Proposal to ??:
Tools to Develop Profitable Business Ventures that Conserve Biodiversity
DRAFT

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& ??

1 Summary

Software systems will be created to help a firm develop profitable business ventures that conserve biodiversity.

Amount requested: $100,000
Grant Duration: 1 year
Number of supported students: 1

2 Deliverables

2.1 Overview

Haas (2022) describes a sustainable business strategy wherein firms launch profitable products or services (*offerings*) that harness market forces to fund projects that result in biodiversity conservation or climate change mitigation. In this business strategy, costs of such projects are minimized while their positive impacts on biodiversity or climate change are maximized.

The gulf between customer interactions with such offerings and either the survival of a *managed species* is bridged with technology. First, technological tools are developed to build a profitable biodiversity-conserving business venture via new stochastic, agent-based models of business networks that span consumer countries and species-hosting countries. These models are optimized for profitability through the use of new optimization algorithms that

run on high performance computers. Then, customer loyalty to the offering is maintained through a new technology called a *biodiversity dashboard*. This web-based dashboard displays in real-time, monitoring data on the offering's impact on the managed species. Doing so allows customers to see for themselves how the offering is positively impacting biodiversity.

These business lines are built by first, understanding the political context of a particular biodiversity threat, and then, designing a profitable offering that is tied to a minimum-cost, politically feasible project that conserves biodiversity.

2.2 Business venture evaluation tools

1. A platform will be developed for evaluating the profit potential of a sustainable business venture in the form of a stochastic, agent-based model (ABM) of a network of small businesses and either their effects on a managed species modeled with an individual-based model (IBM). Call an ABM coupled to an IBM, a *coupled ABM-IBM* model. Refer to this model as a *simulator*.

   No such platforms exist.

2.3 Business model assessment via HPC

1. HPC algorithms will be developed to statistically estimate the parameters of a simulator, and assess their sensitivities.

2. HPC algorithms will be developed for assessing the out-of-sample performance of a simulator.

3. HPC optimization algorithms will be developed to find parameter values that optimize both the business network's overall profit and its ability to attract repeat customers through demonstrable beneficial effects on either biodiversity.

2.4 Business-integrated computer graphics

1. A biodiversity dashboard system will be built that connects to data streams generated by a simulator; online news story parsers; remotely-sensed observations on the abun-

dance of a managed species; and remotely sensed biodiversity-affecting landuse such as fire in the Amazon basin, or human settlement density bordering wildlife reserves;

2. The biodiversity dashboard will be integrated into existing cloud-based enterprise resource planning (ERP) systems systems such as Oracle corporation's Fusion Cloud ERP™ or Microsoft corporation's Microsoft Dynamics 365™.

3. New graphical displays of categorical time series will be developed.

4. Animated graphical components will be created and added to presentations of the business venture evaluation platform. These presentations will be delivered at business innovation conferences.

2.5 Testing

The tools developed in this proposal will be tested by running them on a business venture plan to conserve rhinoceroses in South Africa.

3 Budget

3.1 Salary Support

Item	Date		Amount
1.	summer 2024	Professor ??: 1 month	$1,000.00
2.	2024	Student	$5,000.00
Total Direct Costs			$0
Indirect costs		(45% of Direct Costs)	$0
Total Salary Support			$0

3.2 Software and Data

Parsing software, satellite images, and survey data from interviews conducted with people living close to Kruger National Park (KNP), South Africa.

Item	Date		Amount
1.	Summer 2024	purchase of satellite images from ??	$1,000.00
2.	Summer 2024	survey contract with ??	$1,000.00
Total direct costs			$0
Indirect costs (45% of Direct Costs)			$0
Total software and data			$0

3.3 HPC

Item	Date		Amount
1.	2024	?? hours of computer time	$1,000.00
Total direct costs			$0
Indirect costs (45% of direct Costs)			$0
Total HPC			$0

3.4 Travel

Item	Date	Description	Amount
1.	2024	Demonstrations of the new platform at business conferences	$10,000.00
Total travel			$20,000.00

3.5 Total

Total requested	$100,000.00

4 Rationale

4.1 Starting points

The work of Dias et al. (2020) on self-healing connectivity between Internet of Things (IoT) devices will be a starting point for the deliverable of a system to persistently connect a biodiversity dashboard and its data streams to a firm's website.

4.2 HPC

Models of political-ecological are used to discover politically feasible, species-saving projects. In these models, agents make decisions about actions that affect an at-risk species. Agents include poachers, trafficking syndicate kingpins, wildlife product consumers, farmers, wildlife protection agencies, and governments. The simulator's IBM submodel tracks how the managed species' abundance affects and is affected by the decisions of these agents.

4.2.1 Need for massive computing

Because single runs of these stochastic models are expensive, massive computing resources are needed to compute:

- Statistical estimates of model parameters
- Out-of-sample prediction error rates
- Parameter sensitivities
- Profitable, politically-feasible, and species-saving projects.

Parameter estimation consists of finding simulator parameter values that simultaneously maximize a data-agreement function and minimize a theory disagreement function. The data agreement function is the statistical agreement between simulator-generated agent actions and species abundance – and observed agent actions and species abundance. The theory disagreement function is the value of a probabilistic metric between the simulator's probability distribution at its estimated parameter values and its probability distribution defined by a set of hypothesized parameter values that have been derived from theory.

This is a black-box optimization problem. One algorithm that is known to find a local extremum is due to Haas (2020). This algorithm, however, is only locally convergent and does not scale well. Other algorithms need to be explored. Research on this topic then, will begin by evaluating the performance of the Parallel Asynchronous Coupled Simulated Annealing algorithm of Gonçalves-e-Silva et al. (2018).

Model-based forecasts need to be computed of actions that would happen under a proposed venture. For example, the following is a plot of the cheetah system simulator's actions history under a proposed species-saving project.

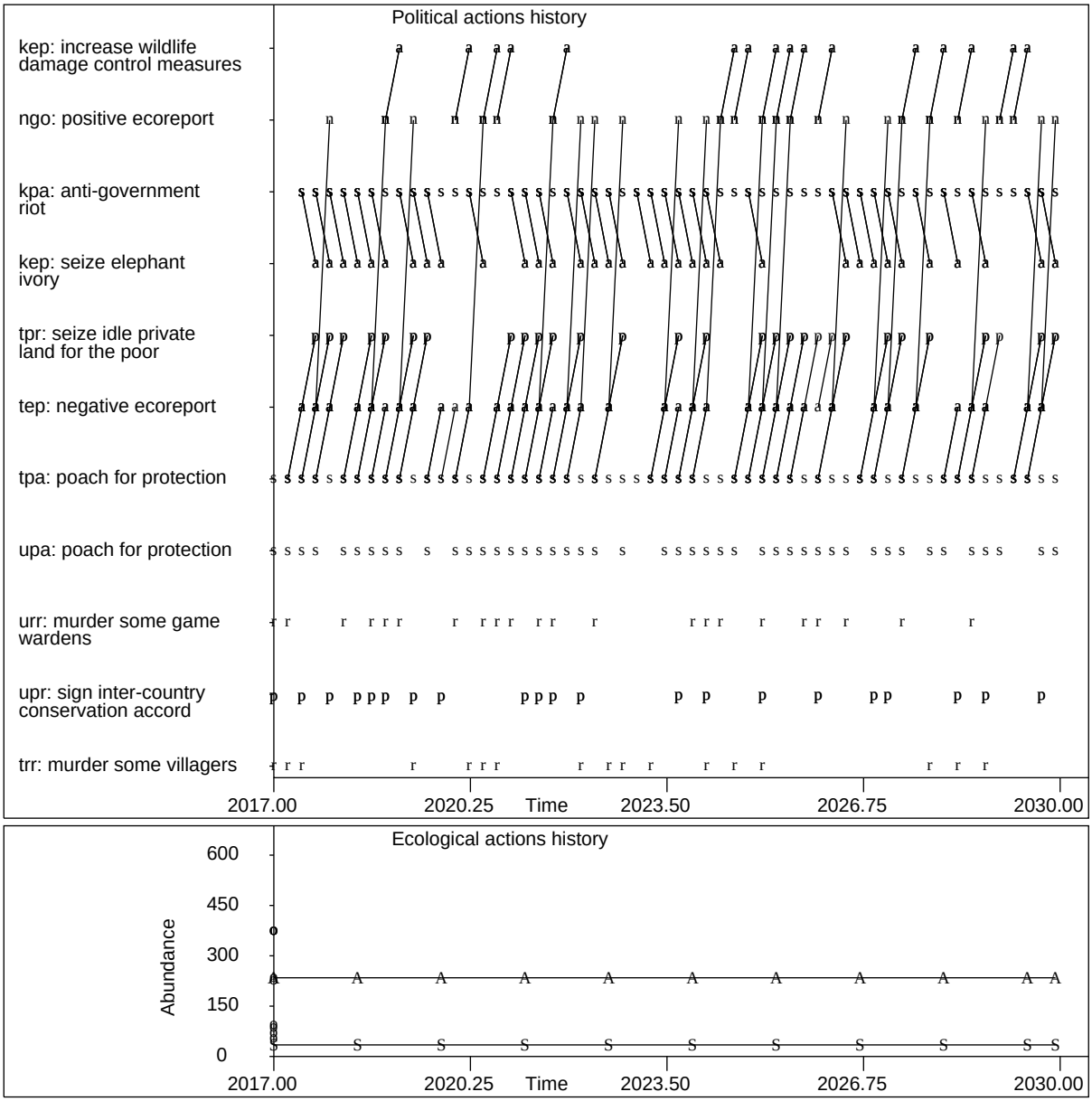

Figure 1: Political-ecological actions over the period January 2007 through June 2019. The symbol"p" indicates an action taken by a presidential office, "a" an action taken by an EPA, "r" an action taken by rural residents, "s" an action taken by pastoralists, and "n" an action taken by an NGO. Selected out-combinations only are labeled. The bottom plot is observed cheetah abundance. Lines connect action-reaction sequences.

4.3 Display and analysis of categorical time series

Algorithms will be developed that can detect significant features in a categorical time series. Episode detection is a first step in this direction (Haas, 2021). For instance, one frequent action sequence or **episode** in the above plot is:

poaching event
$\Downarrow$
negative ecosystem status report
$\Downarrow$
land gift to the poor.

Many displays of a categorical time series including Figure 1 are too busy, hard-to-read, and unattractive. New methods in computational graphics will be developed that can display a categorical time series in a way that is easily interpretable (Weiss, 2008).

References

Dias, J. P., Lima, B., Faria, J. P., Restivo, A., and Ferreira, H. S. (2020), "Visual Self-healing Modelling for Reliable Internet-of-Things Systems," V. V. Krzhizhanovskaya et al. (Eds.): *ICCS 2020, LNCS 12141*, pp. 357-370, Springer Nature Switzerland AG. DOI: 10.1007/978-3-030-50426-7_27

Gonçalves-e-Silva, K., Aloise, D., and Xavier-de-Souza, S. (2018), "Parallel Synchronous and Asynchronous Coupled Simulated Annealing," *Journal of Supercomputing,* 74: 2841-2869. DOI: 10.1007/s11227-018-2327-4.

Haas, T. C. (2022), "Profitable Biodiversity," *Cogent Social Sciences*, 8(1): 1-24. DOI: DOI: 10.1080/23311886.2022.2116814.

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Haas, T. (2020), "Developing Political-Ecological Theory: The Need for Many-Task Computing," *PLOS ONE*, November 24, doi: 10.1371/journal.pone.0226861. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0226861

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