



# Bird Community Monitoring for Grand Canyon National Park

## *2011 Summary Report*

Natural Resource Data Series NPS/SCPN/NRDS—2013/465



**ON THE COVER**

Black-throated gray warbler (*Dendroica nigrescens*)  
Photography by: Ned Harris

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# 1 Introduction

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a strong scientific foundation for making decisions and working with other agencies and the public for the protection of park ecosystems. The goal of bird community monitoring is to provide status and trends data on bird communities in several predominant habitats where integrated upland or riparian vegetation monitoring is also occurring.

For Grand Canyon National Park (GRCA), Southern Colorado Plateau Network (SCPN) and park staff selected the mixed conifer forest and pinyon-juniper woodland as important ecosystems for vegetation and bird community monitoring. Occurring at elevations above 2500 m, mixed conifer forest occupied approximately 17,600 hectares on the North Rim of GRCA in the year 2000. Since then, large, stand-replacing fires (fig. 1) have reduced the amount of mature mixed conifer forest. This system is represented by a few extensive areas on the Colorado Plateau, but climate change and altered fire regimes threaten its integrity. GRCA's pinyon-juniper woodlands are located on the South Rim of Grand Canyon; this ecological site represents large areas of the park and the surrounding landscape.

In 2011, through a Colorado Plateau Cooperative Ecosystems Study Unit agreement with SCPN, we continued monitoring the upland bird community of the target mixed conifer habitat in GRCA, which had been initiated in 2007. We also initiated monitoring in the target pinyon-juniper habitat. In this report, we document monitoring activities in the 2011 field season and summarize the data that were collected.

## 2 Methods

### 2.1 Sampling frame

A sampling frame is the area within which we locate our sites, and hence, the area to which statistical inferences can be made based on monitoring data. The sampling frames for vegetation and bird community monitoring at GRCA mixed conifer were derived from the maps of the Loamy Hills Cold and the Loamy Hills ecological sites (see Appendix A of DeCoster et al. 2012). Ecological sites are landscape divisions with characteristic soils, hydrology, plant communities, and disturbance regimes and responses, and are based on soil survey data (Butler et al. 2003).

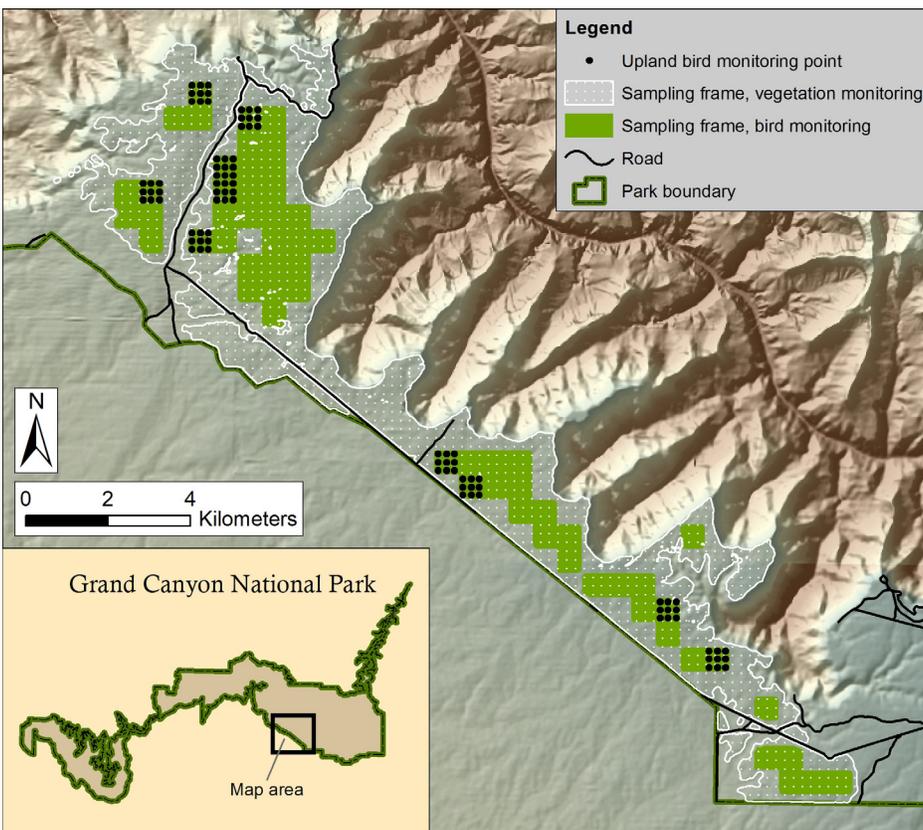
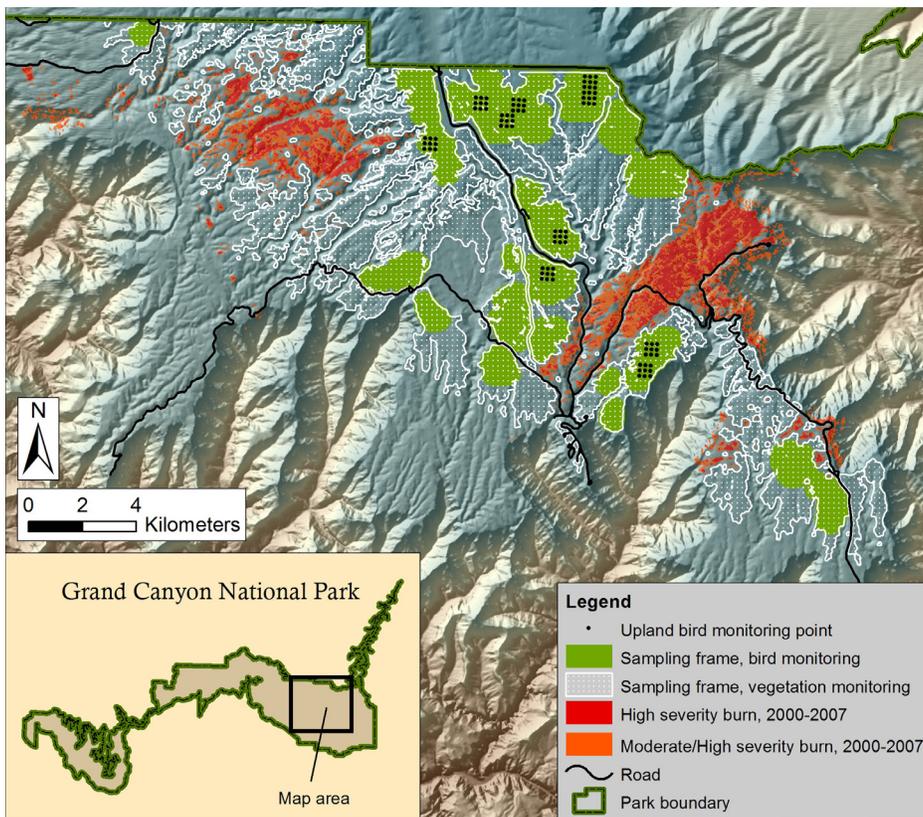
The Loamy Hills Cold and Loamy Hills ecological sites are high elevation areas with mixed conifer and spruce-fir forests. We merged the two ecological sites into one, henceforth referred to as mixed conifer habitat (fig. 1A).

For GRCA pinyon-juniper, we derived the sampling frames for vegetation and bird community monitoring from a map of the Limestone Upland ecological site (see Appendix A of DeCoster et al. 2012). The Limestone Upland ecological site elevation ranges between 5800 to 7300 feet, and is characterized by flat to gently sloping sedimentary rock and pinyon-juniper woodland (fig. 1B).

To complete the mixed conifer and pinyon-juniper bird community monitoring sampling frame, we modified the maps of the sampling frame using Geographical Information System (GIS) technology to eliminate

- areas that were not within the target habitat (roads, buildings, and infrastructure, and elevations below 2500 m)
- areas that were expected to differ substantially from the norm for the target habitat, such as areas that have experienced fire of moderate to high burn severity and mechanically treated areas, because these areas would have increased ecological variation, making it more difficult to detect trends
- areas too small to fit an entire cluster of 9 plots spaced 250 m apart within the target habitat
- areas with slopes  $\geq 30\%$  to prevent erosion from occurring as a result of the field work

When monitoring in large target habitats, such as GRCA mixed conifer forest and pinyon-juniper woodland,



**Figure 1. Top:** Bird monitoring sampling frame of mixed conifer habitat and upland vegetation monitoring sampling frame in Grand Canyon NP. Extent of large, stand-replacing fires is indicated in red and orange. **Bottom:** Bird monitoring sampling frame of pinyon-juniper habitat and upland vegetation monitoring sampling frame in Grand Canyon NP.

we employ a cluster sampling method in which bird sample plots are clustered around a primary sampling unit, so that a cluster of plots can be sampled in a single morning. Primary sampling units are selected in a probabilistic manner from a grid of uniformly-spaced points using Generalized Random-Tessellation Stratified (GRTS) design (Stevens and Olsen 2004).

GRCA staff first reviewed the sampling plots and rejected those plots that landed in the proximity of archeological sites. Next, the bird monitoring crew evaluated the accessibility of each cluster in the field and rejected clusters that were inaccessible. For GRCA mixed conifer, sites were deemed inaccessible if they were greater than two hours of traveling time (by car and foot) from the North Rim’s main entrance. For GRCA pinyon-juniper, sites were deemed inaccessible if they were greater than two hours of traveling time (by car and foot) from camp sites on the adjacent national forest.

The bird monitoring crew then visited and assessed each sampling plot to ensure that (1) it fell within the target habitat, (2) had a slope of less than 30%, and (3) did not contain a major disturbance. Any plots that did not meet these criteria were rejected. For GRCA mixed conifer, ten clusters were selected for monitoring and 20 clusters were rejected. In the pinyon-juniper habitat, we selected ten clusters and rejected ten.

## 2.2 Field methods

We conducted bird sampling at permanent sampling plots, or Variable Circular Plot (VCP) count stations, within mixed conifer and pinyon-juniper habitats at GRCA (fig. 1) over two survey periods. For each habitat, we sampled a total of ten clusters, each containing 9 sampling plots (table 1). A brief description of the field methods we employed is provided here. A more detailed description can be found in Holmes et al. (in preparation).

At each sampling plot, we conducted a VCP count, noting all birds seen or heard during an 8-minute sampling period, regardless of the distance from the observer. We recorded (1) the species, (2) method of detection, (3) gender (if known), and (4) distance from the sampling plot center to the individual bird. Distances were measured to the nearest meter using a laser range finder. During a single morning, three technicians surveying separate groups of sampling plots conducted approximately 9 vcp counts each.

Habitat sampling was conducted on a 50 m radius macroplot centered on a sampling plot, and in four subplots within the macroplot. First, for the macroplot, we estimated and recorded the area occupied by vegetation types and other land-use types. Then, in the four subplots, we recorded tree and snag density and basal area, canopy closure, and foliar vegetation cover by functional group (e.g. forbs, shrubs). We measured basal area using a Cruz-All (a type of angle gauge), and canopy closure using a spherical densiometer. Ocular estimates of foliar cover were made using a modified Braun-Blanquet cover class scale.

**Table 1. Survey periods and sampling effort for mixed conifer and pinyon-juniper bird community monitoring at Grand Canyon NP (GRCA); dates that VCP counts were conducted in GRCA mixed conifer and pinyon-juniper in 2011, and the number of clusters and plots sampled.**

Habitat	Survey period	Dates	Number of clusters	Number VCP counts
Mixed conifer	1	5/20–5/24	10	90
	2	6/16–6/22	10	90
Pinyon-juniper	1	5/6–5/10	10	90
	2	6/4–6/8	10	90

## 2.3 Data summary

### 2.3.1 Variable Circular Plot count data

We summarized the following data for all sample units in each of the target habitats (mixed conifer and pinyon-juniper) at GRCA. The sample unit for bird data is the cluster (which contains nine VCPs).

- Observed species richness (unadjusted for detectability) is the number of species detected within a given area and specified time.
- Mean number of individuals detected for each species is reported as the average number of individuals detected per 8-minute VCP count. To calculate mean number of individuals detected for each species, the data for a given cluster are averaged across the two survey periods, and a mean number of individuals detected per VCP count and standard deviation are calculated. Then the cluster means are used to calculate the mean number of individuals detected and standard deviation for the target habitat. Detectability-based density estimates are not reported here, but they will be derived for multi-year trend reports.
- Frequency is the proportion of plots or clusters in which each species was detected. To calculate species frequency, we first calculated the proportion of plots in each cluster where the species was detected. For example, if Cordilleran flycatchers were detected on 5 of the 9 plots in a cluster, (during one or both visits to that plot), the plot frequency for that cluster is 0.55 (55%). We then calculate the mean proportion of plots occupied across the ten clusters for the target habitat. Cluster frequency is calculated as the proportion of clusters in which the species was detected in at least one plot.

### 2.3.2 Habitat data

Habitat data will be used with bird sampling data to examine bird-habitat relationships. For GRCA, habitat data

were collected within a circular 0.8 ha macroplot which contained four subplots and was centered on each bird sampling plot. Data were summarized at three levels: the macroplot, the cluster, and the target habitat. The means and standard deviations for the target habitats were calculated from the cluster data.

*Vegetation cover types.* We classified vegetation into six cover types for GRCA mixed conifer habitat, and five cover types for pinyon-juniper as shown in Table 2. For each vegetation cover type we calculated

- mean percent cover, by calculating the mean cover per cluster for each vegetation or other landcover type (using the cover class midpoints), and then calculating the mean of the cluster means to determine the mean and standard deviation for the target habitat
- frequency, by calculating the number of macroplots within a cluster where a specific cover type had been recorded as a proportion of the nine macroplots per cluster, then calculating the mean and standard deviation of the proportion of macroplots per cluster for the target habitat

*Sapling density.* For sapling trees, we calculated density (stems/ha) for each species and size class, and for all species within a size class. Mean density was calculated for the macroplot, then for the cluster, and finally a mean species density and standard deviation were calculated for the target habitat.

*Basal area.* We calculated tree basal area (m<sup>2</sup>/ha) for each species, with one exception. In 2011, we “lumped” spruce species into one category (*Picea* spp.) that included *Picea engelmannii* (Engelmann spruce), *Picea pungens* (blue spruce), and trees that we were only able to identify to genus (i.e., *Picea*). We calculated snag basal area for all snags. Mean basal area was calculated for the macroplot, then for the cluster, and finally a mean basal area and standard deviation were calculated for the target habitat.

**Table 2. Vegetation cover types in mixed conifer and pinyon-juniper habitats at Grand Canyon NP.**

Habitat	Vegetation cover type	Description
Mixed conifer	Mixed conifer forest (target habitat)	Dominated by various combinations of ponderosa pine ( <i>Pinus ponderosa</i> ), Douglas fir ( <i>Pseudotsuga menziesii</i> ), white fir ( <i>Abies concolor</i> ), blue spruce ( <i>Picea pungens</i> ), southwestern white pine ( <i>Pinus strobiformis</i> ), and sometimes other species. Typically consists of a topographically determined heterogeneous mosaic of patches, some of which are dominated by quaking aspen <sup>a</sup> ( <i>Populus tremuloides</i> ).
	Aspen grove <sup>a</sup>	Dominated by aspen. Typically, aspen groves occur in areas that have been impacted relatively recently by disturbance that removed the tree canopy.
	Ponderosa pine forest	Dominated by ponderosa pine. Occupies the lowest elevation of the montane zone and often contains elements of the pinyon-juniper woodland type.
	Gambel oak shrubland	Dominated by gambel oak ( <i>Quercus gambelii</i> ) and other species, such as mountain mahogany ( <i>Cercocarpus montanus</i> , <i>C. ledifolius</i> ) or serviceberry ( <i>Amelanchier utahensis</i> ); occasionally occurs between the pinyon-juniper woodland and ponderosa pine forest types.
	Montane grassland	Consists of meadows; scattered in valley bottoms and on dry, steep, south-facing slopes in the montane zone.
	Spruce-fir forest	Characterized by Engelmann spruce ( <i>Picea engelmannii</i> ) and subalpine fir ( <i>Abies lasiocarpa</i> ).
Pinyon-juniper	Pinyon-juniper woodland	Overstory comprised of Utah juniper ( <i>Juniperus osteosperma</i> ) and Colorado pinyon ( <i>Pinus edulis</i> ) with an understory comprised of big sagebrush ( <i>Artemisia tridentata</i> ), Stansbury cliffrose ( <i>Pursia stansburiana</i> ), muttongrass ( <i>Poa fendleriana</i> ), and blue gramma ( <i>Bouteloua gracilis</i> ).
	Sagebrush shrubland	Dominated by big sagebrush ( <i>Artemisia tridentata</i> ), with few to no trees.

<sup>a</sup> Although groves of quaking aspen are considered to be part of the mixed conifer vegetation type, we estimated the percent cover of aspen groves separately from mixed conifer.

*Foliar cover of functional groups.* We calculated the mean foliar cover of each functional group for the macroplot (using the cover class midpoints), and for the cluster. The mean and standard deviation were then calculated for the target habitat.

## 3 Results

### 3.1 Mixed conifer habitat

#### 3.1.1 Summary of bird community data

In 2011, we conducted a total of 180 VCP counts in mixed conifer habitat at GRCA and detected 2,282 individuals of 36 species (table 3). The most commonly detected species was the yellow-rumped warbler. This species comprised 23.05% of the total number of individuals detected.

**Table 3. Bird species and number detected during VCP counts in mixed conifer habitat at Grand Canyon NP, 2011. Species are listed in descending order of the total number of individuals detected.**

Common name	Scientific name	Total number of detections	Proportion of all detections (%)
yellow-rumped warbler	<i>Dendroica coronada</i>	526	23.05
ruby-crowned kinglet	<i>Regulus calendula</i>	302	13.23
house wren	<i>Troglodytes aedon</i>	176	7.71
hermit thrush	<i>Catharus guttatus</i>	166	7.27
warbling vireo	<i>Vireo gilvus</i>	130	5.70
violet-green swallow	<i>Tachycineta thalassina</i>	127	5.57
northern flicker	<i>Colaptes auratus</i>	111	4.86
chipping sparrow	<i>Spizella passerina</i>	97	4.25
mountain chickadee	<i>Poecile gambeli</i>	97	4.25
western tanager	<i>Piranga ludoviciana</i>	85	3.72
Williamson's sapsucker	<i>Sphyrapicus thyroideus</i>	72	3.16
pine siskin	<i>Carduelis pinus</i>	62	2.72
western wood-pewee	<i>Contopus sordidulus</i>	56	2.45
dark-eyed junco	<i>Junco hyemalis</i>	52	2.28
black-headed grosbeak	<i>Pheucticus melanocephalus</i>	39	1.71
hairy woodpecker	<i>Picoides villosus</i>	30	1.31
red-breasted nuthatch	<i>Sitta canadensis</i>	30	1.31
Cassin's finch	<i>Carpodacus cassinii</i>	24	1.05
Steller's jay	<i>Cyanocitta stelleri</i>	18	0.79
brown creeper	<i>Certhia americana</i>	10	0.44
downy woodpecker	<i>Picoides pubescens</i>	10	0.44
white-breasted nuthatch	<i>Sitta carolinensis</i>	10	0.44
evening grosbeak	<i>Coccothraustes vespertinus</i>	8	0.35
red-naped sapsucker	<i>Sphyrapicus nuchalis</i>	7	0.31
American three-toed woodpecker	<i>Picoides dorsalis</i>	7	0.31
American robin	<i>Turdus migratorius</i>	6	0.26
western bluebird	<i>Sialia mexicana</i>	5	0.22
broad-tailed hummingbird	<i>Selasphorus platycercus</i>	4	0.18
pygmy nuthatch	<i>Sitta pygmaea</i>	4	0.18
dusky flycatcher	<i>Empidonax oberholseri</i>	3	0.13
red-tailed hawk	<i>Buteo jamaicensis</i>	3	0.13
Grace's warbler	<i>Dendroica graciae</i>	1	0.04
green-tailed towhee	<i>Pipilo chlorurus</i>	1	0.04

**Table 3** *continued*

Common name	Scientific name	Total number of detections	Proportion of all detections (%)
Lewis's woodpecker	<i>Melanerpes lewis</i>	1	0.04
olive-sided flycatcher	<i>Contopus cooperi</i>	1	0.04
Townsend's solitaire	<i>Myadestes townsendi</i>	1	0.04

The mean number of individuals detected per species during a VCP count, the frequency of detections, and the percent of clusters with detections for each species detected in GRCA mixed conifer habitat are presented in Table 4. The yellow-rumped warbler had the highest mean number of individuals, with an average of 2.92 individuals detected during an eight-minute count. Yellow-rumped warblers were also widespread in the target habitat—detected, on average, in 97.78% of the plots in a cluster, and in 100% of the clusters. The hairy woodpecker had a relatively low abundance (0.17 individuals/count), but was fairly widely distributed—detected, on average, on 32.22% of the plots in a cluster, and on 90% of the clusters.

**Table 4. Mean number of individuals detected per species per VCP count, standard deviation (SD), plot frequency, and cluster frequency (% of clusters in which the species was detected) in mixed conifer habitat at Grand Canyon NP, 2011.**

Species	Number of individuals	SD	Plot frequency (%)	Cluster frequency (%)
yellow-rumped warbler	2.92	0.79	97.78	100
ruby-crowned kinglet	1.68	0.64	91.11	100
house wren	0.98	0.37	85.56	100
hermit thrush	0.92	0.30	84.44	100
warbling vireo	0.72	0.31	72.22	100
violet-green swallow	0.71	0.41	51.11	100
northern flicker	0.62	0.28	75.56	100
chipping sparrow	0.54	0.25	72.22	100
mountain chickadee	0.54	0.19	64.44	100
western tanager	0.47	0.49	47.78	90
Williamson's sapsucker	0.40	0.29	50.00	100
pine siskin	0.34	0.19	52.22	100
western wood-pewee	0.31	0.19	48.89	100
dark-eyed junco	0.29	0.08	42.22	100
black-headed grosbeak	0.22	0.20	33.33	90
hairy woodpecker	0.17	0.11	32.22	90
red-breasted nuthatch	0.17	0.19	27.78	70
Cassin's finch	0.13	0.15	15.56	60
Steller's jay	0.10	0.12	16.67	70
brown creeper	0.06	0.07	7.78	50
downy woodpecker	0.06	0.07	11.11	50
white-breasted nuthatch	0.06	0.08	8.89	40
evening grosbeak	0.04	0.08	4.44	30
red-naped sapsucker	0.04	0.05	7.78	40
American three-toed woodpecker	0.04	0.06	7.78	30
American robin	0.03	0.04	6.67	50

**Table 4 continued**

Species	Number of individuals	Standard deviation	Plot frequency (%)	Cluster frequency (%)
western bluebird	0.03	0.05	3.33	30
broad-tailed hummingbird	0.02	0.03	4.44	40
pygmy nuthatch	0.02	0.05	4.44	20
dusky flycatcher	0.02	0.05	3.33	10
red-tailed hawk	0.02	0.04	3.33	20
Grace's warbler	0.01	0.02	1.11	10
green-tailed towhee	0.01	0.02	1.11	10
Lewis's woodpecker	0.01	0.02	1.11	10
olive-sided flycatcher	0.01	0.02	1.11	10
Townsend's solitaire	0.01	0.02	1.11	10

### 3.1.2 Summary of bird habitat data

We found five vegetation cover types (mixed conifer forest, aspen grove, spruce-fir forest, ponderosa pine forest, and montane grassland) in the GRCA mixed conifer sample area (table 5). Mixed conifer forest, the target habitat, was recorded on 81.11% of the macroplots. When we calculated the mean percent cover for each vegetation type, mixed conifer forest was the most common cover type, accounting for, on average, 67.53% of the overall vegetative cover of the macroplots.

**Table 5. Mean cover of vegetation types, standard deviation (SD), and range; and mean frequency within macroplots in a cluster in target mixed conifer habitat in Grand Canyon NP, 2011.**

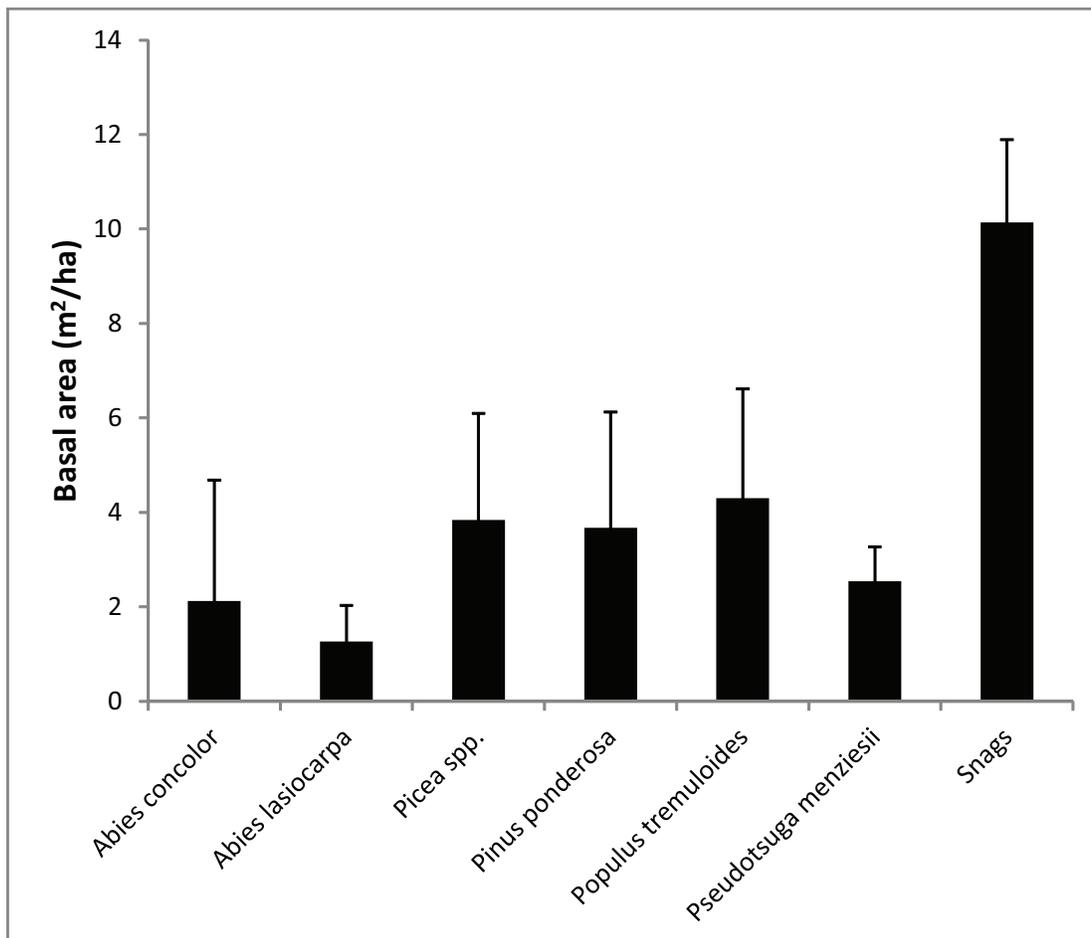
Vegetation or other landcover type	Cover (%)	SD	Range	Frequency (%)
Mixed conifer forest	67.53	18.02	38.89–87.50	81.11
Aspen grove	8.86	10.12	0.00–29.17	18.89
Spruce-fir forest	7.42	10.13	0.00–29.72	12.22
Ponderosa pine forest	3.81	9.29	0.00–29.78	8.89
Montane grassland	0.13	0.27	0.00–0.83	4.44

In Table 6, the abundance of trees is expressed in terms of basal area of overstory trees and sapling density, by species. The abundance of snags is expressed in terms of basal area, recorded for all species combined. Table 6 and Figure 2 illustrate basal area of trees by species and snags. Five tree species and spruce species were recorded on the sampling plots and of them, aspen had the highest basal area (see table 6 for scientific and common names of tree species). Table 6 and figure 3 illustrate the density of sapling trees (less than 10 cm DBH) by species and size class. Aspen dominated both of the sapling classes. The average canopy closure in the mixed conifer habitat was 50.75 % (Standard Deviation = 10.99).

The understory of the mixed conifer habitat at GRCA is mainly comprised of understory trees (less than 1.4 m in height), shrubs, dwarf shrubs, perennial grasses, and forbs (table 7). Of these, the cover of small trees and shrubs is likely to have the most influence on bird community composition. There is considerable variation in the amount of understory tree cover —mean foliar cover for this functional group ranged from 1.04% to 6.93%.

**Table 6. Basal area of overstory trees, by species, and snags, and mean density of saplings by species in mixed conifer habitat in Grand Canyon NP, 2011. Basal area (m<sup>2</sup>/ha) is provided for overstory trees (DBH greater or equal to 10 cm), and density (number of stems/ha) is provided for saplings (<10 cm DBH). Common names are provided for each tree species.**

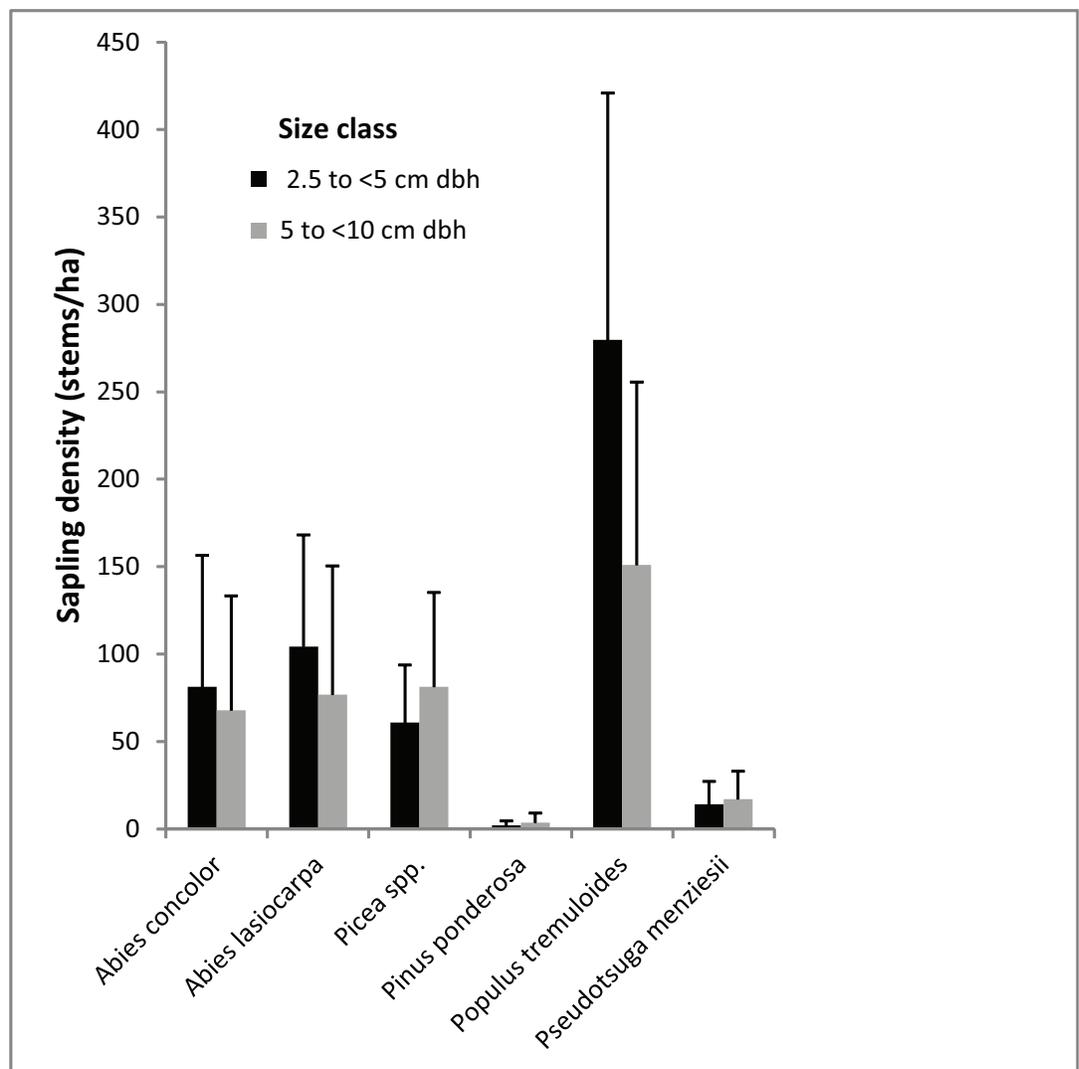
Species	Common name	Basal area (m <sup>2</sup> /ha)	Sapling density by size class	
			2.5 to <5 cm	5 to <10 cm
<i>Populus tremuloides</i>	aspen	4.30	279.76	151.02
<i>Picea</i> spp.	spruce	3.84	60.83	81.35
<i>Pinus ponderosa</i>	ponderosa pine	3.67	2.12	3.54
<i>Pseudotsuga menziesii</i>	Douglas fir	2.54	14.15	16.98
<i>Abies concolor</i>	white fir	2.12	81.35	67.91
<i>Abies lasiocarpa</i>	subalpine fir	1.27	104.33	76.75
All tree species		17.75	542.54	397.53
Snags		10.14		



**Figure 2. Basal area of trees, by species, and snags in mixed conifer habitat in Grand Canyon, NP, 2011. Error bars represent one standard deviation.**

**Table 7. Mean foliar cover, standard deviation (SD), and range of functional groups in target mixed conifer habitat in Grand Canyon, NP, 2011.**

Functional groups	Foliar cover (%)	SD	Range
Understory trees (<1.4 m height)	3.79	1.94	1.04–6.93
Total shrub and herbaceous cover (no trees) <2 m	2.20	1.64	1.11–6.47
Perennial grasses, graminoids	0.70	0.34	0.38–1.43
Annual grasses	0.01	0.01	0.00–0.03
Forbs	0.68	0.63	0.13–2.26
Shrubs, dwarf shrubs, and woody vines	0.82	0.59	0.18–2.04
Cacti, succulents	<0.01	<0.01	0.00–0.01
Standing dead herbaceous	0.81	0.51	0.42–1.85
Woody standing dead	1.08	0.47	0.54–1.97



**Figure 3. Size structure of sapling trees. Mean density (number of stems/ha) of sapling trees in two size classes (2.5 to <5, and 5 to <10 cm DBH) in mixed conifer habitat in Grand Canyon, NP, 2011. Error bars represent one standard deviation.**

## 3.2 Pinyon-juniper habitat

### 3.2.1 Summary of bird community data

In 2011, we conducted a total of 180 VCP counts in pinyon-juniper habitat at GRCA and detected 1,324 individuals of 41 species (table 8). The most commonly detected species was the black-throated gray warbler. This species comprised 22.96% of the total number of individuals detected.

**Table 8. Bird species and number detected during VCP counts in pinyon-juniper habitat at Grand Canyon NP, 2011. Species are listed in descending order of the total number of individuals detected.**

Common name	Scientific name	Total number of detections	Proportion of all detections (%)
black-throated gray warbler	<i>Dendroica nigrescens</i>	304	22.96
gray flycatcher	<i>Empidonax wrightii</i>	152	11.48
juniper titmouse	<i>Baeolophus ridgwayi</i>	125	9.44
pinyon jay	<i>Gymnorhinus cyanocephalus</i>	97	7.33
ash-throated flycatcher	<i>Myiarchus cinerascens</i>	83	6.27
mountain chickadee	<i>Poecile gambeli</i>	81	6.12
white-breasted nuthatch	<i>Sitta carolinensis</i>	64	4.83
chipping sparrow	<i>Spizella passerina</i>	56	4.23
blue-gray gnatcatcher	<i>Polioptila caerulea</i>	52	3.93
Bewick's wren	<i>Thyromanes bewickii</i>	44	3.32
western scrub-jay	<i>Aphelocoma californica</i>	39	2.95
gray vireo	<i>Vireo vicinior</i>	35	2.64
plumbeous vireo	<i>Vireo plumbeus</i>	34	2.57
spotted towhee	<i>Pipilo maculatus</i>	24	1.81
hairy woodpecker	<i>Picoides villosus</i>	20	1.51
western bluebird	<i>Sialia mexicana</i>	19	1.44
Steller's jay	<i>Cyanocitta stelleri</i>	13	0.98
common raven	<i>Corvus corax</i>	13	0.98
northern flicker	<i>Colaptes auratus</i>	11	0.83
bush tit	<i>Psaltriparus minimus</i>	11	0.83
dusky flycatcher	<i>Empidonax oberholseri</i>	8	0.60
western wood-pewee	<i>Contopus sordidulus</i>	5	0.38
mourning dove	<i>Zenaida macroura</i>	5	0.38
broad-tailed hummingbird	<i>Selasphorus platycercus</i>	4	0.30
black-headed grosbeak	<i>Pheucticus melanocephalus</i>	4	0.30
turkey vulture	<i>Cathartes aura</i>	3	0.23
white-throated swift	<i>Aeronautes saxatalis</i>	2	0.15
pine siskin	<i>Carduelis pinus</i>	2	0.15
brown-headed cowbird	<i>Molothrus ater</i>	2	0.15
yellow-rumped warbler	<i>Dendroica coronada</i>	1	0.08
western tanager	<i>Piranga ludoviciana</i>	1	0.08
violet-green swallow	<i>Tachycineta thalassina</i>	1	0.08
Townsend's solitaire	<i>Myadestes townsendi</i>	1	0.08
ruby-crowned kinglet	<i>Regulus calendula</i>	1	0.08

**Table 8 continued**

Common name	Scientific name	Total number of detections	Proportion of all detections (%)
red-breasted nuthatch	<i>Sitta canadensis</i>	1	0.08
pygmy nuthatch	<i>Sitta pygmaea</i>	1	0.08
northern goshawk	<i>Accipiter gentilis</i>	1	0.08
lesser goldfinch	<i>Carduelis psaltria</i>	1	0.08
house finch	<i>Carpodacus mexicanus</i>	1	0.08
black-chinned hummingbird	<i>Archilochus alexandri</i>	1	0.08
barn swallow	<i>Hirundo rustica</i>	1	0.08

The mean number of individuals detected per species during a VCP count, the frequency of detections, and the percent of clusters with detections for each species detected in GRCA pinyon-juniper habitat are presented in Table 9. The black-throated gray warbler had the highest mean number of individuals, with an average of 1.69 individuals detected during an eight-minute count. Black-throated gray warblers were also widespread in the target habitat—detected, on average, in 97.78% of the plots in a cluster, and in 100% of the clusters. The gray vireo had a relatively low abundance (0.19 individuals/count), but was fairly widely distributed—detected, on average, on 33.33% of the plots in a cluster, and on 90% of the clusters.

**Table 9. Mean number of individuals detected per VCP count; standard deviation (SD), mean plot frequency (% plots in a cluster in which the species was detected), and cluster frequency (% of clusters in which the species was detected) in pinyon-juniper habitat at Grand Canyon NP, 2011.**

Species	Number of individuals	SD	Plot frequency (%)	Cluster frequency (%)
black-throated gray warbler	1.69	0.49	97.78	100
gray flycatcher	0.84	0.35	84.44	100
juniper titmouse	0.69	0.17	80.00	100
pinyon jay	0.54	0.46	57.78	100
ash-throated flycatcher	0.46	0.22	58.89	100
mountain chickadee	0.45	0.24	54.44	100
white-breasted nuthatch	0.36	0.20	54.44	90
chipping sparrow	0.31	0.08	48.89	100
blue-gray gnatcatcher	0.29	0.17	38.89	90
Bewick's wren	0.24	0.12	33.33	100
western scrub-jay	0.22	0.17	30.00	100
gray vireo	0.19	0.13	33.33	90
plumbeous vireo	0.19	0.16	30.00	80
spotted towhee	0.13	0.13	21.11	70
hairy woodpecker	0.11	0.11	17.78	80
western bluebird	0.11	0.11	15.56	70
Steller's jay	0.07	0.09	13.33	60
common raven	0.07	0.07	14.44	60
northern flicker	0.06	0.10	11.11	50
bush tit	0.06	0.09	8.89	40
dusky flycatcher	0.04	0.05	8.89	50

**Table 9 continued**

Species	Number of individuals	SD	Plot frequency (%)	Cluster frequency (%)
western wood-pewee	0.03	0.06	5.56	20
mourning dove	0.03	0.06	5.56	20
broad-tailed hummingbird	0.02	0.03	4.44	40
black-headed grosbeak	0.02	0.04	4.44	30
turkey vulture	0.02	0.03	3.33	30
white-throated swift	0.01	0.04	1.11	10
pine siskin	0.01	0.04	2.22	10
brown-headed cowbird	0.01	0.04	1.11	10
yellow-rumped warbler	0.01	0.02	1.11	10
western tanager	0.01	0.02	1.11	10
violet-green swallow	0.01	0.02	1.11	10
Townsend's solitaire	0.01	0.02	1.11	10
ruby-crowned kinglet	0.01	0.02	1.11	10
red-breasted nuthatch	0.01	0.02	1.11	10
pygmy nuthatch	0.01	0.02	1.11	10
northern goshawk	0.01	0.02	1.11	10
lesser goldfinch	0.01	0.02	1.11	10
house finch	0.01	0.02	1.11	10
black-chinned hummingbird	0.01	0.02	1.11	10
barn swallow	0.01	0.02	1.11	10

### 3.2.2 Summary of bird habitat data

We found two vegetation cover types (mesa top pinyon-juniper and mesa top scrubland), and one other landcover type (dry arroyo) in the macroplots in the GRCA pinyon-juniper sample area (table 10). Mesa top pinyon-juniper, the target habitat, was recorded on 98.89% of the macroplots. When we calculated the mean percent cover for each vegetation type, it was the most common cover type, accounting for, on average, 83.53% of the overall vegetative cover of the macroplots.

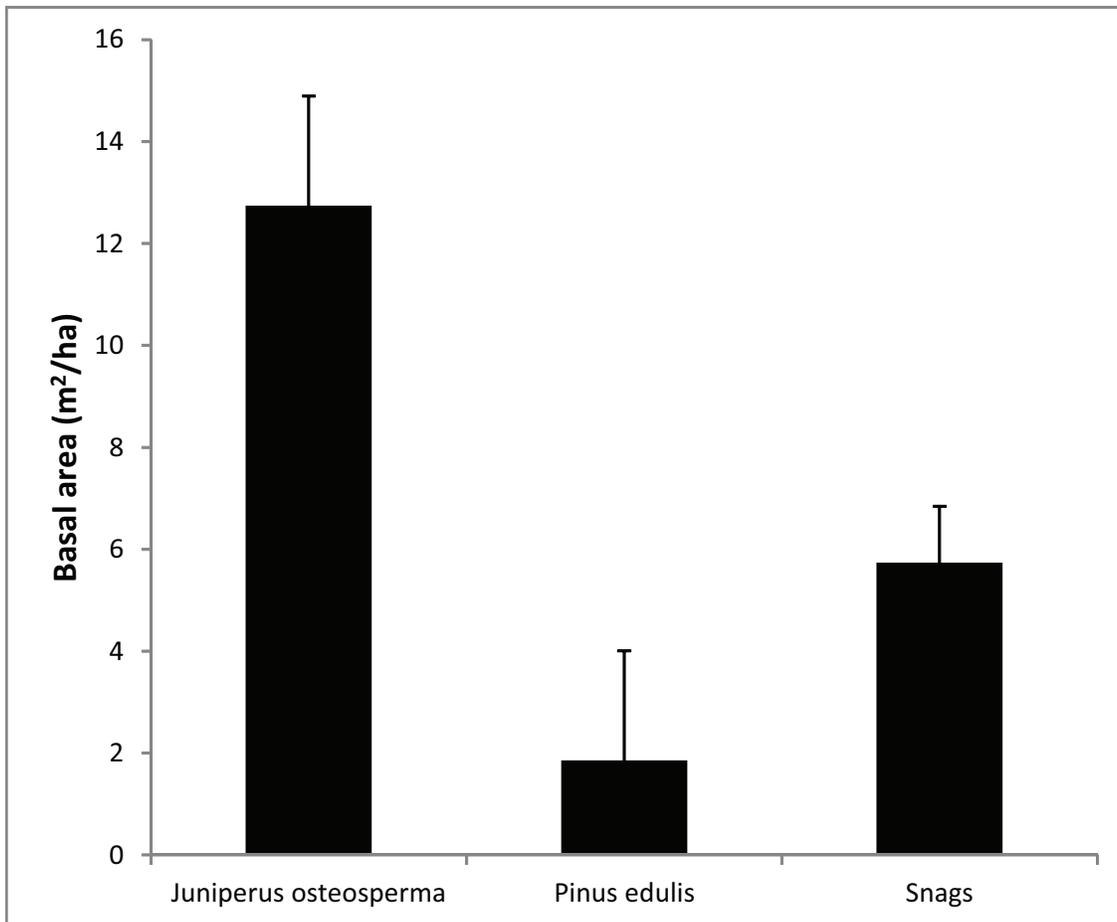
**Table 10. Mean cover of vegetation types, standard deviation (SD), and range; and mean frequency within macroplots in a cluster, in target pinyon-juniper habitat in Grand Canyon NP, 2011.**

Vegetation or other landcover type	Cover (%)	SD	Range	Frequency (%)
Mesa top pinyon-juniper	83.53	4.69	76.39–87.50	98.89
Mesa top scrubland	2.81	4.38	0.00–12.28	15.56
Dry arroyo	0.13	0.25	0.00–0.78	10.00

In Table 11, the abundance of trees is expressed in terms of basal area of overstory trees and sapling densities, by species. The abundance of snags is expressed in terms of basal area, recorded for all species combined. Table 11 and Figure 4 illustrate basal area of trees by species and snags. Two tree species—Utah juniper and two-needle pinyon—were recorded on the sampling plots (see Table 6 for scientific and common names of tree species). The basal area of Utah juniper was considerably higher than that of two-needle pinyon. The average canopy closure in the pinyon-juniper habitat was 32.20 % (Standard Deviation = 4.13).

**Table 11. Basal area (m<sup>2</sup>/ha) of overstory trees (DBH greater or equal to 10 cm), by species, and snags, and mean density (stems/ha) of saplings (<10 cm DBH) by species in pinyon-juniper habitat in Grand Canyon NP, 2011. Common names are provided for each tree species.**

Species	Common name	Basal area (m <sup>2</sup> /ha)	Sapling density by size class	
			2.5 to <5 cm	5 to <10 cm
<i>Juniperus osteosperma</i>	Utah juniper	10.42	32.18	68.26
<i>Pinus edulis</i>	Two-needle pinyon	5.36	95.85	113.53
All tree species		15.83	129.45	181.79
Snags		1.60		



**Figure 4. Basal area of trees, by species, and snags in pinyon-juniper habitat in Grand Canyon, NP, 2011. Error bars represent one standard deviation.**

Sapling densities provide insight into the structure and dynamics of the forest. Two-needle pinyon dominated both of the sapling size classes (trees 2.5 to less than 5 cm DBH and trees 5 cm to less than 10 cm DBH; table 11 and fig. 5).

The understory of the pinyon-juniper habitat at GRCA is mainly comprised of shrubs and herbaceous cover and woody standing dead cover, with some perennial grass, forb, cacti, and understory tree cover (table 12). There is considerable variation in the amount of shrub and herbaceous cover—mean foliar cover for this functional group ranged from 0.99% to 5.63%.

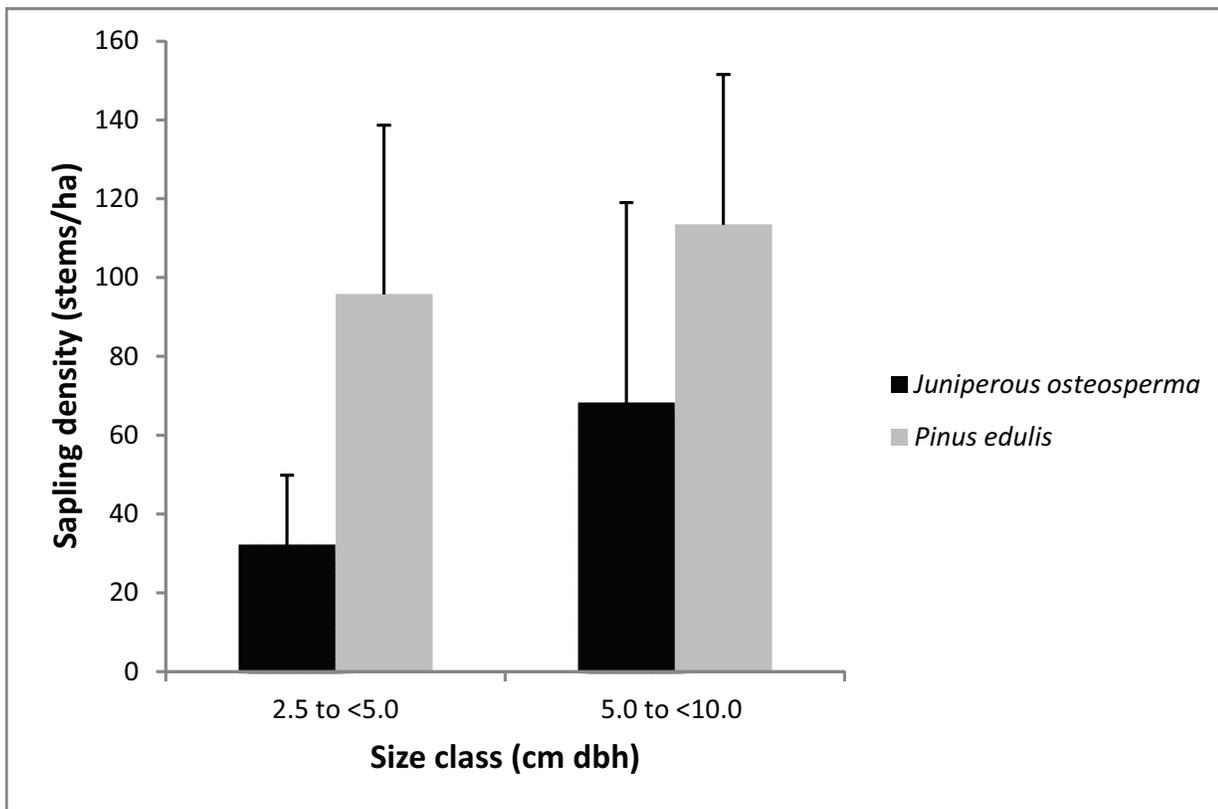


Figure 5. Size structure of sapling trees. Mean density (number of stems/ha) of sapling trees in two size classes (2.5 to <5, and 5 to <10 cm DBH) in pinyon-juniper habitat in Grand Canyon, NP, 2011. Error bars represent one standard deviation.

Table 12. Mean foliar cover, standard deviation (SD), and range of functional groups in target pinyon-juniper habitat in Grand Canyon NP, 2011.

Functional groups	Foliar cover (%)	SD	Range
Understory trees (<1.4 m height)	0.69	0.51	0.13–1.58
Total shrub and herbaceous cover (no trees) <2 m	2.53	1.48	0.99–5.63
Perennial grasses, graminoids	0.56	0.16	0.46–0.99
Annual grasses	0.03	0.06	0.00–0.15
Forbs	0.40	0.10	0.24–0.54
Shrubs, dwarf shrubs, and woody vines	1.89	1.45	0.26–4.35
Cacti, succulents	0.09	0.09	0.00–0.28
Standing dead herbaceous	0.66	0.35	0.47–1.58
Woody standing dead	1.25	0.82	0.36–3.11

## 4 Discussion

These data represent the second year of sampling for the mixed conifer bird community, and the initial year of sampling for the pinyon-juniper bird community at GRCA. The two habitats and their bird communities are quite distinct. The mixed conifer bird community is primarily comprised of species closely associated with mixed conifer forests. Many of these are bird species that are near the southern extent of their breeding ranges. Tracking trends in the distribution of species at the ‘trailing edge’ of their ranges may be particularly useful as an early indicator of climate change impacts to the persistence of bird populations. For example, the Williamson’s sapsucker is fairly common in the mixed conifer habitat of GRCA (detected at an average of 50% of the plots in a cluster and at 100% of the clusters). Its breeding range is confined to western forests of the U.S. and south-central British Columbia, with the exception of a disjunct population in Baja California Norte (Dobbs et al. 1997). This species is on the Yellow WatchList of declining species, part of the United States WatchList of Birds of Conservation Concern (Butcher et al. 2007), and is on the Federal list of Birds of Conservation Concern (U.S. Fish and Wildlife Service 2002). If climate change affects the distribution of mixed conifer forests, it may also affect the distribution of the Williamson’s sapsucker.

The pinyon-juniper habitat at GRCA has a relatively low density of trees, and is dominated by *Juniperus osteosperma*. Basal area of *Pinus edulis* was approximately half that of *J. osteosperma*. The pinyon-juniper bird community includes several species that are considered pinyon-juniper obligate species, two of which are on the Yellow WatchList of declining species (Butcher et al. 2007)—the pinyon jay and gray vireo. The pinyon jay is of particular interest in GRCA because it can play a role in reforestation of burned areas by bringing in pinyon seeds from some distance and planting them (see Balda 2002). Pinyon jays coevolved as non-migratory mutualists with pinyon pines. Jays disperse the large wingless seed of pinyon pines over long distances, which can result in relatively rapid colonization. At the same time, the jays obtain energy and nutrients from the seeds. The pinyon jay was the fourth most commonly detected species in GRCA pinyon-juniper habitat during our bird counts and was detected at all of the sampling clusters.

Our long-range plan for mixed conifer and pinyon-juniper bird community monitoring in GRCA is to conduct VCP counts every three years to continue collecting data on bird species abundance, distribution, and habitat metrics. When sufficient data has been collected, we will analyze changes in these data over time.

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