Kobayashi Makoto

Tips for the next phase of winter climate-change study in plant–soil systems

Published online: 2 July 2014
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Winter climate, characterized by cold temperatures and snowfall, influences organismal physiology, which is closely related to individual survival, growth, and reproduction (Sakai and Larcher 1987). Therefore, winter climate change can have significant effects on individual and population behaviors and their related biogeochemical cycles (e.g., greenhouse gas emissions from soil microbes (Yanai et al. 2014) and nitrogen retention by plant uptake (Campbell et al. 2014)). However, the consequences of winter climate change are less well understood than those of summer time change (Kreyling 2010). This information gap may exist partly because the effect-process of winter climate change on ecosystems is more complex than that in summer. For instance, winter warming influences organisms not only via the increase in air temperature itself but also via changes (both increases and decreases) in snowfall, which has multiple functions, such as insulation and water source (Groffman et al. 2001). Because snowpack depths are spatially highly heterogeneous at regional and even micro-topographical scales, and because organismal responses are highly species specific, predicting the consequences of winter warming is more difficult than predicting summer changes (Makoto et al. 2014). For an integrative understanding of such changing patterns, a functional trait-base framework would be powerful (Cornelissen and Makoto 2014; Mori et al. 2014).

“How do you spend winter days?” While organisms are generally least active during winter among the four seasons, some species develop traits or specific organs, such as “snow roots” to benefit from winter (Onipchenko et al. 2014). This example is not just as an interesting case of plant evolution; it reminds us that winter can be a temporal niche for resource competition.

Furthermore, snow fungi is revealed as fundamental food resources for litter feeding micro-arthropods during winter and spring (Bokhorst and Wardle 2014). This implicates the importance of winter-adapted organisms in the trophic interaction and coincidental nutrient cycling in plant-soil system, possibly including the carry-over effects on the following seasons (Xia et al. 2014).

Generally in “winter climate change study”, an applied ecological perspective is largely lacking. While ski resorts are an ecosystem service provided by winter processes, such resorts are mainly located in areas vulnerable to winter warming. Furthermore, the snowpack management regime (e.g., snow compaction, artificial snow supply) can both directly and indirectly influence the local plant–soil system and ecosystem functions such as erosion control (Meijer zu Schlochtern et al. 2014). For sustainable ecosystem management, we must consider the consequences of management practices on the mountain landscape and other aspects [e.g. selective cutting during winter in forest, preparation of agricultural field (Yanai et al. 2014)] in terms of changes in winter conditions.

The importance of the linkage between plant and soil organisms in predicting the future of terrestrial systems under a changing climate was recently addressed (Bardgett et al. 2013). However, compared to individual- or population-level studies, community responses, such as plant interactions with soil microbes and soil fauna, to winter climate change have been little explored (Mori et al. 2014). For instance, the differential temperature requirements between insects and plants could to disrupt their linkage because of “phenological mismatch”, which has the potential to diminish the pollination services (ecosystem service), for instance, by plants to insects (Kudo 2014). Furthermore, compared to the effects of gradual change (press events), those of extreme events (pulse events) whose frequency is predicted to increase under a changing climate (IPCC 2012), have not been focused on (Mori et al. 2014). To study the influences of extreme events, long-term monitoring and/or field manipulation studies have been accumulating (e.g. Bokhorst et al. 2008; Kudo 2014; Schürings et al. 2014).

K. Makoto (✉)
Nakagawa Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Ootoinpu, Hokkaido 981-2501, Japan
E-mail: makoto@fsc.hokudai.ac.jp
Tel.: +81-1654-5-3216

To help advance an integrative understanding of the consequences of winter climate change in plant–soil systems, this special feature provides a summary of recent findings, ongoing problems, and future perspectives,

and several original articles reminding us of the importance of winter for organisms are included. With the figures related to the topics in this feature (Figs. 1, 2, 3, 4, 5, 6, 7), I hope you enjoy reading it!

Fig. 1 Open-top chambers which have passively captured snow on a peat bog at Abisko, northern Sweden, thereby creating a winter treatment with enhanced snow depth (By Dr. Cornelissen J.H.C.)

Fig. 2 EVENT-experiment in Bayreuth, Germany investigating the effects winter warming pulse on above and belowground processes in plant–soil systems (By Dr. Kreyling J.)

Fig. 3 Advancing now-melt experiment in cool-temperate forests, northern Japan. (By Dr. Makoto K.)

Fig. 4 Late winter of mixed-conifer broadleaved forest in Hokkaido, Japan. Future performance of matured trees under warmer winter is one of the unknown topics to be clarified (By Dr. Makoto K.)

Fig. 5 Earthworms distributing in the shallow soil under deep snow in northern Japan. The response of soil fauna to winter climate change and its consequence in biogeochemical cycles has been little understood (By Dr. Makoto K.)

Fig. 6 Machines for snowmaking in Davos, Switzerland, which change the local snow regime drastically (By Dr. Rixen C.)

Fig. 7 Sparse vegetation cover and lower diversity under ski slopes (By MSc. Meijer zu Schlochtern M.P.)

Acknowledgments We gratefully acknowledge all attendees of the symposium at the 60th Annual Meeting of the Ecological Society of Japan (ESJ60) in 2013 in Shizuoka. This symposium was held as the Ecological Research Symposium and supported by the annual meeting planning committee of ESJ60. We deeply thank Prof. Naoki Kachi and Dr. Atsushi Kume for their intensive support throughout this winter climate change project.

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