Alaska Geobotany Center 2020 Calendar
Greening of the Arctic

By Skip Walker

Happy New Year!

This year's calendar photos were taken from around the Arctic in the last 20 or so years during various expeditions. I've picked photos that tell a piece of the story about how the Arctic is generally greening as temperatures rise. Sometimes the story is not obvious from the photos, and with Mimeo, the software I used to make the calendar, I didn't see a way to make captions to help explain, so please keep this handout with the calendar to provide some insight to the photos. There are a few scientific references at the end that provide more details.

Cover:

The title of the calendar, "Greening of the Arctic", comes from our International Polar Year 2007-2008 initiative that generated several projects up to the present that examine the circumpolar patterns of Arctic vegetation greenness in relationship to sea-ice retreat and warming land temperatures.

The best evidence of the circumpolar changes to vegetation comes from satellite sensors that can measure the greenness of the land surface with the Normalized Difference Vegetation Index (NDVI), which could also be called the "greenness index". The NDVI has increased over most of the Arctic since records began in the 1980s.

The photograph shows two muskoxen feeding on tall willows and fireweed along a buried section of the Trans-Alaska Pipeline in the Arctic Foothills of the Brooks Range, Alaska. The pipeline warms the soils and increases plant productivity, providing an analog of what may happen more broadly as the tundra warms over larger areas due to climate change.

January: *Hayes Island, Frans Josef Land, Russia (80˚37'N, 58˚03'E), mid-August 2010.* This area has some of the coldest summer temperatures in the Arctic. The mean July temperature is 1˚C (33.8˚ F). Most of land masses in FJL are glacier covered — as on the islands in the background. Snow still lies in all the stream channels. The land looked pretty barren from a helicopter after a 10-day journey by a Russian ship. We heard from the ship's crew that we were wasting our time if we wanted to see vegetation. So, we initially thought the dark areas were mainly black soils derived from volcanic basalts, which are common in much of Frans Jozef Land. Ha! (See next month for the rest of the story).

February: *Hayes Island, Frans Josef Land, Russia, mid-August 2010.* The soils of Hayes Island are covered in vegetation — mostly small cushion plants, lichens, and mosses. Much of the black soil (see January photo) turned out to be dark biological soil crusts that have surprisingly high biomass and high Normalized Difference Vegetation Index (NDVI). This type of vegetation, has many unique features not found elsewhere in the Arctic. It is almost limited to remote northern islands in a small area of the Arctic. It is very sensitive to warming temperatures, and will likely change to vegetation similar to that further south if the mean summer temperatures warm more than 1–2 ˚C.

March: *Low-centered ice-wedge polygons, central Yamal Peninsula, Russia.* The colors of the vegetation provide clues to the vegetation occurring in different microhabitats. The **brown** areas have wet nutrient-poor sedge, moss tundra. **Yellow** areas are better drained and have a diversity of sedges, dwarf shrubs, mosses, and lichens. **Bright green** patches of wet nutrient-rich tundra occur where ice-wedges, which are buried in the permafrost between the polygons, are melting. Disturbances of any kind tend to promote warmer soil temperatures— also wetter soils if the tundra surface subsides due melting ground ice — leading to release of nutrients from soil organic matter and greener more productive vegetation. Vegetation associated with melting ice wedges is becoming more common as rising temperatures warm the soils and melt the ice in the permafrost. The **gray-green** areas on the left and lower right have low willows growing on somewhat better-drained soils. Willows are also becoming more common as the summer temperatures warm. The shifts in these greenness patterns provide good clues on how the tundra vegetation is changing as the temperatures warm. Caribou trails are visible in the lower right corner of the photograph.

April: *Surveying the plant species composition and cover on a vegetation plot near Isachsen, Ellef Ringnes Island, Canada (78˚ 37'N, 103˚ 33'W), August 2006.* The vegetation here is similar to that on Hayes Island, Russia. Surveys of the vegetation, soils, environments, and spectral properties, were collected from many small plots along 1700-km transects of the full Arctic temperature gradient in Russia, Canada, and Alaska. The data from these plots tell us how the plant species and plant growth forms occur in relationship to present day Arctic temperatures and provide clues as to how they might change as the temperatures warm.

May: *Active-layer detachment landslide, Green Cabin vicinity, near the Thomson River, north central Banks Island, Canada, July 2004.* Active layer detachment sliding occurs on hill slopes where shear strength of thawed soils overlying permafrost is exceeded by pore water pressures, and the destabilized active layer slides down slope, scrunching the tundra turf into these neat piles, and exposing the permafrost table to further thawing.

June: *Greening patterns along a meandering river in the Central Yamal Peninsula, July 2008.* Most of the greener areas are due to low willow shrubs along river banks, and some well drained tundra areas that are becoming increasingly shrubby as the climate warms.

July: *Camp of Nenets reindeer herders on the shore of a lake, Central Yamal Peninsula*. The Nenets reindeer herders are nomadic and annually migrate up to 2000 km each year. They appear to be adapting to a wide variety of changes along the routes of the annual migration from the forest to the reindeer calving grounds near the west coast of central Yamal Peninsula. The changes have been studied for decades by Bruce Forbes and Timo Kumpula (see references) and include increasing shrubby tundra, overgrazing, anthrax outbreaks, large rain on snow events, and obstruction of the migration route by gas development.

August: *Shrub tundra along the Moscow–Labytnangi Railroad, Polar Ural Mountains, Russia, July 2007.* Shrub tundra is common in the southernmost portion of the generally treeless Arctic. And is the most extensive type in the Arctic, and the forest boundary is slowly shifting northward in some areas. The Polar Urals are hidden behind the clouds.

September: *Collapsed tundra caused by a huge flood of the Sagavanirktok River in May-June 2015.* This type of landform is created by underground thermal erosion of the permafrost and has only recently been described by Yuri Shur and colleagues (see reference). Several areas along the Dalton Highway developed these types of features. Several climate- and infrastructure-related factors conspired to create an epic event that closed the Dalton Highway for nearly a month, prompting the Governor to declare a state of disaster. The climate-related factors, included (1) extremely high runoff in the Sagavanirktok river basin during the previous two years, (2) an exceptionally large river icing (a sheet-like mass of layered ice that forms by the freezing of successive flows of water) developed in the Sagavanirktok River delta creating a dam to the northern flow of water; (3) very warm temperatures throughout the watershed in January–March 2015 initiated early flooding, and (4) very warm temperatures above freezing during May 15–30, which melted the snowpack early and quickly producing a swift breakup. These types of events appear to becoming more common as the climate of interior and northern Alaska is becoming wetter as well as warmer. Disturbances of any kind tend to promote warmer soil temperatures, and release of nutrients from soil organic matter, leading to greener more productive vegetation.

October: *Frozen debris lobe, adjacent to the Dalton Highway, Brooks Range, Alaska.* These features have only recently been described and studied by Ronnie Daanen and colleagues (see references). These frozen landslides appear to be becoming more active as the climate warms and present a slow-moving (approximately 5 m per year) geohazards to the highway. Note the toppling trees, and steep face on the front of this lobe, which is predicted to reach the highway in 2023. Photo by Yi Wang.

November: *Muskoxen, Arctic Foothills of the Brooks Range, Alaska, summer 2018.* The animals are feeding on tall willows and fireweed that occur along a buried portion of the Trans-Alaska Pipeline, which warms the soils and increases plant productivity.

December: *Glacier Avens* (Geum glaciale), *surrounded by Arctic White Heather* (Cassiope tetragona). *Jade Mountain, near Toolik Lake, Alaska, mid-June 2018.* These beautiful flowers are most abundant in shallow snow beds and bloom soon after the snow patches melt. They are heavily visited by pollinators such as flies and bees, several of which can be seen on these flowers. The patterns of snowbed plant communities are likely to shift as wind and winter snow patterns shift. Photo by Amy Breen.

January 2021: *Lettuce going to seed on my deck, during an exceptionally warm fall, September 2019.* The growing season is getting longer in Fairbanks and has extended the timing of my tomato harvest into October (see back cover).

Back cover: *Tomatoes brought inside the house as the temperatures outside cooled in fall 2019.* Super year for tomatoes, which I grow in pots on my deck and put on wheels to roll into the house when the night-time temperatures drop below 10 ˚C (50 ˚F).

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