

Climate Change & Adaptive Management

Chapter 9

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**Session Objectives: By the end of this session,
participants will be able to:**

- Frame a climate change adaptation problem using the tenets of adaptive management
- Articulate the concept of stationarity, understand its role in traditional analyses, and appreciate the significance of its absence in climate change problems
- Relate the activity of scenario building to the articulation of uncertainty in models for climate adaptation
- Describe several kinds of uncertainty about system change
- See how time-dependent optimization, with passive or active handling of uncertainty, can be used to derive solutions for climate adaptation decisions

Key References

- Conroy et al. (2011), *Biological Conservation* 144:1204-1213
- Nichols et al. (2011), *Journal of Wildlife Management* 75:6-18
- McDonald-Madden et al. (2011), *Nature Climate Change* 1:261-265

A New Approach for Ecology

Many new ecological applications, in response to concerns about climate change, have taken a new integrative approach. Global circulation models (GCMs), which are climate prediction models, are being coupled with habitat suitability models, as well as demographic models, to predict plant and animal population changes into the future. As an example, the polar bear assessment conducted in 2007 by USGS and partners, coupled GCMs, polar bear habitat models, and a Bayes net, to forecast polar bear status over the next 100 years.

Framing Climate Change

Stationarity Assumption

- Our traditional view of ARM contains a hidden, but fundamental, assumption about stationarity of the system in question
- We may be uncertain about the parameters of that process
- But we assume the process is stable, and learning over time will reveal what it is
- All of our optimization has depended on this

Climate Change

- Special case of system change
- Focus on external system change that is outside of the control of management
 - That is, we're not focusing on how to adaptively manage the system change itself, but how to manage in the face of it
- Both spatial and temporal aspects to the system change

Challenges

- Do we need to change the scale of management?
 - If so, how do we bring about the institutional change necessary to support that?
- Do our objectives still make sense?
- Are our alternatives still adequate under a new system regime?
- Can our models anticipate the system change?
- How do we track the changing system?

The Scale of Management (in the face of system change)

- Does system change require us to change the scale of focus of management?
 - Global change may change what's possible to achieve locally
 - But the same goals might be possible somewhere else
- Specifically, do we have to take a broader spatial perspective in seeking management goals?

Management Objectives (in the face of system change)

- When do objectives need to be modified?
- Do current local objectives need to be sought somewhere else?
- Can other objectives be better achieved locally?
- How do we set objectives that anchor on anticipated future conditions rather than on known past conditions?

Management Alternatives (in the face of system change)

- May need to switch to new areas
- May need to consider completely new methods
- Example:
 - Management of albatross in the HI islands—protection of small shoals vs. predator control on main islands

System Models (in the face of system change)

- Need system models that anticipate change, either explicitly or implicitly
- Where we can articulate our hypothesis about system change, we can incorporate those models explicitly in our decision-making
- Models for temporal change: Passive approach
 - A set of models that capture uncertainty about long-term equilibria, but aren't specific about timing of change
 - Reactive response to change
- Models for temporal change: Active approach
 - A set of models that are specific about the timing of the change
 - Proactive response to change
- Models for spatial change
 - Translating global trends to a local scale
 - Interpreting local events in a global context

Monitoring (in the face of system change)

- Match monitoring to the key uncertainties
- Find the appropriate spatial scale
- But, how do you monitor for the unknown?

Institutional Challenges (in the face of system change)

- Securing collaborative commitment to manage for common objectives over time and across boundaries
 - Just setting common objectives will be a challenge
- Fostering learning across agencies, states, and international boundaries
- Interestingly, FWS and USGS have already begun to initiate such change through the LCCs and other structures

“Scenario Planning”

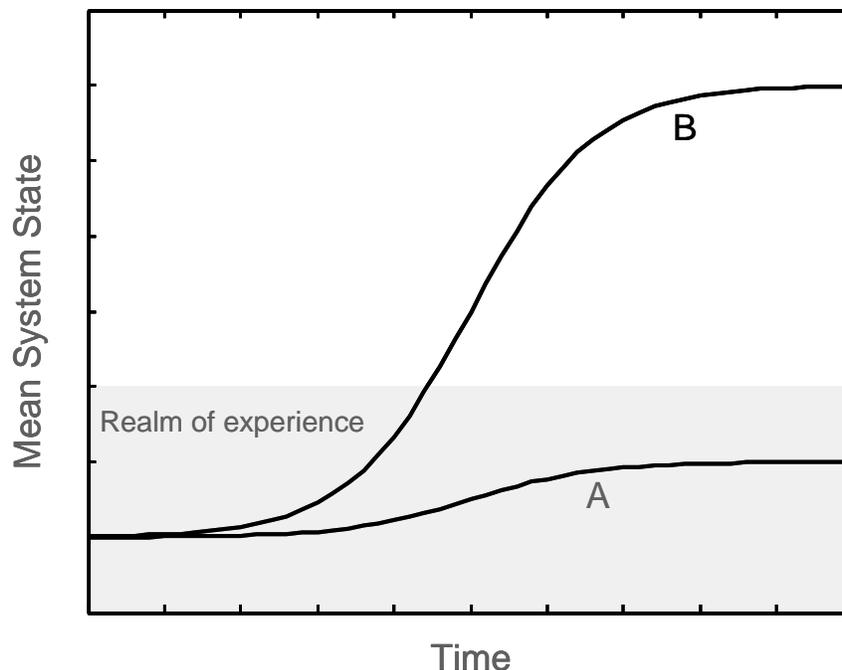
The Uncertainty about System Change

A Spectrum of Scenarios

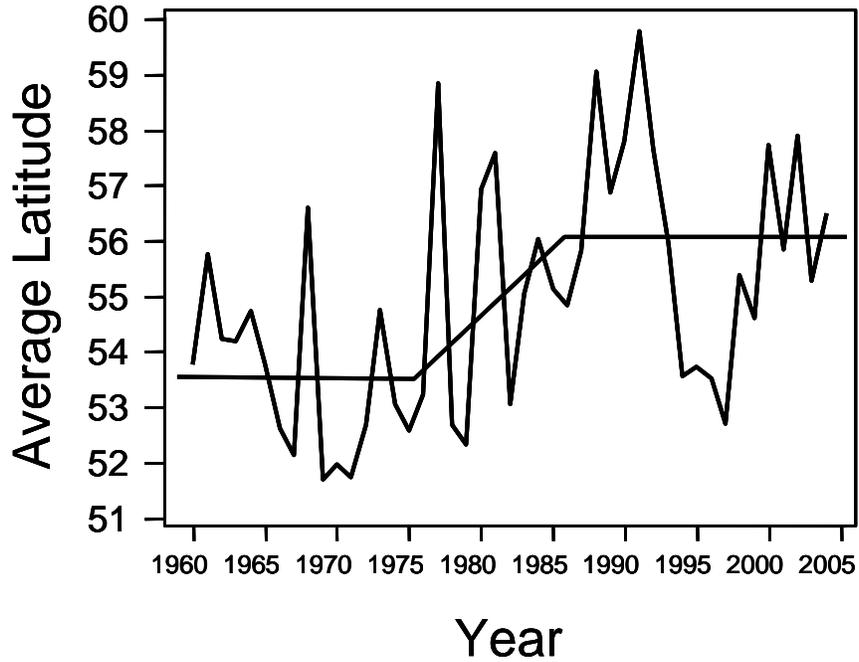
Spectrum of Scenarios

1. Known change to a new equilibrium
 - A. In the realm of experience
 - B. Outside of the realm of experience
2. Uncertain but anticipated change to a new equilibrium
 - A. Uncertainty in new equilibrium point
 - B. Uncertainty in rate of change
 - C. Uncertainty about ecological thresholds
3. Uncertain but anticipated change with no effective equilibrium
4. Unknown change (for which no hypotheses exist)
 - A. Severe uncertainty
 - B. Beyond severe uncertainty

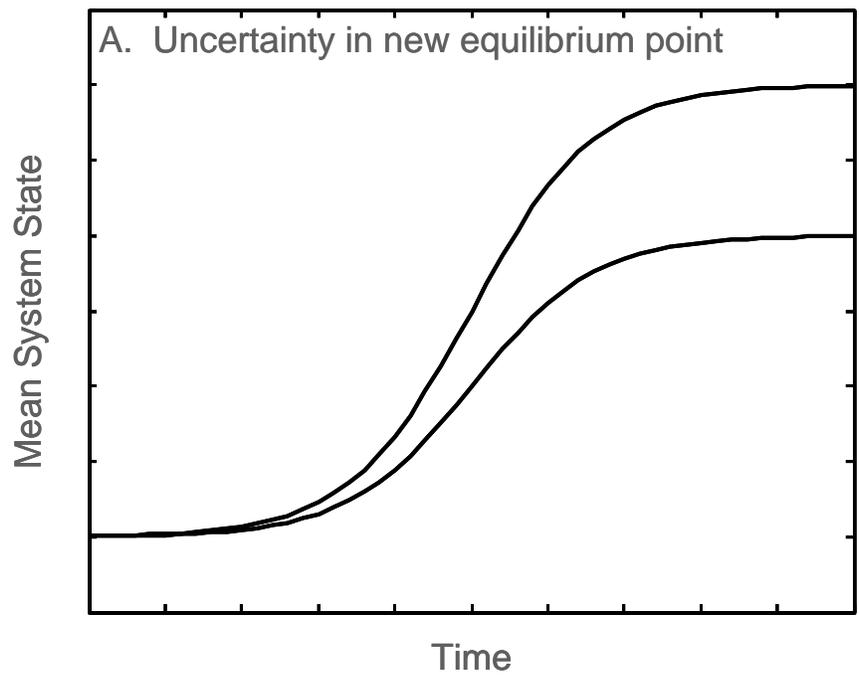
1. Known change to a new equilibrium

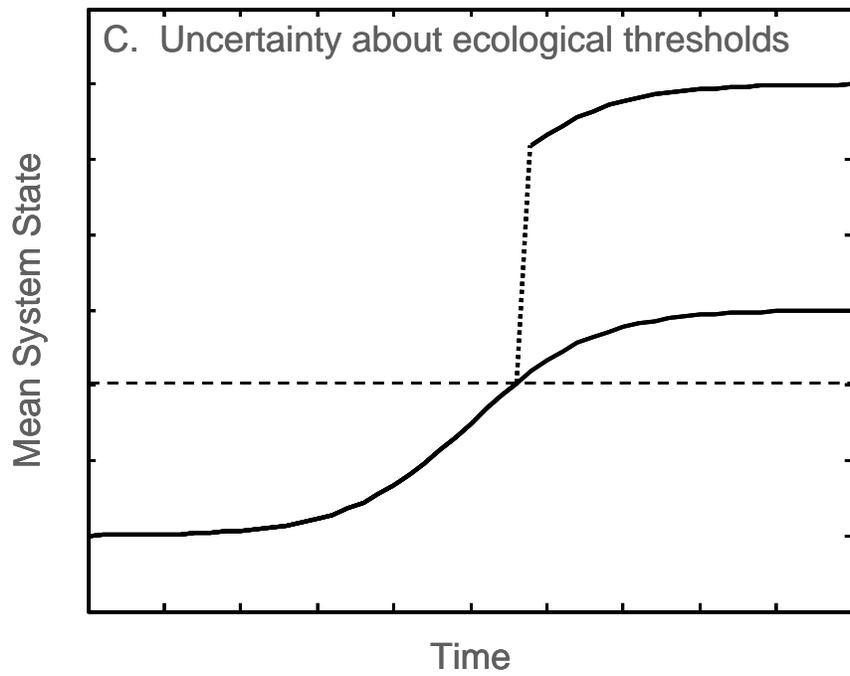
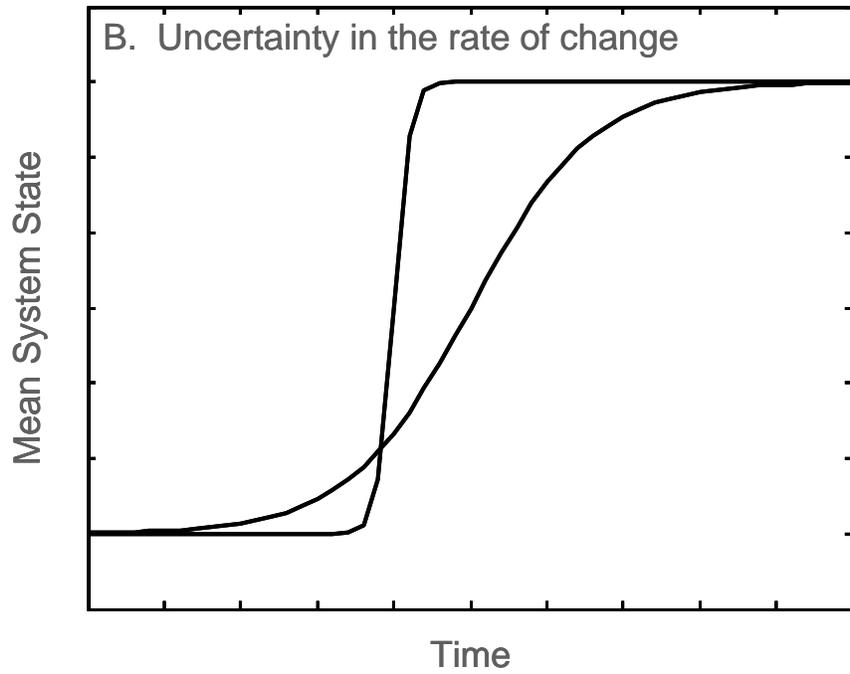


Pintail breeding distribution

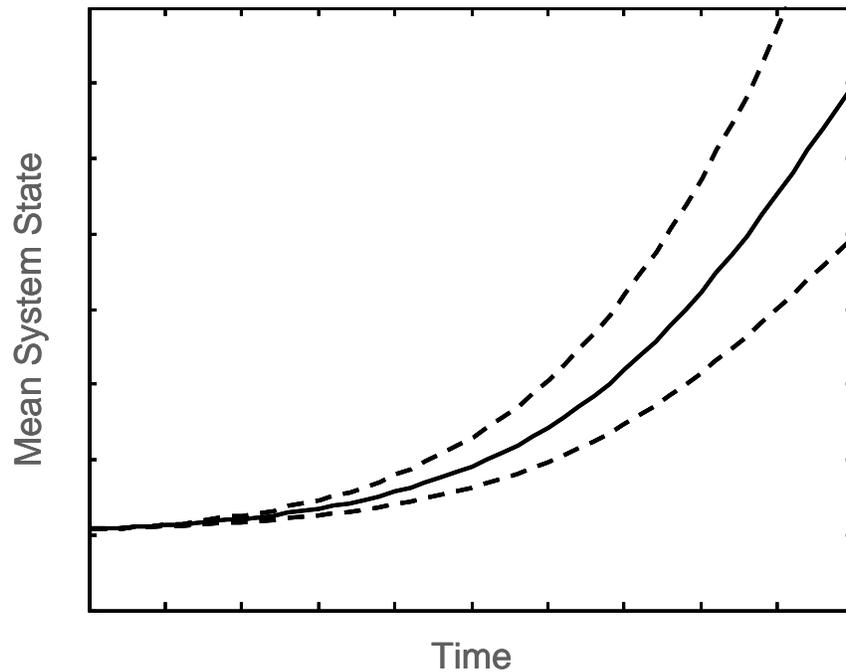


2. Uncertain change to a new equilibrium





3. Anticipated change with no equilibrium



4. Unknown change

- Change for which no hypotheses exist
 - Donald Rumsfeld
 - The Black Swan
- A. Severe uncertainty (in the sense of Ben-Haim's info-gap theory)
- B. Beyond severe uncertainty
 - "We just don't know, so we have to monitor to detect change, so then we can decide how to respond."

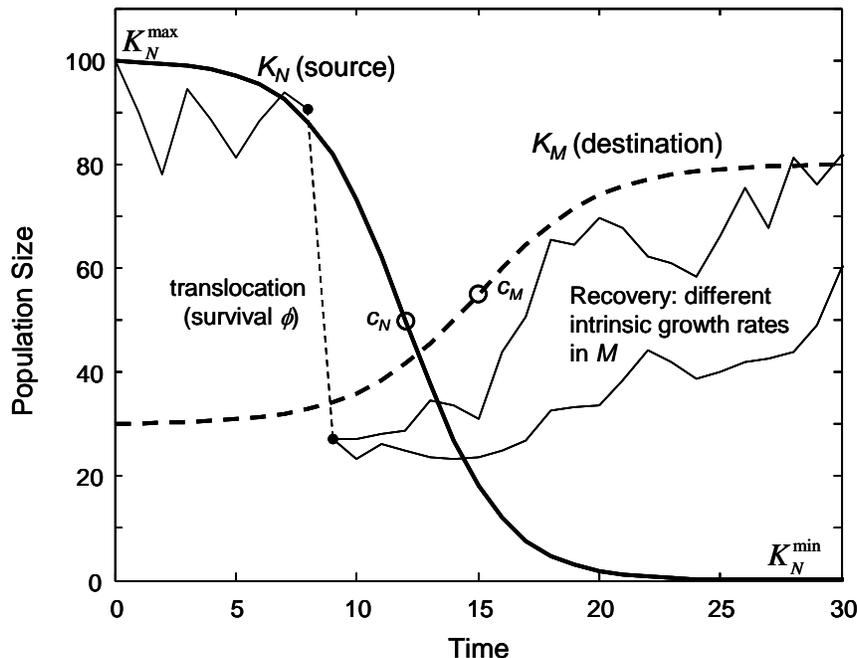
If and when to move species in the face of climate change?

McDonald-Madden E, Runge MC, Martin TG, Possingham H. 2011. Optimal timing for managed relocation of species faced with climate change. *Nature Climate Change* 1:261-265.

Managed Relocation

- *aka* assisted migration, assisted colonization, assisted translocation
- A controversial adaptation option that has received considerable attention of late
- Several published frameworks exist
 - Hoegh-Guldberg et al. 2008. *Science* 321:345-346.
 - Richardson et al. 2009. *PNAS* 106:9721-9724.
 - Neither really deals with the adaptive question

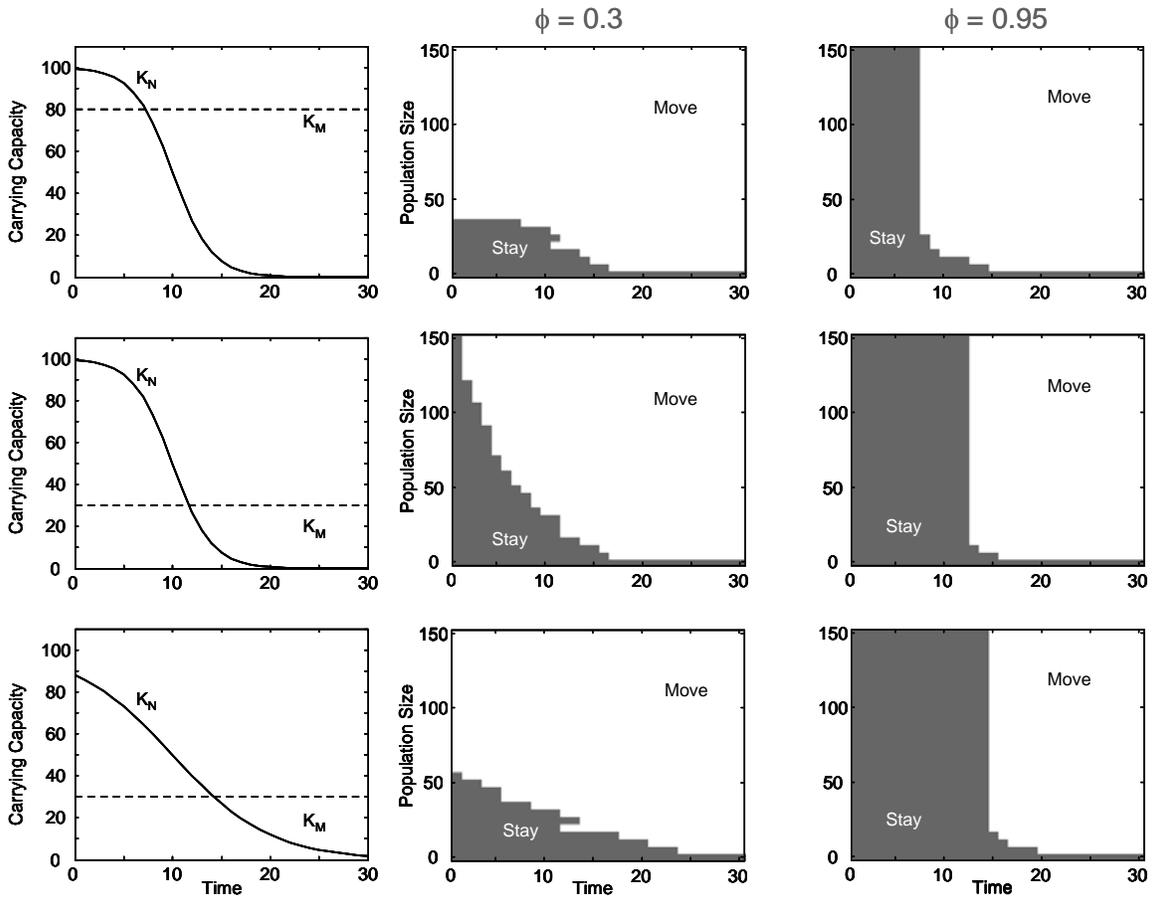
Implicit Assumptions



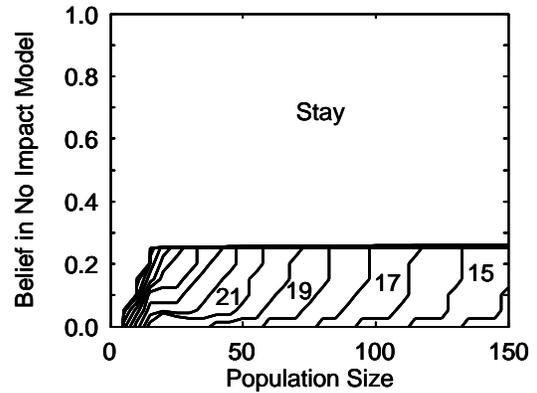
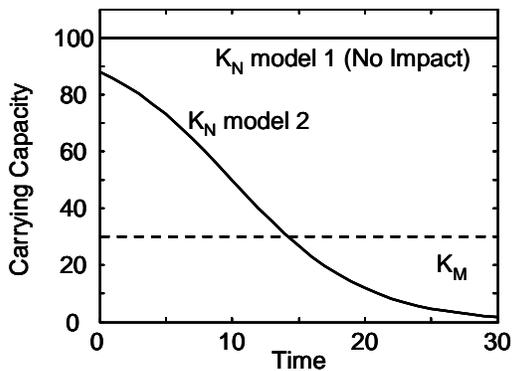
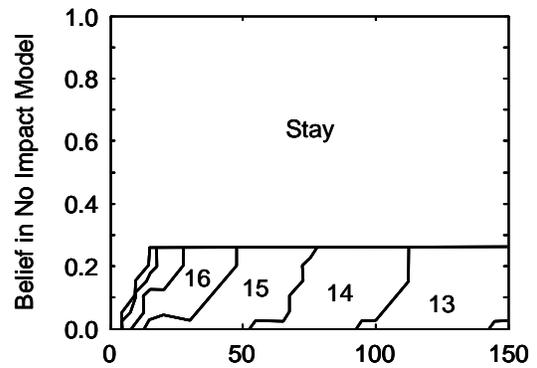
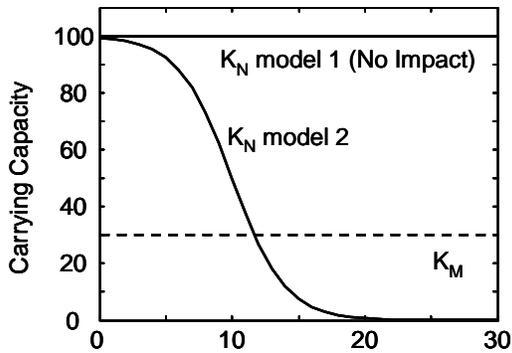
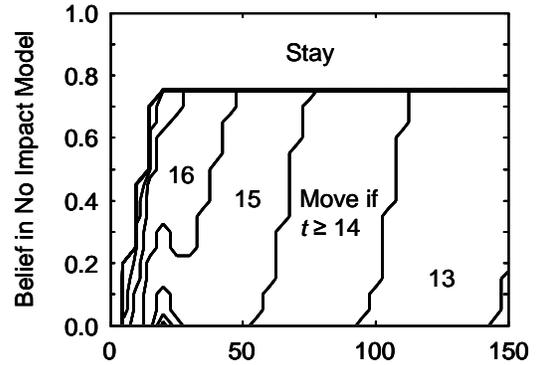
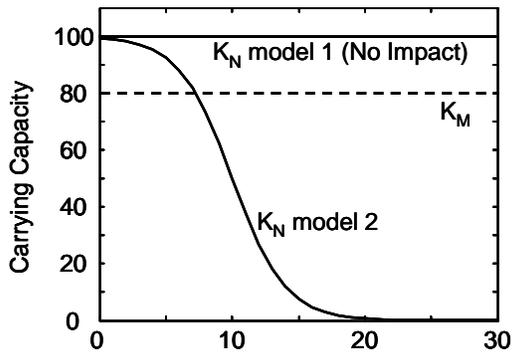
Factors in timing the move:

- Current (source) site dynamics
- New (destination) site dynamics
- Interaction between source & destination dynamics
- How many individuals are in the system
- Probability of the move working
- Potential for population to recover

Known system change



“Known unknown” system change



Summary

- We can do optimal management in a changing system
 - Time-dependent strategies emerge

- One of the fundamental issues is uncertainty in the system change
 - Known unknowns
 - Scenario planning
 - Unknown unknowns?

- The first challenge, as always, is framing the decision problem
 - Does climate change induce revision of all the elements of the problem: scale, objectives, alternatives, models, monitoring, and even institutional structures?

- The adaptive management framework is precisely the right paradigm for addressing climate adaptation