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Monitoring of vascular plant diversity in a changing climate in the alpine zone of the Central Greater Caucasus

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Abstract: Short-term changes in plant species number, cover, frequency, and composition were studied along an altitudinal gradient crossing 4 GLORIA summits (from 2240 m to 3024 m a.s.l.) from the treeline ecotone to the subnival zone in the Central Caucasus. Large-scale (summit area) and small-scale (16 plots of 1 m^2/summit) patterns were monitored in 2001. Recording was repeated in 2008. During the monitoring period, the average soil temperature and growing-degree days did not significantly increase. After 7 years, a revisitation of the summit area revealed a considerable increase of species richness, especially at the lower alpine zone (CP1 and CP2 summits). At a small scale (1 m^2), species richness also increased at the lower summit (from 12.5 ± 2.87 to 15.5 ± 3.12 species on the CP1 summit). The cover of 17 species significantly decreased, while that of 5 increased. There were significant linear relationships between species richness and altitude and climatic variables. The main newcomers were species from the lower altitudinal zones and their percentage was highest on the southern slope. Endemics and cold-adapted species were not seriously endangered. In the Central Caucasus we do not consider climate warming as the primary driver of the changes of plant richness and competition.

Key words: Alpine plant diversity, global climate change, GLORIA-Europe, richness, species cover

1. Introduction

High mountains of the temperate zone are among the most sensitive areas in terms of environmental impacts of climate change (Körner, 2002; Nagy and Grabherr, 2009). Development and normal functioning of alpine ecosystems are largely determined by the low temperature conditions, frequency and intensity of wind, and the distributional character of precipitation (Larcher, 2012; Larcher et al., 2012). Changing of these limiting effects will have an impact on the diversity of the vegetation: migration of species from low altitudes to high altitudes will start and the species adapted to high altitude conditions will gradually disappear (Körner, 1992; Nagy and Grabherr, 2009). According to the recent data (IPCC, 2007; Erschbamer et al., 2009), the minimum temperatures in the Alps have increased by 1.1–2 K during the past century. It is expected that climate warming of 1–2 °C will cause small changes in alpine vegetation, but even greater warming of the climate will cause more significant changes (Theurillat and Guisan, 2001). Climate change will likely lead to increased stress from drought and warm winters (St. Clair and Howe, 2011). As single species have individual responses to environmental changes, creation of a new plant community is more feasible than migration of already existed species (Pauli et al., 2007).

Many observations, e.g., in the Alps (Gottfried et al., 1998; Keller et al., 2000; Grabherr et al., 2001; Walther et al., 2005), Scandinavian mountains (Klanderud and Birks, 2003), Rocky Mountains, and the Central Greater Caucasus (Nakhutsrishvili et al., 2004, 2009), have shown that climate warming leads to the changes of habitats, distribution peculiarities, and viability of some vegetation types. In particular, the investigations conducted in the South and Central Alps (Erschbamer et al., 2006) have shown the change in the diversity of vegetation from the treeline to the alpine zone, invasion of forest elements in alpine meadows that represents a certain danger to the prior ones. Vertical shifting of the treeline has been shown for several mountain systems of the world (Moiseev and Shiyatov, 2003; Kullman, 2007) and in particular in the Central Greater Caucasus (Nakhutsrishvili, 2003; Akhalkatsi et al., 2006; Hughes et al., 2009). Studies in the high mountains of the Kazbegi region (the Central Greater Caucasus) revealed enhancement of seed formation process in birch forests, with individuals of *Betula litwinowii* Doluch. of 6–8 years old found at the altitude of 2200–2550 m (Akhalkatsi et al., 2006; Hughes et al., 2009). Subalpine forests have been shifted upwards by 60–80 m in the South Urals during the last 70 years (Moiseev and Shiyatov, 2003). In Scandinavia the observed treeline

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