

STATUS OF POPULATIONS OF THE WHITE-TAILED PTARMIGAN AT THE SOUTHERN EDGE OF ITS RANGE

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ABSTRACT.—The White-tailed Ptarmigan (*Lagopus leucura*) is the only ptarmigan species endemic to North America. In New Mexico, the species was first reported from the Sangre de Cristo Mountains in 1865. At a latitude of slightly below 36° N, this location is the extreme southern extent of White-tailed Ptarmigan distribution. Over the next 125 years, the species was reported in New Mexico only occasionally, usually by sheep herders or backpackers. By 1981, it was generally thought that White-tailed Ptarmigan had become extirpated from the state, and a reintroduction was attempted. Regardless of whether the remaining White-tailed Ptarmigan in New Mexico are a result of this reintroduction effort or are indigenous to the state, this remnant population might now be imperiled due to changes in the alpine vegetation and advancing timber lines resulting from climate change. Recent survey efforts have shown that White-tailed Ptarmigan exist in at least two areas in New Mexico, albeit separated by a considerable distance. *Received 7 March 2011, accepted 6 June 2011.*

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HIGH ALTITUDE ECOSYSTEMS are sensitive to climate change and other anthropogenic disturbances such as livestock grazing (Pauli et al. 1996, Beniston 2003, Dirnböck et al. 2003, Walther et al. 2005). Advancement of timber-

line and changes in species composition of alpine vegetation attributed to climate change have already affected various alpine obligate animals in North America and Eurasia. For example, by the end of the twentieth century,

the American Pika (*Ochotona princeps*) had been extirpated from 28% of its range in western North America (Beever et al. 2003), and advancing timberlines have been associated with declines and increased isolation of populations of the Rock Ptarmigan (*Lagopus muta*) in France, Switzerland, and Japan (Revermann et al. 2007, Novoa et al. 2008, Bech et al. 2009, H. Nakamura, pers. comm.).

As a result of this burgeoning research on threats to high altitude ecosystems, both Wang et al. (2002) and Hoffman (2006) drew attention to possible deleterious effects of global climate change on the White-tailed Ptarmigan (*L. leucura*), the only ptarmigan species endemic to North America. As alpine habitat continues to be altered—and continues to shrink as timberlines creep upslope—some populations of the White-tailed Ptarmigan, particularly at the southern limits of the species' range, might be in jeopardy.

New Mexico hosts the southernmost population of the White-tailed Ptarmigan (Braun et al. 1993). Although this species was discovered in the region's high mountains in 1865 (Coues 1875), decades before New Mexico statehood, little is known of the species' distribution and abundance in the state. Indeed, after a lengthy period with no reported sightings, it was posited that the species was extirpated from New Mexico (Hubbard 1978), a supposition that led, in 1981, to the transplanting of 43 ptarmigan from Colorado into the Truchas Peaks area of the Sangre de Cristo Mountains. Yet Hoffman's (2006) statement that birds were released into "suitable habitat outside of natural range" is erroneous because the species was long known from the Sangre de Cristo Mountains (Coues 1875), including Truchas Peaks specifically (Bailey 1928). Additionally, sightings as late as 1974 in the vicinity of the releases as well as sightings from several other locales in New Mexico through at least 1979 belie the notion that the species was being introduced into the state in 1981.

Various misunderstandings and the general dearth of information aside, no formal survey of the species has previously been attempted in New Mexico. From 2006 through 2010, we surveyed for the White-tailed Ptarmigan in alpine areas of north-central New Mexico to fill gaps in our knowledge of the species' current distribution and abundance. In this paper we detail results of those surveys, compile historical records, and add a compendium of all recent sightings. We map sites of occurrence and highlight other alpine sites with suitable habitat to present as thorough as possible an assessment of the White-tailed Ptarmigan's status and distribution in New Mexico given the still limited information.

METHODS

Our paper mimics Martin et al.'s (2004) detailed review of the status and distribution of *L. l. saxatilis*, the White-tailed Ptarmigan subspecies endemic to Vancouver Island, British Columbia. In our case, Oldenettel (<http://sites.google.com/site/oldenettelspage/Home/yyyy>) summarized ptarmigan records for New Mexico for a number of years, during which he collected fortuitously from numerous contacts in New Mexico birding and research circles. To these data, we added records from our surveys in the summers of 2006–2010, as well as data from other sources (e.g., a search of the ORNIS on-line database, <http://ornisnet.org>). We began limited surveys in areas where presence of the species seemed likely or had been reported recently. From 2006 through 2010, we searched ~25 km² of alpine habitat in the Latir Peak, Pecos, and Wheeler Peak wilderness areas and ~2 km² of alpine habitat on nearby peaks. In addition to searching for birds, we also searched for and collected all ptarmigan feces and feathers. From 2006 through 2010, approximately 900 person hours were spent surveying. In 2010, we also deployed temperature/humidity data loggers. We placed these loggers in paired sets, with one on the surface, and a second nearby in a rift trench or crevice between boulders that we deemed may be a suitable

thermal refugium. We derived New Mexico White-tailed Ptarmigan density ranges based on Colorado ptarmigan surveys where estimates range from 2.0 to 13.5 birds/km² (Braun et al. 1993).

RESULTS

The White-tailed Ptarmigan was reported in New Mexico only sparingly before the 1970s (Figure 1), but early records include three extant specimens from 1904–1906 (USNM 193236, 194588, and 194589) and another from 1924 (MSB 891). The sharp uptick in records in recent decades most likely reflects an increase in observer awareness and reporting rather than an increase in the species' population size.

The species currently is known from two core areas in New Mexico (Figure 2), the first being along the Santa Barbara Divide in the Pecos Wilderness Area, the second in the Wheeler Peak Wilderness Area. Alpine portions of these wilderness areas are separated by ~50 km. Historical records include those from three additional areas of alpine habitat, all located north of the two aforementioned areas of alpine habitat.

Demographic data are almost non-existent, but there are several indications of successful reproduction. For example, a recently hatched nest was found in 1993 on Barbara Peak, ~5 km east of the 1981 release site (Wolfe 2006) and, in the same area, Oldenettel observed a brood in 1996, as well as a single chick with a pair of adults in 2005. In the Wheeler Peak Wilderness Area, ~50 km from the 1981 release site, broods were observed in 1979 and 2007 (Wolfe and Patten 2009). In 2010, we found nest remains on South Jicarita Peak, but we could not determine the nest's outcome because of the poor condition of remaining eggshell fragments.

Pecos Wilderness Area.—On the basis of US Geological Survey topographic maps and prior knowledge of the Pecos Wilderness Area, we

surveyed thoroughly at least 70%, and perhaps as much as 80%, of potentially suitable ptarmigan habitat in the wilderness area. The only locations where ptarmigan were observed were on the ridge between Jicarita and Trouble peaks. We found birds—as well as their feces and feathers—in the vicinity in all 5 years of our effort. In addition, Bosler (2007) photographed a cock and hen on Jicarita Ridge on 28 July 2007; one published photograph was of a bird with almost completely white plumage, certainly a different individual than any we had seen that year. We found feathers on Barbara Peak in 2007 and 2010 and feces on Trouble Peak in 2008, 2009, and 2010.

We surveyed ridges between Barbara Peak and Chimayosos Peak, but found neither ptarmigan nor their sign except for 2 fecal piles on an unnamed peak just east of Chimayosos Peak, but, in 2008, we discovered ptarmigan feathers on Chimayosos Peak. There had been no records for Chimayosos Peak since a 1992 sighting of 10 individuals (P. Hendricks, in litt.). We failed to find ptarmigan on the summit of North Truchas Peak and on the eastern slopes of the other Truchas peaks and, thus, we surmise that it is unlikely ptarmigan occupy any of the Truchas peaks. We conclude that the White-tailed Ptarmigan occupies the area from Barbara Peak (southwest) to Jicarita Peak (northeast), but occasionally ventures as far west as Chimayosos Peak. We estimate that 10–15 km² are occupied in the Pecos Wilderness Area with a population numbering between 50 and 100 individuals with a range of 20–203 based on Colorado densities (Braun et al. 1993).

Wheeler Peak Wilderness Area.—On the basis of USGS topographic maps and our familiarity of the area and of ptarmigan occupancy, we crudely estimate that the Wheeler Peak population could number fewer than 50. Approximately 3–6 km² is occupied range giving a population size range of 6–81 ptarmigan in the Wheeler Peak Wilderness Area. All birds detected in the Wheeler Peak Wilderness Area

Figure 1. Reporting history of White-tailed Ptarmigan (*Lagopus leucura*) in New Mexico.

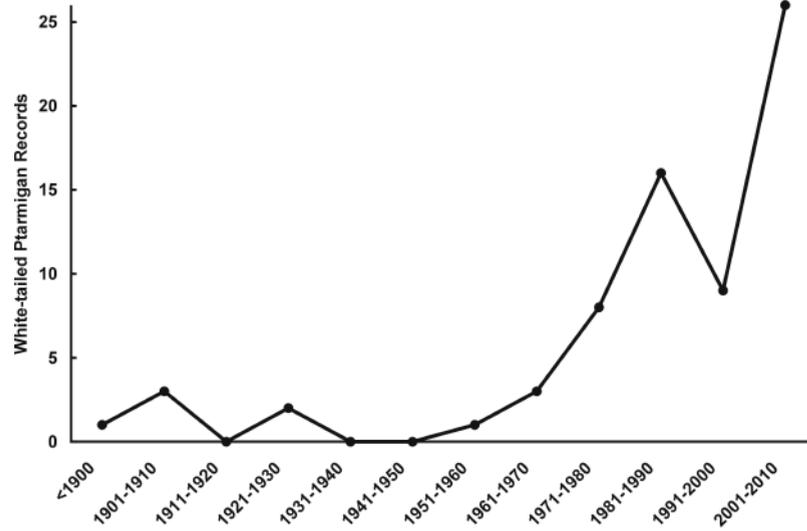
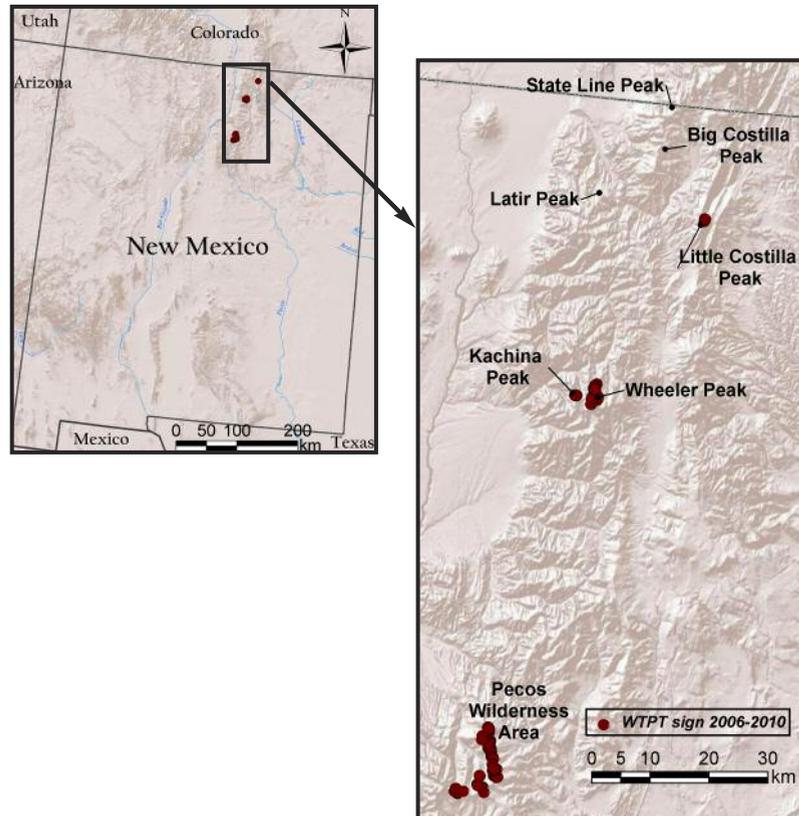


Figure 2. Distribution of White-tailed Ptarmigan sightings or sign in New Mexico, 2006–2010.



were at elevations between 3780 m (12,400 ft.) and 3860 m (12,660 ft.), although sign (feathers or feces) was found as high as 4000 m (13,100 ft.).

Despite suitable habitat surrounding trails to Wheeler Peak, we did not locate any ptarmigan nor find any of their feces or feathers in proximity to these trails. Several groups of hikers traverse these trails daily en route to Wheeler Peak, the highest peak in New Mexico. Hikers are not the sole disturbance on and near trails. Many hikers are accompanied by unleashed dogs that range 100–200 m from the trail, and some dogs doubtless range farther. During our 2008 survey, one dog befriended many hikers, including us, but did not seem to belong to anyone. These dogs could represent a constant threat of predation to ptarmigan and could result in ptarmigan avoiding suitable habitat <500 m from heavily traveled trails. Away from these trails, which receive heavy foot traffic, we posit that ptarmigan might be fairly abundant.

Additional alpine habitat adjacent to the Wheeler Peak Wilderness Area occurs on land that belongs to the sovereign nation of Pueblo de Taos and access is restricted. Other alpine habitat can be found north of Wheeler Peak Wilderness Area, including Frazer Mountain, Kachina Peak, and Gold Hill. We surveyed Frazer Mountain and Kachina Peak in 2010; we located ptarmigan on Kachina Peak, but found no sign on Frazer Mountain. We have received unsubstantiated reports of ptarmigan from Gold Hill, so future plans include extensive surveys of that area.

Latir Peaks Wilderness Area.—Historical White-tailed Ptarmigan records exist from the Latir Peaks Wilderness Area. In 2009, we surveyed approximately 30% of the alpine habitat in the area and found no sign of ptarmigan. There appears to be a paucity of large boulder fields and willow stands, both of which seem to correlate with ptarmigan presence. We conclude that, although the Latir Peaks Wilderness

Area might support a small ptarmigan population, it more likely is visited only periodically by dispersers.

DISCUSSION

Whereas ptarmigan are known currently from only the Pecos and Wheeler Peak wilderness areas, which are separated by ~50 km, there might yet remain remnant populations in other alpine areas. Aside from the areas that we have not yet surveyed, we estimate that the number of ptarmigan within the two wilderness areas ranges from 100 to 150 individuals. If the species occurs on areas we have yet to survey (see below), an estimated census of the White-tailed Ptarmigan for the whole of New Mexico might be closer to 200–300 individuals.

Historical White-tailed Ptarmigan records also exist from State Line Peak and Big Costilla Peak (Figure 2), although these locations support less suitable habitat than do the known occupied areas. In 2010, we received a report from a hiker of a ptarmigan sighting on Little Costilla Peak, and investigated that area in August 2010. As with the Latir Peaks Wilderness Area, there was a paucity of both boulder fields and willows. After several person-hours of searching, we did find a few old fecal piles, likely from the previous winter or older. We doubt that Little Costilla Peak supports a year-round population, but it might be a stopover site for dispersers. The Wheeler Peak Wilderness Area is the closest known occupied site to the unsurveyed areas. Latir Peaks Wilderness Area is ~25 km north of and Big Costilla Peak is ~30 km northeast of Wheeler Peak Wilderness Area. State Line Peak lies ~25 km northeast of Latir Peaks and ~15 km north of Big Costilla Peak. The distance of State Line Peak to the nearest suitable alpine habitat in Colorado is only ~5 km.

In Colorado, Giesen and Braun (1993) and Hoffman and Braun (1975) documented ptarmigan maximum dispersal distances of 29 km and 23 km, respectively, but these long-dis-

Figure 3. Distribution of White-tailed Ptarmigan sightings or sign by elevation in the Sangre de Cristo Mountains, New Mexico, 2007–2010.

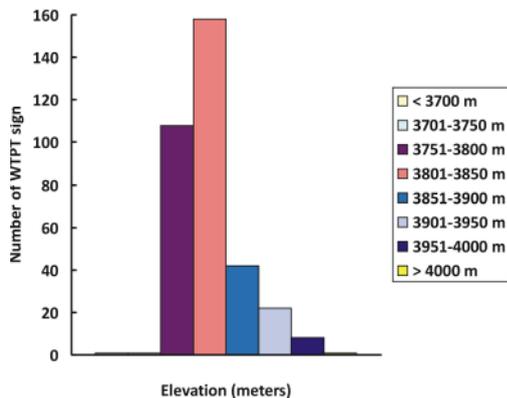


Figure 4. Average daily temperatures for the month of August, 2010 in the Pecos Wilderness Area, New Mexico.

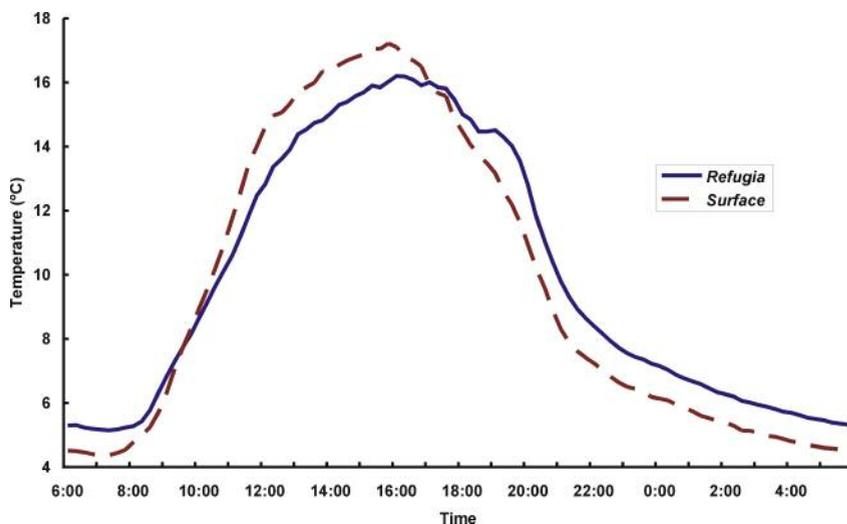
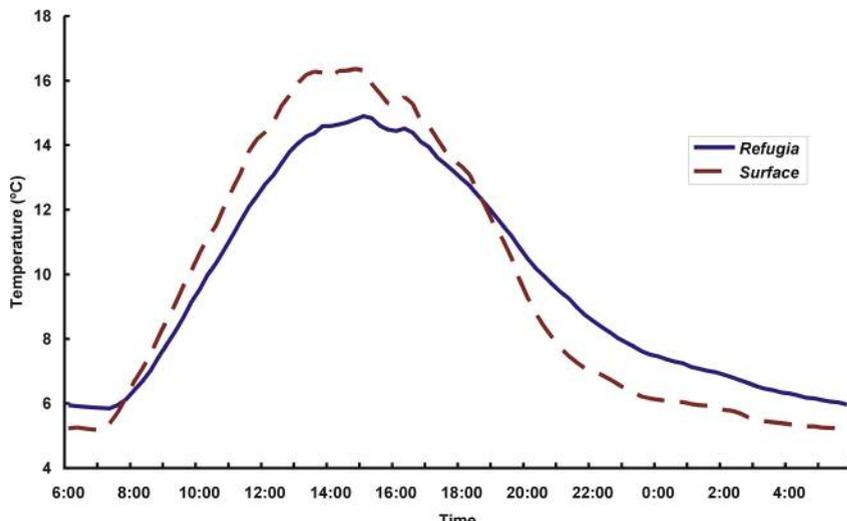


Figure 5. Average daily temperatures for the month of August, 2010 in the Wheeler Peak Wilderness Area, New Mexico.



tance dispersals were in areas where suitable alpine habitat occurred among larger populated areas, even if some were in the form of small, stepping-stone patches of alpine habitat. Because alpine habitat is generally lacking between the Pecos and Wheeler Peak wilderness areas, we surmise that there is likely to be little movement between them. Dispersal between Wheeler Peak Wilderness Area and alpine habitats farther north in New Mexico might be more plausible, although single movements 25 km or greater would be required among patches of suitable habitat.

The amount of intact high alpine habitat is likely the primary factor limiting White-tailed Ptarmigan distribution in New Mexico: >99% of ptarmigan sightings or sign were at elevations >3750 m (12,300 ft.), and 67% were >3800 m (12,470 ft.; Figure 3). Even within alpine above 3750 m, we surmise that the proximity of large boulder fields, rifts, and large willow stands (either on ridges or slightly downslope) are essential for ptarmigan persistence. Willows likely provide food, protection from predators, and thermal refugia. Indeed, the refugia temperatures were both lower during the day and warmer at night than were surface temperatures (Figures 4–5).

Much of the remaining "alpine" habitat within both the Pecos Wilderness Area and Wheeler Peak Wilderness Area seems to be transforming into lush grassy pasture with, at least in some locations, a paucity of sedges and forbs. We recommend further investigations on ptarmigan diet, microclimate, and vegetation composition on the alpine ridges to determine

if conditions are suitable to support a viable population of the White-tailed Ptarmigan. Moreover, populations in some areas with suitable habitat (e.g., Wheeler Peak Wilderness Area) might be limited by the presence of unleashed dogs that frequently accompany day hikers. If maintaining a viable ptarmigan population in this wilderness area is a priority, it might be necessary to enact and enforce a leash law.

We also recommend that genetic analyses be conducted—using material from molted feathers or blood from captured birds—to compare population structure and detect potential inbreeding depression in New Mexico relative to core populations in southern Colorado. Lastly, we recommend routine photographic points at different elevations to monitor advancing timberlines associated with global climate change. To this end, photo points we established in 2007 and 2008 should be repeated at least every five years and additional photo points established. As timberline creeps upslope, alpine habitat shrinks, and as alpine habitat shrinks, the ptarmigan population either will have to become denser (i.e., smaller home ranges) or will risk falling to levels below a threshold of viability.

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Appendix. Records sorted by date of White-tailed Ptarmigan (*Lagopus leucura*) sightings and collections in New Mexico.

Date	County; Location	Number	Data Source ^a
A. EARLY RECORDS (1860s–1949)			
? 1865	?	?	Coues (1875)
? 1892	Taos; Mora Pass	?	Bailey (1904)
24 Jan 1904	Taos; above Twining	“flock”	Bailey (1904); one specimen taken (USNM 193236)
24 Jul 1904	Taos; Wheeler Peak (?)	1	Bailey (1905); specimen (USNM 194589)
06 Aug 1904	Taos; Wheeler Peak (?)	1	Bailey (1905); specimen (USNM 194588)
Jul–Aug 1904	Taos	2	Bailey (1905)
20 Aug 1904	Taos; Costilla Peak	sign	Bailey (1905)
19 Jun 1924	Colfax; 20 mi NE of Taos; Wheeler Peak	1	specimen (MSB 891)
Nov 1926	Taos; Costilla Peak	2	J. S. Ligon *
B. RECENT RECORDS (1950–1999)			
Jul 1952	Taos; Costilla Peak; Ricardo Creek	5	J. Brewer *
Dec 1966	Santa Fe; Santa Fe Baldy	?	? *
Apr 1969	Taos; Latir Peak	3	D. Saylor *
Feb 1970	Taos; Costilla Peak	2	R. Welsh *
Nov 1974	Rio Arriba; Cumbres Pass	3	J. Lesparance *
Sep 1976	Taos; Wheeler Peak	5	J. Crellin *
Nov 1976	Santa Fe; Santa Fe Baldy	2	F. Stimson *
Jul 1977	Taos; Gold Hill	?	B. Morris *
Aug 1978	Taos; Latir Peak	2	J. Hubbard *
Aug 1979	Taos; Latir Peak	?	A. Renfro *
Aug 1979	Taos; Wheeler Peak	2+brood	A. Renfro *
Aug 1979	Taos; State Line Peak	2	R. Peterson *
May 1981	Rio Arriba/Mora; Pecos W. Area	22 (released)	J. Hubbard *
Aug 1981	Taos; North Fork Lake	1	W. Baltosser *
Sep 1981	Rio Arriba/Mora; Pecos W. Area	21 (released)	W. Baltosser *
Jun 1982	Taos; State Line Peak	1	E. Espanoza *
Aug 1982	Taos; El Vintrero	7	R. Peterson *
Sep 1983	Mora; Middle Fork Lake	20	D. De Lorenzo *
Sep 1983	Mora; Rincon Bonito	?	D. De Lorenzo *
Jul 1985	Rio Arriba; Truchas Peak	10	M. Frenzel *
Aug 1985	Mora; Rincon Bonito	5	A. Sandoval *
Aug 1985	Rio Arriba; Truchas Peak	10	A. Sandoval *
Aug 1985	Taos; Jicarita Peak	4	A. Sandoval *
Aug 1986	Santa Fe; Santa Fe Baldy	1	E. Johnson *
Oct 1986	Mora; Rincon Bonito	12	T. Stevenson *
Aug 1987	Mora; Pecos Baldy	1+4 chicks	C. MacCarter *
Aug 1990	Santa Fe; Santa Fe Baldy	4	C. Crawford *
1 Sep 1992	Rio Arriba/Mora; Chimayosos Peak	10	P. Hendricks in litt.
11 Aug 1993	Rio Arriba; Barbara Peak	nest	Wolfe (2006)
Aug 1996	Taos; Barbara Ridge	6+3 chicks	J. Oldenettel *
Sep 1998	Taos; Jicarita Peak	?	B. West *
Jul 1999	Mora; Pecos Baldy	1	E. Rominger *
Sep 1999	Taos; Wheeler Peak	6	E. Rominger *

– STATUS OF WHITE-TAILED PTARMIGAN –

Date	County; Location	Number	Data Source ^a
C. MODERN RECORDS (2000–PRESENT)			
May 2000	Taos; Kachina Peak	5	E. Rominger *
Jul 2000	Taos; Jicarita Peak	6	? *
Sep 2000	Taos; Mount Walter	3	L. Ahlm *
Jun 2002	Taos; Latir Peak	5	E. Rominger *
Aug 2002	Taos; Jicarita Peak	5	R. Gardner *
Aug 2002	Taos; Jicarita Peak	2	E. Rominger *
Aug 2002	Rio Arriba; Truchas Peak	1	E. Rominger *
17 Aug 2002	Santa Fe; Santa Fe Baldy	feather	J. Klingel*; specimen (MSB 23301)
Sep 2002	Taos; Wheeler Peak	11	E. Rominger *
Jul 2004	Taos; Jicarita Peak	1	C. Black *
Jul 2004	Taos; Jicarita Peak	3	J. Beason *
Aug 2004	Taos; Jicarita Peak	2	S. O. Williams *
Aug 2005	Taos; Barbara Ridge	2+chick	J. Parmeter *
Jun (?) 2006	Taos/Rio Arriba; Jicarita Peak/Ridge	4	C. E. Braun #
Jun (?) 2006	Rio Arriba/Mora; above Rio Santa Barbara	2	C. E. Braun #
19 Jul 2006	Rio Arriba; Trouble Peak; Jicarita Ridge	feathers	D. H. Wolfe, specimens (MSB 25518–25521)
19 Jul 2006	Rio Arriba; Jicarita Ridge	3	Wolfe (2006); photographs
11 Jul 2007	Rio Arriba; Jicarita Ridge	2	Wolfe and Patten (2009); photographs, feather specimens
12 Jul 2007	Rio Arriba, Barbara Peak	feathers	Wolfe and Patten (2009); specimens
28 Jul 2007	Taos; Santa Barbara Ridge	2	Bosler (2007); photographs
28 Aug 2007	Taos; Mount Walter	6+2 chicks	Wolfe and Patten (2009); photographs
23 Jul 2008	Taos; Horseshoe Lake	1	E. Rominger in litt.
5-6 Aug 2008	Rio Arriba/Mora; Chimayosos Peak	feathers	Wolfe and Patten (2009); specimens
8 Aug 2008	Rio Arriba; Jicarita Ridge	3	Wolfe and Patten (2009); photographs
10 Aug 2008	Taos; Mount Walter	3	Wolfe and Patten (2009); photographs
16 Aug 2008	Taos; Wheeler Peak	4–6	E. Rominger in litt.
25 Jun 2009	Taos; Jicarita Ridge	1	Wolfe and Patten (2010); photographs
26 Jun 2009	Taos; Jicarita Peak	3	Wolfe and Patten (2010); photographs
1 Aug 2009	Taos; Mount Walter	3	Wolfe and Patten (2010); photographs
22 May 2010	Taos; Jicarita Peak	2	Wolfe et al. (2010); photographs
23 May 2010	Taos; Jicarita Peak	1	Wolfe et al. (2010); photographs
Jul 2010	Taos/Colfax; Little Costilla Peak	4	Hassell (Pers. Comm.)
Jul 2010	Taos; Gold Hill	?	Malixi (Pers. Comm.)
7 Jul 2010	Taos; Mount Walter	1	Wolfe et al. (2010)
8-10 Jul 2010	Taos; Wheeler Peak	feathers	Wolfe et al. (2010); specimens
19 Aug 2010	Taos; Kachina Peak	1	Wolfe et al. (2010); photographs
15 Sep 2010	Taos; Mount Walter	3	Wolfe et al. (2010); photographs
17 Sep 2010	Taos; Jicarita Peak	nest	Wolfe et al. (2010); specimens
19 Sep 2010	Taos; ridge north from Jicarita Peak	feathers	Wolfe et al. (2010); specimens

^a Museum abbreviations: MSB = Museum of Southwestern Biology, University of New Mexico, Albuquerque; USNM = National Museum of Natural History, Smithsonian Institution, Washington, DC.

* Records compiled by J. R. Oldenettel (<http://sites.google.com/site/oldenettelspage/Home/yyyy>), data from several sources, primarily the New Mexico Ornithological Society Field Notes. Some location names are likely the nearest known landmark. It is also likely that several location name discrepancies exist, and also possible that some records are of misidentified birds.

USDA Forest Service. 2007. Management indicator species assessment – Carson National Forest. USDA Forest Service – Southwestern Region. Unpublished report. http://www.fs.fed.us/r3/carson/plans/mis%20assessment/2007_mis_assessment.shtml

LITERATURE CITED

- BAILEY, F. M. 1904. Additional notes on the birds of the Upper Pecos. *Auk* 21:349–363.
- BAILEY, F. M. 1905. Notes from northern New Mexico. *Auk* 22:316–318.
- BAILEY, F. M. 1928. *The Birds of New Mexico*. New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA.
- BECH, N., J. BOISSIER, S. DROVETSKI, AND C. NOVOA. 2009. Population genetic structure of Rock Ptarmigan in the "sky islands" of French Pyrenees: Implications for conservation. *Animal Conservation* 12:138–146.
- BEEVER, E. A., P. F. BRUSSARD, AND J. BERGER. 2003. Patterns of apparent extirpation among isolated populations of Pikas (*Ochotona princeps*) in the Great Basin. *Journal of Mammalogy* 84:37–54.
- BENISTON, M. 2003. Climatic change in mountain regions: A review of possible impacts. *Climatic Change* 59:5–31.
- BOSLER, D. 2007. The ptarmigan trek. [Louisiana State University Museum of Natural Science] *Museum Quarterly* 25(3):12–13.
- BRAUN, C. E., K. MARTIN, AND L. A. ROBB. 1993. White-tailed Ptarmigan (*Lagopus leucurus*). In A. Poole and F. Gill (Eds.). *The Birds of North America*, no. 68. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.
- COUES, E. 1875. On the breeding-habits, nest, and eggs, of the White-tailed Ptarmigan (*Lagopus leucurus*). *Bulletin of the United States Geological and Geographical Survey of the Territories* (2nd series) 5:263–266.
- DIRNBÖCK, T., S. DULLINGER, AND G. GRABHERR. 2003. A regional impact assessment of climate and land-use change on alpine vegetation. *Journal of Biogeography* 30:401–417.
- GIESEN, K. M., AND C. E. BRAUN. 1993. Natal dispersal and recruitment of juvenile White-tailed Ptarmigan in Colorado. *Journal of Wildlife Management* 57:72–77.
- HOFFMAN, R. W. 2006. White-tailed Ptarmigan (*Lagopus leucura*): A technical conservation assessment. USDA Forest Service, Rocky Mountain Region.
- HOFFMAN, R. W., AND C. E. BRAUN. 1975. Migration of a wintering population of White-tailed Ptarmigan in Colorado. *Journal of Wildlife Management* 39:485–490.
- HUBBARD, J. P. 1978. Revised check-list of the birds of New Mexico. New Mexico Ornithological Society Publication 6.
- MARTIN, K., G. A. BROWN, AND J. R. YOUNG. 2004. The historic and current distribution of the Vancouver Island White-tailed Ptarmigan (*Lagopus leucurus saxatilis*). *Journal of Field Ornithology* 75:239–256.
- NOVOA, C., A. BESNARD, J. F. BRENOT, AND L. N. ELLISON. 2008. Effect of weather on the reproductive rate of Rock Ptarmigan *Lagopus muta* in the eastern Pyrenees. *Ibis* 150:270–278.
- PAULI, H., M. GOTTFRIED, AND G. GRABHERR. 1996. Effects of climate change on mountain ecosystems—upward shifting of mountain plants. *World Resources Review* 8:382–390.
- REVERMANN, R., N. ZBINDEN, H. SCHMID, AND B. SCHROEDER. 2007. Habitatmodelle für das Alpenschneehuhn *Lagopus muta helvetica* in den Schweizer Alpen—Skaleneffekte und mögliche Auswirkungen des Klimawandels. *Vogelwarte* 45:276–277.
- WALTHER, G.-R., S. BEIßNER, AND C. A. BURGA. 2005. Trends in the upward shift of alpine plants. *Journal of Vegetation Science* 16:541–548.
- WANG, G., N. T. HOBBS, K. M. GIESEN, H. GALBRAITH, D. S. OJIMA, AND C. E. BRAUN. 2002. Relationships between climate and population dynamics of White-tailed Ptarmigan *Lagopus leucurus* in Rocky Mountain National Park, Colorado, USA. *Climate Research* 23:81–87.
- WOLFE, D. H. 2006. Nesting documentation for the White-tailed Ptarmigan in the Sangre de Cristo Mountains, New Mexico. *Publications of the Oklahoma Biological Survey* 7:21–23.
- WOLFE, D. H., AND M. A. PATTEN. 2009. 2008 Surveys for White-tailed Ptarmigan in the

Sangre de Cristo Mountains, New Mexico. Unpublished report submitted to Oklahoma Biological Survey and New Mexico Department of Game and Fish. Sutton Avian Research Center, Bartlesville, Oklahoma, USA.

WOLFE, D. H., AND M. A. PATTEN. 2010. 2009 Surveys for White-tailed Ptarmigan in the Sangre de Cristo Mountains, New Mexico. Unpublished report submitted to Oklahoma Biological Survey and New Mexico Department of Game and Fish. Sutton Avian Research Center, Bartlesville, Oklahoma, USA.

WOLFE, D. H., M. A. PATTEN, AND L. C. LARSON. 2010. Status, distribution, and ecology of White-tailed Ptarmigan (*Lagopus leucura*) in the Sangre de Cristo Mountains, New Mexico. Final Report. Submitted to New Mexico Department of Game and Fish. Contract Number 10-516-0000-00018. Sutton Avian Research Center, Bartlesville, Oklahoma, USA.