

Sustainability Solutions

University of Maine

Michael J. Eckardt

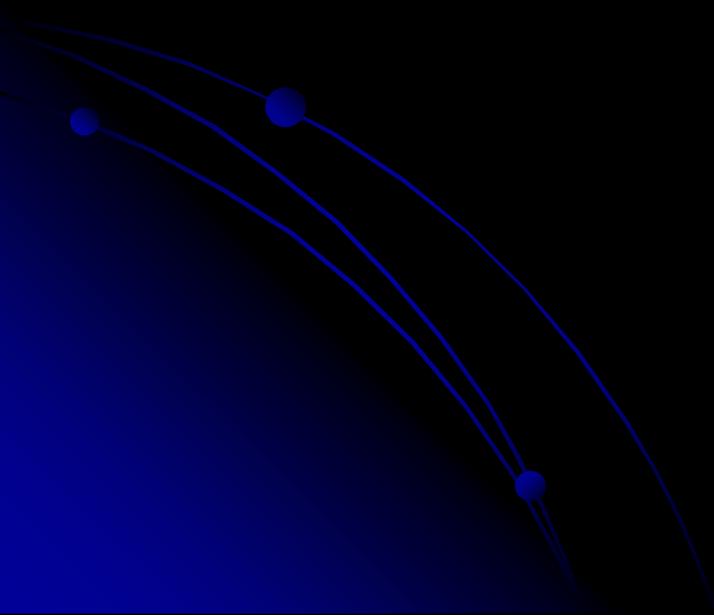
David D. Hart

Vicki L. Nemeth



- A critical investment priority identified in NSF's Strategic Plan (2006) is “fostering research that improves our ability to live sustainably on Earth”.
- Producing knowledge and linking it to actions that meet human needs while preserving the planet's life-support systems is one of science's most fundamental challenges. The process for generating natural science and engineering knowledge must be fundamentally reorganized, because such knowledge by itself is necessary but not sufficient for producing a transition to sustainability (Kates et al., *Science*, 2001).

- The goal of linking knowledge to action requires analyses of interactions among research and decision-making (Cash et al., *Proc. Natl. Acad. Sci.* 2006).

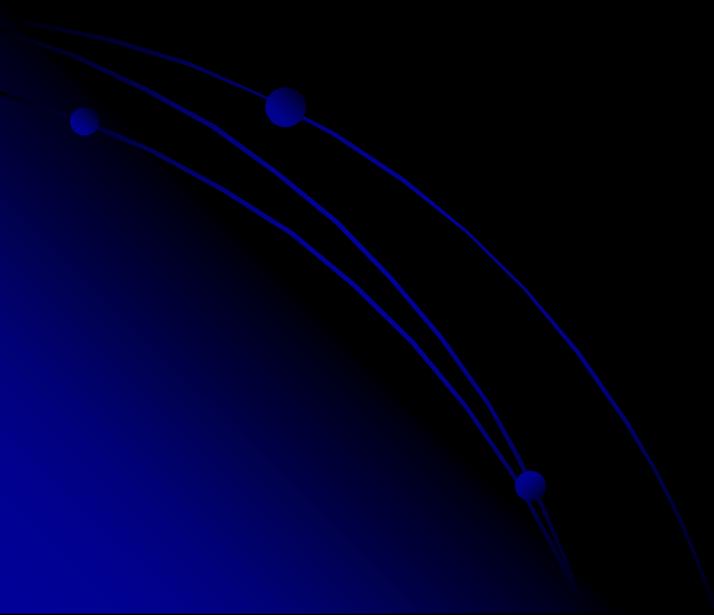


- Maine's project in sustainability science is designed to research the coupled dynamics of social-ecological systems (SES) and the translation of knowledge about SES dynamics into informed decision-making processes by stakeholders.
- These efforts will involve the overlap of ecology, economics, and social sciences; consequently, researchers are from a number of SES-related disciplines (climate change, hydrology, biogeochemistry, ecology, economics, spatial engineering) interacting with knowledge-to-action disciplines (communication, anthropology, sociology, political science, public policy, risk analysis, regional planning, law, and organization theory).

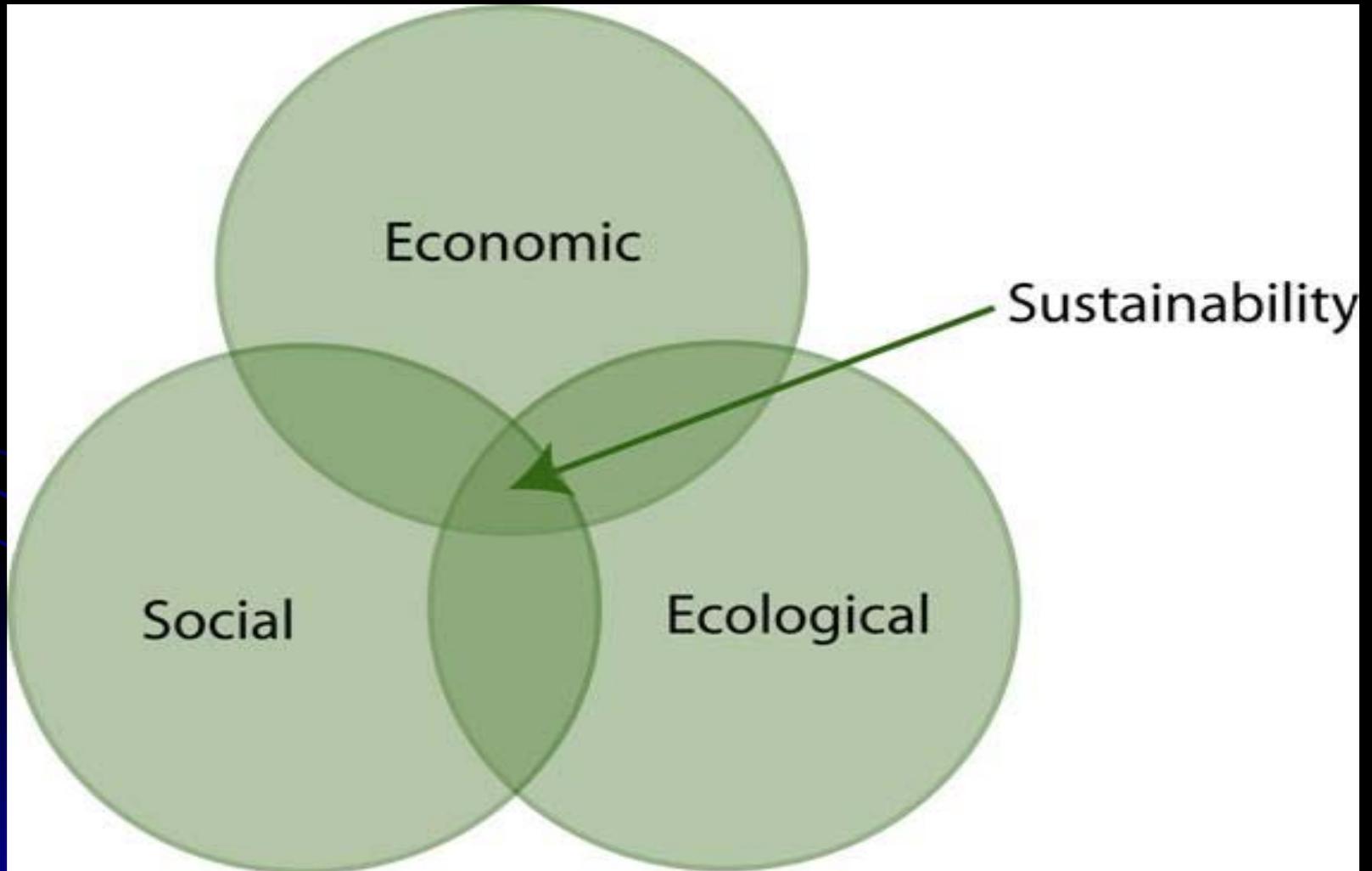
Maine has a number of interesting characteristics that make it particularly suitable for studying the dynamic interactions between nature and society.

1. History of developing novel solutions to sustainability challenges such as water pollution (many streams and lakes), habitat conservation, and forest management (90% forested).
2. Many of Maine's solutions have focused on private land, which is subjected to heterogeneous patterns of public regulatory control (contrast with publicly owned, homogeneous and exclusive jurisdiction).

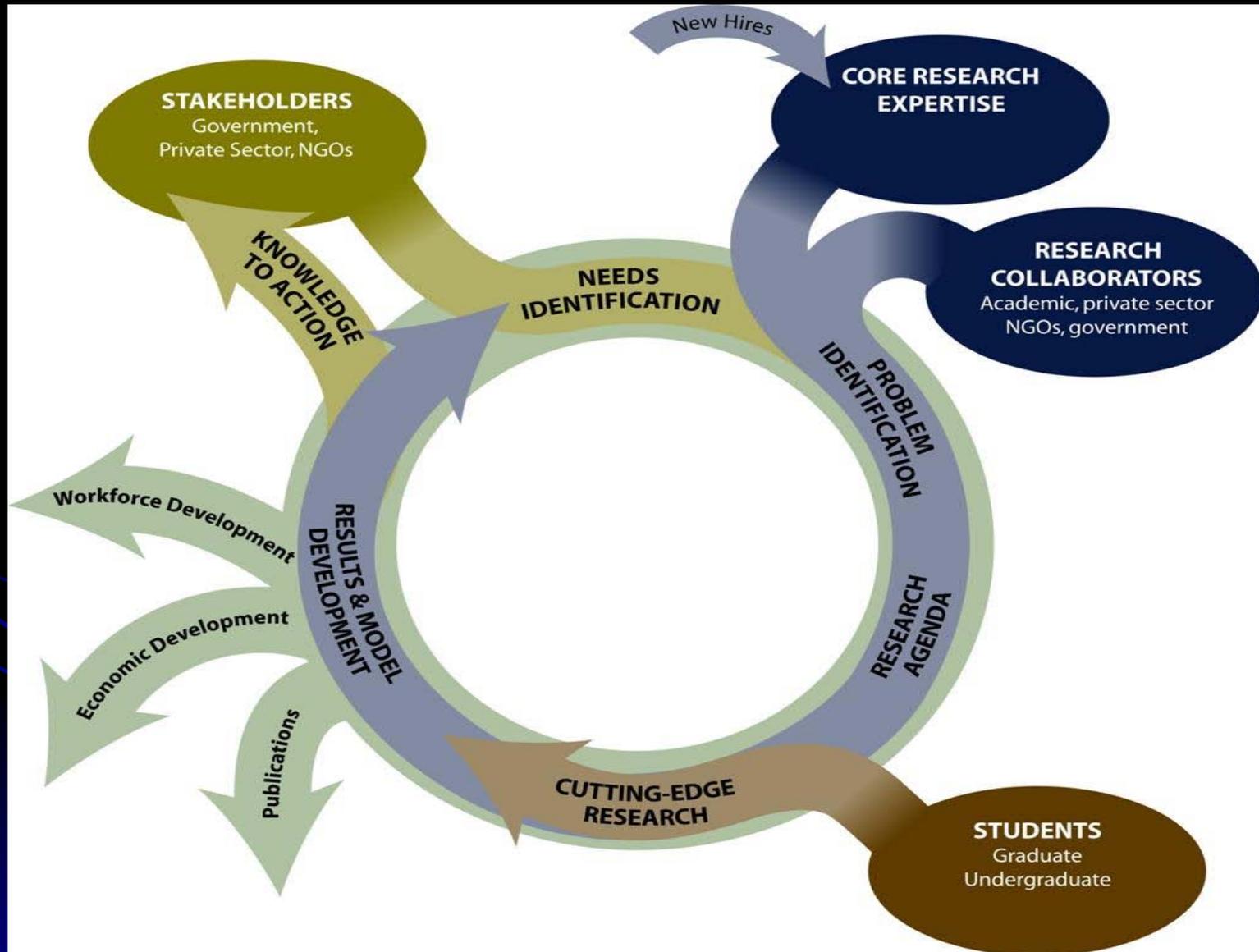
3. Most previous research has involved ecosystems already in crisis (e.g., Everglades, Chesapeake Bay), while Maine ecosystems have generally not reached a crisis point, allowing Maine to be a valuable model system for exploring more proactive, cost-effective approaches to sustainable development.



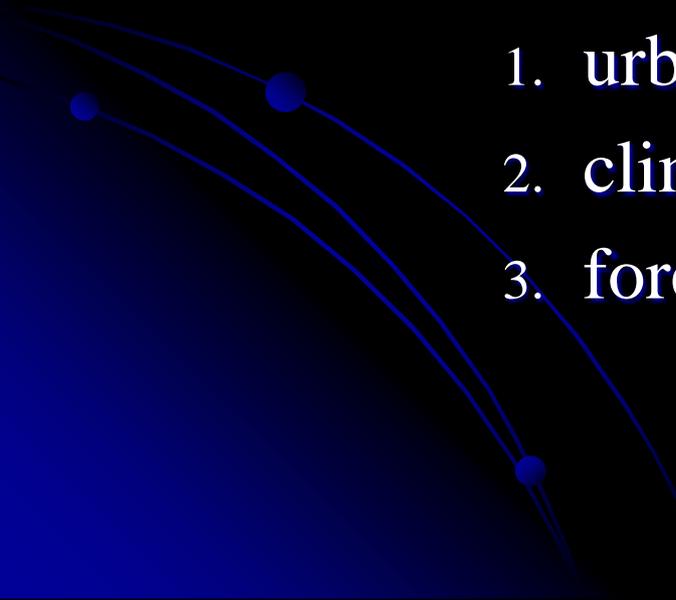
Location of Sustainability Science



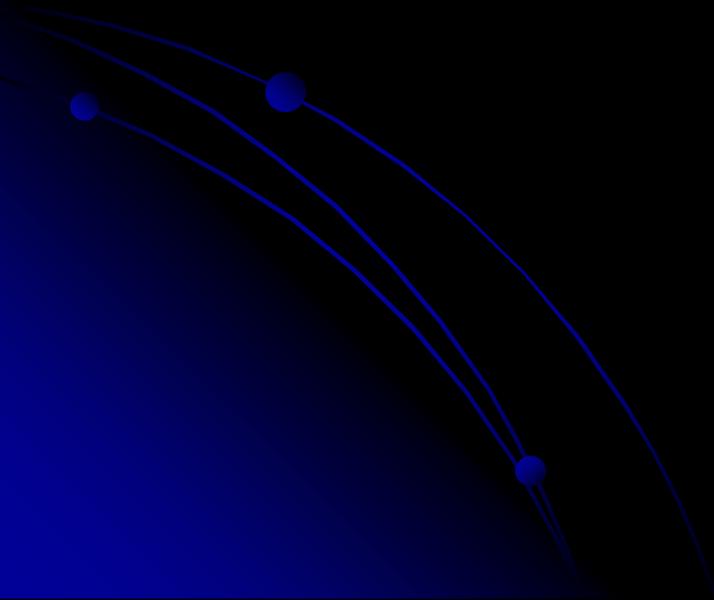
Conceptual Model of Sustainability Research



Our research project focuses on three interacting drivers of landscape change that profoundly affect Maine and other regions. Landscape change was identified as one of the grand challenges in environmental sciences by the National Research Council (2001).

- 
1. urbanization
 2. climate change
 3. forest ecosystem management

Urbanization



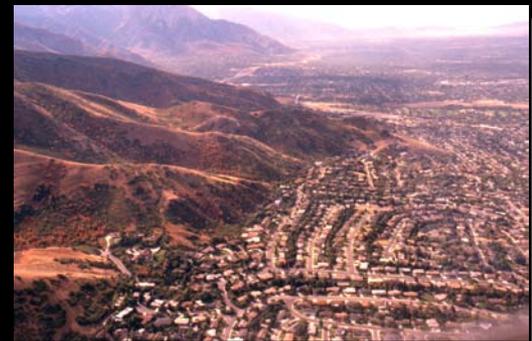
What is Alternative Futures Modeling?

Spatially explicit models that depict future landscapes under various “drivers of change” & land use policies...

- *Socio-demographic*
- *Economic*
- *Biophysical*

Anticipates future landscape conditions by modeling a wide range of alternative scenarios

From
this...



To
this...



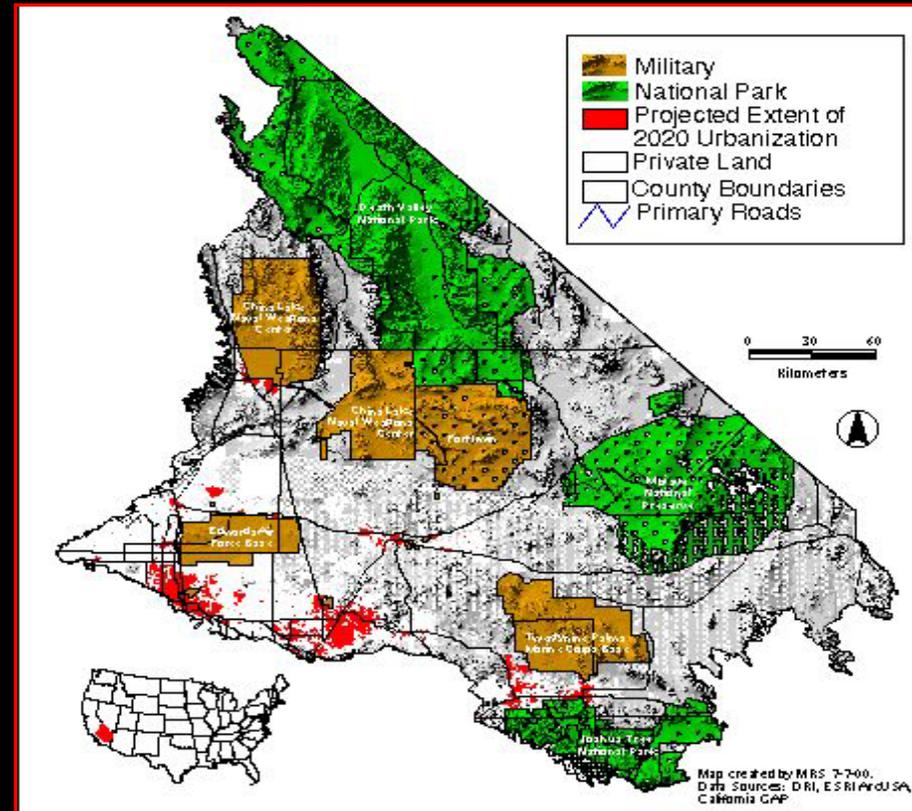
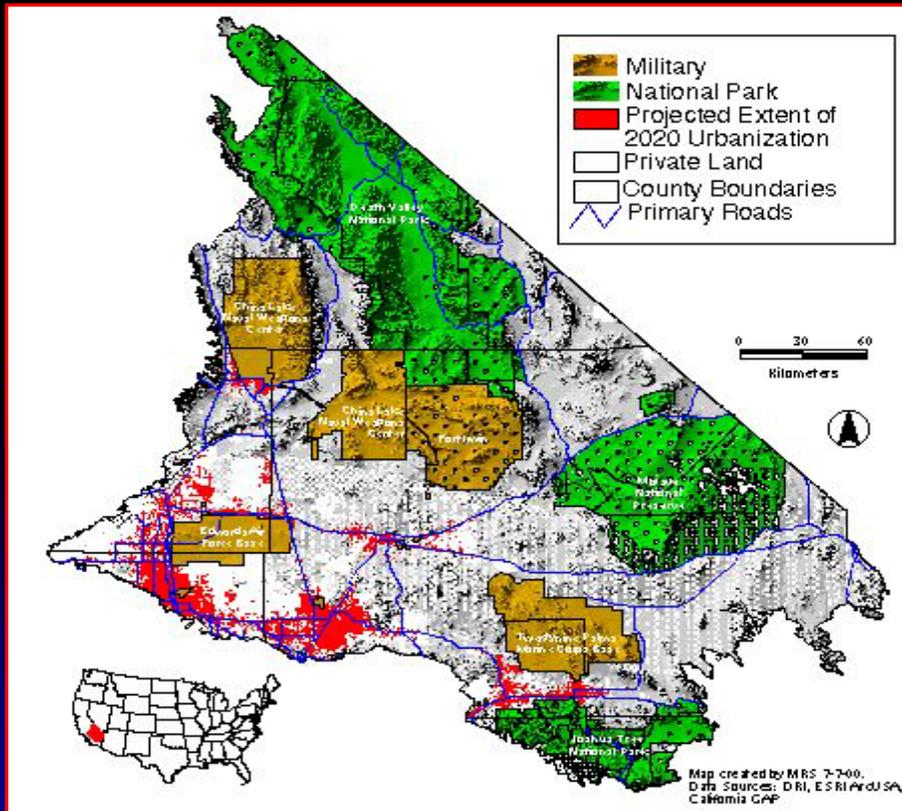
Benefits of Alternative Futures Modeling

- Requires input from a wide range of disciplines
- Engages stakeholders in scenario development & assessment...
- Provides a common visual reference for decision-making...



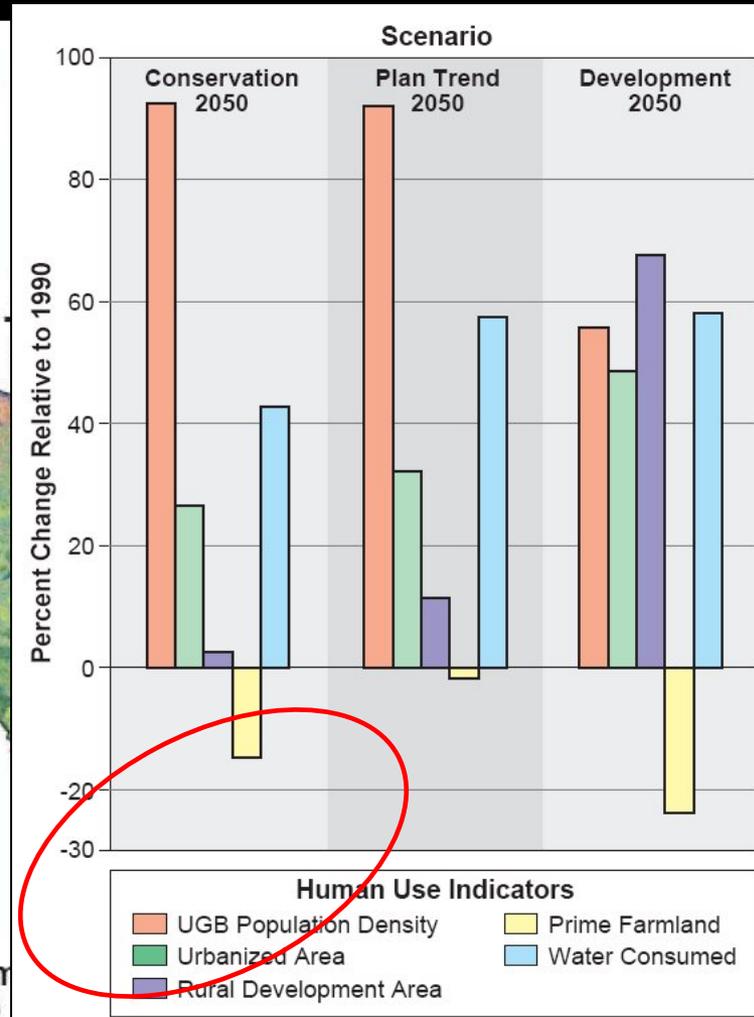
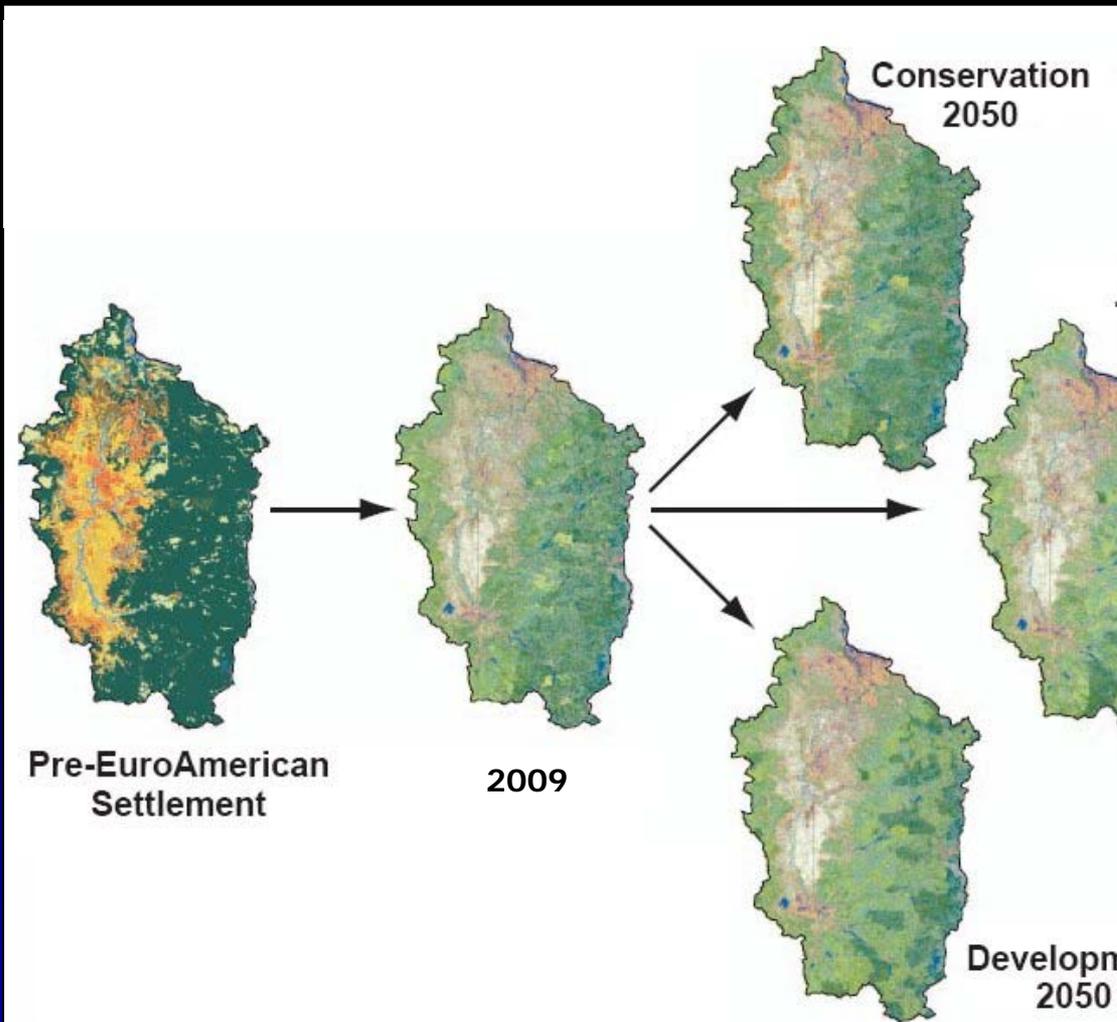
California's Mojave Desert

(4 vs 20 people/ha)

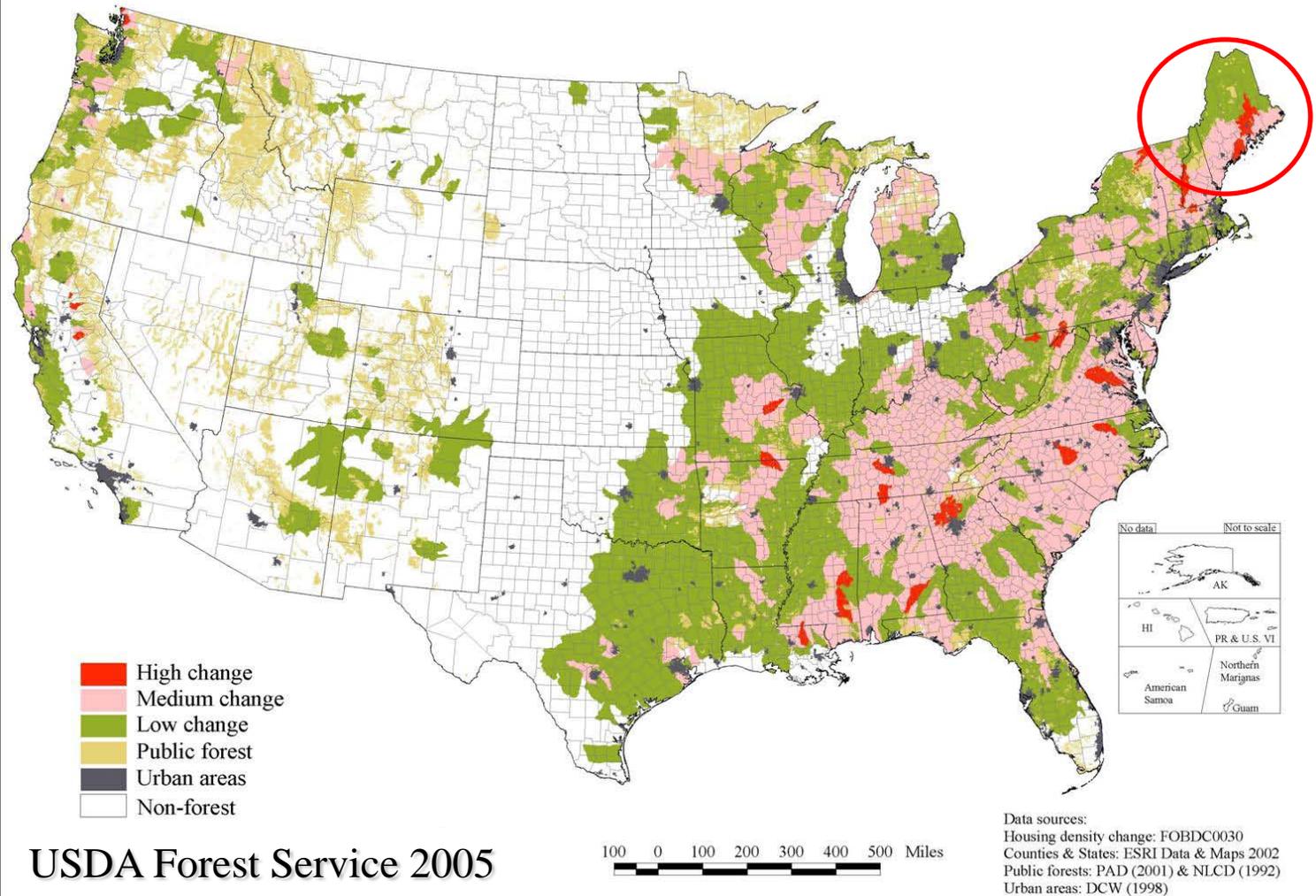


Alternative development footprints for 2020

Modeling Landscape Change...

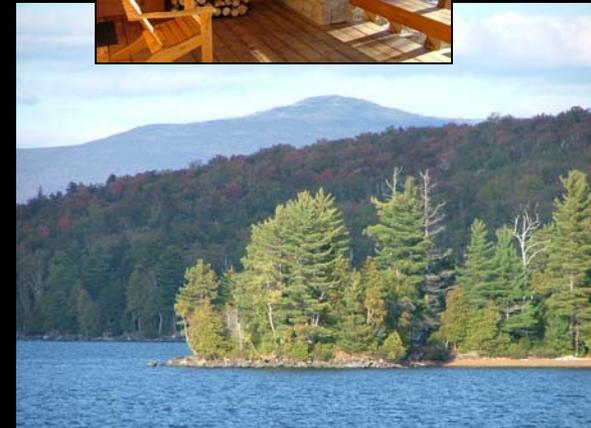


Modeling Future Development



Applications for Maine

- Modeling Future Development
- Assessing Risks from Climate Change
- Protecting Working Forests & Ag Lands
- Industrial Sector Development
- Protecting Public Health & Safety
- Energy & Transportation Planning
- Municipal Fiscal Impact Analysis
- Tourism Sector Planning



- Protecting wetlands from over development has been an ongoing concern at the federal level (Clean Water Act), and recently, has involved the U.S. Supreme Court and renewed legislative activity (Clean Water Authority Restoration Act).
- Maine was notified that it was in violation of certain aspects of the federal legislation on wetlands and in response established vernal pool regulations and clarifying legislation in 2008.
- Aram Calhoun is an expert on vernal pools and is one of the leaders in the urbanization section of landscape change in Maine's NSF EPSCoR project.

Vernal Pools

Naturally occurring, temporary to semi-permanent pools occurring in shallow depressions in *forested landscapes*. Vernal pools provide the primary breeding habitat for **wood frogs**, **blue-spotted** and **spotted salamanders**, and **fairy shrimp** and provide habitat for other wildlife including several endangered and threatened species.



This is the general vernal pool definition used by regulatory agencies in Maine. Pools were defined as “naturally occurring” so that skidder ruts, farm ponds, recent gravel pits, and roadside ditches would not be considered vernal pools. Amphibians will lay their eggs in some of these human-made wetlands, but they are not the primary breeding habitat.



Fairy Shrimp



Blue-spotted Salamander

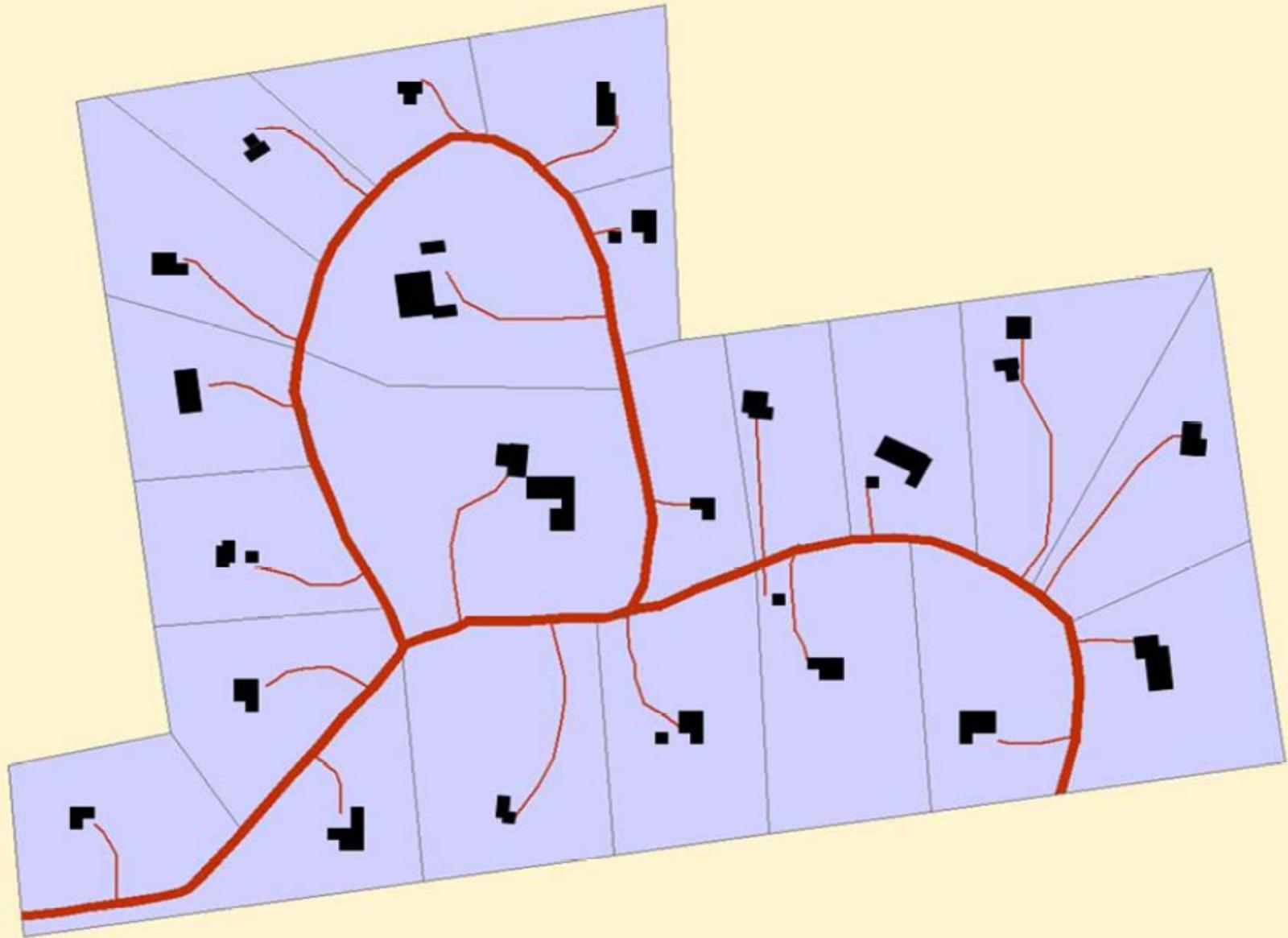


Spotted Salamander



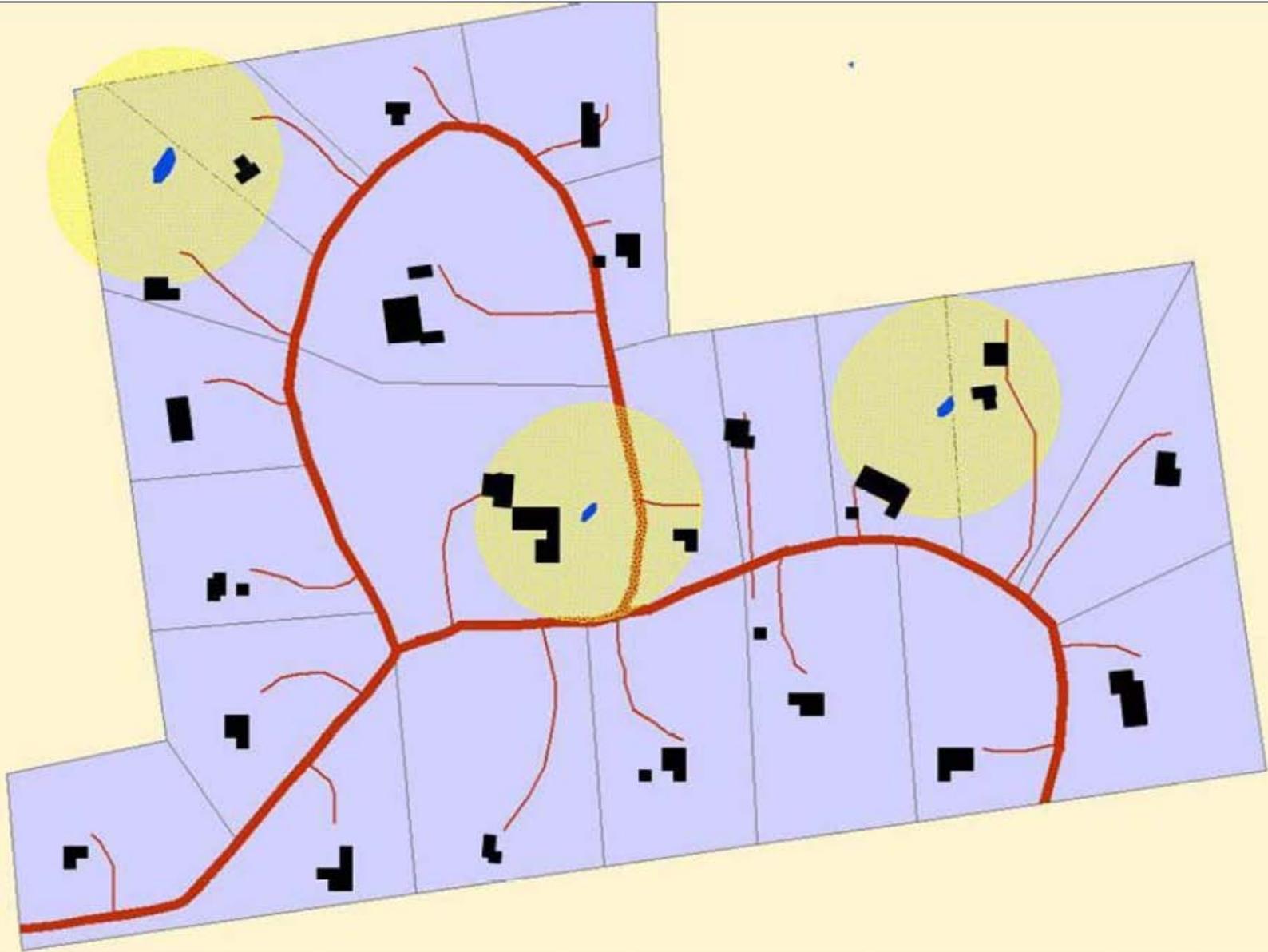
Wood Frog

There are 4 vernal pool indicator species in Maine: fairy shrimp, blue spotted and spotted salamanders, and wood frogs. These species are considered indicator species because vernal pools are their PREFERRED breeding habitat where reproductive success is the greatest.

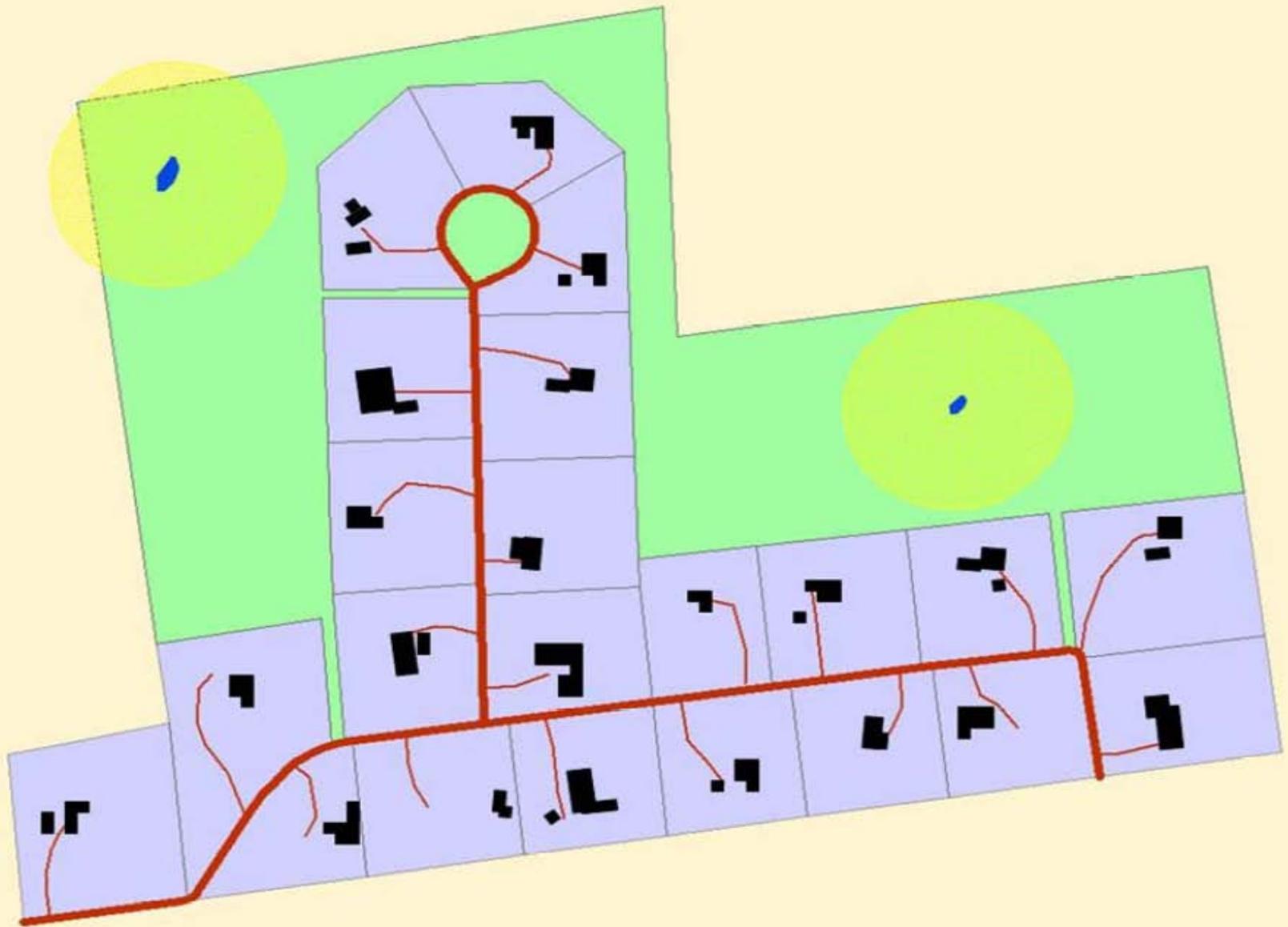


Example of a proposed subdivision without knowledge of the location of Significant Vernal Pools.

The following example of a proposed subdivision is intended to demonstrate how knowledge of the location of Significant Vernal Pools may be used in the development planning process.

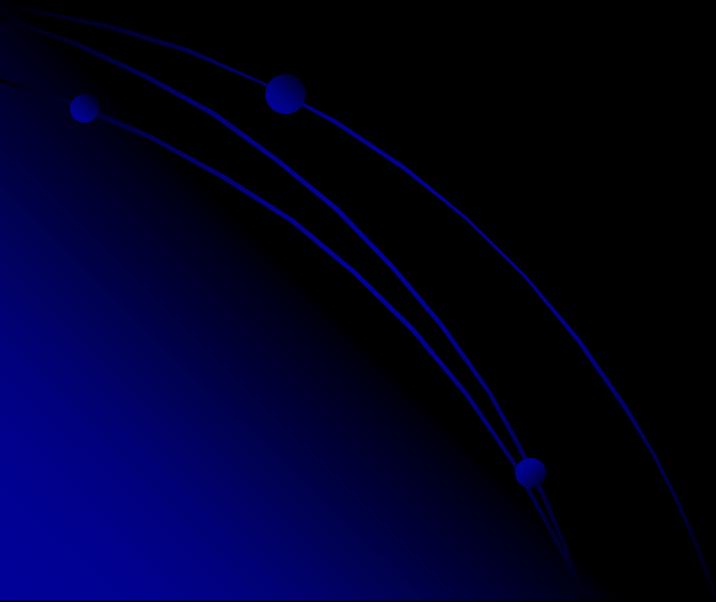


Had the town and developer known the location of significant vernal pools before investing in the subdivision design, they could have planned accordingly and saved both time and money involved in subdivision design, surveying and permitting.



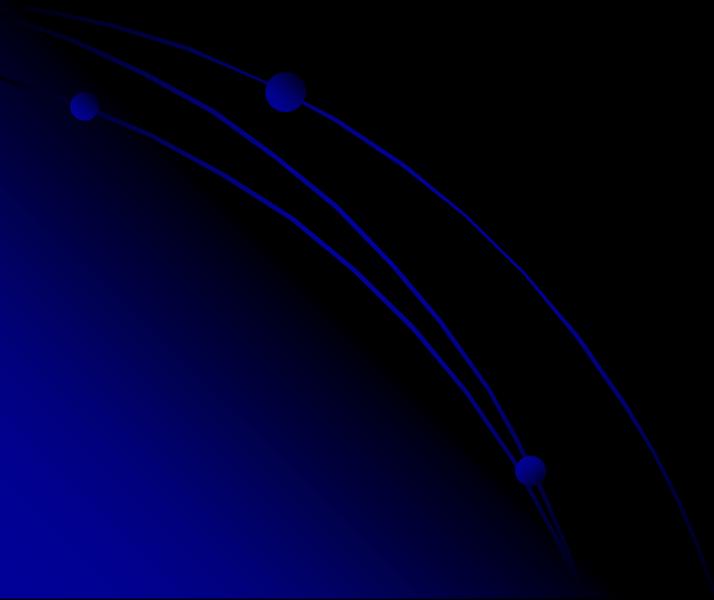
Knowing where pools are in advance, one option might be to work around the Significant Vernal Pools. In this slide you notice that one of the pools is lost because it is not always feasible to conserve all significant pools. The original number of house lots is maintained in this example, but they are smaller in size. You can see that many lots abut green space and all property owners have access to the common natural areas.

Climate Change



Global climate change is a fact: temperatures are increasing, Arctic and Antarctic ice sheets are melting

- Naturally occurring, induced by man, interactions
- What do we do about it? (I will come back to this)

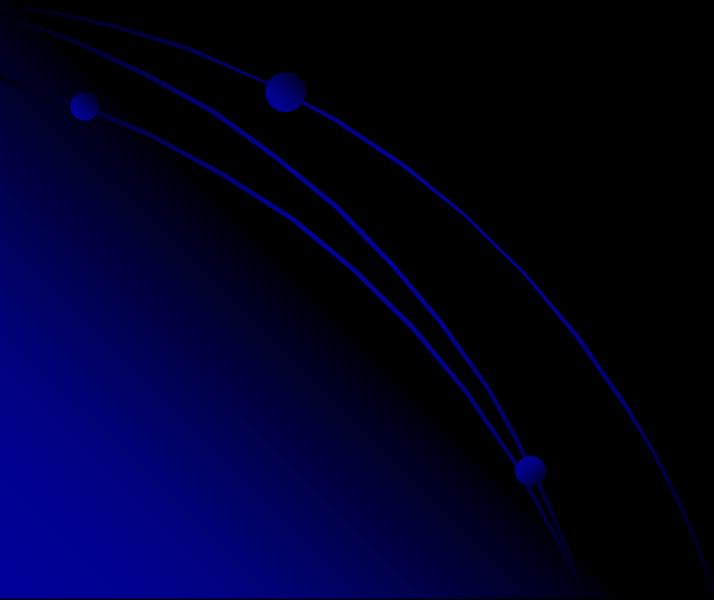


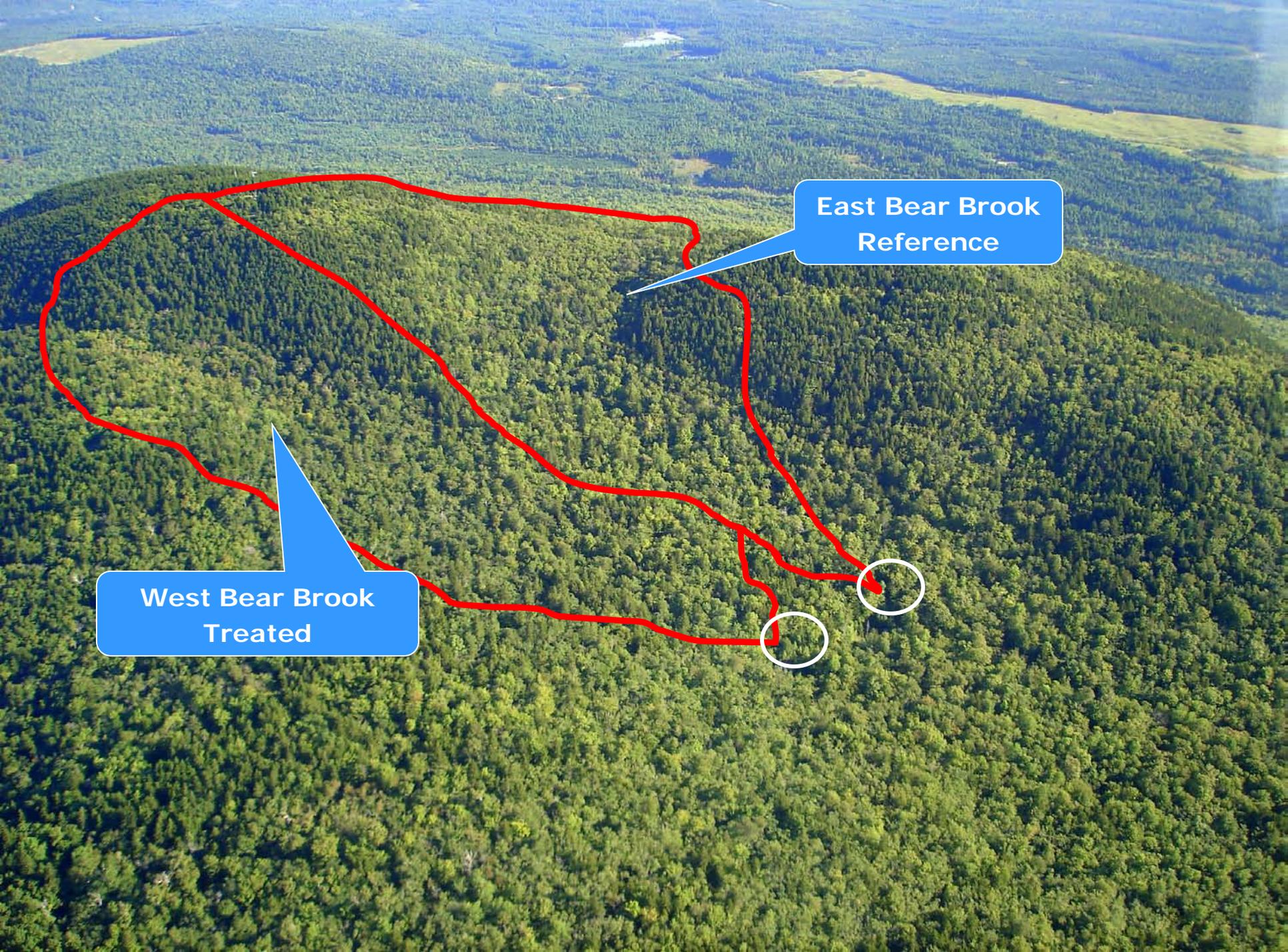
Senator George Mitchell Center for
Environmental and Watershed
Research
(David Hart)



- Clean Air Act Amendments of 1990
- George Mitchell was majority leader of the U.S. Senate and led the successful reauthorization.
- Curb three major threats to the nation's environment and to the health of millions of Americans.
 1. Acid rain
 2. Urban air pollution
 3. Toxic air emissions

In the mid-1980s a group of UMaine faculty members began an experimental study of acid rain in the Bear Brook Watershed in Maine. Today, that project continues under the leadership of Professor Ivan Fernandez (one of the leaders of the climate change section of the current NSF EPSCoR)





East Bear Brook
Reference

West Bear Brook
Treated

Helicopter treating watersheds



Treatments

- ◆ Initiated November, 1989
- ◆ $1800 \text{ eq ha}^{-1} \text{ yr}^{-1} (\text{NH}_4)_2\text{SO}_4$, or
 25.2 and $28.8 \text{ kg ha}^{-1} \text{ yr}^{-1} \text{ N}$ and S
- ◆ Added in 6 bi-monthly applications

Inside the Box

- ✓ Tree foliar chemistry
- ✓ Tree physiology
- ✓ Understory vegetation
- ✓ Litterfall and decomposition
- ✓ Roots
- ✓ Soil chemistry
- ✓ Soil microbiology
- ✓ Soil solutions
- ✓ Trace gas flux
- ✓ Groundwater
- ✓ Stream chemistry
- ✓ Stream sediments
- ✓ Hydrology
- ✓ Ecosystem mass balance
- ✓ ...etc.



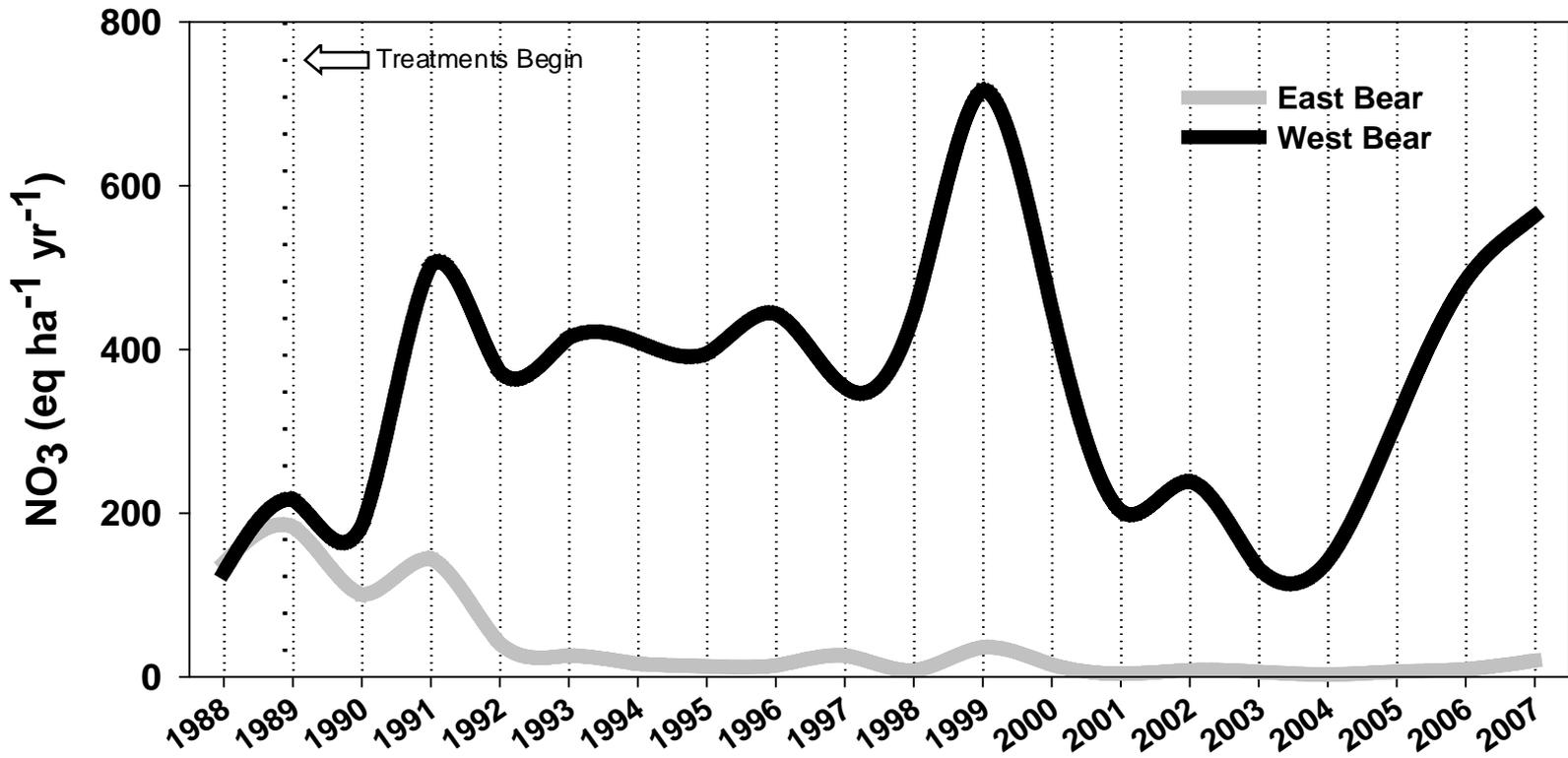


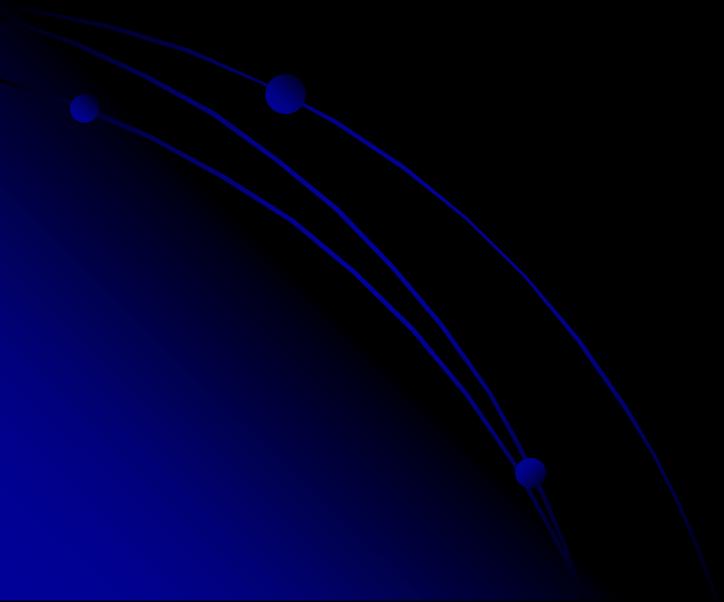
Figure 2 – Time series of East Bear (gray) and West Bear (black) stream NO₃ concentrations.

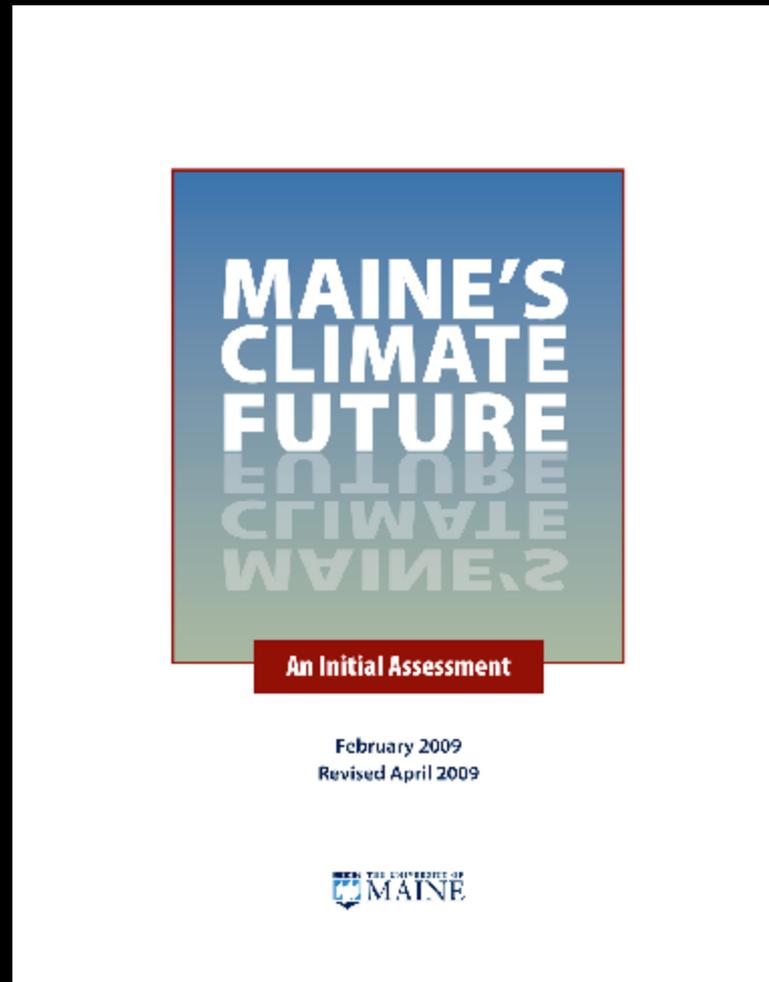


1987	Pre-treatment Monitoring Begins
1988	Treatments Begin
1989	
1990	Nitrogen Surprise #1 (native N)
1991	
1992	Nitrogen Surprise #2 (regional N)
1993	
1994	Stochastic Event – Caterpillars
1995	
1996	Base Cation Surprise
1997	
1998	SO4 Surprise
1999	Stochastic Event – Ice Storm
2000	
2001	
2002	Nitrogen Surprise #3 (N retention)
2003	Forest Growth Surprise #1 - BAI
2004	P surprise
2005	
2006	Forest Growth Surprise #2 - roots
2007	Emerging evidence of P limitations
2008	The Future?

Surprises and Transitions
at BBWM
- The First Two Decades -

What are the local effects of
climate change?





Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine's Climate Future: An Initial Assessment. Orono, ME: University of Maine.

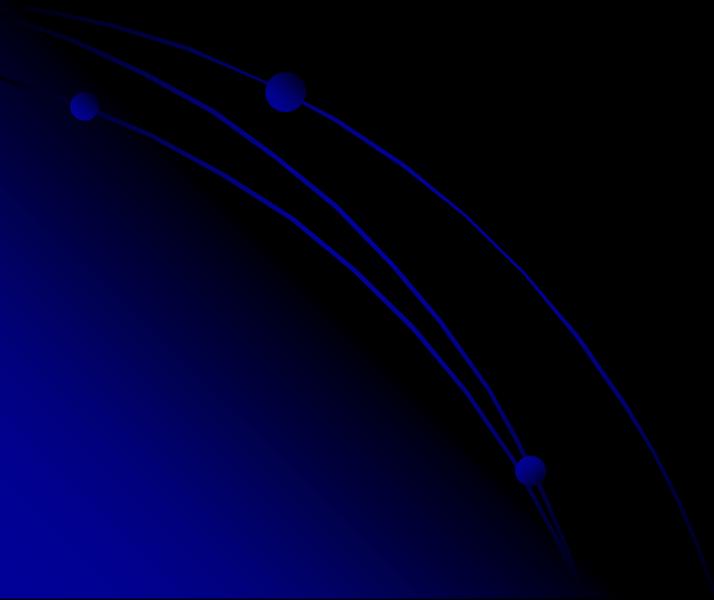
<http://www.climatechange.umaine.edu/mainesclimatefuture/>

Cite individual sections using Team Leader as first author.

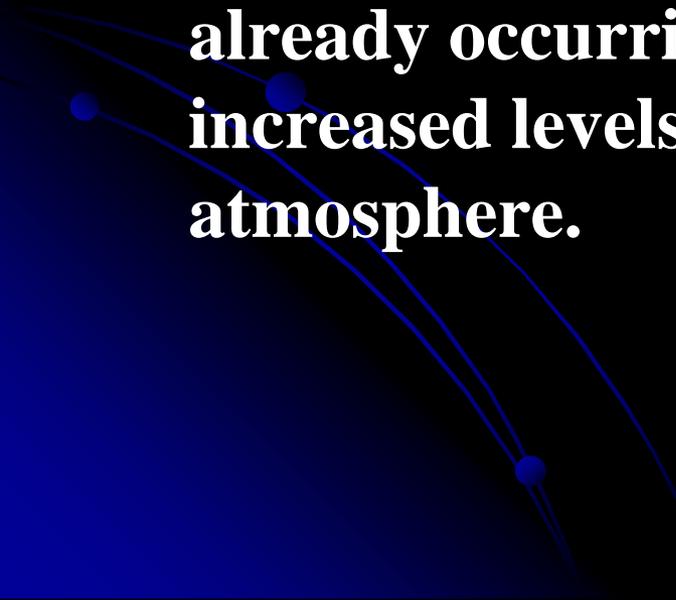
Design and production: Kathlyn Tenga-González, Maine Sea Grant

Printing: University of Maine Printing Services

SP0163, LD 460, item 1, 124th Maine State Legislature
Resolve, To Evaluate Climate Change Adaptation Options for
the State SP0163, LR 529, item 1, First Regular Session -
124th Maine Legislature



The Maine Department of Environmental Protection is directed to create a stakeholder group to evaluate the options available to Maine people and businesses for adapting to the most likely impacts of climate change and to focus on the climate impact assessment by the University of Maine that concluded that climate change is already occurring in the State as a result of increased levels of greenhouse gases in the atmosphere.



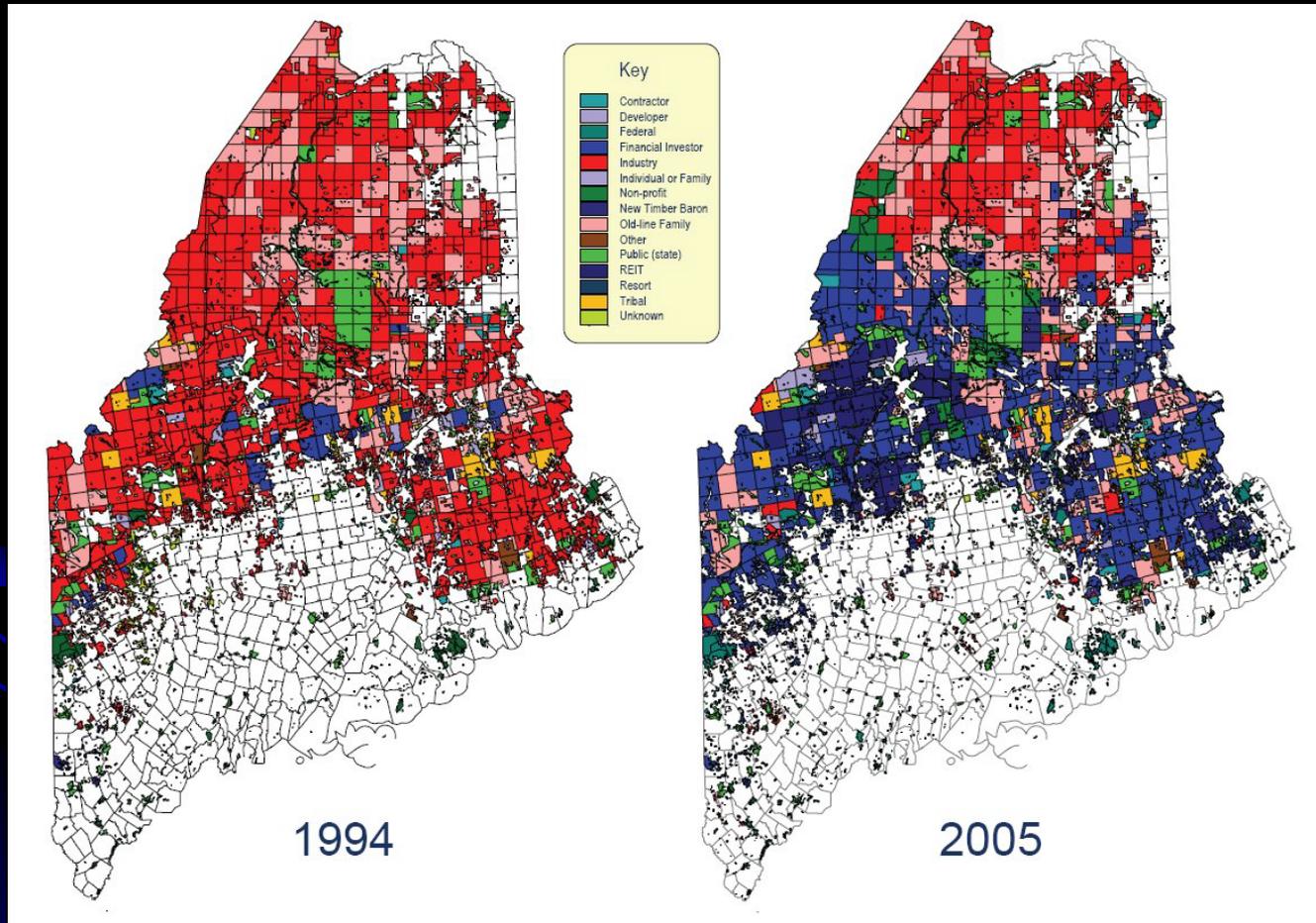
Forest Ecosystem Management



- Maine is the most heavily forested state in U.S. (90%; 16.9 million acres)
- More than 96% of its timberland is privately owned
- Maine is among the highest in the U.S. in percentage of certified forests (37%)
 - Sustainable Forestry Initiative
 - Forest Stewardship Council
- Forest-based manufacturing provides 4.2% of Maine's total economy, with wages and salaries totaling \$1.0 billion.

Changing Ownerships

The health of the industry depends upon access to forests...



Coupled Natural-Human Systems

- In the 1970s & 1980s, the spruce budworm infested millions of acres of Maine's woods...

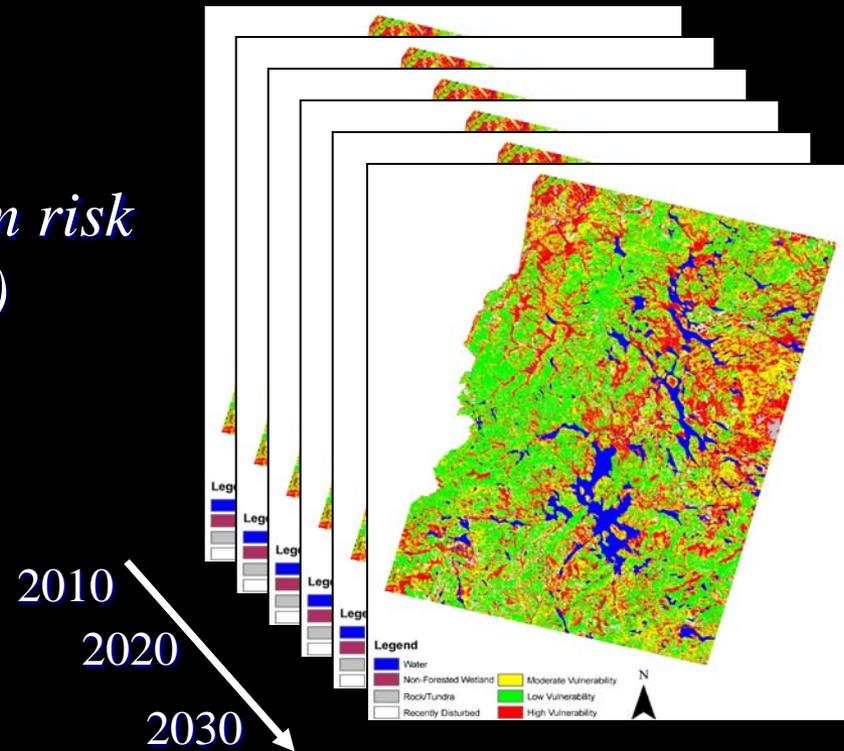


Modeling Forest Health

- UMaine is working with industry partners to better predict the timing, severity & spatial distribution of future budworm outbreaks...

*Spruce budworm risk
(4 million acres)*

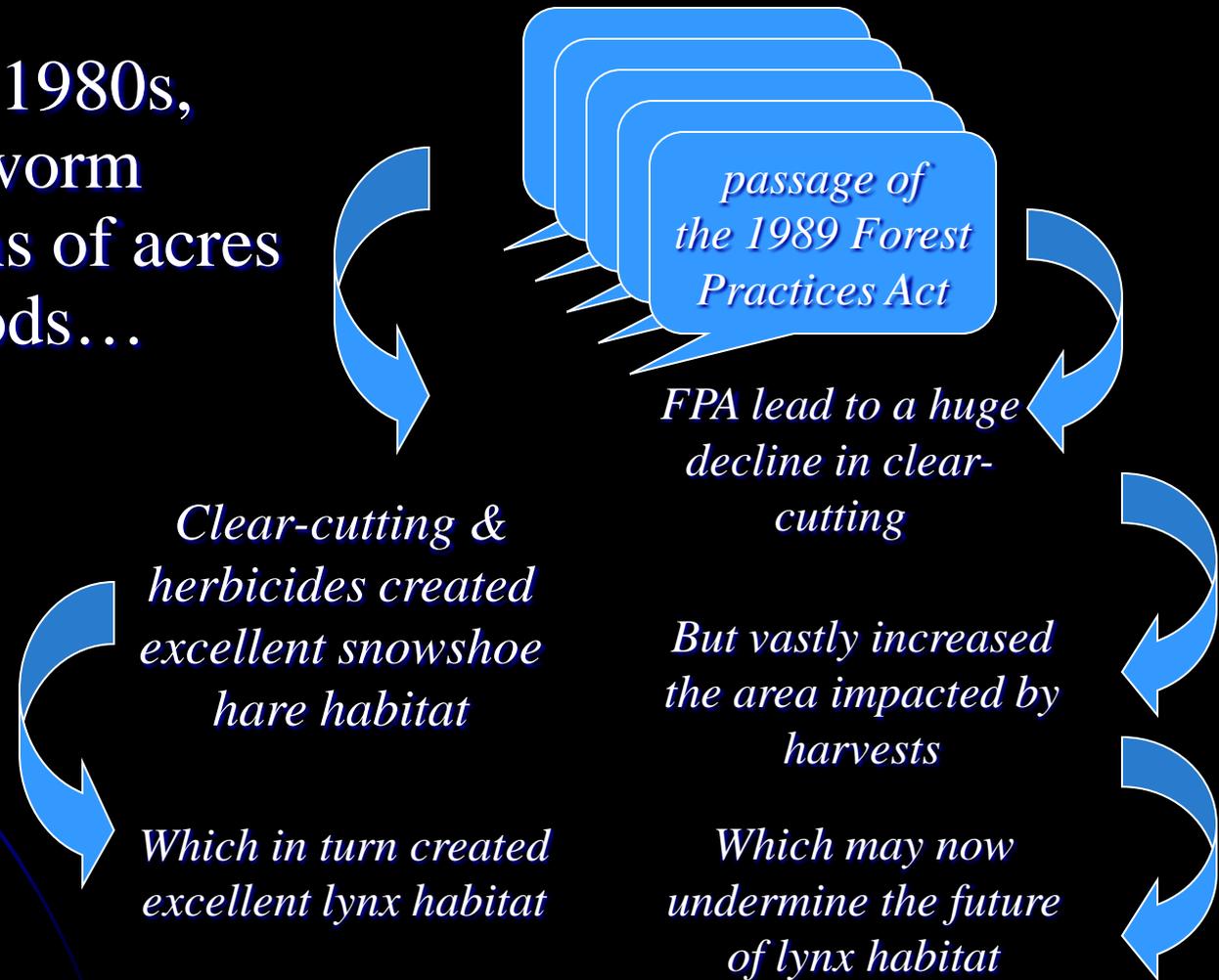
*Over 10 million acres
in Maine are at risk to
future outbreaks...*



(Sader, Wilson & Legaard 2008)

Coupled Natural-Human Systems

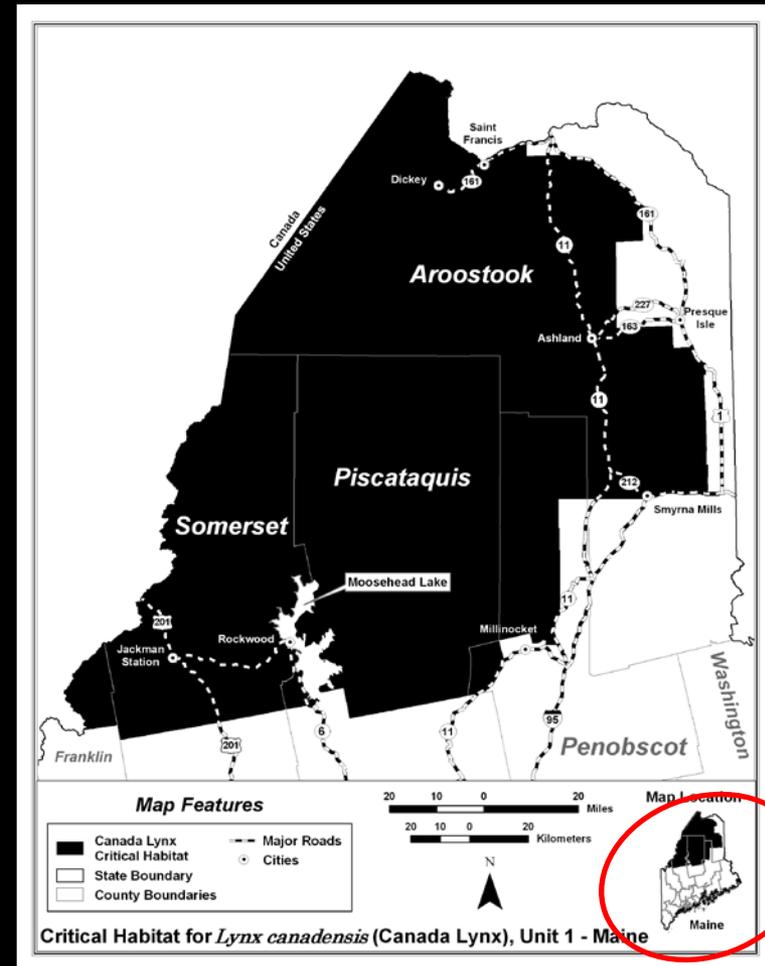
- In the 1970s & 1980s, the spruce budworm infested millions of acres of Maine's woods...



Habitat Protection

- 2002 Canada lynx listed as “threatened”
- 2009 F&WS designated 39,000 mi² as “critical habitat”

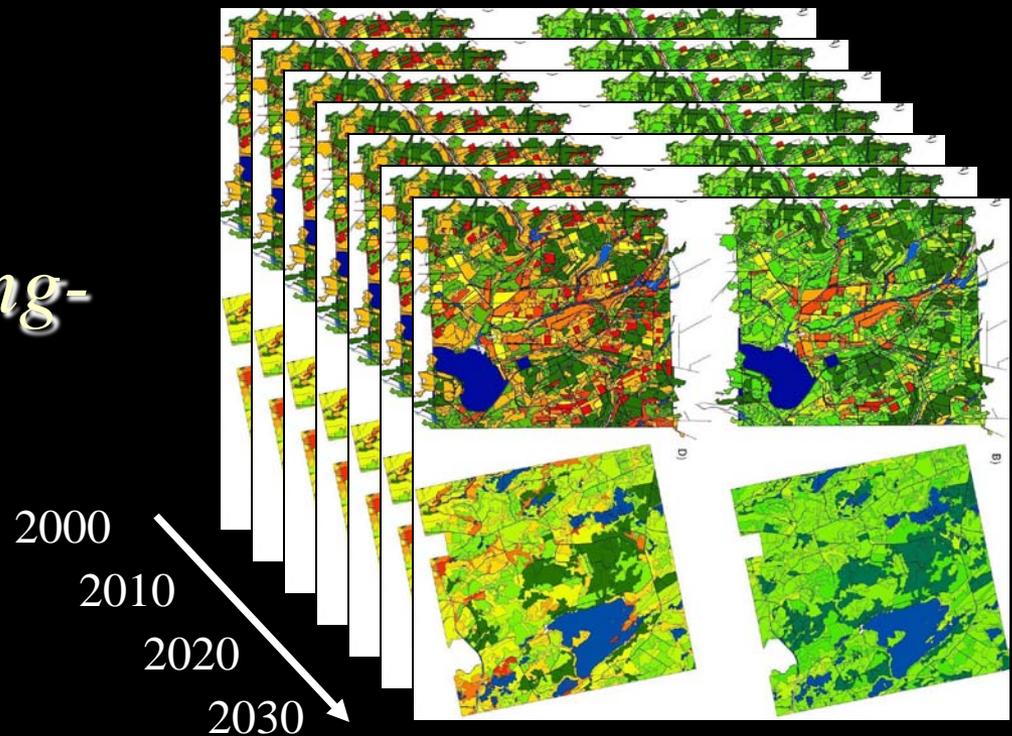
Designation could affect forest management on 6.1 million acres



Habitat Protection

- A 2008 partnership between the F&WS, UMaine & Maine's forest products industry seeks to...

Develop landscape models that depict long-term interactions between forest management & lynx habitat....



(Harrison, Sader & Simons 2008)

Major Drivers of Landscape Change in Maine

- Urbanization
- Climate Change
- Forest Ecosystem Management



Thank You!

