

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

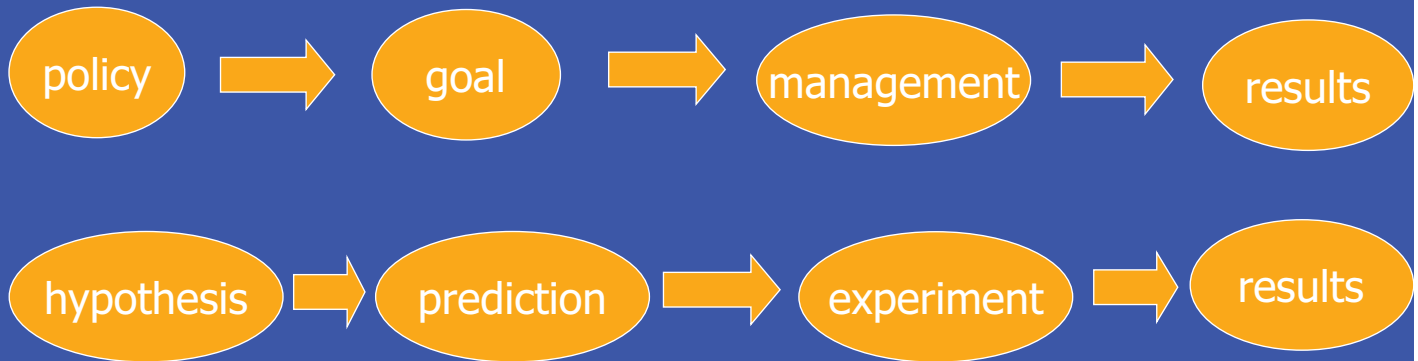
“Learning *while* doing ... ”



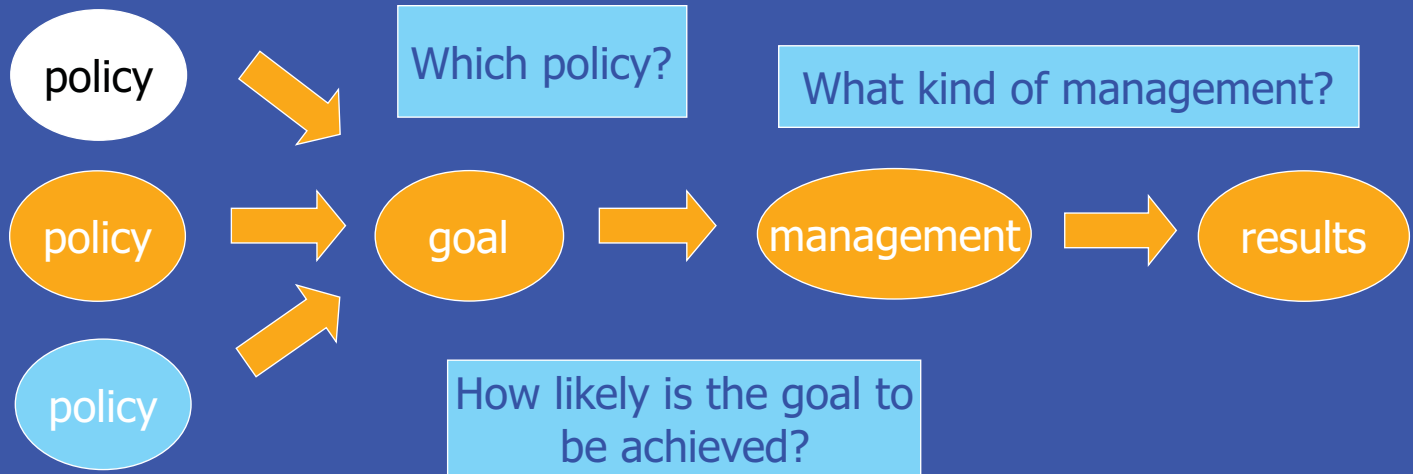
Adaptive Management

“Policy as Hypothesis; Management by Experiment”

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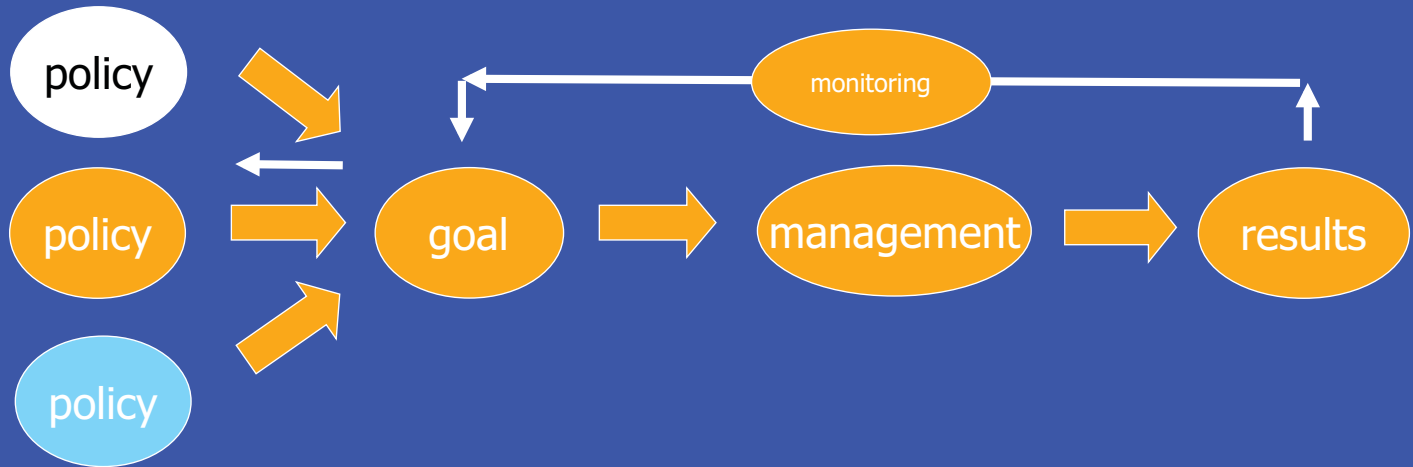


Adaptive Management and Decision Analysis



Embrace uncertainty!

Adaptive Management and Decision Analysis



"10 steps to successful DAAM¹"

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)

¹ 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.

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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)

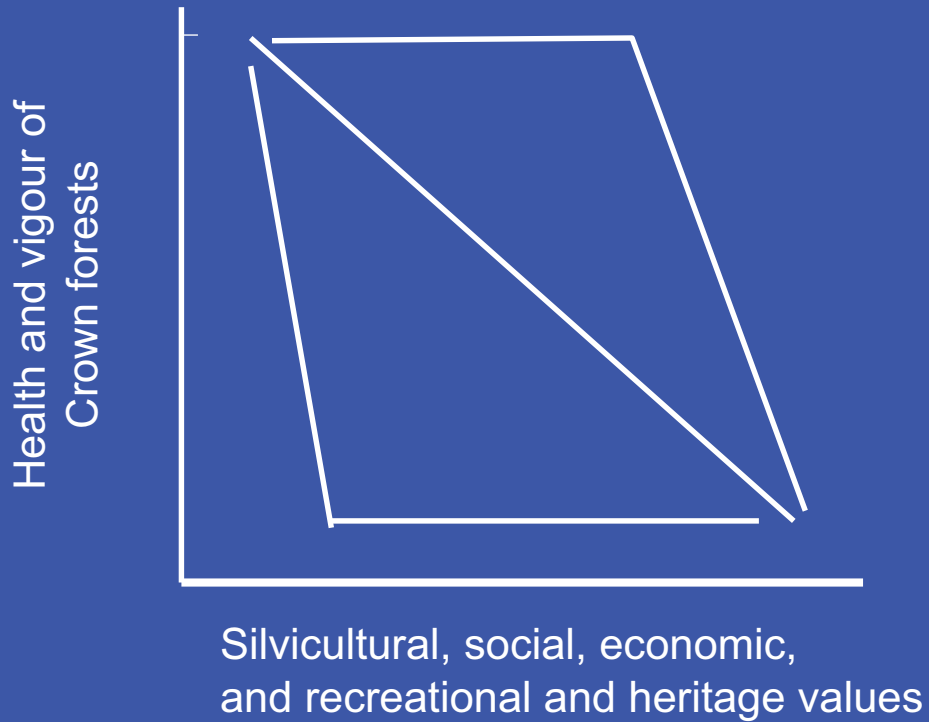
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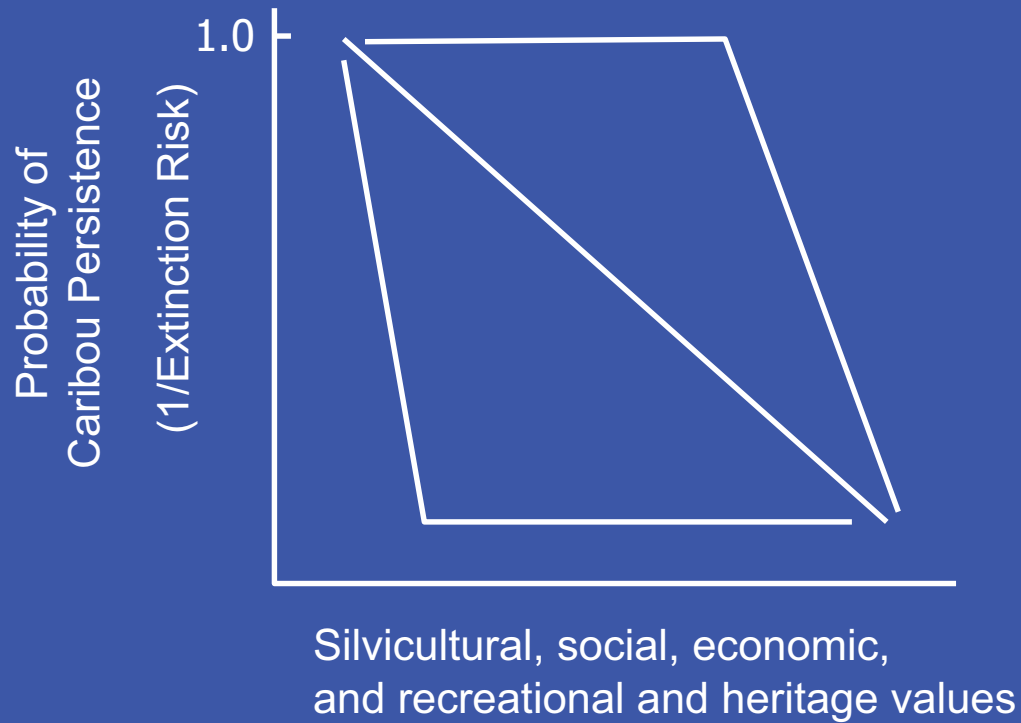
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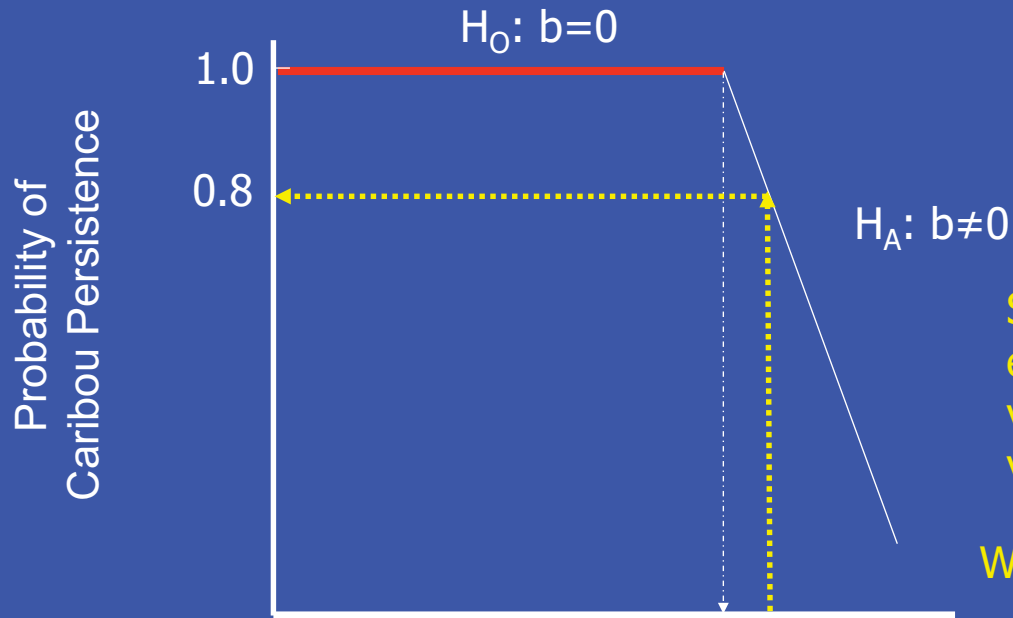
The Example of Woodland Caribou in Ontario



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!

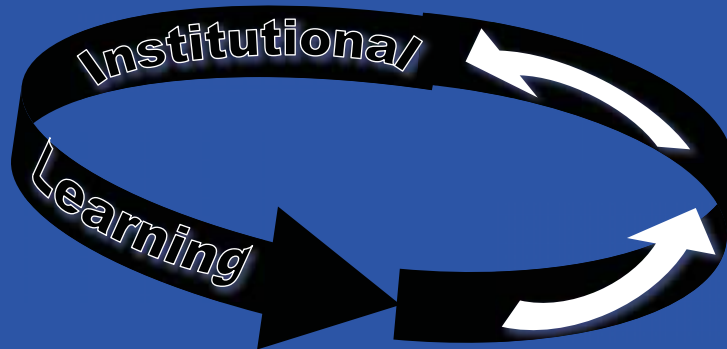
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Adaptive Management integrated with Decision Analysis

Decision Analysis



Policy-makers open to institutional
change and stakeholder input

NGOs and private interests
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Resource scientists establish working
trust with policy makers and stakeholders

Conceptual Model

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

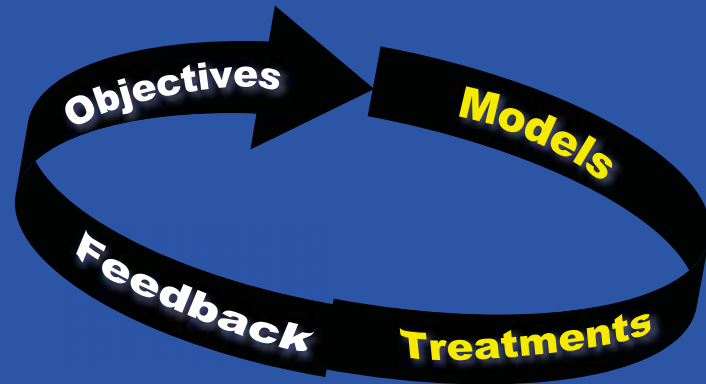
mature conifer
large patches
connected
roads, linear
features, etc.

humans
wolves
bears
brainworm

moose
deer

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to "management experiments"



Resource scientists
collaborate with managers

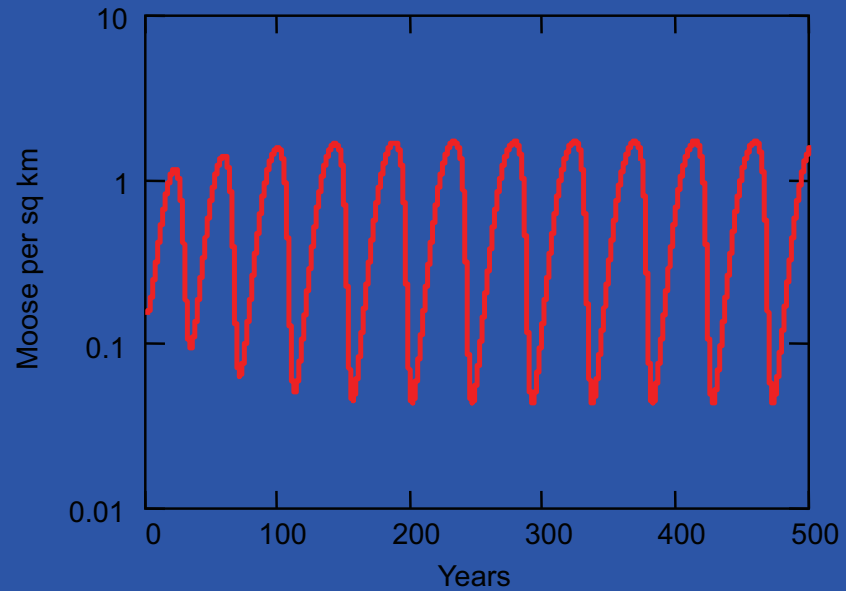


Adapted from Linkov et al. 2006 and Blann and Light 2000

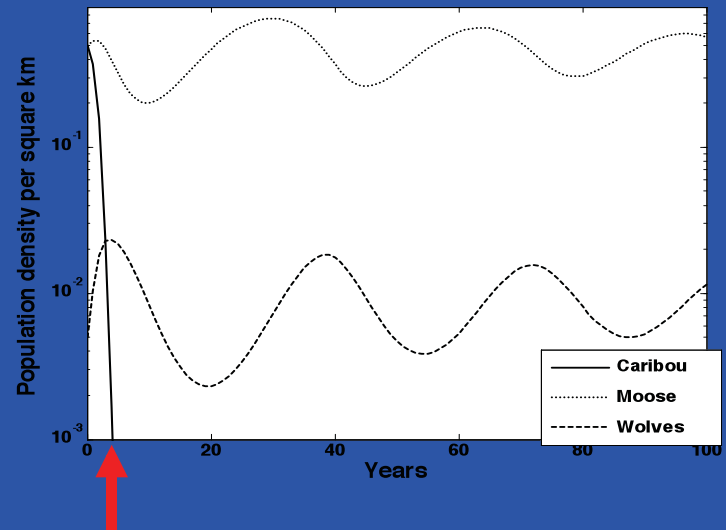
Ontario woodland caribou PVA

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

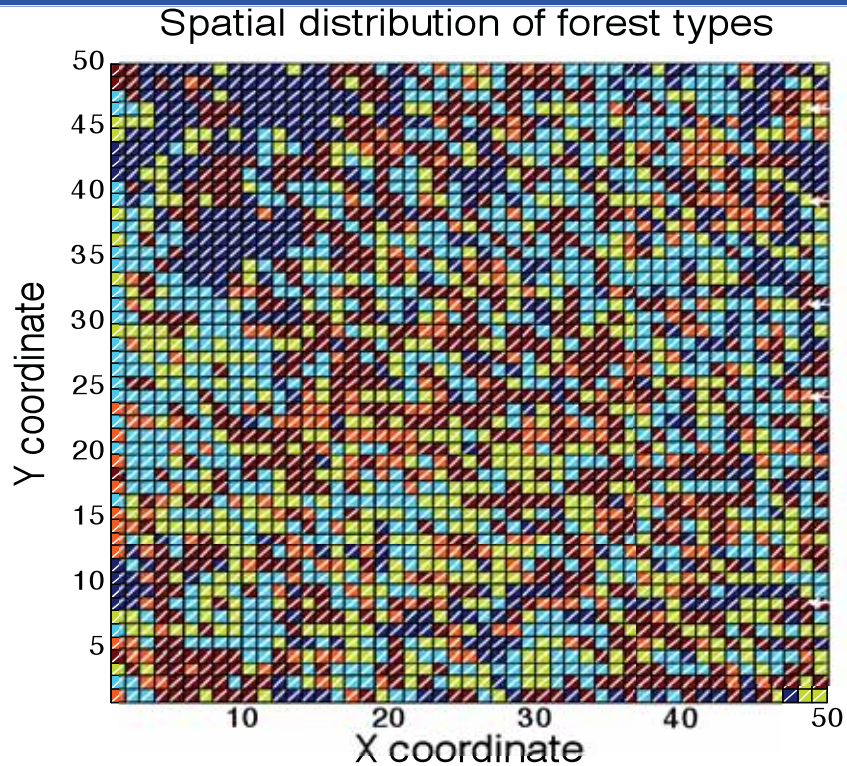
Nonspatial Moose-wolf model

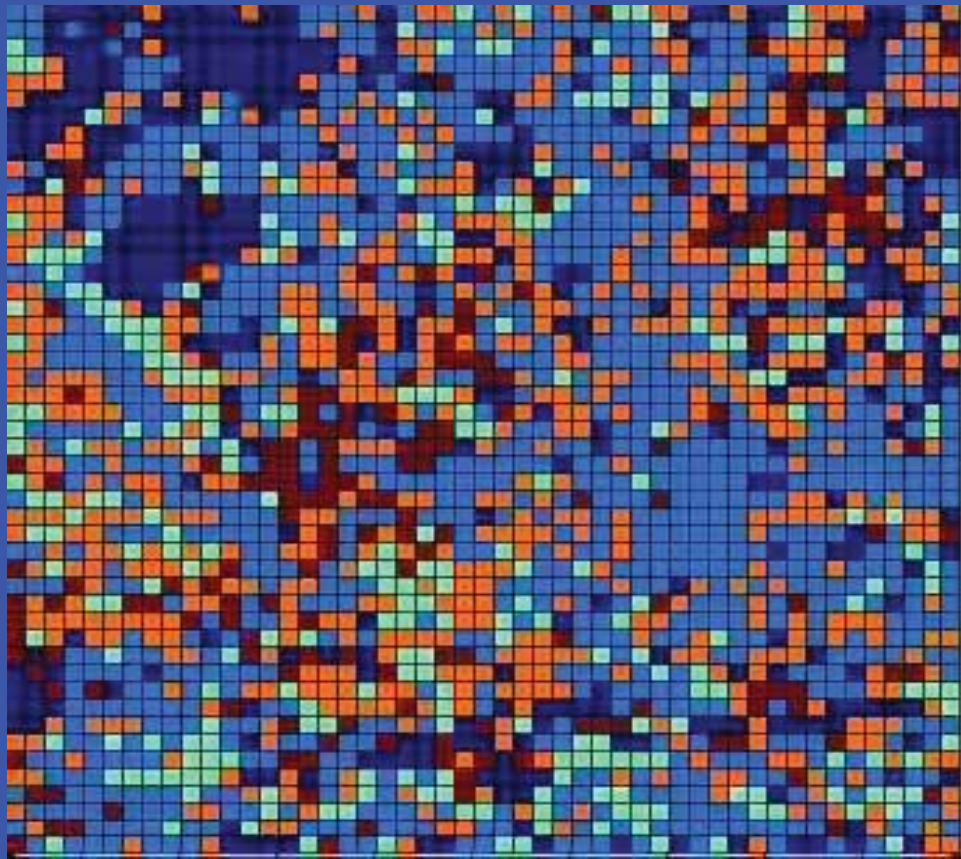


Nonspatial caribou-moose-wolf model

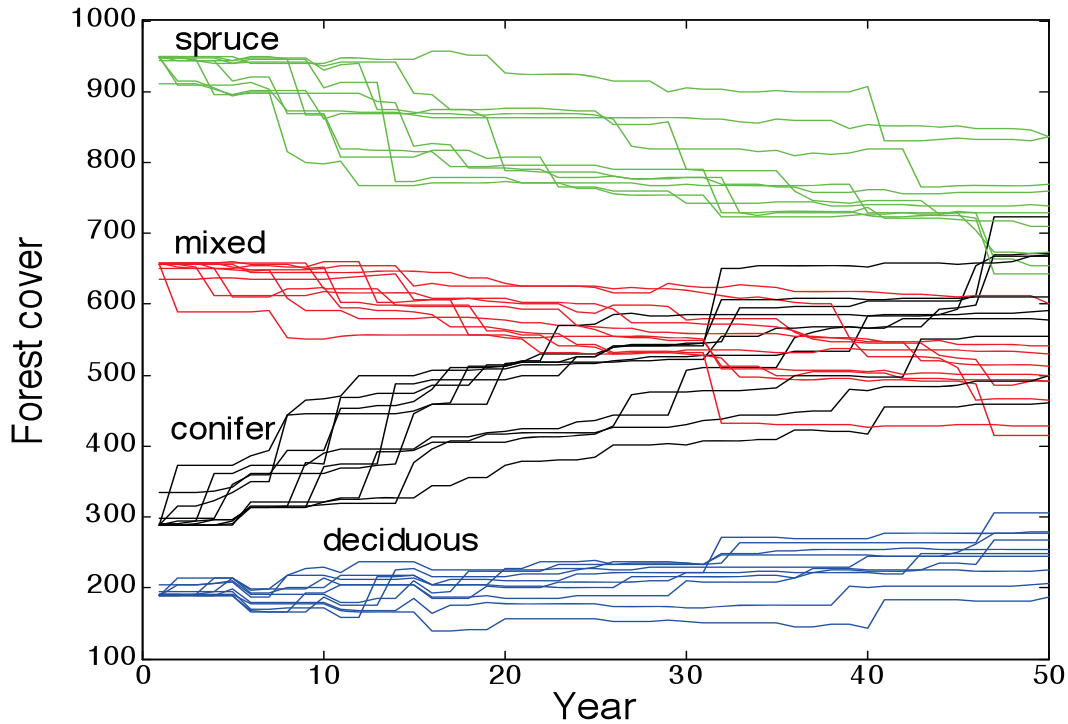


Spatial habitat dynamics





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**

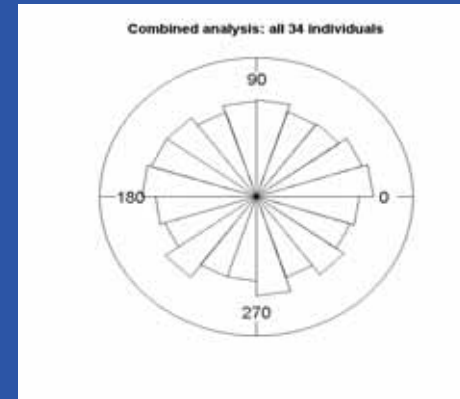
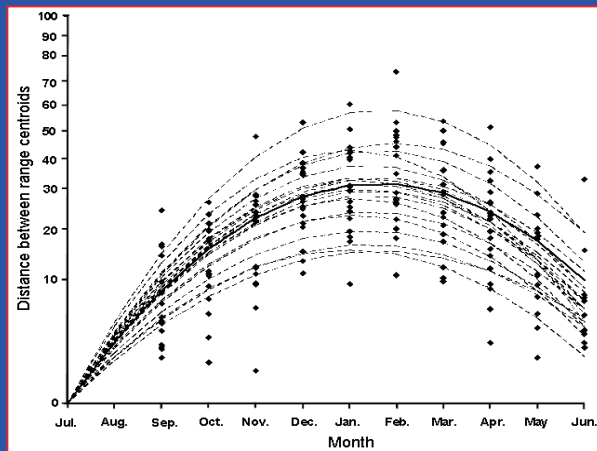
2-7 day location interval

- **160 000 km² study area,**

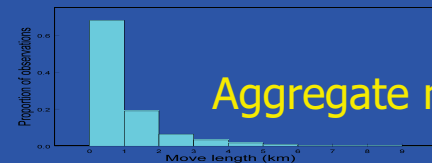


Spatial caribou dynamics

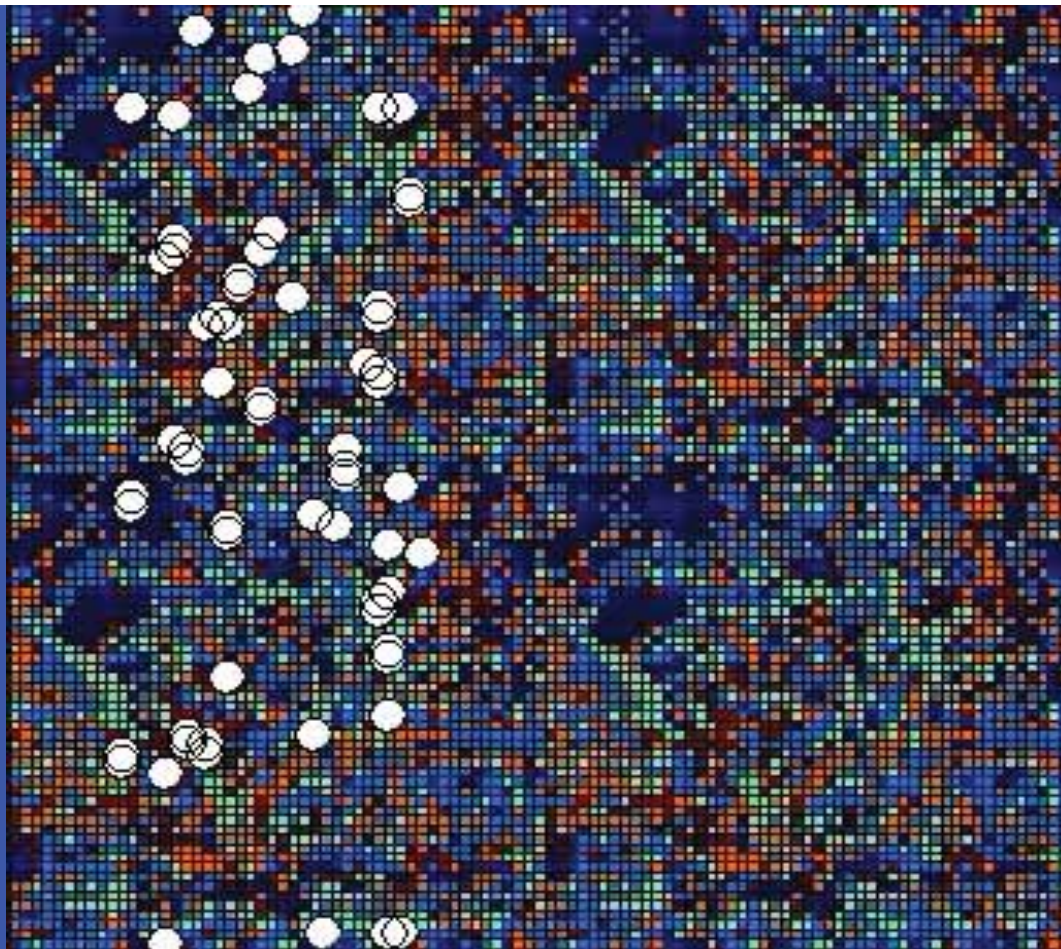
Individual seasonal movement



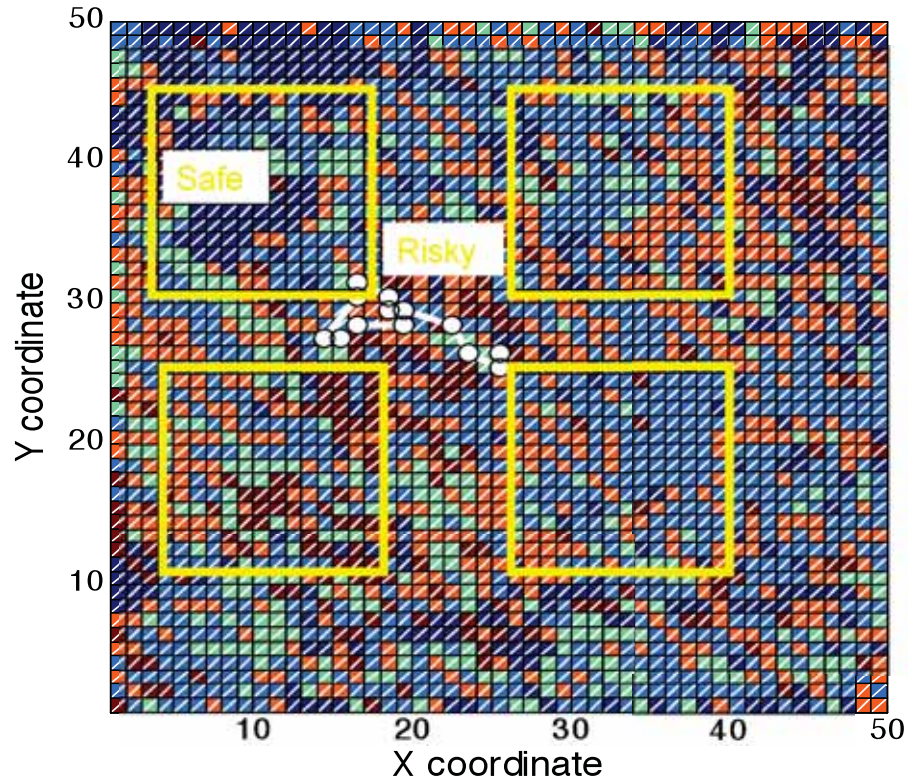
Aggregate turning angles



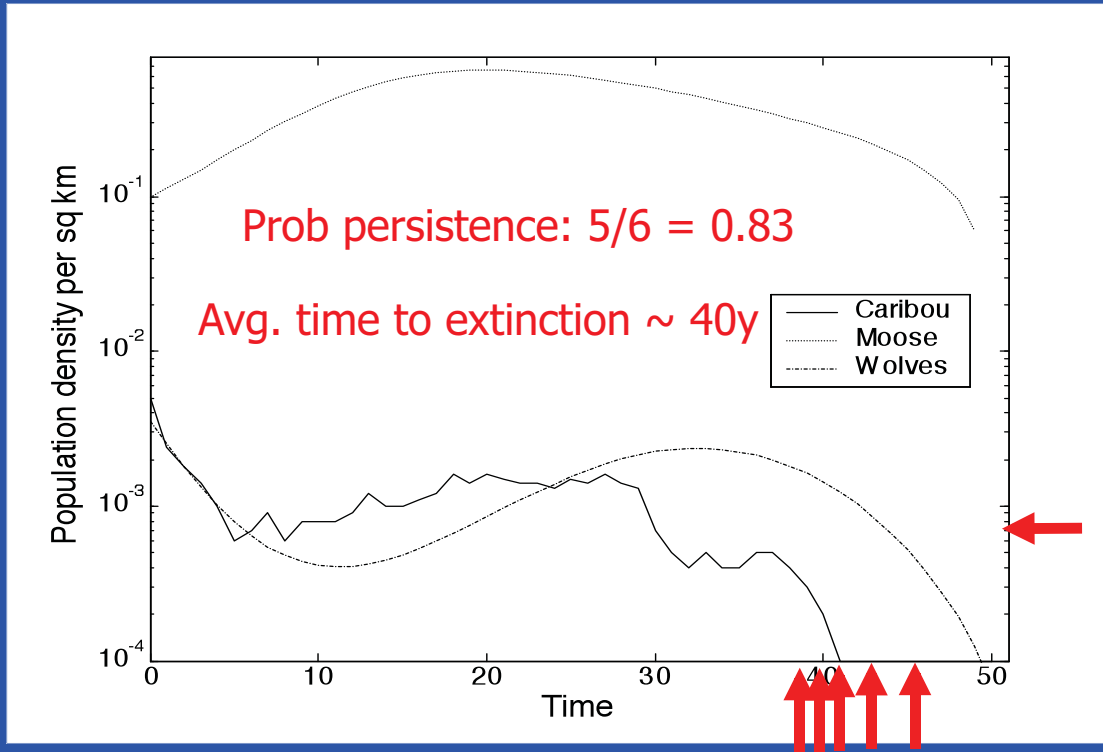
Aggregate move lengths



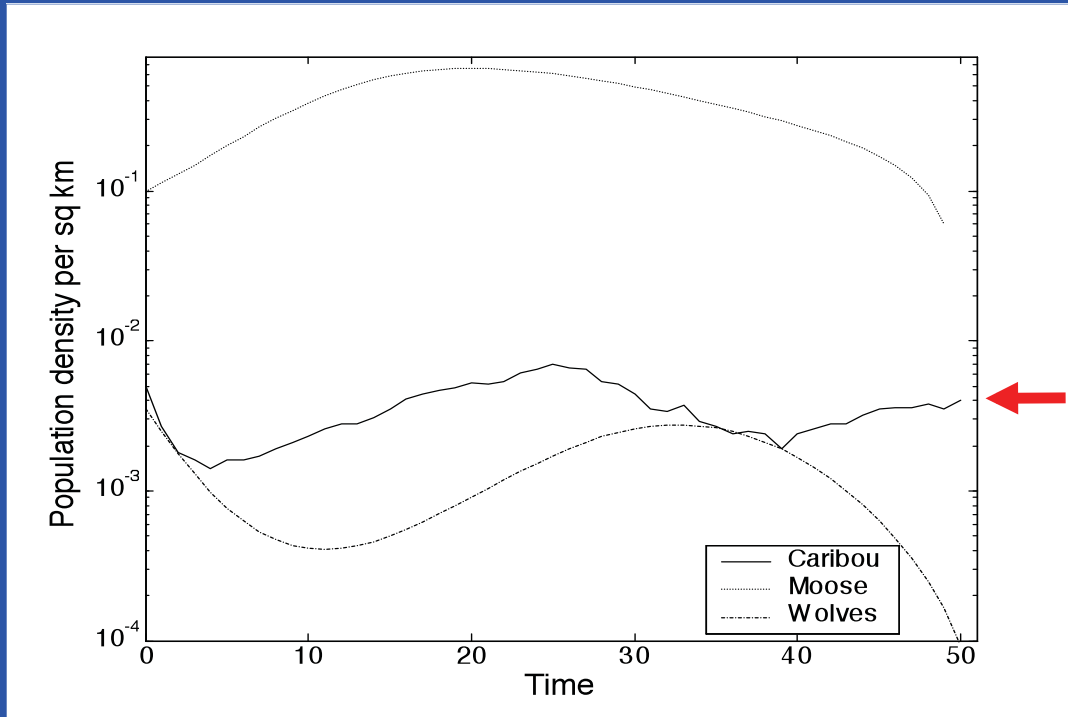
Spatial caribou PVA



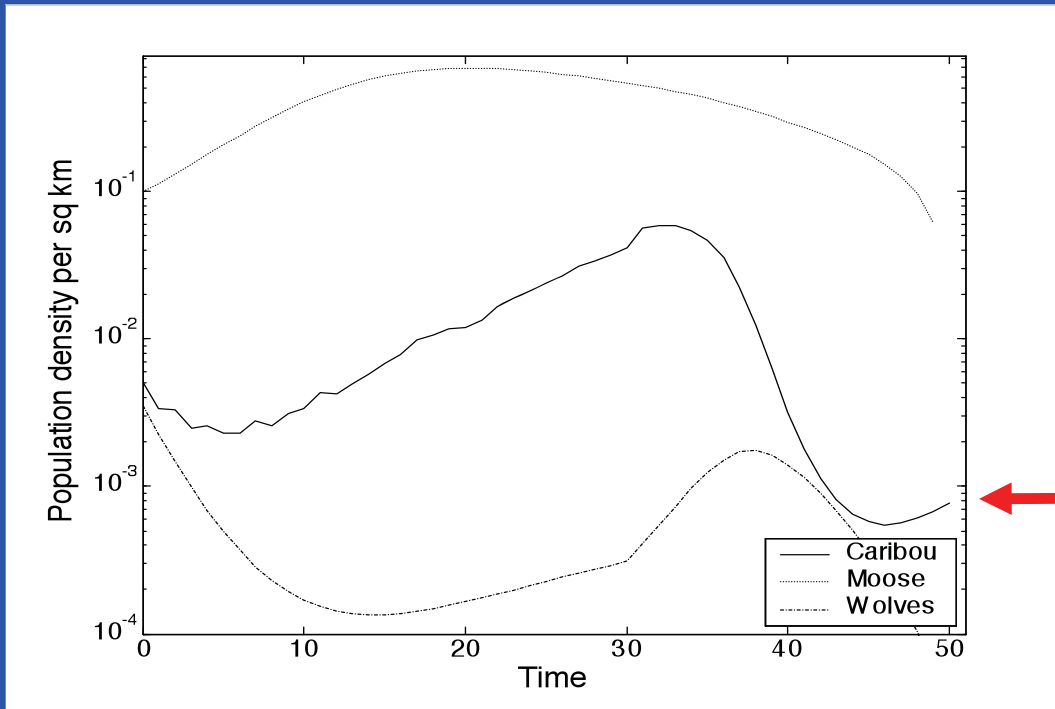
Simulated population dynamics (40% mature stands)



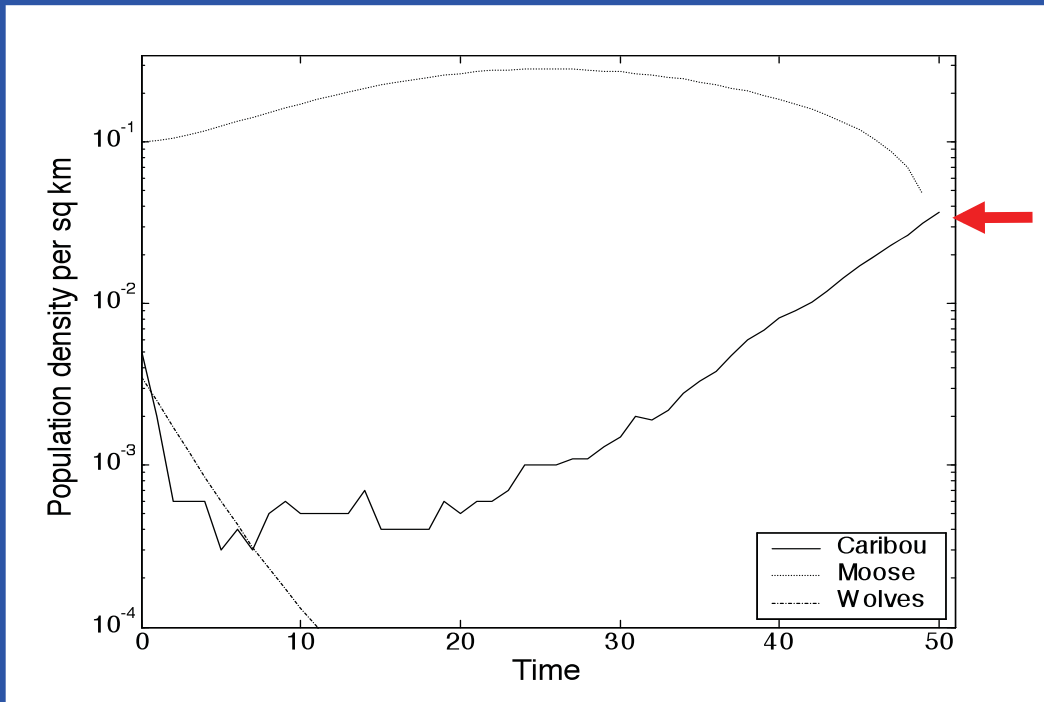
Simulated population dynamics (60% mature stands)



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



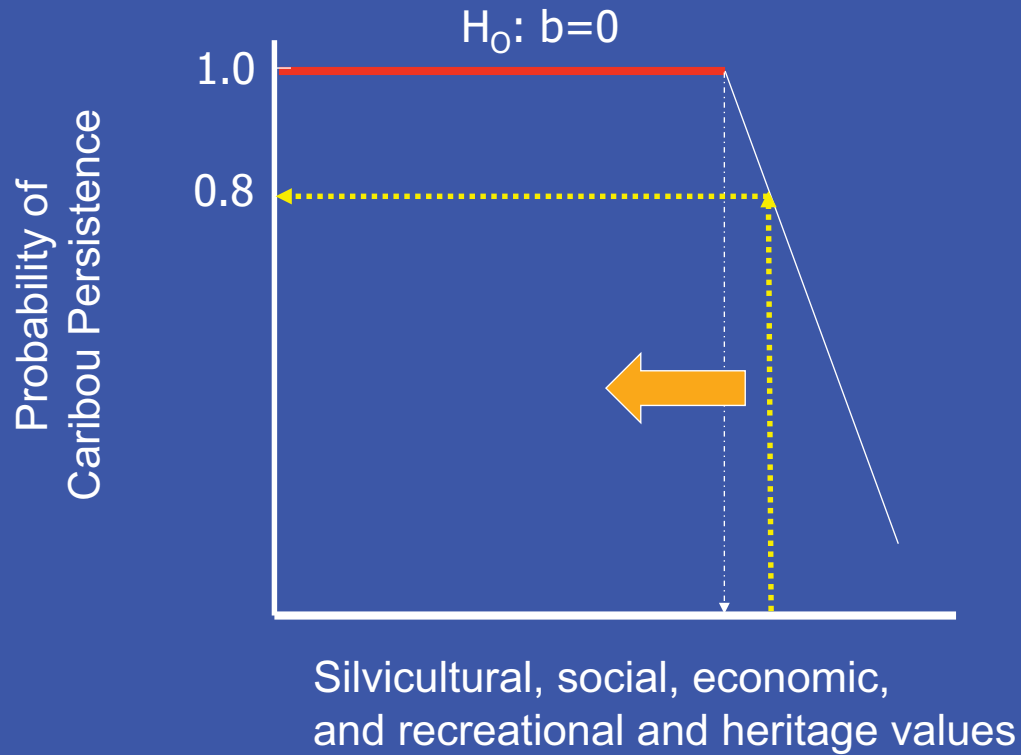
Simulated population dynamics (40% mature stands)
+ 10% annual moose harvest.



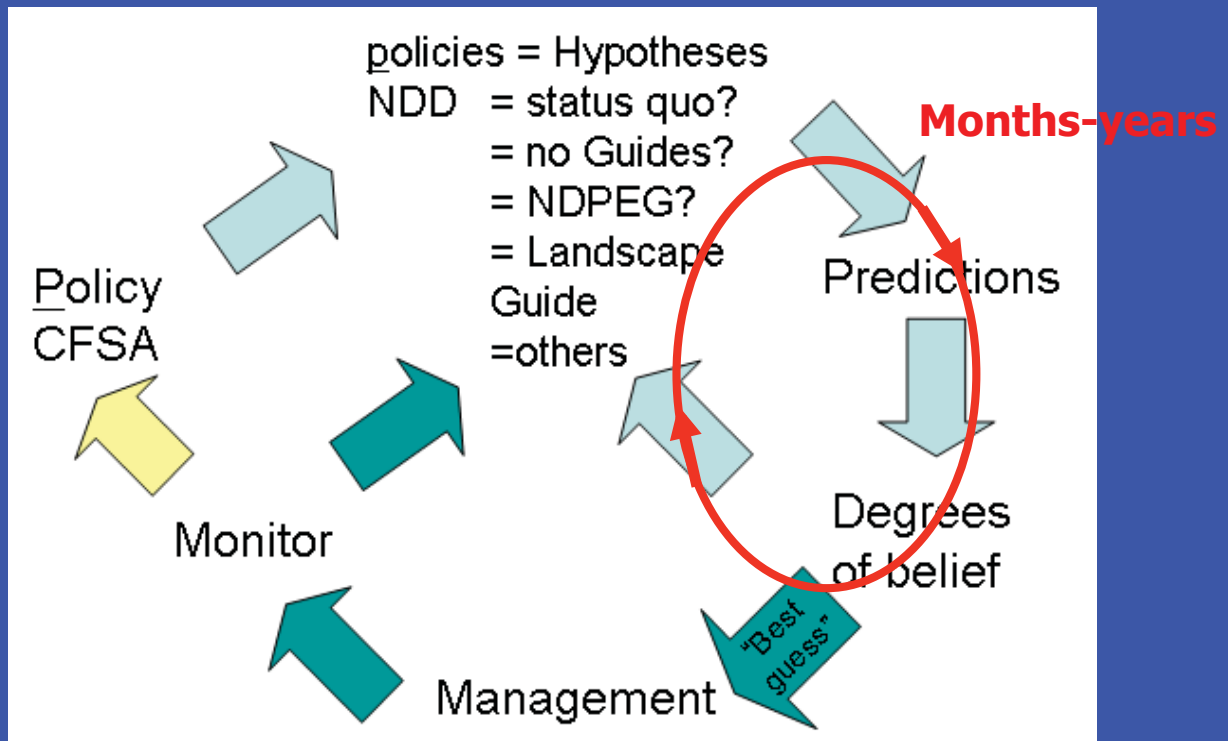
Woodland caribou PVA

- 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

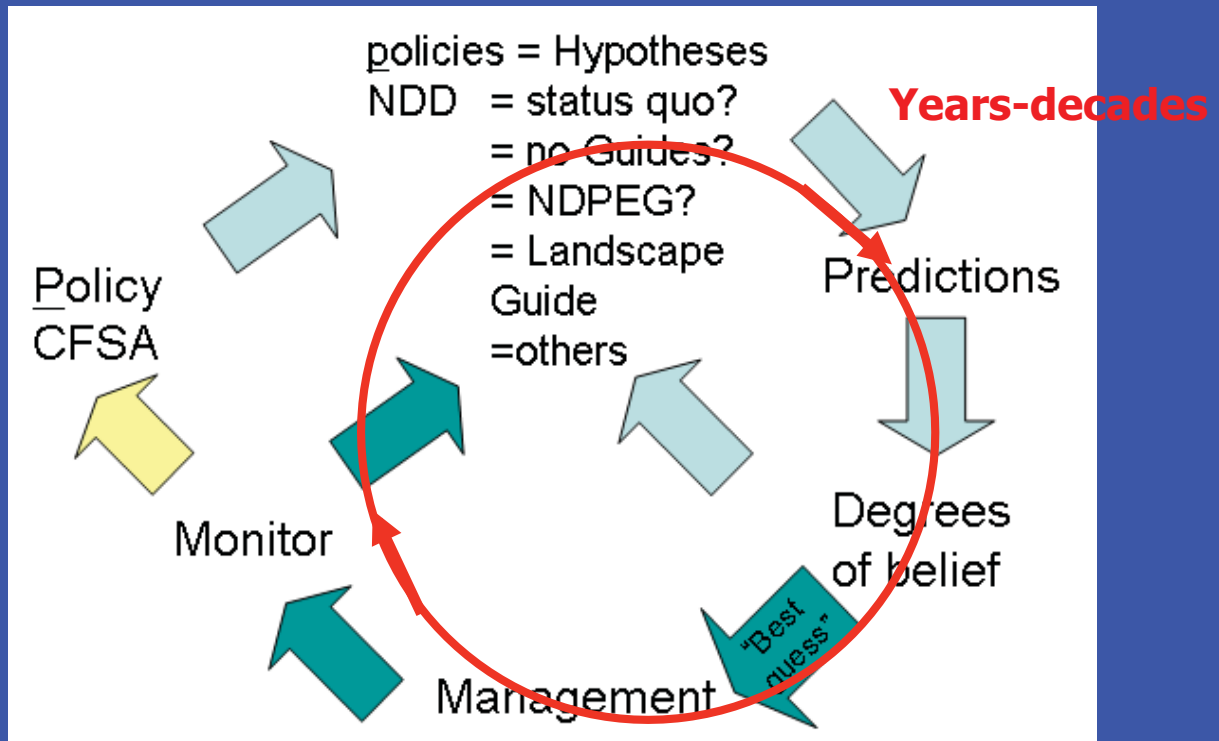
Policy as scientific null hypothesis



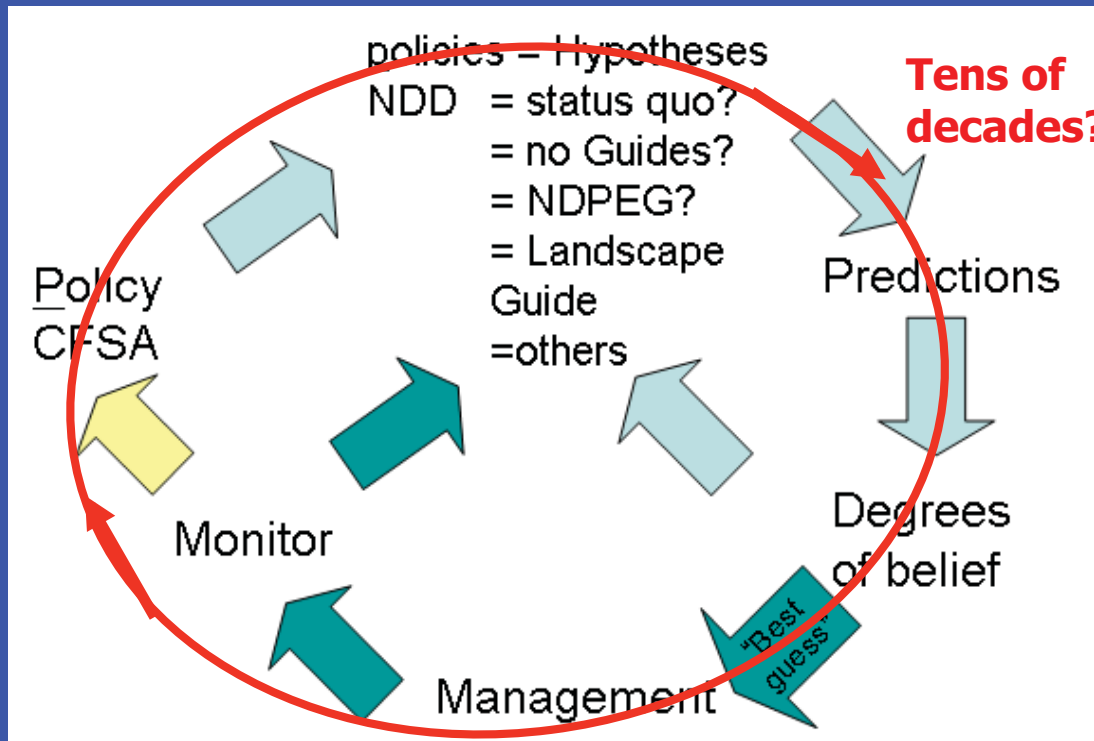
Be patient ...



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