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WILDLIFE REFUGE, NEW MEXICO: 2019 ANNUAL REPORT AND
PRELIMINARY FINDINGS



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Abstract: In 2019, we studied Gray Vireo (GRVI; *Vireo vicinior*) demography at the Sevilleta National Wildlife Refuge (SNWR) in central New Mexico as part of an ongoing project. We assessed and implemented successful capture, banding, tissue sampling, and harness attachment methods, and monitored nests and juveniles post-fledging. We systematically located and monitored 38 nests at SNWR; apparent nest success was 57%, and parasitism by Brown-headed Cowbirds (BHCO; *Molothrus ater*) was ~25%. Compared to previous years (24% in 2017, 25% in 2018), apparent nest success was much higher, coinciding with considerably lower BHCO parasitism rates. From June through July, we used radio telemetry to track 43 GRVI juveniles during the post-fledging period (i.e., after nest departure) and monitored survival, space use, and habitat associations. Model-averaged daily juvenile survival rate from days 1-13 post-fledging was 0.57 and differed significantly from survival in previous years ($p < 0.05$; 0.8 in 2017, $n=30$; 0.39 in 2018; $n=19$). These observed annual differences in juvenile survival appear to be due to climate differences among years (i.e., precipitation preceding the breeding season, seasonal temperature trends, etc.), though these analyses are preliminary and ongoing. In the lab back at the University of Toledo, we used an osmometer to examine relative hydration levels in both juveniles and adults from plasma samples collected from 2017-2019. We found that relative hydration was highest in 2017 (mean=260), lowest in 2018 (mean=359), and low to moderate in 2019 (mean=336). These hydration levels were significantly different among years overall ($p < 0.05$; ANOVA) and were consistent with seasonal differences in drought indices and rates of juvenile mortality due to apparent exposure. Greater detailed analyses on nest survival, juvenile survival, habitat associations to inform management, population modeling, and climate factors are ongoing and will be included in an MS thesis and manuscript for peer review in 2020 and 2021.

Many Neotropical migratory songbirds are experiencing significant population declines (Robbins et al. 1989, Ballard et al. 2003). Additionally, many species remain critically understudied, impeding reliable and informed science-based management. One such

species, the Gray Vireo (GRVI; *Vireo vicinior*), is a short-distance migratory songbird that breeds primarily in pinyon (*Pinus* spp.)-juniper (*Juniperus* spp.) habitats in the Southwestern US and winters in areas of Mexico that contain elephant trees (*Bursera microphylla*; Bates 1987, Bates 1992, Barlow et al. 1999, Schlossberg 2006). GRVI are currently listed as threatened in New Mexico (NM), as a species of Conservation Concern by US Fish and Wildlife Service (USFWS), and as a Watch List Species by Partners in Flight (NMDGF 2004, USFWS 2008, Rosenberg et al. 2016). Population trends and distributions are not well known partly because GRVI are difficult to detect and occupy remote, inhospitable habitats (Barlow 1977, Barlow et al. 1999, Schlossberg 2006). Studies of GRVI have largely focused on nest success, winter ecology, and breeding territories; the post-fledging period and migration have not been intensively studied (Barlow et al. 1999).

To properly manage a species, it is critical to understand its population dynamics and demography, which are most informative when all stages of a species' life cycle are incorporated (Sillett and Holmes 2002). In passerines, this means considering the full annual cycle, including periods that may be difficult to study, such as migration, the non-breeding season, and the post-fledging period (Sillett and Holmes 2002, Cox et al. 2014, Marra et al. 2015). The post-fledging period, or the time after juveniles leave the nest, is critical to assessing productivity and population growth; however, this stage has never been studied in GRVI (Streby 2010, Cox et al. 2014). Only recently did the technology become available and "small enough" to make songbird fledgling studies possible with radio telemetry. The post-fledging period is generally divided into the dependent stage, during which juveniles rely on adult care; and the independent stage, or the stage of

independence prior to migration (Dybala et al. 2013). Survival is generally lowest during the first week after fledging from the nest, most likely because of the immobility of young and therefore increased vulnerability to exposure and predators (Tarwater et al. 2011, Lloyd and Martin 2016).

Our continuing research objective is to determine full season-productivity (i.e., # of young raised to independence from adult care) of GRVI at Sevilleta National Wildlife Refuge (SNWR), NM. We will assess how nesting and post-fledging habitat associations and cover type selection influence productivity and will model population growth, especially under multiple future climate scenarios.

STUDY AREA

We continued our GRVI demography study on the SNWR in central NM, at which breeding GRVI have been studied annually since 2011 through the NSF REU Program. The SNWR is a 230,000-acre limited-access refuge that protects a massive arid-land ecosystem and is managed by the United States Fish and Wildlife Service (USFWS 2012). We conducted this study within Piñon Canyon, Sepultura Flats, Montoso, Cottonwood, and Tomasino (i.e., SNWR roads within juniper savannas) on the eastern side of the refuge within the foothills of Los Pinos Mountains, where GRVI are known to breed.

On SNWR, GRVI generally breed in juniper savannas that are comprised mainly of one-seed juniper (*Juniperus monosperma*), creosotebush (*Larrea tridentata*), and other shrubs and succulents (e.g., *Yucca* spp., *Cylindropuntia* spp., and *Opuntia* spp.). At higher elevations within piñon-juniper woodlands, piñon pines (*Pinus edulis*) are more

common on the landscape. During the late summer months, Mexican monsoon storms affect the SNWR, and precipitation levels vary annually and are unpredictable (Douglas et al. 1993, Gosz et al. 1995, Zlotin and Parmenter 2008).

METHODS

This work was conducted under the University of Toledo IACUC protocol #108708. All sampling and marking methods are identical to those implemented in our 2017-2018 study.

Capturing, Banding, and Tissue Sampling – To catch adult GRVI, we used 12-m mist-nets and conspecific song and call playback to elicit aggression and territorial responses. All adults were marked with unique combinations of 3 color bands and one metal USGS band. Juveniles were captured from nests prior to fledging and marked with one white color band and one metal USGS band. Juveniles receive a different color band in each year for cohort identification. We recorded standard morphometric data, including mass, age, wing length, and tail length. Adult sex was determined by both breeding condition (cloacal protuberances and brood patches) and behavior, and sex of juveniles is currently being determined via molecular analysis at the Cleveland Museum of Natural History.

We removed 3-5 crown feathers from adult birds and took small hallux (i.e., hind claw) clippings for analysis of spectral reflectance (i.e., a measure of feather pigments) and diet in the lab. We also sampled blood (<1% of GRVI body mass) in adults and juveniles from a vein in the wing using sterile 27-gauge needles and heparinized capillary tubes. Samples were spun down in the field using a centrifuge to separate red blood cells from plasma. Red blood cells were mixed with cryoprotectant buffer (90% fetal calf

serum, 10% DMSO) and flash-frozen in the field. Plasma samples were also flash frozen in the field and will be used to examine relative hydration using osmometry and to assess body condition and immune capacity using multiple immune response assays. Samples were then stored at -80C pending lab analysis. We made peripheral blood smear slides and stored remaining red blood cells in lysis buffer for avian blood parasite screening (e.g., haemosporidian parasites) in collaboration with the University of New Mexico. Following sampling and marking (see below), all birds were returned and released at the capture location.

Radio Transmitter and Geolocator Harness Design and Attachment – Our 2017-2019 study is the first to employ radio telemetry unit attachment on GRVI. We used 0.45-g radio transmitters (~3.5% of body mass; Blackburn Transmitters, Nacogdoches, TX) with a modified figure-eight leg-loop harness (Rappole and Tipton 1991, Streby et al. 2015) that has been successfully implemented in other studies of small migratory songbirds (e.g., Peterson et al. 2016). After finding the correct harness size (13 mm) in 2017, we successfully attached radio transmitters to both females and males of various ages, including juveniles. In 2019, we attached only radio transmitters and no geolocators.

Nest Searching, Monitoring, and Vegetation Data – We searched for nests by following singing males and by radio tracking incubating or brooding females to their nests both during the day and at night. Nest locations were recorded using handheld GPS devices. After locating nests, we monitored them every 3-4 days to record adult activity, nest contents (i.e., presence of Brown-headed Cowbird [*Molothrus ater*] eggs/young, Gray Vireo eggs/young), and nest condition. We determined nest fates by visiting until the expected fledging date. Nests were considered successful if ≥ 1 young fledged, but final

analysis will differentiate numbers of young fledged. Once nests were inactive (i.e., they failed or fledged), we collected associated vegetation data, including: substrate, diameter and density of nest tree, nest height, nest tree height, and the compass bearing of the direction that the nest is facing out from the tree (nests in the center of the tree will be measured as ‘center’). We will record the apparent sex of dioecious one-seed juniper nest trees as determined by presence of cones (indicating males) or scale-like “berries” (indicating females; Ffolliott and Gottfried 2002) because these trees appear to be the sole nesting substrate of Gray Vireos on SNWR (S.E. Fischer and K. Granillo, unpublished data).

Nest Success –When field data collection is completed in 2020, we will use logistic exposure modeling (modified generalized linear models) of nest survival to allow covariates and hypothesis testing.

Post-fledging Period – Using radio telemetry, we tracked GRVI fledglings daily during the first 15 days post-fledging to assess survival, space use, and habitat associations. After 15 days post-fledging, we tracked fledglings every 3 days because, in previous years, we observed no evidence of mortality after 12 days post-fledging. Upon locating each fledgling, we recorded: location, fate (alive or dead), other fledglings and/or adults seen, activity, vocalizations, and vegetation data (i.e., substrate, fledgling height from ground, and vegetation density). We used logistic exposure modeling (modified generalized linear models) of juvenile survival to allow covariates and hypothesis testing. Covariates included year, ordinal date, age from fledge, age from hatch, and vegetation density. We also included a random effect of brood in these models to account for interdependence among juveniles from the same nest. Additional modeling will be

completed in the future (i.e., after data collection is completed in 2020) to assess other potential covariates, such as climate data, osmolarity, and landscape habitat factors. We will use QGIS (QGIS Development Team 2020) to determine the mean distance between daily fledgling movements, the mean daily distance from the nest, and both nest and post-fledging cover type selection.

Plasma Osmometry (Osmolarity as a Measure of Hydration) – We used a centrifuge to separate blood plasma from red and white blood cells in samples taken from 2017-2019. We used an osmometer (Precision Systems Micro Osmette) to measure osmolarity (i.e., # of solutes/L, or osmotic strength) of GRVI plasma as a proxy for relative hydration. We compared relative hydration of juveniles and adults from 2017 ($n=80$ total, $n=41$ juveniles, $n=39$ adults), 2018 ($n=54$ total, $n=16$ juveniles, $n=38$ adults), and 2019 ($n=95$ total, $n=70$ juveniles, $n=25$ adults).

RESULTS

Nest Searching and Success – We found and monitored 38 GRVI nests at SNWR in 2019. We calculated an apparent nest success rate of 57% and a parasitism rate of ~25%. All nests found were in one-seed juniper, as has been the case for all previous years of GRVI study at SNWR. Interestingly, apparent nest success was higher in 2019 compared to previous years (25% in 2017, 24% in 2018; Figure 1). This difference was likely driven by lower rates of brood parasitism by Brown-headed Cowbirds in 2019 than in previous years; however, further analysis is upcoming.

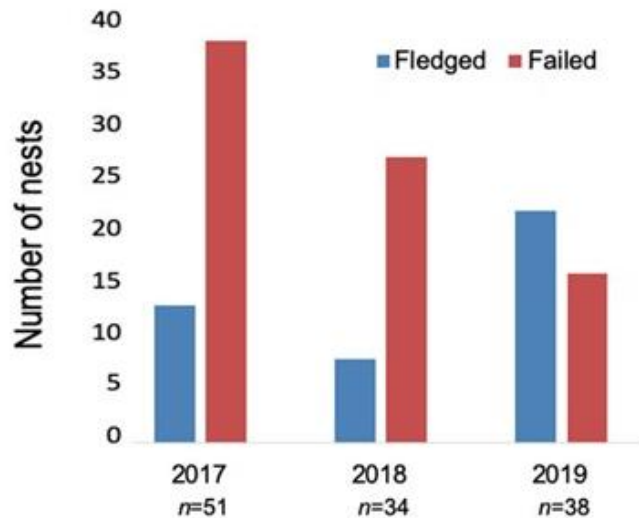


Figure 1. Number of failed (red) and fledged (blue; i.e., successful in fledging one or more young) Gray Vireo (*Vireo vicinior*) nests among the nests we found and monitored at Sevilleta National Wildlife Refuge, New Mexico (2017-2019).

Post-fledging Period – We tracked 43 juvenile GRVI using radio telemetry during the dependent fledgling stage in 2019, achieving our largest sample size compared to previous years. This increase in sample size is attributable to excellent success finding nests combined with relatively high nest success, and thus more fledglings to track. Overall, mortality was highest during the first week post-fledging, as was the case in previous years. For modeling purposes, we subset survival data to include only days 1-12 post fledging, as we did not observe any mortalities after day 12 post-fledging from 2017-2019. Model-averaged daily juvenile survival rate from days 1-12 post-fledging

was 0.57 and differed significantly from survival in previous years ($p < 0.05$; 0.8 in 2017, $n = 30$; 0.39 in 2018; $n = 19$; Figure 2).

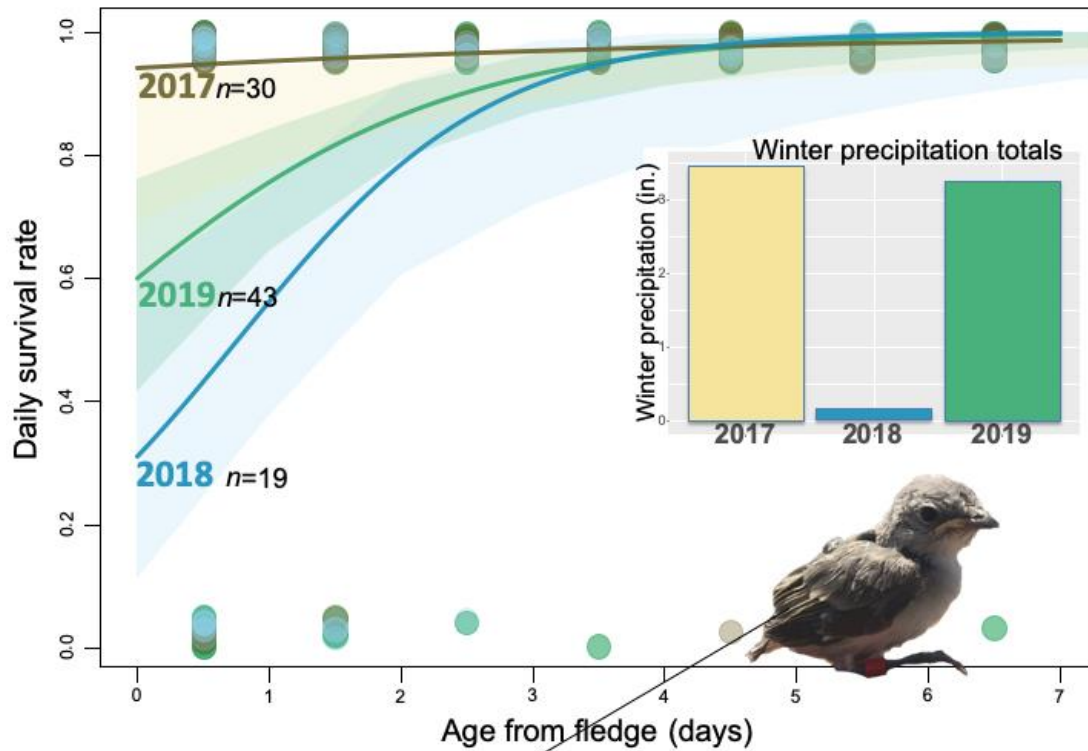


Figure 2. Daily survival rate (first 7 days off nest) of juvenile Gray Vireos (*Vireo vicinior*) at Sevilleta National Wildlife Refuge, New Mexico, calculated using logistic exposure modeling (2017=yellow, 2018=blue, 2019=green). Annual winter precipitation (i.e., precipitation preceding the breeding season from November-April) totals (in.) are shown in the top right.

In terms of types of mortality (i.e., exposure-related death versus predation), 43% of juveniles died due to exposure in 2019, compared to 67% in 2018 and 36% in 2017 (Figure 3).

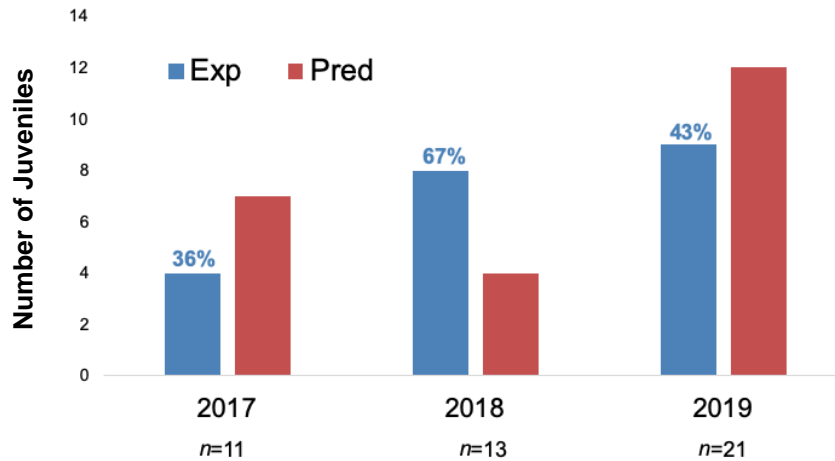


Figure 3. Types of mortality (blue=exposure, red=predation) in Gray Vireo (*Vireo vicinior*) juveniles during the post-fledging period from 2017-2019 at Sevilleta National Wildlife Refuge, New Mexico. Percents are percent of total mortalities attributed to exposure each year.

Plasma Osmometry (Osmolarity as a Measure of Hydration) – Overall, relative hydration was highest in 2017 (mean=260), lowest in 2018 (mean=359), and moderate in 2019 (mean=336), and rates were significantly different among years overall ($p < 0.05$; ANOVA; Figure 4).

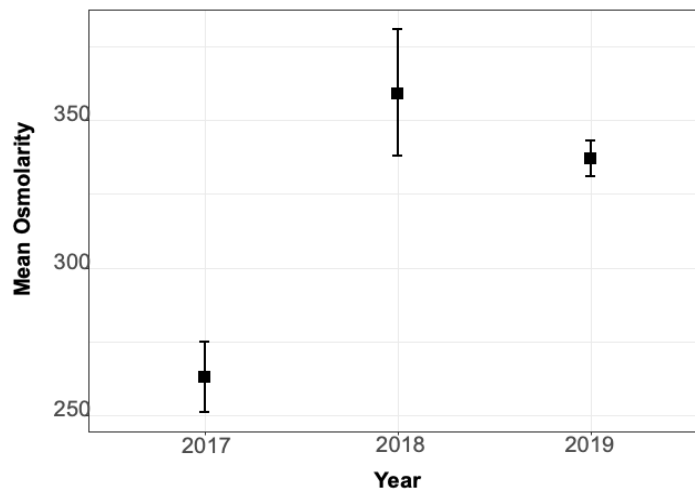


Figure 4. Relative hydration rates of Gray Vireos (*Vireo vicinior*) including juveniles and adults at Sevilleta National Wildlife Refuge, New Mexico, obtained from plasma osmometry from 2017-2019. Lower values indicate that birds were more hydrated compared to higher values.

Juveniles were significantly more hydrated than adults in both 2017 and 2019 ($p < 0.05$), but there were no differences in relative hydration among adults and juveniles in 2018 ($p > 0.05$; Figure 5). Both juveniles and adults were significantly more hydrated in 2017 compared to both 2018 and 2019 ($p < 0.05$; Figure 5).

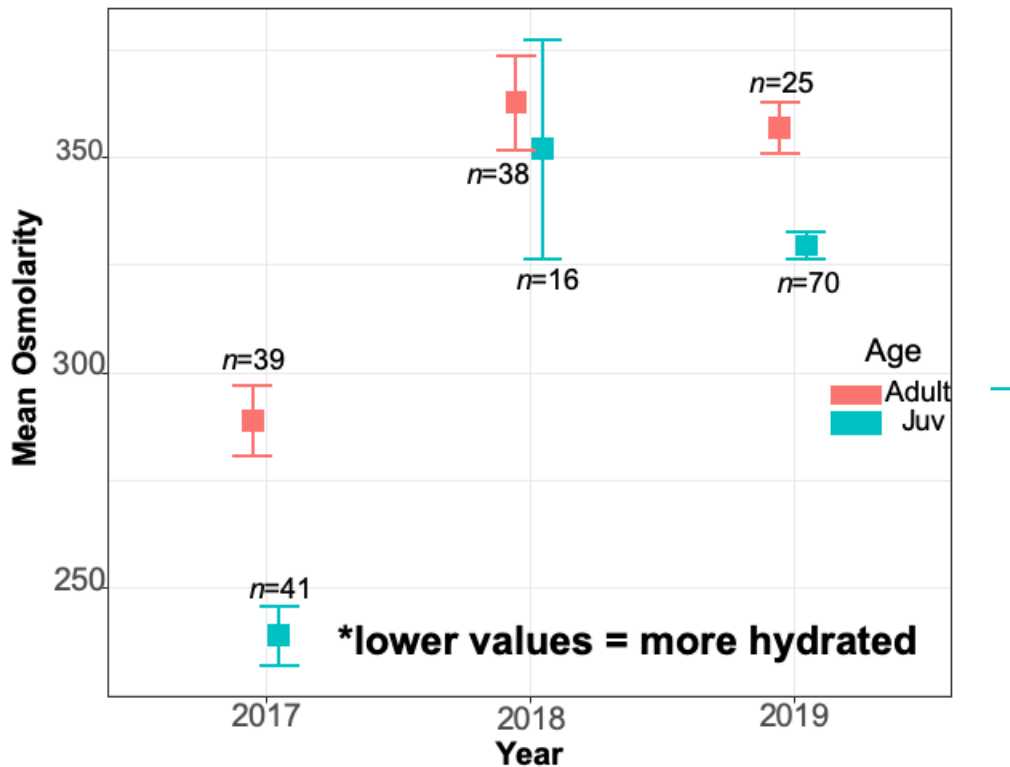


Figure 5. Relative hydration rates of Gray Vireo (*Vireo vicinior*) juveniles (blue) and adults (red) at Sevilleta National Wildlife Refuge, New Mexico, obtained from plasma osmometry from 2017-2019. Lower values indicate that birds were more hydrated compared to higher values.

DISCUSSION

During previous years (i.e., 2017-2018), GRVI apparent nest success at SNWR was consistently ~25%. We observed higher apparent nest success in 2019 compared to previous years, which coincided with a lower parasitism rate by BHCO. We are currently working on model-averaging nest success for all years to identify other important

covariates. Interestingly, nest survival was not apparently influenced by climate conditions, unlike juvenile survival. Nest habitat versus post-fledging habitat associations will be analyzed in further detail after field data collection in 2020 and will be incorporated into full-season landscape productivity models along with data from the post-fledging period.

Juvenile survival was significantly different among years from 2017-2019. In 2019, we observed “moderate” survival compared to higher survival in 2017 and lower survival in 2018. Trends in relative hydration were similar to trends in juvenile survival, though blood samples were taken from juveniles in the nest and not from mobile fledglings. During the drought year of 2018, low relative hydration and higher rates of mortality due to exposure may indicate that juvenile GRVI are susceptible to evaporative water loss. Annual trends in juvenile survival, type of mortality, and relative hydration appear to relate to observed differences in the statewide drought index from 2017-2019, and therefore we speculate juvenile survival may be linked to annual climate conditions (i.e., precipitation preceding the breeding season, temperature, etc.).

Historically, many arid land songbird species and communities have exhibited marked population declines apparently related to decreasing precipitation and increasing temperatures (Iknayan and Beissinger 2018). Our results indicate that the mechanism for these declines, at least in GRVI, is likely decreased juvenile survival during drought conditions. Juvenile survival is often one of the most important demographic parameters in population models. We suspect that changes in insect availability compounded with evaporative water loss resulted in increased risk of mortality due to exposure, potentially including both dehydration and starvation susceptibility. Though arid land birds like

GRVI are adapted to hot, dry climates, these organisms may be operating near the limits of their thermal tolerances, which is likely exacerbated during the first few days of the vulnerable juvenile life stage.

Thus far, we have only performed exploratory climate analyses, but in the future, we will model GRVI population growth and decline under future climate scenarios. We will also model how nest and post-fledging habitat associations influence productivity. We expect that our findings will have substantial implications for habitat management and GRVI population demographics, as well as those of other southwestern songbirds in the context of global climate change, but will require further data collection and analysis in 2020. Our preliminary results suggest that water (and therefore potentially insect availability) may be limiting GRVI juvenile survival during drought conditions, and therefore the conservation of water refugia (even artificial water refugia, such as drinkers) may be pertinent in a warmer, drier future (Smit et al. 2019).

PRODUCTS

We presented preliminary post-fledging results at the Ecological Society of America (ESA) conference in Louisville, Kentucky in August 2019. In addition, we presented results from our geolocator tracking of GRVI migration at The Wildlife Society meeting in Reno, Nevada in September 2019.

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