

Arctic Steppe: Snapshot of the Past or Glimpse of the Future?

By Sara Wesser and Penny Knuckles

When continental ice sheets blanketed much of North America, land was exposed connecting Siberia and Alaska, forming an area known as Beringia. Paradoxically, Beringia itself remained unglaciated and may have been covered with vast areas of steppe, a vegetation type characterized by grasses and low shrubs very different from the present widespread forest and tundra of the region. Today, a few geographically isolated plant communities of this type survive only in Siberia and Yukon-Charley Rivers National Preserve in Alaska. High above the waters of the Yukon River, arctic steppe communities contrasting distinctly with the surrounding taiga forest find refuge on a few steep, south-facing river bluffs near the border between Alaska and Canada.

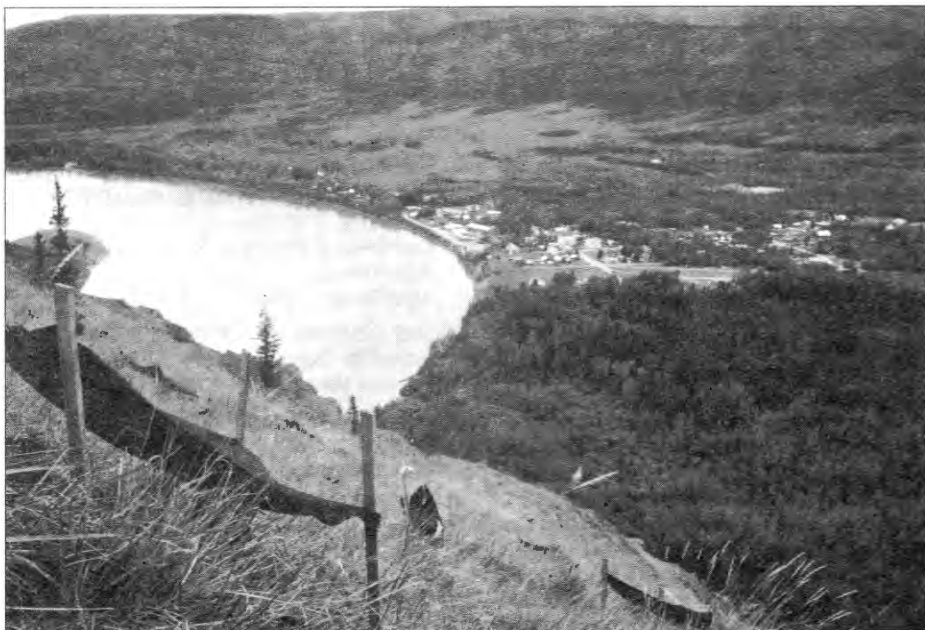
A chain of ecological islands strung along the Yukon, the steep bluffs above the river preserve these unique assemblages of plants. Endemic species found on one bluff are not always present on the next a few miles away, but other species are common to all. Four taxa are candidates for federal listing as endangered species, while the population levels and distribution of several others is too poorly known to justify classification at this time. Disjunct populations of mosses and lichens also occur, their nearest relatives 2,000 miles away in Siberia.

This persistence of a plant community prevalent during the Pleistocene on today's dry south-facing slopes is puzzling. What conditions have allowed the survival of arctic steppe and what conditions limit its present distribution? There is evidence that today's steppe species are at the limit of their ecological and distributional ranges. Warm, treeless islands in a sea of cool, mesic forest, arctic steppe intergrades with the aspen and tundra. What factors control this interface? More importantly, how do fluctuations in climate affect the distribution of steppe species? These questions prompted the research that we describe.

The mere logistics of studying these steep, south-facing bluffs challenged both researcher and park manager. Hot daily climbs lugging water and equipment up unstable scree were never merely routine, since bears frequent the same slopes. Mini-landslides could send the objects of study tumbling downhill. Eroded trails appeared like magic. American peregrine falcons, an endangered species, and other raptors oversaw projects from their nest sites. Over-zealous collectors, while not yet a problem, could have decimated rare plant species. Logistics were complex, since the study site required boats for access during high water.

Despite these factors, Eagle Bluff was chosen as a study site. Twelve miles upriver outside the preserve boundary, it is representative of arctic steppe on other bluffs within the preserve. While the site's location adjacent to the town of Eagle had its advantages, it was still necessary to cross a large creek via hip waders or an exciting cable ride. The peregrines nesting on the opposite side of the bluff are somewhat habituated to human use. Fortunately, a trail to the study site already existed.

I, Sara Wesser, as principal investigator, recall feeling a bit daunted by my first view of Eagle Bluff in 1987 as I rounded a bend in the Taylor Highway. I remember



Eagle Bluff Study Site (Eagle is in background) Shade treatment in foreground.

slowing my vehicle to a halt as my eyes traversed the 2000 foot rise from the Yukon River to the top. After an initial feeling of dismay – surely the bluff supporting the arctic steppe community was not quite so steep nor so high! – those doubts were put aside by the thought that I was at Eagle Bluff precisely because that imposing slope provided the perfect environment for an arctic steppe community. The next two field seasons focused on analyzing the environmental conditions of the bluffs that allow the steppe communities to survive.

The goal was to describe the abiotic and biotic factors that control species distribution across the transition between steppe and forest. These questions were addressed using correlative methods to show relationships between vegetation and environment and experimentation to test predictions from correlative models and establish the causal pathways of species' response to environment.

A correlative model was developed to portray explicit hypotheses about vegetation-environment relationships. To do this environmental variables were measured and percent cover of all understory species present was sampled in 70 plots. Environmental variables included the extent of tree cover (an estimator of radiation below the canopy), litter, slope, aspect, soil temperature and moisture, pH, organic matter and disturbance. Among the measured variables, soil moisture and the extent of tree cover most strongly controlled the transition in species composition. It was assumed that understory species responded most strongly to the influence exerted by tree cover on radiation below the canopy. Soil moisture controlled the tree cover itself.

If species are distributed according to their physiological optima (that is, where their growth would be best in the absence of biological factors such as competition or herbivory which may reduce physiologically potential growth and survival), we would expect each

species to be most robust in the light and moisture environment most similar to its native habitat. Forest species would perform best in the low light and high soil moisture characteristics of forests, and steppe species in the high light and low soil moisture of steppe. However, species are not always distributed this way. Biotic factors (e.g., competition for limiting resources) eliminate species from sites that are otherwise more favorable for their growth. An alternative explanation of the results of the correlative model that was developed: steppe species may tolerate aridity better than forest species but are excluded from the more mesic and presumably more favorable conditions inhabited by forests today due to low light conditions.

These hypotheses were tested in experiments with two forest natives and two steppe natives transplanted into the steppe community. To test for the effects of light, plants were either shaded to simulate the low light levels of the forest, or left unshaded in the steppe's high light environment. To test for the effects of soil moisture, plants were either watered daily to simulate moist forest soil conditions or were given no supplemental water in the dry steppe. The results suggested steppe species are eliminated from forest areas primarily by competition for light, but revealed differences in the relative importance of environmental factors among species. The forest taxa appeared to be restricted to their observed range because of intolerance for the high light and dry soil of steppe. Growth of steppe taxa would be improved in the mesic conditions of forest if they were not limited by the forest's low light.

If arctic steppe provides a snapshot of environmental conditions 12,000 years ago, can changes in its distribution indicate global climate trends in the future? Since steppe communities span two ecotones (steppe-forest and steppe-tundra), minute variations in climate could cause observable changes in the vegetation of steep south-facing bluffs. The distribution of

steppe communities may depend on conditions that ensure a high light environment by eliminating the growth of trees, a circumstance likely to occur if conditions become drier. Steppe species might thrive under these conditions because of their aridity tolerance. On the other hand, if conditions become more moist we might expect the distribution of trees to expand, favoring forest understory species. Steppe species might then lose the competitive battle for light as forest encroaches onto south-facing bluffs.

These questions suggest that long-term monitoring of arctic steppe communities, supplemented by basic research, may show them to be useful barometers of global climate change. As interest in that international issue grows, arctic steppe provides a tangible link to our Soviet neighbors and glacial past, a link that may someday result in designation of the Yukon River bluffs as part of an international park.

Wesser is a Biologist at the NPS Alaska Regional Office; Knuckles is a Natural Resource Management Specialist at Yukon-Charley Rivers National Preserve.