19 The Plant-Vertebrate Herbivore Interface in Arctic Ecosystems

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19.1 Introduction

Both natural and anthropogenic disturbances affect ecosystem integrity and biodiversity. Nearly all natural disturbances in arctic regions and elsewhere are directly or indirectly driven by climate (Walker and Walker 1991). Human disturbances also operate over large spatial and temporal scales and produce immediate direct effects and numerous indirect effects (Harte et al. 1992). The effects of these two types of disturbances on ecosystem function and biodiversity may be synergistic. Each disturbance reinforces the other, so that there is mutual amplification of their respective effects (Myers 1992). Organisms often respond nonlinearly to environmental variability (DeAngelis 1992). The responses are linked, to positive and negative feedback processes which involve both abiotic and biotic components of the environment. The environmental changes associated with these feedbacks, which are not easily predictable, may lead to a loss of ecosystem resilience and biodiversity.

The theme of the mutual amplification of the effects of different disturbances on biodiversity is developed in the remainder of the chapter. We begin by describing patterns of vegetation and vertebrate herbivory in arctic tundra, and then consider how expected responses of northern vegetation to warming might affect interactions between plants and vertebrate herbivores in ways that change biodiversity in tundra ecosystems. We conclude by focusing on a well-documented study of how anthropogenic influences are affecting both top-down and bottom-up trophic processes in arctic coastal habitats, leading to loss of biodiversity and ecosystem integrity. These influences are linked to recent weather patterns and provide a potential climatic scenario for some of the predicted ecological effects associated with global warming.

19.2 Patterns of Vegetation and Vertebrate Herbivory in Arctic Tundra

Without good knowledge of floristic and vegetation patterns within the vast northern regions of Eurasia and North America (approximately 7 500 000 km^2),

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studies of effects of ecosystem processes on biodiversity are difficult (Bliss and Matveyeva 1992). Tundra vegetation varies at several spatial scales (Walker and Walker 1991; Walker et al. 1993). From the forest-tundra ecotone to the High Arctic, woody vegetation decreases in importance, graminoids and forbs increase in importance, and both the standing crop of plant biomass and aboveground net primary production decline (Bliss 1988; Bliss and Matveyeva 1992). Within each latitudinal zone tundra vegetation varies as a result of geology and history. For example, "tundra steppe" plant communities occur on Wrangel Island and locally on the Chukotka mainland. These communities are dominated by grasses and a rich herbaceous flora and are considered a relic from the cold, dry Beringian Steppe of the Pleistocene (Yurtsev 1974). In low arctic regions, chemical defenses of shrubs such as willow and birch that are important foods of vertebrate herbivores (Bryant and Kuropat 1980) vary longitudinally (Bryant et al. 1989). Although unresolved, the reason for this biogeographical variation may be a response by vegetation to selective browsing in the Holocene (Bryant et al. 1992). At the landscape level topography, geomorphology, and patterns of snow accumulation and melt, and wildfires interact to generate vegetation mosaics exploited by vertebrate herbivores in their annual cycle of foraging.

Vertebrate herbivores of the arctic tundra all have catholic diets. However, the mixture of graminoids and woody species normally eaten varies among species. Some species, for example, geese (Jefferies 1988a, b) and brown lemming (*Lemmus sibericus*) (Batzli and Jung 1980), are primarily grazers, whereas others such as caribou (*Rangifer tarandus*) (Kuropat 1984), musk-oxen (*Ovibos moschatus*) (Robus 1981), and tundra vole (*Microtus oeconomus*) (Batzli and Jung 1980) eat substantial quantities of both graminoids and woody browse, and other species such as ptarmigan (*Lagopus*) (Williams et al. 1980), collard lemming (*Dicrostonyx torquatus*) (Batzli and Jung 1980), and moose (*Alces alces*) (Mould 1977) are primarily browsers. Few species feed heavily on nonvascular plants, but there are notable exceptions such as the dependence of caribou and reindeer on lichens in winter. Thus, climate change would affect the plant-herbivore interface by altering absolute and relative abundances of plant growth forms.

19.3 Vertebrate Herbivory in a Warming Climate: Implications for Tundra Biodiversity

In high-latitude ecosystems, warming is expected to result in northward migration of vegetation (Davis 1988; Pastor and Post 1988; Bryant and Reichardt 1992). This migration would (1) shift a modified forest-tundra ecotone northward, (2) increase the area dominated by shrub tundra, and (3) restrict graminoid-dominated tundra either to a latitudinal zone bounded on the north by the Arctic Ocean, the High Arctic islands or to the higher elevations of mountains. Paleoecological evidence (cf. Hopkins et al. 1982) and recent experiments (Chapin and Shaver 1985; Barta et al. 1989) indicate such a reduction in the