Rapid Landscape Changes, Their Causes, and How They Affect Human History and Culture

Antony R. Berger

Abstract: Despite common knowledge about harmful natural processes and disasters, there appears today to be a widespread belief that somehow if only people would be less destructive in their behaviour with respect to the environment, natural systems and landscapes would remain unchanged—static and immutable. Yet there are many landscape changes that can be readily seen within a normal human lifetime, and the record of past environments provides clear evidence that rapid changes occurred in many places. Variations in climate are one cause, but there are other "drivers," too, such as volcanic eruptions, coastal erosion, floods, fires, and earthquakes. Although abrupt changes prior to the mid-Holocene are primarily of non-human origin, the current warming in the Arctic appears to be largely human-induced. However, sorting out human from non-human drivers is not an easy task. Environments and ecosystems around the planet are clearly under stress from human activities, but even when left alone natural landscapes by and large are not static and fixed. The story of landscape change in the North is being refined by paleoenvironmental science through fossil remains, lake sediments, ice cores, tree rings, ground temperature profiles, and by archaeology and ethnography. It is also told through the cultural narratives of Indigenous peoples, which speak of ancestors and how they lived. When integrated with the recent findings of science, even shadowy recollections of landscape changes in the distant past may yield information as to how people reacted. Such insights could serve to influence the way people today think about history and about nature, and might even provide perspectives to help cope with environmental change in the coming years.

Introduction

Rapid landscape change in the Circumpolar North region exemplifies many contemporary key issues: extraordinary departures from the average, surprise and unpredictability, importance of the local scale, and the value of insights of local people. Many different research projects are helping to shape

our understanding of the many ways that landscapes change and how these changes affect human behaviour. As it seems clear that we are now entering a time of extraordinary climatic and ecological change (Steffen et al. 2004), it may be helpful to puzzle out the effects of past rapid events and the ways in which people adapted to them. History is full of examples where societies and settlements failed or were harmed when faced with environmental change (e.g., Issar and Zohar 2004, Diamond 2005). Human-induced change is obvious and of profound importance, but recognizing more clearly the role of non-human causes of many environmental changes might make a difference in the way people think about the world around them, and in the kinds of policies adopted to deal with change.

Northern insights into these issues are likely to come from the First Nations, the Dene, the Inuit, Inuvialuit, Inupiat, and other northern peoples, and especially from the history of their ancestors who, over the millennia, must have had to adjust their way of life to many changes in climate, landscape, and ecosystem. These certainly influenced the way in which the earliest peoples spread out across the Arctic and Subarctic, and even southward. Now their descendants again face rapid environmental change, this time linked at least partly to human-driven climate warming, in which the Arctic is the vanguard. Moreover, whatever their ancestry, the experience of local peoples ("community knowledge") is likely to be relevant when puzzling out environmental risks and causes.

Scientific studies of the environments and ecosystems of the Holocene provide the baseline record of biophysical change. A window to past human history and behaviour comes from archaeological and ethnographic research, for if we are now moving quickly into a period of rapid climatic and environmental change, there may be lessons for the near future from the record of past events and their impacts on people. The challenge is to extend such insights into the deeper realms of time, beyond the memories of those now living, or their parents and grandparents, but not, perhaps, beyond the reach of cultural traditions, beliefs, attitudes, and practices (Cruikshank, 2001).

The Time Scale of Landscape Change

Earth science deals generally with "deep" time, working to unravel the geological development of the Earth, and now other planets, over hundreds and even thousands of millions of years. Of more immediate relevance is the other end of the temporal spectrum—"shallow" time—on two broad scales. One scale deals with changes over the past 10,000 years or so, the Holocene, while the other concentrates on more rapid events of the past century or two.

The old uniformitarianist principle that the present is the key to the past has often been interpreted in terms of gradualism, in which earth processes work slowly and pervasively. This is certainly true for plate tectonics, mountain building, and basin formation and deposition, but there are also sudden, sometimes catastrophic, events that can be observed during a normal human lifetime, and certainly within one hundred years—earthquakes, eruptions, floods, landslides, surface subsidence, and glacier advances and retreats. A convenient summary of such changes can be found in the geoindicator concept (see Berger and Iams 1996 and www.geoindicator.org).

Sophisticated computer models show that climate change is likely to be especially marked in Alaska and the Western Arctic; current conditions bear this out. However, models deal with average change and not with the extraordinary events that are so important on a local scale. Extreme events generally involve surprise. Thus understanding climate change requires consideration of many temporal and spatial scales, present and past, global and local.

Despite the evidence of rapid change, there are many places where landscapes have changed little in thousands of years. In the Arctic, some pre-Dorset house sites near beaches, for example, have remained undisturbed on the surface for between four thousand and five thousand years. But elsewhere the land changes: coasts erode, inland rivers switch channels and migrate, glaciers surge and melt, slopes fail, and floods occur and re-occur. Many of these changes can be seen in the Arctic and Subarctic today, as on Herschel Island and at Shishmaref in Alaska (Kolbert 2006). Although I concentrate in this article on the harmful effects of rapid change, there are many examples where change has been advantageous, as when a coastal storm deposits sediment to create new land.

Causes of Abrupt Change

Rapid changes in mean temperature of as much as ten degrees Celsius or more have occurred repeatedly throughout the Quaternary (about the last two million years) (Alley et al. 2003, Weart 2003), each leading to a longer period of steady temperatures. What pushed the annual average regional temperatures, preserved by proxy in the ice of Greenland, up some seven degrees Celsius over a decade or so is not fully known, but there are a range of possible causes, from solar radiation forcing, to albedo feedback and ocean circulation patterns.

A picture has recently emerged, from ice cores, lake sediments, and ground temperature profiles in the North, of much shorter episodes of rapid change, which have affected ecological and socio-economic systems. Some

of these changes can result from non-climatic events such as earthquakes and volcanic eruptions (see table 1), and there can be feedbacks to local or even global climate systems. For example, volcanic emissions from the 1991 eruption of Pinatubo in the Philippines altered, for a brief period, global atmospheric circulation patterns and induced a temporary cooling (Pinsker 2002). The Storegga submarine slump off the Norwegian continental shelf 7,300 years ago led to a catastrophic tsunami with run-ups of at least twenty metres on land in the northeast Atlantic (Bondevik et al. 2003), and of course there was the earthquake-driven Indian Ocean tsunami of December 26, 2004. Even under a stable climate regime, there are weather extremes such as hurricanes and cyclones that can cause rapid changes along coasts, in river valleys, and on steep hillsides. Likewise, there are background hydrological processes that transport sediment in rivers, or that dissolve soft rocks underground causing surface subsidence. These smaller, but far more common, landscape changes rarely capture public attention and are virtually ignored in public discourse. They hardly fit into the catastrophe theme so popular today in policy discussions and the media (e.g., Diamond 2005, Posner 2004).

The condition of the environment at any time reflects not only the natural processes that can be viewed as running in the background, but also the human influences. Industrial, urban, and agricultural activities certainly have direct impacts on the environment, and these influences generally become more marked as populations increase and economic growth proceeds. Away from obvious sources of disturbance (e.g., towns and cities, waste disposal sites, mines, farms, forest harvest areas), however, it may be extraordinarily difficult to separate even the direct effects of human actions from those due to natural processes. Moreover, in remote and less populated areas there may be indirect, far-travelled human influences, such as the long-range aerial transport of acid and toxic contaminants now affecting many people in the Arctic (Einarsson et al. 2004). Despite many efforts to do so, there remains the difficulty of separating predominantly human-driven change, both direct (e.g., via overhunting) and indirect (e.g., via the human component of climate warming), from non-human natural change (e.g., volcanicity, climate fluctuations, floods, and coastal erosion and deposition).

Table 1. Rapid landscape changes that can occur when climate is stable

	Changes
Water	Surface and groundwater quality, groundwater level, karst activity (sub-surface dissolution)
Hazards	Earthquakes, eruptions, landslides, avalanches, floods, surface subsidence
Rivers	Streamflow, sediment movement and storage, channel migration
Lakes	Levels and salinity
Coastal	Shoreline movement, relative sea levels
Arid Lands	Dune movement, dust transport, wind erosion
Soils	Texture, quality (e.g., fertility), erosion
Cryosphere	Glacier advance/retreat, frozen ground activity
Wetlands	Areal extent, hydrology

Indigenous Knowledge

Are there ways to gain insights from past climatic and non-climatic landscape change, of which ancient peoples would have been very much aware and to which they would likely have reacted in some way? Did they adapt and remain where they were? To what extent did such changes force migration as people sought places more amenable to their way of life, to survival? Are the changes remembered today in story and tradition, or revealed through traditional ecological knowledge (TEK), or Indigenous science, as it is sometimes called by those who record and interpret local observations of today's weather, wildlife, and vegetation (e.g., Fox 2003, IISD 2000, Ashford and Castledean 2001, Krupnik and Jolly 2002)? Are there any lessons for the Circumpolar North region or for people elsewhere facing rapid environmental and climate change? Does the long history of successful survival in the Arctic hold insights for coping with global change elsewhere?

The answers to these questions might throw light on what is a very modern problem—survival in a world of increasing natural hazards and climate change where a dominant vision is that of sustainability. The Arctic Human Development Report (Einarsson et al. 2004) sees many northern cultures as vigorous and likely to remain so, despite what outsiders see as destructive changes. Others think that the current changes in the environment may be starting to challenge the collective ability of northern peoples to adapt (Berkes 2002, p. 339). Regardless, it can be argued that past

waves of migration across the Arctic on a longer time scale were profoundly affected, if not driven, by climate and by changes in land and ice distribution (Schledermann 1996), though McGhee (2007) emphasizes the importance of changing trade patterns in the way ancient peoples moved from place to place in the North.

There is a flood legend among some Inuvialuit, in which a barren land was transformed into one of lakes, rivers, and plentiful fish and game. The cause was a sealskin bag full of water that grew and grew until the hunter who found it began to get worried and warned his neighbours. He built a large raft and on it a cabin, and so was able to escape when the bag burst flooding the land and drowning the other people (Alunik et al. 2003, p. 15). This story is certainly pre-European and pre-Christian in origin, and recalls the flood legends of many other cultures. It seems hard to deny that these stories might reflect actual experience with huge floods or even, perhaps, tsunami.

Cruikshank (1998) reminds us that oral histories have social contexts that are ever changing. "Meaning is not fixed" like in the Bible or the Q'uran. As stories are told and re-told they gain a kind of "social life" of their own. "An enduring value of informal storytelling is its power to subvert official orthodoxies and to challenge conventional ways of thinking. Such systems of knowledge … can be understood as having the power to inform and enlarge other forms of explanation rather than as data for analysis using conventional scholarly paradigms" (p. 13). A leader of the Russian Association of Indigenous Peoples of the North recalls asking his grandmother why she had not told a visiting scientist the same story she had been telling him since his childhood. "He's a foreigner," she explained. "He's not in a position to ask me such questions. But he'd come from so far away I had to give him some sort of answer" (Guardian Weekly, Dec 17–23, 2004, p. 17).

Interviewing First Nations women, Cruikshank (1998, p. 45–6) records that "although my initial concern was that they were narrowing our focus by insisting on the primacy of traditional stories, it became clear as we continued working together that they were actually enlarging our project." To a gathering of historians in the Yukon in 1982, Mrs. Annie Ned, a Southern Tutchone elder, asked: "Where do these people come from, outside? You tell different stories from us people. You people talk from paper—Me, I want to talk from Grandpa." So she spoke about many things, including how early caribou migration routes were disrupted when glacier-dammed lakes emptied "catastrophically into the Alsek River valley," and about trade between coast and interior (see also Cruikshank 2001).

The resolution of climate and rapid landscape change issues by conventional scientific methods may be intractable. This is partly because the social and physical sciences, with their fixed disciplinary boundaries, have difficulty in dealing with so-called "wicked problems," which have no clear definitions and no test for a solution (Ludwig quoted by Berkes 2002, p. 337). Such a problem occurs where it is necessary for a wide range of researchers to interact with local people to define the issues and to seek resolutions. Where the local people are Indigenous, as in the Arctic and Subarctic, there is the further requirement for researchers to deal with traditional knowledge. There is also a need, as Cruikshank (2001) points out, to advance and communicate knowledge that gives weight to local understandings as well as to Western science. There is the further consideration that rapid landscape changes now occurring may have no historical counterpart, as in the case of industrial contaminants transported from the south.

How Long Does Memory Last?

A key question is how long collective memory as expressed in oral traditions can last. Some ethnographers think that several hundred years is an upper limit, at least in the North, though Moodie and others (1992) argue that the Athapaskan tradition, which speaks of a huge eruption, had its origins in the White River volcanic eruption some 1,300 years ago. Others argue that many so-called myths and legends around the world have their basis in actual natural events that took place as much as 5,000 years ago (Barber and Barber 2004, see also Blong 1982).

Some large-scale catastrophes are enshrined in long-lasting myth, legend, and narrative perhaps because they offer a reason ("bad behaviour") for natural disasters. For example, there are ancient stories from the Swiss Alps of large destructive rock falls that were viewed as God's punishment for mistreating animals (M. Grosjean and C. Pfister, pers. comm. 2005). The destruction of Pompeii may not have been regarded as punishment for loose living, but the great Lisbon earthquake and tsunami of 1755 certainly was explained thus by contemporaries (de Boer et al. 2005).

Many lives were saved on the Indonesian island of Simeuleu (off the northwest coast of Sumatra) after the December 2004 earthquake in the Indian Ocean because people there had kept alive the memory of past huge waves and escaped by immediately heading to higher ground. Perhaps in the distant past people also learned from a catastrophic event how to take appropriate measures, and these lessons then entered tradition. As time passes, although the source of the tradition might become lost in the collective

memory, the society continues to act appropriately because the traditions are not questioned or challenged.

A Range of Responses

The main choices for those who survive severe and rapid landscape change are relocation to a new place nearby, migration to new territory, or eventual return to the homeland, adapting as required to new conditions. A return to home territory affected by natural disasters is quite common. This is evident today in the coastal zones of Sumatra, Sri Lanka, and Thailand, as fishermen and townspeople re-build on the coastal plains swept by the tsunami of 2004. The reasons are easy to understand—a need to return to traditional way of earning a living (e.g., fishing), a lack of other places to settle, a strong attachment to the (only) land they own. A return to risky land today may also be related to poverty, to ownership—it is their land whatever the condition—or simply to acceptance (or ignorance) of risk and vulnerability. Indeed, abrupt landscape changes can be especially harmful to firmly established and relatively immobile societies, and to modern built environments such as cities.

In advancing understanding of human responses to rapid change, it might be helpful to develop a typology or classification of abrupt change and human response. In addition to those discussed recently by Diamond (2005), potentially useful case studies might include the following:

- the reaction of early peoples in the Arctic to post-glacial landscape change;
- the ways in which successive early Chinese dynasties coped with the dynamic Yellow River system and its repeated floods and channel switches (Zheng et al. 1998);
- the collapse of the Moche society, in what is now Peru, when their intricate system of canal irrigation was disrupted by neotectonic movements (Moseley 1999);
- the changes in glaciation and precipitation that controlled human development in the Tien Shan region of eastern Siberia (Aubekerov et al. 2003);
- the way Bangladeshis living on islands and sand bars in the Ganges, Meghna, and Brahmaputra rivers respond to frequent flooding, erosion, and deposition (Sarker et al. 2003); and
- the reaction of people living along the shores of the Caspian and Aral seas to frequent changes in shoreline position (Goudie 2002, Nihoul et al. 2004).

Thinking About Rapid Change

Everyone knows, either from direct experience or from the media, about earthquakes, floods, and landslides, yet there appears to be a widespread belief that somehow if only people would be less destructive in their behaviour towards the environment, natural systems and landscapes would remain relatively unchanged, even static and immutable. The graphic evidence of coastal regions transformed by the Indian Ocean tsunami and by recent hurricanes in the Gulf of Mexico is a reminder of the destructive power of nature. Nevertheless, the ideal of a bountiful, peaceful, and balanced natural world prevails.

At the heart of the new environmental ethic is the idea that landscapes endure unless disturbed by people. A few years ago, Prince Charles attributed the storms and floods then ravaging Britain to the result of humanity's "arrogant disregard of the delicate balance of nature" (Guardian Weekly, Nov 9–15, 2000, p. 9). In the Outer Hebrides, a current plan to install a bank of giant windmills has met with opposition on the grounds that "irreplaceable landscapes" are "being hastily sacrificed in the name of clean energy." In an impassioned polemic against the wind farm, Macfarlane (2005) contrasts the care with which great landscape paintings are protected and thus endure, with landscapes, which would also last were it not for human intervention. He comments that "language and even a people may go, but the land was immutable, a last and lasting bastion for human sanctity and belonging" (2005, p. 5). Here is Nature as stable, benevolent, and predictable.

This is not a new attitude. Early Chinese societies were mainly located in river valleys (the Yangtze, Yellow, Wei) where flooding was common. Yet one of the great classics of thought that emerged from this period, the Dao De Jing, states that "water is good; it benefits all things and does not compete with them … The goodness of water is goodness without qualification; it is a goodness unlimited by evil" (Chan 1963, p. 113; see also Allan 1997). Not only are the glories of nature widely praised in song and poem and the disvalues commonly ignored (Rolston 1992), save where large-scale disasters are involved, but there also are some rather surprising gaps. It is remarkable, for example, that the sagas of Iceland, one of the world's longest historical archives extending for some 1,000 years, contain so few references to volcanic eruptions and earthquakes, despite the scientific evidence that there were in this period a number of major events that affected both land and weather.

Recognizing more clearly the role of non-human inputs to abrupt environmental change might make a difference in the way people think about the world around them and in the kinds of policies that are adopted

to deal with change. Philosophers of the environment commonly reflect on how people's values and beliefs influence their behaviour towards the environment. This modern question can be turned around by asking how is it that the natural environment influences people's actions and behaviours? The dichotomy between what the public seems to believe, and what scientific research and Indigenous narrative reveal about the persistence in time of rapid natural change, challenges notions of a sustainable world in which natural, as well as human, systems persist (Berger 2007).

Final Comment

Though there are many outstanding questions, a full history of environmental and human events in the North over the past 10,000 years continues to emerge, and there is growing recognition of the importance of natural events in shaping human lives. Nevertheless, there remains the enormous challenge of persuading governments and environmental agencies to strengthen efforts to unravel the record of past changes, to track what is taking place now in northern regions, and to learn from the peoples of the North who have long been witnesses to and survivors of a changeable landscape.

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Author

Antony R. Berger is an adjunct professor at the Institute for Environment and Development at the National University of Malaysia, and at Sir Wilfred Grenfell College, Memorial University of Newfoundland and Labrador.

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