# Conflict, lobbying and compliance predict the sustainability of biological resource use

https://bradduthie.github.io/talks/gmse_conflict.pdf

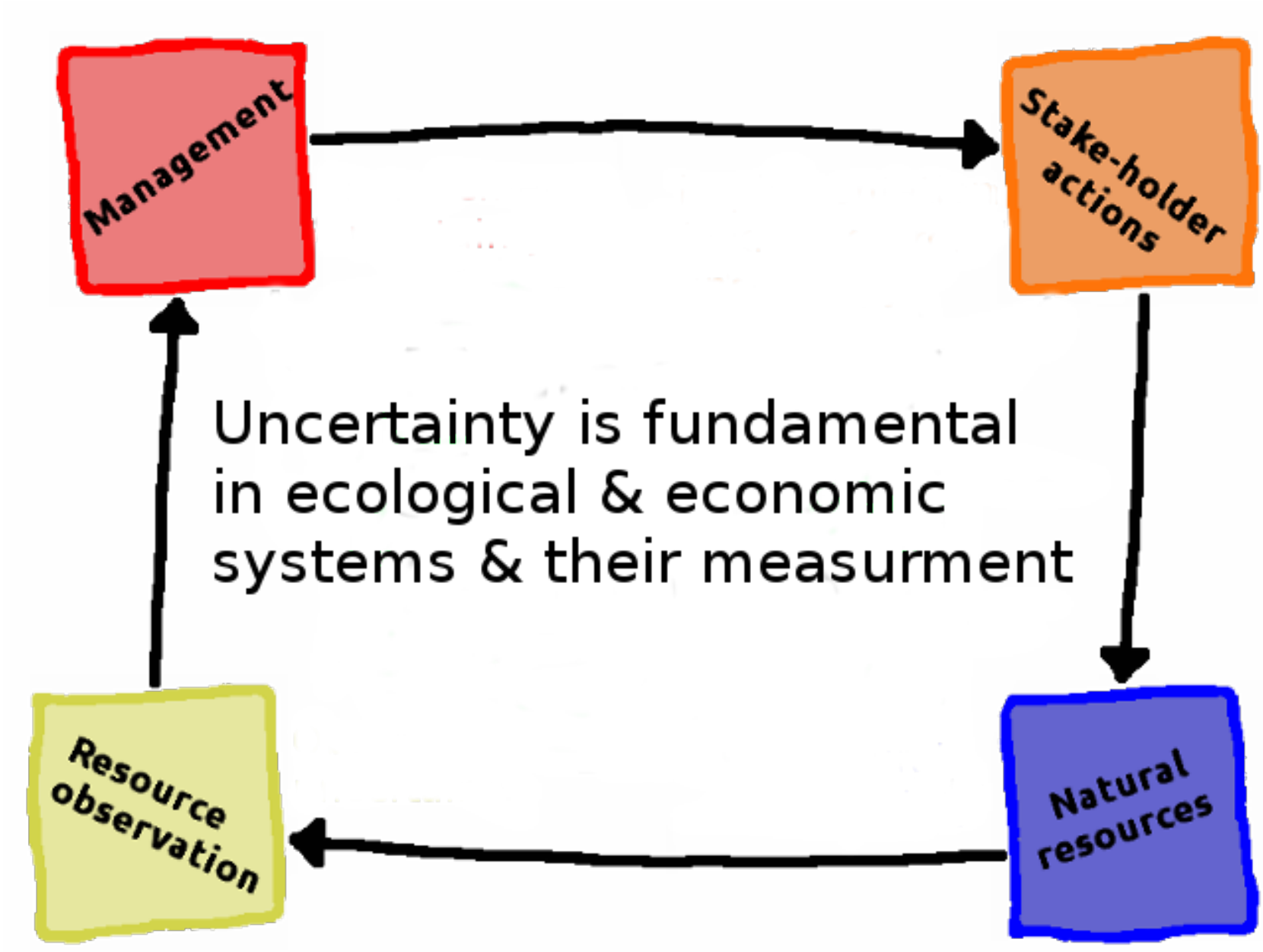
Jeremy Cusack, **Brad Duthie (@bradduthie)**, Rocío Pozo, Steve Redpath, and Nils Bunnefeld

2 October 2019

# Conflict between natural resource conservation and use

[1] Richard Crossley. 2010. Barnacle Goose From The Crossley ID Guide Eastern Birds. CC 3.0


[1]Bunnefeld, N. et al. 2011. *Trends. Ecol. Evol.*, **26**: 441-447.
[2]Chadès et al. 2017. *Theor. Ecol.*, **10**: 1-20.

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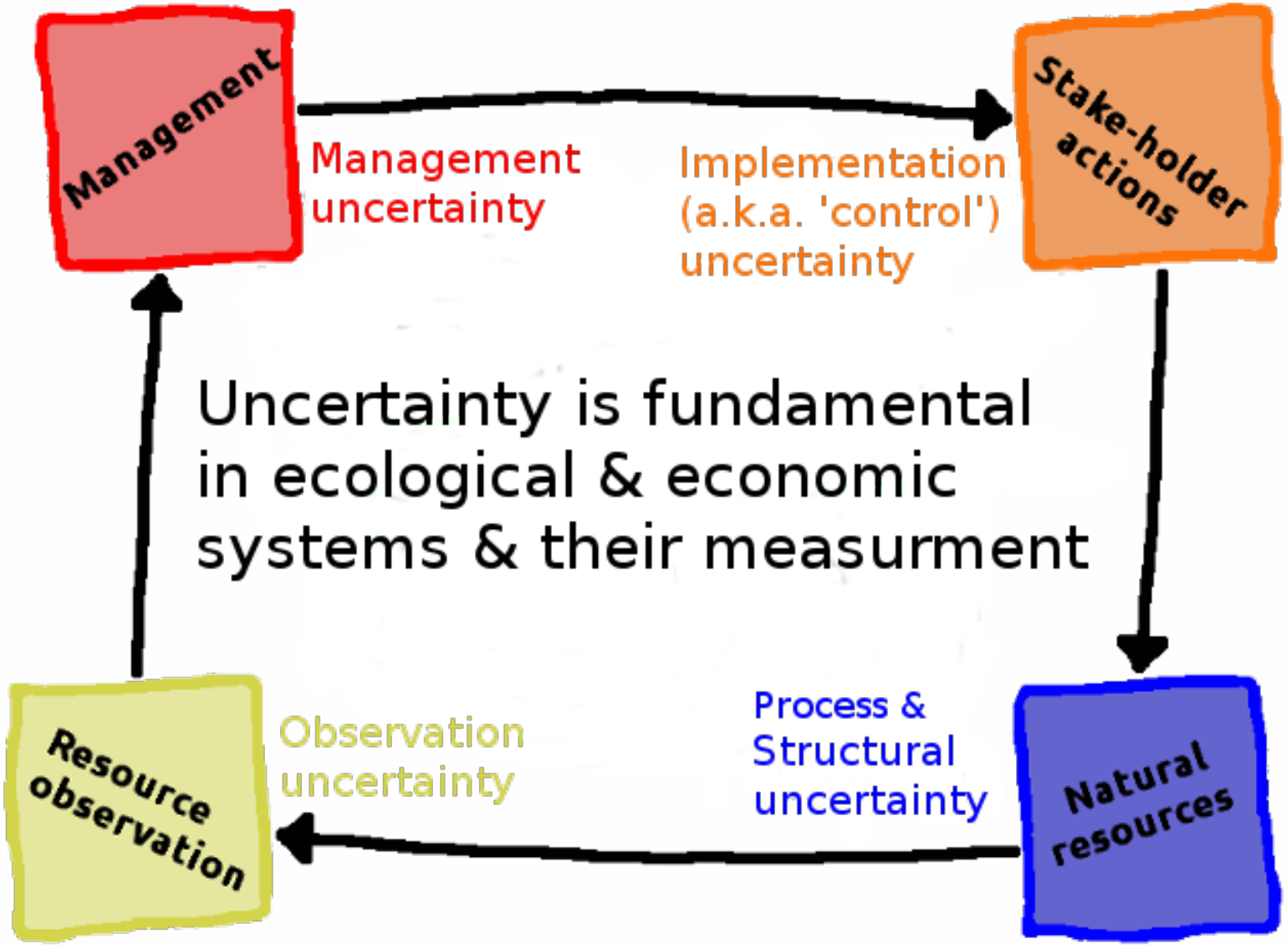


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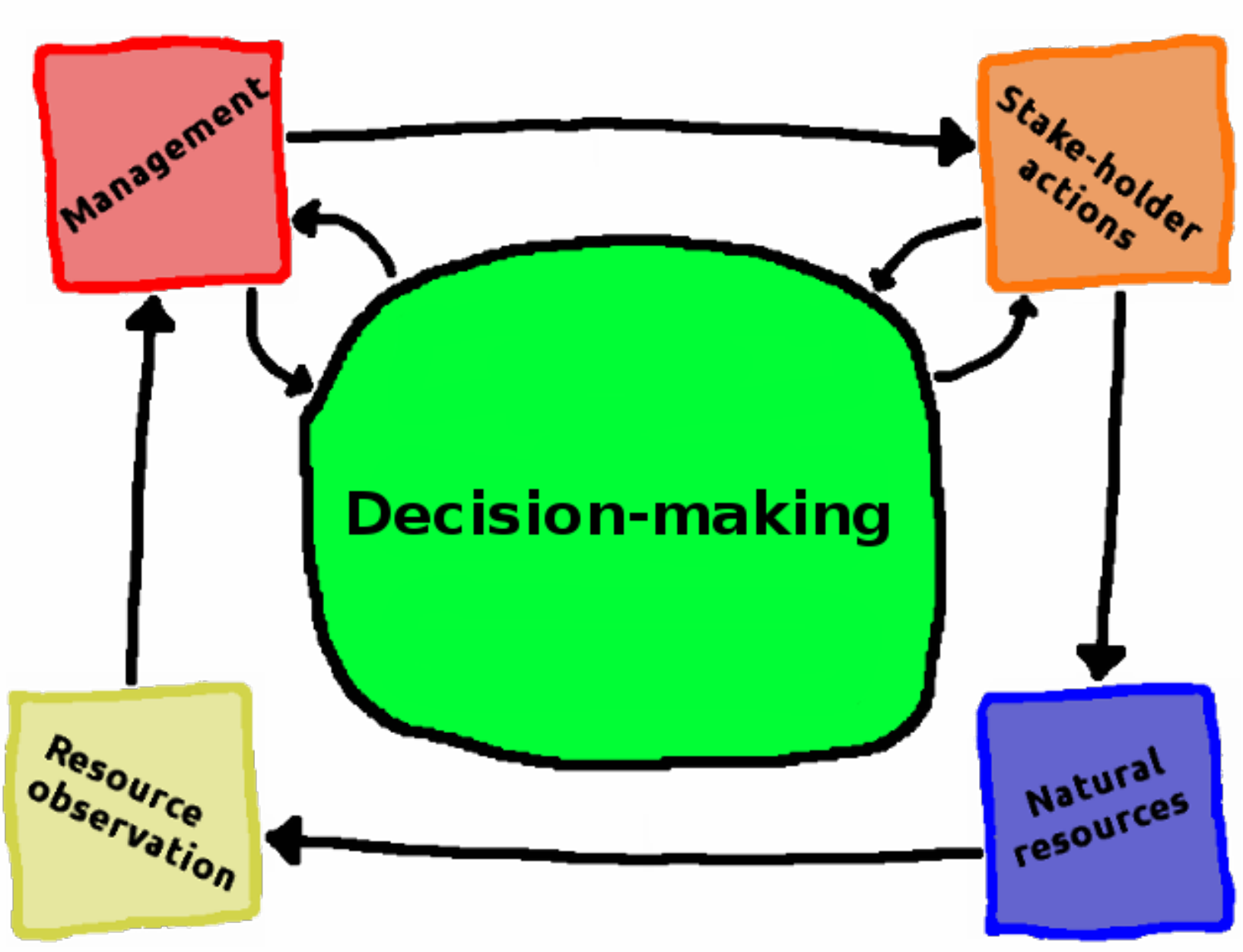
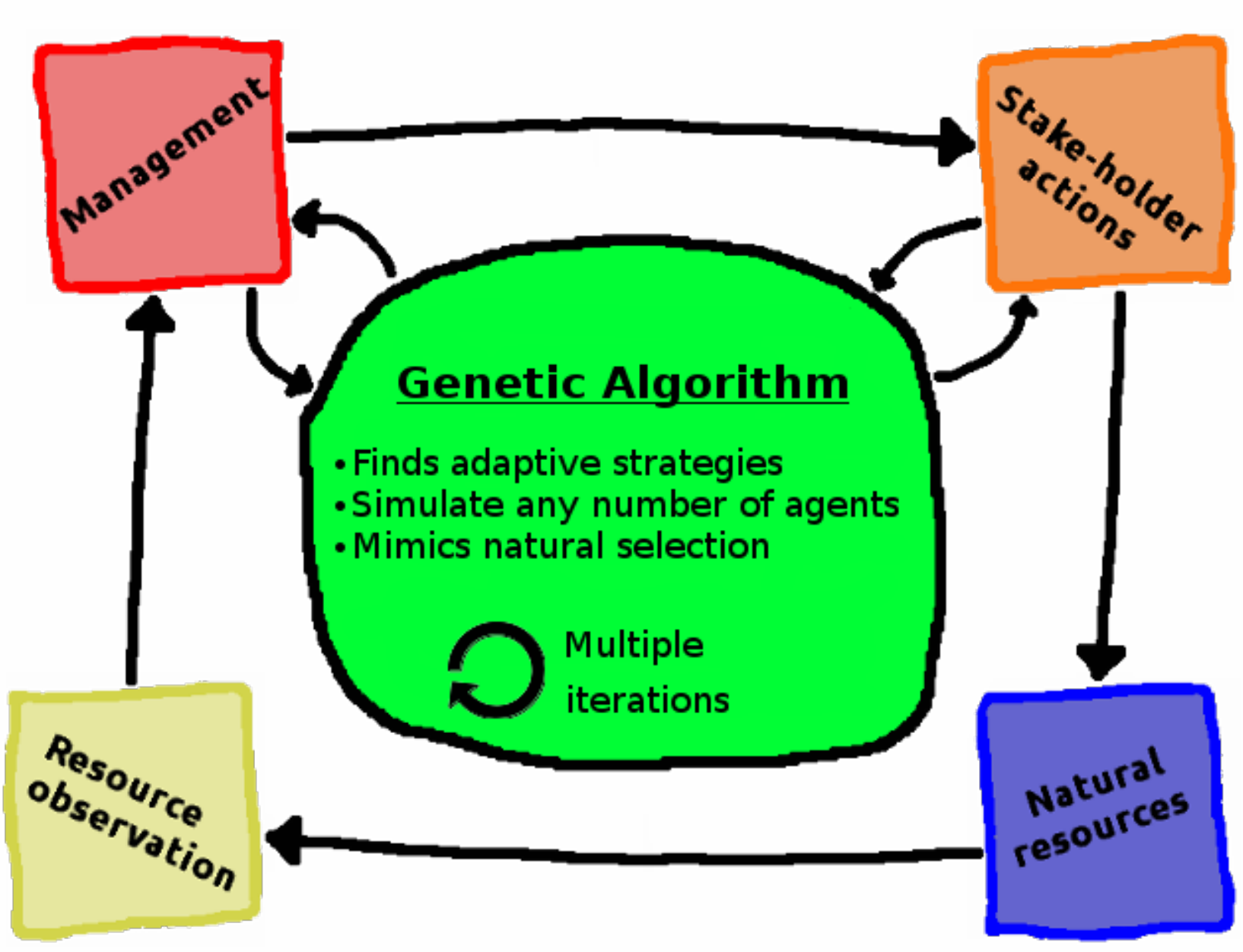
# Generalised Management Strategy Evaluation (GMSE)

- Model biodiversity dynamics & realistic human decision-making
- Predict resource & land-use changes in social-ecological systems
- Integrate flexibly with existing ecological models
- Default models individual-based (IBMs) on a spatially explicit landscape
- Open-source on CRAN & GitHub

[1] Duthie, A. B. et al. 2018. *Method. Ecol. Evol.*, **9**: 2396-2401.


Management
Stake-holder actions
Decision-making
Resource observation
Natural resources


Management
Stake-holder actions
Genetic Algorithm
•Finds adaptive strategies
•Simulate any number of agents
•Mimics natural selection
Multiple iterations
Resource observation
Natural resources

# GMSE: modelling decision-making

Multiple options can be run using gmse in R.

```
sim <- gmse(time_max = 30, land_dim_1 = 100,
            land_dim_2 = 100, observe_type = 1,
            res_death_K = 4000,
            manager_budget = 2000, user_budget = 500,
            scaring = TRUE, land_ownership = TRUE,
            tend_crops = TRUE, stakeholders = 7,
            res_consume = 1, RESOURCE_ini = 600);
```

One function shows the general results of simulation dynamics.

```
plot_gmse_results(sim);
```

Another function shows manager permissiveness, and stakeholder effort, for each action.

```
plot_gmse_effort(sim);
```

# Custom sub-models with gmse_apply

Custom models can be integrated into GMSE with `gmse_apply`, which takes the arguments `res_mod`, `obs_mod`, `man_mod`, and `use_mod`.

```
sim <- gmse_apply(
            res_mod      = custom_resource_model,
            obs_mod      = custom_observation_model,
            man_mod      = manager, # GMSE default
            use_mod      = user,    # GMSE default
            stakeholders = 5,       # GMSE option
            custom_arg   = 200      # Custom arg.
            );
```

The `gmse_apply` function needs to be looped for modelling more than one time step (e.g., using the `old_list` argument).

# How does conservation conflict affect management?

**Investigate how disagreement over target population size affects natural resource management**

- Divergent conservationist & harvester goals
- Modified `gmse_apply` to allow for policy lobbying and illegal harvesting
- Varied manager 'impartiality' (bias toward lobbying pressure)
- Compared population dynamics given conservationist and resource user disagreement over population target

Jeremy Cusack
@jeremyjcusack

# Natural resources submodel

**Simple discrete logistic growth model,**

$$N(t+1) = \frac{N(t)Ke^{r(t)}}{K + N(t)(e^{r(t)} - 1)} - H(t).$$

- $N(t)$ is resource population at time $t$
- $K$ is carrying capacity
- $r(t) =$ is intrinsic growth rate at time $t$
- $H(t)$ is total harvest at time $t$

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**For simplicity, we assume no error in resource observation.**

$$\hat{N}_{t+1} = N_{t+1}$$

# Natural resources submodel

**Simple discrete logistic growth model,**

```
pop_mod <- function(N, K, r, H){
                top <- (N * K * exp(r));
                bot <- (K + N*(exp(r) - 1);
                New <- (top/bot) - H;
                return(New);
}
```

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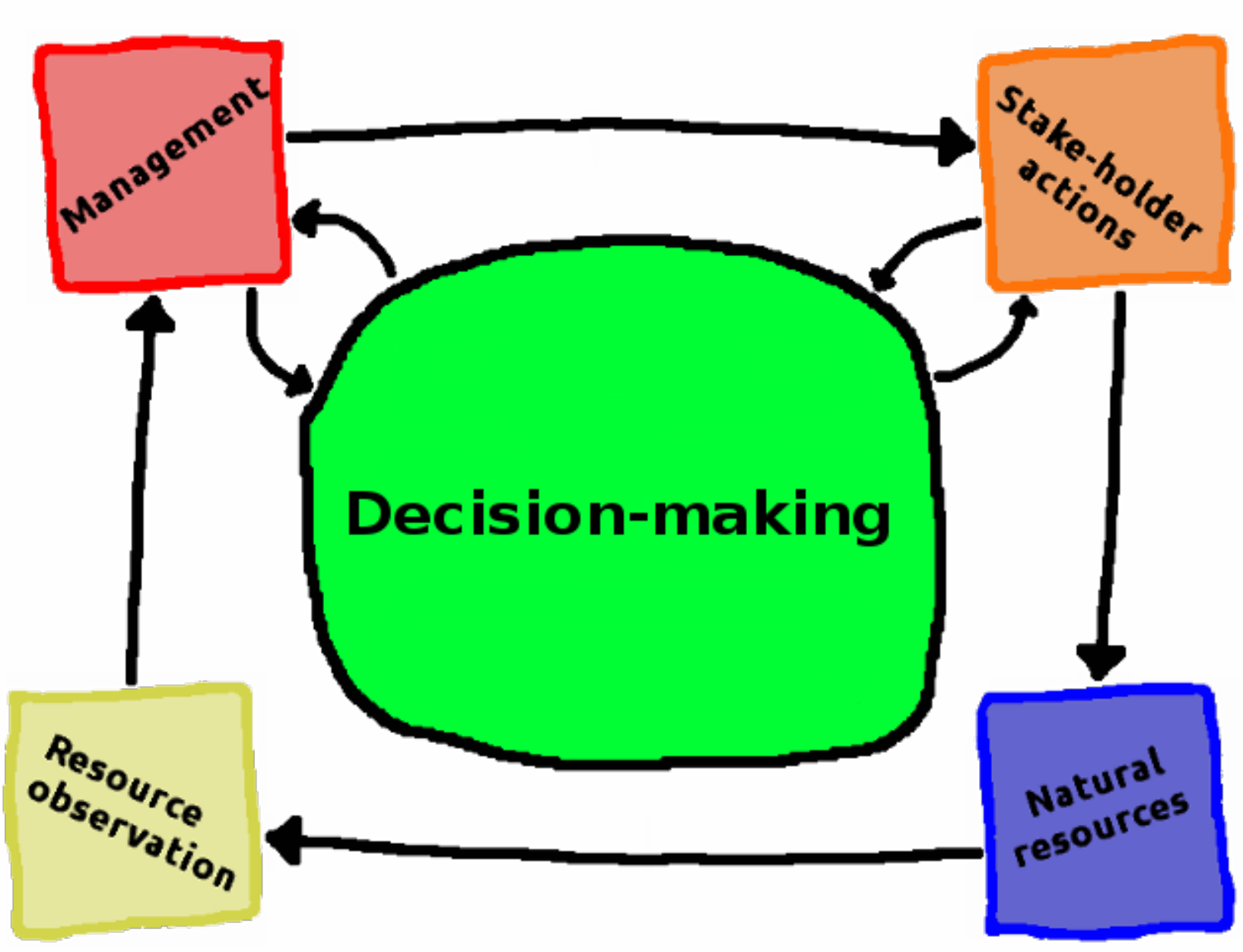
```
obs_mod <- function(N) return(N);
```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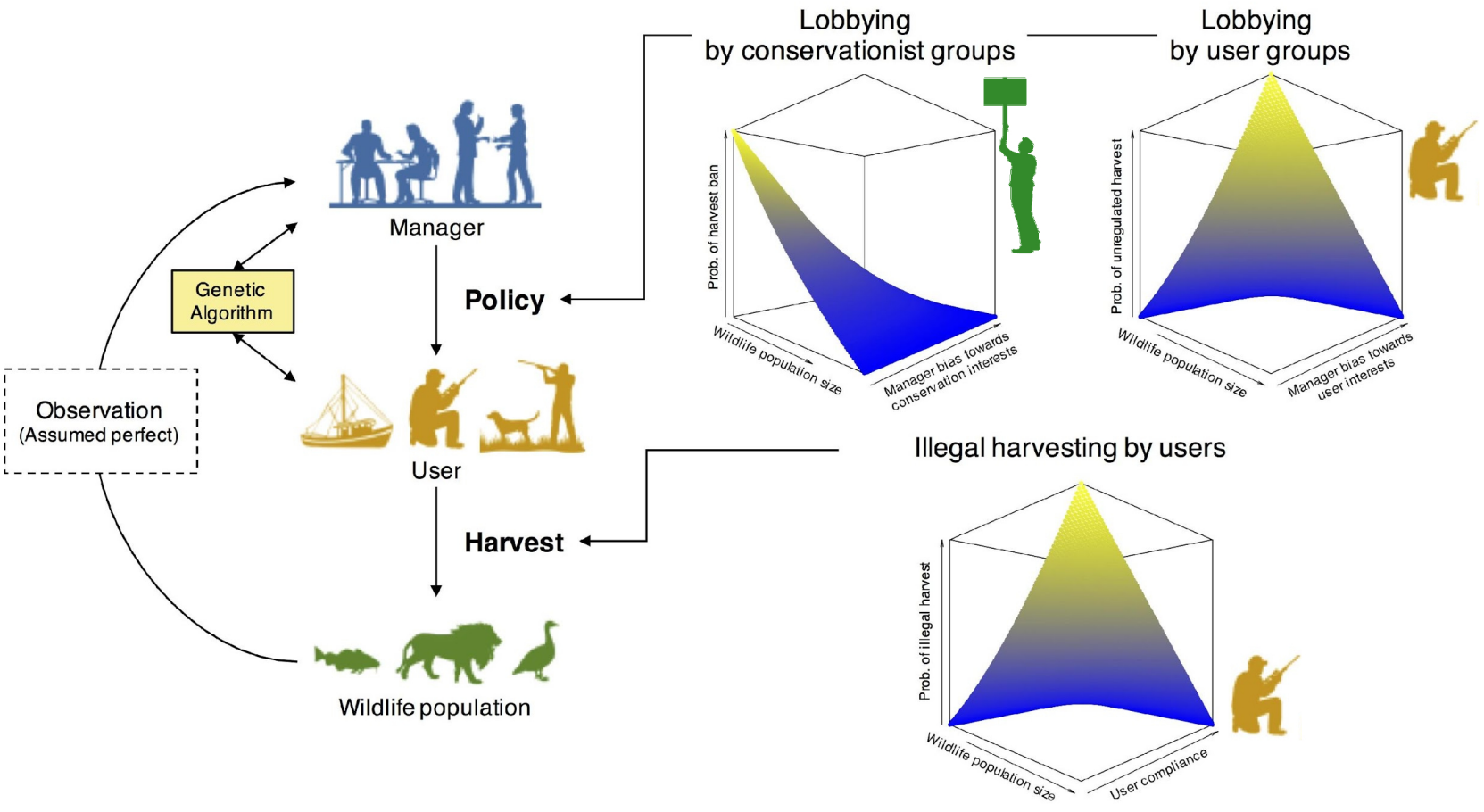
# Social dynamics: Goals and Power

| | **Conservationist** | **Manager** | **Harvester** |
|---|---|---|---|
| **Target** | $N(t) \geq N_c$ | $N(t) = N_m$ | $N(t) \leq N_u$ |
| **Power** | Lobbying | Set harvest cost | Lobbying, harvesting |

# Policy, lobbying, and illegal harvesting



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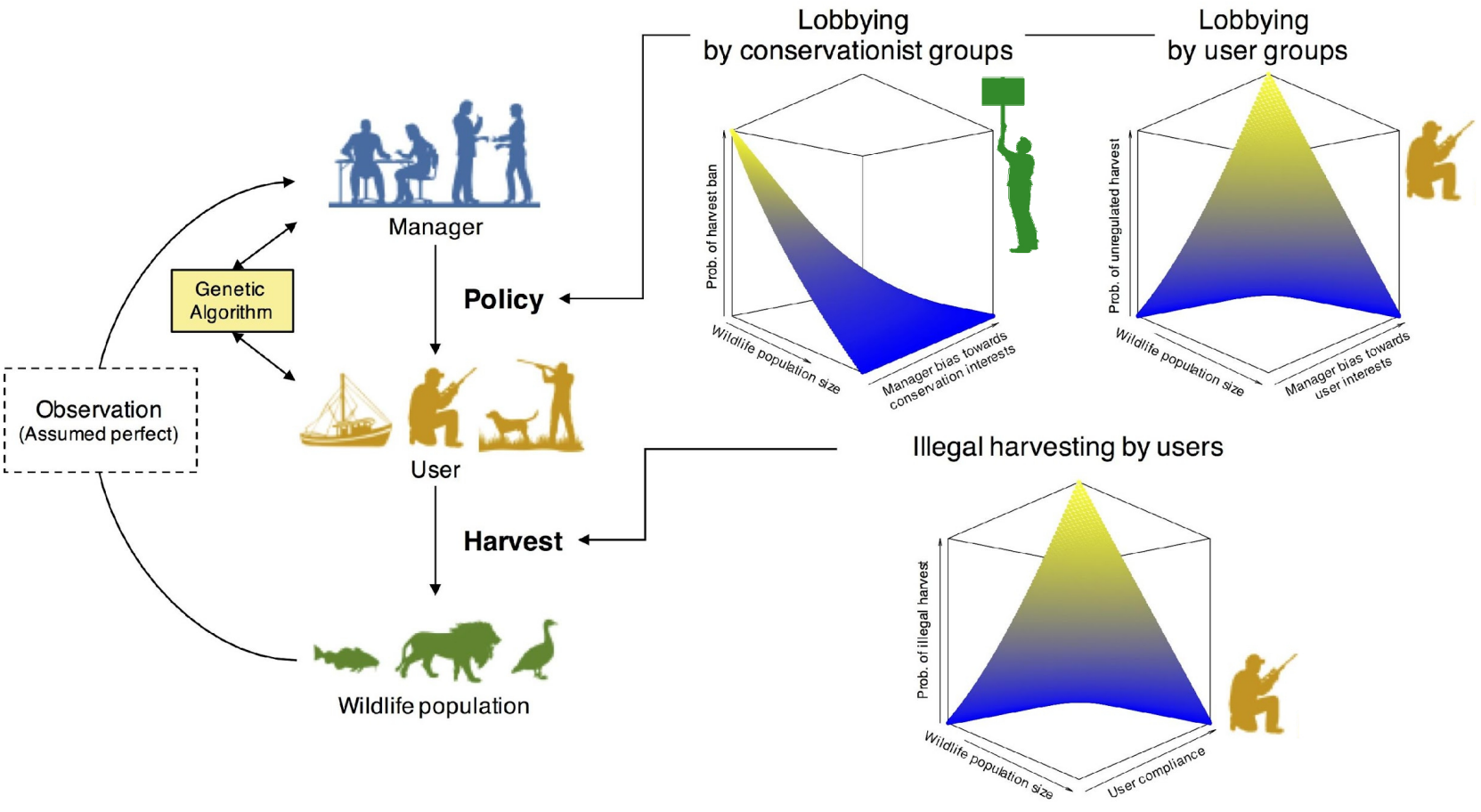


**Separate simulations for conservationist or user lobbying.**

# How lobbying works

**Conservationists lobby for a total harvesting ban:**

- Distance of resource $N(t)$ from $N_c$
- Manager bias toward conservationist $(0 < I_c < 1)$

$$\Pr(ban) = \left[(2 - I_c)^{\frac{N_c - N(t)}{N_c}}\right] - 1.$$

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**Harvesters lobby for unregulated harvesting:**

- Distance of resource $N(t)$ from $N_u$
- Manager bias toward harvester $(0 < I_u < 1)$

$$\Pr(unregulated) = \left[(2 - I_u)^{\frac{N(t) - N_u}{K - N_u}}\right] - 1.$$

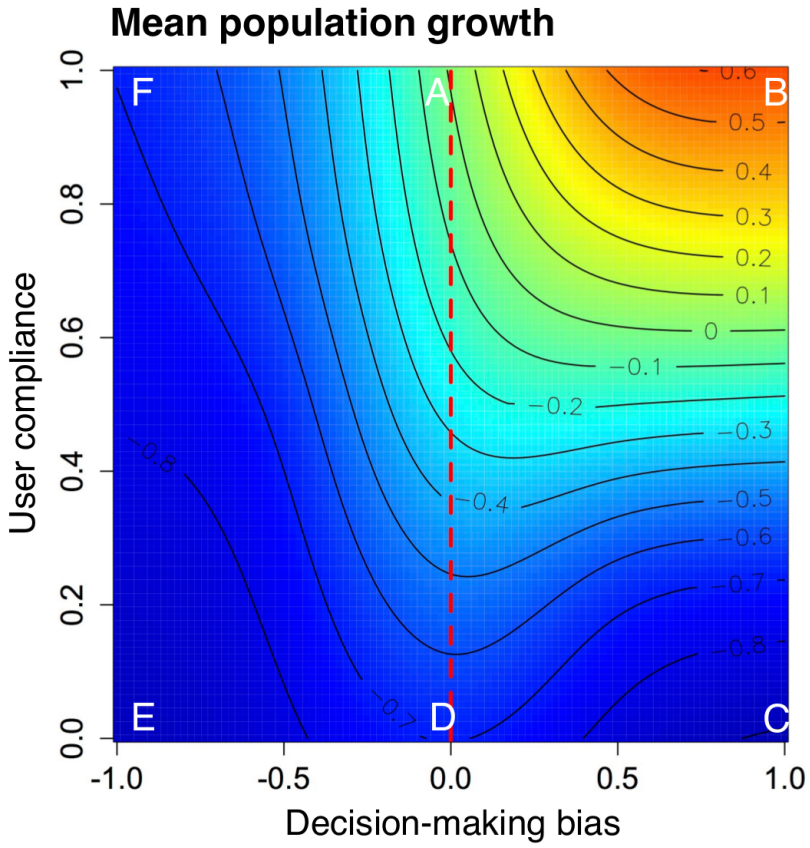
# How illegal harvesting works

**Harvesters decide whether to harvest illegally:**

- Distance of resource $N(t)$ from $N_u$ and $K$
- User compliance with harvesting rules $(0 < E < 1)$

$$\Pr(\textit{illegal}) = \left[(2 - E)^{\frac{N(t) - N_u}{K - N_u}}\right] - 1.$$

# Results given manager bias and harvester compliance




- Mean population growth over 10 years
- User compliance range from guaranteed illegal harvesting (0) to total compliance (1)
- Manager decision-making bias from guaranteed unregulated harvest (-1) to guaranteed ban on harvesting (1)

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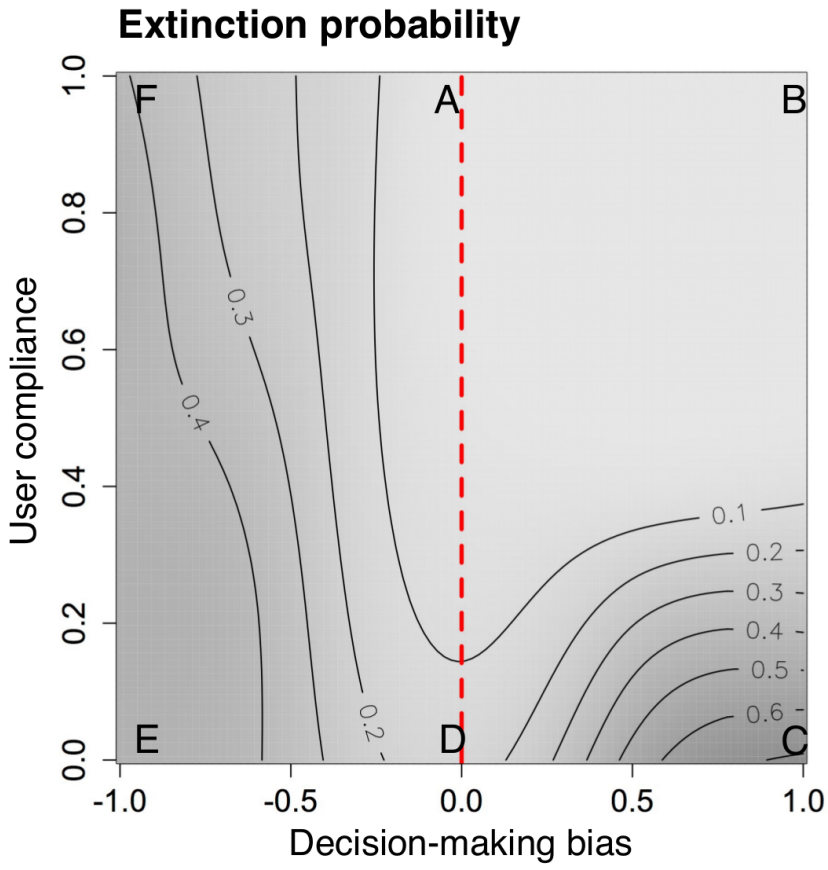


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# Five key model predictions

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4. Minimal compliance always leads to population decline.
5. Populations decline when managers are biased toward harvester interest

# Application of model to harvested species

- Compared model predictions to data from 206 harvested species from IUCN Red List
- Anseriformes, Cetartiodactyla, Carnivora included
  - Commonly hunted globally
  - Least Concern or Near Threatened
- Assessed manager bias and user compliance
  - Bias: unregulated, regulated, or banned
  - Compliance: low, medium, or high reported illegal harvesting
- Assessed if population is decreasing, stable, or increasing

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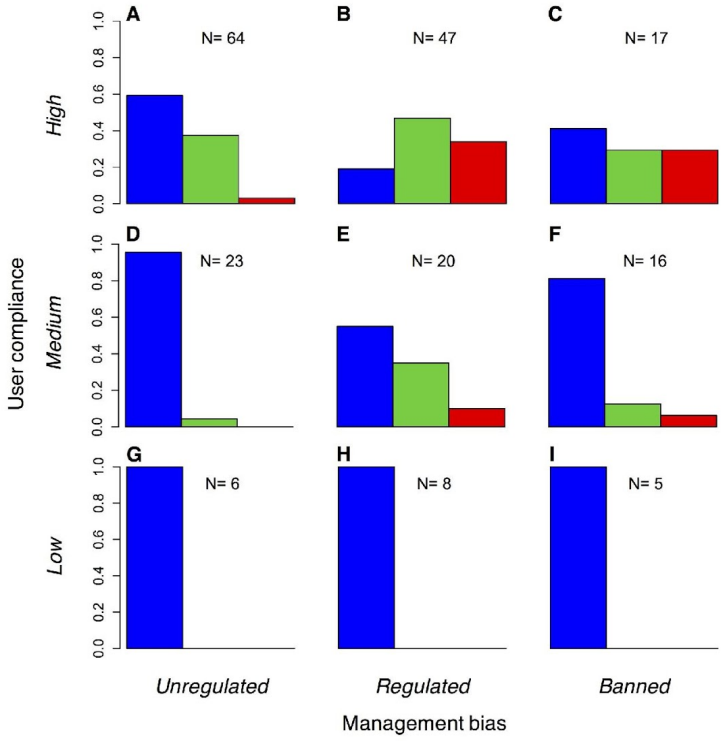


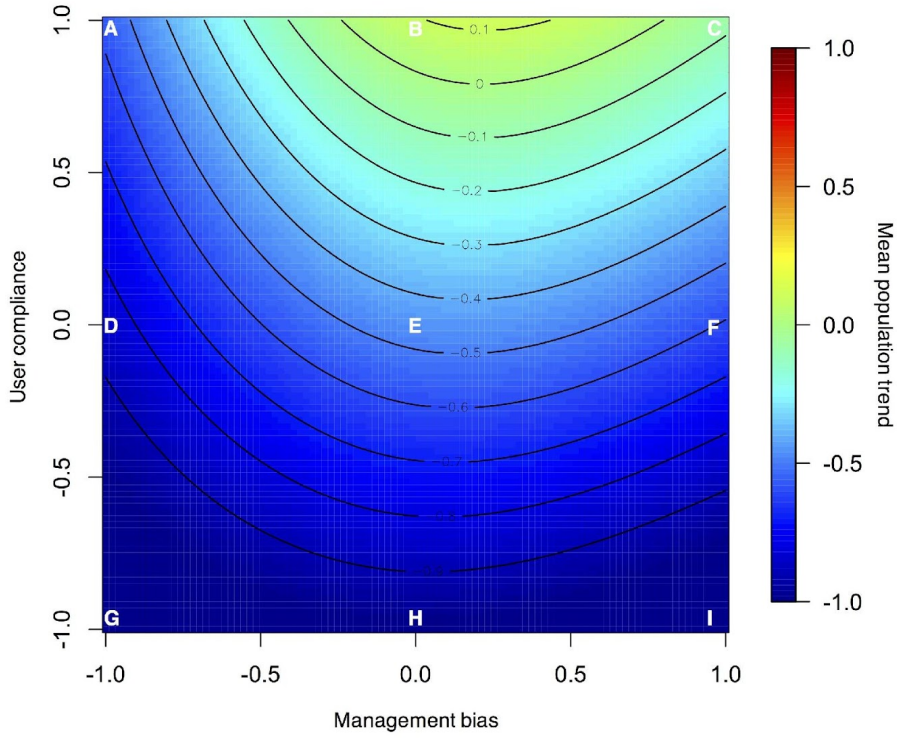


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