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ABSTRACT

An opportunity to study the effects of commercial harvesting of Mojave Yucca (Yucca schidigera) on bird populations was provided when 66% of an established bird census plot in Mojave Yucca-Staghorn Cholla (Opuntia acanthocarpa) desert scrub in the eastern Mojave Desert of San Bernardino Co., California was mistakenly harvested from July to September 1978. Harvesting impacts on the yucca population were measured to determine the extent of reductions in foliage height diversity and yucca density in the harvested area. About 26.5% of the total number of yucca trunks were removed from the harvested area, including 54% of all trunks over four feet in height plus 23% of trunks less than four feet. Pre-harvest data on bird species composition and densities gathered during spring 1977, spring 1978, and winter 1977-78 were compared with data from post-harvest surveys during spring 1979 and winter 1978-79. Comparisons were also made with data from a control plot established in similar habitat after the harvesting incident and surveyed during the same period as the experimental plot. There was a 52% reduction in number of bird species and a 94% decrease in average number of individuals from winter 1977-78 (pre-harvest) to winter 1978-79 (post-harvest) on the experimental site. However, there were 25% fewer species and equal numbers of individuals recorded on the control site as compared with the disturbed area during the post-harvest winter surveys. Winter species diversity showed a considerable decrease after harvesting although species diversity on the control plot was lower than either survey on the experimental plot. Numbers of breeding bird species did not appreciably vary between the surveys on either plot although the post-harvest census of the disturbed plot did have the lowest species total of all. The post-harvest census on the distrubed site showed a 30% decrease in number of breeding bird territories from 1977 and a 55% decrease from 1978. The experimental plot had 50% fewer breeding territories than the control during 1979. Only three breeding bird species showed obvious reductions below pre-harvest densities and of these, only Cactus Wren was also considerably less abundant on the post-harvest experimental plot than on the control plot. Breeding bird species diversity was not significantly different between any of the censuses. General impressions from the data indicate that yucca harvesting leads to slight reductions in the majority of species, which brings about a considerable decrease in the density of the bird community as a whole without affecting species diversity. Species composition tended to fluctuate a great deal between years and plots with proportions of shared species ranging from 26.9% to 44% for the winter surveys and from 47% to 71.4% for the breeding surveys. It is speculated that hole-nesting species which must rely on yucca trunks may be adversely affected by harvesting although no serious or immediate declines in hole-nester populations were noted. It was concluded that yucca harvesting was primarily responsible for the reductions in bird populations outlined above, even though no definite reasons for the declines could be determined.

INTRODUCTION

The eastern Mojave Desert of southern California contains a remarkable diversity of habitats for wildlife as compared with most other areas of the Mojave and Sonoran Deserts and this diversity is especially reflected in the rich avifauna of the area (Remsen and Cardiff in prep.). The Mojave Yucca (*Yucca schidigera*)-Staghorn Cholla (*Opuntia acanthocarpa*) plant association is one of the more distinctive habitats found in the East Mojave and is characterized by dense mixed stands of these two species found within a narrow elevational range from three to four thousand feet at the top of gently sloping alluvial surfaces near the Providence, Woods, and Hackberry Mountains. This particular yucca-cholla association is apparently unique to the East Mojave and of quite limited distribution.

From 1975 to 1979 the U.S.Bureau of Land Management (BLM) actively conducted inventories of biological resources in the California desert regions with the purpose of formulating a utilization and management plan for public land in these areas as required by the Federal Land Policy and Management Act of 1976 (Ruch 1980). As part of these studies, bird census plots were established in most of the major desert habitat types to gather baseline data on bird species composition and population densities. One such study site was located in yucca cholla habitat in the East Mojave about 12 miles NNW of Goffs, San Bernardino County, between Hackberry Mountain and Vontrigger Hills. Breeding and winter bird surveys were conducted here from spring 1977 to spring 1978.

Quite unexpectedly, from July to September 1978, the above study area was mistakenly and illegally harvested for Mojave Yucca with two-thirds of the twenty hectare study plot affected by the logging operations. This event, although not a premeditated and controlled experiment, nonetheless provided an opportunity to study the effects of yucca harvesting on vegetation and birdlife. The BLM authorized continued bird studies, vegetation analysis, and establishment of a nearby unharvested control plot to take advantage of the situation. This paper analyses and discusses the effects of yucca harvesting on bird populations through comparisons of pre- and post-harvest censuses of the experimental plot and data from the control plot.

Studies of this type have been fairly infrequent and usually discuss successional recovery from clear-cutting (Connor and Adkisson 1975,1979). The few papers dealing with the effects of selective harvests of "dominant" tree-like vegetation components have mostly been concerned with coniferous or hardwood forests (Webb et.al. 1977;Franzreb and Ohmart 1978), since desert regions are generally not thought of as producing plant species worth the effort of commercial logging and harvesting is usually rather localized. It is hoped this study will make some contribution to the existing information on the effects of habitat alteration on birds and create an awareness of yet another source of human disruption of the environment.

THE STUDY AREAS

A. The Experimental (Harvested) Plot

The original bird study plot was established in April 1977 about 12 mi. NNW of Goffs, San Bernardino Co., at coordinates Township 11 north, Range 17 east, NE 1/4 section 5 and NW 1/4 section 4, USGS Lanfair Valley Quadrangle (35°04'N, 115°10'W). The site lies along the southern borders of the Lanfair Valley in an area of irregular terrain somewhat isolated by the Bobcat Hills to the north, the Vontrigger Hills to the south and east, and Hackberry Mountain to the south and west. Extensions of the latter two ranges nearly meet just south of the study site and several large washes draining a substantial portion of the southern Lanfair Valley converge at this gap.

The plot itself is twenty hectares in size, arranged in a five by four hectare rectangle with the length oriented along a magnetic north axis. The terrain is fairly flat, well drained and slopes slightly down to the south. Elevations range from 3630 to 3670 ft. A moderately large wash passes from north to south through the eastern third of the plot and comprises about 10% of the plot area. This and a number of smaller side washes gives the plot two or three meters of vertical relief below the general surface level in some spots.

Evidence of human activity from several decades past still persists on the site. The remains of a narrow gauge railroad bed are still present as well as faint impressions of a small dirt road. Assorted artifacts such as old lumber, pieces of wire, tin cans, and bottles are also in evidence but none of these indicators of past diturbance appear to have any influence on present bird populations. Livestock grazing has been another source of widespread disturbance in this region and has almost certainly had some effect on the birds in the area through long-term changes in soil and vegetation characteristics. Cattle are regularly seen on the site and grazing may be somewhat more intense in the immediate area due to the presence of a livestock watering site near the southern boundary of the plot. Additional unnatural features which may influence the plot include a well maintained dirt road and small power line which parallel the west edge of the study area. Small game hunters and motorcycle enthusiasts occasionally visit washes in the area but generally avoid the yucca-cholla habitat due to its thorny nature.

Yucca harvesting took place on the experimental plot between early July and mid-September 1978. The western two-thirds of the plot area was affected by the logging operations, which resulted in the removal of a substantial proportion of the yucca trunks at the site. Harvesting also took place in adjacent areas to the north, south, and west. There was also a considerable (but unmeasured) amount of damage inflicted on soil, cacti, and other shrubs, primarily by vehicles haphazardly driving over the plot to pick up cut yucca trunks. Appendix 1 describes yucca-cholla habitat, yucca growth patterns, and yucca harvesting procedures, regulations, and politics in greater detail.

This particular area was chosen as the study plot because of its easy accessibility, exceptionally tall and dense stand of yuccas, and because it is located on public land and is thus supposedly immune to major forms of abuse. Height and density of Mojave Yucca stands appears to reach a maximum between 3600 and 3900 ft elevation, depending on the topography of a given area, and it appears that this plot encompassed one such stand. The plot itself had a fairly homogeneous stand of yuccas and although yucca-cholla habitat adjacent to the site was similar to that on the plot in nearly all respects, there were no tall, dense stands of equal size. This small scale patchiness presented difficulties during the process to establish a suitable control plot near the harvested area. Bird surveys took place here during spring 1977 (Cardiff 1978), 1978 (Cardiff 1979b), 1979 , and winter 1977-78 (Cardiff 1979a) and 1978-79 .

B. The Control (Unharvested) Plot

Following the harvesting incident, a control plot as closely comparable in terms of vegetation and topography to the experimental site as possible, was established in order to provide additional data with which to evaluate the effects of harvesting on the original plot. Although stands of yucca-cholla habitat were available adjacent to the harvested area, none of these were of comparable size or vegetation height structure and it took a good deal of searching before a new study area was chosen on state-owned land approximately six miles WSW of the harvested site.

The exact location of the control site is Township 11 north, Range 16 east, NE 1/4 of section 16, USGS Mid Hills Quadrangle (35°02' N, 115°16' W). The site is on the SW edge of Watson Wash, which passes roughly north to south between the Woods Mountains to the west and Hackberry Mountain to the east. It is strikingly similar to the experimental plot, both in its close proximity to a large wash near a gap in the southern edge of the Lanfair Valley, and in its location on a slightly sloping and well-drained, gravelly bajada. The plot is located in a tall and dense stand of yucca cholla habitat and is surrounded by similar but somewhat less tall habitat. One corner of the plot (about 5% of the total area) extends into Watson Wash in order to simulate the wash habitat present on the experimental site (about 10% of the total area).

Compared with the experimental plot, the control is of similar size and shape except the length runs east-west instead of north-south; topography is more uniformly flat with less vertical relief due to a general lack of well developed wash tributaries. Elevations are somewhat higher but still quite similar, ranging from 3780 to 3850 ft. A seldom used dirt road passes through the NE portion of the plot; otherwise there are fewer evidences of human activity. Cattle are occasionally seen on the site but grazing pressures are probably less since the nearest livestock watering area is one mile to the NW. There is no evidence that either plot has been previously exposed to yucca harvesting. Bird surveys were conducted spring 1979 and winter 1978-79 .

METHODS

A. Substrate and Perennial Plant Sampling Procedures

Perennial plant species composition and cover plus substrate characteristics were measured using the toe-point transect method . Five 100-point transects were conducted on each plot for a total of 500 sample points on both areas. The transects were arranged in such a fashion as to give equal proportional coverage to each vegetation type present on the plots. Both sites were sampled within the period 12-14 June 1979.

Most of the perennial plants are still easily identifiable at this time of year, and the major herbaceous perennials are not yet in advanced stages of dessication. Although harvesting operations did cause some damage to the vegetation in general, we felt it was not of sufficient magnitude to significantly change overall vegetation characteristics and that the post-harvest survey was still representative of pre-harvest conditions in most respects. Thus we concluded that valid comparison of the two plots was still possible. Two obvious exceptions included an understandable reduction in yucca density and a related increase in the amount of dead plant litter versus bare ground due to an accumulation of discarded yucca debris.

B. Analysis of Yucca Populations

Ten belt transects (10m x 100m) were performed on each plot to determine clone density, stem (trunk) density per clone, and height distribution of the yuccas. The transects were distributed so as to represent all areas of the plot with fairly homogeneous yucca-cholla habitat. In other words, no transects were conducted in large washes where a different vegetation type exists and yucca density is very low. Numbers of stems per clone included ground level sprouts which had not yet developed visible trunks.

Heights of stems were measured from base to vertical midpoint of the tallest leaf head. Stems were divided into two height classes, one including stems greater than or equal to four feet (corresponding to legally harvestable sizes) and those less than four feet. These height classes were also convenient in relating the yucca data to the vertical height stratification of the habitat since the taller yucca height class constituted the uppermost vegetation layer. Stems higher than twelve feet were extremely rare, with only one seen on the experimental plot (in the unharvested portion) and less than five found on the control plot. None at all were encountered on the transects. Thus, stems over twelve feet were deemed too insignificant for discussion here, even though they are illegal to cut.

In order to compare pre- and post-harvest height distributions on the experimental plot and between the experimental and control plots, a method was devised to predict the heights of cut yucca stems encountered during belt transects in the harvested area. Sixty stems of various heights from each plot were measured for height and basal diameter. The relationship between height and diameter was similar for both plots. All 120 points were combined to establish a linear relationship between height and diameter (Fig.1) and this was used to estimate the height of cut stems from measuring basal diameter of the stumps.

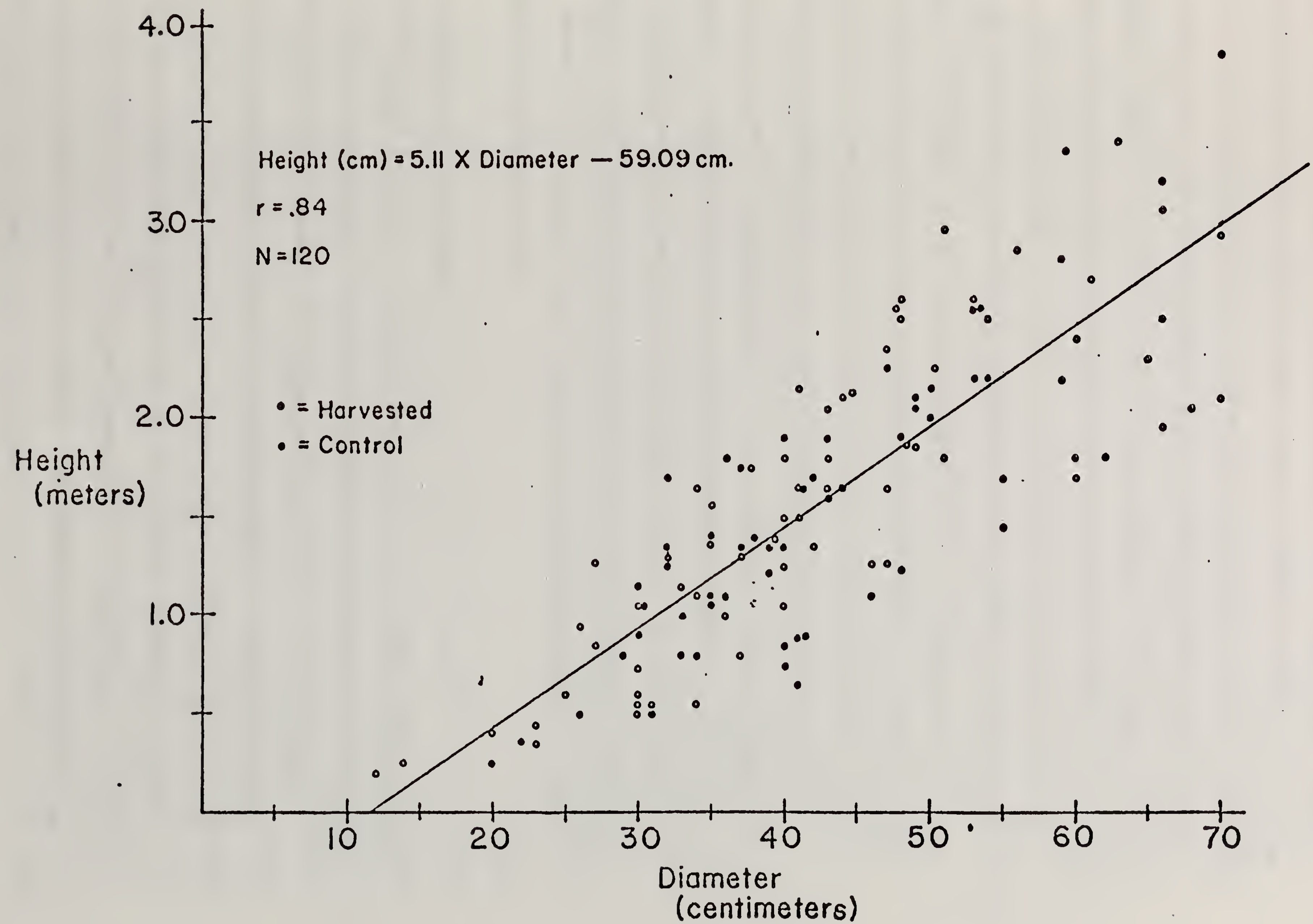
C. Bird Censusing Procedures

Censusing of breeding birds followed the spot-mapping method of determining territorial densities (Williams 1936) and was conducted in accordance with standardized rules outlined by Van Velzen (1972). In brief, survey techniques involved traversing the study area in an orderly fashion over a two to three hour period beginning at or just before sunrise and plotting locations of singing individuals, nests, and other territorial behavior. These surveys, when conducted at regular intervals during the peak of the nesting season, can allow a fairly accurate determination of breeding bird species composition and density of breeding pairs. Bird species diversity was calculated by the Shannon-Weiner index method (MacArthur and MacArthur 1961).

Wintering bird populations were surveyed using techniques similar to those above in most respects. However, actual densities of each species were usually determined by taking an average of the number of individuals present on each survey. This approach works well during the winter when territory sizes tend to increase and many species are found in mixed flocks (and wander over a large area, frequently changing species composition and number of individuals). Spot-mapping was occasionally helpful in elucidating densities of non-flocking species.

Figure

Figure 1. Relationship between height and basal diameter used to estimate heights of cut yucca stems on the experimental plot.



Surveys using the above methods are usually fairly effective in desert communities with good visibility and sound transmission. We believe our censusing methods are quite consistent between different years and seasons and between the two plots. All censuses were conducted by Cardiff except during winter 1978-79 when time limitations made it necessary for both observers to alternate surveys between the experimental and control sites. Both observers are quite familiar with all species likely to be encountered and used the same survey methods. Table 1 outlines winter and breeding bird survey visits to both plots. Estimations of weather conditions were recorded during each census and surveys were not made during abnormal weather. Unfortunately, there were no permanent weather stations nearby to provide year round meteorological data and no correlations of annual variations in weather and bird populations could be made.

RESULTS

Substrate characteristics and perennial plant composition and cover are shown in Tables 2 and 3 respectively. Substrates were quite similar for the two plots, the main difference being that the experimental site was somewhat more rocky than the control. Total perennial plant cover was 17.4% on the experimental area and 18.8% on the control, again reinforcing the close structural similarities of the vegetation on the two plots. Of the 21 major species encountered (comprising at least 1% of the total density on at least one plot), 18 were common to both plots. Several discrepancies between the plots, such as the difference in cover for Acacia, are probably attributable to the greater amounts of wash habitat on the experimental plot. However, cover values for Mojave Yucca and Staghorn Cholla, the two habitat indicator species, are very close for both plots.

Belt transect data on yuccas is presented in Table 4. Various comparisons were made between the control plot, the undisturbed portion of the experimental plot, and pre- and post-harvest conditions on the disturbed portion

Table 1. Schedule of bird censuses made during this study.

	Census period	# visits	Average interval between visits (days)	Average number hours per visit
Winter Surveys				
Experimental 1977-78	22 Dec-25 Feb	8	9.2	3.0
Experimental 1978-79	14 Jan-24 Feb	8	5.8	2.8
Control 1978-79	21 Jan-25 Feb	8	4.8	2.7
Breeding Surveys				
Experimental 1977	24 Apr-8 Jun	8	6.4	3.0
Experimental 1978	22 Apr-28 May	8	5.1	3.0
Experimental 1979	4 Apr-4 Jun	8	8.7	2.4
Control 1979	5 Apr-12 Jun	9	8.5	2.6

Table 2. Comparison of substrate characteristics on the experimental and control plots.

	COMPOSITION (%)	
Characteristic	Experimental	Control
Bare ground	43.2	49.4
Dead plant litter (includes dead annuals)	25.0	32.8
Small rocks (1/8"-2")	23.2	13.8
Large rocks (2")	2.4	0.0
Perennial plant stems (basal hits)	6.2	4.0
	100.0	100.0

Species	EXPERIMENTAL composition(%)	EXPERIMENTAL cover(%)	CONTROL composition(%)	CONTROL cover(%)
Catclaw (Acacia greggii)	3.4	20.7	1.0	0.0
Goldenhead (Acamptopappus sphaerocephalus)	0.8	1.1	14.2	4.2
Burrowbush (Ambrosia dumosa)	1.4	0.0	2.4	2.1
Ragweed (Ambrosia eriocentra)	0.2	0.0	1.2	0.0
Senna (Cassia armata)	0.0	0.0	1.6	3.2
Hedgehog Cactus (Echinocereus engelmannii)	0.0	0.0	0.4	0.0
Nevada Joint Fir (Ephedra nevadensis)	1.2	1.1	4.8	3.2
California Buckwheat (Eriogonum fasciculatum)	20.4	18.4	9.4	4.2
Fluffgrass (Erioneuron pulchellum)	1.6	0.0	0.0	0.0
Cooper Goldenbush (Happlopappus cooperi)	16.8	11.5	19.4	12.8
Big Galleta Grass (Hilaria rigida)	10.2	2.3	8.0	3.2
Cheesebush (Hymenoclea salsola)	4.2	3.5	6.0	3.2
Little-leaved Ratany (Krameria parvifolia)	10.0	4.6	5.2	6.4
Creosote Bush (Larrea tridentata)	1.6	1.1	2.8	14.9
Deerweed (Lotus rigidus)	1.0	0.0	1.2	2.1
Anderson Thornbush (Lycium andersonii)	0.4	0.0	0.0	0.0
Mojave Aster (Machaeranthera tortifolia)	0.2	0.0	0.0	0.0
Four-O'Clock (Mirabilis tenuiloba)	0.0	0.0	0.2	0.0
Staghorn Cholla (Opuntia acanthocarpa)	8.0	18.4	4.6	20.2
Silver Cholla (Opuntia echinocarpa)	0.0	0.0	0.2	0.0
Pencil Cholla (Opuntia rammosissima)	2.2	1.1	2.8	4.2
Purple Sage (Salvia dorrii)	3.6	1.1	0.0	0.0
Paperbag Bush (Salazaria mexicana)	4.6	4.6	1.4	0.0
Desert Mallow (Sphaeralcea ~~Sphaerophysa~~ ambigua)	0.2	0.0	0.0	0.0
Stephanomeria (Stephanomeria pauciflora)	1.0	0.0	0.0	0.0
Needlegrass (Stipa speciosa)	0.2	0.0	0.0	0.0
Cottonthorn (Tetradymia axillaris)	3.8	3.5	4.8	4.2
Turpentine Broom (Thamnosma montana)	0.0	0.0	3.6	4.2
Mojave Yucca (Yucca schidigera)	2.8	6.9	4.4	7.5
	99.8	100.0	99.9	99.9

T[illegible] 4. Comparisons of yucca populations before an[illegible]er harvesting, from belt transect data The first three columns represent unharveste[illegible] areas, giving an idea of variability in natural yucca populations and providing three sets of data with which to evaluate impacts on the harvested area (column four).

	Control	Undisturbed area of Experimental Plot	Estimated Pre-harvest conditions on disturbed area of Experimental Plot	Post-harvest conditions on dist. area of Exp. Plot
Size of area (hectares)	19.3	6.8	11.2	11.2
Area of sample (hectares)	1.0	0.4	0.6	0.6
Density yucca clones/hectare	148.0	215.0	144.0	112.0
Density yucca stems/hectare	752.0	1358.0	740.0	547.0
Mean number stems/clone	5.1	6.3	5.1	4.9
Percent clones with one or more stems ≥ 4 ft.	60.1	52.3	46.6	18.7
Percent stems < 4 ft.	82.3	88.8	88.1	93.0
Percent stems ≥ 4 ft. (harvestable)	17.7	11.2	11.9	7.0

of the experimental plot. In general the two study sites were fairly close in terms of pre-harvest clone and stem densities. Although clone densities on the control site and the pre-harvest disturbed portion of the experimental site were nearly the same, the density on the undisturbed portion of the experimental site was considerably higher and the average density of the experimental plot was probably somewhat higher than on the control. The same is true of stem densities. Stems in the upper height class were slightly more common on the control plot. It was concluded that prior to harvesting, the two plots presented equivalent yucca-cholla habitat to birds, and in this respect, the control was a good replicate of the harvested plot.

Data concerning the impact of harvesting on the affected yucca population are shown in Table 5. The selective yucca harvest removed an estimated 2200 yucca trunks, or about 26.5% of all yucca trunks present within the affected area of the plot. The proportion of yucca clones with stems exceeding four feet in height dropped from about 47% to 19% (Table 4) and 54% of all trunks over four feet were cut. The habitat, from a bird's-eye view, had a substantial proportion of its upper canopy removed. In addition, many yucca clones were clearcut, resulting in a lowered clone density in the disturbed area. Thirty of 86 clones found in the belt transects in the harvested area (35%) had at least one stem removed and 20 of the 86 (23%) had been clearcut. Eight of the clearcut clones were estimated not to have had any stems of legally harvestable size. A survey was also made of new yucca sprouts which had emerged from cut stumps in the year since harvesting took place. A total of 82 sprouts were counted of which 66 (80%) had sustained heavy damage from small mammal depredations, indicating a poor survival rate for regenerating shoots.

Winter and breeding bird census results are shown in Tables 6 and 7 respectively. Both post-harvest surveys of the experimental plot showed

Table 5. Additional calculations summarizing the direct impact of harvesting on yucca populations.

	Stems < 4 ft.	Stems ≥ 4 ft.	Total
Number unharvested stems in sample	305	23	328
Total estimated no. unharvested stems in area	5704	430	6134
Number harvested stems in sample	91	27	118
Total estimated no. harvested stems in area	1702	505	2207
Percent total stems present before harvest	88.8	11.2	100.0
Percent total stems present after harvest	93.0	7.0	100.0
Percent stems removed from pre-harvest totals of combined height classes	20.4	6.1	26.5
Percent stems removed from pre-harvest totals of each height class	23.0	54.0	-

represent mean numbers of individuals recorded per visit. A "+"indicates sence only (<.5 indiv.) and a "-" indicateas absence.

	EXPERIMENTAL		CONTROL
Species	Pre-harvest 1977-78	Post-harvest 1978-79	1978-79
Red-tailed Hawk	+	-	-
Prairie Falcon	+	-	-
American Kestrel	+	-	-
Gambel's Quail	4	+	+
Greater Roadrunner	-	-	+
Common Flicker	1	-	-
Ladder-backed Woodpecker	+	1	1
Common Raven	1	-	+
Verdin	1	+	+
Bewick's Wren	1	+	-
Cactus Wren	3	1	-
Rock Wren	1	-	-
Sage Thrasher	+	-	-
LeConte's Thrasher	1	-	2
Crissal Thrasher	+	+	+
Mountain Bluebird	+	-	-
Black-tailed Gnatcatcher	1	1	-
Ruby-crowned Kinglet	+	-	-
Loggerhead Shrike	-	+	1
Yellow-rumped Warbler	+	+	-
Western Meadowlark	1	-	-
House Finch	+	-	-
Vesper Sparrow	+	-	-
Sage Sparrow	11	1	-
Black-throated Sparrow	5	+	+
Brewer's Sparrow	1	-	-
White-crowned Sparrow	37	1	~~+~~ -
Total individuals	69+	4+	4+
Total species	25	12	9
Species diversity	2.41	2.00	1.50

Table 7. Breeding bird census data. Numbers are estimated breeding territories inside the plot bounds. A "+" indicates presence only (< .25 territory) and a "-" indicates absence.

	EXPERIMENTAL			CONTROL
Species	1977	1978	1979	1979
American Kestrel	+	-	-	-
Gambel's Quail	2.0	3.0	0.5	0.5
Mourning Dove	+	7.0	1.0	5.0
Greater Roadrunner	1.0	-	1.0	0.5
Screech Owl	-	1.0	-	+
Ladder-backed Woodpecker	1.0	1.0	1.0	1.0
Ash-throated Flycatcher	1.0	1.5	1.5	2.0
Say's Phoebe	+	0.5	-	-
Verdin	+	-	-	-
Cactus Wren	2.5	2.5	0.5	1.5
Northern Mockingbird	-	+	-	-
Bendire's Thrasher	1.0	0.5	0.5	0.5
LeConte's Thrasher	-	+	-	1.0
Crissal Thrasher	-	-	+	+
Black-tailed Gnatcatcher	+	-	+	-
Loggerhead Shrike	-	+	+	1.0
Scott's Oriole	1.0	-	-	1.0
Black-throated Sparrow	2.0	1.0	2.0	2.0
Total breeding territories	11.5+	18.0+	8.0+	16.0+
Total Species	13	12	11	13
Species Diversity	2.89	2.63	2.83	3.06

reduced numbers of species and individuals from pre-harvest surveys. Winter bird decreases were especially striking with 52% fewer species and 94% fewer individuals present on the experimental plot in 1978-79 as compared with 1977-78. Twenty-two winter species decreased after harvesting while only two increased and three remained unchanged. The number of breeding bird species on the post-harvest survey was only slightly lower than the two pre-harvest surveys but densities of breeding territories were 30% less than in 1977 and 55% below 1978 levels. Comparing the two pre-harvest breeding bird surveys with the post-harvest census shows that seven species decreased, four increased, and four showed no change in each case. This is in contrast to decreases in seven species, increases in eight species and no change in two species from 1977 to 1978.

Average total winter bird densities were the same for the experimental and control plots during 1978-79 and there were slightly more species present on the experimental plot. This is puzzling, since we expected bird populations on the control site to approximate those found on the pre-harvest experimental plot. Breeding bird densities on the other hand were 50% lower on the post-harvest experimental plot than on the control while numbers of species and density of territories was fairly similar for both the control and pre-harvest surveys of the experimental plot. Several species, such as Black-throated Sparrow, were relatively unaffected by the harvesting or even increased afterwards, whereas others, such as Cactus Wren, showed significant declines. Species composition tended to fluctuate a great deal between years and plots with proportions of shared species ranging from 26.9% to 44% for the winter surveys and from 47% to 71.4% for the breeding surveys.

DISCUSSION

Assuming the observed post-harvest declines in winter and breeding bird populations on the experimental plot are too large to be explained by normal annual variation, it seems reasonable to conclude that the change in habitat structure brought about by yucca harvesting was in some way responsible. Breeding bird data from the control plot tend to support these assumptions, with overall density fairly close to pre-harvest surveys of the experimental plot. Winter data from the control plot do not follow this pattern at all, with numbers of species and individuals far below that found on the pre-harvest census of the experimental plot. However, it is hard to believe that the drastic reductions in numbers of species and individuals observed after harvesting could be accounted for by normal year to year population fluctuations.

When comparing data from the experimental and control plots it is important to keep in mind certain characteristics of each and differences between them. First of all, only two-thirds of the experimental plot was actually affected by the yucca harvesting, with fairly extensive areas to the northeast, east, and southeast remaining untouched. This "edge effect" would tend to dampen the harvesting impacts since birds can infiltrate into the damaged area from surrounding healthy habitat, and birds with territories in the harvested zone probably did not have to completely rely on the disturbed portion of the habitat. We feel that had the harvesting extended over the entire plot and good distances into adjacent habitat, the effects on bird populations at the site would have been much more dramatic.

Secondly, we feel that although the experimental and control plots are fairly good replicates of each other in terms of their yucca-cholla habitat, there is considerably more wash habitat within and adjacent to the experimental plot and that this extra wash influence boosts bird populations on the experimental plot above what they would be if the plot were in an area of more uniform topography and habitat. It is true that the control plot was also associated with a large wash but we feel Watson Wash , since it is subjected to more frequent and violent flooding, is lower in vegetation and bird diversity than washes near the experimental area.

The close proximity of water to the experimental site might also serve to attract greater numbers of birds to the area. The possibility of heavier grazing pressures on the experimental plot must also be taken into consideration , and is directly related to the close water source. There is some scanty evidence that heavier relative grazing pressures can have detrimental effects on bird populations (   ) and the fact that bird populations on the experimental plot prior to harvesting were closely similar to the control, despite heavier grazing intensities, indicates that the experimental plot is somehow more productive than the control or that some other factor cancels the grazing effect. Taking all of the above factors into consideration, it seems that harvesting impacts on bird populations may be larger than the data might imply.

Since yuccas are the tallest plants in this habitat, they are heavily utilized for perching and nesting sites, and their sharp protective leaves make them especially attractive in the latter role along with Staghorn Cholla. Mojave Yuccas are the sole host plant in this habitat for hole-nesting species such as American Kestrel, Screech Owl, Ladder-backed Woodpecker, and Ash-throated Flycatcher. Neither of the latter two species showed any decline after harvesting and thus there still must have been sufficient nesting and foraging sites available to them even though they may be less suitable than prior to harvesting. It is interesting to note that two Ash-throated Flycatcher nests found in the harvested area of the experimetnal plot were abnormally low at only two feet above the ground; thus some species may have been forced to use poorer quality nest sites. The habit of knocking dead yucca stumps out of the way during harvesting operations may severely lower the number of available nest holes, and removal of a large proportion of the tallest yucca stems may affect long-term availability of nest cavities since it is these large central stems which die as the yucca clone expands outward.

This study posesses a number of obvious shortcomings, most of which stem form the fact that the experiment takes advantage of an accidental occurrence and was never originally planned. Thus, problems arise in trying to compare the plots and develop consistent methods. Reasons for many of the observed population changes may be too subtle to be adequately discussed with the rather superficial bird data available for this analysis. Ideally, a study such as this should be planned in advance with several pairs of replicate plots surveyed over a period of several years. Improvements could also be made with more detailed vegetation analysis (including better information on foliage height diversity), careful surveys of nest cavity availability and utilization, data on bird foraging strategies, and monitoring of other vertebrate populations. Increased plot size might improve accuracy in estmating less dense desert bird populations. The problem of finding identical pairs of plots for comparison could be much reduced if plots were established in large expanses of uniform habitat to begin with.

Without more detailed observational data, it is difficult to compare our results with those of other investigators. Genral impressions from the data tend to agree with the conclusions of Franzreb and Ohmart (1978), who noted that although breeding bird species diversity is not seriously altered by selective timber removal, there was a significant overall drop in territory density in harvested areas accompanied by definite changes in species composition. Connor et.al. (1979), in a study of avifaunal responses to pine-oak clearcuts, found an overall net negative effect on bird populations. Connor noted that winter species diversity was lowest in more recently cut stands and highest in mature stands while breeding bird diversity did not vary significantly from one area to another. An extensive ten year study by Webb et.al. (1977) monitored plots of hardwood forest in which various proportions of timber had been removed (from entirely clearcut to completely uncut). Long term surveys such as this help clarify how much of the observed changes in diversity and density are due to annual fluctuations versus those that result from habitat alteration. Webb's studies emphasized the effects of different logging intensities rather than comparisons of successional regeneration from clear-cutting. Somewhat contrary to the above examples, Webb found a positive correlation of increasing number of species and species diversity to increased logging intensity. However, increased species diversity does not always indicate an improvement in the variety and abundance of the bird community.

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APPENDIX 1

General Information on Yuccas and Yucca Harvesting

The Mojave Yucca-Staghorn Cholla association occurs within a rather narrow elevational range between three and four thousand feet, below which it merges with yucca-creosote scrub and above which it gradually blends into joshua tree woodland or miscellaneous sub-shrub associations which are transitional to pinyon-juniper woodland. The habitat is named for the two most visually dominating species present, although several shrub species commonly have higher density and cover values. Both Mojave Yucca and Staghorn Cholla are common above and below the yucca-cholla habitat zone but nowhere else are both species found in such obvious, dense associations.

Thorny perennial species dominate the vegetation. Most of the plants present in this habitat can be placed in one of four overlapping height strata, although we have made no supportive measurements. The lowest layer is composed of herbaceous species and low sub-shrubs (Hilaria, Acamptopappus) with maximum heights of about one foot. Another group of species (Happlopappus, Tetradymia, Eriogonum fasciculatum) forms a second layer about one to two feet tall. A third layer between two and four feet in height includes such species as Larrea tridentata, Opuntia ramnosisssima, and most of the Staghorn Cholla and Mojave Yucca populations. The uppermost layer, above four feet, includes the taller yucca stems and occasional tall individuals of Staghorn Cholla and Acacia.

Mojave Yuccas can reproduce vegetatively as clones as well as sexually via seed production. When a seed sprouts and successfully matures, it will eventually produce secondary sprouts at the periphery of the trunk base which will grow into full sized trunks themselves. The original central trunk will gradually senesce and die and this continual process of basal sprouting and central aging results in an outward expansion of the clone. Extremely ancient clones tend to form hollow rings and most well developed clones are probably at least several hundred years old.

Commercial harvests of Mojave Yucca have taken place on the Mojave Desert of southeastern California and western Arizona for several decades. Mojave Yucca juice is apparently composed of a unique chemical mixture which can yield certain steroid chemicals used for medical purposes, foaming agents used in such things as root beer, and extracts which are supposedly effective for use as organic "plant food" and odor control agents (at stockyards, for instance). All supporters of yucca harvesting are unanimous in agreeing that harvest, transport, and processing of yuccas is more economical and allows for a bigger profit margin than does synthetic manufacture of the above products. The validity of these claims and the usefulness of the products is probably open to question. Joshua Trees (_Yucca brevifolia_) apparently have lesser amounts of lower quality juice per unit trunk weight and other local species such as _Yucca bacata_ are of much smaller size and more restricted distribution and therefore cannot be feasibly harvested. There have been no attempts to farm yuccas even though commercial cultivation does seem to have promise.

Prior to about 1976, actual harvesting was accomplished by bulldozing the yuccas down. New regulations require harvesters to cut the trunk at ground level with a chain saw, thereby leaving the stump and roots intact and allowing for subsequent resprouting. Before cutting the trunk base, leaves and shaggy debris are stripped away and then used later to cover the exposed stump and aid in recovery. The cut stems are then collected into piles and picked up by vehicles in an orderly fashion to minimize vehicle damage to the area.

Commercial harvesting of Mojave Yucca takes place on Southern Pacific Land Company property through lease agreements. Permits are issued by the Agricultural Commisioner's Office of San Bernardino County after review by the county Environmental Improvement Agency and are subject to a set of management regulations designed to lessen harvesting impacts and insure a constant future supply of yuccas. Data on the harvested yuccas were compared with these commercial harvesting conditions to determine the degree of harvester compliance.

The major permit condition is that only stems between six and twelve feet tall can be taken. This theoretically leaves the tallest and most scenic plants as well as assuring that a large population of smaller individuals remains to later mature and repopulate the area. The "chain saw" rule is also aimed at reducing permanent damage to clones with the idea of eventual regeneration and sustained-yield harvesting. However, we feel this policy is based on misconceptions of yucca population dynamics and is contrary to its intended goals. Our personal experience has led us to believe that the six to twelve foot segment of the population constitutes the majority of reproductively active individuals and that removal of this group severely limits the reproductive effort. It has also been demonstrated that Mojave Yucca increase their height by only one centimeter per year (LaPre' 1979). Therefore, about 150 years are required for new sprouts to grow to legal size and it is doubtful that yuccas can be considered a renewable resource to be harvested on a sustained-yield basis. The low rate of sprout survival must also be taken into account. The amount of Southern Pacific property containing yuccas is not sufficient to last beyond this century at the current rate of harvesting.

Considerable confusion exists as to the interpretation of the "six-foot" rule. Harvesters normally measure height as being from trunk base to tip of highest leaf. Since yucca leaves usually average 1-2 ft.in length, this procedure allows harvesters to cut many stems which have only about four feet of actual trunk length. We feel the six foot rule (for what it is worth) should apply to actual length of the trunk exclusive of the leaves, and this is reflected in our method of measuring yucca height from trunk base to leaf base. Thus, our four foot measurement roughly approximates the harvester's idea of six feet and the lower limit of harvestable trunk size.

Inspection of Table 5 demonstrates the poor compliance of harvesters to the six foot rule. About 77% of the harvested stems were less than the legal requirement. Many multiple-stem clones were clearcut (clones with all stems greater than four feet tall are virtually non-existant) and our calculations show that a fair number of clones were clearcut which did not posess any stems over four feet in height. It is also a common practice to cut away and discard small stems which block access to larger ones. We estimate that for every legal-sized stem removed, three undersized ones were also destroyed. Although only 11.9% of the stems in the harvested area met the size requirement, 26.5% of all stems were taken.

Other permit conditions concern the protection of bird nests, restrictions on off-road travel, marking of section boundaries, and procedures for covering the cut stumps. All these conditions were violated to some degree on the harvested bird census plot. The bird plot is located on public land, making the entire harvesting operation there illegal, but the observed compliance with the county's conditions for private lands which we experienced is considered typical of yucca harvesting operations in general.

The ineffectiveness of the regulations issued by San Bernardino County governing commercial harvesting of yuccas illustrates several problems concerning land management for use by wildlife. Some immediate unresolved questions about the control of commercial yucca harvesting (besides those already addressed to the problem of renewable resource) include:

1. Will yucca harvesting be allowed on private land within BLM designated Wilderness Study Areas ? Four of the tracts recently harvested under permit from San Bernardino County have been within WSA 271 or WSA 272. Very few private land tracts with good yucca stands now remain outside proposed wilderness area boundaries and pressure is being brought to bear to exploit these areas before they are declared wilderness (or possibly to prevent the declaration). The Southern Pacific Land Company had agreed to consider not issuing leases within WSA's until the Agricultural Commissioner's Office and the Environmental Improvement Agency urged reversal of the policy.

2. Will Yucca harvesting be expanded to include public land? The recently released final draft of the Desert Plan considers the alternative of commercial harvesting of native plant species but contains no discussion of the effects of yucca harvesting on the environment. Meanwhile, the companies which use yucca products are pressing for BLM approval of yucca harvesting throughout the East Mojave, since the Arizona BLM allows this activity on public land near Kingman, Mohave County.

Conservationists should press for elimination of commercial yucca harvesting on lands owned by Southern Pacific and insist that it not be allowed on public lands treated by the Desert Plan. Continuing to harvest the yuccas will mean reductions in bird populations. It will probably mean selective losses of hole-nesting species, including American Kestrels and Screech Owls. Habitat for the Bendire's Thrasher, Desert Tortoise, and Bighorn Sheep will be degraded further. The loss of yucca-cholla habitat in the East Mojave will make this part of the desert lose some of its uniqueness and exceptional aesthetic qualities.