

Pinyon Jays and Pinyon Pines at North Oscura Peak, White Sands Missile Range, New Mexico

2007 Annual Report



Kristine Johnson and Jacqueline Smith
Natural Heritage New Mexico Publication No. 08-GTR-328
29 February 2008

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED. OPSEC REVIEW
CONDUCTED ON 14 MARCH 2008

Table of Contents

Introduction.....	3
Methods.....	3
Tree Data.....	3
Capturing and Banding	4
Radio Telemetry.....	6
Pinyon Jay Nesting	8
Results and Discussion	8
NOP Pinyon Jay Population	8
Pinyon Jay Reproduction	8
Breeding Activity.....	8
Nests.....	9
Fledglings.....	9
Radio Telemetry.....	10
Trees.....	10
Vigor	10
Cone Production.....	11
Correlations among Vigor, Cone Production, and Years	14
Conclusions.....	15
Literature Cited.....	17

List of Figures

Figure 1. Solar-powered pinyon seed feeder.	5
Figure 2. Modified Australian crow trap.	5
Figure 3. Pinyon jay in hand, showing antenna from radio transmitter.....	6
Figure 4. Nests, fledglings, and observation points, 2007.....	7
Figure 5. Size of NOP pinyon jay flock, 2004-2007.	9

List of Tables

Table 1. Nest success 2007.	10
Table 2. ANOVA comparing vigor per tree on all transects combined.....	11
Table 3. ANOVAs comparing vigor among years, on each transect.....	12
Table 4. Relative vigor rankings of the transects over four years.	12
Table 5. ANOVA comparing number of cones per tree on all transects over four years.	12
Table 6. ANOVAs of cone number by transect among years.....	13
Table 7. ANOVAs comparing cone number by transect for each of four years.....	13
Table 8. Relative rankings among transects on cone number over four years.	14
Table 9. Correlations between years on average cone number per point	14
Table 10. Correlations between cone number and vigor by year	15

Introduction

After three-and-a-half years of studying the pinyon-juniper woodland and pinyon jays at North Oscura Peak (NOP) on White Sands Missile Range, the dominant impression is that of change. Vigor ranks of the pinyon trees change between years, cone crops vary from year to year, and trees die. Pinyon jays are present some times of the year and absent others; we do not know where they go when they leave. Nesting varies temporally and spatially; nesting effort and success are inconstant.

And yet, some changes are at least sometimes predictable. The pinyon jays have returned to the top of NOP in the spring for four years running. They bred in 2005, 2006, and 2007. In 2004 we arrived too late to observe breeding activity but suspect that they bred that year as well. The flock has left NOP during the winter for four years, and we have no evidence that they remain in their breeding home range. Where they go and how they survive the winter is a mystery. Although we have not observed a large mast crop, at least some trees have produced seeds in the fall of all four years. For three of the four fall seasons, enough pinyon cones were produced that the NOP flock stayed to harvest and cache seeds. In the spring of 2007, following the best pinyon seed crop of the four years, we predicted that the jays would return early to breed in the spring, relying on seeds cached in the fall of 2006. Our prediction was borne out. We observed the most successful nesting season of the study and documented 64% maximum nesting success for the colony.

We see a classic keystone mutualism in operation at NOP. The trees provide the birds with seeds, albeit so far not enough for them to survive an entire winter at NOP; on occasion enough seeds are produced to assist breeding the following spring. The birds perform without fail their duty for the trees. Nearly every pinyon seed is cached or eaten before the flock departs for the winter.

Aside from documenting the functional relationship between the trees and the jays, our interest is in the health and viability of the system that rests upon this mutualism. Is the stand structure of the woods productive enough to sustain its long-distance seed disperser? Are the jays numerous and reliably-present enough to provide adequate ecosystem services for the woodland? If not, what are the signs of failure on the part of either? And finally, can management of the woodlands improve upon the natural dynamics? Answers to these basic questions may not be attainable any time soon. Our aim in continuing this study is to begin to answer these questions and provide a foundation of knowledge to inform management decisions.

Methods

Tree Data

We collected vegetation data on 15, 16, 21, and 24 September 2007 on six existing transects (Johnson and Smith 2007). Transects contained 11 (one transect), 12 (four transects) or 13 (one transect) points each. Using the point-centered quarter method, we

collected data from the nearest tree over 1 m tall, in each quarter at each point on each transect, 288 trees in all. Points were approximately 50 m apart and situated at the same GPS coordinates used for each point in 2004, 2005, and 2006. Due to GPS inaccuracy, some points were not exactly at the same spot as in previous years, but we recognized many as being in the same place. Tree selection likewise varied among years. In 2006 and 2007, we flagged the northernmost tree at each point, to facilitate collecting data on the same trees in subsequent years.

For each tree, we recorded any symptoms of disease (needle loss or discoloration, needle scale, popcorn sap, etc.). Vigor was assigned a ranking from 1-5 (1-dead/defoliated, 2-majority of needles lost or brown, 3- half or more of needles present and green, 4- a few needles brown or lost, 5- vigorous). Standing approximately 5m from the uphill side of the tree, we counted the number of cones within a binocular field, using the same binoculars for all counts. Counts were made for three fields in each tree, from areas of the tree containing the most cones. We averaged the three field counts for each tree to produce an index of cone production. We performed statistical analyses using Minitab 13 (Minitab, Inc. 1999) and plotted transect and pinyon jay locations using ArcGIS (ESRI 2008).

Capturing and Banding

In 2007 we purchased a solar-powered, battery-operated automatic feeder (Sweeney Enterprises, Boerne, TX). The feeder holds about five pounds of pinyon seeds and delivers a pre-set volume of pinyon seeds as programmed, obviating the need to fill feeders several times each week. We modified the seed tray on the feeder to create a larger platform the jays could perch on. We set up the feeder (Figure 1) on 10 April 2007, along the road between the barracks and the top of NOP. We set the feeder to deliver about two cups of seeds twice a day, early morning and late afternoon. We stopped filling the feeder after we finished trapping in June.

On 25 May and 21, 22, 27, and 28 June we captured jays in a modified Australian crow trap (Figure 2) set near the feeder and baited with pinyon seed. We removed birds from the trap, placed them in closed cardboard boxes, and took them to a truck parked near the trap for processing. We took the following data on each bird: age, sex, weight, tarsus, wing, and culmen. Each bird was banded with a US Fish and Wildlife Service numbered aluminum band and a unique combination of one to three color bands. Although it is not possible to unequivocally determine the sex of HY (hatch-year) pinyon jays (Pyle 1997), for our information we attempted to assign sex using a combination of weight, tarsus, and culmen, as we have done for adult and SY (second-year) pinyon jays. (Because they were not definite, sexes of HY birds were not reported to the Bird Banding Lab.) Birds were released within sight of the trap after processing.



Figure 1. Solar-powered pinyon seed feeder.



Figure 2. Modified Australian crow trap.



Figure 3. Pinyon jay in hand, showing antenna from radio transmitter.

We visited the study site at least weekly until 13 July, noting flock size and location. We visited the site again in August to look for the flock and on four days in September to collect tree data. We stopped visiting the study site for the winter after we were unable to find jays at NOP on our last two tree data visits,

Radio Telemetry

We affixed radio transmitters to two birds, one hatch-year bird and one second-year bird. We used 2.5 g, glue-on transmitters from Advanced Telemetry Systems. We attached transmitters using figure-eight harnesses made of 0.5 mm and 0.8 mm elastic beading cord and super glued to the transmitter (Mennill 2000, Rappole and Tipton 1991).

Transmitters sat on top of the synsacrum, with the antenna extending past the end of the tail (Figure 3). All banded birds flew away when released, although the two birds with radios flew shorter distances and stayed near the release site for several hours.

We tracked birds with a TRX-1000 receiver from Wildlife Materials International, Inc. We attempted to locate the two birds with radios each time we visited the study site from the time we banded them until transmitter batteries failed in early July. Each time we radio tracked birds, we recorded their locations and noted behavior of the radioed bird and any other pinyon jays in the vicinity.

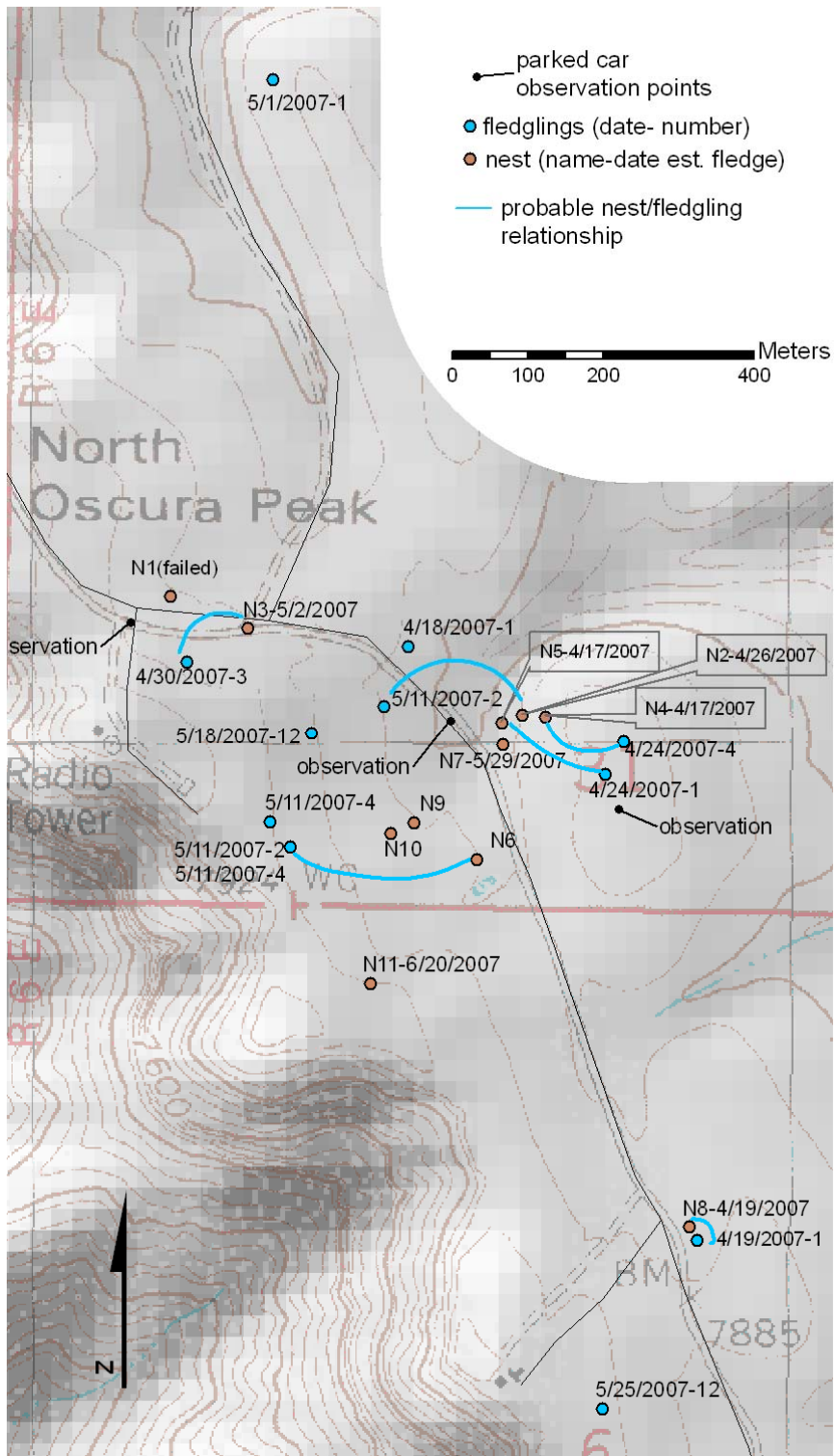


Figure 4. Nests, fledglings, and observation points, 2007.

Pinyon Jay Nesting

We visited the study site for 1-3 days each week during the nesting season to monitor nesting, find nests, and monitor fledglings. We used vehicles as blinds and observed the majority of the nesting area from one of three vantage points (Figure 4). We noted spots where males flew in and out to feed incubating females. When we were certain of an active nest, we noted landmarks and walked into the area to search for the nest. We collected GPS coordinates (NAD 27) at each nest, and on each subsequent visit we checked each nest for activity. In some cases we placed a flag at a known distance and direction from the nest to assist us in re-locating it. We approached fledgling groups we heard, took GPS points, counted the number of fledglings in the group, and noted stage of development, especially of flight. We spent approximately 75 h observing the colony site and searching for nests on 13 days between 12 March and 1 May. After 1 May, we spent most of our time checking known nests and finding fledglings.

Although we visited the study site every week during the breeding season, we were not able to be present every day. We therefore assigned most fledgling groups to probable nests based on expected fledging date, last date the nest was active, location of fledglings relative to nests, and developmental age of nestlings. A few fledgling groups could not be logically matched to known nests using this method. In those cases we assumed the fledglings came from undetected nests in the area where the fledglings were first found.

Results and Discussion

NOP Pinyon Jay Population

For the first three years of the study, we observed few or no birds in the winter months. The flocks left the study site in September 2004 and October 2005 and 2006, following a period of pinyon seed harvest in which flock size swelled to at least 100 birds. In 2007, the poorest seed year of the study, we did not observe a large flock harvesting seeds in August and September, as in previous years. The birds left the area gradually as their fledglings matured. We observed a flock of only 25 birds on 16 September and found no birds on two subsequent visits later in September (Figure 5).

Pinyon Jay Reproduction

Breeding Activity

We first detected the pinyon jay flock at NOP on 8 February 2007, when we counted 52 birds. On 26 February we observed 50 jays at NOP. On 12 March birds were showing breeding behavior: making rattle calls, carrying nesting material, and flying into and out of probable nests, apparently males feeding incubating females. Nesting activity continued from 12 March until 6 June, the last date we observed an active nest.

Nests

In 2007, the jays nested in the same general area as in 2005, along the road at the top of NOP. We found 11 nests in 2007 (Figure 4). We are uncertain about the fates of several nests, because we found them after they had failed or fledged. We inferred the presence of three additional nests based on fledgling locations and timing, for a total of 14 nests (11 known and 3 inferred). Given the difficulty of finding pinyon jay nests and our inability to be present every day, we suspect that we missed a few additional nests and that 14 can be considered the minimum number of nests constructed in 2007 (Table 1). Of these 14 nests, we believe that nine were successful, a 64% success rate.

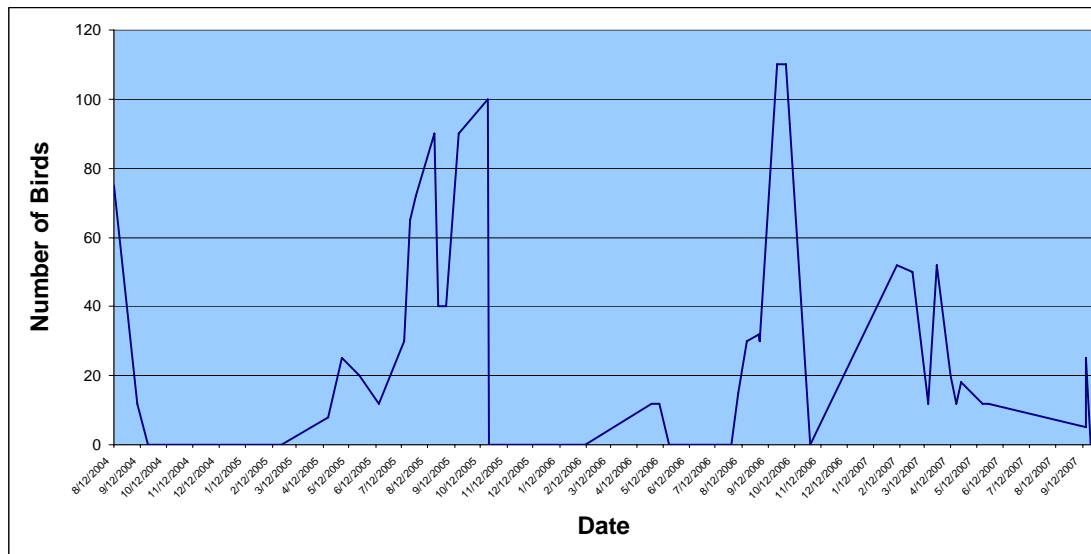


Figure 5. Size of NOP pinyon jay flock, 2004-2007.

Any additional nests we missed were likely to have failed, because fledglings are quite conspicuous, and we would probably have inferred undetected successful nests based on their fledglings. If this assumption is correct, the actual success rate was likely somewhat lower than 64%, owing to undetected nests that failed and therefore were not included in the calculation.

Fledglings

We found ten apparent broods of fledglings, ranging in number from 1-4 fledglings (mean=2.3), and totaling 23 juveniles. This number is consistent with the 16 fledglings (hatch-year birds) we banded, assuming we did not capture all fledglings. All broods were found on or before 11 May. On 18 May and 25 May we found a flock of 12 fledglings, suggesting that some of the earlier-hatched broods had begun to crèche (form flocks of juveniles) by mid- to late-May (Figure 4).

Nest ID	Date Found	Expected Fledge Date	Success?	Number Fledglings
1	4/2/07	5/2/07	F	0
2	4/11/07	4/26/07	S	2?
3	4/11/07	5/2/07	S	3
4	4/11/07	4/17/07	S	4
5	4/11/07	4/17/07	S	1
6	4/19/08	*	S	4?
7	4/19/08	5/29/07	F	0
8	4/19/07	*	S	1
9	4/24/08	6/7/07	F	0
10	4/24/07	*	F	0
11	5/11/07	6/20/07	F	0
None	NA	*	S	1
None	NA	*	S	2
None	NA	*	S	4

Table 1. Success of known/inferred nests in 2007. Unnumbered nests are inferred from fledgling broods.

Radio Telemetry

Both birds with radios flew well on release and were located later the day they were banded (25 May). We detected both in the colony area on 6, 14, 22, 27, 28 June and 3 July. One of the birds with a transmitter appeared to move around less than the other, and once we observed him on the ground with his feathers erected, apparently sunning. He flew when we approached, and we observed him moving on three other dates. Therefore, it is unclear whether his movements were somehow limited by the transmitter or if he was tied to the area by a nesting mate or brood. Both birds were alive and moving the last time we detected them on 3 July; on 13 July and later we were unable to detect either bird. The transmitter batteries appear to last about six weeks.

Trees

Vigor

An ANOVA comparing the vigor per tree on all transects across four years showed significant differences among years ($F=53.5$, $P<0.001$, Table 2). Multiple comparisons showed that 2004 had significantly higher vigor than all other years. Vigor was also significantly higher in 2005 than in 2006 and 2007, which did not differ from each other. We attempted to reduce subjectivity by having the same person rank vigor each year

Source	DF	SS	MS	F	P
Factor	3	106.53	35.51	53.52	<0.001
Error	1132	751.09	0.66		
Total	1135	857.62			

Table 2. ANOVA comparing vigor per tree on all transects combined, across four years.

and by reviewing our vigor definitions several times while ranking vigor. However, vigor ranks are nevertheless subjective and could vary systematically from year to year. Per point vigor scores were highly correlated among years. This pattern could still occur if we consistently ranked trees relative to each other within a year but changed our ranking between years. On our ranking scale, a “1” signifies a dead tree. The rank of 1 is therefore much less subjective than other ranks - the tree appears dead. Comparisons among years show 8 dead trees in 2004, 9 in 2005, 13 in 2006, and 10 in 2007. For 2004-2006, the pattern is consistent with decreased vigor scores we observed and provides some confidence in the consistency of our vigor ranks. The lower number of dead trees in 2007 than in 2006 is an exception to this pattern. However, several dead trees had fallen between the two years, we only scored standing trees, and some trees that appeared dead in 2006 could have sprouted needles in 2007 after a wet winter. Thus, the number of standing dead trees could have been reduced between 2006 and 2007.

We performed another ANOVA to compare vigor among years on each transect (Table 3). On all except transect 9, trees had significantly higher vigor scores in 2004 than in other years and significantly lower vigor scores in 2007. On transects 5, 7, and 8, 2005 vigor (2006 vigor on transect 7) was also significantly higher than in 2007 (and 2006 on transect 8). Vigor on transect 7 in 2006 was also higher than in 2007. This analysis is generally consistent with the overall ANOVA but indicates that vigor scores on transect 9 did not vary among years in concert with the other transects.

Comparisons of transects within years showed that transects 0 and 2 were ranked significantly higher than other transects in all four years. Transects 5 and 7 were ranked intermediate over the four years, and transects 8 and 9 were ranked lowest or intermediate, making them the least vigorous transects over the four years (Table 4).

Cone Production

An ANOVA comparing the number of cones per tree on all transects across four years showed significant differences among years ($F=21.9$, $P<0.001$, Table 5). Multiple comparisons showed cone number to be significantly higher in 2006 than in 2004, 2005, and 2007. Cone number in 2004 and 2005 did not differ, but in 2005 trees produced significantly more cones than in 2007.

Transect	F	P	Comparisons Among Years
0	10.72	<0.001	04>05, 06, 07
2	22.98	<0.001	04>05, 06, 07
5	9.22	<0.001	04>06, 07; 05>07
7	21.12	<0.001	04>05; 06>07
8	6.47	<0.001	04, 05>06, 07
9	0.49	0.61	05=06=07

Table 3. ANOVAs comparing vigor among years, on each transect.

No. Years Ranked	Transect					
	0	2	5	7	8	9
<i>Best</i>	4	4				
<i>Moderate</i>			4	4	1	1
<i>Worst</i>					3	3

Table 4. Relative vigor rankings of the transects over four years.

Source	DF	SS	MS	F	P
Factor	3	1445.7	481.9	21.9	<0.001
Error	1132	24910.4	22		
Total	1135	26356.1			

Table 5. ANOVA comparing number of cones per tree on all transects over four years.

Transect	F	P	Among Years
0	2.79	0.42	06>07
2	2.36	0.073	04=05=06=07
5	4.75	0.003	06>05, 07; 04=05=07
7	10.9	<0.001	06>04=05=07
8	6.69	<0.001	06>04, 07
9	15.64	<0.001	06>05, 07

Table 6. ANOVAs of cone number by transect among years.

Breaking the cone data down by transect reveals that trees on all transects except transect 2 produced more cones in 2006 than in at least one other year (Table 6). Transect 2 showed no significant differences in cone number among years. A comparison of transects for each of the four years indicates that transects 0 and 2 produced the most cones over the three years in which transects differed significantly in cone production (Table 7). Transects 5 and 8 produced intermediate numbers of cones over the three years, and transects 7 and 9 produced the fewest, making them the poorest producers over the three years (Table 8). The cone results were consistent with vigor results, except that the ranks of transects 7 and 8 are reversed (Table 4). Thus, for the most part, healthier trees produced more cones over the four-year period.

Year	F	P	Among Transects
2004	3.97	0.004	0>7,8
2005	4.78	<0.001	2>0,5,7,8, 9; 8>9
2006	1.03	0.4	0=2=5=7=8=9
2007	2.4	0.037	8>5,7

Table 7. ANOVAs comparing cone number by transect for each of four years.

No. Years Ranked	Transect					
	0	2	5	7	8	9
<i>Best</i>	1	1			1	
<i>Moderate</i>	2	2	2	1	1	1
<i>Worst</i>			1	2	1	1

Table 8. Relative rankings among transects on cone number over four years.

We measured root crown diameter and computed tree density in 2004 on each transect except transect 9, which was done in 2005. Transects 0 and 2, the highest cone producers over the four years, had significantly lower tree density than transects 7, 8, and 9, indicating that more densely packed trees consistently produce fewer cones. We previously found tree density to be the single most important variable determining cone production, with tree maturity providing additional influence (Johnson and Smith 2006). The four-year results further support the finding that tree density strongly influences cone production through competition among trees.

Correlations among Vigor, Cone Production, and Years

We added transect 9 after 2004, so we performed two correlations between cones and vigor per point over the years, one leaving out transect 9 but including all four years and one including transect 9 but leaving out 2004. Both analyses showed vigor measurements among years at each transect point to be highly correlated ($P < 0.001$ for all possible comparisons). This result suggests that tree vigor in an area remained high or low relative to other areas over the four years.

Average cone number per point, however, was not significantly correlated between 2004-2005 or 2005-2006 but was correlated between 2004-2006 and between 2007 and all other years (Table 9). Three of four significant correlations among years were between non-consecutive years, and the two non-significant correlations were between consecutive years. This result suggests that trees in an area do not typically produce cones, even in moderate numbers, in consecutive years. This is consistent with knowledge of pinyon mast behavior and is not surprising, given the energy and environmental requirements necessary for a cone crop.

	2004	2005	2006
2005	-0.015		
2006	0.263*	-0.032	
2007	0.253*	0.295*	0.323**

Table 9. Correlations between years on average cone number per point. * $P \leq 0.05$, ** $P \leq 0.01$

Cone number and vigor were significantly correlated in 2004 and 2005, but not in 2006 or 2007 (Table 10). This result may have occurred because in 2004 and 2005, only more vigorous trees produced many cones, thus creating the correlation. In 2007, the worst

cone year, very few trees produced any cones at all, so no correlation could occur between cones and vigor. In contrast, 2006 was a better cone year in which many trees, not only the most vigorous, were able to produce cones.

	Vigor			
Cone	2004	2005	2006	2007
2004	0.345**			
2005		0.247*		
2006			0.199	
2007				0.227

Table 10. Correlations between cone number and vigor by year. *P≤0.05

Conclusions

The pinyon jay flock at NOP is relatively small and lives at the southern edge of the species' range (Marzluff and Balda 1992). In addition, the pinyon-juniper woodlands on the Oscuras comprise a higher-elevation habitat island surrounded by lower-elevation grasslands and shrublands. Juniper savannah occurs in lower elevations to the east, desert grasslands below the cliffs to the west, and desert grasslands in the Tularosa Valley to the south. The area of the Oscuras is small relative to nearby sky island ranges where pinyon-juniper occurs (e.g., Sacramento, Magdalena, and San Mateo Mts.). Suitable habitat in these mountains is a 65 km (Sacramentos) to 95 km (San Andres) flight away from NOP. These geographic factors have probably always limited the NOP flock, but the new reality of climate change poses an additional and potentially significant threat.

Pinyon jay populations rely on periodic mast crops of pinyon seeds, which provide the fuel for highly successful reproductive events (Ligon 1978, Marzluff and Balda 1992). Mast events are reported to have occurred historically every five to eight years (Ligon 1978, Christensen and Whitham 1991, Floyd 2003). A large mast crop of pinyon has not been produced at NOP in the four fall seasons we have been at NOP. Horacio Perez, a year-round worker at NOP for many years, reported seeing no significant mast crop in over eleven years. Although we observed a crop in 2006, it was neither widespread nor bountiful. Only 156 of 297 trees sampled (52.5 %) produced seeds, and only trees at the top of the mountain produced large numbers of seeds. Trees in other areas produced a few or no cones per tree. Enough seeds were produced on the very top of NOP to allow the flock to cache seeds into October, and reproduction was likely enhanced during the spring. However, it was by no means a legendary mast crop that required an entire winter to cache or allowed multiple breeding events in a year, as reported following significant mast crops (Ligon 1978, Marzluff and Balda 1992). The following year, 2007, was poor indeed, and birds left the area when fledglings could fly, without a seed crop to cache.

The first decade of the 21st century has not been good for pinyon-juniper woodlands. Since 2001, dramatic, rapid, large-scale mortality of pinyon trees has occurred in the

southwestern US (USDA Forest Service 2004). Pinyon mortality due to drought, bark beetle (*Ips confusus*) infestations, fungus (*Leptographium wageneri*), and other diseases such as needle scale (*Matsucoccus acalyptus*) threaten pinyon woodlands and their inhabitants in the Southwest. At NOP, widespread disease and mortality were evident in 2005 and 2006, although we observed few obvious casualties due to bark beetles. Most trees appeared to be losing needles due to needle scale or simply lack of water. After the wet winter of 2006-2007, many trees that had lost most or all of their needles began producing new needles. At lower elevations in the pinyon-juniper habitat, larger numbers of trees have died. The combination of tree mortality and morbidity, along with lack of mast crops, suggests that the pinyon trees have been impacted by lack of moisture and possibly changes in temperature regime.

Fire history may have affected stand structure in the Oscuras. Several small (most < 1 ha) stands of “doghair” pinyon are scattered over the study site. However, we have observed natural mortality in these tight stands, which suggests that they may be self-thinning, particularly in times of drought. Our impressions accord with those of Muldavin et al. (2003): the pinyon woodlands at NOP “exhibit a complex multi-age class sub-structure that has both vertical and horizontal patterning ... driven by recruitment cohorts during inter-drought periods and occasional fires, both large and small” (Muldavin et al. 2003). Fire studies in the Oscuras estimate historical fire frequencies to be from 30-100 years, with turnover time of over four centuries. Muldavin et al. (2003) concluded that a prescribed burn program with high frequency burns similar to a ponderosa pine model would not be appropriate for the Oscuras.

The woodlands atop NOP fit the definition of “persistent woodlands” proposed by Romme et al. (2007). These are woodlands with relatively dense stands of large trees. Pinyon and/or juniper were historically and are currently the dominant species. In contrast to pinyon-juniper savannahs, persistent woodlands “do not represent 20th century conversion of formerly non-woodland vegetation types to woodland” (Romme et al. 2007). They conclude that low-intensity surface fires had a very limited role in determining stand structure and dynamics of persistent woodlands. In sparse woodlands, fires typically burned individual trees but did not spread, while surface spread was more likely to occur in higher-density woodlands, where most or all trees were killed. These fires did not “kill from below.” Some persistent woodlands are stable for hundreds or thousands of years, and stand dynamics are driven more by climate, insect outbreaks, and disease than by fire. During the 20th century, gradual increase in canopy cover in most persistent woodlands has not been due primarily to fire exclusion but likely to livestock grazing or favorable climatic conditions (Romme et al. 2007).

Our data lead us to the hypothesis that climate change may be impacting health and productivity of the woodlands at NOP and in turn their ability to support pinyon jays. Although pinyon jays are known to inhabit pinyon-juniper savannahs, juniper savannahs, and even ponderosa pine forest types, persistent woodlands are their most suitable habitat because of the large, mast-producing pinyon trees with which they have co-evolved and on which their population viability depends. The size and timing of cone crops have clear potential to impact the seemingly fragile pinyon jay population at NOP. As the jay

population decreases, the jays will become unable to provide seed dispersal. We recommend that management of persistent pinyon-juniper woodlands such as those in the Oscuras consider the importance of maintaining and nurturing old-growth pinyons. The value of these trees lies in their necessity to the wildlife that perform essential ecosystem services for the woodland, as well as in production of succeeding generations of pinyon trees. Not only pinyon jays, but other species of concern such as the Oscura Mountains Colorado chipmunk (*Neotamias quadrivittatus oscuraensis*) are likely impacted by reduced pinyon seed productivity. Populations of several birds that occur at NOP such as mountain chickadee (*Poecile gambeli*), juniper titmouse (*Baeolophus inornatus*), and western scrub jay (*Aphelocoma californica*) have been identified as declining (Sauer et al. 2004). Management for old growth pinyon trees is critical for maintaining natural, healthy woodlands supportive of integral wildlife in this ecosystem. If under climate change precipitation and temperature regimes continue to impact tree health, thinning to benefit the oldest, largest trees, which we found to produce the most seeds, might be in order.

Literature Cited

- Christensen, KM, and TG Whitham. 1991. Indirect herbivore mediation of avian seed dispersal in pinyon pine. *Ecology* 72:534-543.
- ESRI. 2008. ArcGIS Version 9.2. Redlands, CA.: Environmental Systems Research Institute (ESRI), <http://www.esri.com>.
- Floyd, ML. 2003. Ancient pinyon-juniper woodlands. Boulder, CO: University Press of Colorado.
- Johnson, K and JW Smith. 2006. Interdependence of pinyon pines and pinyon jays White Sands Missile Range, NM, 2004-2005 final report. Natural Heritage New Mexico publication no. 06-GTR-309, Albuquerque, NM.
- Johnson, K and JW Smith. 2007. Relationship of pinyon jays and pinyon pines at North Oscura Peak, White Sands Missile Range, 2006 draft report. Natural Heritage New Mexico publication no. 07-GTR-311, Albuquerque, NM.
- Ligon, JD. 1978. Reproductive interdependence of pinyon jays and pinyon pines. *Ecological Monographs* 48:111-126.
- Marzluff, JM and RP Balda. 1992. The pinyon jay: the behavioral ecology of a colonial and cooperative corvid. T & AD Poyser, London.
- Mennill, D. 2000. How to radiotrack chickadees or other small birds. <http://web2.uwindsor.ca/courses/biology/dmennill/radiotelem.html>. Last accessed 25 January 2008.
- Minitab Inc. 1999. Minitab Release 13 for Windows. State College, PA.

- Muldavin, E, C Baisan, T Swetnam, L DeLay, and K Morino. 2003. Woodland fire history studies in the Oscura and northern San Andres Mountains, White Sands Missile Range, New Mexico. Natural Heritage New Mexico publication no. 03-GTR-256, WSMR document No. 92F018, Albuquerque, NM.
- Pyle, P. 1997. Identification guide to North American birds. Slate Creek Press, Bolinas, CA.
- Rappole, JH and AR Tipton. 1991. New harness design for attachment of radio transmitters to small passerines. *Condor* 62:335-337.
- Romme, W, C Allen, J Bailey, W Baker, B Bestelmeyer, P Brown, K Eisenhart, L Floyd-Hanna, D Huffman, B Jacobs, R Miller, E Muldavin, T Swetnam, R Tausch, and P Weisberg. 2007. Historical and modern disturbance regimes of pinyon-juniper vegetation in the western US.
- Sauer, JR, JE Hines, and J Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. [USGS Patuxent Wildlife Research Center](#), Laurel, MD.
- USDA Forest Service 2004. GIS layers of pinyon mortality in New Mexico, 2003 and 2004. Courtesy Dan Ryerson, USDA Forest Service.