

Plant Phenology and Vulnerability in Acadia National Park, Maine

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BACKGROUND

Changes in plant phenology are a simple, straightforward signal of the ecological effects of climate change. Moreover, inflexible phenology has been linked to declines in species performance and increased vulnerability to local extinction^{1,2}. Taxa that do *not* track warmer temperatures with earlier leaf out or flowering may struggle to survive in a changing climate³.

In Acadia National Park, on Mount Desert Island Maine, plant communities on the subalpine summits do not have space to migrate to higher elevations in the face of climate change⁴. Since 1895, the island’s flora has experienced a local extinction rate near 20%. To test the phenological flexibility and potential vulnerability of three plant species, we established three reciprocal transplant gardens in the park along an elevation gradient and monitored leaf out phenology over three growing seasons.

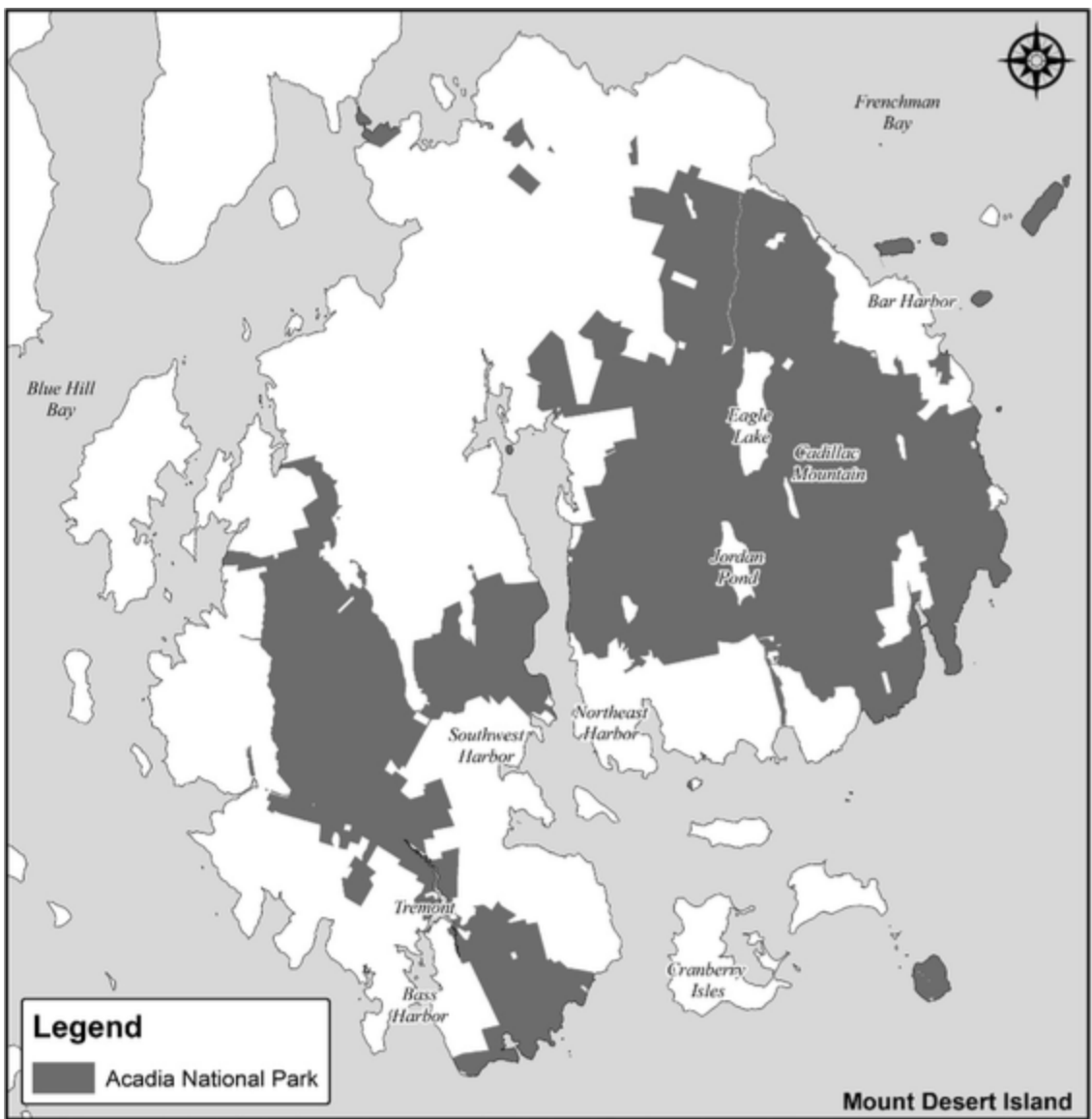


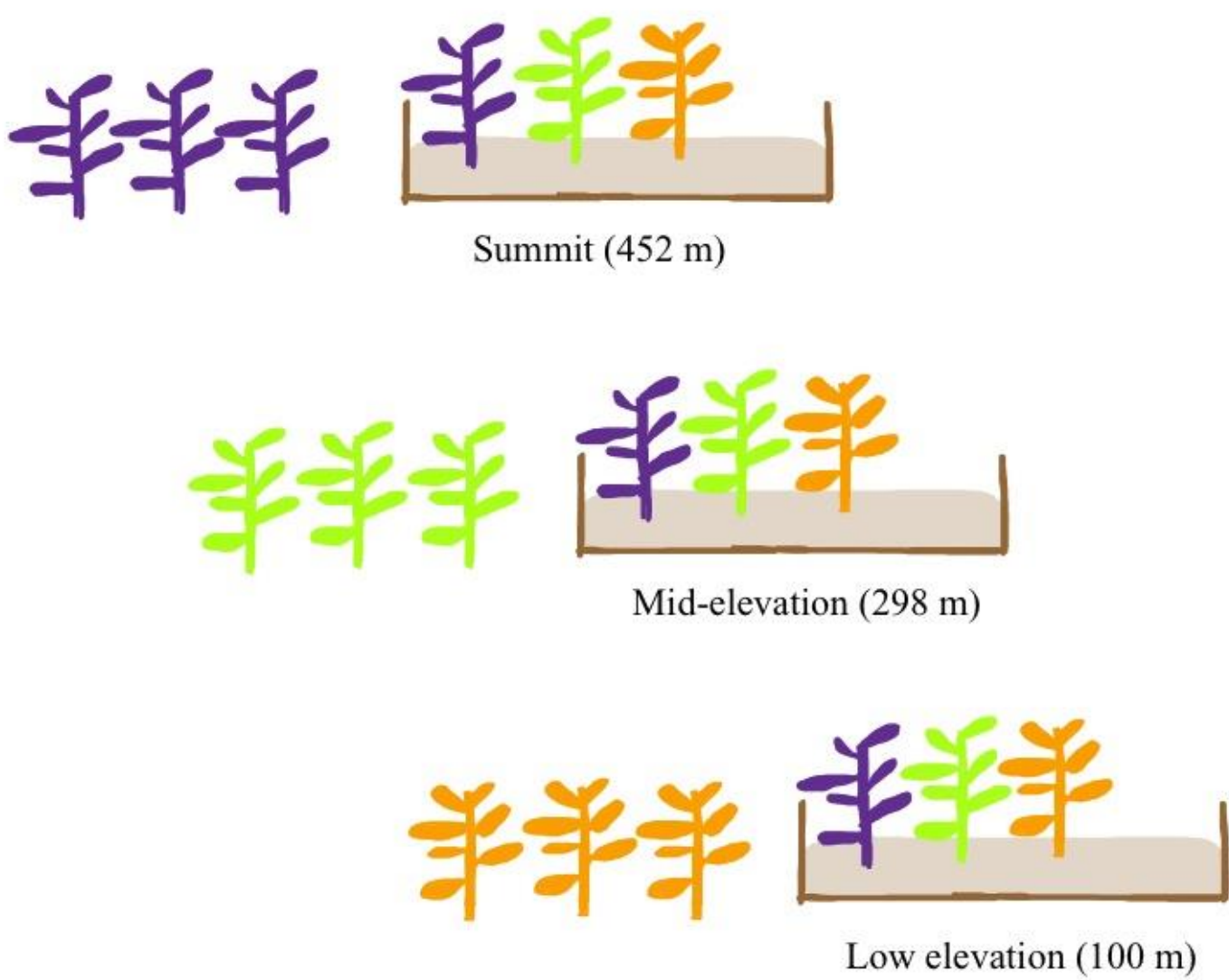
Fig. 1. Map of Mount Desert Island (MDI), and Acadia National Park, Maine.



Scan the QR code
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for a video introduction to this experiment
produced by *The Bangor Daily News*



METHODS



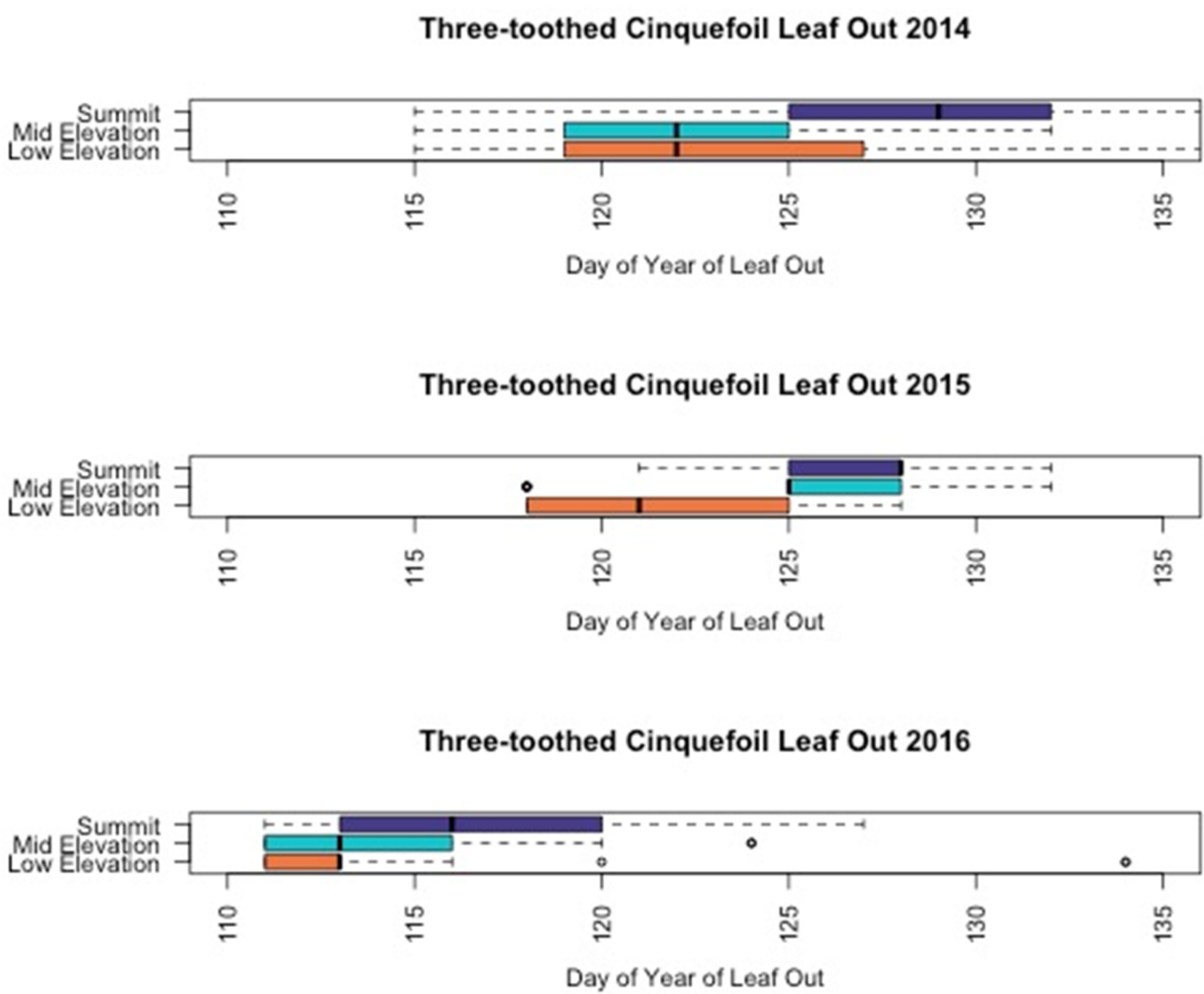
We partnered with volunteers from *Friends of Acadia* to build three raised beds on Cadillac Mountain in September 2013. We filled each bed with ten *Kalmia angustifolia*, *Vaccinium angustifolium*, and *Sibbaldiopsis tridentata* sourced from each elevation (90 plants in each garden — 10 replicates x 3 species x 3 source elevations) and flagged un-transplanted control plants adjacent to each garden. Gardens and controls were monitored twice a week from April through June for leaf out.

Flexible phenology is expected if the microclimate at each garden was the primary driver of leaf out phenology. However, if genetic adaptations within the source populations influence leaf out phenology, then plants from the colder summit sites will not respond to warmer conditions at lower elevations by leafing out earlier in the spring and may be more vulnerable to local extinction.

RESULTS

Table 1. We used ANOVAs to determine the main drivers of leaf out phenology for each species. The results are summarized here.
*** for $\Pr(>F) = 0.0001$ * for $\Pr(>F) = 0.05$

Species	Garden Site	Year	Source (Provenance)	Site x Year	Site x Provenance
<i>Kalmia angustifolia</i>	***	***		*	
<i>Vaccinium angustifolium</i>	***	***	*		
<i>Sibbaldiopsis tridentata</i>	***	***			*



CONCLUSIONS

The importance of garden site indicates that for these three species phenology is a flexible trait tracking temperature. Population-level adaptations controlling leaf out phenology are relatively weak: provenance is not significant at all for *Kalmia angustifolia*, while for *Vaccinium angustifolium* provenance is less significant than site and year, and for *Sibbaldiopsis* it is only significant as an interaction effect with site. Vulnerability assessments for the subalpine communities in Acadia National Park should likely focus on other species.

ACKNOWLEDGEMENTS

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1.Pau, S., Travers, S. E., Zavaleta, E. S. & Wolkovich, E. M. Phenological tracking enables positive species responses to climate change. *Ecology* (2012).
2.Willis, C. G., Ruhfel, B., Primack, R. B., Miller-Rushing, A. J. & Davis, C. C. Phylogenetic patterns of species loss in Thoreau's woods are driven by climate change. *PNAS* **105**, 17029–17033 (2008).
3.Morellato, L. P. C. *et al.* Linking plant phenology to conservation biology. *BIOC* **195**, 60–72 (2016).
4.Harris, T. B., Rajakaruna, N., Nelson, S. J. & Vaux, P. D. Stressors and threats to the flora of Acadia National Park, Maine: Current knowledge, information gaps, and future directions 1. *The Journal of the Torrey Botanical Society* **139**, 323–344 (2012). [Fig 1 Map from this paper.]