearman correlations. I use entropy calculations (JSD and Von Neuman). I believe that the entropy method I use is a similar type of evaluation yet superior compared to using Spearman.]

Results

Outdegree and Specialization: The authors observed that as the outdegree of households in the network increased, there was an increased specialization in the production and distribution of goods and services. This was particularly evident across all resource networks. Households comprising elderly, young, and disabled members were found to be lower on the outdegree distribution, suggesting their limited capacity to contribute resources or services.

Spearman Correlation Analysis: Using Spearman correlation, the study assessed the relationship between households' activities across different network layers. The findings revealed strong positive correlations, indicating that households highly active in one layer were also active in other corresponding layers. This pattern underscores the interconnectedness within the community, where engagement in one aspect often translates to engagement in others. Conversely, strong negative correlations indicated that high activity in one layer could correlate with low activity in another.

Shapley Values and Two-Part Models: The contribution of specific resources and social relations to the patterns of giving and receiving within the communities was analyzed using Shapley values and two-part models. The results significantly highlighted that social relations accounted for a larger portion of the variance in both giving and receiving patterns, more than the specific resources themselves. For example, in Kaktovik, 88% of the variance in giving patterns was attributed to social relations.

Community-Specific Patterns: Each community displayed unique patterns in terms of resource and social relation contributions. In Wainwright and Venetie, caribou were pivotal in explaining the variance in giving patterns, whereas in Kaktovik, social relations were more dominant. This variation was also seen in receiving patterns, where certain social relations like contributions and helper shares were consistently important across all communities, but the significance of specific resources varied.

Impact of Removals on Network Robustness: The study explored the effects of random and targeted removals of households, social relations, and resources on community interconnectedness. Targeted removals had a more pronounced effect than random removals, emphasizing the critical role of specific households and social relations. Notably, targeted removals of resources had a lesser impact on interconnectedness compared to the removal of households or social relations.

Community-Specific Responses to Targeted Removals: There were distinct differences in how communities responded to the loss of households. For instance, the loss of 20% of households in Wainwright led to a 66% reduction in interconnectedness, while in Kaktovik and Venetie, the same loss resulted in an 80% reduction. This indicates that the effect of disruptions is influenced by community-specific factors.

Geographic Variation in Resource Dependence: The study's analysis of targeted removals by resource category (marine, terrestrial, riverine) revealed the different dependencies of communities on these resources. Coastal communities were more dependent on marine resources, while Venetie showed a greater dependence on terrestrial and, to a lesser extent, riverine species. This variation highlights the importance of geographical location in determining community resilience to resource loss.

Cultural Ties and Species Loss: The results also suggest that the loss of a single species may not drastically affect the community unless it impacts cultural ties related to cooperation and sharing. This finding points to the integral role of cultural aspects in the utilization of resources and in community responses to ecological changes.

Reinforcement of the 30:70 Theory: The study reinforces the idea that key households are central to the distribution of resources and contributions within the communities. The loss of these key households significantly affects the overall robustness of the communities, indicating their vulnerability to changes in household composition or social relations.

Annotation

This study's multiplex network approach is mildly relevant to my research as it examines the influence of various types of interactions within a community, similar to the professional and personal interactions networks. Like Baggio et al. (2016), SNAP is interested in the distribution of interactions and the resilience of teams in the face of change. The authors' use of Spearman correlation to analyze the relationships between layers offers a potential methodological approach for my analysis of professional and personal interaction layers and their impact on team dynamics and creative productivity. Especially if I cannot get multivariate ERGMs to run.

Furthermore, the concept that key households generate and share most of the food within their communities parallels the idea in my research that empowered individuals or leads within teams could play a central role in fostering team productivity and resilience. While Baggio et al. (2016) focus on the robustness of subsistence networks in response to climate change, my research aims to explore how positive professional and personal interactions contribute to small-team resilience and creative work productivity within academic settings.