Profitable Biodiversity

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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.

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.

What to do

- To curb this non-reversible destruction, 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.
- These initiatives need to be derived from credible models of those **political-ecological** systems that host endangered species.

Private enterprise could save biodiversity

- Private, for-profit firms could save biodiversity by developing and running these initiatives.
- **REALLY? HOW?**
- In short, by making biodiversity conservation profitable.

Selling to biodiversity-concerned customers

Step 1: A firm identifies a species they want to save.

Step 2: They launch a new product or service called a **biodiversity offering** that is attached to a **biodiversity project**.

Step 3: They maintain a public-facing **biodiversity dashboard** that contains real-time, detailed, and audited information on the project and the species being saved.

Why would this work?

- Firms exist to make a profit. Biodiversity offerings would be 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.

Firms are resourceful 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.

Building a biodiversity project

- First, the firm builds a model of the political-ecological system that contains their species.
- Based on this model, the firm identifies a biodiversity project that will encourage species-preserving behaviors.
- Finally, the firm implements this project and an attendant monitoring program that feeds real-time data to the firm's biodiversity dashboard.

Suggested biodiversity projects (ranked 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 projects (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.

Needed technology

- To be credible, political-ecological models need to be statistically fitted to parsed streams of news articles, and streams of ecological metric observations such as species abundance.
- These fitted models need to be simulated under different biodiversity projects to find ones that work.

Modeling a political-ecological system

- 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 how the targeted species' abundance affects and is affected by agent decisions.

Computational challenge: Model assessment

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

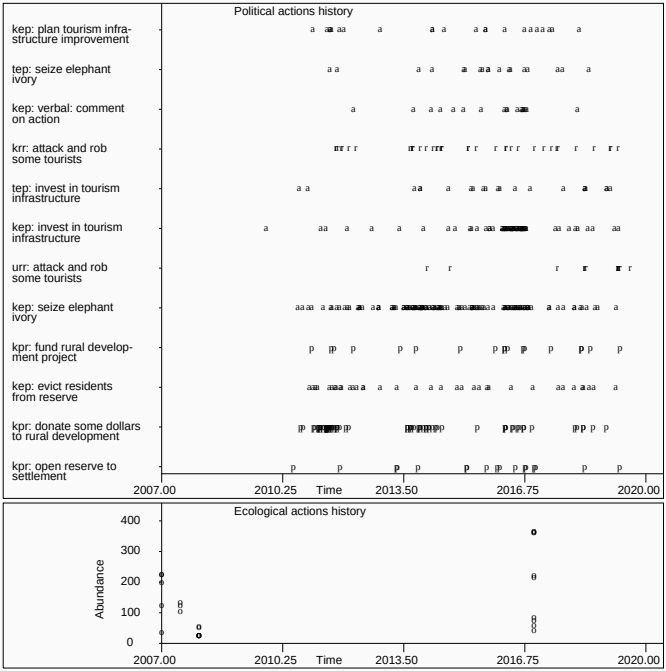
- Statistical estimates of model parameters
- Out-of-sample prediction error rates
- Parameter sensitivities

Computational challenge: Search for the optimal ecosystem management plan

Politically-feasible and species-saving biodiversity projects need to be found by computing the Most Practical Ecosystem Management Plan (MPEMP) via optimization.

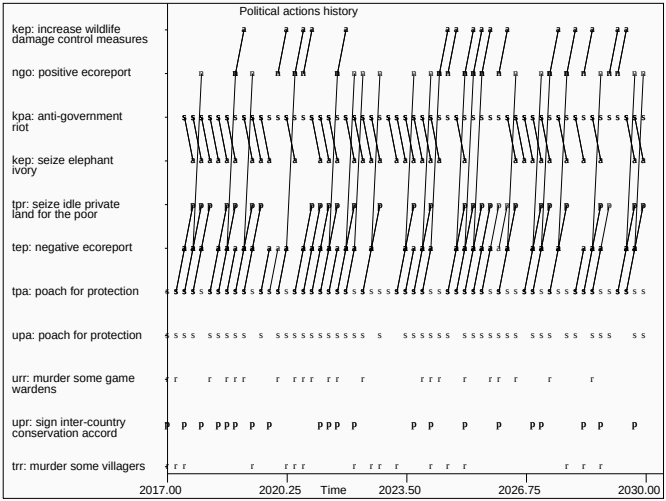
East African actions from online news

This plot 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.

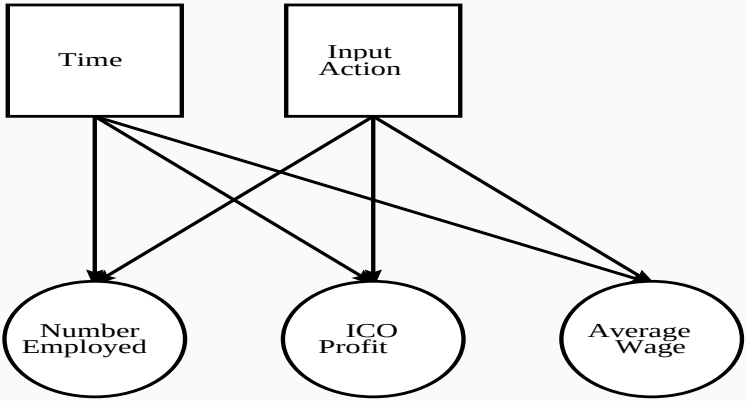

Political actions history
kep: plan tourism infra-structure improvement
tep: seize elephant ivory
kep: verbal: comment on action
krr: attack and rob some tourists
tep: invest in tourism infrastructure
kep: invest in tourism infrastructure
urr: attack and rob some tourists
kep: seize elephant ivory
kpr: fund rural develop-ment 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 project

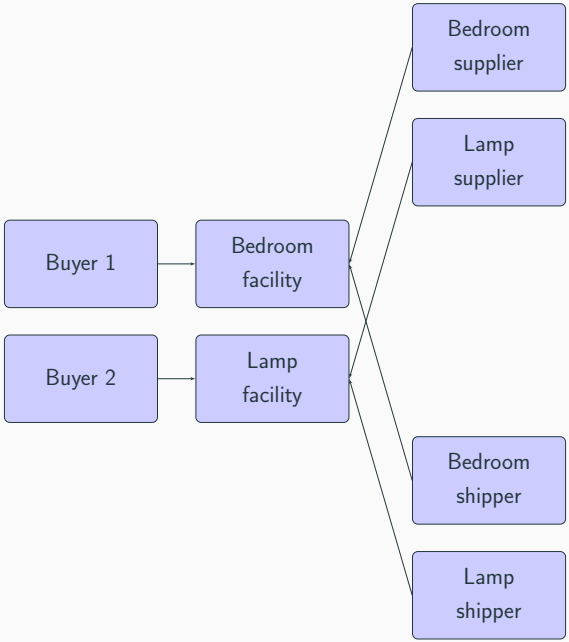
- The following is a plot of the cheetah system simulator's actions history under a proposed project.
- Lines connect action-reaction sequences.
- One frequent action sequence or **episode** is:
  poaching event $\rightarrow$
  negative ecosystem status report $\rightarrow$
  land gift to the poor.


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
urr: murder some game wardens
upr: sign inter-country conservation accord
trr: murder some villagers
2017.00
2020.25
Time
2023.50
2026.75
2030.00
Ecological actions history
Abundance
600
450
300
150
0
2017.00
2020.25
Time
2023.50
2026.75
2030.00

The manufacturing network submodel



This submodel interacts with the simulator's other submodels through its ID representation.

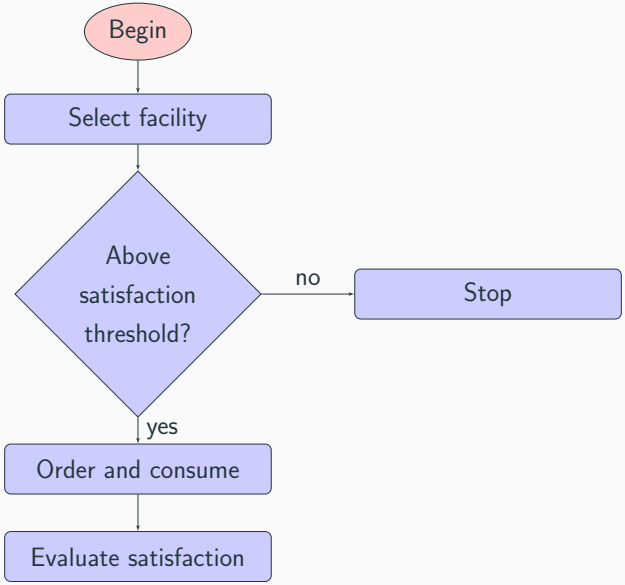


An ID composed of a set of interacting, stochastic agents.

This submodel is made up of furniture buyer agents and business agents. Business agents consist of manufacturing facilities and suppliers to these facilities. Elegant Furniture owns a bedroom facility and a table lamp facility. Buyers interact exclusively with these two facilities. Each 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.

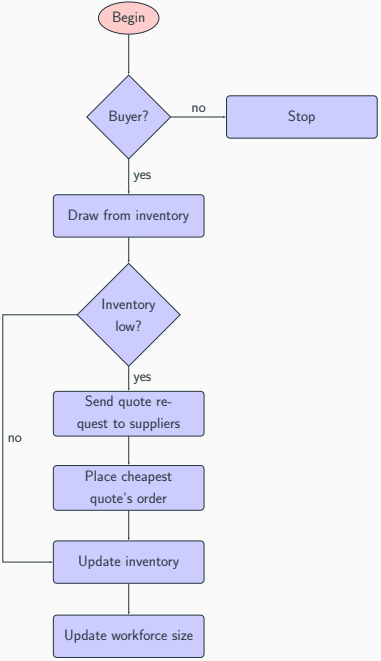
Agent mechanisms

All business agents have customers and a workforce. Buyer-facing agents set prices that were determined in the demand shaping campaign, and have inventories that they replenish from suppliers. At each time point, all buyer agents update in a random order. Then, all buyer-facing agents update in a random order followed by all supplier agents updating in a random order. An order placed by an agent at one time step is filled within the next time step.

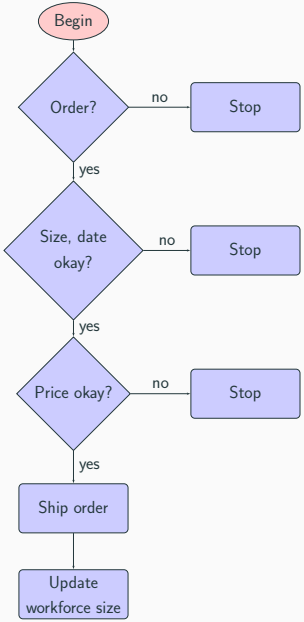


The update flowchart performed by a buyer agent.

Each business agent has two goals: make a profit, and grow – as indicated by increased revenue and a larger staff size.



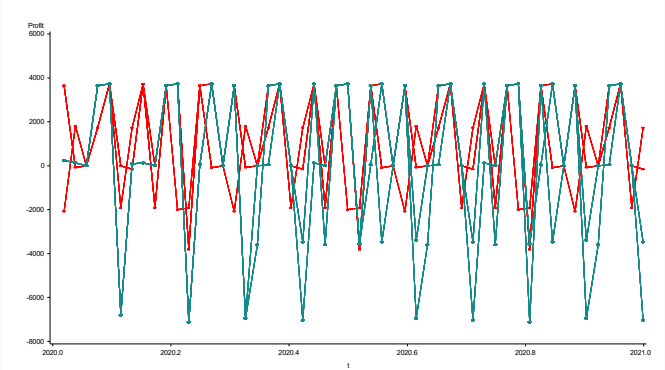
The update flowchart of a facility agent.

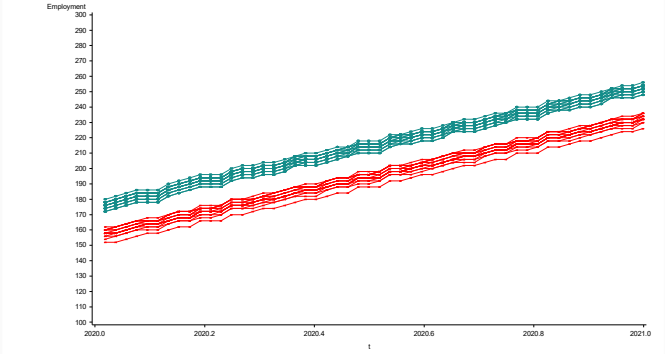


The update flowchart of a supplier agent.

Example

Say that the ICO's capacity is 10000 units per year and there is a market of 10000 buyers each having a reserve price of 20 USD. The starting value of the manufacturing network's i^{th} business, w_i is 1500 USD. The model is run under two different strategies: Pure profit – the ICO keeps its reserve price at 50% of the buyers' reserve price; and maximum employment – the ICO keeps its reserve price at 95% of the buyers' reserve price.


Profit
6000
4000
2000
0
-2000
-4000
-6000
-8000
2020.0
2020.2
2020.4
2020.6
2020.8
2021.0
t


Employment
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
2020.0
2020.2
2020.4
2020.6
2020.8
2021.0
t

Employment is higher under the maximum employment strategy relative to the pure profit strategy. 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.

MPEMP solution

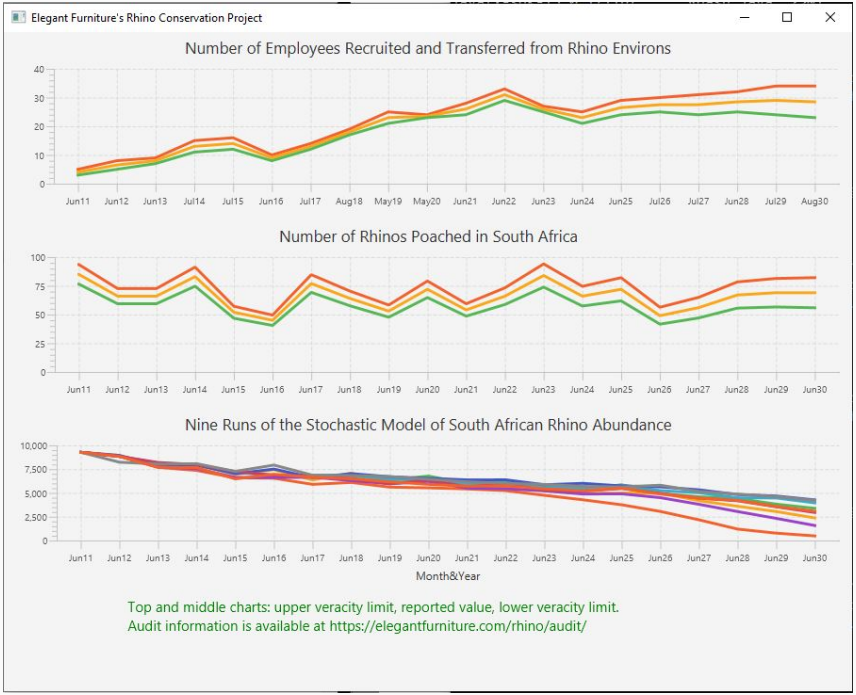
The planning horizon extends from 2015 through 2040. ICO wage is adjusted to find the MPEMP. Its value under a pure profit management strategy is 59.0. At this value, the MPEMP multiobjective function equals -86.31. After 20 function evaluations run within an optimization algorithm, this function increases 96% to -3.58 at an ICO wage of 1245.58. The MPEMP then, consists of setting the ICO wage to 1245.58.


10
8
6
4
2
0
I (x 10)
30
25
20
15
10
5
0
Number of rhinos poached
2015
2020
2025
2030
2035
2040

The causal chain that this plot depicts is: Changes in poachers group perceptions cause changes in their behaviors that, in-turn, cause changes in the ecosystem. Rhino extinction is avoided under the MPEMP but not under the pure profit strategy.

The project's biodiversity dashboard

The 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/

By looking at this dashboard, biodiversity-concerned customers can immediately see for themselves if Elegant Furniture's efforts are doing any good.