Steppe Bluff Biophysical Setting

Interior Alaska

Conservation Status Rank: S3 (vulnerable)

Introduction

Steppe bluffs are open, graminoid and sagebrush (*Artemisia frigida*) dominated sites occurring on steep, south-facing slopes in the interior of Alaska (Figure 1). The warm and dry microclimates of the steppe bluffs are thought to exclude trees and foster a distinctive flora characterized by a high diversity of Beringian and endemic plant species (Edwards and Armbruster 1989, Murray et al. 1983, Roland 1996). Steppe associations are considered analogues of vegetation that was widespread across Beringia during the colder and drier conditions of the late Pleistocene (Kassler 1979, Lipkin and Tande 1991, Murray 1981, Murray et al. 1983, Walker et al. 1991).

Figure 1. Steppe bluff habitat near Delta Junction, Alaska.

Distribution

Steppe associations occur primarily on bluffs overlooking interior rivers, including the Tanana, Porcupine, Copper and a section of the Yukon east of Galena (Edwards and Armbruster 1989, Hanson 1951, Juday and Dyrness 1985, Kassler 1979, Lipkin and Tande 1991, Murray et al. 1983, Osgood 1909, Tande 1996, Roland 1990). Beyond interior river systems, steppe associations occur on bluffs in Denali National Park and valley sides along Arrigetch Creek (Cooper 1986) and the Matanuska River. The northernmost occurrence of steppe-like associations in North America has been reported from the south-facing slopes and summits of pingos within the central Arctic Coastal Plain of Alaska (Walker et al. 1991). The Anderson River steppe in Canada’s Northwest Territory is the easternmost known occurrence of steppe in North America (Kesting 1993). Additional steppe locations in Canada include esker slopes above Kluane Lake (Marsh et al. 2006) and south-facing slopes in the Aishihil-Sekulmun Lakes area, both in the Yukon Territory (Vetter 2000).

The Steppe Bluff biophysical setting distribution was modeled from locations documented in literature or represented by collections of *Artemisia frigida* and *Calamagrostis purpurascens*. Herbaria records were only accepted into the model if location notes explicitly described the site as steppe habitat and/or inspection of the underlying remotely-sensed imagery indicated steppe habitat. Modeling was performed using MaxEnt (Phillips and Dudík 2008), a predictive technique that expresses the suitability of the landscape for a given species or system as a function of the environmental variables that are most highly correlated with its documented occurrences. The final model incorporated the following environmental variables (listed in order of decreasing importance): mean annual precipitation, elevation, mean summer temperature, heat load index, mean spring temperature and mean winter temperature (SNAP 2016) and had an AUC value of 0.863 (Figure 2).

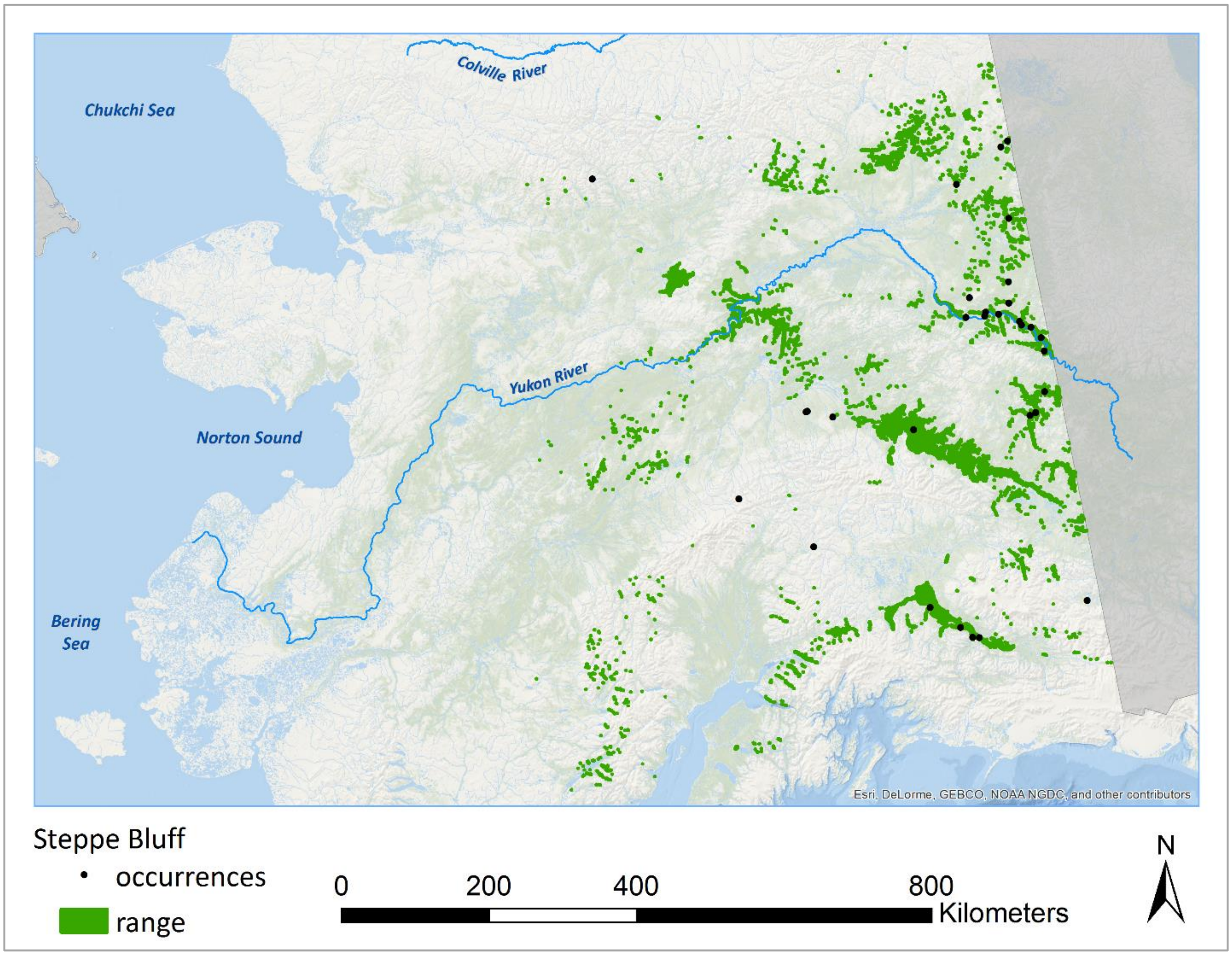

Figure 2. Distribution of the Steppe Bluff Biophysical Setting. Note that areas of occurrence in this map are buffered for greater visibility.

Climate

Short, warm summers and long, cold winters characterize the subarctic continental interior of Alaska. Average annual precipitation ranges from less than 25.4 cm in valley bottoms and lowlands to between 51 and 102 cm at higher elevations. Greatest rainfall occurs in late summer, primarily as a result of thunderstorms. Average annual snowfall ranges from 114 to 254 cm. Average annual temperature is between -8.8 to 12.2 °C in the north and ranges from highs of 20 to 25 °C to lows of -6.7 to -3.9 °C in the south. The average frost-free period is 60 to 100 days with the temperature remaining above freezing from June through mid-September (NRCS 2004).


Figure 3. Steppe bluff habitat near Copper River, Alaska.

Environmental Characteristics

Steppe bluffs typically occupy steep slopes (inclination 30-46°) that are oriented to the south (aspect 121-225°) and range in elevation from 244 to 914 m (Figure 3; Roland 1990). Associated landforms are commonly river bluffs, but can also include terraces, (Howenstein et al. 1985) low hills (Vetter 2000) or pingos (Walker et al. 1991). The topography of steppe bluffs has implications for microclimate in so far that surfaces undergo great daily and annual fluctuations in temperature and moisture (Edwards and Armbruster 1989, Lewis 1998, Roland 1996, Walker et al. 1991). Moisture of steppe soils is strongly limited by exposure to wind, low accumulation and residence of snow, drainage across steep slopes, and high soil evaporation and transpiration caused by the slopes' direct orientation to the low-angled sun (Bliss et al. 1973, Lewis 1998, Lloyd et al. 1994, Kassler 1979, Roland 1990, Wesser 1989).

Steppe soils are well-drained, silty loams to loams with low organic matter content (Roland 1996). Permafrost is typically absent due to warm soil temperatures in the summer and poor insulation in the winter (Boggs and Sturdy 2005). Soil pH ranges from 6.2 to 8.0 with a mean of 7.0 and is often elevated by input of calcium carbonate-rich loess (Kassler 1979, Marsh et al. 2006, Roland 1996, Walker et al. 1991). Bare soil is characteristic of developing steppe (Howenstein et al. 1985, Lewis 1998, Murray et al. 1983, Shacklette 1966).

Vegetation

Steppe bluffs are generally vegetated with dry, open low shrub and dry, graminoid-herbaceous associations characterized by the low shrubs *Artemisia frigida, Amelanchier alnifolia, Elaeagnus commutata, Shepherdia canadensis,* and *Juniperus communis*, the dwarf shrub *Arctostaphylos uva-ursi*, the grasses *Bromus pumpellianus, Festuca altaica, Calamagrostis purpurascens,* and *Poa glauca,* and the forbs *Artemisia arctica, A. alaskana, Bupleurum americanum,* and *Saxifraga tricuspidata* (Lipkin and Tande 1991). *Populus tremuloides* (quaking aspen) and *Picea glauca* (white spruce) associations occur peripheral to bluffs. Vascular plant cover is often sparse (Lipkin and Tande 1991, Roland 1996) with bare soil or lichen occupying the interstices (Batten et al. 1979, Lewis 1998, Roland 1996). A variety of shrub and herbaceous plant associations of conservation concern are provided in Table 3 (Batten et al. 1979, Boggs and Sturdy 2005, Chapin et al. 2006, Hanson 1951, Juday and Dyrness 1985, Kassler 1979, Lewis 1998, Lipkin and Tande 1991, Roland 1990, 1996; Tande 1996, Vetter 2000, Wesser and Armbruster 1991).

The presence of biological soil crusts have been noted in several mature steppe bluffs (e.g. Dickson 2000, Marsh et al. 2006, Walker et al. 1991, Zazula et al. 2002). Predominance of cyanobacteria in the *Collema* genus suggests that crusts make important contributions to the nitrogen budget of steppe ecosystems (Marsh et al. 2006). Foliose lichens and bryophytes are also sometimes common, and can include *Dermatocarpon, Diploschistes, Endocarpon, Fulgensia, Psora, Toninia, Xanthoparmelia, Rhytidium rugosum* and *Tortula ruralis* (Roland 1996). Steppe bluffs support a disproportionately high diversity and abundance of rare plant taxa (Murray et al. 1983, Shacklette 1966). The rare plants are often associated with rock outcrops and scree (C. Roland pers. comm. 2014).

Succession

Large scale disturbances affecting steppe bluffs include fire and mass wasting (Lewis 1998); smaller scale disturbances include burrowing and/or grazing by rodents and ungulates (Vetter 2000). Fire is thought to favor steppe development by removing competitive forest taxa that would otherwise exclude steppe taxa (Lewis 1998, Roland 1990). Similarly, landslides are thought to favor steppe development by removing forest taxa, exposing mineral soil for colonization by seedlings, and altering the competitive balance in favor of faster growing, more readily dispersed plants (Roland 1990 and 1996).

The herbaceous and shrub steppe associations depend on disturbance to persist (Lewis 1998) and are thought to be seral to *Populus tremuloides* (quaking aspen) woodlands with dry understory species such as *Arctostaphylos uva-ursi*, *Rosa acicularis* and *Sheperdia canadensis* (Vetter 2000, Boggs and Sturdy 2005). Where there is sufficient moisture, *Betula neoalaskana* (paper birch) and *Picea glauca* (white spruce) are able to colonize the *Populus tremuloides* woodland; a xeric *Picea glauca* forest may eventually establish (Chapin et al. 2006, Lewis 1998). Following fire, *Populus tremuloides* woodlands may revert to steppe associations (Lewis 1998).

Conservation Status

Rarity: Although limited in spatial extent (31 km^2) and occurrence (31 sites documented from literature), steppe bluffs contribute significantly to regional biodiversity and provide an analogue of late Pleistocene vegetation and the climatic conditions responsible for its formation (Murray et al. 1983, Roland 1990, Kassler 1979). Modern day steppe bluff habitats support high insect diversity (Guinn and Armbruster 1985), as well as a distinctive flora comprised of a disproportionately high number of rare, endemic and disjunct taxa (Roland 1996, Shacklette 1966). Consequently, this biophysical setting provides an opportunity to conserve a diversity of rare taxa by focusing management on a single habitat (Parker and Batten 1995).

Threat: Threats to steppe habitats in Alaska include invasion by nonnative plant species and increased use and development. As one of the warmest and driest microclimates in Alaska, steppe bluffs may be susceptible to invasion by nonnative ruderal species introduced from more temperate climates (Flagstad et al. 2012). The open and rocky substrates of steppe bluffs offer natural hiking routes, yet are unstable enough to be greatly disturbed by foot traffic (Parker and Batten 1995). Development of roads and pipelines, or material sourcing to support such development are additional threats (Batten et al. 1979, Parker and Batten 1995); however, the remote locations and steep topography of most steppe habitats would likely preclude the economic feasibility of such projects.

Trend: Climate envelopes modeled for steppe bluffs predict increases in the suitability of existing habitat and shift in the extent of suitable habitat toward the continent center in response to higher continental rates of evapotranspiration (Boucher et al. 2016, Flagstad et al. 2012). In a warming and drying climate, graminoid-dominated systems such as steppe bluffs could expand into areas currently occupied by xeric forests (Blinnikov et al. 2011, Chapin et al. 2006). Moreover, it is possible that the distinctive flora of steppe associations could source the initial colonization of habitat (Kesting 1993, Roland 1996) or provide destination habitats for taxa purposefully migrated from more temperate regions.

Species of Conservation Concern

The mammal, bird, insect, and plant species listed below are designated critically imperiled or vulnerable either globally (G1-G3) or within Alaska (S1-S3) and are known or suspected to occur in this biophysical setting (Table 1, Table 2). Please visit the Alaska Center for Conservation Science website for species descriptions (ACCS 2016).

Table 1. Bird, mammal and insect species of conservation concern within the Steppe Bluff Biophysical Setting.

Common Name	**Scientific Name**	**Global Rank**	**State Rank**	**Habitat Description**
Mammals				
Alaska tiny shrew	*Sorex yukonicus*	GNR	S3	A habitat generalist that is suspected to use steppe bluff habitat when present.
Woodchuck	*Marmota monax*	G5	S2	Prefers dry, open grassy areas – and are suspected to occur in steppe bluff habitat.
Birds				
American Peregrine Falcon	*Falco peregrinus anatum*	G4T2	S3B	Thought to utilize steppe bluff habitats for nesting and hunting.
Fox Sparrow	*Passerella iliaca*	G5	S3	Occur within edge habitat of steppe bluffs, primarily in wooded understory.
Mountain Bluebird	*Sialia currucoides*	G5	S3B	Thought to use steppe bluff habitats for feeding, nearby open woodlands provide nesting habitat.
Osprey	*Pandion haliaetus*	G5	S3	Known to use bluff habitat near Northway-Tetlin and other riverine bluffs in Interior Alaska.
Sharp-shinned Hawk	*Accipiter striatus*	G5	S3	Inhabits the boreal forest, steppe bluff habitat would be for opportunistic feeding.
Smith’s Longspur	*Calcarius pictus*	G5	S3	Breed in dry tundra and is known to occur near steppe bluff habitat in southern Central AK (Wrangell Mountains).
Swainson’s Hawk	*Buteo swainsoni*	G5	S2	Could use steppe bluff habitat within its known range for opportunistic feeding on mammals and insects.
Insects	various species	-	-	Steppe bluff systems are hot spots for insect diversity. Many species of solitary bees includes members of the *Andrena, Andrenidae, Lasioglossum, Halictus, Megachile, Osmia, Coelioxys, Anthophora*, *Nomada* and *Epeolis* genera appear to be restricted to the hottest and driest sites in the interior.

Table 2. Plant species of conservation concern within the Steppe Bluff Biophysical Setting.

Scientific Name	Global Rank	State Rank	Habitat Description
Alyssum obovatum	G5	S2S3	Occurs on south facing steppe bluffs near the Porcupine River.
Apocynum androsaemifolium	G5	S3	Reaches its northern distribution limit in steppe communities of interior Alaska.
Artemisia tanacetifolia	GNR	S3	Grass shrub steppes, grass forb steppes, aspen woodland, dwarf shrub tundra.
Botrychium campestre var. *lineare*	G2?	S1	Grows on open soil in dry graminoid-forb steppe vegetation on steep, treeless S-facing slopes of the Nutzotin Mountains.
Carex eburnea	G5	S3	Occurs on south facing steppe bluffs near Porcupine River.
Chamaerhodos erecta	G5	S2S3	Reaches its northernmost distribution in steppe communities of Interior Alaska.
Cryptantha shackletteana	G1Q	S1	Recruitment is high on steppe bluffs. Four populations in Alaska.
Douglasia arctica	G3	S3	Sparsely vegetated, aspen and spruce woodland, low birch scrub, graminoid steppe, and Dryas heath.
Draba murrayi	G2	S2S3	Small populations occur on open slopes or in graminoid steppes along the upper Yukon River.
Elymus lanceolatus ssp. *psammophilus*	G3G4	S1S2	Populations on steppe bluffs near the confluence of the Copper and Chitina Rivers represent the most western distribution for this species of grass.
Erigeron ochroleucus	G5	S1S2	Occurs on sparsely vegetated graminoid steppes.
Eriogonum flavum var. *aquilinum*	G5	S2	Sparsely vegetated river bluffs and rock outcrops. Seedlings appear to be uncommon, suggesting that this species reproduces slowly.
Erysimum angustatum	G5T2	S2	Found on sparsely vegetated, open graminoid steppe, open sites in aspen or birch forest.
Maianthemum stellatum	G5	S3	Occurs on steppe slopes along the Yukon River.
Orobanche fasciculata	G4	S1	A parasitic plant, known from a few locations in eastern Interior Alaska.
Phacelia mollis	G2G3	S3	Occurs in steppe communities in eastern Interior Alaska.
Rosa woodsii ssp. *woodsii*	G5T5	S2S3	Steppe and hill prairie communities, open Aspen-mixed forest woodlands.
Townsendia hookeri	G5	S1	In Alaska known only from a few locations at south-facing steppe bluffs along the Porcupine River.

Plant Associations of Conservation Concern

The plant associations listed below are designated critically imperiled or vulnerable either globally (G1-G3) or within Alaska (S1-S3) and are known or suspected to occur in this biophysical setting (Table 3).

Table 3. Plant associations of conservation concern within the Steppe Bluff Biophysical Setting.

Name	Global Rank	State Rank	Concept Source
Tree			
Populus tremuloides/Elaeagnus commutata-Shepherdia canadensis/Arctostaphylos spp./*lichens*	G3	S3	Neiland and Viereck 1977
Shrub			
Amelanchier alnifolia	G3	S3	Wesser and Devoe 1987
Artemisia frigida-Bromus pumpellianus	G3	S3	Hanson 1951
Artemisia frigida	G3	S3	Young and Racine 1976
Festuca altaica-Calamagrostis spp.	G3	S3	Batten et al. 1979
Juniperus communis	G3	S3	Young and Racine 1976
Herbaceous			
Agropyron spicatum-Artemisia frigida	G3	S3	Hanson 1951
Calamagrostis purpurascens	G3	S3	Hanson 1951
Calamagrostis purpurascens-Artemisia frigida	G3	S3	Boggs 2000

Classification Concept Source

The classification concept for this biophysical setting is based on Osgood (1909).

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