e) The Impact of Extreme Weather Events

Serious weather events are difficult to factor into the calculus of climate change impact because we will never be sure if these events are natural and unusual or due to global warming. The general rule is that with global warming, there will tend to be more extremes of extreme weather. At this point, perhaps the best we can do is to carefully document the extremes of weather that do occur.

The Fairbanks Storm of September 12–13, 1992

The stage was set for this weather event by an unusually cold early September that was recorded as the coldest in 100 years. A 700 mb high-pressure system north of Wrangel Island in Russia set up a northwesterly flow aloft across the Interior of Alaska. By Saturday, September 12, at the surface, a warm front stretched in a generally northwest-southeast line across the Fairbanks hills with a strong moisture-laden southwest flow off of the Bering Sea at ground levels. This flow produced several inches of rain in Minchumina and produced snow further downstream to the east as the flow was forced up over the Fairbanks hills. This resulted in 16–19 inches of snow falling between September 12 and 15, with temperatures dropping to 20˚F.[13]

This storm eliminated power to homes and business in the Fairbanks region for up to a week, as well as 6000 homes in Denali National Park (where three feet of snow fell) and Delta Junction. Wet snow was captured by trees that had not yet lost their leaves. Because of the rural wooded setting of Fairbanks, a large percentage of the Golden Valley Electric Association's 27,000 customers lost power due to the damage caused by wet snow breaking branches of large trees causing, in turn, broken distribution poles and lines, and damaged service drops to individual consumers. Secondly, the amount of snow damage to trees over the roads made road passage almost impossible. Many of the area's rural roadways were of narrow width because the customers preferred the narrow road access for aesthetic reasons. This prevented service vehicles from getting to damaged areas.

Because this storm damage required many individual repairs in adverse conditions, despite the deployment of all available resources, some customers remained without power for as long as a week. As the storm continued through subsequent days, trees continued to break power lines, further hampering the process of restoring service. GVEA estimates that the hard costs of repairing storm damages to their system from this single event exceeded $1M.[14,15]

In 1992, GVEA's consumers experienced an average of 11.16 hours of power outage compared to 1.56 hours per consumer in 1993. Based on these figures, as much as 259,200 outage hours could be attributable to the September storm. A number of studies have attempted to analyze the value to consumers of undelivered power. In a recent benefit/cost study, a GVEA consultant addressed applicable ranges for different classes of customers. The cost for power interruptions to residential consumers ranged from $0.07 to $2.00 per kWh in 1987 dollars. Because of the impact of outages on residential heating systems in Alaska, $2.00 was selected for use in Fairbanks. Industrial values are considerably higher due to interrupted processes, idled resources, and serious safety hazards. The top range for industrial consumers was $69.00/kWh. GVEA's largest industrial customer, the Fort Knox Gold Mine, estimates their cost of power outages at over $16,000 per hour. High values for outage costs for commercial customers range from $195.00 per kWh for office buildings, $23.40 per kWh for retail business, to $2.20 per kWh for institutions. We estimate the total cost of power interruptions to customers from this event at $1M.

If a storm of this scope were to occur during the winter months, when temperatures can dip to -60˚F, the threat to human life and safety would be extreme. There are no emergency plans of GVEA or the Fairbanks North Star Borough that could begin to cope with the situation that would result. While residents in years past often maintained backup heating and lighting systems, the majority of the population today is no longer prepared to be self sufficient in the absence of central station electrical service.

The Flooding of the Villages of Allakaket, Alatna and Hughes on the Koyukuk and Kobuk Rivers, August 18–24, 1994[16]

During the second half of August 1994, a persistent high-level low was located to the northwest of Alaska and a strong high directly in the Gulf. The combination caused a strong southwesterly low-level flow across central and northern Alaska, a flow typical of August. But this August differed in that two troughs rotated about the upper low, causing a deep southerly flow at mid levels into the state that carried Pacific moisture from as far away as the subtropics. This situation caused two extreme rain events in the Koyukuk and Kobuk drainages in northern Alaska on August 15–18 and August 24–27. In addition, several weather fronts moved across the area from the 18th to the 27th, concentrating the rainfall and ending with a cold front.[17]

The worst flooding since the 1930s occurred in the villages of Allakaket and Hughes, both Athabaskan villages, and Alatna, an Eskimo village. Three to six inches of rain over the Kobuk and Koyukuk river drainages was concentrated into the rivers, creating high flood stages which essentially wiped out these villages. The Koyukuk rose so fast that there was little time for evacuation, and people lost nearly everything—including houses, sled dogs, snowmachines, guns, family belongings, and freezers filled with fish, meat and berries.

It was a particularly bad time of year for this event. Hunting was about to start for these largely subsistence villages, and many did not know how they would make it through the winter. Aid poured in from around the state. The Department of Fish and Game collected more than 60,000 pounds of salmon from Valdez Seafood and Peter Pan for relief. The State Game Board extended the hunting season that fall so that subsistence hunts could continue for people returning to the villages. Governor Walter Hickel declared a disaster, calling in the state emergency services and federal disaster relief. The Federal Emergency Management Agency (FEMA) helped to coordinate and fund relief efforts.

The villages were all moved to nearby higher ground by the following spring. The total cost of this disaster was $55M in FEMA funds and $16M in state funds.

As Governor Hickel said: “The uniqueness of the disaster-affected area cannot be overstated. There is virtually no local economy in the destroyed villages. Due to the lack of local resources, an extraordinary burden has been placed on state government.”

f) Impact on Power Transmission Lines and Hydroelectric Installations

Within the State of Alaska, there are approximately 1800 miles of high-tension long-distance transmission power lines. These are located in the interior, central and southeast parts of the state. Within the energy supply to the state, there are 25 hydroelectric facilities, which supply 26% of the distributed power. Weather affects these facilities directly and steps must be taken to ensure their maintenance.[18,19]

The cost of maintaining power lines in Alaska is about $.002/kWh of transmitted power (or two mills). If we realize that the cost of power may be somewhere around $.10/kWh (or 100 mills) then the cost of power line maintenance is about 2% of the total power cost. In Alaska about five billion kWh of electricity is sold per year for a total of $500 million with $10 million spent for maintenance. Maintenance costs will increase with the increase in extreme storm events that affect the power lines. Improvements could include engineering structures that are more robust and establishing smaller span lengths.

Extreme weather events can also affect hydroelectric installations above and beyond the normal long-term prediction of rates based upon adequacy of water supply. Climate scenarios indicate that high latitudes may expect greater hydrological activity associated with global climate change (i.e., more rain). Additional inspections of hydroelectric installations would be required for items such as plunge pools, drains, slides and the increased monitoring of dams and streams connected with those facilities. These are Federal Energy Regulatory Commission (FERC) requirements and the cost would be $50,000 per year for each affected facility. This amounts to a total inspection cost to Alaska of $1.25M.[20]

Aside from these FERC inspections, global climate change has not been a factor that industry has considered a priority in their planning. In the case of extreme events, industry usually looks to the federal government for assistance. If industry, however, were to bear the cost of weather changes directly it might start planning for them.

g) The Impact on Ocean and River Systems in Alaska

The land is not the only locus of impact due to global climate change. Important ocean barge and river transport exists in-state for transport to the oil fields of the North Slope and rural Native villages. Contrary to our other examples, warming may be beneficial to barge ocean and river traffic by reducing near-shore ice in the Bering and Beaufort Seas. On the other hand, many of the very low-lying islands and near-shore fixed communities such as Shishmaref and Kivalina on the Yukon-Kuskokwim Delta are now at serious risk due to thawing of underlying permafrost and the impact of storm surges that require a large fetch and are more prevalent now with the reduction in near-shore ice.

Crowley Marine Barges to the North Slope[21]

Since 1968, convoys of barges have plowed the northern seas of Alaska to deliver supplies, workers, equipment and modules for construction on the North Slope. The barges originate in the Gulf of Mexico, the West Coast, Seattle and Anchorage and travel across the Gulf of Alaska into the Bering Strait, around Pt. Barrow and into Prudhoe Bay. The choke point in the trip is Pt. Barrow, because although the Bering Sea may be ice free early, the Beaufort Sea does not become passable until July. The captains get to the west of Barrow by the end of July, wait for the Beaufort ice to clear, and then push on to Prudhoe Bay, a distance of some 185 miles. Unloading cargo requires some two or three weeks and their return trip is set for the first week in September.

Offloading takes place at 3 or 4 docks at Prudhoe Bay and Kaktovik. Small shallow draft tugs take the barges from the deep-water tugs and shift the barges to the shallow draft docks.

Since 1968, 324 barges carrying 1,226,477 tons of material have landed at Prudhoe Bay, with the largest haul of 47 barges occurring in 1975 at the peak of North Slope oil field and pipeline construction. If, as happened in 1975, barges get stuck in the ice around Pt. Barrow, material is trucked up the alternate route of the Dalton Highway, a gravel road running north from Fairbanks to Prudhoe Bay. From 1995–1998 no sealift was run. In 1999, there will be 6–7 barges. Each tug pulls one or two. An ice-strengthened vessel or icebreaker is available during transit to break ice. (See Figure 7).

The meteorological and oceanic variables that most concern the captains and Crowley Marine Services that run the sealift are:

- the existence of multi-year pack ice from the north in the Arctic Ocean that drifts south and chokes the traffic around Pt. Barrow,
- the formation of ice in leads, and,
- high seas, which may occur with wind as well as storms, and particularly when there is no sea ice cover to negate the effect of the long fetch.

Further controlling variables are average temperatures in western Alaska during the previous winter, and the strength and position of the Aleutian Low, further to the south, which governs the path of storm tracks into the Bering Sea—when the Aleutian Low is located in a more northerly position in

Sealift History, 1968–1999				
Year	Number of Tugs	Number of Barges	Date of Arrival at Prudhoe Bay	Tonnage
1968	[illegible]	2	08/12/68	5,529
1969	5	11	08/01/69	25,000
1970	13	35	08/09/70	163,000
1971	4	8	08/16/71	16,822
1972	3	2	08/16/72	6,182
1973	4	8	07/29/73	20,006
1974	8	16	08/3[illegible]/74	65,[illegible]
1975	21	47	09/0[illegible]/75	154,130
1976	[illegible]	21	08/[illegible]/76	54,[illegible]
1977	10	7	08/09/77	15,7[illegible]
1978	2	10	07/31/78	59,555
1979	10	[illegible]	07/30/79	7,084
1980	5	10	08/15/80	44,941
1981	7	14	08/31/81	55,[illegible]46
1982	8	15	08/14/82	49,050
1983	12	26	08/13/83	96,135
1984	6	11	08/03/84	50,189
1985	7	13	08/23/85	46,150
1986	14	22	07/31/86	103,153
1987	3	5	08/13/87	27,052
1988	0	0		
1989	2	3	08/04/89	6,675
1990	3	-	08/05/90	25,881
1991	1	1	08/25/91	2,200
1992	0	0		
1993	2	1	07/28/93	6,421
1994	2	2	08/07/94	22,895
1995	0	0	-	
1996	0	0	-	-
1997	0	0	-	-
1998	0	0	-	-
1999	[illegible]	unknown	unknown	unknown

Figure 7. Matrix showing the numbers of barges transported to the North Slope since 1968.

the Bering Sea, it blocks the passage of storm tracks to the north through the Bering Strait and deflects them into a trajectory across the Gulf of Alaska.

The impact of warming on the extent or seasonal variation of sea ice may, in some cases, be beneficial to barge traffic and river travel and lead to an economic gain for certain businesses. Fewer delays in ship passage through open leads around the western and northern coasts of the state, and a shortened season of ice cover in the open ocean and up along the rivers, are all conditions that benefit commerce. For these reasons, we place a damage cost of $0 associated with the impact of global climate change. However, there are some disadvantages: a longer season of damaging ocean storms and coastal erosion would be particularly hazardous for low-lying villages. This means increased costs for village relocation by the state. The effects of sea level rise or biological effects due to disruption of travel and feeding of marine mammals will not be discussed in this report.

Examples of Potential Costs of Global Climate Change Effects

1.	Permafrost Effects on Road Building and Maintenance	$7–12M/yr
2.	Loss of Ice (Winter) Roads	$1–3M/yr
3.	Extreme Weather Events (1992 storm, 1994 flooding)	$77M
4.	Hydroelectric Dams and Electrical Transmission Lines	$12M/yr
5.	Coastal Ocean Barge Transport and River Transport	$0

Based on these limited examples, the yearly cost for damages due to global climate change for the State of Alaska could be as high as $35M, or 1.4% of the total state budget. This is a significant cost. It is very similar to the state and federal costs for fire fighting each year; it represents a sizeable fraction of the state's capital projects budgets of around $70M; it is about equal to the budgets of the Department of Fish and Game at $34M and the Department of Natural Resources at $40M. It exceeds by a large amount the budgets of individual State agencies such as the Department of Law, $27M; Department of Environmental Conservation, $12M; and the Department of Labor at $8M. If the costs due to global climate change grow in future years, and if the state acknowledges cost for climate change on its budgetary balance sheets, these costs, which cannot be avoided, will seriously cut into other standard state programs with serious consequences for state fiscal policy.

This concludes the enumeration of some of the dollar values of recent impacts of global climate change in Alaska. Since we cannot be sure at this time to what degree climate change really has changed the weather, we present the examples of weather events as a worst case scenario—as if all damages since 1992 had been caused by climate change.

Conclusions

We have analyzed six statewide examples of climate change impact on Alaska's economy and attempted to put a price on their cost. Based on these examples, the cost for damages due to global climate change for Alaska could be as high as $35M per year. This value is roughly equal to or exceeds the yearly budgets of at least five individual State agencies—Fish and Game, Natural Resources, Environmental Conservation, Law, and Labor.

Alaska stands in a unique and perilous position with respect to the threat of global climate change. If warmer weather prevails, the smallest Alaska Native communities will confront a transportation and subsistence revolution: their winter ice roads, dogsled trails, frozen river beds, solid near-shore ice, even skiplane landing pads will become short-season phenomena or totally disappear. Perhaps these villages will become pioneers of new, less expensive hovercraft bus routes or new power generation technologies.

In the past two centuries we have solved technological problems and transformed the world in wonderful ways. But many of these improvements to life have cost a little each time, as we have continued to add CO_2 to the finite envelope of air surrounding our planet. Although global climate change started out as a narrowly defined problem in geophysics, the solution to it now requires a broad multidisciplinary effort that must embrace a greater range of stakeholders: science, business, Native communities, government, nonprofits and the public, to create a unified forum for debate and discussion, to propose, model, and test workable strategies and, finally, to take the actions needed.

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