Monarch Population Decline Debate: The Expert Opinions

**GROUP 1: Unravelling the annual cycle in a migratory animal: breeding-season habitat loss drives population declines of monarch butterflies**

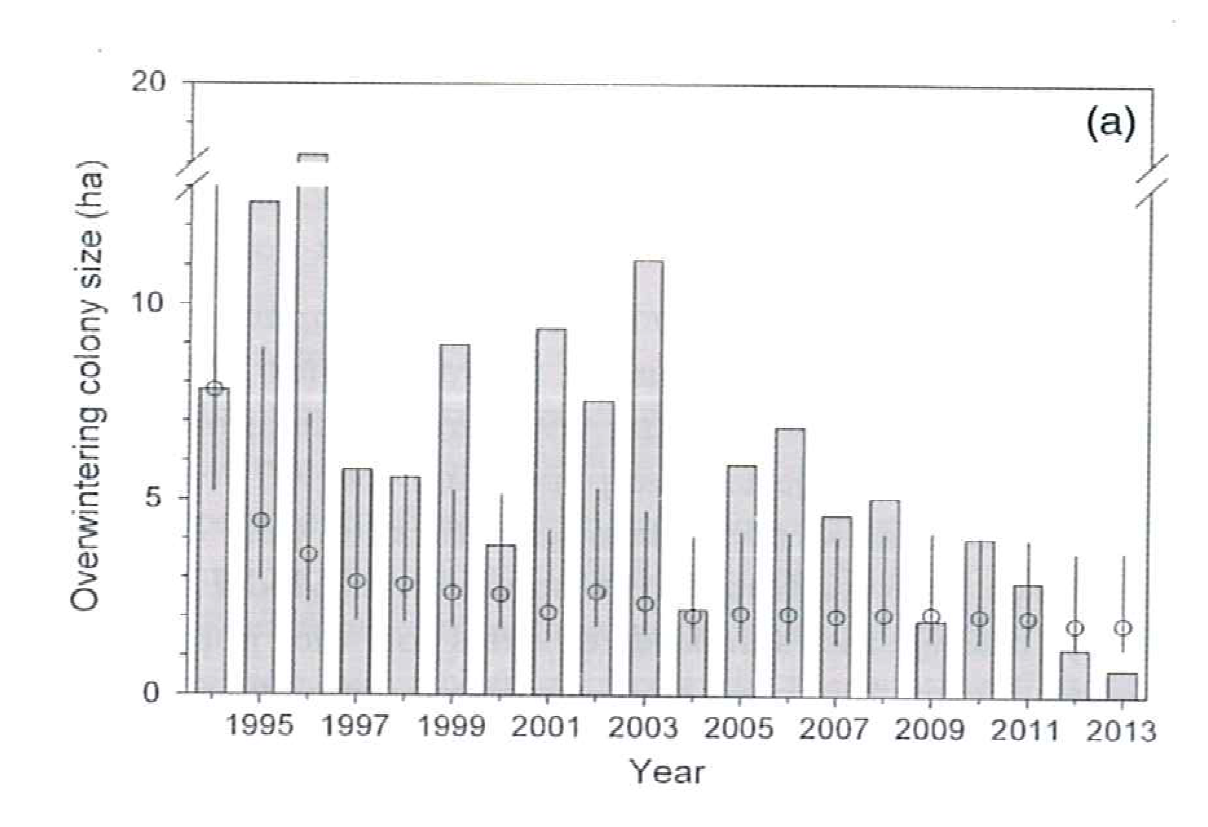
*D.T. Tyler Flockhart, Jean-Baptiste Pichancourt, D. Ryan Norris and Tara G. Martin (2015)*

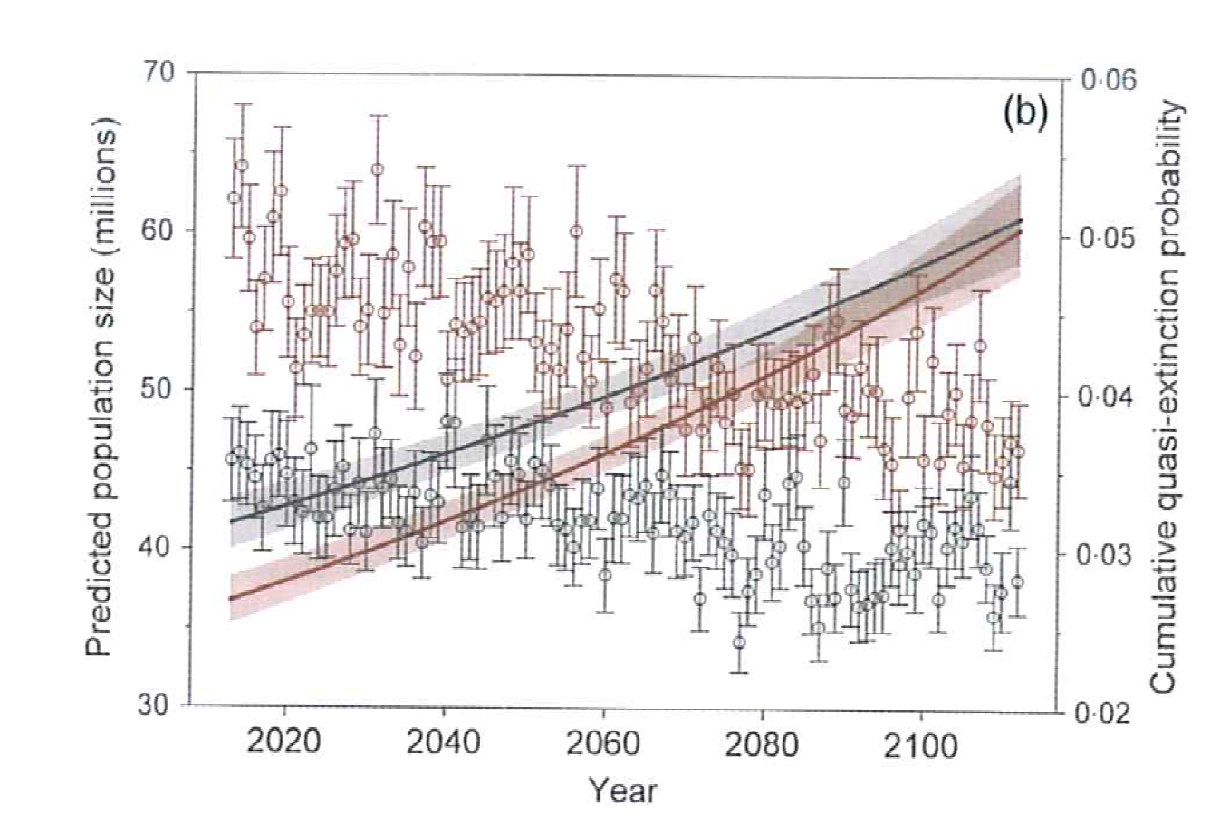
Background: “Threats to migratory animals can occur at multiple periods of the annual cycle that are separated by thousands of kilometres and span international borders. Populations of the iconic monarch butterfly (*Danaus plexippus*) of eastern North America have declined over the last 21 years.”

Question and Methods: Using computer models of the monarch life cycle, these researchers sought to determine the life stage where monarchs were most vulnerable, as well as the season and geographic area that affects population the most.

Hypotheses Considered: Habitat loss on the overwintering grounds in Mexico; milkweed loss on the breeding grounds in the United States and Canada; extreme weather events.

Key Results:

* Researchers found that estimates of monarch population sizes drawn from their computer model were not significantly different from those drawn from observed monarch population data. In the figure below, showing the overwintering colony size in Mexico over time, observed values are shown with the bars while the average values predicted by the model are shown with the circles. The size of the lines above and below the circles relate to the range of values the model predicts could be possible. The researchers argue that because there is a good match between the circles and the bars, their model will be good at making predictions for the future.
* The model predicted the monarch population will decline by 14% in the next 100 years, and the probability of extinction will increase. In the figure below, the points show the population size of monarchs that the model predicts for the next 100 years. The lines show the model predictions for the probability that the population will go extinct. The different colors show different predictions under different scenarios the model can account for, depending on whether farming practices continue to kill milkweed plants (red) or not (black).



* When researchers tested the different parts of the model to see what was most important, they found that monarch population size was much more dependent on milkweed in the breeding grounds rather than the size of overwintering grounds or temperature changes.

Conclusion: Due to the use of genetically modified crops and herbicides, milkweed plants that serve as monarch food and habitat have been declining, and these are the major cause of the monarch population decline.

“Overall, observed monarch butterfly population decline and future increased extinction risk are largely driven by conditions on the breeding ground… Our results imply that conserving monarch butterflies by addressing the negative impacts of changing land-use and the adoption of genetically modified, herbicide- resistant crops on host plant abundance is the highest conversation priority. These conclusions should not be misconstrued as implying that efforts towards improving the social, economic and environmental conditions on the wintering grounds are not important, but rather, that inaction in one location during a portion of the annual cycle can undermine conservation efforts in other portions of the annual cycle.”

**GROUP 2: Linking the continental migratory cycle of the monarch butterfly to understand its population decline**

*Hidetoshi Inamine, Stephen P. Ellner, James P. Springer and Anurag A. Agrawal (2016)*

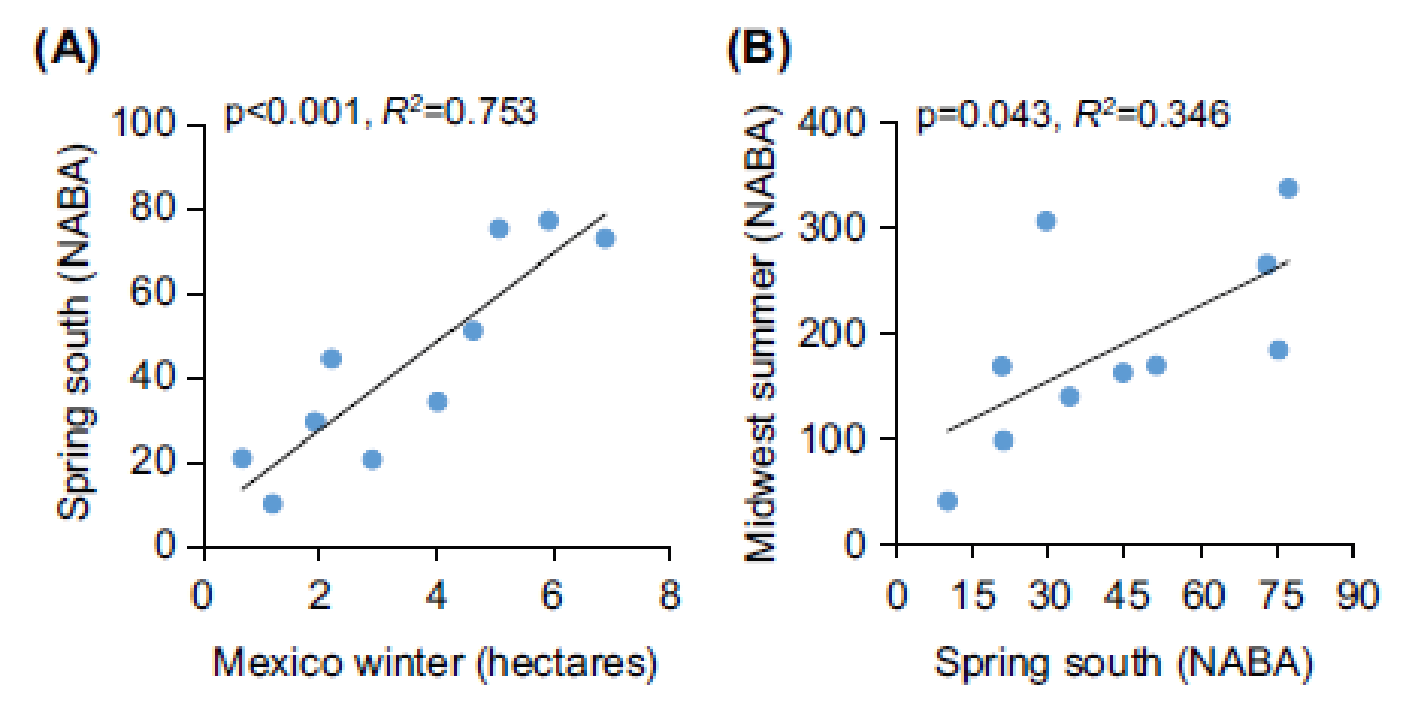
Background: “Recent analyses have linked the monarch decline to reduced abundance of milkweed host plants in the USA caused by increased use of genetically modified herbicide-resistant crops.”

Question and Methods: These scientists used data collected by citizen scientists over 22 years to identify which stages in the monarch life cycle are most likely contributing to the decline of monarch populations. There are some questions about the citizen science data because people in different regions spend different amounts of time looking for monarchs, but the authors think they have been able to use the data reliably.

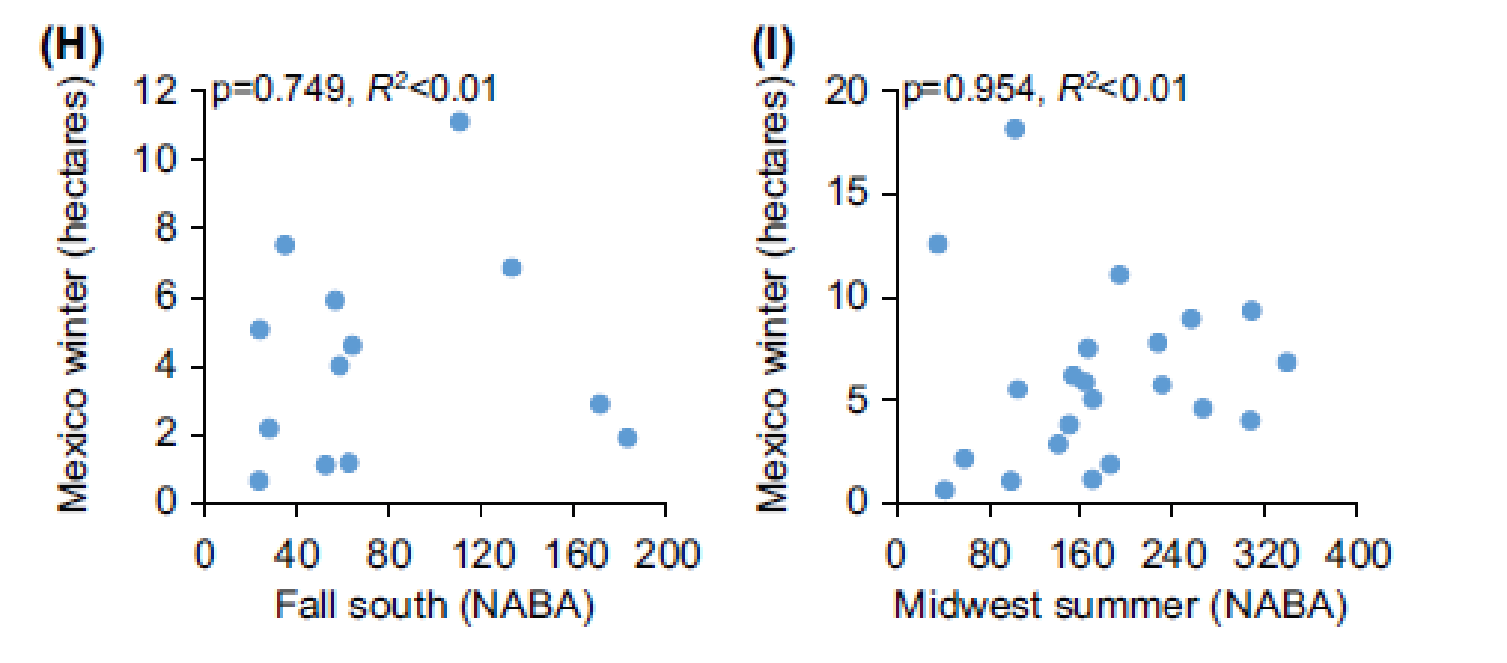
Hypotheses Considered: These authors had two primary assumptions. First, they expected the population size at one stage in the monarch life cycle to predict the population size at the next stage. That is, if there are lots of monarchs in Mexico over the winter, there should then be lots of them migrating into North America in early spring that year. Second, they predicted that if this relationship declined over time for certain life stages, those life stages would be most responsible for Monarch population decline. With these ideas in mind, they could test different hypotheses about the monarch population decline: 1) are monarchs finding less and less milkweed in their breeding grounds in North American summers, 2) are they suffering during the fall migration into Mexico, or 3) are they failing to successfully return from Mexico in the spring.

Key Results:

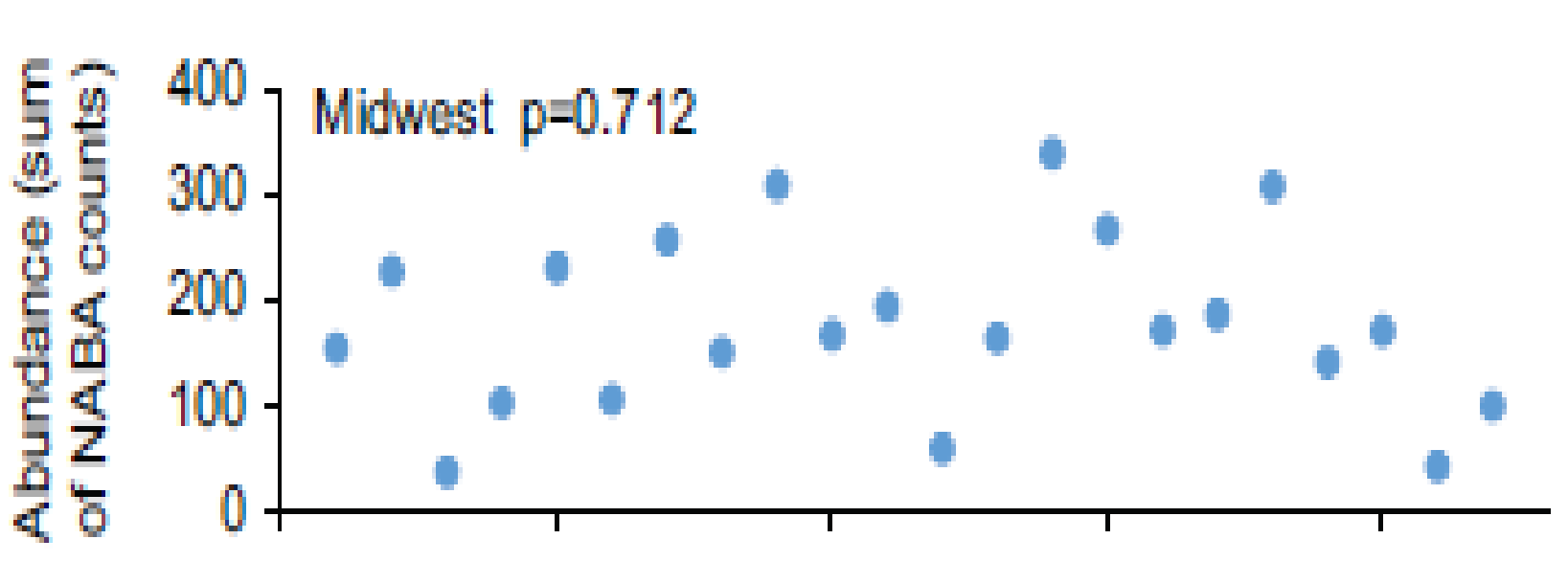
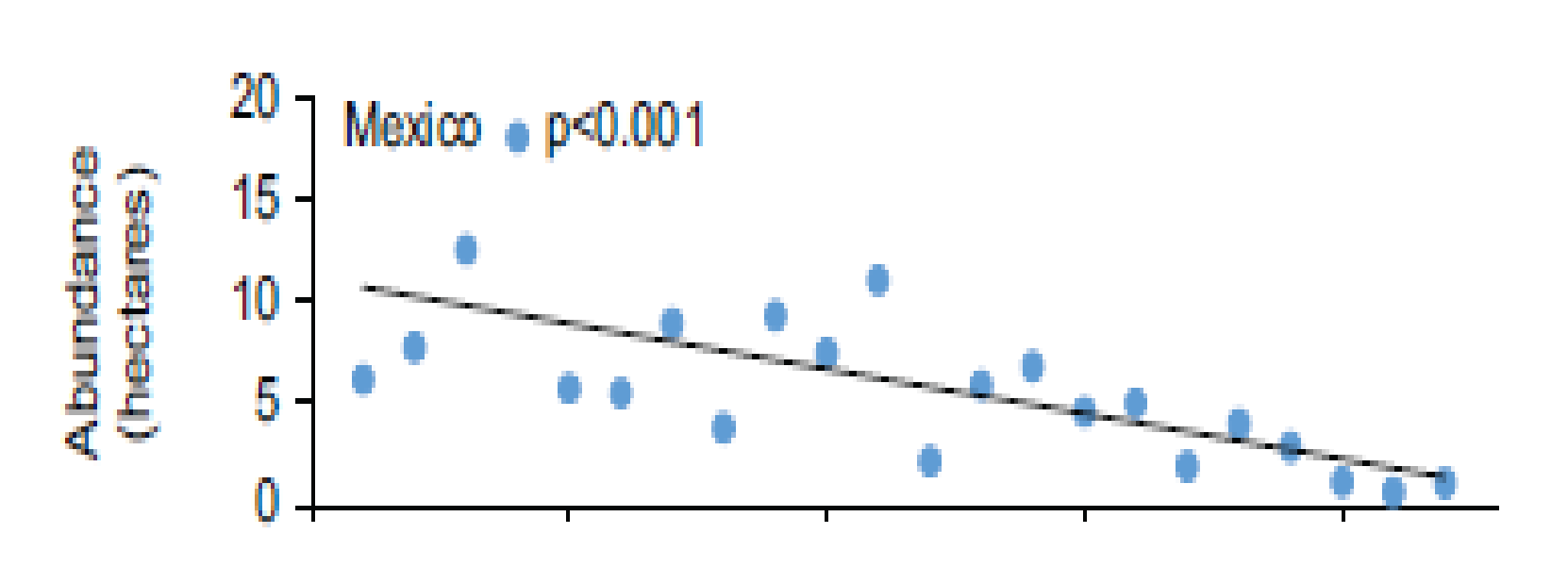
* The size of the overwintering monarch population in Mexico was positively related to the size of the populations in the United States in the spring and summer as the monarchs migrate northward. In the figures below, population size estimates from the preceeding generation are on the X-axis, and the following generation is shown on the Y axis. NABA refers to the North American Butterfly Association records of citizen science buttefly counts.



* The size of the populations returning to Mexico was not strongly related to the size of the summer populations in the United States.



* Over time, the size of the monarch populations in Mexico declined, but the counts in most of the United States did not (Midwest shown below).



Conclusion: The evidence does not support the milkweed limitation hypothesis, because the monarch population didn’t change over time in the breeding grounds in the US. In contrast, the decline at the overwintering grounds in Mexico, suggesting that monarch success during the fall migration and re-establishment strongly contributes to the butterfly decline.

“Lack of milkweed, the only host plant for monarch butterfly caterpillars, is unlikely to be driving the monarch’s population decline. Conservation efforts therefore require additional focus on the later phases in the monarch’s annual migratory cycle. We hypothesize that lack of nectar sources, habitat fragmentation, continued degradation at the overwintering sites, or other threats to successful fall migration are critical limiting factors for declining monarchs.”

**GROUP 3: Decline of monarch butterflies overwintering in Mexico: is the migratory phenomenon at risk?**

*Lincoln P. Brower, Orley R. Taylor, Ernest H. Williams, Daniel A. Slayback, Raul R. Zubieta and M. Isabel (2012)*

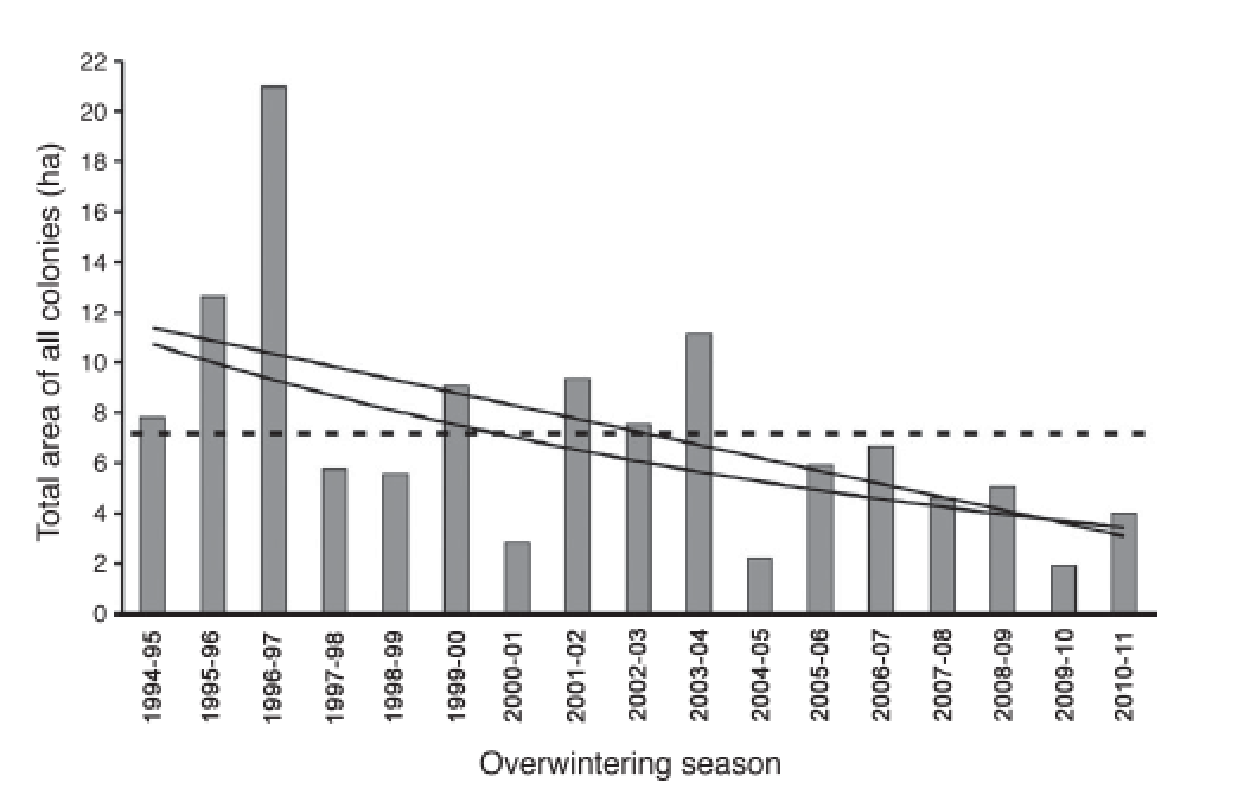
Background: “During the 2009–2010 overwintering season and following a 15-year downward trend, the total area in Mexico occupied by the eastern North American population of overwintering monarch butterflies reached an all-time low. Despite an increase, it remained low in 2010–2011.”

Question and Methods: Concerned with the rapid decline in monarch populations, Researchers used existing data to determine if the drop is significant using multiple statistical models.

Hypotheses Considered: Lost of forest habitat in overwintering areas such as Mexico; loss of milkweed habitat and food in the United States due to genetically-modified, herbicide-resistant crops; severe weather.

Key Results:

* Researchers found that downward trends in monarch population were statistically significant with both linear and exponential models, even though the data they used only spans 17 years. In the figure below, the dashed line shows the 17-year average and the solid lines show the significant trends in the area occupied by overwintering monarch butterflies over time.



* Regression models are still significant even with removal of either of two extremes- the highest population value (in 1996-1997) and the lowest population value (in 2009-2010).
* Illegal logging in Mexico has severely damaged monarch overwintering habitat; between 1971 and 1999, 44% of one overwintering forest was degraded.
* 85-92% of overwintering monarchs in Mexico fed on Common Milkweed as caterpillars. Common Milkweed was especially abundant in in disturbed areas like farmland. “Roundup Ready” crops from Monsanto were adopted by corn and soybean farmers in the United States in 1999. Farmers can spray Roundup herbicides on their fields, which kills Common Milkweed, reducing breeding habitat for monarchs.
* Severe weather events such as unusually high precipitation, high winds, or temperatures that are too high or low can harm monarch populations at all stages of their life cycle. As many as 50% of overwintering monarchs may have died in 2010 as a result of excess rain, high winds and cold temperatures.

Conclusion: Even though the monarch population fluctuates from year to year, researchers still determined all three hypotheses considered in their paper have the potential to wipe out monarch populations.

“In this paper, we have presented an analysis of the long-term trend in monarch abundance, a decline that exists despite some fluctuation year-to-year. The combination of lowered numbers of fall migrants, the illegal logging in the overwintering region, the severe losses of breeding habitat due both to GM crops and development, and the near miss of catastrophic mortality by the 2010 storm suggest that better stewardship is needed to assure the future of the monarch migratory phenomenon.”

**GROUP 4: Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population**

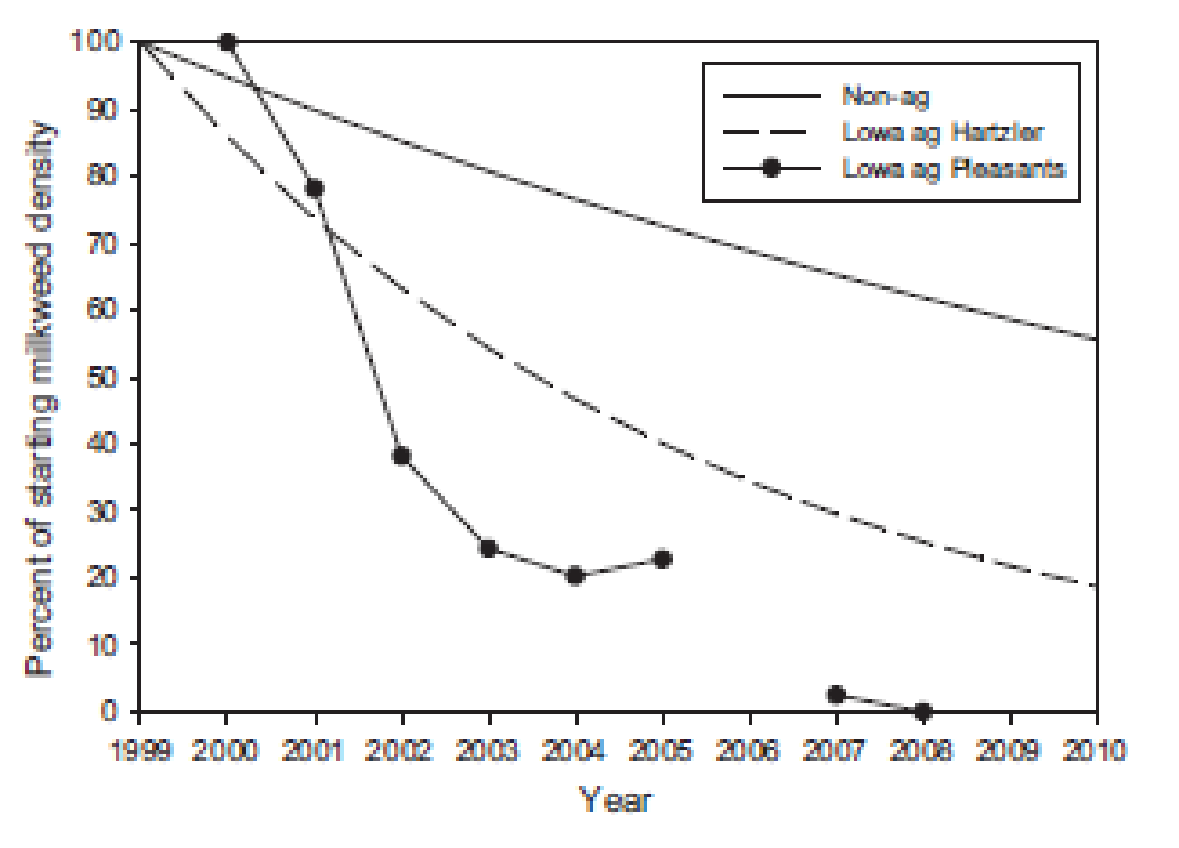
*John M. Pleasants and Karen S. Oberhauser (2012)*

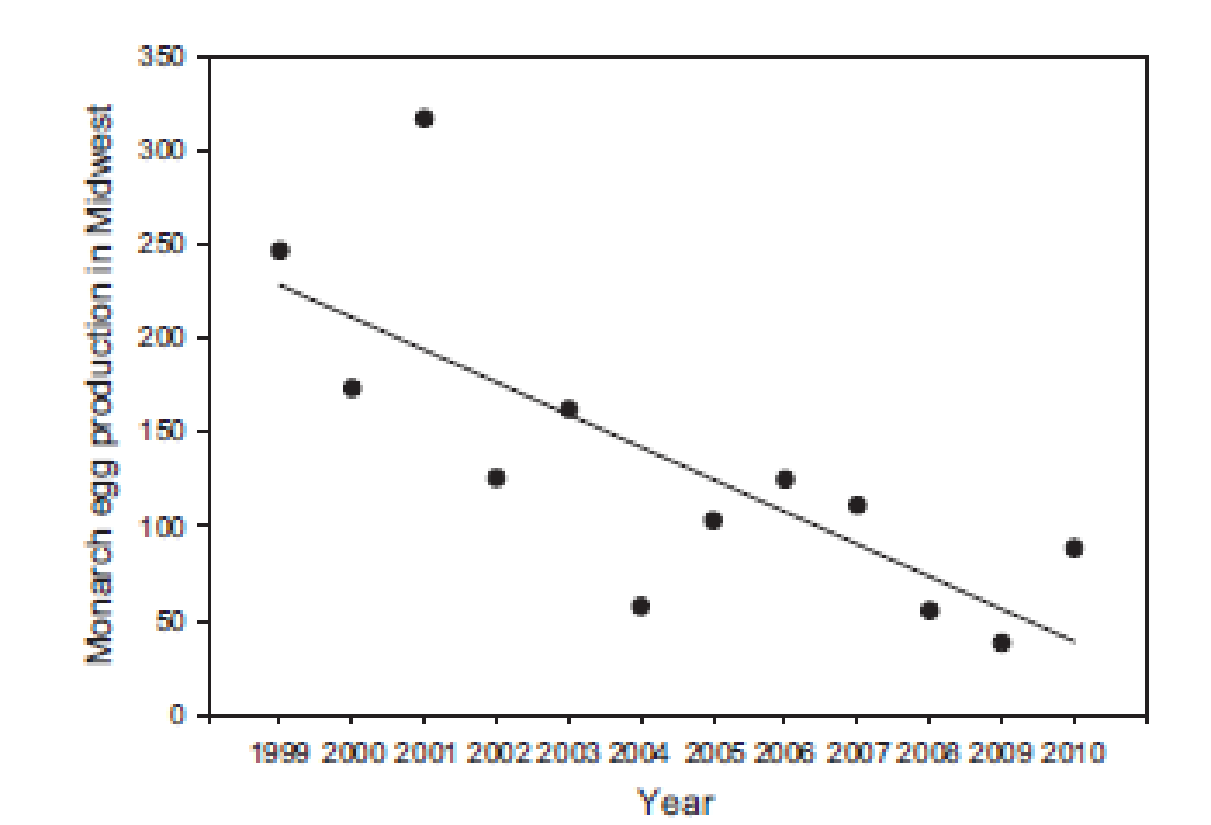
Background: “Approximately half of [the monarch butterflies overwintering in Mexico] come from the U.S. Midwest where larvae feed on common milkweed. There has been a large decline in milkweed in agricultural fields in the Midwest over the last decade. This loss is coincident with the increased use of glyphosate herbicide in conjunction with increased planting of genetically modified (GM) glyphosate-tolerant corn (maize) and soybeans (soya).

Question and Methods: These authors used calculations and estimates from data collected through observations by citizen scientists to create a logical argument about one potential reason for the decline in monarch populations. They ask whether the decline in overwintering monarchs could be caused by a reduction in the availability of milkweed in agricultural fields in the Midwest.

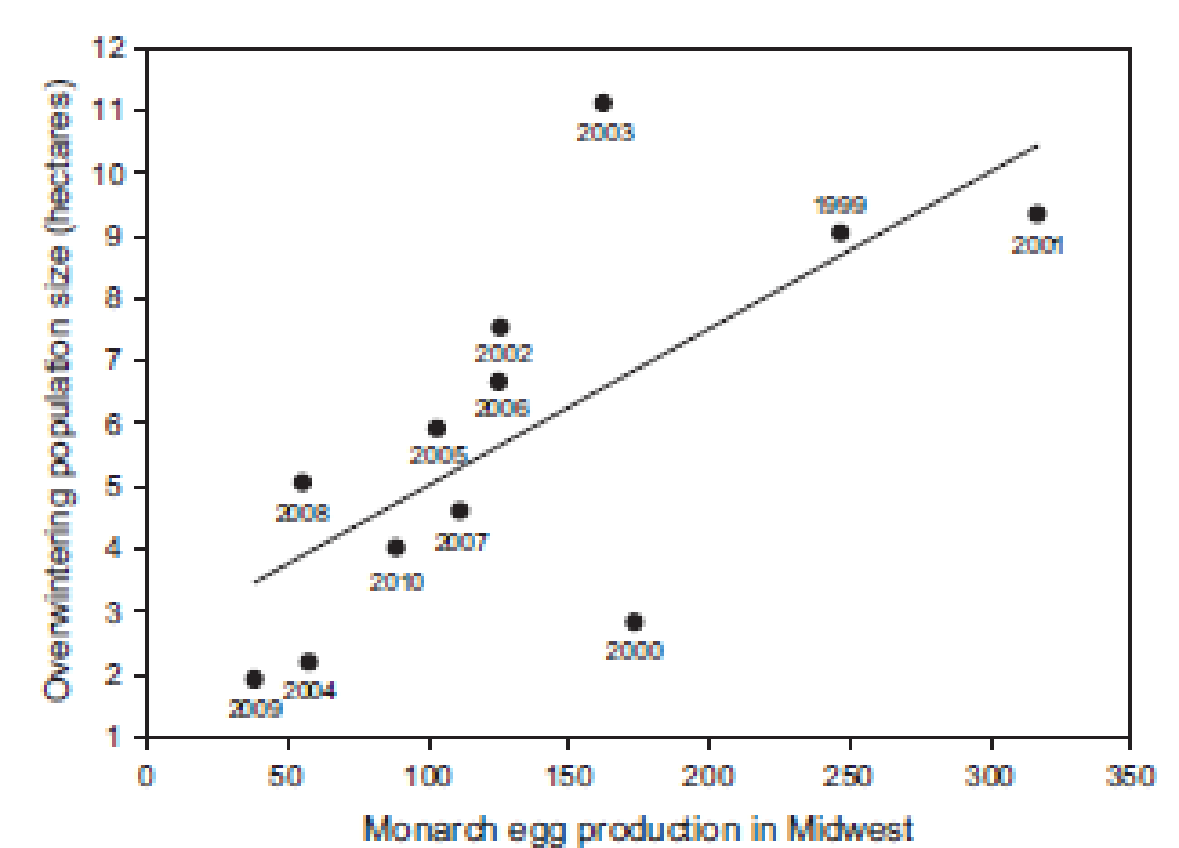
Hypotheses Considered: The researchers hypothesized that a lack of Common Milkweed in the Midwest is causing the monarch decline. They hypothesize that the use of a herbicide called Roundup in genetically-modified crops has dramatically reduced the availability of common milkweed in the Midwest. Fields of Roundup Ready crops, like corn and soybeans, can be sprayed with Roundup, killing all the weeds without killing plants. As more and more Roundup Ready crops have been planted, beginning with the introduction in 1996 and widespread adoption by 2011, milkweeds have disappeared from many agricultural fields.

Key Results:

* Between 1999 and 2010, there was a 31% decline in the density of non-agricultural milkweeds and an 81% decline in the density of agricultural milkweeds in Iowa. In 1999, milkweeds in agricultural fields constituted 53% of total milkweeds, but by 2010 were only 24% of the total. The figure shows three estimates for the change in milkweed density over time. The solid line represents milkweed density in non-agricultural fields. The dashed line and the line with dots each represent a separate estimate of milkweed density in agricultural fields.
* Almost 4 times as many monarch eggs are laid on agricultural milkweed as on non-agricultural milkweeds.
* An estimated 81% fewer monarch eggs were produced in the Midwest in 2010 compared with 1999. The figure below shows estimates of monarch egg production based on estimates of the amount of milkweed available multiplied by the average number of monarch eggs laid per milkweed.



* Estimated monarch egg production in the Midwest each year, as described above, [from 1999 to 2010] was positively correlated with the size of the subsequent overwintering population in Mexico.



Conclusion: The use of “Roundup Ready” crops in agricultural fields in the Midwest is likely contributing to the decline of overwintering monarch populations.

“Taken together, these results strongly suggest that a loss of agricultural milkweeds is a major contributor to the decline in the monarch population. The smaller monarch population size that has become the norm will make the species more vulnerable to other conservation threats.”