

> On Jan 23, 2020, at 7:41 AM, Szymanski, Jennifer <jennifer_szymanski@fws.gov> wrote:

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> Hello and Happy New Year!

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> Recall, the monarch ESA listing decision was postponed from June 2019 to Dec. 2020. After a bit of a hiatus, we now in the throes of updating our monarch SSA analyses. In addition to incorporating the 2018-19 and 2019-20 population counts into our analyses, we also need to update the future scenarios (the plausible future state condition for each primary influence).

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> In predicting how climate change effects will influence monarch habitat and numbers, we are relying on LeMoine (2015) data. We are hoping that you'll be able to help us with a few questions we have in applying this data.

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> LeMoine predicted a northward expansion of milkweed and monarch range (see attached maps). His approach assumed that milkweed will track a shifting niche over the coming decades, expanding northward in Canada and monarchs will successfully use at least some portion of this newly expanded habitat. Overall, substantially more habitat becomes available (up to 85% increase in total suitable habitat...some of this increase is due to now unsuitable habitat within the current range becoming suitable), but at increasing distances from Mexico and with the possibility of some connectivity gaps occurring in the southern portion of the range.

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> We are interested in your views regarding whether the predicted range expansion is likely and whether monarch will be able to successfully track and use this northern expanded habitat (i.e., will monarchs be able to fully realize any potential expansion of habitat in the north given increasing distance from the overwintering grounds). Specifically, your responses to the following questions would be greatly appreciated:

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> 1. Are you aware of data that either support or contradict LeMoine's predictions? If so, please describe.

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> 2. Assuming the LeMoine predictions are accurate, do you expect monarchs to expand northern to use this new habitat? Why or why not?

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> 3. Assuming yes to Q2, do you expect monarch butterflies using this northern habitat to be as successful as they are now (i.e., have similar survival and reproductive rates as monarchs do now in their current range)? Please explain why or why not.

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> 4. Given that predicted habitat losses in the south are relatively small (compared to the acres gained in the northern range expansion), do you expect climate-driven impacts to habitat in the southern geography to limit any potential benefits of a northward range expansion?

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> Your feedback will be greatly appreciated. It will be most helpful if we can hear back from you by Jan 27th. Please do not hesitate to contact me if you have any questions.

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> Thank you kindly,

> Jennifer

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> The statements of science are not of what is true and what is not true, but statements of what is known with different degrees of certainty. - Richard Feynman

> <LeMoine_AnalysisSummary_ForExperts.pptx>

1. Are you aware of data that either support or contradict LeMoine's predictions? If so, please describe.

Yes, it is likely that the niches of milkweeds will shift to the northeast and rather rapidly. Others have predicted similar niche shifts. Nothing new here. That said, and to be a bit snarky, milkweeds don't walk, run or fly and won't track these shifts sufficiently to be of use to monarchs. In other words, there will be a significant lag, perhaps decades before milkweeds "catch up" with these niche shifts. For milkweeds to be of value in these new areas it will have to be through human assisted transfers. Tribes are already doing this with culturally important plants. The rate of change for milkweed niches is one thing and that is reasonably predictable. However, how monarchs will respond to the same physical factors that affect the plant distributions is another. I'll deal more with that below.

2. Assuming the LeMoine predictions are accurate, do you expect monarchs to expand northern to use this new habitat? Why or why not?

Ok, if we assume that the milkweeds track the niche shifts with only a trivial lag, which I consider to be unlikely, yes, monarchs could find these more northerly and easterly milkweeds but, to do so, we have to make a number of assumptions. Monarchs don't know where milkweeds are and disperse with the spring conditions in a way that mimics what the weather gives them. If the weather involves high temperatures and SW winds from 15 May to 10 June, monarchs end up well beyond the current northern distribution of milkweeds. We saw these distributions in 2012 – and you can see it still in the first sightings reported to JN for that year. Currently, monarchs barely reach the northern limits of milkweeds (50N = Winnipeg) before directional flight ends in the first part of June (probably between the 6-10th of June). (The halt in directional flight stops coincident with a rate of change in day length and other solar parameters that drops to near zero sometime in early June – varying with latitude as well.) To expect them to go N of 50N by early June in the future is unrealistic unless future spring conditions are similar to those of 2012. Even then, colonizing areas N of 50N or far to the NE would be hit or miss. So, no, the likelihood that monarchs would use milkweeds north of 50N or well into the furthest reaches of the NE is quite low. Further, as tagging shows, the recovery rate of monarchs tagged in the northern portions of the NE is lower than for any other inland locations east of the Rockies. To reach MX from the NE, monarchs have to be at the leading edge of the migration. Laggards don't make it. Being at the leading edge is difficult for monarchs in the NE since late recolonizations in the spring and frequently cooler summer temperatures result in large number of NE monarchs migrating too late to reach the overwintering sites. There is another problem in the NE – i.e., the tendency for a significant portion of the population to move down the eastern seaboard – a pathway with another extremely low recovery rate.

3. Assuming yes to Q2, do you expect monarch butterflies using this northern habitat to be as successful as they are now (i.e., have similar survival and reproductive rates as monarchs do now in their current range)? Please explain why or why not.

Well, yes and no. Yes, if monarchs get to new areas and find milkweeds, there is no a priori reason why they shouldn't reproduce successfully. But, no, if the ultimate goal is to produce monarchs that reach the overwintering sites in Mexico. We already have a lot of areas that are colonized sparingly, and sometimes even quite successfully (coastal Maine in 2019), that produce very few monarchs that make it to Mexico. Reproduction is not the end game. Getting to Mexico and surviving the winter to reproduce offspring in the spring is the end game.

4. Given that predicted habitat losses in the south are relatively small (compared to the acres gained in the northern range expansion), do you expect climate-driven impacts to habitat in the southern geography to limit any potential benefits of a northward range expansion?

Absolutely, which is why this exercise – while necessary – is more than unnecessary. None of the above really considers how monarchs are responding to the current rates of change or are likely to respond to the conditions that cause the plant niches to shift to the NE.

Ok, I could write pages about why the proposition that new habitats for monarchs in the N and NE will not save the monarch migration. That won't happen for some of the reasons already outlined. There are other basic reasons that fall into two categories: future weather and the behavioral and physiological responses of monarchs to increasing temperatures and drought episodes.

First, let's deal with CO₂. Some year in the mid 2040s, CO₂ will hit 500ppm. Rising temperatures in the spring and summer will accompany those changes and the number of 100-degree days per year will continue to increase. San Antonio has gone from 8 to 27 100-degree days per year from the 1890s to the present. The number of such days will creep northward with each decade. Monarchs don't currently breed in good numbers in years and locations with a substantial number of 100-degree days (2012). I could go on, but my point here is that change is happening and will continue to happen at such a rapid pace that the proposition of advancing distribution of milkweed niches is a non-starter.

We already have an example of the future – the interval from 2011 to 2013 – a story of a drought in Texas (2011), extremely high March temperatures in 2012, followed by extreme temperatures and drought in the upper Midwest, again in 2012, then poor overwintering that led to the low overwintering numbers of 2013. 2012s are in our future and monarchs and flowering plants, and the nectar they provide, do not do well under these conditions.

We already know that the most sensitive period for population development is March – specifically the interval from 12 March to about 15 April in the South region (TX and OK). Monarch overwintering numbers have declined 9/11 years when March temperatures in TX exceeded 1.9F above average. (March temperatures in TX are projected to have means temperatures that AVERAGE +6F above the long term mean by mid-century). These high temperatures drive monarchs and egg laying too far north too soon which tends to increase the average generation length for the first generation across the latitudes from S to N. Another way to describe this impact is to point out that the average age to first reproduction for the first-generation monarchs is greater than it would be if the eggs were laid in the south.

I could go on about how realized fecundity negatively responds to higher temperatures and drought but I have to get on to other things.