A scruffy cycad. This species predates the dinosaurs.

A New Technology-Based Tool for Building Profitable Biodiversity-Conserving Offerings

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Me

Following my 34 years at the Lubar College of Business, University of Wisconsin-Milwaukee, I am now the director of my *Profitable Biodiversity* consultancy.

My consultancy helps private enterprise create profitable offerings whose sale indirectly benefits biodiversity.

Table of Contents

Biodiversity is Going Away

- The sixth mass extinction in the history of the planet is underway.
- Most large, wild mammals, many fish species, and many rare plants will be gone by 2060.
- Current conservation strategies are not working.

Cycads, Sharks, and Elephants

- For instance, the cycad plant, poached as a status symbol and investment, has been on this planet for about 280 million years. Dinosaurs didn't show up until 245 million years ago.
- The great white shark, a particular species of fish is endangered.
- And the African savanna elephant was added to the IUCN Red List in 2021.

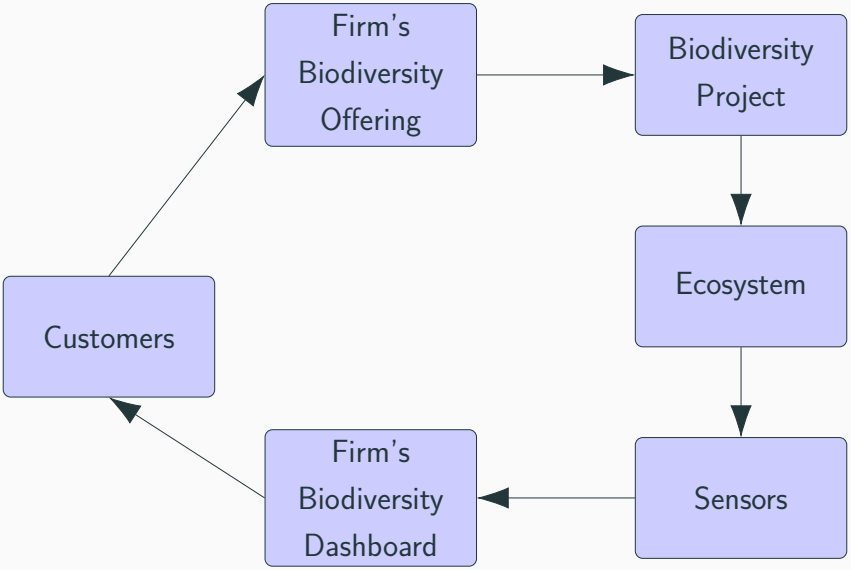
Curbing These Human-Driven Extinctions

- The wholesale killing of animals and plants needs to stop, and habitat destruction needs to be curtailed.
- But achieving these two goals will require **initiatives** that move people away from these behaviors.
- To be realistic, these initiatives need to be derived from credible models of those **political-ecological** systems that host endangered species.

Private Enterprise to the Rescue

- Private, for-profit firms could save biodiversity by developing and running these initiatives. Indeed, private enterprise might be the last hope for many species.
- **HOW COULD THIS BE MADE TO WORK?** In short, by making biodiversity conservation **profitable**.

Profitable Biodiversity Business Model



Selling to Biodiversity-Concerned Customers

1. A firm identifies a species they want to save.
2. They launch a new product or service called a **biodiversity offering** that is attached to a **biodiversity project**.
3. They maintain a public-facing **biodiversity dashboard** that contains real-time, and audited information on the project and the species being saved.

Overview of the Ecosystem Management Tool (EMT)

- Developed by Me, written in JAVA$^{(TM)}$, and freely available.
- Models political-ecological systems.
- Statistically estimates the parameters of these models.
- Solves the Most Practical Ecosystem Management Plan (MPEMP) optimization problem.

An EMT-Generated Biodiversity Project

1. The firm models the political-ecological system that contains their species.
2. Using this model, the firm computes the MPEMP and designs a project to implement it.
3. The firm implements this project and an attendant monitoring program that feeds real-time data to the firm's biodiversity dashboard.

Why Would this Work?

- Firms exist to make a profit: Biodiversity offerings are priced and managed to be profitable.
- Biodiversity offerings would tap into a giant market niche of people wanting to help but feeling powerless.
- Customers buying the offering would know that they are paying a premium that will cause a measurable improvement in the species' sustainability.

This Conservation Strategy is Resource-Rich and Distributed

- Firms hold most of the world's wealth and expertise. Collectively, they have the resources to solve a planet-level problem.
- Because firms are not all under a single, hierarchical control structure, a few newly-minted tyrants would not be able to shutdown all firm-level biodiversity projects.

Biodiversity Project Types Ordered by Effectiveness

1. Improving habitat by reducing the firm's raw material demands from species-hosting countries.
2. Improving habitat by relocating/shutting operations within species-hosting countries.
3. Reducing poaching by owning and operating a production/service facility in a city that draws people away from ecological **hotspots**.

Biodiversity Project Types Continued

4. Providing expertise, data, software, and hardware to international law enforcement teams fighting wildlife trafficking.
5. Owning and operating a private wildlife reserve.
6. Owning and operating captive breeding facilities for critically-endangered species.

Modeling a Political-Ecological System with the EMT

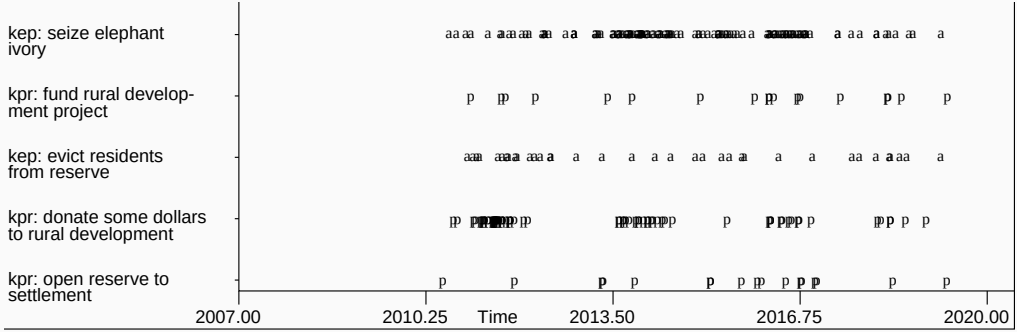
- Agent-based submodels make decisions about actions that affect an at-risk species.
- Agents include poachers, kingpins, consumers, farmers, wildlife protection agencies, and governments.
- An individual-based submodel of the targeted species' abundance affects and is affected by agent decisions.

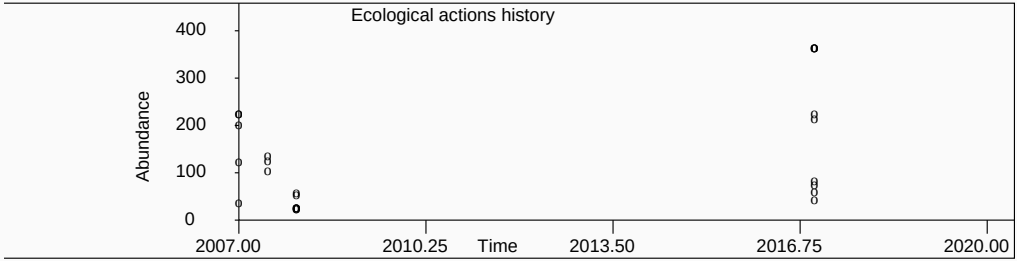
Searching for the Best Ecosystem Management Plan with the EMT

- Try each of the above biodiversity project types to find the most politically-feasible and ecologically-effective biodiversity project.
- Do this by solving the MPEMP optimization problem.

A Modeling Example: East African Actions from Online Sources

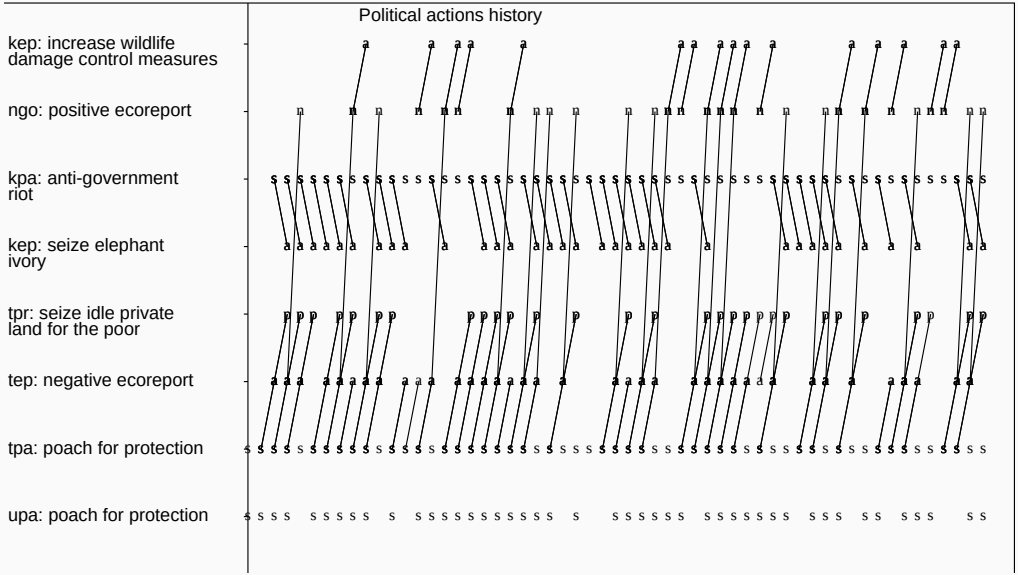
This plot segment is for the period from January 2007 through June 2019. The symbol "p" indicates an action taken by a presidential office, "a" an action taken by an EPA, "r" an action taken by rural residents, "s" an action taken by pastoralists, and "n" an action taken by an NGO. Selected out-combinations only are labeled. The bottom plot is observed cheetah abundance.


kep: seize elephant ivory
kpr: fund rural development project
kep: evict residents from reserve
kpr: donate some dollars to rural development
kpr: open reserve to settlement
2007.00
2010.25
Time
2013.50
2016.75
2020.00


Ecological actions history
Abundance
400
300
200
100
0
2007.00
2010.25
Time
2013.50
2016.75
2020.00

Forecasted Actions under a Proposed Biodiversity Project

- Actions history time series generated by the cheetah ecosystem model under a proposed biodiversity project (lines connect action-reaction sequences).
- One frequent action sequence or **episode** is:
  poaching event $\rightarrow$
  negative ecosystem status report $\rightarrow$
  land gift to the poor.

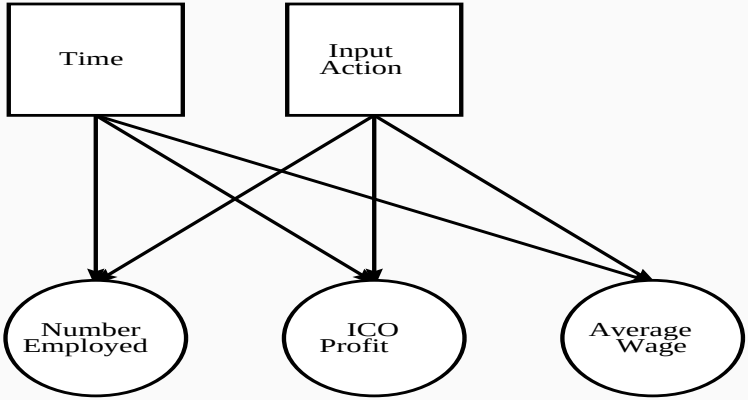

Political actions history
kep: increase wildlife damage control measures
ngo: positive ecoreport
kpa: anti-government riot
kep: seize elephant ivory
tpr: seize idle private land for the poor
tep: negative ecoreport
tpa: poach for protection
upa: poach for protection

A Project Example: An In-Country Operation (ICO)

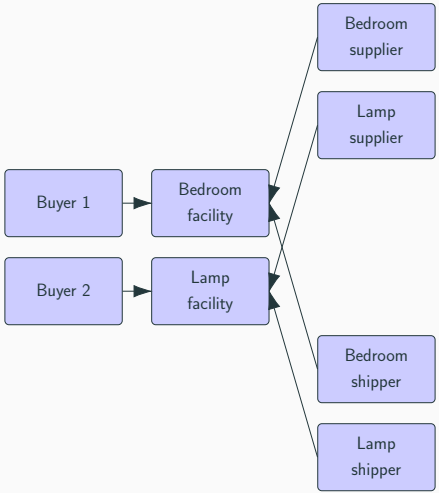
- A furniture manufacturer decides to open a facility in a rhino-hosting country in order to draw would-be poachers into manufacturing jobs – and away from rhinos.
- They name their ICO, "Elegant Furniture."

The Project's Business Network

The model's manufacturing network interacts with the other submodels through its *influence diagram* (ID):



Agents in this ID are Stochastic and Interact with Each Other



Business Network Architecture

- Elegant Furniture owns a bedroom facility and a table lamp facility.
- These business agents are either manufacturing facilities or suppliers to these facilities.
- Each manufacturing facility is supplied by a component parts supplier who carries an unlimited inventory, and a service provider such as a shipper who carries no inventory.

Agent Mechanisms

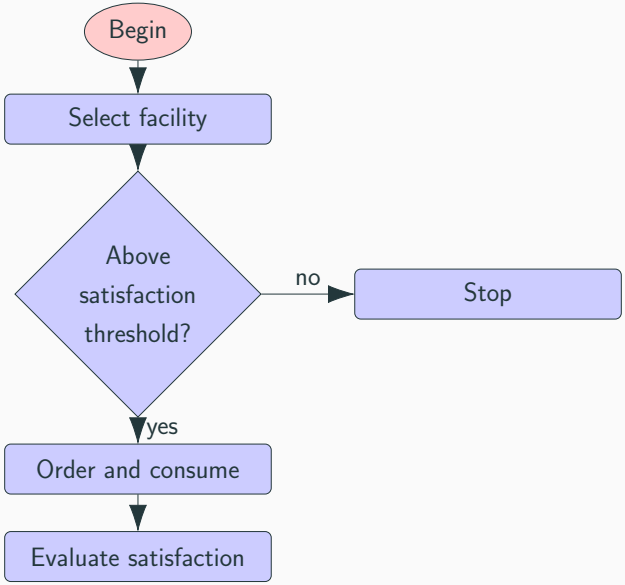
- All business agents have customers and a workforce.
- Buyer-facing agents set prices that were determined in the firm's previous *demand shaping campaign*, and have inventories that they replenish from suppliers.
- Agents update in a nearly random order.
- An order placed by an agent at one time step is filled within the next time step.

Business Agent Goals

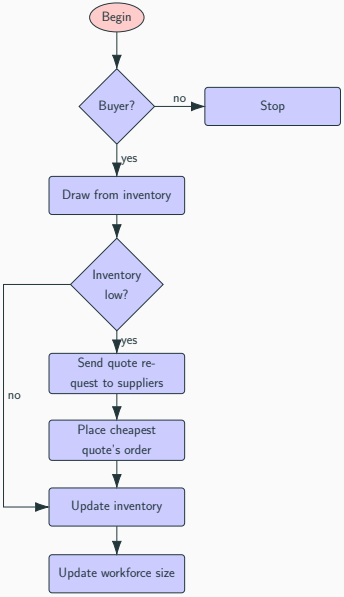
In this agent-based submodel, agents set prices, bid, and hire in order to advance their goals of:

- Increasing profits by increasing revenue.
- Growing by increasing staff size.

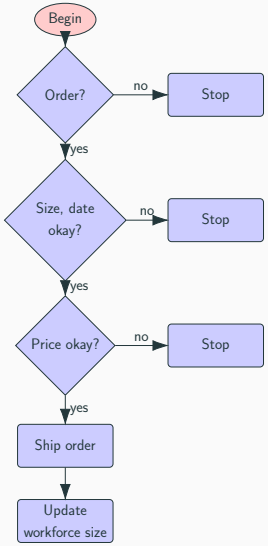
The Update Flowchart of a Buyer Agent



The Update Flowchart of a Facility Agent



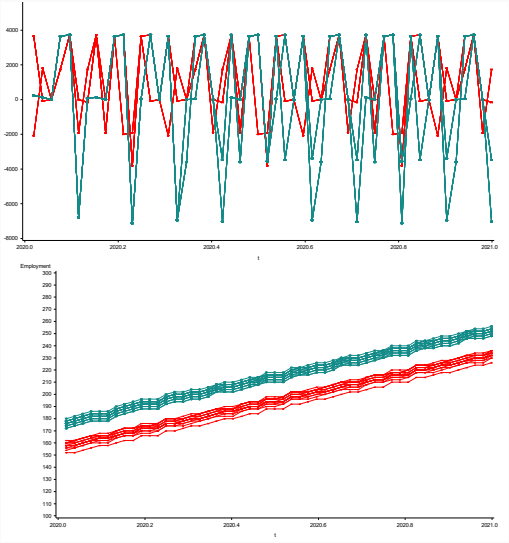
The Update Flowchart of a Supplier Agent



Simulating Project Operation with the EMT

- ICO capacity: 10000 units per year; Market 10000 buyers, each having a reserve price of 20 USD.
- Starting value of i^{th} business, w_i: 1500 USD.
- **Pure Profit:** Constant reserve price of 50% of buyers' reserve price
- **Maximum Employment:** Constant reserve price of 95% of the buyers' reserve price.

Employment and the ICO's Profit



Plot Interpretation

- Employment is higher under **Maximum Employment** relative to **Pure Profit**. This higher employment comes at the expense of the ICO's weekly profit.
- When there are no orders placed by ICO businesses to their suppliers, the ICO's profit is equal to its revenue – and this revenue is the same under both strategies because the buyers' reserve price is always the same.

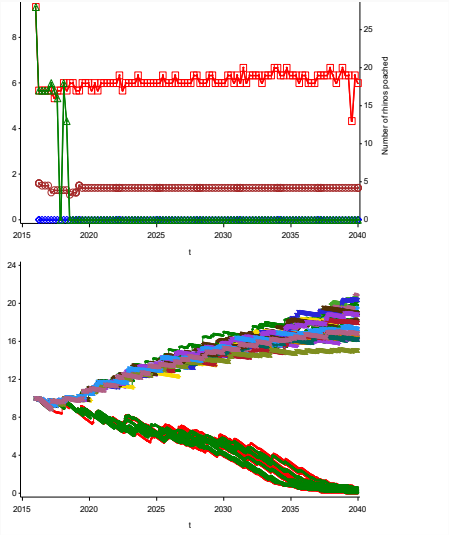
Using the EMT to Find the MPEMP

- The planning horizon is from 2015 through 2040.
- ICO wage is adjusted to find the MPEMP. Its value under **Pure Profit** is 59.0 – giving an MPEMP multiobjective function of -86.31.
- After running an optimization algorithm, this function increases 96% to -3.58 at an ICO wage of 1245.58.
- The MPEMP then, is: Set the ICO wage to 1245.58.

Poachers Learn to Not Poach

- Poachers learning parameter, l: diamonds= **Pure Profit**, circles= MPEMP.
- Number of rhinos poached: squares, triangles.

Learning Parameter and Rhino Abundance



Plot Interpretation

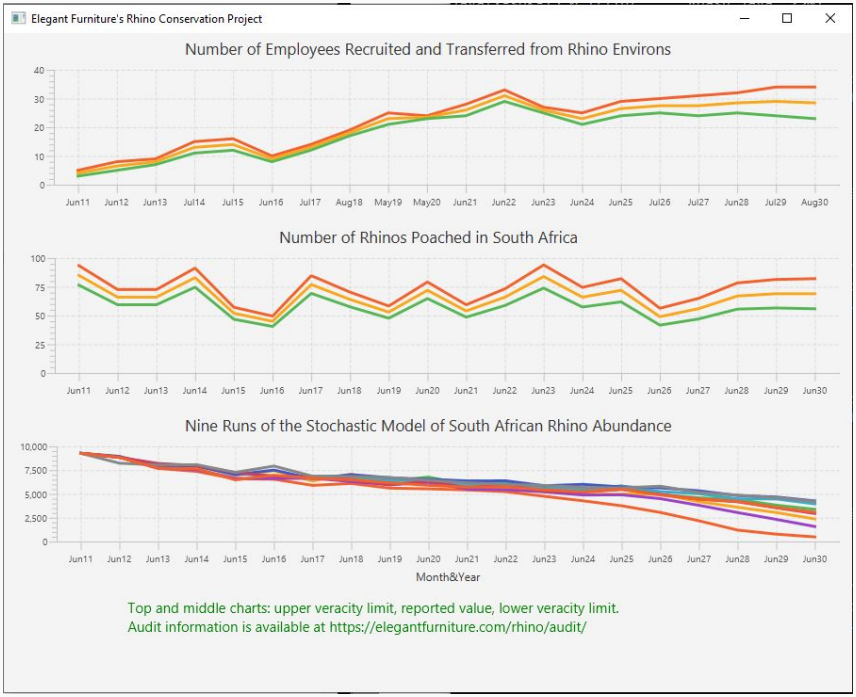
The causal chain that this plot depicts is:

1. Changes in poachers group perceptions cause
2. Changes in their behaviors that, in-turn, cause
3. Changes in the ecosystem.

Rhino extinction is avoided under the MPEMP but not under **Pure Profit**.

The Project's Biodiversity Dashboard

The biodiversity dashboard depicts the effect of Elegant Furniture's biodiversity project on poacher behavior – and that behavior's effect on the survival of the South African rhino.


Elegant Furniture's Rhino Conservation Project
Number of Employees Recruited and Transferred from Rhino Environs
40
30
20
10
0
Jun11 Jun12 Jun13 Jul14 Jul15 Jun16 Jul17 Aug18 May19 May20 Jun21 Jun22 Jun23 Jun24 Jun25 Jul26 Jul27 Jun28 Jul29 Aug30
Number of Rhinos Poached in South Africa
100
75
50
25
0
Jun11 Jun12 Jun13 Jun14 Jun15 Jun16 Jun17 Jun18 Jun19 Jun20 Jun21 Jun22 Jun23 Jun24 Jun25 Jun26 Jun27 Jun28 Jun29 Jun30
Nine Runs of the Stochastic Model of South African Rhino Abundance
10,000
7,500
5,000
2,500
0
Jun11 Jun12 Jun13 Jun14 Jun15 Jun16 Jun17 Jun18 Jun19 Jun20 Jun21 Jun22 Jun23 Jun24 Jun25 Jun26 Jun27 Jun28 Jun29 Jun30
Month&Year
Top and middle charts: upper veracity limit, reported value, lower veracity limit.
Audit information is available at https://elegantfurniture.com/rhino/audit/

Real-time Display of the Project's Effectiveness

- The dashboard's top, middle, and bottom charts are ICO employment of would-be poachers by time, number of poaching events by time, and rhino abundance by time, respectively.
- Thus, the direction of causality is from top to bottom.
- Ten years of historical data and ten years of predicted values are displayed under the MPEMP.

Closing the Loop Back to the Customer

- By looking at this dashboard, biodiversity-concerned customers can immediately see for themselves if Elegant Furniture's efforts are doing any good.
- If they are satisfied by this progress, they may become *repeat customers* – the **holy grail** of business.

Next Steps

1. Communicate to the world's senior managers that marketing biodiversity offerings may be the last hope for many species.
2. Improve the EMT's user-friendliness.
3. Perform a marketing analysis of a specific biodiversity offering to gauge potential sales.

Improving the EMT: Data Acquisition and Analytics Technologies

- Accurate *event detection* from all sorts of social media
- Statistical estimation of interacting agent-based models of political-ecological systems via optimization of expensive, black-box objective functions

Improving the EMT: Computing Technology

Runs of these stochastic, many-parameter models are expensive. Hence, massive computing resources and new optimization algorithms are needed to compute:

- Statistical estimates of model parameters
- Out-of-sample prediction error rates
- Parameter sensitivities
- Optimal ecosystem management plans

Open Problem: Autonomous Monitoring and Display of Ecological Data

- Needed: Persistent, self-healing, and self-restarting Internet-of-Things robots to continuously monitor political-ecological systems.
- Needed: Autonomous maintenance of a biodiversity dashboard so that it can display ecosystem monitoring data in real time.