Representing Landowners in a Dynamic Agent-Based Model: A Tool for a Fuzzy World

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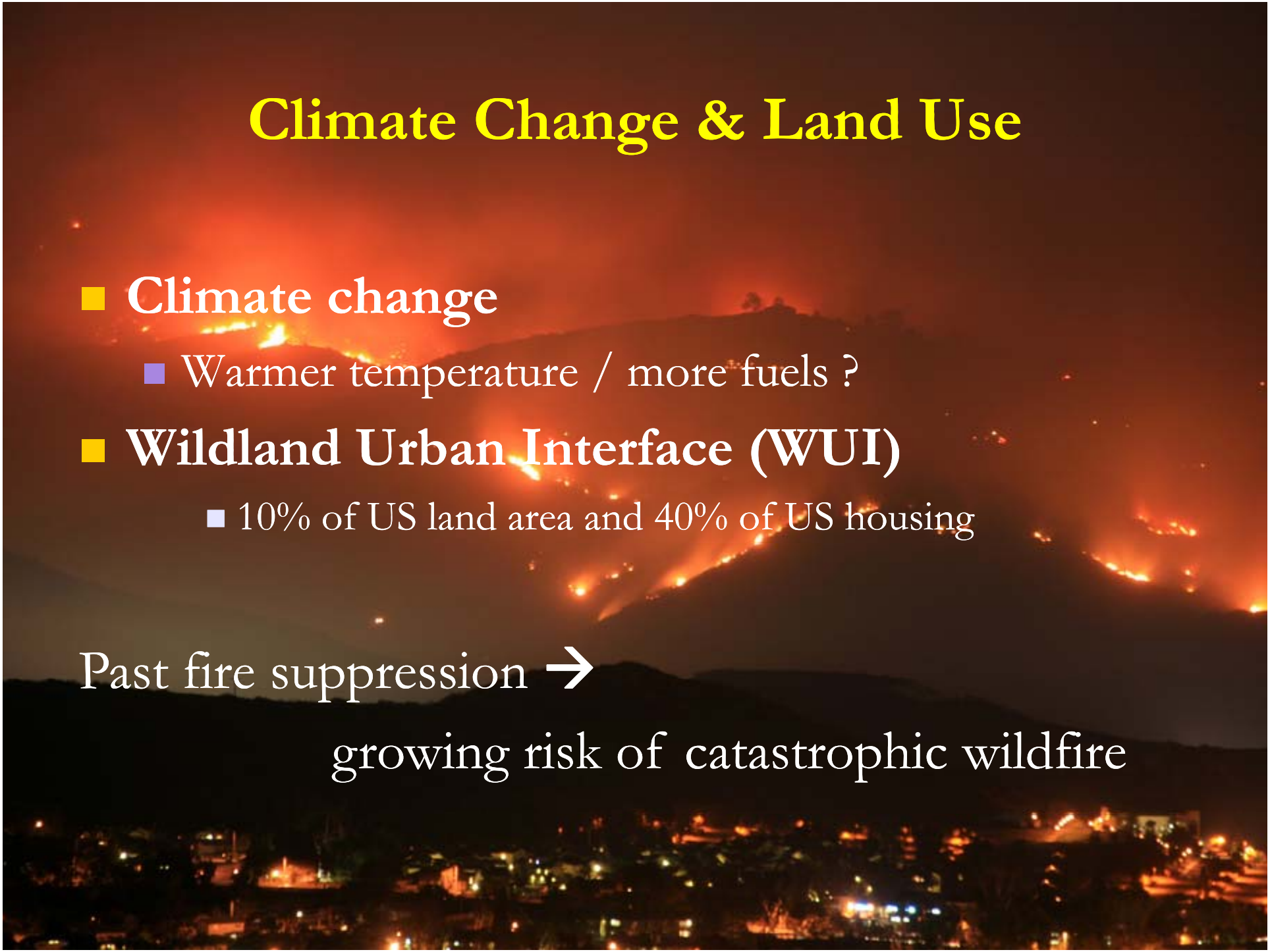
Rob Ribe
ISSRM 2011



Climate Change & Land Use

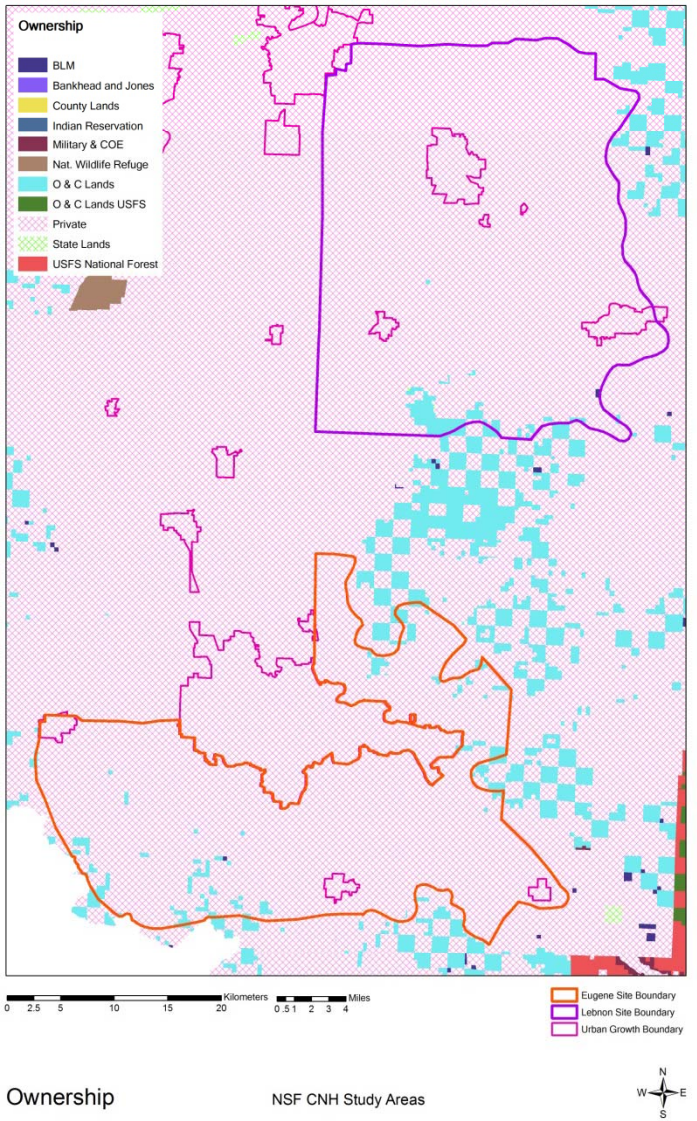
- **Climate change**
  - Warmer temperature / more fuels ?
- **Wildland Urban Interface (WUI)**
  - 10% of US land area and 40% of US housing

Past fire suppression →

growing risk of catastrophic wildfire

Oregon's Willamette Valley

Hulse et al. 2002



Area: **30,000 km²** Oregon's population: **68%**

Projections:

- **1.5-4.5℃ higher temperatures**
- **0-50% more precipitation (winter)**
- **Longer and deeper summer drought**
- **More wildfire likely**
- **Doubling of population**

Fire Adapted Oak Savanna Landscape

Oak savanna is a key conservation target
Highly vulnerable: 95% loss in 150 years

Low-intensity fires maintained savanna & prevented forest succession.
Fire suppression has caused savanna habitat loss

Intense wildfires endanger human and ecological values

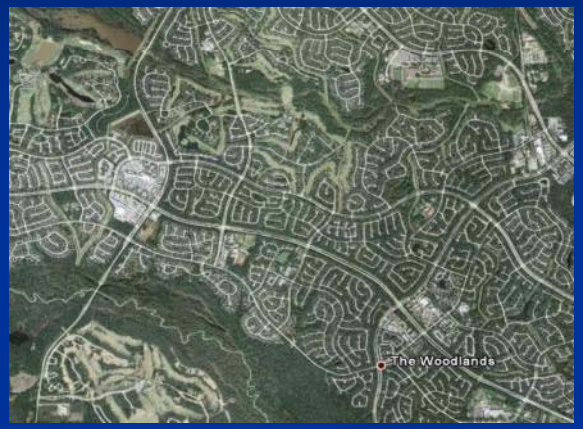
How will we respond to wildfire hazard?

Fire Suppression

Hazard Mitigation

Ecological Restoration

How will we choose to develop?



Dispersed development

Compact or clustered development

Multi-Agent Systems (MAS)

- MAS Models –
  - Useful in the context of simulating landscape change
  - Environment is represented spatially
  - **Agents (actors) are decision making entities**
    - **Actors (e.g., a landowner) are authorized to make decisions influencing their land**
  - Policies influence or constrain actor decisions
  - Actors can respond to change around them

How will climate change, wildfire, and land use interact?

Answer

- Depends on regional land use policy
- **Depends on how rural landowners behave, interact, and respond to policy**

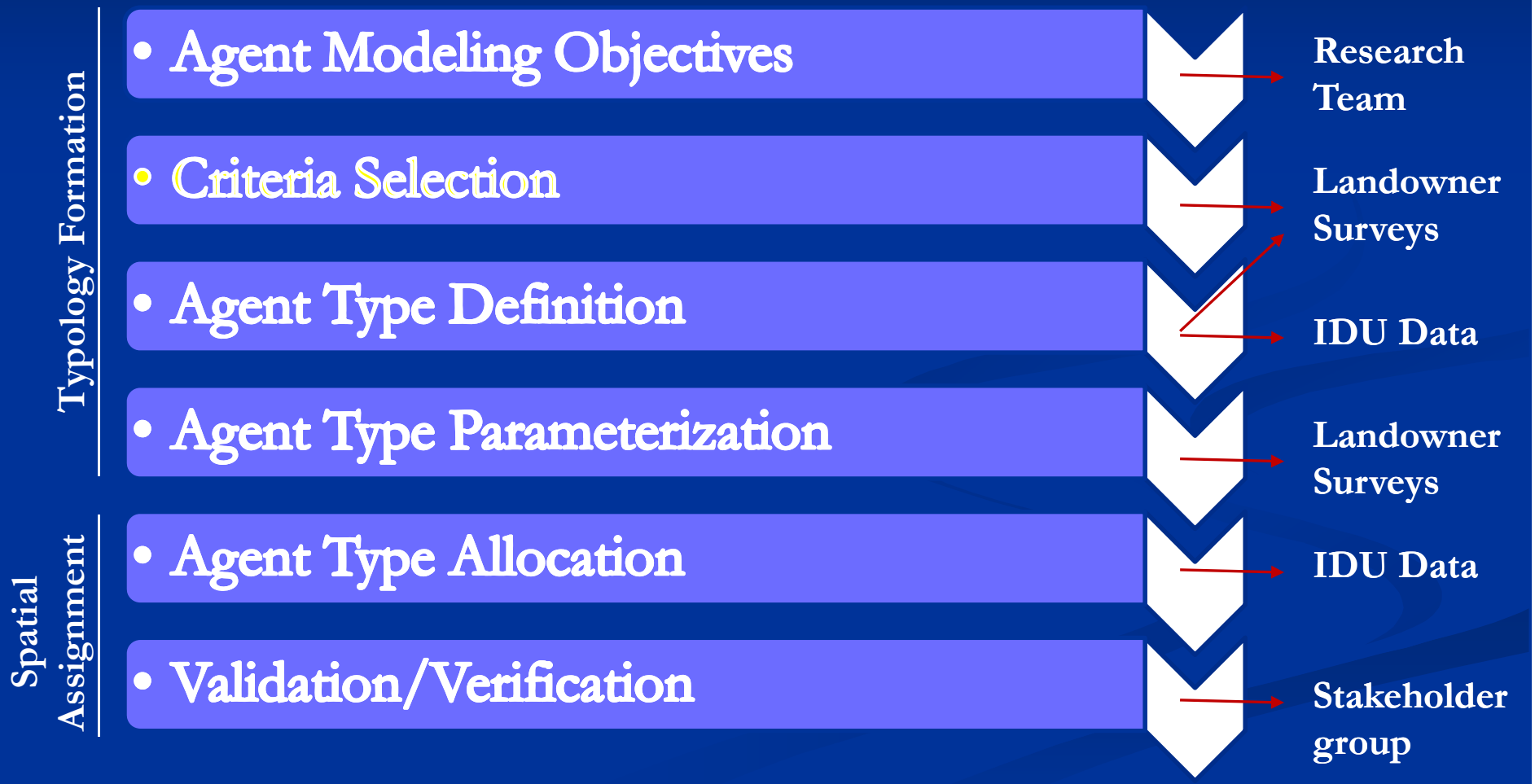
Objective

- Identify different types of people on the landscape
- Characterize motivations and land management values
- Assign them to the places in the landscape

<u>Goal</u>

Search for policies that are robust at protecting people and biodiversity across a range of plausible scenarios

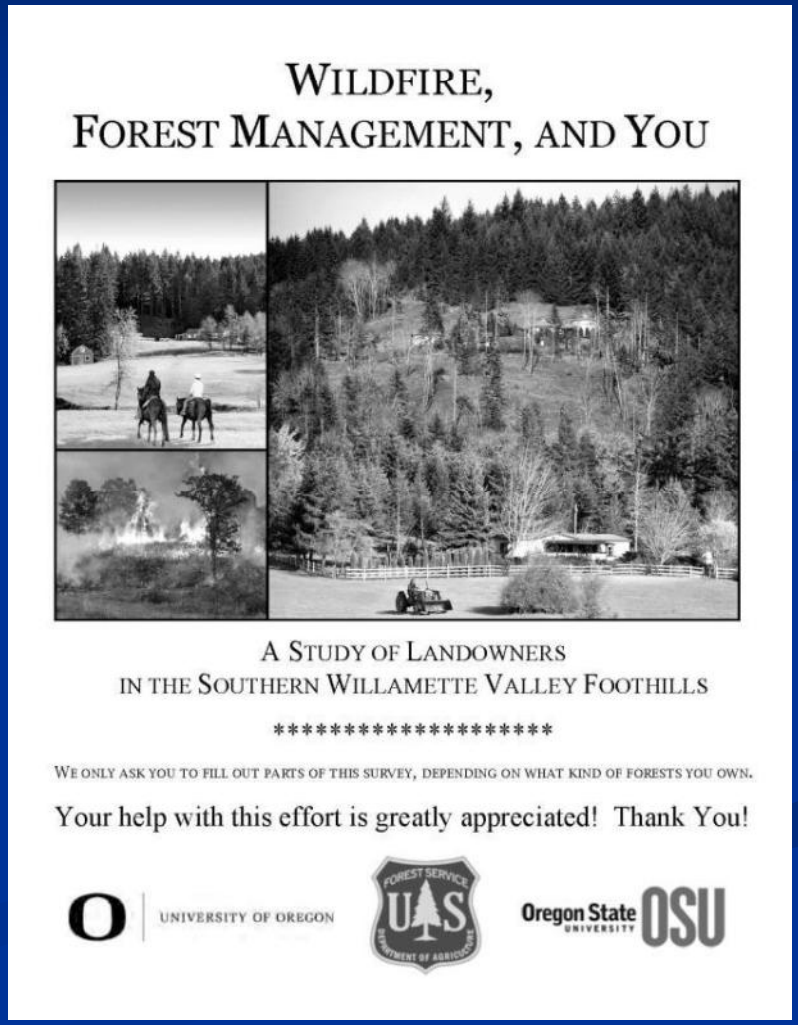
A Method for Creating Agents



(adapted from *Valbuena et al.* 2008)

Landowner Surveys

- **2 Surveys (Dillman 2000)**
- Lane and Linn County
- Non-industrial Private Owners
- Land Mgmt: n=652 (40%)
- Forest Mgmt: n=362 (49%)



WILDFIRE,
FOREST MANAGEMENT, AND YOU

A STUDY OF LANDOWNERS
IN THE SOUTHERN WILLAMETTE VALLEY FOOTHILLS

****

WE ONLY ASK YOU TO FILL OUT PARTS OF THIS SURVEY, DEPENDING ON WHAT KIND OF FORESTS YOU OWN.

Your help with this effort is greatly appreciated! Thank You!

UNIVERSITY OF OREGON

Oregon State UNIVERSITY OSU

Methods for Agent Definition, Allocation, and Parameters

- Do groups of respondents exhibit unique characteristics that ***relate to the landscape***?

  Criteria

  - Motivations → **Agent Definition**
  - Land Characteristics → → **Agent Allocation**
  - Land Management Values → → → **Agent Parameters**

Agent Definition

- Criteria: 18 goals and objectives for property (factor analysis)

  A set of underlying ***motivations***

- ***Group*** landowners by underlying motivations (cluster analysis)

Agent Type Parameterization: Land Management "Values"

From this: **RESTORING OAK SAVANNA** To This:

Mixed Deciduous and Conifer Forest

Wildfire Risk	Habitat Value	Property Rts. Risk
VERY HIGH	MODERATE	VERY LOW

Oak Savanna

Wildfire Risk	Habitat Value	Property Rts. Risk
VERY LOW	HIGH	MOD. HIGH

What is generally involved: Hire a logging company to remove and sell nearly all the trees except a few scattered oaks, and mow shrubs and weeds. After that, seedlings, shrubs and grass will need mowing and/or grazing every few years.

Estimated finances: Cost = $1,500/acre to $5,000/acre. Revenue = $500/acre to $3,000/acre.

21d. What is the likelihood that you will implement oak savanna restoration on a patch of mixed deciduous and conifer forest on your property during the next 10 years? *For each option, mark a slash through the number line to indicate the probability that you will implement this forest change.*

For Example: 0 10 /20

a. If you had to bear the full cost or profit of implementing and maintaining it with risks to your rights.

0 10 20 30 40 50 60 70 80 90 100

b. If you received enough financial assistance to break even, with risks to your property rights.

0 10 20 30 40 50 60 70 80 90 100

c. If you received financial assistance to guarantee a profit of $1,000 per acre, with risks to your rights.

0 10 20 30 40 50 60 70 80 90 100

d. If you only had a legal guarantee that the government would not take any ot your property rights.

0 10 20 30 40 50 60 70 80 90 100

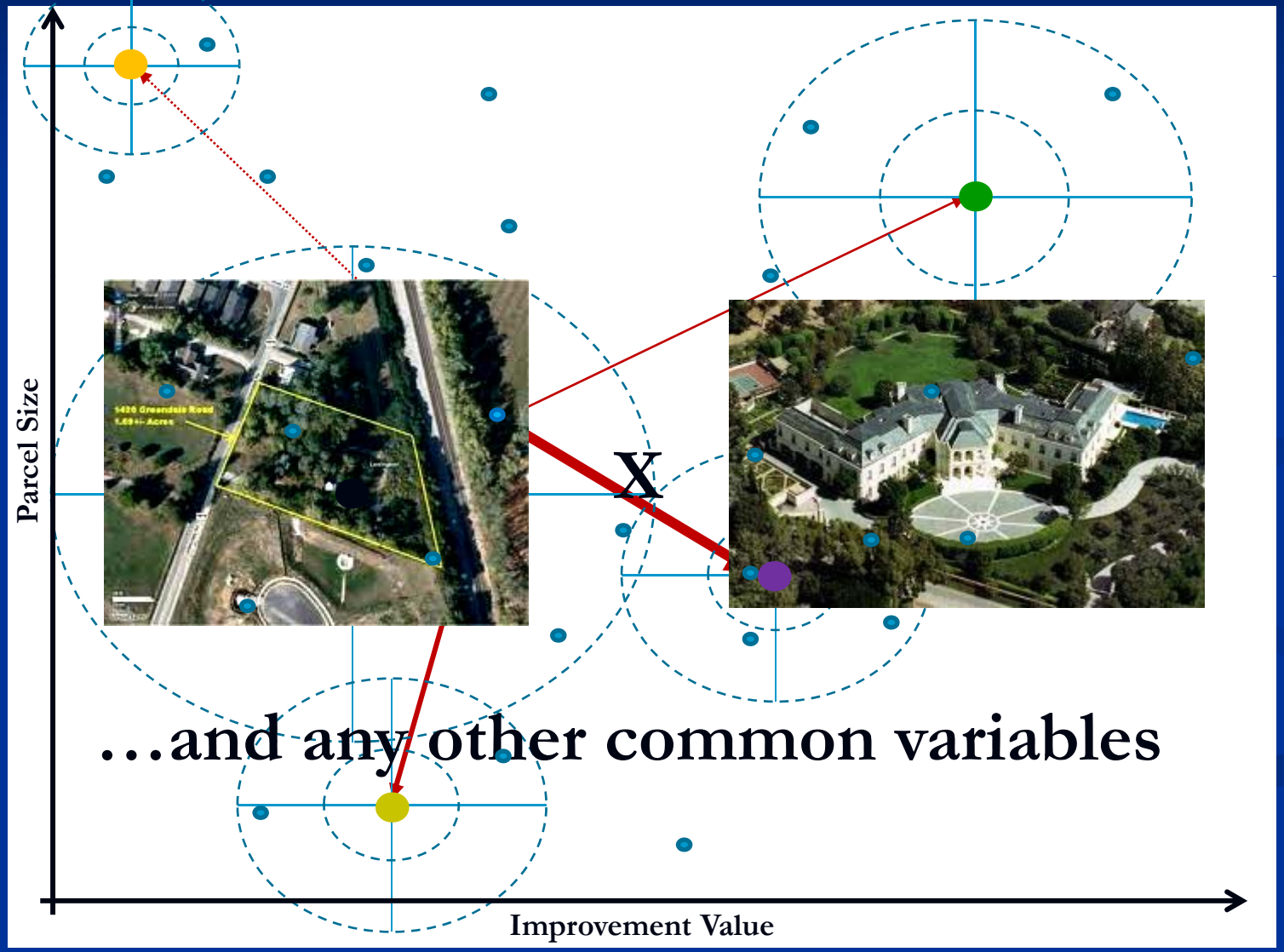
e. If you were guaranteed to keep your property rights and earn a profit of $1,000 per acre.

0 10 20 30 40 50 60 70 80 90 100

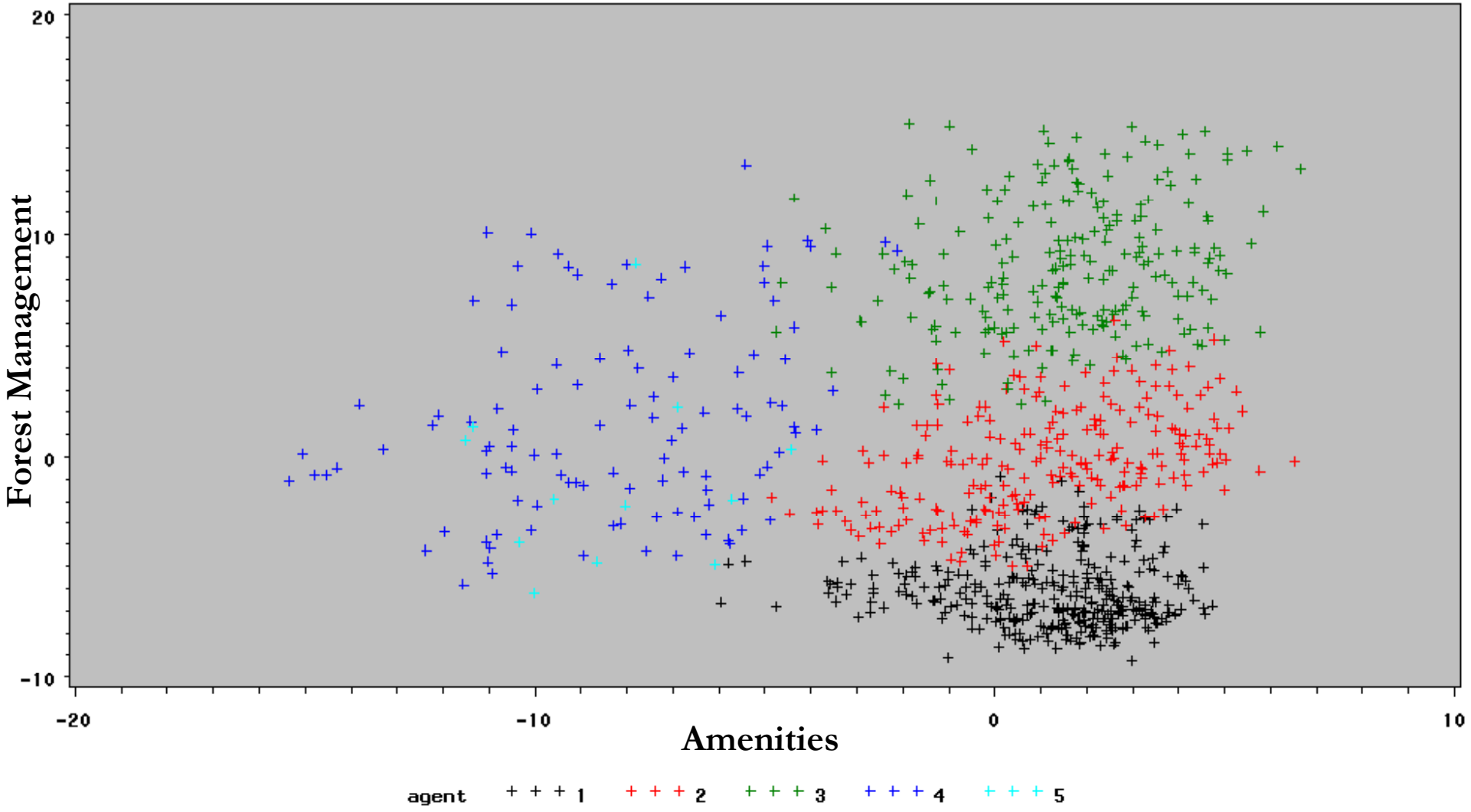
Agent Spatial Allocation

- Use **common variables** to landscape and survey
- **Compare** each parcel's characteristics to the average characteristic for each agent type
- Assign a **probability** of that each parcel belongs to each agent type
- Based on the probability, which agent type does the parcel ***most likely*** belong to?

Agent Type Allocation



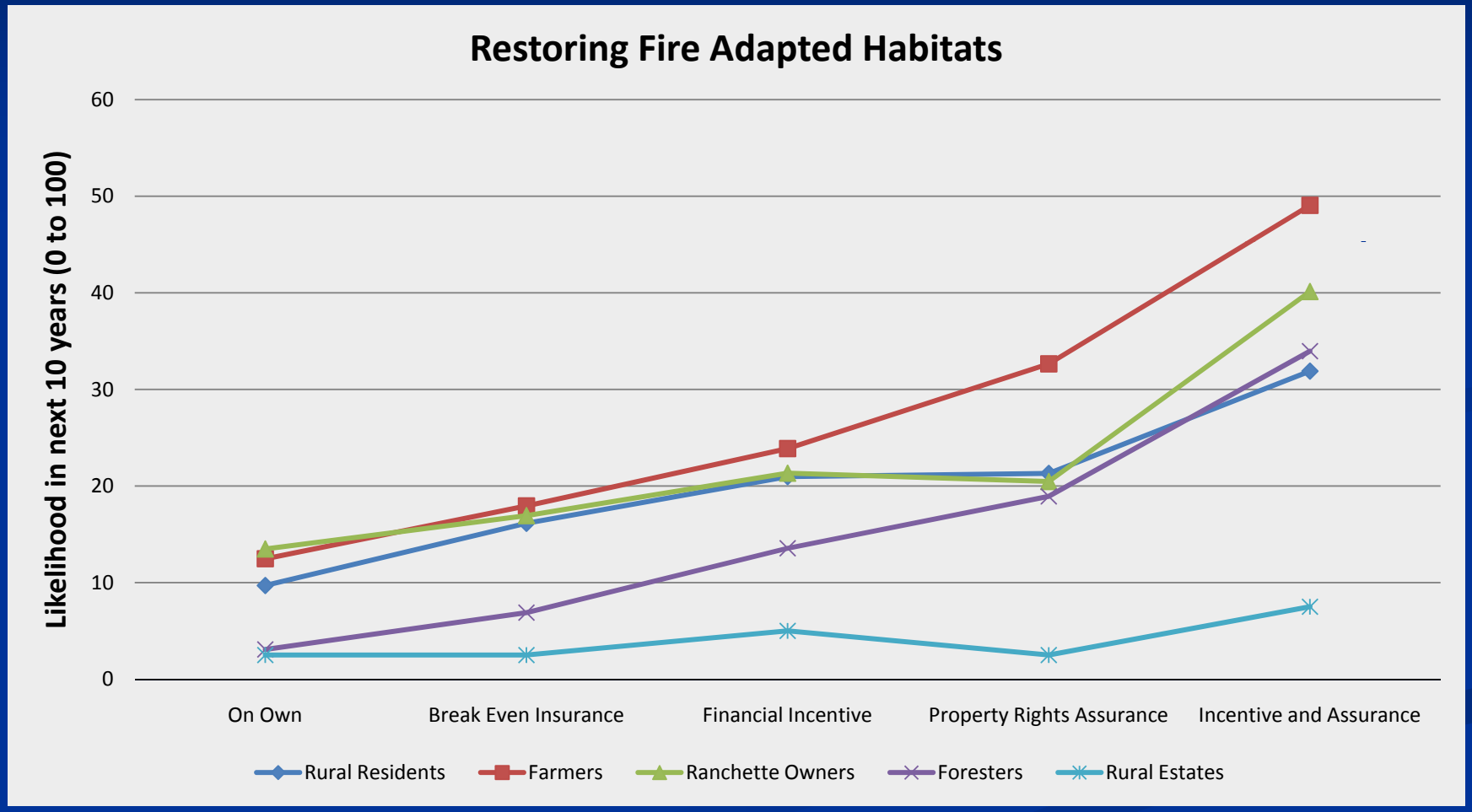
Results – Agent Types Motivation Scores



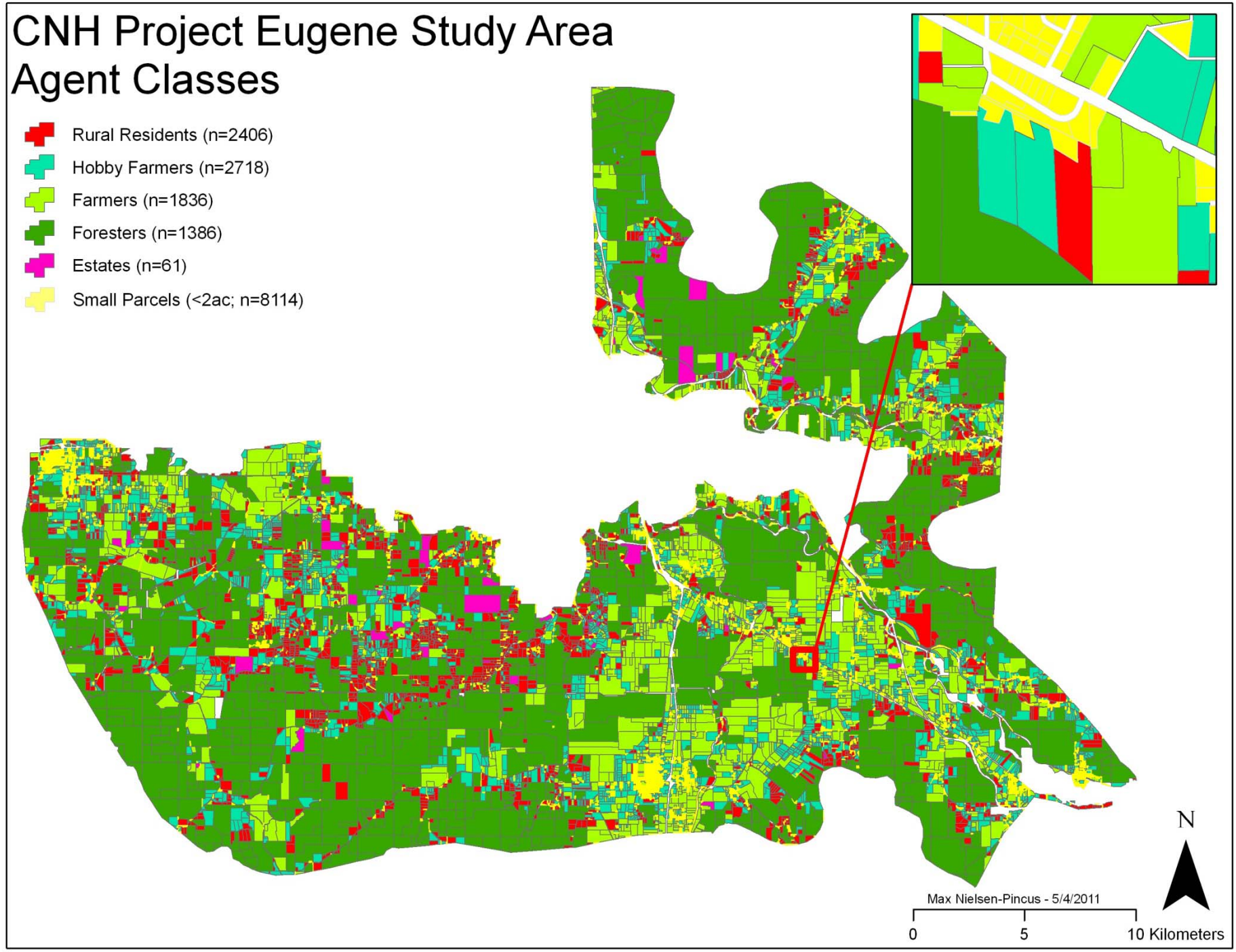
Results – Agent Types

- **Type I – Rural Residents (37%)**
  Small Parcels, Moderate Value, Amenity Motivated
- **Type II – Ranchette Owners (26%)**
  Moderate Parcels, Moderate Value, Diversified Motives
- **Type III – Farmers (24%)**
  Large Parcels, Low Value, Agricultural Motives
- **Type IV – Foresters (12%)**
  Large Parcels, Low Value, New, Forestry & Development Motives
- **Type V – Rural Estates (1%)**
  Moderate Parcels, High Value, New, Educated, Development Motives

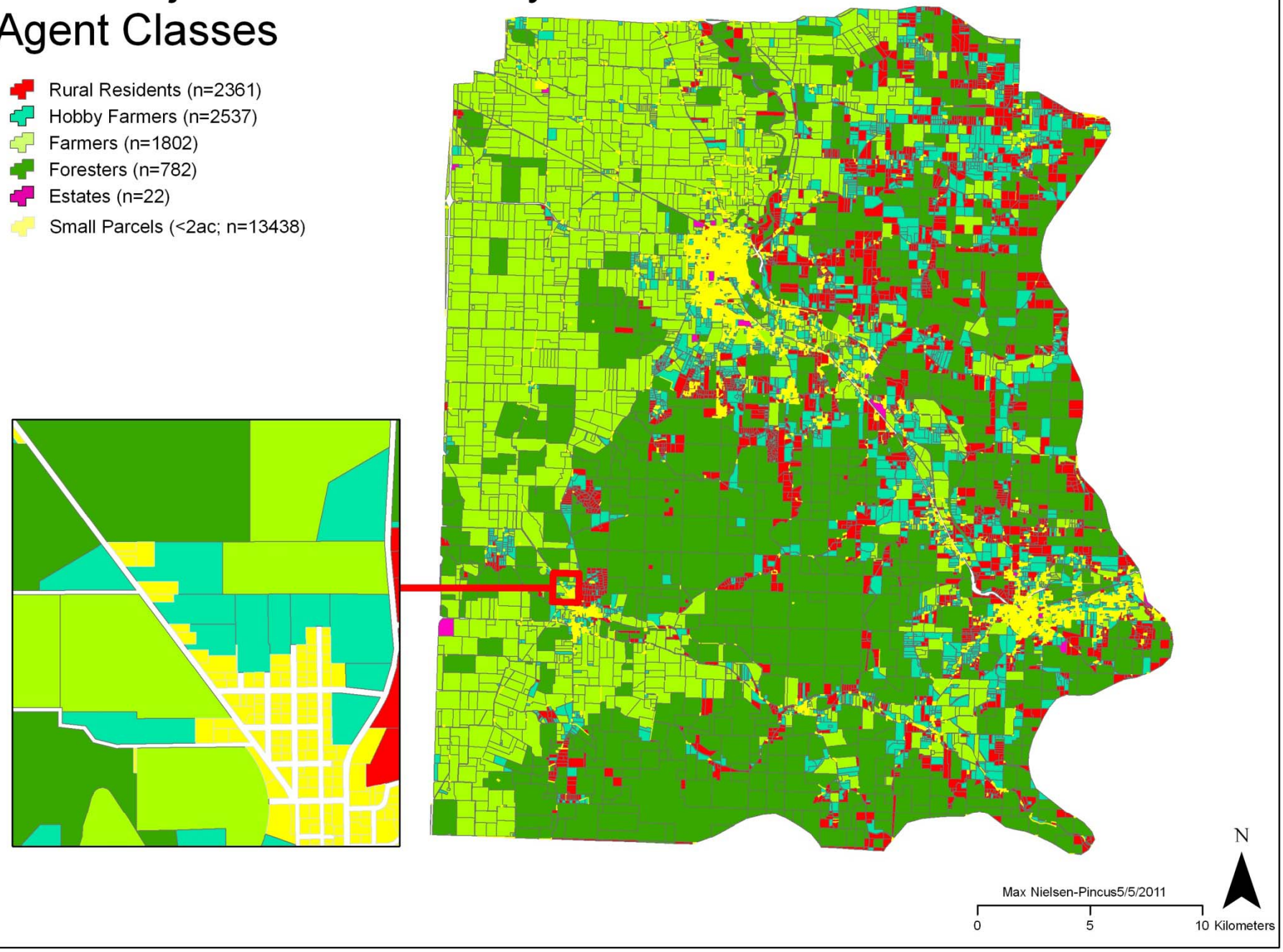
Results – Agent "Values"



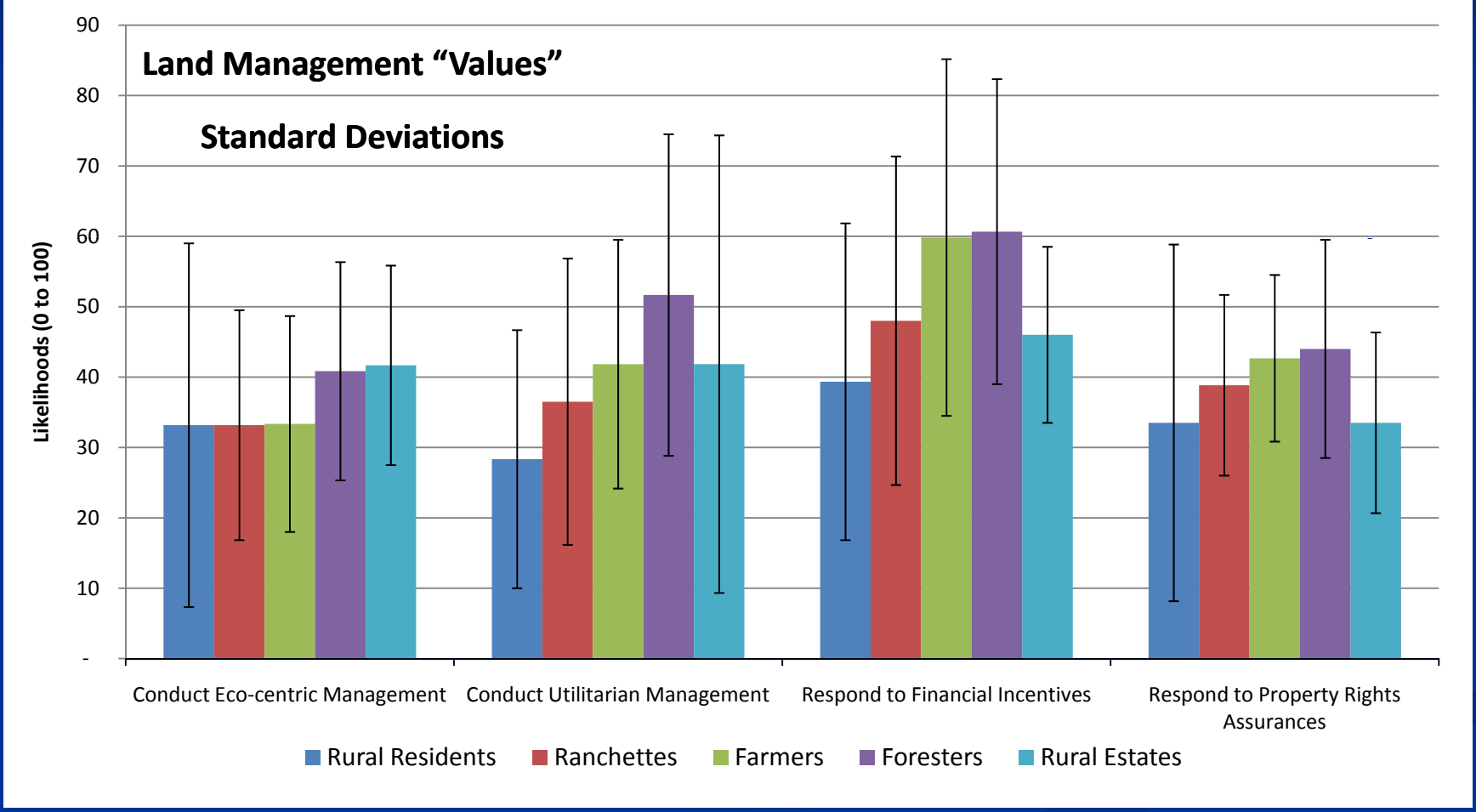
CNH Project Eugene Study Area
Agent Classes



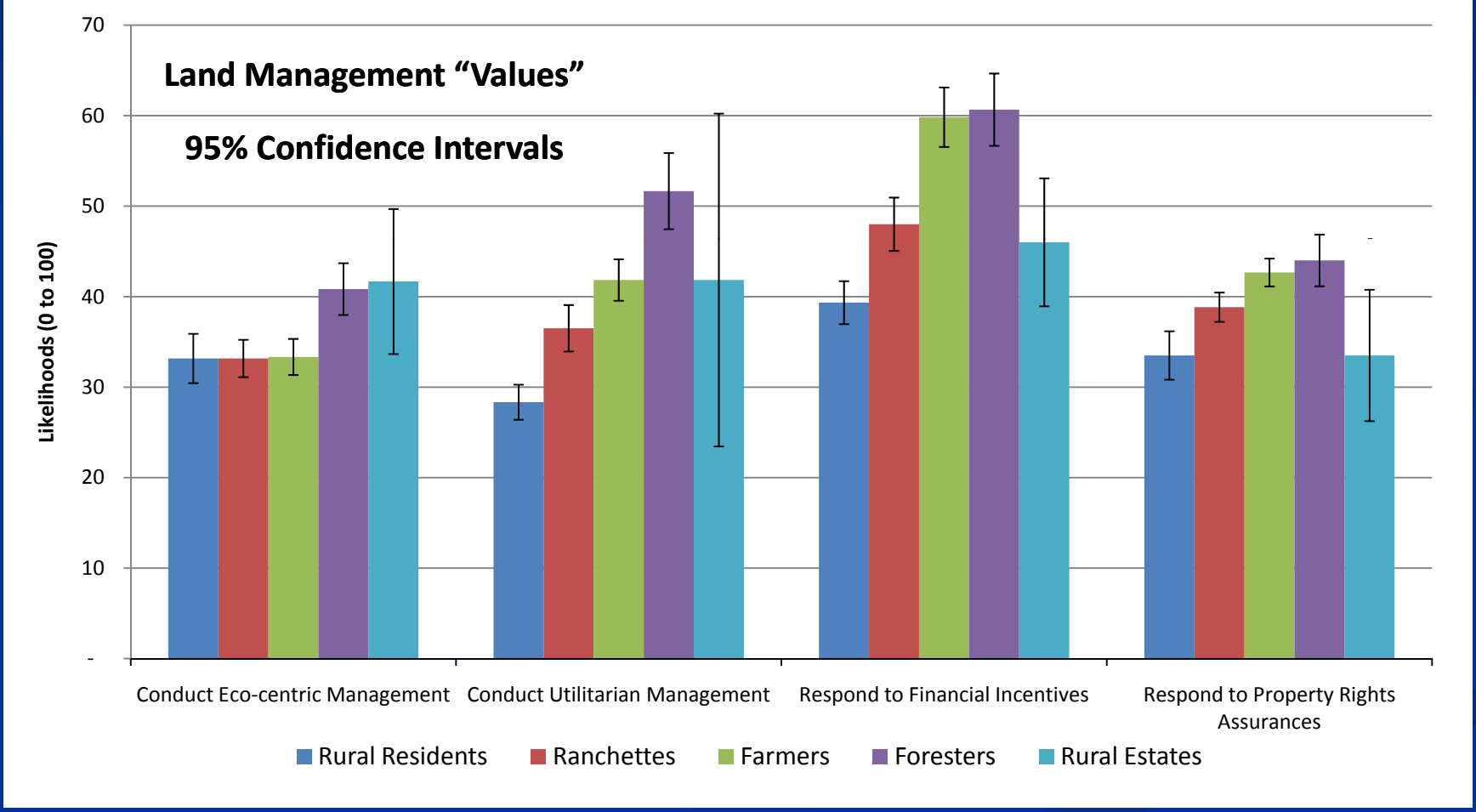
CNH Project Lebanon Study Area
Agent Classes



Why Fuzzy?


Land Management "Values"
Standard Deviations
Likelihoods (0 to 100)
90
80
70
60
50
40
30
20
10
-
Conduct Eco-centric Management
Conduct Utilitarian Management
Respond to Financial Incentives
Respond to Property Rights Assurances
Rural Residents
Ranchettes
Farmers
Foresters
Rural Estates

Why Fuzzy?


Land Management "Values"
95% Confidence Intervals
Likelihoods (0 to 100)
70
60
50
40
30
20
10
-
Conduct Eco-centric Management
Conduct Utilitarian Management
Respond to Financial Incentives
Respond to Property Rights Assurances
Rural Residents
Ranchettes
Farmers
Foresters
Rural Estates

Next Steps

- Stakeholder group developing **policy scenarios** (Summer and Fall 2010)
- Couple models of agents, policies, vegetation, climate, and wildfire, and **run fully coupled landscape simulations** (Summer 2011)
- Identify **scenarios that best protect people and ecosystems** across the uncertainties of climate, wildfire, and land use
- **Refine –**
  - How do agents learn (neighbors, adaptive mgmt)
  - Allow agents to change as landscape changes around them
  - New agent types (climate migrants?)

Acknowledgements

Bart Johnson, David Hulse, John Bolte, Landowners

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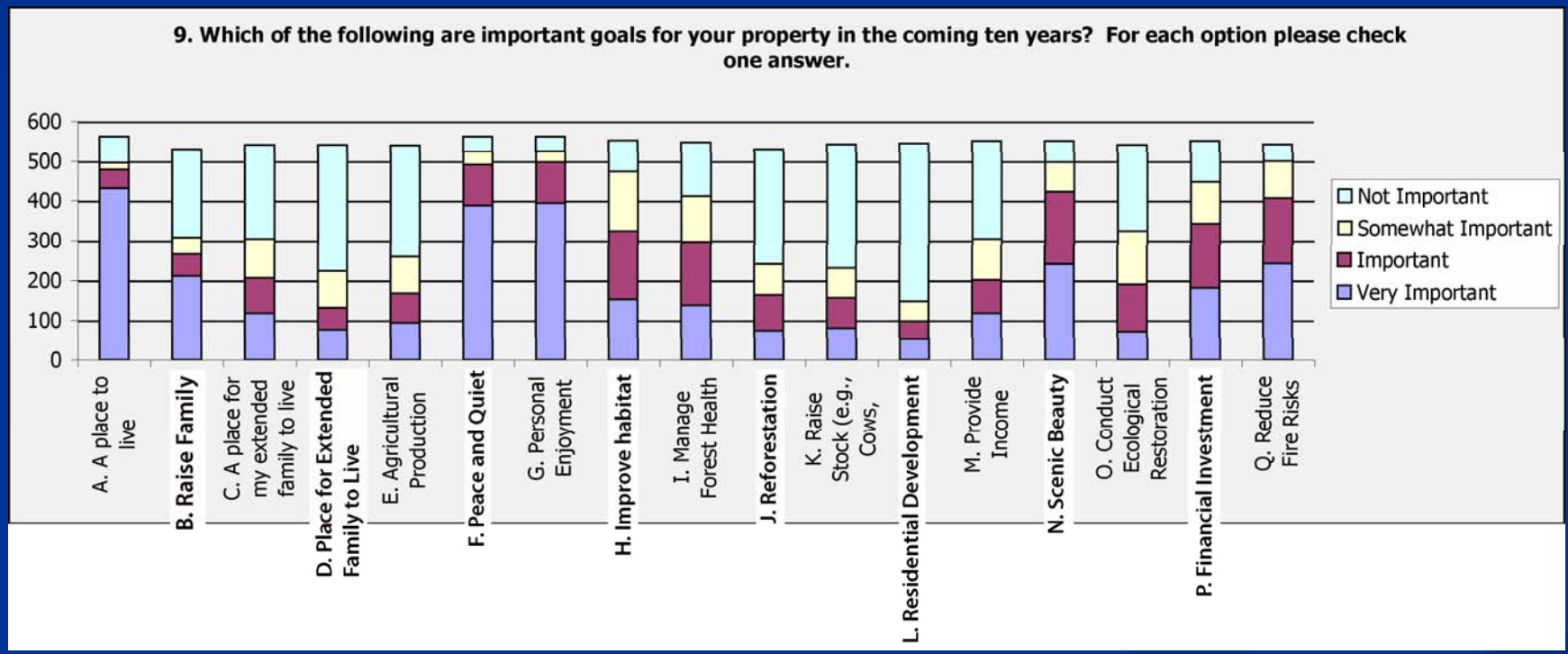
Agent Type Definition: Goals for Managing Land

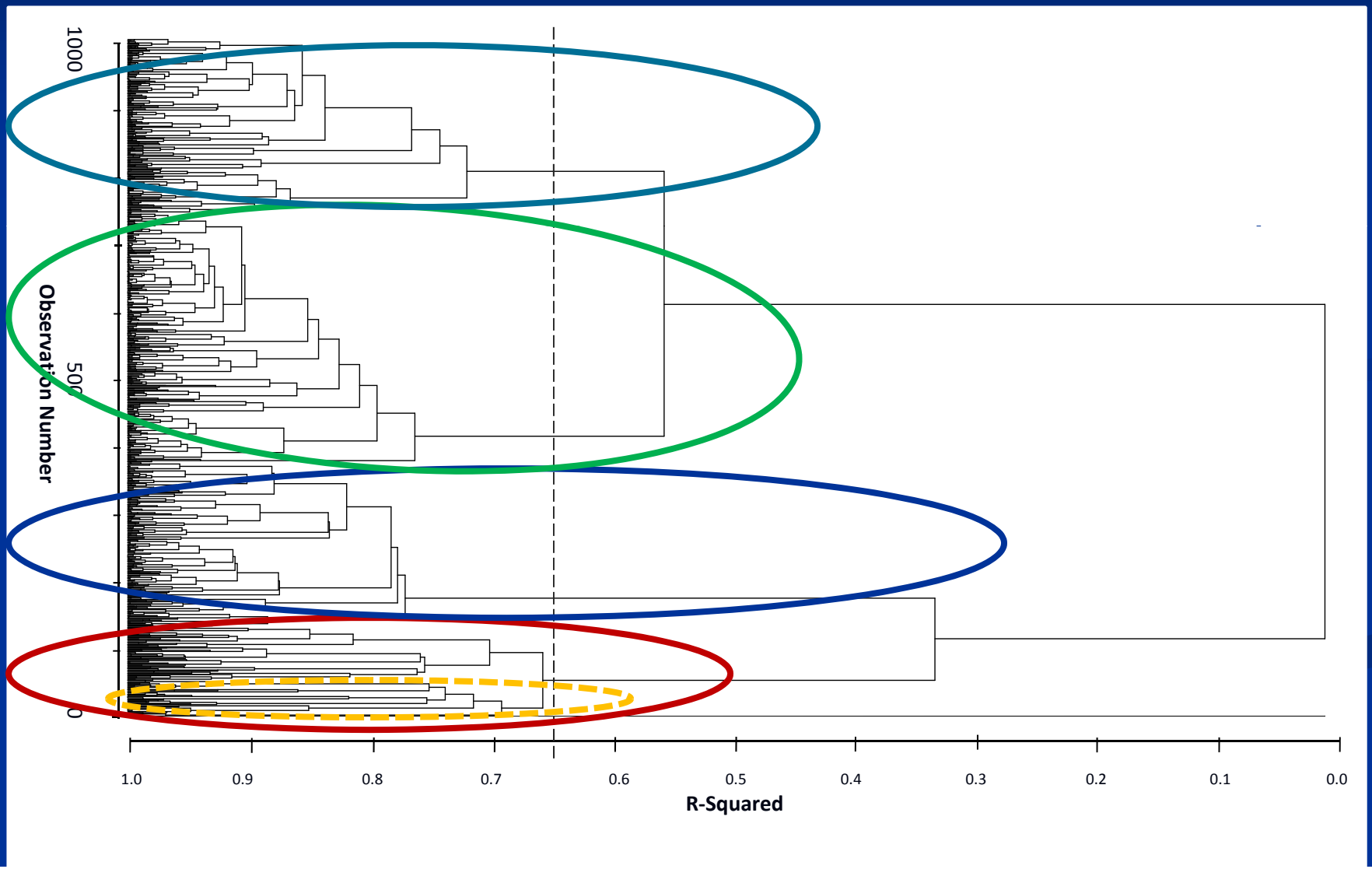


Factor Analysis – Landowner Goals

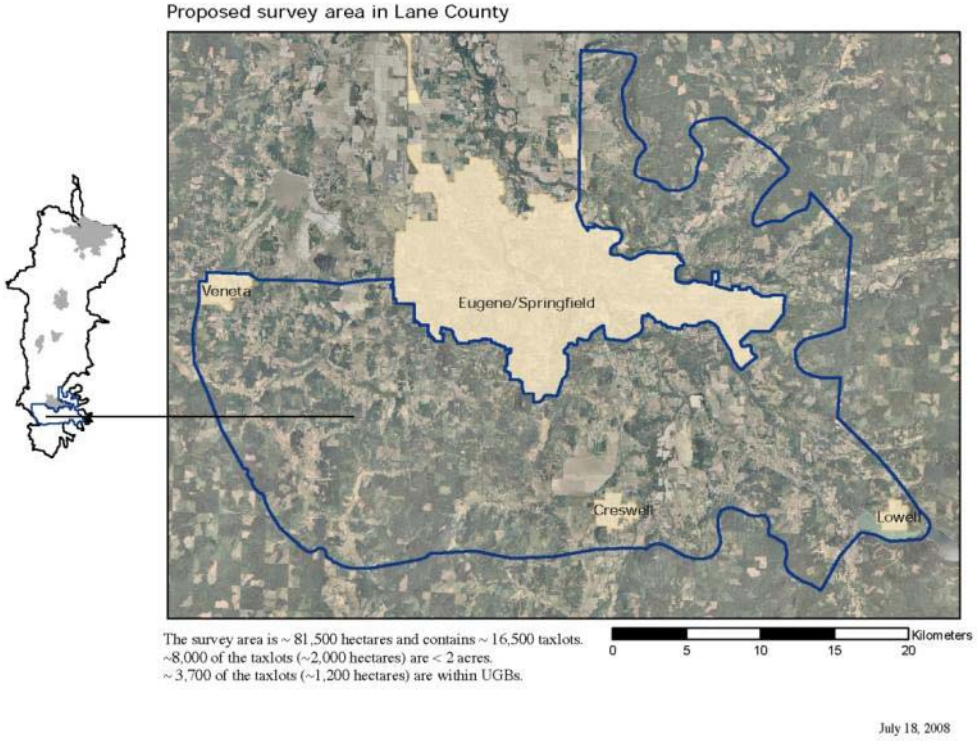
Ownership Goals	Amenity Engagement	Forest Management	Home & Family	Farming	Development
Peace and quiet	.76 | .76				
Personal enjoyment	.78 | .78				
Improve wildlife habitat	.62 | .62				
Maintain or improve scenic beauty	.77 | .77				
Conduct ecological restoration	.57 | .57				
Reduce fire risks	.49 | .50				
A place to live	.60 | .58		.58 | .59		
A place to raise my family			.75 | .75		
A place for my extended family to live			.73 | .74		
Timber production		.79 | .79			
Manage forest health		.78 | .77			
Reforestation of cleared land		.81 | .81			
Agricultural production				.88| .87	
Raise stock				.74| .74	
Provide income				.60| .60	
Residential development					.72 | .72
Land as a financial investment					.77 | .78

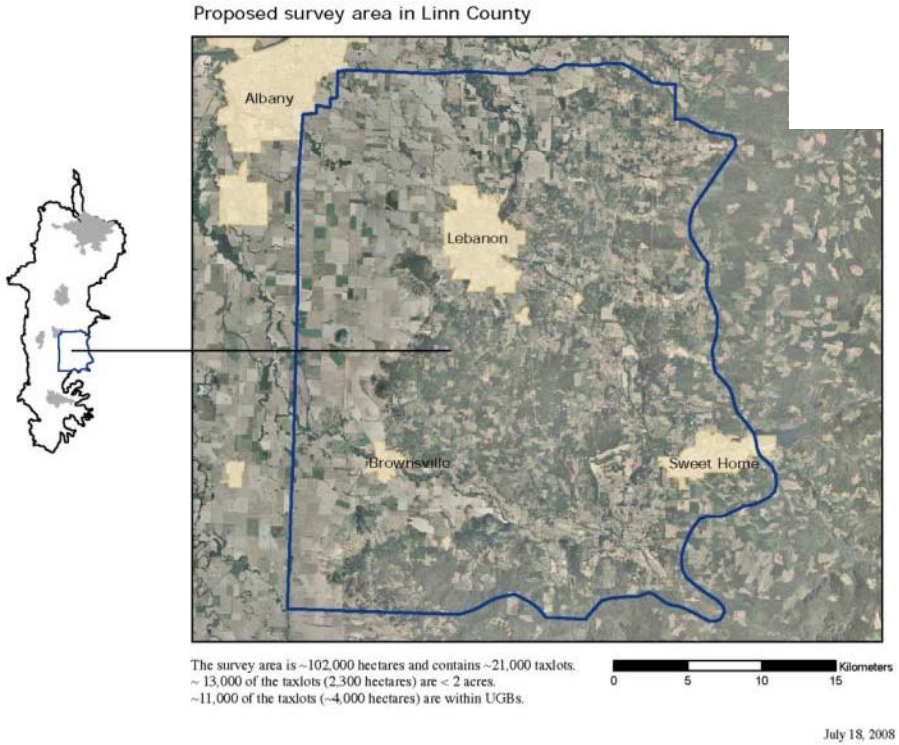
Raw Results (n=847) | Imputed Results (n=943); Eigenvalues > 1.0; Five factors account for 65% of variance

Cluster Tree – 5 Underlying Motivations



Agent Type Allocation





Two contrasting 1000-km^2 study areas

Agent Type Allocation

- Use variables common to survey respondents and all parcels:
  - Parcel Size
  - Improvement Value
  - Average acres of Oak
  - Percent of parcel classed as Agriculture
  - Percent of parcel classed as Forest
  - Percent of parcel not classed as Other LULC