# Better ignorant than misled: Including uncertainty in forecasts supporting management and policy

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Uncertainty Analysis: A Critical Step in Ecological Synthesis
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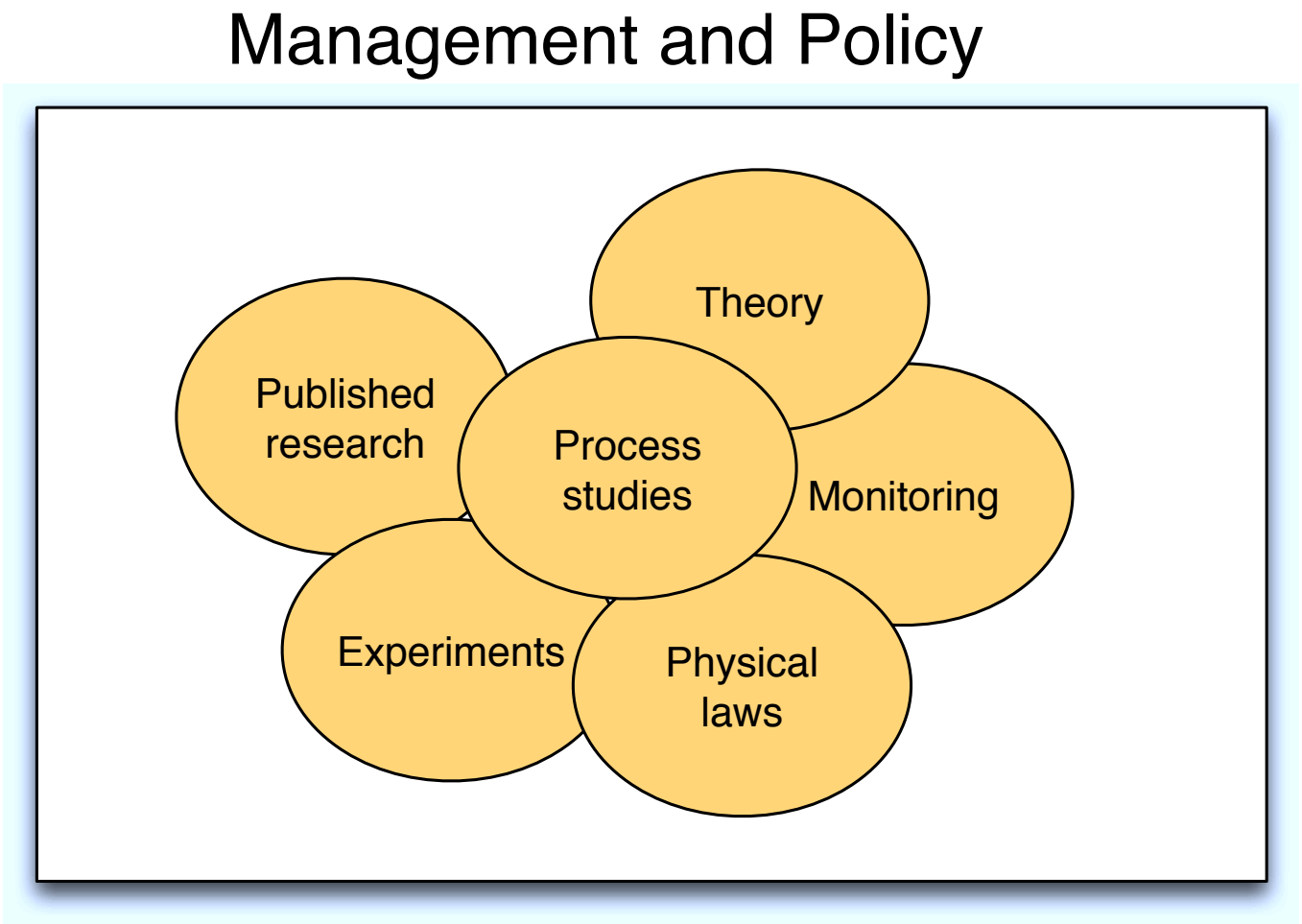
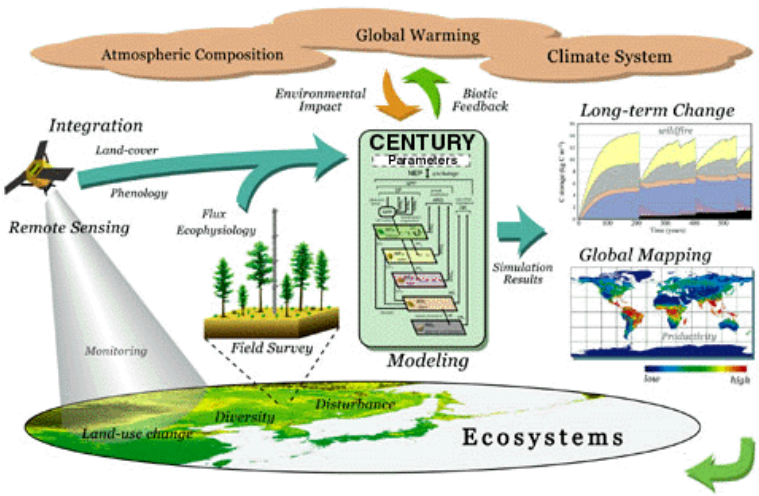
# Honest synthesis

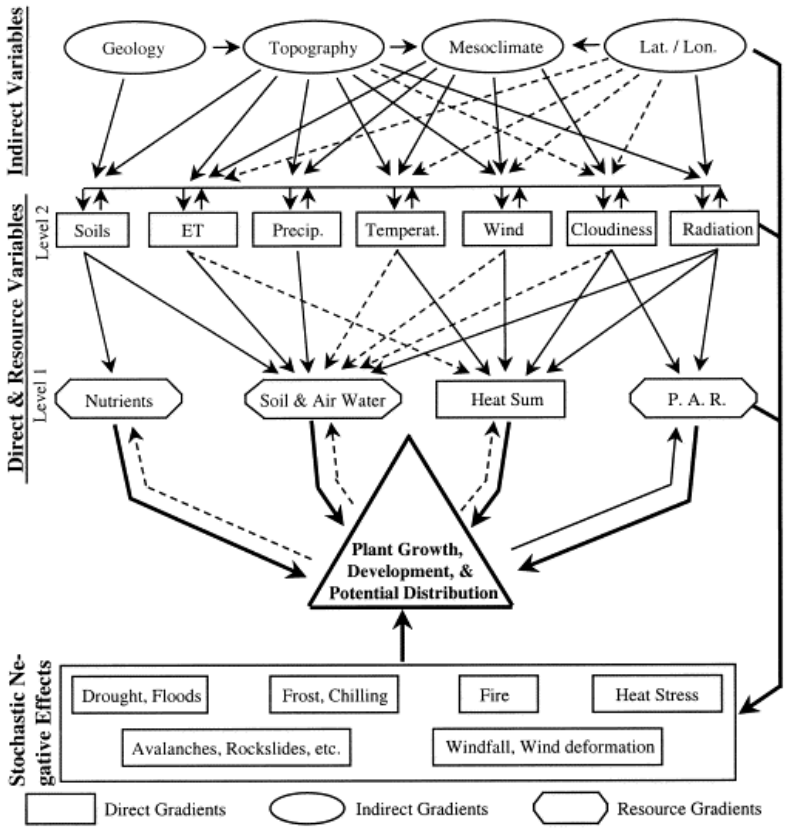


## The problem of management:

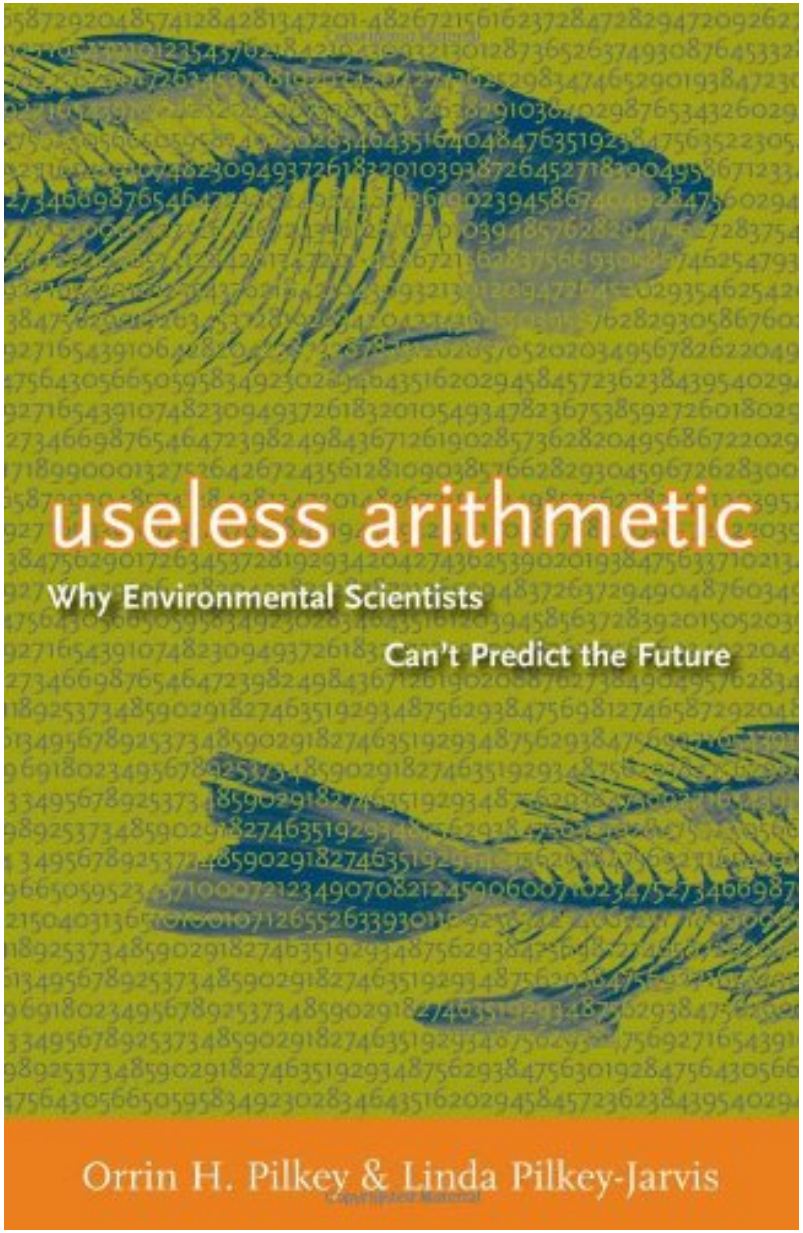
What actions will allow us to meet goals for the future?

# Synthesis with deterministic models



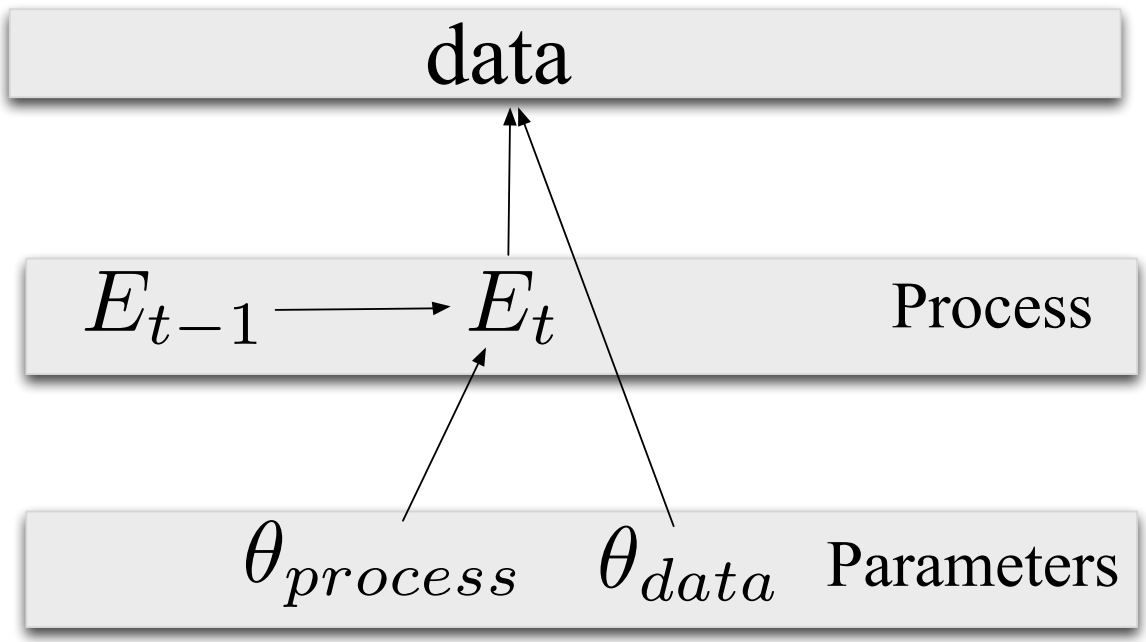



# Orrin H. Pilkey and Linda Pilkey-Jarvis 2007



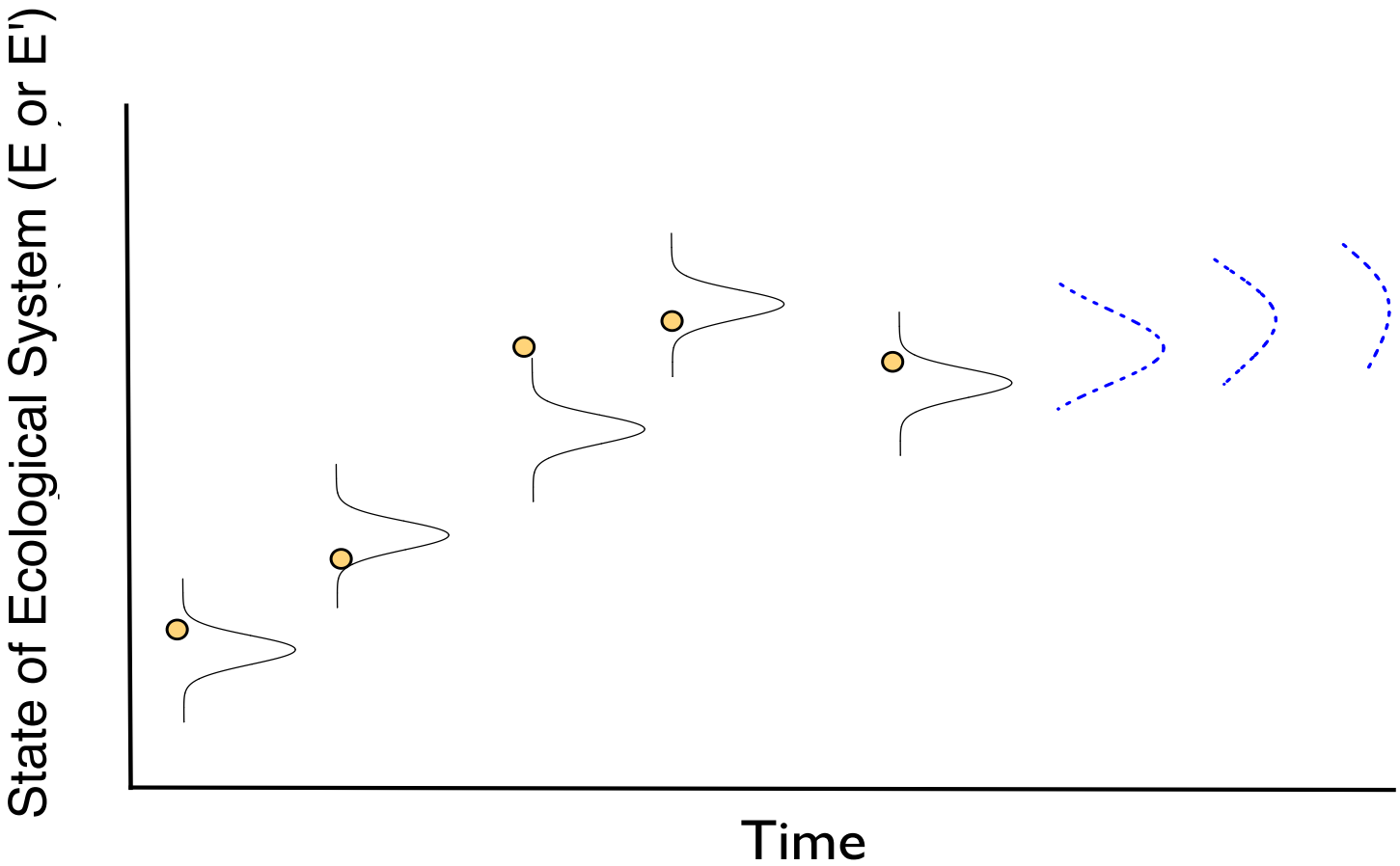
## A broadly applicable approach to ecological modeling in support of management

$$[\mathbf{E}, \theta_{process}, \theta_{data} | \text{data}] \propto$$
$$[\text{data} | \theta_{data}, E_t] \, [E_t | \theta_{process}, E_{t-1}] \, [\theta_{process}, \theta_{data}, E_0]$$

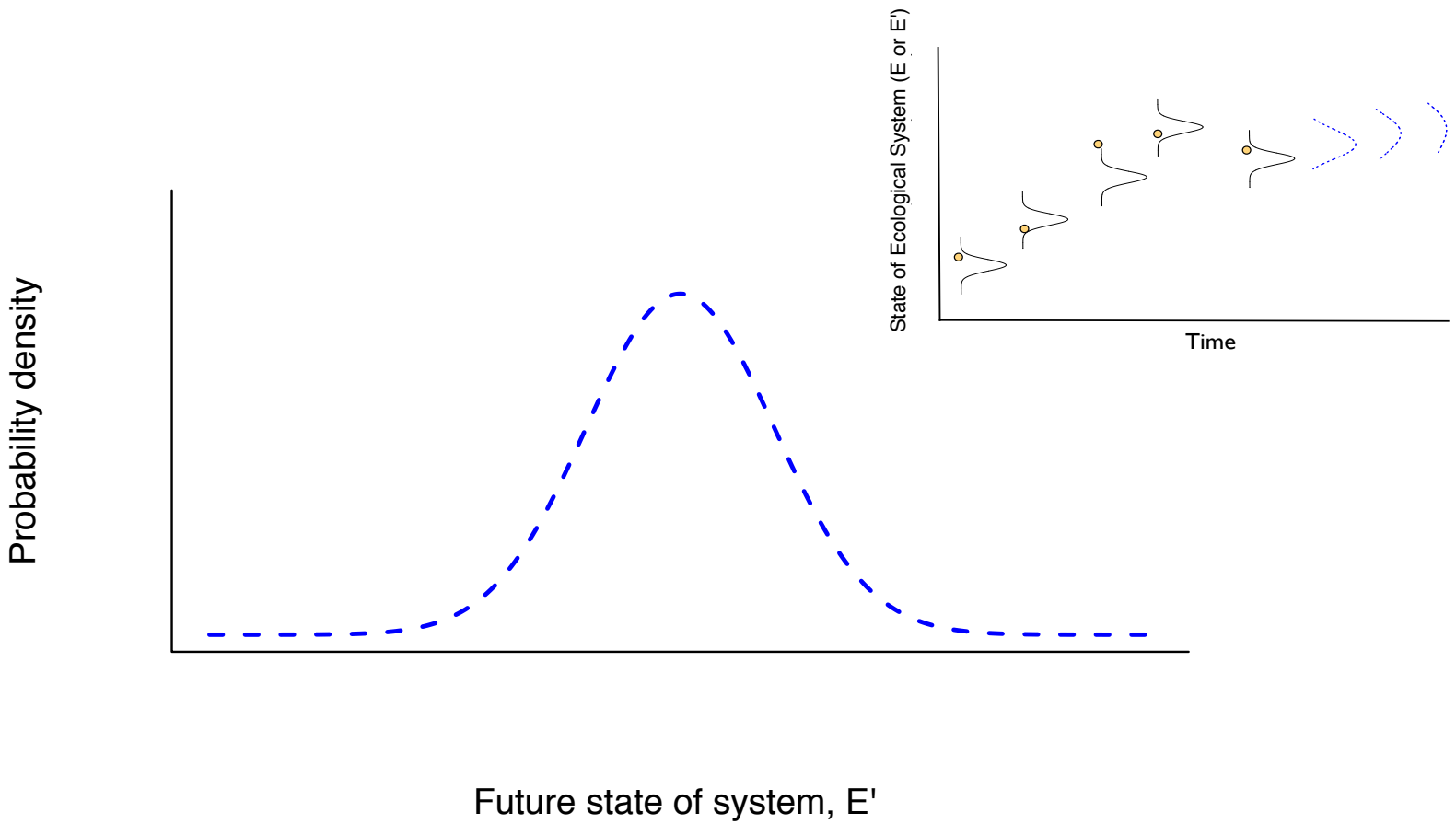


# Posterior predictive distributions

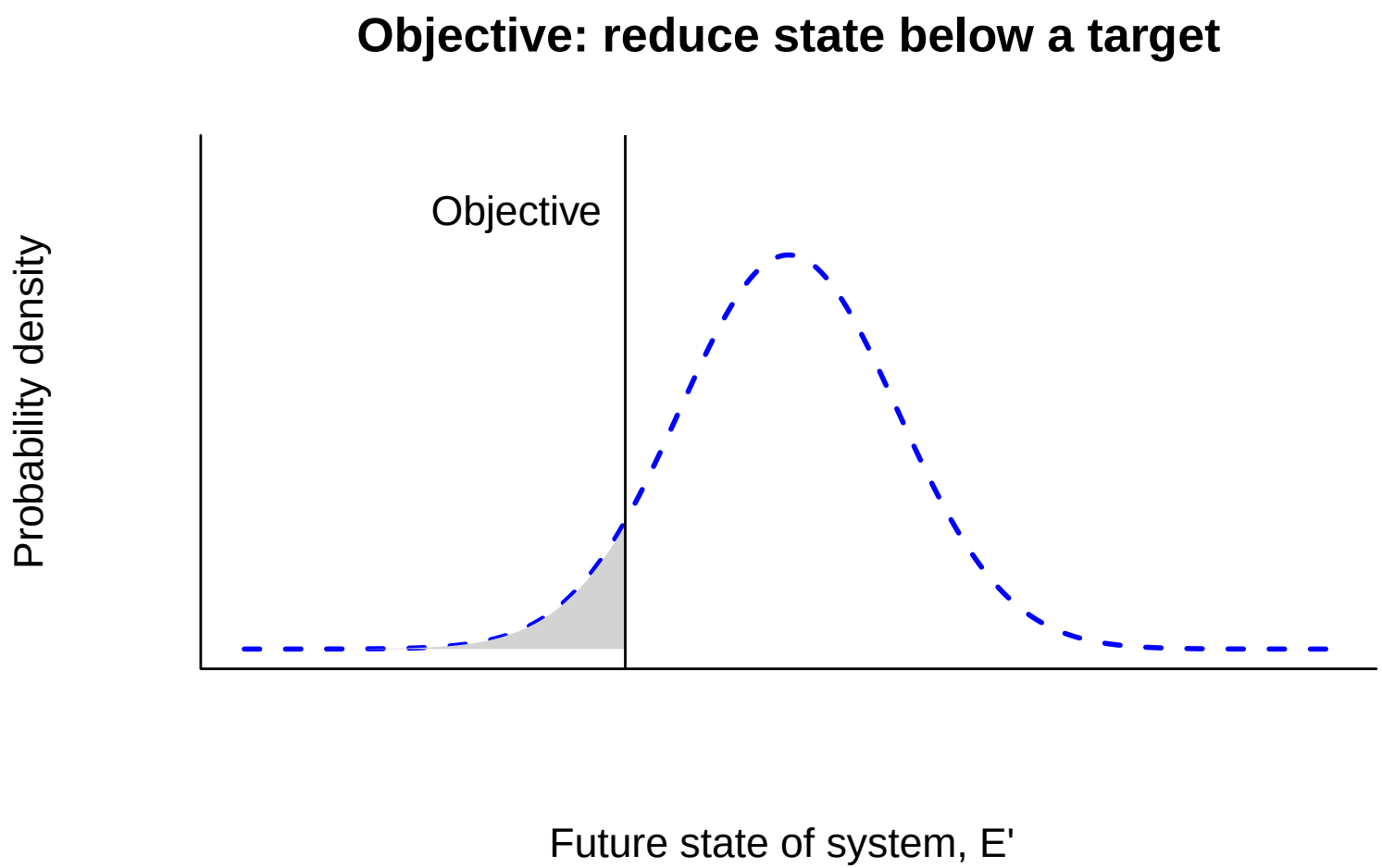
$$[E'|\text{data}] = \int_{\boldsymbol{\theta}} \int_{E} [E'|E, \theta_{data}, \theta_{process}] [E, \theta_{data}, \theta_{process}|\text{data}] \, \mathrm{d}E \mathrm{d}\theta_{data} \theta_{process}$$



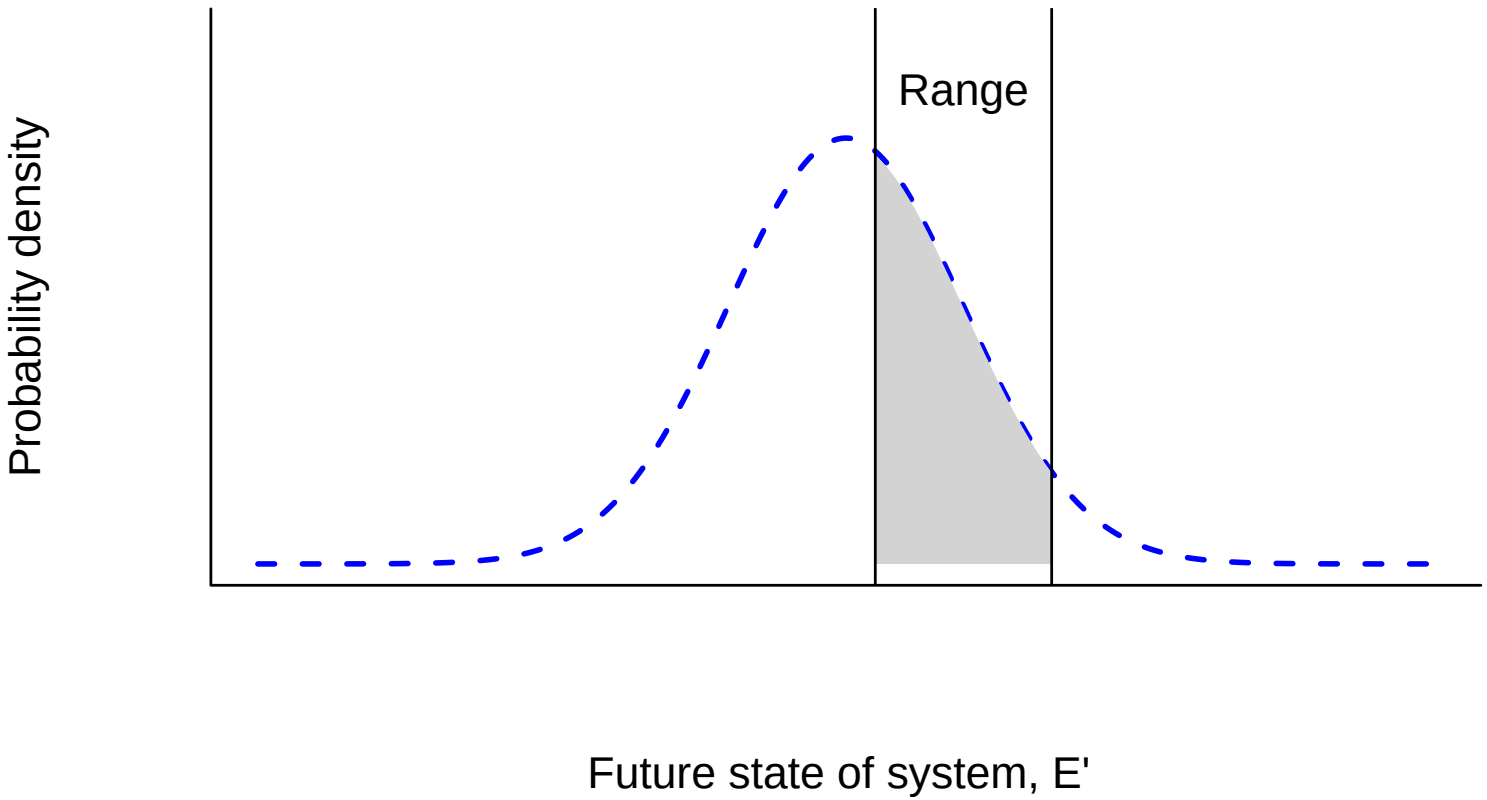
# Posterior predictive distribution of future states, $E'$



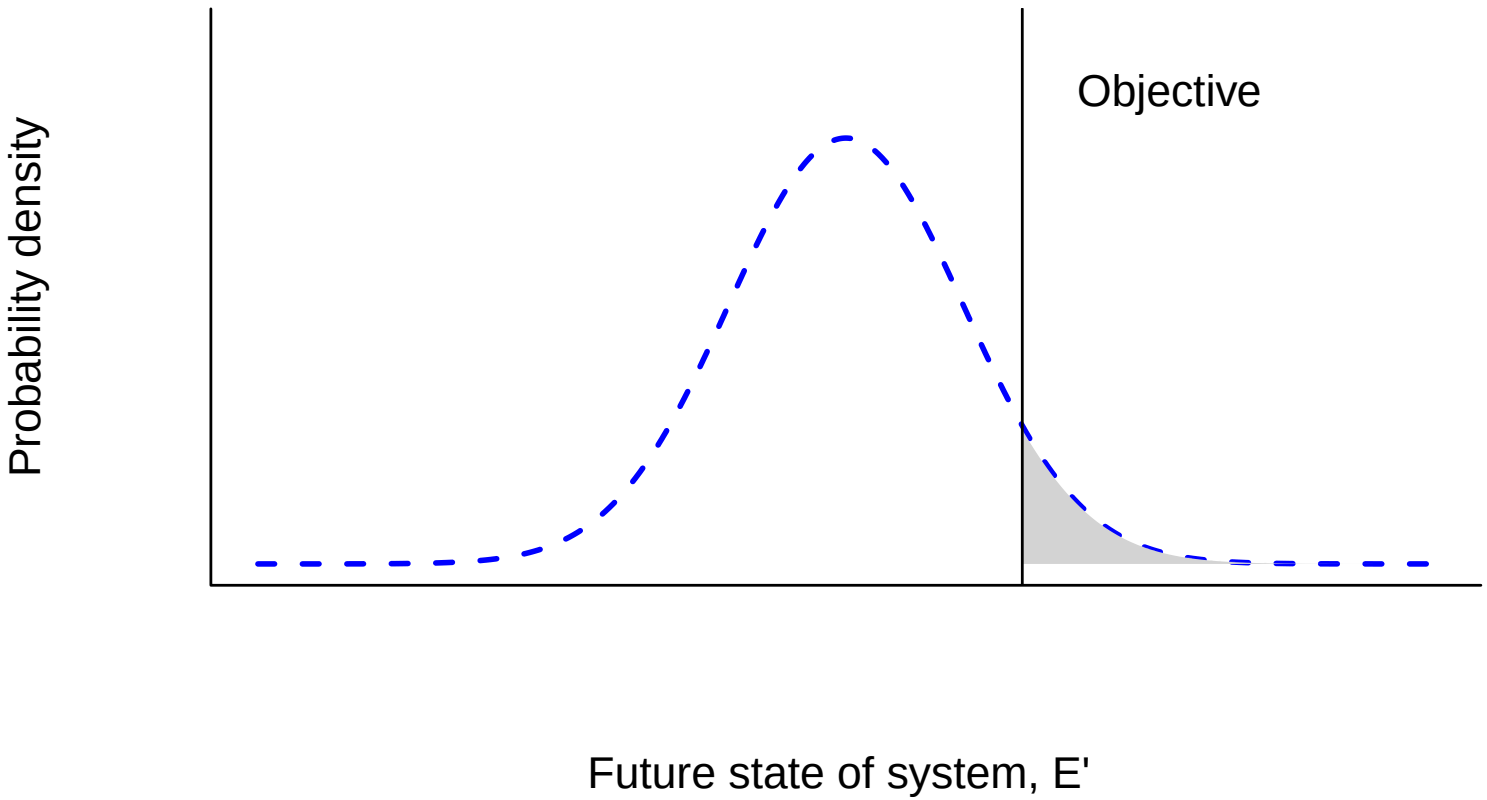
# How to evaluate actions?



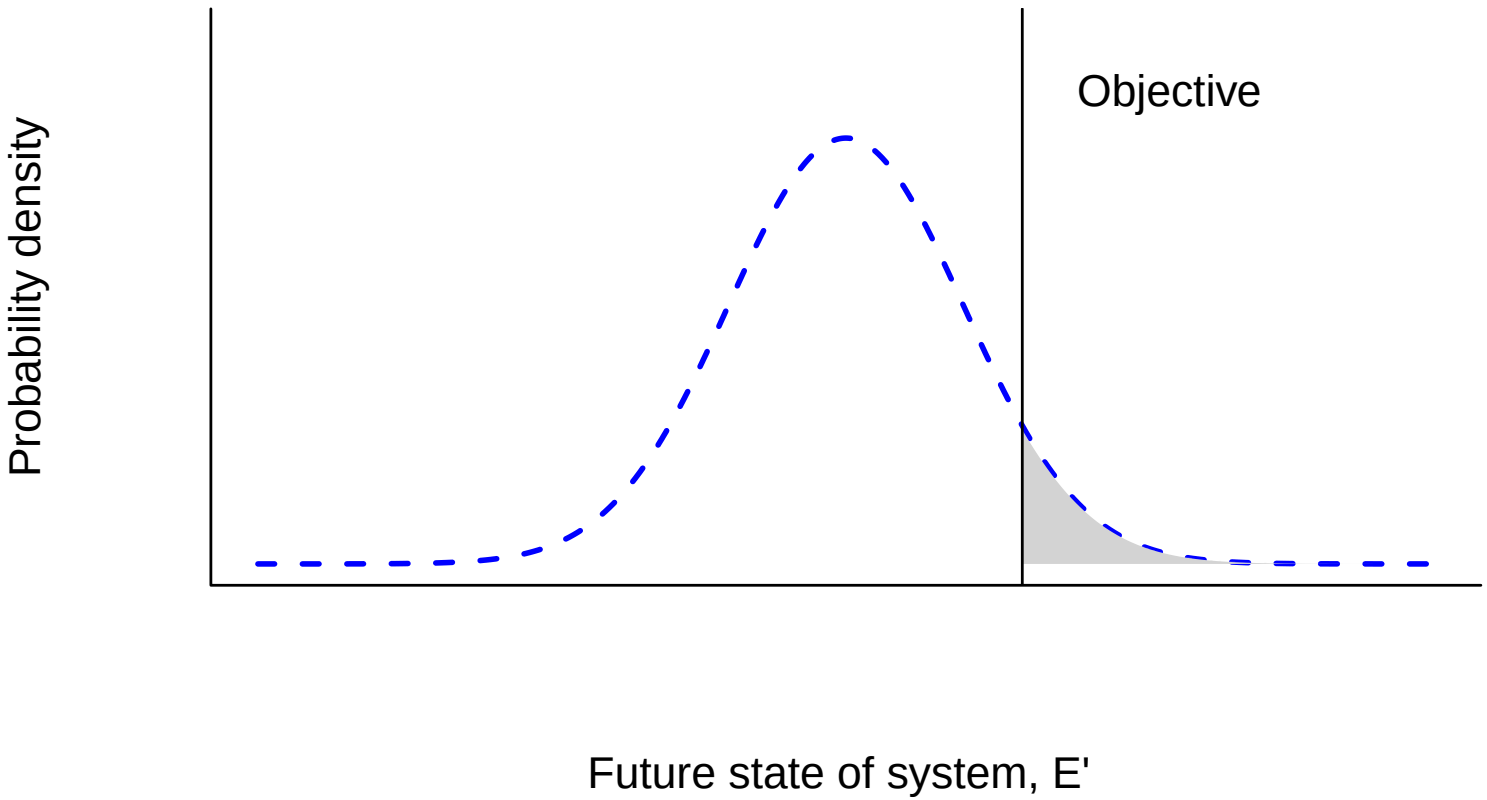
## Objective: maintain state within acceptable range



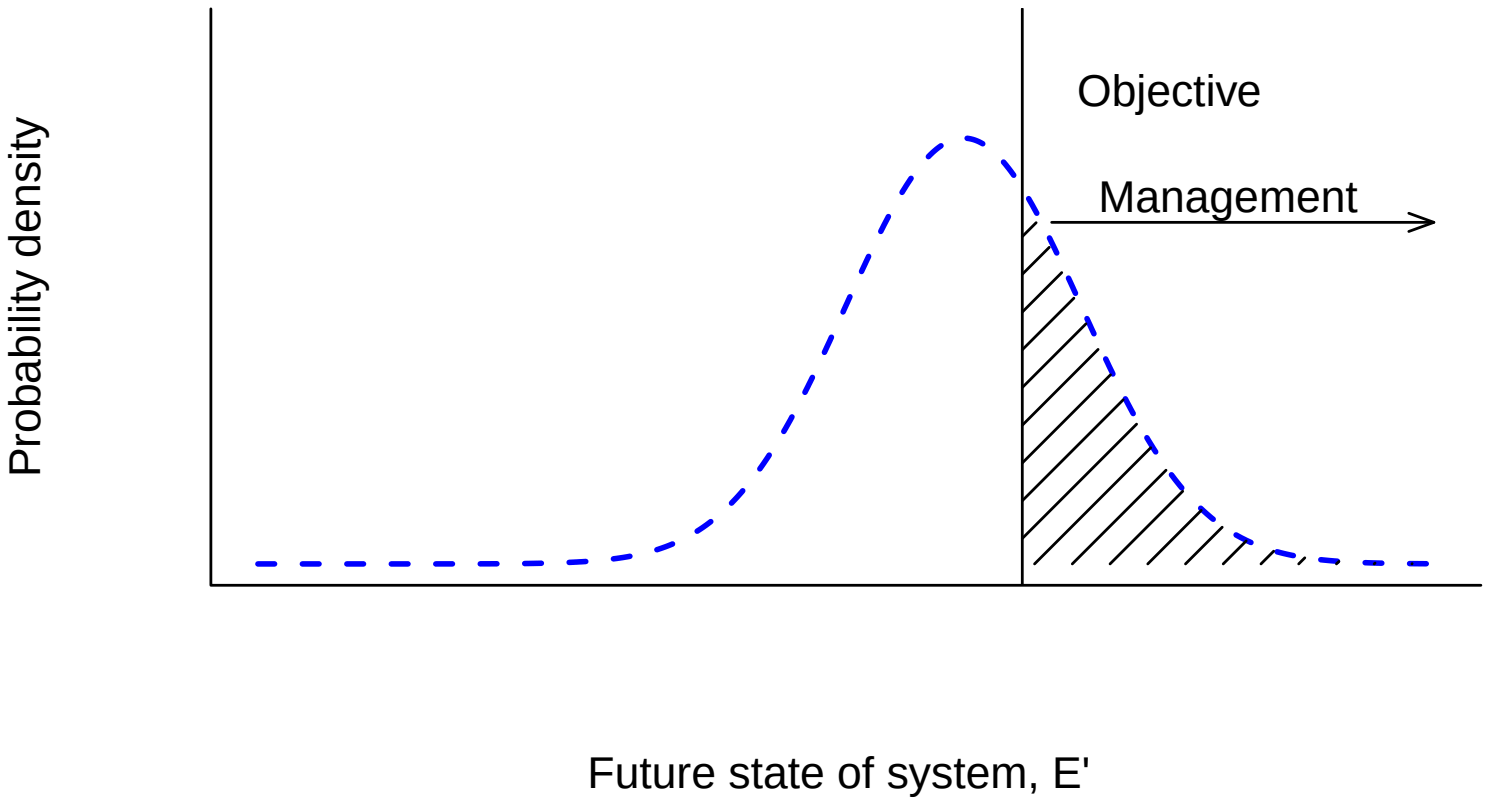
## Objective: increase state above a target

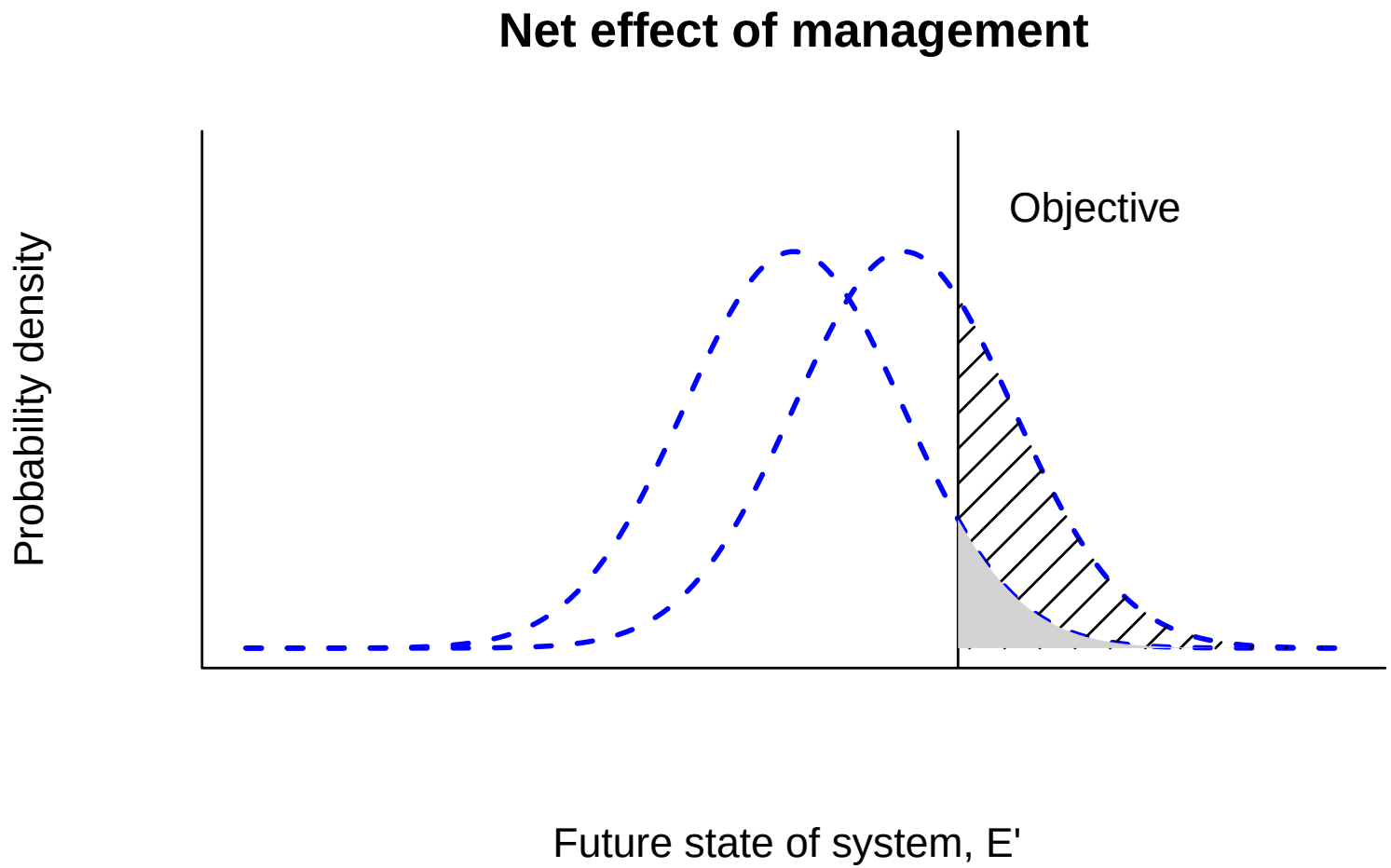


## Action: do nothing

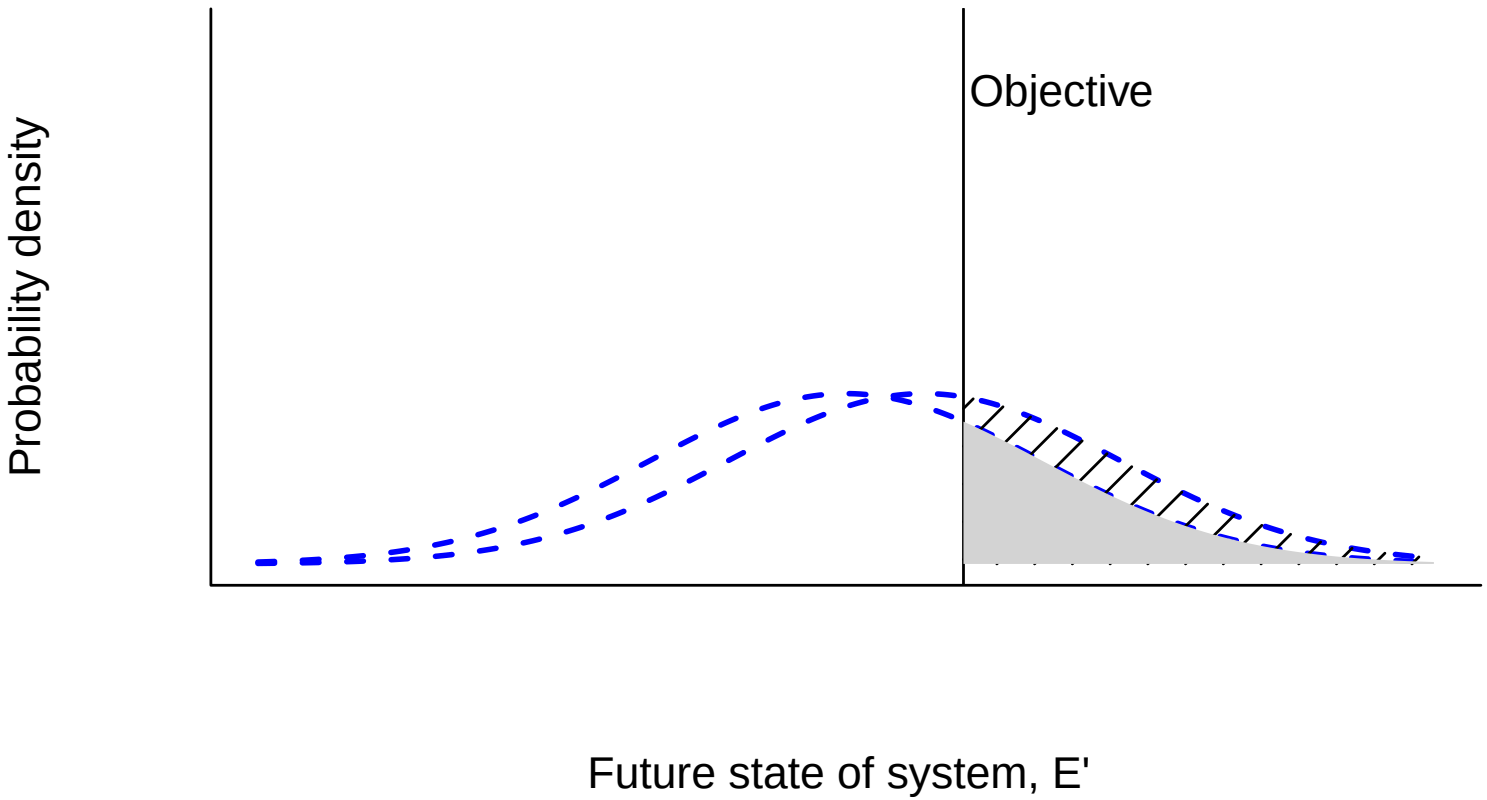


**Action: implement managment**

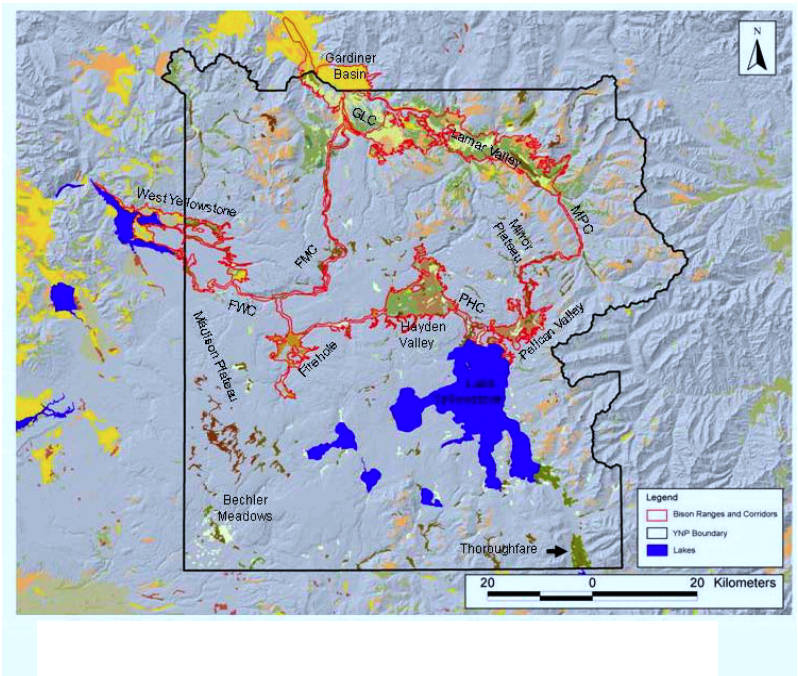



Net effect of management
Objective
Probability density
Future state of system, E'

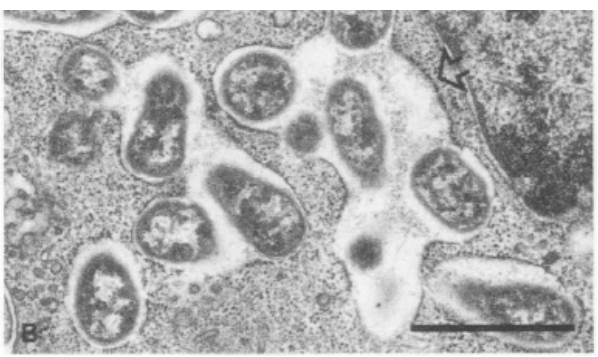
## Net effect of management



# Example: Managing brucellosis in Yellowstone Bison



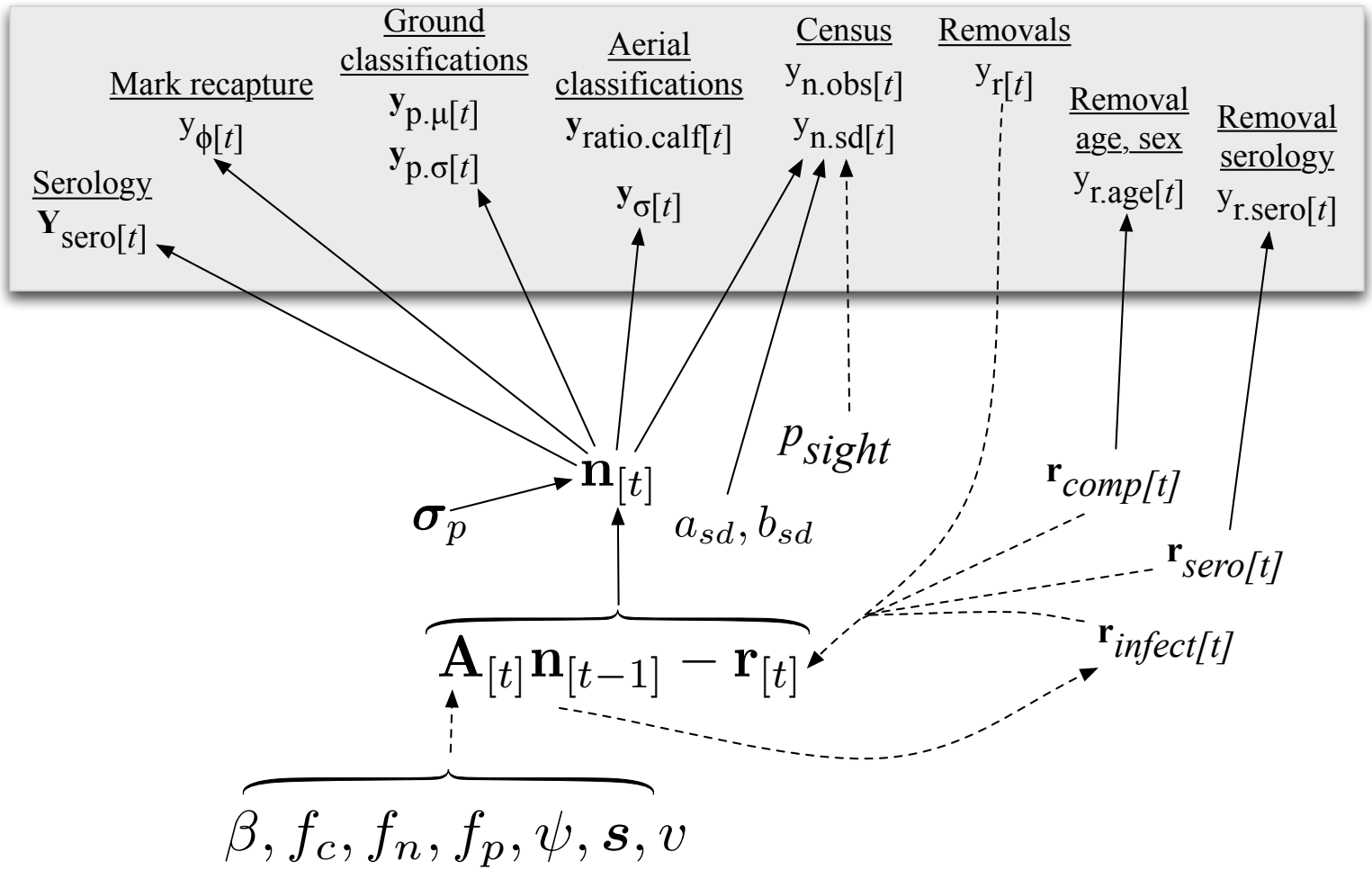




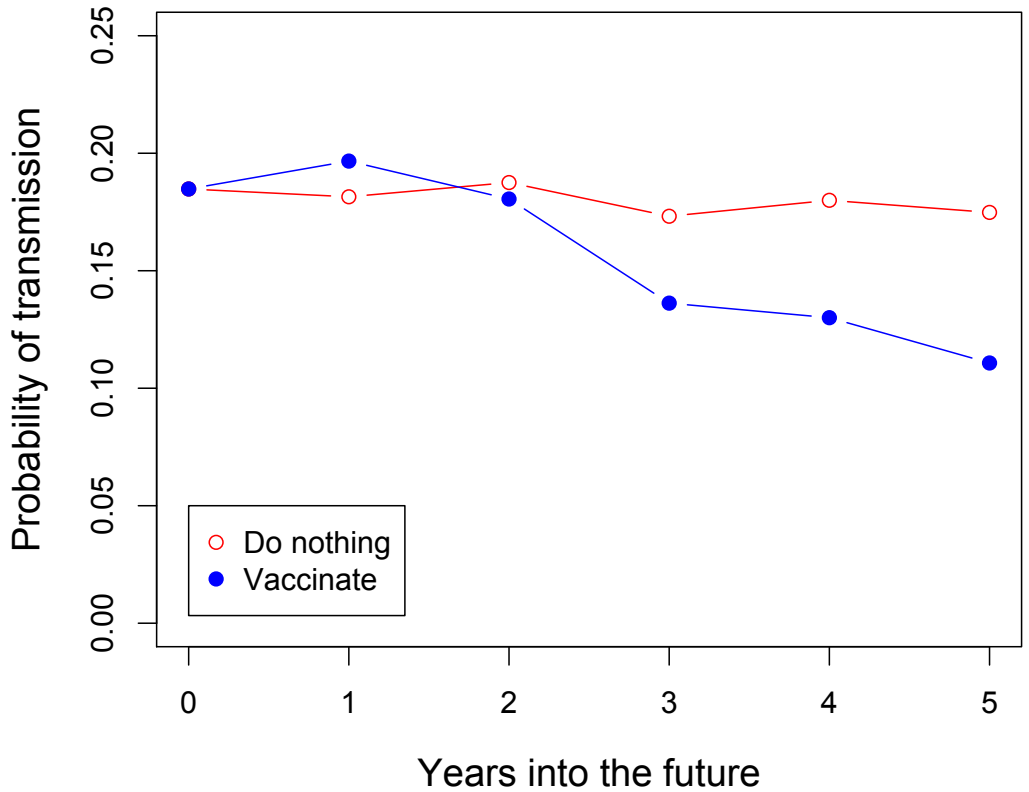
Goal: Reduce probability of infection by half in five years.

Action: Annually vaccinate 200 sero-positive females.

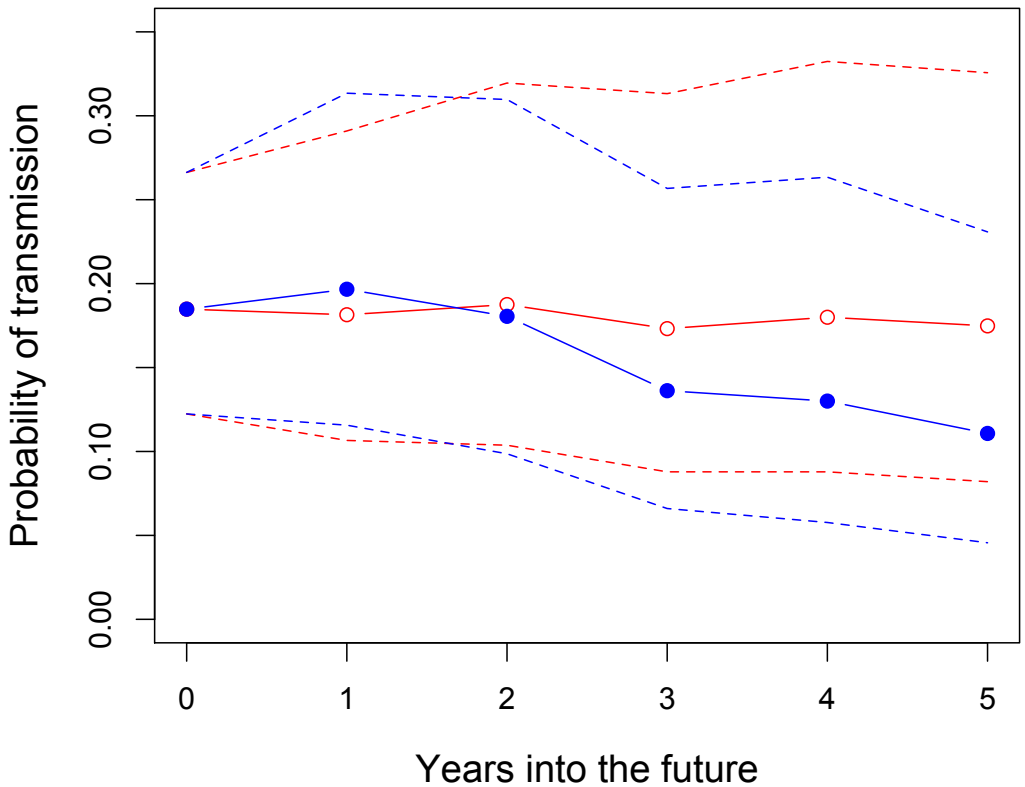
# Bayesian matrix model with multiple sources of data



# Effect of vaccination: Treat 200 sero-positive / year

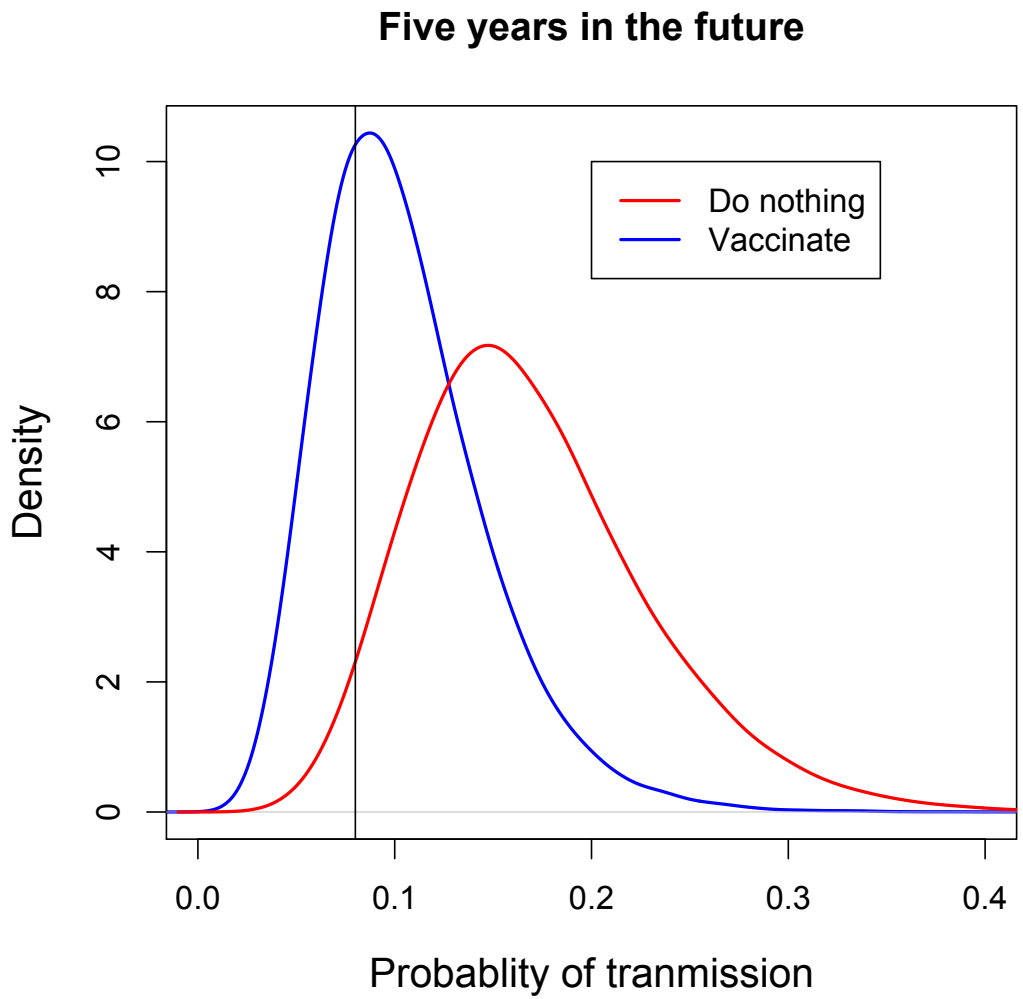


# Effect of vaccination



# Effect of vaccination

## Objective: reduce transmission probability by half



# Comparison of alternatives

| Management action | Probability of meeting goal |
|---|---|
| Do nothing | .05 |
| Vaccinate 200 sero-positives | .33 |
| Cull 200 sero-positives | .29 |
| Cull 200 females | .15 |
| Boundary hunting | .03 |

# Multiple objectives, multiple actions

## Objectives

- Reduce P(infection) by half
- Sero prevalence $< 40\%$
- Population size between 3000 - 3500
- Appropriate demographic composition

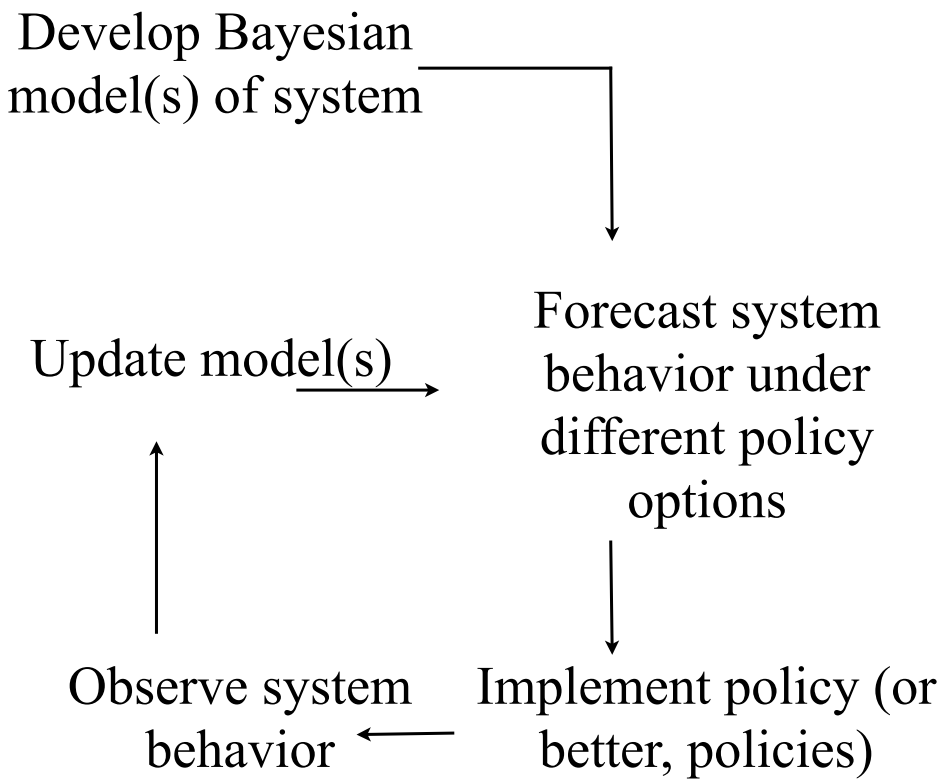
## Actions

- Vaccination
- Remove sero-positives
- Remove sero-negatives
- Boundary hunting (or removal)

# Closing

- Value
  - Provides honest forecasts relevant to actions and goals.
  - Informs the conversation
- Limitations
  - Demonic intrusions aren't included.
  - Forecasting horizons are short.

Walters, C. J. 1986. Adaptive Management of Renewable Resources. Macmillan, New York.



# May 21-30, 2013 Google "NREL Bayes"

Building capacity in Bayesian modeling for practicing ecologists

A workshop for faculty and agency researchers. $1000 stipend. See www.nrel.colostate.edu/projects/bayesworkshop/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