Modeling socio-ecological adaptation in fire-prone landscapes

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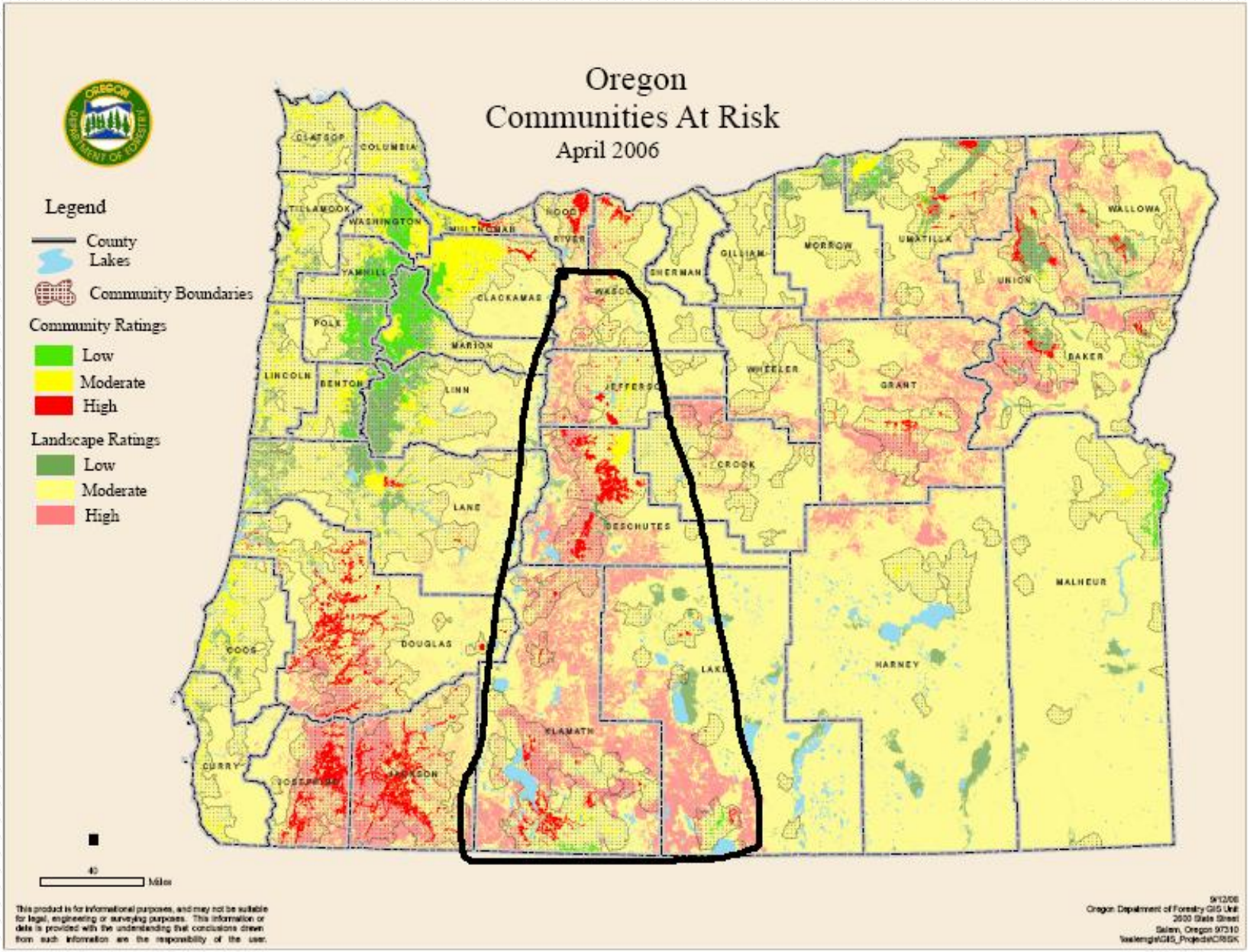
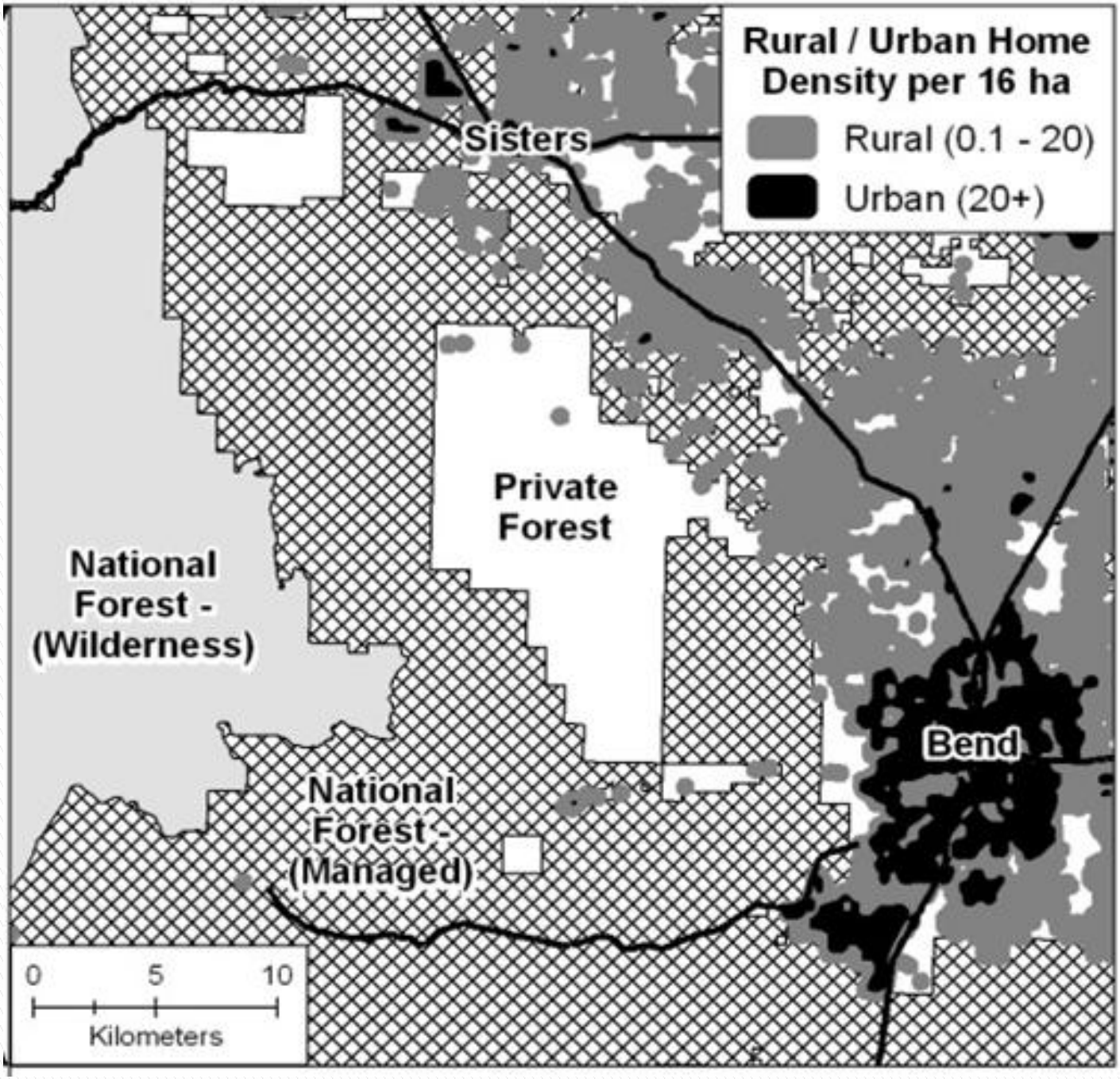
Coupled Natural Human Systems

- Individual actions modify, connect or disconnect
- Flows of materials and information
- Mediated by social and cultural institutions



Central Oregon's fire-prone landscape



Rural to urban gradient

patterns
complex
influences
scientists
effects
factors
adaptation
e.g
example
values
model
federal
Spies
approach
severity
range
vegetation
policies
including
increase
managers
conditions
set
resources
new
groups
potential
wildfires
study
Envision
fuel
area
fire
actor
models
lands
used
agencies
treatment
decision
biodiversity
change
management
fire-prone
forest
learning
include
forests
communities
large
work
developed
services
wildlands
activities
high
behaviors
institutions
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time
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burn
role
CNHS
weather
studies
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landscapes
suppression
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Fire
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treatments
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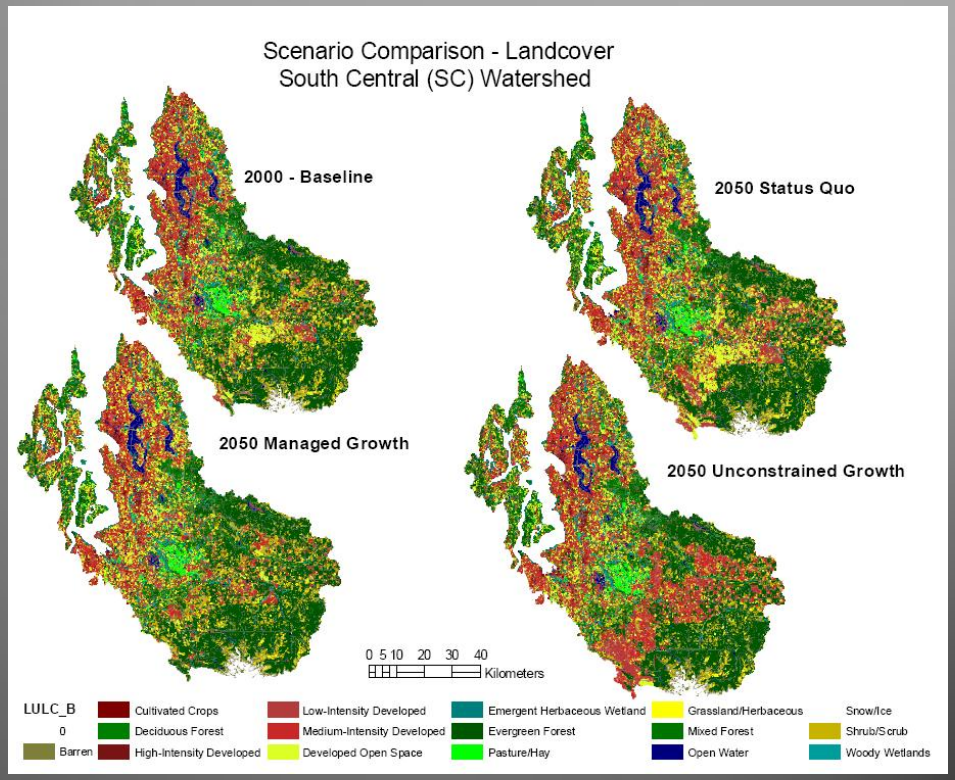
decision-making
scenario
analysis
spatial
species
project
homeowners
adapt
public
interactions
growth
based
use
changes
Figure
natural
rules
structure
actions
interviews

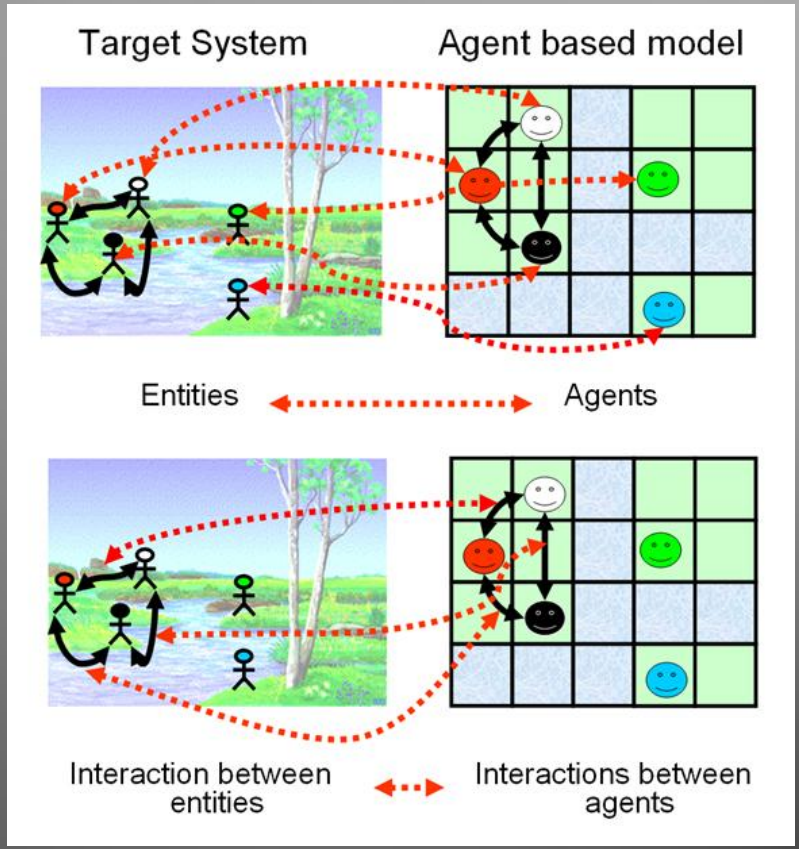
Simulation models

- Incorporate critical system features
- Represent likely real-world outcomes with some accuracy
- Useful when
  - system is complex
  - relationships are poorly understood
  - uncertainties are high



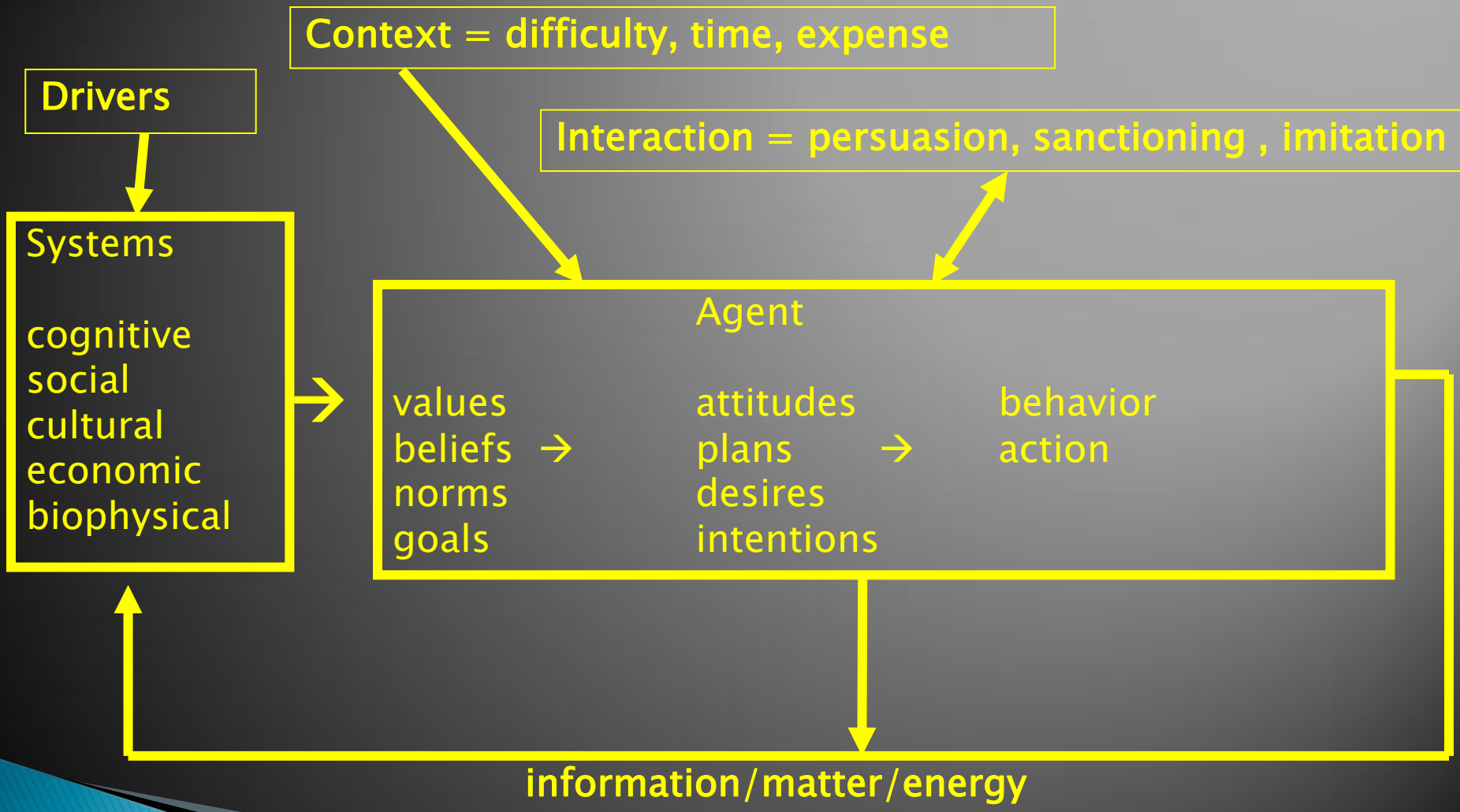
Agent-based modeling

- Represents the behaviors of actors in a system
- Actors have rules (i.e., policies, norms) that guide and constrain actions
- Actors are autonomous and adaptive agents
- Autonomous processes simultaneously modeled



JASSS 2009

Theory of individual action



Conceptual structure of Envision

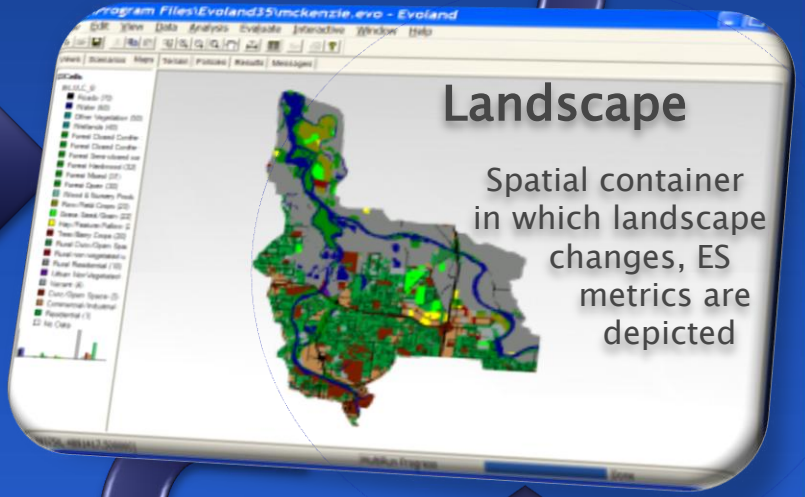
Actors
Decision-makers managing the landscape by selecting policies responsive to their objectives

Landscape Feedbacks

Landscape Production Models
Generating Landscape Metrics Reflecting Ecosystem Service Productions

Scenario Definition

Multi-agent Decision-making
Select policies and generate land management choice affecting landscape pattern



Policies
Fundamental descriptors of constraints and actions defining land use management decision making

Autonomous Change Processes
Models of Non-anthropogenic Landscape Change

Simulating individual behavior: private land owners

- Important due to location and extent of land
- Are capable of influencing forest conditions
- Are more influenced by social norms and peers than formal rules

Management approaches

Factor group	Practices with factor loadings of ≥0.4	Eigenvalue	Proportion Explained	Cronbach's alpha
Timber harvesting	Harvest timber for profit Sell logs or other wood products	2.397	14.980	0.935
Defensible space creation	Prune or limb trees Thin by hand or with chainsaw Pull by hand Clear around structures Make structures more fire-proof Create fuel breaks	5.732	35.823	0.886
Mechinized thinning	Thin with mechanized equipment Mow, crush, grind or chip	1.151	7.195	0.718
Cultivation	Plant fire-adapted trees Shade out vegetation	1.205	7.531	0.754
Grazing	*Grazing cattle* *Applying herbicides*	*1.020*	*6.375*	*0.464*

Manager types

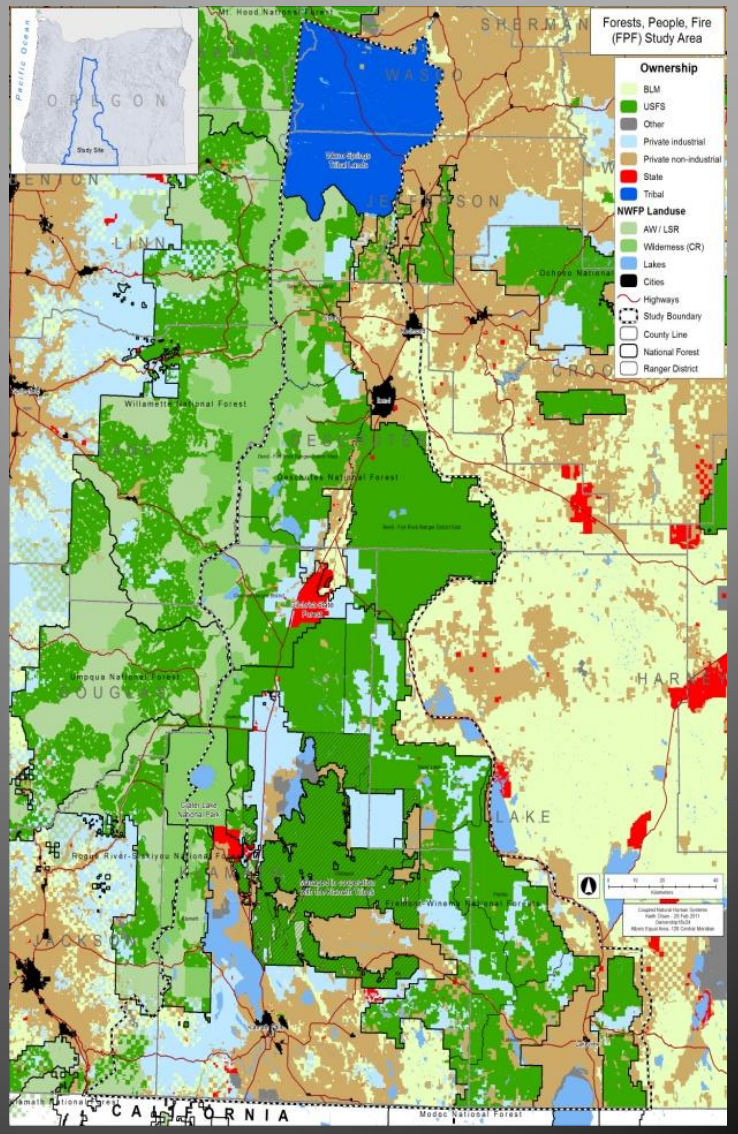
Characteristics	Sample	Fuel manager cluster group: Commodity-oriented	Amenity-oriented	Non-committal	Unlikely	
Percentage of sample	100	26.5	21.1	27.8	24.6	
						X^2
Treated acres to reduce fire risk (%)	68.9	49.3	83.8	82.6	53.5	66.106***
Very concerned about fire (%)	44	52.6	59.3	43	25.5	62.729***
Primary residents (%)	22.5	22.8	44.6	25.2	12.7	27.477***
Timber most important goal (%)	9.6	22.9	3.2	2.4	9.1	34.1***
Grazing most important goal (%)	14.6	20.3	7.4	11.3	18.2	9.636*
Residence most important goal (%)	16.8	5.1	27.7	21.8	14.5	24.533***
Real estate most important goal (%)	7.8	5.1	3.2	11.3	10.9	9.074*
Earn some income from forestry (%)	33.0	61.0	25.5	18.5	25.5	57.08***
More likely to manage with incentives (%)	73.2	85.6	83.7	76.6	48.1	45.768***
						F
Acres treated to reduce fire risk (mean)	186.9	324.6^{a}	146.4	174.9	89.9^{a}	3.964**
Parcel acreage (mean)	1240.4	1973.1^{ab}	735.6^{a}	1225.4	899.4^{b}	6.147***
Ownership acreage (mean)	2584.3	4031.2^{a}	1225.4^{a}	2405.9	2510.6	5.279**

$*p \leq 0.05$; $**p \leq 0.01$; $***p \leq 0.001$

Means with same superscripts are significantly different at $p \leq 0.05$ based on Games-Howell method

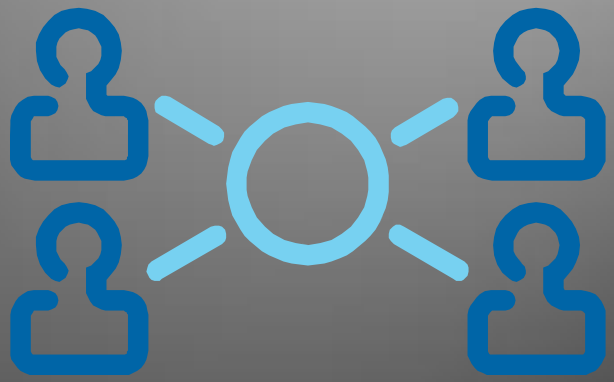
Representing agents spatially

- Assign probability parcel belongs to each agent type based on agent characteristics
- Represent practices that the agent group most likely to control parcel is most likely to conduct
- Simulate resulting changes in conditions on parcel and how they affect ecological conditions and processes and human behaviors on other parcels

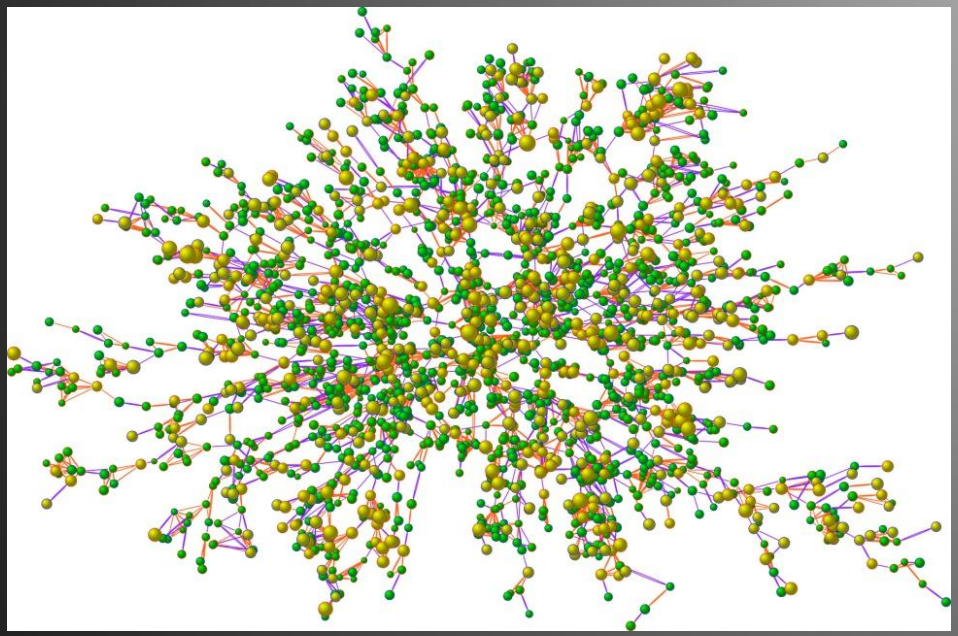


Simulating social influences

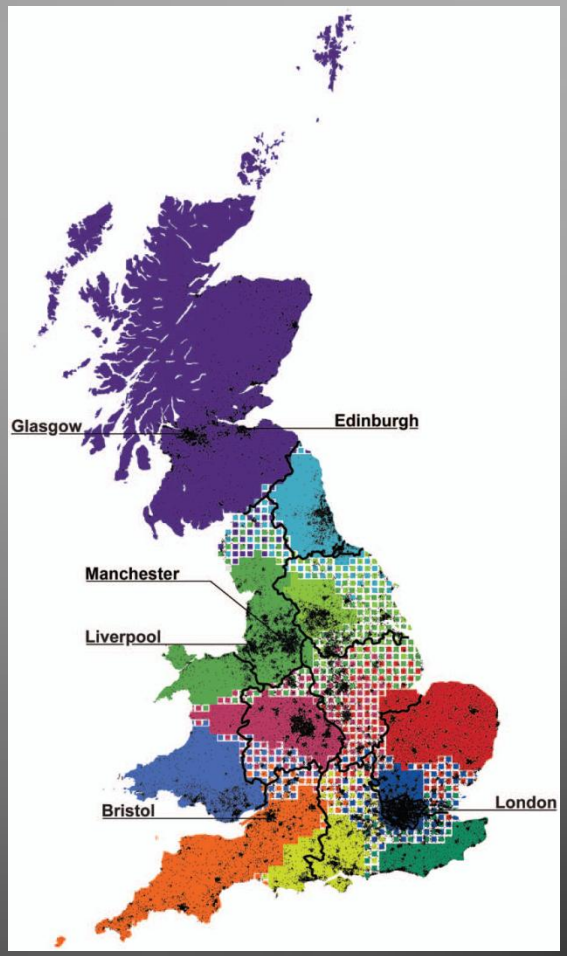
- How to account for changes in determinants of agent behavior that result from social influences
  - Learning
  - Persuasion
  - Change in social norms
  - Thresholds in adoption of ideas and behaviors
- What influences who agents interact with and what they take away from those interactions?



Social network analysis



James Fowler



Ratti et al. 2010

Examples from ABM literature

- Agents cooperate with others when they anticipate future interactions with the same individuals (Axlerod 1981, 2002; Cohen 2001)
- Communication about common goods reduces chance of exploitation just as well as punishment (Janssen et al. 2008)

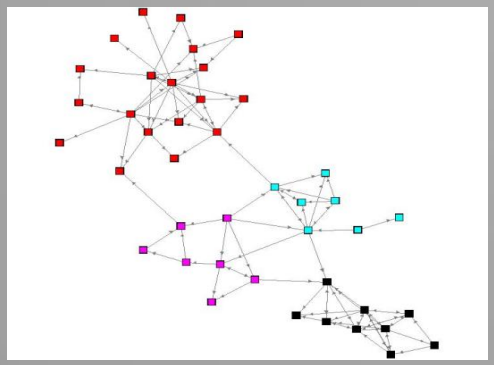
Theory

- Social interactions shape social value and uncertainty attributed to farming (Deffuant et al. 2005)
- Kinship ties define possible behaviors and normative expectations; institutions constrain and inform production choices (Entwisle et al. 2008; An et al. 2005, Manson 2006)
- Preferences to live near and adopt practices of similar others hape landscape (Brown et al. 2008)
- Technological conditions affect diffusion among farmers (Berger 2001)

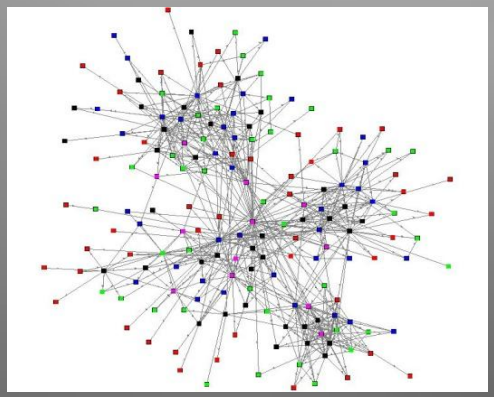
Empirical studies

Social network measures

- Can represent social structures that have bearing on adaptation:
  - diffuse information
  - foster learning
  - promote cooperation
  - promote innovation



Information communication network



Learning network

Acknowledgements

- National Science Foundation
  National Fire Plan

CONCEPTUAL MODEL OF RELATIONSHIP BETWEEN NETWORK STRUCTURE AND ADAPTATION

Influences on social organization

People associate with others with similar knowledge, beliefs, values, risk constructs, behaviors and socio-economic characteristics. (homophily)

Psychological/ cognitive processes (e.g., risk perception, attitudes)

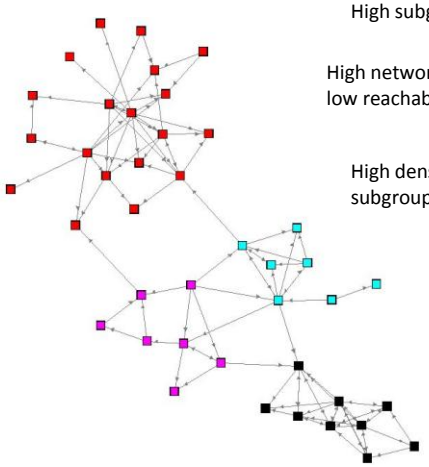
Cultural beliefs and values

Institutions (e.g. rules, norms, reward systems)

Individuals and institutions can foster heterophily (associations between people with diverse knowledge, beliefs, values, risk constructs and socioeconomic characteristics)and bridging

Typical pattern of network structure

Network consists of discrete homophilous groups of agents. Few bridging actors connect these groups. The groups have sparse homogeneous peripheries of resource actors.



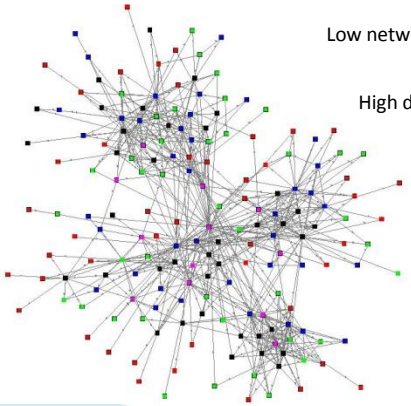
High subgroup centrality

High network betweenness; low reachability

High density within subgroups

Potential pattern of network structure

Multiple connections exist among homophilous or heterophilous groups with dense peripheries of resource actors. Network consists of heterophilous



High network reachability; low betweenness

Low network centrality

High density

Implications for knowledge communication

Information communicated easily within homophilous groups; but innovation and knowledge generation not occurring.*
Individual groups of agents may share understandings of causes and solutions to problems but understandings not shared across network.
Little collective action across network; low social capital

*Knowledge** generated through iterative, two-way process of inquiry and experience (social learning)*
Mutual understanding of array of causes and solutions to problems
Collaborative identification of knowledge needs and strategies
Cultivation of formal and informal relationships that promote trust and reciprocity (i.e., social capital)
Greater likelihood of collection action

*Information = organized data, data endowed with relevance
**Knowledge = mix of information and experience brought to bear on a problem