Long-Term Wildlife Protection:

A Dynamic Approach

2026051

Guangzhou NO.7 Middle School

Contents

Introduction

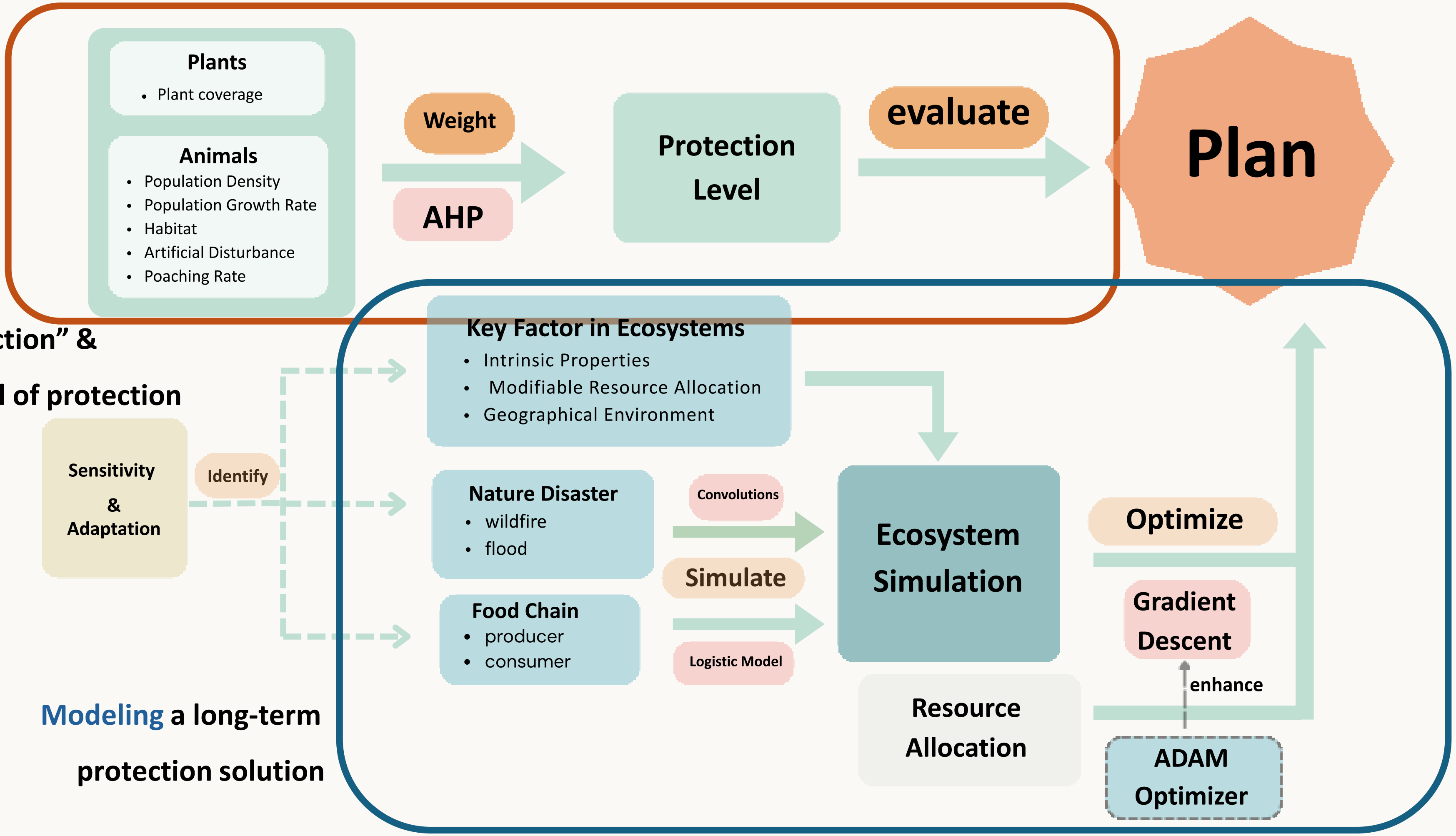
We defined what constitutes conservation and developed a model capable of effectively optimizing resource allocation, which we applied to Etosha National Park. We tested the model and adapt it to other protected areas.

Figure1: deer drinks water by the waterhole

Overview: Technical Roadmap

Defining “protection” &

evaluating the level of protection



Modeling a long-term

protection solution

Overview: Overall Analysis

CORE Problem

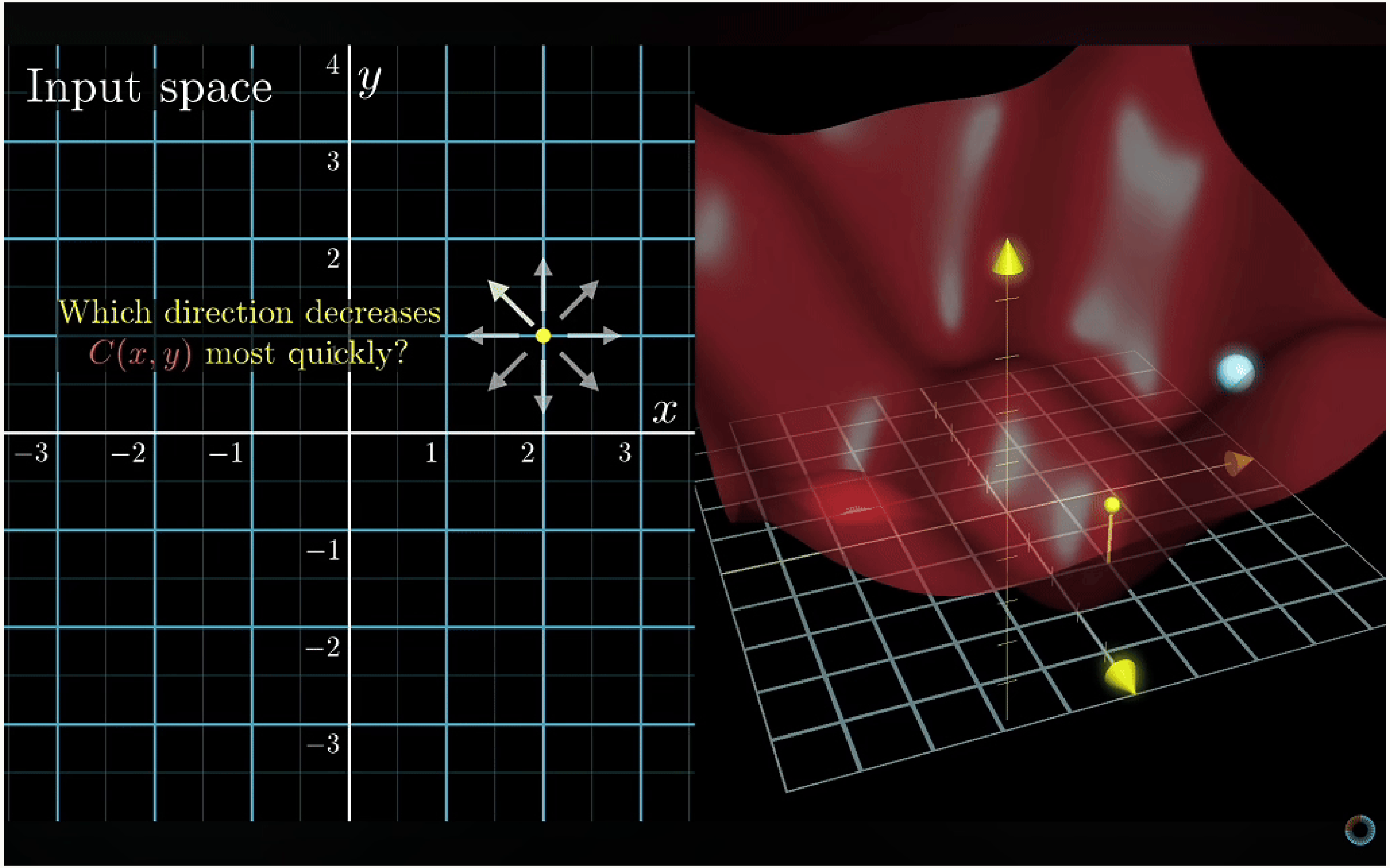
Resource Allocation
&
Protection Overall Time

Essence

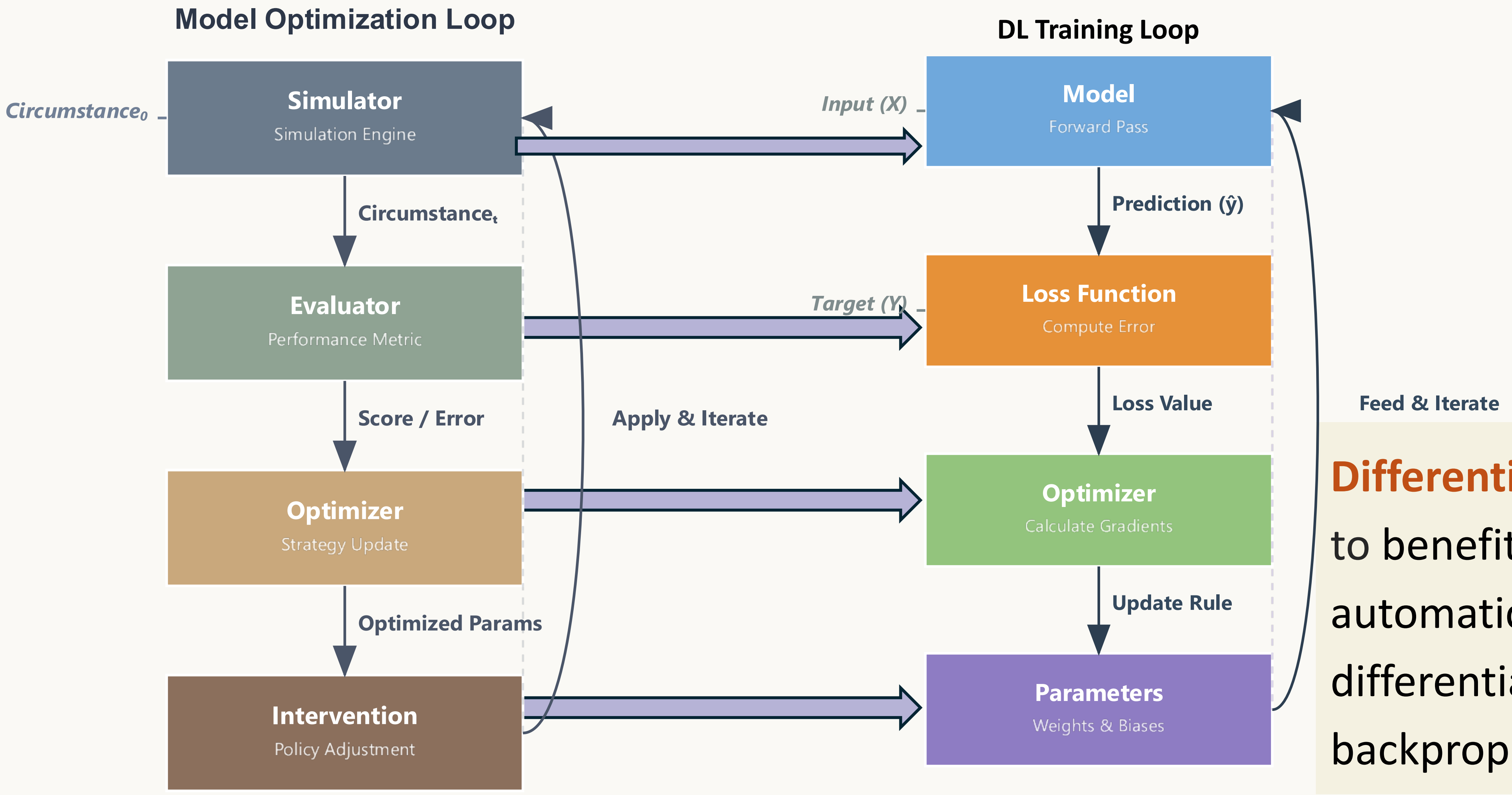
a Multi-dimensional Optimization Problem

Gradient Descent Approach

Overview: Relationship with DL



Overview: Relationship with DL



Differentiable models: to benefit from automatic differentiation with backpropagation.

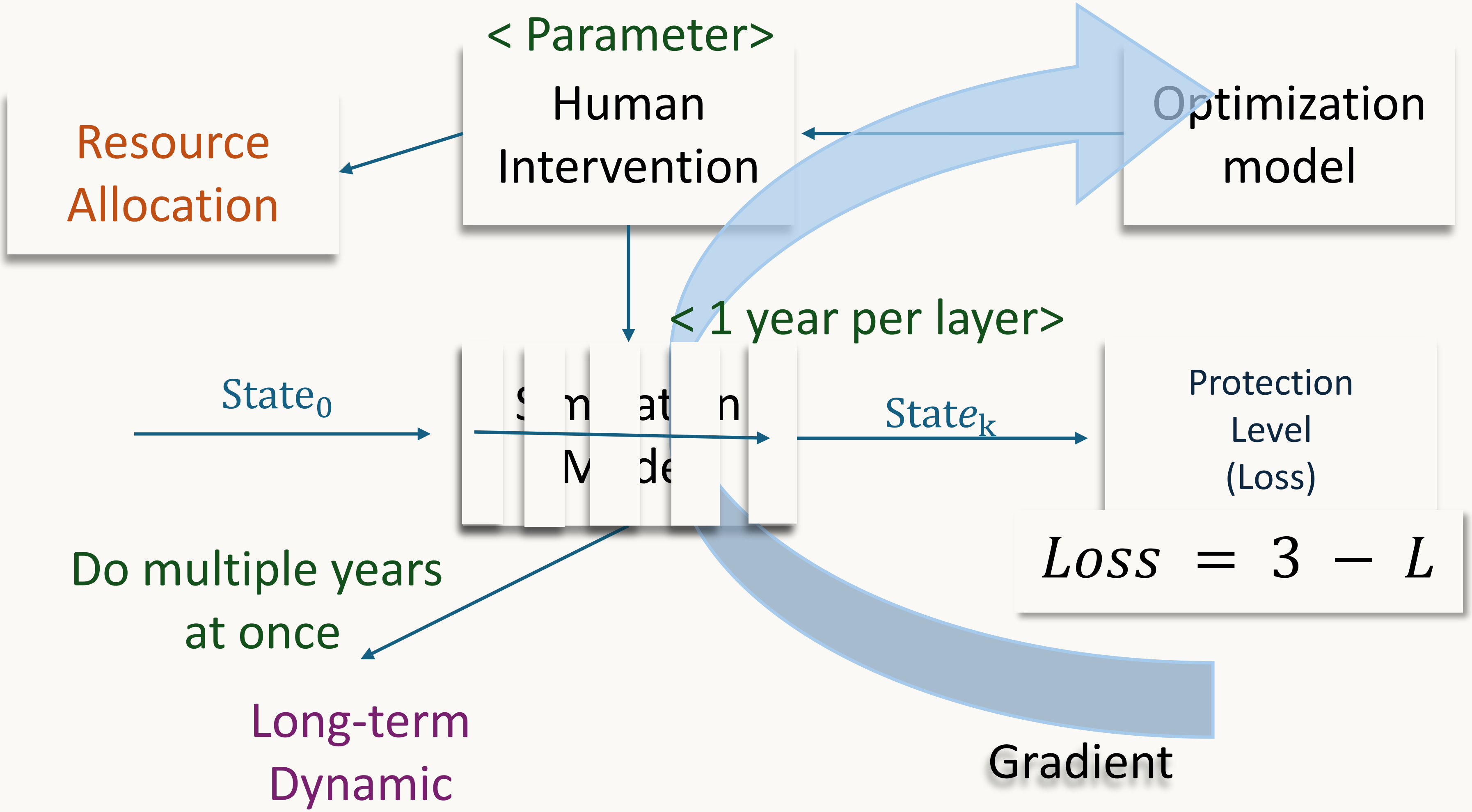
Overview: Assumptions

Assumption 1 Balanced Distribution of Animals

Assumption 2 Uniformity of Drone Prices Across Countries

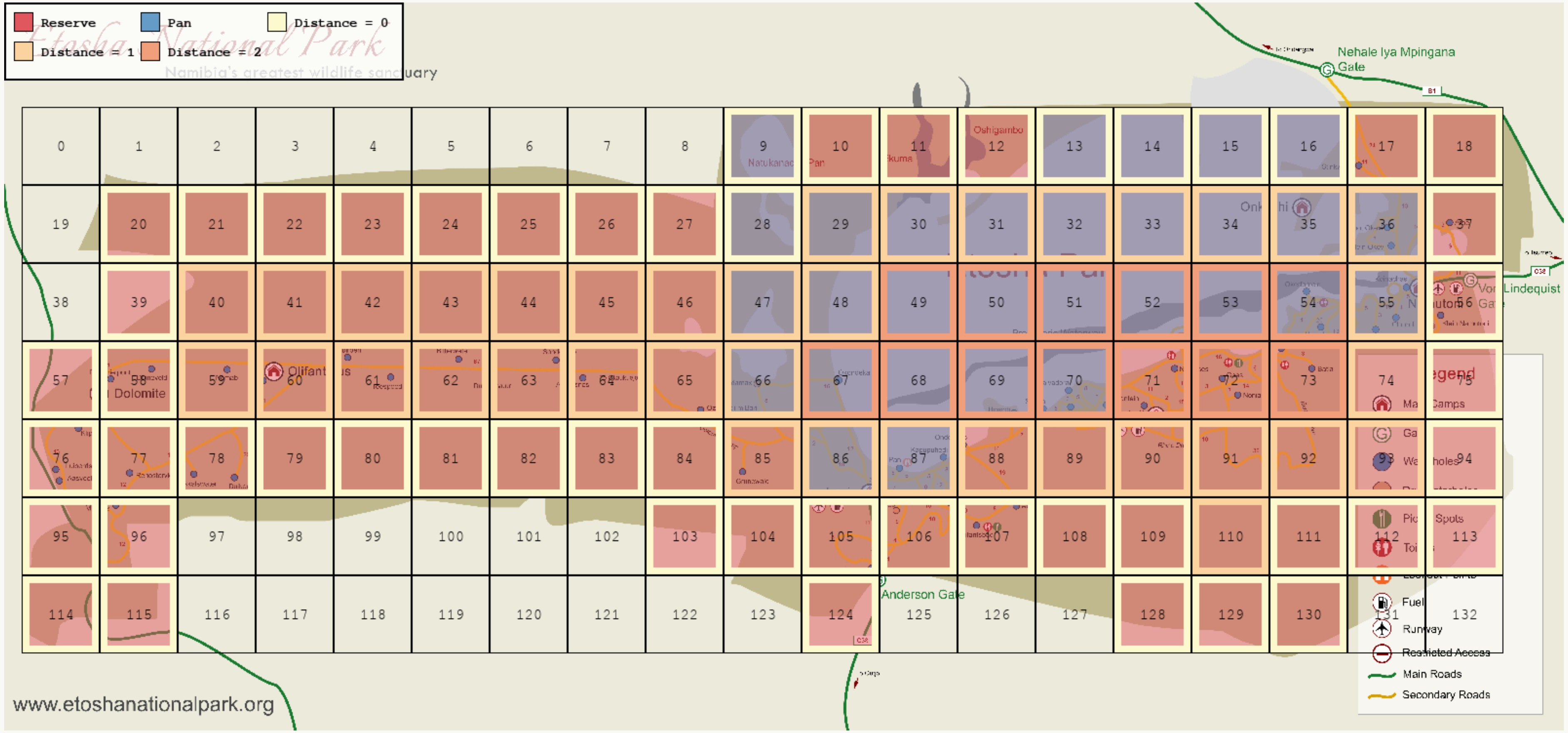
Assumption 3 The Immutability of Interspecific Competitive Relationships

Simulating & Optimizing: the Architecture



Simulating: Grid the National Park

By means of
20-kilometre-by-20-kilometre squares



Simulating: Implementation for Simulation Layers

Here are constants:

- **Intrinsic growth rate** (r)
- **Intrinsic poaching rate** (p_{ipoach})
- **Food consumption** (c)

Here are variables:

- **Population Density** (d)
- **Population Growth Rate** (λ)
- **Habitat** $(p_{habitat})$
- **Artificial Disturbance** $(p_{disturb})$
- **Poaching Rate** (p_{poach})

Simulating: the Threats

Natural Threats

Wildfire

Food

Habitat

Artificial Threats

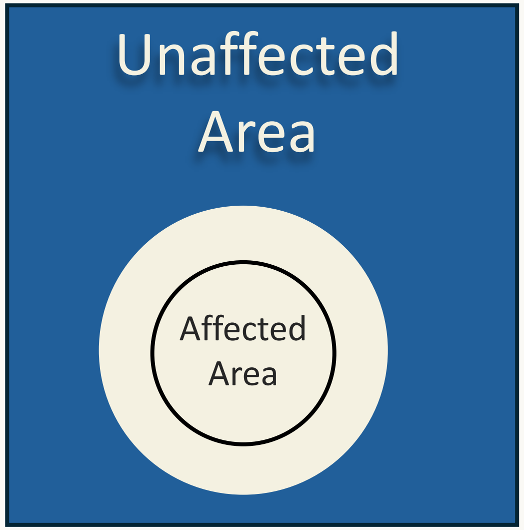
Poaching

Artificial Disturbance

staff

drones

Simulating: the Threats of Poaching & Disturbance



Affected area

Artificial Disturbance

$$p_{\text{disturb}} = \frac{\pi \cdot \left(n_{\text{staff}} R^2_{\text{staff,disturb}} + n_{\text{drone}} R^2_{\text{drone,disturb}}\right)}{l^2_{\text{plot}}}$$

Poaching

Unaffected area & **Distance**

$$p_{\text{poach}} = p_{\text{ipoach}} \cdot \left(1 - \frac{\pi \cdot \left(n_{\text{staff}} R^2_{\text{staff,poach}} + n_{\text{drone}} R^2_{\text{drone,poach}}\right)}{l^2_{\text{plot}}}\right) \cdot \frac{1}{d_{\text{boundary}} + 1}$$

Simulating: Threats of Wildfire

to modify the wildfire

Convolutions

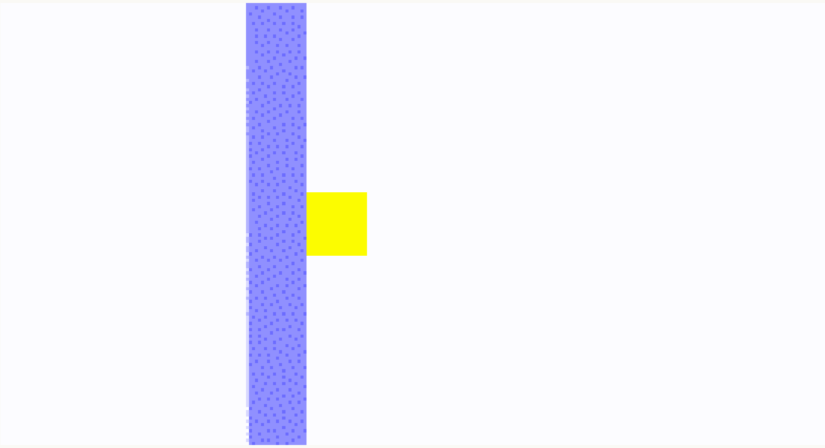
$$p_{\text{wildfire}} = 1 - \frac{\pi \cdot \left(n_{\text{staff}} R_{\text{staff,fire}}^2 + n_{\text{drone}} R_{\text{drone,fire}}^2 \right)}{l_{\text{plot}}^2}$$

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Display of kernel of wildfire

Without
Human Intervention

With
Human Intervention



Simulating: Logistic model

Logistic model with three trophic levels

Plants

$$N(P)_{t+1} = N(P)_t \cdot \left[1 + r(P) \cdot \left(1 - \frac{N(P)_t}{K(P)}\right)\right] \cdot p_{\text{survive}}$$

Herbivore Animals

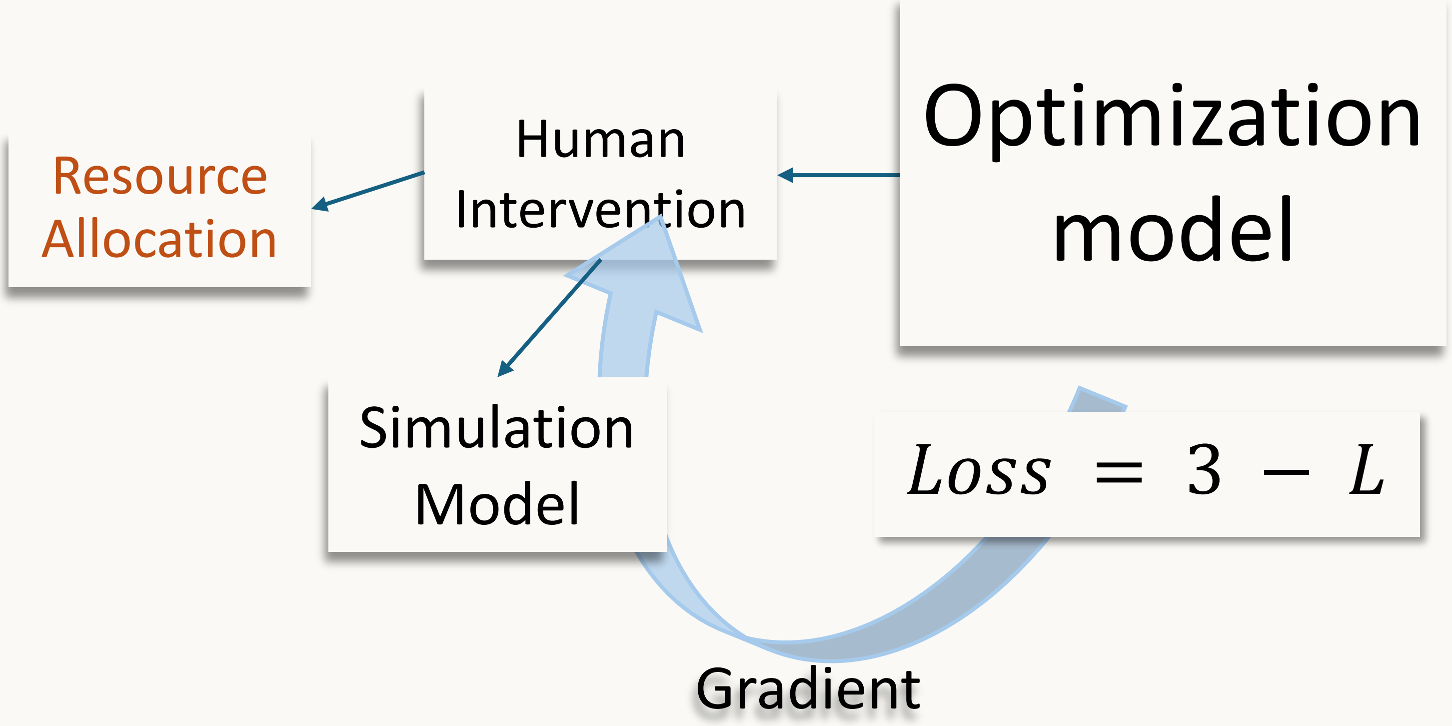
$$N(H)_{t+1} = N(H)_t \cdot \left(1 + r(H) \cdot (1 - p_{disturb}) \cdot \left(1 - \frac{N(H)_t}{K(H)}\right) - p_{poach}(H)\right)$$

Carnivore Animals

$$N(C)_{t+1} = N(C)_t \cdot \left(1 + r(C) \cdot (1 - p_{disturb}) \cdot \left(1 - \frac{N(C)_t}{K(C)}\right) - p_{poach}(C)\right)$$

Optimizing: Optimization Model

The optimization model consists of a gradient descent optimizer for optimizing the parameters and a parameter clipper to limit the total cost under a given budget.



ADAM Optimizer

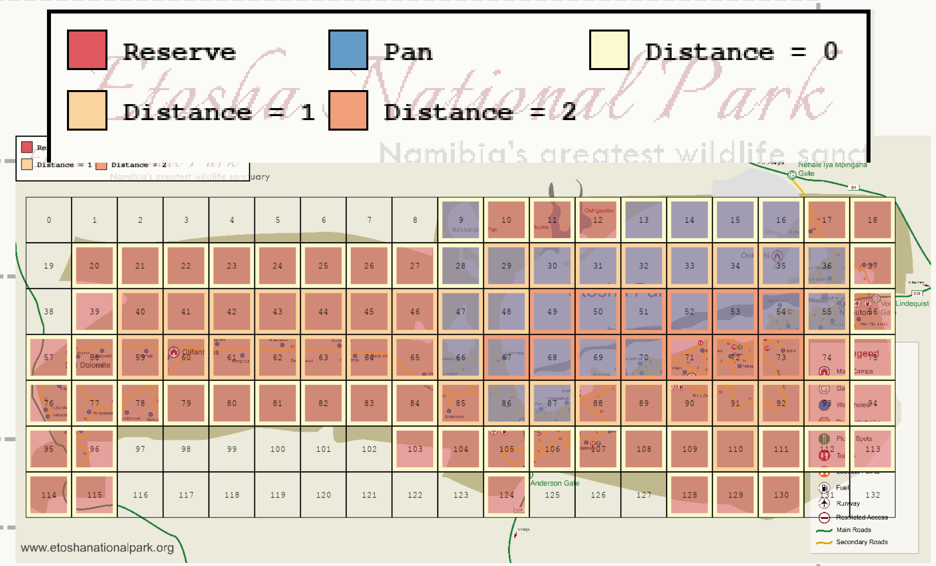
<More stable & efficient>

Clip

<to prevent over budget>

Optimizing: Training of Model

- The learning rate is 0.1



- Assign constants

- Species

Endangerment

Global Attention

Black Rhinos
&
Lions

Optimizing: Run for 30 steps

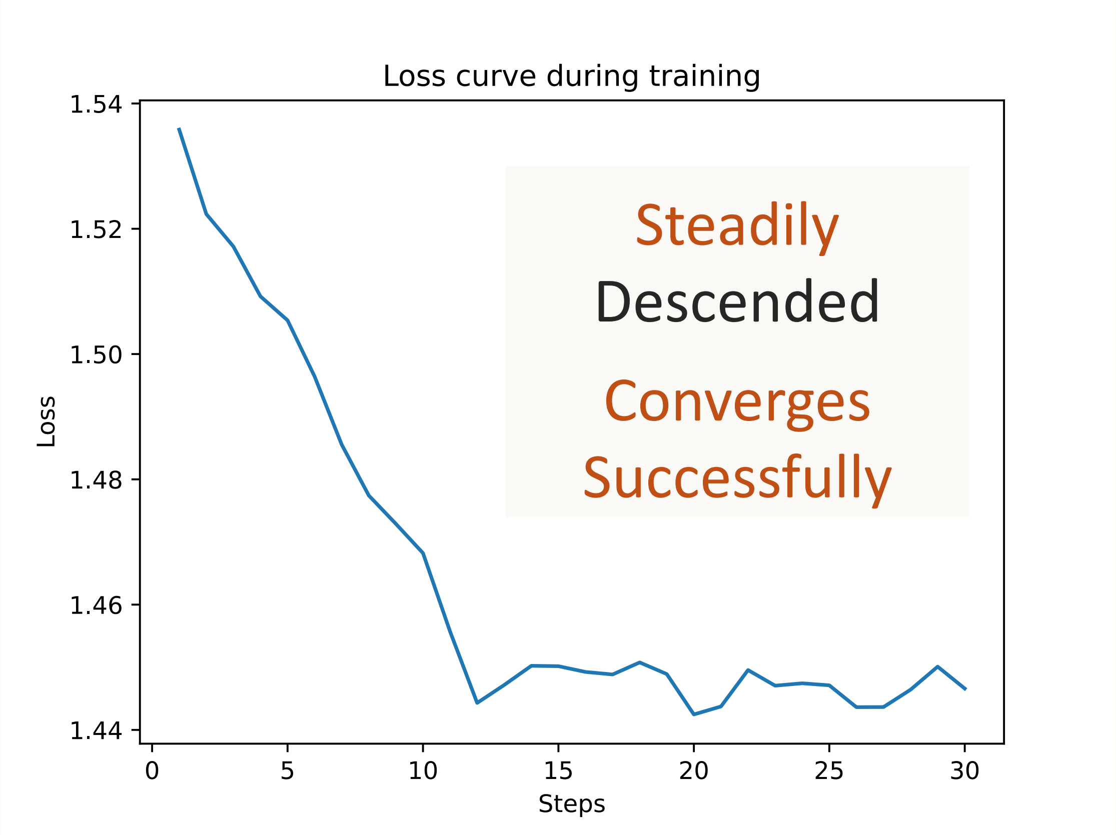


Figure2: Loop for 30 optimization steps

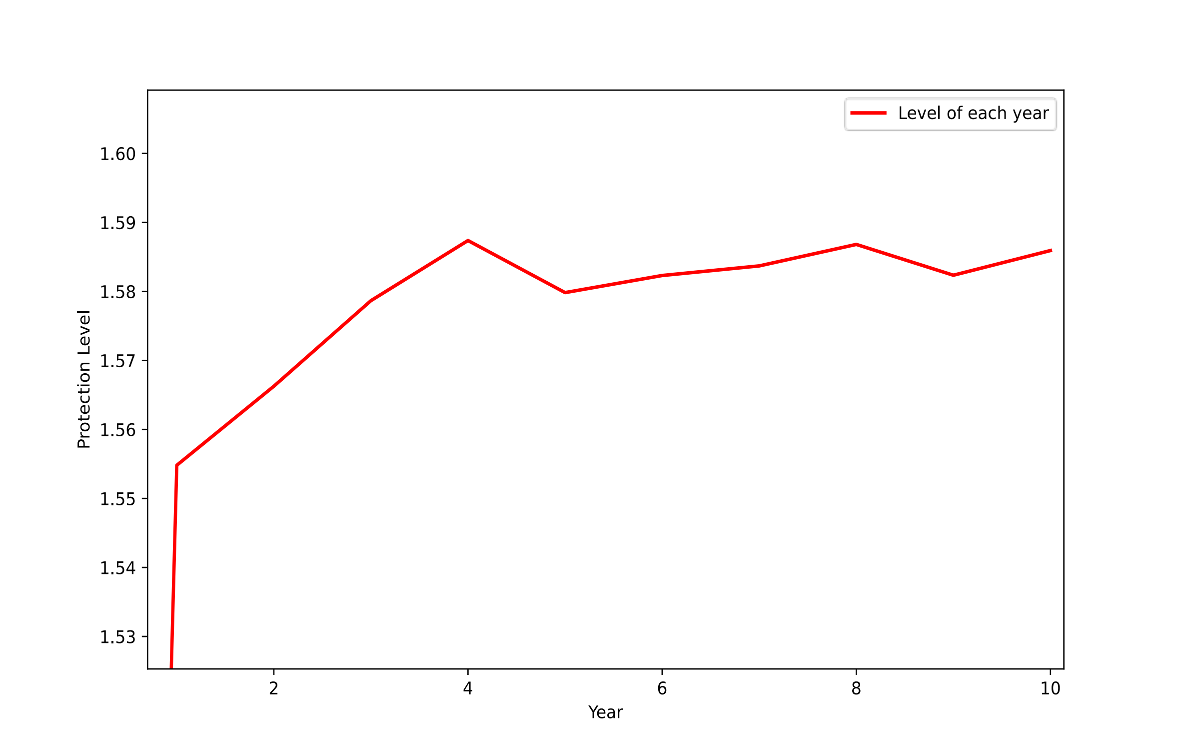


Figure 3: the expectation protection levels in 10 years

Optimizing: Resource Allocation

We estimate that roughly 185 employees and 180 drones are needed to maintain the level of protection.

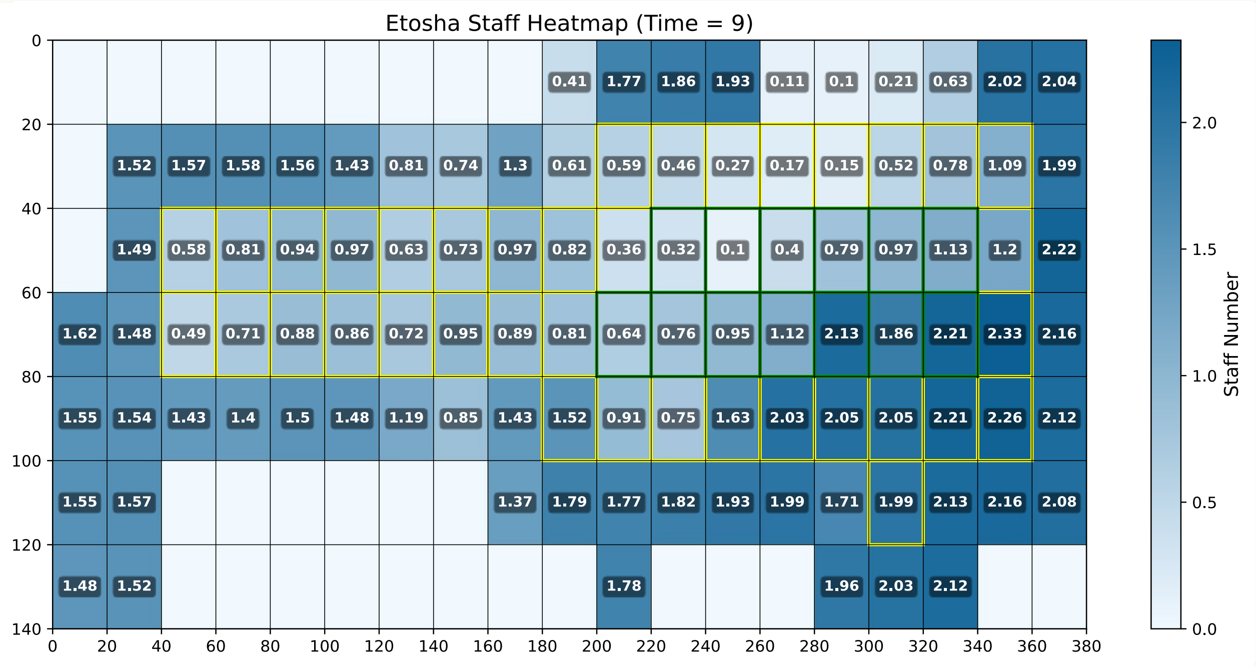


Figure4: Staff allocation in different times

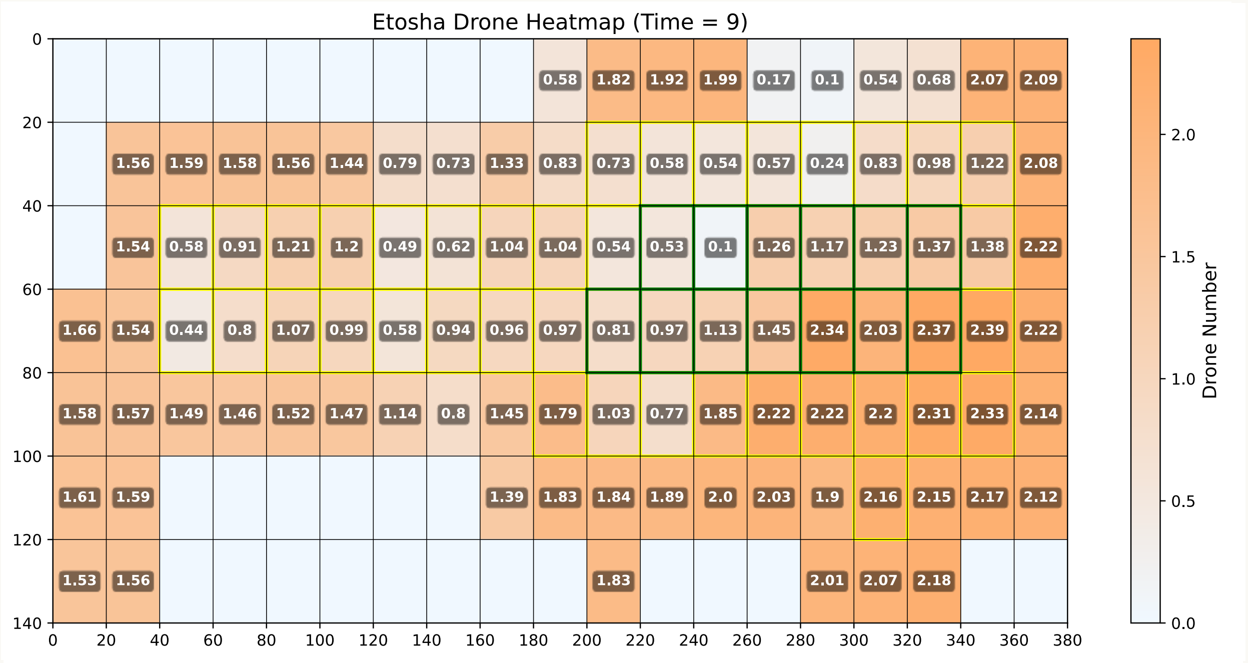


Figure5: Drones allocation in different times

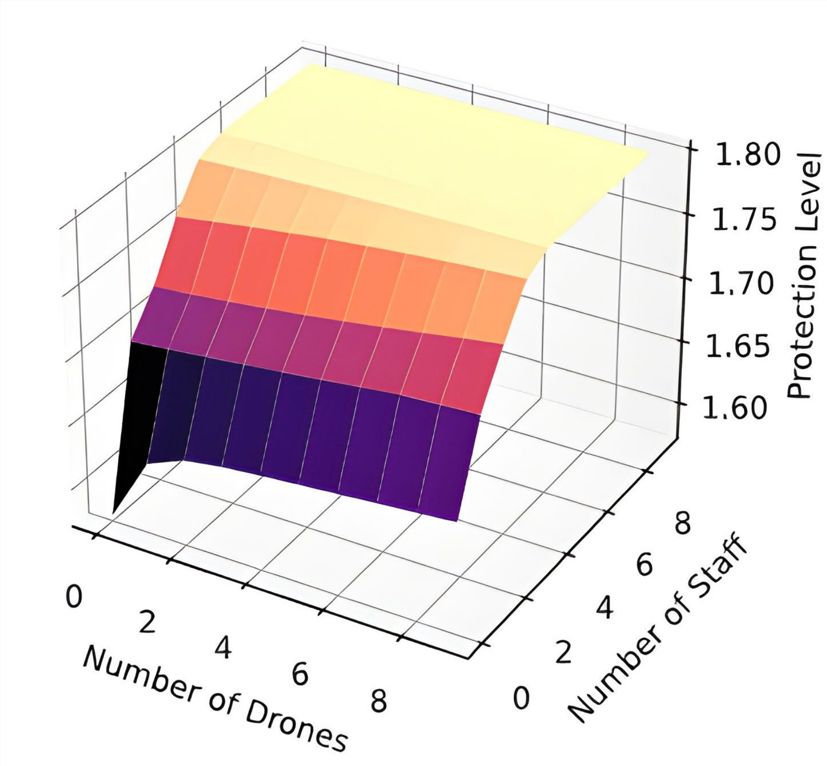
Test: Sensitivity Analysis

Deployment personnel

Drone count

Budget

Drone Power

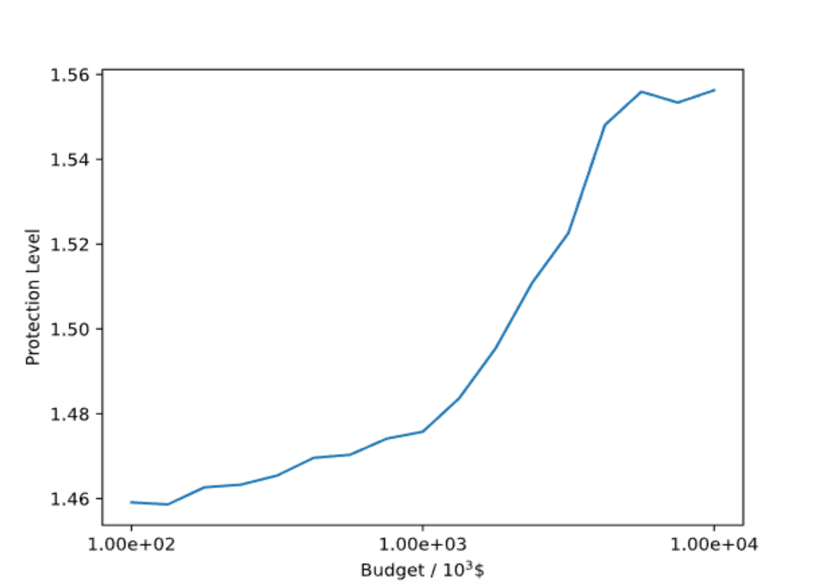


Staff number more sensitively than drones.

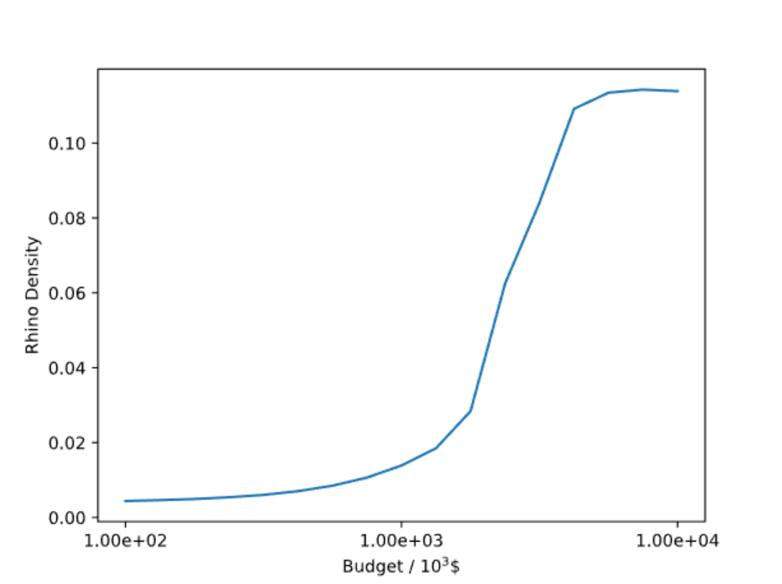
Test: Sensitivity Analysis

- Deployment personnel
- Drone count
- **Budget**
- Drone Power

Protection Level



Rhino Density



Test: Sensitivity Analysis

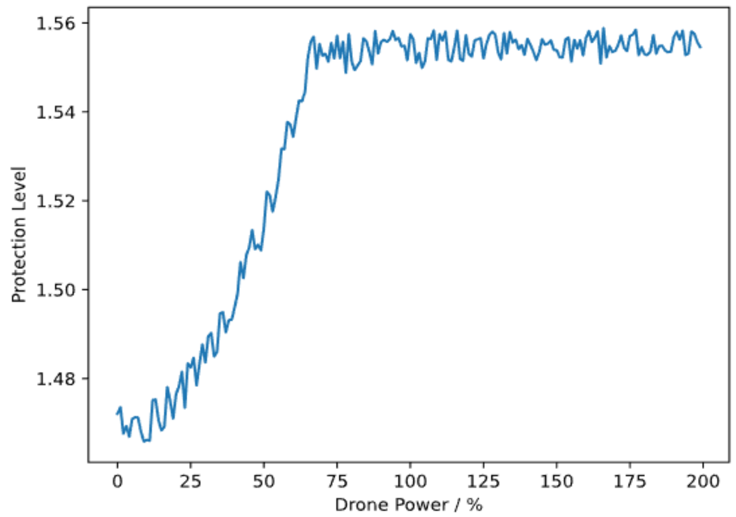
Deployment personnel

Drone count

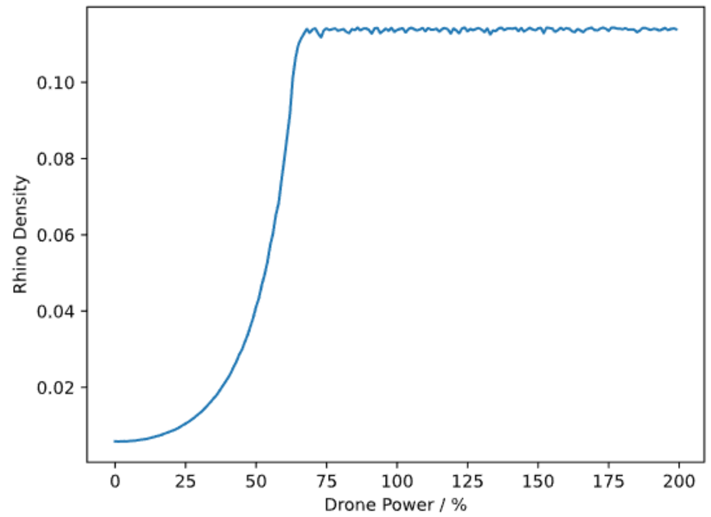
Budget

Drone Power

Protection Level



Rhino Density

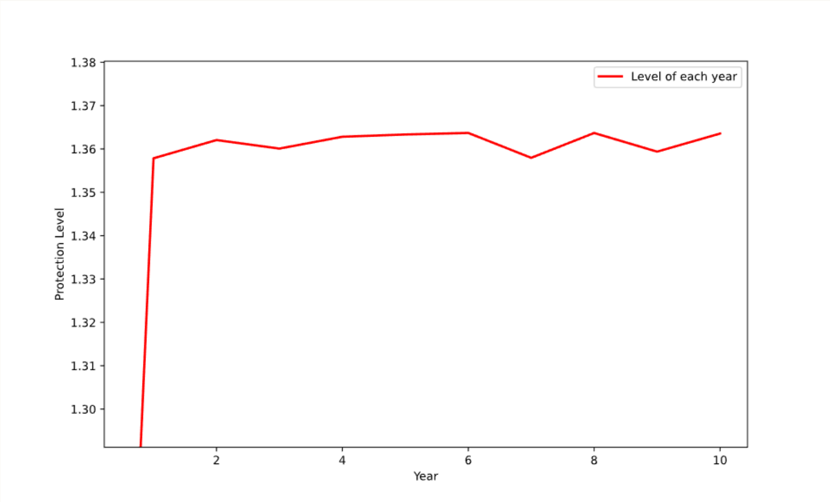


Sufficient drone performance is required.

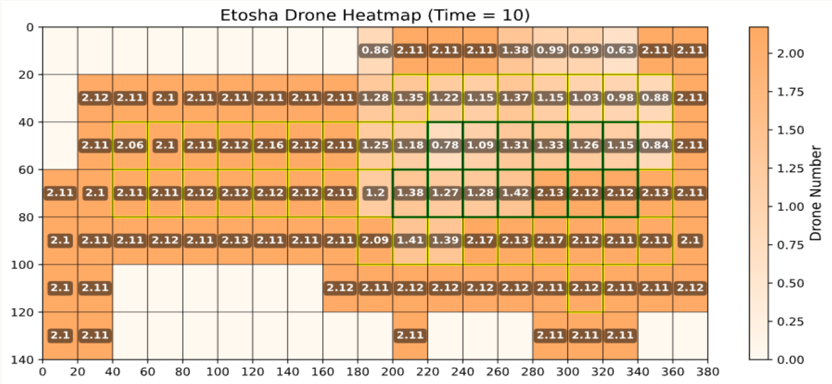
Test: Scenario Analysis

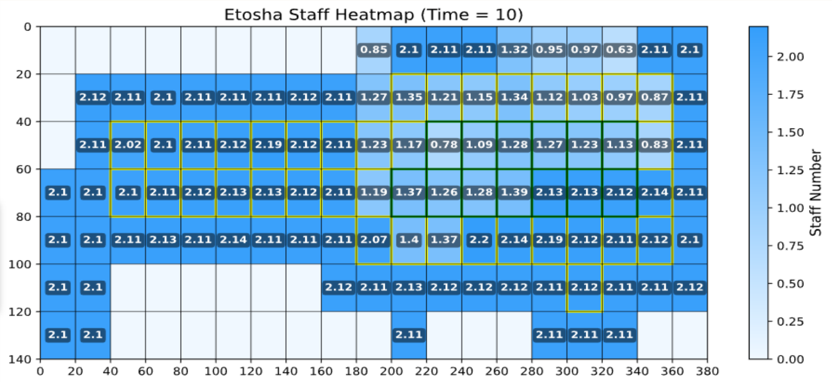
Scenario 1 : a Severe Drought

Protection Level



Tenth year



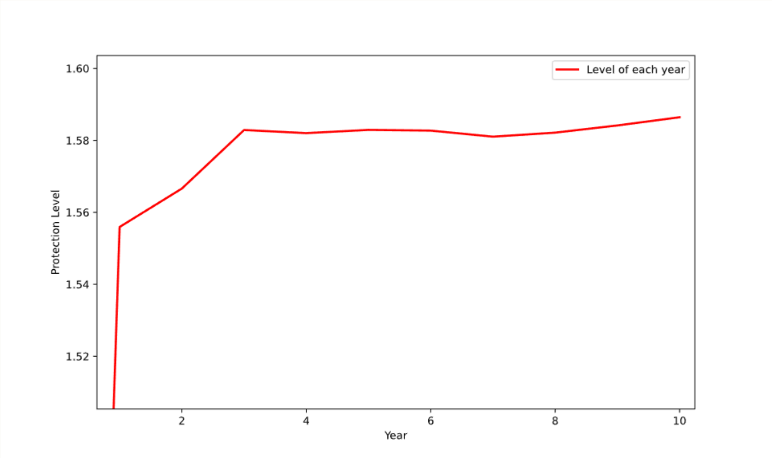


Droughts have serious threat to the ecosystem

Test: Scenario Analysis

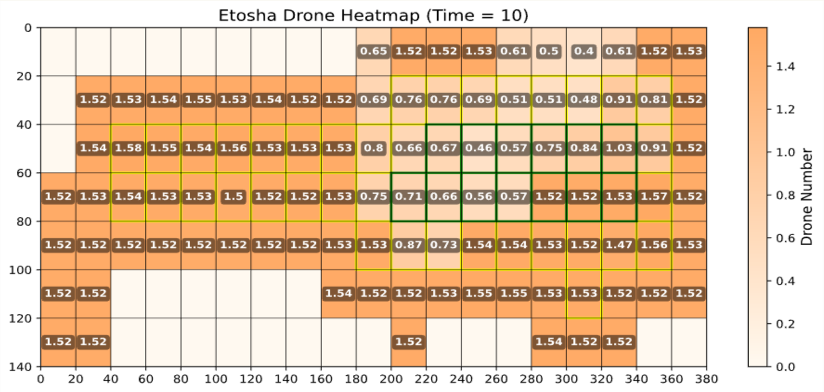
Scenario 2: Significant Increase in Labor Costs

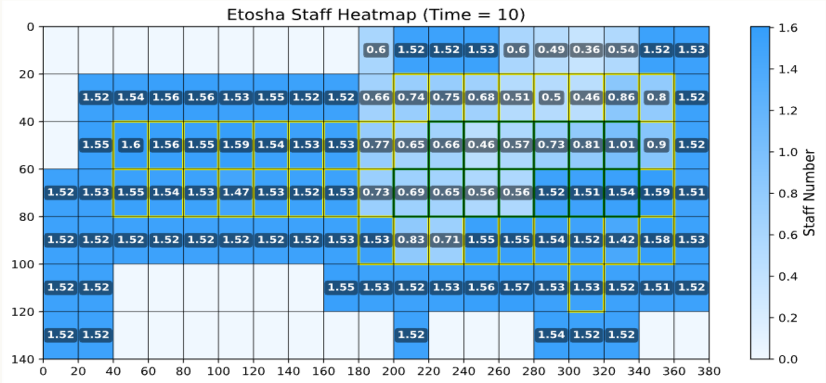
Protection Level



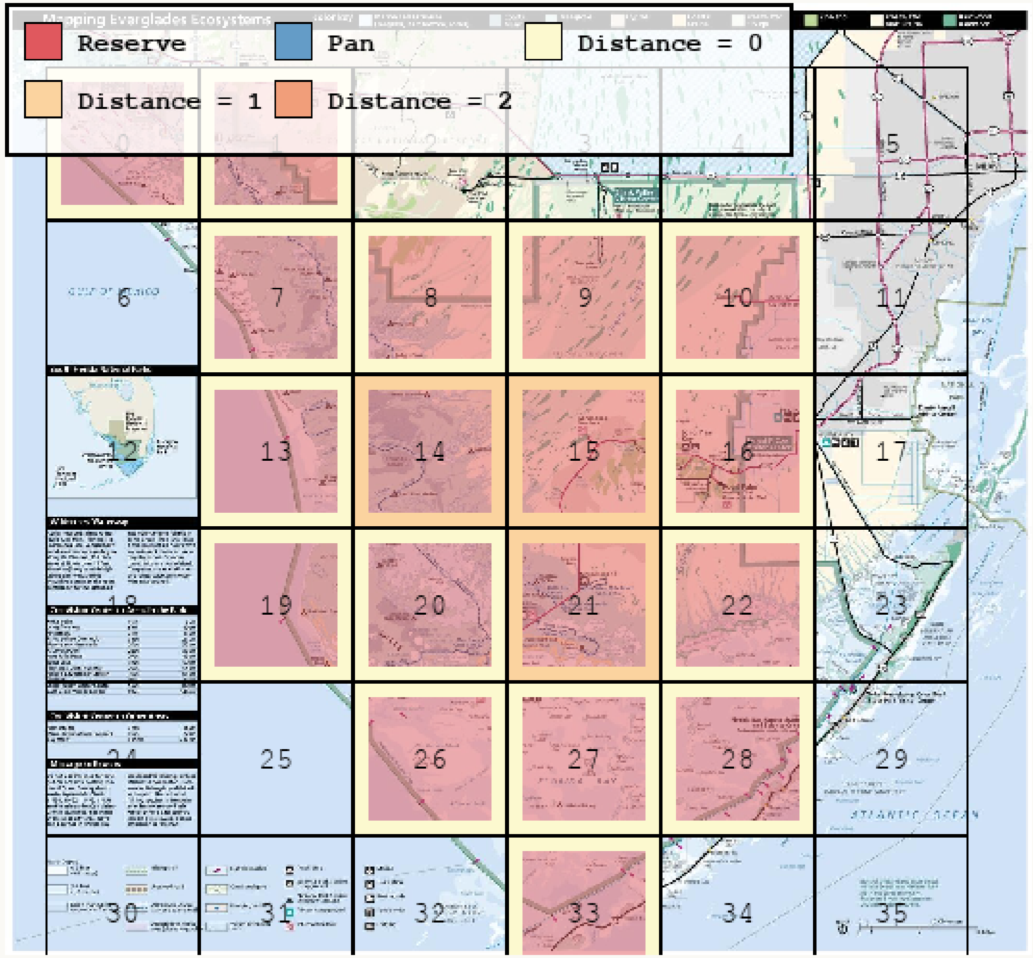
Affects the protection level slightly, but not significant.

Tenth year





Adapting: to Everglades, North America



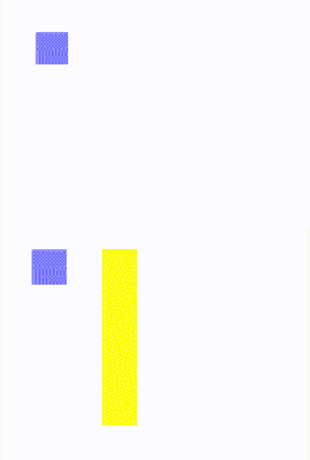
Plot division in Everglades

Adapting: to Everglades, North America

Another Threat: Flood

$$\begin{bmatrix} \frac{1}{4} & \frac{1}{4} & 0 \\ \frac{1}{4} & \frac{1}{4} & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Display of kernel of flood



Display of how flood spread
Blue: Flood
Yellow: Human Intervention

Adjusted Parameters

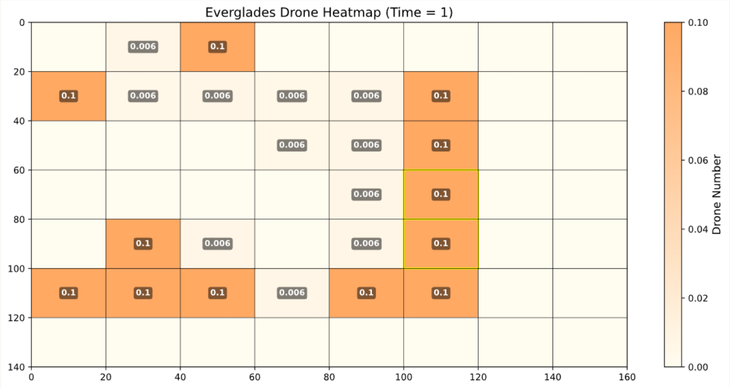
Params & Description	Value
$N(P)_0$ (Coverage of Grass)	1
s_{staff} (Annual salary per person)	$70,000
B (Budget of the year)	$1.5 B
$p_{\text{ipoach}}(H)$ (Intrinsic Poaching Rate of Herbivores)	0
$p_{\text{ipoach}}(\mathrm{C})$ (Intrinsic Poaching Rate of Carnivores)	0.4
$N(H)_0$ (Initial Density of Herbivores)	3.4
$N(\mathrm{C})_0$ (Initial Density of Carnivores)	0.05

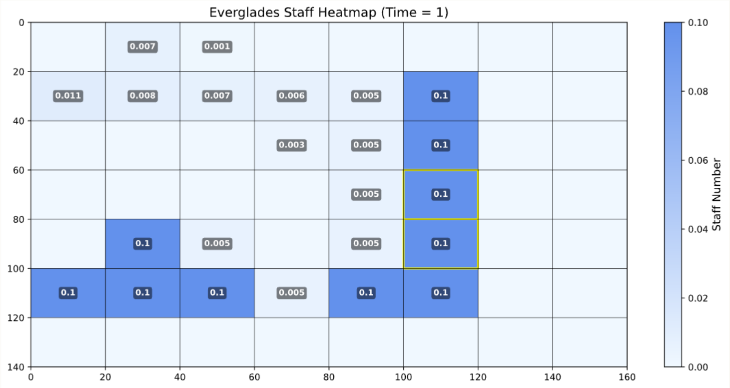
Adapting: Results for Everglades

Drones Deployment

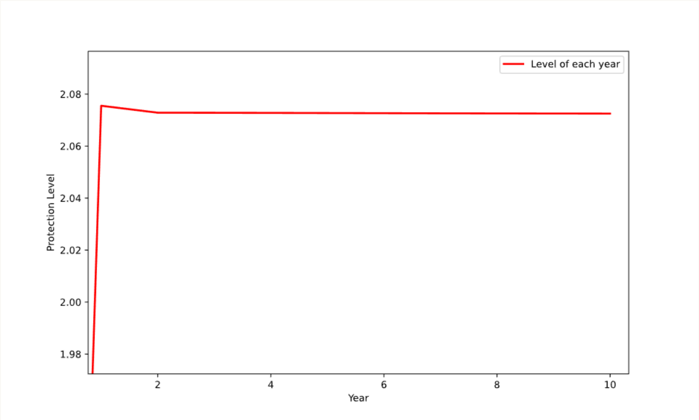
Staff Deployment

First Year

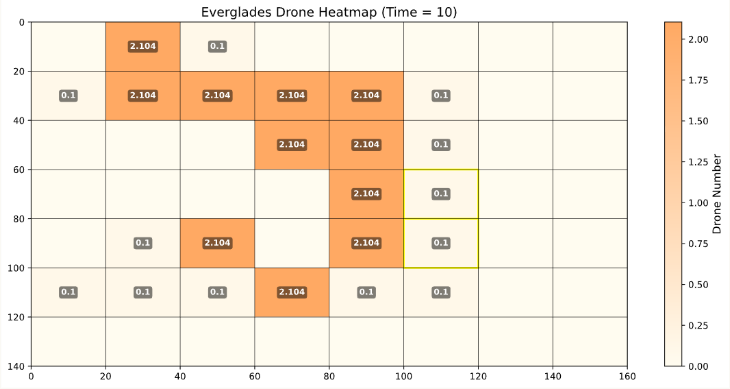


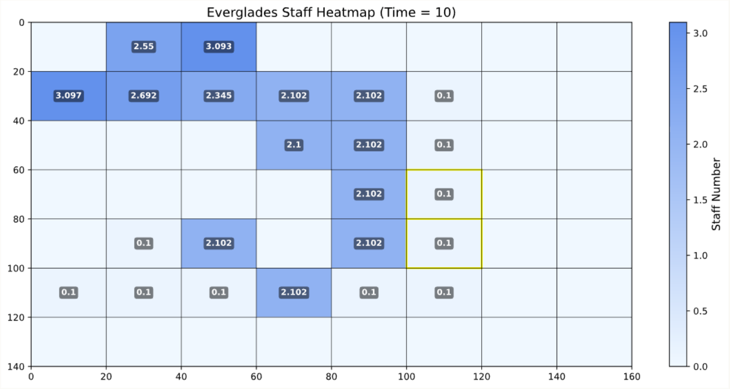


Protection Level

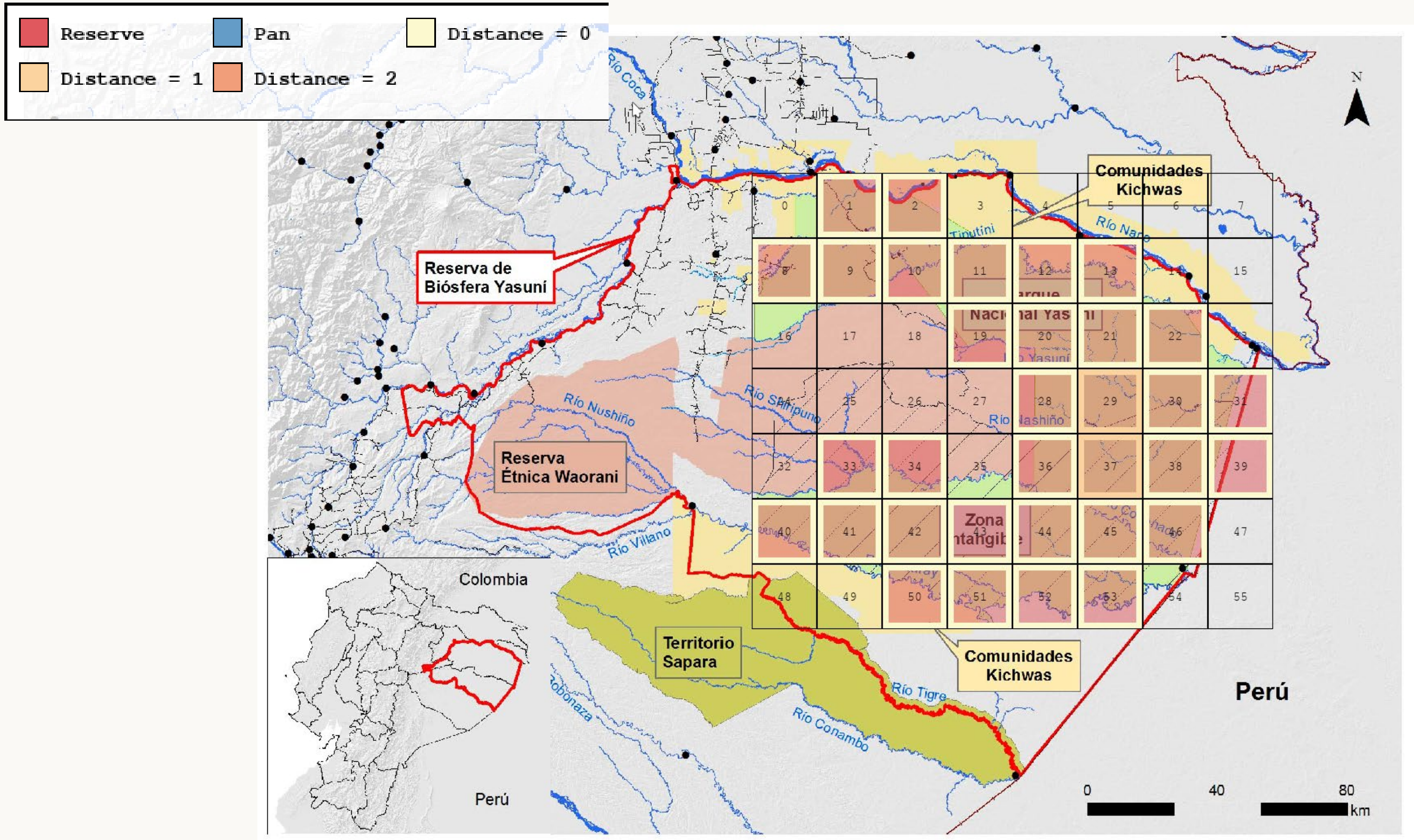


Tenth Year





Adapting: to Yasuní, South America



Plot division in Yasuni

Adapting: to Yasuní, South America

Adjusted data

Params & Description	Value
$R_{\text{staff,poach}}$ (Monitoring Radius of Human Staff)	1000 m
$R_{\text{drone,poach}}$ (Monitoring Radius of Drones)	5000 m
$R_{\text{drone,fire}}$ (Fire Prevention Radius of Drones)	1000m

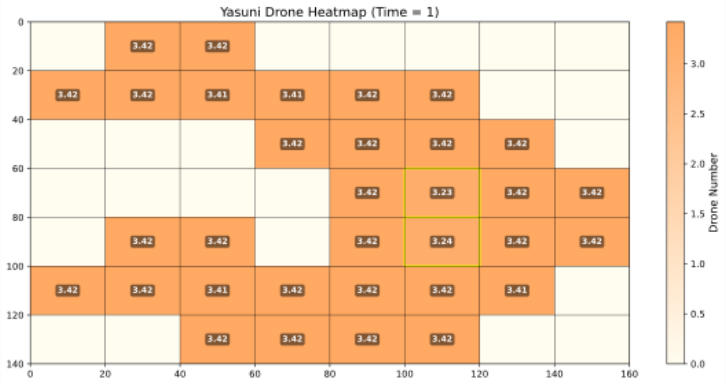
Params & Description	Value
$N(P)_0$ (Coverage of Grass)	1
s_{staff} (Annual salary per person)	$13,000
B (Budget of the year)	$1 M
$p_{\text{ipoach}}(H)$ (Intrinsic Poaching Rate of Herbivores)	0.05
$p_{\text{ipoach}}(\mathrm{C})$ (Intrinsic Poaching Rate of Carnivores)	0.4
$N(H)_0$ (Initial Density of Herbivores)	5
$N(\mathrm{C})_0$ (Initial Density of Carnivores)	0.041

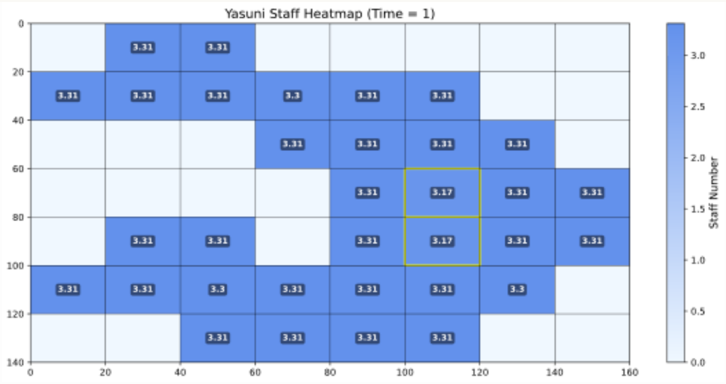
Adapting: Results for Yasuní

Drones Deployment

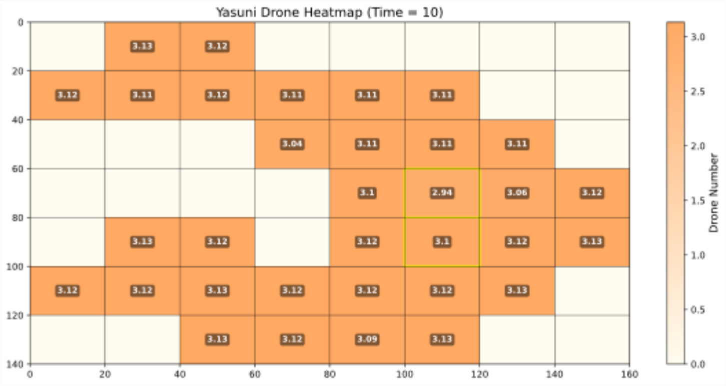
Staff Deployment

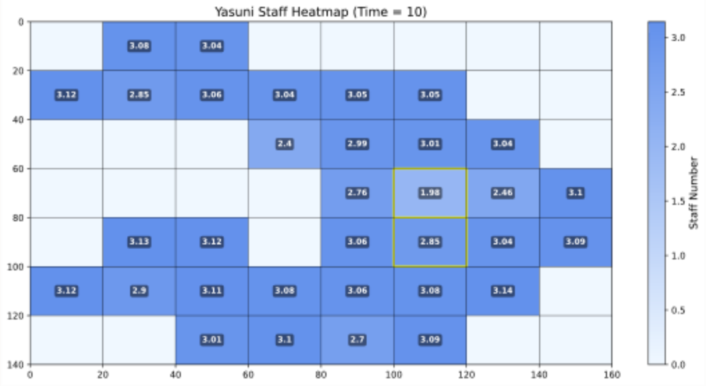
First Year



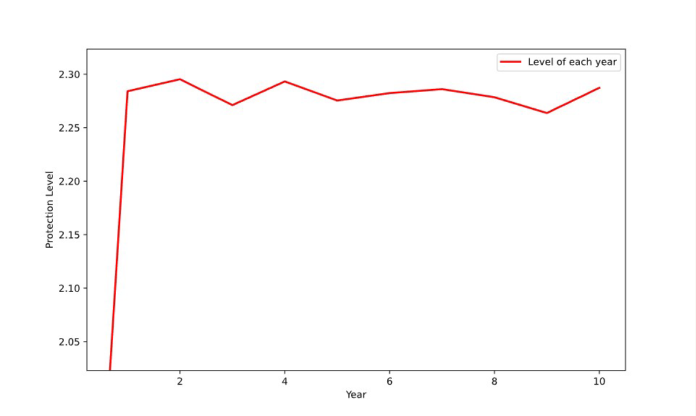


Tenth Year





Protection Level



Conclusion: Strengths & Weaknesses

Strengths

- Application of Gradient Descent and ADAM Optimizer
- Incorporation of Sensitivity Analysis
- Model Generalizability

Weaknesses

- Subjective assumption
- Rough simulation of the ecosystem

Thanks for
Your listening

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