Conservation Strategy for the Pinyon Jay (*Gymnorhinus cyanocephalus*)

Photo by Scott Somershoe

Version 1, February 2020

This strategy was developed by the Pinyon Jay Multi-State Working Group, led by Scott Somershoe, Land Bird Coordinator, Migratory Bird Program, Legacy Region 6, U.S. Fish and Wildlife Service, Lakewood, Colorado.

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https://www.partnersinflight.org/resources/pinyon-jay-working-group/

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Abbreviations

BBS – Breeding Bird Survey

BCR – Bird Conservation Region

CBC – Christmas Bird Count

DBH – Diameter at Breast Height

IMBCR – Integrated Monitoring of Bird Conservation Regions

PIF – Partners in Flight

U.S. – United States

Glossary

Bird Conservation Regions – Ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues (http://nabci-us.org/resources/bird-conservation-regions/).

Sagebrush restoration treatments – Complete tree removal (clear cutting) typically used in vegetation management projects for sagebrush restoration.

Great Basin – The area defined by Bird Conservation Region 9 (see above). This area includes the Northern Basin and Range and Central Basin and Range level iii ecoregions (https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states), and portions of the eastern slope of the Cascade Range.

Home range – The extent that a flock of Pinyon Jays use throughout the annual cycle.

Southwest – For the purpose of this document, the portions of the Pinyon Jay range that occurs south of the Great Basin, primarily in Arizona and New Mexico.

Executive Summary

The Pinyon Jay (*Gymnorhinus cyanocephalus*) is an obligate bird of piñon-juniper and other pine-juniper woodlands that has experienced significant population declines and is of increasing conservation concern. The purpose of this strategy is to summarize current knowledge about Pinyon Jays and identify research, monitoring, and conservation actions required to improve their population status.

Pinyon Jays are highly social and maintain year-round flocks that occupy large home ranges and use a variety of woodland habitats for foraging, caching piñon nuts, nesting, and roosting. The Partners in Flight North American Landbird Conservation Plan estimates a current global population of 770,000 Pinyon Jays. Over the period from 1967–2015, populations declined by 3.69% annually for an estimated total loss of 83.5%. The causes of these declines are unclear, largely because Pinyon Jays remain understudied. Most earlier research has occurred in New Mexico and Arizona and has focused on behavior or on habitat associations at nest colonies. More recent and ongoing research efforts are focused on understanding habitat requirements, resource needs, and movement patterns throughout the entire annual cycle in different regions of the species' range. Future research needs include: identifying home ranges and nesting colony sites, habitat use and requirements, nesting biology and survival, assessing causes of local and regional declines, and assessing effects of management.

As Pinyon Jay populations have declined, the piñon-juniper woodlands that provide most of their habitat also face potential threats, including removal of trees to accomplish other management priorities, long-term fire suppression, changes in woodland age and tree density, and changing climatic conditions that cause reduced piñon nut production and increased piñon pine mortality.

Effective management and conservation of the Pinyon Jay depends on a better understanding of the species' habitat requirements, identification of the factors that limit population size, and a clearer understanding of woodland dynamics and health. The information provided in this strategy to inform management is based on the best available science and is intended to help minimize unintended negative impacts to Pinyon Jays associated with current vegetation management activities. Collaboration between land managers and Pinyon Jay researchers provides a compelling approach to increase our knowledge of the species, better understand management trade-offs, and identify positive actions that could improve habitat for the species and reverse negative long-term population trends.

Scope of the Document

The Pinyon Jay Working Group developed this strategy to provide a comprehensive review of the current knowledge of Pinyon Jays (*Gymnorhinus cyanocephalus*), a species of conservation concern experiencing significant long-term, range wide population declines. The goals of the working group and the strategy are to present key information and research needs for the species and to support management and conservation of Pinyon Jays using the best available science. The strategy describes how negative impacts to Pinyon Jays could be minimized or mitigated in the context of ongoing management of piñon-juniper and other pine-dominated woodlands based on current knowledge. These preliminary management considerations are intended to supplement and enhance existing management guidance, but as with all Partners in Flight products, this strategy is a non-regulatory, non-binding document. Because our understanding of Pinyon Jay habitat requirements and preferences is still limited, the management considerations presented here will be updated as scientific knowledge increases. In the course of preparing these periodic updates, the Working Group is planning to develop geographically-specific management guidance for the variety of forest types and Bird Conservation Regions (BCRs) that occur across the range of the Pinyon Jay. The Working Group is also planning to identify any beneficial conservation actions for Pinyon Jays, to supplement the current strategy's focus on minimizing negative impacts. In the interest of achieving these longer-term goals as quickly as possible, we emphasize that ongoing management projects are excellent opportunities to conduct research and monitoring to characterize Pinyon Jay responses. We encourage active collaborations among researchers and with managers to take advantage of these opportunities to address our current information gaps about Pinyon Jays.

Objective of the Strategy

The objective of this strategy is to improve population status of the Pinyon Jay by identifying data gaps, and by presenting data-supported conservation actions that can be implemented by managers, landowners, and policy/decision makers.

Chapter 1. Pinyon Jay Conservation Status and Trends

The Pinyon Jay (*Gymnorhinus cyanocephalus*) (Figure 1) is a highly social corvid of the interior West (Figure 2) that has experienced a major population decline over the past half century. Data from the North American Breeding Bird Survey (BBS) indicate that Pinyon Jay numbers have decreased significantly survey-wide by 3.69% per year from 1967–2015, with an overall population loss of approximately 83.5% (Sauer et al. 2017). On the basis of current trends, the estimated global population of 770,000 Pinyon Jays (range 530,000-1,100,000, 95% confidence bounds) is predicted to be reduced by an additional 50% over the next 19 years (the so-called population "half-life") (Rosenberg et al. 2016, Partners in Flight 2019; see Table 1 and Figures 3, 4, and 5 for population abundance and BBS trends at multiple spatial and temporal scales).

The Pinyon Jay was listed as *Vulnerable* on the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN), which suggests it faces a high risk of extinction in the medium-term future (BirdLife International 2017). The Pinyon Jay is also recognized as a Species of Greatest Conservation Need (SGCN) in State Wildlife Action Plans (Table 1). The U.S. Fish and Wildlife Service has identified the Pinyon Jay as a priority species continentally and in several Bird Conservation Regions (BCR's; for definition and geographic boundaries, see http://nabci-us.org/resources/bird-conservation-regions-map/) on the Birds of Conservation Concern (BCC) list (U.S. Fish and Wildlife Service 2019, in review). Partners in Flight (PIF) identified Pinyon Jay as a Yellow Watch List Species in the 2016 PIF Landbird Conservation Plan (Rosenberg et al. 2016) due to overall population declines and moderate to high threats. Department of Defense PIF has elevated the Pinyon Jay to their list of 16 "Mission Sensitive Species" (R. Fischer, pers. comm.).

Figure 1. Pinyon Jay in southern Idaho. Photo by Wallace Keck, USNPS.

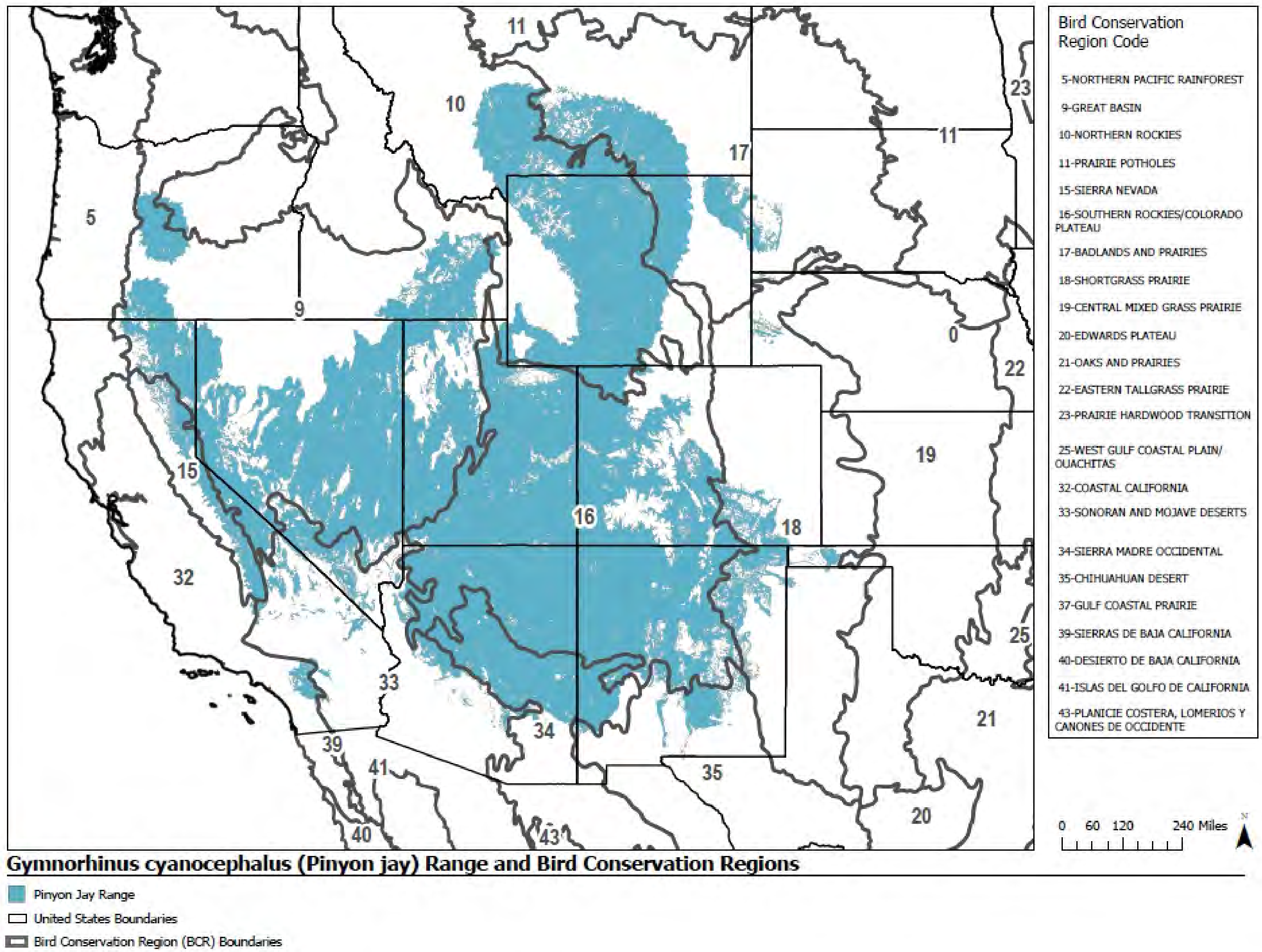

Figure 2. Pinyon Jay range and Bird Conservation Regions. Image courtesy of Liz Moore, Utah Division of Wildlife Resources.

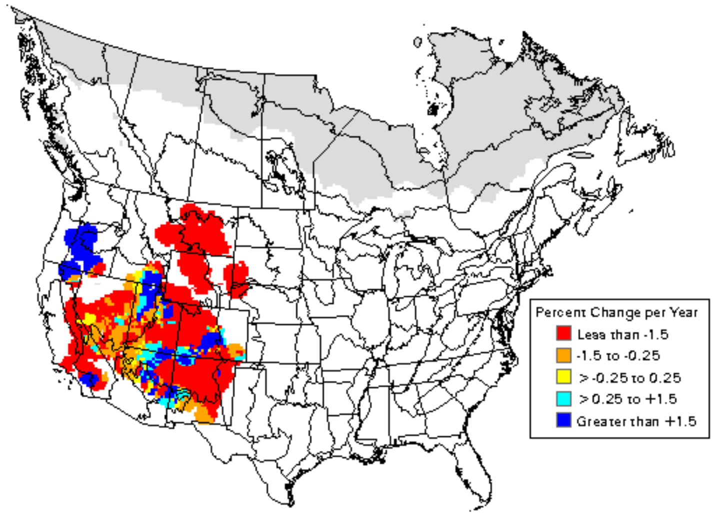

Figure 3. Geographic patterns in population change for Pinyon Jay from 1967–2015 based on analysis of BBS point estimates (Sauer et al. 2017). Map depicts state boundaries in the conterminous United States, provincial boundaries in Canada, and BCR boundaries.

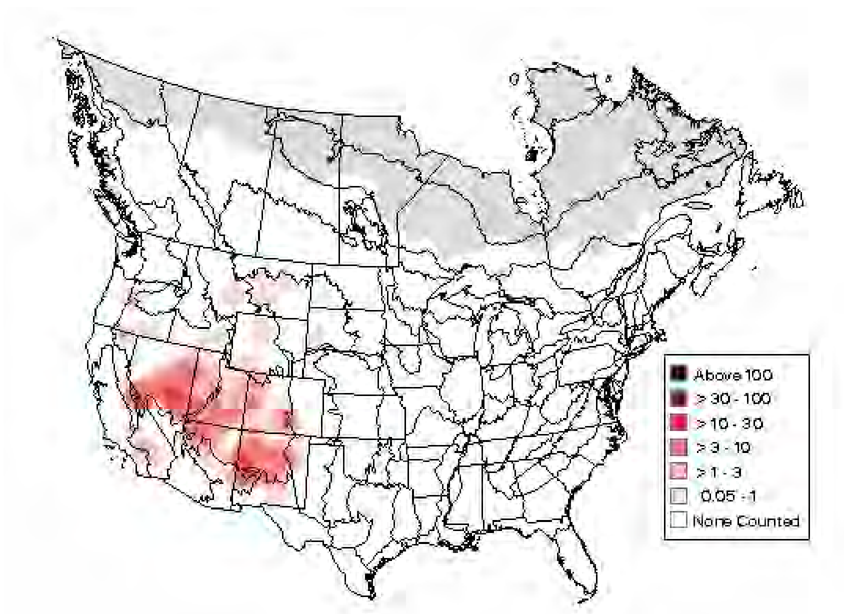

Figure 4. Map of Pinyon Jay range and relative abundance from 2011–2015 based on BBS point estimates (Sauer et al. 2017). Map depicts state boundaries in the conterminous United States, provincial boundaries in Canada, and BCR boundaries.

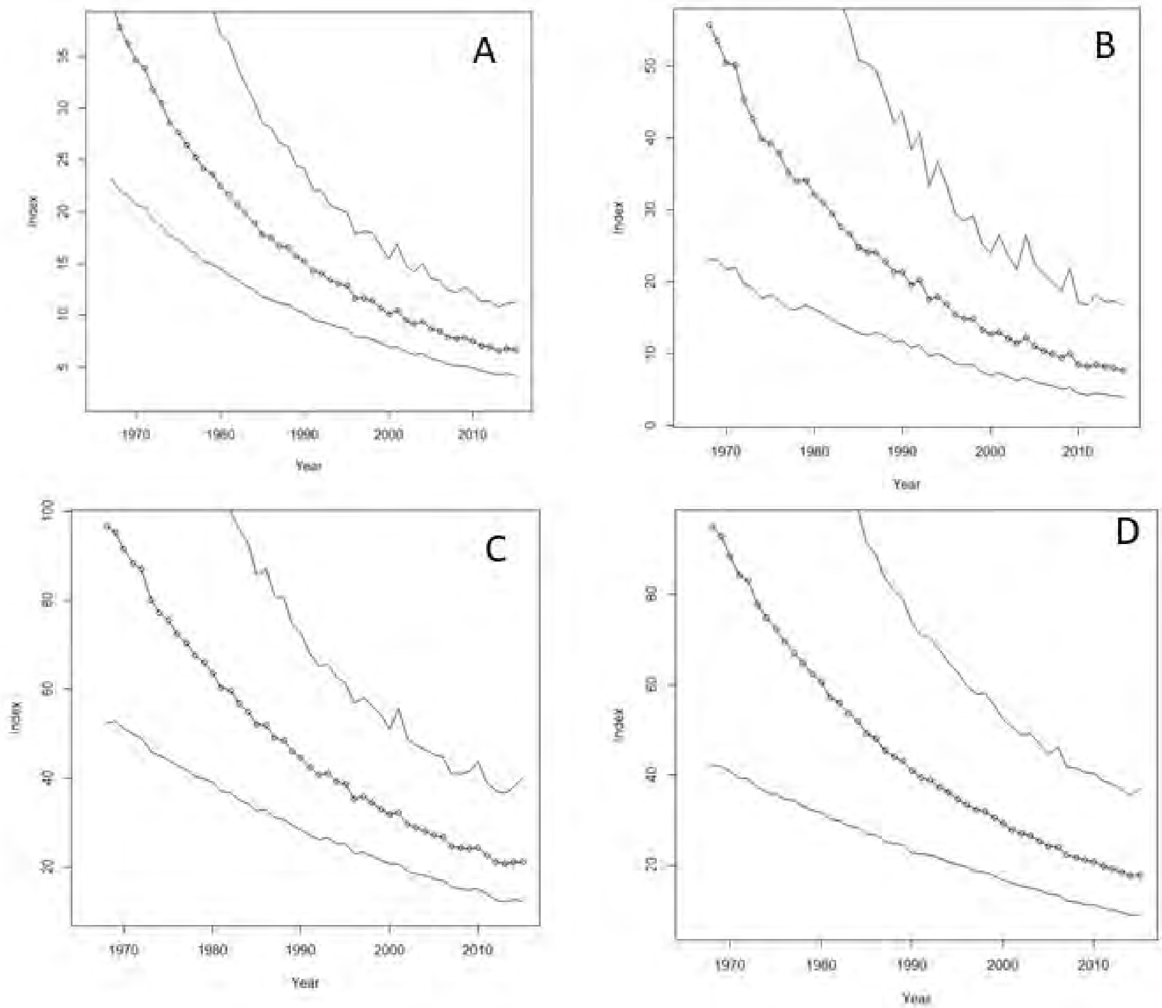

Figure 5. Pinyon Jay relative abundance from BBS data collected from 1967–2015 (Sauer et al. 2017) for (A) range wide (survey wide), (B) Great Basin (BCR 9), (C) Southern Rockies/ Colorado Plateau (BCR 16), and (D) New Mexico. Open circles show annual indices of relative abundance; lines above and below represent credible intervals (2.5% and 97.5%).

Table 1. Estimated Pinyon Jay population and trends by BCR and state for the entire analyzed BBS period (1967–2015) and most recently analyzed 10-year BBS period (2005–2015). For the BBS trends, n = number of survey routes on which the species was encountered during the entire survey period. BBS trends are presented as yearly percentage change. Numbers in parentheses are the credible intervals for the trend estimate; the values represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates (Sauer et al. 2017). Trends for which credible intervals do not include zero are considered statistically significant, and red text represents a significant negative trend. Where there are data deficiencies or where the species does not breed, "n/a" is used, meaning data are not available or not applicable.

Region/State	Percentage of population	BBS Sample size (n)	BBS Trend 1967-2015 (%/yr, 95% CI)	BBS Trend 2005-2015 (%/yr, 95% CI)
Range wide				
Survey wide	n/a	285	-3.69 (-5.1, -2.4) [a]	-2.67 (-4.9, 0.4)
BCR-level [b]				
S. Rockies/CO Plateau BCR	50.3	138	-3.16 (-4.7, -1.5) [a]	-2.56 (-5.0, 1.4)
Great Basin BCR	37.5	53	-4.12 (-6.4, -1.8) [a]	-3.57 (-7.7, 0.9)
Sierra Madre Occidental BCR	4.0	10	-4.00 (-10.6, 2.9)	-4.16 (-17.9, 11.1)
Northern Rockies BCR	3.2	29	-4.37 (-9.0, 0.1)	-1.81 (-12.1, 15.7)
State				
Arizona*	9.7	29	-2.13 (-5.8, 1.7)	1.28 (-7.3, 8.1)
California	3.1	30	0.49 (-4.1, 4.2)	3.42 (-2.9, 13.8)
Colorado*	9.0	51	-3.61 (-6.3, -1.0) [a]	-3.12 (-7.8, 2.2)
Idaho*	0.2	n/a	n/a	n/a
Montana*	1.7	12	-5.46 (-9.8, -0.6) [a]	-4.12 (-17.6, 13.0)
Nebraska*	0.2	n/a	n/a	n/a
Nevada*	27.3	20	-4.55 (-7.4, -1.6) [a]	-4.66 (-9.9, 1.1)
New Mexico*	30.4	37	-3.46 (-5.6, -1.4) [a]	-3.09 (-5.9, 0.8)
Oregon	0.3	12	-2.90 (-9.2, 3.5)	-1.13 (-9.6, 10.6)
South Dakota	0.2	4	-6.11 (-13.9, 2.9)	-8.79 (-36.3, 7.3)
Utah	15.7	65	-4.03 (-6.1, -2.1) [a]	-3.76 (-7.1, 0.01)
Wyoming	1.4	25	-5.61 (-10.5, -1.0) [a]	-5.35 (-17.5, 3.5)

BBS trends: [a] High confidence (Sauer et al. 2017).

[b] Percentage of populations for BCRs do not equal 100% as BCRs with <3% of the global population are excluded from this table.

*Designates SGCN (Species of Greatest Conservation Need) per the State Wildlife Action Plans.

Chapter 2. Pinyon Jay Distribution, Natural History and Habitat

Distribution Patterns and Natural History

The Pinyon Jay is most abundant in the southern Great Basin and the southwestern U.S. (Figure 4), where it is usually associated with the piñon pines (e.g., *Pinus edulis*, *P. monophylla*) for which it is named (Figure 6). Pinyon Jays are found in lower densities outside the range of piñon pines, in South Dakota, Nebraska, California, Oregon, Wyoming, and Montana, where they occur in habitat types dominated by ponderosa pine (*P. ponderosa*), Jeffrey pine (*P. jeffreyi*), and limber pine (*P. flexilis*) (Burleigh 1972, Grenfell and Laudenslayer 1983, Balda 2002, Faulkner 2010, Marks et al. 2016, Drilling et al. 2018, Silcock and Jorgensen 2018). Pinyon Jays are associated with juniper (in the absence of piñon pine) in southern Idaho (Brody 1992) and may also use juniper-dominated areas in Montana (J. Marks, pers. comm.), New Mexico (Johnson et al. 2014) and other areas.

Pinyon Jays are highly social throughout the year. They occur in flocks of up to a few hundred individuals and nest colonially, sometimes cooperatively, often using the same general nesting colony site annually (Marzluff and Balda 1992). Home ranges are large, typically 8,645 acres (3,500 hectares) to 15,800 acres (6,400 hectares) (Marzluff and Balda 1992; Balda 2002; Johnson et al. 2016, 2017a). Unlike traditionally territorial species, their nests are spatially clumped in nesting colonies that can cover 141 acres (57.4 hectares) or more (Figure 7, Johnson et al. 2014, 2015, 2018a).

Across their geographic range, Pinyon Jays inhabit varying elevations and latitudes with diverse woodland structures, dominant tree species, and landscape characteristics, and thus home range attributes may vary substantially from region to region. Additionally, local home ranges may shift seasonally, and jays may occasionally make large-scale movements (up to hundreds of miles) out of their normal home range when food resources are limited in fall and winter (Balda 2002). Pinyon Jays may also adjust daily and annual habitat use within home ranges as habitat conditions and resources vary over space and time. As a result, well-established occupancy patterns can change with seasons and with habitat conditions in unanticipated ways.

Pinyon Jays have a mutualistic relationship with piñon pines where they co-occur (Ligon 1978, Lanner 1996). Piñon pines are a masting species, producing highly nutritional nuts in large crops that historically occurred within local stands or regions at irregular intervals, from one to three crops every 10 years for *P. edulis* (Forcella 1981) and one crop every one to three years for *P. monophylla* (Sutton 1984). These intermittently abundant nuts sustain Pinyon Jays throughout the winter, support successful nesting, and significantly influence population viability (Marzluff and Balda 1992). Pinyon Jay nesting success and productivity are higher following mast years than non-mast years (Ligon 1978, Marzluff and Balda 1992), and adult survivorship is highest after moderate cone crops (Marzluff and Balda 1992). In turn, Pinyon Jays serve as the primary long-distance seed disperser for piñon trees within the species' range. They transport piñon nuts to caching areas up to several miles from the source woodland and may cache in sites favorable for seed germination (Ligon 1978). Therefore, Pinyon Jays likely serve an important role in overall woodland health and regeneration.

Outside the range of piñon pines, Pinyon Jays feed on and cache nuts of other pines, such as Jeffrey, limber, and ponderosa pines, but no information is available on the importance this seed dispersal by Pinyon Jays on the ecology and distribution of these other tree species. The effects of what may be a lower-quality food source on Pinyon Jay ecology, diet, and movements are also unknown. In addition to consuming piñon and other pine nuts, Pinyon Jays also forage extensively for insects in the shrub and grass understory.

Although Pinyon Jay mutualism with piñon pines has been emphasized, the species also eats insects (Ligon 1978, Balda 2002). Jays may rely on insects when piñon nuts are unavailable. Pinyon Jays have been reported to nest successfully in response to a large emergence of periodical cicadas (Ligon 1978), and most foraging observed during the nesting season involved capture of insects in the shrub understory of woodlands (Balda 2002, J. Boone and E. Ammon, unpublished data).

Piñon-Juniper Woodland Types

Piñon and piñon-juniper woodlands vary considerably across the Pinyon Jay's range. Perhaps the best framework for classifying these woodlands is the U.S. National Vegetation Classification (NVC, http://usnvc.org/), a collaborative effort of NatureServe and the Ecological Society of America (ESA). This classification system has been formally adopted by the U.S. Forest Service, the ESA, NatureServe, and the U.S. Geological Survey Core Science System. The NVC is a hierarchical classification of all U.S. vegetation types which provides common reference points for the various land management and conservation entities in the U.S.

Within the NVC, in the Southern Rockies and Colorado Plateau region, Pinyon Jays occur in the Intermountain Pinyon-Juniper Woodland Macrogroup, including the Colorado Plateau Pinyon-Juniper Woodland Group, and associated alliances. Jays also occur in the Southern Rocky Mountain Two-needle Pinyon-Juniper Woodland Macrogroup and associated groups and alliances. In New Mexico, Pinyon Jays have been documented nesting in the Southern Rocky Mountain Pinyon-Juniper Open Woodland Macrogroup, including the Southern Rocky Mountain Juniper Open Woodland Group (juniper-dominated woodland and savanna) and Southern Rocky Mountain Pinyon-Juniper Woodland Group (woodlands dominated by *P. edulis* and *Juniperus monosperma*) (Johnson et al. 2014, 2015). Here they tend to winter at lower-elevation, juniper-dominated woodland and savanna types of the Southern Rocky Mountain Juniper Open Woodland Group (Johnson et al. 2014). In the Great Basin, Pinyon Jays primarily occupy the Intermountain Pinyon-Juniper Woodland Macrogroup, including the Great Basin Pinyon-Juniper Woodland Group and associated alliances.

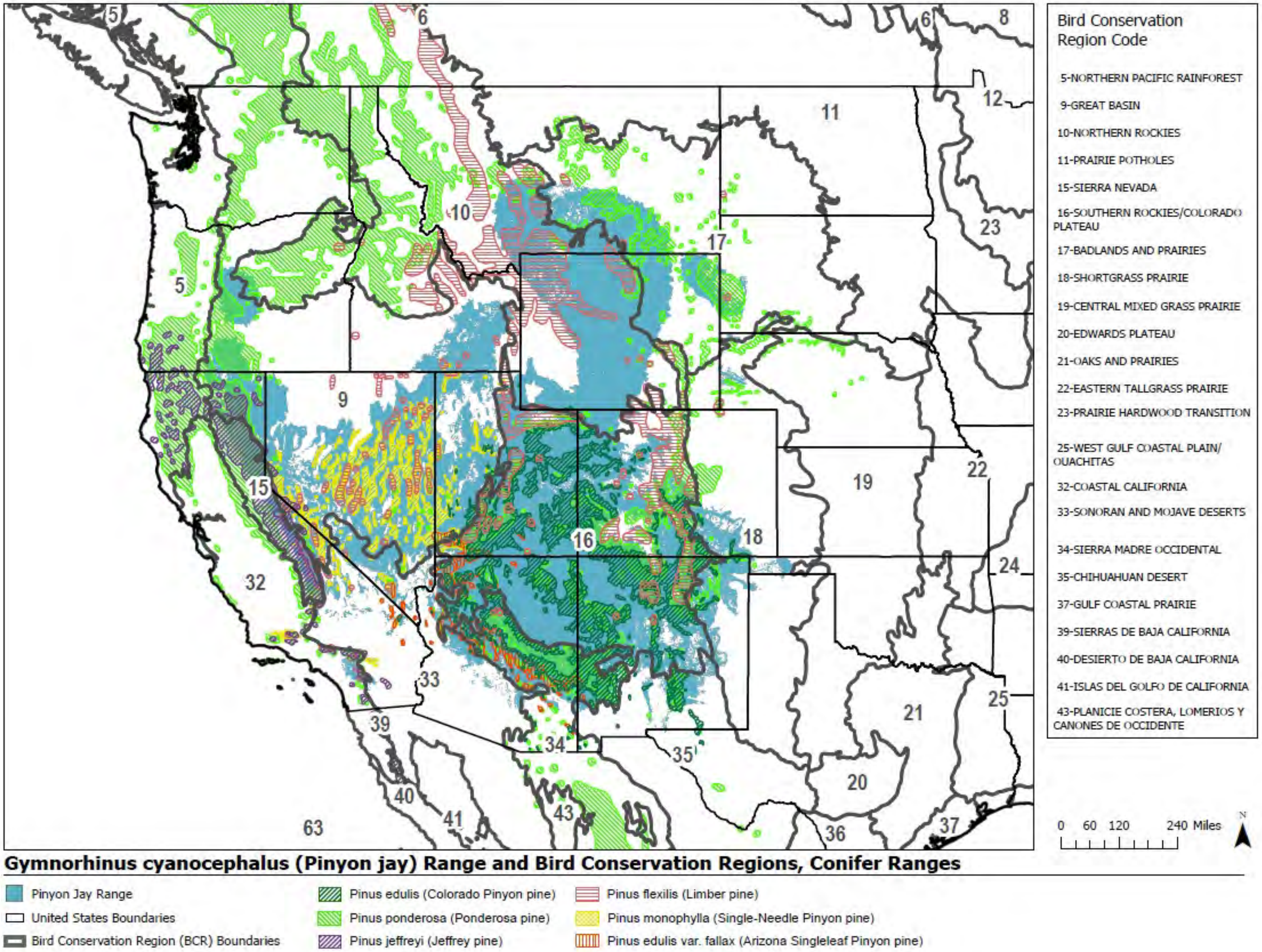

Figure 6. Distribution of dominant conifer species in the range of the Pinyon Jay. Courtesy of Liz Moore, Utah Division of Wildlife Resources.

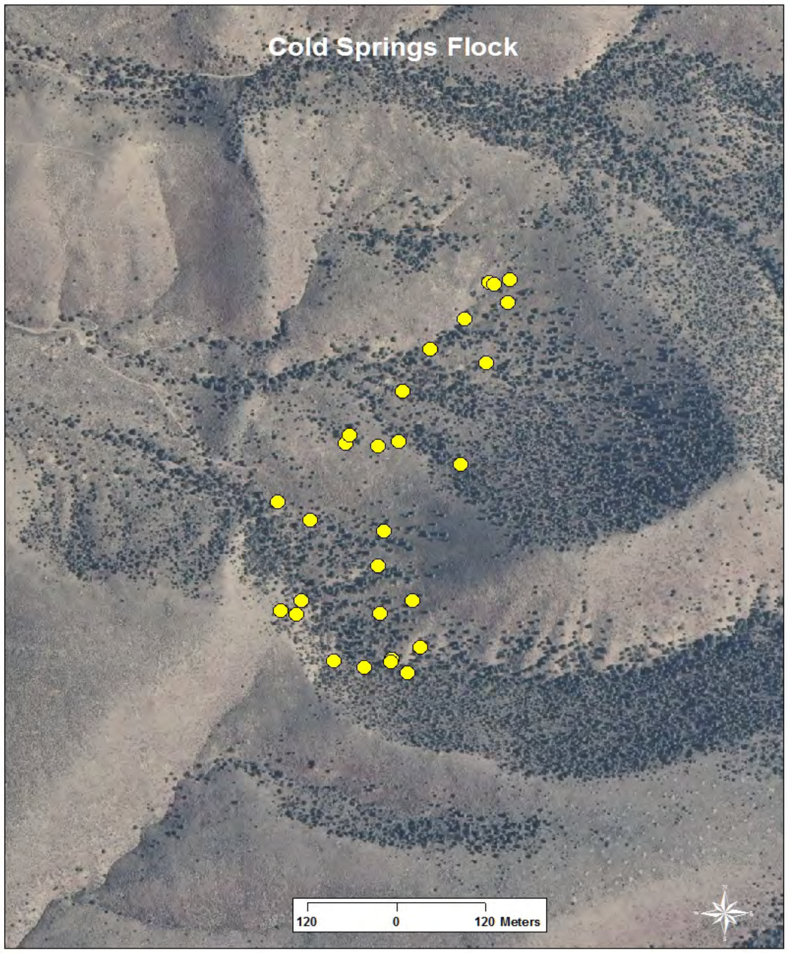

Figure 7. Spatial extent of a typical nesting colony in Nevada, with known nest sites as yellow points (J. Boone and E. Ammon, unpublished data).

Two other classification systems for piñon-juniper vegetation provide useful additional perspectives (Table 2, Figures 8–20). First, Romme et al. (2009) define three main piñon-juniper vegetation types based on historical disturbance regimes (Table 2) that vary in geography, site condition, and tree species. A second scheme (Miller et al. 2008 and references therein) classifies piñon-juniper vegetation in the Great Basin in terms of “phases”. This system has become widely referenced in areas where Greater Sage-Grouse (*Centrocercus urophasianus*) are a management focus. The descriptions shown in Table 2 refer to the early (Phase I), middle (Phase II), and late (Phase III) successional phases of woodland development (Miller et al. 2008).

Table 2. Descriptions of piñon-juniper woodland types (Romme et al. 2009) and successional stages (phases) in the Great Basin (Miller et al. 2008).

Piñon-juniper vegetation types
Persistent piñon-juniper woodlands: sparse to dense tree cover, typically in rugged areas with coarse soils, and with minimal herbaceous ground cover (Figures 8–13)
Piñon-juniper savannas: low to moderate tree density with dense, nearly continuous grass and forb understory on coarse- to fine-textured soils (Figures 14 and 15)
Wooded shrublands: variable tree density, from very sparse to relatively dense, and shrubs are the dominant understory plants, including sagebrush (*Artemisia* spp.) (Figures 16–20)
Piñon-juniper woodland phases (Great Basin)
Phase I: trees present, but shrubs and herbaceous cover are the dominant vegetation type (Figures 16–18)
Phase II: trees co-dominant with shrubs and herbaceous cover (Figures 8 and 18)
Phase III: trees are dominant vegetation (Figures 9, 11, and 18)

Figure 8. Medium density piñon-juniper wooded shrubland (Phase II) near a nesting colony, western Nevada, April 2018. Photo by Scott Somershoe.

Figure 9. High density persistent piñon-juniper woodland (Phase III, background), western Nevada, April 2018. Photo by Scott Somershoe.

Figure 10. Persistent piñon-juniper woodland with Utah juniper and Colorado piñon, northwestern New Mexico. Photo by Natural Heritage New Mexico.

Figure 11. Persistent piñon-juniper woodland in Nevada (Phase III).
Photo by Great Basin Bird Observatory.

Figure 12. Persistent piñon-juniper woodland with Colorado piñon, White Sands Missile Range, southern New Mexico. Photo by Natural Heritage New Mexico.

Figure 13. Persistent piñon-juniper woodland, Mesa Verde National Park, Colorado. Photo by Scott Somershoe.

Figure 14. Piñon-juniper savanna, New Mexico. Photo by Natural Heritage New Mexico.

Figure 15. Piñon-juniper savanna, central New Mexico.
Photo by Natural Heritage New Mexico.

Figure 16. Low density piñon-juniper wooded shrubland (Phase I), western Nevada, April 2018. Photo by Scott Somershoe.

Figure 17. Wooded shrubland (Phase I), Nevada.
Photo by Great Basin Bird Observatory.

Figure 18. Wooded shrubland (multiple phases), Nevada.
Photo by Great Basin Bird Observatory.

Figure 19. Wooded shrubland with Colorado piñon and big sagebrush, northwestern New Mexico. Photo by Natural Heritage New Mexico.

Figure 20. Wooded shrubland with Colorado piñon and big sagebrush, northwestern New Mexico. Photo by Natural Heritage New Mexico.

Regional Patterns of Pinyon Jay Habitat Use and Associations

Overview

Studies of Pinyon Jay habitat use and associations have been concentrated in New Mexico and the central Great Basin in Nevada. Available descriptions of vegetation type and habitat characteristics associated with Pinyon Jay nesting, foraging, and caching are relatively general, but appear to vary between these two regions in several respects (Johnson et al. 2014, 2015, 2018a; Boone et al. 2018; J. Boone and E. Ammon, unpublished data). Additionally, characteristics of habitat used in either region may vary seasonally within and among flock home ranges. Pinyon Jays also appear to select distinctive subsets of the woodland landscape for different activities. For instance, in both New Mexico and the Great Basin, jays use lower density persistent piñon-juniper woodlands, wooded shrublands, and piñon-juniper savannas for caching piñon nuts and foraging for other food items (Phase I, Table 2, Miller et al. 2008), but tend to use denser persistent piñon-juniper woodlands and wooded shrublands for nesting, though there is significant variation in tree density and percent canopy cover across nesting sites (Johnson et al. 2014, 2015, 2016, 2018a; Johnson and Sadoti 2019; J. Boone and E. Ammon, unpublished data). During the non-breeding season, Pinyon Jays may use a wider variety of habitats, including suburban neighborhoods and bird feeders that provide additional and/or supplemental food resources when piñon nut availability is limited (Balda 2002).

New Mexico

In New Mexico, Pinyon Jays nest in various piñon-juniper habitats, including dense to sparse persistent piñon-juniper woodland (Johnson et al. 2014, 2017b; Petersen et al. 2014) and juniper-dominated savanna (Petersen et al. 2014). Compared to random sites on the landscape at the nesting colony scale, a study in New Mexico found colonies more likely to occur on gradual slopes, with a low heat load, in large patches of dense piñon-juniper habitat (Johnson et al. 2017b). Jays nest in larger than average trees within persistent piñon-juniper woodlands in areas of relatively high canopy cover (Johnson et al. 2014, 2015) and high tree density (e.g., up to 2,725 tree per acre, 1,102 trees her hectare) (Johnson et al. 2018a). Large trees with dense crowns, but not the largest emergent trees, appear to be favored as nest trees (Wiggins 2005, Johnson et al. 2014, 2015). Larger trees also produce more nuts (Parmenter et al. 2018). Johnson and Sadoti (2019) also found that tree height and diameter, stem density, and canopy cover within 5.5 yards (5 meters) were predictive of nest location in nest models at four study sites and nine nesting colonies. An assessment of model transferability between nesting sites indicated that the application of information from one nesting area to the management of another may be effective but can also result in significant loss of nesting habitat; hence, there is apparently no one-size-fits-all habitat management prescription for Pinyon Jays (Johnson and Sadoti 2019).

Pinyon Jays in New Mexico use lower-elevation piñon-juniper savanna, shrubland, and grassland habitats in the nonbreeding season (Johnson et al. 2014). Cache sites are variable, including open areas of juniper savanna or previously burned areas (Johnson et al. 2010) and dense piñon woodland (Johnson and Smith 2006).

Great Basin

In the Great Basin region of Nevada and southern Idaho, Pinyon Jays are most likely to occur in the lower-to-middle elevation portions of the piñon-juniper zone (Figures 21 and 22) (J. Boone and E. Ammon, unpublished data). They tend to cache in flatter areas where canopy cover is low and where there is pronounced interspersion of woodlands and adjoining shrublands (Phase I), and they sometimes cache in pure sagebrush up to four miles (6.4 kilometers) from a woodland edge. They typically forage within 437 yards (400 meters) of the woodland-sagebrush ecotone during the nesting and fall seasons. Nest colony sites tend to have somewhat denser tree cover (typically Phase II) than caching sites (J. Boone and E. Ammon, unpublished data). Roost sites are found in relatively high-density stands, usually within ~550 yards (500 meters) of the nesting colony. Denser woodland interiors (Phase III) at higher elevations tend to be avoided for most daily activities, with the possible exception of roosting (J. Boone and E. Ammon, unpublished data).

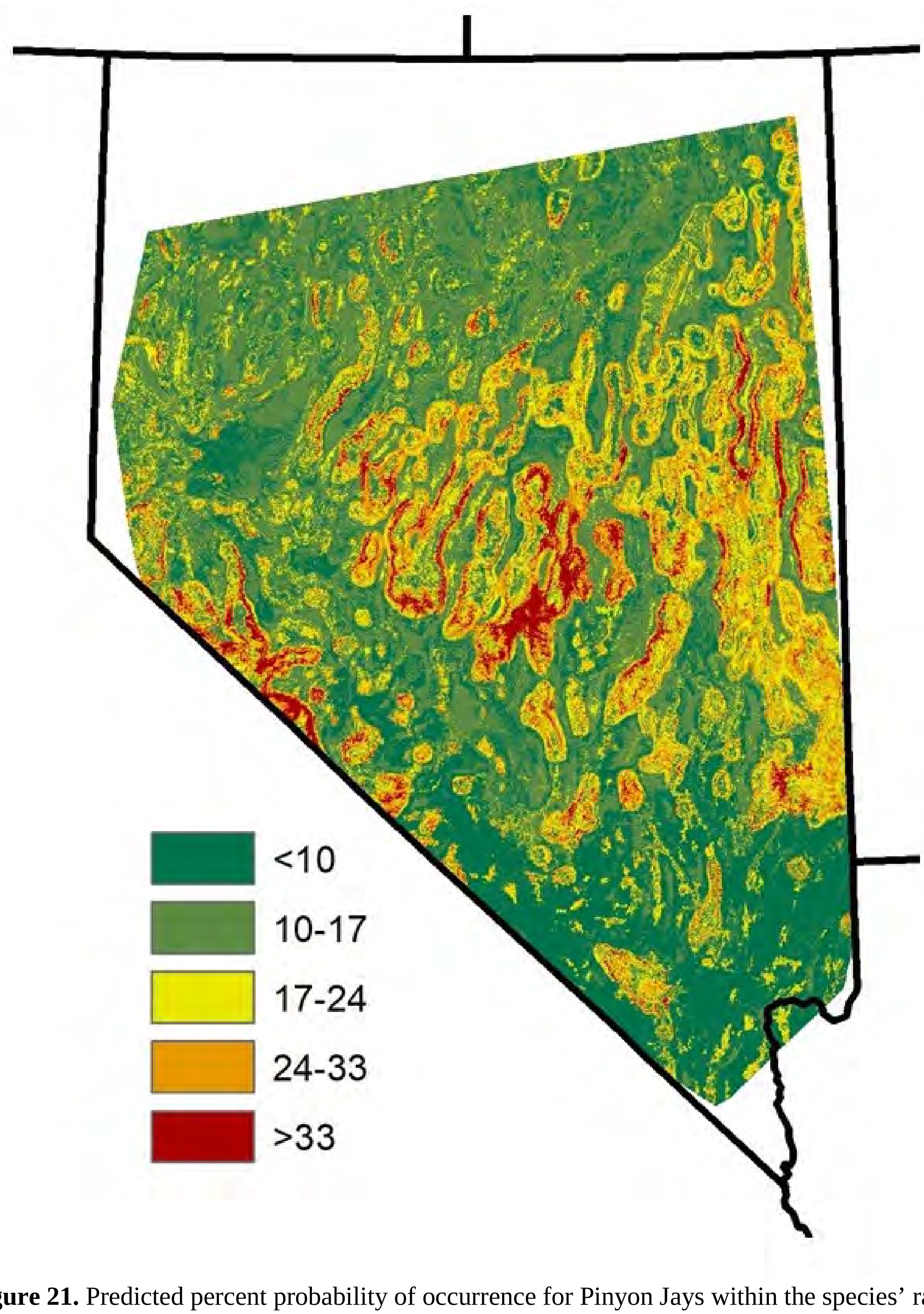

Figure 21. Predicted percent probability of occurrence for Pinyon Jays within the species' range, based on random forest tree regression analysis of Nevada Bird Count data (J. Boone and E. Ammon, unpublished data). The model predicts highest occurrence probability at lower elevations of the mountain ranges along the woodland-shrubland ecotone. Map courtesy of Great Basin Bird Observatory.

Figure 22. Finer-scale depiction of predicted percent probability of occurrence for Pinyon Jays from Figure 21 within a representative section of central Nevada based on random forest tree regression analysis of Nevada Bird Count data (J. Boone and E. Ammon, unpublished data). Deeper reddish shading indicates higher probability of occurrence. This figure highlights Pinyon Jay preference for lower elevation piñon-juniper woodlands that are adjacent to and transitioning into sagebrush shrubland. Map courtesy of Great Basin Bird Observatory.

Other Regions

Outside of the range of piñon pine, Pinyon Jays are usually found in low-elevation pine-juniper woodlands or open pine woodlands with less juniper. In many of these areas, there is considerable interspersed grassland or shrub-steppe where Pinyon Jays forage and cache nuts. A nesting colony site in Carbon County, Montana was dominated by Utah juniper (*J. osteosperma*), with a very low density of limber pine, and extensive bare ground (Figure 23; J. Marks, pers. comm.). Recent nesting in South Dakota has been concentrated at low elevations of the southwestern Black Hills in dry, sparse ponderosa pine woods and scrub habitat with interspersed grassland (Drilling et al. 2018). Silcock and Jorgenson (2018) suggest jays use ponderosa pine in western Nebraska. In California, Pinyon Jays use Jeffrey pine woodlands (Grenfell and Laudenslayer 1983), while in Oregon they occupy juniper and ponderosa pine transition habitats (Marshall et al. 2003).

In Colorado, nesting is primarily restricted to piñon-juniper woodlands, but adults feeding fledglings have also been observed in ponderosa pine, riparian and shrubland habitats (Wickersham 2016). In southwestern Colorado, jays were not observed in extensive ponderosa pine forests (Wickersham 2016). In 2019, Pinyon Jay nests were found primarily in junipers within moderately dense to sparse piñon-juniper woodland/shrub areas (L. Rossi, unpublished data).

In southeastern Idaho, Brody (1992) found nesting colonies in woodlands consisting solely of junipers, with no piñon pines present (n = 64 nests). Another flock nested in a mixed site with both piñon and junipers, though 12 of 13 nests were placed in junipers.

Figure 23. Utah juniper dominated nesting site in the Bighorn Canyon National Recreation Area, southeastern Carbon County, Montana. Photo by Jeffrey Marks.

Chapter 3. Causes of Population Declines: Historical and Current Threats

Overview

The causes of Pinyon Jay population declines are poorly understood. Several causal factors have been hypothesized, and these factors could interact, vary spatially within the species' range, and may have varied temporally over recent decades and centuries. In this section, we describe some of the processes that could contribute to Pinyon Jay declines, but we emphasize that additional investigation is needed to understand which of these potential threats are most important, and how they function and interact in different portions of the species' range.

Changes in Habitat Extent and Vegetation Structure

In some regions and during some periods, significant areas of piñon-juniper woodland have been removed by humans for a variety of reasons (see below). In other regions and at other times, the extent of piñon-juniper woodlands is thought to have increased compared to the pre-settlement period, along with the changes to the properties of those woodlands, including tree density and age structure. Fire suppression, land use and climate change may also have altered habitat extent and structure in potentially important ways. Some or all of these factors could also have affected piñon nut productivity, but this question is largely unexplored. Complicating matters, there is uncertainty about the "normal" historical reference condition of woodlands used by Pinyon Jays, making it difficult to define and identify undesirable "departure" conditions.

In the Great Basin, large scale clearing of piñon-juniper woodlands began as early as the Nevada silver mining boom of 1859–1880 to provide cooking and heating fuel and material for fencing and other construction. Similar clearing occurred more broadly across the western United States to support mining activities and to create rangeland for livestock (Morris and Rowe 2014). At roughly the same time, a period of woodland expansion peaked during 1880–1920, which coincided with a relatively mild and wet climate, the introduction of livestock, and reduction of fire (Miller et al. 2008, 2019). Whether this expansion was a response to clearing activities (Lanner 1981) versus an independent process is unclear. Regardless, widespread down- and up-slope expansion and infilling of western juniper and piñon-juniper woodlands occurred in the Great Basin, sometimes culminating in a closed or nearly-closed canopy (Bradley and Fleischman 2008, Friggens et al. 2012, Morris and Rowe 2014, Miller et al. 2019). The extent, timing, and rate of expansion have been highly variable at the local scale, and often related to land use history, soil type, and climate (Gedney et al. 1999, Morris and Rowe 2014). Baker and Shinneman (2004) and Shinneman and Baker (2009) suggest that increasing tree density is probably not a result of fire suppression, but rather driven by climate, grazing, and long-rotation high-severity fires. Miller et al. (2019) note that the aforementioned causes of expansion and infilling are not well understood and there is no scientific consensus on the relative importance of each of these variables. Some researchers and managers have considered this expansion and infill dynamic to be a problematic departure condition that occurred at a landscape scale (Miller et al. references, Chamber et al. 2019), but others have suggested that expansion and contraction patterns have varied significantly at the local scale, and that the overall dynamic at the landscape scale may fall within the normal range of historical variability (Lanner 1981, Sallach 1986, Belsky 1996, Manier et al. 2005, Miller et al. 2008, Romme et al. 2009). Miller et al. (2019) suggests that increasing atmospheric carbon dioxide levels could be an important factor driving current woodland expansion.

Contemporary Habitat Dynamics and Vegetation Management Activities

From 1950 to the late 1990s, piñon-juniper expansion appears to have decreased considerably and may have ceased in some areas, possibly due to a prolonged drought across most of the piñon-juniper range, with regional exceptions (Miller et al. 2008, 2019; Sankey and Germino 2008; Bradley 2010). This general climate pattern is expected to continue (Thompson et al. 1998, Cole et al. 2008, McDowell et al. 2016). Concurrently, piñon-juniper woodlands have also been removed or thinned over the last 70 years by multiple management agencies and private landowners using primarily mechanical and also herbicide treatments. The reasons for these treatments include the following:

1) **Creating rangeland for livestock**: From 1950–1964, the U.S. Forest Service used the method called “chaining” to clear millions of acres of piñon woodlands to create pasture for cattle grazing (Lanner 1981). Many of these woodlands have regenerated and now support dense stands of young piñon or junipers (Romme et al. 2009). In Arizona, approximately 1.2 million acres (485,000 hectares) were cleared between 1950 and 1964 (Arnold et al. 1964) with the rationale that piñon-juniper had invaded historical grassland and shrub-steppe habitat, a hypothesis that has been challenged (Lanner 1981).
2) **Habitat enhancement**: Removing and thinning piñon-juniper woodlands to increase habitat suitability for focal game species (e.g., mule deer, pronghorn, elk), increase forage production, and improve watershed conditions became common in the 1950s–1970s (Johnson 1967, Terrel and Spillet 1975, Ffolliott and Stropki 2008). Starting in the 1970s, a focus on game species management continued (Gottfried and Severson 1994, Arizona Game and Fish Department 2014, Kramer et al. 2015), but there was also attention directed to other species of conservation concern across much of the Pinyon Jay’s range (Gottfried and Severson 1994, Morris and Rowe 2014). The most notable and widespread example of this newer management practice is removal of woodlands (mostly at their lower elevation boundary) to maintain or create additional sagebrush habitat for Greater Sage-Grouse in the Great Basin. Sage-grouse numbers have declined in the West, and significant conservation and recovery efforts, including complete removal of pines and junipers within sagebrush (*Artemisia* spp.) communities, is one of the primary conservation strategies to restore habitat and promote species recovery (Baruch-Mordo et

al. 2013, NRCS 2015, Chambers et al. 2017, Donnelly et al. 2017). From 2010 to 2017, private landowners and partners treated over 617,000 acres (250,000 hectares) of conifers through the Natural Resource Conservation Service's (NRCS) Sage Grouse Initiative (NRCS, unpublished data, Maestas et al. unpublished data). Similarly, over 494,211 acres (200,000 hectare) have been treated in Utah through the Watershed Restoration Initiative (Chambers et al. 2017).

3) **Fuels reduction and fire prevention**: Piñon-juniper woodlands may be thinned or cleared to slow movement of potential wildfires and/or create fire breaks (Schwilk et al. 2009, Miller et al. 2019), especially in the Southwest. Thinning is also implemented to improve biodiversity and ecological conditions within the woodland matrix (Bombaci and Pejchar 2016, Bombaci et al. 2017, Holmes et al. 2017), and to increase piñon pine health and drought resistance via reduction in conspecific competition. These assumptions have not been thoroughly tested, and existing data do not consistently support the ideas that thinning enhances biodiversity (Bombaci and Pejchar 2016, Bombaci et al. 2017) or piñon health (Clifford et al. 2008, Holmes et al. 2017, Morillas et al. 2017).

The effects of thinning treatments on Pinyon Jays have been studied, but little information is available about the effects of woodland removal, especially in the Great Basin. A recent review by Bombaci and Pejchar (2016) reported that although woodland thinning had non-significant impacts to most wildlife species, the majority of detected negative responses involved woodland birds. At a more local scale, one study found thinning treatments that reduced canopy cover from 36% to 5% reduced local-level occupancy by Pinyon Jays in treated areas in the Southwest (44–190 acres [18–77 hectares], Magee et al. 2019). Another southwestern study found that Pinyon Jays stopped nesting within parts of a known colony site after the colony site was significantly thinned (87% reduction of trees per acre, specifically 1,893 to 248 trees per acre [766 to 100 trees per hectare]). However, a few birds nested (with unknown reproductive success) in untreated woodlands immediately adjacent to the treated area, suggesting fidelity to the traditional site (Johnson et al. 2018b). These findings suggest that shifting nesting sites to an adjacent untreated area depends on the availability of potentially suitable habitat, which cannot be assumed. Other studies appear to confirm that Pinyon Jays may be sensitive to habitat "quality". For example, Pinyon Jays appeared to abandon colony sites when tree vigor declined in association with low winter precipitation (Johnson et al. 2017c).

The cumulative effects of multiple woodland treatments on Pinyon Jays, especially at the landscape scale, have not been studied. Treatment planning is becoming more nuanced, and now considers ecological site potential, phases of woodland succession, and ecosystem resilience to treatments (disturbance) and resistance to invasive plants (Tausch et al. 2009, Miller at el. 2014); so opportunities may exist to incorporate measures for Pinyon Jay conservation.

Climate Effects on Habitat

The effects of climate change on piñon-juniper woodlands may include large-scale increased mortality rates of piñon pines (Breshears et al. 2005, 2008; Mueller, et al. 2005; Shaw et al. 2005; Clifford et al. 2008, 2013; Greenwood and Weisberg 2008; Adams et al. 2009; Romme et al. 2009; Meddens et al. 2015; Flake and Weisberg 2018; Friggens et al. 2018), significant reductions in canopy cover (Clifford et al. 2011), declines in piñon nut production (Redmond et al. 2012, Wion et al. 2019), and reductions in piñon tree vigor (Johnson et al. 2017c). Prolonged drought appears to facilitate outbreaks of Ips beetles (*Ips confusus*) causing mortality for both *P. edulis* and *P. monophylla* (Shaw et al. 2005, Clifford et al. 2008). Larger, older piñons, which generally produce the majority of piñon nut mast, are typically more susceptible to mortality by Ips beetles (Shaw et al. 2005, Clifford et al. 2008), but all tree sizes may be affected (Mueller et al. 2005, Shaw et al. 2005, Wiggins 2005, Clifford et al. 2008, Greenwood and Weisberg 2008). Various climate models predict distributional changes of piñon-juniper woodlands (Thompson et al. 1998; Rehfeldt et al. 2006, 2012; Cole et al. 2008; Rondeau et al. 2017) and widespread piñon and juniper mortality across the southwestern U.S. (Rehfeldt et al. 2006, 2012; McDowell et al. 2016). Indirect impacts of climate change could include increased incidence and severity of wildfire (Floyd et al. 2004, Miller et al. 2019) and insect outbreaks (Mopper and Whitham 1992, Romme et al. 2009, Gaylord et al 2013). Meddens et al. (2015) summarize studies assessing the effects of drought, tree density, elevation, beetle outbreaks, and their possible interactions on piñon pine mortality. Miller et al. (2019) summarizes effects of a changing climate and potential changes to piñon-juniper woodlands. Although most of the predicted effects of climate change on piñon-juniper woodlands are negative, the severity will likely vary regionally, and the overall impacts on Pinyon Jays remain to be further explored.

Other Threats

Energy infrastructure development in piñon-juniper woodlands could be detrimental to local Pinyon Jay populations either through direct habitat loss or indirect impacts such as disturbance via traffic or noise (Kleist et al. 2018). Commercial piñon nut collection may also affect Pinyon Jays, owing to continued high demand, large economic value, and reduced availability of piñon nuts. Collection methods may damage trees and disturb the soils and hydrology if heavy machinery is used. The decline of insect populations (Collen et al. 2012, Dirzo et al. 2014) may also be a threat; further research is needed to determine which insects consumed by Pinyon Jays may be declining.

Chapter 4. Research Needs

Overview

The majority of research on Pinyon Jays has been conducted in the southern and western portions of their range, which coincide with core population centers of the species (Figures 2 and 4, Table 1). Social behavior has been thoroughly studied in a suburban population near Flagstaff, Arizona (Marzluff and Balda 1992, Balda 2002) and this work still provides most of the knowledge regarding the natural history of Pinyon Jays. It may, however, not be representative of Pinyon Jays across their range because the data are from a single population in a possibly-atypical suburban locality (Marzluff and Balda 1992, Balda 2002). Recent studies in New Mexico (Johnson et al. 2014, 2015, 2016, 2017a, 2017b, 2018a, 2018b) have modeled Pinyon Jay habitat use at the nest, colony, and landscape scales. In Nevada, Boone et al. (2018, and unpublished data) have studied Pinyon Jay habitat use, and characterized landscape use in species distribution modeling and home range mapping. Much remains to be studied about home ranges, nesting colonies, specific habitat requirements during nesting and other life stages, and other features of Pinyon Jay natural history across the majority of the species' geographic distribution. Studies that incorporate measures of Pinyon Jay productivity, non-breeding season survival, recruitment, and other demographic factors may shed light on the specific life cycle phases that are the strongest drivers of population declines. In addition, studies are needed to determine habitat and landscape factors driving habitat suitability at the home range scale, including: piñon nut productivity and distribution; the extent, structure, density, and understory of woodlands at the home range scale; and the differences between occupied and unoccupied woodlands. Because this species' range includes several ecoregions, geographically specific information is necessary to develop appropriate conservation and management strategies for the Pinyon Jay.

Specific Research Needs

Significant additional information is needed to effectively manage Pinyon Jays. These research needs are listed below in five categories, each with various subcategories. This presentation order does not represent a prioritization or reflect the relative importance of each topic. We also note where relevant information has already been collected using the heading "Current Knowledge".

Pinyon Jay Distribution, Abundance, and Population Trends

The overall Pinyon Jay breeding range has been fairly well delineated (Figures 2 and 4); however, finer-grained location data are still very limited, and increased survey coverage and development of standardized protocols will increase our knowledge and understanding of this species' local distribution, abundance, population trends, and habitat use and associations.

Specific research needs are:

a. Document locations of flocks, home ranges, and nesting colonies across the Pinyon Jay's range. Baseline information on Pinyon Jay local and regional distribution and populations, including locations of breeding colonies, home ranges, and population estimates, are needed across most of the range. It would also be useful to add data from parts of the Pinyon Jay range that occur away from piñon pines. **Current knowledge:** Home ranges and/or nesting colonies have been primarily located or mapped using VHF radio-tracked birds in New Mexico (Southern Rockies/Colorado Plateau, BCR 16) (Johnson et al. 2014, 2016, 2017a), the mountains of western and central Nevada and southern Idaho (Great Basin, BCR 9, see Figure 4) (J. Boone and E. Ammon, unpublished data), and Flagstaff, Arizona (Sierra Madre Occidental, BCR 34) (Marzluff and Balda 1992). Recently, successful documentation of home ranges, cache sites, roost sites, and nesting colonies was completed without radio-telemetry through direct observation and delineation of Pinyon Jay activity centers and movements (J. Boone and E. Ammon, unpublished data).

b. Monitor Pinyon Jay nesting colonies to assess stability in population size over time. By monitoring known nesting colonies over multiple years, the stability of flock size can be determined, along with nest colony site fidelity. **Current knowledge:** Nesting colonies have been located, primarily in New Mexico, Nevada, and Arizona (BCRs 9, 16, 34); some locations have been monitored over multiple years (see Balda 2002, Johnson et al. references).

c. Develop and implement standardized survey protocol to monitor Pinyon Jays across their range. A robust, standardized and repeatable survey protocol is needed in order to collect statistically rigorous data to estimate abundance and population trends at different spatial scales. **Current knowledge:** Peterson et al. (2014) provide a non-statistical monitoring protocol to find and monitor nesting colonies. A statistically robust breeding season survey was developed in Colorado and Utah in 2019. This survey could serve as a basis for a protocol that could be used across the range of the Pinyon Jay, while allowing for modifications of scale and other considerations (S. Somershoe, pers. obs.).

d. Determine causes of local/regional increases or decreases in Pinyon Jay populations. According to the BBS trend map for Pinyon Jay, populations appear to be increasing or decreasing significantly in different portions of the range (Figure 3). Additional monitoring data are needed in these areas to assess and refine trend estimates identified by BBS. Therefore, it would be informative to identify some core populations across the range, including suburban populations, and conduct an integrated trend analysis using BBS, IMBCR, eBird, and Christmas Bird Count (CBC) data, along with other relevant research. With trends identified, potential causes of trend direction and magnitude could be investigated analytically. **Current knowledge:** General summaries of BBS data (Sauer et al. 2017).

Pinyon Jay Habitat Use and Requirements

Little is known about how Pinyon Jays use different woodland structures throughout the year, how this use varies regionally, and what specific habitat or landscape features jays select for. Data from a limited number of local and regional studies may not be applicable outside a given region or BCR, and geographically specific information is required to develop effective conservation actions for the species.

Specific research needs are:

a. **Assess and quantify habitat structure, composition, and piñon nut availability within Pinyon Jay home ranges.** Available information suggests that habitat associations may vary regionally. Further work is needed to identify range wide or regional patterns of habitat use. Piñon nut availability could be a critical covariate of Pinyon Jay occupancy and should be included in data collection whenever possible. **Current knowledge:** Habitat structure and piñon nut production have been assessed primarily in home ranges in New Mexico (BCR16) (Johnson et al. 2014, 2015, 2017b; Johnson and Sadoti 2019), western and central Nevada (BCR 9) (J. Boone and E. Ammon, unpublished data), and southern Idaho (BCR 9) (Brody 1992).

b. **Assess habitat structure used by Pinyon Jays during specific parts of the daily and annual cycle.** Habitat used by Pinyon Jays for different parts of their daily cycles (e.g., nesting, foraging, caching, and roosting) and annual cycles should be characterized and compared. Further distinctions in habitat use and movements could be made between birds in breeding condition (e.g., males with cloacal protuberance present) and birds in non-breeding condition (e.g., immature birds and non-breeding adults), if these designations can be made when birds are captured. **Current knowledge**: Habitat use has been primarily assessed in New Mexico (BCR 16) (Johnson et al. 2014, 2015, 2017b, 2018a; Johnson and Sadoti 2019) and southern Idaho (BCR 9) (Brody 1992), and through the use of VHF radio telemetry in central Nevada (BCR 9) (J. Boone, unpublished data).

c. **Assess Pinyon Jay responses to vegetation management within home ranges.** Jay responses (e.g., occupancy, abundance or density, nest success, productivity, survival) to vegetation management activities at various locations and temporal scales (short- vs. long-term, 0-3 years vs. 10+ years) need to be documented across the range. Through collaborations with natural resource managers, opportunities may exist to design thinning, complete tree removal, or herbicide treatments to accomplish not only their primary objectives, but simultaneously investigate Pinyon Jay responses. This could include designing treatments with different levels of retained woodland cover (e.g., canopy cover) to assess jay response and determine critical thresholds to minimize negative impacts to jays. **Current knowledge:** Pinyon Jay response to management has been assessed in one study in central Colorado (BCR 16) (Magee et al. 2019) and at a single nesting site in New Mexico (BCR 16) (Johnson et al. 2018b).

d. Investigate Pinyon Jay responses to disturbances. Very little is known about how sensitive Pinyon Jays are to physical disturbances associated with management and multiple-use activities, such as infrastructure development, infrastructure operation, recreation, and noise. Clarifying these issues, especially with regard to nest colony disturbances that might affect nest success, is important. This will facilitate the development of clear and regionally-specific guidelines (including non-disturbance buffers) for management and other activities to minimize or avoid negative impacts to Pinyon Jays. **Current knowledge**: The limited guidance recommends maintenance of a 0.6 mile (1 kilometer) undisturbed buffer around Pinyon Jay nest colonies when planning energy develop projects, OHV trails, or road building, especially when there is potential for significant noise disturbance or vehicular traffic associated with developments (Wiggins 2005, Johnson et al. 2013, Kleist et al. 2018).

Pinyon Jay Nesting Biology

With the exception of studies by R. Balda and students in the 1980s in Flagstaff, Arizona, little information exists about nest success, productivity, adult and juvenile survival, and other associated demographic parameters across most of the range. More importantly, few studies have related habitat covariates to reproductive success and current information may not be applicable to a broader geographic region, specifically regions and/or BCRs.

Specific research needs are:

a. Conduct research on Pinyon Jay nesting biology, productivity, and other demographic parameters. Studies to assess nesting success, productivity, and site fidelity are needed, as basic nesting demographics are largely unknown. Additional largely unstudied population parameters critical to understanding declines include adult and post-fledging juvenile survival, and causes of predation. The degree to which Pinyon Jays have a strict or approximate fidelity to nesting colony sites over multiple years is also unknown (see item d., below). **Current knowledge:** Nesting demographic data are largely limited to New Mexico (BCR 16) (Johnson et al. references in literature cited) and Flagstaff, Arizona (BCR 34) (Balda 2002). Survivorship has only been assessed in Flagstaff, Arizona (BCR 34) (Balda 2002).

b. Assess environmental and vegetation structure characteristics that may influence Pinyon Jay nest colony and nest site selection. The environmental and vegetation structure attributes that may influence colony site and nest site selection remain to be determined. Candidate factors include structural properties of colony sites or nest trees, thermal properties, local piñon nut productivity, and distance to nut producing trees. Documenting shifts in colony location may also help to define suitable Pinyon Jay nesting habitat. **Current knowledge:** Unknown except for studies in New Mexico (BCR 16) (Johnson et al. 2014, 2015, 2016, 2017c, 2018b; Johnson and Sadoti 2019) and Nevada (BCR 9) (J. Boone and E. Ammon, unpublished data).

c. Investigate relationships between Pinyon Jay reproductive success and habitat and landscape covariates. Nest success could be related to specific habitat covariates at the colony and/or nest level, including distance to piñon nut sources and caches, size of piñon mast crops, woodland type and density, elevation, etc. Additionally, consider landscape-level covariates such as distance to water sources, various types of development (e.g., energy development and roads), and other land cover types such as residential and agricultural. **Current knowledge:** Assessments have been conducted in New Mexico (BCR 16) (Johnson et al. 2017a, 2018a, 2019), southern Idaho (BCR 9) (Brody 1992), and Flagstaff, Arizona (BCR 34) (Balda 2002).

d. Assess movement of Pinyon Jay nesting colonies. Pinyon Jays may sometimes shift location of nesting colonies between years. There is a need to understand causes of colony shift and the ability of a flock to move a colony site or home range in response to habitat changes or loss (e.g. fire, vegetation management, etc.). **Current knowledge:** In northern Arizona, one flock initiated nesting at 24 different sites over 12 years of observation (BCR 34) (Marzluff and Balda 1992). A nesting colony in New Mexico shifted location 550 and 1640 yards (500 and 1500 meters) when piñon tree condition declined (BCR 16) (Johnson et al. 2017c). At another New Mexico site, jays avoided nesting in treated areas within the boundaries of a traditional colony site after a treatment was implemented (Johnson et al. 2018b). A Nevada study found that three colonies shifted their colony site by as much as 550 yards (500 meters) without the presence of treatments at or near the colony site (BCR 9) (J. Boone and E. Ammon, unpublished data).

Piñon Pine Biology and Woodland Dynamics

Extensive research has been conducted on piñon pines and piñon-juniper woodlands, but limited information is available on how temperature, precipitation, changing climate, tree density, tree age, and other variables can affect tree mortality rates and mast production. Obtaining this information in a robust and regionally-specific manner may require long-term studies, but these are essential to better understand the dynamics of woodland ecology, effects to Pinyon Jays, and how to effectively manage woodlands for wildlife and improved ecological health.

Specific research needs are:

a. **Assess woodland attributes that influence tree vigor, survival, and piñon nut production.** Basic research on the microhabitat requirements of piñon pine**,** factors affecting piñon nut productivity, and tree survival is needed to manage Pinyon Jay habitats given their dependence on piñon pine health and piñon nut production. **Current knowledge:** Johnson et al. (2017c) found piñon tree vigor in New Mexico was negatively associated with increased tree size and density. Flake and Weisburg (2018) assessed how various environmental factors are related to piñon pine mortality in central Nevada (BCR 9). Meddens et al. (2015) summarize literature on the causes of piñon pine mortality and how they relate to variables such as tree density and elevation.

b. **Assess weather and climate attributes that affect annual piñon nut production and tree vigor.** Characterizing the climate, microclimate, and weather attributes that lead to nut production in non-mast and mast years will allow for better management of potentially critical pine stands in the overall landscape. **Current knowledge:** Zlotin and Parmenter (2008) and Parmenter et al. (2018) reported on a multi-decade study on weather variables and piñon mast production in New Mexico (BCR 16). They found that *P. edulis* mast production is negatively associated with spring and summer temperatures of the current year. While the current year's precipitation did not appear to affect production, total annual precipitation was positively correlated to production with a lag time of two years (during primordia formation) and one year (during strobili/green cone development). In semi-arid woodlands, these authors predicted that frequent drought and high heat will result in more years with low or no mast production. Results may not be applicable for other *Pinus* spp. or other BCRs. Breshears et al. (2005) (BCRs 9 and 16), Shaw et al. (2005) (BCR 16), and Greenwood and Weisberg (2008) (BCR 9) summarize impacts of drought on piñon pine mortality. Meddens et al. (2015) summarize literature on the causes of piñon pine mortality, including climatic variables. Johnson et al. (2017c) found piñon tree vigor declined with reduced winter precipitation (BCR 16).

c. **Develop a spatially-explicit model to predict changes/shifts in piñon-juniper woodlands over time.** Predictive models of temporal woodland dynamics as a function of climate change and other factors would facilitate identification of the most critical Pinyon Jay habitat in each state, with emphasis on designating occupied and climate-resilient areas as the highest priority for conservation (Rondeau et al. 2017, Friggens et al. 2018). These models would ideally predict how many acres will move into and out of "prime piñon nut productivity" over a defined time period, and could incorporate information about management and tree removal projects to obtain a more complete perspective of landscape change. **Current knowledge:** Rondeau et al. (2017) have developed models for the Colorado portion of the Colorado Plateau (BCR 16). Several climate projection models exist for the Southwest.

Effects of Piñon-Juniper Woodland Management

Although current paradigms for "best woodland management practices" and "forest health" could translate into benefits for Pinyon Jays, this conjecture has not been explicitly studied and evaluated. Determining how current vegetation management practices and goals relate to Pinyon Jay conservation needs, including health and productivity of piñon pines, is a high priority, and a prerequisite to inform future management designed to benefit or minimize negative impacts to Pinyon Jays.

Specific research needs are:

a. **Investigate the effects of woodland thinning on tree health and survival**. Woodland thinning treatments using mechanical approaches and herbicide application occur mostly, but not exclusively, in the Southwest region of the Pinyon Jay range. However, the effects of these management practices on mast production and health of remaining trees are largely unexplored. **Current knowledge**: Instead of improving tree health or survival within the stand by reducing intraspecific competition, limited information suggests under some circumstances, thinning can be detrimental due to increased evapotranspiration (Greenwood and Weisberg 2007, Clifford et al. 2008, Morillas et al. 2017). There is also anecdotal evidence that piñon pine trees retained after woodland thinning may be highly vulnerable to drought-related bark beetle mortality (Coop and Magee 2016). Limited research suggests the survival of remaining trees after thinning may depend upon the type of piñon-juniper woodland; wooded shrublands, and perhaps piñon-juniper savannas, may respond positively to thinning, while persistent piñon-juniper woodlands may respond negatively (Roundy et al. 2014, Morillas et al. 2017, Flake and Weisberg 2018). Further, effects of thinning could vary with pre-treatment tree density and age, soil type, and final tree density (e.g., canopy cover, basal area). Thinned piñon pines may be more vulnerable to drought conditions than undisturbed stands in central New Mexico (BCR 16) (Morillas et al. (2017).

b. **Examine the comparative effects of different vegetation management techniques and designs on Pinyon Jays, tree health, and pine nut productivity.** In some cases, vegetation management goals can be accomplished through multiple methods. For instance, woodland stands can be removed by prescribed fire, mastication, or lop-and-scatter cutting. A comparative assessment of impacts on tree health, productivity and habitat quality, along with Pinyon Jay response, could be used to identify the best management option for a given situation. In order to quantify habitat and jay response, monitoring should be conducted in association with management projects. **Current**

knowledge: Lop-and-scatter may be preferable to other slash management methods by reducing erosion, protecting the health of the remaining trees, and promoting healthy invertebrate populations (Stoddard et al. 2008). Prescribed surface fire is not recommended as a follow-up to thinning within persistent piñon-juniper woodlands and wooded shrublands because these ecosystems did not evolve with frequent, low-intensity surface fires (Baker and Shinneman 2004, Romme et al. 2009). Targeting thinning in areas of natural die-offs (from drought, beetle kill, or other factors) may promote or retain a diverse woodland mosaic that better mimics how historical fire would have affected the landscape in these woodland types (Romme et al. 2009).

c. Incorporate expanding knowledge about Pinyon Jays and habitat use into existing guidelines for vegetation management. As the new information outlined in this chapter is obtained, it will be advantageous to actively look for opportunities to integrate these insights into existing vegetation management guidelines. This will ensure that appropriate knowledge is considered with designing and implementing vegetation management for a variety of compatible goals.

Chapter 5. Techniques for Studying Pinyon Jays

Pinyon Jay populations can be difficult to study owing to their flocking behavior, large daily movements within the flocks' home ranges, and clumped distribution across the larger landscape. Nesting birds are secretive and generally difficult to detect, even when a surveyor is walking through a nesting colony. Additionally, standardized surveys of breeding birds (i.e., BBS and IMBCR) typically occur two to three months after peak Pinyon Jay nesting. Although the BBS likely provides reliable population trends because it is a long-term, landscape-level monitoring program, annual monitoring of nesting birds at colony sites may be more effective for local trend assessments (Petersen et al. 2014).

Pinyon Jays do not use suitable habitats evenly across the landscape or within a home range, and this incomplete use presents difficulties in quantifying and predicting occupancy. Unlike typical passerines that have small and well-defined breeding territories that allow for effective monitoring, Pinyon Jays routinely use resources located miles from their nesting colonies, a life style more similar to raptor species. As a result, a different approach is necessary to characterize habitat use and to quantify response to local habitat treatments.

Radio-telemetry offers a potentially useful method for studying habitat use, but it presents challenges. Because Pinyon Jays are too small for satellite tags, traditional VHF telemetry has been the only viable option. However, the daily and periodic movements of flocks can exceed the range of the relatively small radio tags suitable for Pinyon Jays, particularly in rugged, wooded terrain, necessitating time-consuming efforts to relocate a flock that has moved away from the known portions of its home range. Capturing Pinyon Jays from a typical flock also requires considerable investment of time and effort. Several approaches have been employed, with walk-in traps using high-quality bait (piñon nuts, sunflower seeds, peanuts), feeder stations with mist nets, and call-playback being the most successful (Johnson et al. 2014, 2015; E. Ammon, pers. comm.). Several weeks may be required for Pinyon Jays to begin using feeders. Spatial and temporal factors in placement of feeders affects success in attracting jays, and traps near nesting colonies or habitually used water sources have been most successful (K. Johnson pers. comm.). Once birds are coming to feeders regularly, they can be captured relatively easily in modified Australian crow traps or walk-in pigeon traps, using piñon nuts as bait. Details of trapping, radio attachment, and tracking are available (Johnson and Smith 2008; Johnson et al. 2010, 2014, 2015). In Nevada and southern Idaho, jays have been captured and radio-tagged at well-established feeder stations with a walk-in trap operated by observers hidden in a blind at least 40 feet (12 meters) from the trap. In years with large piñon nut crops, however, baiting the birds may be unsuccessful. For radio transmitter attachment, a tail-mounted 1.5 gram transmitter (2.5 to 3 month battery life) has worked best (E. Ammon, pers. comm.).

Also, Pinyon Jay flock size can be estimated when the flock is observed going into or coming out of their nightly communal roost site (an entire flock roosts communally except during nesting when the females roost on the nest; E. Ammon, pers. comm.). Generally, a combination of direct observation assisted by telemetry works best to identify specific locations used by Pinyon Jays for various activities, such as caching, foraging, loafing, nesting, and roosting. However, it is critical that observers maintain sufficient distance from a flock to avoid altering their behaviors, a significant risk given that flocks post sentinel birds to keep the flock informed about any threats. Alternately, a skilled observer can, over time, become sufficiently familiar with flock movements to gather accurate locational and activity information from observation alone, without the assistance of radio-telemetered birds (J. Boone and E. Ammon, unpublished data).

Statistically robust point count surveys can be conducted during the breeding season to detect Pinyon Jays, and follow up can lead to discovery of nesting colonies. Peterson et al. (2014) provide recommendations on conducting field surveys and interpreting jay behavior. A minimum of three surveys of a given site are recommended in order to increase detection probabilities (Peterson et al. 2014). A lack of detections does not necessarily mean that the site is outside of a flock's home range, as it may be used during a different part of the annual or daily cycle. Using field methods recommended by Peterson et al. (2014), a grid-based sampling design using point counts for conducting standardized, repeatable surveys was developed and implemented in Colorado and Utah in 2019 (S. Somershoe, R. Norvell, S. Gibson, L. Rossi, pers. comm.). Based on these pilot projects, the Pinyon Jay Working Group plans to develop a scalable, standardized survey method and create a range wide survey data network for the species.

Investigations of Pinyon Jay habitat use and responses to management should consider multiple scales (e.g., Johnson et al. 2016), given flocks typically move within their home ranges, and home ranges may shift. Landscape-scale assessment of habitat use, including the identification and location of key resources utilized, typically relies on landscape-scale data such as remote sensing imagery and GIS, while characterizations of the nesting colony or nest site are best done at smaller scales. Colony-scale habitat modeling can employ mid-scale measures, including geographic and on-the-ground variables (Johnson et al. 2016, J. Boone and E. Ammon, unpublished data), while nest-site analysis typically focuses on data at the nest tree or small plot scale, including tree size and density (Johnson et al. 2014, 2015; Johnson and Sadoti 2019). On-the-ground management occurs at variable scales, ranging from 200 to 30,000 acres (80–12,140 hectares) treatments, treatments with different management objectives may occur in the same general area or adjacent to one another. These scales should also be considered when studying Pinyon Jays in areas where vegetation treatments are occurring.

Because Pinyon Jays have a complex life history and are a challenging species to study, we recommend contacting seasoned Pinyon Jay researchers willing to share their experience and knowledge and provide guidance in developing an effective research project. We recommend contacting the lead author on this strategy and other contributors to this document to identify these researchers.

Chapter 6. Management Considerations

Overview

Currently, our understanding of how land and vegetation management may affect Pinyon Jay populations is not sufficient to support comprehensive recommendations for Pinyon Jay conservation. However, the limited data that are available provide a basis for the management considerations outlined in this section. In presenting these considerations, we recognize there is a wide variety of objectives and priorities that managers must balance in designing and implementing their woodland treatment projects in areas used by Pinyon Jays. Most often, these are either: a) thinning or herbicide treatments in the Southwest for fuels management or wildlife habitat, or b) sagebrush restoration treatments in the Great Basin to create or improve habitat for priority species such as Greater Sage-Grouse and other sagebrush obligate species. The information presented below is a resource for managers who wish to adopt measures that reduce the likelihood of negative impacts to Pinyon Jays. We do not have sufficient knowledge to describe and quantify management actions that would actively improve habitat for Pinyon Jays at this time; rather we focus on minimizing adverse effects when woodland treatments are conducted for other purposes. As new research becomes available, the Working Group plans to update this document with more detailed conservation actions and recommendations that encompass a wider variety of objectives, including Pinyon Jay population recovery and forest health, with improved regional specificity.

Considerations for the Location of Woodland Treatment Projects

Pinyon Jay use of the landscape within a flock's home range is likely to vary across a daily cycle, a seasonal cycle, and possibly across years. Although it is important to model Pinyon Jay habitat and occupancy at multiple scales (Johnson et al. 2014, 2015, 2016, 2017), standardized, site-specific assessments to determine whether Pinyon Jays are present in a proposed treatment area and how they are using the habitat may be especially useful in informing management at the treatment scale. These assessments can include surveys to locate nests during the breeding season (e.g.; "clearance surveys", as typically used for Migratory Bird Treaty Act [MBTA] compliance) or other surveys to identify whether Pinyon Jays use the area for other activities, such as caching or foraging.

Vegetation thinning within a traditional nesting colony site can cause the birds to abandon treated areas (Johnson et al. 2018b) or alter the suitability of the habitat (Johnson et al. 2019), and complete removal of the colony site removes nesting substrate altogether. Therefore, avoiding treatment of nest colony sites is recommended. Pinyon Jays often use the same general area each year for nesting, with colony site shifts of up to 550 yards (~500 meters) between years (Marzluff and Balda 1992, Johnson et al. 2017c, J. Boone and E. Ammon, pers. comm.). Thus, a buffer of undisturbed habitat of 550 yards (~500 meters) around a known breeding colony is recommended and allows for typical colony shifts across years (Johnson et al. 2017c).

The Working Group website (https://www.partnersinflight.org/resources/pinyon-jay-working-group/) provides information about how to conduct clearance surveys for Pinyon Jays. Similar guidance is available from Natural Heritage New Mexico (Petersen et al. 2014) and Great Basin Bird Observatory (www.gbbo.org). Additional information and assistance with conducting more generalized occupancy surveys that incorporate caching and foraging habitat use can be obtained by contacting partners in the Working Group with Pinyon Jay survey experience.

Considerations for the Timing of Woodland Treatment Projects

It is preferable to conduct treatments outside of the Pinyon Jay breeding season, especially if an active nest colony is within the area where a treatment must occur. Pinyon Jays tend to breed earlier than most passerine land birds. Data from Nevada (J. Boone and E. Ammon, unpublished data), Utah, and Colorado (R. Norvell and L. Rossi, unpublished data) indicate that nesting activity in these regions begins in late February or early March and ends in late May. Studies in New Mexico suggest that nesting phenology may occur later than in more northerly regions, except in the case of a mast crop the previous fall (Johnson et al. 2014, 2015, 2017c); however, Pinyon Jays in New Mexico still breed earlier than most piñon-juniper bird species. The specific timing of the breeding season may vary from year-to-year depending on the severity of the preceding winter and on the availability and abundance of nuts cached during the previous fall (Balda 2002).

Documenting the Effects of Woodland Treatments on Pinyon Jays

If a woodland treatment is conducted in an area that is occupied by Pinyon Jays, conducting systematic, standardized pre- and post-treatment monitoring of Pinyon Jay habitat use and vegetation parameters will help to determine the effects of the treatment on Pinyon Jays. If treatments are conducted within a known nesting colony, post-treatment monitoring should be completed to determine if the colony moves and if the new habitat has similar characteristics to the original colony location. Pre- and post-treatment monitoring of vegetation measures (e.g., tree size, tree density, canopy cover, tree vigor, and piñon nut productivity) is necessary for understanding the impacts of thinning treatments on Pinyon Jays (Johnson et al. 2018a, 2018b, 2019).

Post-treatment monitoring could be conducted by the agency performing the treatment, but may be facilitated by collaboration between managers and Pinyon Jay researchers. We strongly encourage this collaboration to take advantage of the information gathering opportunities presented by ongoing woodland treatments and among researchers to compare and contrast regionally-specific findings to strengthen our overall knowledge of Pinyon Jay conservation needs.

Considerations for Implementation of Woodland Treatments

If a woodland treatment is conducted in an area that is, or could be, occupied by Pinyon Jays, particularly during the breeding season, the following considerations and implementation parameters may help to reduce negative impacts to Pinyon Jays. The information presented below is organized according to regions and by woodland treatment types and objectives. The bulk of this material is derived from research conducted in the Southwest (mostly New Mexico); less information is available about the Great Basin and other regions occupied by Pinyon Jays. Some of the information shown below may be applicable across the broader Pinyon Jay range, but this remains to be determined.

Southwest Region - Woodland Thinning and Herbicide Treatments

The information in this section is informed primarily by research conducted in New Mexico and to a lesser extent, Arizona. In this region, most woodland treatments involve thinning, with a limited occurrence of herbicide treatments and large scale woodland removal. The goals of these projects are often fuels reduction, but may also include reduction of juniper to increase grass and forbs for ungulates (i.e., big game) and cattle, management for other wildlife species, and watershed restoration. Treatment plans that include plans for collaboration with Pinyon Jay researchers allow managers to identify whether particular treatment parameters (e.g., different percentages of retained canopy cover and/or tree density) can meet primary management objectives while remaining within the range of suitable nesting, caching, and foraging habitat.

a. Pinyon Jays often use the same general area each year for nesting, with colony site shifts of up to 550 yards (~500 meters) between years (Marzluff and Balda 1992, Johnson et al. 2017c, J. Boone and E. Ammon, pers. comm.). Thus, if a buffer area of 550 yard (~500 meters) around a known breeding colony remains undisturbed, it allows for colony shifts across years (Johnson et al. 2017c).

b. If thinning in persistent piñon-juniper woodlands or wooded shrublands, creating a patchy-clumpy mosaic of suitable nesting habitat within the treated area, as opposed to evenly spaced thinning, allows for shifting colony locations. This treatment pattern also better mimics how fire would have impacted the landscape in persistent piñon-juniper woodlands and wooded shrublands (Romme et al. 2009). Provided that sufficient suitable habitat is retained throughout the treatment area, retaining as many larger trees as possible within areas of higher tree density and/or higher canopy cover will likely conserve more Pinyon Jay nesting habitat than thinning all size/age classes to a uniform density. For example, a guideline is to retain trees within the 25–75% quartiles of these measures at the target site or similar sites (Johnson and Sadoti 2019).

c. If using herbicide treatments in juniper or piñon-juniper woodlands, a mosaic of treated and untreated areas better mimics the natural landscape setting than large monomorphic treatment areas. If juniper is the target species, avoiding treating areas that contain piñon trees avoids compromising piñon nut production.

d. As piñon nut production is critical to Pinyon Jays, mast-producing trees are particularly valuable. Therefore, thinning may be particularly detrimental in known productive piñon woodlands containing old or very old trees, likely of prime piñon nut producing age, and trees of moderate age to support future nut production (Parmenter et al. 2018, Crist et al. 2019). Parmenter et al. (2018) identified age and size of *P. edulis* as an indicator of probable nut productivity: little to no productivity (<3.5 inches or <9 centimeter diameter at breast height [dbh]); medium productivity (3.5–5.9 inches or 9–15 centimeter dbh); and high productivity (>6.3 inches or >16 centimeter dbh) (Zlotin and Parmenter 2008). Old and very old trees likely produce more mast due to their large size and larger number of fruiting branches (Parmenter et al. 2018).

e. South- and west-facing slopes, as opposed to north- and east-facing slopes, may be more suitable for treatments avoiding impacts to Pinyon Jays because north- and east-facing slopes are projected to better survive future climate change scenarios (Rondeau et al. 2017). Sites with lower heat load (north-facing) are also favored for Pinyon Jay colony sites (Johnson et al. 2017b).

f. Large and densely crowned trees are particularly valuable for Pinyon Jay nesting, particularly when they occur within areas of higher tree density (Wiggins 2005, Johnson et al. 2014, 2015, Johnson and Sadoti 2019).

g. Retaining and promoting native grasses, forbs, and shrubs in the understory may increase available invertebrate prey for Pinyon Jays (Bombaci and Pejchar 2016).

h. If cheatgrass and other invasive annual plants are in the vicinity of a planned treatment area, aggressive invasive species control in post-treatment management plans decreases fire risk and fire intensity (Chambers et al. 2017), thus lowering the risk to stands important to Pinyon Jays. A minimum of 20% perennial native herbaceous cover in a treatment area is recommended for preventing a large increase in cheatgrass and other annual invasive plants post-treatment (Chambers et al. 2017).

Great Basin Region - Sagebrush Restoration and Thinning Treatments

In the Great Basin, the dominant woodland treatment involves complete tree removal of generally lower-elevation patches of woodland to reclaim or improve shrubland habitat to benefit Greater Sage-Grouse and other sagebrush obligate species. Compared to the Southwest, there is less information about Pinyon Jay habitat use in the Great Basin upon which to base suggested treatment parameters.

a. Pinyon Jays often use the same general area each year for nesting, with colony site shifts of up to 550 yards (~500 meters) between years (Marzluff and Balda 1992, Johnson et al. 2017c, J. Boone and E. Ammon, pers. comm.). Thus, if a buffer area of 550 yard (~500 meters) around a known breeding colony remains undisturbed, it allows for colony shifts across years (Johnson et al. 2017c).

b. Pinyon Jays appear to use Phase I woodlands most frequently, Phase II woodlands at an intermediate level, and Phase III woodlands rarely (J. Boone and E. Ammon, unpublished data). Therefore, preferentially treating denser woodlands as opposed to less-dense woodlands is recommended. We recognize that Phase III woodlands are rarely the target of typical woodland treatments in this region at the current time for several reasons, including their low potential to revert to high-quality shrubland habitat after complete removal.

c. Treatments that create "feathered" transition zones of approximately 270–550 yards (250–500 meters) between the treated area and untreated piñon-juniper woodlands more accurately mimic the transitional zones that Pinyon Jays use most often in the Great Basin. More specifically, a woodland / shrubland ecotone that is irregular, diverse, and gradual is likely to be more favorable for Pinyon Jays than a linear ecotone with sharp transition from open shrubland to dense woodland (Crist et al. 2019, J. Boone and E. Ammon, unpublished data).

d. If using herbicide treatments in juniper or piñon-juniper woodlands, a mosaic of treated and untreated areas more accurately mimics the natural variation in woodland cover. If juniper is the target species, treating areas with piñon trees will compromise piñon nut production.

e. If cheatgrass and other invasive annual plants are in the vicinity of a planned treatment area, aggressive invasive species control in post-treatment management plans decreases fire risk and fire intensity (Chambers et al. 2017), thus lowering the risk to stands important to Pinyon Jays. A minimum of 20% perennial native herbaceous cover in a treatment area is recommended for preventing a large increase in cheatgrass and other annual invasive plants post-treatment (Chambers et al. 2017).

Considerations for Region Wide Fuels Reduction and Fire Management Projects

Reduction of fuels and fire risk is a common reason for woodland thinning or prescribed fire treatments in some regions. For the purposes of this document, we assume that treatments that successfully reproduce the woodland conditions associated with historical natural fire patterns may help minimize negative impacts for Pinyon Jays, but considerable research is still needed to confirm this assumption.

The historical role of fire in piñon-juniper woodlands is not fully understood, but Romme et al. (2009) provide a comprehensive assessment of the frequency and significance of fire in each of the three piñon-juniper vegetation types. In persistent piñon-juniper woodlands and wooded shrublands, low-intensity, frequent surface fire generally did not occur due to the limited ground fuels; instead, these habitats typically experienced stand-replacing crown fires at approximately 300–400 year intervals (Baker and Shinneman 2004, Romme et al. 2009, Friggens et al. 2018, Miller et al. 2019). As a result, management actions designed to replicate the effects of frequent, low-intensity fires, such as thinning and prescribed burning may not achieve ecological restoration goals. Fire disturbance regimes are not well understood in piñon-juniper savannas. Although the higher grass component in savannas would suggest these habitats supported low-severity fires, there is little empirical information to support this supposition (Romme et al. 2009). Because of these complexities and information gaps, there are no one-size-fits-all recommendations for fuels reduction and fire management treatments. If fuels treatments are planned, the following guidance may help to minimize negative impacts to Pinyon Jays:

a. If thinning in persistent piñon-juniper woodlands or wooded shrublands, creating a patchy-clumpy mosaic of suitable nesting habitat within the treated area, as opposed to evenly spaced thinning, allows for shifting colony locations. Further, thin and/or retain Phase I and/or II woodlands rather than closed canopy woodlands (Phase III) to provide woodland conditions preferred by Pinyon Jays. This treatment pattern also better mimics how fire would have impacted the landscape in persistent piñon-juniper woodlands and wooded shrublands (Romme et al. 2009). Provided that sufficient suitable habitat is retained throughout the treatment area, retaining as many larger trees as possible within areas of higher tree density and/or higher canopy cover will likely conserve more Pinyon Jay nesting habitat than thinning all size/age classes to a uniform density. For example, a guideline is to retain trees within the 25–75% quartiles of these measures at the target site or similar sites (Johnson and Sadoti 2019).

b. As piñon nut production is critical to Pinyon Jays, mast-producing trees are particularly valuable. Therefore, thinning may be particularly detrimental in known productive piñon woodlands containing old or very old trees, likely of prime piñon nut producing age, and trees of moderate age to support future nut production (Parmenter et al. 2018, Crist et al. 2019). Parmenter et al. (2018) identified age and size of *P. edulis* as an indicator of probable nut productivity: little to no productivity (<3.5 inches or <9 centimeter diameter at breast height [dbh]); medium productivity (3.5–5.9 inches or 9–15 centimeter dbh); and high productivity (>6.3 inches or >16 centimeter dbh) (Zlotin and Parmenter 2008). Old and very old trees likely produce more mast due to their large size and larger number of fruiting branches (Parmenter et al. 2018).

c. Limited research suggests retention of 15–35% canopy cover may be sufficient to stop many, but not all, piñon-juniper crown fires during extreme fire behavior (Coop and Magee 2016). Retained canopy cover of <15–35% may render a site unsuitable for Pinyon Jays for nesting habitat but may still be suitable for foraging and caching. However, variation, perhaps even large variation, in habitat use/preference could occur in some regions and vegetation types and warrants further research. If the entire project area to be thinned for fuels reduction has a pre-treatment canopy cover of less than or within 15–35%, evaluate whether fuels reduction is necessary. If the entire area to be thinned for fuels reduction has a pre-treatment canopy cover of greater than 15–35%, target retention of approximately 15–35% canopy cover in thinned patches.

d. South- and west-facing slopes, as opposed to north- and east-facing slopes, may be more suitable for treatments avoiding impacts to Pinyon Jays because north- and east-facing slopes are projected to better survive future climate change scenarios (Rondeau et al. 2017). Sites with lower heat load (north-facing) are also favored for Pinyon Jay colony sites (Johnson et al. 2017b).

e. Large and densely crowned trees are particularly valuable for Pinyon Jay nesting, particularly when they occur within areas of higher tree density (Wiggins 2005, Johnson et al. 2014, 2015, Johnson and Sadoti 2019).

f. If cheatgrass and other invasive annual plants are in the vicinity of a planned treatment area, aggressive invasive species control in post-treatment management plans decreases fire risk and fire intensity (Chambers et al. 2017), thus lowering the risk to stands important to Pinyon Jays. A minimum of 20% perennial native herbaceous cover in a treatment area is recommended for preventing a large increase in cheatgrass and other annual invasive plants post-treatment (Chambers et al. 2017).

Considerations for Infrastructure Development

Relatively little is known about how nearby disturbances and infrastructure affect Pinyon Jays. The limited guidance available suggests maintaining a 0.6 mile (1 km) undisturbed buffer around Pinyon Jay nest colonies when planning energy development projects, OHV trails, or road building, especially when there is potential for significant noise disturbance or vehicular traffic associated with these developments (Wiggins 2005, Johnson et al. 2013, Kleist et al. 2018).

Chapter 7. Future Work to Advance the Conservation Strategy

This conservation strategy presents an assessment of the state of current knowledge about Pinyon Jays, identifies research and information needs, and describes various management considerations. In addition to information provided in this strategy, the Working Group has identified several projects, resources and actions needed to further facilitate planning, coordination, and data management to support Pinyon Jay conservation. These are:

a. Determine extent and acreage of piñon-juniper treatments that have occurred and are planned to assess cumulative impacts throughout the range of the Pinyon Jay.

b. Develop regional- and habitat-specific recommended management considerations.

c. Finalize and make available online standardized protocols for conducting robust surveys to locate and monitor Pinyon Jays, locate and identify nests and nesting colonies, and assess vegetation and habitat on the Pinyon Jay Working Group website.
https://www.partnersinflight.org/resources/pinyon-jay-working-group/

d. Promote and develop use of the Avian Knowledge Network (AKN) to host data from all parties conducting jay surveys.
http://avianknowledge.net/

e. Develop a strategy to present information on the current status of piñon-juniper woodlands, including the end of the expansion era, and begin to change the paradigm and negative image and value of piñon-juniper woodlands across the Intermountain West. Evaluate utility and consider development of a conservation road show about piñon-juniper woodland systems and conservation issues.

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