Agent-Based Modeling in ArcGIS

Kevin M. Johnston

The problem

- Have a phenomenon that changes with time and space
- Want to model time and space explicitly – not as a snap shot
- 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

Agents

Behaviors

The Model

Home Ranges

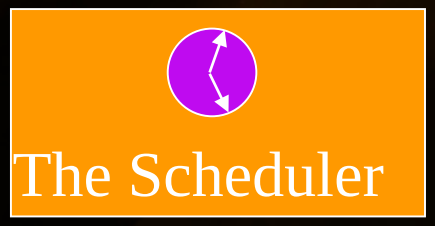
Other Agents

Based on Energetics

Safety

Prey

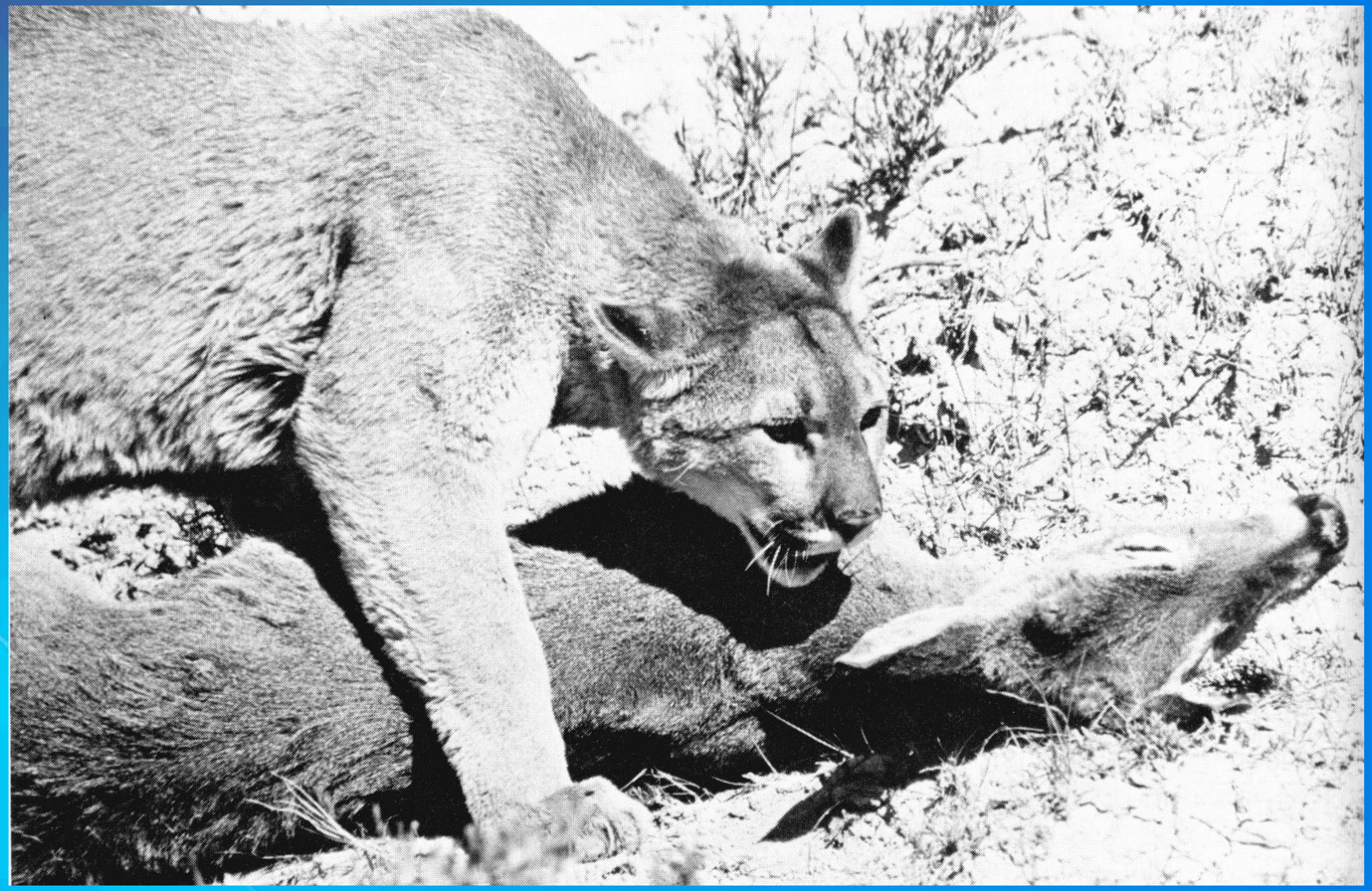
Surrogate for Human population



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



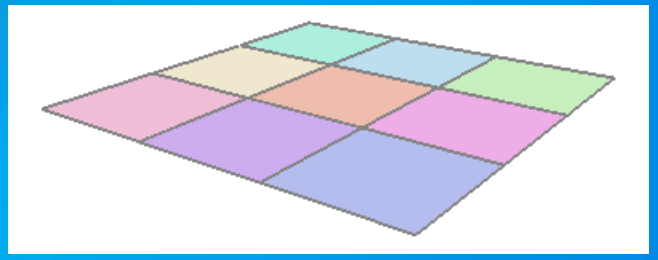
Hunting behavior

Movement is based on attractors

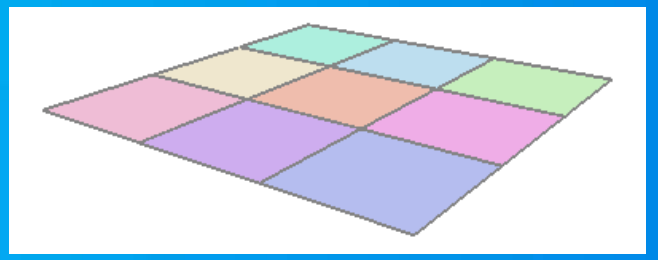
- Home range
  - Makes sure the cougar stays within the home range
- Habitat
  - Moves from one good habitat within their home range to another to protect their resources
- Kill
  - When make kill it will be a strong attractor - depends on type of kill (how long it takes to consume it)
- Female
  - When find one strong for 12 hours.

Balancing Security/Habitat/Home Range

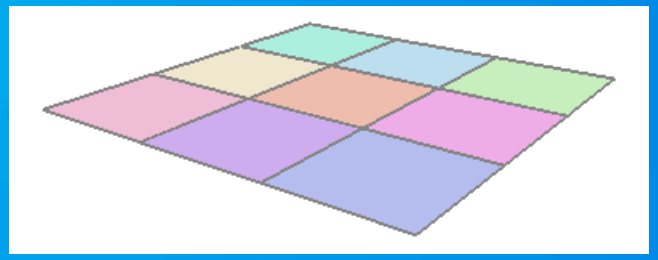
- Competing goals – trade offs
- Opportunistic and maximize
- Marbles algorithm
- Temporary
  - Female
  - Kill



Home Range Repellant

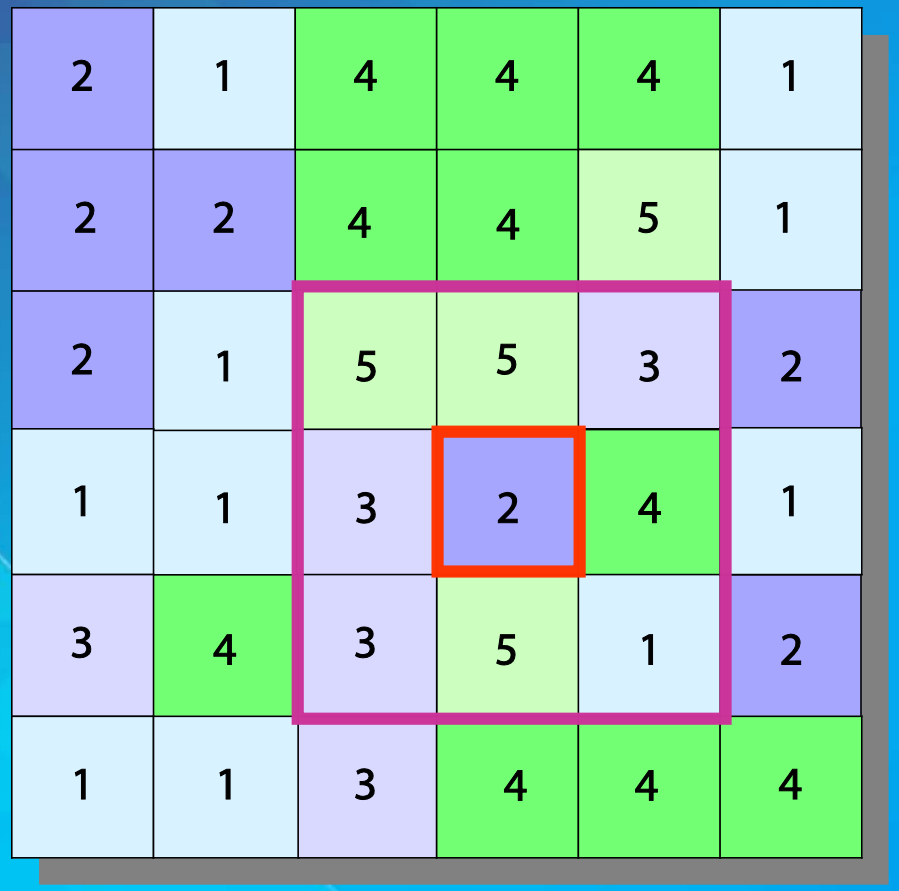


Habitat Attractor

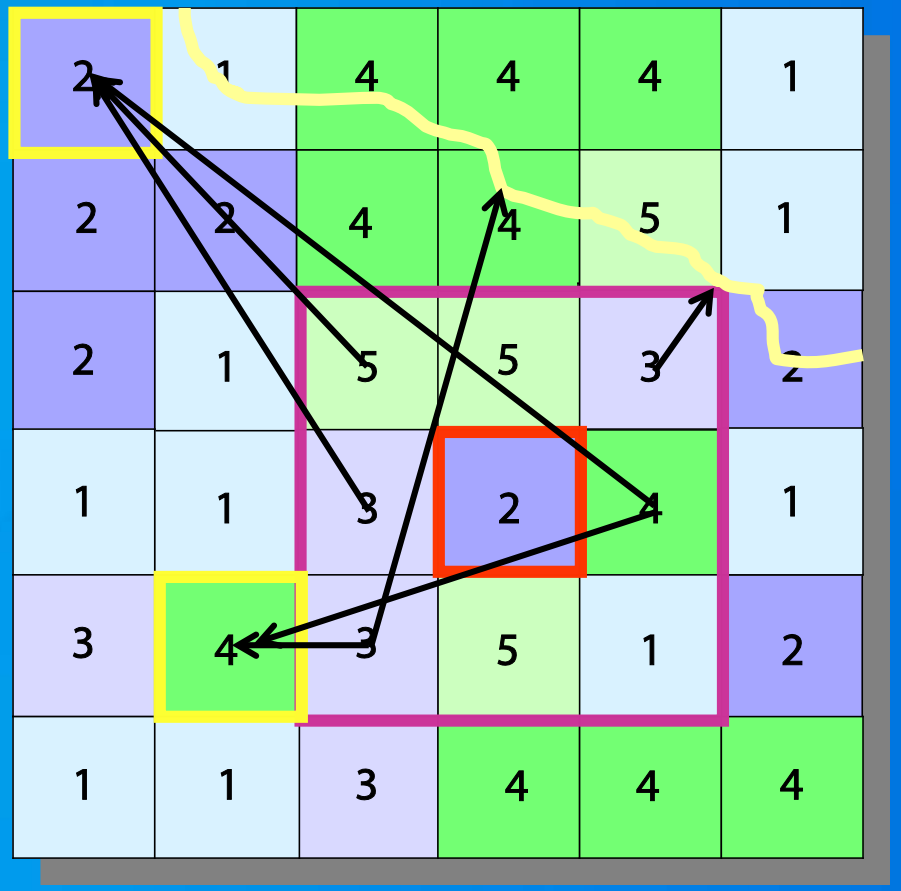


Security

Movement is based on attractors



Attribute weighting



Spatial weighting

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:

http://resources.arcgis.com/en/help/agent-analyst/

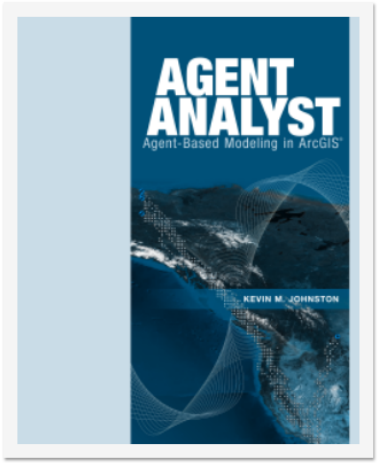
The resource center

ArcGIS Resources

ArcGIS Online Sign In English esri

Home Communities Help Blog Forums Videos Search ArcGIS Resources

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 representative 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]

Contributors: Kevin M. Johnston (Editor), Daniel G. Brown, Nicholson Collier, Hamid R. Ekbia, Mary Jo Fraley, Elizabeth R. Groff, Michelle A. Gudorf, Naicong Li, Arika Ligmann-Zielinska, Michael J. North, Derek T. Robinson, and Nathan Strout.

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

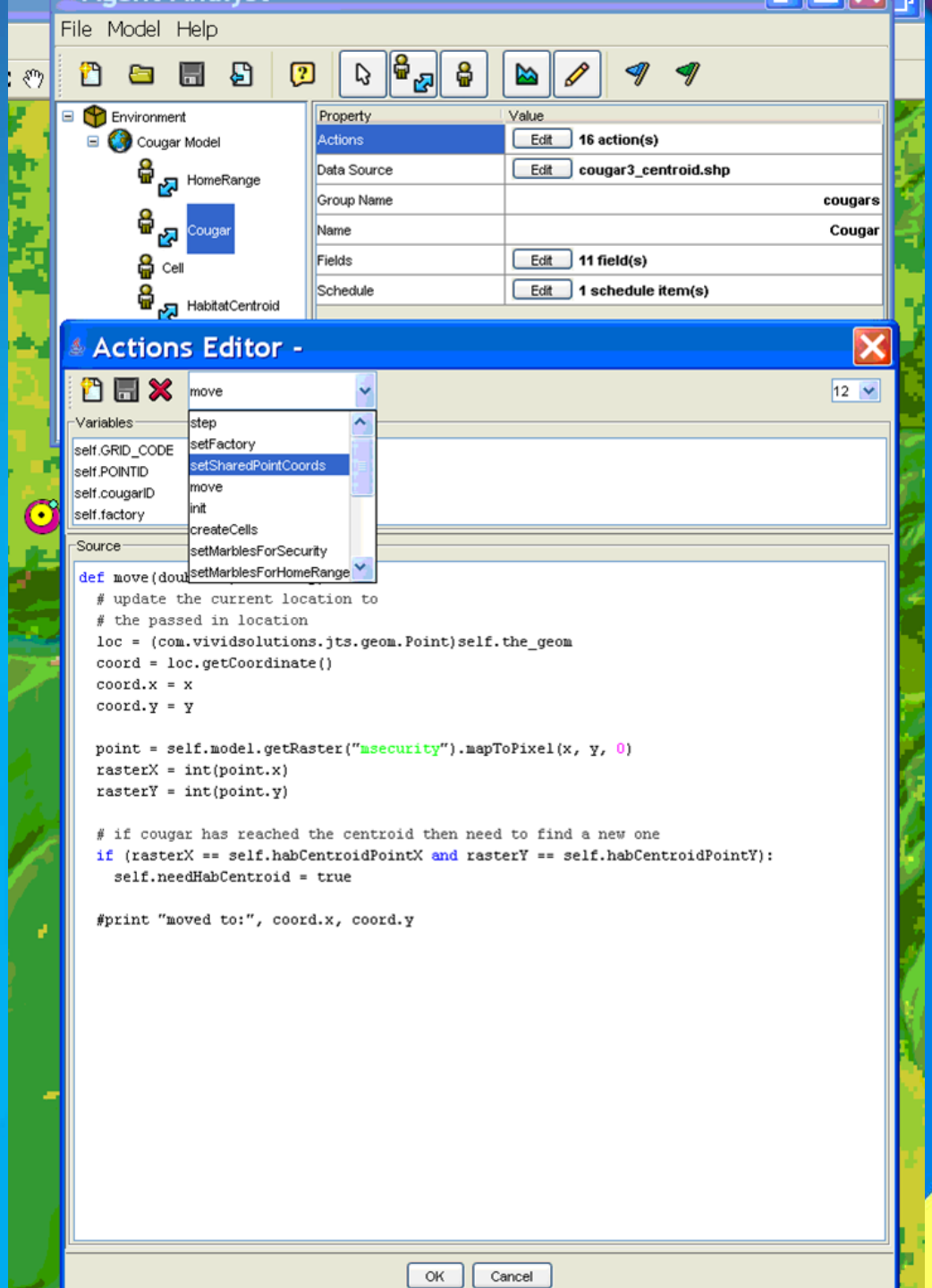
Collaborators

- Esri
- Argonne labs
- University of Redlands
- University of Michigan
- Michigan State
- Temple University
- University of Indiana
- USGS
- Hopefully will be many more….

Demo

Agent Analyst

- Agents
- Fields
- Actions



Summary

- Model time and space explicitly – not as a snap shot
- Explores causality
- The aggregate of the individual decisions creates observed patterns as emergent patterns
- Agent-based modeling is composed of agents, actions, fields, and a scheduler
- Agent Analyst is a mid-level integration between Repast and ArcGIS
- Open source with the software and book free from:

http://resources.arcgis.com/en/help/agent-analyst/

Understanding our world.