

# Making better conservation decisions



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# Acknowledgements

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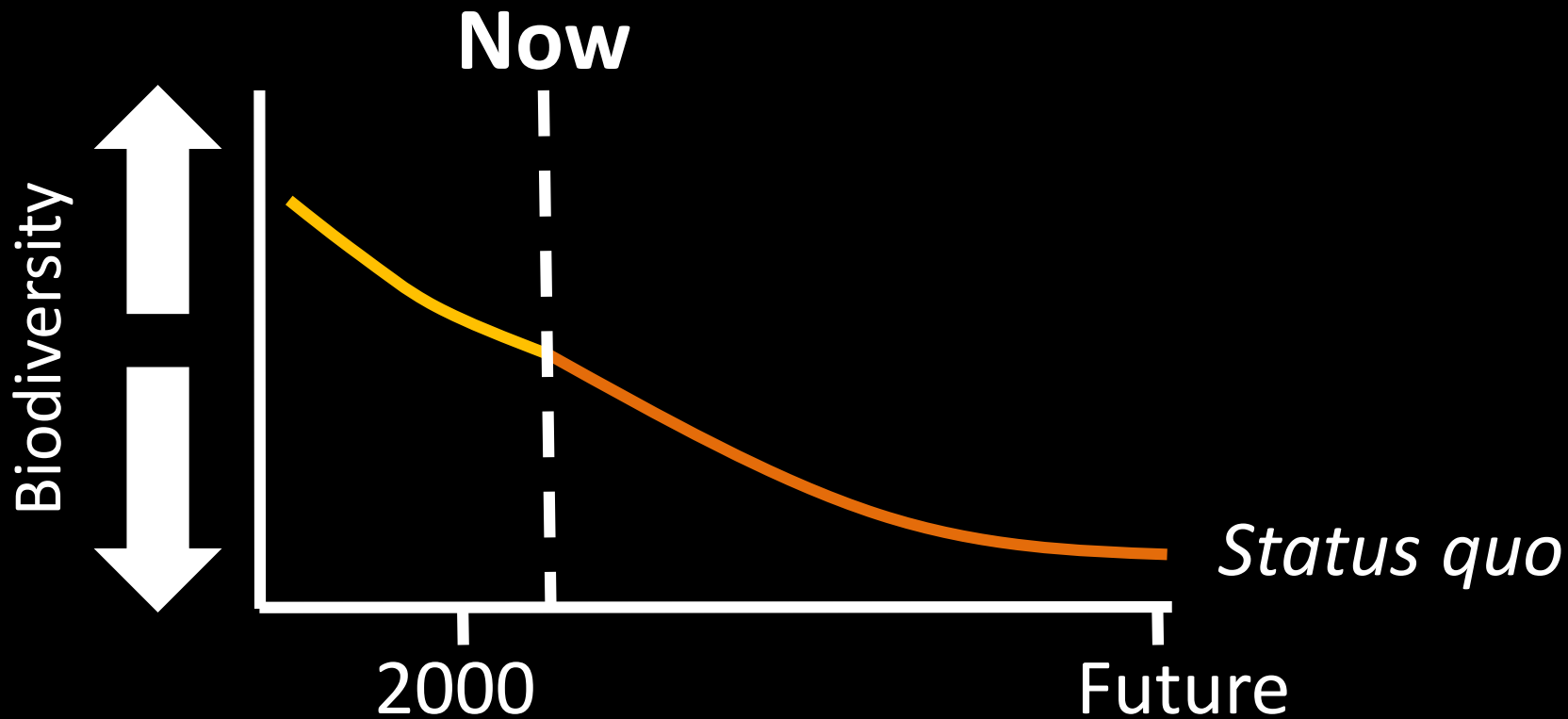


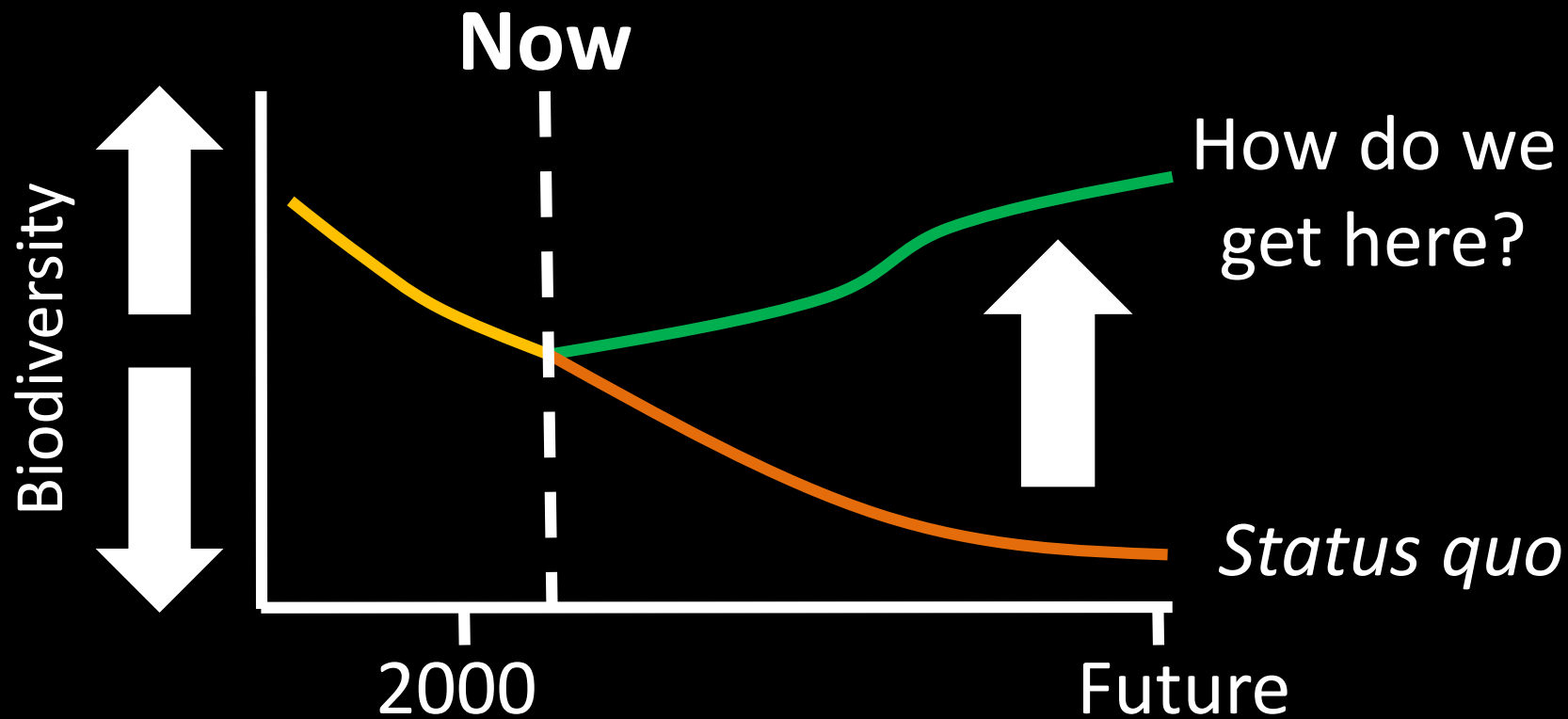
NATURE  
CONSERVANCY  
CANADA



Environment and  
Climate Change Canada





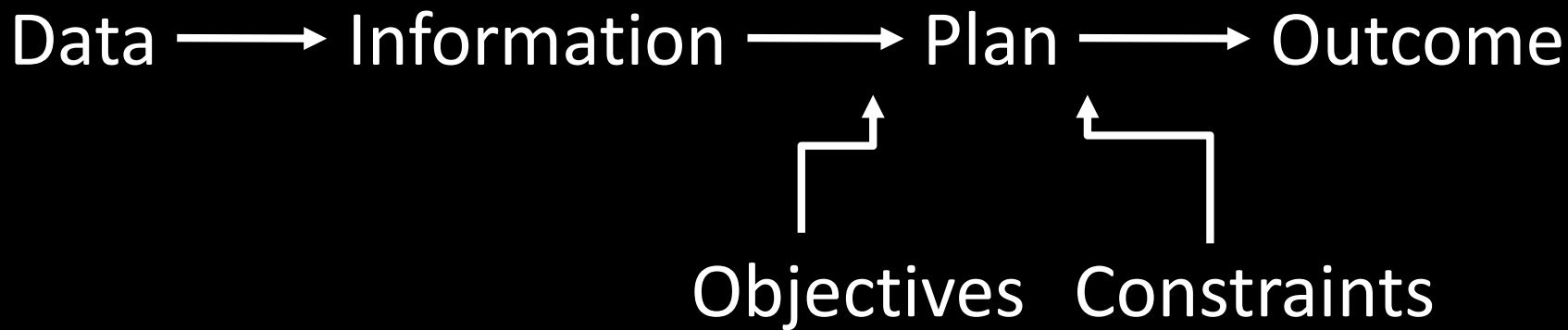
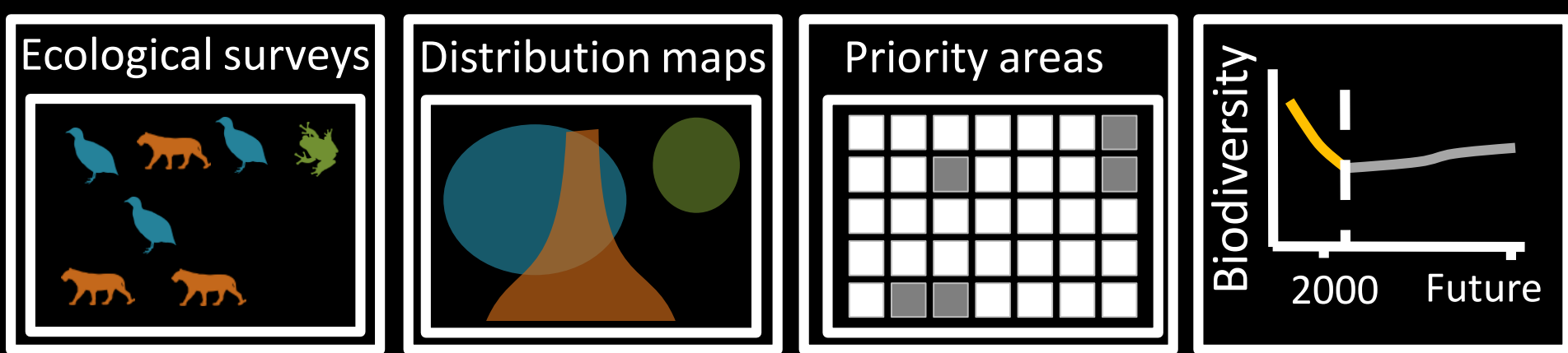


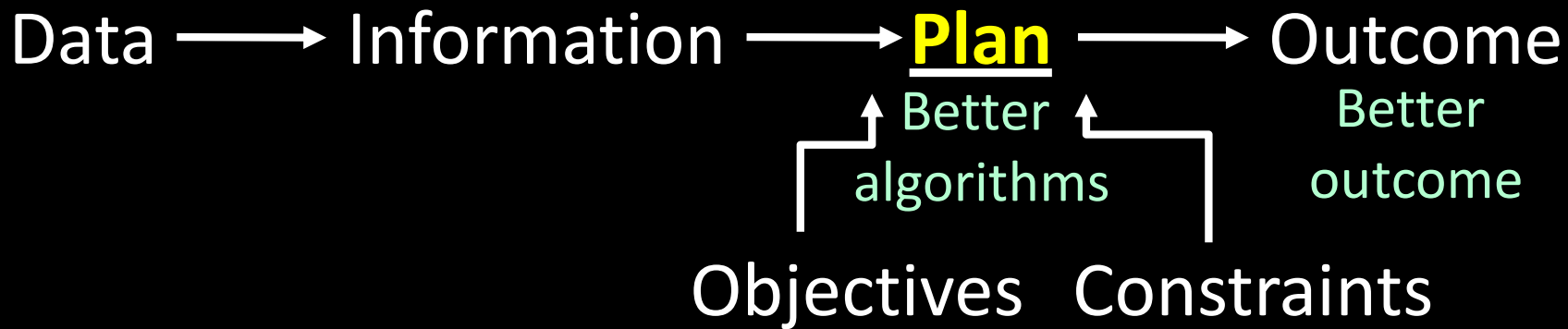
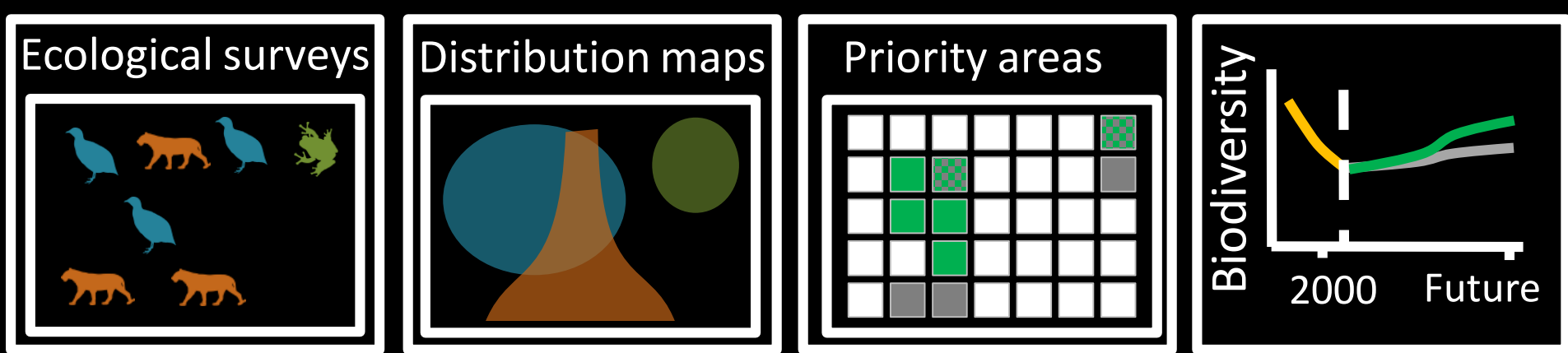
# How can we get a better conservation decision?

(1) Better algorithms

(2) Better data

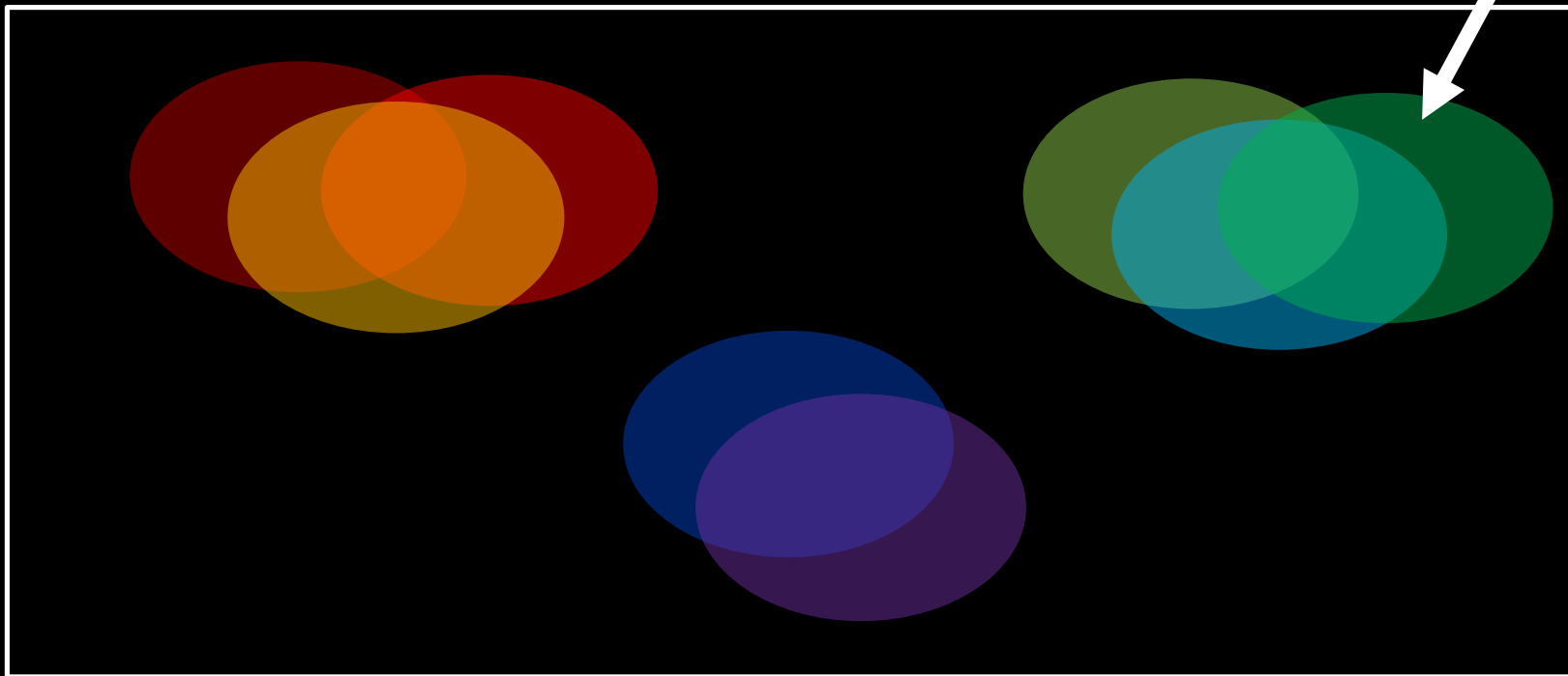
(3) Better surrogates





# Reserve selection

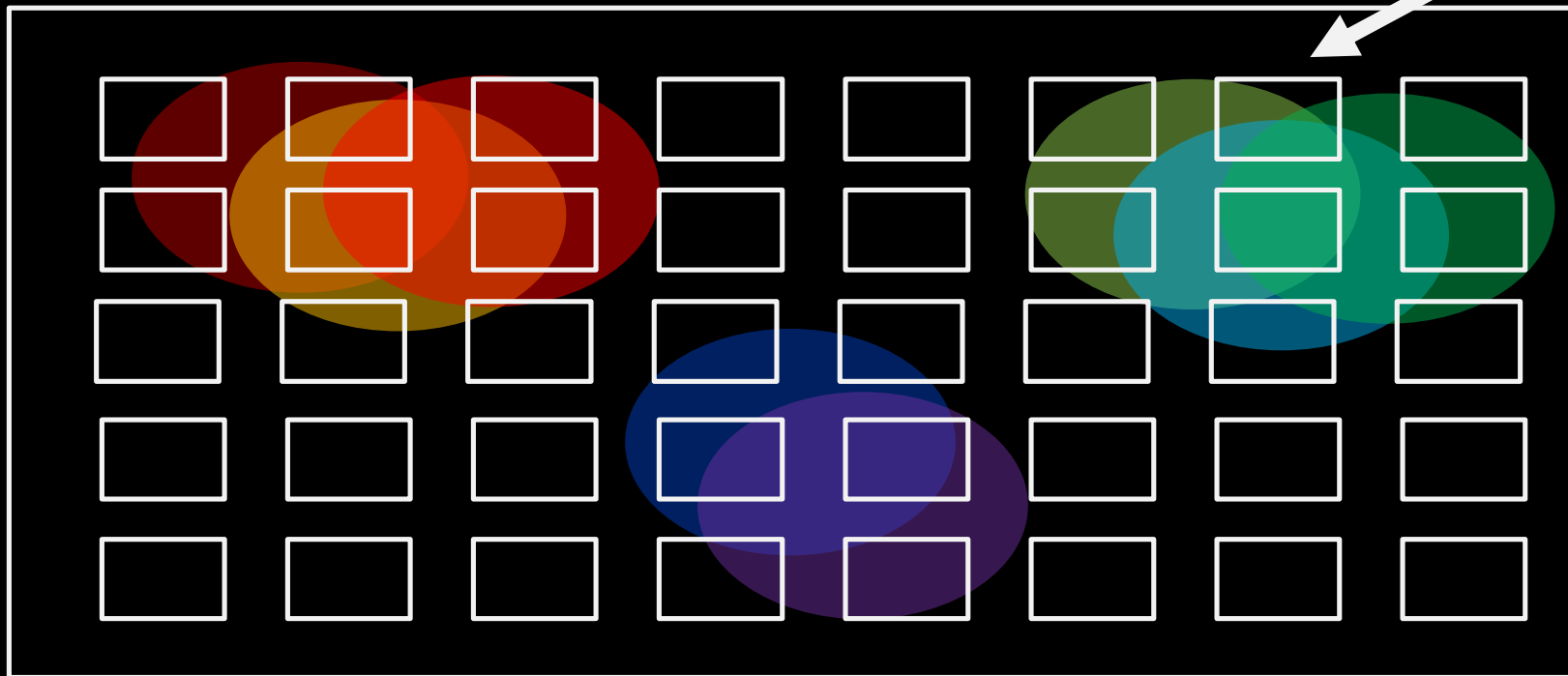
Features



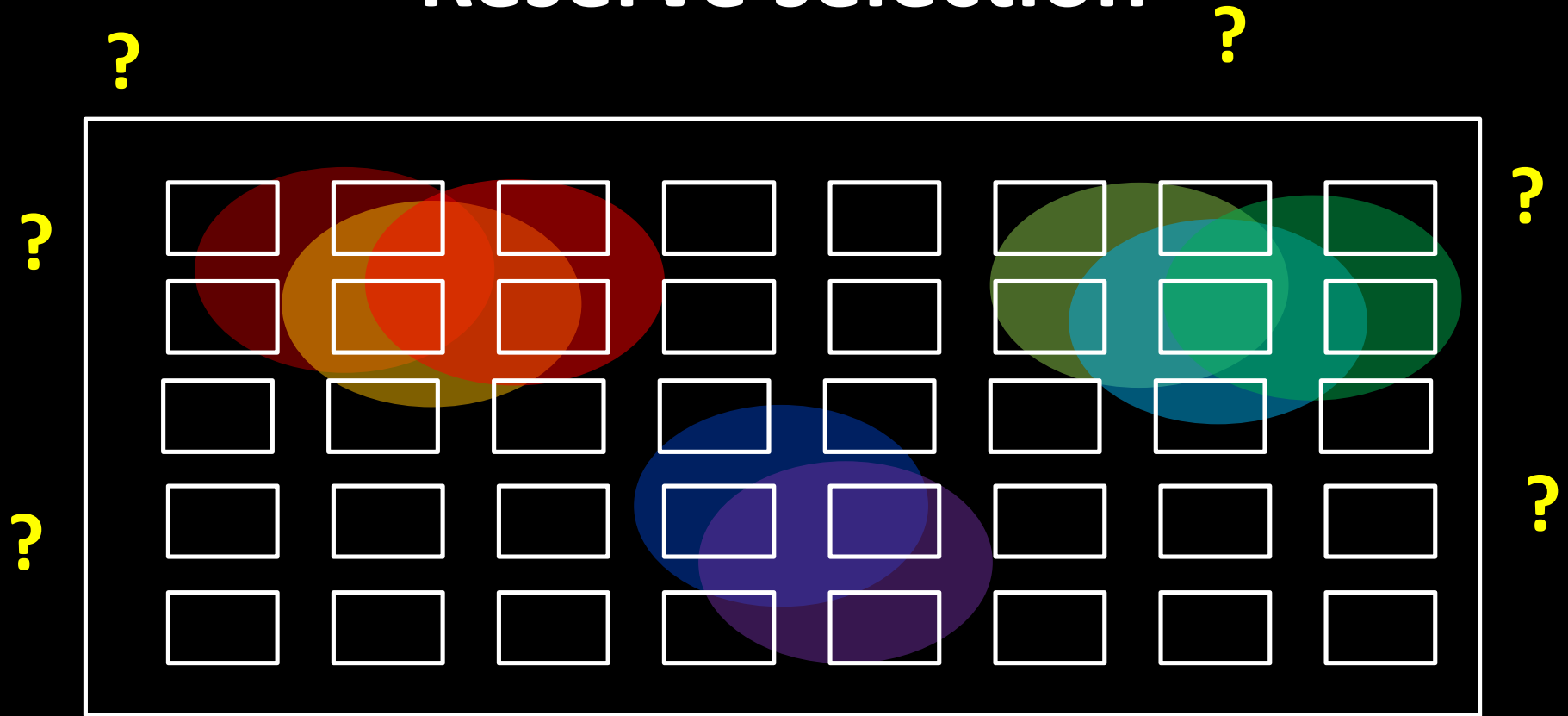


# Reserve selection

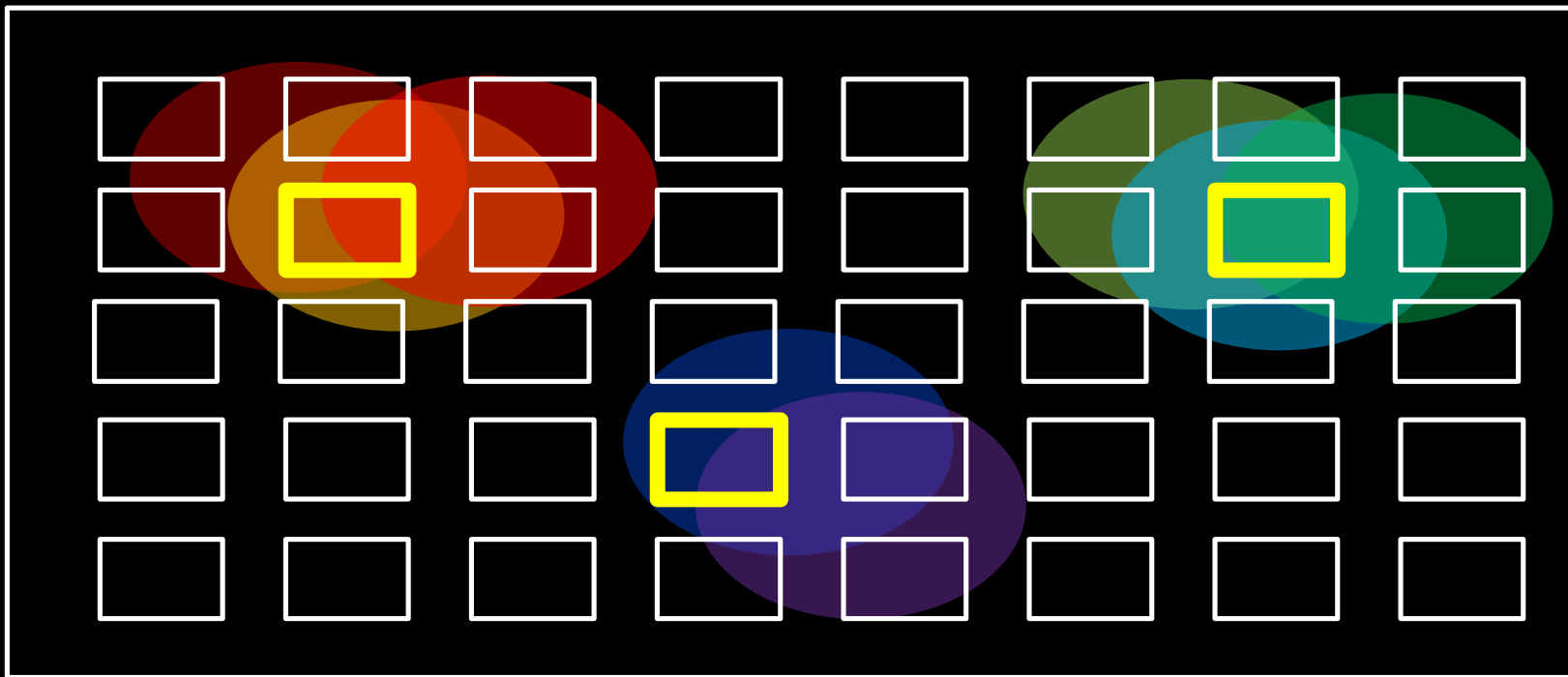
Planning units



# Reserve selection

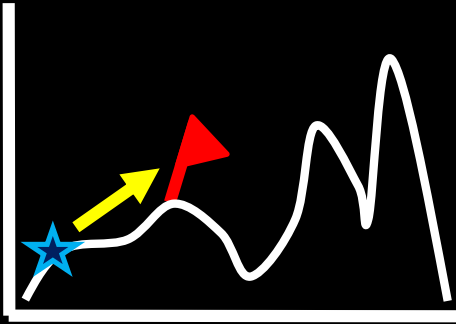


# Reserve selection



## Heuristic algorithm

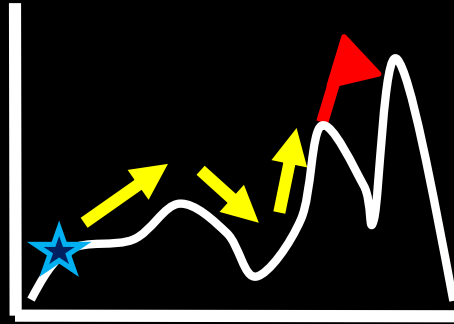
Quality



Different solutions



## Meta-heuristic algorithms

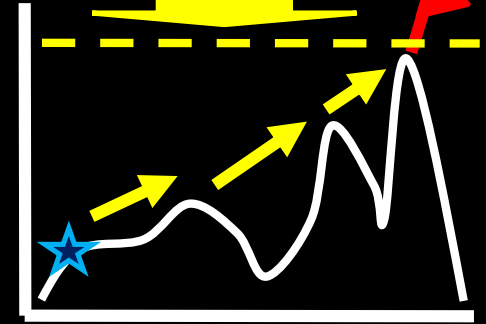


Different solutions



## Exact algorithms

Estimate of best quality



Different solutions





# prioritizr R package

Objective

what makes the solution better?

Data

Biodiversity  
Land use  
Economic  
Social

Mathematical  
optimization  
problem

Constraints

what must the solution do?

Input to solver

Solve problem

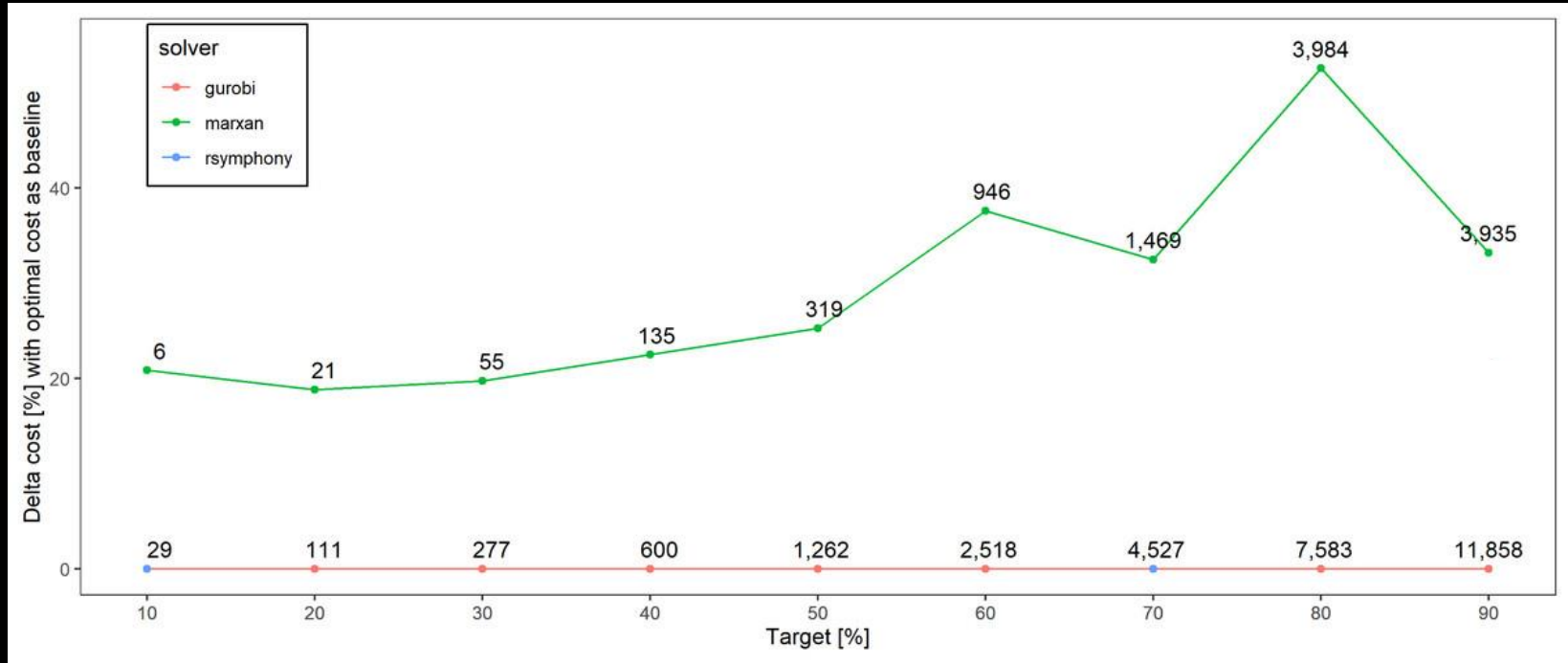


Maps

Metrics

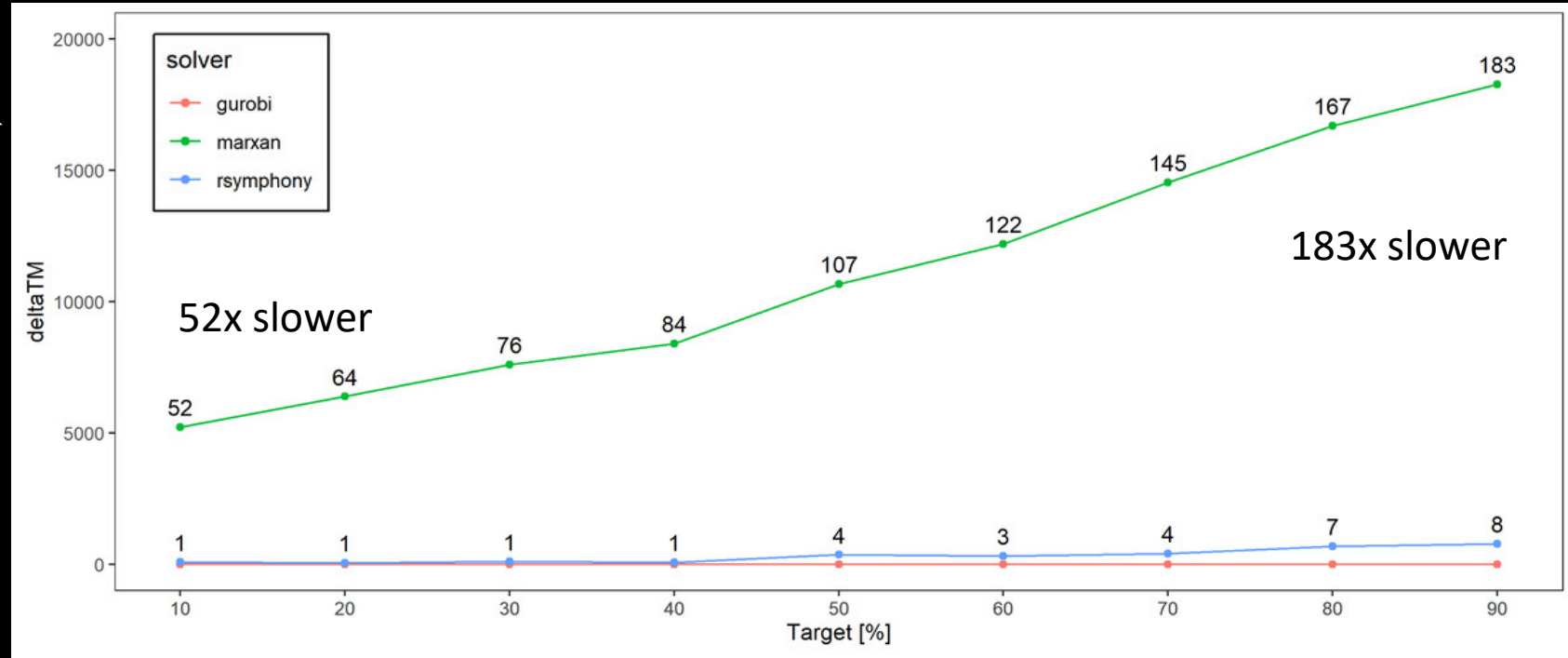
Better solution quality

# Better solutions



# Faster too!

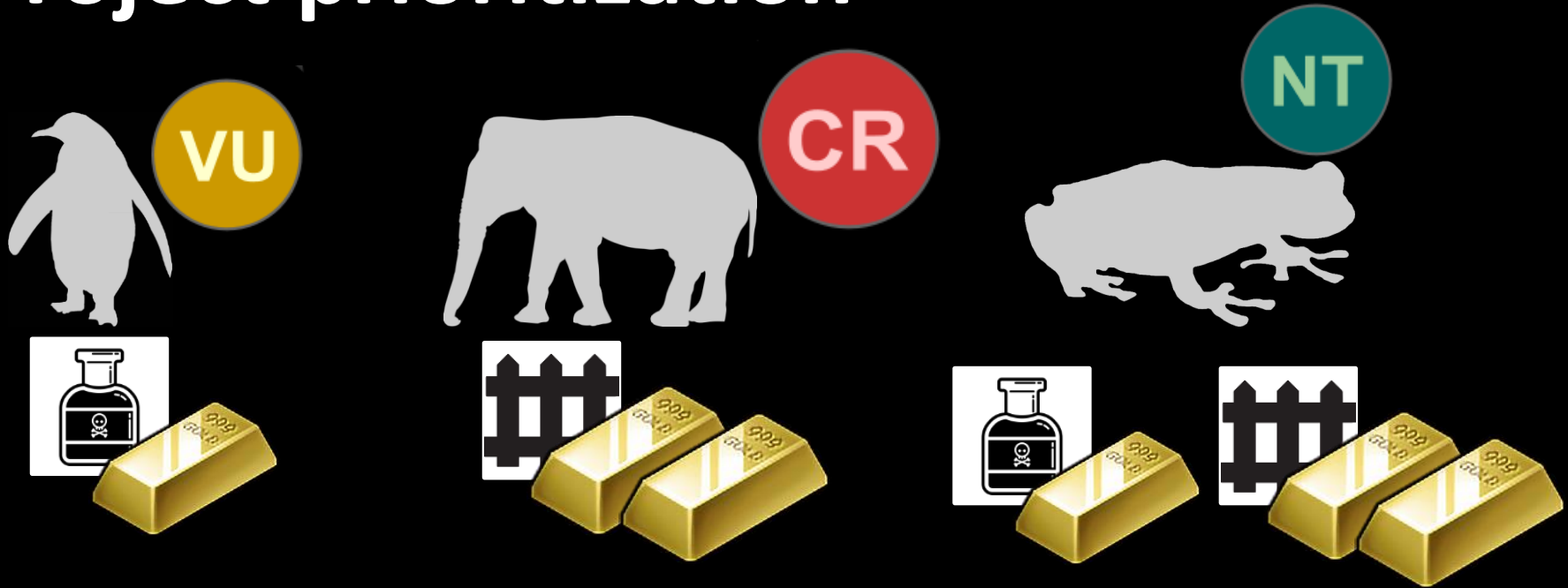
Slower run time



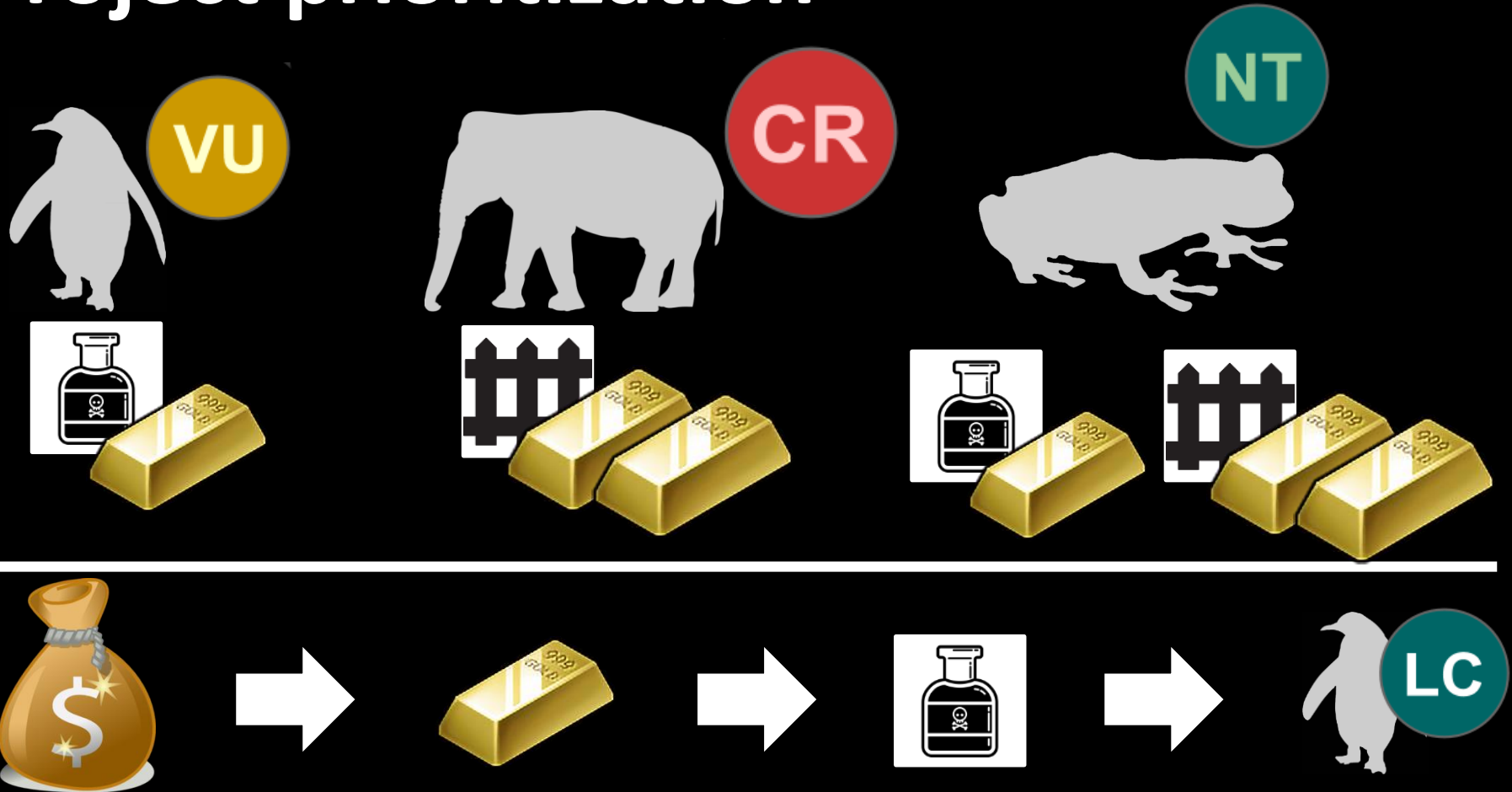
What about other  
types of problems?



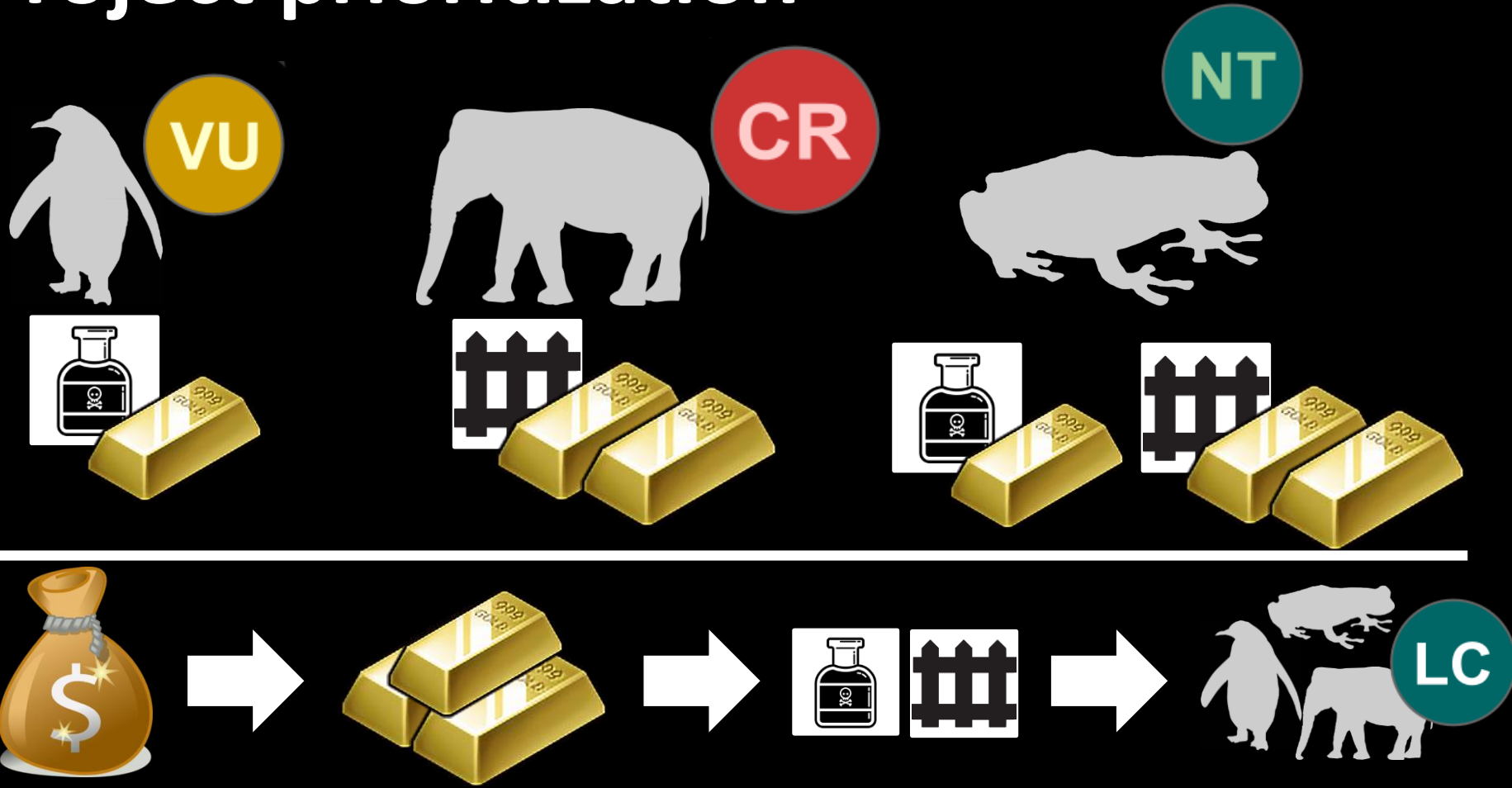
# Project prioritization



# Project prioritization

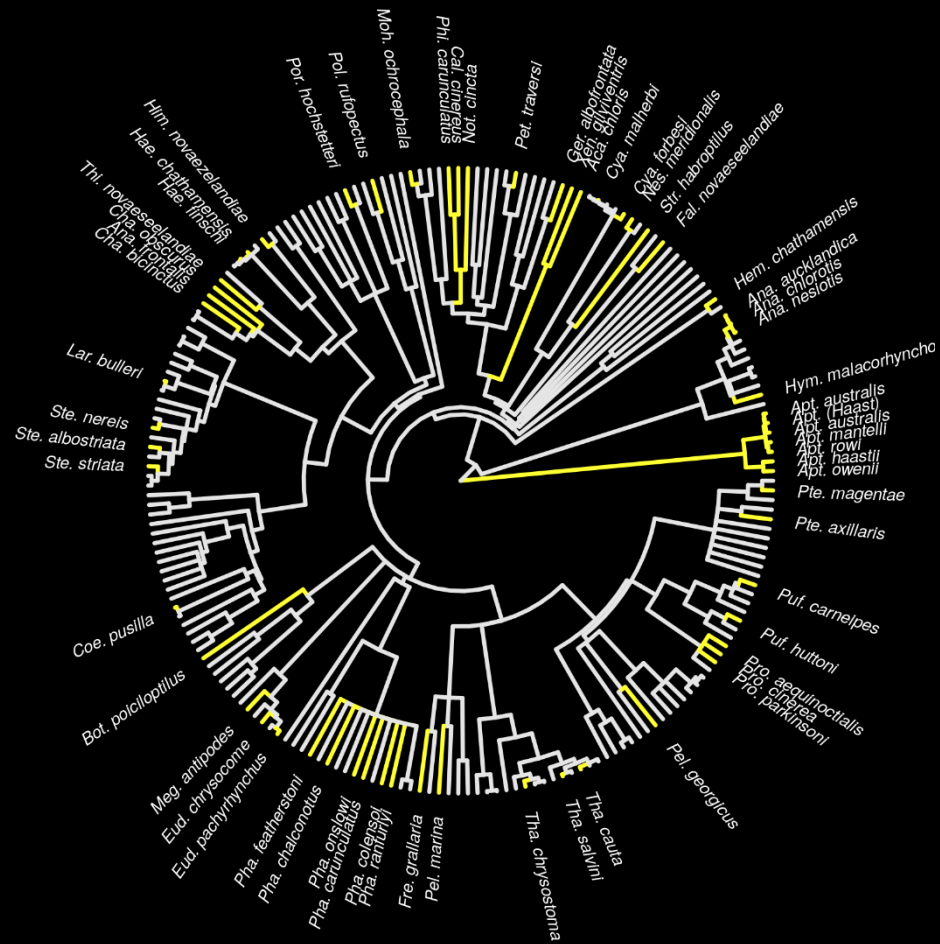


# Project prioritization

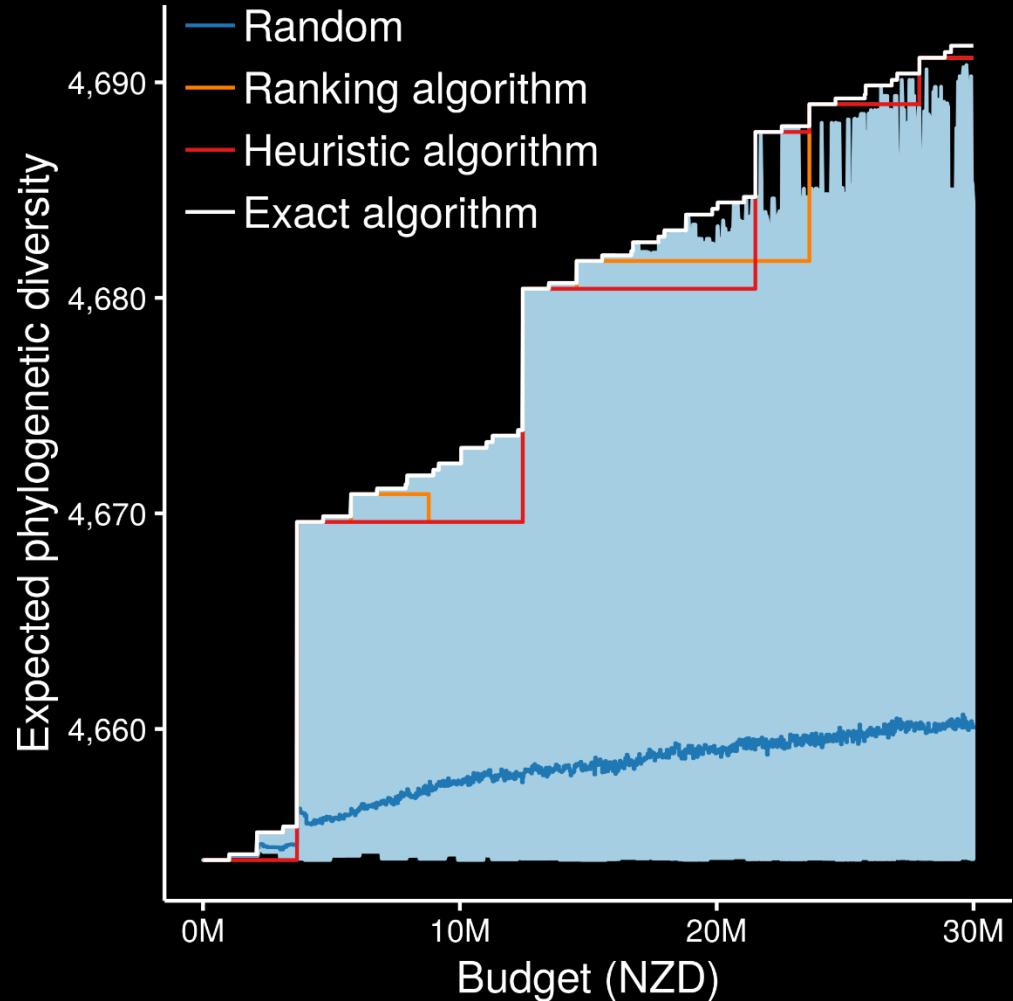


# New Zealand case study

- Projects for 62 imperiled bird species
- 1,218 different actions
- Many actions shared between projects for different species



- Exact algorithms always best
- Ranking and heuristic algorithms sometimes produced optimal plans
- Randomly funding projects sometimes produced better plans than ranking and heuristic algorithms
- oppr R package

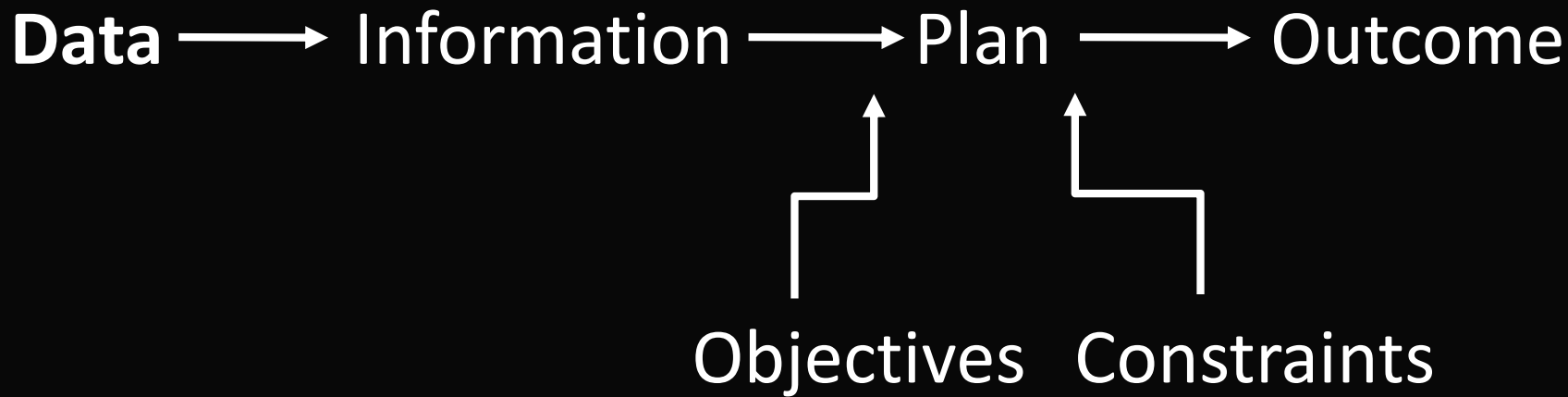
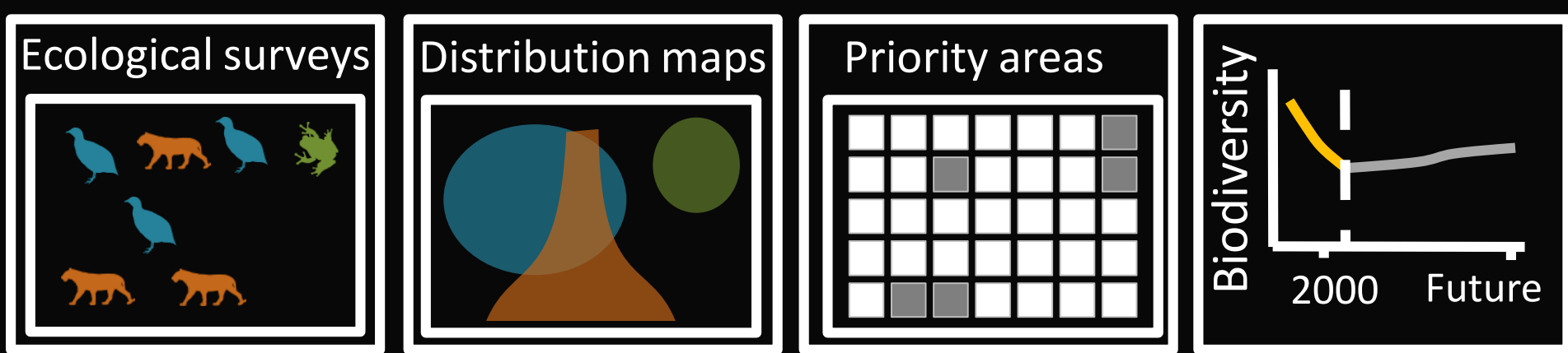


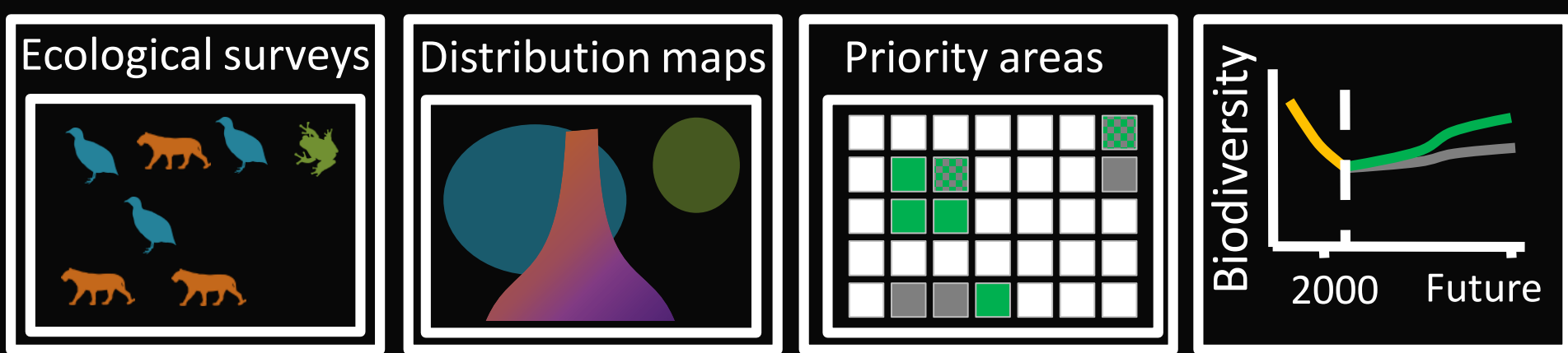
# How can we get a better conservation decision?

(1) Better algorithms

(2) Better data

(3) Better surrogates





**Data**

Information

Plan

Outcome

Better  
understanding  
of biodiversity

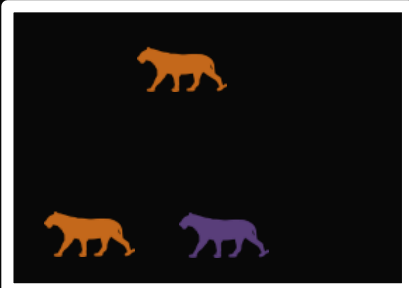
Better  
plan

Better  
outcome

Objectives

Constraints

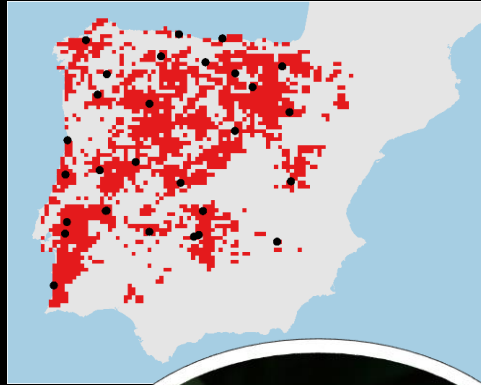
Genetic samples



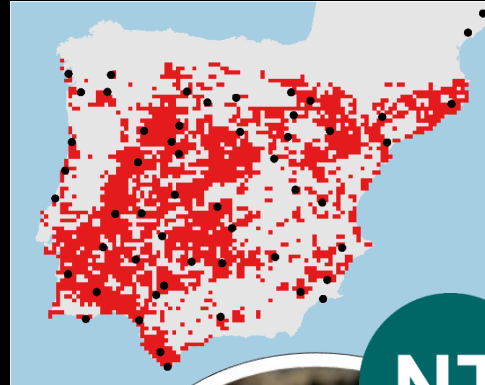


# Conservation planning for adaptive and neutral evolutionary processes

*Hyla molleri*



*Pelobates cultripipes*



NT

*Rana iberica*

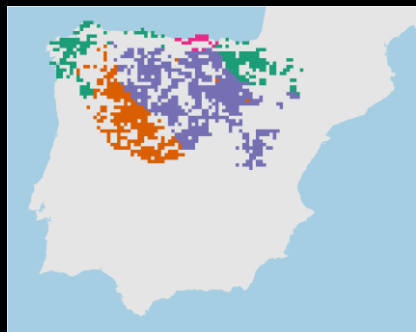


NT

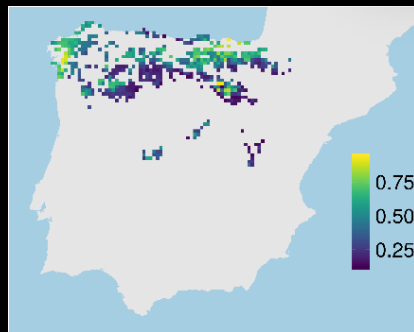
## Adaptive processes



Adaptive  
clusters

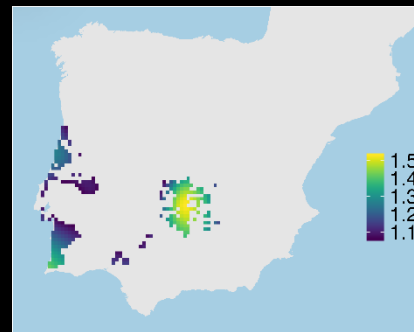


Climate  
refugia

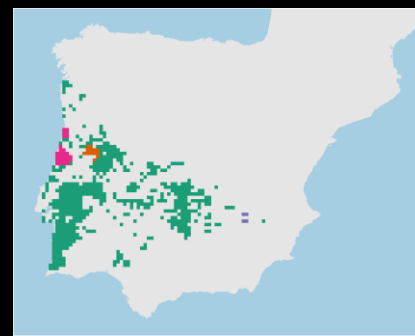
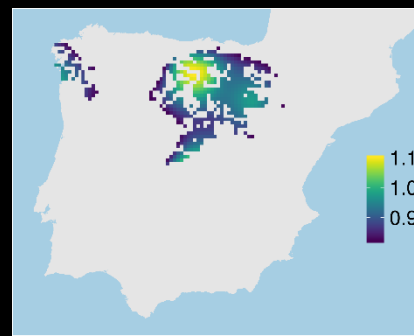
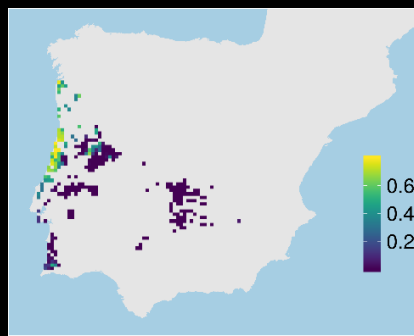
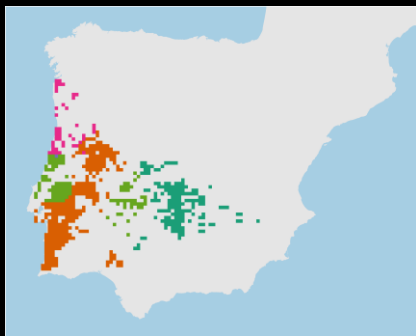
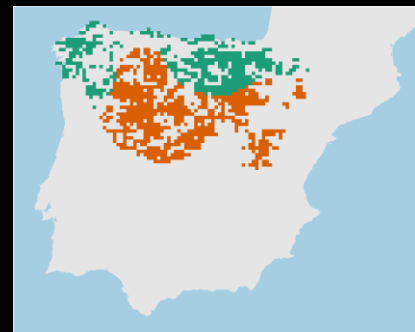


## Neutral processes

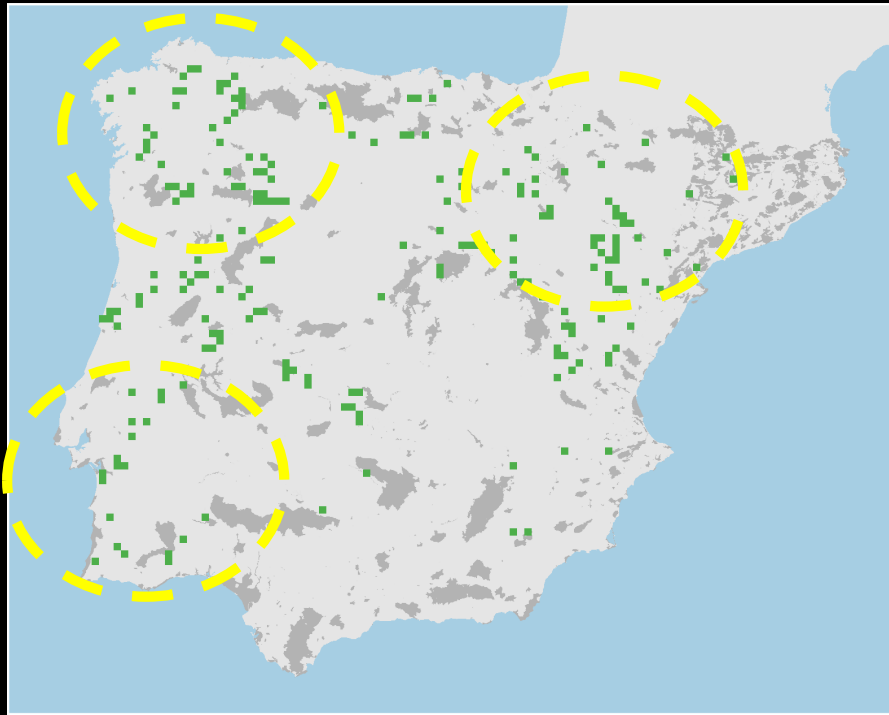
Individual  
heterozygosity



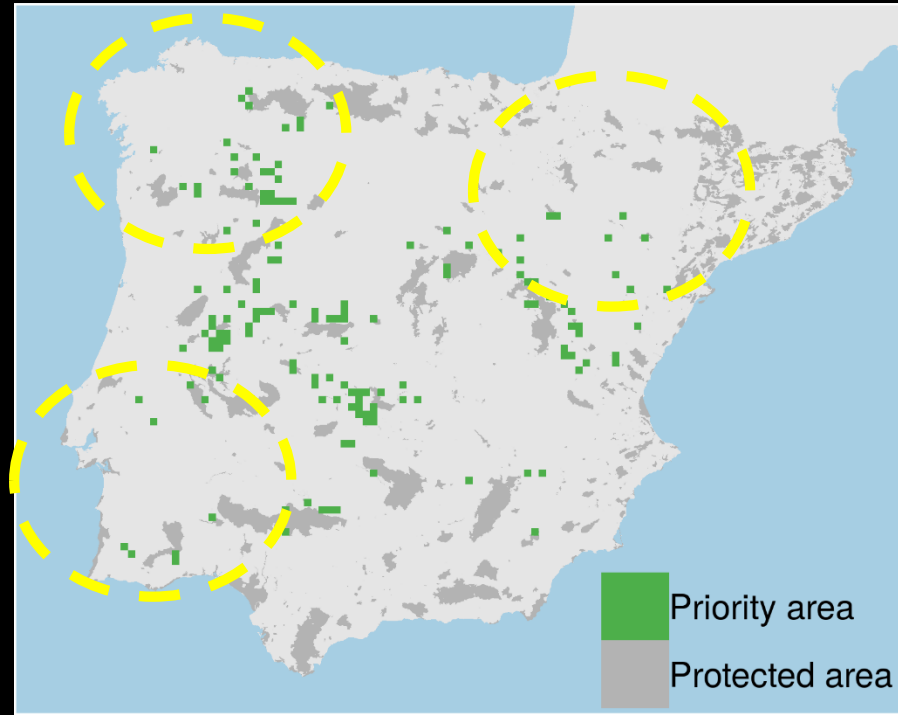
Neutral  
clusters



# Prioritizations



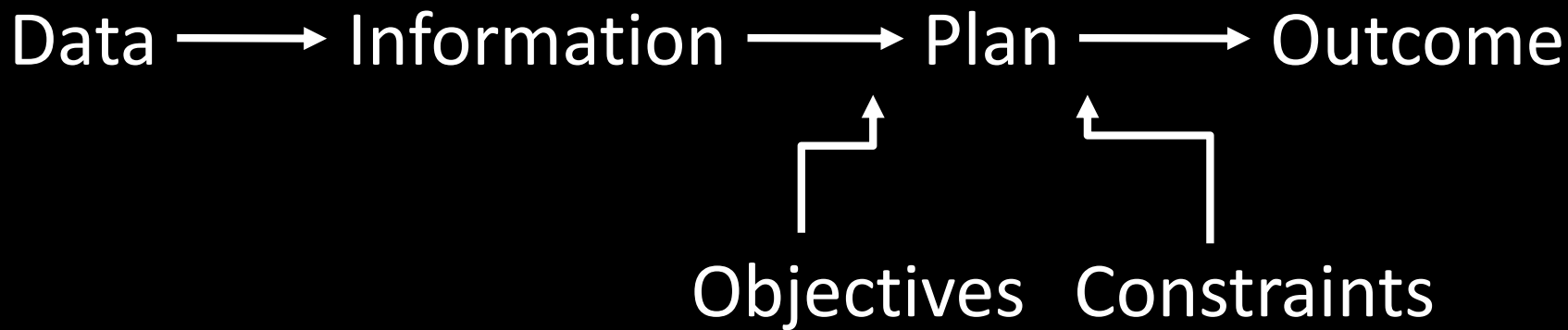
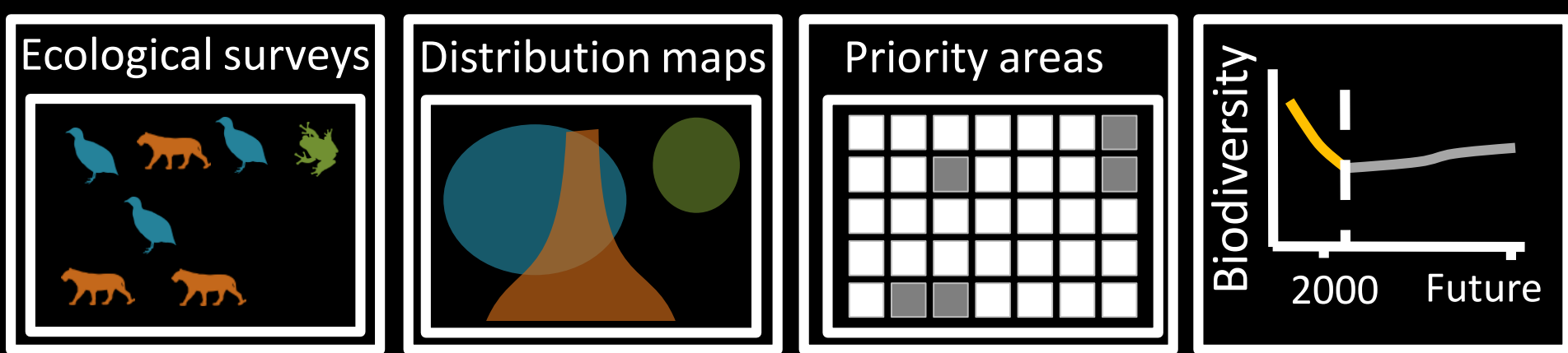
Plan with evolutionary processes

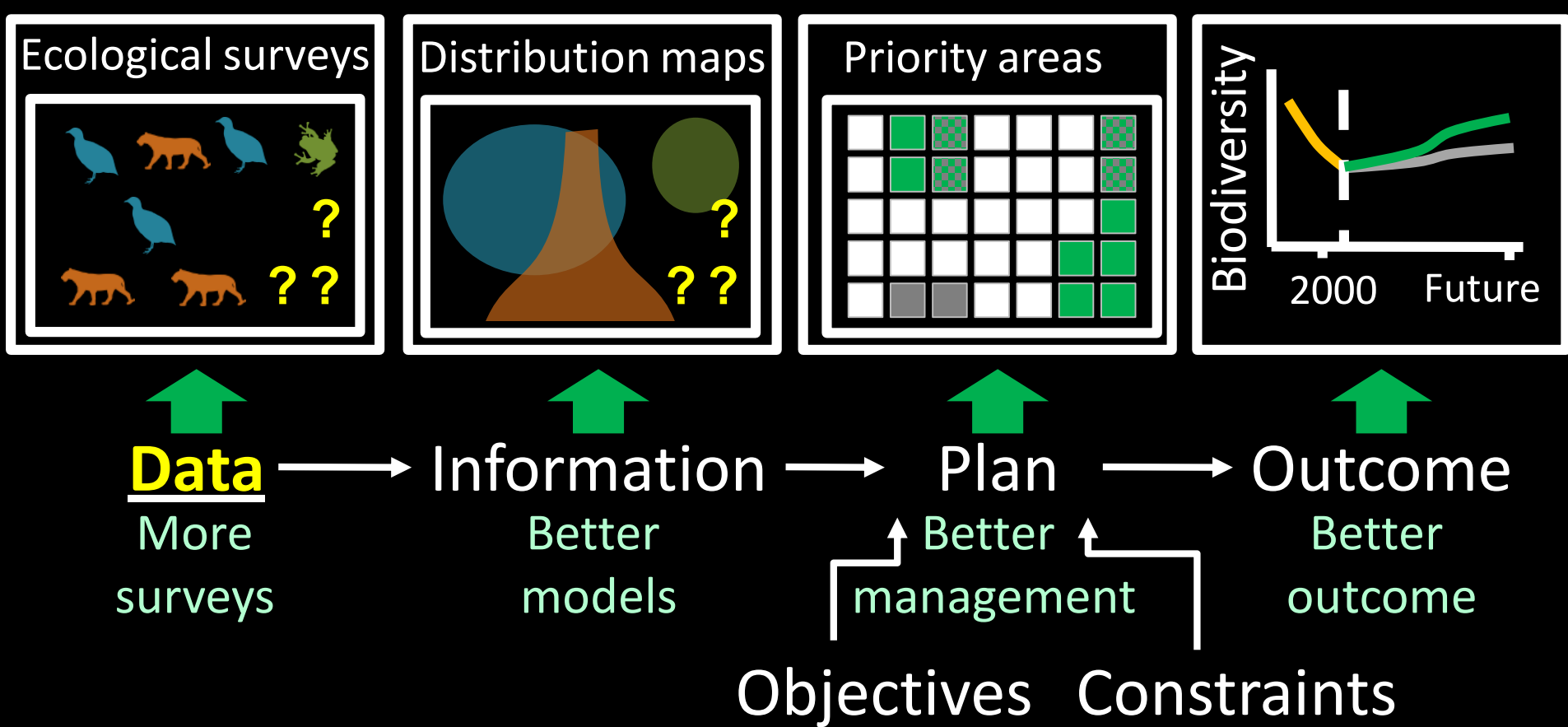


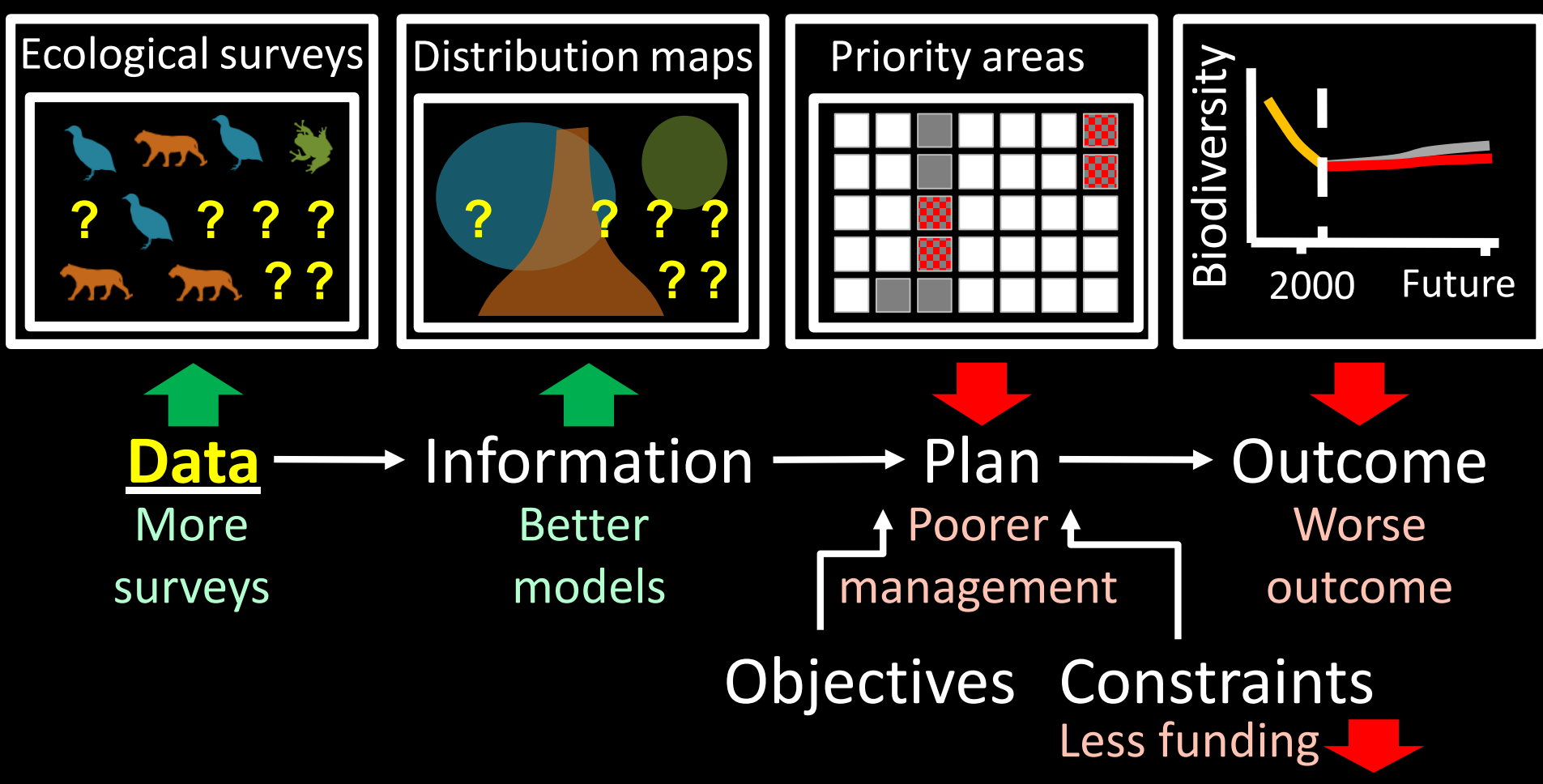
Conventional plan

**Only costs 9% less**

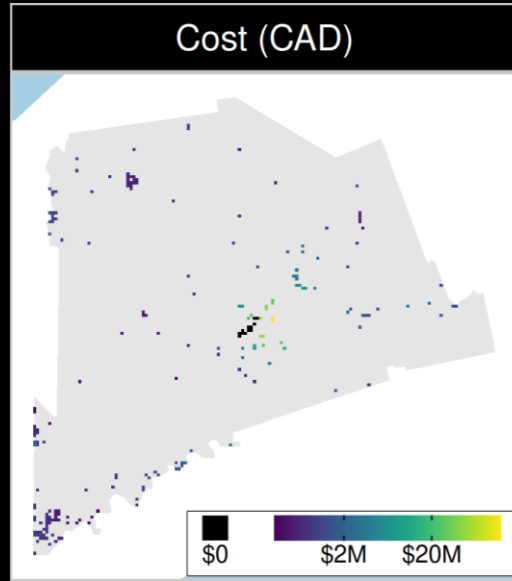
However, more data  
isn't always better...



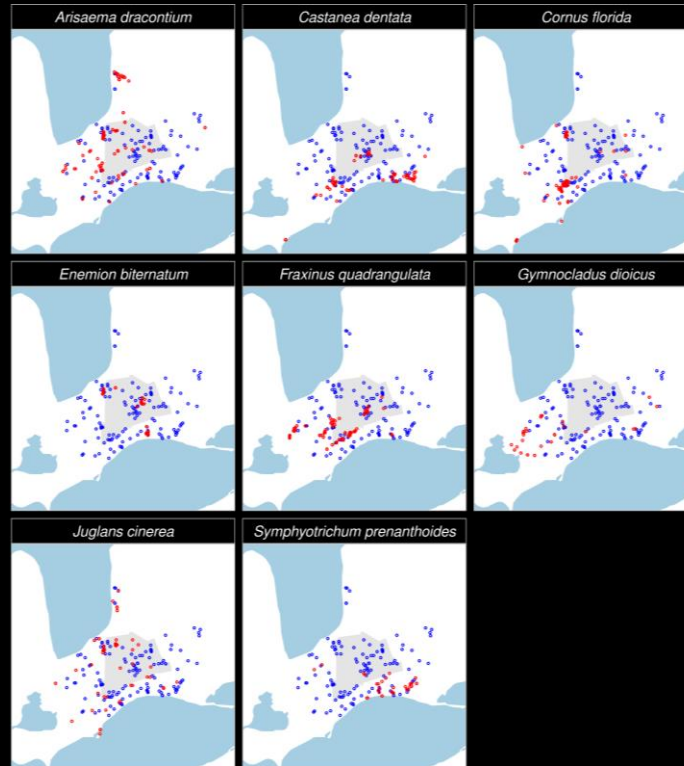




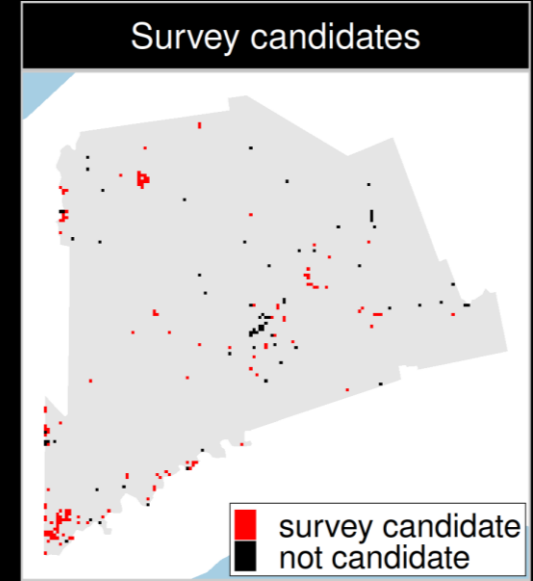
# Study system: Middlesex county, Canada



199 places that could potentially be acquired for protected area establishment



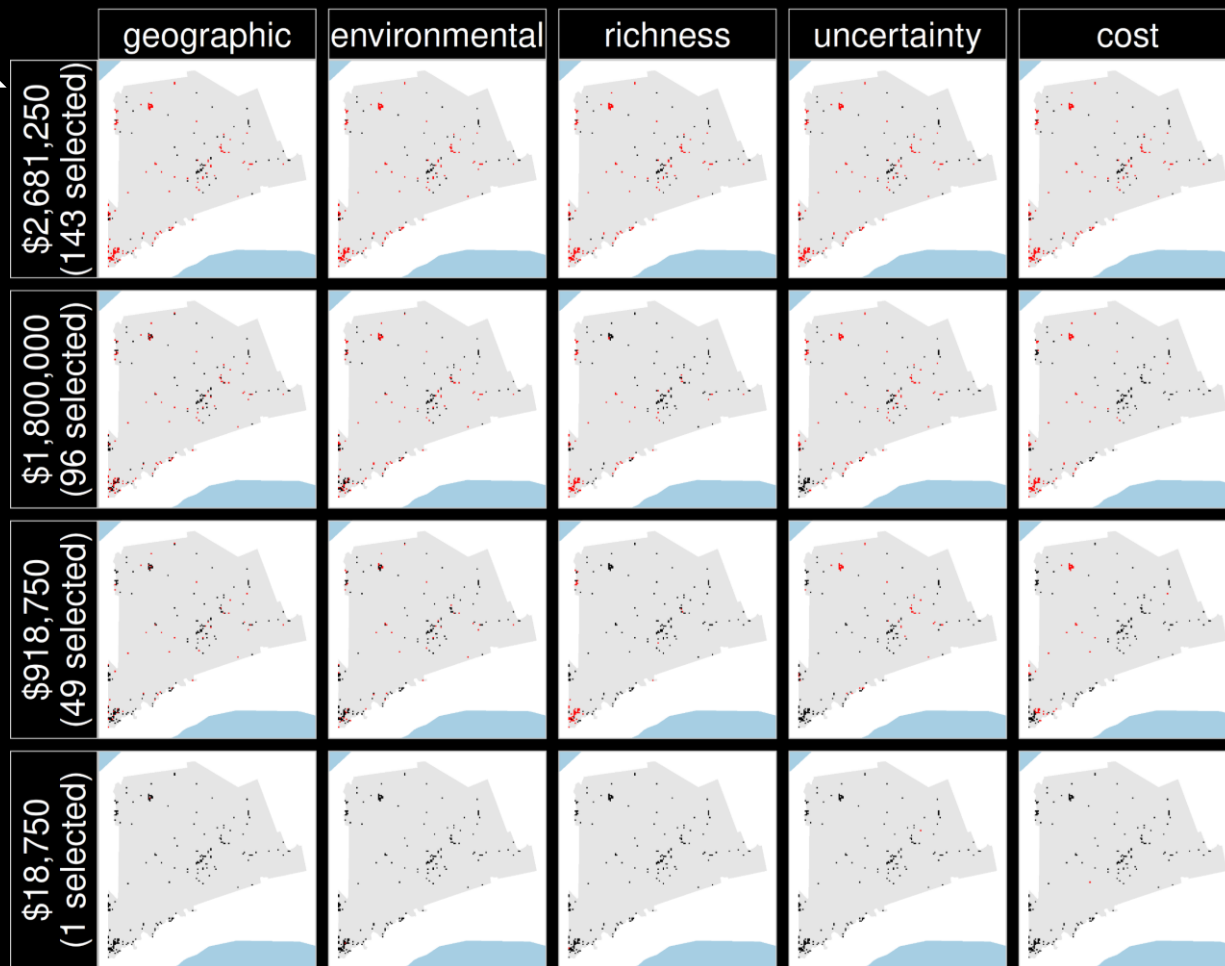
8 imperilled plant species



143 places that could potentially be surveyed to improve existing data



Number of places selected for surveys  
(amount of funds allocated for collecting extra data)



Selected  
for survey

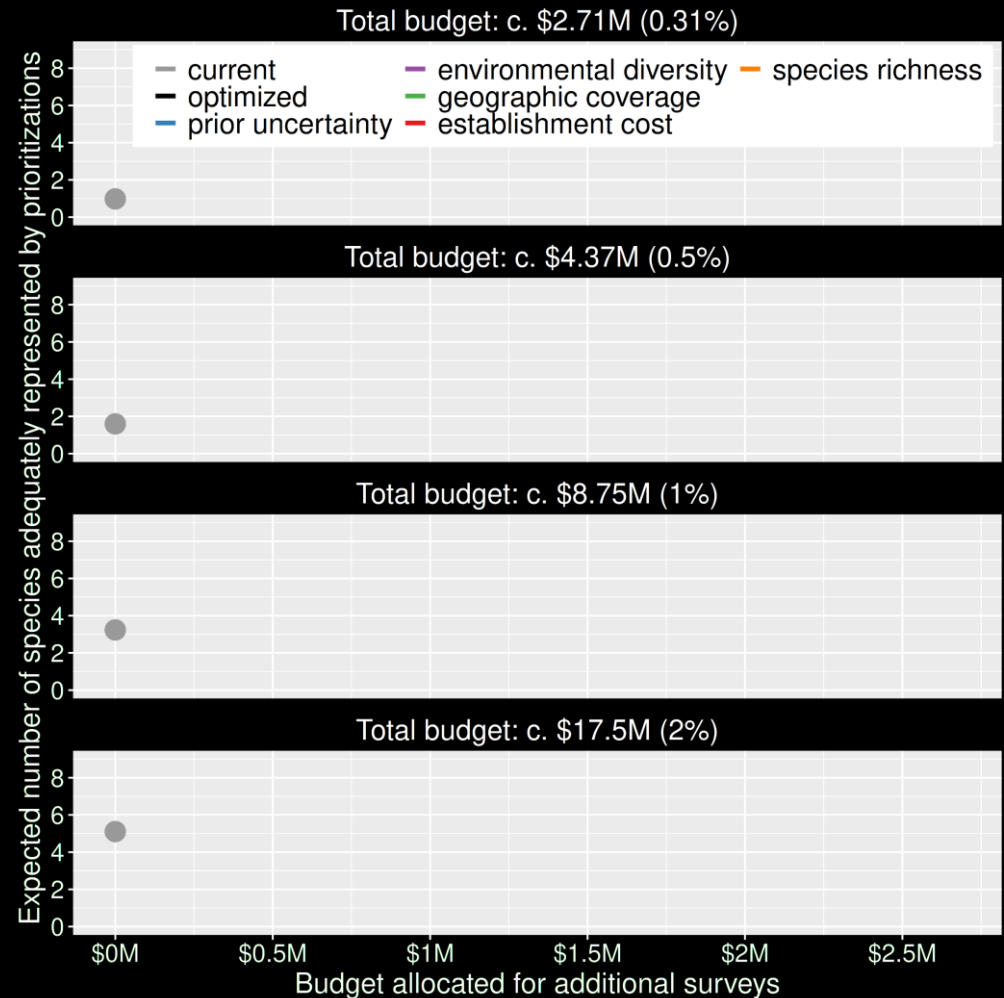


NOT selected  
for survey

Different approaches for designing survey schemes

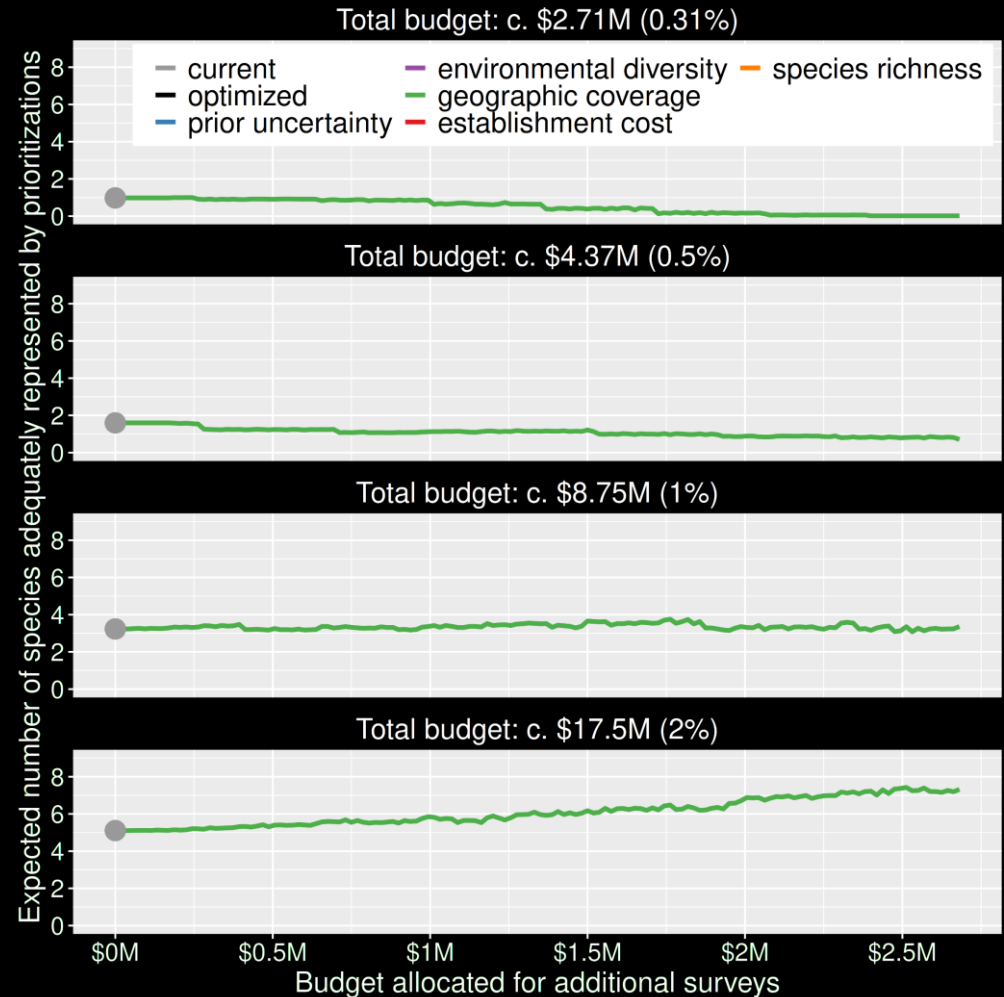
# Value of information

- Using existing data could lead to positive outcomes
- More fundings could mean better outcomes



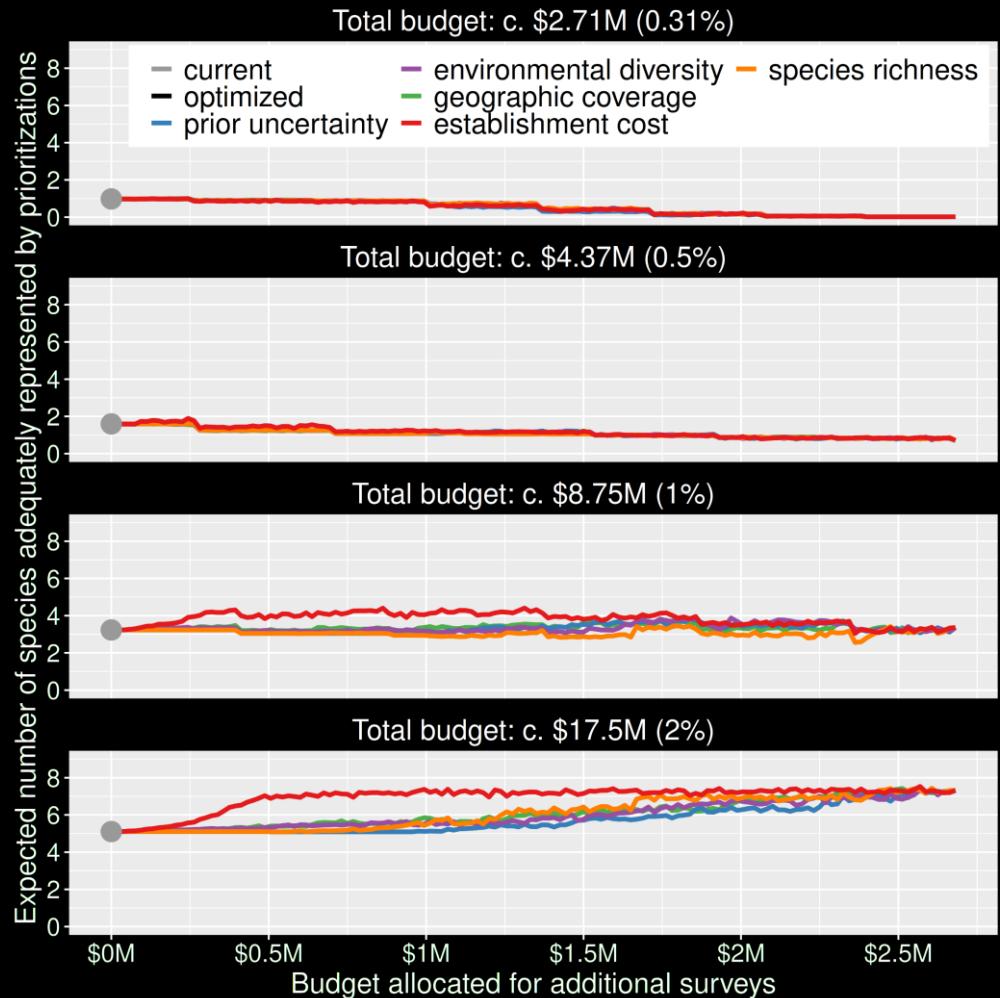
# Value of information

- Allocating funds for data collection can mean worse outcomes
- Allocating funds for data collection can mean better outcomes too



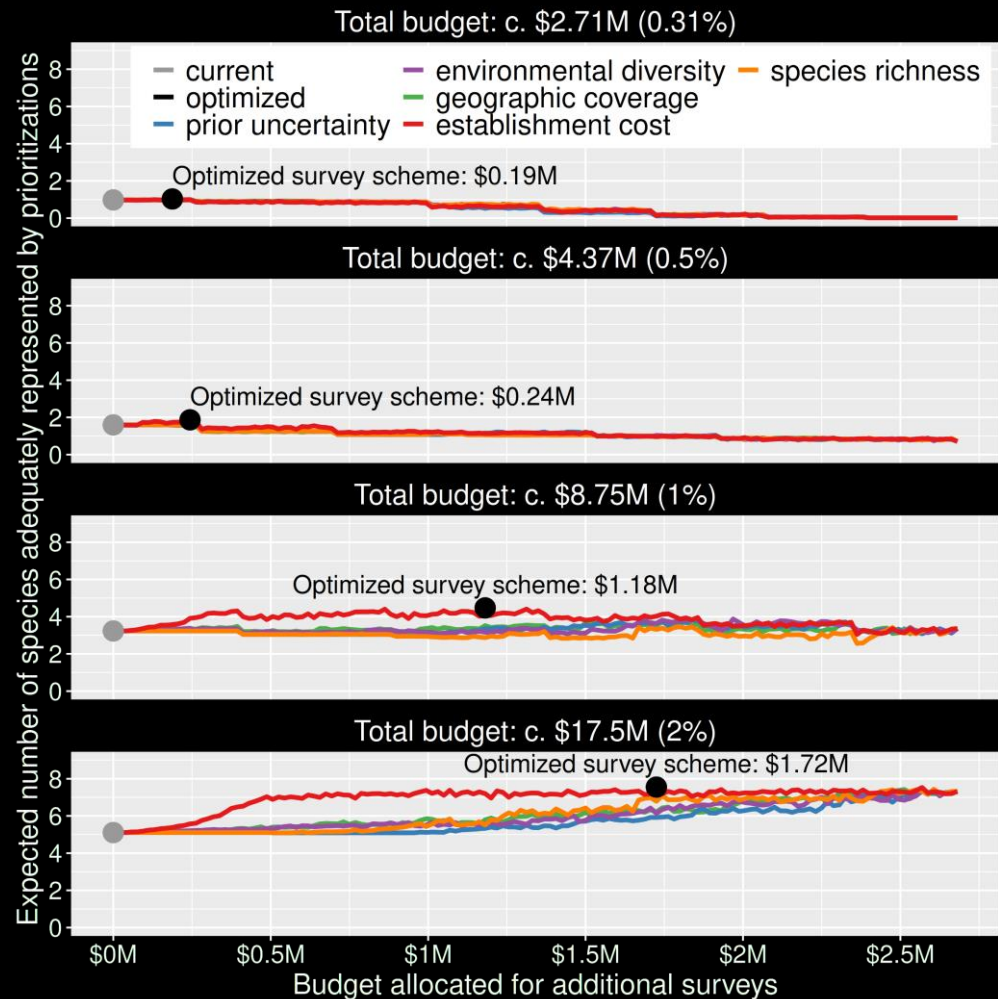
# Value of information

- Different conventional approaches have different performance
- Performance of these approaches depends on available funds
- All of them could lead to lead to worse outcomes



# Value of information

- Maximizing return on investment is best
- This considers objectives and constraints that underpin conservation plans and their success
- surveyvoi R package



# How can we get a better conservation decision?

(1) Better algorithms

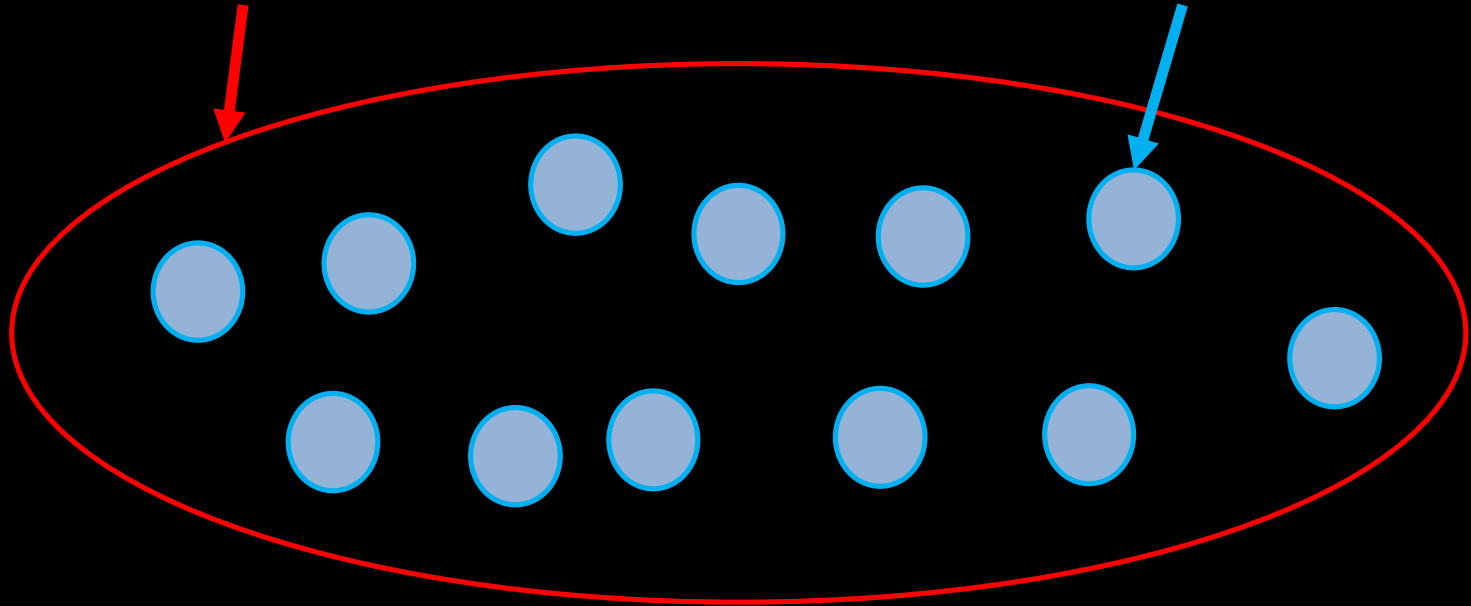
(2) Better data

(3) Better surrogates

# Evolutionary processes

Species range

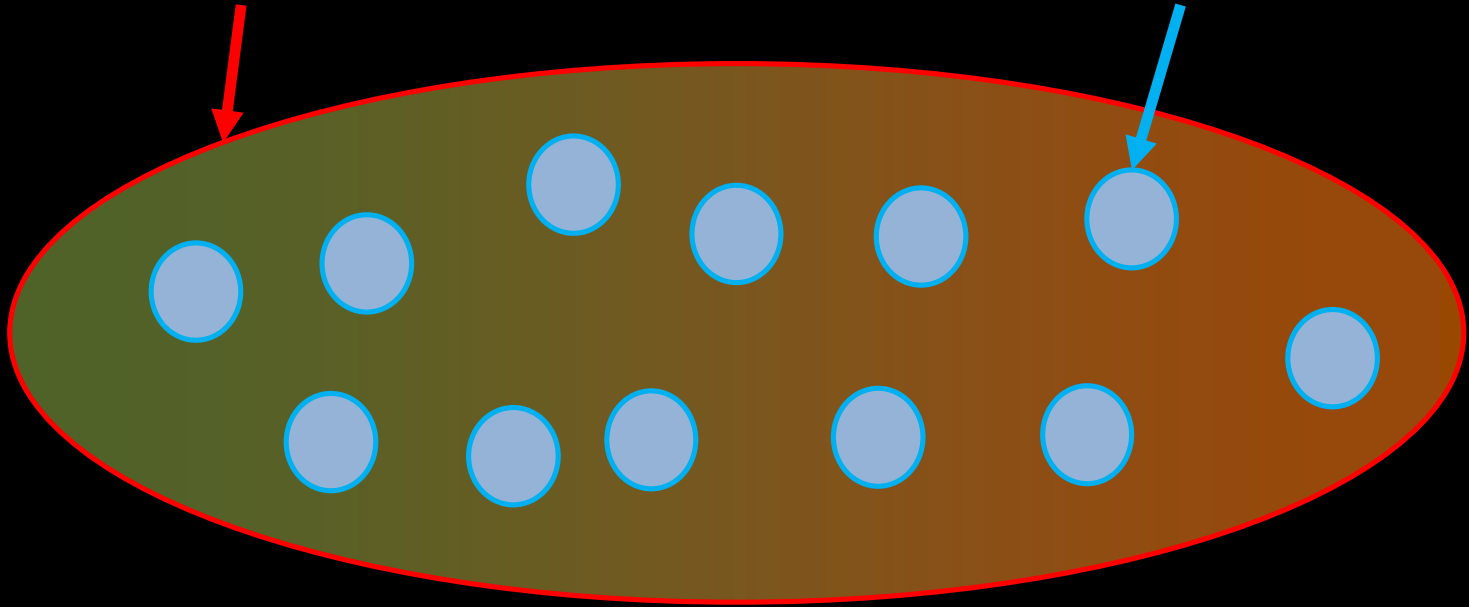
Population



# Evolutionary processes

Species range

Population

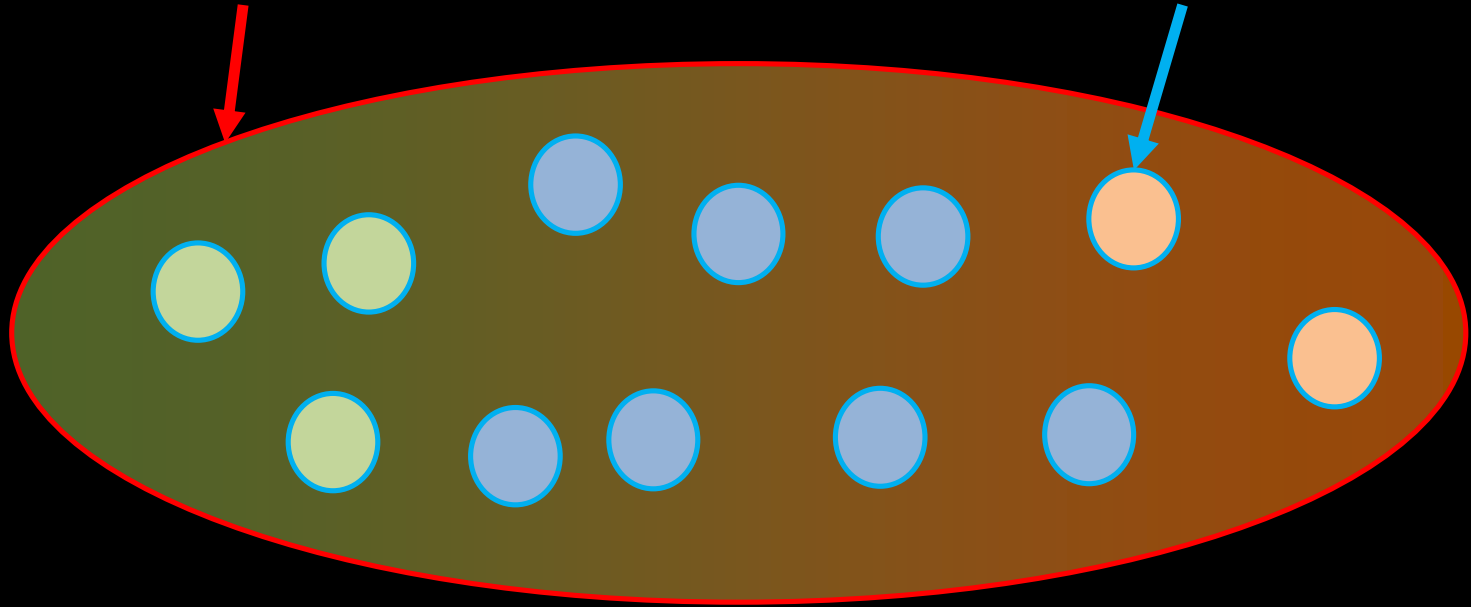




# Evolutionary processes

Species range

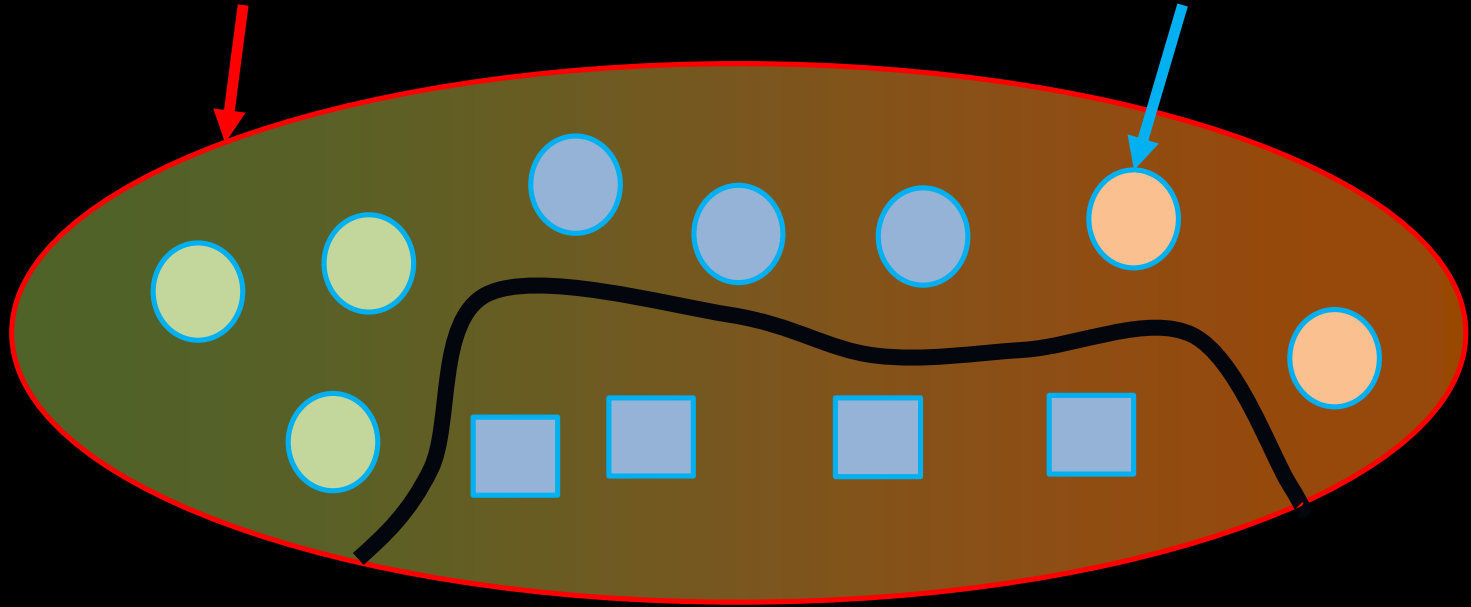
Population

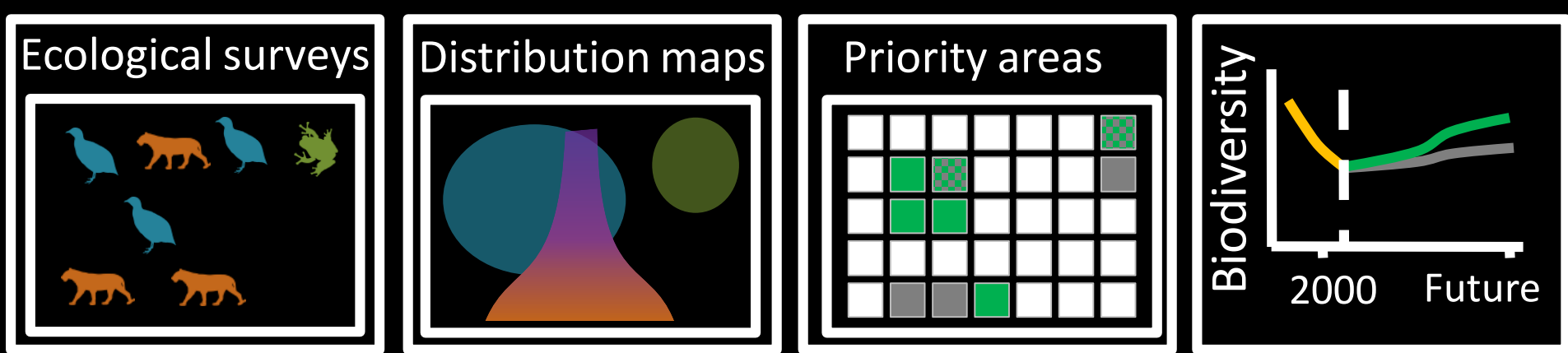


# Evolutionary processes

Species range

Population





**Data**



Information

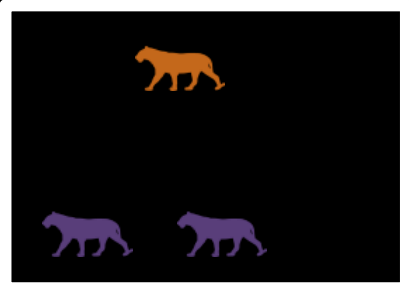


Plan



Outcome

Genetic samples

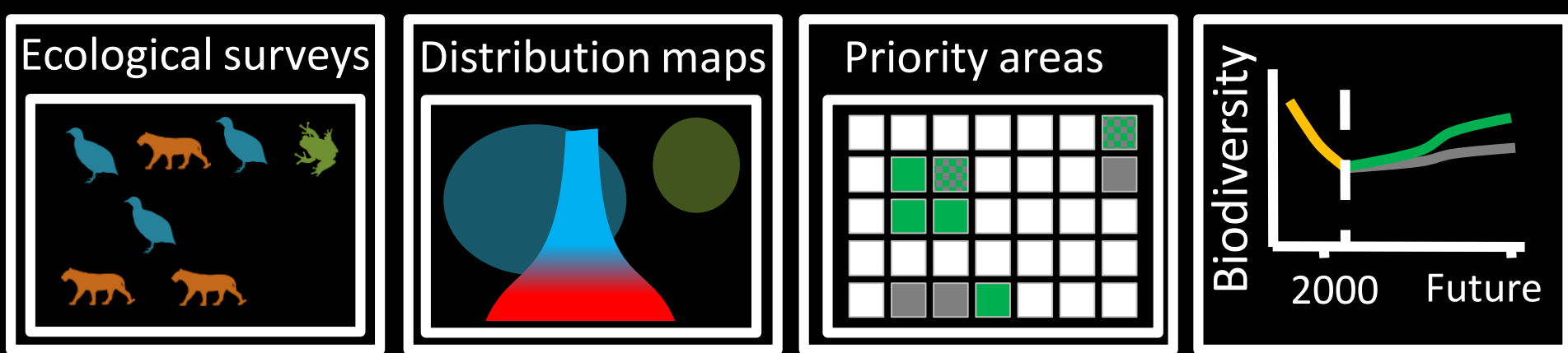


Better  
understanding  
of biodiversity

Better  
plan

Better  
outcome

Objectives      Constraints



**Data**



**Information**



**Plan**



**Outcome**

Environment data

Cold

Hot

Good enough  
understanding  
of biodiversity

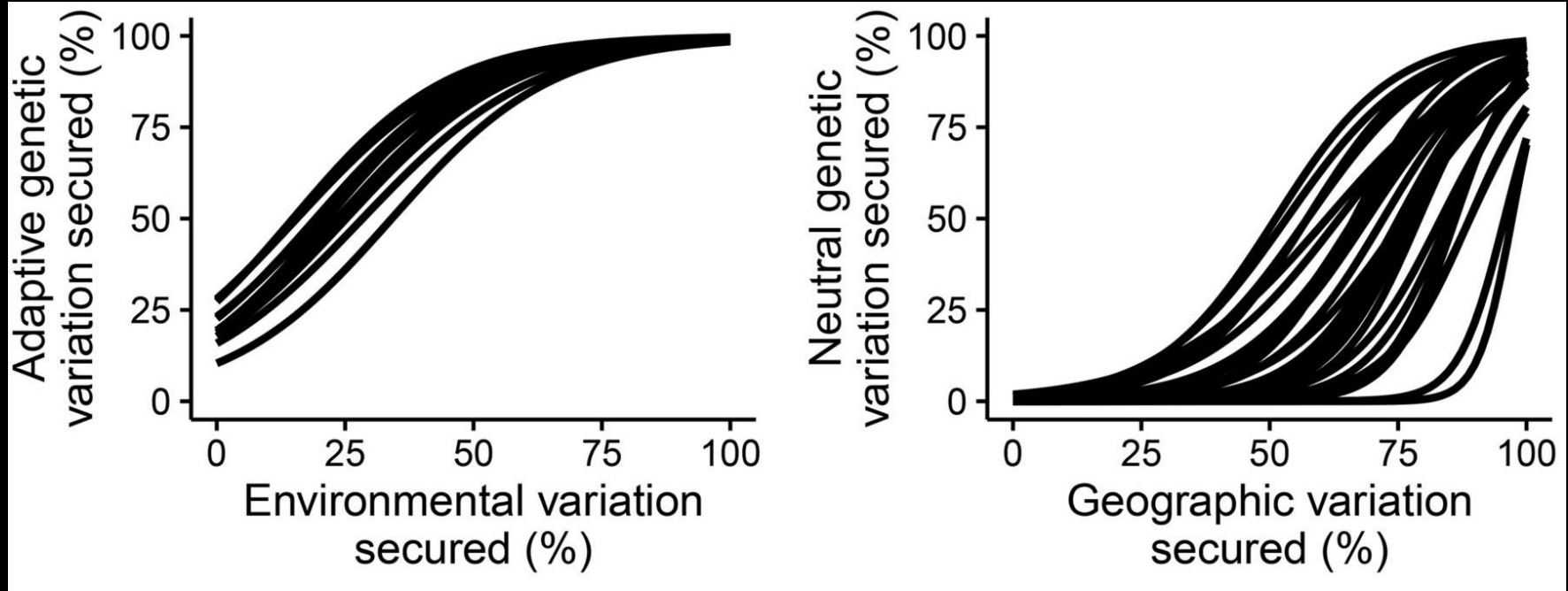
Better  
plan

Better  
outcome

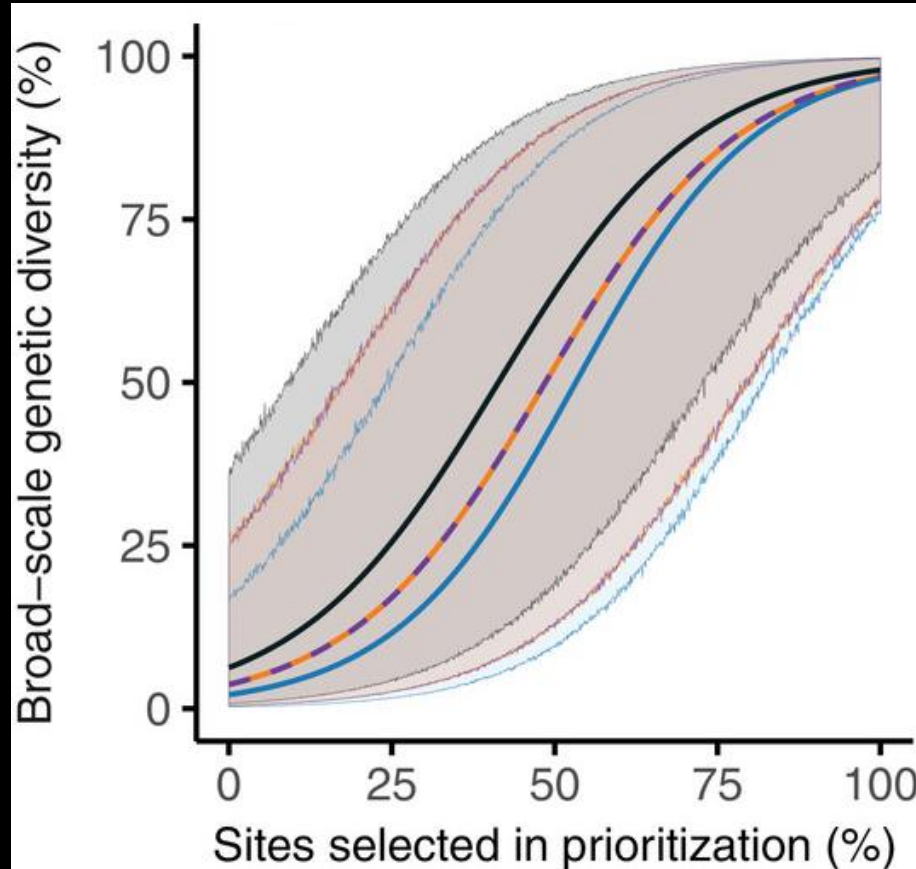
Objectives      Constraints

Can we use environmental  
and geographic variables  
as surrogates of  
genetic variation for  
conservation planning?

# Environmental and geographic surrogates might work



# Geographic surrogates not guaranteed



Selecting sites by...

- maximizing genetic diversity
- randomly
- maximizing geographic spread
- maximizing spread across isolation barriers

Assuming environmental  
surrogates work,  
how can we use them  
for conservation?

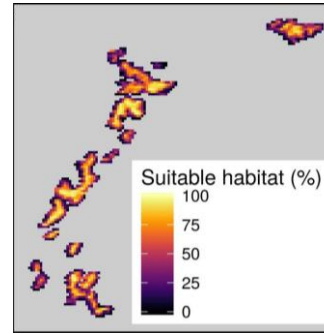


# Data

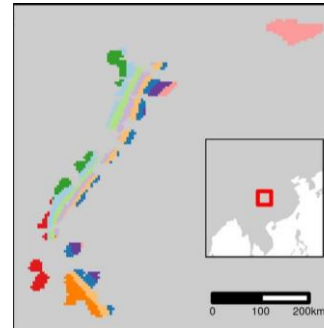
- 9,670 bird, 5,070 mammal, 5,197 amphibian species
- 5 × 5 km maps delineating suitable habitat
- Subdivided each species' spatial distribution into multiple "environmental partitions"
- Set targets for each environmental partition for each species' spatial distribution

## Giant panda (*A. melanoleuca*)

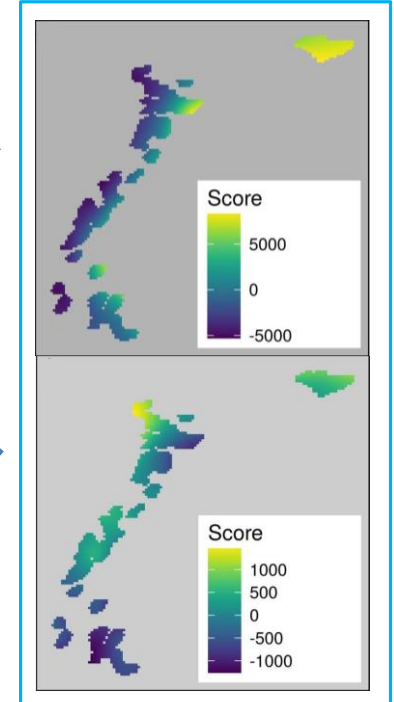
Habitat data



Environmental partitions

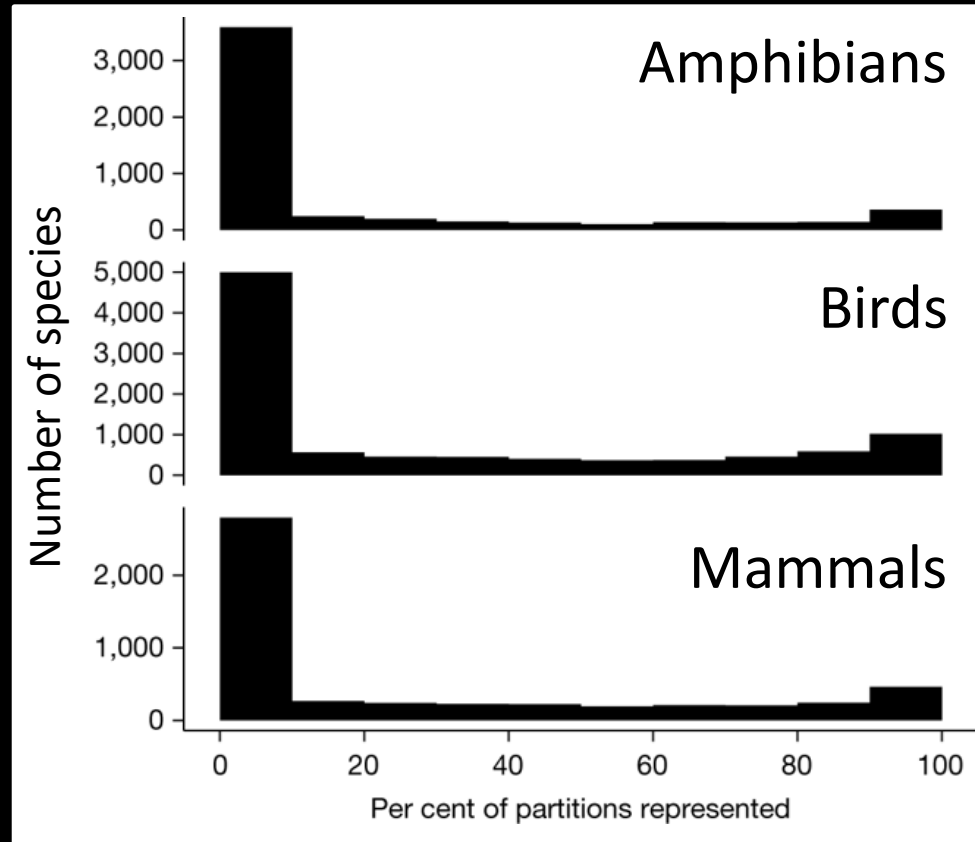


Environmental variation (PCA scores)

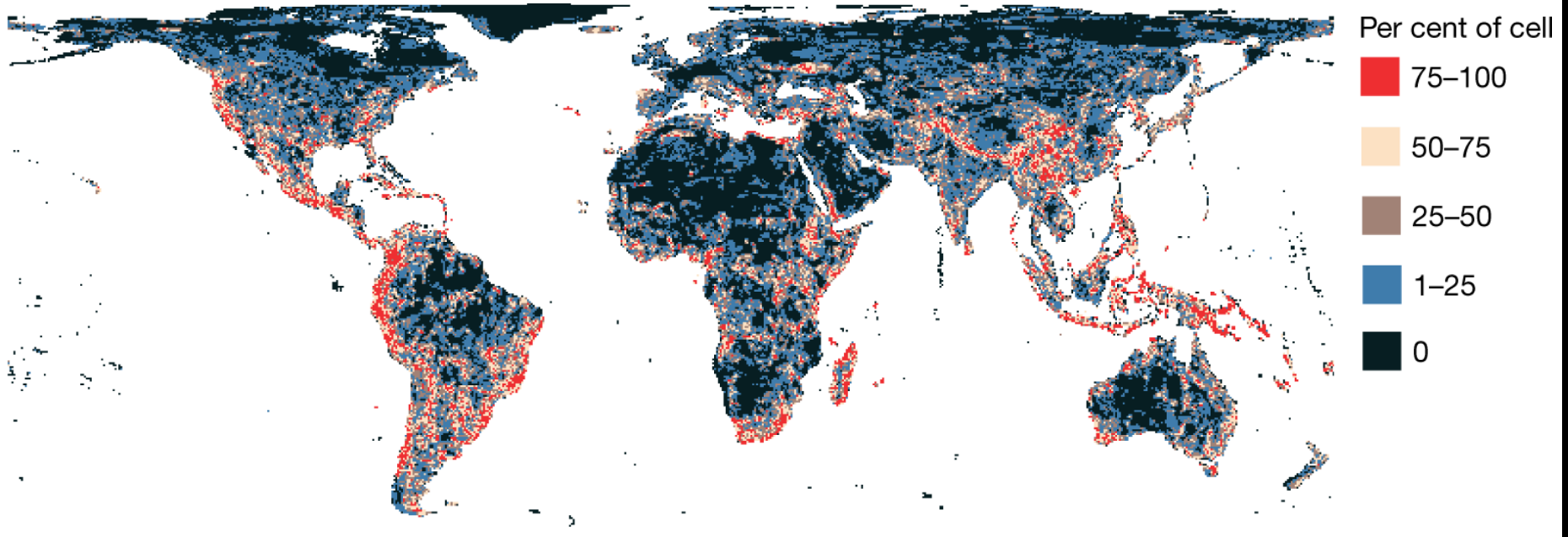


# How good is the existing protected system?

- 18,097 (90%) species are not adequately represented in reserves
- 9,651 (48%) species do not have a single partition adequately represented
- Of these, 2,385 species are globally imperilled



# Prioritization



**34% of Earth's land and inland waters**

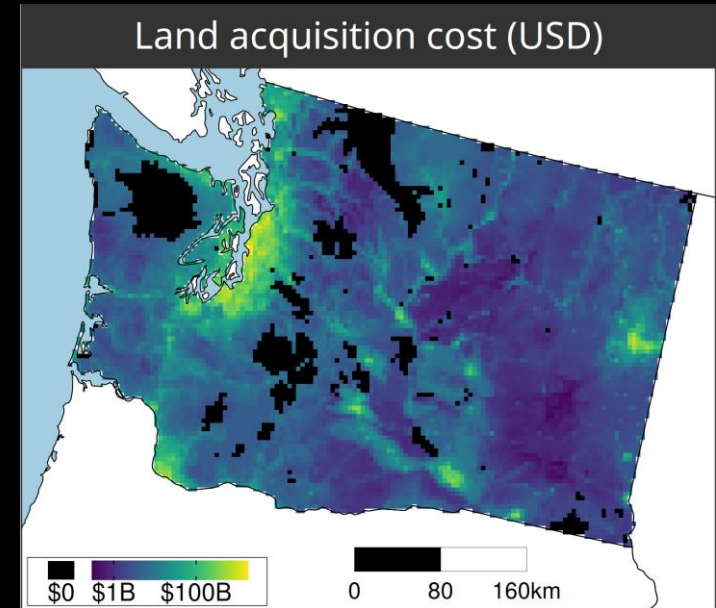
Many surrogates are  
often available,  
how do our choices  
affect results?

# A comparison of approaches for including connectivity in systematic conservation planning

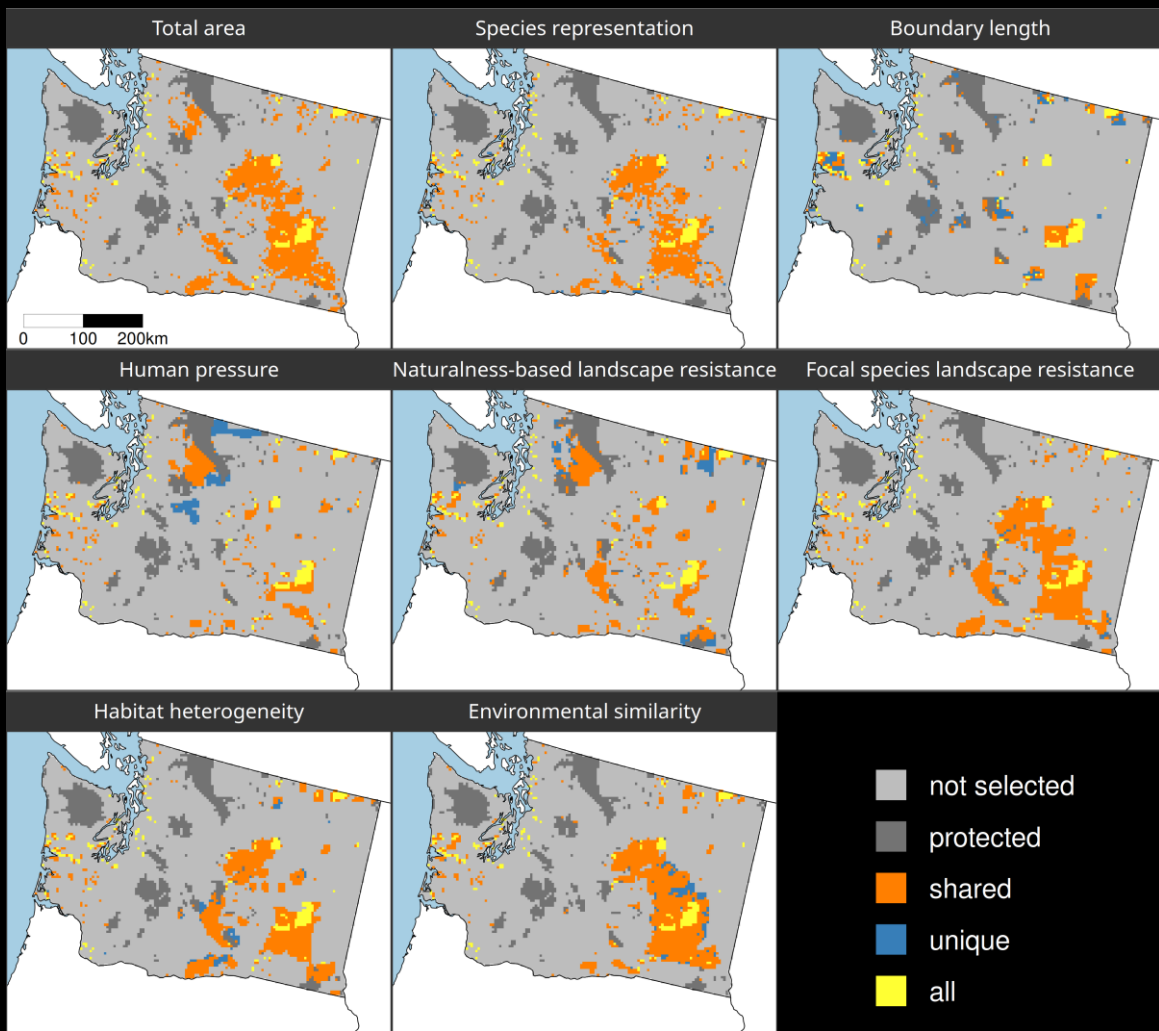
## Washington State, USA

- 261 bird species
- Land acquisition costs
- Existing protected areas
- Multiple land-uses
- Multiple eco-systems

Hanson *et al.* (in press) J Appl Ecol



- Different connectivity approaches produce different prioritizations
- Different connectivity approaches can yield similar prioritizations



# Make better conservation decisions by using...

1. Better algorithms
2. Cost-effective data
3. Reliable surrogates



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