

# Understanding the Impacts of Climate Change on Obligate Spruce-fir Birds

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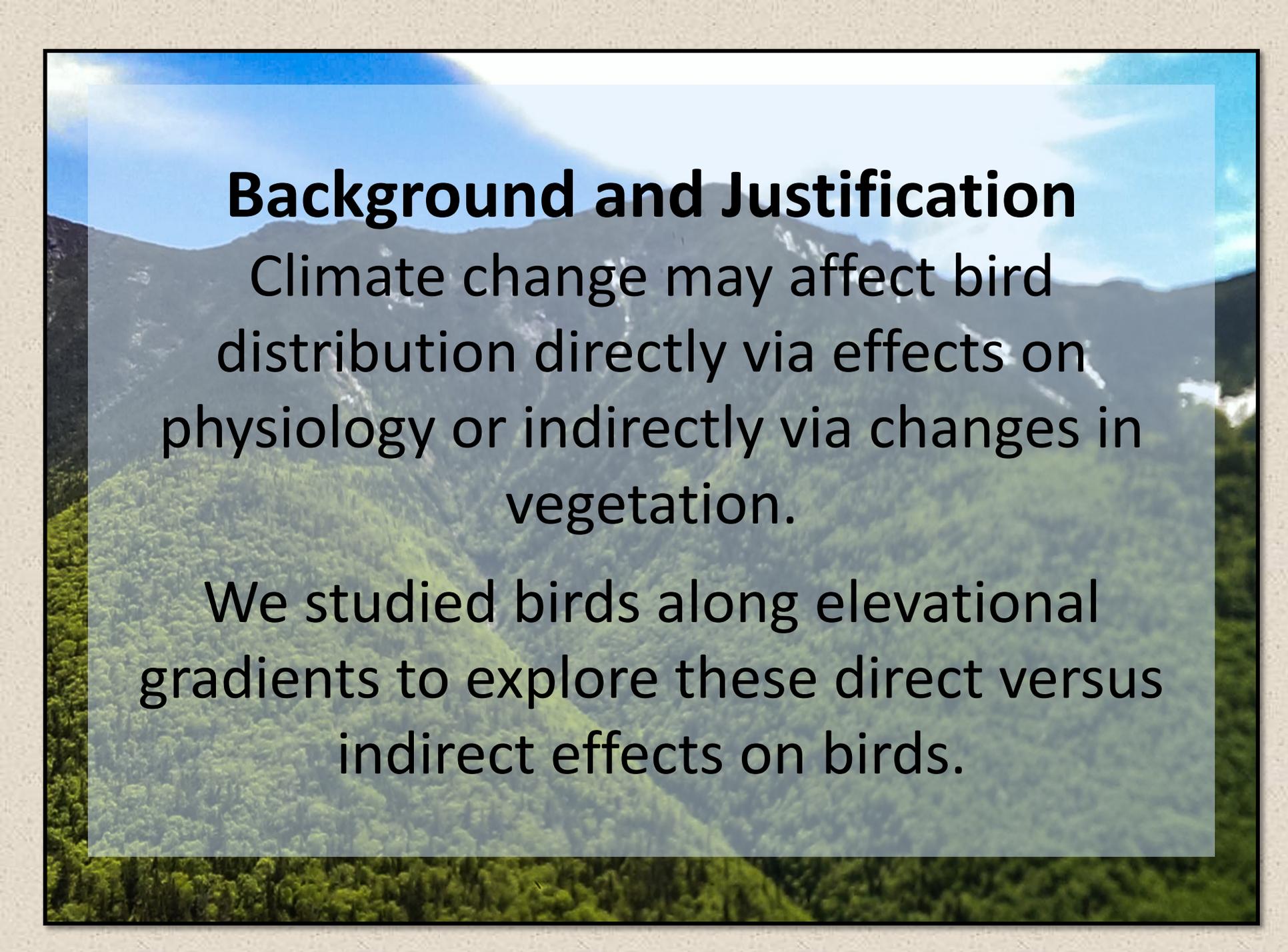
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- Dr. Aaron Weiskittel, University of Maine, School of Forest Resources

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<http://www.nsrcforest.org>

# Project Summary

- Climate exerts direct influences on bird abundance and indirect influences mediated by vegetation composition and structure.
- 77% exhibited both direct and indirect effects and 53% exhibited stronger indirect effects.
- These results provide insight into the mechanistic pathways of how climate influences the distribution of species along elevational gradients, underscoring the complex vulnerability of species to climate change.

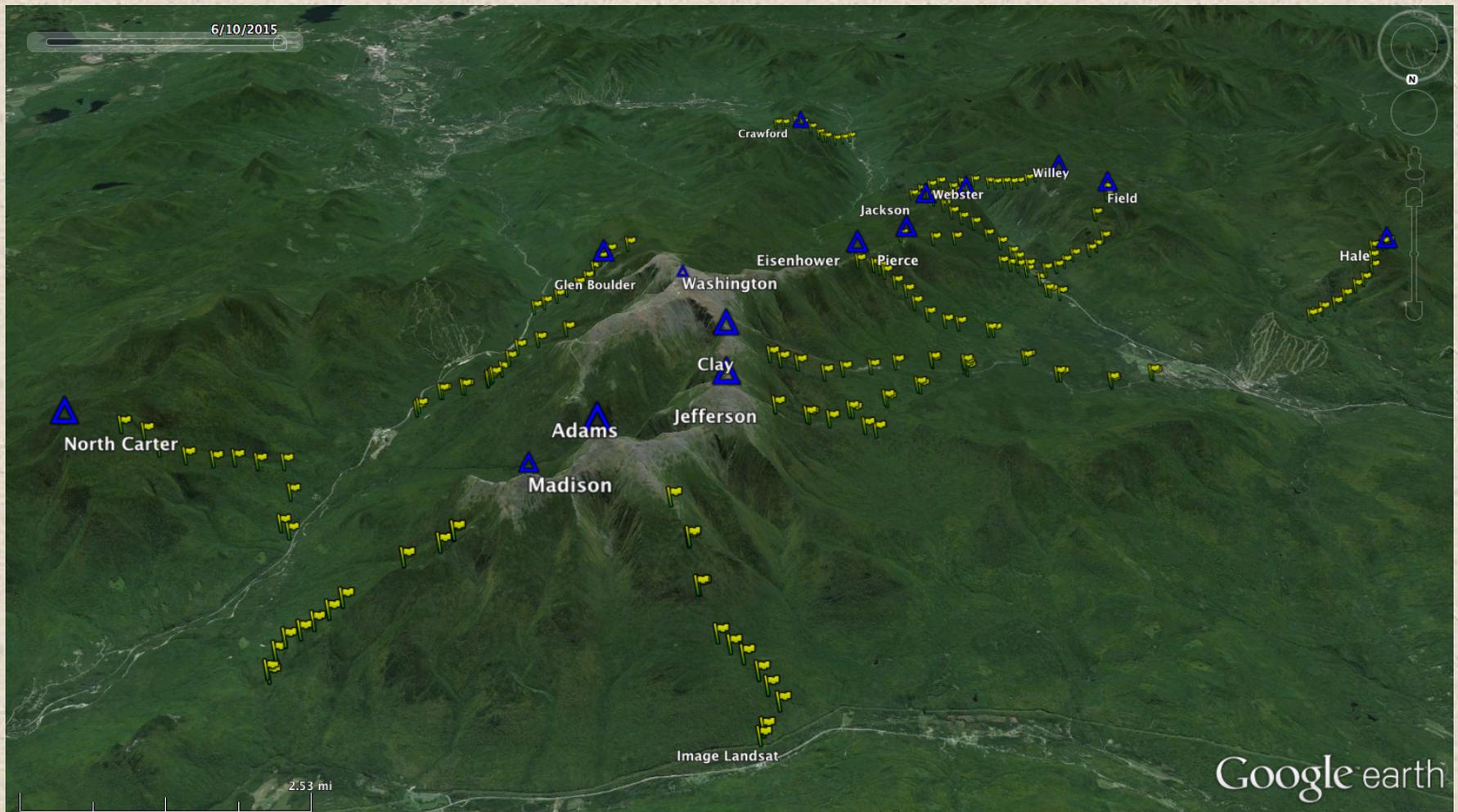


## **Background and Justification**

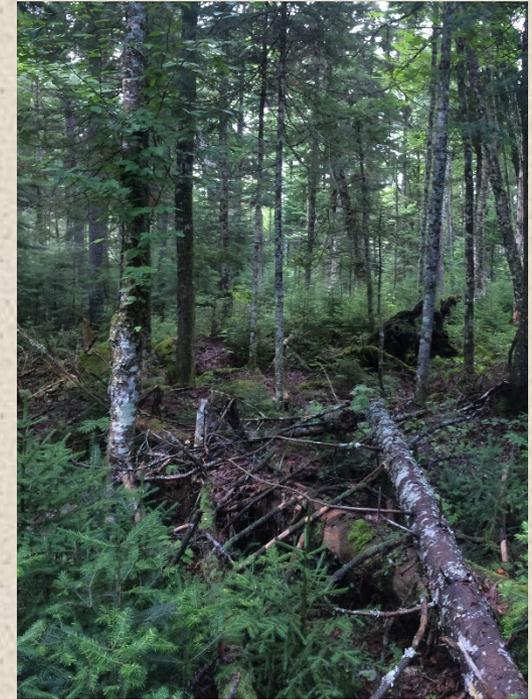
Climate change may affect bird distribution directly via effects on physiology or indirectly via changes in vegetation.

We studied birds along elevational gradients to explore these direct versus indirect effects on birds.

We established 150 sample points along transects from 319 m to 1,412 m in elevation

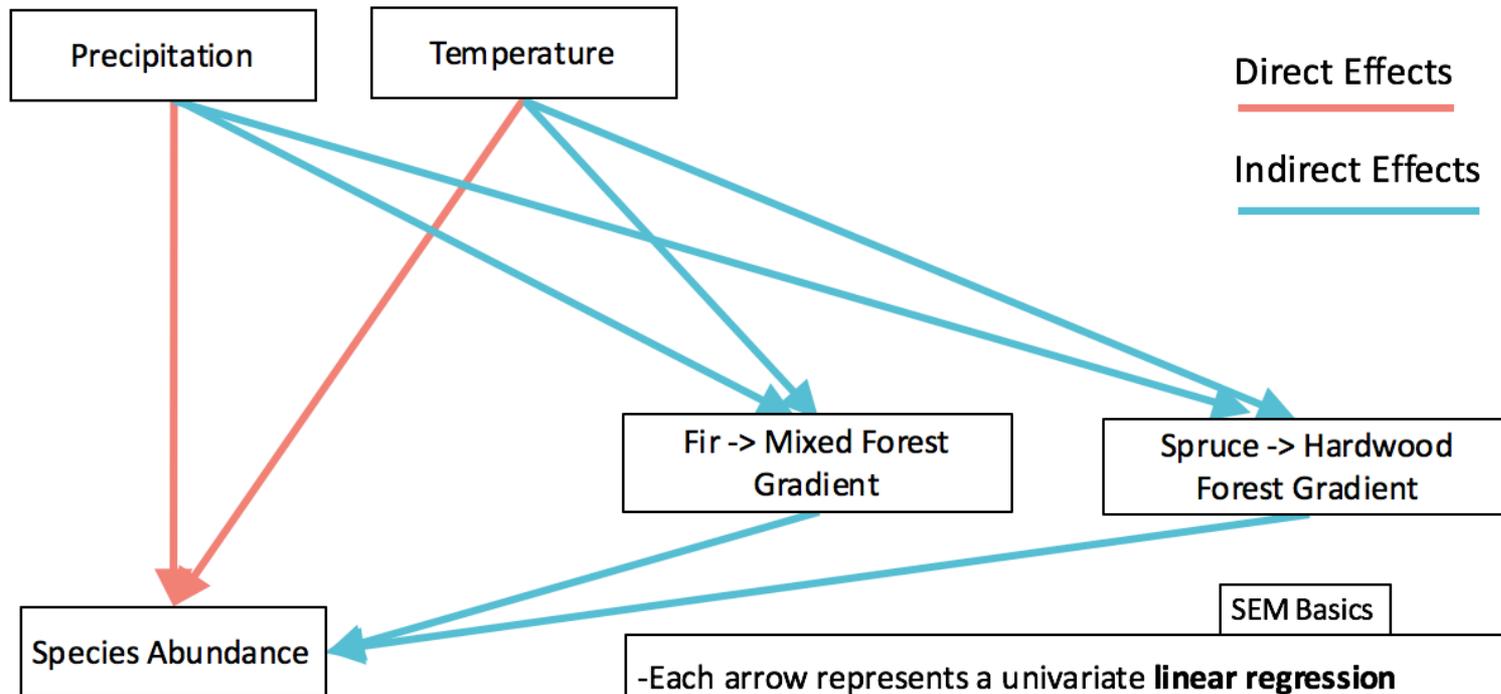


We sampled birds, temperature and vegetation along these elevational gradients



# We used structural equations modeling to distinguish direct and indirect effects

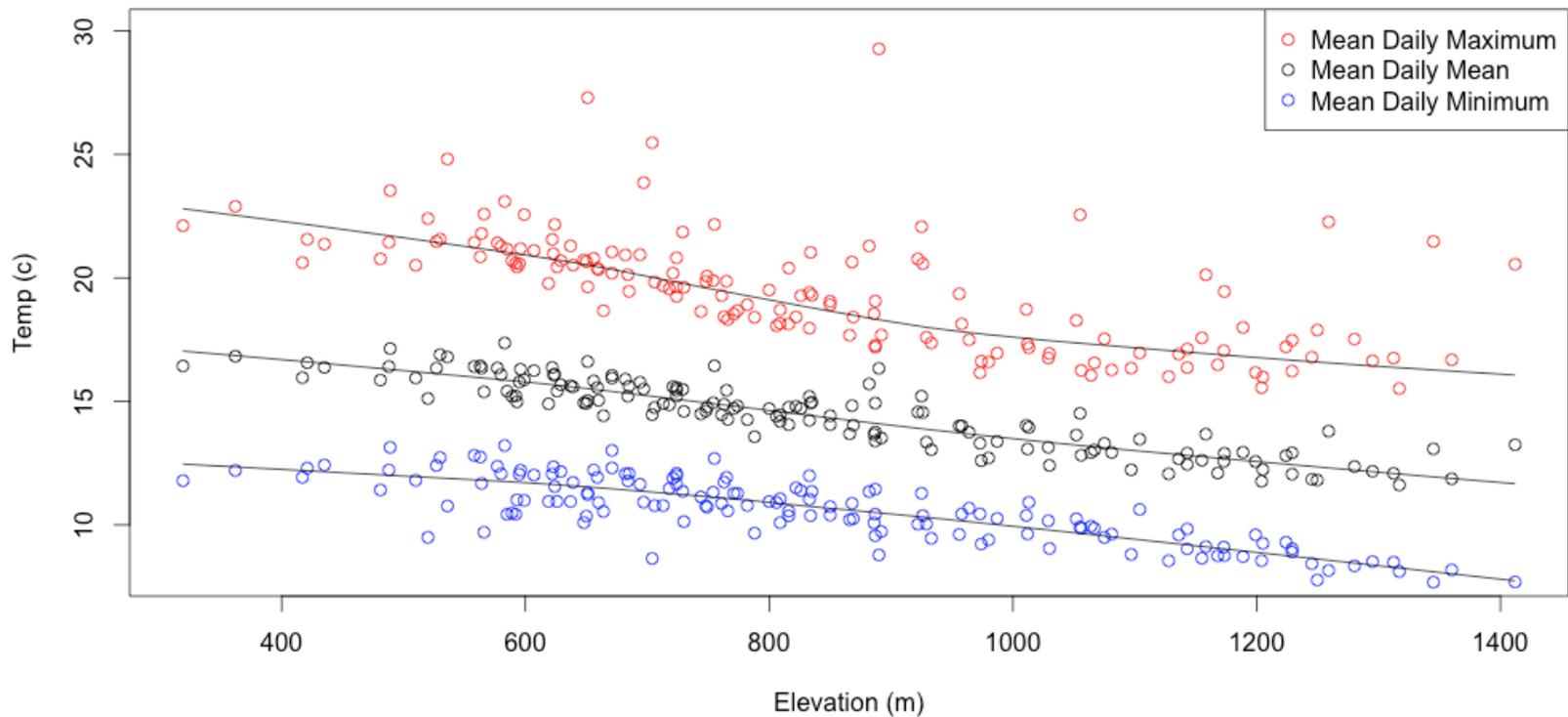
## Statistical Methods- Structural Equation Model (SEM)



- Each arrow represents a univariate **linear regression**
- Mediating variables are both **response variables and predictors**
- Fit to **maximally explain covariance structure**

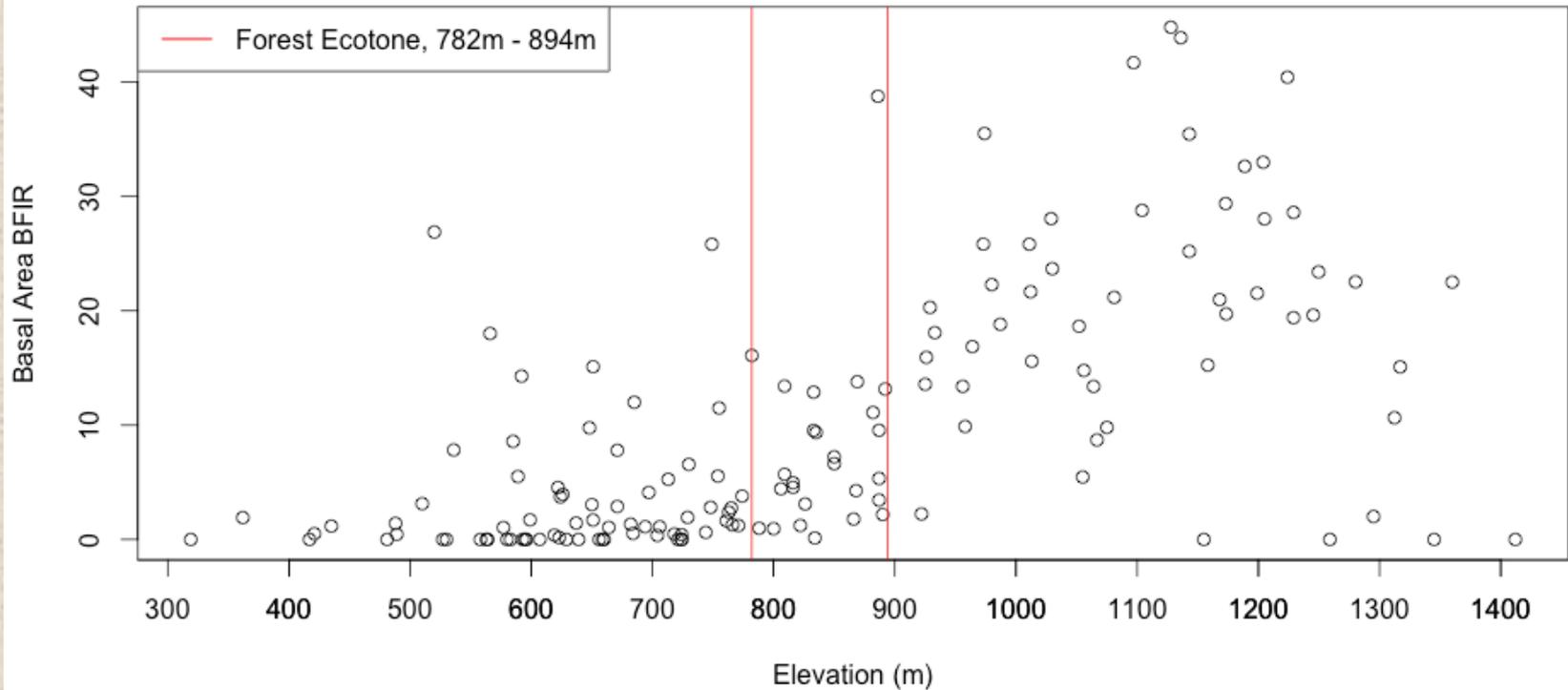
# We found temperature decreased 8°C over 800 m elevation

2015 Seasonal Mean Temperatures for 150 Sites in the WMNF

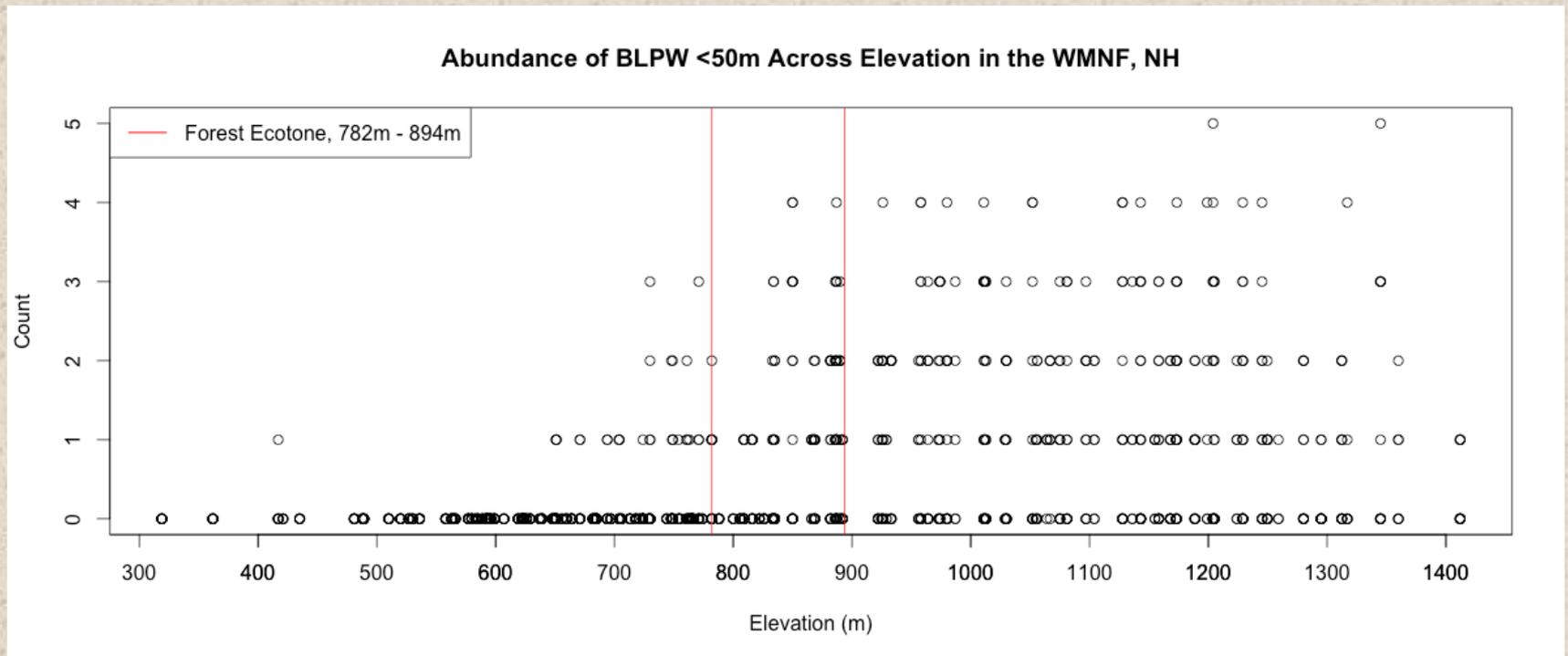


# Forest composition also changes with elevation

Basal Area of Balsam Fir Across Elevation in the WMNF, NH



# Spruce-fir birds increase with elevation

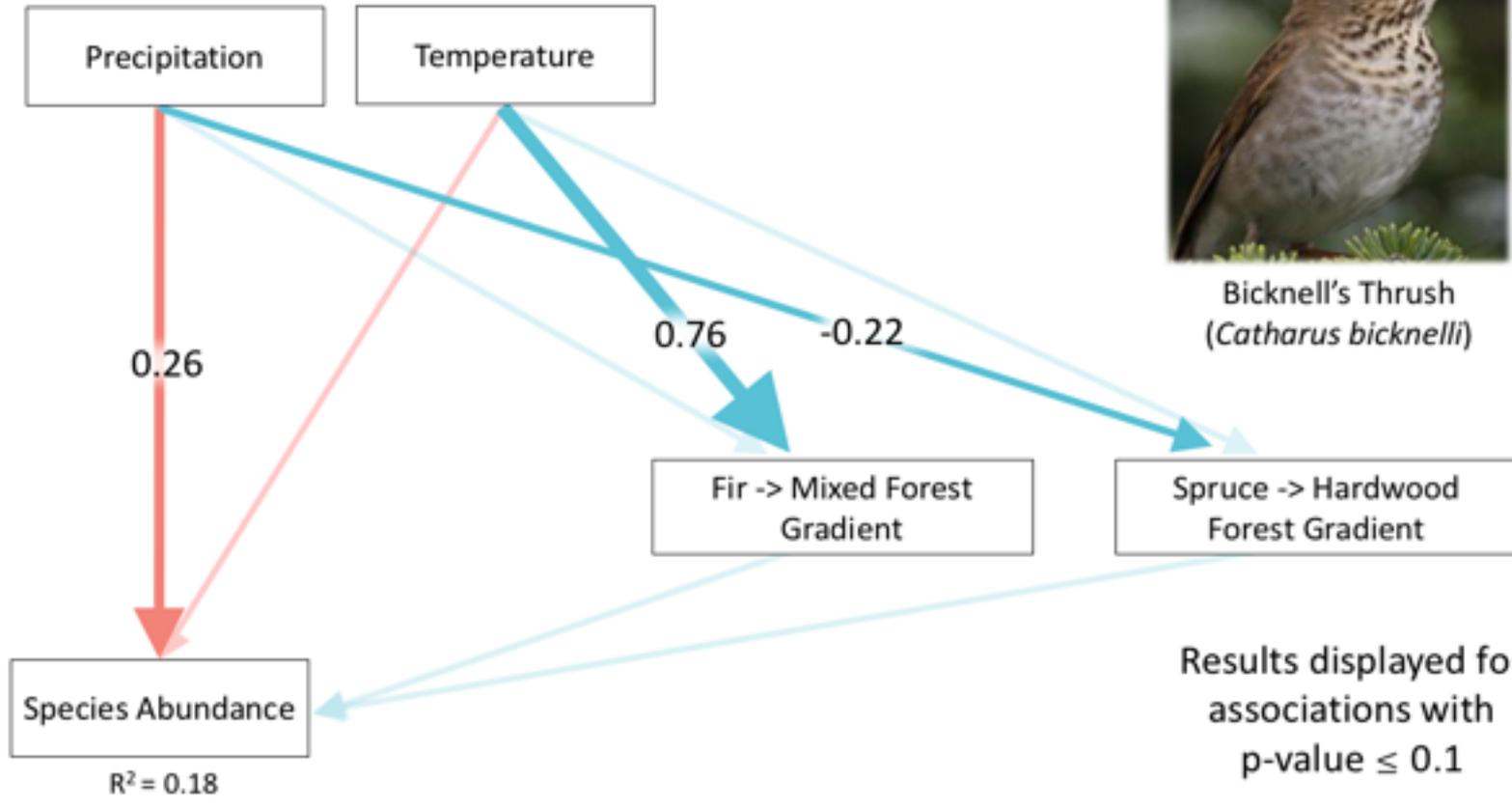


# Example of a species exhibiting direct effects of climate

## Results: Direct Effects of Climate



Bicknell's Thrush  
(*Catharus bicknelli*)

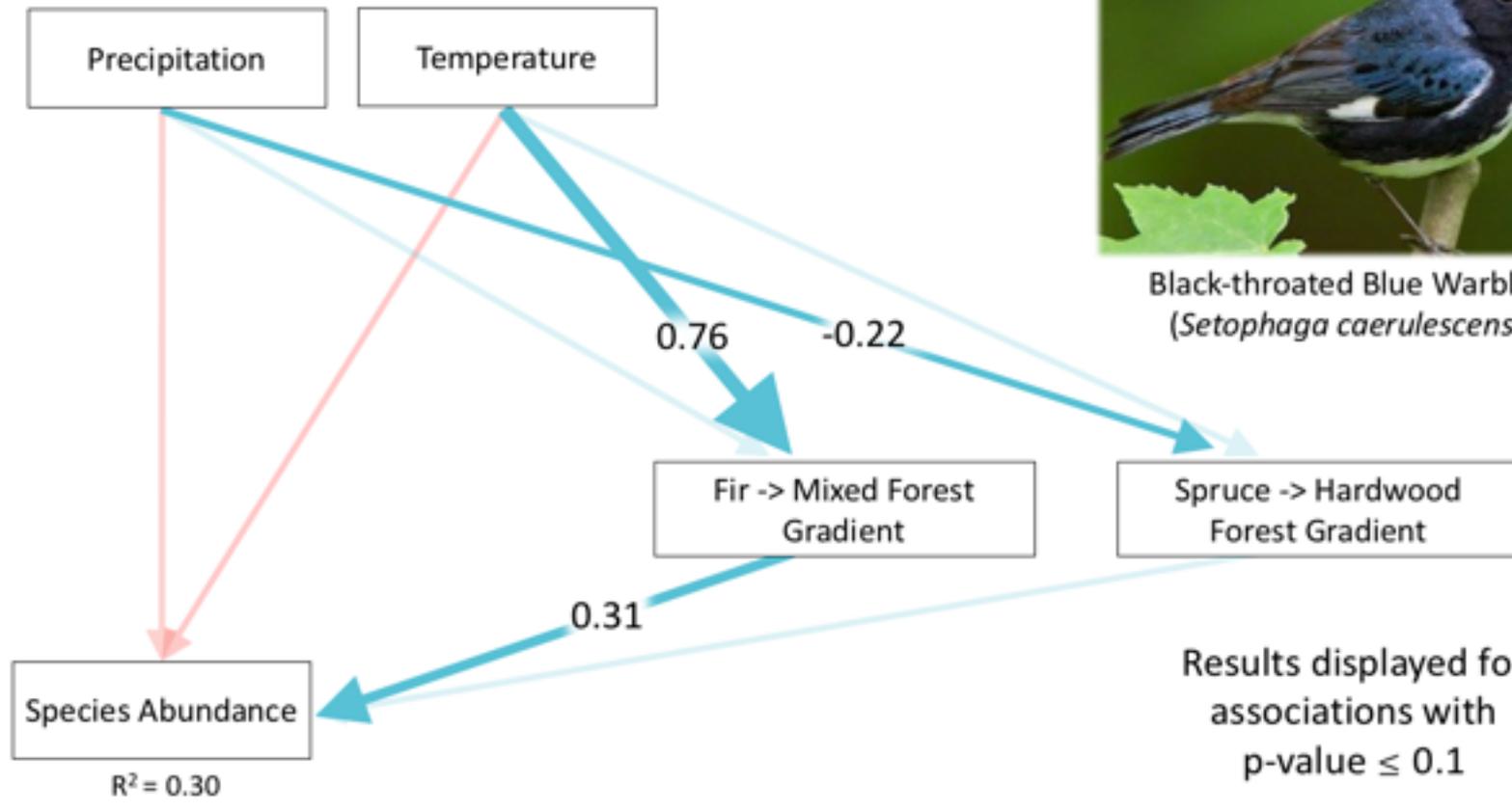


# Example of a species exhibiting indirect effects of climate

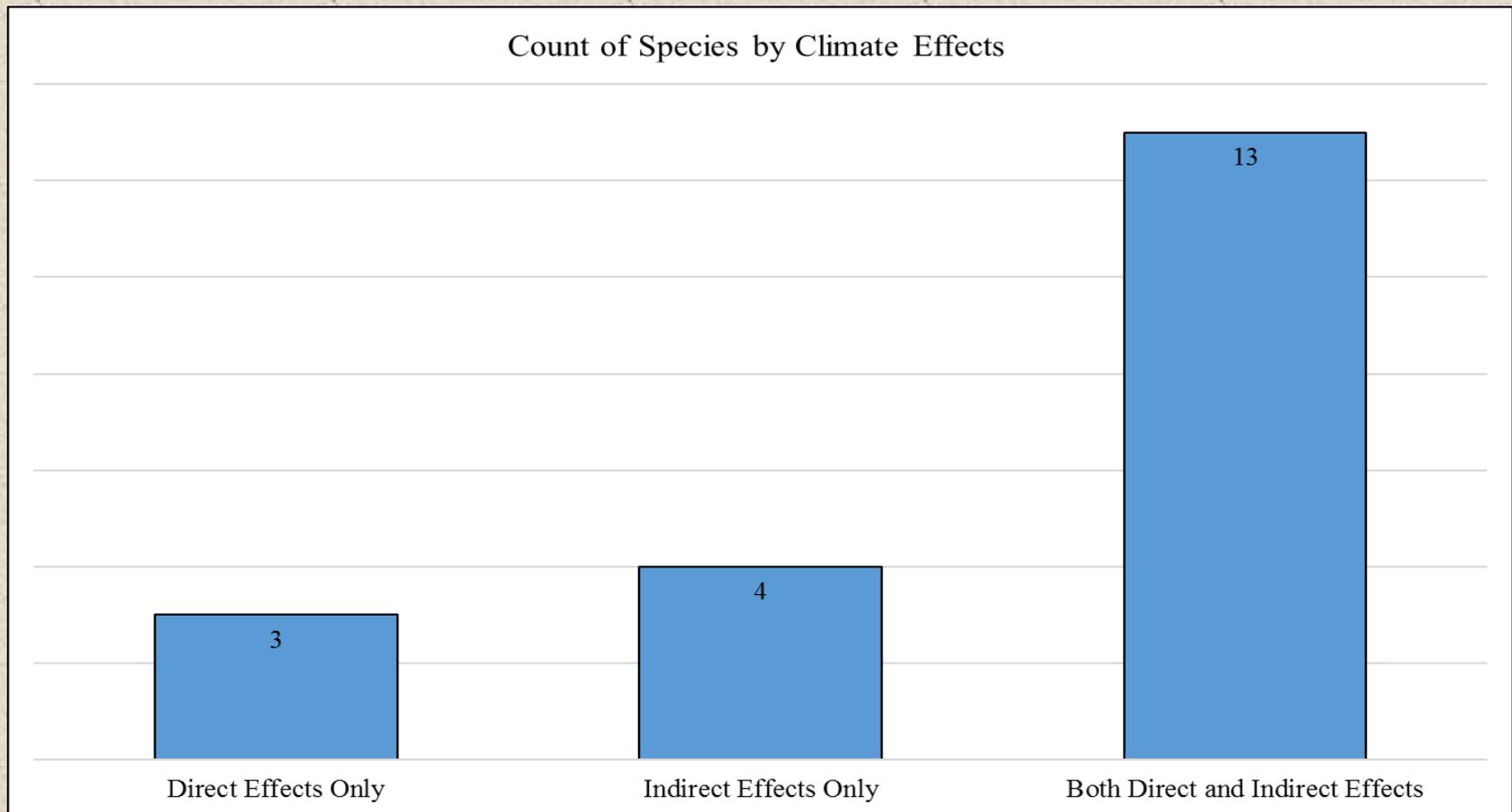
Results: Indirect Effects of Climate



Black-throated Blue Warbler  
(*Setophaga caerulescens*)



# The majority of species exhibited both direct and indirect responses



# **Implications and applications in the Northern Forest region**

For species that are primarily influenced by climate directly, typical climate envelope models may continue to be informative, but for the majority of the species included in this study, we show that distribution models should also include measures of habitat.

# List of products

- Duclos, T.R., W.V. DeLuca and D.I. King. 2016. "Direct and indirect influences of climate on bird species abundance along elevation gradients in the northern Appalachians". Oral, presented by Duclos. North American Ornithological Congress, Washington DC, to the Nature Conservancy of Vermont, Montpelier, VT, and the Northeast Chapter of Wildlife Society Annual Fall Conference, Hadley, MA.
- Duclos T.R., W.V. DeLuca and D.I. King. 2019. Direct and indirect effects of climate on bird abundance along elevation gradients in the Northern Appalachian mountains. *Diversity and Distributions* 25:1670-83.