

Running Head: JUNIPER TITMOUSE

Of Birds and Brush:

A Case Study of the Juniper Titmouse *Baeolophus ridgwayi* in the Great Basin

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INTRODUCTION

Birds are often cited as important indicators of ecosystem health and integrity since they encompass a wide variety of generalists and specialists species that have an equally broad range of habitats and niches (Gillihan 2006). In addition, some of these species may be more or less sensitive to habitat changes, degradation, or destruction, and even environmental changes. Furthermore, the absence or presence of certain bird species may provide clues to diversity of flora and fauna upon which they depend and co-exist (Gillihan 2006). One such species is the juniper titmouse (*Baeolophus ridgwayi*), which was recently split from the plain titmouse (*Parus inornatus*) in 1996 (Cicero 2000, 2004). The juniper titmouse is a small, gray bird found throughout the Great Basin in warm, dry open woodlands, especially mature juniper (*Juniperus* spp.) and piñon-juniper woodlands that provide large trees with natural nesting cavities (see Fig. 1; Cicero 2000).

The breeding distribution of juniper titmice extends from southeast Oregon to southeast Idaho, throughout Nevada and Utah, as well as significant parts of Colorado, New Mexico, and Arizona (Cicero 2000). As a specialist species, it is often found in and near old-growth woodlands with large size-class junipers and mature piñons (*Pinus* spp.) for foraging and nesting needs (Pavlacky and Anderson 2001; Idaho Conservation 2005). However, the juniper titmouse differs from its other Parid cousins in that it consumes many large seeds, specifically juniper, piñon pine, and oak (*Quercus* spp.) seeds, which play a large role in seed dispersal of piñon-juniper woodlands (Christman 2001).

The extent of the piñon-juniper woodland ecosystem ranges from 22.5-20 million hectares and spans across several western states, from the Mogollon Rim in Arizona up to the Snake River Plain in Idaho as well as significant sections in New Mexico, southeastern California, and Colorado (O'Meara et al. 1981; Gillihan 2006). While parts of this ecosystem seem to be expanding due to changing climatic and fire regime changes, other areas have been largely cleared during the last thirty years through intensive removal strategies, such as chaining (i.e. dragging a heavy anchor chain between two

bulldozers) in order to create space for forage/grazing for big game and livestock, mining (mainly coal and shale), and energy development (O'Meara et al. 1981; Gillihan 2006; Tausch and Hood 2007). In addition, the composition of the piñon-juniper woodlands seems to be changing as well. According to a study by Francis et al. (2011), piñon pines may be more sensitive than junipers to drought as well as insect herbivory. For example, during the region-wide drought of the southwestern United States from 2002–2003, more than 90% of piñon pines in northern New Mexico died in fifteen months (Francis et al. 2011). A similar result was observed in northern Arizona where 32% of piñon pines died over a 1-year period while only 5% of junipers died (Francis et al. 2011).

Although juniper titmouse populations may have increased following piñon-juniper expansion, this species has also showed widespread declines throughout its range (Sabol 2005; Gillihan 2006). In particular, declining juniper titmouse populations have been observed in the Sierra Madre Occidental, Chihuahuan Desert, Colorado, and New Mexico, likely attributed to loss of habitat through tree removal for fuelwood, rangeland conversion, Christmas trees, and fence posts (Table 1; Figure 5; Cicero 2000; Sauer et al. 2012). Accordingly, the juniper titmouse is ranked as a priority species in the piñon-juniper woodlands ecosystem in several Partners in Flight Bird Conservation Plans that cover the majority of this ecosystem's range, including New Mexico and Colorado (Gillihan 2006).

While the titmouse may seem small and insignificant, this species (among the many important to the piñon-juniper woodland) provide key ecosystem services, especially seed dispersal through caching behavior (Christman 2001). Moreover, as reported by Gillihan (2006), bird watching is a major economic input to the piñon-juniper woodlands ecosystem as it is home to a group of specialist avian species seen rarely anywhere else. In 2001, over 46 million birdwatchers in the United States paid \$32 billion towards bird-watching and related activities (Gillihan 2006). As a result, these expenditures generated \$85 billion in overall economic output, \$13 billion in federal and state income taxes, and supported more than 863,000 jobs (Gillihan 2006). In light of climate change and noting the changes in the piñon-juniper

woodlands ecosystem, the future of the juniper titmouse is uncertain despite its status as Least Concern under the IUCN (Birdlife International 2012). The purpose of this paper is to (1) identify and examine the threats facing the juniper titmouse, (2) population ecology and dynamics of this species, and (3) provide critique of current management as well as suggestions of better management for this species and the broader avian community of the piñon-juniper woodlands ecosystem.

POPULATION ECOLOGY

Perhaps due to the fact that the juniper titmouse was so recently split from the plain titmouse, limited information is available regarding the population dynamics and population ecology of this species. In general, densities of juniper titmouse are lower than those of oak titmouse, especially in piñon-juniper woodlands (Cicero 2000). Whereas population densities of oak titmice range from 0.3-0.7 (with the highest reported density at 1.8) pairs/ha, reported densities for juniper titmice span from 0.1-0.5 pairs/ha (Cicero 1996; Cicero 2000). Other than this information, nothing is known about the life span or survivorship of the juniper titmouse, or the range of this species (i.e. dispersal from breeding site or colony, initial dispersal from natal site, home range, etc.; Cicero, 2000). Even sources of citizen science, such as eBird, seem to lack population information regarding this species.

The Breeding Bird Survey (BBS), however, is one of the few sources that has basic information on the population status and trends of this species, although there are only a few states and regions (Arizona, New Mexico, Sierra Madre Occidental, and the Southern Rockies/Colorado Plateau) that have sufficient data about the juniper titmouse (i.e. at least 14 samples in the long term, of moderate precision, and of moderate abundance on routes; Sauer et al. 2012). The other states and regions sampled by the BBS (including the Great Basin, Chihuahuan Desert, California, Colorado, Utah, western BBS region, United States, and survey-wide) reflect data with a deficiency, such as low regional/state abundance of the juniper titmouse, a sample size of than 14 routes, or the results are so inexact that a 3%

per year change would not be detected over the long-term (Sauer et al. 2012). Nevada is the only state for the BBS that contains an important deficiency of data for the juniper titmouse; the regional abundance for this species is very low, or the sample is based on less than 5 routes for the long term, or the results are so coarse that a 5% per year change would not be detected over the long term (Sauer et al. 2012). Population status and trends are largely unknown in states where juniper titmouse occur rarely or uncommonly, such as Wyoming and Idaho (Idaho Conservation 2005; Wyoming Natural 2010).

According to the BBS, juniper titmouse populations are increasing significantly in the Great Basin (11.7 % from 2001-2011; Table 1 and Figure 5; see Figure 2 for definition/extent of Great Basin). However, it should be noted that the BBS provides population trends from 1966-2011 and from 2001-2011. Because the juniper titmouse was split from the plain titmouse in 1996, it is more appropriate to examine the 2001-2011 population trends, as the 1966-2011 will most likely include population trends of the plain titmouse (Sauer et al. 2012). Juniper titmouse populations also seem to be increasing in California (6.9%), although not significantly (Table 1; Figure 5; Sauer et al. 2012). Other regions and states, including the Southern Rockies/Colorado Plateau, Arizona, Nevada, Utah, and the western BBS region have observed small increases in juniper titmouse populations as well (approximately 1.2% per year on average between the listed regions/areas, although the population trend is increasing at 18% in Nevada).

However, the Sierra Madre Occidental, Chihuahuan Desert, Colorado, and New Mexico have documented decreases in population trends (not statistically significant; Table 1; Figure 5; Sauer et al. 2012). It is worth noting that the juniper titmouse is listed as an indicator species in Nevada, an imperiled, protected nongame species (S2) in Idaho, a Level 1 (SC1) Species of Conservation Concern for the New Mexico Partners in Flight Program (with a rating of high stewardship responsibility for New Mexico), and a species with high conservation need locally and throughout its range for the Colorado Partners in Flight Program (Pinyon-Juniper n.d.; Idaho Conservation 2005; Rustay and Norris 2007; Hutchings 2000). In addition, according to the Colorado Partners in Flight, the Colorado Plateau has the highest area

responsibility for this species because more than 40% of their range occurs within that particular physiographic area (Hutchings 2000).

In addition to basic population trends, the BBS has also generated maps concerning the percent change in population size per year and summer distribution. As seen in Figure 3, juniper titmice populations seem to be increasing rapidly throughout Nevada and parts of Utah and Arizona. Yet, for the majority of the range of this species, there seems to be a negative percent change per year, especially in New Mexico, Colorado, southwest Utah, and northwest Arizona (Sauer et al. 2012). In addition, it should be noted that the estimated range in Figure 3 is smaller than that of the estimated range in Figure 1 because many of the BBS routes for the juniper titmouse do not provide adequate data for estimation of population trends (Sauer et al. 2012). In terms of summer distribution (Figure 4), the data seem similarly or exactly positioned as in the previous map (Figure 3) as juniper titmice are not migratory species (Sauer et al. 2012; Cicero 2000). The highest distributions of juniper titmice occur in New Mexico, Colorado, southwest Utah, and northwest Arizona (Sauer et al. 2012).

HUMAN RELATIONSHIPS

Based on the trends described in the previous section, juniper titmouse population abundance and population viability is uncertain. Because juniper titmice are piñon-juniper specialists, it might be expected that the range of this species has expanded in relation to piñon-juniper woodland expansion/invasion (Miller et al. 2008; Tausch and Hood 2007). However, juniper titmice (like other piñon-juniper woodland specialist species) depend upon certain abiotic and biotic features of the piñon-juniper woodland, many of which have been negatively affected by climate change, livestock grazing, changes in fire regime, invasive weed and insect species, tree harvesting, residential development, water development, and energy/resource development (Gillihan 2006).

While the expansion of the piñon-juniper woodlands is often tied to anthropogenic causes, it has been established through several studies that an increase in the range of this ecosystem throughout North America occurred initially due to a shift to milder temperatures and wetter conditions at the end of the Little Ice Age (Miller et al. 2008). However, this period also (partly) coincides with the introduction of livestock in the 1860s (Tausch and Hood 2007). Out of all the human interactions with the piñon-juniper woodlands, grazing has had one of the largest impacts in that it has greatly changed herbaceous vegetation cover (Miller et al. 2008; Tausch and Hood 2007). Before grazing, ground cover of old-growth tree stands in piñon-juniper woodlands (like Utah juniper [*Juniperus osteosperma*]) was quite rocky and grassy understories capable of carrying a surface fire would develop rarely, if ever (Tausch and Hood 2007). In addition, piñon-juniper woodlands were found most commonly in areas with steep slopes with shallow soils; a few pre-settlement woodlands have been found to not having been exposed to fire for over 200 years (Miller et al. 2008; Tausch and Hood 2007). Since Euro-American settlement and the introduction of livestock, much of the western landscape, especially in areas of heavy grazing, has experienced increasing homogeneity of herbaceous vegetation cover, resulting in increased fuel loads (Miller et al. 2008). In addition, cattle may have acted as agents in seed dissemination of non-native and/or invasive species that increased fuel loads as well. As a result, areas that were in fire regime V (fire occurs rarely, frequency is >200) became fire regime IV (less frequent, every 35-200 years) and even III (infrequent, every 35-200 years; Tausch and Hood 2007).

Although some of these conditions may have opened the door for piñon-juniper expansion, these changing fire regimes have major implications for the juniper titmouse (and other specialist species of this ecosystem). In particular, juniper titmice are highly dependent upon stands of mature piñon pine and juniper species for a variety of needs, such as foraging, roosting, and nesting (Francis et al. 2011). For example, juniper titmice are secondary cavity nesters and require either a natural cavity or one already excavated by a woodpecker (Wyoming Natural 2010). Only large trees, especially those that are dead or

partially dead, can provide these specific cavities used by juniper titmice (Gillihan 2006). In addition, cavities are very important for roosting because they reduce convective heat loss, crucial for species such as juniper titmice that are relatively poorly insulated and must increase their thermoregulatory costs significantly to survive cooler temperatures overnight in their native habitats (Weathers and Greene 1998; Cooper 1999). However, many of these old juniper and piñon pine trees have been lost to non-selective tree harvesting for use as fuelwood and fence posts as well as rangeland “improvement” projects (i.e. large-scale chaining or non-selective thinning projects; Gillihan 2006; Rustay and Norris 2007). In addition, modern fire return intervals (sometimes as frequent as 10-35 years) do not allow for the development of this type of habitat (Lankford 2012). Prescribed fire in piñon-juniper woodlands have also been used in an attempt control the establishment of trees, increase habitat diversity, and control invasion of other species - all of these factors together have detrimental effects upon the population abundance and viability of juniper titmouse in their native habitats (Miller et al. 2008).

In addition, various types of development have resulted in habitat loss of mature piñon-juniper woodlands. Vast tracts of woodlands have been cleared for crop production as well as grazing lands for cattle (Knick et al. 2003). According to Knick et al. (2003), approximately 2.7 million ha of western lands administered by the U.S. BLM are currently in production status for oil, gas, or geothermal energy and another 9.3 million ha throughout Montana, Wyoming, Colorado, Utah, and New Mexico, are available for oil and gas leasing (Knick et al. 2003; Wyoming Natural 2010). Moreover, the range occupied by piñon and juniper species includes large areas rich in minerals; mining of these materials (as well as the extraction of other desirable resources such as natural gas and coal) have degraded and destroyed large tracts of piñon-juniper woodlands (Gillihan 2006). Associated road networks, pipelines, and power line transmission further fragment habitats or create opportunities to facilitate the spread of invasive species that can further impair or degrade remaining piñon-juniper patches (Knick et al. 2003). Other developments, such as residential zones, have removed large areas of piñon-juniper woodland and

converted it to a land-cover type that is of little use to juniper titmice (Gillihan 2006). Even low-density residential development fragments piñon-juniper habitat into many small, isolated patches (Gillihan 2006).

Interestingly enough, water developments designed for livestock and wildlife (such as pipeline and tank systems, catchment systems [guzzlers], and artificial ponds or reservoirs) have led to concentrations of livestock in arid and semi-arid regions. While this has led to somewhat local negative effects, such as soil compaction, local trampling of vegetation, overgrazing, and invasion by exotic vegetation, it has also led to elevated rates of brown-headed cowbird (*Molothrus ater*) brood parasitism (Gillihan 2006). In fact, as livestock have increased through the piñon-juniper woodlands, brown-headed cowbirds have followed and parasitized more than 75% of the nests of some species (including juniper titmice) in areas (Gillihan 2006).

FUTURE RESEARCH NEEDS

As noted earlier in this paper, existing information regarding population estimates and trends for the juniper titmouse are quite limited, perhaps due to the relatively recent taxonomic split. This species has an extremely large range, extending throughout Oregon, Idaho, Wyoming, California, Nevada, Utah, Colorado, Arizona, and New Mexico, and the population trend (in general) seems to be stable with a total estimated population size at 330,000 (Birdlife International 2012; Rustay and Norris 2007). In addition, it is worth noting that the few articles focused specifically on the juniper titmouse took place in a limited area, mainly Arizona, Utah, and Wyoming- relatively small when compared to the entire range of this species.

However, the density of juniper titmouse varies across this massive range. For example, New Mexico supports approximately 28% of the total juniper titmouse population (about 98,000 birds) whereas Idaho supports only 2,500 individuals (Idaho Conservation 2005; Rustay and Norris 2007).

Moreover, population trend data is sparse or unknown in areas where titmice are uncommon or rare; there are no trend estimates for Idaho and there is insufficient data over most of the range of this species for statistically rigorous trend estimates at the state level (Idaho Conservation 2005).

Other than basic demographic and population data, much remains unknown about this species. Following the taxonomic split, many studies focused explicitly on the oak titmouse, specifically addressing topics of natural and life history information, such as pairing, territoriality, survivorship, dispersal, molt, and nesting and foraging behavior (Cicero 200). However, juniper titmouse have been extensively studied in terms of physiology, thermoregulation, and energetics, especially in Utah and Arizona (Cooper 1999; Cooper 2000; Cicero 2000). More studies concerning population dynamics, territoriality, juvenile dispersal, molt, and other aspects of the annual cycle in populations of the juniper titmouse are still needed (Cicero 2000). As detailed by Cicero (2000), current research efforts concerning the juniper titmouse are focused on: (1) genetic study of a contact zone between oak and juniper titmice in northern California; and (2) differences in physiological responses to winter and summer temperature extremes between oak and juniper titmice near their respective range limits in northern California.

Despite the many unknowns regarding the juniper titmouse, there is a general, unified consensus regarding management for this species. In particular, best management practices should seek to preserve mature juniper and piñon pine stands, especially large snags, as these can provide key nesting and roosting sites (Idaho Conservation 2005). In addition, invasive, understory plant species should be controlled as juniper titmice have been found to prefer habitats with bare ground/rock cover and dead-limb density as well as old-growth juniper and piñon pine stands on south- to west- facing slopes (Pavlacky and Anderson 2001). It is thought that these habitats tend to support productive understories and high herbaceous ground cover; in addition, Pavlacky and Anderson (2001) argue that preserving the biologic integrity of the piñon-juniper woodlands community could be further supported by ensuring the presence of multiple stages of mature woodland throughout a given landscape. Other actions that also

may benefit the juniper titmouse include the installation of artificial nest boxes, removal of brown-headed cowbirds in areas where cowbird parasitism and/or cowbird populations are high, and regulation of species (specifically the European starling [*Sturnus vulgaris*] and house sparrow [*Passer domesticus*]) in habitats in which they compete with juniper titmice for nesting cavities (Idaho Conservation 2005). Next to habitat availability of mature piñon-juniper woods, it is thought that the availability of cavities for roosting also may be the next largest factor in regulating populations of juniper titmice due to thermal and energetic benefits (Cooper 1999; Cooper 2000; Cicero 2000).

A major benefit of protecting juniper titmice is that their roles as important seed dispersers (among many other avian species of the piñon-juniper woodlands) are preserved as well. As detailed by Gillihan (2006), birds are effective agents in seed dispersal since they often deposit seeds under woody vegetation (i.e. a suitable site for germination and seedling growth). In particular, bird-facilitated dispersal is important for reestablishing juniper stands that have been burned or killed by insects or drought. In the broader avian community of the piñon-juniper ecosystem, juniper titmice are not the only species that engage in caching behavior and seed dispersal. For example, pinyon jays (*Gymnorhinus cyanocephalus*) are characteristic birds of the piñon-juniper woodlands and have a strong, co-evolved relationship with pinyon pines (Rustay and Norris 2007). Due to the wingless structure of the pinyon pine seeds, these trees rely heavily upon the pinyon jay (and other caching species) for seed dispersal (Rustay and Norris 2007). As habitat becomes degraded, fragmented, or converted to other uses, species like the juniper titmouse and pinyon jays may decline as well as important ecosystem services, in particular seed dispersal, which in turn further negatively affects the long-term viability of the piñon-juniper woodlands.

Although much remains to be discovered about the juniper titmouse, there is no doubt that a changing climate and disappearing habitat will affect this species. Data and research about this may be sparse but juniper titmice populations are still robust and widespread. As such, management ought to

take a proactive stance and protect what habitat remains to ensure that this species will remain as common as it is now in the future.

APPENDIX



Figure 1. Distribution of the oak and juniper titmice.

Note: Cicero, C. 2000. Juniper Titmouse (*Baeolophus ridgwayi*). The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America. Retrieved February 2, 2014 from <http://ida.lib.uidaho.edu:2123/bna/species/485b>.

Table 1. Juniper titmouse *Baeolophus ridgwayi* North American Breeding Bird Survey trend results.

Region	1966-2011 trends			2001-2011 trends		R.A.
	N	Trend	(95% CI)	Trend	(95% CI)	
Great Basin	36	5.5	<i>(0.9, 9.8)</i>	11.7	<i>(1.7, 28.2)</i>	0.1
Southern Rockies/Colorado Plateau	95	0.1	(-1.4, 1.7)	0.7	(-2.1, 3.9)	1.1
Sierra Madre Occidental	21	-1.3	(-3.9, 1.5)	-1.4	(-6.6, 4.0)	1.8
Chihuahuan Desert	5	-2.4	(-7.0, 2.0)	-2.8	(-9.9, 2.6)	1.1
Arizona	32	0.1	(-2.2, 2.6)	0.7	(-3.3, 5.7)	1.6
California	18	6.4	<i>(2.3, 10.7)</i>	6.9	(-1.0, 18.4)	0.2
Colorado	35	-0.7	(-3.8, 2.4)	-0.6	(-4.9, 4.9)	0.4
Nevada*	8	10.9	<i>(4.2, 20.5)</i>	18.1	<i>(1.4, 48.6)</i>	0.1
New Mexico	33	-1.8	(-3.9, 0.1)	-1.6	(-4.7, 1.8)	1.7
Utah	40	1.9	(-1.2, 4.9)	1.4	(-4.1, 5.8)	0.5
Western BBS Region	168	0.0	(-1.4, 1.7)	1.9	(-0.9, 7.0)	0.8
United States	173	0.0	(-1.4, 1.7)	1.9	(-0.9, 7.0)	0.8
Survey-wide	173	0.0	(-1.4, 1.7)	1.9	(-0.9, 7.0)	0.8

Note: Numbers in italics are statistically significant (i.e. if the credible interval does not contain 0, the result could be judged significant). The star next to Nevada signifies that this regional abundance is less than 0.1 birds/route (very low abundance) and/or that the sample is based on less than 5 routes for the long term (very small samples); or the results are so imprecise that a 5%/year change (as indicated by the half-width of the credible intervals) would not be detected over the long-term (very imprecise); or users should be aware that a variety of circumstances may lead to imprecise results. For example, imprecise results are sometimes a consequence of a failure of the models to converge in those local areas, even though the model performs adequately in larger regions. Great Basin, Southern Rockies/Colorado Plateau, Sierra Madre Occidental, and Chihuahuan Desert are based off of North American Bird Conservation Initiative Terrestrial Bird Conservation Regions, which are shown in Figure 2.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2012. The North American Breeding Bird Survey, results and analysis 1966 - 2011. Version 07.03.2013. USGS Patuxent Wildlife Research Center, Laurel, MD.



Figure 2. North American Bird Conservation Initiative Terrestrial Bird Conservation Regions.

Note: They are based on the scale-flexible hierarchical framework of nested ecological units delineated by the Commission for Environmental Cooperation (CEC). These ecoregions encompass areas that are similar in their biotic (e.g., plant and wildlife) and abiotic (e.g., soils, drainage patterns, temperature, and annual precipitation) characteristics.

NABC I Bird Conservation Regions. n.d. Bird Studies Canada. Retrieved February 8, 2014 from <http://www.bsc-eoc.org/research/gislab/index.jsp?targetpg=bcr>.

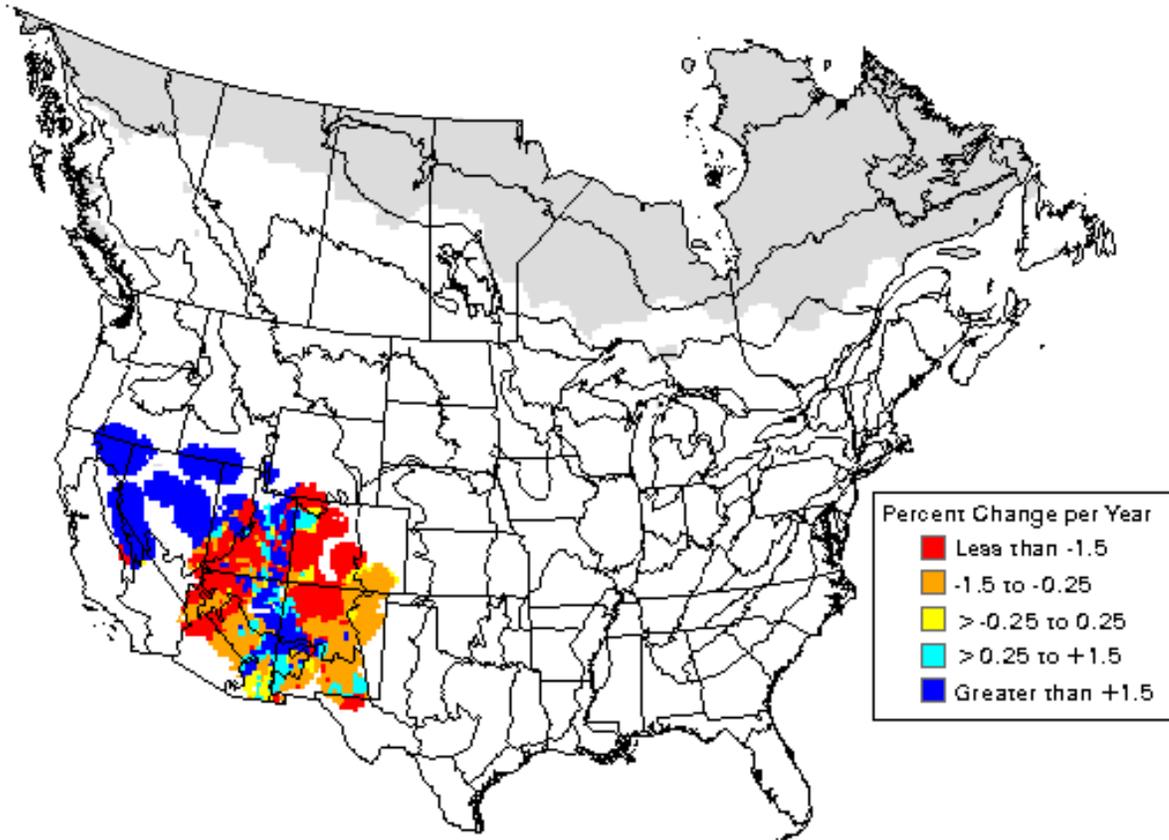


Figure 3. Juniper titmouse *Baeolophus ridgwayi* BBS trend map, 1966 – 2011.

Note: Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2012. The North American Breeding Bird Survey, results and analysis 1966 - 2011. Version 07.03.2013. USGS Patuxent Wildlife Research Center, Laurel, MD.

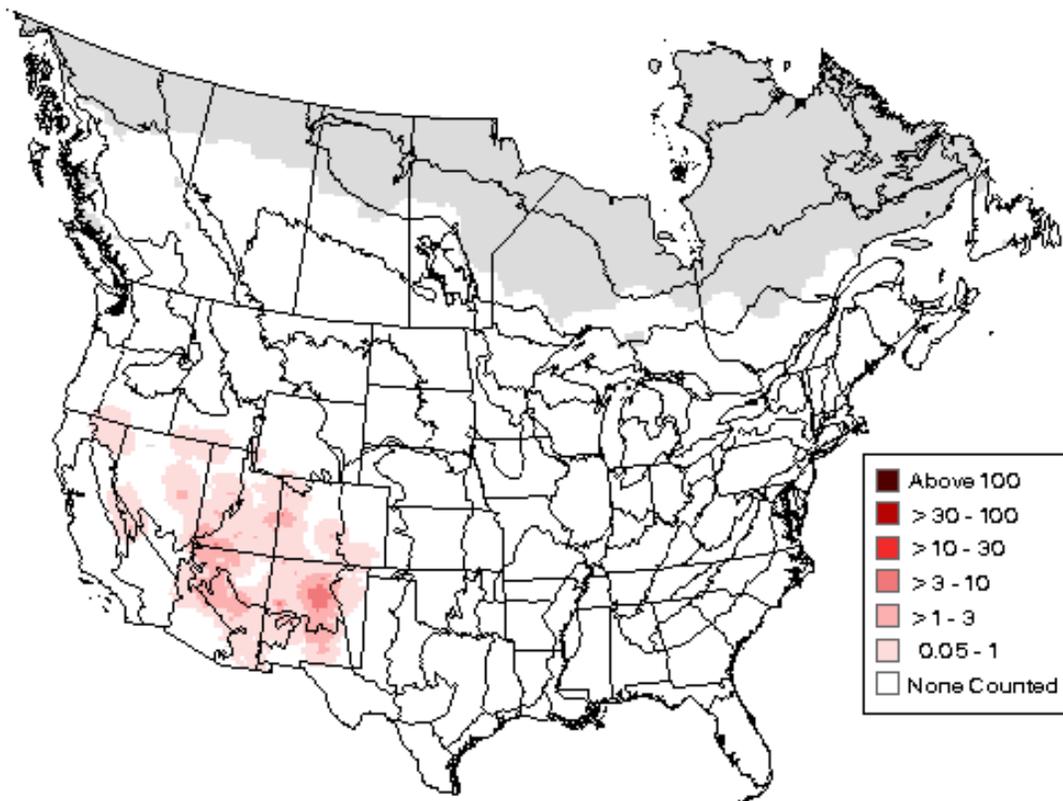


Figure 4. Juniper titmouse *Baeolophus ridgwayi* BBS summer distribution map, 2006 – 2011.

Note: Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2012. The North American Breeding Bird Survey, results and analysis 1966 - 2011. Version 07.03.2013. USGS Patuxent Wildlife Research Center, Laurel, MD.

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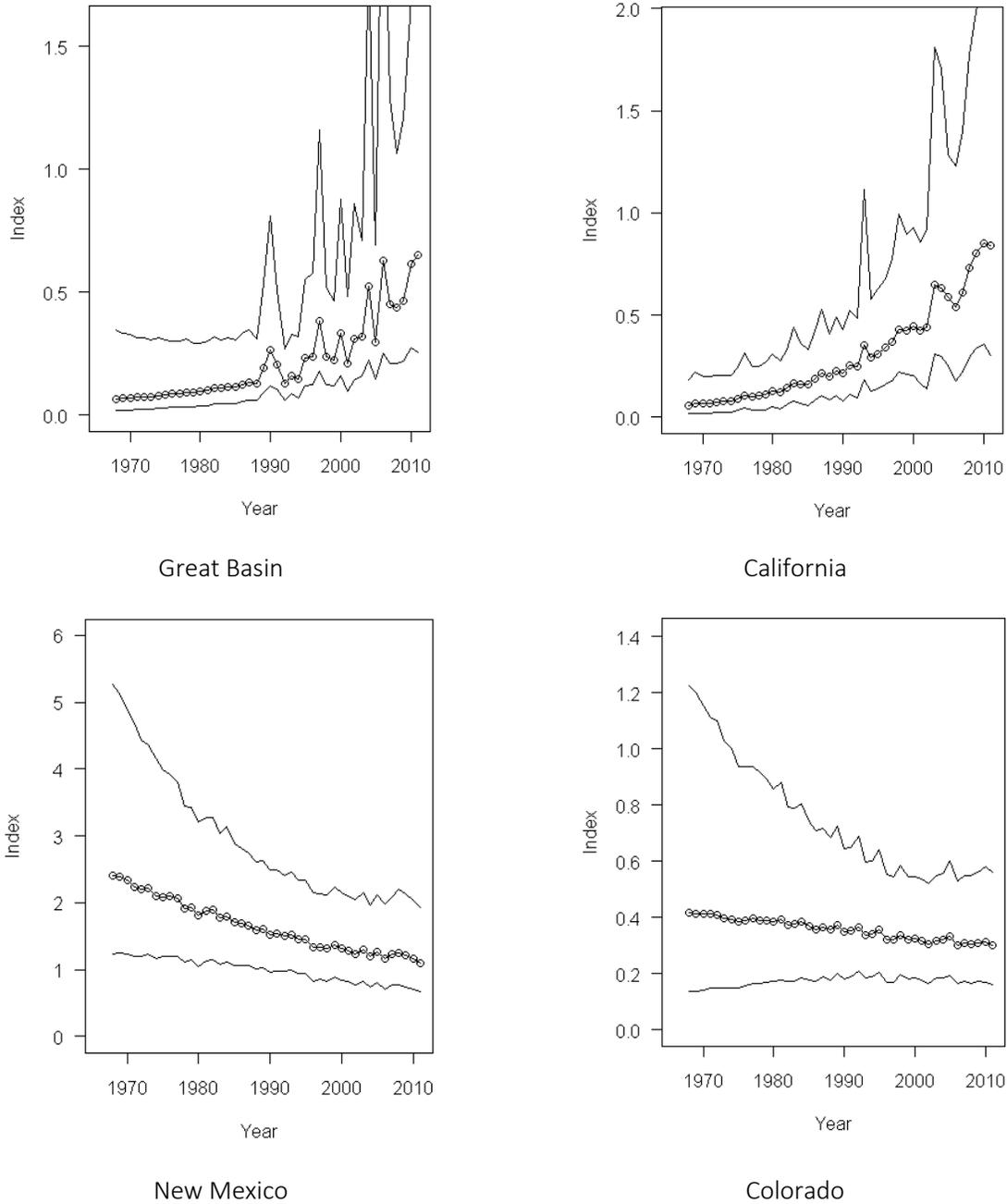


Figure 5. Juniper titmouse *Baeolophus ridgwayi* North American Breeding Bird Survey trend results.

Note: Great Basin region includes the Northern Basin and Range, Columbia Plateau, and the eastern slope of the Cascade Range. Populations are increasing significantly in the Great Basin region and California.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2012. The North American Breeding Bird Survey, results and analysis 1966 - 2011. Version 07.03.2013. USGS Patuxent Wildlife Research Center, Laurel, MD.

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