INDICATOR
#13

Appearing and disappearing lakes in the Arctic and their impacts on biodiversity

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Arctic Canada Oksana Perkins/iStockphoto

The Arctic contains a variety of types of lakes but overall, it is thermokarst lakes and ponds that are the most abundant and productive aquatic ecosystems in the Arctic [1]. They are found extensively in the lowland regions of western and northern Alaska [2], Canada [3, 4] and Siberia. These (i.e., thaw) lakes are most commonly formed by the thaw of ice-rich permafrost, which leads to the collapse of ground levels and ponding of surface water in the depression [e.g., 4, 5]. Continued thawing of the permafrost can lead to the drainage and eventual disappearance of these lakes, as can erosion and lake coalescence [e.g., 4, 6].

Thermokarst lakes act as "hot spots" of biological activity in northern regions, with abundant microbes, benthic communities, aquatic plants, plankton, fish, and birds [1]. Such biologically productive systems are also of direct importance to Arctic peoples for supporting traditional indigenous lifestyles providing water for rural/urban communities and development, especially where groundwater resources are unavailable [7].

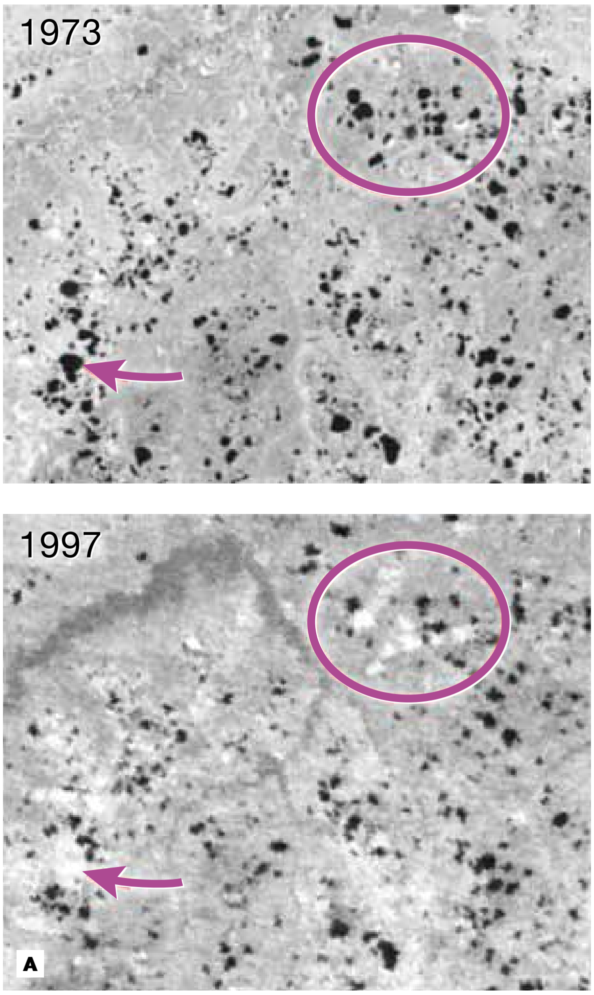
Thermokarst lakes are also important because of greenhouse gases emitted at scales large enough to create significant feedbacks to the global climate system. When draining, organic matter decomposes and releases carbon dioxide to the atmosphere [e.g., 8, 9], while their growth can result in methane emissions through higher lake productivity [e.g., 10]. Thermokarst lake formation or drainage can also cause changes in vegetation through radiative feedbacks [e.g., 11, 12, 13], and such changes in vegetation are important to the "greenness" of the Arctic [e.g., 14, 15] (see also Indicator #11 – Greening of the Arctic).

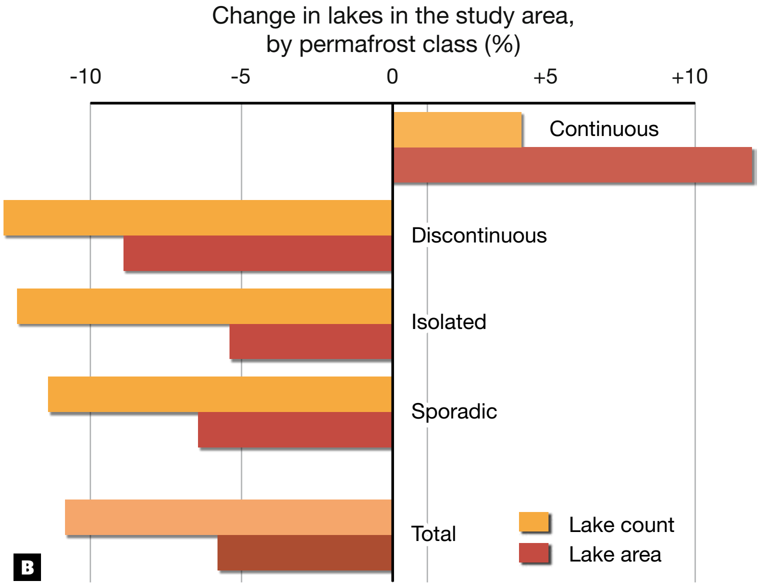
While having an effect on climate, the behavior of thermokarst lakes is also strongly controlled by climate. Due to their wide Arctic distribution, thermokarst lakes have the potential to be a useful indicator of climatic changes that are occurring in high-latitude regions.

Population/ecosystem status and trends

Drainage and appearance of thermokarst lakes is a relatively common occurrence as described by the "thaw lake cycle" [5]. Research is now trying to determine whether the warming air temperatures observed in northern regions are affecting patterns of lake disappearance and appearance, as well as affecting changes in lake area. Whilst the direction of some of the trends remains unclear, there seems to be general agreement of a net decrease in the number of thermokarst lakes over the last fifty years, although not for all regions.

Historical observations of thermokarst lakes in different regions, primarily conducted over the last five to six decades, show both increases and decreases in lake area and number. On northern Alaska's Barrow Peninsula, for example, there has been a slight decrease in total lake area and number over the last 25 years of the 20th century in the continuous permafrost of the Arctic Coastal Plain [6]. Many of the lakes drained completely but for reasons which were unknown in many cases, although the role of intentional or inadvertent modification by human activity was also noted to be a significant factor. In the discontinuous permafrost of the Alaskan boreal forest, there have been reductions in lake area and decreases in lake numbers for the period 1950–2002 [16]. In Siberia, there has been an overall net decrease in lake area and number since the 1970's [17], although increases were observed within the northern continuous permafrost, and





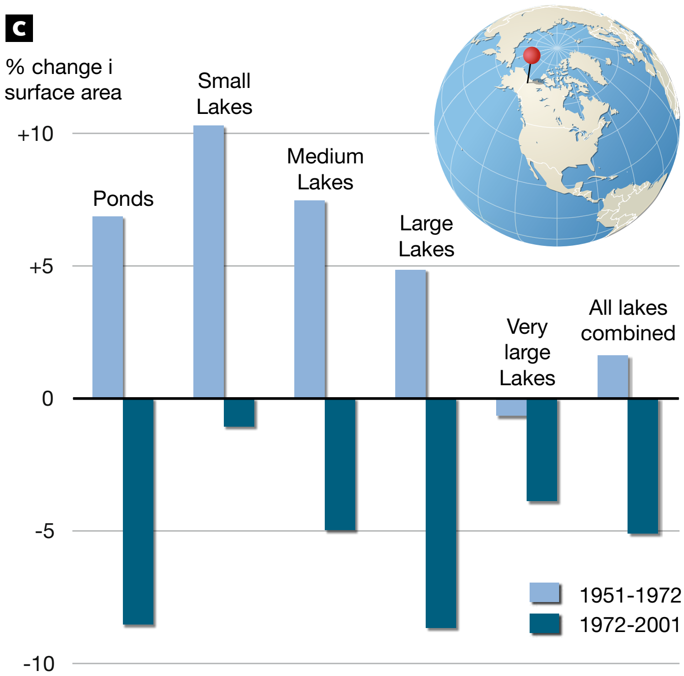


Figure 13.1: (A) Total lake abundance and inundation area have declined since 1973 including permanent drainage and revegetation of former lakebeds (the arrow and oval show representative areas). **(B)** Net increases in lake abundance and area have occurred in continuous permafrost, suggesting an initial but transitory increase in surface ponding [17]. **(C)** Percentage change in surface water area for ponds and lakes, 1951–1972 and 1972–2001 in Old Crow Basin, Canada [20].

decreases only seen in the more southerly discontinuous, sporadic, and isolated permafrost zones (Figure 13.1.A and B). Increases are believed to be due to the effects of surface permafrost thawing whereas the decreases are due to drainage, possibly related to taliks, areas of unfrozen ground in permafrost, completely penetrating the permafrost into the underlying groundwater system.

In northwest Canada, where ground ice content is high, thawing and erosion of drainage channels has resulted in a catastrophic drainage of lakes [18, 19]. In the Old Crow Flats, Yukon, the overall surface area of water decreased 1300 ha (3.5%) from 1951 to 2001 (Figure 13.1.C) [20]. Most large lakes decreased in extent over this 50-year period while small ponds increased. The changes were due to a number of effects that include sudden lake drainage through the collapse of permafrost, and an overall drying trend from hotter summers in recent years.

There is also concern about the rates of change, particularly during the most recent period of Arctic warming that has caused some abrupt increases in permafrost degradation [e.g., 21]. However, such information is sparse and what is available is not spatially consistent.


Barrow Point, Alaska, USA George Burba/iStockphoto


Yamal Peninsula, Russia Peter Prokosch

Concerns for the future

Given the ecological importance and role in climate-feedbacks of thermokarst lakes, significant concern has been raised about their future in a changing climate [22–24]. Thermokarst development has been linked to changes in climatic variables – particularly air temperature (summer and annual) and winter snow depth, both of which are likely to see further, significant increases at high northern latitudes [e.g., 25]. As a result, appearance of thermokarst lakes in continuous permafrost regions and disappearance in the discontinuous permafrost zone is likely to become a more common occurrence given future climate-change scenarios. The situation could be exacerbated in coastal plains where rising sea levels and related erosion could enhance thermokarst lake drainage [e.g., 26].

Such habitat shifts will affect local aquatic populations, as well as having other wide-ranging effects on transient species such as waterfowl. Although these are expected to flourish with the formation of new thermokarst lakes in the continuous zone [e.g., 27], the effect of large-scale regional changes in lake availability on their migratory patterns is unknown. The water quality of growing or newly formed lakes is also likely to be increasingly affected by changes in the adjacent permafrost landscape as it progressively thaws and degrades [e.g., 28–31]. Complex changes in vegetation regimes are also likely to result from the appearance/disappearance of thermokarst lakes; the suite of changes further complicated by the northward movement of vegetation types that will accompany climate change [e.g., 32]. Lake appearance and drainage may increasingly affect the traditional practices of the indigenous peoples in the region as well, particularly where they are used for subsistence fisheries or small mammal harvesting [33–35].

In general, the appearance and disappearance of thermokarst lakes could be used as an indicator of climate warming and the associated effects on permafrost in northern regions. However, more research about the processes controlling their formation and loss in different permafrost regimes is still required to be able to make robust links to changes in climate. Furthermore, more studies need to be conducted at broader regional scales that span permafrost zones and at finer temporal resolution to be able to accurately define spatial patterns and rates of changes.