Pinyon Jay Surveys in the Gila National Forest, New Mexico 2021

Final Report to Share with Wildlife

Pinyon Jays in ponderosa pine, Gila NF, April 2021. Christina M. Selby

Kristine Johnson, Nathan Petersen, and Giancarlo Sadoti

Natural Heritage New Mexico Report # 21-420
Biology Department, University of New Mexico, Albuquerque, NM
September 2021

Table of Contents

List of Figures

List of Tables

Introduction

The Pinyon Jay (*Gymnorhinus cyanocephalus*) is an immediate priority Species of Greatest Conservation Need (SCGN) in New Mexico (NMDGF 2016; nmswap.org). It is listed as vulnerable on the Red List of Threatened Species by the International Union for the Conservation of Nature (IUCN), suggesting that it is at risk of extinction in the medium-term future (Birdlife International 2017). It is a US Fish and Wildlife Service (USFWS) species of conservation concern (USFWS 2019) and is the fastest declining bird associated with piñon-juniper habitats (Boone et al. 2018). Its rangewide population has declined an estimated 3.69% annually from 1967 to 2015; similar annual declines (3.46%) have been documented in New Mexico (Sauer et al. 2017).

The Pinyon Jay is named for its coevolved mutualism with piñon trees (primarily Colorado piñon, *Pinus edulis*, and single-leaf piñon, *P. monophylla* across the bird's range). Pinyon Jays are adapted for the harvest, transport, caching, and retrieval of piñon-pine seeds (Johnson and Balda 2020). Physiologically, the presence of piñon seeds and green cones reverses gonadal regression and stimulates testis growth in wild and experimental birds from central New Mexico (Ligon 1974, 1978). The bill is featherless at its base, which allows individuals to probe deep into green cones without pitch blocking the nostrils. A Pinyon Jay can carry up to 50 seeds in a single trip in its expandable esophagus. Pinyon Jays cache seeds in micro-habitats favorable to seed germination (Ligon 1978). Hence, the Pinyon Jay is the primary long-distance disperser of piñon-pine seeds and the only species capable of re-planting a piñon woodland decimated by fire, drought, or disease.

The causes of Pinyon Jay decline are not well documented, but climate change has been associated with widespread piñon mortality (Clifford et al. 2013), reductions in canopy cover (Clifford et al. 2011), declines in piñon nut production (Wion et al. 2019), and reductions in piñon tree vigor (Johnson et al. 2017). In addition, the current management practice of thinning piñon-juniper woodlands for fuels reduction, habitat enhancement for other wildlife species (Boone et al. 2018), or ecological restoration can impact habitat quality for Pinyon Jays. In one study in the Southwestern US, thinning treatments that reduced canopy cover from 36% to 5% reduced local-level occupancy by Pinyon Jays in treated areas (Magee et al. 2019). In another study, Pinyon Jays stopped nesting within parts of a known colony site after the colony site was significantly thinned (87% reduction of trees per acre; Johnson et al. 2018).

In response to concern about the status of the Pinyon Jay and the need for information on its management, the Pinyon Jay Working Group recently released a Conservation Strategy for the Pinyon Jay (Somershoe et al. 2020). This comprehensive document outlines research necessary to understand Pinyon Jay biology, causes of decline, and management actions needed. A primary research need identified by the strategy is to document locations of flocks, home ranges, and nesting colonies across the Pinyon Jay's range. The location of Pinyon Jay nesting colonies is best known in New Mexico, where researchers with Natural Heritage New Mexico (NHNM), within the UNM Biology Department, have documented 39 Pinyon Jay nesting colonies (e.g.; Petersen et al. 2014; Johnson et al. 2014, 2015, 2018, 2021). These nesting colonies are spread throughout New Mexico and southwestern Colorado in suitable piñon and juniper habitats.

However, a significant data gap exists in the area of the Gila National Forest (Gila NF). Although Pinyon Jays have been documented there (Figure 1), prior to this study, systematic surveys across suitable habitats had not been conducted. The Gila NF area is especially important because Breeding Bird Survey data suggest that Pinyon Jay populations in the forest

Figure 1. Pinyon Jay pair mobbing American Kestrel, Gila NF, April 2021. Photo Christina M. Selby.

may be more stable than those in other areas of the state and range-wide and may even be increasing in some sites (Figure 2; Sauer et al. 2017). The Gila may also be important to the species rangewide, as New Mexico harbors an estimated 29% of the global population (Partners in Flight 2020).

Occupancy modeling is a method which accounts for imperfect detection in surveys of birds and other animals via spatially or temporally repeated surveys. It provides an estimate of true occurrence in a surveyed area (MacKenzie et al. 2017). These models use information from repeated observations at each site to estimate and account for detectability, which may vary with site or survey characteristics (for a straightforward explanation of occupancy modeling, see https://www.nps.gov/olym/learn/nature/upload/OccupancyModelFactSheet.pdf). We employed occupancy modeling to estimate true occurrence of Pinyon Jays in the surveyed area.

The objectives of this study are to:

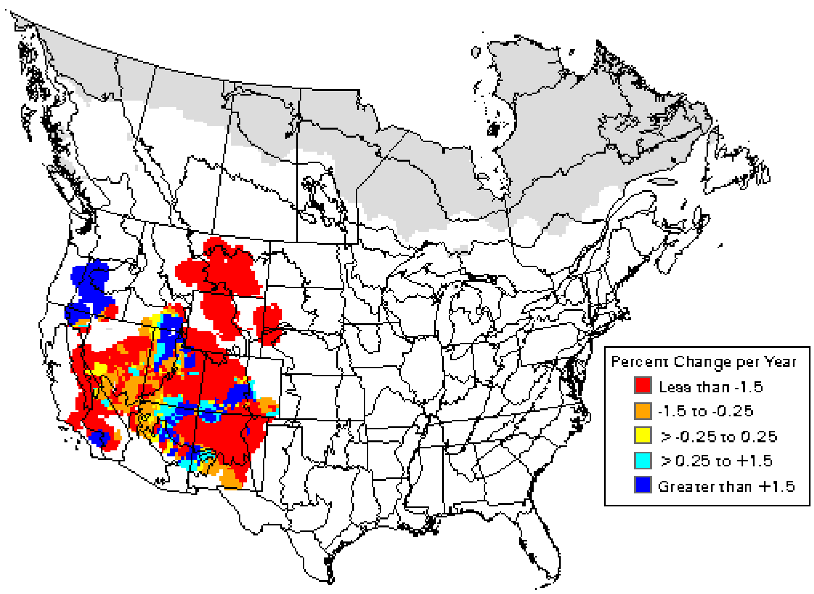
1. Conduct systematic Pinyon Jay breeding-season surveys in suitable habitat in the Gila NF.
2. Document locations of nesting colonies.
3. Use survey data and occupancy modeling techniques to estimate detection probabilities and occurrence of Pinyon Jays in the study area.
4. Delineate areas of Pinyon Jay population concentration and breeding.

Tasks Accomplished in Year 1

The following tasks were accomplished in 2021:

1. Assembled a geodatabase of existing Pinyon Jay occurrence data.
2. Overlaid Pinyon Jay observations with land cover data to identify likely areas of Pinyon Jay use. Set priorities for areas to be surveyed. Highest priority areas had previous Pinyon Jay breeding season occurrences, were within suitable Pinyon Jay habitat, and had road access.
3. Conducted vehicle and walking surveys for Pinyon Jay flocks and nesting colonies, in order of previously determined priorities (see 2 above).
4. Modeled detection probabilities and occupancy of Pinyon Jays at Gila National Forest survey sites.
5. Mapped areas of Pinyon Jay occurrence and nesting.

Figure 2. Pinyon Jay yearly population trends, 1967-2015, from Breeding Bird Survey (Sauer et al. 2017). Blue area indicating population increase in west central New Mexico roughly aligns with the Gila NF.



Methods

Field Surveys

We conducted vehicle and walking surveys for Pinyon Jay flocks in areas prioritized based on compiled Pinyon Jay occurrence data (eBird 2020, NHNM observation database, and anecdotal observations), availability of suitable habitat, and access via roads. The criteria for designating these priority areas were developed from known New Mexico nesting colonies (Johnson et al. 2014, 2015; Johnson and Sadoti 2019) and required at least 2% piñon-containing vegetation classes (from the LANDFIRE 2016 Existing Vegetation Type raster layer; https://www.landfire.gov) within a given 25 km^2 area around each nesting colony. This information was generated in ArcGIS via a moving window analysis with a radius of 2821 m. A 25 km^2 area approximated the area used by southwestern Pinyon Jay flocks within the breeding season (Marzluff and Balda 1992, Johnson et al. 2014). To conform to a standardized grid sampling framework, we then placed a 25 km^2 grid (5 km x 5 km blocks) over areas of suitable habitat, as defined above, within the Gila NF, retaining blocks that contained areas above the 2% piñon-class threshold. In this framework, blocks were treated as areas of potential occurrence by individual breeding flocks. For comparability to surveys in areas that may have employed scales recommended by Somershoe et al. (2020), each 5 × 5 km (25 km^2) block was further divided into four smaller, 2.5 × 2.5 km sub-blocks. Within each block prioritized for survey, all survey points were at least 1 km apart along public roads (with no minimum number of points per sub-block). Additional survey points were added in the field (1 km from existing points) when adjacent suitable habitat was identified and accessible. Survey points were removed when habitat was found to be unsuitable in the field or poor road conditions limited access. Pinyon Jay surveys followed the general protocol outlined in Petersen et al. (2014) and Johnson et al. (2020). The surveyor drove slowly through designated blocks, listening for Pinyon Jay calls and watching for jays flying over. All Pinyon Jays detected while driving were recorded on data sheets.

The surveyor also stopped at each pre-designated survey point and watched and listened for 6 min. When Pinyon Jays gave breeding calls (rattle, piping rattle, begging) or displayed breeding behaviors (courtship chases or feeding, begging by females, nest construction, copulation, fledglings), suggesting that the birds were nesting nearby, the surveyor attempted to follow them to nesting colonies by vehicle or on foot.

For every block the surveyor recorded
1. date
2. wind at start and end of day (first and last point in block) in Beaufort units
3. start and end cloud cover (%)
4. start and end temperature.

For every point, he recorded
1. time start and end
2. detection method (if PIJA detected). Audio (A) and/or visual (V) and an estimate of the number of birds
3. distance bin (if PIJA detected)
4. bearing (if PIJA detected, degrees)
5. behavior (if PIJA detected)
6. resighting (if PIJA detected; notes, e.g., "maybe")

7. comments on habitat, access, water availability, and additional behavior

In March 2021, surveys began in the southern part of the Gila NF. Finding very few Pinyon Jays in the south, the surveyor moved to the northern part of the study area, where Pinyon Jays were abundant (Figure 3). Finally, priority blocks in the east, between the southern and northern areas, were surveyed.

As Pinyon Jays were detected on many points, blocks, and sub-blocks, the surveys required substantial time. Given the limited length of the nesting season and available funding, we prioritized surveying as many blocks as possible over the time-consuming activity of searching on foot for nesting colonies. Surveys were completed in late April 2021.

Multi-scale Occupancy Models

Our survey methodology employed a surveyor with extensive experience surveying, monitoring, and researching Pinyon Jays. Nonetheless, this species is well-known to exhibit behaviors that result in imperfect detection within areas of breeding season use. To address this challenge, we used an occupancy modeling approach (MacKenzie et al. 2017) to improving estimates of Pinyon Jay prevalence in the Gila NF. Occupancy modeling depends on repeated sampling in time and/or space over a closed period (i.e., the state of a given site [species present or absent] does not change over the sampling season).

The use of point counts with a 100 m (or similar) radius as sites in occupancy models, while often suitable for birds with small territories, is not appropriate for Pinyon Jays, which range over several thousand hectares during the breeding season. We defined sites as 5 x 5 km blocks in which roaming, breeding-season Pinyon Jay flocks, if present, are likely to exploit food resources. This area (25 km^2) approximates the size of area used by southwestern Pinyon Jay flocks within the breeding season (Marzluff and Balda 1992, Johnson et al. 2014). To address this tendency for birds to cluster temporarily (except where nesting) in small areas across a much larger home range and improve the probability of detecting birds at least once within a given block, we selected multiple individual sampling locations within each site. Our sampling approach is ideally suited for the "multi-scale" occupancy (MSO) model of Nichols et al. (2008), which was later modified by Pavlacky et al. (2012). In these models, spatially-replicated points are used to model θ (Theta, i.e.; "local occupancy" or "availability for detection"). This is essentially the estimated proportion of local sampling units (for this study, points) within a site where a species is likely to be detected, if it is present in the site. Finally, these models accommodate temporally repeated sampling at each point to estimate the detectability of a species given site and local occupancy. In the original model formulation (Nichols et al. 2008), multiple detection types (e.g., animal sign, cameras, auditory surveys) were used as repeated samples, while other types of repeated surveys have been employed in other studies (e.g., multiple observers; Jeffress et al. 2011). We used the six, one-minute increments of each survey as repeated sampling events in our approach and employed a removal design such that no positive or negative observation was recorded after the one-minute increment in which Pinyon Jays were first recorded, the latter as in Pavlacky et al. (2012). This approach to ending surveys after the first detection of a species has been found to yield identical results to models in which full detection histories were included (Kery and Royle 2015).

Model Sets

We modeled detectability with six covariates: region, hour of survey after sunrise, temperature, % cloud cover, wind (Beaufort scale), and Julian day. Covariates relating to topography and vegetation were not modeled but may be included after year 2, pending sufficient sample sizes. Because sites in the south were surveyed primarily in the first round of visits, Julian day and site region were correlated. Therefore, we transformed Julian day to residual values from an ordinary least squares relationship between Julian day and site region. Additionally, because the hour of survey was highly correlated with temperature ($r_s = 0.80$), we did not include these covariates together in the same model.

To build models of multi-scale occupancy, we considered two formulations of Ψ (Psi, i.e.; site-level occupancy): constant (intercept-only) and region-dependent. Region-dependent models incorporate a single formulation of θ or local (point-level) occupancy (constant), and 25 formulations of p or survey (minute-level) detectability. We conducted occupancy modeling in R (R Development Core Team 2019) using the RMark package (Laake 2019), which serves as a front-end for Program MARK (White and Burnham 1999).

These combinations resulted in a total of 50 occupancy models. After fitting each model using the RMark package (Laake 2019), we discarded any models that failed to converge or that contained uninformative parameters (Arnold 2010). We considered models as competitive if their Akaike Information Criterion (AICc) value was within two units of the best (lowest-AICc) model. We generated predicted detection values as the product of the estimates of Ψ, θ, and p. Using a bootstrap selection randomized 1,000 times of one observation per site, we assessed the accuracy of competitive models using predicted vs. observed detection (0 or 1) via the area under the receiver operating curve (AUC; Fielding and Bell 1997).

Results

Field Surveys

The surveyor completed surveys of 124, 25 km^2 blocks, including 514, 6-min surveys (Figure 3). Pinyon Jay flocks were detected at 62 points. Thirteen 25 km^2 blocks were not surveyed because they were inaccessible. Of 124 blocks surveyed over the entire study area, Pinyon Jays were detected in 36 (29%). The southern part of the survey area was dominated by flocks of Mexican Jays (*Aphelocoma wolbeberi*), with Woodhouse's Scrub-jays (*A. woodhouseii*) and Steller's Jays (*Cyanocitta stelleri*) also present. In 48 blocks surveyed in the south area, Pinyon Jays were detected on only 2.3% (one block; Table 1). Pinyon Jays were moderately abundant in the east area and were detected on 9 (25%) of 36 blocks. Of the 44 northern blocks, Pinyon Jays were detected in 26 (59.1%) (Table 1). A similar pattern emerged at the 2.5 × 2.5 km sub-block and point scales, with the northern area having the highest number of detections. Numbers and group sizes of Pinyon Jays were also higher in the north, followed by the east, with the fewest jays in the south (Table 1).

Despite limited time for colony searches, we detected five new nesting areas, as indicated by Pinyon Jay behavior, active or old nests, or fledglings (Figure 3). All five nesting colonies were in the northern area.

Priorities for a second year of surveys in 2022 will be as follows: north – high, east – medium, and south – low; we will survey some blocks in each area for purposes of occupancy modeling. Assuming a similar percentage of blocks will be inaccessible as in 2021, approximately the following numbers of blocks remain un-surveyed: north – 167, south – 40, east –79. The majority of blocks surveyed in 2022 will be in the north, with fewer in the east and very few in the south.

Multi-scale Occupancy Models

After filtering out models with convergence issues or uninformative parameters, we identified six valid models predicting site occupancy by Pinyon Jays (Table 2). Only two of these models were predictive (i.e., ΔAICc < 2); both included survey section as a predictor of occupancy, while one included cloud cover as a predictor of detection (Tables 2, 3; Figure 4). Parameter estimates for the two predictive models are shown in Table 3. (Each model has an intercept for psi, theta, and p. Two models were competitive, one with cloud as predictor of p [plus an intercept], one model with only the intercept ["constant"] p. Each [psi, theta, and p] is a "component" of the model, so each is always estimated, thus an intercept for each, plus any covariates, if considered).

These models indicated occupancy probabilities of 0.91 in the north section, 0.39 or 0.40 (best and second-best models, respectively) occupancy in the east section, and 0.04 in the south section (estimates and associated error for competitive models shown in Table 4). Among points within sites, probabilities of availability for detection (i.e., local occupancy or habitat use) were 0.27 or 0.28. Per-minute detectability probabilities were 0.38 or 0.29. The best model indicated detectability increased with cloud cover (Figure 4). Bootstrapped AUC indicated overall modest accuracy of the best and second-best models (mean AUC = 62.1 and 66.6, respectively).

Table 1. Summary statistics of field detections of Pinyon Jays (PIJA) in three regions of the study area, by point, 2.5 km sub-block, and 5 km block.

Points	**North (n = 201 points)**		**South (n = 162 points)**		**East (n = 148 points)**		**All areas (n = 511 points)**	
Statistic	Mean	Range	Mean	Range	Mean	Range	Mean	Range
PIJA detected (% of points)	23.4	—	0.6	—	9.5	—	12.1	—
PIJA detected per point (n)	1.35	0–32	0.02	0–3	0.39	0–20	0.65	0–32
Flock size (n, points with PIJA only)	5.8	1–32	3.0	3–3	4.1	1–20	5.3	1–32

Sub-blocks	**North (n = 116 sub-blocks)**		**South (n = 96 sub-blocks)**		**East (n = 80 sub-blocks)**		**All areas (n = 292 sub-blocks)**	
Statistic	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Points surveyed (n, per sub-block)	1.7	1–5	1.7	1–3	1.9	1–4	1.8	1–5
PIJA detected (% of sub-blocks)	31.9	—	1.0	—	13.8	—	16.8	—
Birds detected per sub-block (n)	2.34	0–39	0.03	0–3	0.71	0–20	1.13	0–39

Blocks	**North (n = 44 blocks)**		**South (n = 44 blocks)**		**East (n = 36 blocks)**		**All areas (n = 124 blocks)**	
Statistic	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Points surveyed (n, per block)	4.6	1–6	3.7	1–7	4.1	1–6	4.1	1–7
PIJA detected (% of blocks)	59.1	—	2.3	—	25.0	—	29.0	—
Birds detected per block (n)	6.16	0–59	0.07	0–3	1.58	0–34	2.67	0–59

Table 2. Models of 5 x 5 km site occupancy (Ψ) by breeding-season Pinyon Jays accounting for varying availability (θ; also known as local occupancy) and detectability (p). Covariates (subscript) or constants (dots) are presented for each model component. Indicated are the number of estimated parameters (k), the model log likelihood (LL), Akaike information criterion adjusted for small samples (AICc), the difference between the AICc of a given model and the lowest AICc model (ΔAICc), and the Akaike weight of models (w_i). Two models were competitive (shown in bold), indicating variation in occupancy across survey sections of the Gila NF and the effect of cloud cover on detection

Model	k	LL	AICc	ΔAICc	w_i
$\Psi_{section}$ θ. p_{clouds}	**6**	**-259.902**	**532.522**	**0.000**	**0.610**
$\Psi_{section}$ θ. p.	**5**	**-261.456**	**533.420**	**0.898**	**0.390**
Ψ. θ. p_{hour}	4	-277.773	563.883	31.360	<0.001
Ψ. θ. p_{clouds}	4	-279.920	568.176	35.654	<0.001
Ψ. θ. p.	3	-281.204	568.607	36.085	<0.001
Ψ. θ. p_{wind}	4	-280.574	569.484	36.961	<0.001

Table 3. Parameter estimates from the two competitive models of multi-scale occupancy by Pinyon Jays. Estimates, standard errors (SE), and 95% percent lower (LCL) and upper (UCL) confidence limits are shown. The reference (intercept) level for Ψ is the east section. Model 1 and 2 refer to the first and second models listed in Table 2.

	Model 1				Model 2			
Covariate	Estimate	SE	LCL	UCL	Estimate	SE	LCL	UCL
Ψ: intercept	-0.427	0.490	-1.387	0.533	-0.391	0.498	-1.367	0.584
Ψ: north section	2.767	1.570	-0.310	5.843	2.752	1.580	-0.344	5.849
Ψ: south section	-2.840	1.128	-5.051	-0.630	-2.855	1.132	-5.073	-0.637
θ: intercept	-0.972	0.223	-1.409	-0.535	-0.944	0.235	-1.406	-0.483
p: intercept	-1.058	0.282	-1.610	-0.506	-0.892	0.284	-1.448	-0.336
p: clouds	0.025	0.012	0.001	0.048	—	—	—	—

Table 4. Predicted probabilities of site occupancy (Ψ), availability (θ; also known as local occupancy), and detectability (*p*) by breeding-season Pinyon Jays. Model 1 and 2 refer to the first and second models listed in Table 2.

	Model 1				Model 2			
Covariate	Estimate	SE	LCL	UCL	Estimate	SE	LCL	UCL
Ψ: east section	0.39	0.12	0.20	0.63	0.40	0.12	0.20	0.64
Ψ: north section	0.91	0.13	0.32	1.00	0.91	0.13	0.32	1.00
Ψ: south section	0.04	0.04	0.01	0.22	0.04	0.04	0.01	0.23
θ	0.27	0.04	0.20	0.37	0.28	0.05	0.20	0.38
p	0.38	0.06	0.27	0.51	0.29	0.06	0.19	0.42

Figure 3. Results of Pinyon Jay surveys in the Gila NF, March and April 2021.

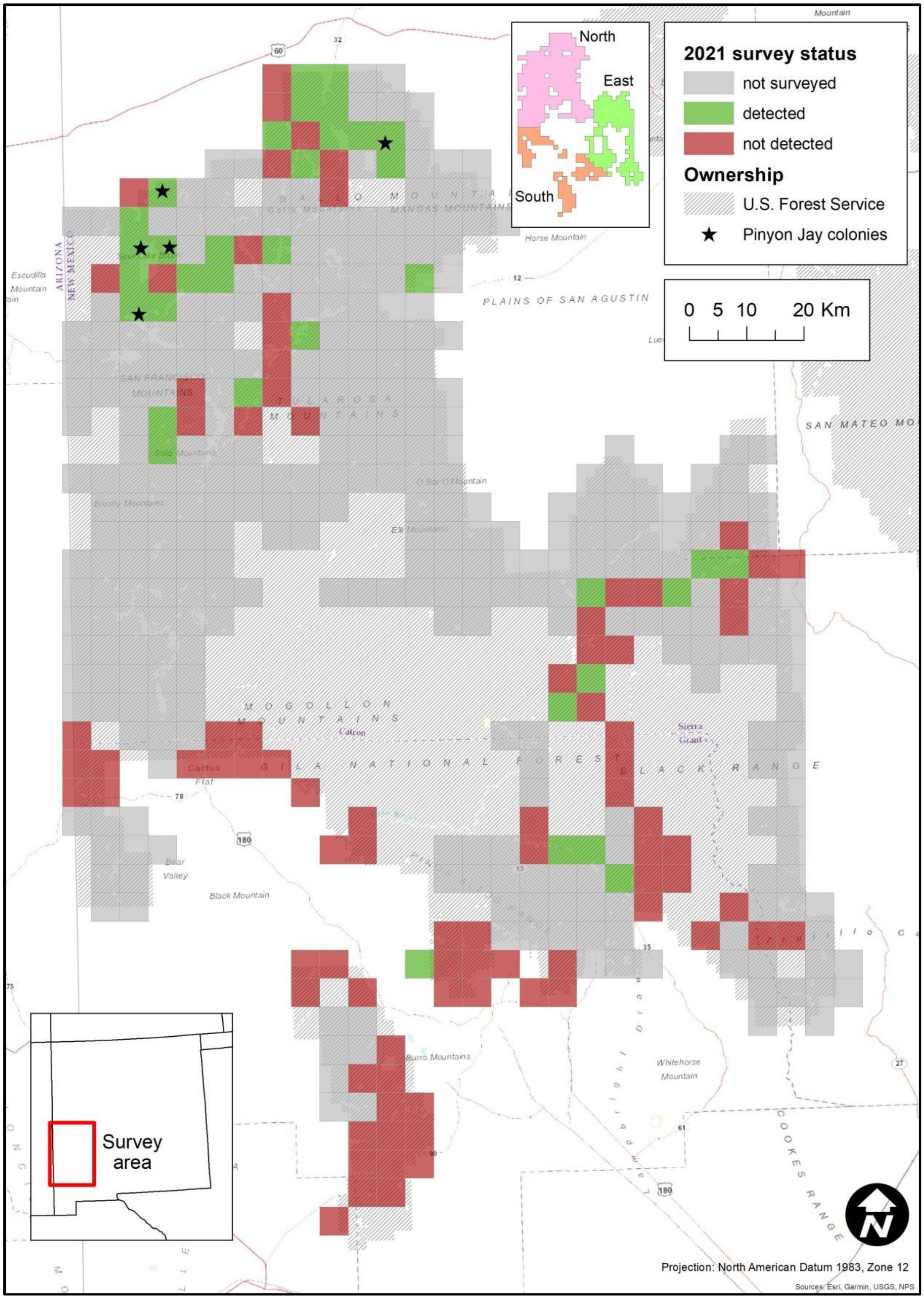
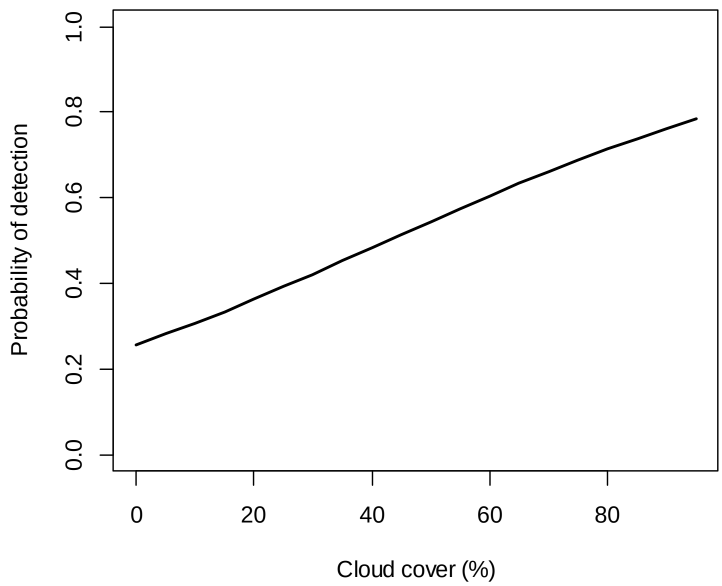


Figure 4. The relationship between percent cloud cover and the probability of per-minute detection of Pinyon Jays, given the presence of birds both in the site and at the local point.



Discussion

Because Pinyon Jays were abundant in the northern blocks (where present), the surveyor elected to devote the majority of survey time to covering additional blocks, as searching for nesting colonies is time-consuming. Given the relatively high occupancy in the north and east sections, we expect that additional surveys targeted at nesting areas will reveal more colonies. For 2022 surveys, relatively more time will be spent delineating colonies.

The habitats used by Pinyon Jays are of interest. Areas with abundant jays were frequently covered in ponderosa pine (*Pinus ponderosa*) woodland. This is the first area of occurrence in New Mexico where we have found Pinyon Jays using ponderosa pine habitat. Colonies found previously were in piñon-juniper (*P. edulis*, *Juniperus* spp.) woodland or juniper savanna habitats. Threats to the Gila NF population include climate impacts to habitat and wildfires, which are currently (August 2021) active over large areas of the Gila NF. Surveys in 2022 will allow sampling of additional blocks and identification of both more nesting areas and more areas of Pinyon Jay detection and non-detection. This will allow for more robust analyses of occupancy patterns, including incorporation of spatial covariates such as woodland cover, water availability indices, and other factors suspected of driving the distribution of this species.

Detectability

Time and temperature had only minor effects on detection and did not appear in the supported models, unlike many songbirds in which singing rates, and in turn detectability, vary with these conditions. Magee et al. (2019) found only observer effects on detectability of Pinyon Jays. Detection probabilities of Pinyon Jays, while not directly comparable to Magee et al. (2019) due to their use of a 100-m radius limit and 2-minute intervals (reported as per-visit probabilities), were higher in our study. We found per-minute detectability of 0.38 and 0.29 in competitive models while Magee et al. (2019) found detectability per visit of 0.18 (95% CI = 0.14–0.23).

So-called naïve detectability in this study is approximated by the inverse of how many minutes of a 6-minute survey passed without a detection on points with Pinyon Jay detections (i.e., the more minutes without a detection, the lower the detectability). Viewed this way, detectability in Pinyon Jays is more likely a measure of activity and movement of birds through a flock's home range than other factors. Magee found different observers had different detectability based on experience, where more experienced observers had higher detectability. As we had only one (highly knowledgeable and experienced) surveyor, we cannot address this factor.

Despite cloud cover effects on detectability in studies of other songbirds (e.g., Gonzalo-Turpin et al. 2008), to our knowledge, this effect has not been previously documented in Pinyon Jay surveys. While Pinyon Jay activity (and thus detectability) may have been higher on cloudier days, these survey days (16% of days had cloud cover > 50%, 43% of days had cloud cover <10%) may have coincided with larger or more garrulous flocks. Further analyses of detection distances from 62 flock detections in 2021 combined with additional data from 2022 will shed additional light on detectability of this species and should increase confidence in our occupancy estimates.

Occupancy
Occupancy estimates were approximately 60% higher than survey results in all survey sections: north – 91% vs. 59.1%; east – 39% vs. 25%; and south – 4% vs. 2.3% (Tables 1, 4). As the assumption behind occupancy modeling is that some occurrences are missed, this result is not surprising and suggests that Pinyon Jays are more widespread across the study area than indicated by naïve survey detections.

We found strong differences in estimated occupancy of sites depending on survey section (highest in north, medium east, low in south). Mexican Jays were common on the southern blocks where Pinyon Jays were absent, perhaps because Mexican Jays tend to be associated with oak (*Quercus* spp.). The surveyor noted the presence of oaks on 13% of points in the north, 28% of points in the east, and 70% of points in the south. In contrast, ponderosa was present on 64% of points in the north, 66% of points in the east, and 17% of points in the south. This suggests an association of vegetation type with differences in Pinyon Jay presence among areas.

Magee et al. (2019) focused at the scale of woodland treatment areas (18–77 ha) and adjacent control sites (20–117 ha). Given scale differences with our study, where we used 2500 ha sites, the two studies are not directly comparable. However, despite this scale difference, we found occupancy in the east and north sections of the Gila (0.39 and 0.91, respectively) to be comparable to that found by Magee et al. (2019) in their control ($\Psi = 0.58$), mastication-treated ($\Psi = 0.67$), and hand-thin treated areas ($\Psi = 0.70$).

Estimates of point-level "local occupancy" or availability probabilities below 1.0 were expected due to the large home ranges of breeding-season Pinyon Jays and their tendency to move through home ranges in flocks. Magee et al. (2019) found higher local occupancy probabilities in their control ($\theta = 0.84$), mastication-treated ($\theta = 0.53$), and hand-thin treated areas ($\Psi = 0.42$) than our finding of 0.27–0.28 local occupancy (i.e., θ) probabilities across the study area. The reasons for these differences are unclear but may be due to differences in habitat or behavior. For example, birds may have been more evenly distributed among their points during surveys. It is more likely due to Magee et al.'s (2019) use of three separate visits to survey locations. In other words, our estimates of local occupancy are more "snapshots" of habitat use, while those of Magee et al. (2019) are closer to cumulative estimates of use at some point in a season.

Management
Magee et al. (2019) state that: "At finer scales of habitat use [i.e., local occupancy], Pinyon Jays may abandon treated forest patches that remove too much cover for nesting and roosting or severely reduce piñon pine seed availability." It is worth noting that without knowing where breeding or nesting occurs in a site, it is difficult to reliably conclude exactly why birds are not detected at a particular point, given occupancy of the encompassing site. It could be due to one or all of these possible factors (cover too low for nesting or roosting and/or too few cone-bearing trees). For the present, the fact that Pinyon Jays avoid thinned sites provides sufficient caution against treating Pinyon Jay habitat without understanding of the birds' local habitat use, as demonstrated by Johnson and Sadoti (2019).

Perhaps most importantly, this survey indicates that the northern Gila NF is an area of high Pinyon Jay occupancy and could reasonably be considered a hotspot for Pinyon Jays in New Mexico. This reinforces the message from Breeding Bird Survey maps that the northern Gila is one of only a few sites rangewide where Pinyon Jay populations may be increasing (Figure 2). The US Forest Service has large conservation responsibility for this population of Pinyon Jays. Management recommendations for Pinyon Jays have been detailed by Somershoe et al. (2020), Johnson and Balda (2020), and others. Pinyon Jay conservation should be a major consideration in any forest planning with potential to impact Pinyon Jays or their habitats in the Gila NF.

Figure 5. Pinyon Jay flock in flight. Photo Christina M. Selby.

Acknowledgments

This study was supported by the Share with Wildlife Program of the New Mexico Department of Game and Fish. We thank Amanda Gehrt, Jerry Monzingo, and Adam Mendonca of the US Forest Service, Gila NF, for granting permission to survey and facilitating access. Jacqueline Smith assisted with GIS. Thanks to Christina M. Selby for sharing photographs of Pinyon Jays (Figure 5).

Literature Cited

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's Information Criterion. The Journal of Wildlife Management 74:1175-1178.

BirdLife International. 2017. *Gymnorhinus cyanocephalus* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017: e.T22705608A110431877. [online] URL: https://www.iucnredlist.org/species/22705608/179592026. Accessed 22 September 2021.

Boone, J. D., E. Ammon, and K. Johnson. 2018. Long-term declines in the Pinyon Jay and management implications for piñon–juniper woodlands. *in* Trends and Traditions: Avifaunal Change in Western North America (W. D. Shuford, R. E. Gill Jr., and C. M. Handel, eds.), pp. 190–197. Studies of Western Birds 3. Western Field Ornithologists, Camarillo, CA.

Clifford, M. J., N. S. Cobb, and M. Buenemann. 2011. Long-term tree cover dynamics in a pinyon-juniper woodland: climate-change-type drought resets successional clock. Ecosystems 14:949–962.

Clifford, M. J., P. D. Royer, N. S. Cobb, D. D. Breshears, and P. L. Ford. 2013. Precipitation thresholds and drought-induced tree die-off: insights from patterns of *Pinus edulis* mortality along an environmental stress gradient. New Phytologist 200:413–421.

eBird. 2020. Pinyon Jay. https://ebird.org/species/pinjay. Accessed 2020.

Fielding, A. H., and J. F. Bell. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 24:38-49.

Gonzalo-Turpin, H., C. Sirami, L. Brotons, L. Gonzalo, and J. L. Martin. 2008. Teasing out biological effects and sampling artifacts when using occupancy rate in monitoring programs. Journal of Field Ornithology 79:159-169.

Jeffress, M. R., C. P. Paukert, B. K. Sandercock, and P. S. Gipson. 2011. Factors affecting detectability of river otters during sign surveys. The Journal of Wildlife Management 75:144-150.

Johnson, K., and G. Sadoti. 2019. Model transferability and implications for woodland management: a case study of Pinyon Jay nesting habitat. Avian Conservation and Ecology 14:17.

Johnson, K. and R. P. Balda. 2020. Pinyon Jay (*Gymnorhinus cyanocephalus*), version 2.0. In Birds of the World (P. G. Rodewald and B. K. Keeney, eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.pinjay.02

Johnson, K., L. Wickersham, J. Smith, G. Sadoti, T. Neville, J. Wickersham, and C. Finley. 2014. Habitat use at multiple scales by pinyon-juniper birds on Department of Defense lands III: landscape, territory/colony, and nest scale. Natural Heritage New Mexico Technical Report No. 14-GTR-381. Biology Department, University of New Mexico, Albuquerque, NM. 128 pp.

Johnson, K., L. Wickersham, J. Smith, N. Petersen, and J. Wickersham. 2015. Nest-scale habitat use by Pinyon Jay and Gray Vireo in the BLM Farmington resource area 2013-2014. Natural Heritage New Mexico Technical Report No. 15-GTR-386. Biology Department, University of New Mexico, Albuquerque, NM.

Johnson, K., G. Sadoti, and J. Smith. 2017. Weather-induced declines in piñon tree condition and response of a declining bird species. Journal of Arid Environments 146:1–9.

Johnson, K., N. Petersen, J. Smith, and G. Sadoti. 2018. Piñon-juniper fuels reduction treatment impacts pinyon jay nesting habitat. Global Ecology and Conservation 16:1-7.

Johnson, K., N. Petersen, and J. Smith. 2020. Powerpoint presentation for Pinyon Jay survey training via Zoom. 5 May 2020.

Kery, M., and J. A. Royle. 2015. Applied Hierarchical Modeling in Ecology: Volume 1: Prelude and Static Models. Elsevier Science.

Laake, J. L. 2019. RMark: R code for Mark analysis. R package version 0.3.0.

Ligon, J. D. 1974. Green cones of the piñon pine stimulate late summer breeding in the Piñon Jay. Nature 250:80-82.

Ligon, J. D. 1978. Reproductive interdependence of Piñon Jays and piñon pines. Ecological Monographs 48:111–126.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. Bailey, and J. E. Hines. 2017. Occupancy estimation and modeling*:* Inferring Patterns and Dynamics of Species Occurrence, 2nd edition. Academic Press, Burlington, MA.

Marzluff, J. M., and R. P. Balda. 1992. The Pinyon Jay: Behavioral ecology of a colonial and cooperative corvid. T & AD Poyser, London.

Magee, P. A., J. D. Coop, and J. S. Ivan. 2019. Thinning alters avian occupancy in piñon–juniper woodlands. The Condor 121:1-17.

New Mexico Department of Game and Fish. 2016. State Wildlife Action Plan for New Mexico. New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA.

Nichols, J. D., L. L. Bailey, A. F. O. C. Jr., N. W. Talancy, E. H. C. Grant, A. T. Gilbert, E. M. Annand, T. P. Husband, and J. E. Hines. 2008. Multi-scale occupancy estimation and modelling using multiple detection methods. Journal of Applied Ecology 45:1321-1329.

Partners in Flight. 2020. Population estimates database version 3.1. URL: http://pif.birdconservancy.org/PopEstimates. Accessed in August 2021.

Pavlacky, D. C., J. A. Blakesley, G. C. White, D. J. Hanni, and P. M. Lukacs. 2012. Hierarchical multi-scale occupancy estimation for monitoring wildlife populations. Journal of Wildlife Management **76**:154-162.

Petersen, N., K. Johnson, and J. Smith. 2014. Pinyon Jay monitoring program for New Mexico. Natural Heritage New Mexico Technical Report No. 14-GTR-382. Biology Department, University of New Mexico, Albuquerque, NM. 46 pp.

R Development Core Team. 2019. R: A language and environment for statistical computing. Version 3.5.3. R Foundation for Statistical Computing, Vienna.

Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski, Jr., K. L Pardieck, J. E. Fallon, and W. A. Link. 2017. The North American Breeding Bird Survey, Results and Analysis 1966–2015. Version 2.07.2017. USGS Patuxent Wildlife Research Center, Laurel, MD.

Somershoe, S. G., E. Ammon, J. D. Boone, K. Johnson, M. Darr, C. Witt, and E. Duvuvuei. 2020. Conservation Strategy for the Pinyon Jay (*Gymnorhinus cyanocephalus*). Partners in Flight Western Working Group and U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2019. Birds of Conservation Concern 2019. http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:S120-S139.

Wion, A. P., P. J. Weisberg, I. S. Pearse, and M. D. Redmond. 2019. Aridity drives spatiotemporal patterns of masting across the latitudinal range of a dryland conifer. Ecography DOI:0.1111/ecog.04856.