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Laboratory and Field Assessment of the Frost Resistance of Sosnowsky's Hogweed

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Abstract—The frost resistance of Sosnowsky's hogweed plants (*Heracleum sosnowsky* Manden.) has been evaluated under laboratory and field conditions. The death of seedlings and adult plants observed within a temperature range from −6 to −12°C indicates low frost tolerance of the species. A snow cover provides a stable soil temperature (no less than −3°C) at the depth of renewal bud location and, therefore, provides the sustainability of meristematic potential in cenopopulations of *H. sosnowsky.* A shifting of freezing temperature for a *H. sosnowsky* meristem from −12°C (autumn) to −5 to −7°C (spring) is probably caused by the lack of a true dormancy stage and by changes in the content of cryoprotectors. Plant seeds also demonstrate reduced frost resistance after stratification (overwintering) and increased tissue water content. Field studies were carried out with assistance of volunteers within the framework of the "Moroz" ("Frost") project arranged within the borders of the invasion habitat of the species in European Russia and based on the principles of citizen science. The results of the study show that the destruction of Sosnowsky's hogweed plants after the snow cover removal depends only on weather conditions. Thus, elimination of *H. sosnovsky* stands by freezing can be recommended only for regions where average long-term minimum temperatures in January and February do not exceed −25°C; this method can be relevant for territories where the use of chemical herbicides is limited or prohibited.

Keywords: Heracleum sosnowskyi, invasion, frost resistance, winter hardiness, citizen science, brush destruction
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INTRODUCTION

Competitive properties of Sosnowsky's hogweed (*Heracleum sosnowsky* Manden.) and its domestication resulted in formation of a large invasive habitat of this species, which covers several natural zones in Russia, from forest steppe in the south to forest tundra in the north (Satsyperova, 1984; Vinogradova et al., 2010, 2018; Pergl et al., 2016; Ozerova et al., 2017; Chadin et al., 2017; Ozerova and Krivosheina, 2018; Ebel' et al., 2018).

To date, no effective and environmentally safe methods to control Sosnowsky's hogweed have been developed (Caffrey and Madsen, 2001; Nielsen et al., 2005; *Ecology and Management...*, 2007; Reznik et al., 2008; Krivosheina, 2011; Yakimovich et al., 2013; Dalke et al., 2015). The analysis of measures aimed to map and eliminate undesirable stands of *H. sosnowsky* showed that the most frequent method to control this weed in Russia is chemical control (Dalke et al., 2018). However, use of pesticides and agrochemicals in populated areas is limited; moreover, herbicides cannot be used in water protection zones or in specially protected natural areas (Hygienic Requirements..., 2016).

The sustainability and expansion of *H. sosnowsky* cenopopulations are provided by numerous renewal buds located on the stem-root, as well as by an annually replenished soil seed bank (Dalke et al., 2015; Gudžinskas and Žalneravičius, 2018). Renewal buds of *H. sosnowsky*, *H. lehmannianum*, and *H. ponticum* die if the exit from dormancy occurs during a snowless period (Aleksandrova, 1971) or after severe conditions of the pre-winter period (Khantimer, 1974). This fact makes it possible to eliminate the stands of these plants (to reduce the meristematic potential) by changing a thermal regime of the soil after snow cover removal. In spite of a successful experiment intended to destroy