HOW THE OTHER HALF LIVES:

MONARCH POPULATION TRENDS WEST OF THE GREAT DIVIDE

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On April 28, 2003, a boy discovered a female monarch butterfly nectaring in his family's garden. Located on its right hindwing was a small white tag (#1934) representing a valuable point of data to a group of researchers from California. They had tagged the butterfly at Andrew Molera State Park in Monterey County, California several months earlier as part of a large-scale monarch butterfly tagging study in western North America. This exceptional monarch had flown almost 1000 miles to reach Pueblo, Colorado, a town located east of the Rocky Mountains. The tagging study, called Monarch Alert and sponsored primarily by Helen I. Johnson, is a joint project between us, California Polytechnic State University, San Luis Obispo, and Jason Scott and Sarah Stock,Ventana Wilderness Society. An objective of this project is to investigate the population dynamics of western monarchs over the northern half of their wintering range. Here we report on the status of monarch populations in western North America.

While eastern North American monarch butterflies are well recognized for their spectacular southern migration to Mexico every winter, much less is known about monarchs in the west. We do know that milkweed abundance and variety is far greater in eastern breeding grounds than in the west. The overwintering pattern is likewise greatly different. Monarchs in western North America winter at over 300 sites along 1,000 km of Pacific Ocean coastline. These habitats range roughly between Ensenada, Baja California and Marin County, California. (Figure 1). Butterfly abundance at these wintering habitats rarely exceeds 1,000 butterflies, and until this past season, abundance had steadily declined for the past several years. The reasons for this dramatic decline are not fully known or agreed upon, but we will propose an explanation based on several factors.

Abundance at California winter habitats has been monitored since 1997 at over 170 habitats as part of the annual Western Monarch Thanksgiving Counts (See Monarch Watch

Update, February 16, 2004 by Mia Monroe). We subjected these data to statistical analyses by conducting paired t-tests for the abundance at specific habitats between pairs of successive years (e.g., 1997 vs. 1998, 1998 vs. 1999, etc.). These analyses indicate that population numbers declined by 92% from a high of 1,237,487 monarchs in 1997 to only 99,063 in 2002. Median (or midpoint) population values are another good measure of abundance patterns. The median value is the middle value of a list of measurements, or in our case, a list of population numbers at many different habitats. Median values declined from 250 individuals in 1998 to 13.5 individuals in 2002, a decline of 95% (Figure 2). This indicates that an increasing proportion of populations became much smaller or had zero monarchs at habitats up and down the state. It is worth noting that many of these particular habitats that "zeroed out" have not been identified as being degraded or modified. This type of abundance decline suggests that large-scale, system-wide factors were responsible rather than more local site-specific factors. In contrast, abundance was almost 1.5 times greater this past season (2003) than in 2002.

We used a statistical regression technique, with the Thanksgiving Count data described above, and found that population abundance at winter habitats was strongly correlated between successive years. In other words, habitats with large populations one winter (i.e., ranked high) would be ranked relatively high the following year, even if the system-wide population was much smaller or larger overall. Similarly, low ranking (low abundance) habitats tended to also be low ranking the following year. This pattern was robust and was present for each pair of successive years, i.e., 1997-1998, 1998-1999, 1999-2000, 2001-2001, 2001-2002, 2002-2003. At least 50% of the year-to-year variation in relative abundance at wintering sites was explained by the previous year's abundance ranking. These findings also support our hypothesis that a large

proportion of the decline in size of western North America monarch populations from 1998 to 2002 resulted from system-wide influences.

Increasing drought conditions in the west seem the most likely system-wide cause for declining populations. Chip Taylor, Kansas University, has regularly made the connection between the extent and severity of drought in eastern monarch breeding grounds as a good predictor of abundance for the next fall migration. In the west, deficits in precipitation have been shown to reduce both milkweed biomass and shorten its late summer availability. We accessed monthly Palmer Drought Severity Index (PDSI) values from National Climatic Data Center (NCDC) archives between 1998 and 2003. We included data for Arizona, California, Nevada, and Oregon, i.e., the states most likely contributing the majority of recruits to the migratory pool. Our analyses show that the extent and severity of the drought increased significantly over this time period and the decline in monarch abundance coincides with increasingly severe drought conditions throughout the west (Figure 2). PDSI values below -4.0 are classified by NOAA as extreme drought and during 2001 and 2002 many readings exceeded this level with some regions having values of –6.0. During the current year, less severe drought conditions were congruent with increased monarch abundance throughout the western wintering range. Our analyses showed that nearly 99% of the variation in western monarch abundance since the last El Nino event in 1998 was explained by variation in PDSI values.

From our statistical regression model, we found that one season's abundance was a fairly accurate predictor of the following year's abundance. However, many individual habitats had abundance patterns that were consistently above or below those predicted by the statistical model. System-wide factors, such as drought, may be influencing overall monarch butterfly generation, but smaller-scale processes such as local weather patterns or changes in habitat

quality may also account for these deviations from the suggested model. For example, the majority of habitats at which we tagged during the 2002-2003 season as part of the Monarch Alert project supported larger populations than were predicted by our model over all year-to-year comparisons. In contrast, populations at habitats in southern California frequently were smaller than expected for most year-to-year comparisons. This type of information can be valuable for both monarch researchers and land managers in evaluating, and preserving or restoring individual habitats.

In the west there is a tendency to focus exclusively on local-level explanations when monarch wintering populations in a community decline. For example, local media attributed the recent decline in abundance at the Pismo State Beach North Beach Campground habitat in San Luis Obispo County to severe habitat degradation and called for immediate habitat restoration/management action. While monarch abundance at the Pismo Beach site declined from over 100,000 in 1998 to just over 30,000 in 2002, monarch populations there have consistently been larger than predicted by our statistical model over that same time period and it is usually the most populous overwintering site in the west. These findings show how important it is to consider both large-scale spatial and long-term temporal context when assessing local patterns of monarch population abundance.

Figure 1. Location of monarch overwintering sites in western North America. Several habitats between the U.S. border and Ensenada, Baja California are not shown. Data source: California Fish and Game Natural Diversity Data Base.

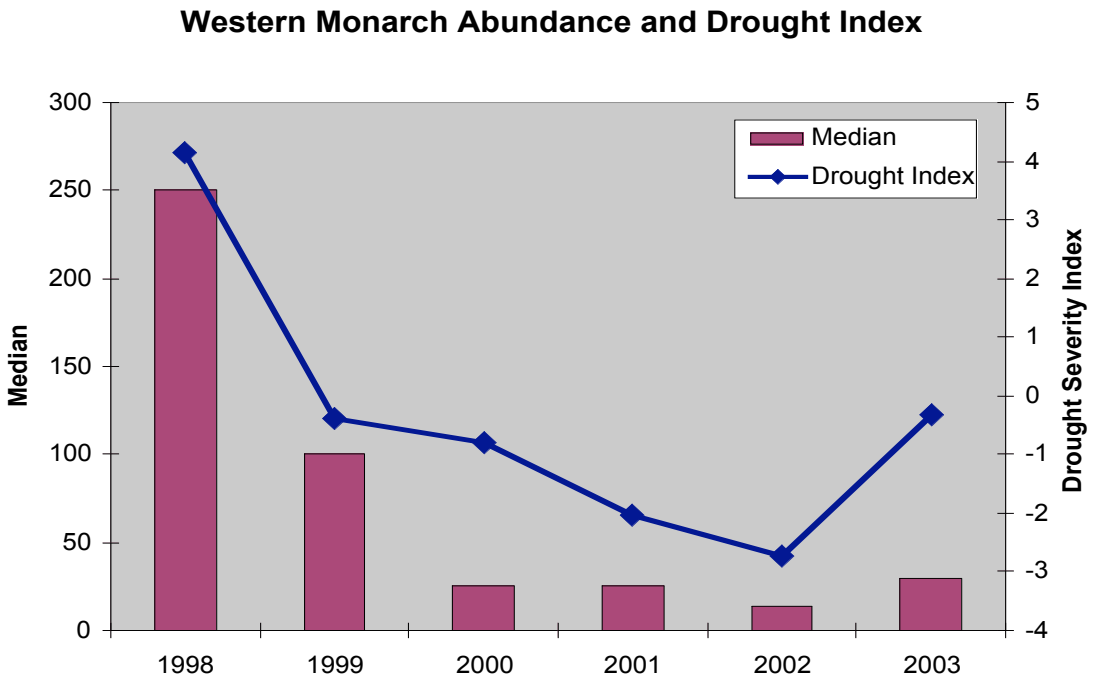

Figure 2. Western North America population abundance based on annual totals reported in Monarch Program Thanksgiving Counts shown with average Palmer Drought Severity Index for California.