HARVEY AND STANLEY ASSOCIATES, INC.

ECOLOGICAL CONSULTANTS • ENVIRONMENTAL PLANNERS • RESOURCE MANAGERS

☐ MAIN OFFICE:
906 ELIZABETH ST., P.O. DRAWER-E
ALVISO, CA 95002
(408) 263-1814

☐ CENTRAL COAST OFFICE:
6001 BUTLER LANE, SUITE #1
SCOTTS VALLEY, CA 95066
(408) 438-4102

MOUNTAIN LION POPULATION TRENDS MONITORING IN CARLSBAD CAVERNS AND GUADALUPE MOUNTAINS NATIONAL PARKS.

Prepared by

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INTRODUCTION

At the turn of the century mountain lion depredations on domestic sheep and goat populations in the Guadalupe Mountains was a major problem for ranchers (Anonymous 1906, USFS records). Historic documents and early literature suggest that the resulting predator control reduced the mountain lion population in the Guadalupes and neighboring mountain ranges (USFS records, Davis 1940). Records of mountain lion mortalities from U.S. Forest Service records and personal communication with several long-time ranching families suggests that mountain lion densities remained low from the 1920's and 30's until the late 1960's and early 1970's.

During this period of low mountain lion density 2 national parks were established; Carlsbad Caverns National Park (CACA), New Mexico, in 1923 (with significant expansion in 1963) and Guadalupe Mountains National Park (GUMO), Texas in 1972. In the late 1970's a recurrence of depredations on several ranches in the immediate vicinity of these national parks led to intensive control of mountain lions in the area surrounding the parks. The question was raised whether depredating mountain lions were inhabiting park lands as well as adjacent sheep range, and if so, what was the effect of the control practices on the mountain lion population?

Difficulties encountered with the contrasting management goals of control and protection resulted in a study sponsored by the United States Department of the Interior, National Park Service (NPS) from 1982 to 1985 (Smith et al. 1985). Several findings of this study were potentially important to NPS management goals of protection and preservation. The frequent killing of mountain lions on ranches bordering the national parks occasionally removed lions that lived, to varying degrees, within park boundaries. Additionally, it was found that regional control efforts resulted in a level of mortality potentially destabilizing to the population. However, during the study, the population was apparently maintained in part by immigration from nearby and distant areas where human related mortality was low or non-existent. This tenuous balance between population mortality and recruitment raises management concerns.

In view of the extent of livestock depredation occurring during the NPS study, it was recommended that if a preventative control program was required, it should be limited to concentrated areas on and around 3 sheep ranches bordering the national parks . A cooperative effort between state and federal agencies was encouraged to monitor mountain lion mortality outside, and presence inside, both national parks. Finally, factors which ultimately influence mountain lion survival should be included in a comprehensive synthesis of the above and used to direct management decisions.

The development of the mountain lion monitoring program described below was sponsored by the NPS to fulfill the need for monitoring trends in mountain lion abundance within the national parks.

REVIEW OF AVAILABLE METHODS

PRELIMINARY CONSIDERATIONS

The primary purpose of the monitoring program is to monitor the presence, distribution, and relative abundance of mountain lions within two unhunted regions of the Guadalupe Mountains (i.e. the national parks). Coupled with mortality data for the regional population provided by the state of New Mexico, this information will provide insight into the impact of control efforts on ranches bordering both Carlsbad Caverns National Park, New Mexico (CACA) and Guadalupe Mountains National Park, Texas (GUMO).

A tremendous effort has been expended in wildlife management toward the development of reliable and robust techniques for determining distribution and measuring abundance of wildlife species. Since its infancy as a science early wildlife biologists have recognized the need for reasonably accurate and precise measures of animal populations in order to develop sound long-term management programs. Several exhaustive reviews of the available techniques for measuring distribution and abundance have been published (see Overton 1971, Eberhardt 1971, 1978, Caughley 1977, Burnham et al. 1980, Davis and Winstead 1980, Seber 1982, White et al. 1982). These reviews provide the theoretical underpining for the various techniques and their corresponding strengths, weaknesses and underlying assumptions. Caughley (1977) indicated that abundance can be measured in three ways: 1) as a total number of animals within the population, 2) as the number of animals per unit area (absolute density) and 3) as one population of animals relative to another (relative density). The choice as to which approach is appropriate depends on the goals, objectives, and economy of the project. Measures of the total population or absolute density tend to be significantly more expensive than obtaining relative densities. The measures of abundance for the puma are further exaserbated by its secretive nature and inherently low population size. The unique nature of the ecology and behavior of the puma requires either specific techniques or modifications of standrad ones for the collection and analysis of data (Hopkins 1984). Caughley

(1977) argues that estimates of population size or abundance density are not instrinsicly more valuable than relative density. He suggests that many biological problems can be solved with estimated of relative density.

Anderson (1983) reviewed several different methods used to estimate number of pumas or indicate trends. Noting the inadequacies of several methods, he recommended that research efforts be made toward developing more efficient techniques for measuring level of abundance for populations of pumas.

The methods employed to estimate density and trend of puma populations can be divided into 2 general categories: those that infringe on the population in a real or potential manner and those that do not. These different methods are termed invasive and non-invasive, respectively.

INVASIVE METHODS

Bounty and Harvest Records

Several attempts have been made to estimate population density or correlate trends with changes in bounty or harvest records (Bryant 1917, Hunter 1921, Grinnell et al. 1937, Johnson and Couch 1954, Koford 1977, Evans 1983, Roberson 1984). The inability of most of these efforts to accurately depict the true changes in the populations of pumas are due primarily to the violation of the numerous and burdensome assumptions taht accompany these analysis.

The common theme that runs throughout these attempts at using harvest and bounty records is the inability for these authors to correct for changes in habitat, hunting effort, environmental conditions, social and cultural factors, and the distribution, abundance and behavior of the prey of the puma.

Grinnell et al. (1937) suggested that the bounty records for California indicated a stable population between 1907 to 1921. These authors believed that changes in bounty records reflected a real change in the puma population in California. They did, however, point out some weaknessess in having the bounty records for assessment of the puma population. They suggested that females are under represented in the bounty records. Hunting methods may favor males and as Grinnell et al. (1937) pointed out, skins that were turned in for bounty and lacked proof of sex were payed the lower bounty given for males.

Johnson and Couch (1954) developed a formula for estimating populations based on kill data:

$$N = 3K + \frac{3K}{10}$$

N = total minimum population
K = number of pumas killed each year

They used life history data reported in Young and Goldman (1946) to generate their formula. They offer no reasonable explanation for this mathematical relationship and it appears they probably worked backward from the N value they felt was reasonable and correct. These authors violated numerous other assumptions, not the last being an understanding of a dispersal sink.

Murphy (1983) has shown the importance of hunter access on hunting effort and eventual harvest rates in Montana. Consequently, the absence of data permitting quantification of hunting effort in these early studies obscures conclusions regarding changes in population density. Evans (1983) provided a detailed and interesting analysis of the available data on the ecology of the puma in New Mexico. He suggested that an analysis of hunting success plotted against season between 1972 to 1983 indicated a declining population of pumas. He rejected the possibility that increase in hunter numbers, changes in methods of data collection, participation of out-of-state hunters and other possible environmental and social factors were responsible for declining harvest success rate. Since Evans does not provide the statistical analysis for rejection of these factors, it is difficult to assess his supposition.

Roberson (1984) believed that trend indices in Utah based upon hunter, hunter days and harvest might have detected a slight decline in the population between 1971 to 1983. He admits, however, that changes in environmental and social factors and data collection were not corrected for and may influence the resulting conclusions.

In summary, the use of bounty and kill data without meeting the underlying assumptions is invalid. Evans (1983) and Roberson (1984) recognized this problem and attempted to correct for changes in environmental and social factors and evolving harvest strategies. How successful they were remains to be seen. They did, however raise some interesting questions that deserve further investigation. Harvest records can provide a realistic assessment of trend if hunting success, and change within the system are carefully quantified.

Capture and Radio-telemetry

At present, the most accurate method used to census mountain lion populations is through an intensive capture methodology (Anderson 1983). This method attempts to identify all resident adults by capture and radio-tracking. Studies using this general approach form the basis of what is currently known of mountain lion density, home range and movements (Seidensticker et al. 1973, Sitton and Wallen 1976, Shaw 1980, Hopkins 1982, Ashman et al. 1983, McBride 1976, Belden 1982, Currier 1976, Donaldson 1975, Murphy 1983, Hempker et al. 1984, Logan et al. 1986, Smith et al. 1985). However, because of fiscal and manpower commitments, this method is often considered prohibitively expensive. For the purpose of monitoring population trends this method may best be applied as a means to obtain a point estimate of initial population density.

NON-INVASIVE TECHNIQUES

The occurance of animal sign has often been used as a measure of abundance. Caughley (1977) sugggests that counting animal sign can often provide a more accurate index of density than counting animals. This is particularly true with rare animals such as large carnivores. Visual sightings of pumas are relatively rare events but when combined with other evidence (e.g. tracks) they can be useful in determining presence (Van Dyke and Brocke 1987). Van Dyke and Brocke (1987), however, stress that sightings should never be used to estimate the abundance and distribution of pumas.

Several researchers have attempted to develop an index of population based on the quantification of tracks or scrapes (Donaldson 1975, Koford 1977, Ashman 1979, Shaw 1980, Kutilek et al. 1983, Fitzhugh and Gorenzel 1984, Smallwood and Fitzhugh 1987). These researchers with the exception of Koford (1977) concluded that track-surveys were of little value in estimating population densities of pumas. However, these studies have resulted in several modifications toward the development of a track-survey that can measure trend on both a local and statewide bases. The index used by Koford to estimate density along his track routes is invalid because it was not developed empirically. Shaw (1980) attempted to use the robust program of line transect developed by Burnham et al. (1980). Shaw calculated that in order to satisfy the requirements of the model he would have to survey 1200 miles of roads on the Kaibab.

In the summer of 1980 and 1981 Kutilek et al. (1983) conducted a series of track surveys in five areas of California to provide baseline data for estimating population trends. These researchers concluded that with some modifications track transects could be used to detect major trends in the population. They argued that this technique is currently inadequate to measure absolute abundance of the statewide population because of the lack of an empirically based track index. They suggested that when trends are needed, the use of numerous one day transects measuring presence or absence on a given day of the year. In 1985 and 1986 Smallwood and Fitzhugh (1987) field tested a modification of the statewide one-day survey. Two years is an insufficient period of time to judge its general utility for measuring trend in the statewide puma population.

Caughley (1977) argues that measures of relative density are often quite adequate for specific management goals. Indices of relative abundance should ideally demonstrate a linear trend (Caughley 1977). This positive linear relationship of sign to density has been established for pumas (Van Dyke et al. 1986) and lynx (Stephenson 1986). Therefore, an inexpensive, non-invasive technique that surveys a reasonable proportion of CACA and GUMO should satisfy the National Parks goals of monitoring trend and distribution of the puma populations in these two parks.

FORMULATING A SURVEY METHOD

Certain modifications of the standard survey methods for pumas are needed for use in the National Parks. Uniqque problems occur when attempting to apply these methods to national parks, because roads are virtually non-existent within the boundaries of many national parks. Further, many existing Park roads are not maintained and may not occur in regions where mountain lion sign is consistently found. Another complication involves frequent restrictions regarding the backcountry use of motorized vehicles. Survey routes must be traveled on foot or horseback and must utilize trail systems or well defined cross-country routes. In many areas of both GUMO and CACA the condition of the tracking substrate both on and off trails is poor.

The establishment of a survey route in CACA and GUMO will be based on telemetric data of home range and movements, documented scrape sites, caves and regions with trackable substrates (Smith et al. 1985). Smith (pers. com.) indicated that little or no marginal habitat for pumas exist in either of the parks. In addition, survey routes will be relatively long so as to include all major watersheds and portions of the parks. A systematic survey route is preferred over a randomized one because of the relative scarcity of puma sign. The establishment of random transects in the steep terrain of these parks would be logistically difficult and prohibitively expensive. The systematic survey routes satisfy the goal for developing an index of puma sign for monitoring trends in GUMO and CACA (Overton 1971).

Long-term monitoring commitments characterize trend studies. Harris (1986) defines trend studies of short duration as less than or equal to 12 years. Eberhardt (1978) points out that trend studies often exhibit considerable variation, often approaching 1.0 (100%). This variation necessitates large sample sizes to accurately assess trends. Harris (1986) suggests the use of multiple counts each year to increase the sample size and precision of the trend estimate during studies of short duration. Consequently, bi-annual surveys are favored with 170-190 days separating each survey.

In summary, relatively long systematic survey routes have been established for each park. These routes should be surveyed bi-annually, collecting data on scats, scrapes, tracks and kills. Data collection should be quantified in a fashion that minimizes the use of complex rules in defining track sets, scrape sites and scats. From the resulting index and four or five years of data collection a clearer picture should emerge as to the feasibility of monitoring trends in GUMO and CACA.

The National Parks have three possibilities: 1) to maintain an expensive, labor-intensive radio-telemetry study, 2) do nothing, or 3) monitor the puma population based on an index of relative density. Herein we recommend the third alternative and have designed a monitoring program using what we consider to be the best available techniques. These are untested methods, and we recognize that there are inherent limitations in their use. However, we support the general call made by other lion researchers for developing and testing methods which will reveal long-term trends.

METHODS

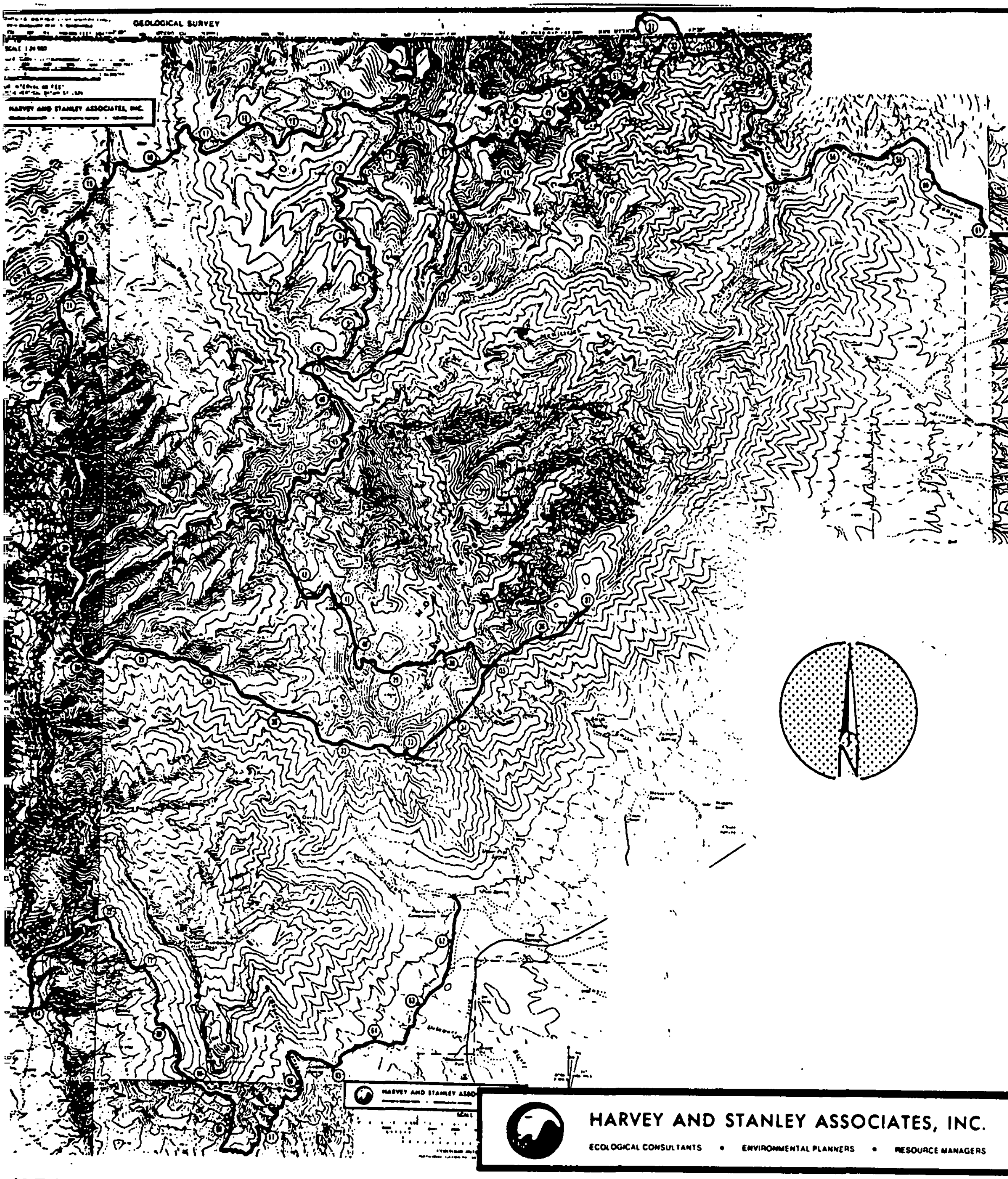
SURVEY ROUTES

The reliance on accumulation of sign rather than a measure of weekly activity or traffic, possess unique problems in designing sampling procedures. The relationship between mountain lion movements and sites that can potentially preserve sign and/or elicit sign-generating behavior is of key interest to the survey. In regions of both parks, sites known to possess this desired movement-preservation-elicitation complex are quite rare. Consequently, the likelihood of incorporating these sites into a transect selected by random procedures is not high.

The procedure used to delineate the survey routes for GUMO and CACA was based primarily on a synthesis of location data for radio-collared lions, locations of documented scrape sites, and clear travel routes where tracks and scats were frequently found during the NPS baseline study (Smith et al. 1985). This synthesis permitted the delineation of transects through areas known to be frequented by mountain lions.

An attempt was made to distribute the coverage of survey routes equally through major regions of each park. The routes are arranged along park trail systems where possible but follow ridges and canyon bottoms when necessary. Route markers will be needed to accurately delineate off-trail routes and key point locations. Where off-trail routes or key points are hard to find compass directions should be taken.

The total number of transect kilometers established for GUMO and CACA was 74 km and 76 km, respectively. Each transect kilometer is numbered sequentially and, when possible, lead from one watershed to the next. Table 1 provides a summary of the number of kilometers in each watershed for both national parks. Figures 1 & 2 show the locations of the transects and Appendix A illustrates each park transect on U.S.G.S. 7.5 minute topographic maps. Minor refinements in actual transect routes may be necessary during the initial surveys.



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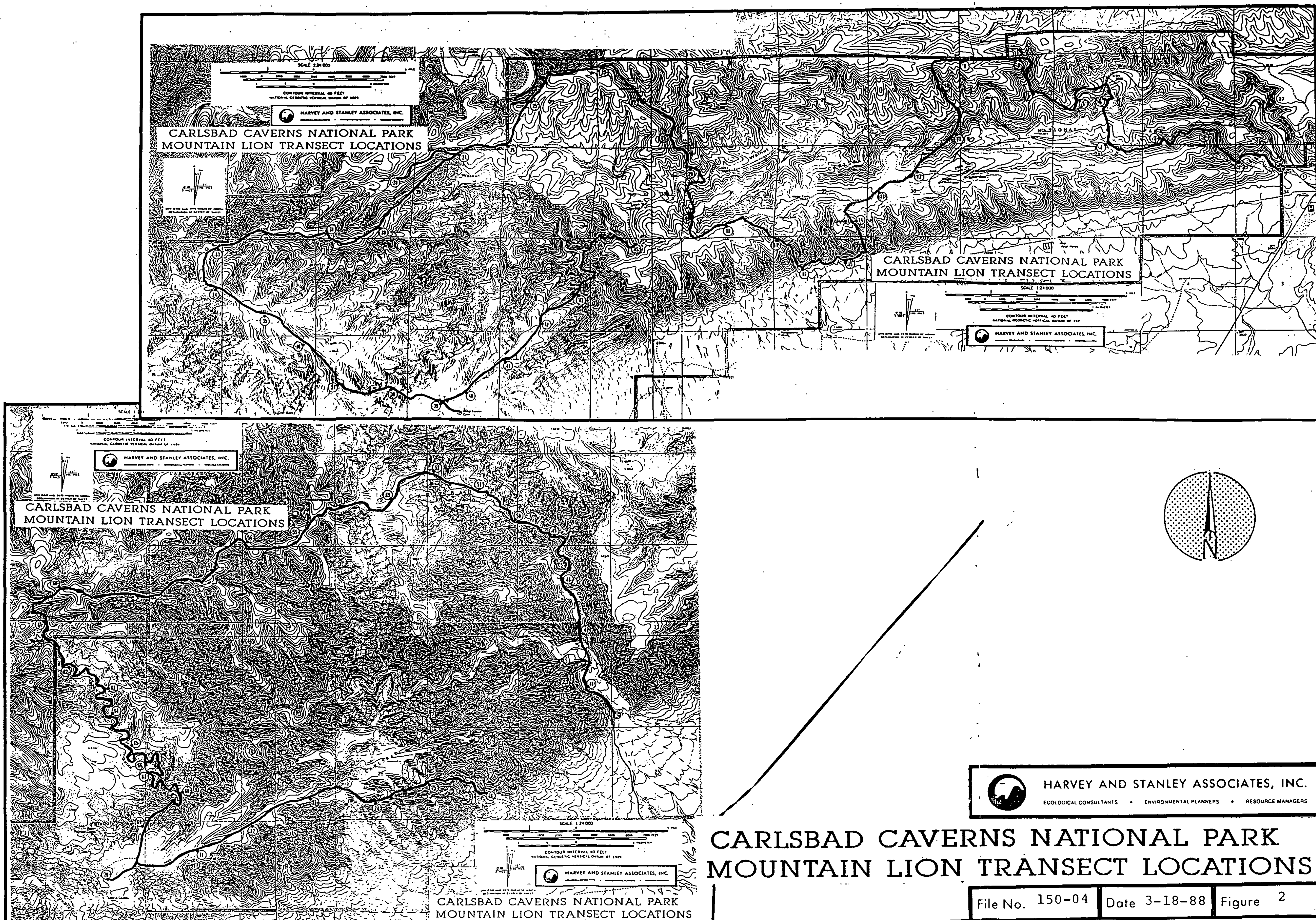
GUADALUPE MOUNTAINS NATIONAL PARK MOUNTAIN LION TRANSECT LOCATIONS

File No. 150-04	Date 3-18-88	Figure 1



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CARLSBAD CAVERNS NATIONAL PARK MOUNTAIN LION TRANSECT LOCATIONS

File No. 150-04 | Date 3-18-88 | Figure 2

Table 1. Summary of survey kilometers and total number of kilometers per watershed each national park.

GUMO

Watershed	Survey Kilometers	Distance per watershed (Km)
Upper Dog	1-13	13
Manzanita-West Dog	14-24	11
South McKittrick	25-47	23
Middle McKittrick	48-61	14
El Capitan	62-74	13
TOTAL GUMO TRANSECT KILOMETERS		74
CACA		
Walnut	1-26	26
Rattlesnake	27-45	19
Slaughter	46-76	31
TOTAL CACA TRANSECT KILOMETERS		76

STANDARDIZED UNITS OF SIGN (SUS)

Several problems are encountered in quantifying sign in a simple and meaningful fashion. Fresh track sets from a single lion are often found crossing and continuing along various lengths of trail. Numerous scrapes may occur at a single site. Scats may be found without any associated sign or may be found with a scrape mark. If each track, scrape, or scat seen in the survey were totaled, then concentrations of sign, potentially made by one lion, would contribute disproportionately to survey results. Consequently, we felt that there was a need to establish Standardized Units of Sign (SUS) which would minimize this disproportionate effect. The methods for defining these SUS values are described below and in the Field Guide (Appendix C).

Tracks

To simplify the recording of numerous tracks, only 1 track-defined SUS value will be recorded for each permanent kilometer of transect. Tracks are identified following criteria outlined in the Field Guide. For example, if the researcher is walking through KM 25 in CACA, and a mountain lion happens to have walked the same trail leaving 10 identifiable tracks, a value of 1 SUS for tracks would be assigned to that kilometer (not 10 for the 10 tracks).

Scrapes

A scrape site will form the basis of each scrape-defined SUS value and not the total number of scrapes. A scrape site is defined herein as any number of scrapes within a circle 20 meters in diameter. Scrapes are to be identified following criteria in the Survey Field Guide.

Scats

A single scat or collection of scats that appear to represent a single defecation will form the basis of a scat-defined SUS value. No attempt, however, should be made to distinguish between droppings deposited on top of one another such as might occur from the use of a common site while feeding on a kill. A scat found in association with a scrape should be recorded as a single scrape-defined SUS value. A scat found in association with tracks should be counted as 2 SUS values (i.e. a scat and track-defined SUS value).

Scats should be identified by diameters equaling or exceeding 30mm in diameter unless associated with scrape markings (see Field Guide).

Kills

Only the clearest evidence of mountain lion predation will be used in determining a kill-defined SUS value. Mountain lion feeding behavior differs to varying degrees with the species of prey being consumed. Consequently, only lion-killed deer will be used to simplify field procedures. A 20 meter diameter circle will define the kill site. No other sign will be counted within the kill site. Criteria used to determine a kill-defined SUS value are outlined in the survey field guide.

The above rules governing the quantification of sign reduces the potential variability of survey results and thereby increases the precision of the trend analysis.

Survey Periods

Surveys should be conducted in mid-October and mid-April when environmental conditions are moderate. Bi-annual monitoring is favored over annual monitoring in order to develop a data base large enough to defect significant changes in trends. A period of 5 days will probably be required to survey each 74-76 km transect, assuming a person can survey about 7.5 km/day. An additional day for transcribing and summarizing data will be required following the completion of the survey.

Personnel

The choice of field personnel is important to the maintenance of a consistent search effort. Individuals must be physically fit, capable of an 8-10 mile hike per day for 4-5 consecutive days, and experienced with hiking in desert conditions. Selected personnel should exhibit interest in and an appreciation for the scientific importance of providing methodological consistency to the survey effort.

FIELD PERSONNEL INSTRUCTIONS

A survey team leader should be appointed to coordinate and instruct field personnel for both national parks. This should be done well in advance of the initiation of any field effort. The survey leader should be familiar with the total scope of the project, from the identification of mountain lion sign to the acquisition and synthesis of the field data. Survey personnel should be briefed on the criteria of sign identification as given in the Field Guide and provided the opportunity to view this sign in the field.

Additional resource activities or interests should not be incorporated into this survey effort. The survey leader should stress the need for maximizing search effort for mountain lion sign while staying on the described survey routes. This is a necessary element of the field procedure and is needed to minimize the variability caused by one form of observer error - lack of detection. Failing to detect sign that is actually present will significantly lower the survey's accuracy in assessing variation. This statistic will be important in determining the required number of surveys necessary to detect significant changes in trend.

FIELD EQUIPMENT

Vernier Calipers - used to measure diameter of scat
Metric Ruler - used to measure size of scrape site, scat, tracks
Map of Survey Route - used to standardize routes year to year
35mm Camera with 55mm lens - used to photograph mountain lion sign

FIELD PROCEDURE

Detailed instructions for finding, identifying, quantifying, and documenting mountain lion sign have been provided in the Field Guide. The identification procedures stresses the use of qualitative and quantitative criteria. A searching procedure is described to aid field personnel in detecting sign and orienting along off-trail sections of transect. Documentation will be done photographically with a 35mm camera. When sign is encountered along the survey route each SUS value should be recorded on the field data sheet (Figure 3). The format of the field sheet will facilitate entry of the data onto a computerized spread sheet. The number of SUS values represented by the sign should be summarized per designated kilometer as indicated on the field data sheet.

Environmental conditions influencing the detection of sign should be summarized qualitatively. Important environmental influences to be noted include any factor that influences the detection of sign. This includes the presence of rain or snow during the survey or shortly before the survey, the occurrence of unusually high flash floods between surveys, trail building or maintenance activities, substrate modification by range and forest fires, etc.

FIELD DATA SHEET
NATIONAL PARK SERVICE
MOUNTAIN LION POPULATION MONITORING

AREA SURVEYED: **GUMO** ___
CACA ___

KILOMETER NUMB.	TRACK WIDTH (mm)	SCAT DIAM (mm)	SCRAPE SITE (no. scrapes)	SUS TOTALS

	DAYS OF SURVEY 1	2	3	4	5	COMMENTS
DATE:						
*WEATHER:						
PERSONNEL:						
KM SURVEYED:						

*Make detailed notes on back of form

DATA SUMMARIZATION

SURVEY RESULTS

The data from the field sheets should be transcribed onto a computerized spread sheet following the format illustrated in Tables 2 and 3. The spread sheet format permits rapid, graphic summarization of the frequency, dispersion, and composition of SUS values. Descriptive information from the field data sheets will not be transcribed onto the spread sheet. Summaries of the survey results should be made following each survey, comparing current and prior values and assessing where changes may be occurring in each park. Appendix B shows examples of types of sign and how they might be distributed along the transect.

Using the computerized spread sheet, SUS values should be totaled for each watershed (Table 3). Watershed totals should be summed to obtain the total for the park-wide transect. The average number of SUS values encountered per kilometer of transect is referred to as the frequency of encounter (FOE). Frequency of encounter values can be derived for the entire transect, portions of the transect lying in different watersheds, or additional to-be-defined subsets of the total transect.

A general measure of the dispersion (DISP) of sign can be obtained by counting the number of designated kilometers containing at least 1 SUS value and expressing this as a fraction of the total number of transect kilometers. In a manner similar to frequency of encounter, measures of dispersion can be calculated for each park transect, watershed, or additional sample subset (Table 3).

The total number of scrapes, tracks, and scats comprising the SUS values should be summarized to evaluate their relative contribution to the survey results. Survey summaries should indicate the percent contribution of the three forms of sign to the SUS total by expressing the number of tracks, scrapes, and scats that defined each SUS value as a percentage of the total (Table 3, T%, S%, Sc%).

Table 2. Example of database format for summarizing survey data.

			SIGN-DEFINED SUS		
TRANSECT	YEAR	KILOMETER	TRACK	SCAT	SCRAPE
GUMO	1987	1	1	1	0
GUMO	1987	2	0	0	0
GUMO	1987	3	0	0	0
GUMO	1987	4	0	1	0
GUMO	1987	5	0	0	0
GUMO	1987	6	0	0	0
GUMO	1987	7	0	0	0
GUMO	1987	8	0	0	0
GUMO	1987	9	0	0	0
.	.	.	.	.	.
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.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
GUMO	1989	69	0	0	0
GUMO	1989	70	0	0	0
GUMO	1989	71	0	0	0
GUMO	1989	72	0	0	0
GUMO	1989	73	0	0	0
GUMO	1989	74	0	0	0
GUMO	1989	75	0	0	0
GUMO	1989	76	1	0	0
GUMO	1989	77	0	0	1

Table 3. Example of format for summarizing survey data.

TOTALS FOR WATERSHED A

YEAR	CUMULATIVE SUS VALUES	%	FOE	+ KM	+ KM %	DISP.	I.V.
1987	14	45	1.27	6	50	0.54	95
1988	9	39	0.82	5	39	0.45	78
1989	10	30	0.91	22	13	0.18	43

TOTALS FOR WATERSHED B

YEAR	CUMULATIVE SUS VALUES	CUM. %	FOE	+ KM	+ KM %	DISP.	I.V.
1987	11	36	1	2	17	0.18	53
1988	5	22	0.45	3	23	0.27	45
1989	12	36	1.09	4	27	0.36	63

TOTALS FOR WATERSHED C

YEAR	CUMULATIVE SUS VALUES	CUM. %	FOE	+ KM	+ KM %	DISP.	I.V.
1987	3	10	0.27	3	25	0.27	35
1988	7	31	0.64	3	23	0.27	54
1989	7	21	0.64	6	40	0.26	61

TOTALS FOR WATERSHED D

YEAR	CUMULATIVE SUS VALUES	CUM. %	FOE	+ KM	+ KM %	DISP.	I.V.
1987	3	9	0.26	1	8	0.09	17
1988	2	8	0.17	2	15	0.17	23
1989	4	12	0.35	3	19	0.26	31

PARK TOTALS

YEAR	CUMULATIVE SUS VALUES	FOE	+ KM	DISP.
1987	31	0.70	12	0.27
1988	23	0.52	13	0.29
1989	33	0.74	25	0.34

SUS=Standardized Unit Of Sign

CUM. % = Cumulative SUS Value For Watershed /Total Park Cumulative (100)
FOE=Frequency Of Encounter
+KM=Kilometers With At Least 1 SUS Value
+KM % = Total +KM For Watershed/Total Park +KM (100)
DISP.= Dispersion Value
I.V.= Importance Value = Cum % + +KM%

DATA ANALYSES

The approach used in analyzing the data is to summarize park wide trends in frequency and dispersion and explain changes on the basis of watershed trends (i.e. where the changes have taken place). The reliance on only 1 measure for quantifying the abundance of sign is undesirable considering that this method has not been tested. Consequently, values for frequency of encounter and dispersion should be summarized independently, with variation assessed for each measure.

At this point the question becomes, "when do fluctuations in frequency or dispersion indicate a significant change in population density?" To answer this question requires a statistically adequate set of baseline data that future results can be compared to for detecting significant changes. The baseline will be comprised of survey results from a currently unknown number of initial surveys. The lesser the inherent variation the fewer the number of surveys required to establish an adequate baseline. However, both frequency of encounter and dispersion may be important in interpreting trends.

INITIAL SURVEYS

The results of initial surveys will provide an important set of data from which a measure of variation will be calculated. Eberhardt (1978) and Harris (1986) have discussed the need for large sample sizes where there is large variation in survey results. Following Eberhardt (1978), an adequate sample size at the .05 level of significance can be estimated by using the coefficient of variation (standard deviation/mean = C) and stating the confidence interval as a percentage of the mean. Using equation 16 from Eberhardt (1978);

$$n= \frac{4}{P^2} C^2 \qquad (1)$$

where p = confidence limits expressed as a proportion of the mean. If C = 1.0 and the confidence limits are ± 20% (0.2) of the mean, n = 100. But, if C = 0.5 and the confidence limits are set at ± 40% of the mean, then n = 6. Consequently, the amount of variation in survey results and the accepted confidence limits will be instrumental in determining adequate sample size. We therefore have to make some initial estimates of variation, in order to approach a sample size which is adequate for statistical purposes.

A working approach for establishing a recognizable baseline where there will likely be considerable variation is to calculate V after the first five years (10 surveys) and determine whether an adequate sample has been obtained using confidence limits ± 20% of the mean at the .05 level of significance. If an adequate sample size has not be achieved, the confidence limits of the current mean can be determined by rearranging equation 1

$$p = \sqrt{\frac{C}{n}\,4} \quad \text{or} \quad p = \sqrt{\frac{4C}{n}} \qquad (2)$$

where n = the current number of surveys and C = the current coefficient of variation.

FUTURE SUMMARIZATION AND ANALYSIS

We predict at this point that approximately 5 years of surveys will be necessary to establish baseline conditions, if variation is high. Once an acceptable baseline is established, using the above criteria, future results can be analyzed for significant changes in trend. The initial focus is to determine trends in frequency and dispersion both for the entire park and for specific watersheds. These watershed values may additionally provide a means of detecting trends in the presence of resident adult lions.

Park-wide Trends

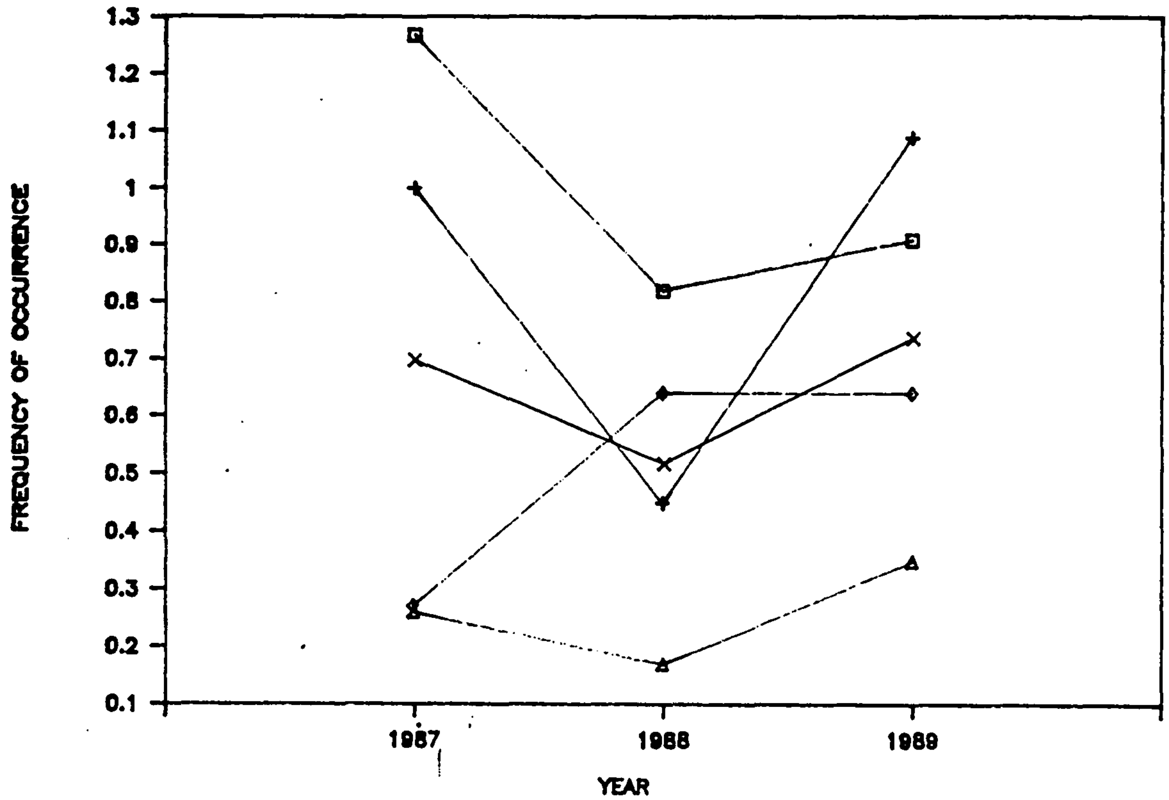
Survey summaries should graphically illustrate changes in frequency of encounter (Figure 4) and dispersion values (Figure 5) for park-wide and watershed trends. Watershed results should be used at this point to determine where park-wide changes are occurring. A brief narrative should be prepared that discusses changes illustrated in these figures. Qualifying information regarding environmental influences on the detection of sign, and trends in the relative composition of sign, should be included.

The finding of relatively consistent proportions of sign comprising each survey will add strength to the detection of significant differences. Assume that following a given survey the frequency and/or dispersion values depart radically from previous results. If most of this departure can be attributed to an increased contribution of scrapes in 1 watershed it is possible that the scrapes were left by a courting male mountain lion and may not be indicative of a population increase.

WATERSHED TRENDS

The analysis of watershed trends noted above provides insight into where changes occur within the park. Values for frequency of encounter and dispersion for each watershed may potentially yield more than a refined view of park-wide trends. The baseline study (Smith et al. 1985) illustrated the influence of topography on home ranges of resident adults. Most notably, adult females were seen to confine or center their movements within a given watershed. Hypothetically, a resident lion could leave more sign in a given area than non-resident or transient lion. Using the procedure outlined below, watershed values may provide insight into the resident status of lions inhabiting the parks.

Absolute values for frequency of encounter and dispersion are converted to relative values by expressing each frequency or dispersion value as a percentage of their respective totals. Relative frequency and dispersion values are combined into a single importance value (IV) which reflects a subjective



LEGEND

WATERSHED A= □
WATERSHED B= ◊
WATERSHED C= +
WATERSHED D= △
PARK-WIDE = X

BASED ON SAMPLE DATA FROM APPENDIX B

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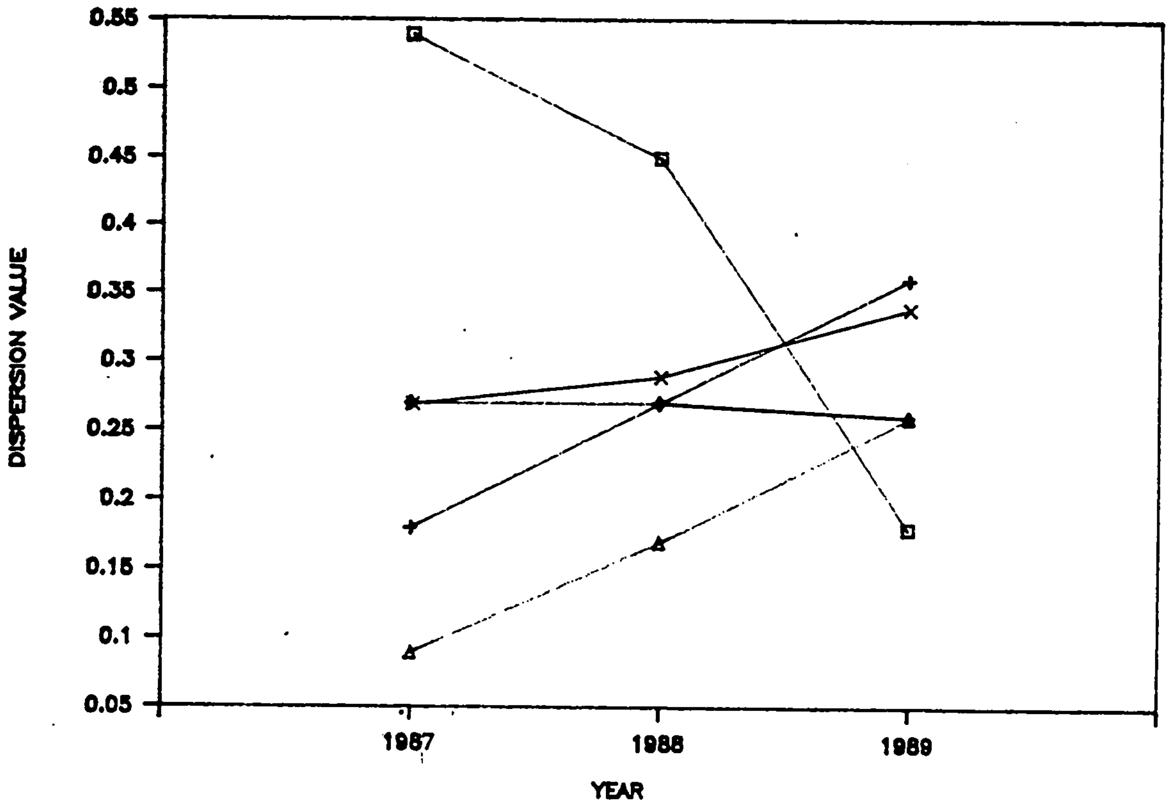
EXAMPLE OF FREQUENCY OF ENCOUNTER (FOE) PLOTTED AGAINST TIME

File No. 150-04	Date 10/02/87	Figure 4



LEGEND

WATERSHED A = □
WATERSHED B = ◊
WATERSEHD C = +
WATERSHED D = △
PARK-WIDE = X

BASED ON SAMPLE DATA FROM APPENDIX B

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EXAMPLE OF DISPERSION VALUE PLOTTED AGAINST TIME

File No. 150—04	Date 10/02/87	Figure 5

assessment of the character of mountain lion sign for the given region according to the Formula below (see Fig. 6). In making this assessment the dispersion of sign, in addition to its abundance, is considered to be an important element characterizing sign of a resident lion.

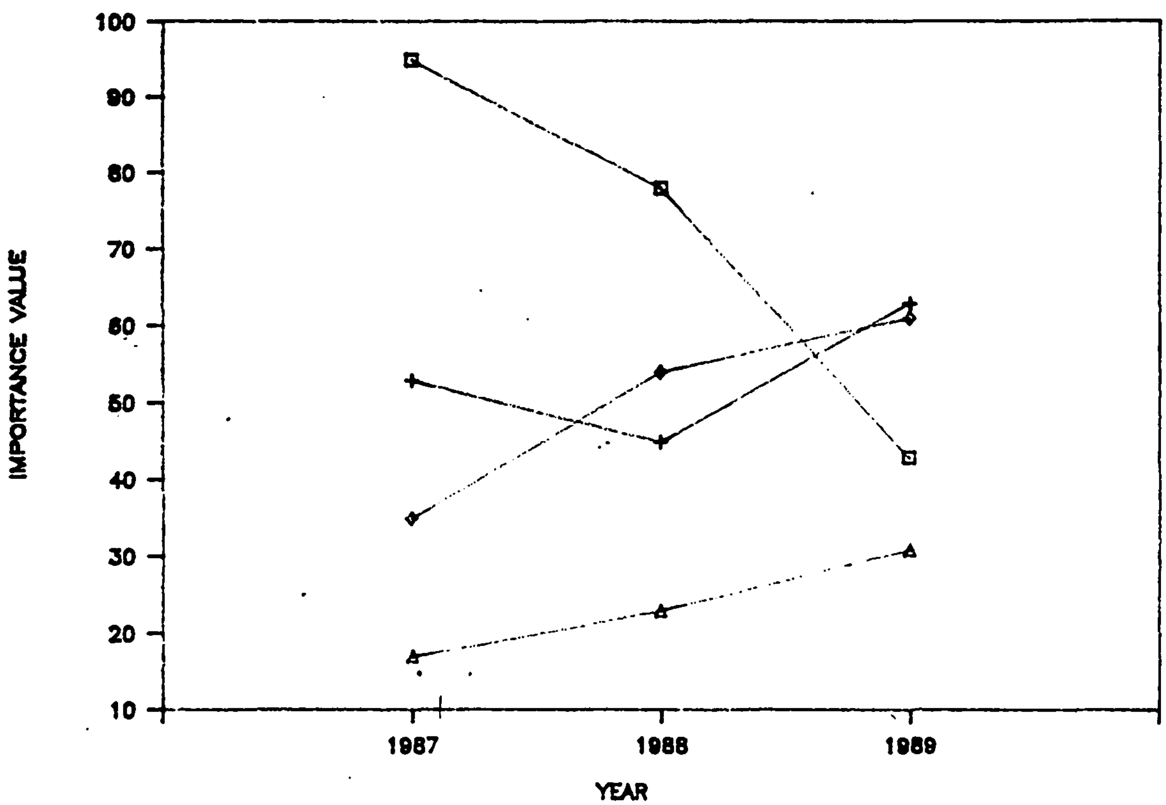
$$\frac{\text{SUS A (100)}}{\text{SUS Park}} + \frac{\text{+km (A) (100)}}{\text{+km Park}} = \text{IV}$$

ADDITIONAL SUBSET ANALYSES

The use of a computer spread sheet format for recording field data permits summarization of survey results for any segment of the total transect (Table 2). A cumulative frequency distribution of sign per kilometer will illustrate portions of the transect where sign is most commonly detected during each survey. For instance, if kilometers 15-25 defines that portion of the transect lying in watershed B and kilometers 26-38 in watershed C, trends in frequency or dispersion for kilometers 20-30 may exhibit less variability than either watershed A or B. The detection of these high yield subsets may reveal sensitive areas that can be useful as indicators to changes in population trends.

CORRELATION ANALYSES

It would be valuable to correlate changes in relative abundance of sign in GUMO and CACA with changes in harvest data in the Guadalupe Mountains. Consistent with the recommendations of Smith et al. (1985), it is suggested that a cooperative agreement with the State of New Mexico be established to provide this information. In addition to the total number of mortalities, useful data would include the age, sex and location of each lion taken during predator control and sport hunting activities. Also, information on hunter effort or changes in harvest strategies would greeatly enhance the ability to generate trend data from the harvest records



LEGEND

WATERSHED A = □

WATERSHED B = ◊

WATERSHED C = +

WATERSEHD D = △

PARK-WIDE = X

BASED ON SAMPLE DATA FROM APPENDIX B

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EXAMPLE OF IMPORTANCE VALUE PLOTTED AGAINST TIME

File No. 150—04	Date 10/02/87	Figure 6

Any combination of permutations are possible. Possibly the most likely scenario would be a slight decline in trend in mortality outside the park with a stable trend of relative density of pumas inside the park. However, if the harvest and depredation pressure is severe enough, sharp declines of the relative density of pumas outside the park may occur. This in turn, depending upon the location of mortality may negatively effect the populations in the parks.

These future analyses may be performed by park resource specialists using established correlation procedures outlined in various statistical texts such as Sokal and Rolf (1981) or may be provided through future contractual arrangements.

The potentially significant effects that predator control and harvest strategies have on the populations of pumas in the parks require a careful assessment through correlation analysis of trends of relative abundance of pumas in the park and mortality outside the park.

DISCUSSION

A fundamental question to this monitoring program is "how does sign deposited by a population of mountain lions change with variations in density?" Valuable insight into this question could be gained from a study documenting characteristics of sign over the course of a change in population density. Unfortunately, few studies have documented the characteristics of sign at known population densities. Moreover, most studies have concluded that their populations were stable while studied.

The documentation of sign used here involves the use of 2 indices to monitor population trends, frequency of encounter and dispersion. Each index differs in its relationship to changes in the abundance of sign (i.e. SUS values). As abundance of sign changes, the frequency of encounter will change directly. However, values of dispersion will be influenced only if the spatial distribution of sign varies with changes in abundance. As a generalization, the frequency of encounter reflects the abundance of sign while the dispersion value reflects sign distribution. It has been assumed that a positive relationship exists between mountain lion population density and the abundance of their sign. Changes in the distribution of sign with changing density may be hypothesized from previous studies.

A summary of seven studies from western North America indicates that a negative, curvilinear relationship exists between mountain lion density and home range size (Table 4 and Figure 7). The increase in home range noted with decreasing density suggests that sign may remain widely distributed during periods of population decline. Conversely, mountain lions and their sign may disappear from areas of marginal habitat if conditions can no longer support site attached residents. Both responses may occur when population declines are related to decreases in carrying capacity.

Localized reduction in density resulting from hunting or predator control may not have population-wide effects. Rather, a localized, relatively short-term reduction in sign would characterize survey results from regions or watersheds

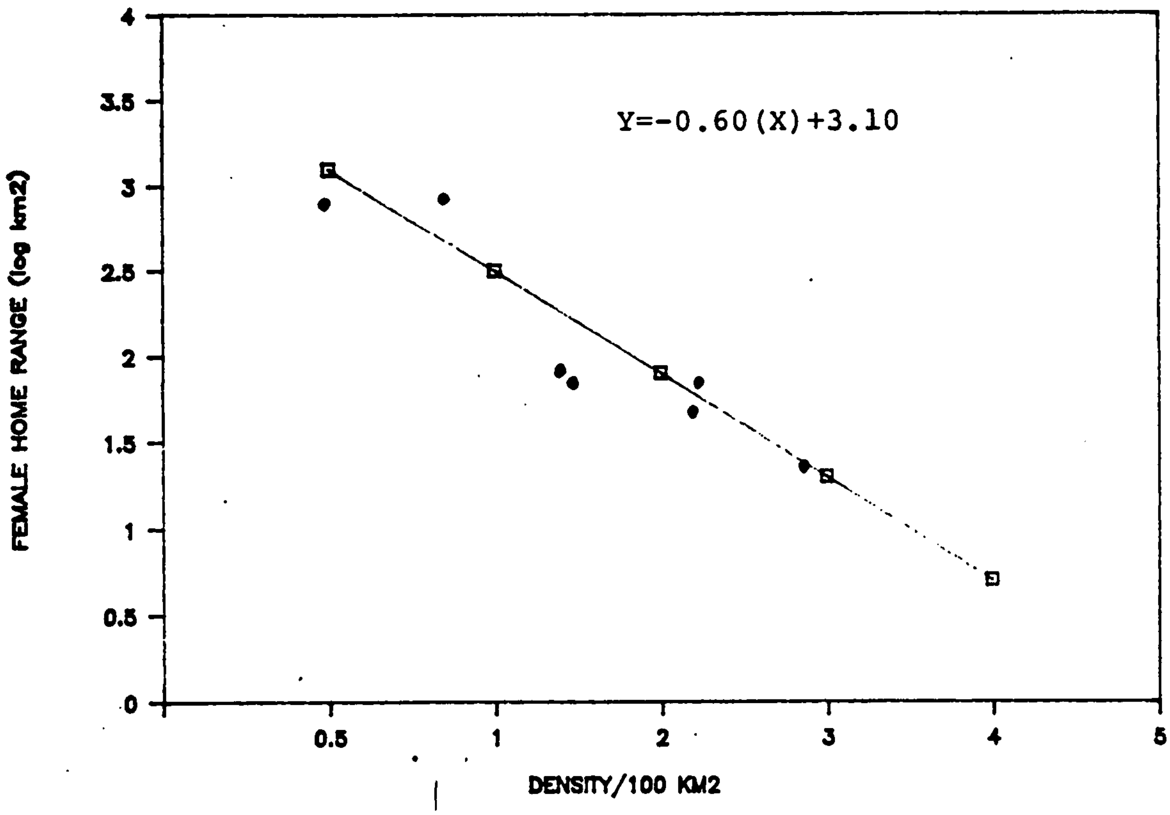
Table 4. Average female mountain lion home range size at known densities 7 North American studies.

Study	Female H.R. Size (km^2)	Density/100km^2
IDAHO		
Hornocker (1969)	33[a]	---
Hornocker (1970)	----	2.9[b]
NEVADA		
Ashman et al. (1983)	70	1.5
TEXAS		
McBride (1976)	1031	0.7[c]
UTAH		
Hempker (1984)	685	0.3-0.5[d]
WYOMING		
Logan (1986)	67	1.4-1.6
CALIFORNIA		
Hopkins (1981)	66	1.9-2.3
NEW MEXICO		
Smith (1985)	59	2.3

a. Taken from Anderson 1983. Believed to be minimum.
b. Derived by capture-recapture methods.
c. Taken from Anderson 1983.
d. Larger value used in regression (Figure 6).

neighboring areas of heavy exploitation. In time, these areas may exhibit larger coefficients of variation, reflecting the unstable character of the population in these areas.

The method of population monitoring outlined above has the potential to detect population responses of mountain lions to control practices as well as providing an index of mountain lion abundance. Proper testing of this method would require a minimum of 5 years of monitoring within which modification of methods,



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RELATIONSHIP OF MOUNTAIN LION DENSITY AND HOME RANGE (7 STUDIES)

File No. 150—04	Date 10/02/87	Figure 7

survey routes, and analyses may prove necessary. With continued evolution and refinement of the methodology the effectiveness of the National Park Services mountain lion management should increase as well.

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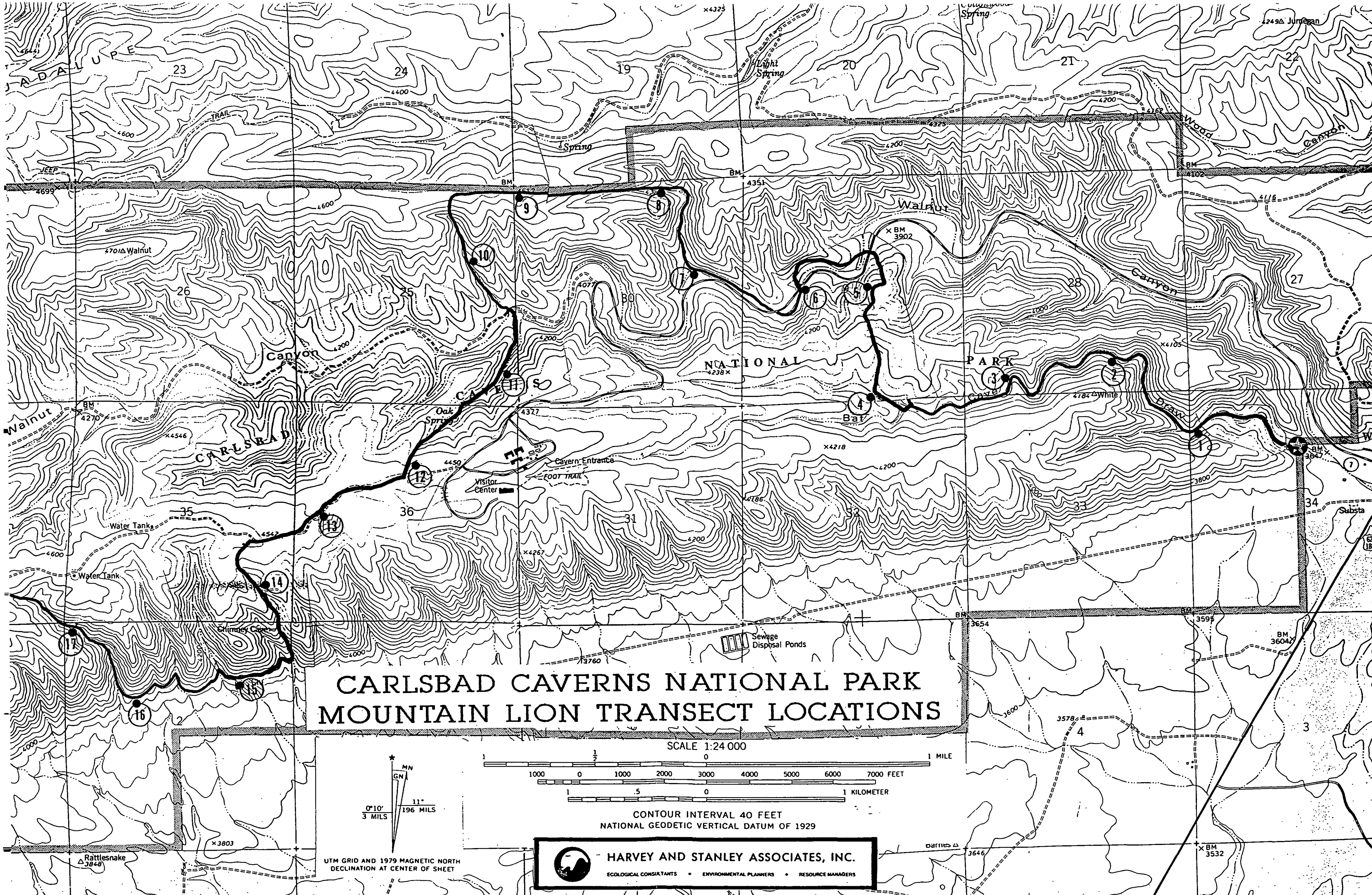
CARLSBAD CAVERNS NATIONAL PARK
MOUNTAIN LION TRANSECT LOCATIONS
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1 KILOMETER
CONTOUR INTERVAL 40 FEET
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UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
MN
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11°
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FOOT TRAIL
Visitor Center
Water Tank
Chimney Cave
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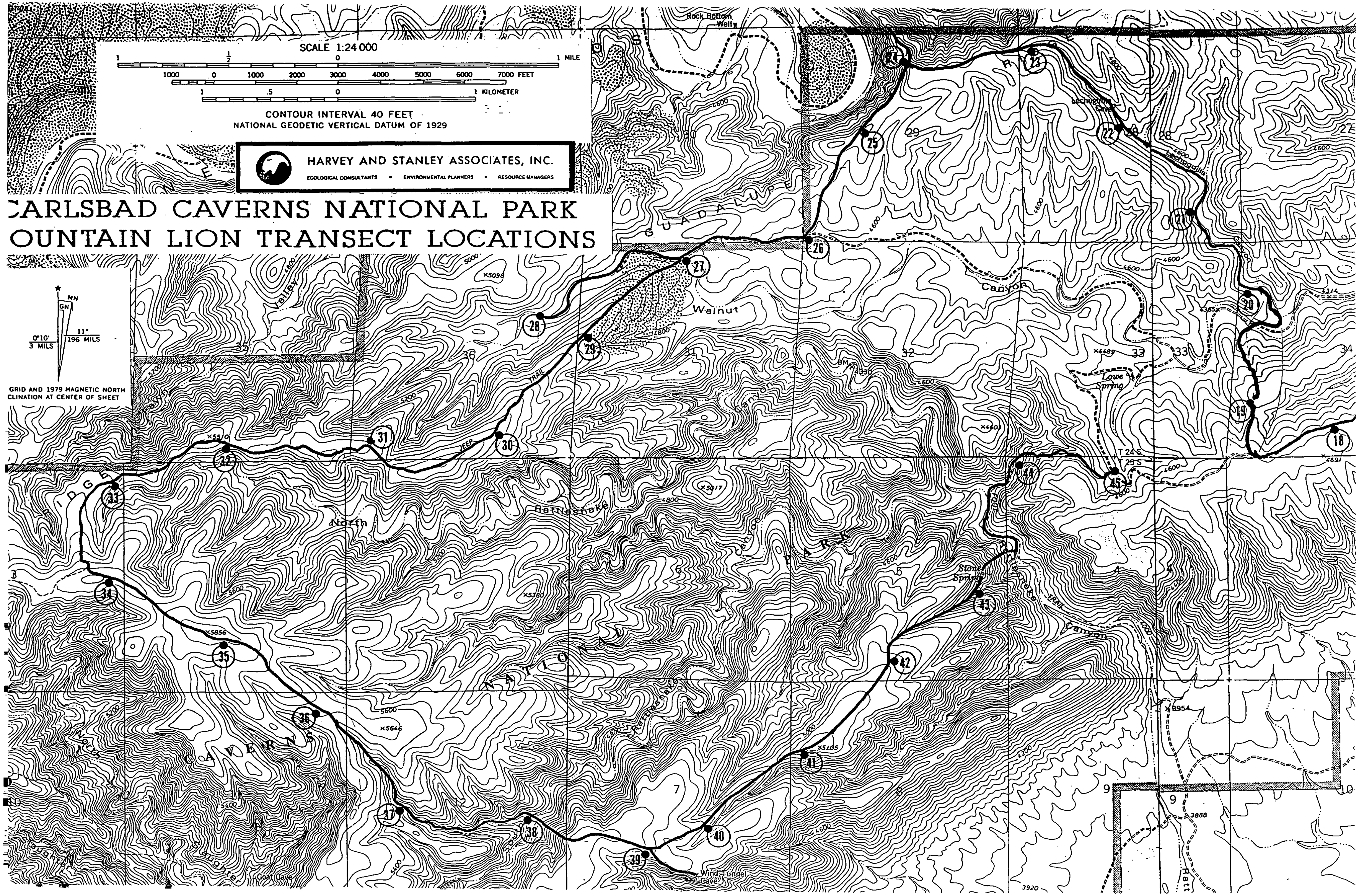
CARLSBAD CAVERNS NATIONAL PARK
MOUNTAIN LION TRANSECT LOCATIONS
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ECOLOGICAL CONSULTANTS • ENVIRONMENTAL PLANNERS • RESOURCE MANAGERS
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7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
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GRID AND 1979 MAGNETIC NORTH
CLINATION AT CENTER OF SHEET
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Walnut
Canyon
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North
Rattlesnake
Stone Spring
Goat Cave
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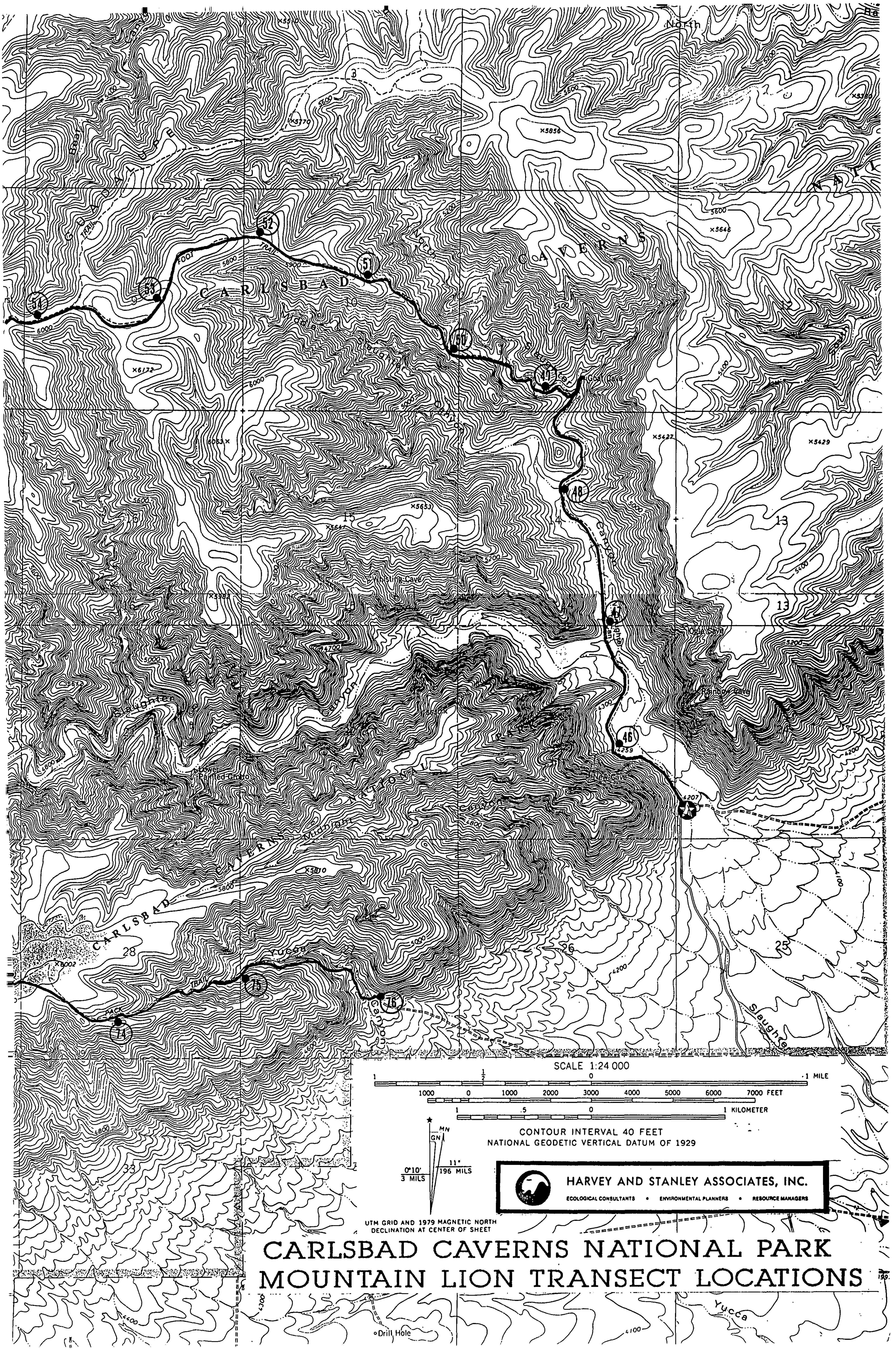
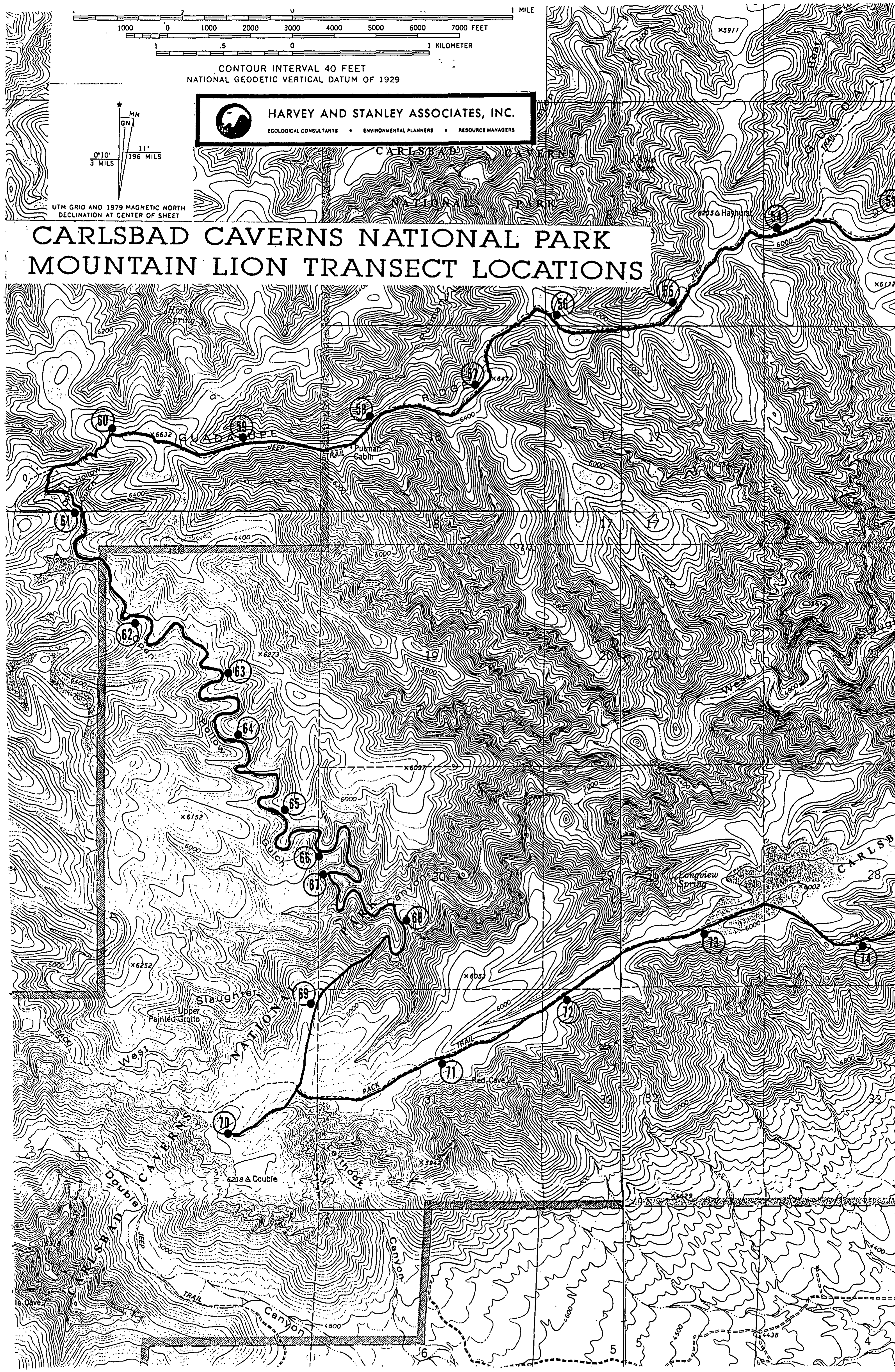
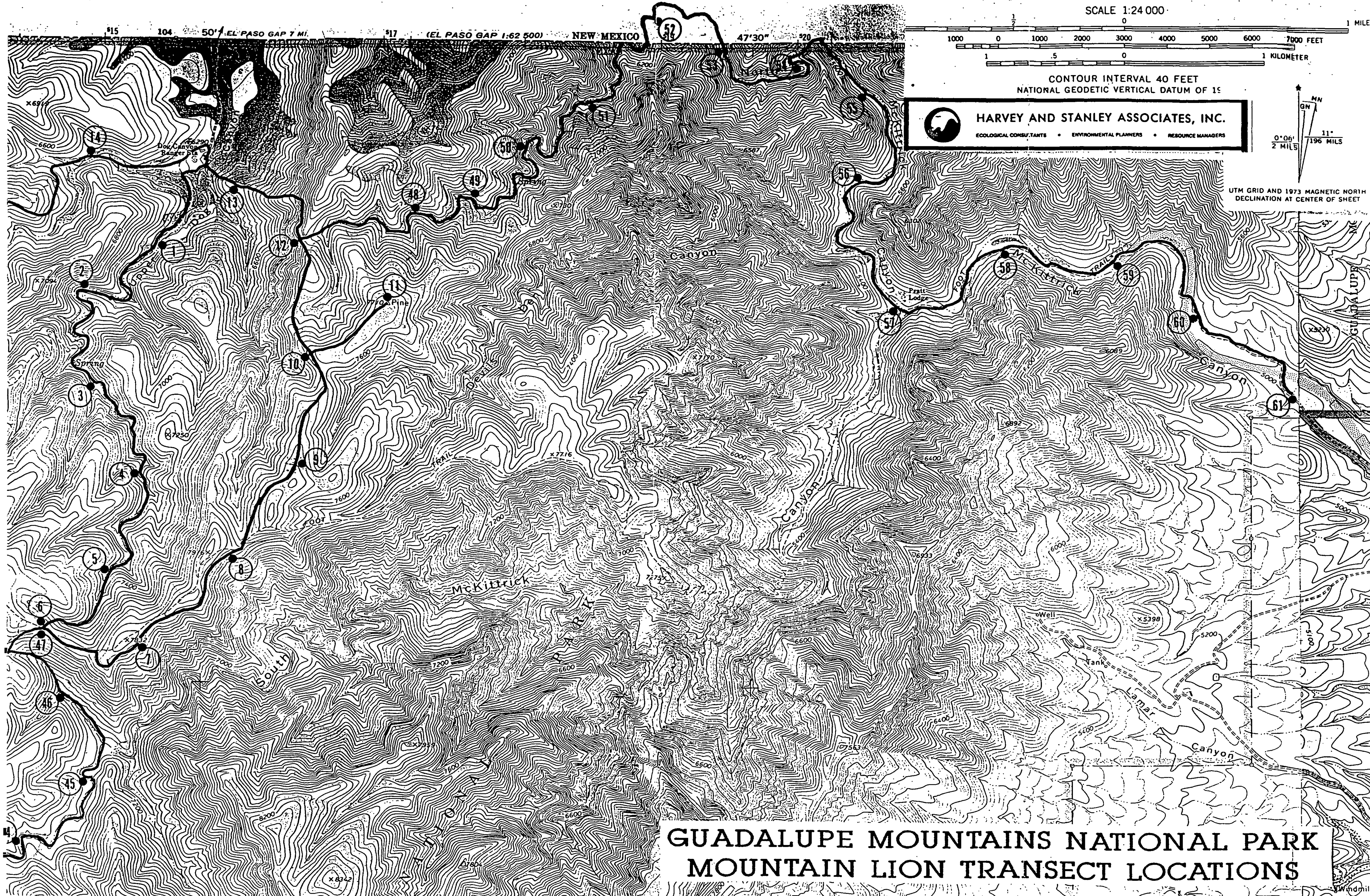


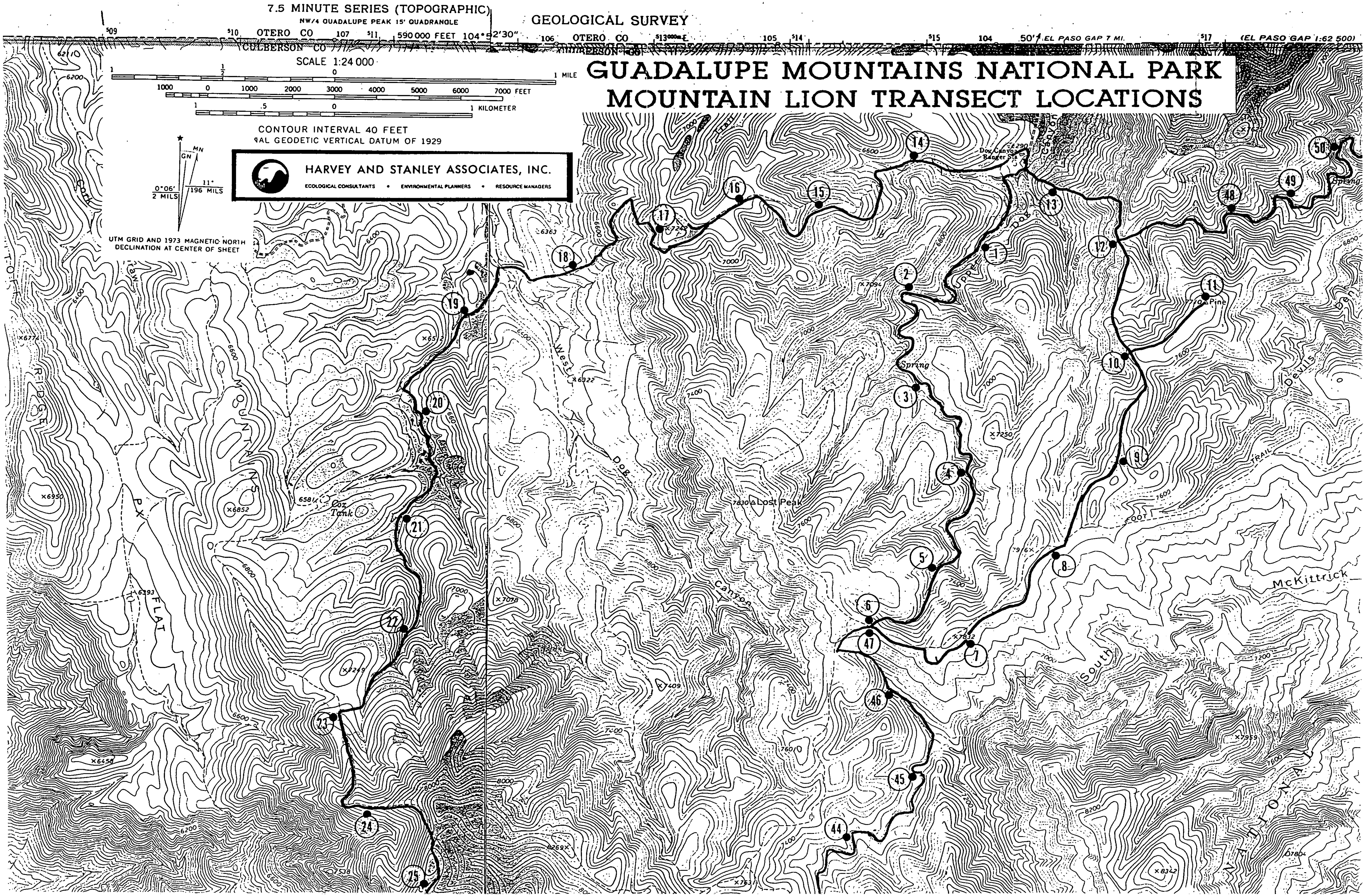
CARLSBAD CAVERNS NATIONAL PARK MOUNTAIN LION TRANSECT LOCATIONS

CARLSBAD CAVERNS NATIONAL PARK MOUNTAIN LION TRANSECT LOCATIONS





GUADALUPE MOUNTAINS NATIONAL PARK
MOUNTAIN LION TRANSECT LOCATIONS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UTM GRID AND 1973 MAGNETIC NORTH
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Cox Tank
West Dog Canyon
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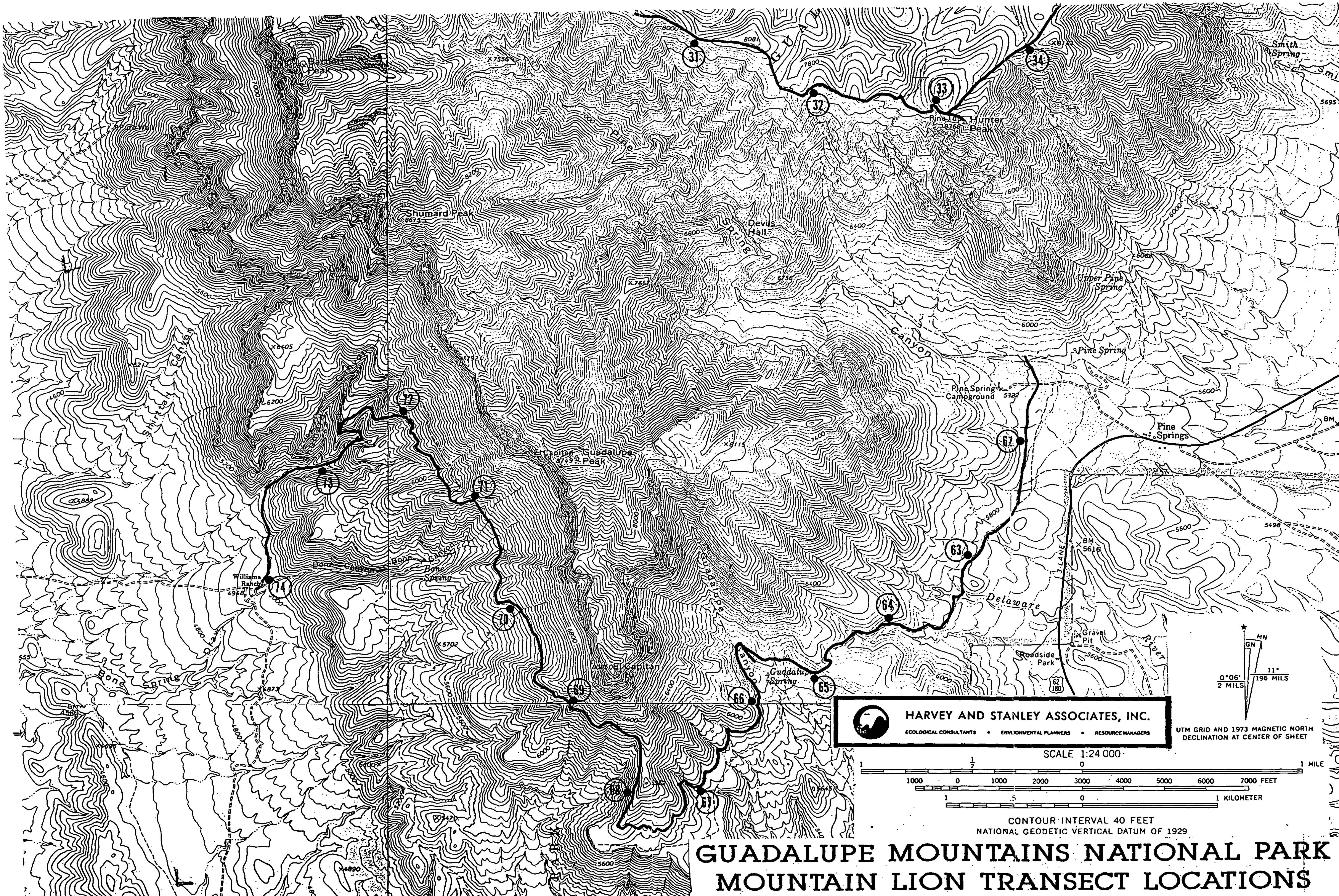
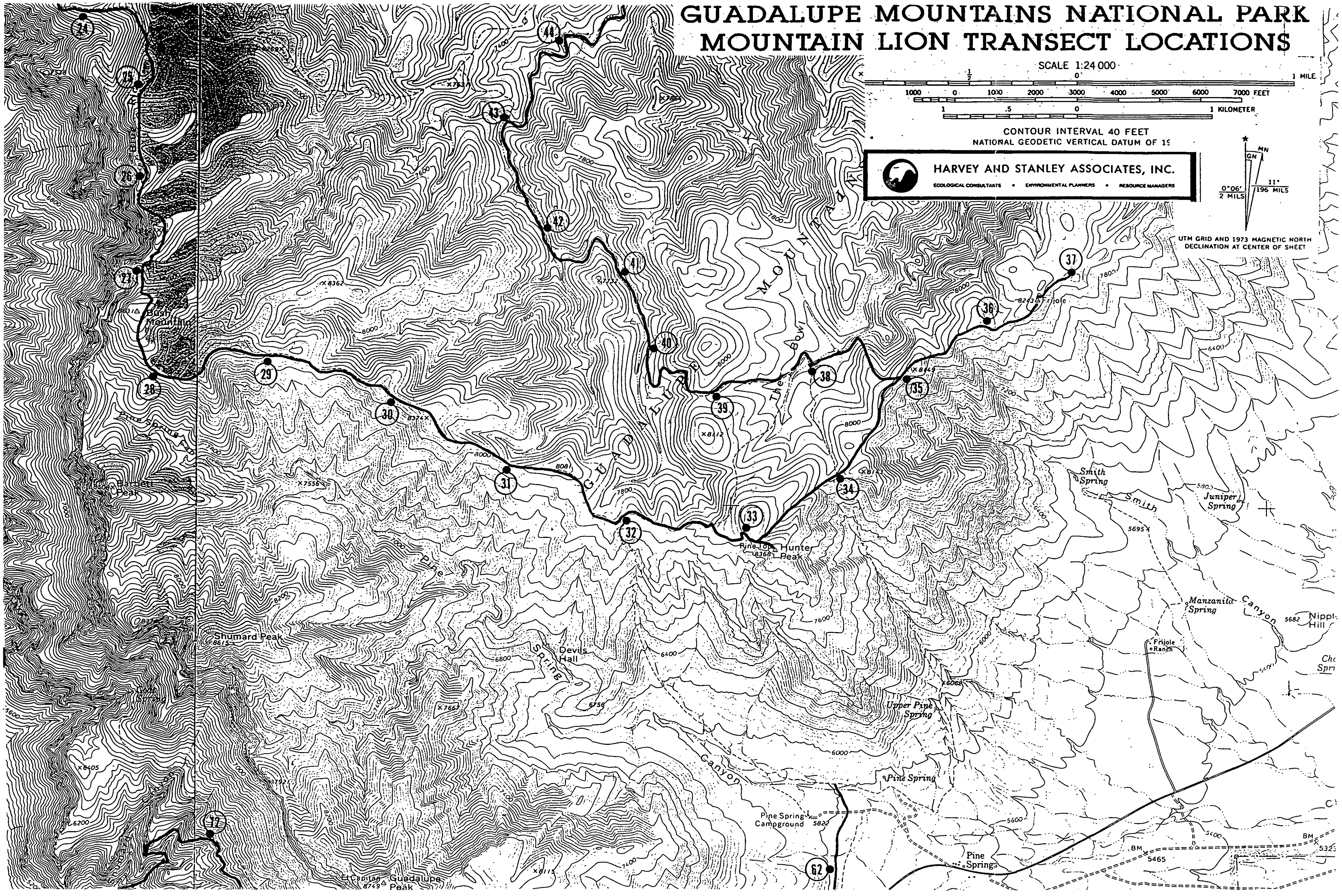


GUADALUPE MOUNTAINS NATIONAL PARK
MOUNTAIN LION TRANSECT LOCATIONS

GUADALUPE MOUNTAINS NATIONAL PARK
MOUNTAIN LION TRANSECT LOCATIONS



APPENDIX B

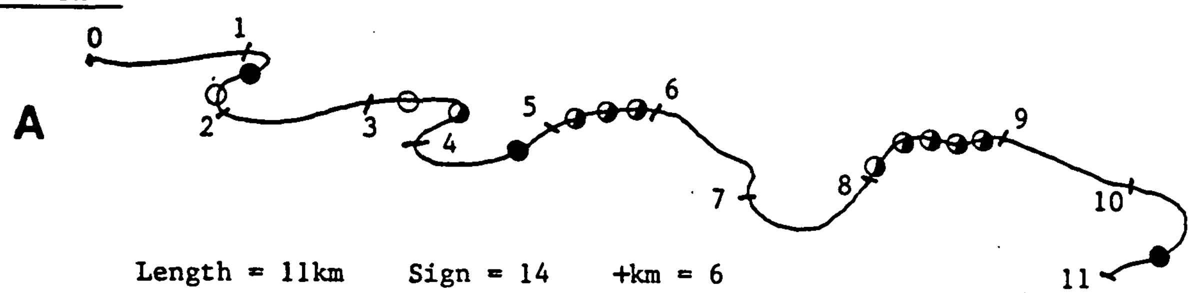
HYPOTHETICAL TRANSECT

APPENDIX B - HYPOTHETICAL TRANSECT

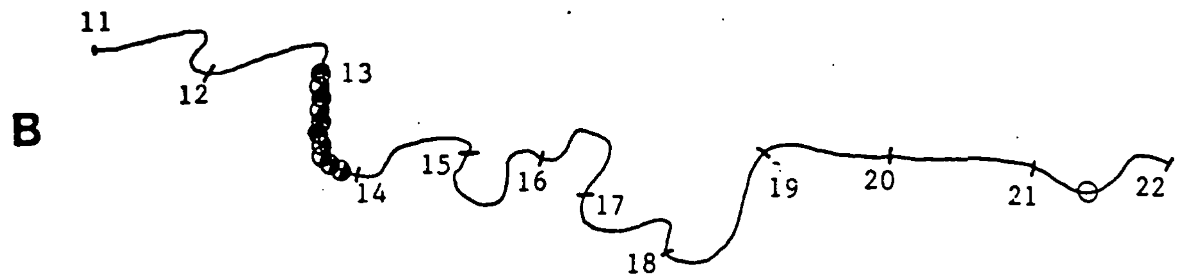
Year:* 1987

● Scat ○ Track ◑ Scrape

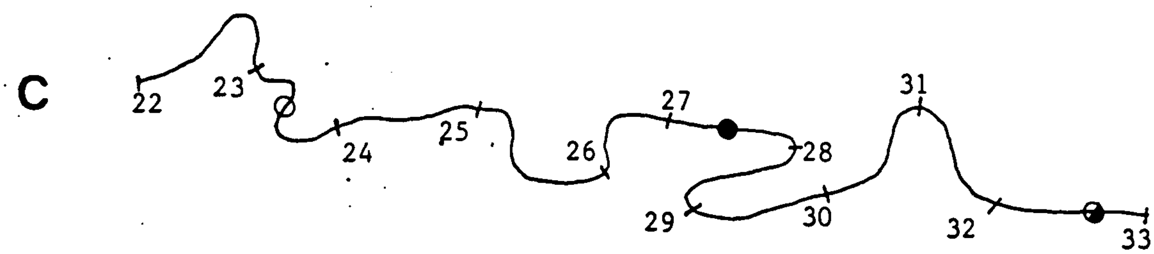
<u>Watershed</u>



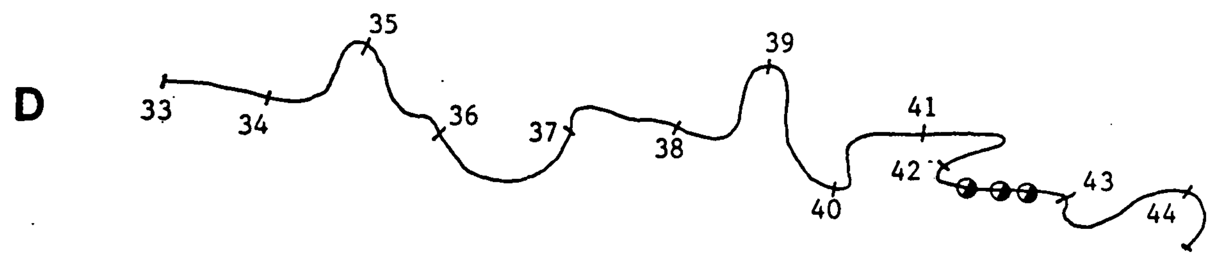
Length = 11km Sign = 14 +km = 6



Length = 11km Sign = 11 +km = 2



Length = 11km Sign = 3 +km = 3



Length = 11.5 Sign = 3 +km = 1

PARK WIDE: Length = 44.5 Sign = 31 +km = 12

* Annual surveys are used in this example.

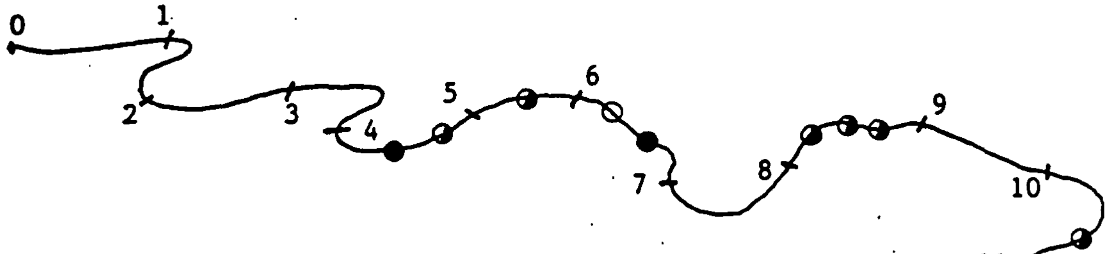
APPENDIX B: HYPOTHETICAL TRANSECT

Year:* 1988

● Scat ○ Track ◐ Scrape

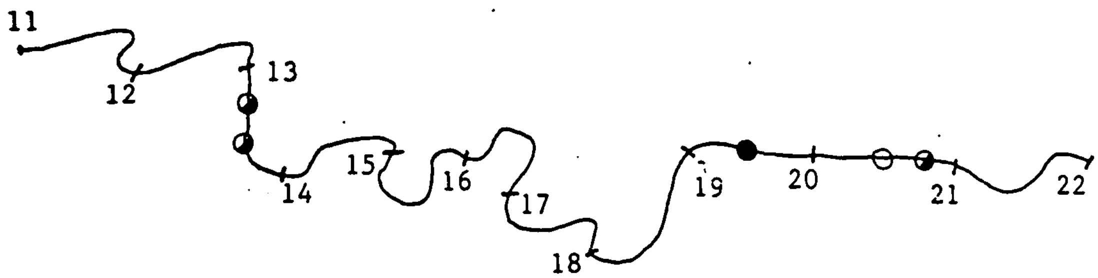
Watershed

A



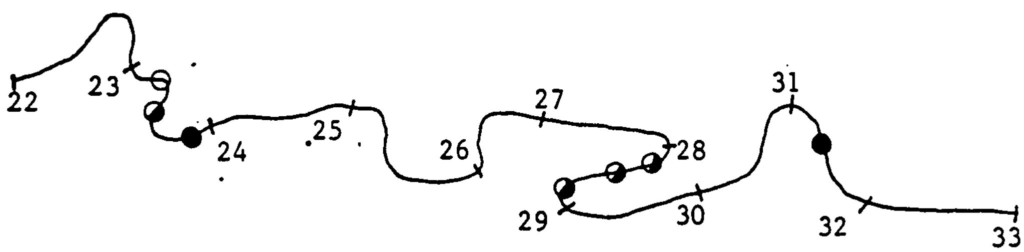
Length = 11km Sign = 9 +km = 5

B



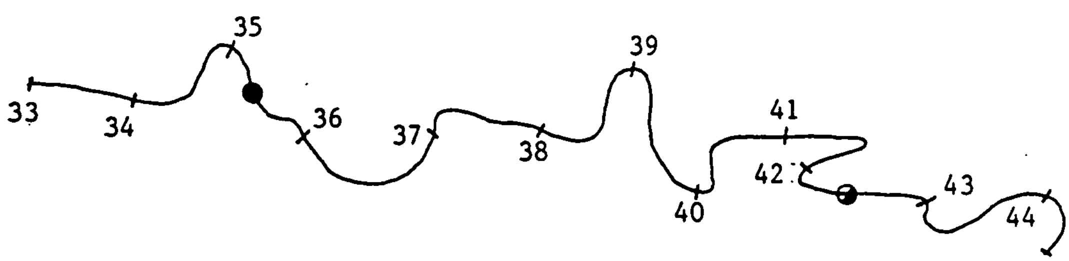
Length = 11km Sign = 5 +km = 3

C



Length = 11km Sign = 7 +km = 3

D



Length = 11.5km Sign = 2 +km = 2

PARK WIDE: Length = 44.5km Sign = 23 +km = 13

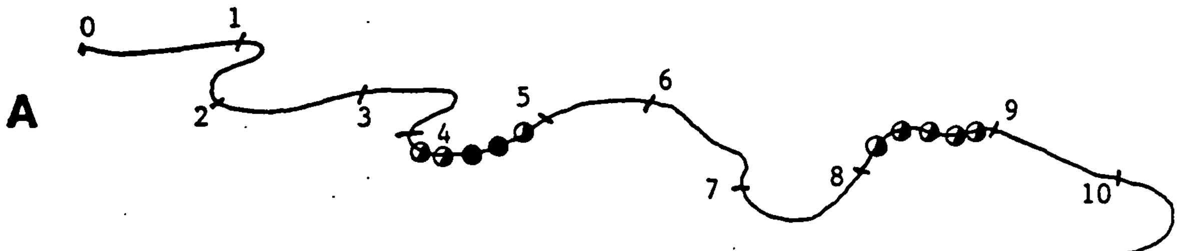
* Annual surveys are used in this example.

APPENDIX B: HYPOTHETICAL TRANSECT

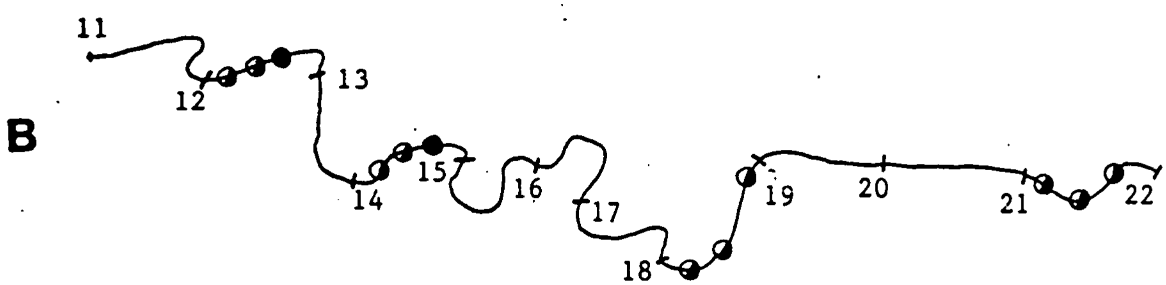
Year:* 1989

Watershed

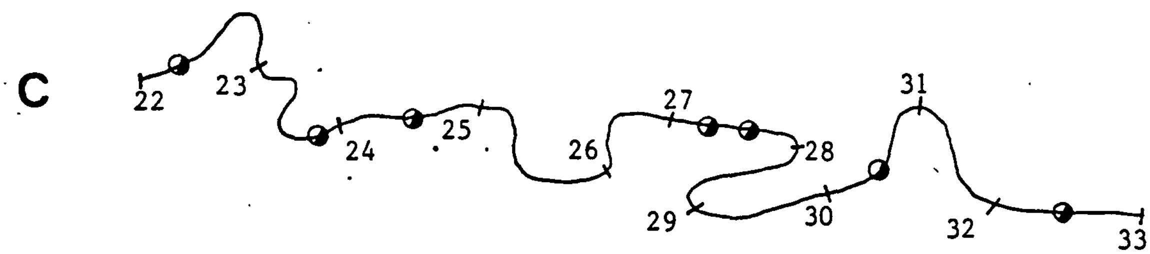
● Scat ○ Track ◑ Scrape



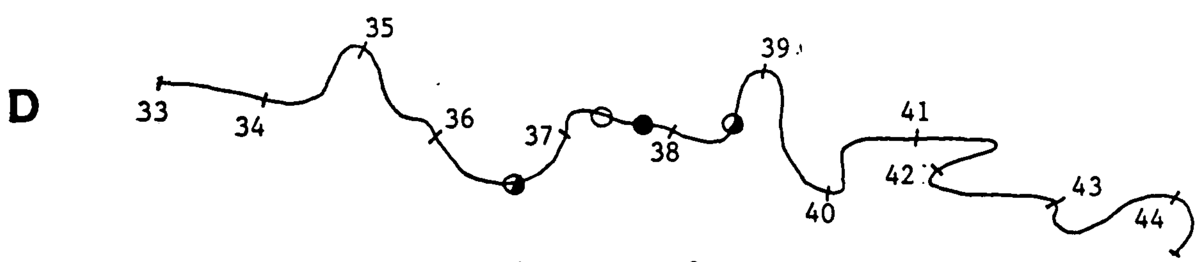
Length = 11 Sign = 10 +km = 2



Length = 11 Sign = 12 +km = 2



Length = 11 Sign = 7 +km = 6



Length = 11.5 Sign = 4 +km = 3

PARK WIDE: Length = 44.5km Sign = 33 +km = 15

* Annual surveys are used in this example.

APPENDIX C

FIELD GUIDE

FIELD GUIDE

Prepared By

Harvey & Stanley Associates, Inc.
Thomas Smith

Prepared For

National Park Service
Mr. Jim Walters

March 17, 1988 File No. 150-04

INTRODUCTION

The following is designed to serve as an instructional guide for identifying and documenting selected forms of mountain lion sign. The scope of this guide is limited and is intended for use by National Park Service personnel while conducting surveys of mountain lion population trend. Four forms of sign are discussed: tracks, scrapes, and scats, and remains of lion-killed prey (kills). Criteria for the identification of each of these forms is provided and the conditions under which each defines a standardized unit of sign (SUS) are described.

BASIC IDENTIFICATION PROCEDURE

Identifying the traces or sign left by a given species of wildlife has traditionally been viewed as more of an art than a science. This is largely due to the lack of objective criteria available to confidently identify the wide variety of sign encountered in the field. Hence, identification is often made by a qualitative, often subject, synthesis of many characteristics learned through experience. The identification of sign is inherently a qualitative process due to the need for identifying shapes or characters that are often difficult to quantify. The scheme followed here to identify mountain lion sign will stress the objective use of both qualitative and when possible, quantitative criteria.

However, quantitative information is not always available, and it's usefulness varies. It will be seen below that the maximum scat diameter is closer to providing an absolute criteria for identifying scats, whereas track and scrape width will be a dimension useful for determining whether the sign lies within the range of acceptable variation. Qualitative rather than quantitative criteria will be favored for identifying the remains of lion-killed deer due to the time and experience required of the latter.

It should be stressed that criteria must be applied in objective process. This is most difficult when the criteria is qualitative. In such cases the process involves a question - is a given attribute present or absent? Granted, some degree of subjectivity is unavoidable; determining the presence or absence of an attribute (e.g. 3 lobed pad, segmented scat, or a typical site for a scrape) requires a subjective determination that given qualities are, "in fact", present. Assuming that the sign exhibits the proper characteristics, quantitative criteria should be employed as a final step in the identification process. If the sign in question does not meet or conform to the quantitative criteria, its identity should be regarded as uncertain and, therefore, lacks the quality necessary for inclusion in the survey results.

Careful attention to the following text and illustrations, complemented with experience, should make identifying mountain lion sign less of a raw art and more of a paint-by-number procedure.

TRACKS

QUALITATIVE CRITERIA

Anatomy and Track Morphology. All too often, a discussion of track identification centers around only the track and not the object that made it - the foot. It actually is of great benefit to have a clear mental picture of the "mold" when searching for the "cast". Consequently, the proper starting place for identifying mountain lion tracks is with the anatomy of the lion's foot.

The structure of a cat foot is referred to as digitigrade. This posture is characterized by the elevated position of the carpals and tarsals with the point of contact between limb and ground being the distal end of the metacarpals and metatarsals (Figure 1). A cat's foot is adapted for grasping and securing prey. Each toe is armed with a sharp retractile claw, five on the front feet and four on each rear foot. The first toe of the front foot (the equivalent of a human thumb) is located on the medial side of the foot and does not touch the ground. The lion track is three lobed, circular in outline, and lacks bilateral symmetry (i.e. one half does not mirror the other, see Figure 2). This asymmetry results in the imprint of the 2nd digit being the most anterior of all four toes. Tracks from the right or left feet can often be distinguished by this character (Figure 3a).

The pad of each foot is where the metacarpals (fore foot) or metatarsals (hind foot) bear the weight of the body as it touches the ground. Consequently, the pad of each foot is composed of a thick layer of shock absorbing connective tissue. The morphology of the pad is an important character in identifying mountain lion tracks. In Figure 2 note the three lobes along the posterior margin of the pad which characterizes all members of the felidae. Also note the prominence and angularity of the medial and lateral cheeks. As with most four footed mammals, the front foot is larger than the rear foot due to the need to bear the greater weight of the head versus the tail (Figure 3b).

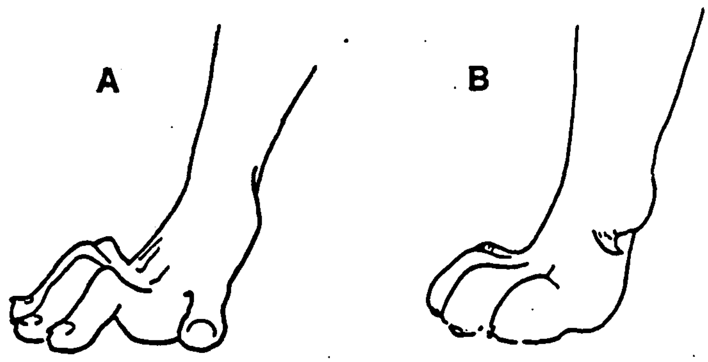


Figure 1. Analogous position of human hand (A) with the digitigrade posture of the mountain lion foot (B). Right hand compared to right front foot.

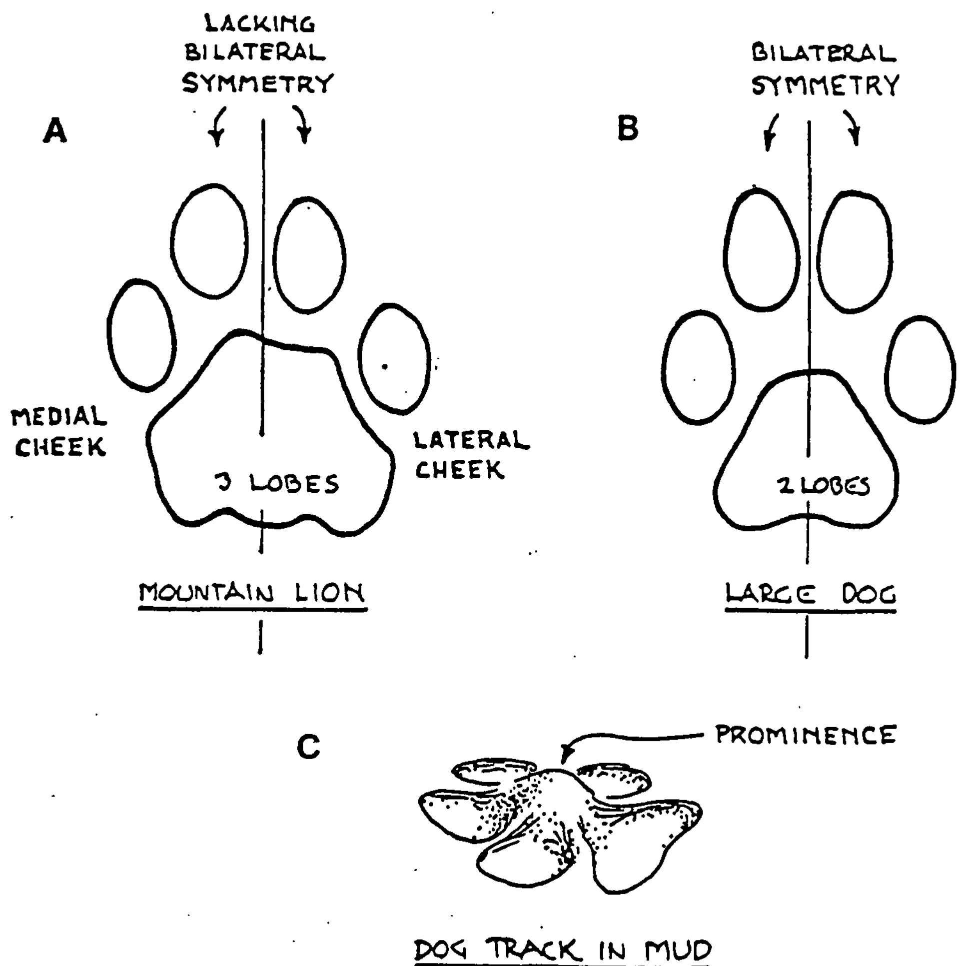


Figure 2. Differences between tracks made by mountain lions and large dogs.

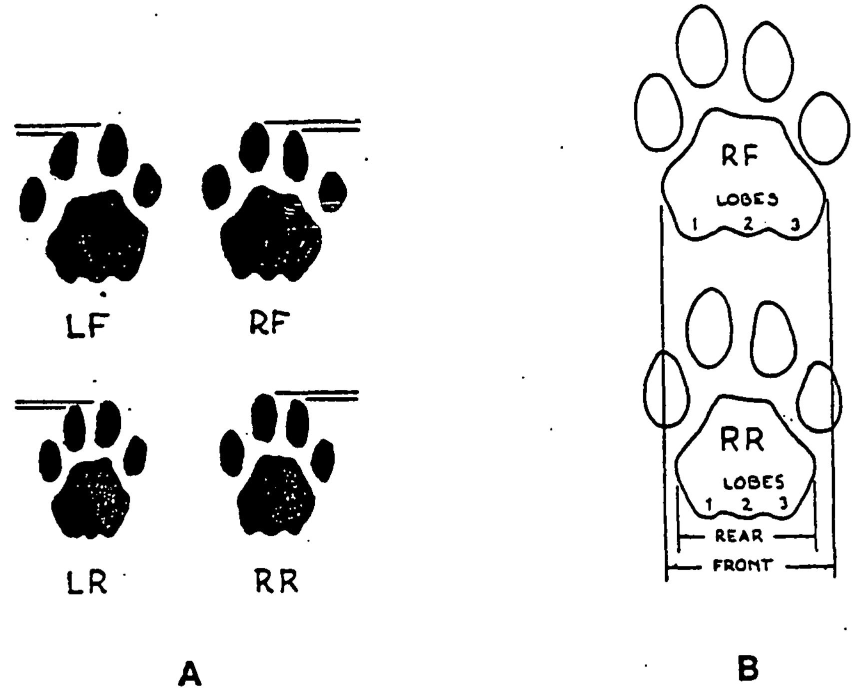


Figure 3. Characteristics of mountain lion tracks that permit identification of right and left tracks (A) and front and rear tracks (B).

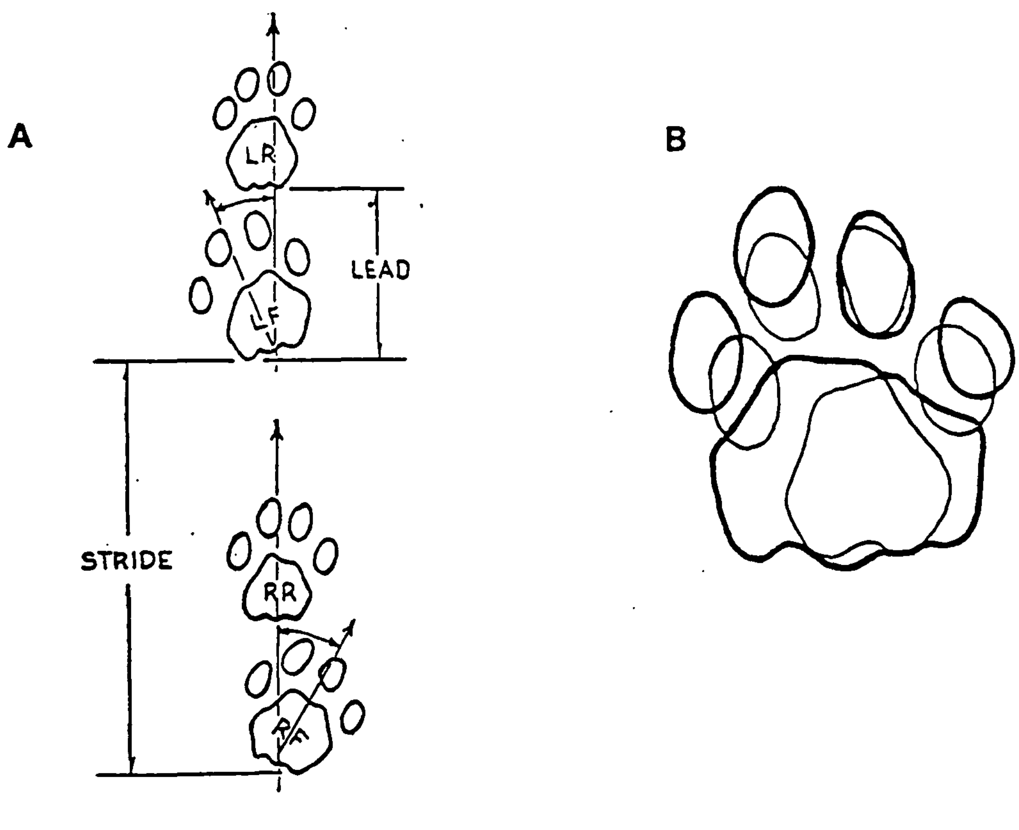


Figure 4. Characteristic walking pattern of mountain lion tracks illustrating stride, lead, and outward deviation of front feet (A). Effect of superimposed rear track on front track - creation of an apparently large track (B).

Members of the cat family also have the ability to supinate with their front feet, or turn their foot palm side up. This is easily noticed when a house cat plays with a ball of yarn. As a result, many cats will walk with their feet splayed laterally, resulting in a track that appears to deviate outwardly from the line of travel (Figure 4a).

The type of substrate that the track is found in will influence the size and shape of the track. The discussion above applies principally to tracks found on dry dirt or dust 1-15mm in depth. The track of an individual mountain lion may appear larger in deep dust, mud, or snow than in shallow dust. Older tracks in snow may grow larger as the snow thaws. Dog tracks in soft dirt or mud may be distinguished from those of a mountain lion by the presence of a prominence formed between the toes and the pad (Figure 2c).

Stride Pattern. The stride pattern of the mountain lion when walking often results in the rear track falling on, or in front of, the front track. The faster the walk the greater the lead between the rear and front track (Figure 4a). Care must be taken not to interpret a superimposed imprint from the front and rear feet as one large track (Figure 4b). If a vague or questionable imprint is found, continue searching along the apparent direction of travel or backtrack to find a more distinct track. The stride length between contralateral tracks (front feet and hind feet) usually ranges from 41-53cm (16-21in.).

QUANTITATIVE CRITERIA

Pad Width. Measurement of pad width of a mountain lion track will provide a degree of confirmation that the track has been properly identified. Most tracks encountered will exhibit a pad width ranging from 42-65mm. This width will vary for lions of different age and sex and between the front and rear tracks of the same lion, as noted above. For the purpose of the trend survey an attempt should be made to identify and measure the width of the pad imprint from the hind foot. Pad width is measured between the medial and lateral cheeks of the pad perpendicular to the anterio-posterior axis of the track (Figure 3b). Table 1 provides a summary of pad widths for rear tracks from different age and sex catagories. These categories should not be used as a basis to classify tracks measured in the field. Rather, they are provided for their heuristic value to field personnel for gaining insight into variation in track size. A representative track should be photodocumented following the procedures described in the photodocumentation section below.

Table 1. Range of pad widths from the rear tracks of mountain lions from the Guadalupe Mountains of New Mexico and Texas, 1982-1985.

Age and Sex	Pad widths of rear tracks (mm)*
Mature Males 24+ mos.	49 - 60
Mature Females 24+ mos.	43 - 51
Sub-adults and Mother Dependant Juveniles 7 - 23 mos.	40 - 49
Kittens 1.5 - 6 mos.	33 - 43

* Measurement of pad width is the maximum width between the medial and lateral cheeks of the pad imprint, measured perpendicular to the anterio-posterior axis of the track.

SCATS

QUALITATIVE CRITERIA

The morphological differences between scats of mountain lion, bobcat, coyote, and bear are subtle and difficult to describe verbally. This leads most authors to rely on illustrations of "typical" scats (Murie 1954, Rockcastle 1966, Seton 1958). Accordingly, Figure 5 provides an illustration of a typical mountain lion scat from the Guadalupe Mountains.

Black bear, coyote, bobcat, and domestic dog are the principal species whose scats must be differentiated from those of mountain lions. Initially, field personnel should distinguish scats of wild carnivores from those of domestic dogs. Scats from wild carnivores will frequently contain hair and bone fragments while those of domestic dogs probably will not. Black bear scats frequently reflect the omnivorous food habits of this species, exhibiting large proportions of readily identifiable plant matter. These scats are often very different morphologically and resemble the shapeless form of many herbivore scats more than that of a carnivore. Yet when feeding on animal remains, bear scats may appear similar to those of mountain lion. These scats will frequently contain plant and insect remains, and, as pointed out by Murie (1954), tend to maintain an even diameter (i.e. cylindrical).

QUANTITATIVE CRITERIA

The problem with providing an illustration of a scat is that it does not describe variation in scat morphology. In order for scats to be employed as a quantitative element of the trend survey they must be confidently identified. As a result, it becomes necessary to either find a method to describe this variation or find a way of getting around it - recent attempts have focused on both strategies.

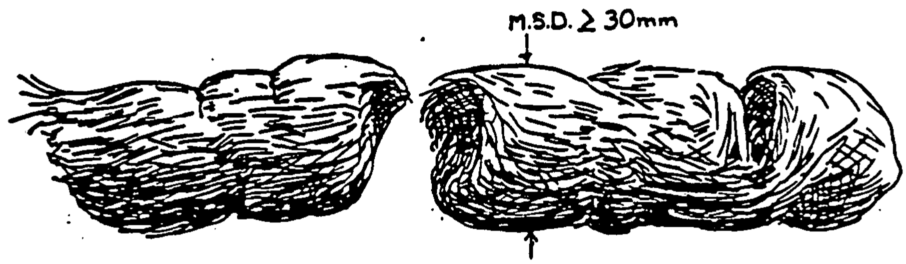


Figure 5. Characteristic mountain lion scat from the Guadalupe Mountains of Texas and New Mexico.

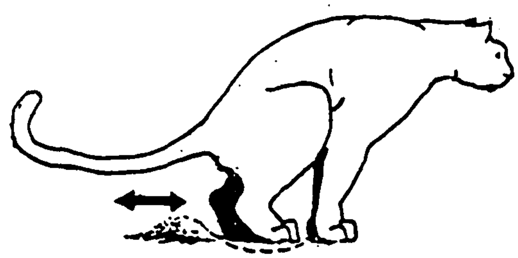


Figure 7. Mountain lion posture and motion of the hind feet when making a scrape mark.

Figure 8. Method of immitating a mountain lion scrape mark.

Biochemical analyses (Johnson et al. 1984, Clinite 1982, Major et al. 1980) and measurements of fecal pH (Green and FLinders 1981, Hansen 1978) are examples of non-morphological methods for identifying scats. Studies using morphometric analyses such as Weaver and Fritts (1979), Green and Flinders (1981) and, Danner and Dodd (1982) represent recent attempts to quantify scat dimensions and to measure variation. These studies established criteria permiting the identification of scats from 2 species of Canidae by using measurements of maximum scat diameter. This method appears to work well when the species involved differ significantly in body size. Additionally, diameter measurements can be easily made in the field.

Measurements of maximum scat diameter will be used to identify mountain lion scats in the trend study. Mountain lions are not only the largest felid in the region but are the only large carnivore common to the entire region. Bears are most common in GUMO and rarely produce scats that can be confused with lion. As a result, scat diameter should be a reliable character for identifying mountain lion scats.

Figure 6 illustrates the frequency distribution of maximum scat diameters for coyote and mountain lion. It is assumed that there is no significant difference between bobcat and coyote maximum scat diameters (Table 2). Based on Figure 6 and Table 2, scats with a maximum scat diameter equal to or exceeding 30mm will be regarded as mountain lion. Measurements should be made with vernier calipers at the widest portion of the scat. If the scat exhibits any sign of having been crushed or physically altered, it should not be considered. All qualifying scats should be photodocumented and removed from the trail (see photodocumentation below). The maximum scat diameter should be recorded on the field data sheet along with the transect kilometer in which it occurs.

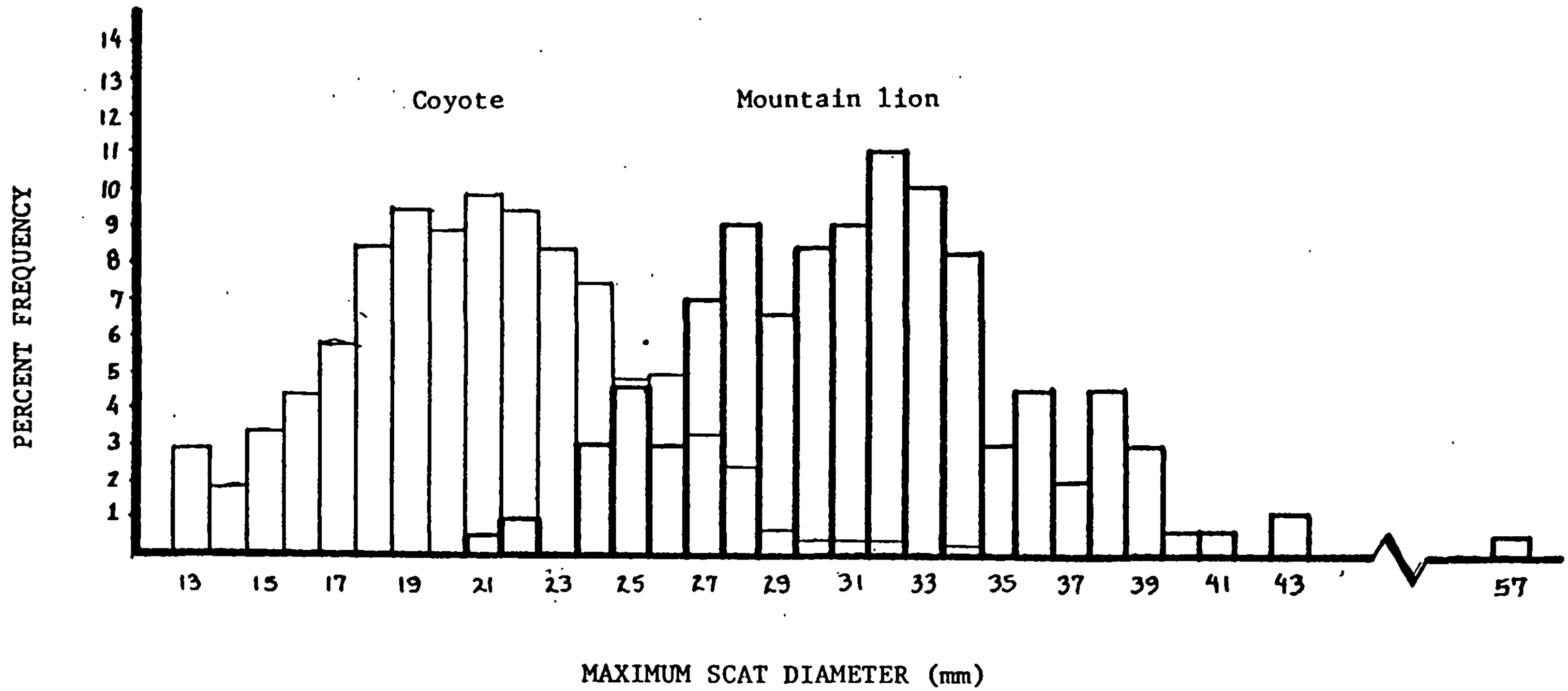


Figure 6. Comparison of maximum scat diameter between mountain lion and coyote. Coyote scat diameters taken from Weaver and Fritts (1979). Mountain lion scat diameters are from scats collected in the Guadalupe Mountains of Texas and New Mexico, 1982 - 1985.

Table 2. Descriptive statistics for the maximum scat diameter of mountain lion, coyote, and bobcat.

Species	Source	N	Mean	Range	S.E.M
Mountain lion	Smith et al.1985	204	31	21-57	0.32
Coyote	Weaver and Fritts 1979	616	21	7-34	0.20
	Green and Flinders 1981	131	22	15-33	0.30
	Danner and Dodd 1982	179	20	10-29	0.27
Bobcat	Unpublished *	13	21	19-25	0.57

* Synthesis of several sources; California, 4 captives (N=10); New Hampshire, wild, (N=1); Murie (1954), (N=2).

SCRAPES

Scent marking is an important form of communication with solitary carnivores (Leyhausen, 1965). How carnivores use scent in communication is largely unknown and is a difficult subject to study. The human sense of smell is too feable to fully appreciate the olfactory spectrum, but a basic understanding of how mountain lions use this mode of communication will help guide field personnel in locating and identifying markings known as scrapes or scratches.

Scrapes are markings made primarily by male mountain lions, with a shuffling motion of their hind feet (Figure 7). They are believed to act as visual markers that direct a passing mountain lion to olfactory information (Seidensticker 1973). This information is provided via urine or feces and probably communicates reproductive status, individual presence, and possibly identity.

The impetus to scrape is ultimately based on a need for advertisement. The desire of an adult male to advertise is probably greatest when actively courting an estrus female. During these times a male will scrape frequently to facilitate contact with the female who, when in estrus, is eagerly seeking the male. Pairing between male and female is a relatively rare event but a male exhibits behaviors on a daily basis that maximizes his potential for just such an encounter. These behaviors include, long-ranging movements to maintain contact with numerous females, agonistic behavior towards other adult males for the rights to females of his home range, and marking behaviors that serve to advertise his presence to both resident females and intruding males.

A fundamental element of advertising is to focus the expenditure of advertising effort to where and when it will be most effective. Therefore, mountain lions place scrape marks where the potential for discovery by another lion is greatest. Routes traveled by mountain lions typically conform to the major topographic features of an area. Examples of such features are ridge lines, canyon bottoms, and low saddles or gaps dividing 2 watersheds. Along such routes mountain lions recognize and respond to the presence of physical features that aid in making and detecting scrapes. This formula-like quality of scrape sites can be of great aid to field personnel when attempting to locate scrapes.

QUALITATIVE CRITERIA

The Scrape Itself. As an aid for learning the appearance of a mountain lion scrape, imitate the marking in various types of plant litter. To make a convincing replica, place paired fists together, thumb to thumb. Draw backward through the litter creating a small pile at the rear of the scrape (Figure 8). In fresh scrapes it will sometimes be possible to note the line in the underlying soil that separates the mark made by each paw. On occasion try imitating scrape marks in different types of substrate. This will provide an impression of how scrapes look in pine needles versus decomposed wood, etc. After studying their appearance, be sure to wipe out these marks to avoid counting them in future surveys.

The Scrape Site. While hiking the survey transect be aware of subtle physical features along the route that funnels your movement through bottlenecks. These same features will funnel mountain lions through bottlenecks. If plant litter is also present, then these are areas where mountain lions will typically scrape. The following is an outline of the "scrape site formula";

- Major topographic funnel.
- Physical features that create a bottleneck in a trail.
    - The presence of a physical object (i.e. tree, stump, rock, etc.).
    - Organic substrate (i.e. leaves, needles, humus, decomposed wood, high water debris).
    - Flat or level ground.

The above characteristics are not always present at a given scrape site but should serve to guide field personnel in recognizing typical scrape sites. The following are examples of where scrapes sites can be found in the Guadalupe Mountains.

- While walking along a forested ridgeline in GUMO scrapes can be found by following the predominant game trail nearest the crest of the ridge. As the trail passes a large, distinctive, ponderosa pine look for scrapes in the pine needle litter near the base of the tree. Pine needles are favored substrate for scraping and old marks can often be seen near objects like large rocks and stumps.

- Traveling down a canyon bottom, it is often easier to avoid rock hopping in the creek bed by finding a game trail along the edge. Where these trails enter and exit flat, forested benches, look for scrapes on litter covered, flat ground.

- While hiking along the Guadalupe Ridge in CACA look for scrapes in decomposed sotols, agaves, or lechuguillas. The shaped of the scrape can be hard to discern in this highly fibrous litter - look carefully. Sometimes a scat may be present.

- If a trail that follows a major ridgeline or canyon bottom crosses the decomposing trunk of a fallen tree, look in the scattered wood chips for evidence of a scrape.

QUANTITATIVE CRITERIA

Bobcats also make scrape markings which can be confused with those of mountain lion. Scrapes measuring less than or equal to 15cm in width should be regarded as bobcat (Bailey 1974). Seidensticker (1973) reports widths of 15-30cm for mountain lion scrapes measured in Idaho.

When a scrape site is encountered a representative scrape should be measured, recorded on the field sheet, and photographed (see photodocumentation below).

KILLS

The identification of prey remains can also be a useful indicator of mountain lion presence. Shaw (1978) provides a thorough treatment of procedures for identifying kills made by mountain lion. Wade and Bowns (1982) provide an illustrated field guide with an equally thorough discussion. The emphasis here will not focus on a thorough search for evidence but will sacrifice thoroughness for a quick, reliable identification of mountain lion presence more suitable to the needs of the monitoring survey.

QUANTITATIVE CRITERIA

While quantitative criteria are available for gleaning evidence of lion predation from prey remains it must not be used in survey procedures. The time and experience required to properly use these criteria are impractical for the purpose of this survey. Field personnel are to restrict their identification of prey remains to the qualitative criteria given below.

QUALITATIVE CRITERIA

The remains of lion-killed deer will be the only prey remains that can qualify for a kill-defined SUS value. Deer are too large to ingest in one meal and are often consumed in a series of feedings. Evidence of one or more burials is often found as the carcass is covered between each daily feeding. The organs of the thoracic cavity (heart, lungs, and liver) are usually consumed within the first 2 feedings. If the carcass is utilized for several days major muscle masses are selectively consumed until only the hide, rumen, and large elements of the skeleton remain. After the remains are abandoned scavengers will frequently feed from the carcass and obliterate much of the sign left by the mountain lion.

Skeletal remains of deer are often found in both parks but determining their cause of death is often not possible due to the time elapsed between death and discovery. Only recent deaths should be studied for signs of predation. These remains are often detected by the smell of the carcass or the activity of vultures. To simplify field procedures the only acceptable evidence for identifying a lion-killed deer or elk will be evidence of buried remains with soft tissues intact. In addition, evidence of thoracic entry should be present by noting whether ribs of one side are bitten off between the chest spine.

DETERMINATION OF STANDARDIZED UNITS OF SIGN (SUS Values)

Several problems are encountered in quantifying sign in a simple and meaningful fashion. Fresh track sets from a single lion are often found crossing and continuing along various lengths of trail. Numerous scrapes may occur at a single site. Scats may be found associated with tracks and scrapes or without any associated sign. The inclusion of each track, scrape, or scat in survey totals permits concentrations of abundant sign, potentially made by one lion, to contribute disproportionately to survey results. To minimize this effect and simplify recording procedures, standardized units of sign (SUS values) should be employed.

Tracks. Because of the difficulties encountered with quantifying and interpreting sets of tracks, only 1 track-defined SUS value per kilometer will be counted. When a set of tracks are found, search along the line of travel for the clearest tracks in the series. The line of tracks may be followed off the trail a short distance if clear tracks are not found on the trail. Determine the transect kilometer, indicate the width and identity of the track (e.g. 46mm, RR) and credit the SUS total with a value of 1. In the unlikely event that one set of tracks crosses the boundary between transect kilometers it should be recorded only once.

Confusion can arise if field personnel are not clear on what constitutes a set of tracks. For the purpose of the monitoring program, a set or subset of tracks should be regarded as any continuous series of tracks that show a direct relationship to one another. As a result, a set of tracks may be composed of several subsets of varying lengths. When dealing with a lengthy series of tracks within a given kilometer, if the gap between 2 apparent sets of tracks is less than the length of the longest set, both should be regarded as subsets of a common set. Conversely, if the gap between 2 apparent sets of tracks is longer than the longest set, both should be regarded as separate sets (Figure 9). This rule is intended as a guide, to be applied

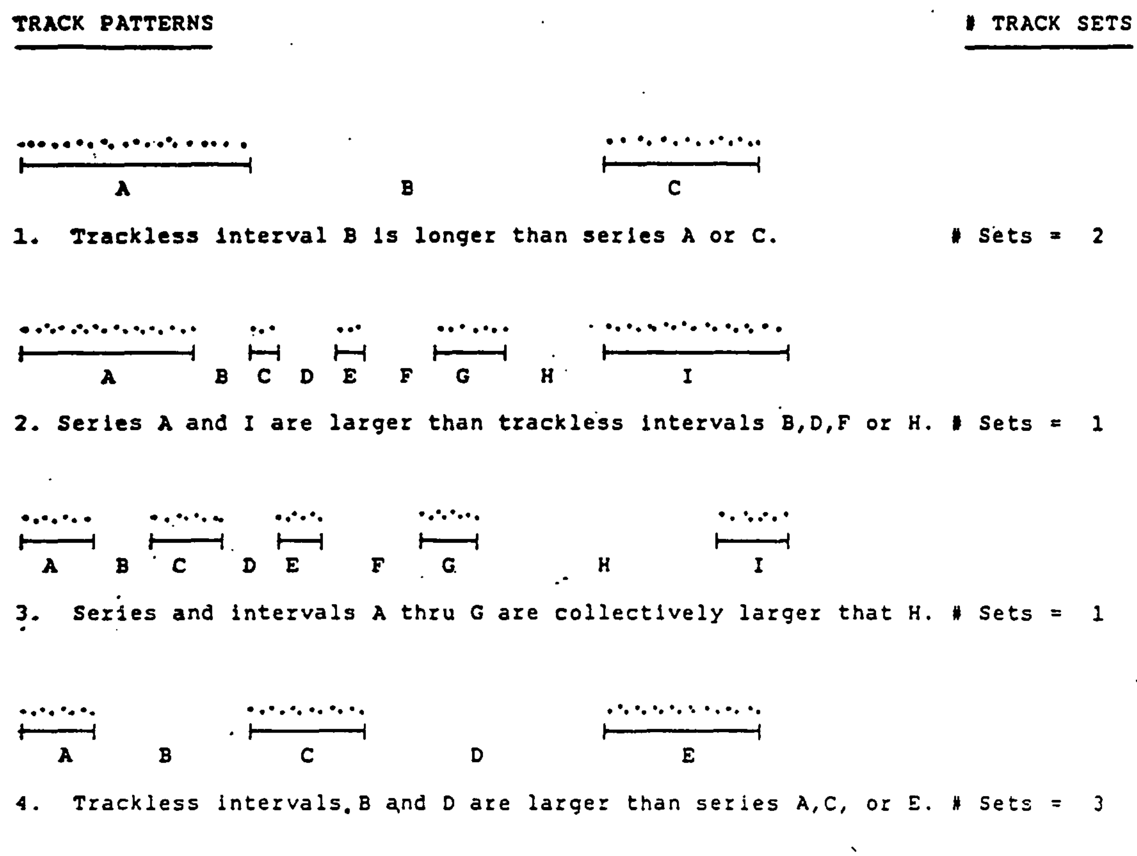


Figure 9. Four examples of track patterns with interpretation of how many track sets each pattern represents.

in principal, using estimated lengths of track sets rather than actual measurements. Keep in mind that regardless of how many true sets of tracks exist in a given transect kilometer, only 1 SUS value will be recorded. The need to define a track set will be necessary only when crossing transect kilometer boundaries.

Scrapes. A scrape site will form the basis of each scrape-defined SUS value and not the total number of scrapes, a scrape site being defined as any number of scrapes within a circle 20 meters in diameter. When a scrape site is encountered the transect kilometer should be identified, the total number of scrapes determined, and an SUS value of 1 recorded. Additional scrape sites found in the same kilometer, but more than 20m from another site, will be recorded as additional SUS.

Scats. A single scat or collection of scats that appear to represent a single defectation will form the basis of a scat-defined SUS value. No attempt, however, should be made to distinguish between droppings deposited on top of one another such as might occur from the use of a common site while feeding on a kill. A scat found in association with a scrape should be recorded as a single scrape-defined SUS value. A scat found in association with tracks should be counted as 2 SUS values (i.e. one scat and one track-defined SUS value). When a mountain lion scat is found the transect kilometer, the maximum scat diameter, and the number of SUS values should be recorded.

Occasionally a scat will be found inside the perimeter of a scrape site. In such instances, it is very likely that the scat was deposited in coincidence with a scrape that has since weathered away. Consequently, any scat found within the limits of a scrape site should be regarded as scrape and not counted as an additional SUS value.

Kills. Lion killed deer are to be counted as one SUS value if the remains meet the criteria given above. If tracks, scats, or scrapes are present within a 20 meter diameter circle of a suspected kill choose the form of sign that is most identifiable and give the site only 1 SUS value. However, if tracks are present within the kill site the criteria for track-defined SUS

values applies. Consequently, additional tracks within that transect kilometer will not qualify for additional SUS values. Scats, and scrapes outside the 20 meter kill site are not subject to this restriction.

PHOTODOCUMENTATION

Photography will be used to document each SUS. Each photograph will permit later review and verification of sign identified in the field. Slide film (ASA 200) should be used with slides stored in clear plastic, 8/12 X 11 inch slide holders. This will provide a convenient method for keeping the slides, field sheets and summary sheets from a survey together in a common file. Film with a relatively fast ASA will permit shooting in dim light such as in the mouth of a cave or a cloudy sunset. Each photograph should be taken as close as possible to the subject with room in the photo for identifying information.

All identifying information should be written neatly, in a large, compact style on a blue 3 x 5 card in bold black ink. Black ink on a white background will often over expose in bright light.

Tracks. Select tracks which are clearly mountain lion tracks, preferably of a rear track (discussed above). Also select a track that will photograph well. Such a track will usually be on flat ground with substrate deep enough to impart a 3-dimensional quality to the photo. Low angle lighting is helpful in visualizing the outline of the track. Early morning and late afternoon usually provide this long-shadowed light with noon time providing the shortest shadows. Even though field personnel will often not have optimal lighting conditions. The use of a flash is not encouraged because of the difficulty of getting clear close up pictures with flash. Identifying information visible in the photographed track should include the date, transect kilometer, pad width, and identity of the imprinting foot (RR, LR, RF, LF).

Scats. All scats meeting the criteria for identification should be photographed and removed from the trail to clear the route for the next survey. The photograph should be taken as close as possible with a clean background that does not disrupt the outline of the scat. Identifying information in the photo should indicate the date, scat diameter, and kilometer location.

Scrapes. Following documentation all scrapes encountered should be cleared for the next survey by smoothing out the marking. Scrapes can be difficult to photograph in natural light. This results in a need for the consistent use of 2 types of photographic compositions. The first photo should be taken directly above the scrape, in a vertical format. A metric scale should be placed in the scrape depression, perpendicular to the apparent line of travel. This places the scrape mound at the bottom of the picture (Figure 10). Identifying information should be placed at the top of the photo and should include the date, kilometer location, and scrape width.

The second photograph should show the site where the scrape was found. This photo should be taken at a distance of about 3 to 10 meters with each scrape marked by an upright 3 x 5 card placed in the scrape mount. It will be the responsibility of the field person to match and label both slides for each scrape site following the survey. Careful notes should be taken on the surroundings in this second photograph to insure correct matching later with photograph number one.

Kills. The objective in photographing lion-killed deer is to record the characters that illustrate the evidence. Before photographing the kill consider pushing back any vegetation that obscures the view. If the kill is buried photograph it covered and uncovered from a distance that shows the kill and the surroundings. Photograph evidence of thoracic entry from 2 - 4 feet, avoiding confusing patterns of light and shadow. The date and transect kilometer should be included in the picture and clearly written in large print to aid viewing at a distance.

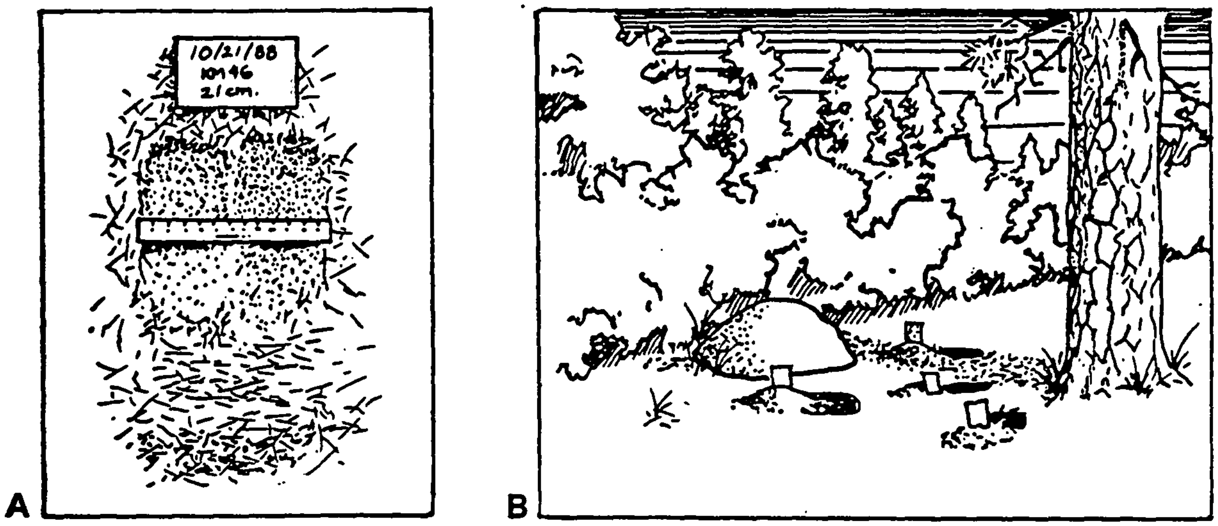


Figure 10. Photographic formats for documenting scrape sites, (A) veritical, close-up; (B) horizontal, 3 - 10 m.

SEARCH PROCEDURE

A map of the transect provides survey personnel with where to search and this field guide has described what to search for and how to document it. What remains to be described is how to search. Soon after beginning a 75 km transect, one can easily feel uncomfortable with the magnitude of adequately searching the route. Relative to the sign of other animals in the park, evidence of mountain lions will be encountered infrequently, even though they may be considered numerous. The search can therefore become exhausting. The key to consistently locating their sign is by recognizing where it can be found. The ultimate objective for survey personnel is to define the transect and search it in a manor that maximizes the detection of sign. The discussion that follows focuses on the 2 major elements of this objective - following the transect and recognizing sites where sign can be found.

FOLLOWING THE TRANSECT

Translating the curvilinear transect indicated on the map into a field survey requires a full appreciation of what that line represents. The map indicates the principal or primary route but many small-scale modifications must be made while on this route to optimally census the transect. As a basic guideline, modifications to the primary route are made when it is recognized that a nearby site has a higher probability of containing sign than that of the primary route. Two types of movements will be made by personnel while following the trail and those that do not, the off-trail or cross country routes. The primary route can be either on or off-trail. Modifications to the primary route are always off-trail.

Primary Routes

Primary routes form the basis of the transect. An attempt has been made to delineate the primary route on the transect maps. On sections of the transect where trails are followed personnel will have little trouble defining this route. Portions of the transect lacking an established trail will begin by interpreting the map to identify the correct topographic features that indicate where to start the off-trail segment. An understanding of how to proceed along an off-trail primary route from this point requires adherence to several basic guidelines.

The first step in determining off-trail primary routes will be through careful attention to the map. The next step will be to traverse the are by utilizing major game trails that approximate the route indicated on the map. In general, the transect takes the shortest route through an area. This route favors the inside curvatures of canyon bottoms and the crests of ridges.

In canyon bottoms, sign is rarely found in the rocky stream bed or on the slopes above. Optimal routes in canyon bottoms should cross stream beds on major game trails as they cross over benches lying above the bed of the canyon. This route is almost invariably the shortest route through the canyon. While following game trails nearest the crest of a ridge, prominences may be skirted to one side by favoring the most prominent trail. If the trail splits equally the criteria given below may be used as a guide in selecting the most promising route.

Modifications to the Primary Route

While searching transects personnel must always maintain a wide field of search. Attention must be given to the trail beneath them while remaining aware of off-trail sites nearby that may hold valuable sign. Promising sites detected on either side of this route warrant a modification to the primary route and should be investigated. After investigating the site personnel should to return to the path constituting the primary route as close as possible to the point where they left it. It must be re-emphasized that modifications to the primary route are made only when it is recognized that an off-trail site has a higher probability of containing sign than the primary route.

Limits to Modification

Survey personnel must restrain themselves from investigating sites too far from the primary route. Frequent, wide ranging searches will consume valuable time and reduce the repeatable character of the transect. Where the transect follows an established trail modifications should not exceed 20 meters from the primary route. The lack of a defined, predetermined route for off-trail sections of transect warrants a larger, 30 meter radius for restricting off-route searches. These limits are intended to serve as a general guide and may be measured in paces. Consequently, if a very promising site lies a short distance beyond these limits - investigate it.

CHARACTERISTIC SITES FOR LION SIGN

Learning to recognize sites where mountain lion sign is most often found should begin with a mental picture of the four types of sign described above. Recall that scrapes occur mainly in organic debris in sites with specific characteristics. Beyond mentioning that scats can be found at scrapes sites, locations where scats are found were not discussed because scats may occur at any point along the transect. Clearly, tracks will be detected only at sites where the substrate permits their preservation. Kills, meeting the criteria given above, are usually found in dense cover and can be detected by odor or drag marks. This brief summary suggests that different kinds of mountain lion sign may occur in a variety of different areas with some notable exceptions. A forest floor with a carpet of pine needles or a decomposing agave might yield a scrape but finding a track in such places can be virtually impossible. Conversely, scrapes are rarely found in the dust of a hiking trail.

This field guide has been developed to compliment a method developed for monitoring mountain lion populations trends. This method favors sign which will accumulate over time. Tracks and drag marks are not preserved long in the dust of an exposed trail. The ability to recognize a lion-killed deer decreased with time due to the activity of scavengers. However, scrapes and scats are less likely to degrade and will accumulate with time. Tracks as well can accumulate or be preserved in the sheltered environment of a dusty cave floor. The key to recognizing promising sites for sign lies not in detecting the substrate in which the sign occurs, but rather, the conditions which create an environment where marking behavior is elicited and sign is preserved.

Results from the first survey yielded far more scrape and scat defined SUS values than either tracks or kills. This is because scrapes sites, grottos and caves were routinely investigated while following the primary transect route. Become familiar with the description of scrape sites given above, use it in your searching procedure while keeping in mind key elements from this discussion.

- The ultimate objective for survey personnel is to define the transect and search it in a manor that maximizes the detection of sign.

- The map indicates the principal or primary route but many small-scale modifications must be made while on this route to optimally census the transect.

- Modifications to the primary route are made when it is recognized that a nearby site has a higher probability of containing sign than that of the primary route.

- As a general rule, modifications to the primary route should not exceed 20 meters when following established trails and 30 meters on off-trail routes.

- Learning to recognize sites where mountain lion sign is most often found should begin with a mental picture of the four types of sign used in this survey.

- The key to recognizing promising sites for sign lies not in detecting the substrate in which the sign occurs, but rather, the conditions which create an environment where marking behavior is elicited and sign is preserved.

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