Assessing the climate change vulnerability of two rare alpine taxa: *Nabalus boottii* and *Nabalus trifoliolatus* var. *nanus*

by Kristen Haynes

Global climate change is already driving community change and species loss worldwide, and will undoubtedly leave its signature on New York's flora. New York's alpine species may be particularly vulnerable to climate change, given their existence in small, isolated populations at the highest and coldest points of the landscape. While small in area (~0.3 km^2), New York's alpine zone represents a hotbed of biodiversity and is home to a suite of rare species, including regional endemics and arctic species at the southern limit of their range (Capers et al., 2013). Understanding the probable response of these species to climate change is critical for identifying conservation priorities.

Species can survive climate change in one of three ways: (1) range shift, (2) evolution, and (3) phenotypic plasticity (i.e. acclimation) (Jump and Peñuelas, 2005). Although the emphasis is often placed on the first two modes of response, phenotypic plasticity—or the modulation of a plant's morphology and physiology in response to environment—is likely critical (Bradshaw, 1965; Nicotra et al., 2010). For species lacking the connectivity or dispersal ability to shift their range and/or the genetic diversity to evolve (many of our alpine species probably fall into this category), phenotypic plasticity may be the primary response to climate change.

With support from NYFA, I conducted a common garden experiment to understand the ability of two rare alpine species to respond to climate change through phenotypic plasticity. The focal species included *Nabalus boottii* (Boott's rattlesnake-root), a state endangered and globally imperiled (G2) species (Young, 2017), and *Nabalus trifoliolatus* var. *nanus*, the rare alpine variety of the widespread three-leaved rattlesnake-root. Non-alpine populations of *N. trifoliolatus* were also included for comparison. I transplanted seeds and seedlings of the focal *Nabalus* species into raised beds at low, mid, and high elevation on Whiteface Mountain in Wilmington, New York, and monitored survival for two months. At the conclusion of the experiment, I removed remaining plants from the field and measured functional traits such as height, biomass, and specific leaf area. Leaf size, shape, and pigmentation were measured from scanned whole-plant images using ImageJ software. Significant differences in average functional trait values among the sites indicated phenotypic plasticity.

Wild *Nabalus boottii* flowering on Whiteface Mountain.

Overall, I found low survival following transplantation, but high and equal functional trait plasticity for survivors across all *Nabalus* taxa. Average trait values across thirteen traits were 39% different between plants grown at the highest and lowest sites. This high degree of plasticity provides a cautiously hopeful message regarding the response of these species to climate change. While abrupt changes in climate could cause mortality in young life stages of alpine *Nabalus*, strong phenotypic plasticity is likely to help populations persist in the face of a changing climate.

Young *Nabalus* plants awaiting transplantation into raised beds on Whiteface.

Example *Nabalus* plants recovered from Whiteface field sites at the end of the growing season.

Acknowledgements:

There are many individuals and organizations that made this project possible. I would like to thank my advisor, Dr. Donald Leopold, and my graduate committee for their advice throughout the project. Samouel Beguin and Russell Haynes provided field assistance, while Hannah Kowalsky and Jani Liu assisted with trait measurement. My thanks also go to the staffs of Cranberry Lake Biological Station, Whiteface Mountain Atmospheric Sciences Research Center (especially Paul Casson), Whiteface Veterans' Memorial Highway, and Whiteface Mountain Ski Resort (especially Mike LeBlanc) for their assistance with logistics and site access. Arthur Haines, Bob Popp, Dan Sperduto, Kyle Turchick, and the Mount Washington Auto Road staff (especially Howie Wemyss) provided essential assistance and advice during initial field collection. This project was supported by New York Flora Association and SUNY-ESF's Grober Graduate Research Fellowship.

References:

Bradshaw, A. D. 1965. Evolutionary significance of phenotypic plasticity in plants. *Advances in Genetics*, *13*, 115–155.