DRAFT

MEMORANDUM

Date: July 6, 2000

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Habitat Selection by Cactus Ferruginous Pygmy-Owls in Southern Arizona**

Background

The attached report on the *Habitat Selection by Cactus Ferruginous Pygmy-Owls in Southern Arizona* is a companion to the study issued under separate cover on July 5, 2000 entitled *Cactus Ferruginous Pygmy-Owl Investigations in Pima County*. Pima County contracted with the Arizona Game and Fish Department to conduct habitat analysis for the pygmy-owl.

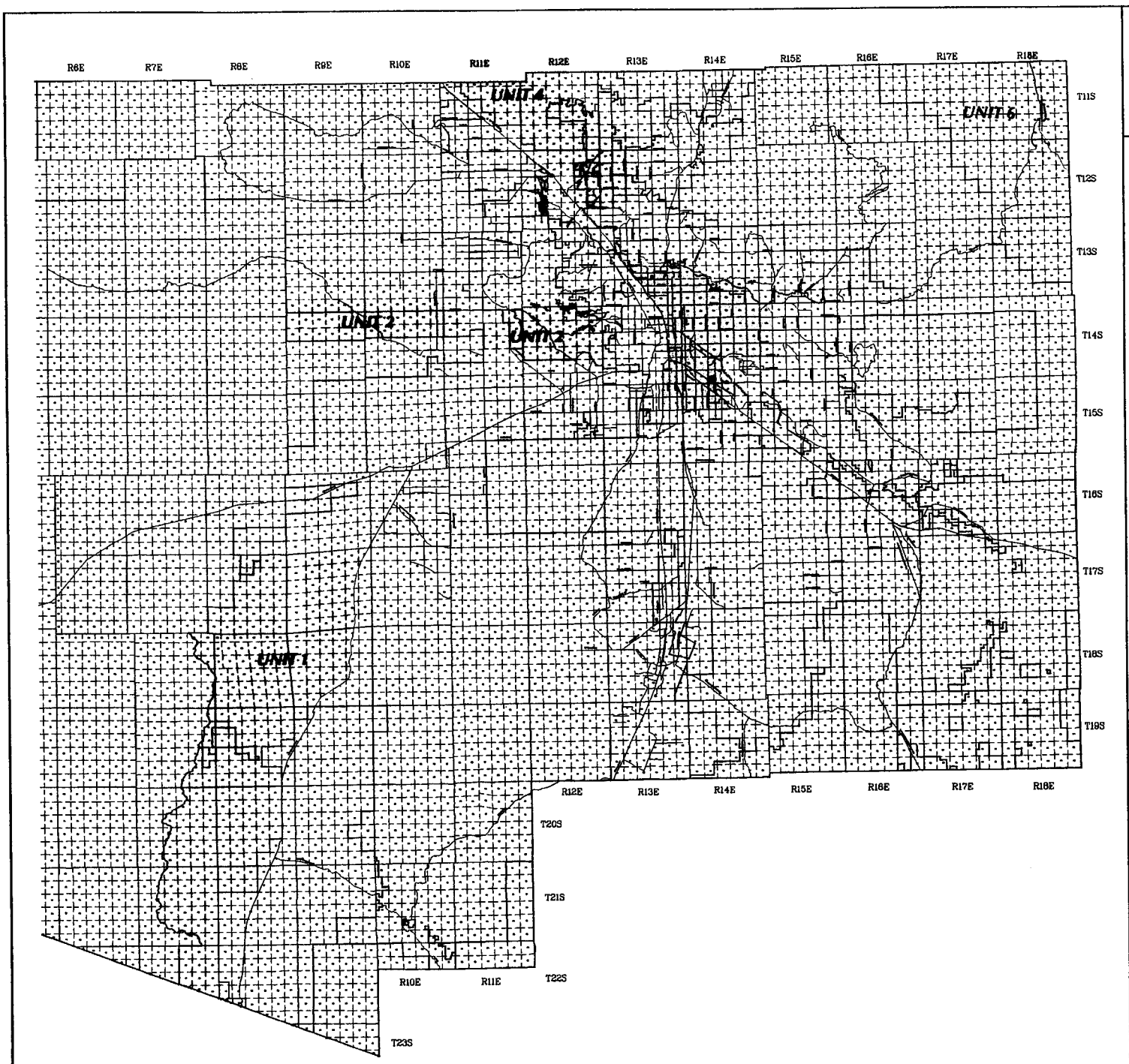
Objective

The major objective of the study was to determine whether pygmy-owls chose nest sites or perch trees with characteristics that differ from other available sites within a nesting territory. Scientists from the Game and Fish Department conducted field studies designed to gather information about these issues:

- Whether distances from sample plot centers to washes, paved roads, and dirt roads in use areas differ from randomly placed sample plots;
- Whether ground cover within sample plots of nests or perch trees differ from randomly placed contrast plots;
- Whether plant species diversity at used areas differ from random sample plots;
- Whether the number of tree, shrub, or cactus species at used areas differ from random sample plots; and
- Whether vertical vegetation densities within sample plots of used areas differ from randomly placed plots?

Need for Habitat Analysis

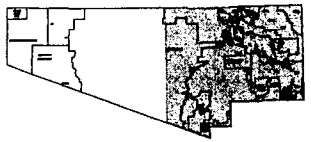
In March of 1997 the pygmy-owl was listed as endangered by the United States Fish and Wildlife Service. Critical habitat was designated for the pygmy-owl in 1999. In Pima County this includes land within the Altar Valley (Unit 1), the Tucson Mountain Park and land north of the Garcia Strip (Unit 2), northwest Tucson (Unit 4), and the San Pedro River (Unit 6).



Designated Pygmy-owl Critical Habitat

- Major Streets
- Township and Range
- Section Lines
- Administrative Boundaries
- Fish and Wildlife Designated Pygmy Owl Critical Habitat
- Urban Exclusion Area

Pima County Index Map



Index Map Scale 1/1,500,000

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Plotted: 4/27/00

Over time pygmy-owls have been associated with these areas and habitat types:

- "Early Arizona records indicate the pygmy-owl occurred along the Gila, Salt, Santa Cruz, San Pedro, and Verde rivers in their major tributaries. However, no pygmy-owls have been documented along these drainages since the 1980s. Habitat along these riparian areas contained cottonwood forests, mesquite-cottonwood woodlands and mesquite bosques. Pygmy-owls were also recorded in Sonoran desertscrub, but from areas that supported xeroriparian and riparian vegetation." [Page 2]

- "During the 1990's, nesting pygmy-owls have been detected in Sonoran desertscrub and semi-desert grasslands below 1,220 m elevation. Areas associated with pygmy-owl locations in the Sonoran desertscrub community have been characterized as gently sloping bajadas drained by a complex of large and small ephemeral washes with dense vegetation. " [Page 2]

- On the issue of owls found in grassland areas such as Altar Valley, the report clarifies: "A number of detection sites initially considered within semi-desert grassland, may actually be within a transition area between Sonoran desertscrub and semi-desert grassland. In general, habitat conditions for pygmy-owls seem to include dense wood thickets or woodlands for foraging and protection of juveniles, and large trees or cacti for nesting." [P. 2]

Method

Habitat characteristics were assessed at eight nest sites, seven guard trees, and random sites within the Tucson Basin, Altar Valley and Organ Pipe Cactus National Monument.

- Nest sites consisted of seven saguaros and a velvet ash tree.

- A guard tree is a perch in the line of sight of the nest cavity where male or female adults station themselves to guard the nest cavity during incubation and the nestling period. Species used as guard trees include mesquite, foothills paloverde, ironwood and velvet ash trees.

Results

These potentially important habitat variables were identified:

- Stem densities at the upper canopy levels appeared greater at actual nest sites;

- Ground cover at nest sites was dominated by litter and bare ground; and

- Plant species diversity was higher at nest sites (mean of 13.5) than random plots (10.8).

Recommendations from the Study

The authors caution against the over application of these results, given the small sample size, but recommend consideration of this series of questions for those evaluating potential impacts to pygmy-owl habitat or potential mitigation action to conserve habitat.

- "Does the area fall within Sonoran desertscrub or semi-desert grassland vegetation types in Southern Arizona?"
- "Is the vegetation in the area characterized by high plant diversity and presence of trees and shrubs providing structural layers at the mid-story and canopy levels?"
- "In semi-desert grassland types, does the area contain washes or drainages supporting tree species such as mesquite, ash, cottonwood or hackberry?"
- "What is the proximity of the site to an occupied pygmy-owl territory?"
- "Does the area fall within any known pygmy-owl dispersal corridors?"

The authors state that under the conditions described above, potential impacts of projects on pygmy-owls "should be considered likely, until further site evaluation, protocol based surveys and monitoring is completed." [P. 9]

HABITAT SELECTION BY CACTUS FERRUGINOUS PYGMY-OWLS IN SOUTHERN ARIZONA - PRELIMINARY RESULTS

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Abstract. The cactus ferruginous pygmy-owl was listed as endangered in Arizona by the United States Fish and Wildlife Service in 1997. Understanding the composition and structure of vegetation and the characteristics of physiographic features in areas used by cactus ferruginous pygmy-owls for nesting, is essential for developing management strategies that will contribute toward population stability and eventual delisting. In Arizona, nesting cactus ferruginous pygmy-owls have been found in both undeveloped Sonoran desert habitats, and within the suburban/urban interface, where natural desert components are mixed with varying levels of development and associated non-native plants, to form complex communities. This unique association raises important questions about the habitat needs of the cactus ferruginous pygmy-owl and challenges wildlife officials to design appropriate management strategies to support population stability and recovery. We measured habitat characteristics at eight nests, seven perch trees and random sites that were paired with each in the Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona. While data did not result in statistically significant findings, some potentially important habitat variables were identified. Stem densities at upper canopy levels (above 3 m) appeared greater at nest sites versus random sites was observed at both communities types. Ground cover was dominated by litter and bare ground. Mean number of plant species diversity was higher at nest sites compared to paired random plots (13.5 and 10.8 respectively).

Key Words: nest site selection, habitat selection, cactus ferruginous pygmy-owl, Glaucidium brasilianum cactorum

INTRODUCTION

Cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) were considered threatened with extirpation in Arizona, as a result the U.S. Fish and Wildlife Service (USFWS) listed the subspecies as endangered (USFWS 1997). Cactus ferruginous pygmy-owls (hereafter pygmy-owl), once believed to be common throughout their historical range in Arizona, are now considered scarce. It is believed this population decline is due largely to loss and alteration of habitat (Millsap and Johnson 1988, Monson 1998). Consequently, the USFWS has designated critical habitat for pygmy-owls in Cochise, Maricopa, Pima, and Pinal counties, Arizona (USFWS 1999).

Southern Arizona constitutes the northernmost edge of the pygmy-owls' range (Millsap and Johnson 1988, Proudfoot and Johnson 2000). Early Arizona records indicate the pygmy-owl occurred along the Gila, Salt, Santa Cruz, San Pedro, and Verde rivers and their major tributaries (USFWS 1997). However, no pygmy-owls have been documented along these drainages since the 1980s. Habitat along these riparian areas contained cottonwood (*Populus* spp.) forests, mesquite (*Prosopis* spp.)-cottonwood woodlands and mesquite bosques. Pygmy-owls were also recorded in Sonoran desertscrub, but from areas that supported xeroriparian and riparian vegetation (Bendire 1888, Bendire 1892, Fisher 1893, Swarth 1914, Howell 1916, Kimball 1921).

During the 1990's, nesting pygmy-owls have been detected in Sonoran desertscrub and semi-desert grasslands (Turner and Brown 1994) below 1,220 m elevation. Areas associated with pygmy-owl locations in the Sonoran desertscrub community have been characterized as gently sloping bajadas drained by a complex of large and small ephemeral washes with dense vegetation. The vegetation includes associations of palo verde (*Cercidium* spp.), bursage (*Ambrosia* spp.), ironwood (*Olneya tesota*), mesquite, acacia (*Acacia* spp.), and saguaro (*Carnegiea giganteus*) (Wilcox et al. 1999). Semi-desert grassland locations have been described as shrub-invaded grassland predominated by linear woodlands of mesquite and patchily distributed upland desertscrub and broadleaf deciduous woodlands (Flesch 1999).

Millsap and Johnson (1988) suggested that Sonoran desertscrub might be lower quality habitat for pygmy-owls. However, until recent detections of pygmy-owls in semi-desert grassland during 1999 (Flesch 1999, and Abbate et al. 2000), Sonoran desertscrub supported the largest number of known pygmy-owls in southern Arizona. A number of detection sites initially considered within semi-desert grassland, may actually be within a transition area between Sonoran desertscrub and semi-desert grassland. In general, habitat conditions for pygmy-owls seem to include dense wood thickets or woodlands for foraging and protection of juveniles, and large trees or cacti for nesting (Phillips et al. 1964, Rea 1983, Hunter 1988, USFWS 1997, Wilcox et al. 1999).

An essential segment of the known pygmy-owl population in southern Arizona occurs in areas where habitat loss is occurring due to alteration and fragmentation resulting from urban development, expansion and associated activities (USFWS 1997). Determining habitat requirements for pygmy-owls is an essential step for determining management practices that will help stabilize the population, guide land use planning, shape appropriate mitigation efforts when needed and for recovery of the pygmy-owl in Arizona.

The objective of this study is to determine if pygmy-owls select nest sites or perch trees with different characteristics than available sites within a nesting territory. To address this question, we investigated: 1) if distances from sample plot centers to washes, paved roads, and dirt roads in use areas differ from randomly placed sample plots, 2), whether ground cover within sample plots of nests or perch trees differ from randomly placed contrast plots and 3) whether plant species diversity at used areas differ from random sample plots, 4) whether the number of tree, shrub, or cactus species at used areas differ from random sample plots, 5) whether vertical vegetation densities within sample plots of used areas differ from randomly placed plots?

METHODS

Study Area

The study area was delineated by locations of four known pygmy-owl population segments (Fig. 1). These included the northwest Tucson (NWT) area of the Tucson Basin, Marana/Redrock (M/R) area of Pinal County, Altar Valley(AV), and Organ Pipe National Monument (OPNM). Locations within NWT, M/R and OPNM are generally characterized as gently sloping uplands or bajadas with ephemeral washes and elevations ranging from 681m (2234 ft) at OPNM to 835 m (2740 ft) in NWT. They fall within the Sonoran desertscrub community described above, and contain leguminous trees, saguaros and a mix of other cacti. NWT is largely residential with a mix of semi-rural and rural areas and many "horse properties" of three acres or more. It is rapidly changing to higher densities of housing and is under pressure for increased commercial development. M/R is comprised of mostly Arizona State Trust and Bureau of Land Management lands with pockets of private areas. Historical use of this area has been grazing and mining, with limited grazing continuing today. OPNM study area is protected by National Monument status.

AV is a semi-desert or mesquite-grassland. It has a long history of cattle grazing and contains a number of active cattle ranches today. The Buenos Aires National Wildlife Refuge is also located in this area. Cattle have been excluded from the refuge for a number of years and it is managed as a sanctuary for masked bobwhite quail (*Colinus virginianus*). Both private ranches and the federal refuge practice prescribed burning to maintain grasses and control mesquite invasion. Study sites in AV are considered riparian and are distinguished by patches of desert willow (*Chilopsis linearis),* mesquite, velvet ash (*Fraxinus velutina*) and netleaf hackberry (*Celtis reticulata*).

Sampling Methods

Sample plots were centered at eight nest sites and seven perch or "guard trees" associated with a nest territory from the 1999 breeding season. Nest sites included seven saguaros and one velvet ash tree. Guard trees were mesquite, foothills paloverde, ironwood and velvet ash trees that were in line of sight of the nest cavity and were used by male or female adults to guard the cavity during incubation and nestling periods. A guard tree was determined when an adult pygmy-owl was observed perched for extended periods of time during multiple observation periods in the same tree. They were observed responding to intruders or potential threats by other birds, for prey exchanges/deliveries, copulation, and day roosts. In a number of cases, the guard tree was also used by young during and after fledging.

We sampled a total of 15 unused random sites (8 eight nest and guard random plots). Each random site was paired with an actual nest or guard tree plot. Random nest sites were determined by identifying an unused saguaro or tree located between 30 and 300 m from the nesting structure in a randomly chosen direction. The minimum and maximum distances (30–300m) were selected to avoid re-sampling the original nest or guard tree plot and to encompass the distance an alternate nest (potentially used by the same pair), that might be located within a nesting territory. The maximum distance was determined from two known alternate nests from

Arizona (Abbate et al. 1999). At nest random sites, the sample plot was centered at the nearest saguaro or tree greater than 2m tall with a cavity that visually appeared to be usable by a pygmy-owl. Random guard tree plots were identified by determining a random distance between 30 and 300m in a random direction from an actual nest site. The nearest saguaro to the random point was identified and the guard tree plot was located at the nearest tree greater than 3m tall and in line of sight of the potentially usable cavity.

We measured 13 variables at each nest and associated guard trees for both used sites and random unused sites. (Table 1). The sample plot was a circular area divided by six randomly placed 15 meter transects (radii), centered on the nest site (saguaro/tree) or guard tree (Fig. 2). The 15 meter diameter plot size was used to focus measurements on specific sites, rather than evaluation of habitat at a larger, landscape scale. The point intercept location interval were arranged to avoid over sampling the center of the plot (Fig. 2). Measurements of habitat variables were recorded on field data forms (Appendix 1).

Analysis.

Data collected from nests measured in semi-desert grassland and those measured in Sonoran desertscrub were grouped separately. We calculated the mean, range or 95 percent confidence intervals for all variables measured. We tested the mean differences in variables measured, at actual nest sites and random potential nest sites and between actual guard trees and random potential guard trees, to determine if they were different from zero using a paired t-test.

RESULTS

Sonoran Desertscrub

The distances from plot center, of actual nest sites and random sites, to dry washes, dirt roads and paved roads were extremely variable (Table 2). The mean difference in distances between nest and random plots to dry washes (p-value = 0.44), dirt roads (p-value = 0.40) and paved roads (p-value = 0.24) were not significant. Similar values were found at guard tree plots where the mean difference for distances to dry washes (p-value = 0.94), dirt roads (p-value = 0.42) and paved roads (p-value = 0.07) were also not significant (Table 3).

Bare ground and litter contributed most to ground cover at nest and guard tree plots (Fig 3 and 4). Mean differences in percent ground cover estimates (bare ground, dead wood, live vegetation, rock, litter) at nest and paired random plots were not significant (p-value = 0.67, 0.96, 0.02, 0.40, 0.59 respectively) [Fig. 5]. Mean difference in ground cover estimates for same cover types stated above between guard tree and paired random plots were also not significant (p-value = 0.31, 0.37, 0.18, 0.53, 0.27 respectively) [Fig. 6].

Mean number of plant species found at nest (13.5) and paired random (10.8) plots were not significantly different (p-value = 0.22) [Table 4]. Mean number of species found at guard tree (14.2) and paired random (12.4) plots were also not significantly different (p-value = 0.27) [Fig. 5].

Shrubs were the most numerous vegetation growth form of the three designated groups (trees, shrubs, and cacti) at nest plots (Table 6). The difference in the number of trees, shrubs and cacti at nest plots compared to random plots were not significant (p-value = 0.70, 0.85, 0.30 respectively) [Table 6]. Similar results were found for trees and cacti when we compared guard tree plots and paired random plots (p-value = 0.63 and 0.75 respectively) [Table 7]. However, shrubs showed a notable difference at guard tree plots (p-value = 0.06).

Vertical vegetation density (the number of stems) was greatest at height classes below 1 m in both nest plots and guard tree plots (Fig. 7 and 8). Mean difference in number of stems found at nest plots and paired random plots were highly variable (Fig. 9). Stem densities appear greater at guard tree plots compared to random plots above 1 m height classes (Fig.10).

Mean heights for all plant species sampled on nest and guard tree plots were summarized by vegetation type (Table 8-13). The differences in heights by species were not tested because the presence of specific species was highly variable amongst nest and guard tree plots. All plant species sampled within plots were cataloged (Appendix 2).

Nests (in Sonoran desertscrub community) were only found in saguaros and ranged in heights from 5.4 m to 12.0 m for nest plots and 5.5 m to 7.3 m for paired random plots (Table 14). Guard tree plots for both used and random plots had similar mean heights and mean crown radius values (Table 15).

Semi-Desert Grassland

Distances from plot center to dry washes, dirt roads and paved roads at nest and paired random plots were highly variable (Table 2). Mean difference in distances between nest and random plots to dry washes, dirt roads, and paved roads were not significant (p-value = 0.34, 0.47, and 0.41 respectively)[Table 2]. Mean differences in distance estimates at guard tree plots and paired random plots were also not significant (p-value = 0.45, 0.13, and 0.63 respectively) [Table 3].

Mean percent ground cover estimates at both nest and random plots were dominated by bare ground (mean = 0.55 and 0.56 respectively), and litter (mean = 0.27 and 0.43 respectively) [Fig. 3 and 4]. Mean differences in percent ground cover estimates (bare ground, dead wood, live vegetation, rock, litter) at nest and paired random plots were not significant (p-value = 0.83, insufficient data, 1.0, 0.41, 0.14 respectively). Mean difference in ground cover estimates between guard tree and paired random plots, for same cover types mentioned above, were also not significant (p-value = 0.61, insufficient data, 0.16, 0.20, 0.15 respectively).

Mean number of plant species found at nest (7.5) and paired random (8.5) plots were not significantly different (p-value = 0.80) [Table 4]. Mean number of plant species found at guard tree (7.5) and paired random (8.5) plots were also not significantly different (insufficient data to calculate p-value).

There were more trees found at nest plots (mean = 28) compared to random plots (mean = 18.5) even though they were not significantly different (p-value = 0.50). The difference in the number of shrubs and cacti at nest plots compared to random plots were not significant (p-value = 0.61 and 0.50 respectively) [Table 6]. The mean number of tree, shrubs and cacti found at guard tree and random plots were not significantly different (p-value = 0.31, 0.83, and 0.43 respectively) [Table 7].

Vertical vegetation density (the number of stems) was greatest at height classes above 3 m in both nest plots and guard tree plots (Fig. 7 and 8). The mean number of stem densities were larger for each height class at both nest and guard tree plots (Fig. 9 and 10).

Mean heights for all plant species sampled on nest and guard tree plots were summarized by vegetation type (Table 8-13). The differences in heights by species were not tested because the presence of specific species at nest and guard tree plots was highly variable..

Only two nests (one in a saguaro and one in a velvet ash tree) were sampled within semi-desert grassland community type. Mean values were not calculated because sample size was not large enough (Table 14). Guard trees were larger at used plots compared to random plots in height and mean crown radius (Table 15).

DISCUSSION

We attempted to identify characteristics of nest sites and guard trees selected for use by pygmy-owls within Sonoran desertscrub and semi-desert grassland communities. Our sample size of eight nest sites and associated guard trees is extremely small and limited the power to detect significant results. We were unable to document statistical significance for 12 of 13 variables measured. In addition to low sample size, we recognize other factors that may contribute to negative results. These include: 1) variables measured may not reflect those characteristics that pygmy-owls select, 2) sampling methodology may not be sensitive enough to detect variation among habitat variables and 3) pygmy-owls may be selecting habitat at a different scale from what we measured. We do not recommend alteration of the methodology at this time and suggest that present results be considered preliminary. We recommend increased efforts to locate nest sites to produce a larger sample size that will increase the likelihood of detecting differences. Despite the difficulties encountered during this analysis, we offer the following observations in response to the preliminary results of habitat selection measurements.

The one variable measured that indicated a significant difference between actual nest sites and random potential nest sites was the live vegetation component of ground cover within Sonoran desertscrub. We did not detect any differences for other ground cover components. This may

indicate that the increased presence of live vegetation at ground level provides some benefit. Live vegetation ground cover can contribute to the diversity of food available to prey species in the form of foliage, seeds, fruits and flowers. It may also increase cover utilized by prey species for hiding and thermal protection. However, live vegetation at ground level may also reach densities that begin to limit the benefits of increased prey. Higher stem densities at ground cover level appeared to be negatively associated with sites selected by pygmy-owls and may reflect a decreased ability to detect prey and lower capture success.

We could not detect significant differences for plant species diversity in Sonoran desertscrub or semi-desert grassland between sites used by pygmy-owls and random sites. However, in Sonoran desertscrub, sample plots with nest structures and guard trees selected by pygmy-owls, were in areas with a tendency toward higher species diversity than random sites (Tables 4 and 5). This tendency may become more pronounced with increased sample size. While this trend was not observed for semi-desert grassland sites, we also expect to see higher diversity in this community with additional sampling. We suspect higher species diversity would be advantageous for pygmy-owl survival and successful reproduction, by providing reliable cover for pygmy-owls and increased prey availability throughout the year. Pygmy-owls appear to rely on cover for concealment from predators and harassment from mobbing song birds. They often hunt from perches that prevent detection by prey species and they seek protective shade when air temperatures are high. The presence of multiple tree and shrub species that can provide adequate cover during drought stress, when some deciduous species do not retain foliage, may indicate higher habitat quality.

Higher plant diversity also increases the likelihood of increased prey species diversity and availability. During stressful or high demand periods such as when young are developing or during winter when prey numbers are reduced, increased prey species may provide more consistent availability.

Actual nest sites and guard trees in both Sonoran desertscrub and semi-desert grassland appear to be located at sites with fewer overall cacti present than random sites (Tables 6 and 7). We recognize these counts are based on very low sample size and may not remain consistent as sample size increases. However, cactus density around nest sites and guard trees may be an important factor in juvenile mortality, especially in Sonoran desertscrub where densities may be high. Each year since 1997, we have observed one or more pygmy-owl fledglings has been impaled or entangled in cholla and prickly pear cactus near the nest. Selection of nest sites with fewer cacti present would reduce mortality and increase dispersal efficiency.

The highest density of trees was found along drainages in semi-desert grassland communities. These same areas were used by pygmy-owls for nesting and dispersal. Although differences between sites used for nesting and perching were not significantly different from random plots, there was a tendency toward higher tree density at used sites (Tables 6 and 7). We suspect this difference will be more pronounced with increased sample size. In addition, the presence of higher tree density within used sites was supported by our measurements of different structural layers. We found a higher stem density at height classes above three meters than lower tree height classes. Higher structural levels probably provide better cover for predator avoidance and increased perch availability for predator observation and hunting.

Nest sites used by pygmy-owls in semi-desert grasslands were located closer to washes than paired random sites (Table 2). Guard tree plots did not show similar results, we expect this will be the case as sample size is increased (Table 3).

Within semi-desert grassland communities, washes and drainages may provide important habitat components with regard to pygmy-owl habitat selection. We have observed the total number of stems (Fig. 7) and stem density index (Fig. 9) values were higher for nest sites and guard trees than for random sites at the mid-story and canopy levels. This may indicate that larger stem densities at taller structural levels may be important in pygmy-owl habitat selection. Only with an increase in sample size will we be able determine if these variables are important.

For both Sonoran desertscrub and semi-desert grassland habitats, data show that the presence of vegetation layers at the mid-story and canopy levels may be important structural components of suitable pygmy-owl habitat (Fig. 9 and 10). Mid-story structure likely contributes to avian prey availability as well as thermal cover when temperatures rise at the canopy level during mid-day. While our earlier work (Wilcox et al. 1999) showed that occupied pygmy-owl sites had vegetation structure relatively evenly distributed from the ground to the canopy, after refinement of the method in this study, the most important structural levels occur up to 1 m and above 3 m in height. These two layers showed the greatest difference from random sites at both Sonoran desertscrub and semi-desert grassland vegetation types.

Additional anecdotal evidence for the selection of sites with a well-developed canopy layer was found when we compared the average height of the most common tree species. For both Sonoran desertscrub and semi-desert grassland sites, the average height of common trees was greater when compared to random sites. Larger mean heights is most likely a product of the sample plots being in close association with washes and drainages.

In an effort to increase sample size, we combined all Sonoran desertscrub sites. Because of vegetation characteristics and human activity levels, future studies should consider sampling three possible strata. However, this would require more time in order to obtain a statistically significant sample. The three possible main sampling areas to consider are Sonoran desertscrub Pinal County in NW Tucson urban areas, ex-urban Sonoran desertscrub in the Tucson area, Pinal County, and Organ Pipe Cactus National Monument, and semi-desert grasslands of Altar valley.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

The results of this study are based on an extremely small sample size and we caution against their use to support any strong conclusions about pygmy-owl habitat selection at this time. Location of additional pygmy-owl nesting, dispersal, and general use areas in Arizona will provide the opportunity for increased sample size, further analysis and more conclusive results. At present, we recommend consideration of the following questions during evaluation of potential impacts to pygmy-owl habitat and possible mitigation action for habitat conservation.

1. Does the area fall within Sonoran desertscrub or semi-desert grassland vegetation types in southern Arizona?

2. Is the vegetation in the area characterized by high plant diversity and presence of trees and shrubs providing a structural layers at the mid-story and canopy levels?

3. In semi-desert grassland types, does the area contain washes or drainages supporting tree species such as mesquite, ash, cottonwood or hackberry?

4. What is the proximity of the site to an occupied pygmy-owl territory?

5. Does the area fall within any known pygmy-owl dispersal corridors?

If any of the above questions can be answered in the affirmative, potential impacts of projects on pygmy-owls should be considered likely, until further site evaluation, protocol based surveys and monitoring can be completed. Each project or parcel should be evaluated on an individual basis.

RESEARCH NEEDS

1. Continue sampling new nest sites and guard trees - The currently small sample size of known nests and guard trees hindered our ability to draw any statistically significant conclusions regarding the selection of nest sites by pygmy-owls. As new nest sites are located, current methodology should be used to sample the nests, guard trees and associated random sites in order to increase sample size and conduct appropriate statistical tests.

2. Develop a list of additional habitat variables to be investigated at the pygmy-owl home range scale – It is possible that we did not sample habitat variables being used by pygmy-owl in selection of nest sites. Additional variables should be identified and appropriate methodology developed to measure and analyze those variables with regard to habitat selection.

3. Conduct habitat selection studies at scales other than the pygmy-owl home range scale – It is possible that pygmy-owl habitat selection is occurring at a scale other than the home range and nest site scales. It is important that selection at other scales be investigated. Appropriate variables and scales should be identified and methodologies developed to implement a wider habitat selection study.

4. Conduct habitat selection studies in three identified study areas, 1) Sonoran desertscrub in urban NW Tucson, 2) ex-urban Sonoran desertscrub in NW Tucson, Pinal County, and Organ Pipe Cactus National Monument, and 3) semi-desert grasslands in the Altar Valley.

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Table 1. List of variables and method of measurement at pygmy-owl nest sites in Arizona 1999 – 2000.

Variable	Method
Distance to nearest dry wash, paved road, and dirt road.	Direct measurement (m) up to 300m. For distances > 300m .measured off USGS Quads
Percent ground cover	Point-intercept, 10 points per radius on sample array (see Fig. 2). Ground cover categories: bare ground, dead woody debris, live vegetation, rock, and litter
Total plant diversity	Direct count within 15m radius of center.
Tree species diversity	Direct count within 15m radius of center.
Shrub species diversity	Direct count within 15m radius of center.
Cacti species diversity	Direct count within 15m radius of center.
Vertical vegetation density	At each sample point (see Fig. 1) the number of stems and amount of a vegetation (percent of band) intersecting 10cm around a 3m cover pole at 20 m intervals.
Height of shrubs species	Direct measurement (m)
Height of tree species	Direct measurement (m)
Height of cacti species	Direct measurement (m)
Height of nest structure/guard tree	Direct measurement (m)
Crown radius (nest and guard trees only)	Mean cover projected on the 6 array lines centered on the nest/guard structure (m) (see Fig. 2)

Table 2. Distance (m) to dry wash and roads (dirt and paved) from cactus ferruginous pygmy-owl nest sites in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Nest			Random				
Vegetation Type		Mean	95% C.I.	Range	Mean	95% C.I.	Range	Mean[1] diff.	*p*-value[2]
$SDS_{n=6}$	Dry Wash	25	-5 to 56	1 to 81	14	5 to 23	8 to 30	11.4	0.44
	Dirt Road	149	-89 to 388	7 to 600	170	-79 to 419	33 to 650	-20.8	0.40
	Paved Road	2220	-932 to 5372	119 to 8000	2157	-1064 to 5378	173 to 8100	62.7	0.24
$SDG_{n=2}$	Dry Wash	11	-116 to 138	1 to 21	24	-207 to 257	7 to 43	-13.8	0.34
	Dirt Road	388	-3583 to 4359	75 to 700	740	613 to 867	730 to 750	-352.5	0.47
	Paved Road	9500	-22265 to 41265	7000 to 12000	9585	22000 to 42000	6800 to 11970	115.0	0.41

[1] Mean difference for distance measurements between nest and random plots.
[2] Significance value for mean difference for distance measurements between nest and random plots.

Table 3. Distance (m) to dry wash and roads (dirt and paved) from cactus ferruginous pygmy-owl guard trees in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999-2000.

Vegetation Type		Guard tree			Random				
		Mean	95% C.I.	Range	Mean	95% C.I.	Range	Mean [1] diff.	*p*-value[2]
$SDS_{n=5}$	Dry Wash	22	-20 to 63	1 to 81	23	-2 to 48	0.5 to 53	-1.3	0.94
	Dirt Road	113	-88 to 314	15 to 400	44	10 to 77	16 to 75	69.6	0.42
	Paved Road	2746	-1059 to 6551	692 to 7970	2622	-1277 to 6521	400 to 7940	118.4	0.07
$SDG_{n=2}$	Dry Wash	9	-74 to 91	2 to 15	1	1 to 1	1 to 1	7.5	0.45
	Dirt Road	375	-3754 to 4504	50 to 700	413	-3621 to 4446	95 to 730	-37.5	0.13
	Paved Road	9500	-22265 to 41265	7000 to 12000	9560	-21061	7150 to 11970	-60.0	0.63

[1] Mean difference for distance measurements between guard tree and random plots.
[2] Significance value for mean difference in distance measurements between guard tree and random plots.

Table 4. Plant species diversity at cactus ferruginous pygmy-owl nest and paired random plots in Sonoran desertscrub and semi-desert grassland vegetation types within Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

	Nest		Random		
	Mean	Range	Mean	Range	*p*-value[1]
Sonoran desertscrub (n = 6)	13.5	4 to 17	10.8	6 to 16	0.22
Semi-desert grassland (n = 2)	7.5	3 to 12	8.5	7 to 10	0.80

[1] Significance value for the mean difference in total number of species found on nest and random plots.

Table 5. Plant species diversity at cactus ferruginous pygmy-owl guard tree and paired random plots in Sonoran desertscrub and semi-desert grassland vegetation types within Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

	Guard		Random		
	Mean	Range	Mean	Range	*p*-value[1]
Sonoran desertscrub (n = 5)	14.2	12 to 18	12.4	11 to 13	0.27
Semi-desert grassland (n = 2)	7.5	7 to 8	8.5	8 to 9	---

[1] Significance value for the mean difference in total number of species found on guard and random plots.

Table 6. Mean number of trees, shrubs, and cacti at cactus ferruginous pygmy-owl nest and associated random plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation type within Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Nest		Random			
		Mean	Range	Mean	Range	Mean[1] diff.	*p*-value[2]
$SDS_{n=6}$	Trees	9	0 to 19	8	0 to 25	0.8	0.70
	Shrub	321	17 to 578	334	191 to 559	-12.8	0.85
	Cacti	69	13 to 175	91	3 to 202	-21.8	0.30
$SDG_{n=2}$	Trees	28	1 to 55	10	1 to 18	18.5	0.50
	Shrub	254	186 to 321	541	38 to 1143	-337.0	0.61
	Cacti	6	0 to 12	18	0 to 36	-12.0	0.50

[1] Mean difference in number of trees, shrubs, and cacti found at nest and random plots.
[2] Significance value for mean difference in number of trees, shrubs, and cacti found on nest and random plots.

Table 7. Mean number of trees, shrubs, and cacti at cactus ferruginous pygmy-owl guard tree and associated random plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation type within Tucson Basin, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Guard		Random			
		Mean	Range	Mean	Range	Mean[1] diff.	*p*-value[2]
$SDS_{n=5}$	Trees	16	6 to 45	11	2 to 33	4.8	0.63
	Shrub	242	118 to 399	506	354 to 760	-264.0	0.06
	Cacti	105	10 to 327	130	67 to 266	-24.6	0.75
$SDG_{n=2}$	Trees	29	8 to 49	14	1 to 26	15.0	0.31
	Shrub	351	254 to 447	396	135 to 657	-45.5	0.83
	Cacti	5	0 to 9	24	4 to 43	-19.0	0.43

[1] Mean difference in number of trees, shrubs, and cacti found at guard tree and random plots.
[2] Significance value for mean difference in number of trees, shrubs, and cacti found on guard tree and random plots.

Table 8. Summary of mean heights (m) of tree species found at cactus ferruginous pygmy-owl nest plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Nest			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=6}$	CEMI	2.7	5	1.7 to 3.8	1.9	4	-0.3 to 4.2
	OLTE	5.4	2	-8.0 to 18.7	3.5	2	-10.5 to 17.5
	PRVE	3.2	4	2.4 to 4.1	2.8	4	0.4 to 5.3
$SDG_{n=2}$	FRVE	11.6	1	---	7.9	1	---
	PRVE	2.9	2	-6.6 to 12.5	2.3	1	---

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific tree species were recorded.

Table 9. Summary of mean heights (m) of tree species found at cactus ferruginous pygmy-owl guard tree plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Guard			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=5}$	CEMI	4.1	5	3.2 to 5.0	3.7	5	2.8 to 4.6
	OLTE	3.9	2	-9.5 to 17.2	3.3	2	-2.1 to 8.7
	PRVE	4.4	4	3.6 to 5.2	3.4	2	-5.5 to 12.3
$SDG_{n=2}$	FRVE	15.5	1	---	---	---	---
	PRVE	2.5	2	1.0 to 4.0	3.0	2	-2.4 to 8.3

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific tree species were recorded.

Table 10. Summary of mean heights (m) of shrub species found at cactus ferruginous pygmy-owl nest plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Nest			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=6}$	ACCO	2.0	3	0.2 to 3.8	1.5	3	-0.1 to 3.1
	ACGR	1.4	3	0.6 to 2.3	1.4	2	-3.0 to 5.7
	AMAM	1.1	4	0.6 to 1.5	---	---	---
	AMDE	0.6	6	0.5 to 0.7	0.6	6	0.6 to 0.7
	BASA	1.0	2	-3.5 to 5.4	---	---	---
	CAER	0.5	1	---	0.5	1	---
	CEPA	1.8	3	1.2 to 2.5	2.0	1	---
	ENFA	0.6	1	---	0.5	1	---
	EPSP	1.3	4	0.7 to 2.0	0.6	1	---
	GUSE	0.6	1	---	---	---	---
	ISTE	0.7	1	---	---	---	---
	LATR	1.6	2	-5.4 to 8.6	1.7	3	0.8 to 2.5
	LYBE	1.4	4	0.4 to 2.4	1.3	4	1.1 to 1.5
	SPAM	0.4	2	-2.5 to 3.2	0.1	1	---
	ZIOB	1.3	2	-1.9 to 4.4	---	---	---
$SDG_{n=2}$	ACGR	1.6	1	---	2.7	2	-4.1 to 9.4
	BAGL	1.9	1	---	2.1	1	---
	BASA	---	---	---	1.3	1	---
	BASP	1.8	1	---	---	---	---
	BESP	1.3	1	---	---	---	---
	CEGR	2.8	1	---	---	---	---
	CEPA	1.8	1	---	---	---	---
	CERE	0.6	1	---	5.9	1	---
	GUSE	0.5	1	---	0.5	1	---
	ISTE	0.6	1	---	0.4	1	---
	LYBE	---	---	---	2.0	1	---
	ZIOB	1.2	1	---	0.9	1	---

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific shrub species were recorded.

Table 11. Summary of mean heights (m) of shrub species found at cactus ferruginous pygmy-owl guard tree plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Guard tree			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=5}$	ACCO	2.0	3	0.2 to 3.8	1.7	3	0.7 to 2.7
	ACGR	1.9	4	0.8 to 3.0	1.4	1	---
	AMAM	1.2	3	0.2 to 2.1	1.1	2	-0.2 to 2.3
	AMDE	0.6	4	0.5 to 0.7	0.6	5	0.5 to 0.7
	CEPA	2.3	4	1.3 to 3.3	1.4	1	---
	DAME	0.5	1	---	---	---	---
	ENFA	---	---	---	0.7	1	---
	EPSP	1.1	3	0.6 to 1.5	1.0	2	0.8 to 1.2
	ISTE	0.9	1	---	---	---	---
	LATR	2.3	3	2.0 to 2.5	1.6	3	-1.5 to 4.7
	LYBE	1.6	3	-0.3 to 3.5	1.2	3	0.1 to 2.3
	PENA	0.2	1	---	---	---	---
	PSCO	---	---	---	0.3	1	---
	SPAM	---	---	---	0.7	1	---
	ZIOB	1.8	3	-1.3 to 4.8	---	---	---
$SDG_{n=2}$	ACGR	1.8	2	1.6 to 2.0	2.0	2	-6.9 to 10.9
	BAGL	1.9	1	---	1.6	1	---
	BASA	1.5	1	---	---	---	---
	BASP	1.0	1	---	---	---	---
	BESP	1.7	1	---	2.5	1	---
	CERE	2.0	1	---	5.4	1	---
	ISTE	0.4	1	---	0.5	1	---
	LYBE	1.2	1	---	1.0	1	---
	ZIOB	1.9	1	---	2.0	1	---

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific shrub species were recorded.

Table 12. Summary of mean heights (m) of cactus species found at cactus ferruginous pygmy-owl nest plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

		Nest			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=6}$	CAGI	3.9	6	1.5 to 6.2	2.2	6	0.8 to 3.6
	CHSP	1.0	6	0.6 to 1.3	1.1	6	0.6 to 1.5
	ECFE	0.2	5	0.1 to 0.3	0.3	5	0.2 to 0.3
	FEWI	0.4	4	0 to 0.8	0.5	5	0.3 to 0.7
	FOSP	---	---	---	2.3	1	---
	MASP	0.1	4	0.1 to 0.1	0.1	4	0.1 to 0.1
	OPLE	0.7	2	0.4 to 1.0	0.8	2	0.1 to 1.6
	PRPE	0.9	5	0.7 to 1.1	0.8	5	0.6 to 1.0
$SDG_{n=2}$	CAGI	9.1	1	---	7.3	1	---
	CHSP	0.8	1	---	0.4	1	---
	FEWI	0.4	1	---	---	---	---
	MASP	---	---	---	0.1	1	---
	OPLE	0.7	1	---	0.7	1	---
	PRPE	0.3	1	---	0.6	1	---

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific cactus species were recorded.

Table 13. Summary of mean heights (m) of cacti species found at cactus ferruginous pygmy-owl guard plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999 -2000.

		Guard			Random		
	Species[1]	Mean	n[2]	95% C.I.	Mean	n[2]	95% C.I.
$SDS_{n=5}$	CAGI	2.3	4	-0.2 to 4.7	3.0	4	0.2 to 6.1
	CHSP	1.2	5	0.7 to 1.8	1.1	5	1.0 to 1.3
	ECFE	0.2	3	0.1 to 0.3	0.2	5	0.1 to 0.4
	FEWI	0.8	2	-4.8 to 6.4	0.4	5	0.2 to 0.6
	MASP	0.1	4	0.1 to 0.1	0.1	5	0 to 0.1
	OPLE	0.7	3	0.1 to 1.3	0.8	3	0.6 to 1.1
	PRPE	0.8	5	0.5 to 1.1	1.0	5	0.8 to 1.2
$SDG_{n=2}$	CAGI	9.1	1	---	---	---	---
	CHSP	1.1	1	---	0.9	1	---
	ECFE	---	---	---	0.1	1	---
	FEWI	0.6	1	---	---	---	---
	OPLE	---	---	---	0.7	---	---
	PRPE	0.1	1	---	0.6	2	-2.5 to 3.8

[1] Plant species acronyms are located in Appendix 2.
[2] Number of plots from total sampled where specific cactus species were recorded.

Table 14. Summary of mean heights (m) and mean crown radius (m) of nest tree/saguaros found at cactus ferruginous pygmy-owl nest plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999-2000.

	Nest		Random	
	Height (±95%C.I.)	Crown radius(±95%C.I.)	Height(±95%C.I.)	Crown radius(±95%C.I.)
$SDS_{n=6}$	8.6 ± 2.5	---	10.2 ± 2.1	---
$SDG^{1}{}_{n=2}$	9	---	7.3	---
	11.6	6.45 ± 1.8	7.6	3.3 ± 2.2

--- Crown measurements on saguaros were not taken.

[1]Only two nest (and paired random) plots were measured within semi-desert grassland vegetation type. Summary of data for each plot was included in the table but mean values were not calculated.

Table 15. Summary of mean heights (m) and mean crown radius (m) of guard trees found at cactus ferruginous pygmy-owl guard plots in Sonoran desertscrub (*SDS*) and semi-desert grassland (*SDG*) vegetation types within Tucson Basin, Altar valley, and Organ Pipe National Monument, Arizona 1999-2000.

	Guard		Random	
	Height (±95%C.I.)	Crown radius(±95%C.I.)	Height(±95%C.I.)	Crown radius(±95%C.I.)
$SDS_{n=5}$	4.6 ± 0.7	3.1 ± 1.0	4.4 ± 0.4	2.8 ± 0.3
$SDG_{n=2}$	10.1 ± 69.2	6.1 ± 47.3	5.1 ± 3.8	3.5 ± 4.6

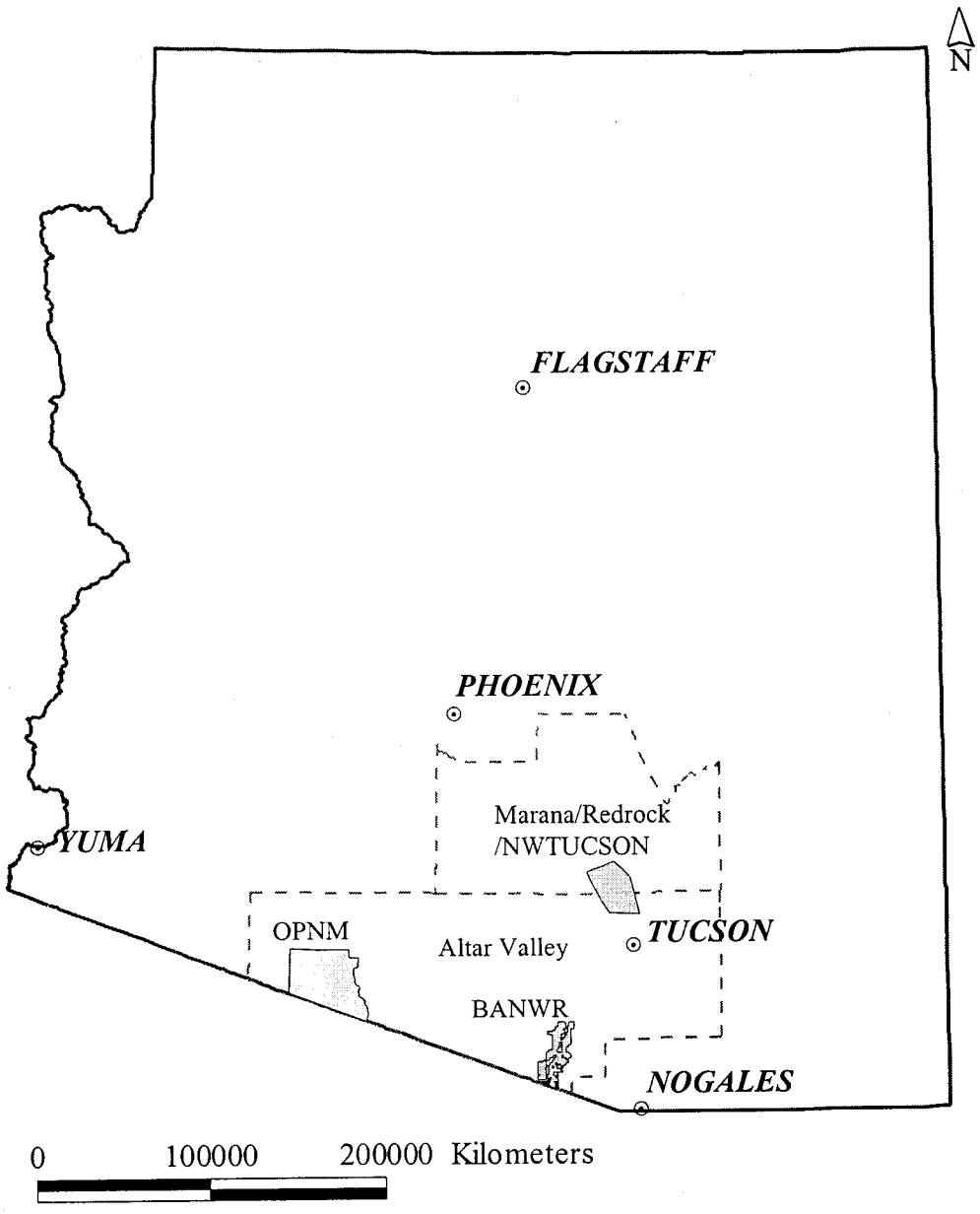


Figure 1. Study area includes parts of northwest Tucson (NWTUCSON), Marana/Redrock, Altar Valley, Buenos Aires National Wildlife Refuge (BANWR), and Organ Pipe National Monument (OPNM) within Pima and Pinal Counties in Arizona 1999 - 2000.

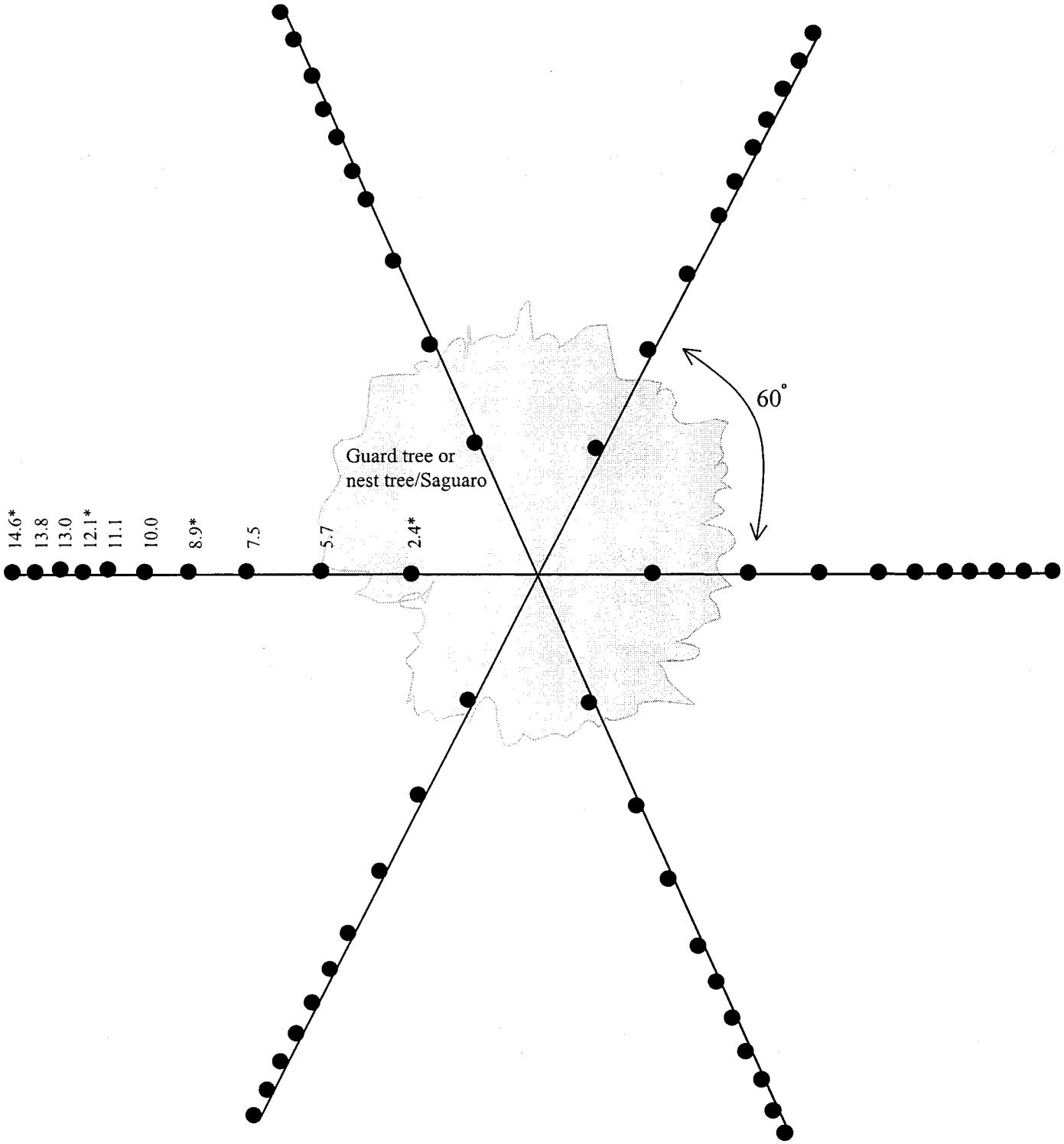


Figure 2. Vegetation sample plot consisting of six 15m radii centered around the nest saguaro/tree or guard tree. There are 10 points extending 2.4, 5.7, 7.5, 8.9, 10.0, 11.1, 12.1, 13.0, 13.8, 14.6 m from plot center on each transect for the collection of ground cover data. Vertical vegetation measurements were taken at four points along each radii denoted by asterisk.

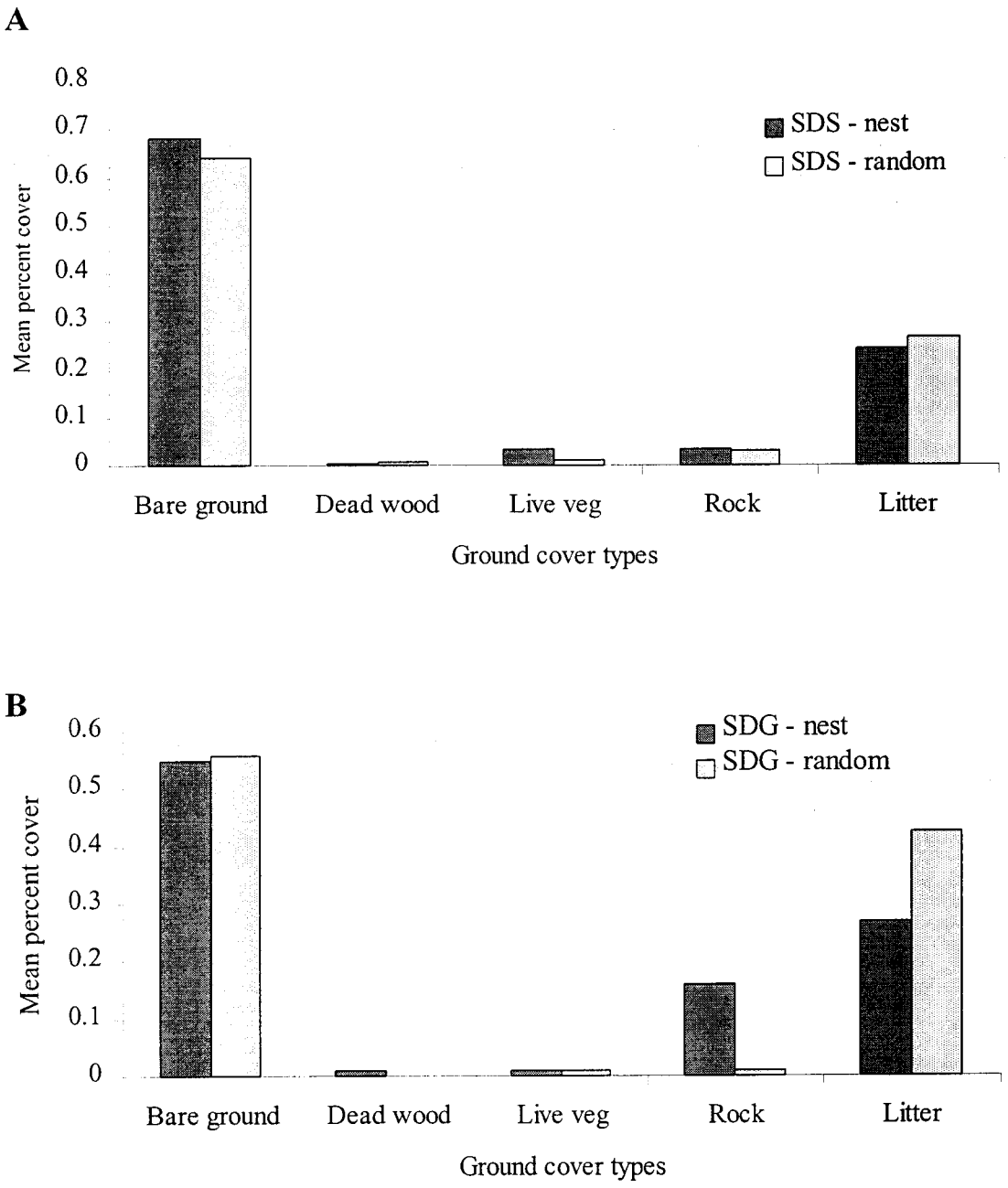


Figure 3. Mean percent ground cover found on pygmy-owl nest plots in (A) Sonoran desertscrub (n=6) and (B) semi-desert grassland (n=2) vegetation types in Arizona 1999 – 2000.

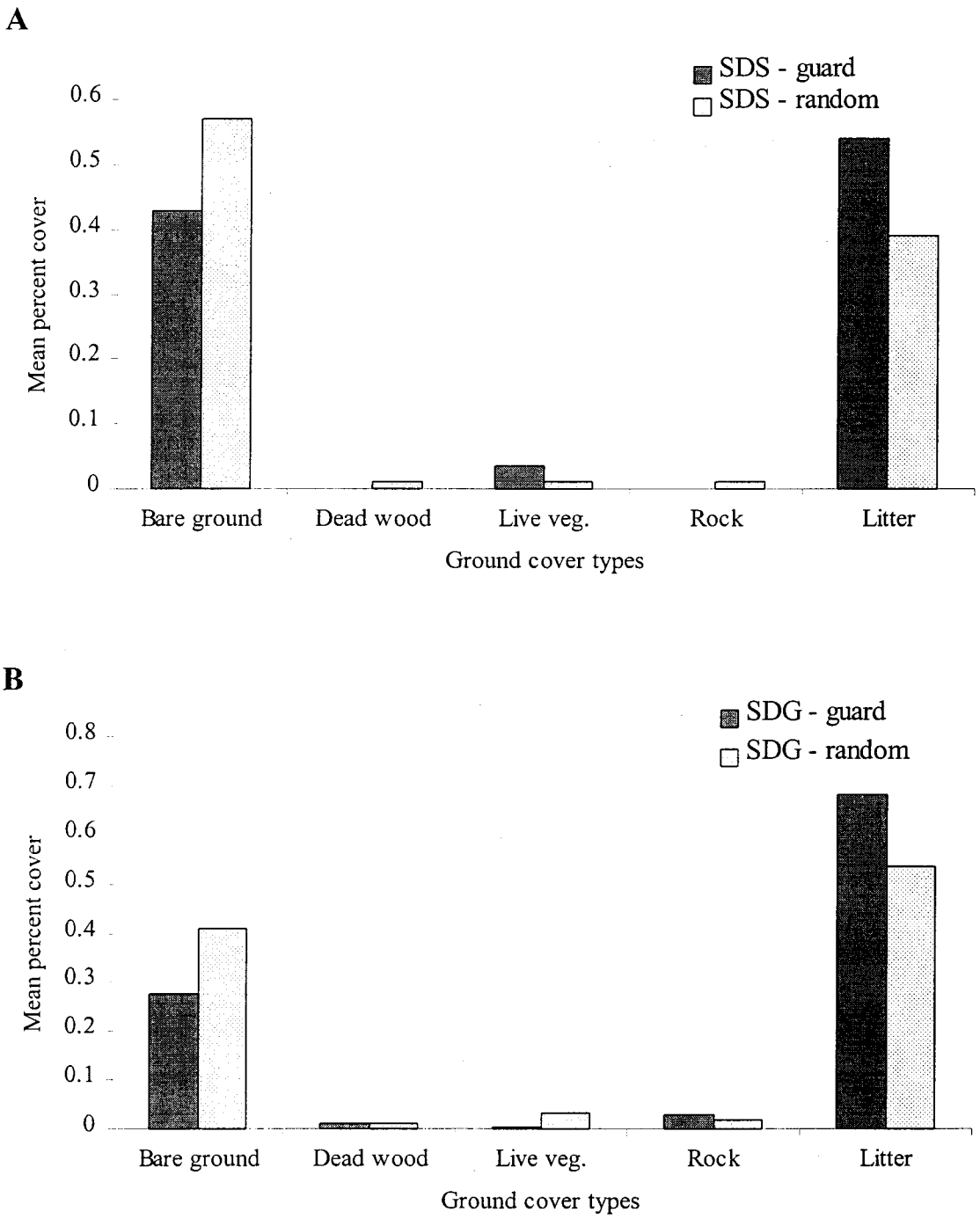


Figure 4. Mean percent ground cover found on pygmy-owl guard tree plots in (A) Sonoran desertscrub (n=5) and (B) semi-desert grassland (n=2) vegetation types in Arizona 1999 – 2000.

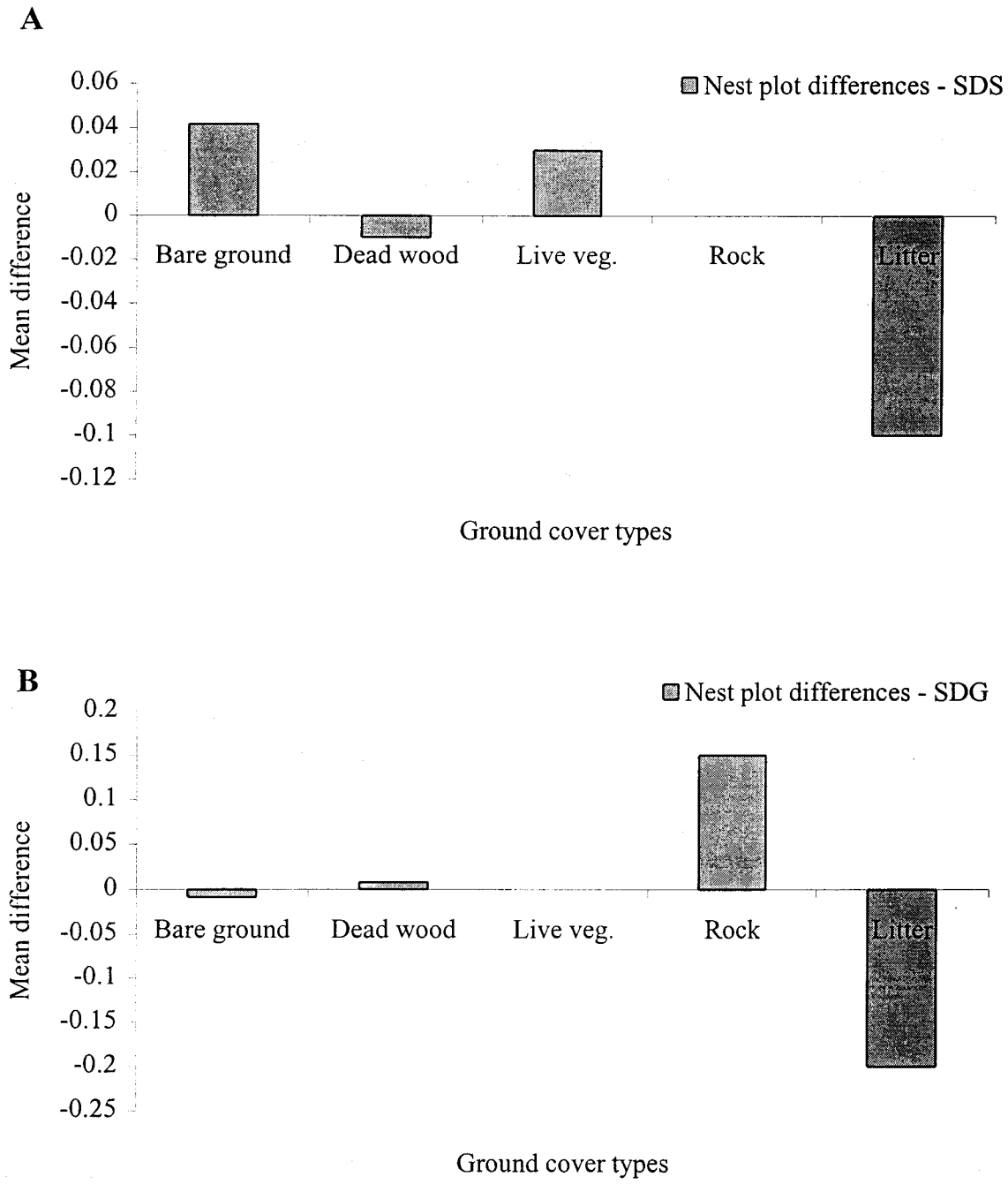


Figure 5. Mean difference in percent ground cover types found on pygmy-owl nest and associated random plot in (A) Sonoran desertscrub (n=6) and (B) semi-desert grassland (n=2) vegetation types in Arizona 1999 – 2000.

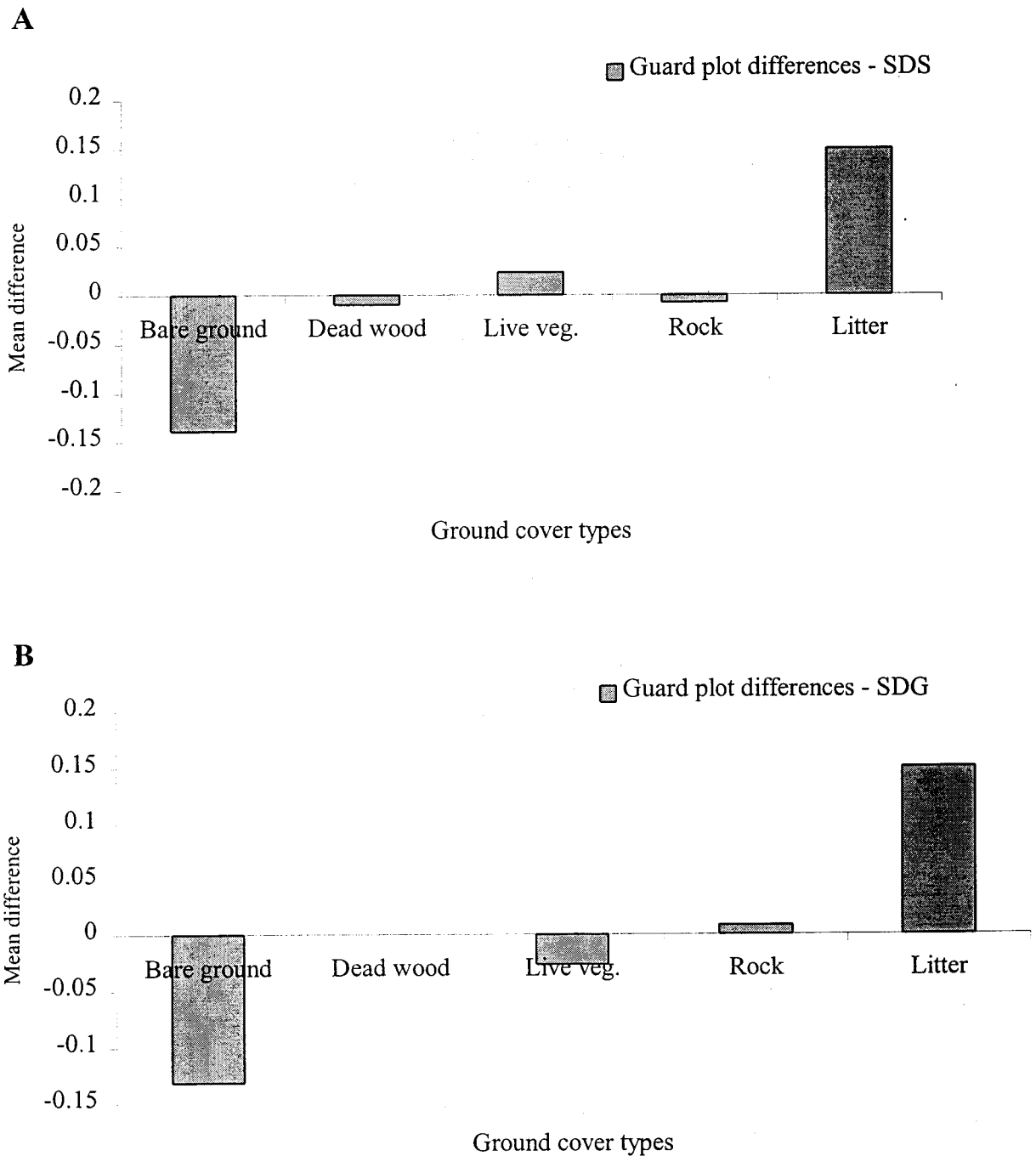


Figure 6. Mean difference in percent ground cover types found on pygmy-owl guard tree and associated random plots in (A) Sonoran desertscrub (n=5) and (B) semi-desert grassland (n=2) vegetation types in Arizona 1999 –2000.

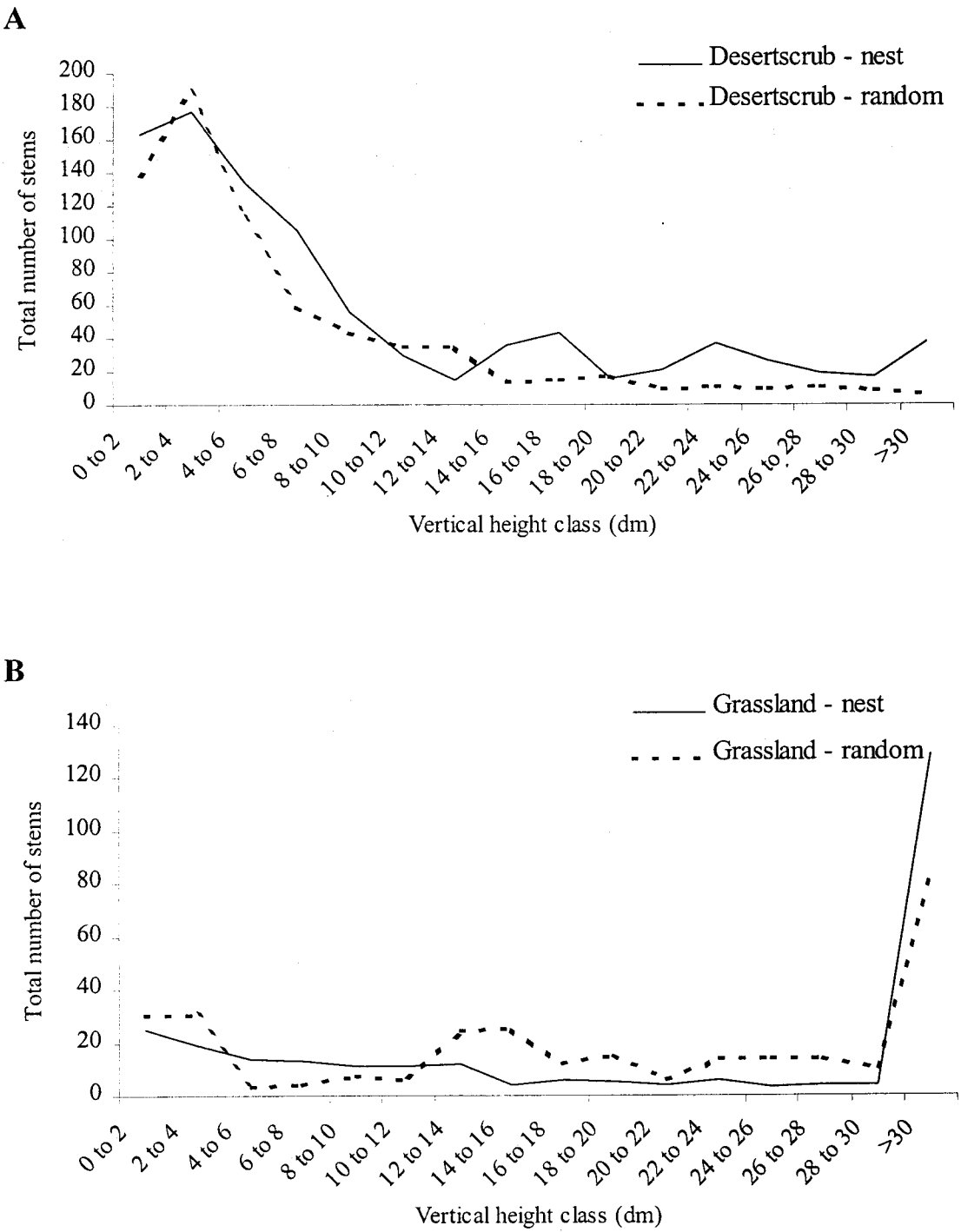


Figure 7. Total number of stems at 16 height classes (2 dm intervals) found on cactus ferruginous pygmy-owl nest plots within Sonoran desertscrub (A) and semi-desert grassland (B) vegetation types in Arizona 1999 - 2000.

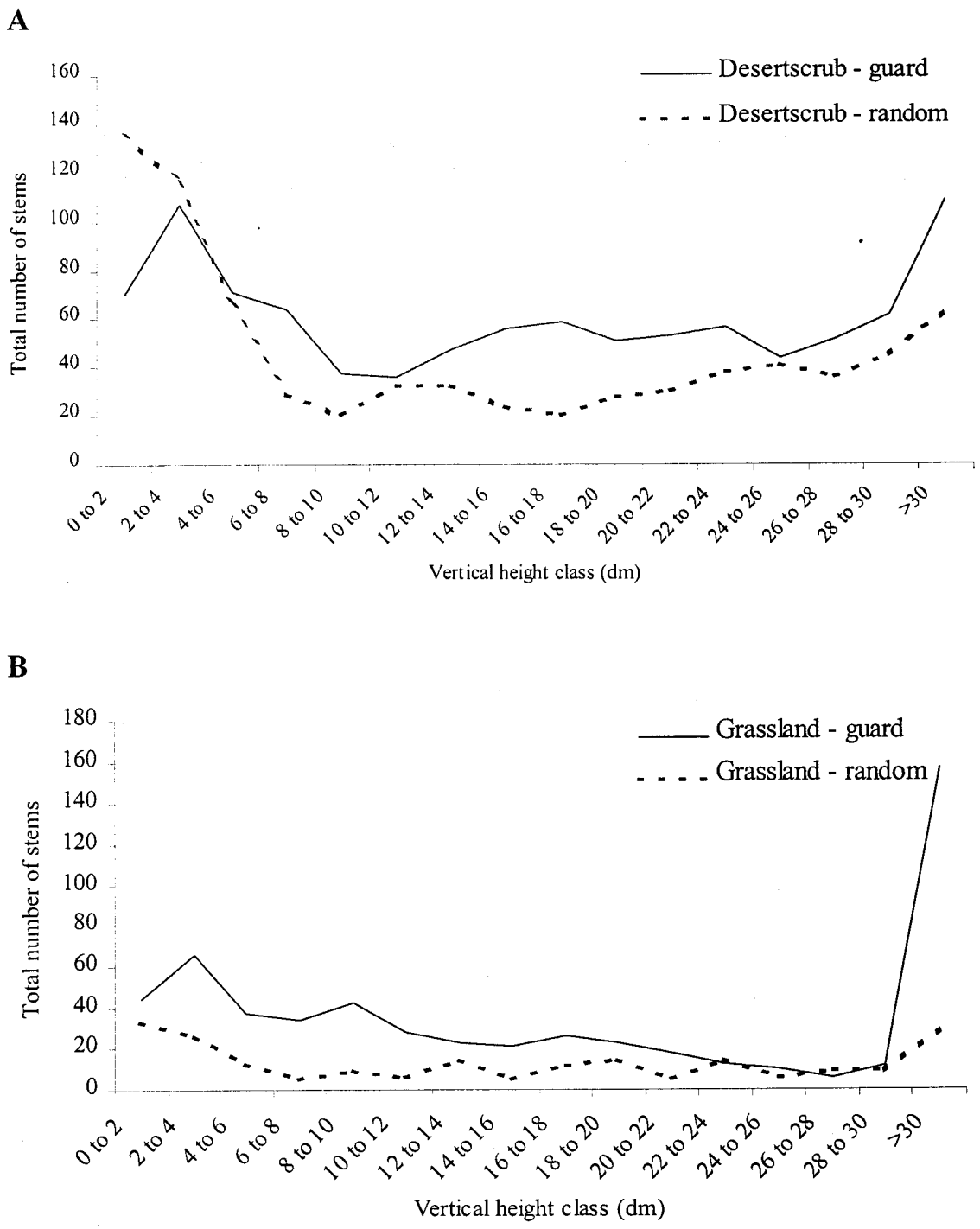


Figure 8. Total number of stems at 16 height classes (2 dm intervals) found on cactus ferruginous pygmy-owl guard tree plots within Sonoran desertscrub (A) and semi-desert grassland (B) vegetation types in Arizona 1999 - 2000.

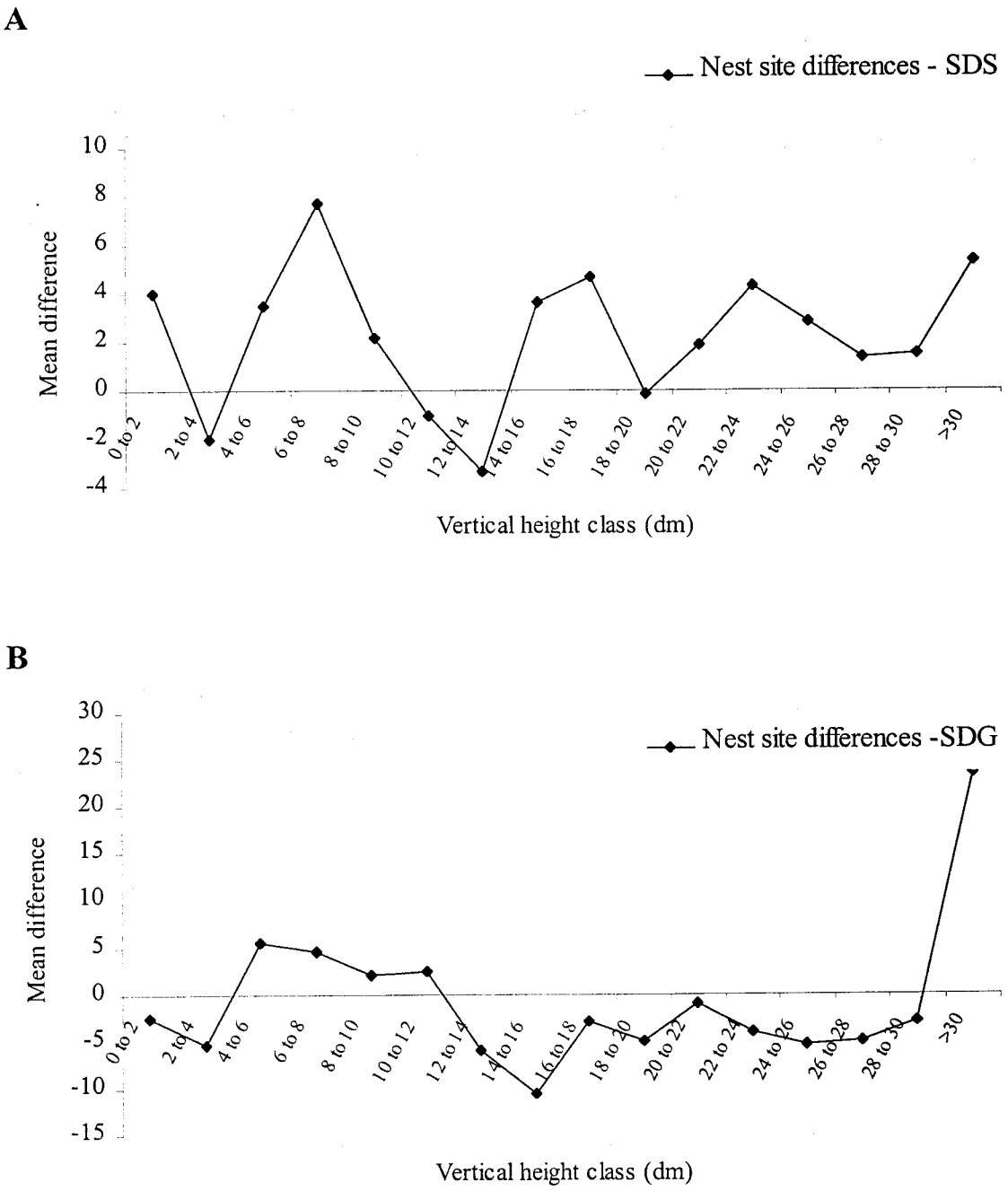
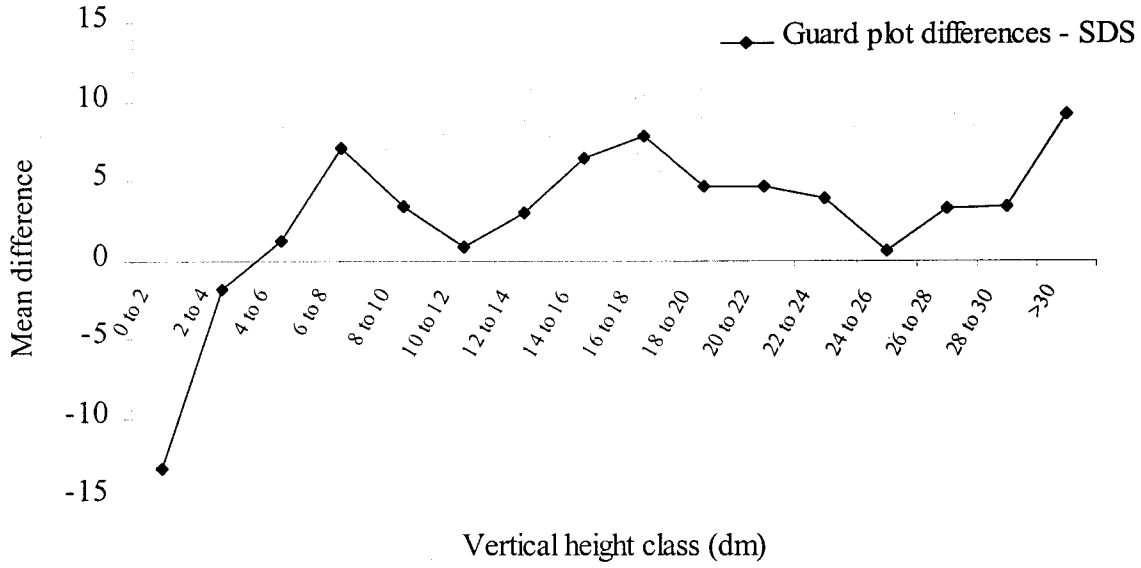


Figure 9. Mean difference in total number of stems at 16 height classes found on cactus ferruginous pygmy-owl nest plots within Sonoran desertscrub (A) and semi-desert grassland (B) vegetation types in Arizona 1999 – 2000.

A



B

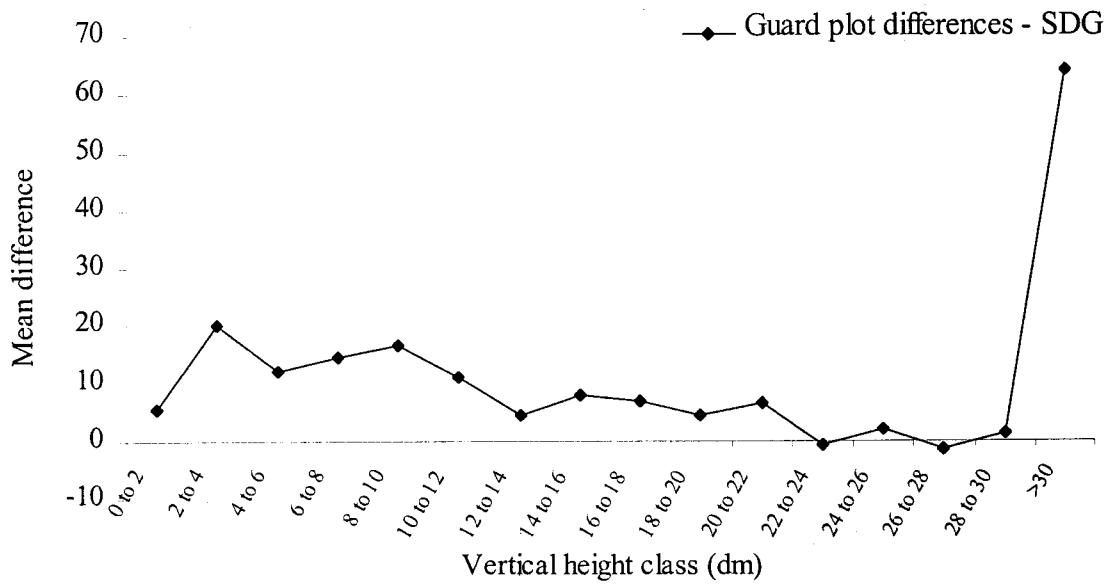


Figure 10. Mean difference in total number of stems at 16 height classes found on cactus ferruginous pygmy-owl guard tree plots within Sonoran desertscrub (A) and semi-desert grassland (B) vegetation types in Arizona 1999 – 2000.

Appendix 1. Vegetation sampling form.

Cactus Ferruginous Pygmy-owl Habitat Sampling Form

Date:_____ Observer(s):_____

_____

Site Name/Number:_____ _____

_____

Perch or Nest location description:

_____

_____

GPS File(s) :_____, _____, _____, _____

Elevation(m):_____

Distance to the following(m):

Permanent/Standing Water:_____ Dry Wash:_____

Dirt Road :_____ Paved Road:_____

Human Habitation/Activity:_____

Photo Points:

T#1 - ex._____ T#2 - ex._____

T#3 - ex._____ T#4 - ex._____

Perch Structure Information:

DBH Perch tree (ignore if has many stems) or CAGI (cm) =_____

Height of center tree or saguaro (ft) = _____

Crown Radius (trees only)

Trans. #1 Bearing___ (m) =_____

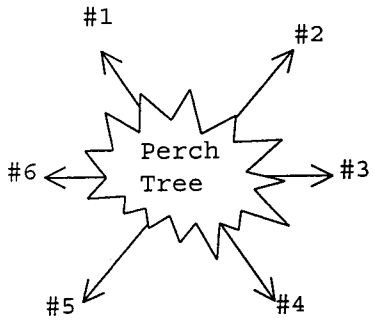
Trans. #2 Bearing___ (m) =_____

Trans. #3 Bearing___ (m) =_____

Trans. #4 Bearing___ (m) =_____

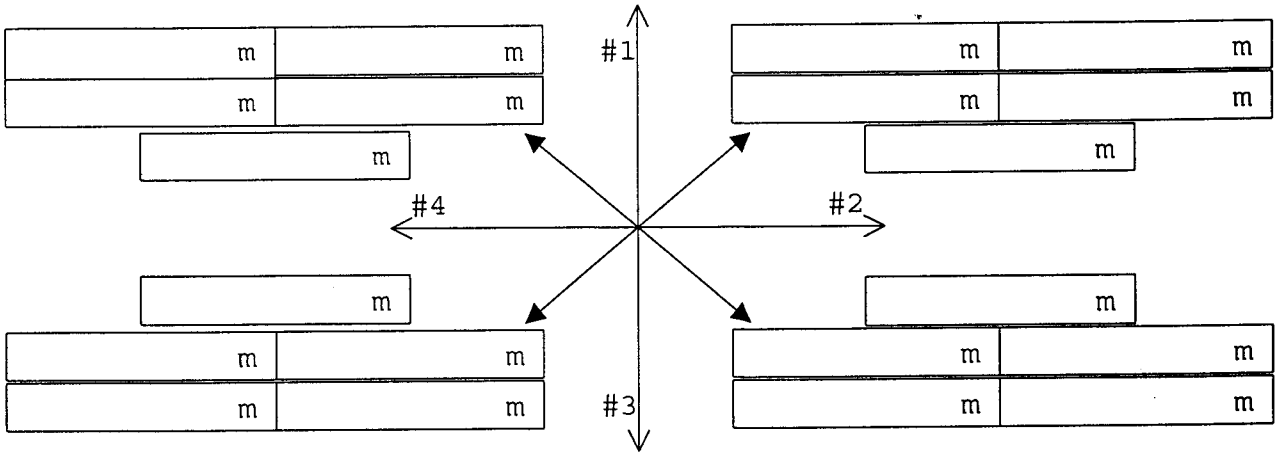
Trans. #5 Bearing___ (m) =_____

Trans. #6 Bearing___ (m) =_____



Distance to nearest live tree by species (both above 2m and below):

(Record species code, distance to center point from main stem, height)



Appendix 1. (cont.)

Species Diversity and Composition:

Count all species found within the 15m plot.

Species Code	Count			Heights (m)				Crown Diameter
	A	B	C					
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								
16.								

Appendix 1. (cont.)

Trns#	Pt (m)	No. of "hits" of each spp. with a 1dm cylinder along the 3m pole															
		0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	>30
	0.4																
	2.9																
	6.1																
	13.6																
	17.4																
	23.9																
	27.1																
	29.6																
	0.4																
	2.9																
	6.1																
	13.6																
	17.4																
	23.9																
	27.1																
	29.6																
	0.4																
	2.9																
	6.1																
	13.6																
	17.4																
	23.9																
	27.1																
	29.6																

Comments:

Appendix 1. (cont.)

Ground Cover Circle one.

Pt.	0.4*	1.2	2.0	2.9*	3.9	5.0	6.1*	7.5	9.3	13.6*	17.4*	20.7	22.5	23.9*	25.0	26.1	27.1*	28.0	28.8	29.6*
	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG
T#1	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW
to	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV
T#4	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI
	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT
	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG
T#2	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW
to	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV
T#5	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI
	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT
	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG
T#3	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW
to	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV	LV
T#6	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO	RO
	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI	LI
	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT	OT

BG = Bare ground DW = Dead wood LV = Live Vegetation RO = Rock LI = Litter OT = Other

Appendix 2. Species list with acronyms for plants observed in greater Tucson area, Altar Valley, and Organ Pipe National Monument, Arizona 1999 - 2000.

Scientific Name	Common Name	Acronym
Acacia constricta	whitethorn acacia	ACCO
Acacia greggii	catclaw acacia	ACGR
Agave scottii	shindagger	AGSC
Agave sp.	Agave sp.	AGsp
Ambrosia ambrosoides	canyon ragweed	AMAM
Ambrosia deltoidea	triangle-leaf bursage	AMDE
Baccharis glutinosa	seep willow	BAGL
Baccharis sarothoides	desert broom	BASA
Baccharis sp.	baccharsis sp.	BAsp
Berbersis haematocarpa	red barberry	BEHA
Calliandra eriophylla	false mesquite, fairy duster	CAER
Carnegiea gigantea	saguaro	CAGI
Celtis pallida	desert hackberry	CEPA
Celtis reticulata	net-leaf hackberry	CERE
Cercidium microphyllum	foothill palo verde	CEMI
Datura meteloides	Western jimson weed	DAME
Echinocereus fendleri	Fendler hedgehog	ECFE
Echinocereus sp.	hedgehog	ECsp
Encelia farinosa	brittlebush	ENFA
Ephedra sp.	ephedra	EPSp
Ephedra trifurca	long-leafed ephedra	EPTR
Eucalyptus sp.	eucalyptus	EUsp
Ferocactus sp.	barrel cactus	FEsp
Ferocactus wislizenii	fish-hook barrel	FEWI
Fouqueria splendens	ocotillo	FOSP
Fraxinus velutina	velvet ash	FRVE
Gutierrezia serotina	snake weed, broom weed	GUSE
Hymenoclea salsola	cheesebush, white burrobush	HYSA
Isocoma tenuisecta	burroweed	ISTE
Larrea tridentata	greasewood	LATR
Lycium berlandieri	wolfberry, desert thorn	LYBE
Mammalaria sp.	Mammalaria	MAsp
Olneya tesota	Ironwood	OLTE
Opuntia leptocaulis	desert christmas cactus	OPLE
Opuntia sp.	cholla	CHsp
Opuntia sp.	prickly pear	PRPE
Perezia nana	desert holly	PENA
Phoradendron californicum	desert mistletoe	DEMI
Prosopis sp.	mesquite	PRSp
Prosopis velutina	velvet mesquite	PRVE
Sphaeralcea ambigua	desert mallow, alkali pink	SPAM
Zizyphus obtusifolia	graythorn	ZIOB