Research Challenges for Abrupt Changes in Ecosystems

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2007 IPCC Conclusions

- The observed change in the climate system over roughly the past century is virtually certain to be due in part to human influences.
- The observed changes in climate are very likely to continue, and even accelerate during the current century.
- There are now many observed, well-documented impacts of changes in natural resources, animal and plant species, and ecosystems in many regions of the world.
- Impacts in the future are very likely to grow in both number and magnitude.
- Climate change and its impacts present challenges for adaptation in both the developing world, and as well among developed countries.

A Major Strategic Challenge

- Understanding the speed, magnitude, and potential for irreversibility of the impacts of climate change
- Of particular concern are those impacts that arise rapidly, result in extremely large changes in resources, or are irreversible in nature, and therefore are difficult to predict
- I.e. those impacts that appear to be the results of crossing thresholds or tipping points in ecosystems

Thoughts on Uncertainties: Focus on the Important

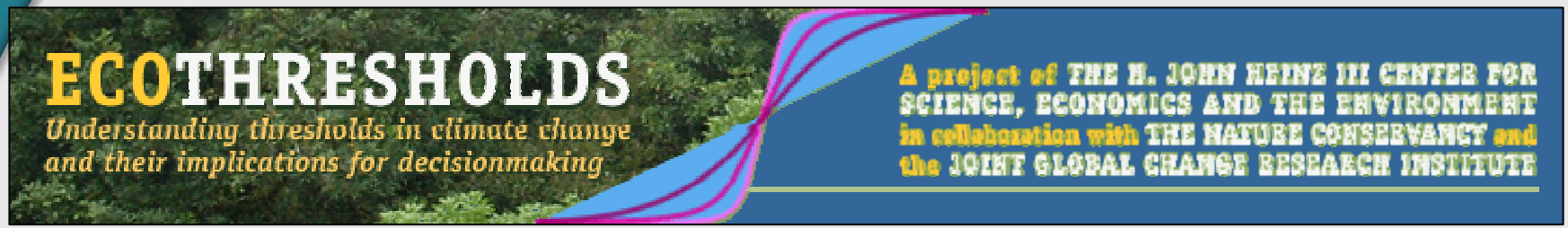
- Acknowledge uncertainties in science, but manage the risks
- Focus on what's really important

Nature of the Challenge

- Thresholds exist in many ecosystems.
- As our climate continues to change, we must now begin to understand
  - What are our options for responding?
  - What areas of new and better understanding are necessary to minimize the risks from such changes?

Management and Research

- Is there a known threshold in managers' systems that their clientele would prefer not to have crossed?
- Given current trends or predictive capabilities, can we determine how much more time is available until the threshold would be passed, in the absence of further action?
- Can the threshold be avoided, either by reduction of stresses (e.g. reducing change in the physical climate system) or by ecosystem management?
- What options exist for managing the ecosystem and coping with the consequences of going through a threshold if it cannot be avoided?



- Addressing major strategic issue
- Begun in 2006
- Involving research institutions, federal agencies, conservation organizations, private industry


Organizing the Science

Engage key scientists and managers in the development of case studies

Type 1: well understood cases where response is well documented	
Peruvian anchovy	*Kenny Broad, U. of Miami*
Mesquite invasion	*Brandon Bestelmeyer, USDA-ARS, NMSU*
Type 2: ongoing cases exhibiting accelerating change	
Sea-level rise	*Jeff deBlieu, The Nature Conservancy*
Drought- Columbia River Basin	*Ed Miles, U. of Washington*
Drought- Colorado River Basin	*Roger Pulwarty, NOAA*
Forest die-off- U.S. West	*David Breshears, U. of Arizona*
Forest die-off African Sahel	*Patrick Gonzalez, The Nature Conservancy*
Coral Reefs	*Phil Kramer, The Nature Conservancy*
Mountain Pine Beetle	*Mike Bradley, Canfor Pulp and Paper*
Type 3: Major systemic change	
Ocean Acidification	*Richard Feely, NOAA*
Terrestrial Carbon Sink	*Lisa Dilling, Center for Science and Technology Policy Research, U. of Colorado*

Major Questions

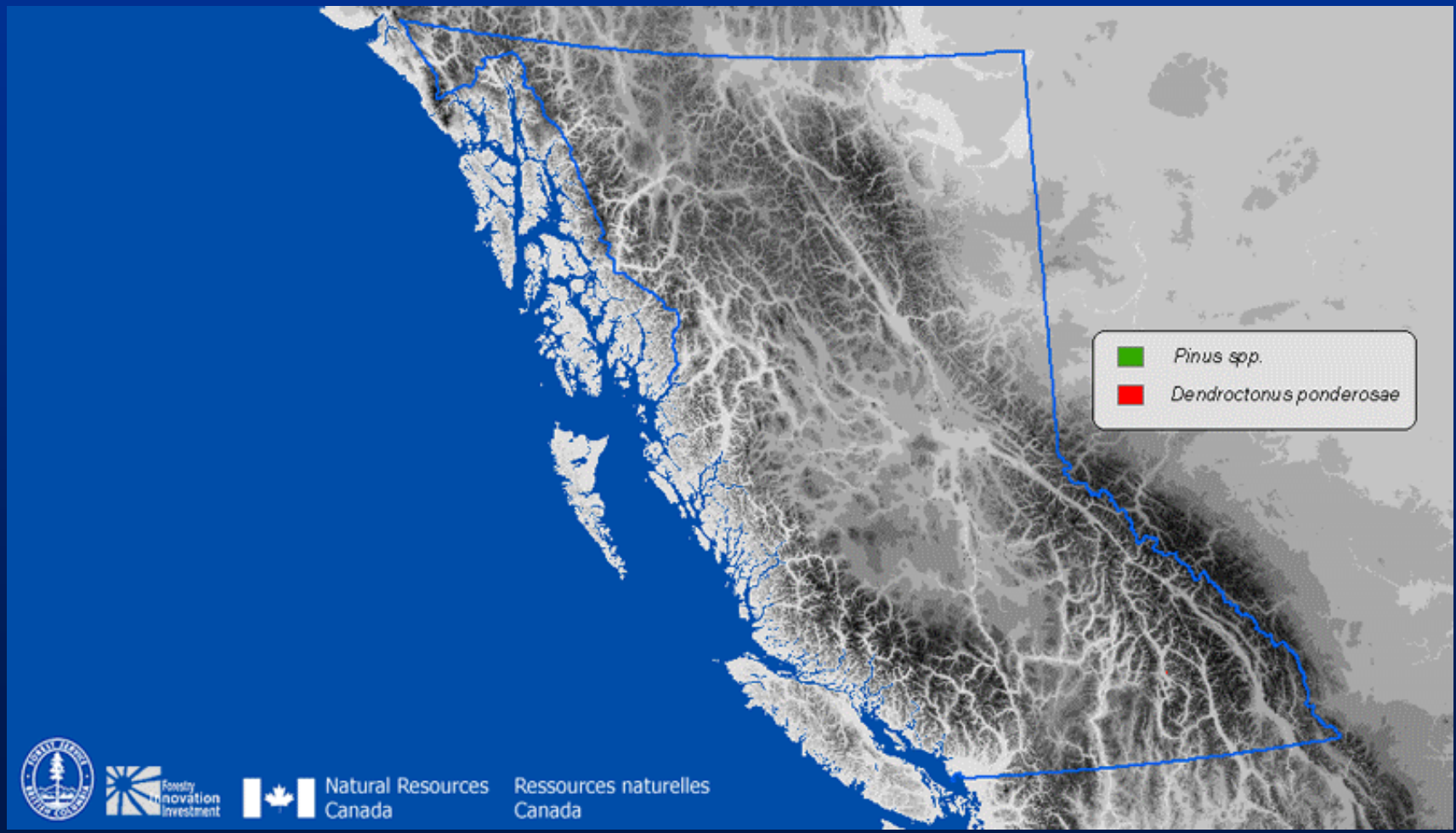
- Threshold responses are *changes in the ecosystem or natural resource that outstrip current adaptive capacity, requiring a response that is novel, rapid or very large.*
- What insights can we garner from existing cases where threshold changes in ecosystems have been important?
- What lessons are there for managers and scientists?
- When do multiple and interacting stresses – physical, ecological, and social – move us beyond our current capacity to adapt?

Insights: What Does a Threshold Problem Look Like?

Mountain Pine Beetle
(*M. Bradley, Canfor Pulp)*

- Native to Lodgepole pine forests of western N. America
- Natural part of the disturbance ecology of Montane forests
- Periodic outbreaks
- Previous largest recorded outbreak 650,000 had during 1930's

Mountain Pine Beetle outbreaks (1959-2002)



Why did this happen?

Successive mild winters during last decade

Over abundance of continuous stands of mature pine

- Provincial fire suppression policy
- preferential planting of native lodgepole pine

Series of higher summer minimum temperatures weakening trees by drought stress

Ideal conditions: abundant host species + mild winters

"Perfect ecological storm" (Kimmins et al 2005)

(Mike Bradley, Canfor Pulp)

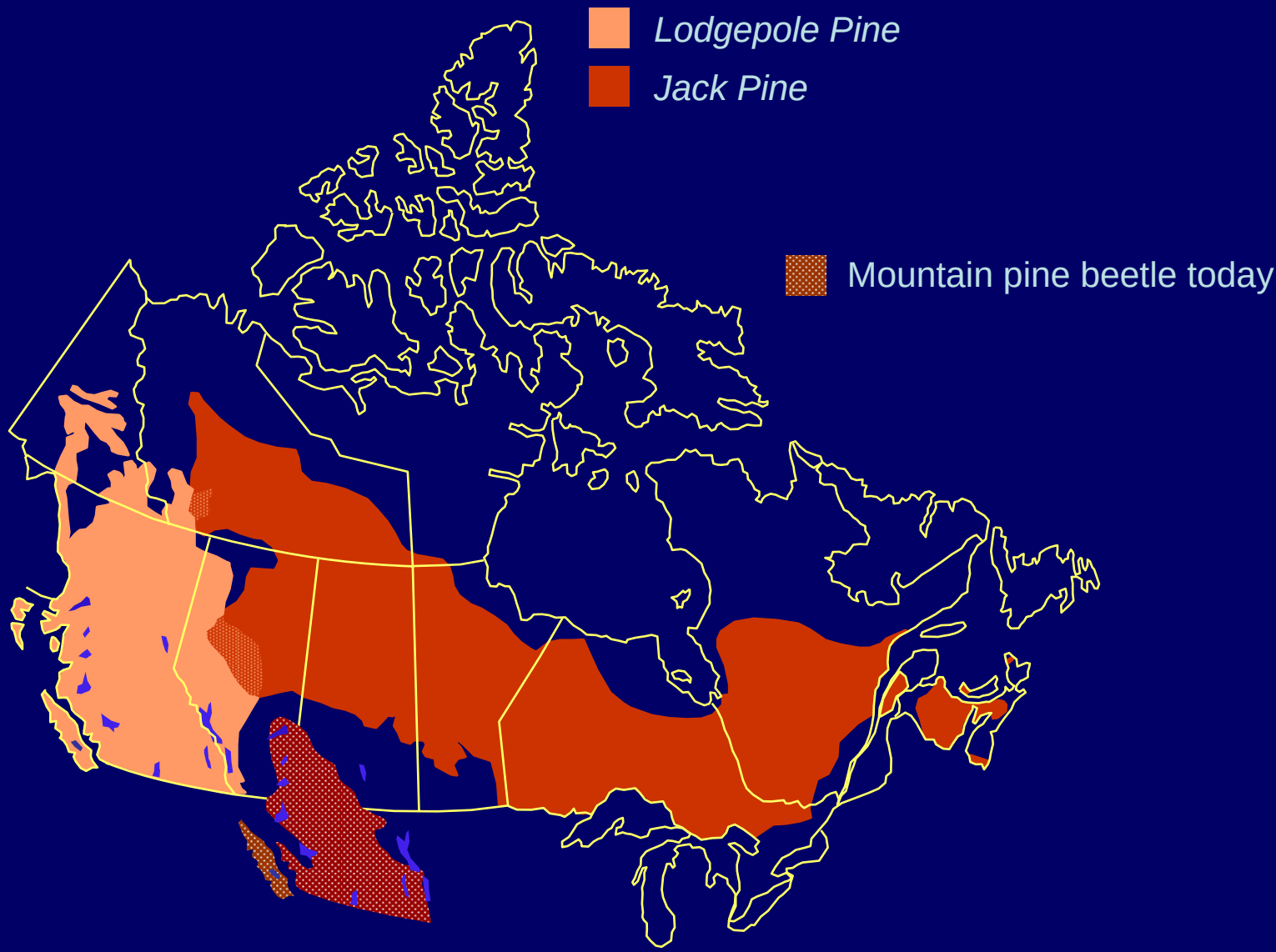
Economic impacts – examples of modeling results, post beetle

Indicator	Nadina forest district	Prince George Timber Supply Area
Reduction in annual allowable cut	-4.6%	-15.8%
Revenue	-2.6%	-5.5%
Employment	-2.5%	-4.8%
Labour Income	-3.6%	-6.2%

General equilibrium model has been used to predict economic impacts of various forest management scenarios Patriquin, 2005

(Mike Bradley, Canfor Pulp)

Could MPB spread through the boreal forest of N. America?



Source: NRCan/CFS/PFC

No climate (?) or biological barriers to MPB

Early Lessons:

Stop thinking of the MPB as an environmental disaster – it is more of a social/economic one

Start thinking of it as one component of a system which includes climate, climate change, harvesting, social/economic values, environmental services

Responses must reflect the diversity of the ecosystem types involved

(Mike Bradley, Canfor Pulp)

Additional insights:

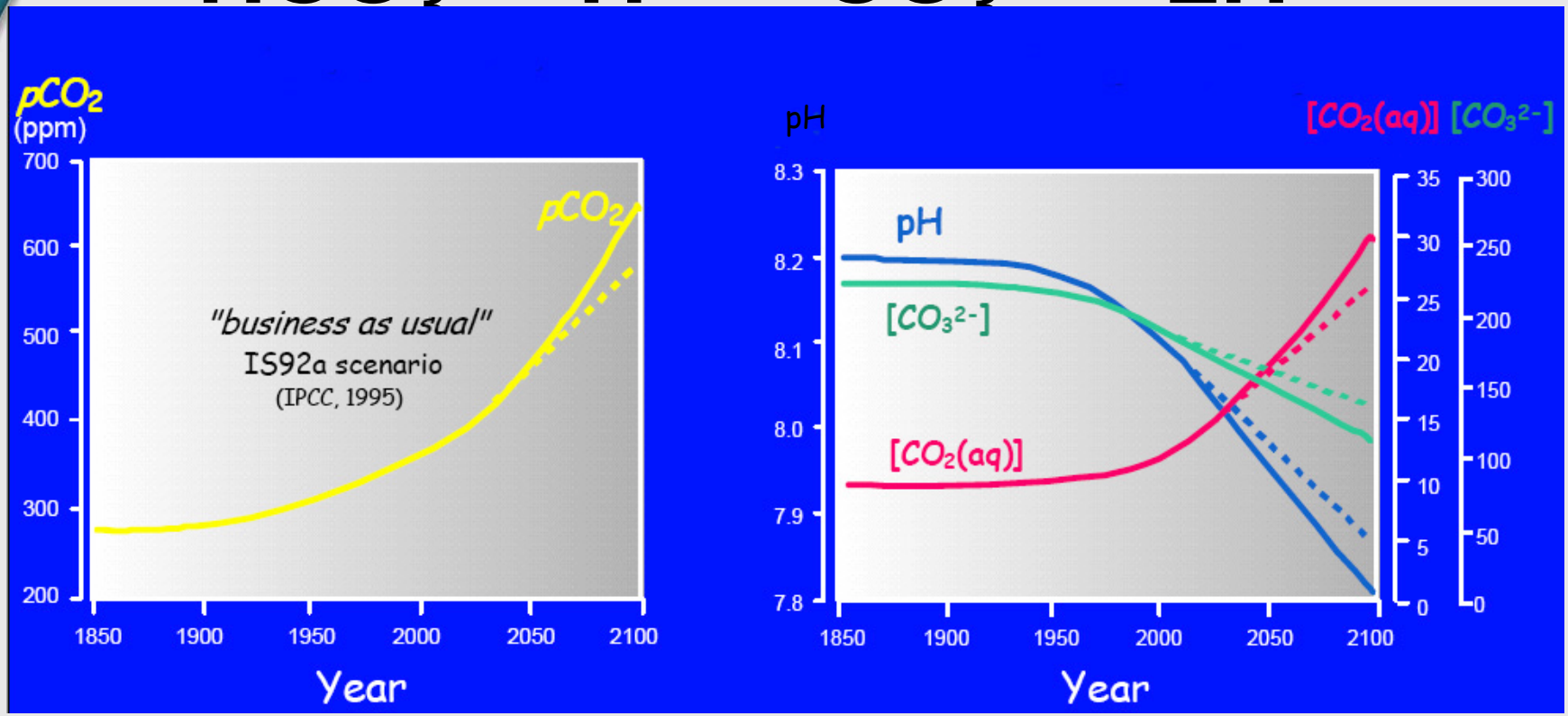
- Incremental changes matter – ‘slight changes’ on top of existing stresses

  can drive social-ecological systems to “tipping points”

(Photo courtesy of R. Pulwarty)

Rising atmospheric CO_2 is changing the chemistry of the ocean

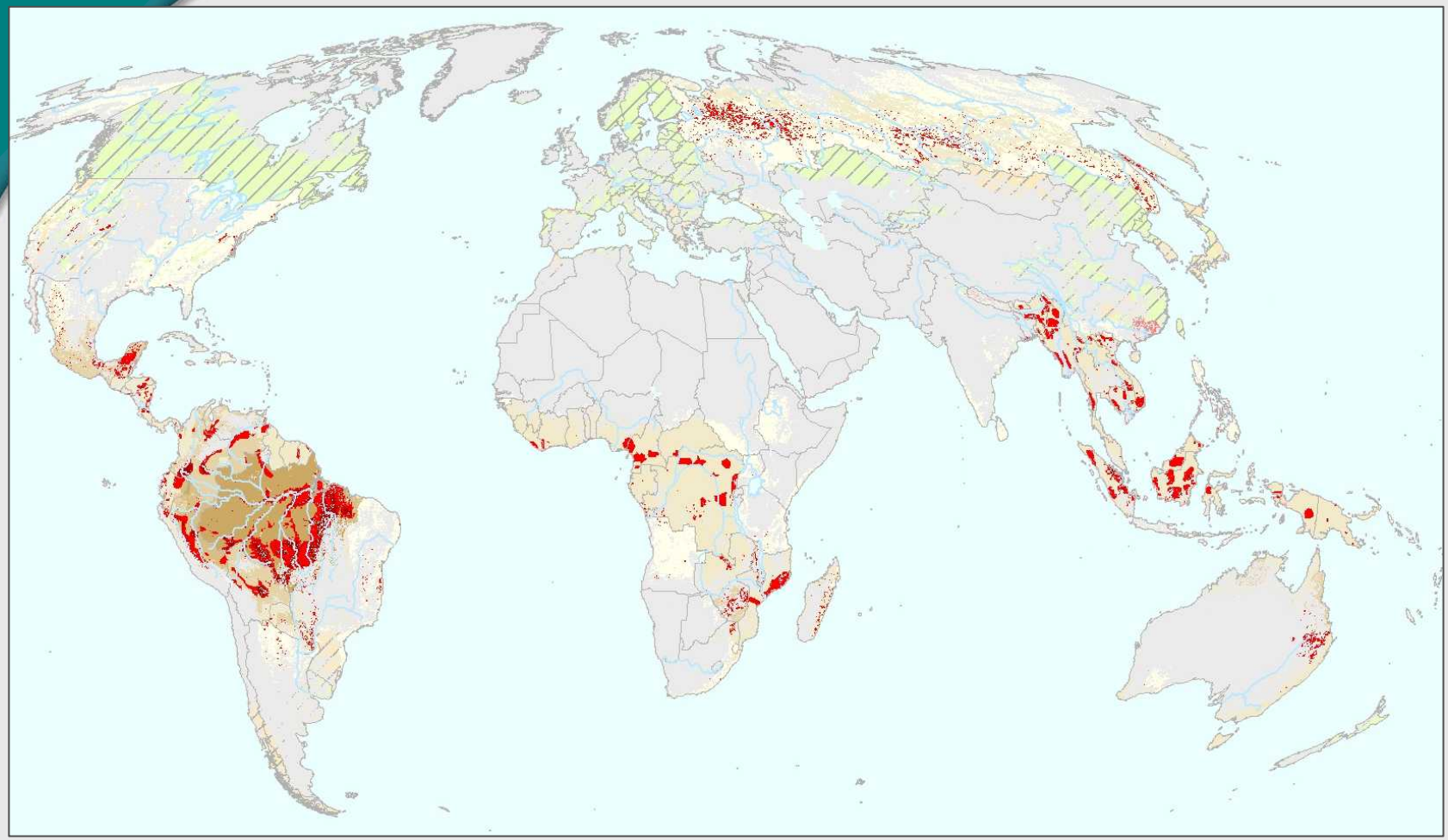
$$CO_2 + H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow$$
$$HCO_3^- + H^+ \Leftrightarrow CO_3^{2-} + 2H^+$$

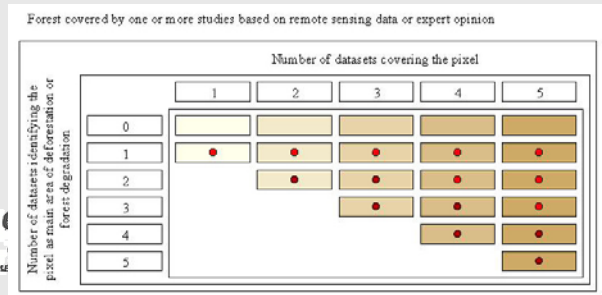


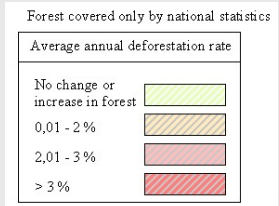
After Turley et al., 2005

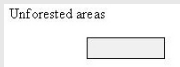

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 1: Main areas of deforestation and forest degradation over the last twenty years (1980-2000)









Main Conclusions

- Climate is indeed driving many ecosystems across thresholds that are important for managers to consider;
- The consequences of known thresholds challenge our current capacity to manage those ecosystems sustainably; and
- We require both better management techniques and a much better predictive capability to use our knowledge of thresholds more effectively in building adaptive management capacity.

Adaptation and Coping

- Because changes occurring now, have both coping to current circumstances and questions about planning for future circumstances to consider
- Requires some knowledge of regional climate changes and environmental consequences
- Requires information on current practices for coping and understanding of factors that control vulnerability
- Requires ability to model effectiveness of adaptation strategies as part of integrated response portfolio

Research Agenda

- Suggests that most important knowledge to get as quickly as possible is information about potential end-points and lag-times.
  - Importance of ecological modeling and monitoring
  - Importance of better regional climate change information
  - Importance of understanding potential costs and effectiveness of adaptation and management strategies
- What are potential magnitudes of important end-points?
- Are there thresholds we must worry about?
- To what degree is there sufficient ecological "buffering" to guard against cascading effects?
- What are the implications for atmospheric greenhouse gas concentrations and therefore emissions and mitigation costs?
  - Need integrated way of understanding potential portfolio of actions and their consequences
  - Collaborations of Integrated Assessment modelers and Earth System modelers have a lot of promise here