2 Causes of Arctic Plant Diversity: Origin and Evolution

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2.1 Introduction

The term biodiversity was coined rather recently as a shorthand reference to biological diversity, i.e., for the sum of all taxa of plants and animals (Wilson 1988), yet the study of biodiversity is the oldest branch of biology (Weber and Wittmann 1992). Today, frames of reference other than taxonomic ones have become important as we recognize the need for understanding diversity at various levels of organization, from inclusive to restrictive, from communities to genotypes. Whatever the level of our focus in the hierarchy, we must ultimately have a precise knowledge of the component taxa.

As we inventory the plants of the Arctic, it is impossible for me not to wonder about the origin and evolution of this flora and which of many historic and contemporary events and processes have most effectively shaped plant diversity. If we are to predict how climate change will affect taxa in both evolutionary and geographic senses, we must understand how, when, and where they were created and then brought to their present positions (cf. Smith 1969).

The reduction of plant diversity with increasing latitude naturally finds its ultimate expression in the Arctic where the abiotic environment challenges even the physiological limits of plants. Changes in dominant life forms and species composition of vegetation are the basis for schemes of the major zonation for the Arctic (Polunin 1951; Young 1971; Yurtsev et al. 1978; Rannie 1986; Edlund and Alt 1989) all of which have demonstrated a pattern of progressive loss of taxa northward and a general agreement of this loss with decreasing temperatures. It is wrong, however, to see only the loss of the boreal species at their northern limits, for there is also some replacement with a distinct arctic element that is generally not known farther south.

The total pool of vascular plants in the Arctic is about 1500 taxa. About 500 of these comprise the flora of the Alaskan Arctic Slope, and localities of roughly the same area in northern Alaska can have from 100 to 300 taxa. We do not see a greater species diversity on the ancient unglaciated surfaces as some contend (Murray 1992; Walker, this Vol.). Obviously, since plants are not evenly distributed, there are differences within the Arctic as to which taxa are actually present: (1) within the confines of one region, such as the Coastal Plain, Foothills, or

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Ecological Studies, Vol. 113
Chapin/Körner (eds) Arctic and Alpine Biodiversity

Mountain provinces of the Arctic Slope of Alaska, (2) at localities of comparable size within the same physiographic province, as in the case of Barrow and Prudhoe Bay on the Coastal Plain and (3) even between localities only a few kilometers apart in the Brooks Range (Murray and Murray 1982). The diversity of plants of any one place is determined by the history of the flora and landscapes, present climate, and the diversity of lithology, landforms, and habitats (cf. Murray 1987, 1992).

2.2 Historical Factors of Arctic Plant Diversity

Because many life forms, genera, and even species are shared by arctic and alpine localities in the northern hemisphere, by places distant from one another, the two floras are often treated as a single entity, the arctic-alpine flora. They mix and become one, in practical terms, in subarctic mountain ranges of North America and northeastern Asia, but each of these major floristic elements has had different origins and histories. Tolmachev (1960), Hultén (1958), Weber (1965), and Hedberg (1992) have drawn our attention to the high mountain systems of Central Asia and western North America as sources of taxa for the arctic flora. Their view is supported by the knowledge that some of these mountain ranges are old enough and high enough to have supported treeless (alpine) environments, and presumably also an alpine flora, in late Tertiary (Neogene) time. Elements of these Tertiary alpine floras moved northward along their respective cordillera to the Arctic. Floristic connections today between mountain ranges such as the Altai and the Rocky Mountains are given as evidence for early migrations (Weber 1987).

During the Tertiary, the Arctic, which is now synonymous with treeless landscapes, actually supported continuous forests across Asia and America. The two continents were joined by a dry land connection for millions of years prior to the Pliocene flooding of the Bering Strait. Exchanges of biota would have been strongly filtered by the forests which dominated the Neogene lowlands. There is a fossil record from which we reconstruct an Arctic covered by forests composed of major floristic elements totally absent from the present environment. In the shift from treed to treeless landscapes at the end of the Tertiary or in earliest Pleistocene, the Arctic lost a rich flora of trees, shrubs, and herbs that are extinct or found today far to the south of their ancient arctic positions. Yet, in every list of Tertiary plant fossils from the Arctic, there are also taxa (genera and species) familiar to us in arctic tundra today, particularly bog and riparian habitats, but also herb communities of well-drained uplands, such as *Cerastium arcticum/alpinum, Draba* sp., *Dryas integrifolia* and *D. octopetala, Oxyria digyna, Papaver* sp., *Saxifraga oppositifolia, Silene* sp., and *Stellaria* sp. (Bennike and Bøcher 1990; Matthews and Ovenden 1990).

Critical to further development of the arctic flora was the exchange of plants in Beringia throughout the Pleistocene, between Asia and America (and largely from Asia to America), when, during glacial maxima and concomitant periods of