

# Integrating Science, Policy and Management: Decision Analysis and Adaptive Management Applied to Woodland Caribou in Ontario

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## Talk in 3 parts:

1. On the natures of science, policy and management: 3 silos
2. DAAM: integration of science, policy and management
3. The examples of woodland caribou

# Science → Policy → Management

- product *and* process
- cyclic feedback and revision
- experimental

- top-down
- linear
- responsive to policy developed with the “best available science”

- “Big P” policy: e.g., sustainable harvest
- “little p” policy: e.g., 10 % harvest rate

“Learning, *then* doing ...”

# BUT! Here's the rub:



“Every age has considered itself the Age of Reason, yet hard facts tend to melt away to be replaced by new hard facts.”

– Lewis Thomas in *Late Night Thoughts While Listening to Mahler's Ninth Symphony*

## Adaptive Management, in contrast, ...

“ ... is done whenever the dual goals of achieving management objectives and gaining reliable knowledge are accomplished simultaneously.”

-- R. A. Lancia et al. 1993. *Wild. Soc. Bull.* 24:436

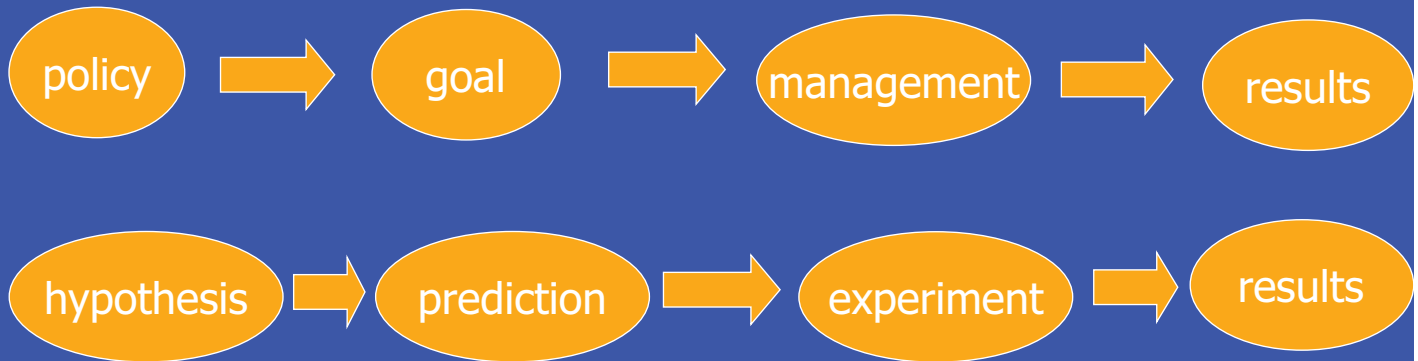
“Learning *while* doing ... ”



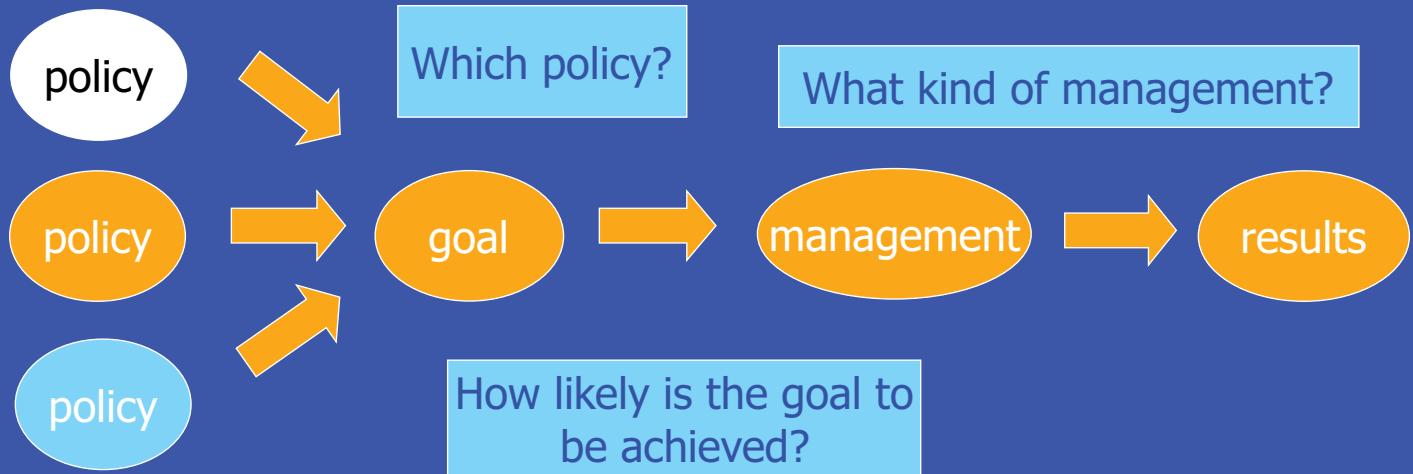
# Adaptive Management

“Policy as Hypothesis; Management by Experiment”

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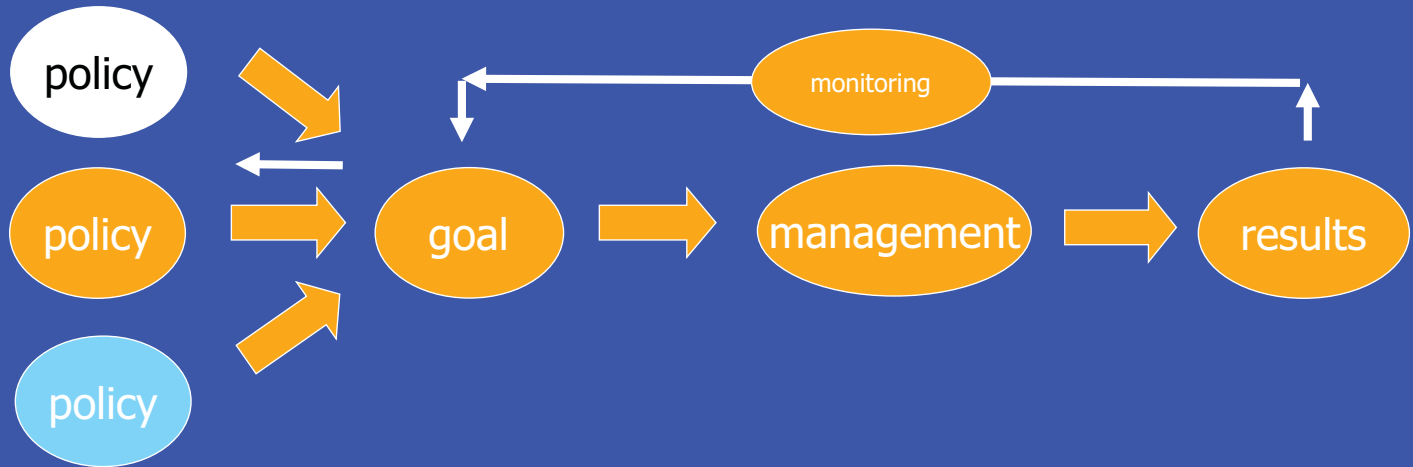


# Adaptive Management and Decision Analysis



*Embrace uncertainty!*

# Adaptive Management and Decision Analysis



## "10 steps to successful DAAM<sup>1</sup>"

1. All parties involved
2. Inclusive specification of management objectives and options
3. Identification of critical uncertainties, as hypotheses
4. Critical, rigorous examination of evidence for alternative hypotheses
5. Development of models to forecast outcomes, given different hypotheses
6. Evaluation and ranking of competing hypotheses by likelihood in light of uncertainty (DA)
7. Evaluation of experimental management options (DA)
8. Design and implementation of management experiments according to sound principles of experimental design (AM)
9. Monitor key responses (AM)
10. Update ranking of competing hypotheses by likelihood given monitoring results (DAAM)

<sup>1</sup> M. Jones, T. Nudds. 2003. *Draft Principles of Decision Analysis and Adaptive Management*.

# Adaptive Management integrated with Decision Analysis

Decision Analysis

Adaptive Management



Policy-makers open to institutional change and stakeholder input

NGOs and private interests open to objective dialogue

Resource managers open to "management experiments"

Resource scientists establish working trust with policy makers and stakeholders

Resource scientists collaborate with managers

## The Example of Woodland Caribou in Ontario

### Crown Forest Sustainability Act (1994)

The health and vigour of Crown forests should be provided for by using forest practices that, within the limits of silvicultural requirements, emulate natural disturbances and landscape patterns, while minimizing adverse effects on ... social and economic values, including recreational and heritage values.

## The Example of Woodland Caribou in Ontario

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## The Example of Woodland Caribou in Ontario

# Policy as scientific null hypothesis

$H_0$ : "treated" (managed) landscape  $\approx$  "control", reference landscape

## The Example of Woodland Caribou in Ontario

### Crown Forest Sustainability Act (1994)

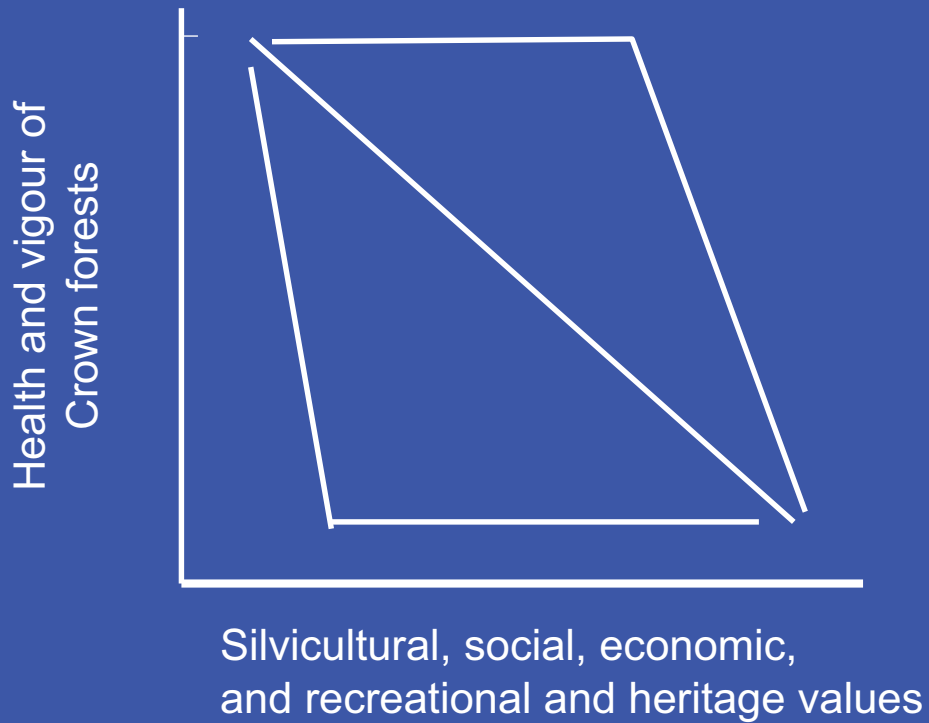
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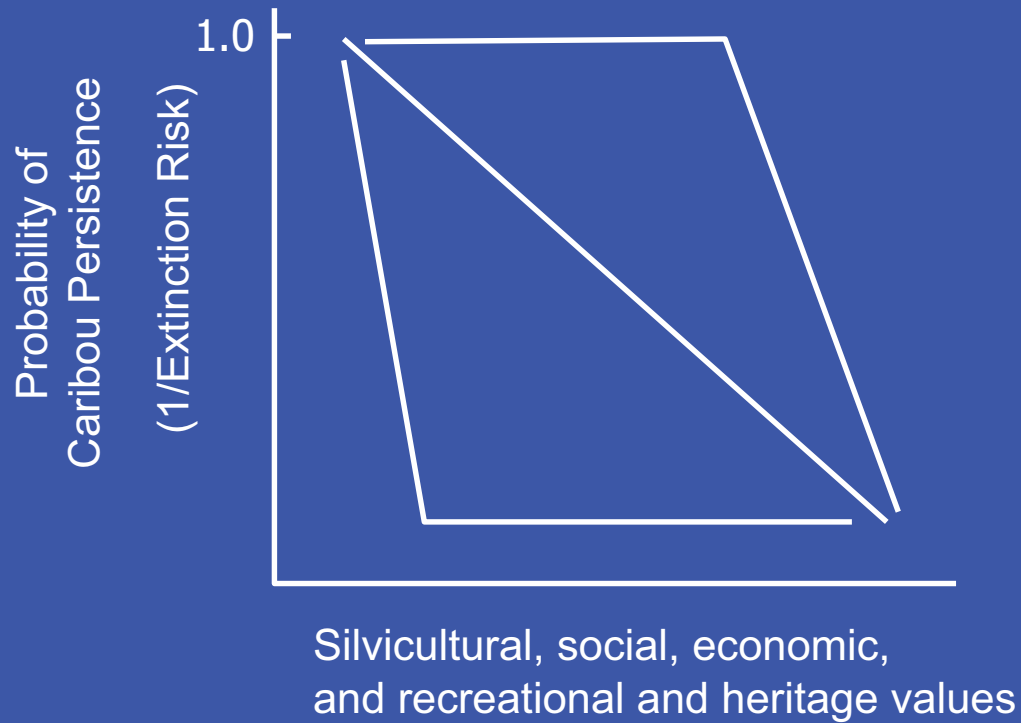
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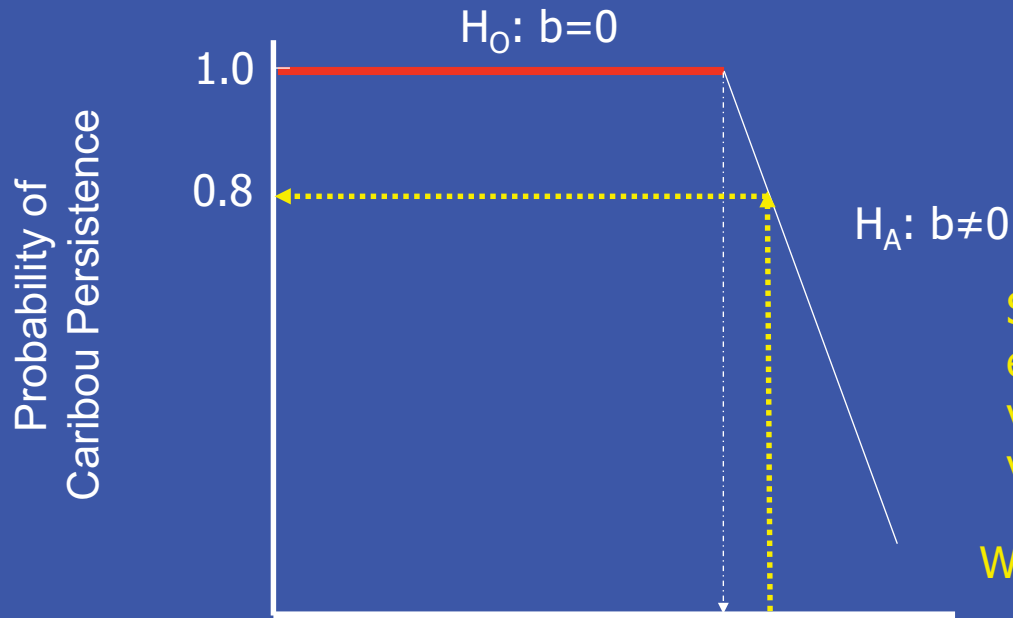
## The Example of Woodland Caribou in Ontario



## The Example of Woodland Caribou in Ontario



# Policy as scientific null hypothesis



Silvicultural, social, economic,  
and recreational and heritage values

So, how does  
extinction risk  
vary with other  
values?

We're not certain!

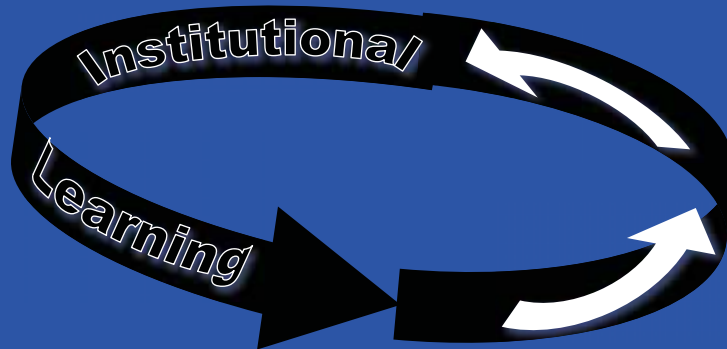
## “10 steps to successful DAAM<sup>1</sup>”

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change and stakeholder input

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trust with policy makers and stakeholders

# Conceptual Model

$$p_{\text{persistence}} = f\{\text{habitat, predators, competitors, climate ...}\}$$



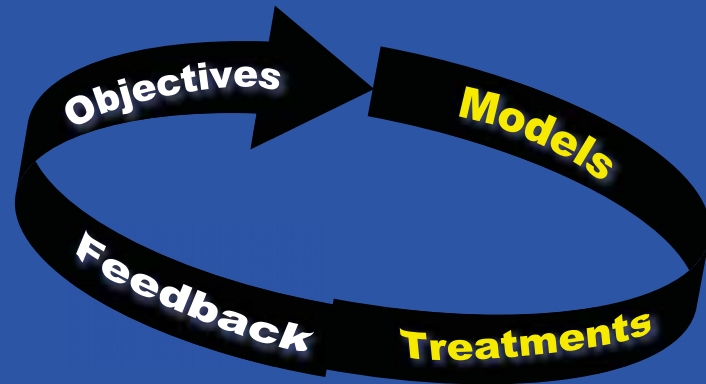
mature conifer  
large patches  
connected  
roads, linear  
features, etc.

humans  
wolves  
bears  
brainworm

moose  
deer

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Resource managers open  
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Resource scientists  
collaborate with managers

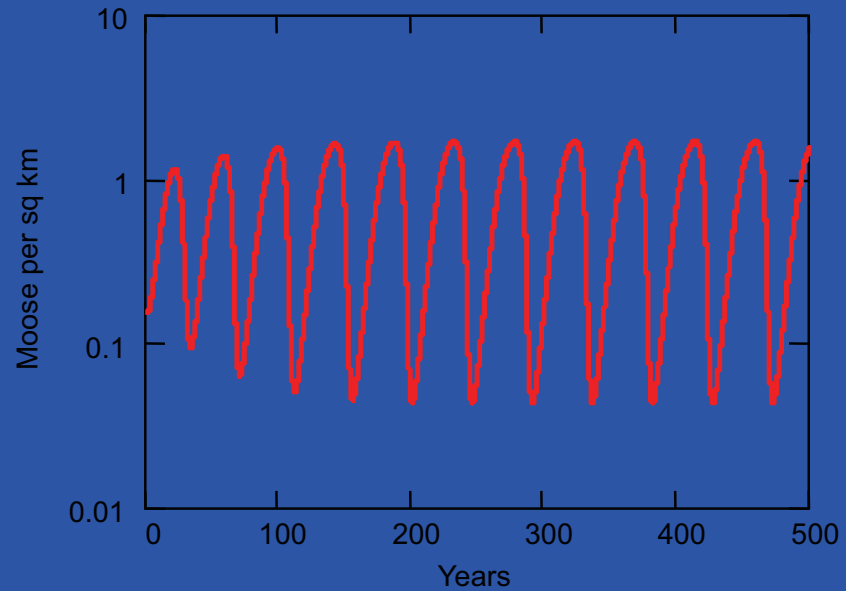


Adapted from Linkov et al. 2006 and Blann and Light 2000

# Ontario woodland caribou PVA

- Nonspatial moose-wolf trophic model
- Nonspatial caribou-wolf-moose trophic model
- Spatial habitat dynamics
- Spatial caribou dynamics
- Spatial caribou PVA

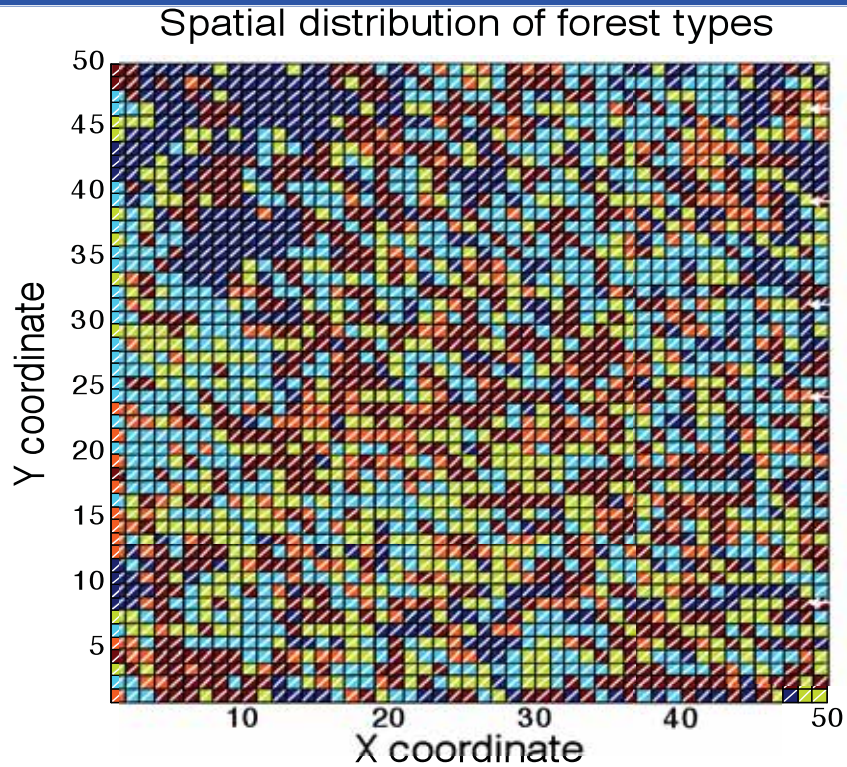
# Nonspatial Moose-wolf model

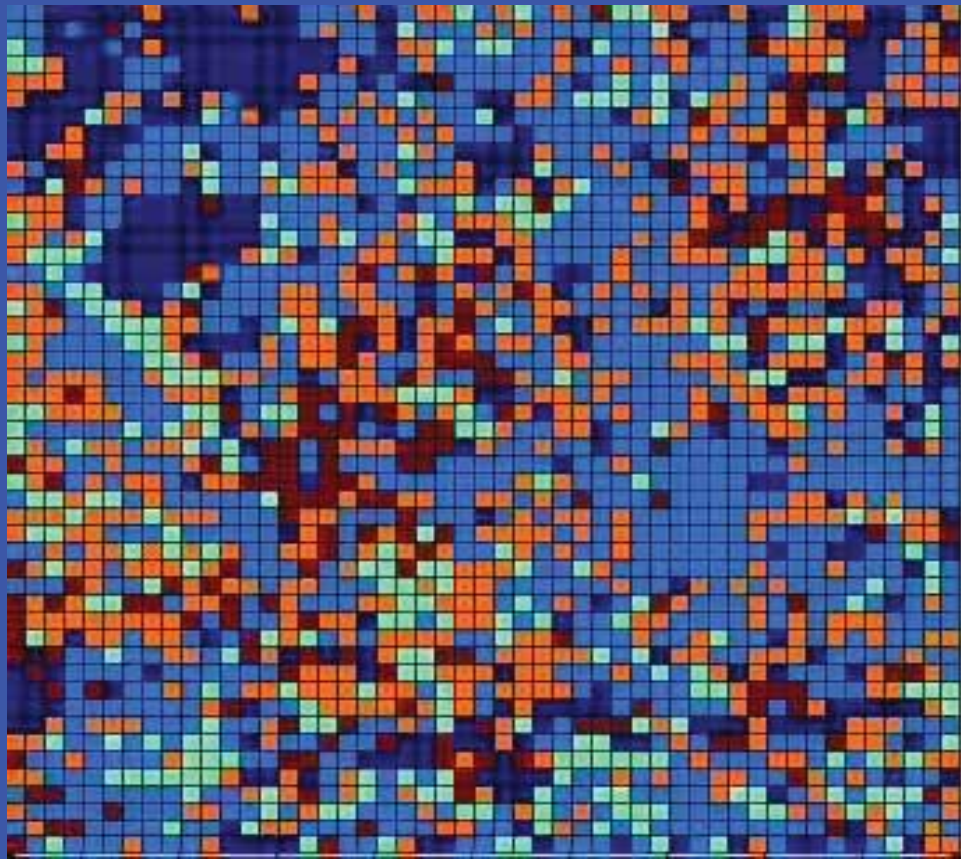


# Nonspatial caribou-moose-wolf model

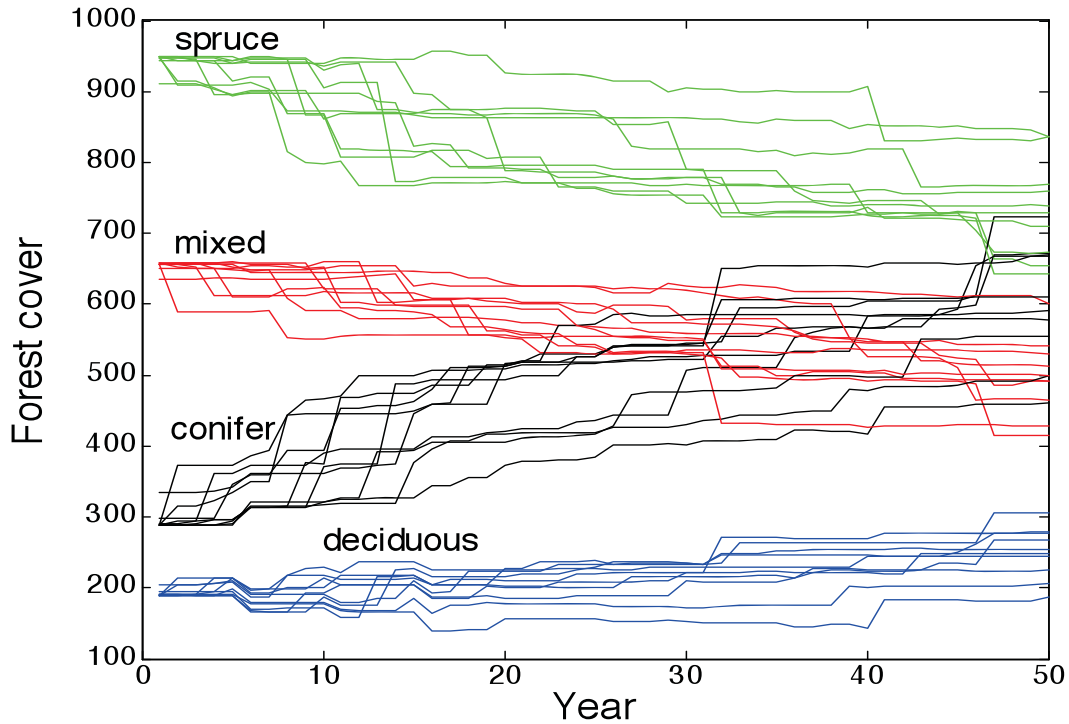


# Spatial habitat dynamics





# Spatial habitat dynamics



# Spatial caribou dynamics

- **Collection period:**

Mar. '95 – Apr. '00

- **34 individuals**

27 females, 7 males

31 adults, 3 yearlings

- **Satellite (UHF) & VHF transmitters**

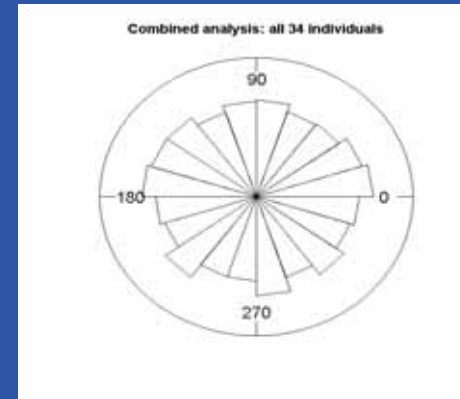
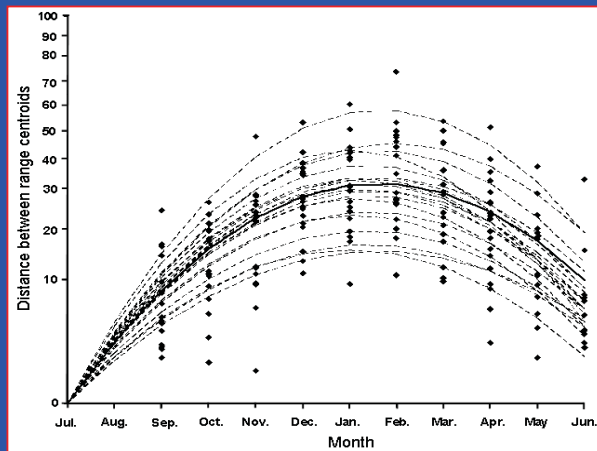
2-7 day location interval

- **160 000 km<sup>2</sup> study area,**

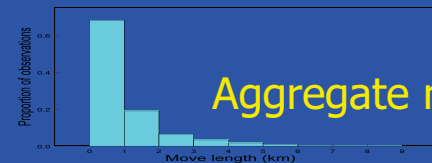


# Spatial caribou dynamics

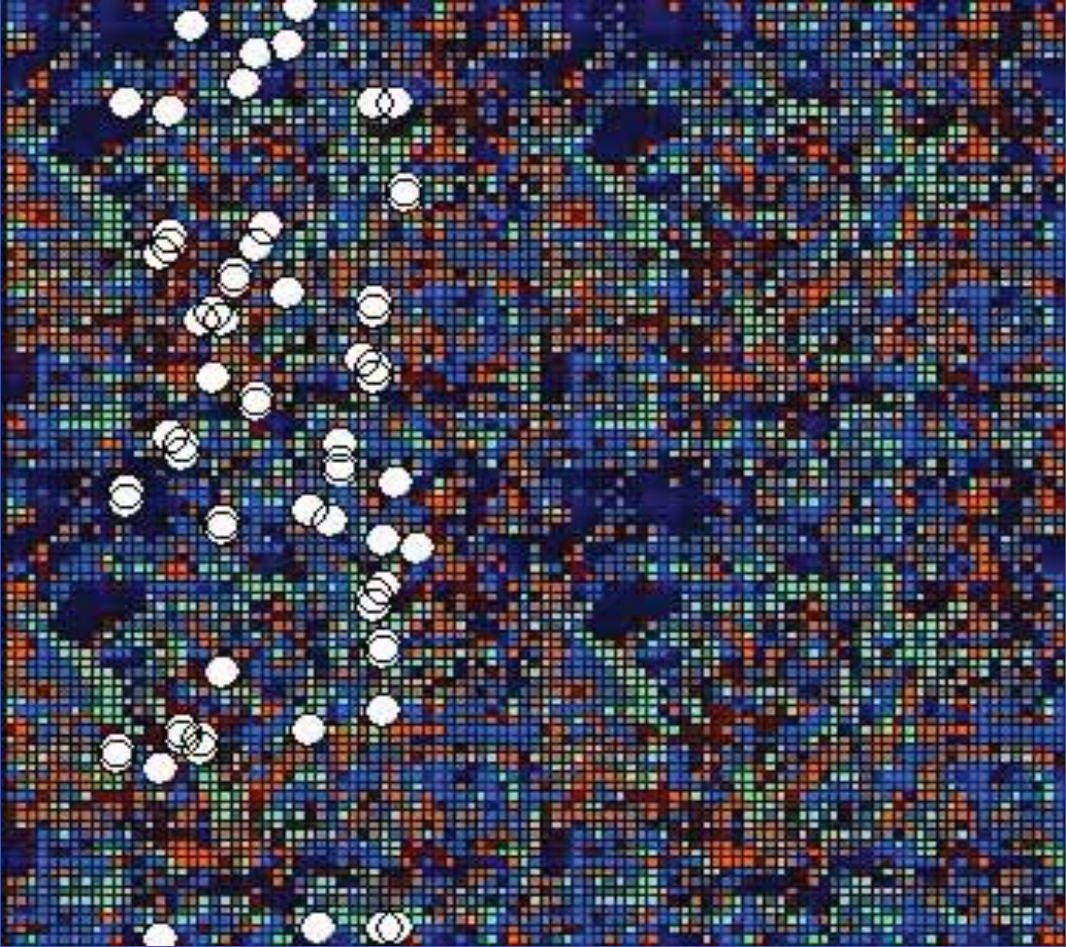
## Individual seasonal movement



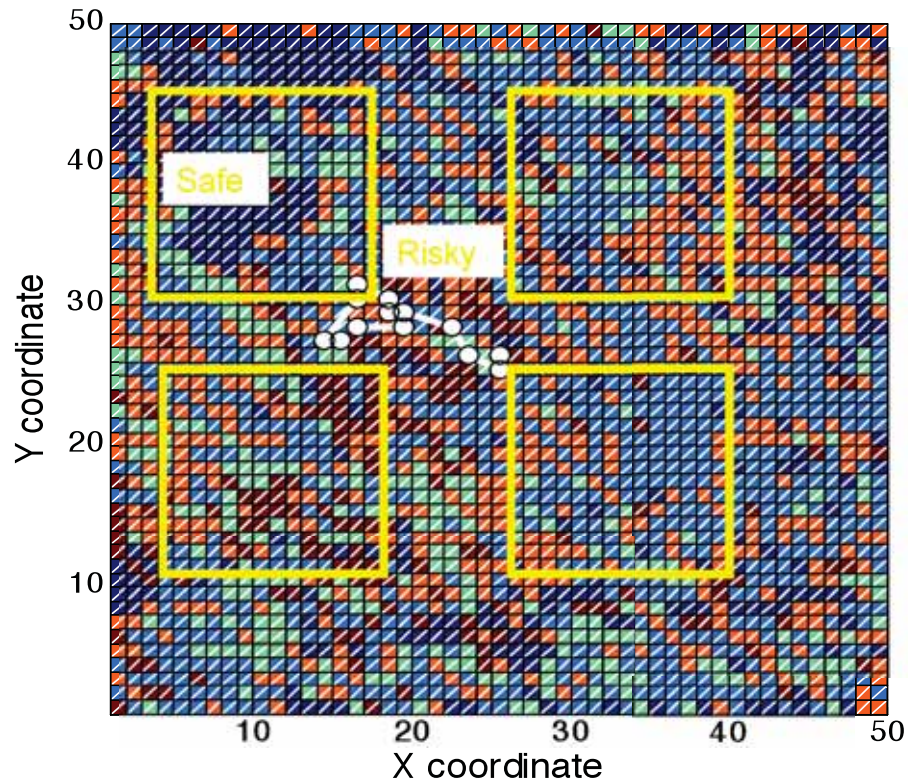
## Aggregate turning angles



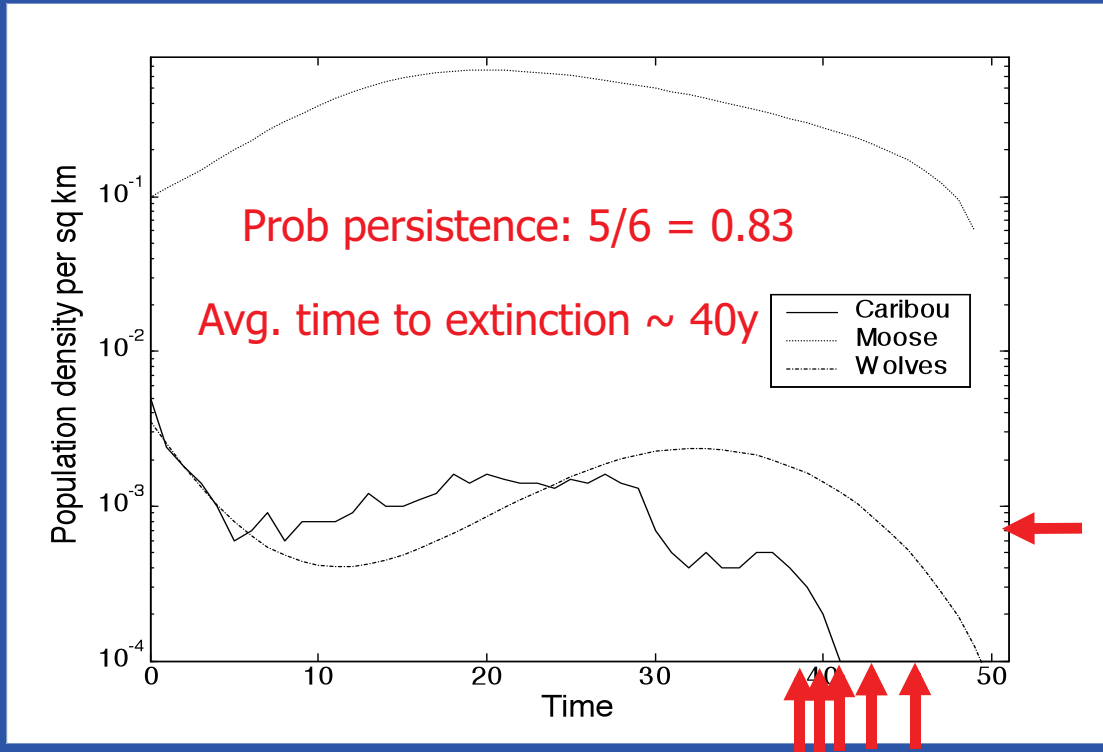
## Aggregate move lengths



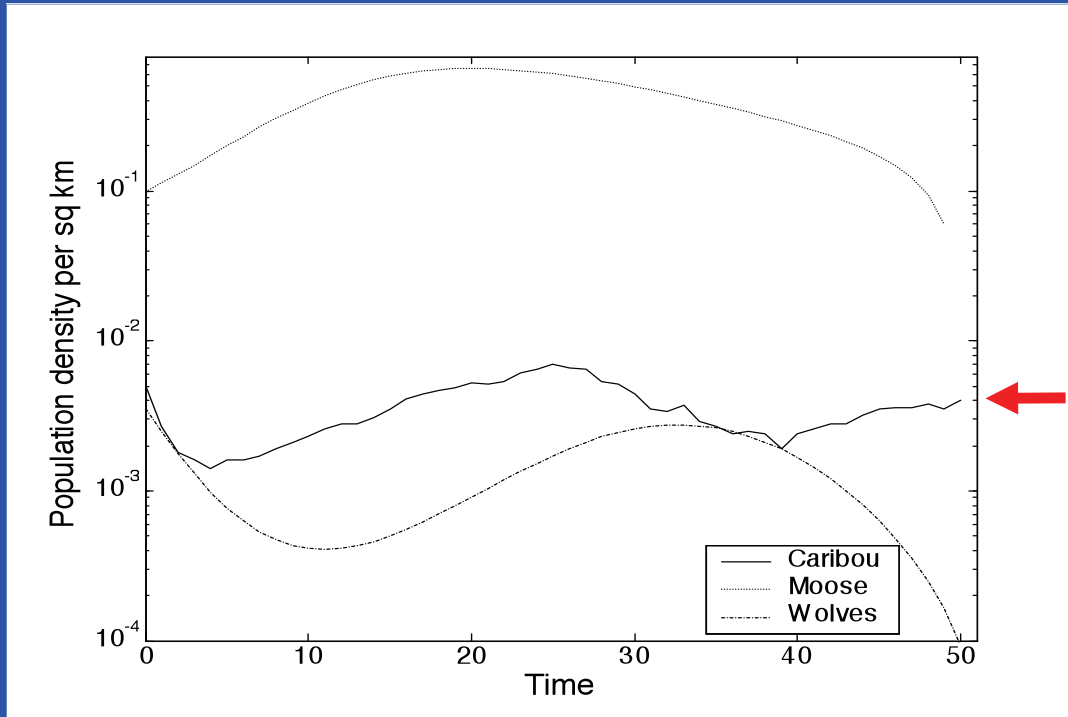
# Spatial caribou PVA



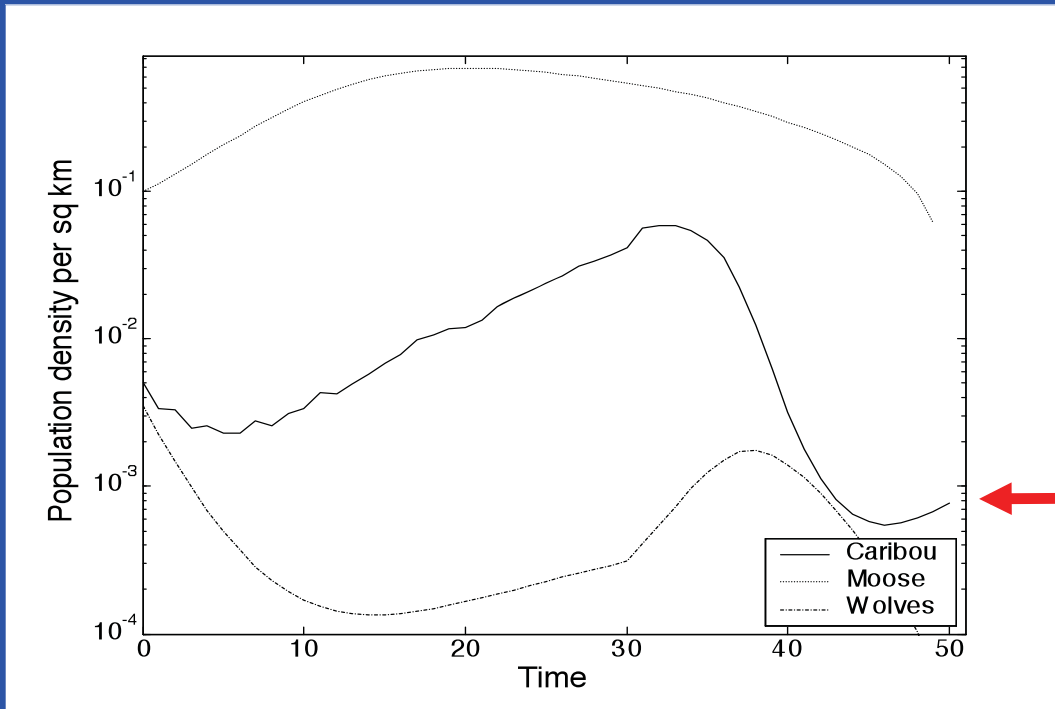
# Simulated population dynamics (40% mature stands)



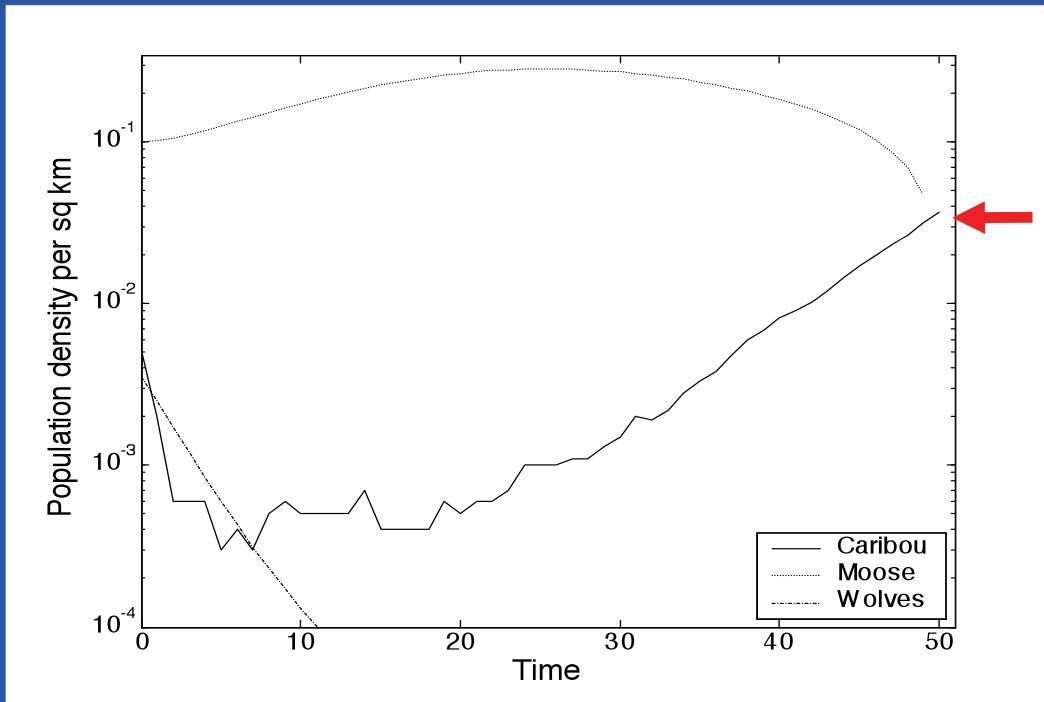
## Simulated population dynamics (60% mature stands)



# Simulated population dynamics (40% mature stands) + 10% annual wolf harvest.



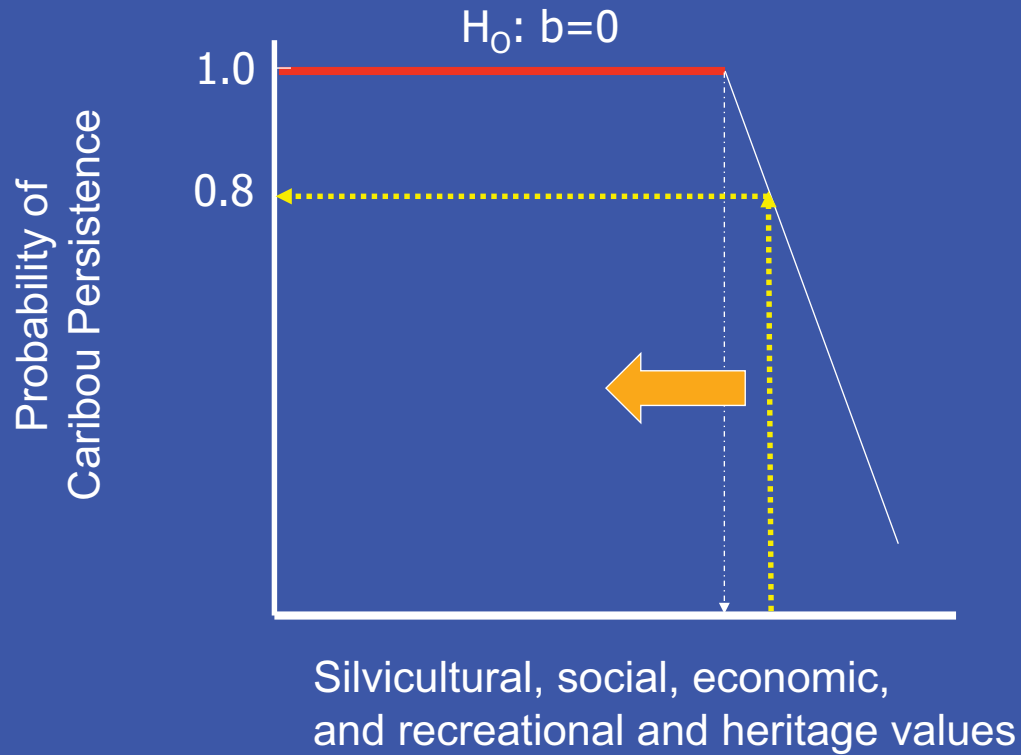
Simulated population dynamics (40% mature stands)  
+ 10% annual moose harvest.



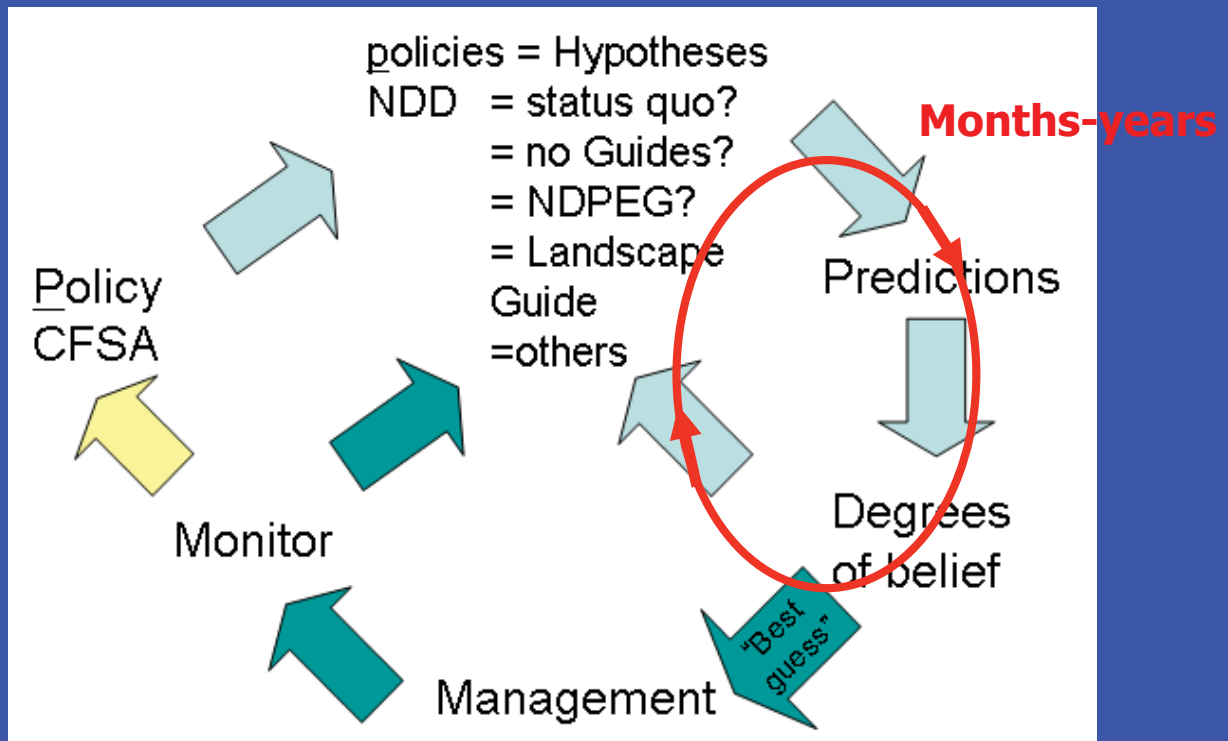
## Woodland caribou PVA

- Apparent competition with moose and wolves may be strong enough to cause extinction
- Reserves of mature forest can sustain caribou provided large enough (~60%)
- Small reserves of mature forest may also be sustainable if combined with moose or wolf harvest

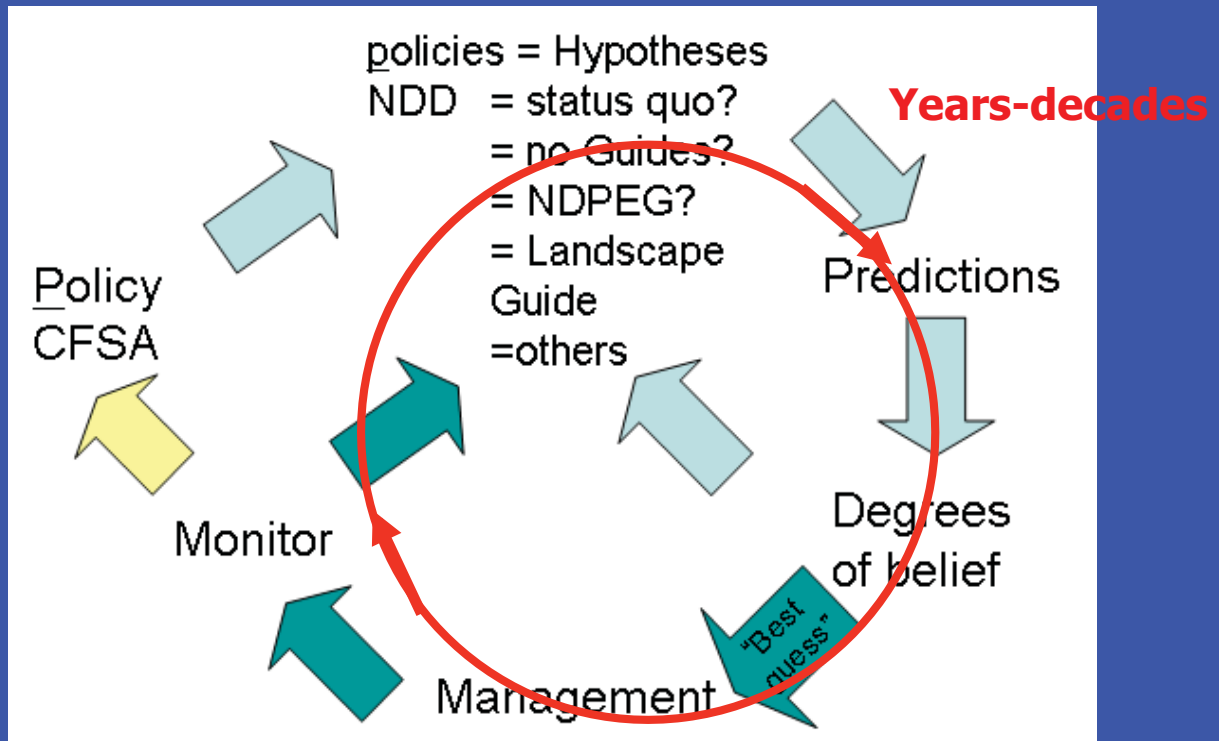
# Policy as scientific null hypothesis



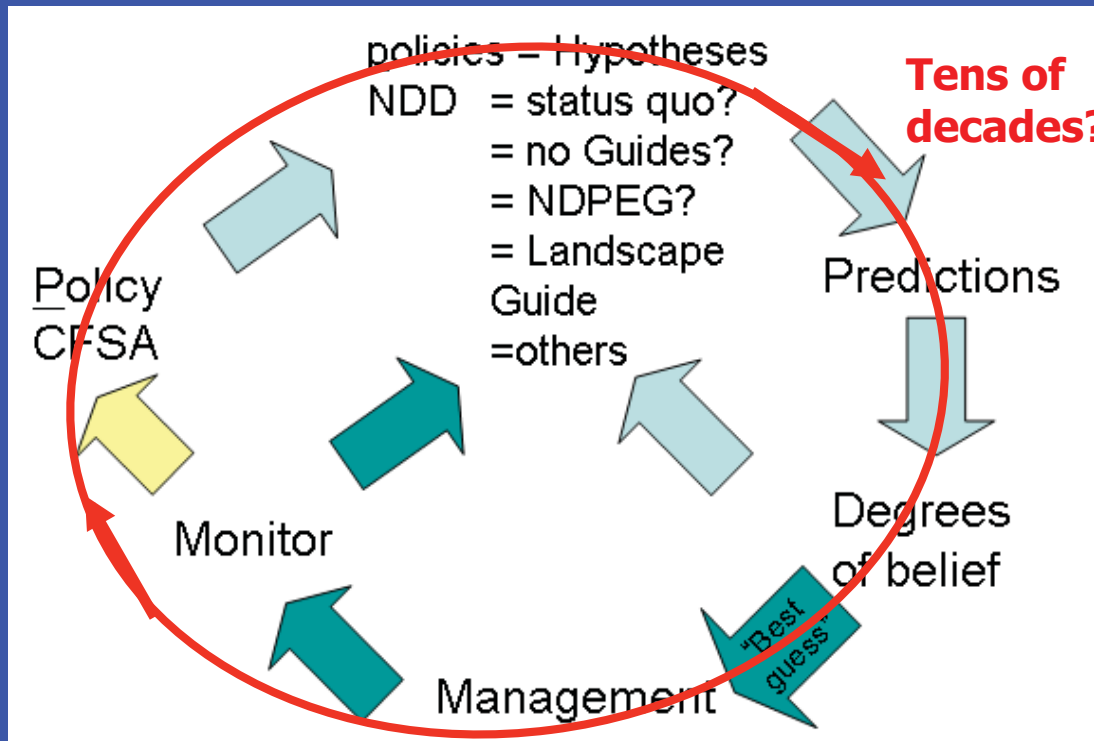
## Be patient ...



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# Key to Types of Adaptive Management

## 1. Deliberate attempt to evaluate policy?

Yes.....Adaptive management; go to **2**.

No.....Reactive management.

## 2. Alternative policies evaluated/compared?

Yes.....Active adaptive management (AAM; go to **3**.

No.....Passive adaptive management (PAM).

## 3. Evaluations/comparisons are designed?

Yes.....Manipulative experimental AAM; go to **4**.

No.....Mensurative "experimental" AAM.

## 4. Evaluations use spatial/temporal controls?

Yes.....AAM with treatments and controls, baselines, etc.

No.....AAM with modeling, prior probabilities and  
Bayesian inference/model selection