Estimating Risk to Alaska's Infrastructure from Climate Change

Peter Larsen

Senior Policy Advisor
Climate Change & Energy
plarsen@tnc.org

April 15, 2008

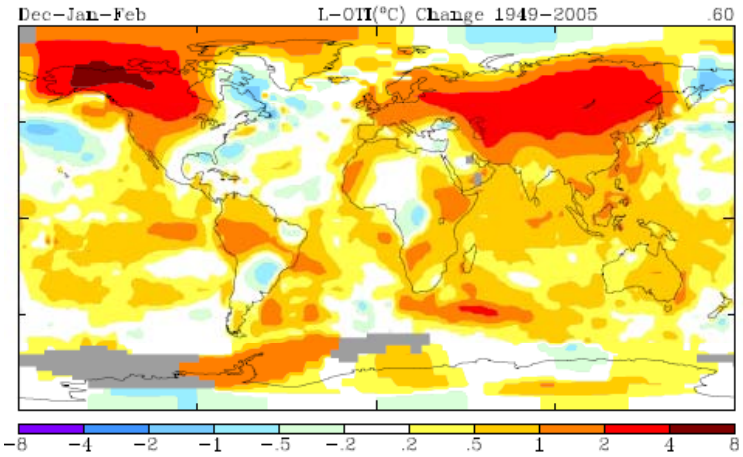
About The Nature Conservancy…

The Nature Conservancy works in more than 30 countries, including all 50 United States.

To date, the Conservancy has nearly one million members and has protected over 130 million acres of land.

We have concluded that rapid climate change threatens all the conservation investments we have made to date and poses an extremely serious threat to our mission.

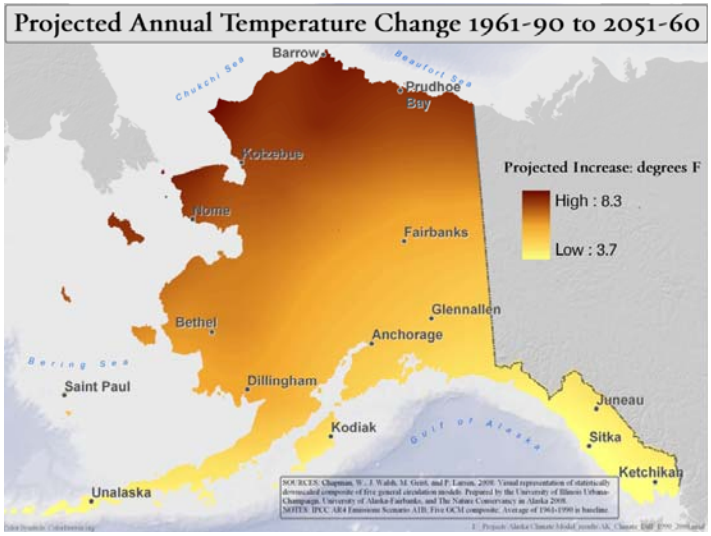
Alaska's Changing Climate



Source: NASA, GISS (2007)

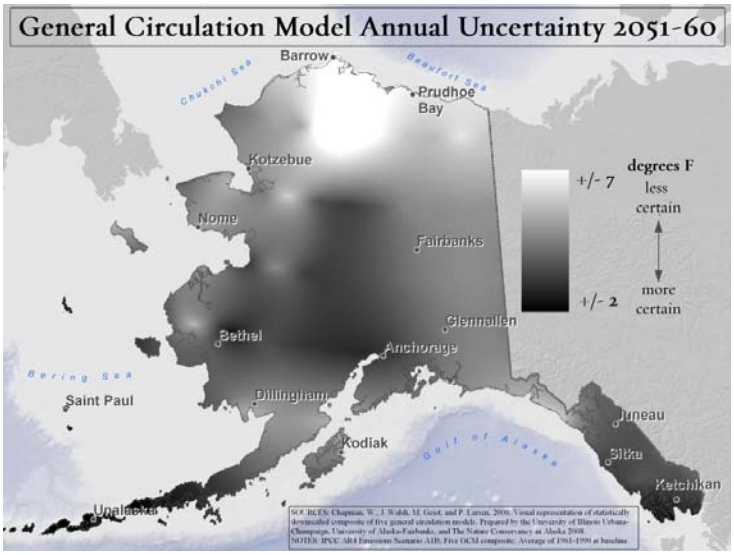
The Nature Conservancy
Protecting nature. Preserving life.

Alaska's *Projected* Climate



The Nature Conservancy
Protecting nature. Preserving life.

Statistical Confidence in GCMs



The Nature Conservancy
Protecting nature. Preserving life.

Climate Change Effects on Alaska

- Expanded marine shipping
- Declining food security
- Human health concerns
- Effects on wildlife migratory patterns
- Increased access to offshore resources
- Changes in marine fisheries
- Decline in freshwater fisheries such as arctic char and salmon
- Enhanced agriculture growing seasons
- Increased forest fire and insect infestation activity
- Disrupted land transportation from thawing permafrost and melting ice roads
- Difficulty maintaining subsistence hunting cultures
- **Increased damage to community infrastructure from coastal erosion and thawing permafrost**

The Nature Conservancy
Protecting nature. Preserving life.

Sources: ANTHC, 2005; USARC, 2003; ACIA, 2005; Weller et al., 1999; Larsen et al, 2008

Climate Change Impacts Structures

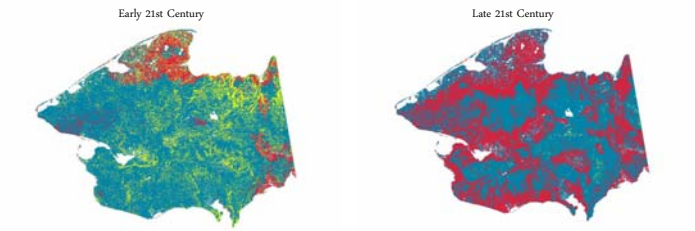
- *Thawing Permafrost*
- *Changes in Sea-level (inundation and subsidence)**
- *Accelerated Coastal Erosion*
- *Increased Likelihood of "Extreme Events"?*

* Effect not considered in preliminary economic analysis.

The Nature Conservancy
Protecting nature. Preserving life.

Example: Thawing Permafrost

Projected Permafrost Distribution, Seward Peninsula, Alaska (Hinzman et al, 2007)

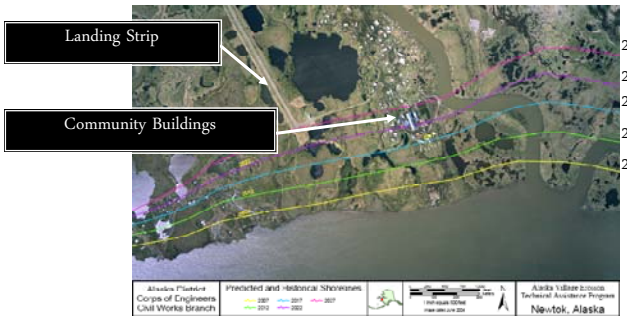


Sinkhole Created by Thawing Permafrost (Romanovsky and UCAR, 2007)

The Nature Conservancy
Protecting nature. Preserving life.

Example: Coastal Erosion

Projected Coastal Erosion at Newtok, Alaska (USACE, 2006)



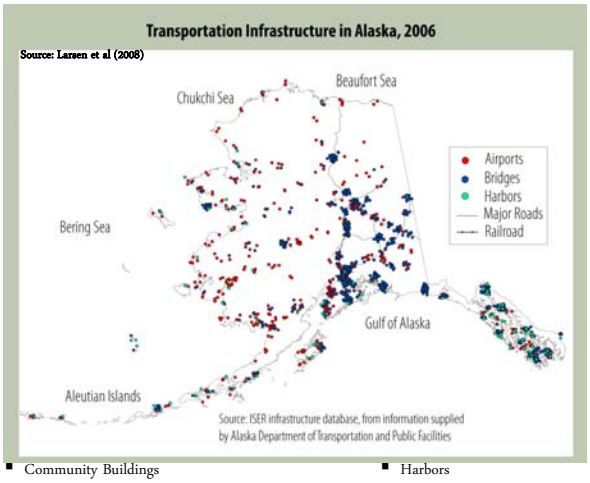
Coastal Storm Activity Undermines Foundations in Western Alaska (USACE, 2006)

Introducing "ICICLE"

I:	*ISER*
C:	*Comprehensive*
I:	*Infrastructure*
C:	*Climate*
L:	*Lifecycle*
E:	*Estimator*

1. **Alaska Public Infrastructure Database**
2. **Climate Projections**
3. **Lifespan Adjustment Scenarios**

Public Infrastructure Database



- Community Buildings
- Hospitals
- Telecommunications/Electric Systems
- Water/Wastewater Systems
- Bridges
- Harbors
- Schools
- Roads
- Airports/Landing Strips

Assumptions about Structure Lifespan, Counts, and Costs

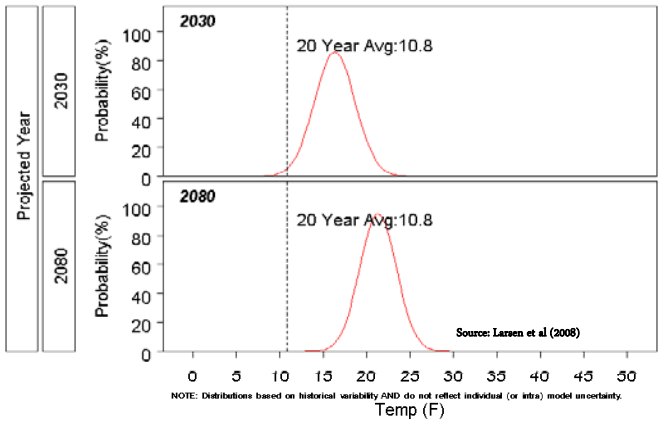
Preliminary Public Infrastructure Database[a]: Counts, Useful life, and Estimated Replacement Costs

Type of Infrastructure	Count/Length	Useful Life (years)	Replacement Cost per Unit	Units	Total Replacement Costs
Airports	252	20	$20 million	Whole	$5.04 billion
Bridges	853	40	$10,000	Per Foot	$1.7 billion
Court facilities	42	40	$16 million	Whole	$678 million
Defense facilities[b]	178	40	$305 thousand	Whole	$54 million
Emergency Services (Fire stations, other)	232	20	$467 thousand	Whole	$108 million
Energy (Fuel tanks, other structures off power grid)	233	30	$32 thousand	Whole	$7 million
Misc. government buildings	1,569	30	$1 million	Whole	$1.6 billion
Power grid (lines, transformers substations)[b]	68/768 miles	15	$100 thousand	Per Mile	$77 million
Misc. health buildings (clinics, other non-hospital)	345	30	$1.6 million	Whole	$563 million
Harbors	130	30	$10 million	Whole	$1.3 billion
Public hospitals	18	40	$44.7 million	Whole	$806 million
Law enforcement facilities (police and troopers stations, prisons, other correctional)	66	30	$4 million	Whole	$259 million
Alaska Railroad	45/819 miles	30	$2.8 million	Per Mile	$2.3 billion
Roads	10,476/9,564	20	$1 million (unpaved) $3 million (paved)	Per Mile	$18.7 billion
Schools	519	40	$2.5 million	Whole	$1.3 billion
Sewer systems	123	20	$30 million	Whole	$3.7 billion
Telecommunications (towers, satellites, other)	274	10	$300 thousand	Whole	$82 million
Telephone lines[b]	20/222 miles	15	$50 thousand	Per Mile	$11.1 million
Water systems	240	20	$5 million	Whole	$1.2 billion
Totals:	**15,653**				**$39.4 billion**

Note: Real discount rate 2.85% for all types of infrastructure
[a]Preliminary database compiled from publicity available information in 2006.
[b]The count and the replacement costs in these categories are obviously low. In part for security reasons, little public information is available about the size and value of defense facilities.
Source:

Source: Larsen et al (2008)

Climate Projections



- Likelihood distributions produced by conducting repeated multivariate (temp. and precip.) Gaussian Monte-carlo simulations using historically observed climate variability.

Useful Life Adjustment Matrix

Reduction in Useful Life (%) per Degree Increase in Annual Temperature

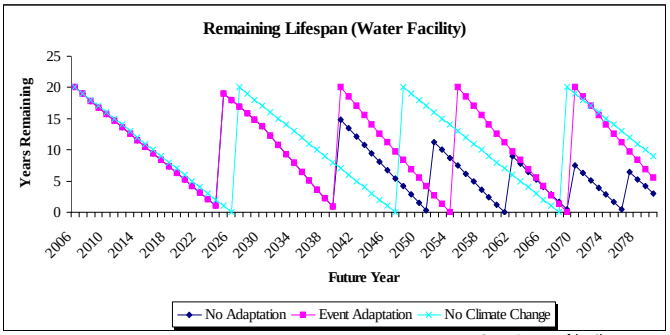
Subclass	Topography	Permafrost Free	Isolated Permafrost	Discontinuous Permafrost	Continuous Permafrost
Courts, Defense, Emergency Services, Energy, Hospitals, Law Enforcement, Misc. Buildings, Schools	Coastal (Exposed)	-5.0%	-5.1%	-5.2%	-5.5%
	Coastal (Protected)	-1.0%	-1.1%	-1.2%	-1.5%
	Interior	0.0%	-0.1%	-0.2%	-0.5%
Airports, Bridges, Grid, Harbors, Railroads, Roads, Sewers, Telecommunications, Telephone, Water	Coastal (Exposed)	-7.5%	-7.6%	-7.7%	-8.0%
	Coastal (Protected)	-1.0%	-1.1%	-1.2%	-1.5%
	Interior	0.0%	-0.1%	-0.2%	-0.5%

Reduction in Useful Life (%) per Inch Increase in Annual Precipitation

Subclass	Topography	Permafrost Free	Isolated Permafrost	Discontinuous Permafrost	Continuous Permafrost
Courts, Defense, Emergency Services, Energy, Hospitals, Law Enforcement, Misc. Buildings, Schools	Coastal (Exposed)	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%
	Coastal (Protected)	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%
	Interior	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%	-5.0% to 0%
Airports, Bridges, Grid, Harbors, Railroads, Roads, Sewers, Telecommunications, Telephone, Water	Coastal (Exposed)	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%
	Coastal (Protected)	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%
	Interior	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%	-7.5% to 0%

- Engineering rules-of-thumb detailing how structures could respond to climate change.
- Assumptions for this component of ICICLE are *very* preliminary.

Assuming Planners Adapt Structures to a Changing Climate

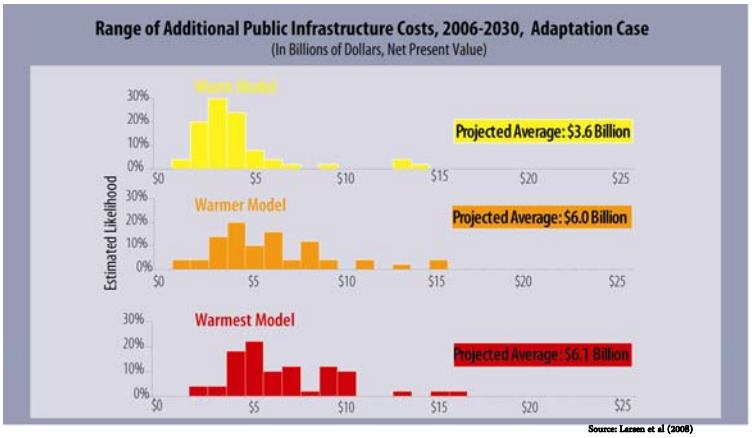


Source: Larsen et al (2008)

- Adaptation algorithm activates when 20% of structure value is damaged from climate change impacts.
- Assumed adaptation cost of +5% above original replacement cost.
- One adaptation scenario considered in this preliminary analysis.

The Nature Conservancy
Protecting nature. Preserving life.

Cost of Alaska's Public Infrastructure at Risk to Climate Change



Source: Larsen et al (2008)

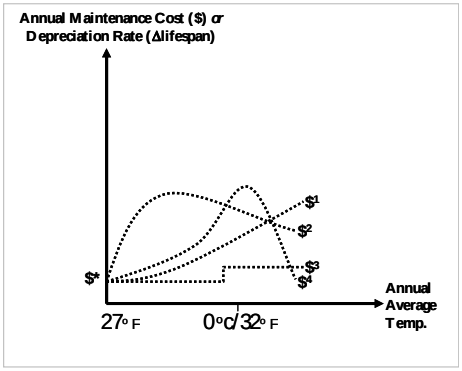
- Additional costs beyond "normal" wear and tear.
- Assumes plausible adaptations will be made.
- Adaptation scenario offsets costs by up to 45% (net) over the long-run.

The Nature Conservancy
Protecting nature. Preserving life.

More Data is Needed to Improve Model Performance

- *Downscaled* data could be used by engineers to develop cost functions relating structural useful life changes to projected environmental changes.

Hypothetical Damage Functions for Fuel Tank Farm on Thawing Permafrost



Building Resilient Communities

- Regardless of climate change, maintaining a database of community public infrastructure is a smart move.
- Consider statistical uncertainty of climate models in your risk assessments.
- Use and document "middle-of-the-road" input assumptions when assessing community risk.
- Assume that climate change is going to negatively *and* positively change the useful lifespan of infrastructure.
- Establish monitoring sites to verify and improve your risk assessment.

Additional Information

- All materials for the economics study can be accessed at: www.iser.uaa.alaska.edu
- Alaska Center for Climate Assessment and Policy (ACCAP): www.uaf.edu/accap/
- The Nature Conservancy: www.nature.org

Questions?