

Ecological Niches in Sequential Generations of Monarch Butterflies and Projections in Future Climatic Conditions

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Introduction: The eastern North American monarch migration may be triggered by climatic cues, suggesting that they could be impacted by ongoing global climate change processes. Zalucki and Rochester (2004) predicted large-scale fluctuations in the abundance of this population resulting from effects of climate on phenology and fecundity. Here, we assess seasonal variation in ecological niche characteristics of breeding populations and then investigate likely effects of global climate change on these seasonal patterns, projecting the predictive models for present-day distributions to future (2055) climate patterns.

Methods: We developed ecological niche models for March through September and projected each month model onto climatic conditions for other breeding months and future climate scenarios.

Niche models

- *Genetic Algorithm for Rule-set Prediction, GARP*
 - Finds non-random associations between point-occurrence data and environmental information to determine parameters that are conducive to monarch presence and reproduction

Input data sets

- Point-occurrence data
 - Date-specific occurrence data from the Monarch Larva Monitoring Project
 - Modeled region limited to within 500 km of sampling region
 - Used egg occurrence data only
- Environmental information
 - Climatic and topographic parameters from USGS
 - Temperature, precipitation, elevation, and slope
- Future distributions
 - Averaged conservative and less conservative views of climate change for next 50 years
 - Results based on a 30 year average around 2055 (2040-2069)

Results:

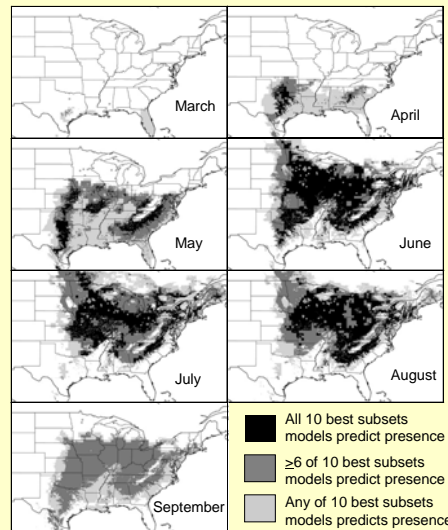


Figure 1. The ecological niche model based on June points used to predict March-September. Occurrence data from the month being predicted are overlaid as dotted circles.

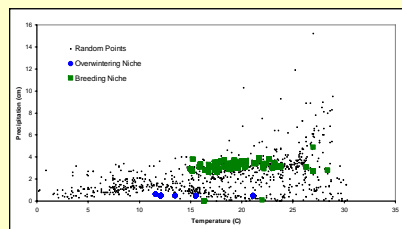


Figure 2. Temperature and precipitation combinations predicted to be suitable for monarchs based on ecological niche models. Breeding model defined by June occurrence data and overwintering model data from Oberhauser and Peterson (2003). Gray points indicate the range of conditions present across the breeding niche study area in June.

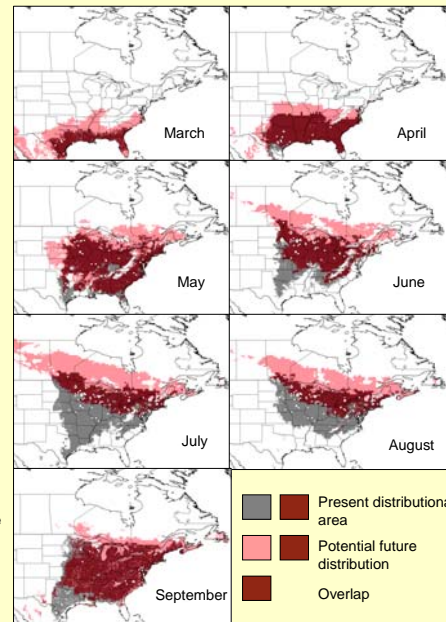


Figure 3. Changed climate (2055) projections for monthly monarch butterfly potential distributions. Occurrence points (present day) are plotted as white squares.

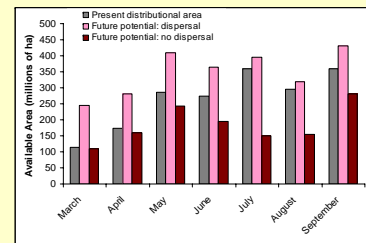


Figure 4. Summary of area estimates for present and future monthly distributional areas for monarch butterflies.

Conclusions: The ability of ecological niche models to predict monarch month-to-month distributional dynamics demonstrates that sequential generations of breeding monarchs are ‘niche followers’ (Figure 1). The lack of correspondence between the spring, summer and fall niche, and the winter niche used by monarch butterflies is evidence that monarchs switch niches (Figure 2).

Future-climate projections of month-specific ecological niche models predict marked changes in the species’ seasonal potential distribution (Figure 3). With climate change, habitable areas are predicted to continue shifting northward through July and contract in August, perhaps necessitating relocation of all local populations of monarchs before breeding.

It is unclear whether monarchs will be able to adjust their seasonal movement patterns to accommodate these changing conditions or what the consequence of lost breeding locations will be. If monarchs cannot track the shifts in ecological niche conditions, they stand to lose a significant amount of habitat (Figure 4).

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References:

- Oberhauser, K & Peterson, AT. 2003. *Proc. Natl. Acad. Sci.* **100**, 14063-14068.
- Zalucki, MP & Rochester, WA. 2004. In *Monarch Butterfly Biology and Conservation*. (eds. Oberhauser, K & Solensky, MJ), pp. 219-228. Ithaca, NY: Cornell University Press.