The problem

- Have a phenomenon that changes with time and space
- Want to model time and space explicitly – not as a snapshot
- Want to model the interactions how they occur, through the eyes of the phenomenon
- Give virtual agents brains and let them interact
- From the aggregation of the individual decisions the perceivable patterns are created
What is Agent-Based Modeling?

- Alternative modeling approach
- Use when all others fail
- Explores causality
- Creates patterns not describes them
Outline

• What is Agent-Based Modeling

• Present the cougar model problem

• Demonstration
How does it work?

- You identify objects or agents
  - Animals
  - Terrorists
  - Land parcels
  - Any thing that “makes a decision” or performs an action
- The agents do things (perform an action or not)
- Base their decisions on:
  - Their state
  - Interactions with other agents
  - Interactions with the external world
    - Global factors
    - Environment Factors (from surfaces or maps)
- Scheduler – defines the time steps
Why ABM and GIS?

- Agents many times make decisions in space
  - Where the agent is and what is around them
  - Where other agents are relative to processing agent

- Behaviors of an agent may involve movement

- Agent’s decisions can be based on spatial analysis derived from a GIS

- Agents can change the spatial arrangement of things

- Agent’s decision making changes with the changing landscape
Modeling cougars
Sample Application – Cougars

The Model

Agents

Behaviors

Home Ranges

Based on Energetics

Safety

The Scheduler

Other Agents

Prey

Surrogate for Human population

Energetics

The Model

Agents

Behaviors

Home Ranges

Based on Energetics

Safety

The Scheduler

Other Agents

Prey

Surrogate for Human population

Energetics
More about cougar biology

• Cougars are opportunistic
  - There is a chance or probability that a cougar can catch prey at any time step

• Whether a cougar makes a kill is based on:
  - Available prey
  - The probability of catching a prey based on hunting advantage
  - How hungry am I

• Whether I have sex (for a male) depends
  - Is there a female within 3 kilometers and do I detect her

• Otherwise I wander (with intent) within my home range
Hunting behavior
Hunting behavior
Movement is based on attractors

- **Home range**
  - Makes sure the cougar stays within the home range

- **Habitat**
  - Moves from one good habitat within their home range to another to protect their resources

- **Kill**
  - When make kill it will be a strong attractor - depends on type of kill (how long it takes to consume it)

- **Female**
  - When find one strong for 12 hours.
Balancing Security/Habitat/Home Range

- Competing goals – trade offs
- Opportunistic and maximize
- Marbles algorithm
- Temporary
  - Female
  - Kill

Home Range Repellant

Habitat Attractor

Security
What happens each time step

- How hungry am I and what is the time of day
- Look at my neighboring values
- Which locations would be best depends on my current goals:
  - to stay within the home range
  - to move toward a habitat
  - to stay secure
- Check on other attractors: a female or a kill
- A movement is made based on a trade off of the above goals
- Did I make a kill
  - If I did, what kind is it
The Agent Analyst extension

- Repast with ArcGIS 10.0 (mid-level integration)

- Argonne National Laboratory collaborated with Esri to create the extension - not an Esri product

- Integrated into ArcGIS Geoprocessing environment and takes advantage of Java ArcObjects

- Free and open source

- It is a user group community product

- Software and book free from:

The resource center

Agent Analyst: Agent-Based Modeling in ArcGIS

Agent Analyst. Agent-Based Modeling in ArcGIS is an introduction to agent-based modeling using an open-source software called Agent Analyst, which is compatible with ArcGIS software. This workbook's step-by-step exercises, written by agent-based modeling experts, demonstrate how to create agent-based models using points, polygons, rasters, and representation networks. Key topics include creating, manipulating, and scheduling actions and fields. The book shows how to implement basic-to-complex decision making by agents, and demonstrates the code to capture these decisions. Agent Analyst: Agent-Based Modeling in ArcGIS includes exercises, case studies, and code necessary to begin building agent-based models in ArcGIS Desktop 10. You can download Agent Analyst: Agent-Based Modeling in ArcGIS by clicking the link below.

Agent Analyst: Agent-Based Modeling in ArcGIS (45.8 MB - PDF)

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Software

You will need ArcGIS Desktop 10 and Agent Analyst software to complete the exercises in Agent Analyst: Agent-Based Modeling in ArcGIS. Any license level of ArcGIS Desktop 10 software will work. If you need ArcGIS Desktop 10 software, you can download a 60-day trial version at http://www.esri.com/trial. You can install Agent Analyst software by clicking the link below. Uninstall any previous versions of Agent Analyst before installing this version.

Agent Analyst software (35.1 MB - EXE)

System requirements for ArcGIS Desktop 10
Collaborators

- Esri
- Argonne labs
- University of Redlands
- University of Michigan
- Michigan State
- Temple University
- University of Indiana
- USGS
- Hopefully will be many more….
Demo 1: Agent Analyst
Thank you…

- Please fill out the session survey:

  First Offering ID: 490/1293

Online – [www.esri.com/ucsessionsurveys](http://www.esri.com/ucsessionsurveys)

Paper – pick up and put in drop box
Understanding our world.