

MONARCH BUTTERFLY (*DANAUS PLEXIPPUS*) IN NEW MEXICO AND A PROPOSED FRAMEWORK FOR ITS CONSERVATION

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May 1, 2016

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EXECUTIVE SUMMARY

This document offers a *prima facie* analysis of 135 years of New Mexico Monarch reports gathered through 2015. There are more than 900 reports of variable accuracy, quality and precision. Number of New Mexico Monarch reports doubled between 1986 and 2001 and again between 2001 and 2015. Increasing uses of digital photography, electronic mail, citizen science and sharing of observations via internet and social media are expected to accelerate Monarch data collection, data precision and overall knowledge of Monarchs in coming years.

Monarch butterflies (*Danaus plexippus*) occur throughout New Mexico during the warm season, generally April through September. Overall, Monarchs seem to be most abundant in southeast New Mexico. At this time there is no evidence that Monarchs overwinter in New Mexico.

To feed their caterpillars, Monarch females place their eggs on milkweeds (Asclepiadaceae: *Asclepias*). New Mexico Monarchs seem to prefer widespread *Asclepias speciosa* (Showy Milkweed) in northern regions and widespread *Asclepias subverticillata* (Horsetail Milkweed) in southern regions. To a lesser extent, New Mexico Monarchs utilize *Asclepias tuberosa* (Butterfly Milkweed), *Asclepias verticillata* (Whorled Milkweed), *Asclepias incarnata* (Swamp Milkweed), *Asclepias asperula* (Antelopehorns) and *Asclepias latifolia* (Broadleaf Milkweed).

In spring, New Mexico receives a modest influx of Monarchs which spread northward from the Mexican overwintering site and upslope across the state, peaking in April and expiring by mid-May. By July the next generation has spread statewide and occupies elevations exceeding 8,000 feet. Continued breeding leads to maximum numbers of home-grown Monarchs in August and September. Late August and September also are times when Monarchs begin to move. The first shift is from cool, northern sites toward the south and downhill from cooling mountain meadows to lower sites, both transitions lead Monarchs to warmer sites where milkweeds remain viable. Subsequent movement is generally southward across the plains in eastern New Mexico and via major valleys like the Rio Grande in central New Mexico. Ultimately, New Mexico Monarchs merge with the continent-scale migration to Mexico. In some years, there is an October influx of Monarchs from eastern parts of the continent, when Monarchs roost in trees by the thousands as they pass through southeast New Mexico en route to the Mexico overwintering site. The frequency of this phenomenon remains to be ascertained.

This first attempt to summarize knowledge of Monarchs in New Mexico Monarchs underscores many things which remain unknown:

- Do Monarchs overwinter anywhere in New Mexico?

- What are Monarchs' key nectar resources in spring?
- To what extent are New Mexico's diverse milkweed species used in Monarch reproduction? Which seem most important to cultivate and plant for habitat restoration?
- There is evidence of Monarch reproduction and immature stages well into autumn, but how many adults result?
- Is the apparent low Monarch abundance in northwest New Mexico real or a function of inadequate data?
- To what extent are north-south riparian corridors along the Rio Grande, Pecos River and Mimbres River zones of concentrated Monarch usage in breeding season or during migration?
- What are the autumn migration destinations for Monarchs that originate in various parts of New Mexico?

INTRODUCTION

Monarch (*Danaus plexippus*) is the only North American butterfly that exhibits an annual round-trip migration. For reproduction purposes Monarchs exploit large milkweed (Asclepiadaceae: *Asclepias* spp.) populations during North America's mid-latitude summers. Monarchs then fly south to overwintering grounds that are safe from harsh continental winters. Up to four generations of Monarchs are required to complete the full round trip. Summer Monarchs that occupy eastern North America generally migrate to overwinter in the Mexican highlands. A second populations that overwinters along the Pacific Coast spends summers breeding in western North America's Pacific slope. For much of the intervening Intermountain West, including New Mexico, little has been published about Monarchs.

In recent years, Monarch butterflies and their host milkweeds have been the subject of escalating conservation concern and focused study (e.g., Pyle 1999, Dingle et al.2005, Fallon et al. 2015, Jepsen et al. 2015). Initial concerns came from habitat losses at overwintering sites in the Mexican highlands. More recently, agricultural weed control methods have become so efficient in the U.S. mid-section that genocide of wild plants, including milkweeds, is a real threat. Past efforts to examine butterfly conservation needs in New Mexico (e.g., Cary and Holland 1992[1994]) predated recently intensifying concerns about Monarchs.

This document lays the foundation for Monarch and milkweed research, restoration and conservation in New Mexico by publically sharing what has been learned to date about Monarchs in New Mexico by providing a *prima facie* analysis of more than 900 observations or reports of Monarch butterflies (*Danaus plexippus*) made in New Mexico from 1881 through 2015. The purpose of this analysis is to promote knowledge and understanding of Monarch occurrence, habitat, breeding biology and migration dynamics in New Mexico. This effort was inspired by the recent and ongoing herculean effort to understand Monarch butterfly (*Danaus plexippus*) population dynamics in adjacent Arizona (Morris et al. 2015). A more comprehensive, in-depth analysis of New Mexico Monarch data is planned for the future.

Finally, this document proposes a framework for future Monarch conservation efforts in New Mexico. Key elements of that framework include goals and objectives related to:

- Conservation Strategy & Organizational Development
- Advancing Science and Spreading Knowledge
- Public Engagement, Volunteer Recruitment and Advocacy
- Conservation and Habitat Restoration

STUDY AREA

New Mexico lies in the southwest U. S. on the Mexican border between the U.S. states of Texas, Colorado and Arizona, and the Mexican state of Chihuahua. Lines for 34°N latitude and 106°W longitude cross near the middle of New Mexico. A variety of Native American groups have occupied various portions of New Mexico for millennia. Spanish explorers and colonists arrived ca. 1600 AD and New Mexico served as the northern frontier of New Spain for more than 200 years. After Mexico gained independence from Spain in 1821, Nuevo Mexico was governed from Mexico City. The U. S. conquered the region in 1846 and New Mexico Territory was established soon after. New Mexico was admitted to the Union as the 47th state in 1912.

New Mexico's natural resources are quite diverse. Elevations range from 3,000 to 13,000 feet above sea level, supporting a broad spectrum of life zones ranging from Chihuahuan Desert up to arctic-like tundra. Between those extremes are a diverse mosaic of grasslands, chaparral and forests. New Mexico lies at the intersection of several ecoregions (Figure 1). The state's northwest quadrant is part of the rugged and semi-arid Colorado Plateau ecoregion that also occupies portions of Colorado, Utah and Arizona. North-central New Mexico hosts the mesic, southern terminus of the Rocky Mountain ecoregion. Eastern New Mexico is the drier, shortgrass, western margin of the Great Plains ecoregion. Chihuahuan Desert habitats sprawl across most of southern New Mexico's basins and flats. These are Northern Chihuahuan deserts with cold winters. West-central New Mexico is ecologically part of the Mogollon Mountains system that ranges into central Arizona. In the far southwest corner, New Mexico's Bootheel offers a piece of Madrean evergreen woodland.

The Continental Divide transects New Mexico from north to south. Pacific-bound waters exit the state to the west via the San Juan and Gila rivers, which join the Colorado River. Most of New Mexico drains to the Atlantic Ocean via the Rio Grande and its primary tributary, the Pecos River. The state's northeast quadrant drains to the Atlantic via the Arkansas River and the Mississippi River. Some large basins in central and southern New Mexico are internally drained.

Because of its generally high elevation, most of New Mexico experiences a semiarid steppe climate with warm summers, cold winters and limited precipitation. New Mexico is the highest and coldest U. S. state south of 37° N latitude in the "Sunbelt." New Mexico has the same range of horticultural zones as can be experienced by traveling from upstate New York to south coastal Virginia. Neighboring states of Texas and Arizona have broad areas at or near sea level and climates with warmer, maritime influences. New Mexico has no lands with frost-free, snow-free climates. Precipitation amounts across New Mexico are such that perennial rivers, lakes, marshes and wetlands are scarce and highly valued by human populations and wildlife. Prevailing winds are generally from the west, but there is a strong northerly influence in winter and a strong southerly influence summer.

Figure 1. New Mexico Ecoregions.

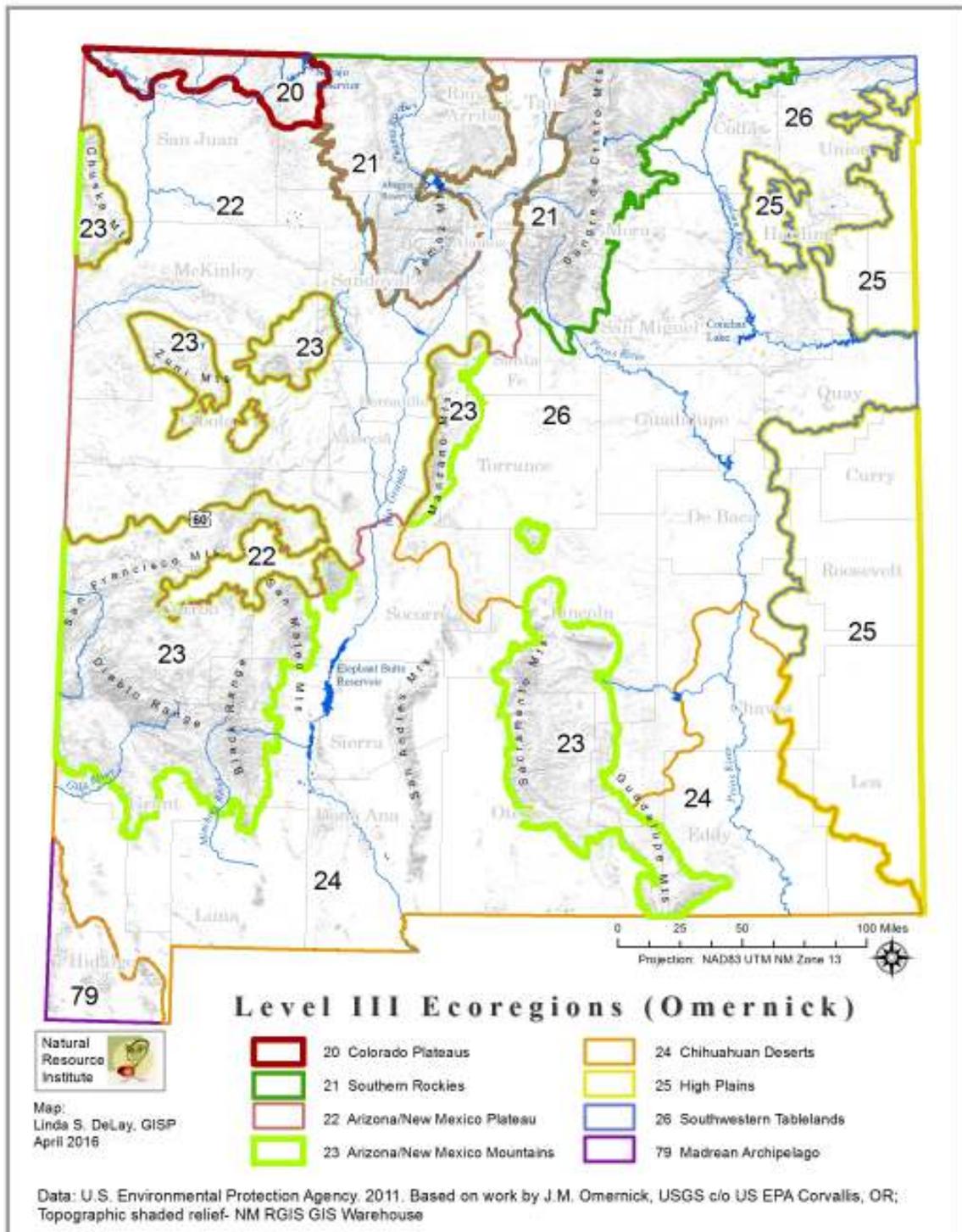
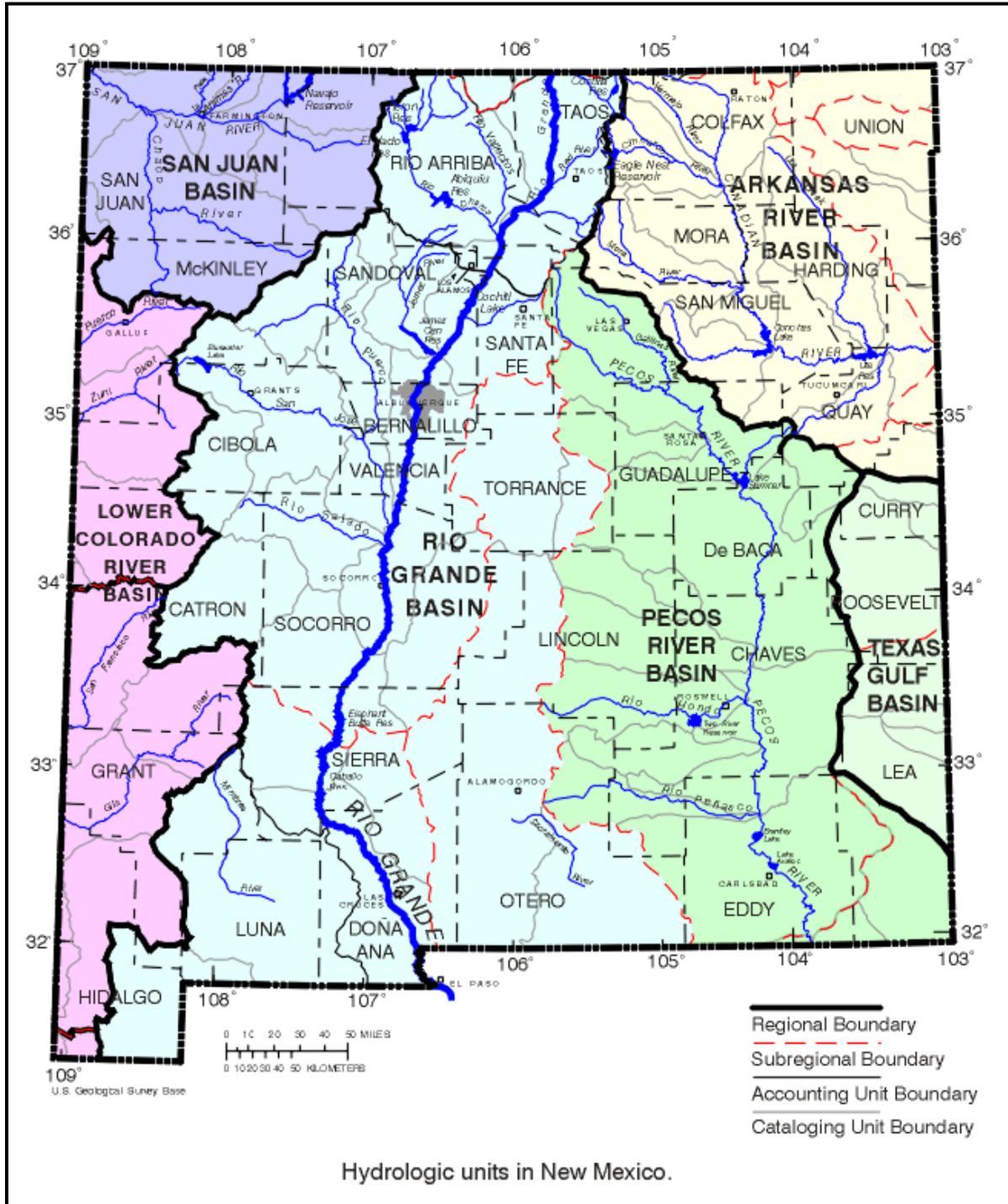


Figure 2. New Mexico Hydrography (<http://www.riogrande-riobravo.org/Map/nmriogrande.gif>).



MATERIALS AND METHODS

For this report, all available Monarch data from New Mexico was assembled, totaling more than 900 records. Specific sources included:

- published sources listed in Literature Cited,
- data gleaned from various museum collections around the country,
- various unpublished sources including the senior author's field notes,
- citizen science websites such as Journey North, Monarch Larva Monitoring Project and Southwest Monarch Study.

The decision to prepare this report was made in January 2016, after which no new field or laboratory studies were conducted for the purpose of this report. Data that becomes available after May 1, 2016, and older data that comes to light after that date, will be incorporated into future analyses. This document was prepared using MS Word and MS Excel. Maps were created with Esri ArcGIS.

Available data can be described in terms of its age (Figure 3) and how well it represents New Mexico geographically (Figure 4). Monarch observations in New Mexico began with Frederick H. Snow in 1881 and T. D. A. Cockerell in the 1900s, but it would be several more decades before the slow pace of discovery accelerated. After World War II came two national laboratories and the Baby Boom. Monarch reports from the 1950s and 1960s show the beginning of student entomological collections at local colleges. With the labs came scientists and their families, including Mike Toliver who recorded Albuquerque area Monarchs in the 1960s and 1970s. Mating adult Monarchs were first reported in 1970. Species-rich southwestern New Mexico began attracting attention from lepidopterists in the 1960s whence John Hubbard (1965), Clifford Ferris (1976) and Dale Zimmerman (2001) generated monarch data.

Figure 3. New Mexico Monarch observations reported each decade since 1880. A report represents a single location and date, but may represent multiple Monarchs.

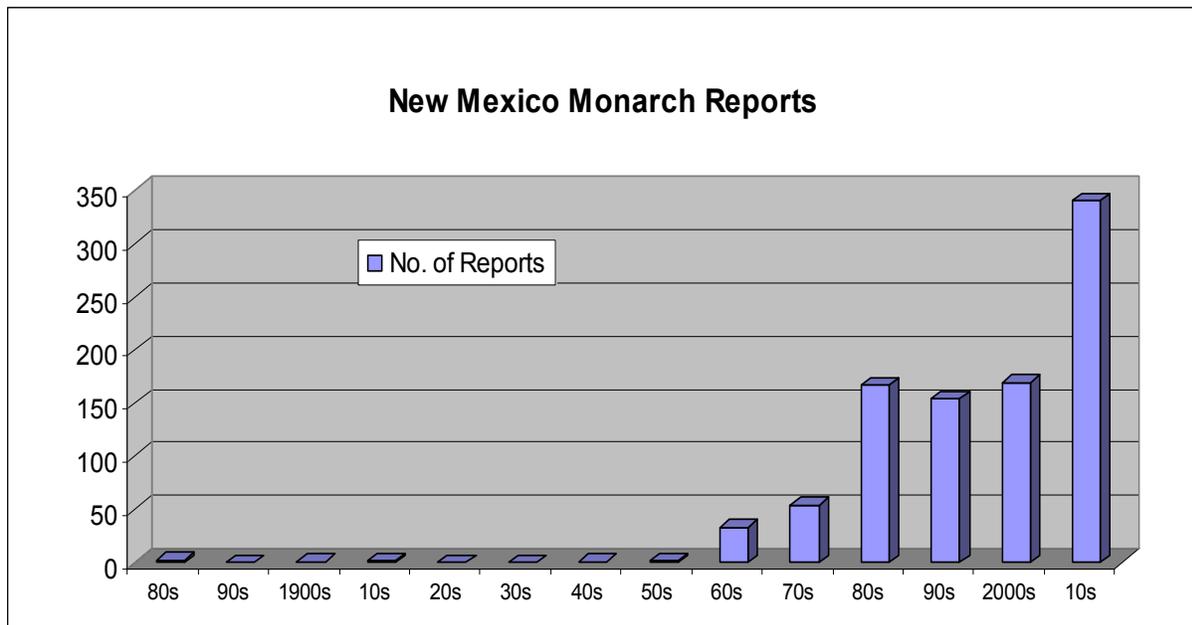
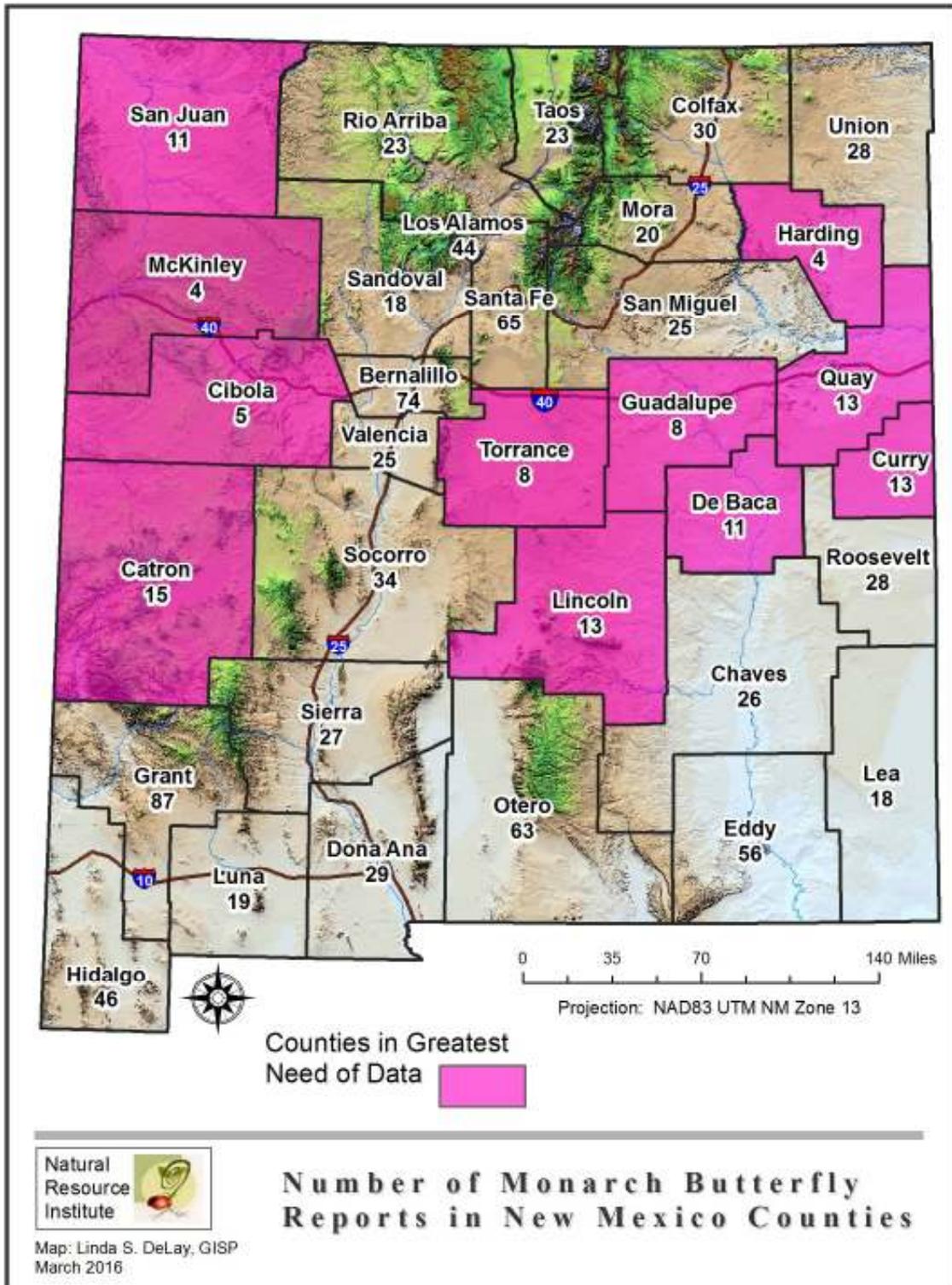


Figure 4. New Mexico county distribution of Monarch observation reports. Each report represents one location, one observer and one date, but could represent multiple Monarchs.



Beginning in the 1970s, Richard Holland alone (e.g., 1974, 1984[1985]) and in collaboration (e.g., Cary and Holland 1992[1994], Holland and Cary 1996, and Toliver et al. 2001) performed butterfly surveys statewide to improve understanding of New Mexico's butterfly fauna. Starting ca. 2000, dedicated birdwatchers began to report Monarchs. Since arrival of GPS technology, digital photography and citizen science websites, the number and geographic precision of New Mexico Monarch reports have been climbing. The number of available New Mexico Monarch reports doubled between 1986 and 2001, and doubled again in the past fourteen years.

New Mexico is the fifth largest state but is ranked 46th in human population density, so each resident has a lot of ground to cover. Geographic data analysis would be best supported if there were similar amounts of Monarch information to evaluate and analyze throughout the state. Alas, Figure 4 shows that the number of Monarch reports available from individual counties varies by an order of magnitude, from as few as four (Harding, McKinley) to more than 70 (Grant, Bernalillo). This disparity underscores that: (1) much Monarch observing still needs to be done in places where key questions remain about life history and migration, and (2) existing data has limits. In Figure 4, the Rio Grande stands out as a corridor of much Monarch information compared to other parts of New Mexico.

The data are squishy, but that is what we have. Data reporting methods are improving and the rate of data accumulation is increasing, so overall data quality is improving as we move forward.

RESULTS

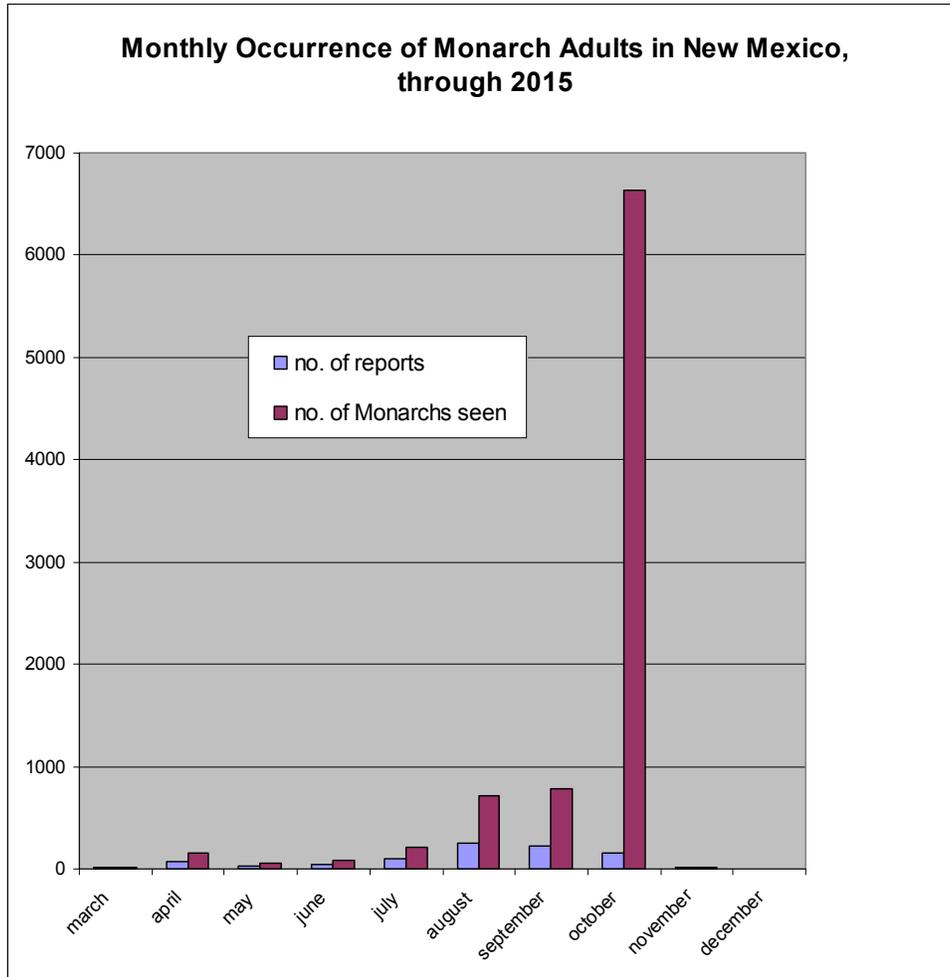
MONARCH PHENOLOGY AND GEOGRAPHY IN NEW MEXICO

Monarch adults have been recorded in New Mexico from March 2 through December 1. The chart in Figure 5 plots all available New Mexico Monarch adult observations to show the seasonal sequence of Monarch abundance for the state as a whole. The modest April bump represents the crest of a small spring wave of Monarchs that were north-bound after leaving the Mexican overwintering site. This influx dissipates by mid-May. Adult offspring of spring females begin to appear in late May or June. Continual breeding through the remainder of summer causes statewide adult Monarch numbers to increase steadily to a population maximum in August/September. Monarch numbers increase 10-fold from April to September and most of those are thought to be locally produced in New Mexico. By September, New Mexico's Monarchs are on their way out of the state, headed south to overwinter in the Mexican highlands.

In comparison, reports from much of northwest New Mexico are almost all of single, solitary Monarchs. The most intensive butterfly searches of San Juan, McKinley and Cibola counties were by Holland (1974, 1984), and his published reports suggest that Monarchs there were uncommon at best. The paucity of reports, in combination with the few Monarchs seen in each report, suggest that Monarchs are less frequently encountered in northwest New Mexico.

The chart in Figure 5 and map in Figure 6 beg a variety of questions that call for closer examination of phenology and geography. Because Monarchs are mobile and purposefully migratory, those time/space questions are addressed under "Monarchs in Migration" below.

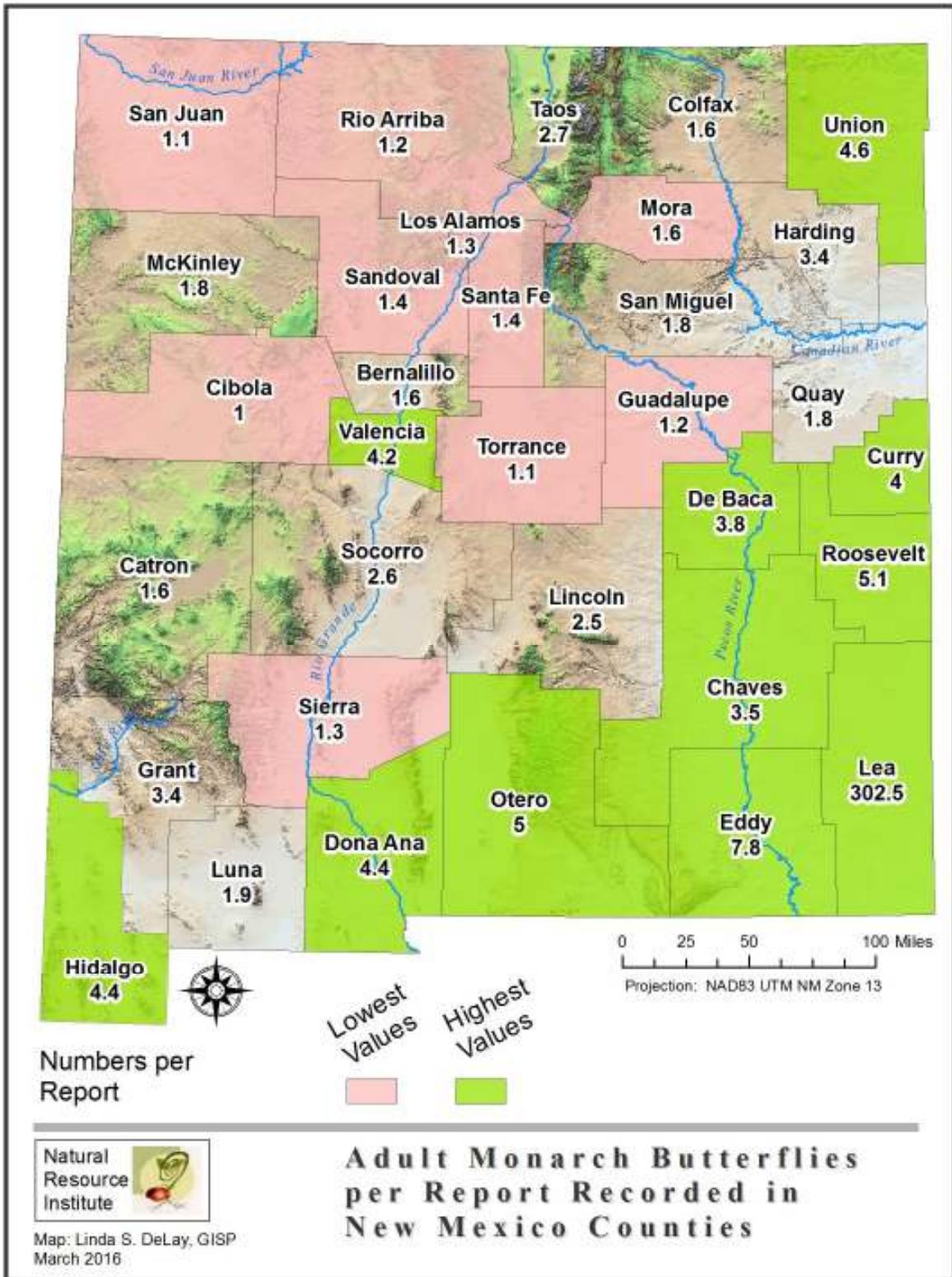
Figure 5. Number of Monarch adults observed in New Mexico, by month.



New Mexico's greatest Monarch maximum of the year, on average occurs in October. This dramatic spike represents Monarchs that have flown in from eastern parts of North America en route southwest to Mexico. Numbers of these transient adults, often seen cloaking tree branches in large roosts, can exceed the number of Monarchs seen statewide the rest of the year.

Monarchs have been found statewide in all New Mexico counties, but Monarch occurrence is not uniform throughout the state. Figure 6 shows that, when standardized by the number of reports from each county (Figure 4), observed Monarch numbers favor southeast New Mexico. This reflects multiple reports of large overnight Monarch roosts from Lea County in New Mexico's southeast corner. Taking Lea County out of the mix for a moment, other counties in southern and eastern New Mexico show multiple Monarchs per report. Counties on the Rio Grande (Doña Ana, Socorro, Valencia, Taos) show slightly elevated values.

Figure 6. Number of Monarch adults per report observed in New Mexico, by county.



MONARCH BREEDING AND REPRODUCTION IN NEW MEXICO

Monarch larvae eat only tissues of plants in the Milkweed Family. In Lepidoptera jargon, milkweeds are "host plants" for Monarchs. Most successful Monarch hosts are in the genus *Asclepias*. North America is home to more than 70 species of milkweed and more than 20 of those are documented hosts for Monarch butterflies (Appendix A). Depending on current taxonomy, New Mexico is home to 25 to 30 milkweed species (Jercinovic undated). Female Monarchs thus have many options for placing eggs, but some milkweeds are small, rare or otherwise unlikely to be chosen. To date, seven milkweed species have been shown, through observed oviposition or larva, to be used by Monarchs in New Mexico (Table 1).

Table 1. Milkweed species documented as hosts for Monarchs in New Mexico.

County	Milkweed species	Common name	Oviposition	Larva
Bernalillo	<i>A. curassavica</i> *	Tropical Milkweed*	X	X
Mora	<i>A. incarnata</i>	Swamp Milkweed		X
Bernalillo	<i>A. latifolia</i>	Broadleaf Milkweed	X	
Bernalillo	<i>A. speciosa</i>	Showy Milkweed		X
Cibola	<i>A. speciosa</i>	Showy Milkweed	X	X
San Miguel	<i>A. speciosa</i>	Showy Milkweed		X
Sandoval	<i>A. speciosa</i>	Showy Milkweed	X	X
Rio Arriba	<i>A. speciosa</i>	Showy Milkweed	X	X
Taos	<i>A. speciosa</i>	Showy Milkweed		X
Eddy	<i>A. subverticillata</i>	Horsetail Milkweed	X	
Grant	<i>A. subverticillata</i>	Horsetail Milkweed	X	
Socorro	<i>A. subverticillata</i>	Horsetail Milkweed	X	X
Catron	<i>A. subverticillata</i>	Horsetail Milkweed	X	
Colfax	<i>A. subverticillata</i>	Horsetail Milkweed		X
Dona Ana	<i>A. subverticillata</i>	Horsetail Milkweed		X
Otero	<i>A. subverticillata</i>	Horsetail Milkweed		X
Valencia	<i>A. subverticillata</i>	Horsetail Milkweed	X	X
Santa Fe	<i>A. tuberosa</i>	Butterfly Milkweed		X
Taos	<i>A. tuberosa</i>	Butterfly Milkweed		X
Bernalillo	<i>A. verticillata</i>	Whorled Milkweed		X

* Tropical Milkweed (*A. curassavica*) is not native to New Mexico. When planted, it winterkills and is functionally an annual.

Data currently available suggests some important geographic variations. Use of Showy milkweed (*A. speciosa*) is reported primarily from northern counties, while use of Horsetail milkweed (*A. subverticillata*) is reported primarily from southern areas. More observations of Monarchs using milkweeds are needed statewide, but especially in eastern regions, where *A. latifolia* has its stronghold, and from most of western New Mexico. Future studies also are needed to determine the extent to which Monarchs use other widespread native milkweeds such as *A. oenotheroides*, *A. involucrata*, *A. macrotis*, *A. brachystephana* and *A. asperula* in New Mexico.

Figure 7. Monarch larva eating *Asclepias incarnata* (Swamp Milkweed) near Wagon Mound, Mora County. Photo by R. Sivinski, August 26, 2011.



Phenologically (Figure 8), Monarch reproductive activity is evident upon their arrival in spring, but spring observations are sparse because Monarchs are relatively scarce. As reproduction progresses through summer, Monarch courtship, mating and egg-laying increase in parallel with overall Monarch numbers. Mating and oviposition peak in August, which coincides with a peak in the population of home-grown Monarchs (Figure 5). Mating and oviposition decline after August, yet remain somewhat popular into September. Numbers of Monarch larvae seem to lag behind mating and oviposition, peaking in September and persisting into October. Fate of late season larvae is not well documented, but Bob Barber watched one adult eclose on November 29 in Otero County, which is far enough south that successful flight to the Mexican overwintering site is plausible.

Figure 8. Observations of Monarch reproductive activity and immature stages by month.

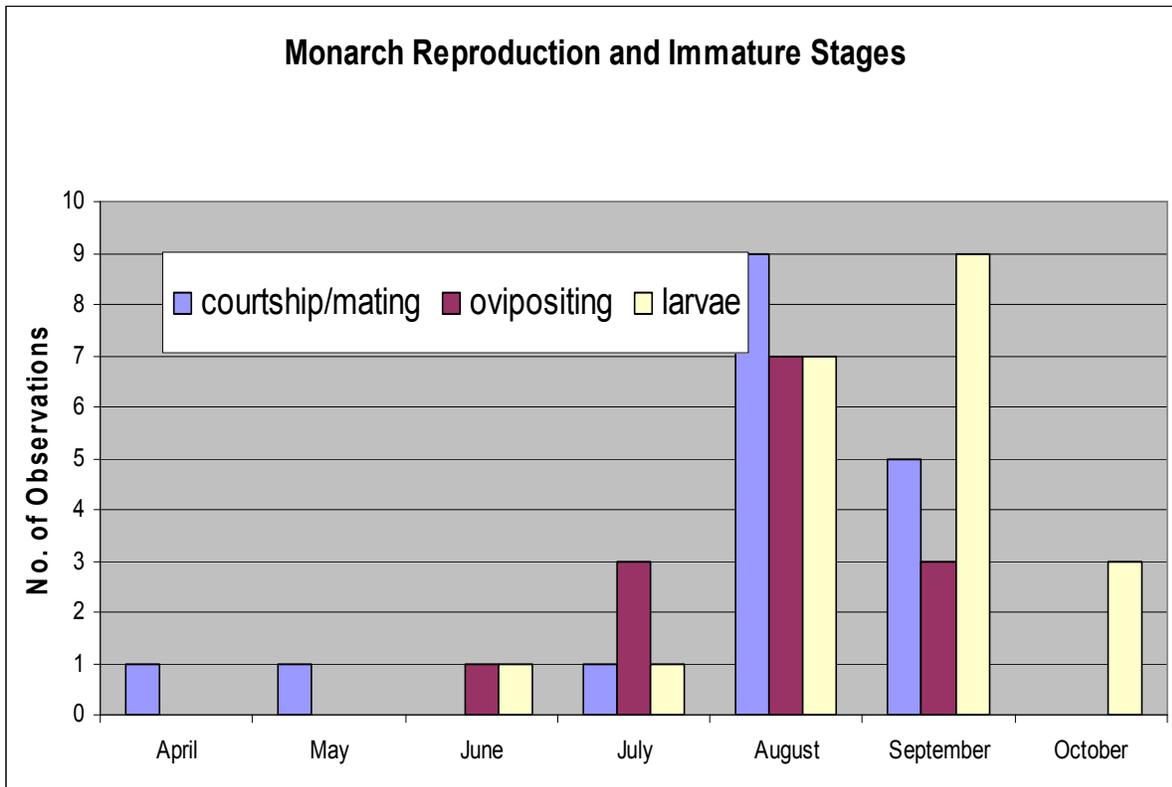




Figure 9. Monarch larvae eating *Asclepias subverticillata* (Horsetail Milkweed) in Dog Canyon, Oliver Lee Memorial State Park, Otero County, October 12, 2014. Photo by Bob Barber.

Monarch Hot Spots

Rattlesnake Springs, part of Carlsbad Caverns National Park in Eddy County, is a Monarch "hotspot." The site has a large spring that has long been tapped as a water supply for the Park. The site has been significantly disturbed by humans over the decades and in this relatively lush, disturbed setting Horsetail Milkweed (*A. subverticillata*) thrives in large numbers dispersed throughout the site. When Holland and Cary spent three years intensively surveying butterflies the Guadalupe Mountains (unpublished data, 1986-1988) Rattlesnake Springs was a key location. Monarch data from those '80s surveys (Figure 10) show initial colonization in March. Monarch numbers increase gradually, if erratically, through the warm season. Population spikes in May, July and September suggest that continuous breeding produces three Monarch generations at this site. A similar hotspot was identified on a private ranch in Hidalgo County in the early 1990s (Cary, unpublished data).

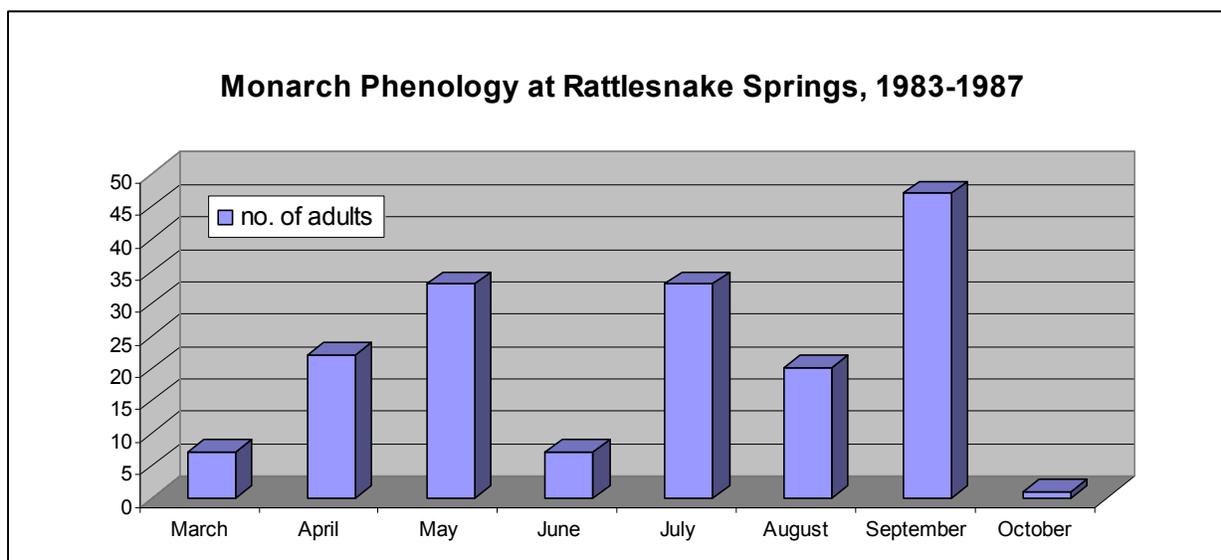


Figure 10. Monarch phenology at Rattlesnake Springs, Eddy County.

Breeding Season Nectar

Most adult butterflies are opportunistic nectar feeders willing to gather nectar from any flowers in their neighborhood. Butterflies with short proboscides, like hairstreaks or blues, may be limited to flowers with short corolla tubes, but Monarchs have a relatively long proboscis and are not so limited. Monarch nectar choices in New Mexico have been documented in only a limited manner.



Figure 11. Monarch female nectaring at *Asclepias subverticillata*, August 14, 2010, Rio Grande Gorge, Taos County, NM. Photo by S. J. Cary.

Documented nectar choices during Monarch breeding season are given in Table 2. Paucity of observations in spring and early summer is due to few Monarchs. With that caveat, various purple-flowered thistles (*Cirsium* spp.) are popular choices in early summer. A non-native musk thistle, *Carduus nutans*, is a locally popular nectar choice for Monarchs in July and August. Monarch use of plants in the Verbenaceae Family (Verbenaceae) is documented in mid-summer months of July and August; the species documented are *Verbena macdougalii* and *Glandularia* spp., all of which have purple flowers. By August, Monarch numbers are up and nectar choices are more varied. Table 2 shows that Monarchs have been documented harvesting nectar from multiple milkweeds (*Asclepias* spp.), a variety of plants in the Aster Family, and other plant families as well. Nectar plants have generally not been identified to species, and this is a shortcoming which needs to be addressed in the future. The list in Table 2 is best considered preliminary.

Table 2. Documented Monarch butterfly nectar choices from May to August.

	May	June	July	August
Asteraceae				
Rudbeckia laciniata				X
Cirsium spp.	X	X	X	X
yellow composites				X
Helianthus spp.				X
Verbenaceae			X	X
Asclepiadaceae				X
Geraniaceae				X
Brassicaceae				X
Lamiaceae				X

MONARCHS IN MIGRATION

Spring

Closer examination of data reveals patterns of Monarch movement into, through and out of New Mexico. A pulse of arriving spring adults begins in March on New Mexico's southern border (Figure 12). Monarchs disperse irregularly north and by the end of April they occupy half the state. The spring influx continues toward the north and, apparently, upslope. Spring reports from Sierra, Socorro, Bernalillo, Santa Fe and Rio Arriba counties suggest the Rio Grande may offer a preferred route north. By mid-May the northbound wave of Monarchs has fulfilled its destiny and expired. Spring Monarchs have not been recorded in parts of north and west New Mexico.

Spring Monarchs seem to arrive from the south and work their way north and east, moving faster and attaining higher latitudes in eastern New Mexico. Figure 12 suggests a preferred, southwest-to-northeast flight corridor that is encouraged by physiographic and meteorological conditions. For example, Monarchs attaining southeastern New Mexico in Eddy and Lea counties usually find winds out of the west and south. April is the month of highest mean wind speed across New Mexico southern counties (<http://www.wrcc.dri.edu/htmlfiles/westwind>), encouraging Monarch movement toward the east and north. They also find terrain which poses few obstacles to travel. An overnight roost was forming below Two Rivers Dam in Chaves County on April 12, 1998.

Spring Monarchs crossing into New Mexico farther west in Doña Ana and Otero counties usually encounter west winds and more challenging topography. Fortunately the basin-and-range physiography provides two broad corridors aligned north and south, the Tularosa Basin and the Rio Grande valley, which offer paths of less resistance toward the north.

Monarchs crossing from Mexico into Hidalgo and Luna counties must have already achieved some upwind, westward movement. Winds may allow or support that on some days, but persistent movement in that direction requires Monarchs to overcome prevailing headwinds. Once in Hidalgo or Luna counties, continued movement toward the northwest requires Monarchs to expend diminishing energy to fly uphill. Absence of spring Monarchs from Catron County (Figure 15) suggests that few individuals make that trip. Zimmerman (2001) reported seeing few Monarchs in spring in Grant County.

Spring Monarchs also move upslope, which in New Mexico is a necessary consequence of northward flight. After crossing into New Mexico at 3500 to 4500 feet elevation, Figure 13 shows that Monarchs arriving in March are seen only below 6,000 feet elevation. By April and May, however, Monarchs are present at elevations exceeding 9,000 feet. Monarch migrants that colonize higher elevations seem to cross fewer lines of latitude, but climbing in elevation accomplishes the same thing as flying north, from a life zone perspective.

Figure 12. Peak months for spring Monarchs in New Mexico counties. Spring includes March through mid-May. Counties with highest spring numbers outlined in red.

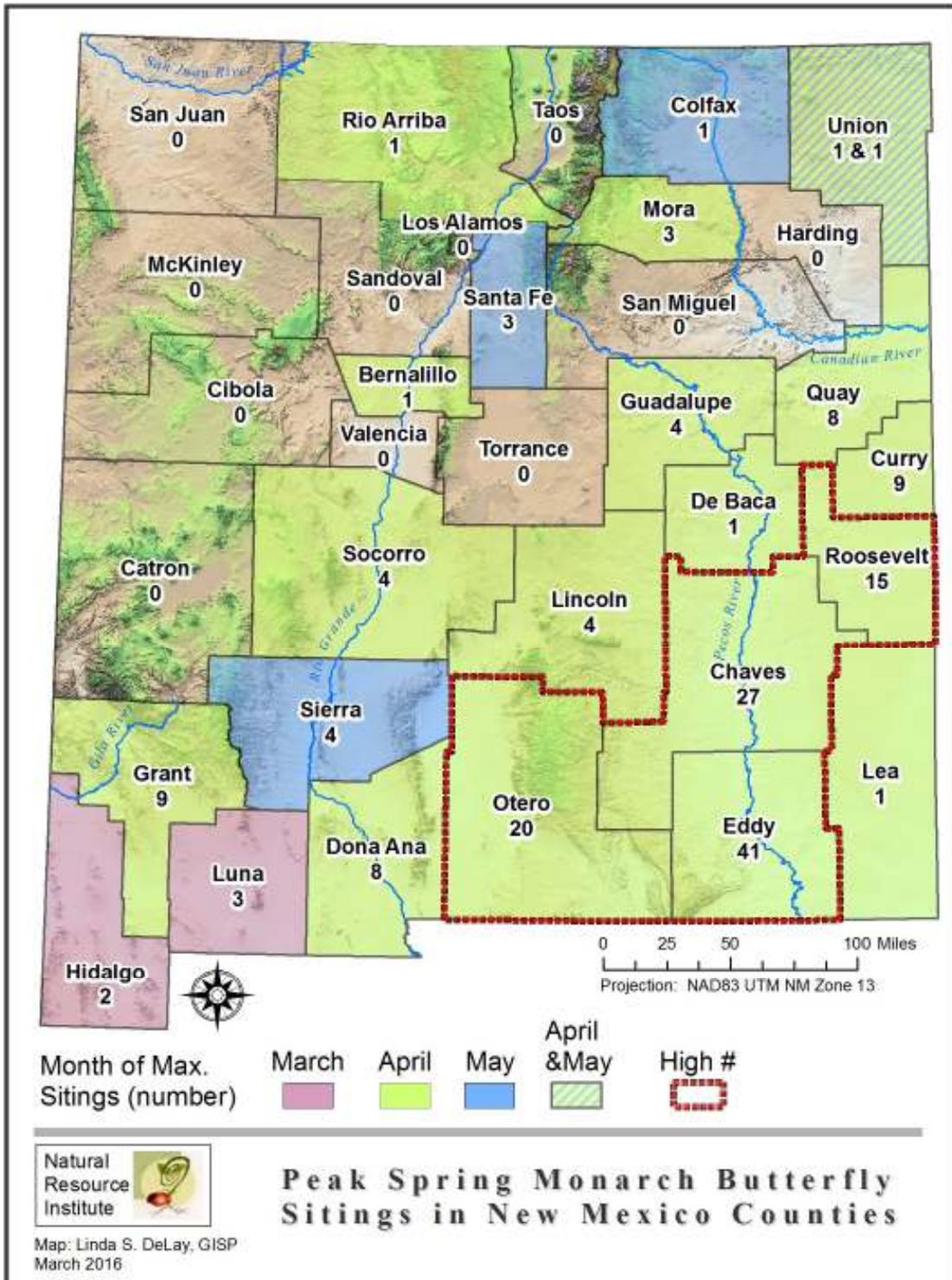
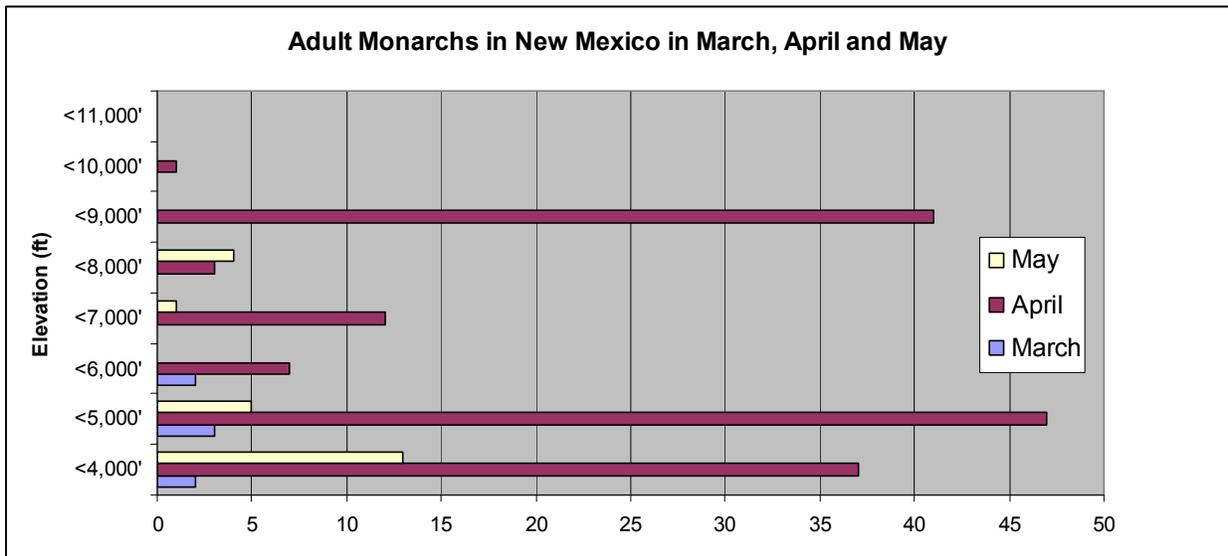


Figure 13. Altitude distribution of adult Monarchs in New Mexico in March, April and May.



Adult Monarch numbers are low in May and June because most monarchs are in immature life stages, or between broods. Continual breeding gradually increases Monarch numbers through the warm season.

Late Summer and Autumn

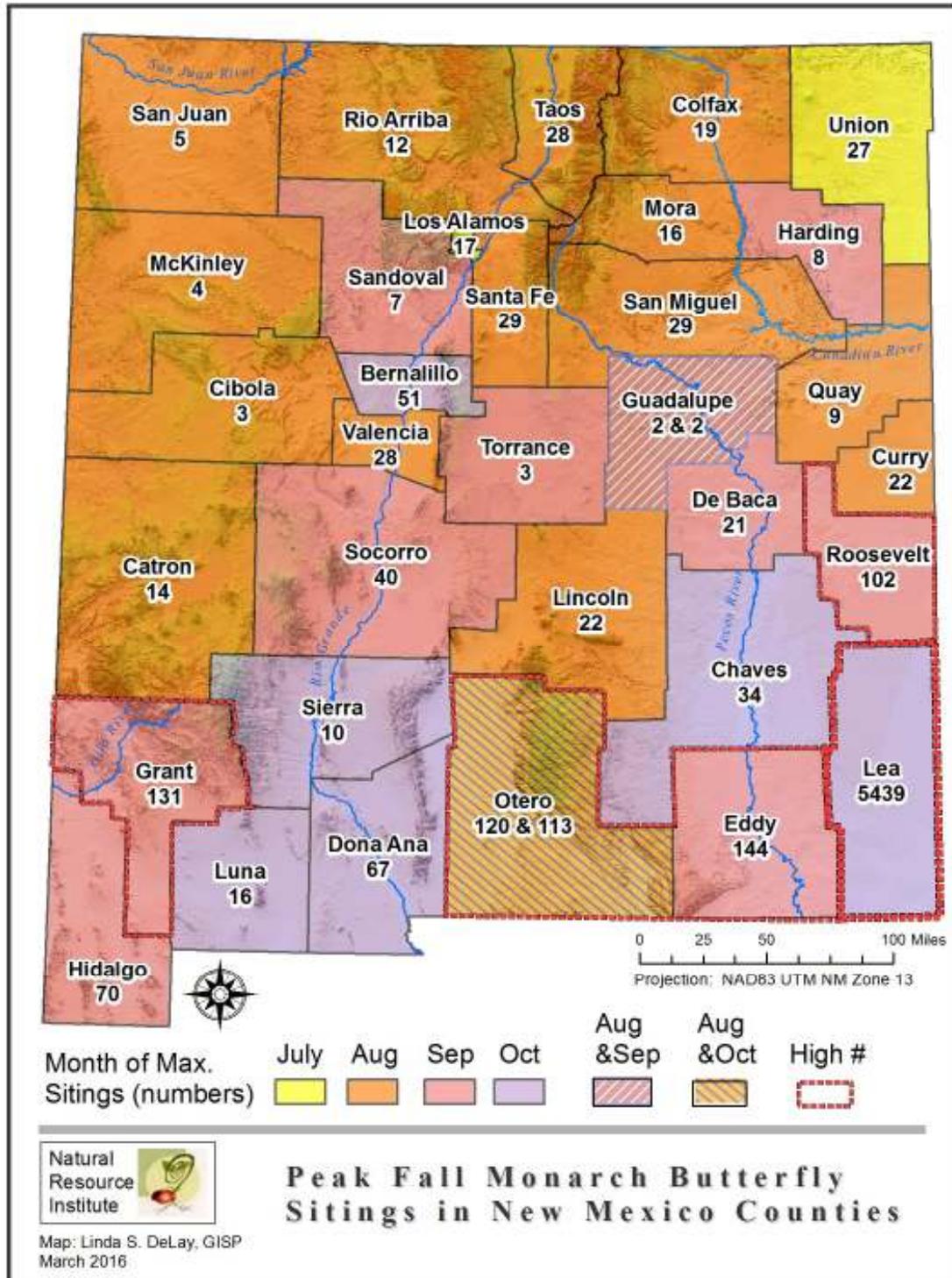
Monarch numbers increase through July, plateau in late summer (Figure 5) and then peak in October. Figure 14 enumerates the maximum Monarch totals for late summer and autumn, shown below county names. Counties with highest Monarch numbers are along the state's southern border, except for Roosevelt and Grant, each of which has at least one large overnight roost in the database. Greatest autumn numbers are in Lea County in southeast New Mexico. High autumn Monarch numbers also seen in Otero and Doña Ana counties, which may collect Monarchs moving south through the Tularosa Basin and Rio Grande Valley, respectively.

The late summer/autumn Monarch maximum occurs at different times in different parts of the state (Figure 14). Northern New Mexico experiences greatest Monarch numbers in August. September is peak Monarch month for many central New Mexico counties. Most counties with October peaks are in southern New Mexico. Monarch maxima move from north to south as late summer transitions to autumn.

That southward Monarch shift seems to occur in three phases. First, Monarchs exit higher terrain in late August into September. Figure 15 suggests that in August there are a lot of Monarchs above 7,000 feet elevation, but by September those Monarchs have relocated to lower elevations. This is a logical transition because the growing season ends first in the mountains, as evidenced by cooling nights, senescing milkweeds and drying nectar resources. Monarchs seek and find life's necessities at lower elevations and this seems to hold true regardless of latitude. Even in south-central New Mexico, where Lincoln and Otero counties host the Sierra Blanca and

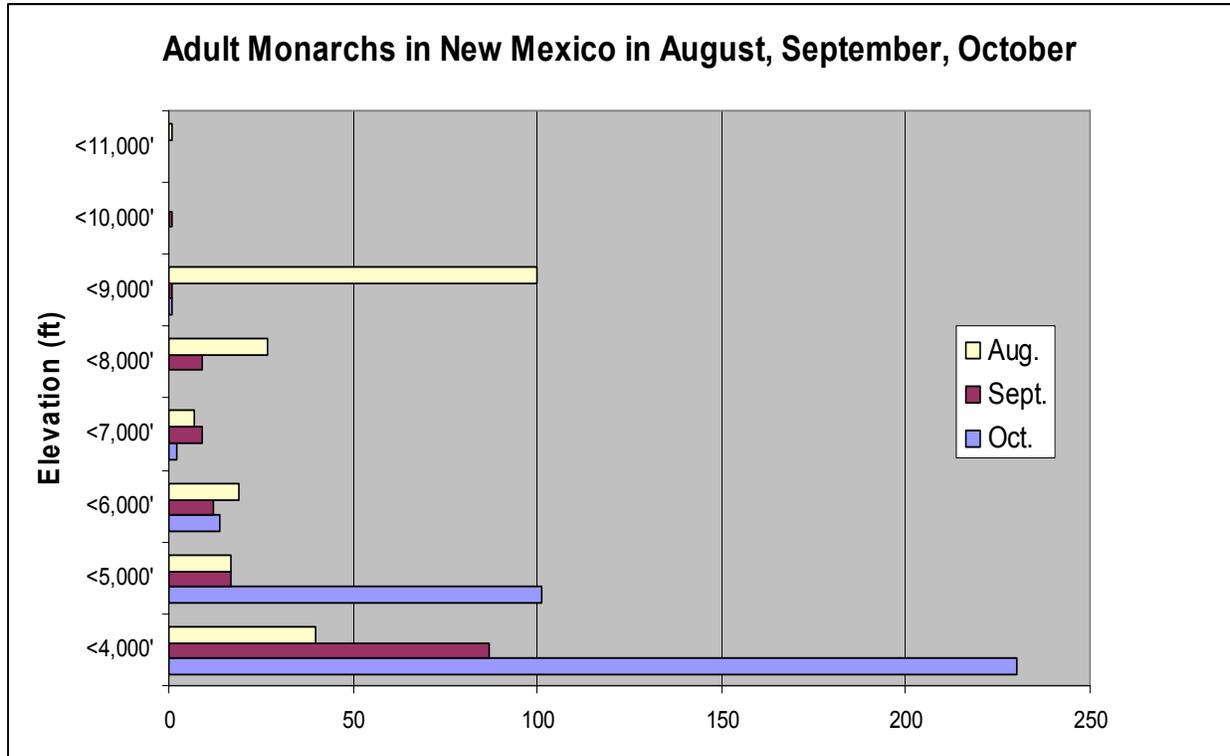
Sacramento mountain complexes, late summer Monarchs peak in August in the high country (Figure 14), but later in the basin bottoms.

Figure 14. Peak months for Monarchs in New Mexico in late summer and autumn.



The second phase of fall Monarch migration in New Mexico seems to be a general movement south. This is evident in New Mexico's eastern tier of counties where the land surface offers few complications. There, the center of Monarch gravity shifts from Union County in July to Curry County in August, Roosevelt County in September, and to Lea County in October (Figure 16).

Figure 15. Altitude distribution of adult Monarchs in August, September and October. The October value is abbreviated from 2,300 to reveal detail at lower values.



Southward movement in mountainous parts of New Mexico may be more nuanced. Below 6,000 feet elevation most of New Mexico is high desert where water, nectar and trees for night roosts are localized along watercourses. We suspect that autumn Monarchs in New Mexico move along drainages, as in Arizona (Morris et al. 2015). Moving downstream along a stream is analogous to following a tree's twigs and branches toward the trunk. Two of New Mexico's "trunk" rivers are the Rio Grande and Pecos River, whose north-south alignment offers Monarchs resource-rich corridors along the New Mexico part of their journey. September/October Monarch peaks along the Rio Grande in Socorro, Sierra and Dona Ana counties, along the Pecos River in DeBaca, Chaves and Eddy counties, and even along the smaller Mimbres River in Grant and Luna counties, all suggest that southward movement of Monarchs in much of New Mexico is focused along watercourses. Continuing south, new Mexico Monarchs merge with the main current of Monarchs from the eastern North America and head for Mexico.

Potentially adding to the southward pulse of Monarchs through New Mexico in autumn is the likelihood that new adults are being produced through ongoing reproduction. Growing seasons at

lower elevations in southern New Mexico extend through October. There is evidence of regular reproduction in September and October, but it is not known how successful it is.

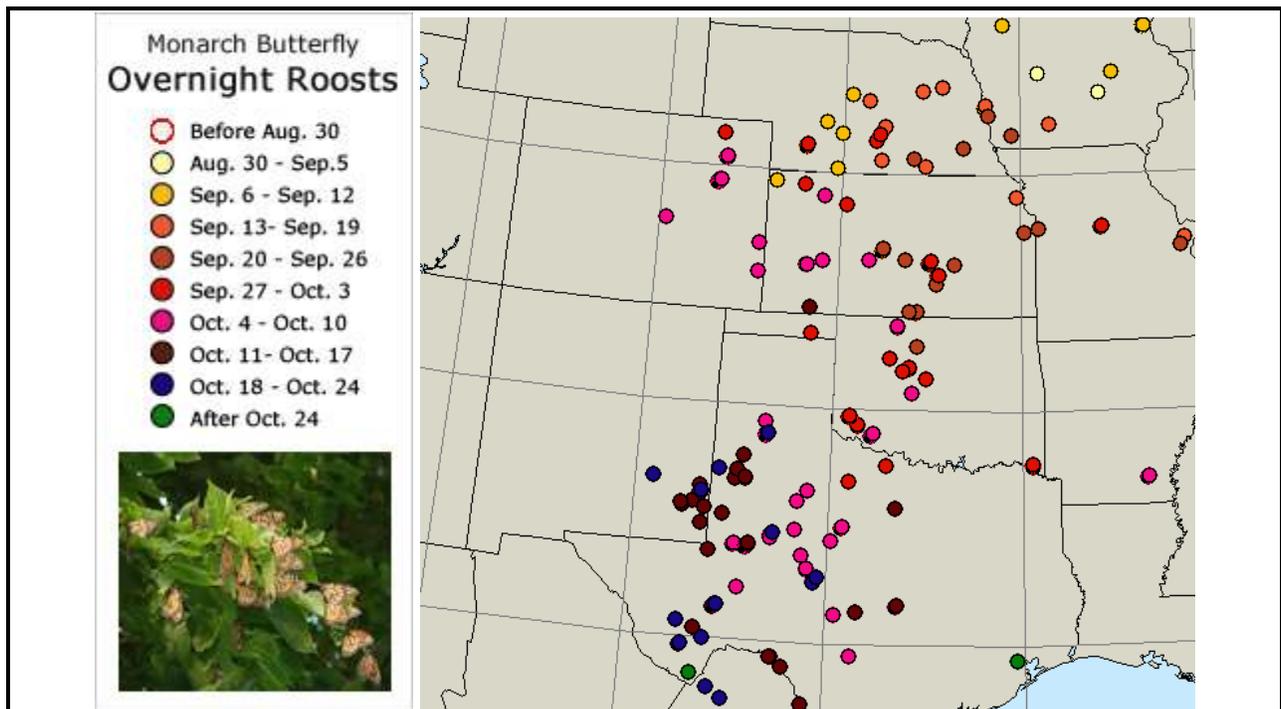
Figure 16. Monarch roost in southern Roosevelt County, October 2015. Photo by B. Williamson.



Passage of the southbound pulse of what is presumed to be mostly "home-grown" Monarchs primarily in September is followed in October by a significant additional influx of Monarchs.

Exclusively in southeast New Mexico, observers in October sometimes witness large numbers of migrant Monarchs from the eastern U.S. passing through on their way south-southwest toward the Mexican overwintering site. Southeast New Mexico is part of the so-called Texas Flyway. Data from Journey North also depict this 2015 pulse of autumn migrants (Figure 17). One Monarch tag recovery supports that conclusion (SWMP 2015). Journey North data from adjacent Texas sites suggests that a similar pulse may have crossed southeast New Mexico in October 2011 before New Mexico observers in the area were posting to Journey North.

Figure 17. Journey North's (http://www.learner.org/jnorth/maps/monarch_roosts_fall2015.html) depiction of roost sites observed during the Monarch migration in autumn 2015.



Migration Nectar

Brower and Pyle (2004) demonstrated the importance of nectar as an energy source for adult Monarchs during their long journey to Mexico in autumn. New Mexico is a semi-arid state and nectar resources can be scarce during many months of the year. However, most of New Mexico experiences its best rains in July and August, when thunderstorms produce 30 to 40 percent of the annual precipitation (<http://www.wrcc.dri.edu/narratives/NEWMEXICO.htm>). Those rains are a boon to plants that bloom in late summer and autumn. As a result, Monarchs generally can expect good nectar resources in late summer and autumn en route through much of New Mexico.

The most important nectar sources for Monarchs during fall migration are plants that are widespread, typically bloom in late summer and autumn, and produce many long-lasting flowers. Archival data and personal observations suggest that milkweeds (*Asclepias* spp.), seepwillow (*Baccharis* spp.), rabbitbrush (*Chrysothamnus* spp.) and sunflowers (*Helianthus* spp.) all play important roles for migrating autumn Monarchs (Table 3).

Table 3. Important nectar plants for Monarchs during autumn migration in New Mexico.

	August	September	October
<i>Asclepias</i> spp. (milkweed)			
<i>Baccharis</i> spp. (seepwillow)			
<i>Chrysothamnus</i> spp. (rabbitbrush)			
<i>Helianthus</i> spp. (sunflower)			

Milkweeds seem to be most available in late summer, before they go to seed. They probably have availability into autumn in southern New Mexico. Rabbitbrush is a widespread native shrub that flowers profusely in northern New Mexico and at higher elevations after most other flowering plants have gone to seed. This makes it a critical nectar resource for Monarchs at the start of the migration. Its invasive character allows it to thrive in the increasing human footprint. Sunflowers are routine roadside plants especially in eastern New Mexico. The October pulse of Monarchs into southeast New Mexico in October 2015 is thought to have occurred in part because of the abundant sunflower bloom in that area, following abundant September rains. This is significant in light of recent findings about the importance of fall migration nectar (Inamine et al. 2016). Seepwillow is a perennial riparian shrub that is prominent along perennial watercourses in southern New Mexico. It blossoms profusely two or three time per season, usually ending with a final bloom in October. Its bloom schedule and riparian habit make it an important source of nectar for all autumn pollinators including Monarchs. Much more data can be obtained in the future by paying closer attention to Monarch nectar plants.

Monarch Tagging

Most New Mexico Monarchs seem to come and go from the Mexican overwintering site, but this statement is merely an educated inference drawn almost entirely from circumstantial evidence of geography and phenology. The most effective way to confirm that an actual monarch butterfly

flew from New Mexico to Mexico, or vice versa, is to mark it and observe it in both places. Monarch Watch and Southwest Monarch Study coordinate tagging programs for that very purpose. Rates at which tagged Monarchs are recovered in Mexico are generally pretty low (<10%), so chances of success are improved by tagging as many Monarchs possible. Monarchs were first tagged in New Mexico ca. 2000 at Bosque del Apache National Wildlife Refuge in Socorro County (Table 4). Those efforts were not ambitious and results were hampered by the small number of Monarchs that could be caught and tagged.

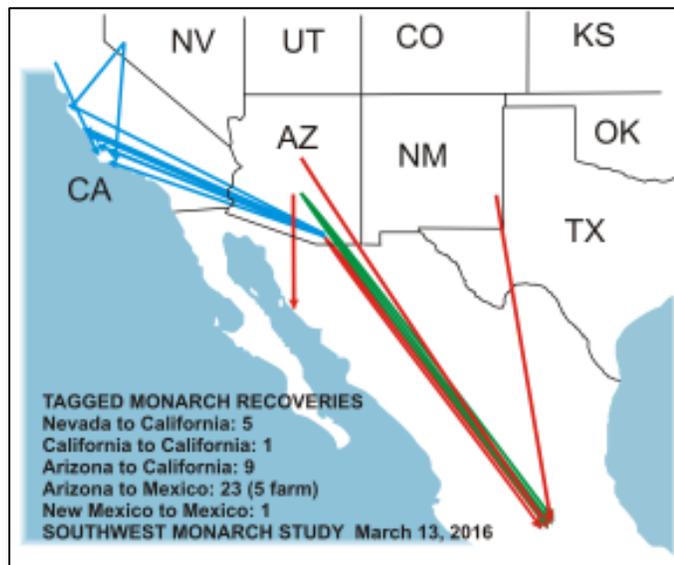
More recent efforts stand a better chance of success because they are overcoming the numbers issue. Rachel Fuchs works with Southwest Monarch Study to tag Monarch at Lindrith School in Rio Arriba Cocunty. She collect monarch larvae from the wild, then helped her students rear them through to adulthood. She and her students have released 100 tagged individuals over the past three years. At Las Vegas National Wildlife Refuge, Debbie Pike works with students to tag and release monarchs raised in captivity by Tatia Veltkamp at Wings of Enchantment Butterfly Farm in Albuquerque. The above two efforts underscore a second crucial value of tagging programs - public engagement.

Table 4. Partial summary of past Monarch tagging in New Mexico.

year	county	# monarchs tagged	tagger	tag source	# recovered
2000	Socorro	5	S. Cary	Monarch Watch	0
2001	Socorro	8	S. Cary	Monarch Watch	0
2013	Rio Arriba	9	R. Fuchs	SW Monarch Study	0
2014	Rio Arriba	23	R. Fuchs	SW Monarch Study	0
2015	Rio Arriba	48	R. Fuchs	SW Monarch Study	0
2015	Lea	1	G. Jones	SW Monarch Study	1

The most successful tagging effort to date occurred in southeast New Mexico, where the large overnight roosts in October 2015 offered an ideal tagging opportunity: lots of Monarchs that were easy to catch and tag not far from their Mexico destination. Only one tag was applied and that tag was recovered. This, New Mexico's first ever tag recovery, was recently reported and appropriately celebrated by the tag sponsor, Southwest Monarch Study (<http://www.swmonarchs.org/az-recoveries.php>) (see Figure 18).

Figure 18. Recent Monarch tag recoveries by Southwest Monarch Study.



PROPOSED CONSERVATION FRAMEWORK FOR NEW MEXICO MONARCHS

Strategy & Organizational Development

Goal: Develop long-term, statewide Monarch conservation/restoration strategy.

Objective: engage partners

Goal: Develop efficient functional organization

Objective: coordinate working groups

Objective: build capacity

Science/Knowledge

Goal: Ascertain/characterize overwintering sites for New Mexico Monarchs

Objective 1: increase number of monarchs tagged to 1000/year

Objective 2: direct tagging efforts to where migration destination is in question

Goal: Learn more about Monarchs' milkweed oviposition preferences and larval survival

Objective 1: study all New Mexico milkweeds for oviposition occurrence.

Objective 2: study all New Mexico milkweeds for larval survival.

Public Engagement/Volunteer Recruitment/Advocacy

Goal: Boost citizen participation in Monarch and Milkweed science statewide

Objective 1: increase social media presence

Objective 2: more citizen participation in monarch tagging, monitoring

Objective 3: more citizen participation in milkweed study, farming

Conservation/Restoration

Goal: Boost population of New Mexico Monarchs

Objective: increase offspring of northbound spring generation.

Task 1: Augment milkweed availability in southern tier of counties so monarchs have plenty of oviposition options.

Task 2: Augment spring nectar along southern border so immigrants can survive longer.

Task 3: monitor success

Objective: Boost survival and reproduction of southbound fall generation(s)

Task 1: supplement milkweed availability statewide, especially along eastern plains and along N-S river corridors (Rio Grande, Pecos, Mimbres).

Task 2: supplement nectar availability statewide, especially along eastern plains and along N-S river corridors (Rio Grande, Pecos, Mimbres).

Task 3: Monitor success.

Objective: Improve seed availability for key native milkweed and nectar plant species

Task 1: issue planting/growing instructions for public dissemination

Task 2: promote commercial milkweed seed supply

Task 3: monitor success

Objective: Restore milkweed patches in nature in key areas

Task 1: ID suitable sites

Task 2: recruit volunteer land owners

Task 3: plant the milkweeds and nectar sources

Task 5: monitor effectiveness

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ACKNOWLEDGMENTS

For a range of support, guidance and assistance the authors wish to thank Melanie Gisler, Tatia Veltkamp, Gail Morris, Julie McIntyre, Christopher Rustay, Jessa Davis, Elaine Halbedel, Rachel Fuchs, Bob Sivinski, Betty Williamson, Gloria Jones, Wyatt Egelhoff, Marcy Leavitt, John Pfeil, Randy Merker and Bob Barber.

APPENDIX A

MILKWEEDS IN NEW MEXICO (FROM JERCINOVIC UNDATED) AND
WHETHER THEY ARE KNOWN TO HOST MONARCHS.

Milkweed (<i>Asclepias</i>) species	Milkweed popular name	Monarch host? source
<i>A. arenaria</i>	Sand Milkweed	Morris et al. 2015
<i>A. asperula asperula</i>	Spider Milkweed	Malcolm & Brower 1986
<i>A. asperula capricornu</i>	Antelope Horns	Malcolm & Brower 1986
<i>A. brachystephana</i>	Bract Milkweed	
<i>A. cutleri</i>	Cutler's Milkweed	
<i>A. engelmannia</i>	Engelmann's Milkweed	Morris et al. 2015
<i>A. glaucescens</i>	Nodding Milkweed	
<i>A. hypoleuca</i>	MahoganyMilkweed	
<i>A. incarnata incarnata</i>	Swamp Milkweed	Cary and DeLay2016, Malcolm & Brower 1986
<i>A. involucrata</i>	Dwarf Milkweed	
<i>A. latifolia</i>	Broadleaf Milkweed	Cary and DeLay 2016
<i>A. linaria</i>	Pineneedle Milkweed	Morris et al. 2015
<i>A. macrosperma</i>	Bigseed Milkweed	
<i>A. macrotis</i>	Longhood Milkweed	
<i>A. nummularia</i>	Tufted Milkweed	
<i>A. nyctaginifolia</i>	Mohave Milkweed	Morris et al. 2015
<i>A. oenotheroides</i>	Zizotes Milkweed	Malcolm & Brower 1986
<i>A. pumila</i>	Plains Milkweed	
<i>A. quinqueidentata</i>	Slimpod Milkweed	
<i>A. rusbyi</i>	Rusby's Milkweed	Malcolm & Brower 1986
<i>A. ruthiae</i>	See uncialis	
<i>A. sanjuanensis</i>	San Juan Milkweed	
<i>A. speciosa</i>	Showy Milkweed	Cary and DeLay 2016 Malcolm & Brower 1986
<i>A. subverticillata</i>	Horsetail Milkweed	Cary and DeLay 2016 Morris et al. 2015
<i>A. tuberosa ssp. interior</i>	Butterfly Milkweed	Cary and DeLay 2016 Malcolm & Brower 1986
<i>A. uncialis</i>	Ruth's Milkweed	
<i>A. verticillata</i>	Whorled Milkweed	Cary and DeLay 2016 Malcolm & Brower 1986
<i>A. viridiflora</i>	Green Comet Milkweed	Malcolm & Brower 1986

¹ Cary and DeLay 2016

² Malcolm & Brower 1986

³ Morris et al. 2015