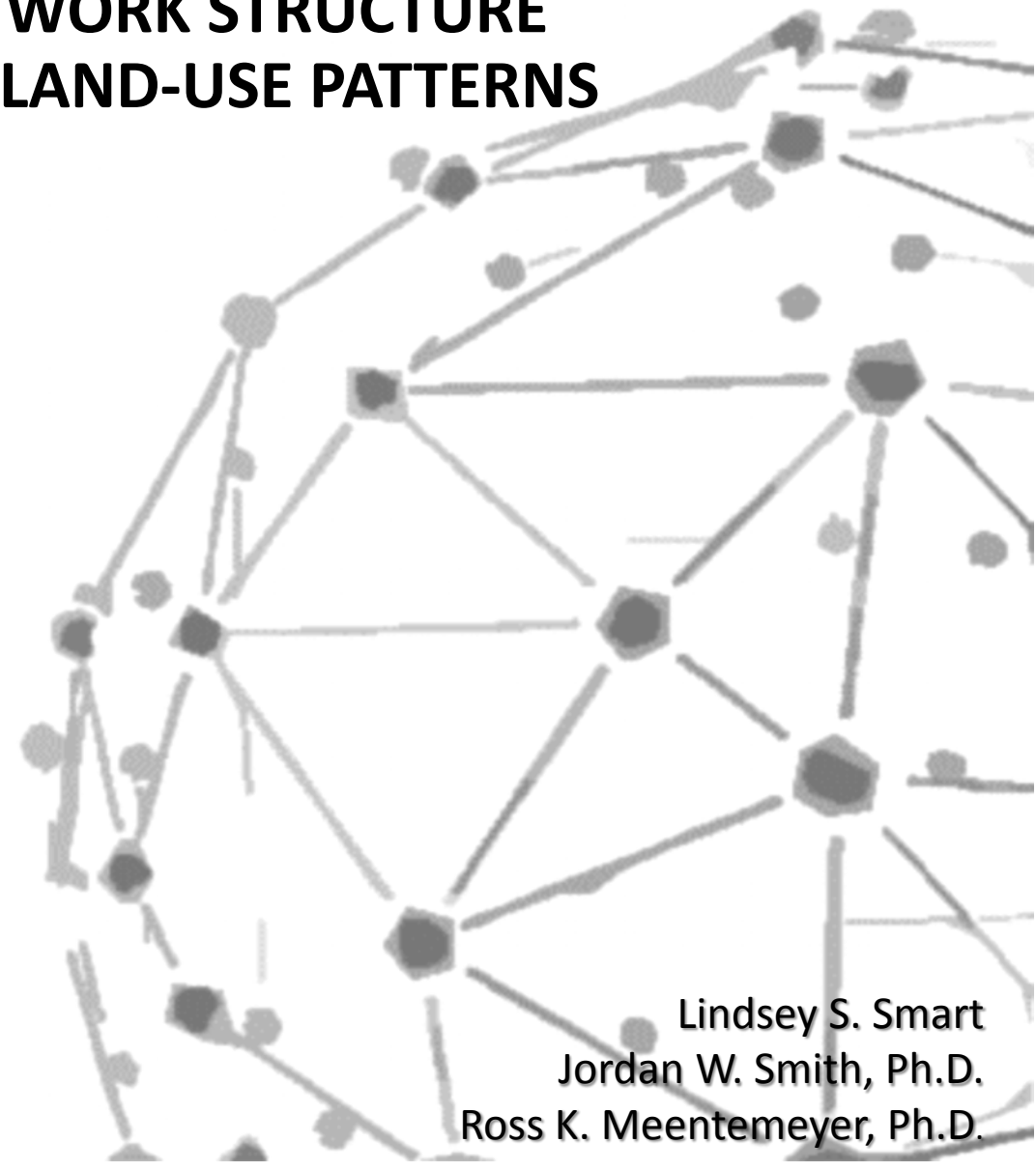
AN AGENT-BASED MODEL FOR EXAMINING THE EFFECTS OF SOCIAL NETWORK STRUCTURE ON COASTAL LAND-USE PATTERNS



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OVERVIEW

Social networks are critical to the governance of socio-ecological systems (Bodin and Crona, 2009)

Understanding the influence of social networks on **land-use decisions** is an important consideration for natural resource managers

We develop a generalizable model of land-use decision making that explicitly incorporates social network influences to explore impacts of different structural characteristics on land-use patterns

BACKGROUND

Landowners make land use decisions using a wide set of information

Their responses can be influenced by:

- Socio-economic characteristics
- Individual preferences for particular behaviors
- Social or peer influence
- Perceived risk or vulnerability

BACKGROUND

Land use decisions in coastal landscapes are influenced by additional factors unique to the characteristics of the region

Proximity to the ocean makes these areas particularly vulnerable to impacts from **climate change** and **sea level rise**

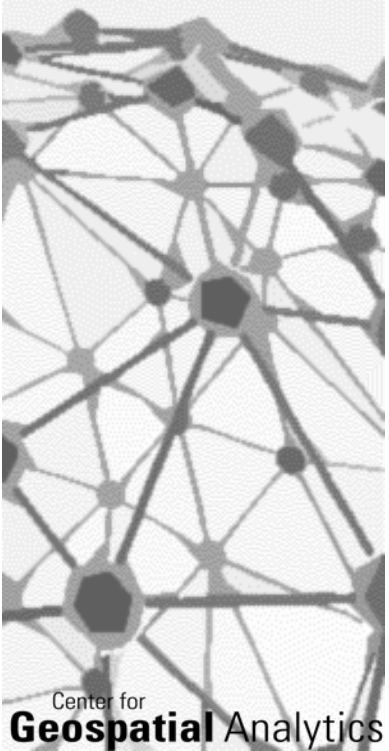
BACKGROUND

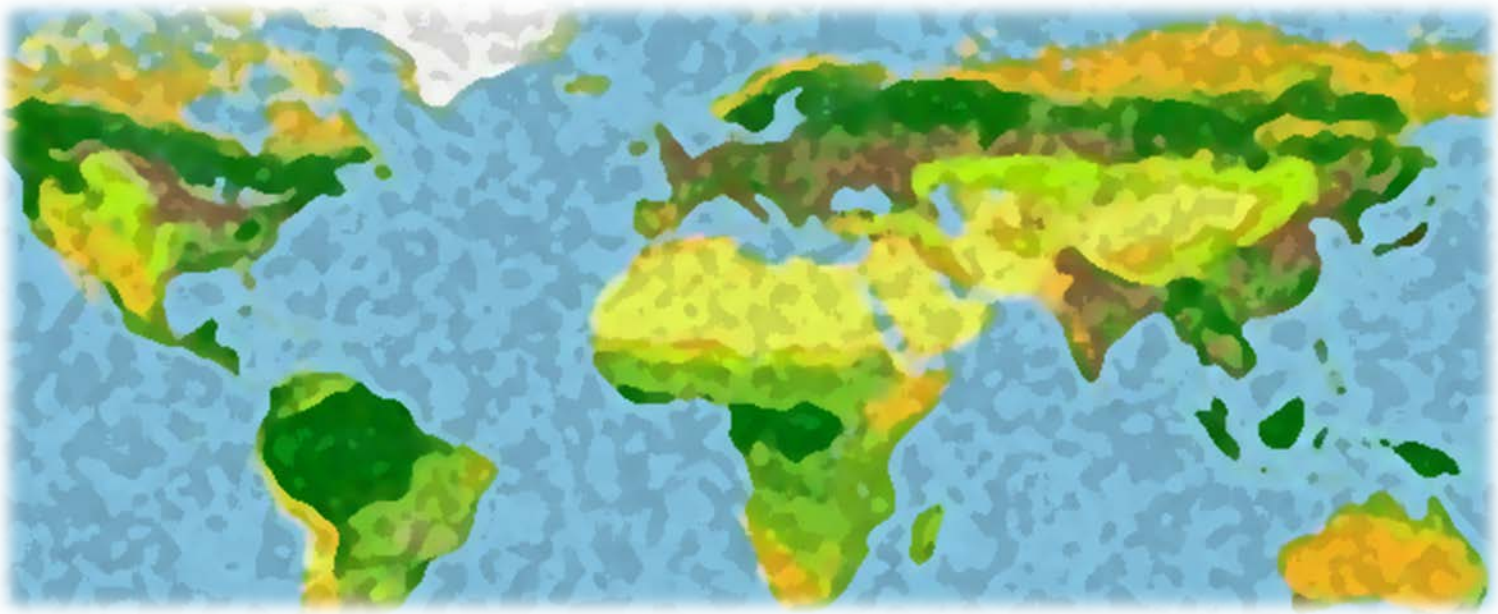
To manage natural resources we need to understand underlying resource dynamics **AND** the dynamics of human use (Little and McDonald, 2007)

Computer-based simulations provide managers with the ability to simulate land use dynamics **AND** simulate dynamic decision-making behavior before allocating limited resources

RATIONALE

Many land-use-change models fail to incorporate social behavior and interactions among land users despite the importance of peer influences on the decision making and adoption of policies and technologies (Sun and Müller, 2013)

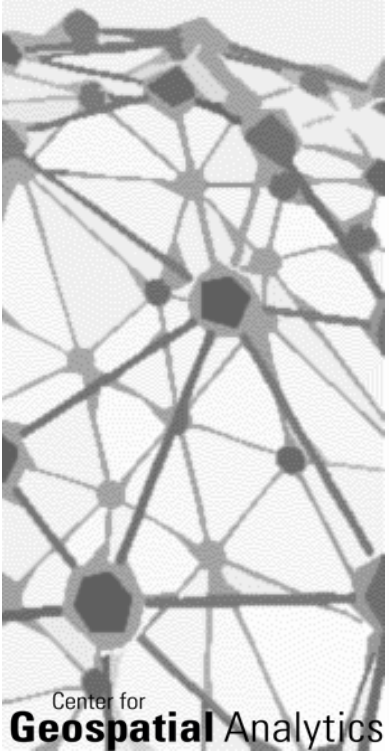




OBJECTIVES

Improve simulations of landscape dynamics by better integrating social science methodologies

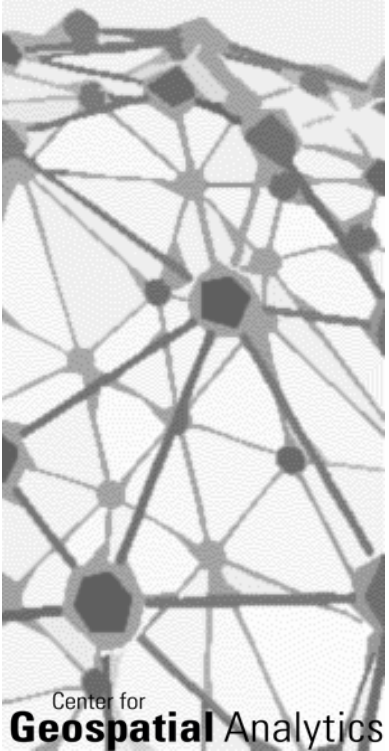
Explicitly incorporate social network effects into land-use decision making models using an agent-based model of land-use change



AGENT-BASED MODELS

An agent-based model (ABM) is a computational model that **simulates actions and interactions** of individual decision-makers

ABMs are **multi-scalar** and can be used to conceptualize disaggregated models of human decision-making



SOCIAL NETWORKS

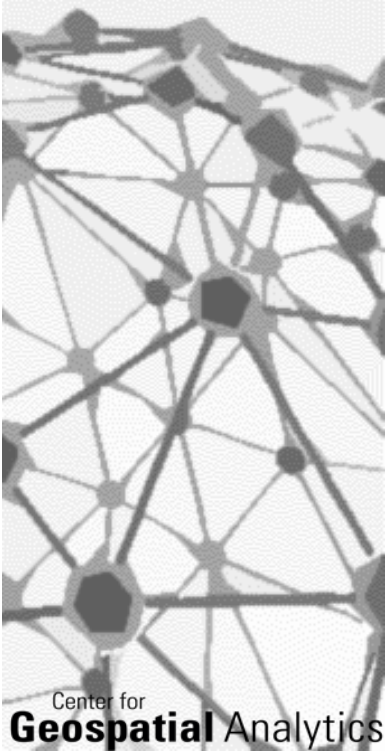
SOCIAL NETWORK STRUCTURE DESCRIBES THE STRUCTURAL PATTERNS OF RELATIONS (links or ties) BETWEEN ACTORS (nodes).

SOCIAL NETWORKS

Not all social networks are created equal (Bodin et al, 2006)

Structural pattern of relations have significant impacts on how actors actually behave

Significant differences in **governance process** and outcomes can be expected among networks with different structures (Bodin and Crona, 2009)



SOCIAL NETWORKS

Social networks play an important role in natural resource management too (Smith, 2013)

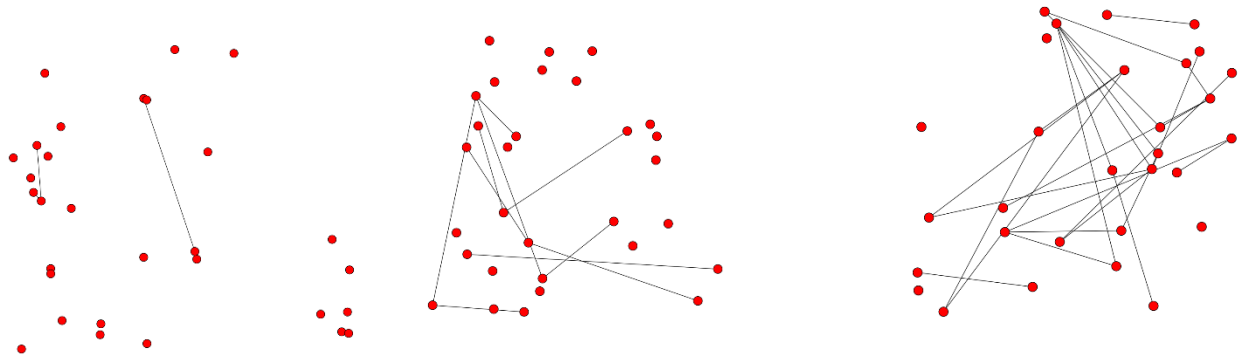
Where do landowners get their information about **management** and **land–use** activities?

- Family…
- Friends…
- Spatially adjacent neighbors…
- Other landowners…
- Agencies…

How do natural resource managers **disseminate** information?

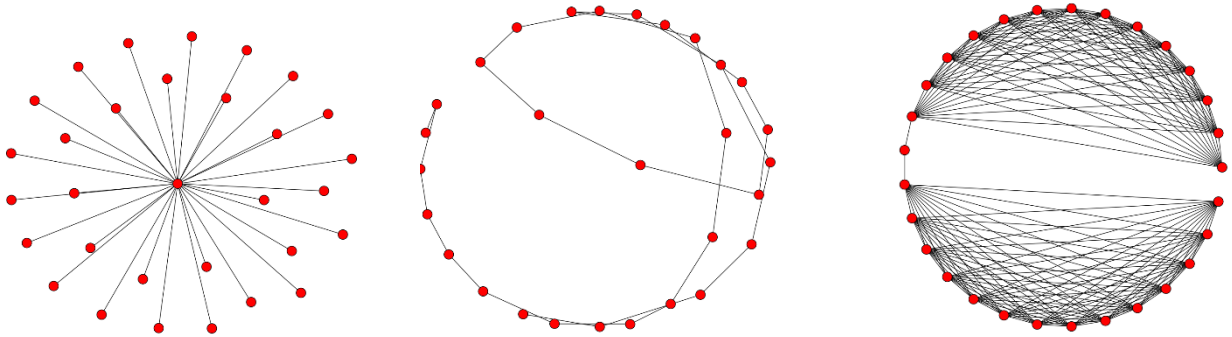
- Identify key players…
- Site visits…
- Facilitate workshops…
- And more…

SOCIAL NETWORKS

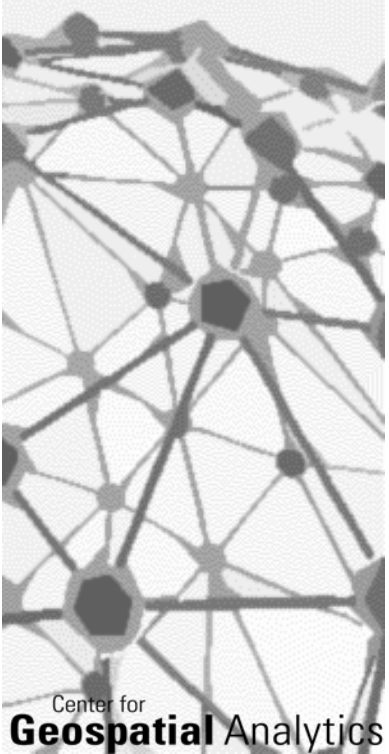


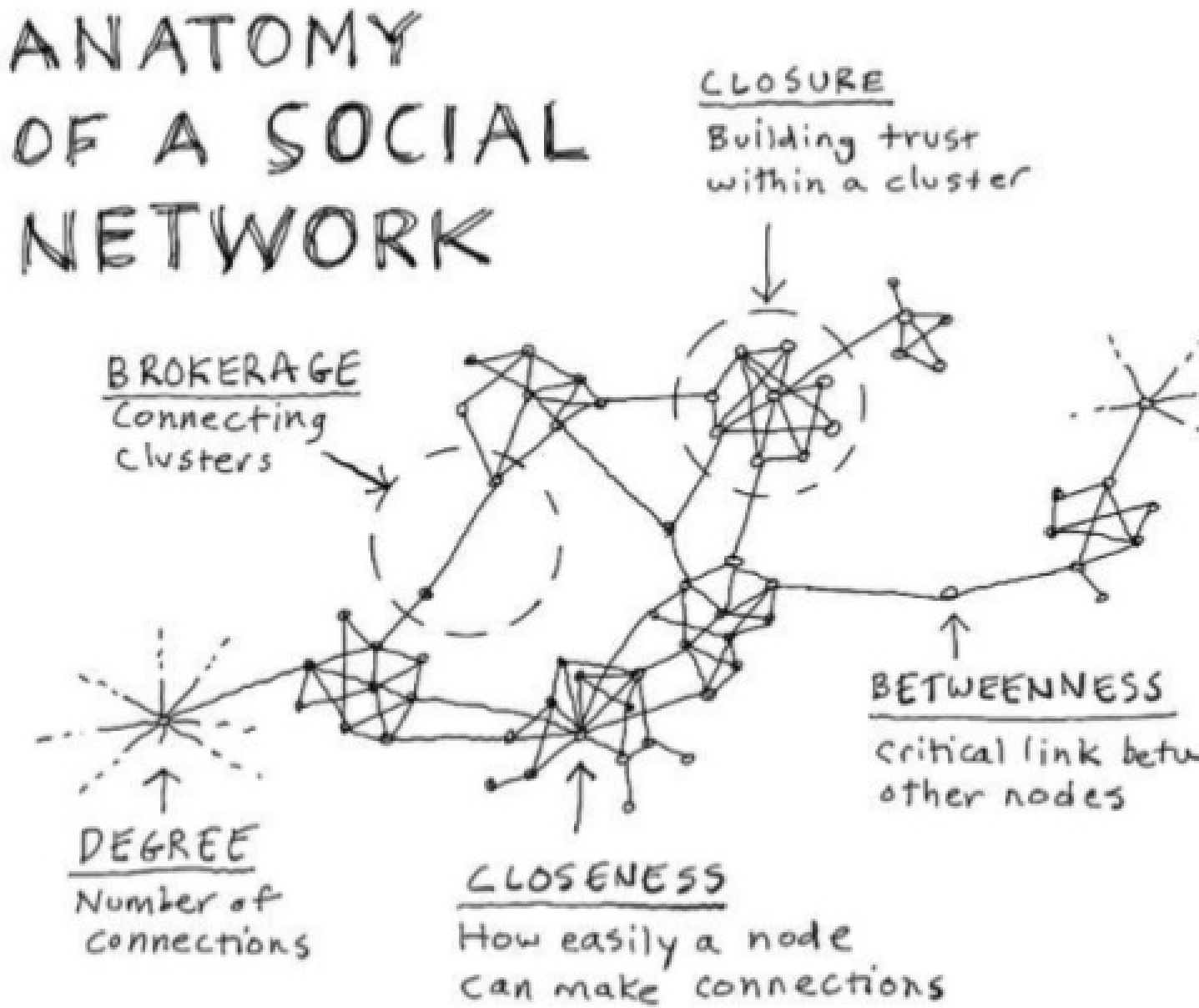
The field of **Social Network Analysis** has generated quantitative metrics to describe different network structural characteristics

Used to describe **key players**, **density**, **hierarchies**, and more



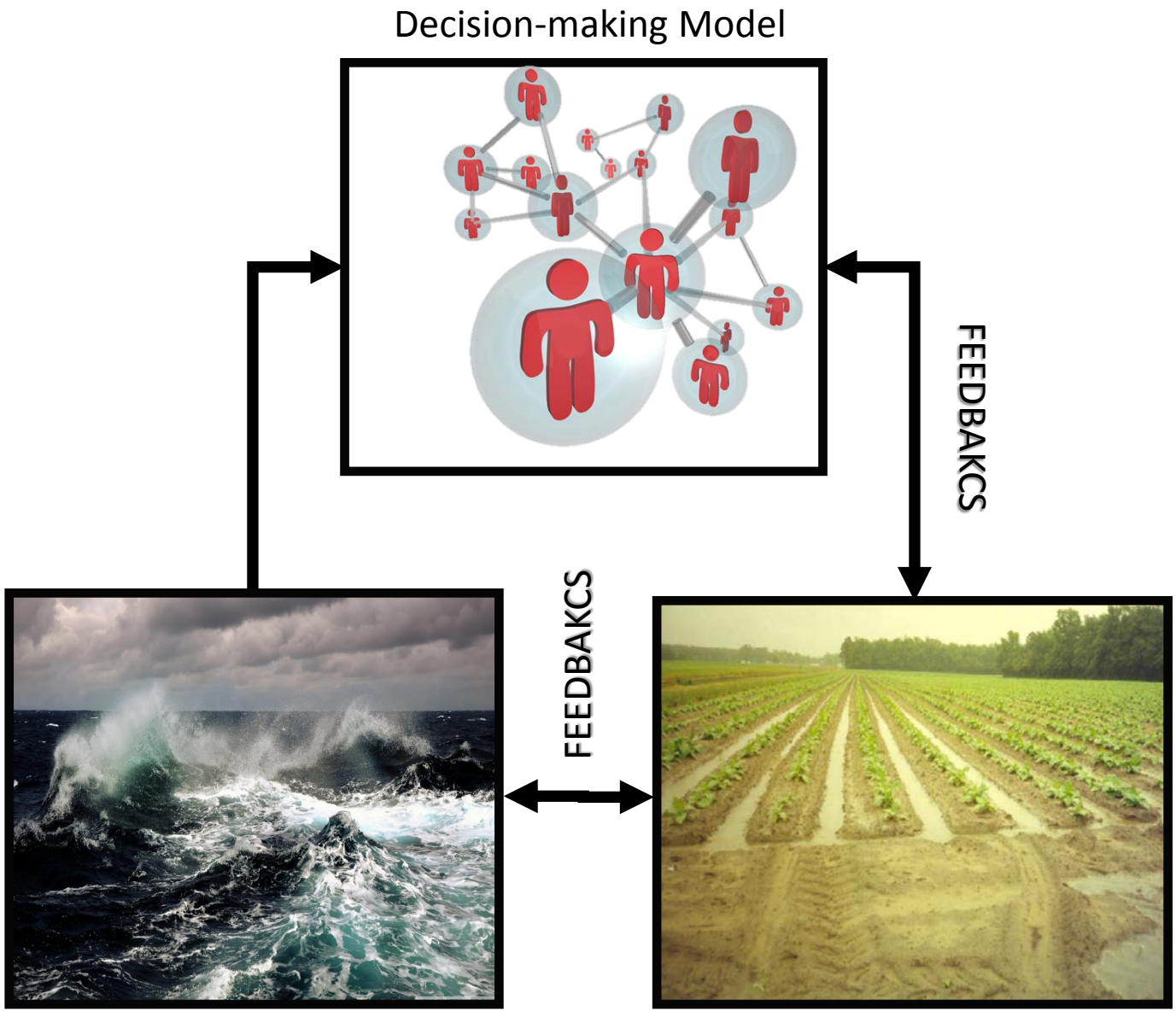
SOCIAL NETWORKS



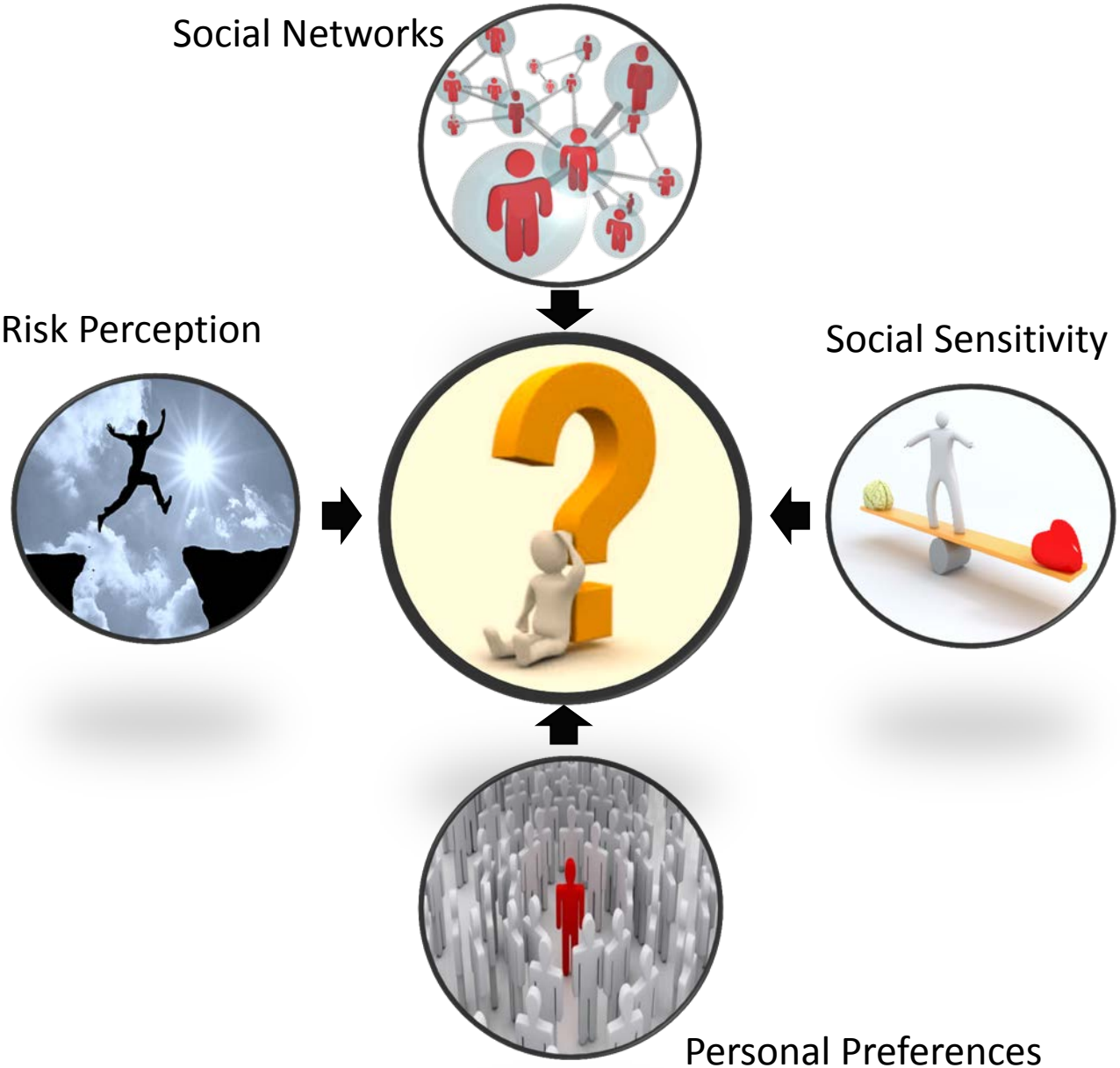


This graphic appeared in Fast Company and was created by Dave Gray

MODEL INTEGRATION

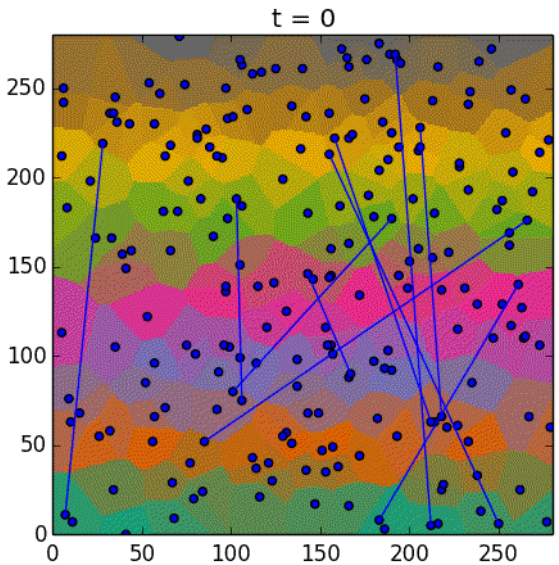


MODEL INTEGRATION

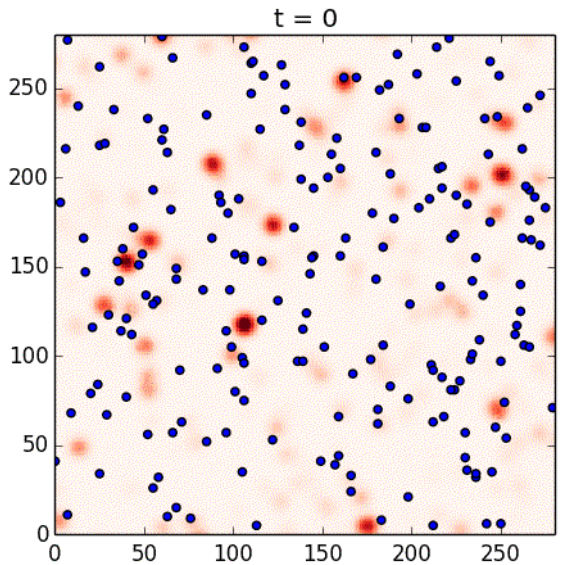


(Adapted from Janssen et al, 2006)

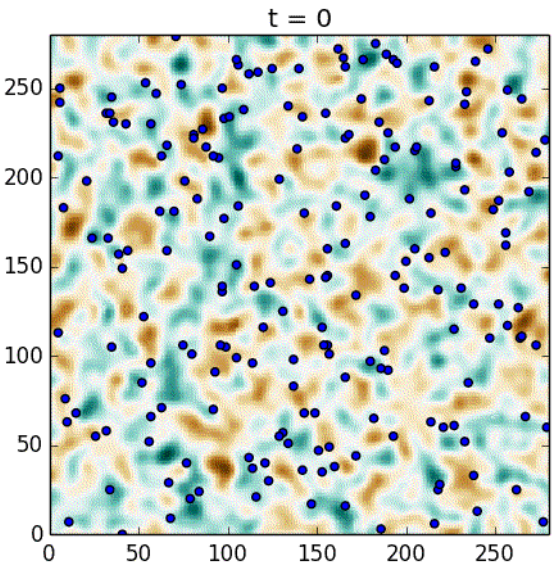
SIMULATION



Landowners and Network

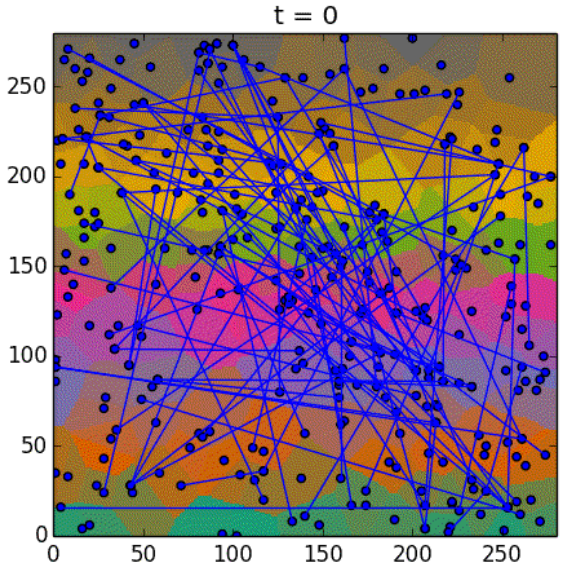


Vulnerability Surface

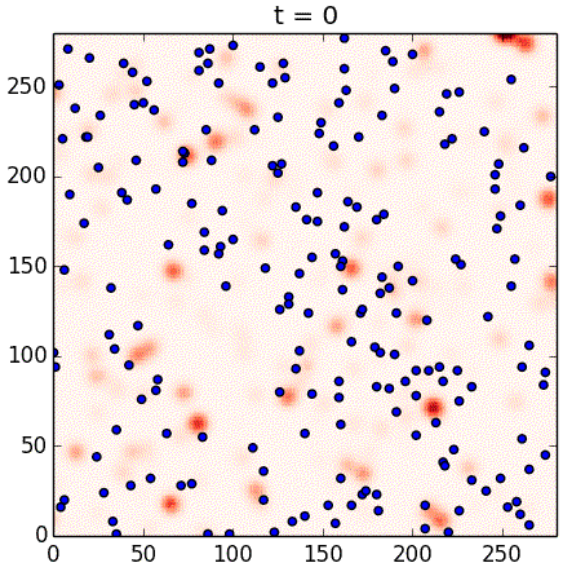


Landscape Response Surface

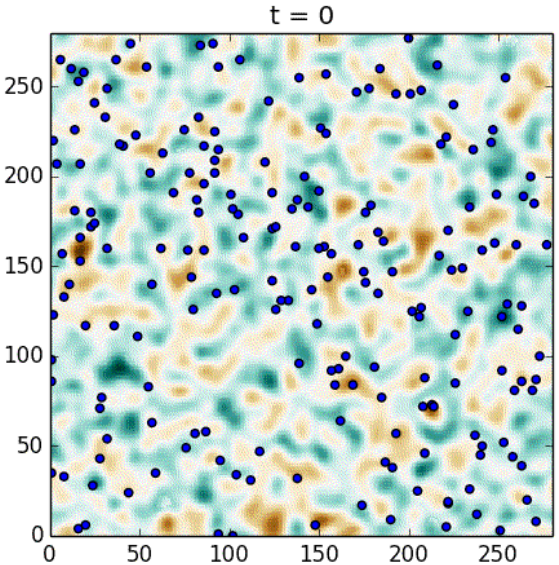
SIMULATION



Landowners and Network

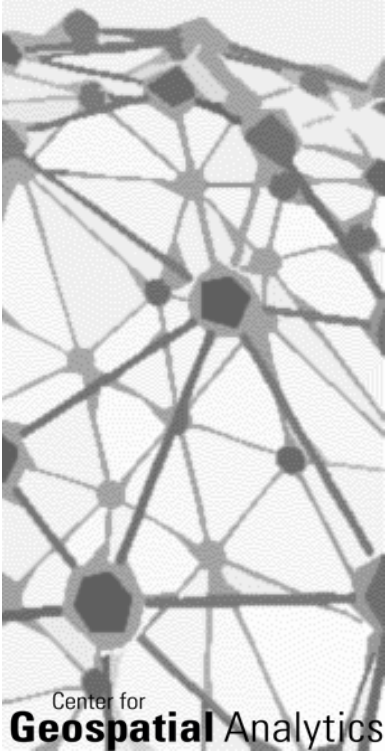


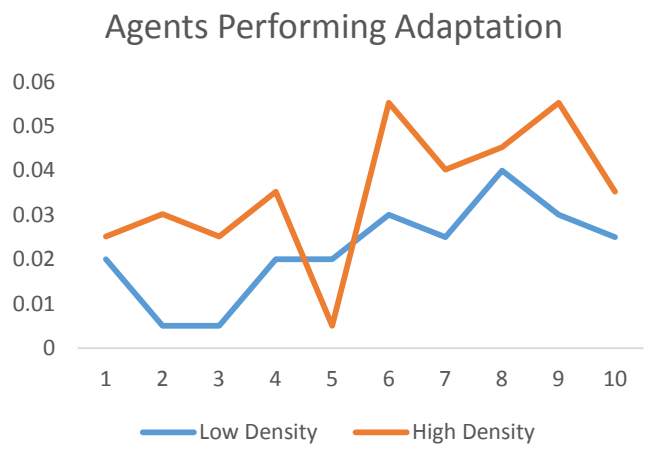
Vulnerability Surface

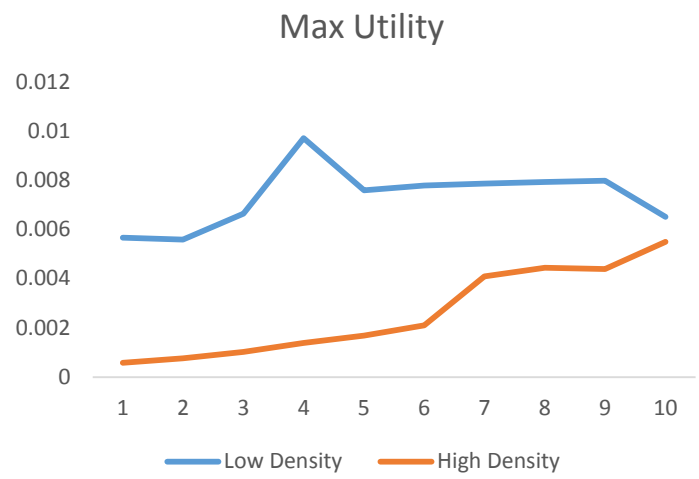


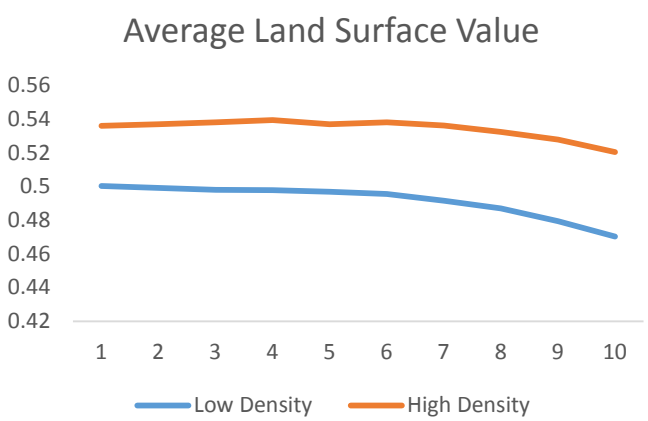
Landscape Response Surface

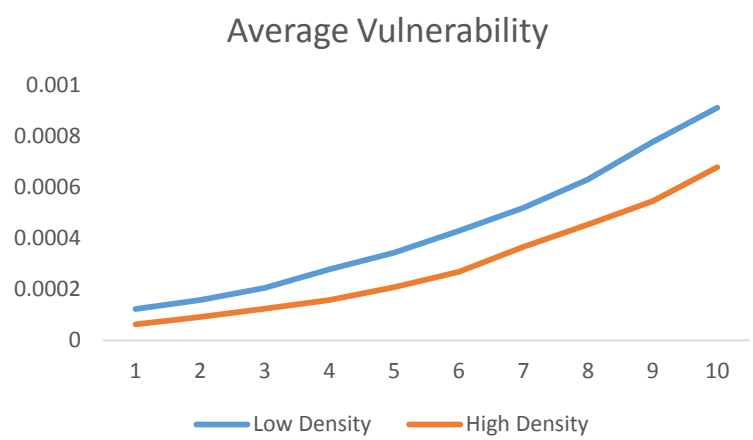
EXPLORATORY RESULTS











IMPLICATIONS

Collecting empirical data via social surveys can be cost-prohibitive and time intensive

It may be difficult to obtain unbiased responses from particular populations

Understanding contingent behaviors is complex

Clearly, no “one size fits all” strategy for communicating management – but which strategy fits with which community?

IMPLICATIONS

Allows for the exploration of management options before implementing in reality

Helps inform strategic approaches – blanket or targeted strategies

Broadens our understanding of the depth and breadth of social processes influencing land-use

IMPLICATIONS

Contextualizing using a natural resource-dependent, rural coastal community:

Individual preferences will be based on **focus groups** and **workshops** with landowners in the coastal plain of North Carolina

Synthetic or abstract landscape will be substituted for a **geographically accurate landscape**

Empirical data on **actual social network structures** and **land-use** in the coastal plain will be collected

This can be used to qualitatively validate the synthetic model

REFERENCES

Bodin, O. and B. I. Crona, 2009. The role of social networks in natural resources governance: What relational patterns make a difference? *Global Environmental Change* 19, 366 – 374.

Bodin, O., B. Crona, and H. Ernston, 2005. Social Networks in Natural Resource Management: What is There to Learn from a Structural Perspective? *Ecology and Society* 11 (2):r2.

Bodin, O. and J. Norberg, 2005. Information network topologies for enhanced local adaptive management. *Environment Management* 35(2): 175-193.

Crowe, J.A., 2007. In search of a happy medium: How the structure of interorganizational networks influence community economic development strategies. *Social Networks* · DOI: 10.1016/j.socnet.2007.02.002.

Janssen, M.A., O. Bodin, J.M. Anderies, T. Elmqvist, H. Ernstson, R.R. J. McAllister, P. Olsson and P. Ryan, 2006. A network perspective on the resilience of socio-ecological systems. *Ecology and Society* 11 (1): 15.

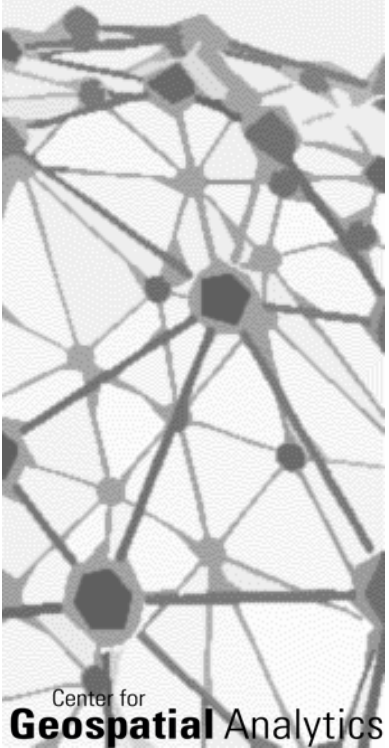
Little, L.R. and A.D. McDonald, 2007. Simulations of agents in social networks harvesting a resource. *Ecological Modeling* 204: 379-386.

Scott, J, 2013. Centrality, Peripherality, and Centralization in Scott, J. (3rd Edition). *Social Network Analysis* (pp 83 – 98) Las Angeles, CA: Sage.

Smith, J. W., 2013. Information networks in amenity-transition communities: a comparative case study. *Human Ecology* 41(6): 885-903.

Sun, Z. and D. Müller, 2013. A framework for modeling payments for ecosystem services with agent-based models, Bayesian belief networks and opinion dynamics models. *Environmental Modelling and Software* 45: 15 – 28.

Watts, J.D. and S. H. Strogatz, 1998. Collective dynamics of 'small-world' networks. *Nature* 393(4): 440-442.
Weisbuch G., 2000. Environment and institutions: a complex dynamical systems approach. *Ecological Economics* 34: 381-391



THANK YOU.

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