

BOULDER OPEN SPACE VISITATION S
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MARTY ZELLER, ETAL.

BOULDER OPEN SPACE VISITATION STUDY

December 17, 1993

Prepared by

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MEMORANDUM

TO: Jim Crain, Dave Kuntz, Alice Guthrie, Rich Smith, Mike Adams, Jeff Holland, Mark Gershman *& NATURAL RESOURCES*
FROM: Brent Wheeler, Resource Planner
SUBJECT: 1994-1995 annual visitation estimates
DATE: July 17, 1995

The results from year three of the Visitation Study have been compiled and the annual visitation estimate for June 1, 1994 through May 31, 1995 is **1,921,205** visits. This estimate was derived from a number of different sources: the predictive model estimate from 1994-1995 (**1,585,720**), Boulder Creek Path estimate from 1992 (**269,714**), Eldorado Mountain trail counter estimates from 1994-1995 (**61,391**), and increased holiday use estimates from 1994 (**4,380**). Below is a brief description of the predictive model, additional use estimates not covered by the predictive model, and comparisons between the 1993-1994 and the 1994-1995 studies.

Predictive Model

During the 1992-1993 Visitation Study a predictive model was developed to explore whether or not information from an indirect measure (counters) could be used to estimate visitation for the Open Space system in following years. Multiple regression analysis was used to establish a relationship between counter readings and the results of the Visitation Study. The data were tested and demonstrated an ability to estimate visitation accurately. Based on these results, the predictive model was recommended for estimating annual visitation in future years¹.

Data for the 1993-1994 and 1994-1995 predictive model were collected on the Open Space system using vehicle and trail counters. This information was collected during 48-hour time blocks in each of the 10 study zones, following a schedule similar to the one used during the original study. Ideally, 8 counter readings would have been recorded for each of the 10 zones, providing a total of 80 valid observations for the year. However, counter malfunctions caused by severe weather, vandalism, and mechanical problems reduced the valid number of observations to 63 during 1992-1993, 72 during 1993-1994, and 78 during 1994-1995.

Additional use estimates

The predictive model does not include use estimates for the Boulder Creek Path, new properties, or increased use during holiday periods. Use estimates for the Boulder Creek Path were derived from a 1992 Parks and Recreation Department Study. Because no new estimates for the Creek Path are available, the same estimate used for 1992-1993 is used for the 1993-1994 estimate. In order to obtain use estimates for Eldorado Mountain and increased holiday use, Open Space staff developed additional indirect measures using trail and vehicle counters. It is important to note that these additional indirect measures (estimates for Eldorado Mountain and increased holiday use) are very rough estimates and have not been correlated with on-site observation samples and should be used accordingly. This information was added to the predictive model to provide a more accurate visitation estimate for the entire Open Space system.

Comparisons

When comparing the increase in visitation estimates from the original 1992-1993 study to the 1993-1994 and 1994-1995 study, use estimates for Boulder Creek Path, Eldorado Mountain, and the increased holiday use are excluded because these were not measured during the 1992-1993 study. The predictive model estimate for 1993-1994 (**1,387,493**) is compared with the predictive model estimate for 1994-1995 (**1,585,720**), for a total increase of approximately **13%** over last year's predictive model estimate.

<i>1992-1993 Estimates</i>	<i>1993-1994 Estimates</i>	<i>1994-1995 Estimates</i>
1,185,704* <i>Visitation Study</i>	1,387,493* <i>Predictive Model</i>	1,585,720* <i>Predictive Model</i>
269,714 <i>Boulder Creek Path</i>	269,714 <i>Boulder Creek Path</i>	269,714 <i>Boulder Creek Path</i>
1,455,418 <i>Annual Visitation</i>	1,657,207 <i>Subtotal</i>	1,855,434 <i>Subtotal</i>
	40,000 <i>Eldorado Mountain</i>	61,391 <i>Eldorado Mountain</i>
	4,380 <i>Increased Holiday Use</i>	4,380 <i>Increased Holiday Use</i>
	1,701,587 <i>Annual Visitation</i>	1,921,205 <i>Annual Visitation</i>

* Numbers used in comparison of original estimates

¹ Information taken from Visitation Study, prepared by Harry Zinn and Michael Manfredo, Human Dimensions in Natural Resources Unit, Colorado State University.

CKM, BA, GT, ER, DP

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EXECUTIVE SUMMARY

The City of Boulder Open Space system consists of approximately 24,000 acres of open lands. Along with the City's Mountain Parks, this open space system is intended to surround the current and future developed areas, provide a permanent natural buffer for the benefit of citizens and wildlife, and provide a natural backdrop, or setting for the City. Since 1967 when citizens of Boulder voted to dedicate a portion of sales tax revenues to buy open space lands, the system has grown to be one of the most extensive municipal open space systems in the Country. The Open Space program is consistently regarded as one of the most popular City programs and in 1989 residents voted to appropriate additional sales tax to accelerate the acquisition and management program.

Background

In 1991, as a result of increases in visitation, acreage and management responsibilities, the Boulder Open Space Department conducted a management study which resulted in a series of recommendations to reorganize the Department to improve management capability and operation. One of the principal recommendations was for the Department to develop detailed area management plans which would tie objectives to manage the system for natural resource values and passive recreation established by the City Charter, to specific area management plans and annual budgets. A cornerstone of the area management plans was to be an understanding of the number and kinds of visits and uses occurring on Open Space. The City of Boulder Open Space Department had never undertaken an effort to acquire user information on a system-wide basis. Therefore, no accurate counts of visits to Open Space existed for the department to incorporate into its budget planning and management processes. Funding for a visitation study of City of Boulder Open Space was approved by the Open Space Board of Trustees in order to obtain accurate estimates of annual visitation to the Open Space system.

The City of Boulder Open Space Visitation Study was designed to obtain one year's data on number, type and origin of visits to Open Space. The study began on June 1, 1992 and ended on May 31, 1993. The study was a collaborative effort between Open Space staff, a consulting team from Design Workshop and Colorado State University's Human Dimensions in Natural Resources Unit, temporary employees and unpaid volunteers. Study design and methodologies presented unique challenges to the study team. For example, the Open Space system has hundreds of uncontrolled access points, making accurate visitor sampling difficult and costly. Alternative sampling procedures and instruments were considered extensively in the study design to maximize the accuracy of the study results.

The Open Space system was divided into 10 zones with 102 exit points in the zones selected for surveying throughout the year according to a random sampling schedule. Data was collected primarily by using 5-by-8 inch registration cards completed by visitors as they left Open Space. Study design and data collection methodologies represented an ambitious effort, given the limited financial resources, the size of the Open Space system and the system's open accessibility.

Results

Total Number of Visitors

The total number of visitors to Open Space lands during the 1992-1993 study period was estimated to be 1,485,314 persons. This estimate of total visitation is derived from two sources. First, the visitation survey estimated 1,185,764 visits to the Open Space system during the year. Second, since usage on the South Boulder Creek path was not surveyed, the Open Space Department estimated that there were 269,714 users of the Open Space portion of the bike path during this period.

Characteristics of Visitation

- When do visitors use Open Space? Visitor use of Open Space is concentrated in the spring, summer and fall months. Spring is the season receiving the highest use levels, accounting for 38% of the total annual use of Open Space.
- How is Open Space use affected by adjacent lands? Management implications of new growth and development in Boulder County are highlighted by the study. Zones with adjacent development received three times the use levels of those Open Space areas in less developed areas.
- How long do visitors stay and how big are their groups? The mean length of a visit was about 53 minutes with more than 70% of all visits consisting of just one person. Ninety percent of all parties visiting Open Space consisted of only one or two people. Season of use affected the length of visit with fall having the longest visits.
- Where do visitors come from? The Open Space system is a regional system which gets substantial visitation from areas outside the City and County. While almost 75% of the visitation on Open Space is by Boulder residents, a relatively high 10% of the visits are from outside both the City of Boulder and Boulder County. Boulder County residents make up about 16% of the visits to Open Space. The origin of visits varies greatly by location within the Open Space system and time of year. Several zones received high use levels from non-Boulder and non-county residents with up to 25% of total visitor use in these zones resulting from residents from other areas of the Denver metropolitan area, Colorado, and outside the state.

- What do visitors do on Open Space? Four activities account for the highest use on Open Space; jogging (39%), hiking (29%), exercising pets (21%) and bicycling (17%). Jogging and hiking together account for 60% to 75% of the use of Open Space in all seasons. Great variations in activities exist between zones. For example, a significant amount of jogging occurs in areas adjacent to developed lands (43%) compared to more modest levels (23%) of jogging in less developed areas. Pets appear to get exercised more in areas adjacent to less developed areas (37%) when compared to more developed areas (17%).

Management Implications

Results of the visitation study demonstrate that portions of the City of Boulder Open Space functions as a regional open space system; and as areas adjacent to Boulder and the metro area grow, it is likely that the uniqueness of the Boulder system will become an increasingly attractive magnet for out-of-town visitors. Seasonal variations in use patterns and types of use place differing and increasing demands on management resources and staffing levels. Most of the current human activities on Open Space require trails and some form of access; therefore, assessing future trail needs, impacts on wildlife habitats and natural areas and potential use conflicts will become even more important as the City and County continue to grow. A number of activities on Open Space are enjoyed by relatively few visitors, but place a disproportionate requirement on management and protection of the Open Space system. These activities usually involve safety issues, conflicts with other uses and impacts on fragile or sensitive areas.

A Visitor Comment Study was developed utilizing the unprompted written comments recorded by almost 4,000 respondents to the survey. These comments provide a valuable source of information on users attitudes and perceptions for the Open Space Department. Although an un-scientific sample of Open Space users, the comments could help to evaluate management directions, effectiveness of program goals and differences in user patterns in various parts of the Open Space system.

Predictive Model

One of the objectives of the study was to develop a predictive model to accurately estimate visitation in years between more extensive studies. The Open Space Department is using information gained from trail and vehicle counters as input to a predictive model which was developed as a result of the analysis of survey results to update visitation estimates. The predictive model will provide estimates of visitation in existing and recently acquired areas of Open Space. As a result, annual estimates of total visitation will be produced by the predictive model. The Open Space Department will continue to develop and evaluate alternative methods and techniques to accurately estimate both total use and use patterns/characteristics of the Open Space system in the future.

Introduction

In 1991, as a result of increases in visitation, acreage and management responsibilities, the Boulder Open Space Department conducted a management study which resulted in a series of recommendations to reorganize the Department to improve management capability and operations. One of the principal recommendations was for the Department to develop detailed area management plans which would tie objectives to manage the system for natural resource values and passive recreation established by the City Charter, to specific area management plans and annual budgets. The Department has begun to develop the area management plans but these will require several years of planning, analysis and public review before they are fully implemented. In the interim, the study recommended that the Department establish management budgets based upon a formula which takes into account both acreage managed and total visitation to the Open Space system. In order to obtain accurate estimates of annual visitation to the Open Space system, a visitation survey was initiated.

This report is the result of a year-long collaborative effort between the staff, a consultant team and many paid and unpaid volunteers to survey visitation from June 1, 1992 through May 31, 1993. The consultant team consisted of Marty Zeller from Design Workshop, who oversaw the effort and interpreted the results, and Michael Manfredo and Harry Zinn from the Human Dimensions in Natural Resources Unit at Colorado State University, who developed the survey methodology, procedures and estimates of visitation. The Open Space system was divided into ten zones with exit points identified where registration boxes were placed. Since access to Open Space is not controlled, there are hundreds of formal and informal access points which required judgments as to which points were used sufficiently to be measured. In all, 102 exit points in the ten zones were surveyed throughout the year according to a random sampling schedule. These exit points included a mix of designated trailheads and exit points as well as informal exit points created by a pattern of social use.

Data was collected primarily by utilizing registration forms filled out by visitors as they exited Open Space. This type of survey has been used successfully by the U.S. Forest Service and was judged superior to four other alternative survey options. This information was supplemented by on-site observation of response to determine the number of non-respondents at exit points. The data was stratified between respondents and non-respondents, between weekdays and weekends, by seasons of the year, and by geographic zones to increase the accuracy of the results. A detailed description of the survey methodology is presented in Appendix A of this report. Given the limited financial resources available for the survey, the size of the Open Space system and its open accessibility, this survey represents one of the most ambitious efforts ever undertaken to obtain accurate estimates of visitor usage.

Study Objectives

The Boulder Open Space Department visitation study was initiated to meet three objectives:

- To estimate the total number of visitors to the Boulder Open Space System between June 1, 1992, and May 31, 1993:
- To describe activity choices, length-of-stay, party-size and composition, and place-of-residence of Open Space visitors during the same period; and
- To develop and test a predictive visitation model using vehicle and trail counters.

RESULTS

Estimate of Visitation

The total estimate of visitation on Open Space lands is derived from two sources. The first is the visitation survey which was conducted in the ten zones of the Open Space system described above. The survey estimates that 1,185,704 people utilized the open space system during the year. In addition, an estimate of recreational usage on the Boulder Creek path was developed. The Boulder Open Space Department, in an extrapolation from observations conducted by the Boulder Parks and Recreation Department, estimates that there were 269,714 visits to the Open Space portion of the Boulder Creek path during 1992. The total estimate of visitation from these two sources is 1,485,314 persons during the year. For purposes of comparison, Rocky Mountain National Park, one of the crown jewels in the National Park System, is visited by approximately 3 million people and encompasses an area of 265,000 acres. The two most heavily visited Colorado state parks, Chatfield and Cherry Creek, are both visited by approximately one million visitors, and several years ago, Jefferson County, which has a similarly sized open space system, estimated its annual visitation at 825,000 persons.

What Was Learned?

A. Seasonality

Analysis of the visitation survey, which covers 80 percent of the total estimated annual visitation (i.e., not the Boulder bike path) yields a variety of information useful for system managers and the general public. These results have been developed at two levels of detail; system-wide information and information on usage in each zone, permitting comparisons among the ten zones. The survey estimates have been calculated with a confidence interval of 95% which means that the potential error on the estimate is +/- 5%. The 1,185,704 persons visiting Open Space lands consisted of 759,552 parties of various sizes. Approximately 90 percent of this visitation occurred in the Spring, Summer and Fall months. Spring is the season which receives the greatest usage with 38 percent of the total, followed by Fall with 27 percent of the total. The importance of Spring usage is heightened by the fact that it receives 40 percent of all parties visiting the system during the year. Summer and Fall seasons each receive approximately 25 percent of the total party usage, while Winter receives slightly over 10 percent.

B. Developed versus Developing Areas

There is a great deal of variation among the zones in the amount of visitation they receive, ranging from about 35,000 persons in the Southeast zone up to 295,871 in the South Boulder Creek zone. This variation reflects a number of factors related to availability of trails (proximity, type, connection, etc.), type of resources present and the proximity to and characteristics of nearby residential areas. In an effort to understand the difference between zones which are adjacent to developed residential areas and zones adjacent to rural and developing areas (typical of areas which have recently been added to the Open Space system), a number of zones which represent these qualities were compared. Three zones which are typical of developed areas were compared with three zones which are more rural, but developing residentially. The developed zones include: South Boulder Creek, Sanitas, and Wonderland, and the developing zones include: Southwest, Southeast, and Boulder Valley Ranch. The developed zones experienced three times the amount of visitation both in terms of numbers of persons and numbers of parties as the developing zones. The three developed zones experienced 53 percent of the total annual visitation while the three developing zones witnessed only 17 percent.

Table 1. System-wide Visitation Included in this Study, Boulder Open Space, 6/1/92-5/31/93.

Period	Persons	Parties
Summer	287,648	186,485
Fall	326,003	189,794
Winter	120,790	82,453
Spring	451,263	300,820
Annual Total	1,185,704	759,552

Chart 1. System-wide Visitation Included in this Study, Boulder Open Space, 6/1/92-5/31/93.

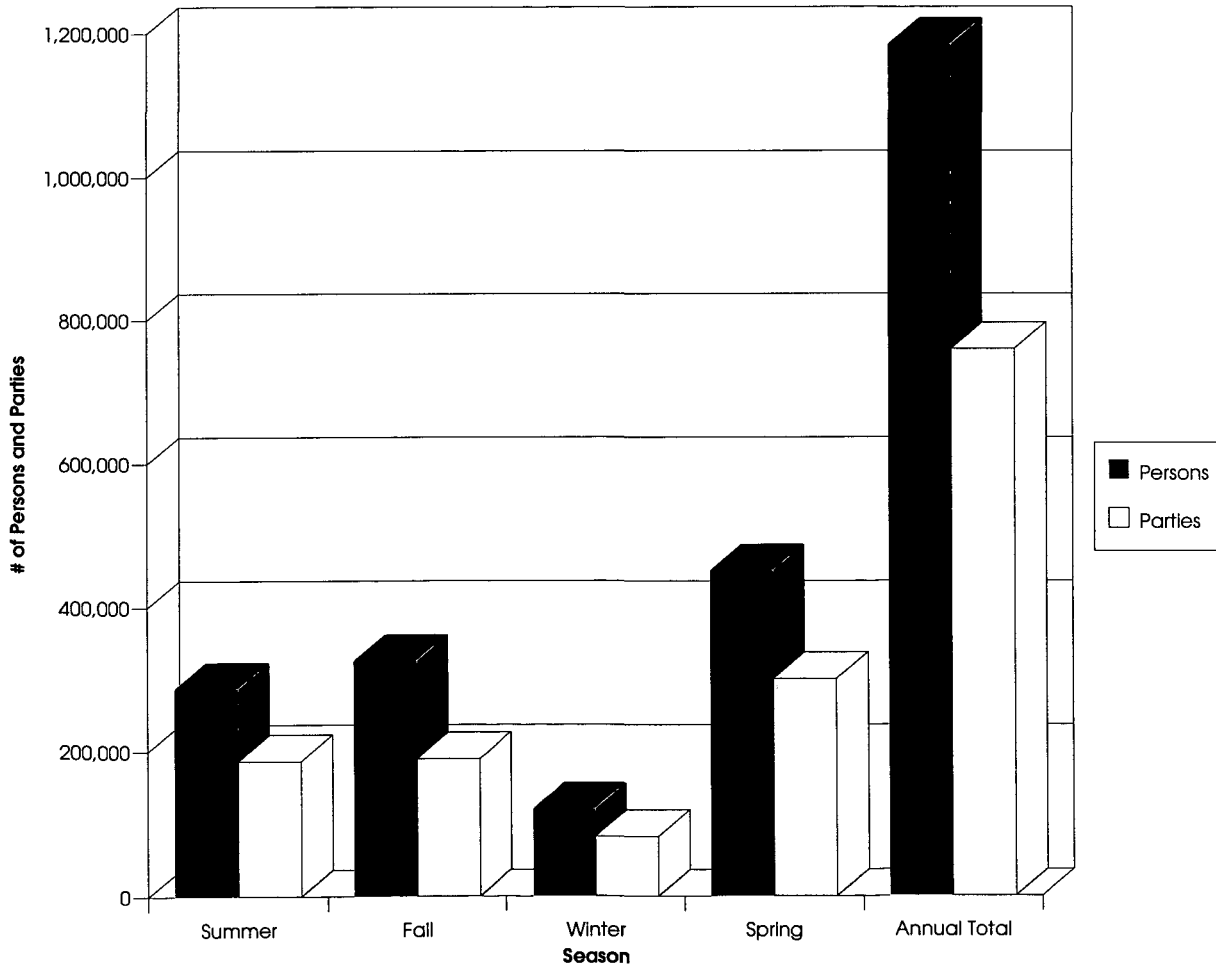
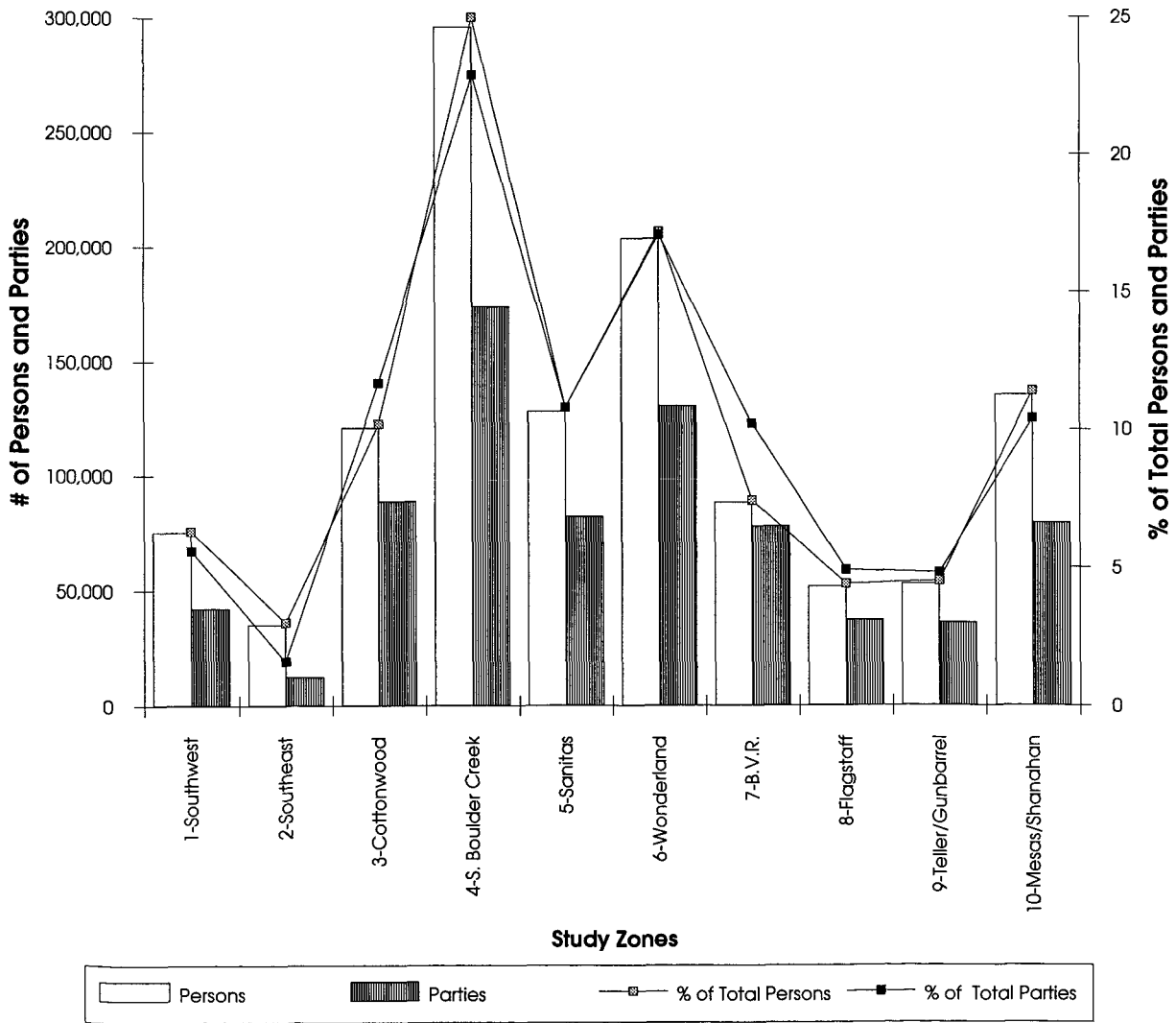


Table 2. Visitation by Zone, Boulder Open Space, 6/1/92-5/31/93.

Zone	Persons	% of Total Persons	Parties	% of Total Parties
1-Southwest	75,216	6.3	42,250	5.6
2-Southeast	35,090	3	12,476	1.6
3-Cottonwood	120,594	10.2	88,541	11.7
4-S. Boulder Creek	295,871	25	173,779	22.9
5-Sanitas	127,862	10.8	82,030	10.8
6-Wonderland	203,451	17.2	130,215	17.1
7-B.V.R.	88,021	7.4	77,736	10.2
8-Flagstaff	51,751	4.4	37,196	4.9
9-Teller/Gunbarrel	52,784	4.5	36,065	4.8
10-Mesas/Shanahan	135,062	11.4	79,264	10.4

Chart 2. Visitation by Zone, Boulder Open Space, 6/1/92-5/31/93.



C. Length of Stay

The mean length of stay of visit on Open Space lands was 53 minutes. Interestingly, while the greatest number of people visit in the Spring, the longest visits are in the Fall. The mean length of visit in the Fall was over 70 percent longer than in the Spring. The mean length of visits in the Summer and Winter are roughly the same, around 50 minutes. Winter receives the second highest mean length of visit, indicating that while only 10 percent of total visitation occurs in the Winter, people who use the system tend to stay longer. The mean party size of 1.4 persons was consistent for all seasons and showed little variation among zones.

A comparison of the mean length of visit across the zones indicates a great variation in the length of time people spend in various parts of the system. The mean lengths of stay vary from a low of about 30 minutes in the Cottonwood zone to more than double that in the Mesa/Shanahan zone (78 minutes). A comparison between the developed and developing zones indicates that visitors have slightly longer visits in the developing zones as compared to the developed zones (developing 52.3 minutes vs. developed 48.6 minutes). One interpretation of these figures is that the longer distances from residences to Open Space in the developing zones results in fewer but longer visits, while the developed areas allow for more convenient, more frequent, and shorter visits.

For the system as a whole, over 70 percent of all visits last from 16 minutes to one hour in length. Almost twenty percent of visits are over one hour in length, indicating a relatively high percent of longer term usage. The Summer and Winter months experience over 15 percent of total visits of less than 15 minutes while in the Fall there are very few visits of such short duration. The Spring has the highest percent of short term visits with over 60 percent of all visits in the Spring lasting less than 30 minutes. Fall experiences the highest percentage of visits greater than an hour in length, with over 21 percent of all visits in this category.

D. Size of Group

The vast majority of visitors to Open Space come alone or in small groups. Over 70 percent of all parties visiting the system were comprised of just one person, and 90 percent of all parties consisted of one or two persons. The mean party size of 1.4 persons was consistent for all seasons and showed little variation across all the zones. The Summer months experience visitation from a higher percentage of larger groups consisting of two or more people than the other seasons (36%). In the Winter months fewer people visit open space, but almost 11 percent consist of larger groups of three or more persons. Among parties larger than one person, groups of friends were slightly more common than family groups while parties comprised of family and friends or organized groups were uncommon.

Table 3. Mean Visit Length And Party Size, Boulder Open Space, 6/1/92-5/31/93

Period	Mean Visit Length(min.)	Mean Party Size(persons)
Summer	49.1	1.4
Fall	71.1	1.4
Winter	51.8	1.4
Spring	41.7	1.4
Annual total	53.4	1.4

Chart 3. Mean Visit Length and Party Size, Boulder Open Space, 6/1/92-5/31/93.

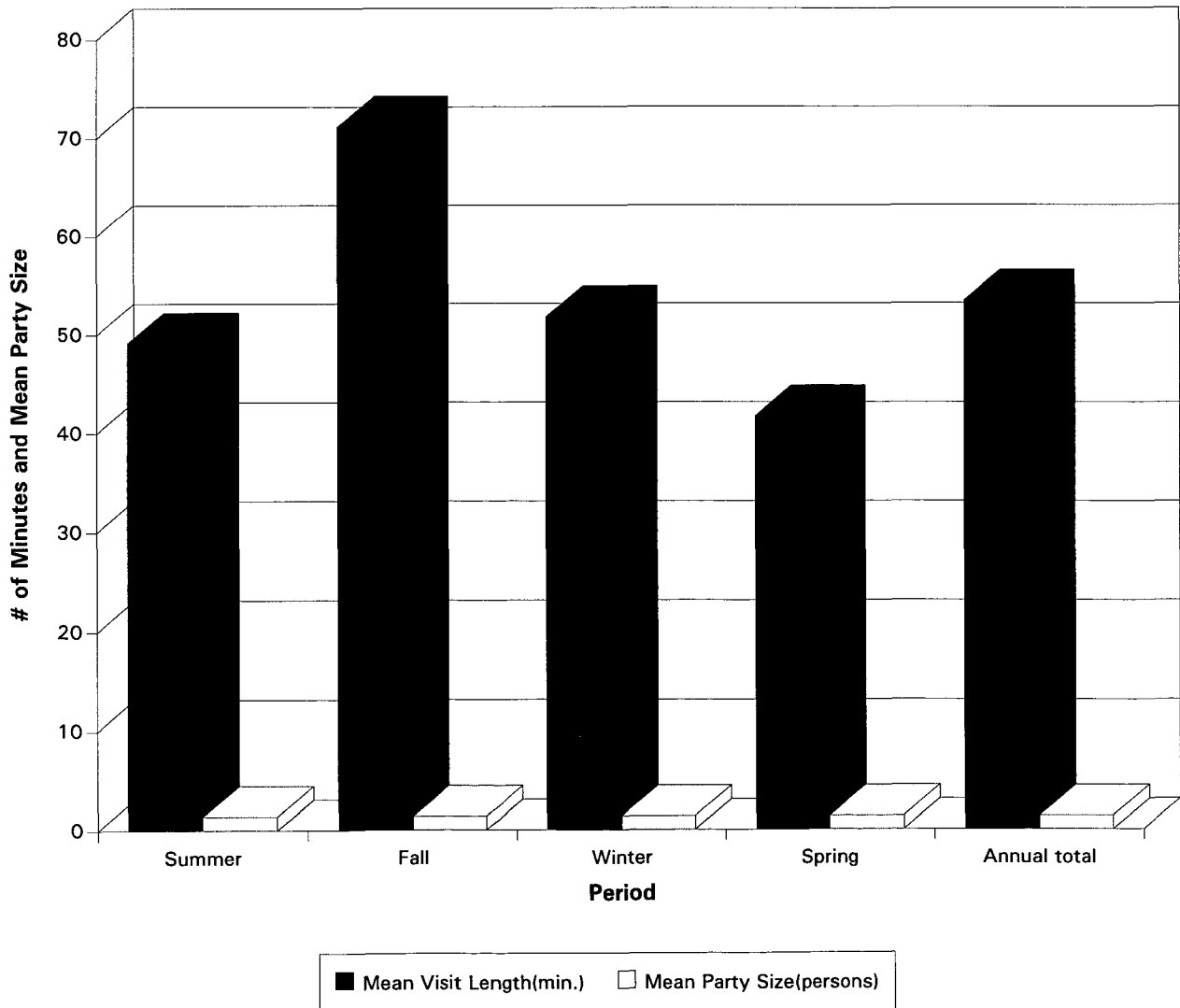


Table 4. Mean Visit Length and Party Size by Zone, Boulder Open Space, 6/1/92-5/31/93.

Zone	Mean Visit Length(min.)	Mean Party Size(persons)
1-Southwest	58.9	1.5
2-Southeast	45	1.5
3-Cottonwood	31.4	1.2
4-S. Boulder Creek	32.9	1.6
5-Sanitas	71.8	1.4
6-Wonderland	41.1	1.3
7-B.V.R.	52.9	1.3
8-Flagstaff	44.6	1.2
9-Teller/Gunbarrel	61.4	1.3
10-Mesas/Shanahan	78.1	1.7

Chart 4. Mean Visit Length and Party Size by Zone, Boulder Open Space, 6/1/92-5/31/93.

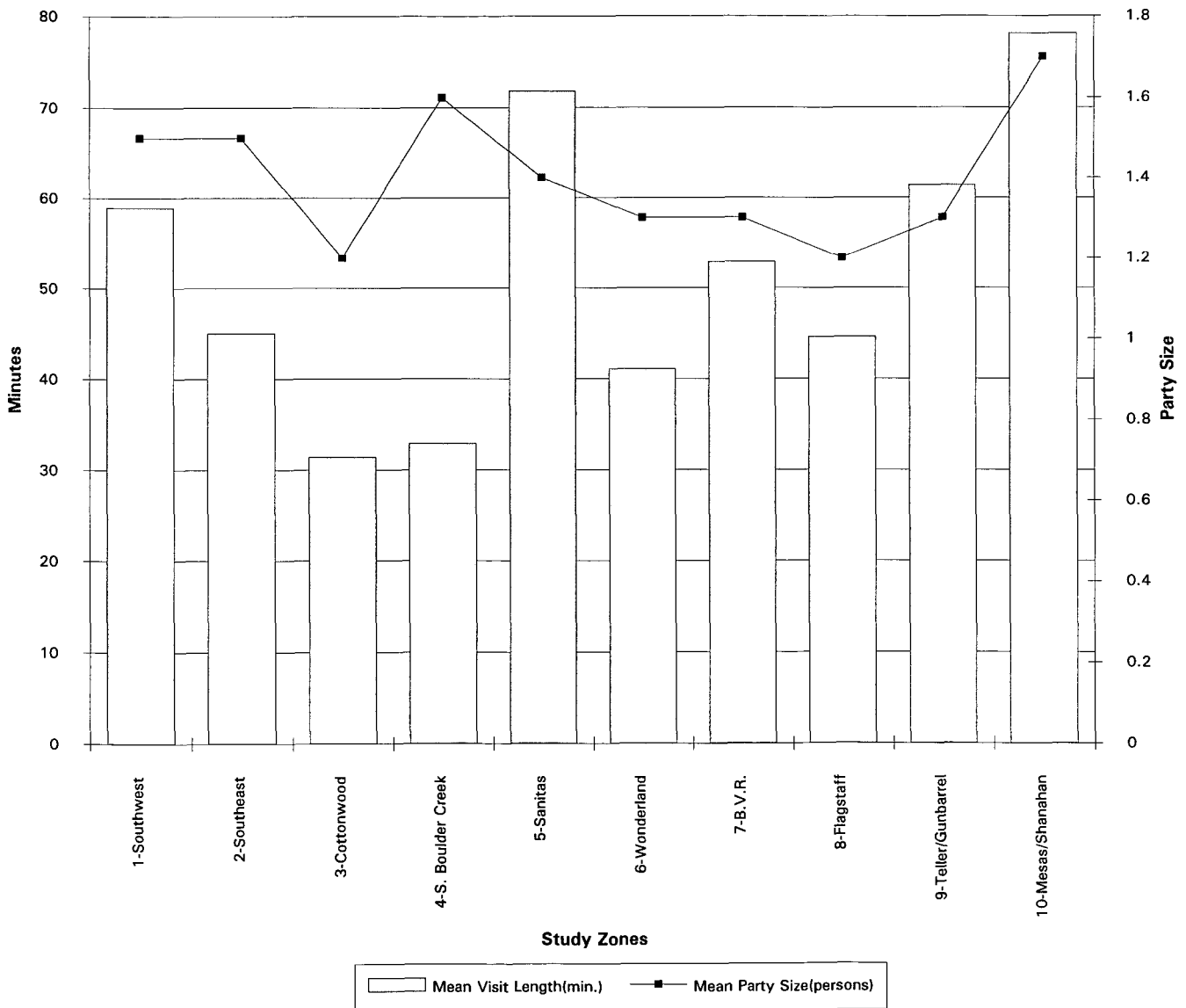


Table 5. Visit Length Distribution by Season, Boulder Open Space, 6/1/92-5/31/93.

Visit Length	Annual (%)	Summer (%)	Fall (%)	Winter (%)	Spring (%)
1-15 Min.	10.6	15.1	2.7	17.1	7.9
16-30 Min.	32.9	22.3	35.3	17.1	55.4
30-60 Min.	37.2	43.6	40.7	47.2	18
1-2 Hr.	13.7	14.7	8.6	15.8	15.9
2-4 Hr.	5	4.3	12.3	0.4	2.8
Over 4 Hr.	0.6	<.1	0.5	1.9	<.1

Chart 5. Visit Length Distribution by Season, Boulder Open Space, 6/1/92-5/31/93.

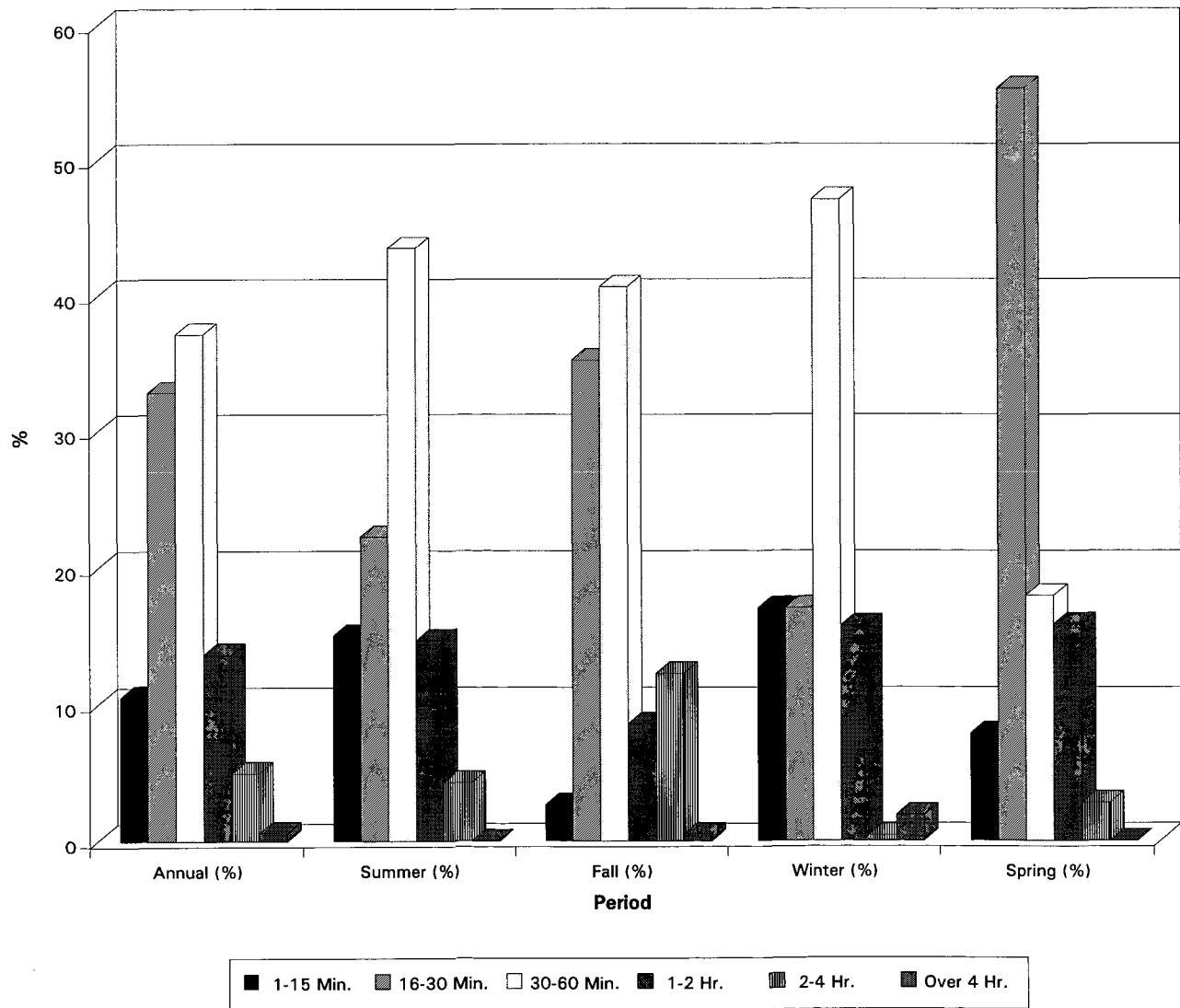


Table 6. Party Size Distribution by Season, Boulder Open Space, 6/1/92-5/31/93.

Number of Persons	Summer	Fall	Winter	Spring	Annual
1	64	72.3	73.6	72.2	70.3
2	28.4	25.4	15.6	23.9	23.6
3	5	1.4	10.4	2.9	4.8
4	1.9	0.5	0.4	0.6	0.9
5-6	0.6	0.2	<.1	0.1	0.2
7-10	0.2	<.1	<.1	0.3	0.1
Over 10	<.1	0.1	<.1	<.1	<.1

Chart 6. Party Size Distribution by Season, Boulder Open Space, 6/1/92-5/31/93.

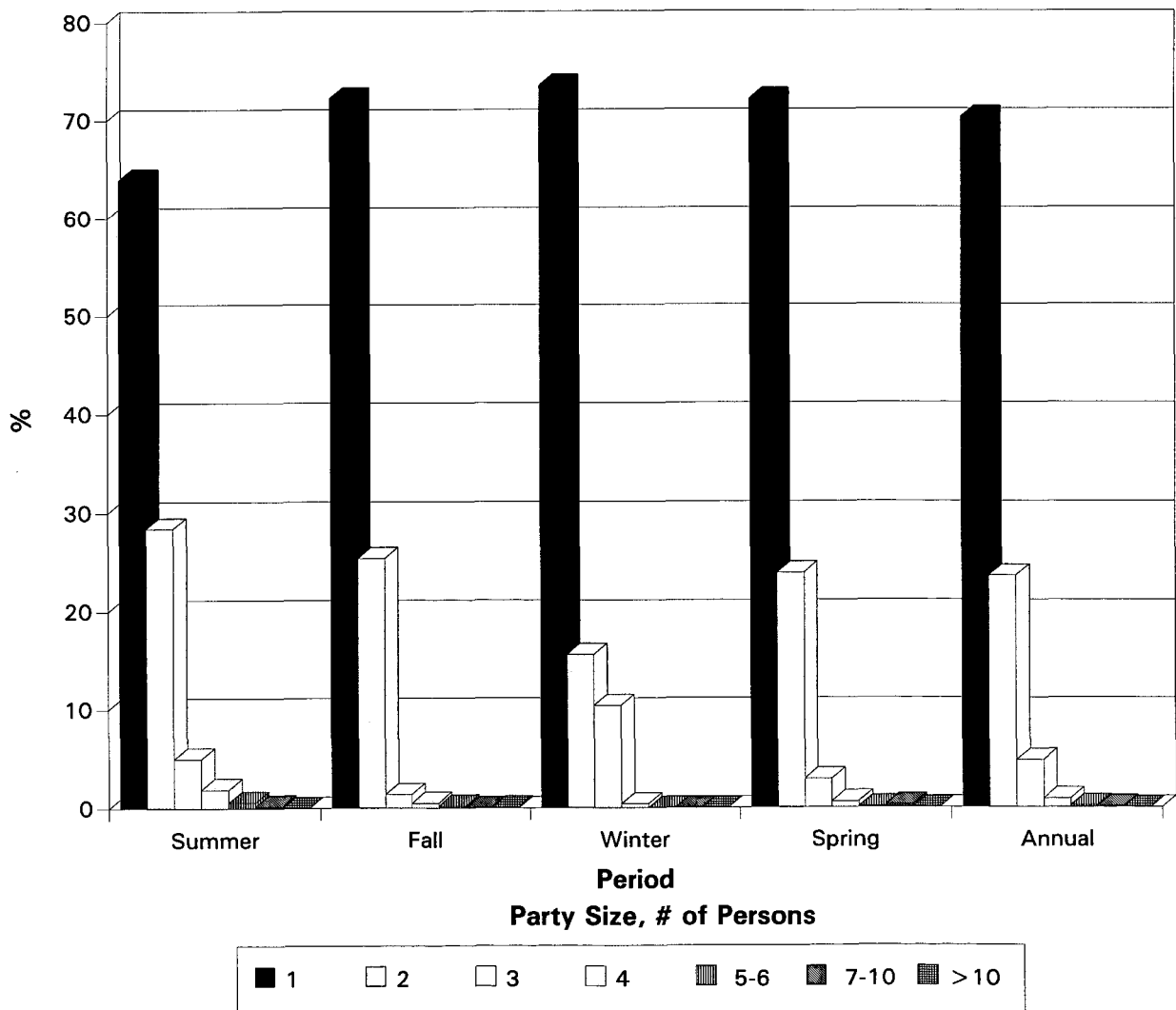
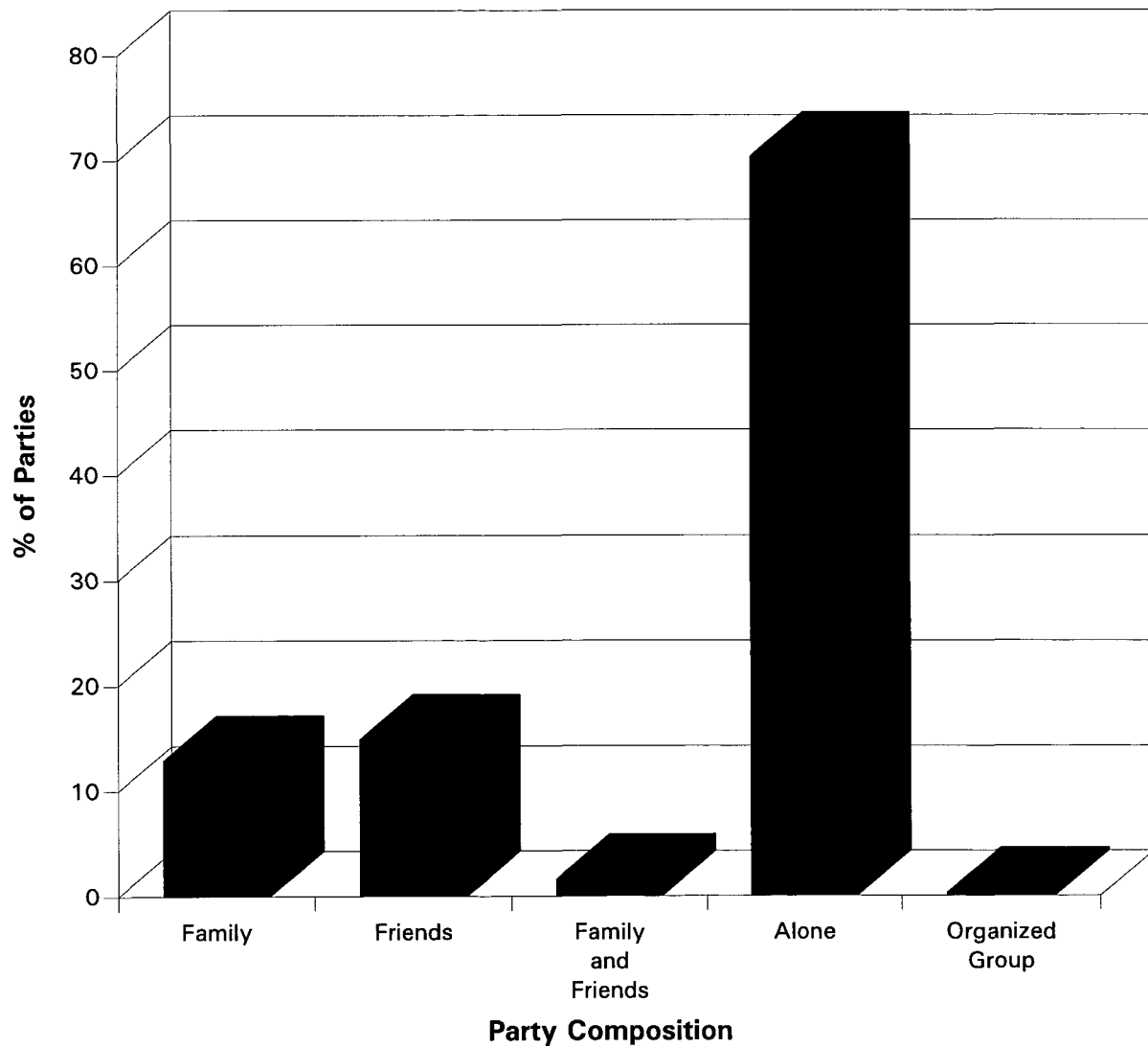


Table 7. Party Composition, Boulder Open Space, 6/1/92-5/31/93.

Party Type	Percent of Parties
Family	12.9
Friends	14.9
Family and Friends	1.6
Alone	70.3
Organized Group	0.3

Chart 7. Party Composition, Boulder Open Space, 6/1/92-5/31/93.



E. Where Visitors Are From

Usage of the Open Space system from people residing outside the City of Boulder is relatively high, particularly at certain times of the year and in certain zones. City of Boulder residents account for almost three quarters of total visitation. Visitation from Boulder County residents comprises over 16 percent of total visitation while visits from those outside the City and County make up almost ten percent of all visitors. Visitation from City residents as a percent of seasonal visitation, was highest in the Spring, relatively the same in the Fall and Winter and lowest in the Summer. Boulder County usage was greatest in the Fall when 19 percent of visitors came from the Country. In the Fall, over 5 percent of visitors come from the Denver metro area. In the summer, visitation from areas outside the City and County accounts for 19 percent of visitation and in the Winter it is over 11 percent.

The place of origin for visitors varies widely in the individual zones. Several of these zones derive less than 50 percent of their visitation from City residents. The percentage of City of Boulder usage varies from 44 percent to over 99 percent. Boulder County resident visitation in the zones varies from a low of less than one percent in two zones to over 50 percent in the Teller/Gunbarrel zone. Zones such as Teller/Gunbarrel, Southwest and Southeast are located primarily in the Country so that a large part of the user population originates outside the City. Use of the system by visitors from outside the City and County varies from less than one percent to 26 and 21 percents in the Southwest and Wonderland zones. These figures demonstrate the attractiveness of the Open Space system to residents in other jurisdictions near or bordering the Open Space system. When the three developed zones are compared to the three developing zones, these patterns are further underscored. Visitation by Boulder City residents as a percent of total visitation in the developed zones was almost 10 percent higher than in the developing zones which are located on the periphery of the system and adjacent to other jurisdictions. The same is true of County usage, where in the developing zones an average of 21 percent of usage was from County residents compared to the developed zones where an average of 15 percent of visitors originated in the County. In terms of residents from outside the City and County there is a slightly higher usage of the developing zones as compared to the developed zones indicating that visitors from further away tend to use areas which have specific attractions in both the developed and developing zones.

Table 8. Place of Residence by Season, Boulder Open Space, 6/1/92-5/31/93.

Visitor's Residence	Summer	Fall	Winter	Spring	Annual
Boulder City	66.4	75.7	76.9	80.3	74.6
Boulder County	17.1	19.1	11.4	17.1	16.3
Denver Metro Area	0.7	5.2	0.2	0.6	1.7
Other Colo. Area	8.7	<.1	8.8	1.8	4.8
Out of State	9.6	0.1	2.7	0.3	3.3

Chart 8. Place of Residence by Season, Boulder Open Space, 6/1/92-5/31/93.

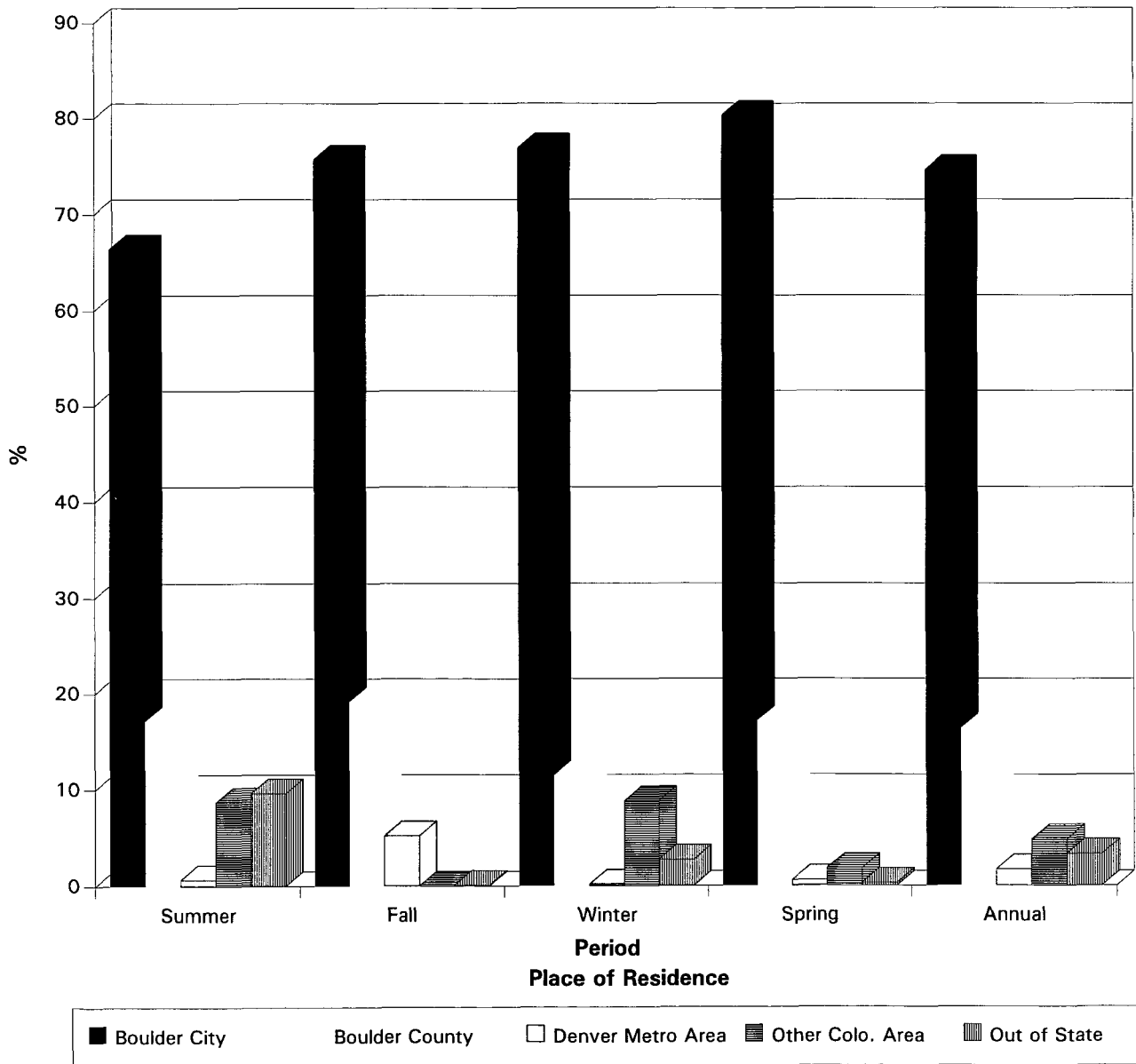
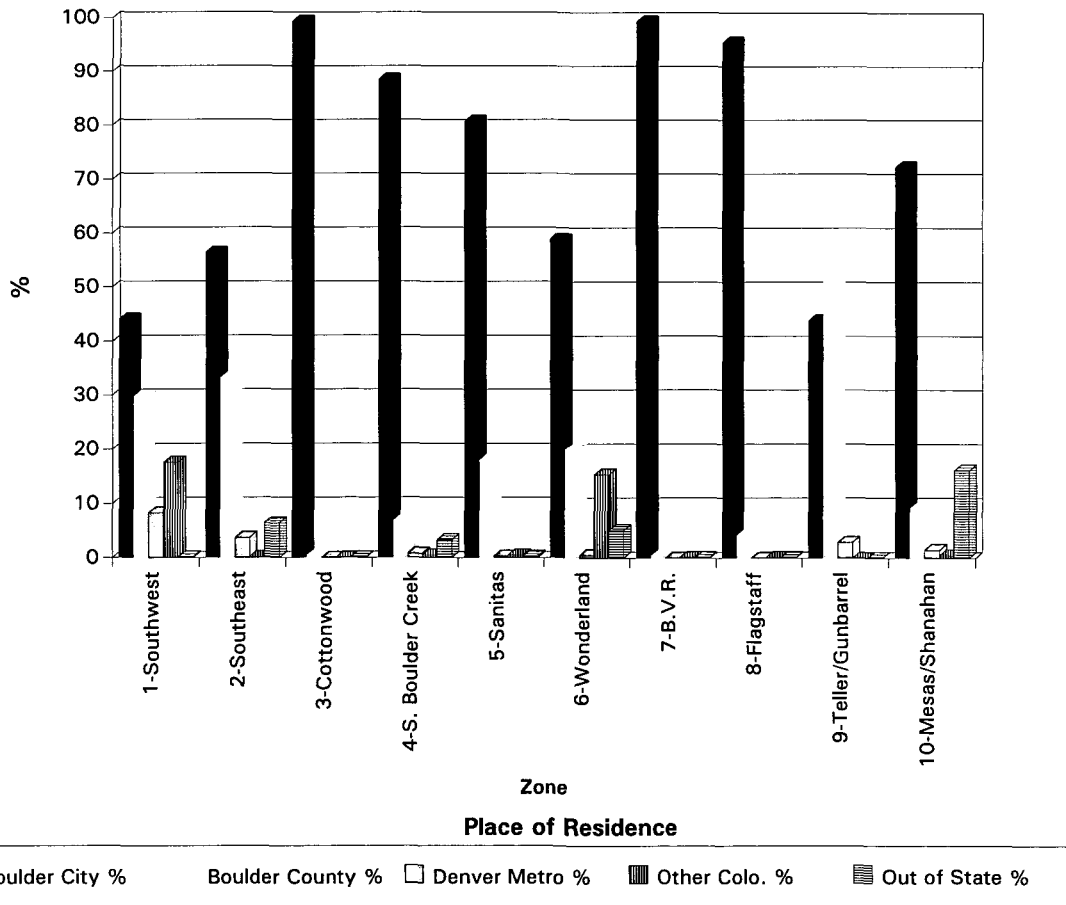


Table 9. Place of Residence by Zone, Boulder Open Space, 6/1/92-5/31/93.

Zone	Boulder City %	Boulder County %	Denver Metro %	Other Colo. %	Out of State %
1-Southwest	44.2	29.8	8.3	17.6	0.1
2-Southeast	56.5	33.2	3.7	0.1	6.4
3-Cottonwood	99.5	0.4	<.1	<.1	0.1
4-S. Boulder Creek	88.6	6.9	0.8	0.5	3.3
5-Sanitas	80.9	18	0.3	0.5	0.3
6-Wonderland	59.1	20	0.5	15.4	5.1
7-B.V.R.	99.5	0.4	<.1	0.1	0.1
8-Flagstaff	95.7	4.2	<.1	0.1	0.1
9-Teller/Gunbarrel	44.1	53	2.9	<.1	<.1
10-Mesas/Shanahan	72.5	9.3	1.5	0.5	16.2

Chart 9. Place of Residence by Zone, Boulder Open Space, 6/1/92-5/31/93.



F. Activities

Visitors were asked on the exit questionnaire to identify their activities during their visit to Open Space. Out of the fifteen activity choices, respondents identified four activities which accounted for the vast majority of usage. These included jogging (39%), hiking (29%), exercising pets (21%), and bicycling (17%). Jogging was the most popular activity in all seasons except Winter when both hiking and exercising pets were more popular. Jogging and hiking together account for 60 to 75% of the activity and usage in all seasons. Exercising pets is a major activity on Open Space lands with usage particularly high in the Fall, Winter and Spring. Bicycle usage is relatively constant in the Summer, Fall and Spring at around 20% with usage dropping off to around 4% in the Winter. Of the other activities in which people participate, wildlife viewing and horseback riding are most popular in the Fall and fishing is enjoyed almost exclusively in the Summer. Although technical climbing, remote control gliders, hang gliding and parasailing are enjoyed by very few visitors, these are the types of activities which require management resources and time to ensure safety and compatibility with the objectives of enhancing the natural resource qualities of the system.

Comparing activity participation by zone reveals a number of interesting patterns of activity. For each of the four major activities, there are great variations between zones in percent of parties participating. While jogging is the most popular activity in 6 out of 10 zones, there is a great variation in percent of usage by parties visiting the system. The Southeast zone experiences very little jogging compared to hiking, exercising pets and horseback riding while five zones (S. Boulder Creek, Wonderland, Boulder Valley Ranch, Flagstaff, and Teller/Gunbarrel) experience visitation from joggers for almost 50 percent or more of the parties visiting those zones. Hiking has a similarly high variation, ranging from a low of about 5 percent in the Cottonwood zone to almost 60 percent in the Mesa/Shanahan zone. Exercising pets has an even greater variation between zones while bicycling has less variation in the zones where bicycling is permitted. Wildlife viewing is a popular activity in the Southwest and Mesa/Shanahan zones compared to the other zones. Not surprisingly, horseback riding is most popular in the Southeast zone and fishing is popular in the Cottonwood zone.

When the activity participation is compared between developing and developed zones, a number of observations can be made. The average of percentage of parties participating in jogging in the developed zones (43%) is nearly twice the rate in the developing zones (23%). As those more rural zones begin to experience more residential development both within Boulder and from areas adjacent to the system, they can be expected to experience a greater volume of joggers. A similar but less dramatic relationship exists between the developed and developing zones in terms of hiking (developed 29%, developing 22%).

Table 10. Activity Participation, Boulder Open Space, 6/1/92-5/31/93.

Percent of Parties Participating

Activity	Annual	Summer	Fall	Winter	Spring
Jogging	39.3	40.5	52.5	28.8	34.2
Hiking	28.9	20.7	22.1	44.6	30.4
Exercising Pets	21.3	8.9	17.9	36.4	24.3
Bicycling	17.3	18.6	22.2	4.3	22.9
Wildlife Viewing	2	1.1	4.2	0.7	1.9
Horseback riding	1.6	0.4	3.6	1.3	1.3
Fishing	1.3	4.6	<.1	<.1	<.1
Photography	0.4	0.1	1.2	0.3	0.1
Picnicking	0.3	0.9	0.2	<.1	0.2
Bouldering	0.2	0.1	0.4	<.1	0.1
Tec. Climbing	<.1	<.1	<.1	0.1	<.1
R.C. Gliders	<.1	<.1	<.1	<.1	<.1
Hang Gliding	<.1	<.1	<.1	0	<.1
Parasailing	<.1	<.1	0	<.1	<.1
Other	4	4.7	2.9	6	2.7

Chart 10. Activity Participation, Boulder Open Space, 6/1/92-5/31/93.

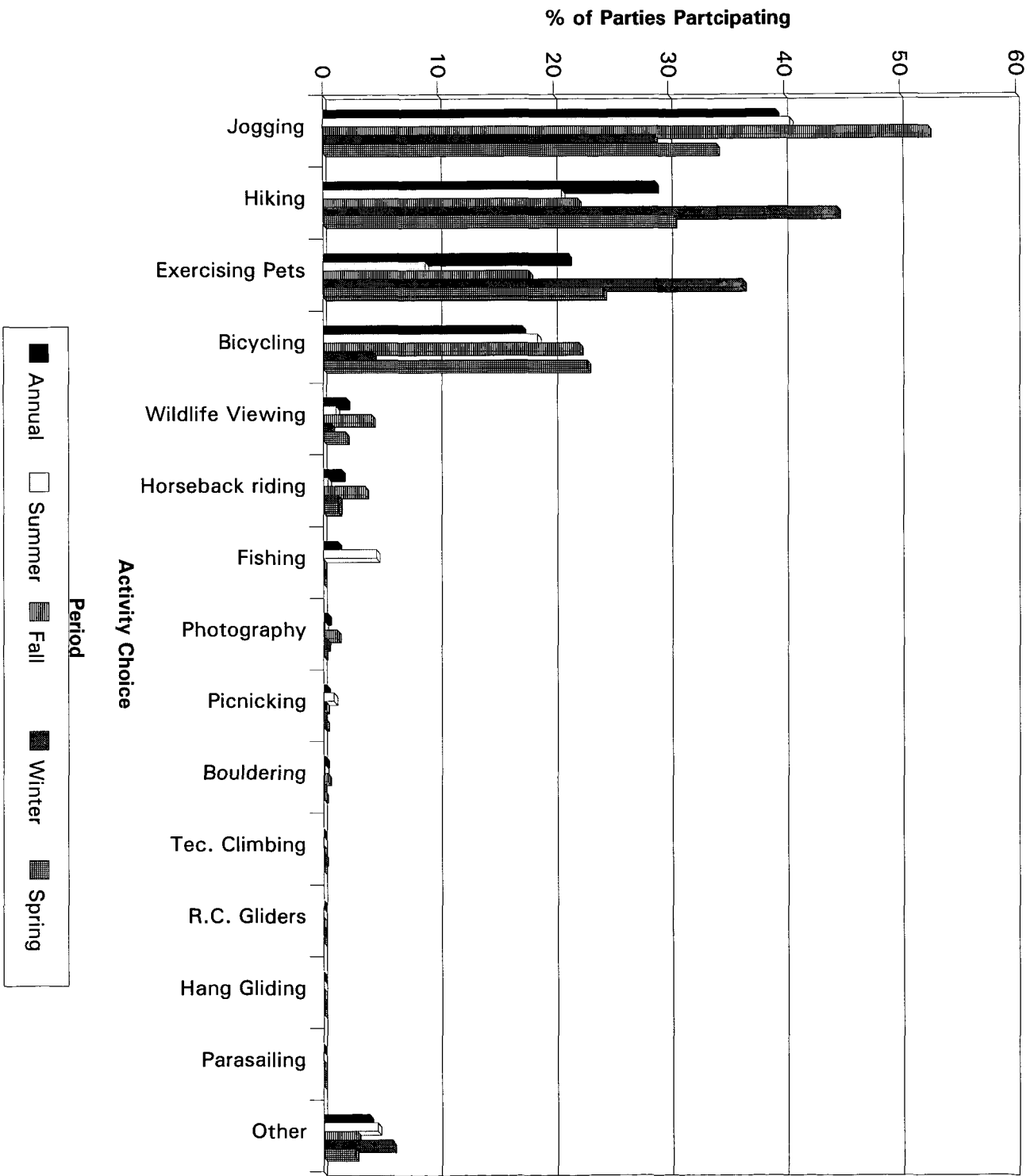


Table 11. Activity Participation by Zone, Boulder Open Space, 6/1/92-5/31/93.

Percent of Parties Participating by Zone

Activity	1-Southwest	2-Southeast	3-Cottonwood	4-S. Bldr. Creek	5-Sanitas	6-Wonderland	7-B.V.R.	8-Flagstaff	9-Teller/Gunbarrel	10-Mesas/Shanahan
Jogging	22.4	1.6	37.4	47.5	29.5	54.1	46.5	47.6	48.8	35
Hiking	40.9	14.8	4.7	10.6	53.4	25.5	9	39.6	12.5	58.2
Exercising Pets	18.7	81.5	14.9	15.9	25.2	9	11.9	37.2	16	33.6
Bicycling	24.3	<.1	32.8	22.6	0.5	24.2	38.7	1.5	28.2	<.1
Wildlife Viewing	4.1	0.5	0.5	1.2	1.9	0.7	2.3	1.3	1.8	7.6
Horseback riding	1.4	14.1	<.1	2.2	<.1	<.1	1	<.1	3.5	0.5
Fishing	<.1	<.1	10.1	<.1	<.1	<.1	<.1	<.1	0.3	<.1
Photography	0.1	0.1	<.1	<.1	1.4	0.1	0.8	2.4	<.1	0.1
Picnicking	0.1	0.1	0.1	0.6	0.2	0.2	<.1	0.1	0.4	0.6
Bouldering	<.1	<.1	<.1	<.1	0.9	0.3	<.1	0.1	<.1	0.1
Tec. Climbing	<.1	0.5	<.1	<.1	<.1	<.1	<.1	<.1	0	2.1
R.C. Gliders	<.1	0.1	<.1	<.1	0	<.1	<.1	0	<.1	0
Hang Gliding	0	0	<.1	0	<.1	<.1	<.1	0	<.1	<.1
Parasailing	<.1	0	<.1	0	<.1	<.1	<.1	0	<.1	<.1
Other	0.5	0.1	2.1	3.8	0.8	7.7	9.7	5.5	0.2	2.6

With regard to exercising pets, a different relationship exists. The average of the percentage of parties participating in exercising pets in the developed zones was 17 percent as opposed to 37 percent in the developing zones. This reflects the impact of leash laws as well as the fact that people prefer to exercise their pets in the more rural areas which will likely come under increasing population pressure which will affect the quality of experience they are currently enjoying. A similar relationship exists for bicycling, with a greater percentage of parties participating in bicycling in the developing areas as opposed to the developed areas (most developed areas prohibit bicycle use). This same patterns holds for horseback riding and wildlife viewing, where a greater percentage of parties are undertaking these activities in developing zones as opposed to developed zones. As growth occurs in the undeveloped areas of the City and County and other jurisdictions adjacent to the system, the potential for conflicts will increase as activities and use levels typical of the developed areas begin to occur in areas preferred for a variety of other uses.

Implications for System Management

The information obtained from the visitation survey will be extremely useful to Open Space managers in a variety of ways. It will be particularly useful for the development of area management plans where the pattern of usage in a particular zone can be related to projected changes in local and regional demographics in order to estimate management requirements given various natural resource protection objectives. The pattern of usage in the developed areas of the system will be valuable for estimating the future pattern of usage in the developing areas of the system. These less used parts of the system are valued by a variety of users who will likely see an increase in other types of activity which may affect the quality of their experience and increase the potential for conflicts. The comparison between developed and developing areas in patterns of visitation and usage can be very helpful in projecting future impacts and management requirements in the developing areas of the system. The Visitor Comment Study (discussed below) identified a number of areas where respondents already perceive that conflicts exist.

The survey also revealed that the Boulder Open Space system is a regional system which gets substantial visitation from areas outside the City and County. As areas adjacent to Boulder and in the Denver metro area grow, it is likely that the uniqueness of the Boulder system will become an increasingly attractive magnet for out-of-town visitors. While it was not the purpose of this study to analyze in detail the management implications of the visitation information, it is clear that such things as the seasonal variation in activity levels and types of uses has implications for staffing and management activities. In addition, since most of the activities occurring on Open Space require trails, careful analysis of the results will assist in designating trails to meet future needs, minimize impact on sensitive natural resources, and minimize user conflicts such as those between equestrians, bikers and people exercising pets. Finally, there are a number of activities which are enjoyed by only a small percentage of visitors, but which

have a disproportionate impact on management resources. These are the activities that involve safety issues and management of sensitive areas which may be affected by those participating in these activities. In general, the high levels of visitation being experienced on the Boulder Open Space system validate the strong emphasis the Department has placed on increasing operational resources in the field.

Visitor Comment Study

In addition to the survey questions, the registration card for the visitation survey asked respondents if they had comments on the Open Space system. The unprompted and non-structured comments were made in the space provided on the back of the survey cards by almost 4,000 respondents. These visitor comments provide a tremendous source of information, although it must be realized that they are not a representative sample of users. Rather they represent only those persons using open space that volunteered comments, a small percentage of total respondents. These comments have been analyzed by the Open Space Department in a Visitor Comment Study which compared comments on specific issues, issues in specific zones, site specific issues, and analysis of trail issues. This information provides Open Space managers with useful information on the public's attitude toward specific open space issues, differences between neighborhoods on specific issues, and existing or perceived conflicts among types of Open Space uses.

Predictive Model

Given the level of funding and staff resources required to conduct the visitation study, it cannot be replicated on an annual basis. Therefore, a component of the study was to develop a predictive model for those years in-between major visitation studies which could estimate visitation numbers. It is important to realize that a predictive model will generate only total number of users, not information on types of activity, place of residence, length of stay, and party size which can only be estimated from an actual survey. It is anticipated that the predictive model will be utilized for three to four years before another visitation study is undertaken.

The study evaluated a number of predictive models for estimating visitation to the Boulder Open Space system in the future. Of these, one model which ties estimates to information gained from trail and vehicle counters achieved a desired level of correlation and will be utilized by the Department to update visitation estimates in the next few years. The predictive model is a series of equations which relate to information generated from trail and vehicle counters that have been placed in each of the ten zones. The predictive model is described in greater detail in Appendix B of this report. With regard to those types of use or areas of the system which were not measured, the study team will continue to develop and evaluate methodologies to increase the accuracy and comprehensiveness of estimates of total usage in the future.

APPENDIX A

VISITATION SURVEY METHODOLOGY

The first step in developing the visitation survey was development of criteria for evaluating alternative study designs. Based on that evaluation, a data collection strategy combining voluntary visitor registration and on-site observation of non-respondents was selected and the sample was stratified between respondents and non-respondents, between weekdays and weekends, by seasons of the year, and by geographic zones.

EVALUATION CRITERIA AND DESIGN ALTERNATIVES

The study design was developed by evaluating alternative methodologies in light of the following criteria:

- Ability to account for the unique characteristics of the study area and visitation patterns within it,
- Level of burden imposed on study subjects, and
- Complexity and administrative burden of implementing the study.

Discussion of the evaluation criteria is followed by consideration of design alternatives.

Study area characteristics and visitation patterns

The Boulder Open Space Department manages land parcels ranging in size from several acres up to several hundred acres. Within the city core, smaller parcels predominate; common adjacent land uses include medium and high density residential development, commercial development, light industrial development, and recreational lands managed by other governmental departments (city, county, state, and federal). On the outskirts of the city, contiguous parcels of land managed by the Boulder Open Space Department tend to be larger. Adjacent residential lands are typically lower density residential developments, and adjacent agricultural lands are more common than commercial or industrial developments. Some adjacent lands are protected areas under municipal, county, state, or federal jurisdiction.

Recreational uses of the Open Space System include picnicking, nature study and observation, walking and hiking, pet exercising, horseback riding, running, bicycling, rock-climbing, hang-gliding, and para-sailing. Recreation facilities include trails built to various standards and a mix of parking areas, picnic areas, and restrooms at some major trailheads. Neither motorized recreation nor overnight use of Open Space lands is permitted. No recreational fees are assessed on Open Space, and daytime access to recreational areas is unrestricted. (After midnight, parking in Open Space areas is prohibited.)

These ownership, management, and use patterns create a complex system with many formal and informal access points, including: fully developed trailheads with parking, picnic facilities, and restrooms; trails entering Open Space lands from other jurisdictions; rarely-used pedestrian gates through agricultural fences; and numerous informal access points from adjacent residential properties. The perimeter boundary of the Boulder Open Space System is over 220 miles in length.

Level of burden imposed on study subjects

Typical recreation use surveys require no more than 5 minutes to complete; recreationists are usually quite willing to participate in these surveys. However, many Boulder Open Space Department users visit sites near their home or place of work as often as once or twice a day. This pattern of frequent repeat use combined with the necessity of sampling over a twelve-month time period creates the risk that survey administration could become burdensome for many subjects, resulting in deteriorating response rates over the course of the study.

Complexity and administrative burdens

A twelve-month study imposes a considerable burden on management staff. The burden is manifested in dollar-cost, level of training required to ensure reliable data collection, the possibility of conflict between the sampling schedule and other assignments, and the loss of continuity that can accompany staff re-assignments. The burden can be reduced and study quality protected by avoiding an overly-complex study design and by providing additional personnel responsible solely for completion of the study.

Design Alternatives

Five types of data collection were considered for the study: 1) on-site interviews; 2) off-site data collection, including in-home interviews and telephone interviews; 3) visitor diaries; 4) on-site observation; and 5) self-administered visitor registration, also referred to as exit surveys.

On-site interviews are advantageous because the response burden for subjects can be mediated by the presence of interviewers who are able to respond to visitor questions and reactions. Disadvantages of on-site interviews include the difficulty in covering Boulder Open Space Department's many informal access points, the need to train interviewers, the inflexible staffing demands of the interview schedule, and the relatively high cost of employing interviewers.

In-home interviews, telephone interviews, and visitor diaries all have the potential to reach visitors who use both formal and informal access points to the Open Space System. In-home or telephone interviewing also places moderate response burdens on subjects. However, all these methods are very expensive and complex to administer, and they pose particular difficulties in sampling Open Space visitors who reside outside the Boulder area. Furthermore, each of these methods assumes accurate recall by respondents; this assumption has been called into question by past research.

On-site observation as a stand-alone method requires a very high commitment of personnel. In addition to this cost, observation without contact yields little information beyond party size and the time and location of observation.

Self-administered visitor registration (exit surveys) allows for the collection of more complete information about parties who respond. A visitor registration system for Boulder Open Space is fairly complex to design; however, once the system is in place, personnel needs and the administrative burden compare favorably to other methodologies. Although non-response is a problem with the visitor registration methodology, it can be accounted for by using observation/interview periods in conjunction with registration. This dual methodology combining self-administered registration and on-site observation/interview was selected as most appropriate for the Boulder Open Space Department visitation study.

OVERVIEW OF THE FINAL DESIGN

The self-administered portion of the study required that subjects complete short survey cards at registration boxes as they exited an Open Space area. The Open Space System was divided into 10 zones with discrete sampling locations in each zone (maps, Figure 1, p. 28). During each designated 48-hour sampling period, registration boxes were placed at all sampling locations within a zone. At the end of each sampling period, the boxes were taken down and moved to another zone.

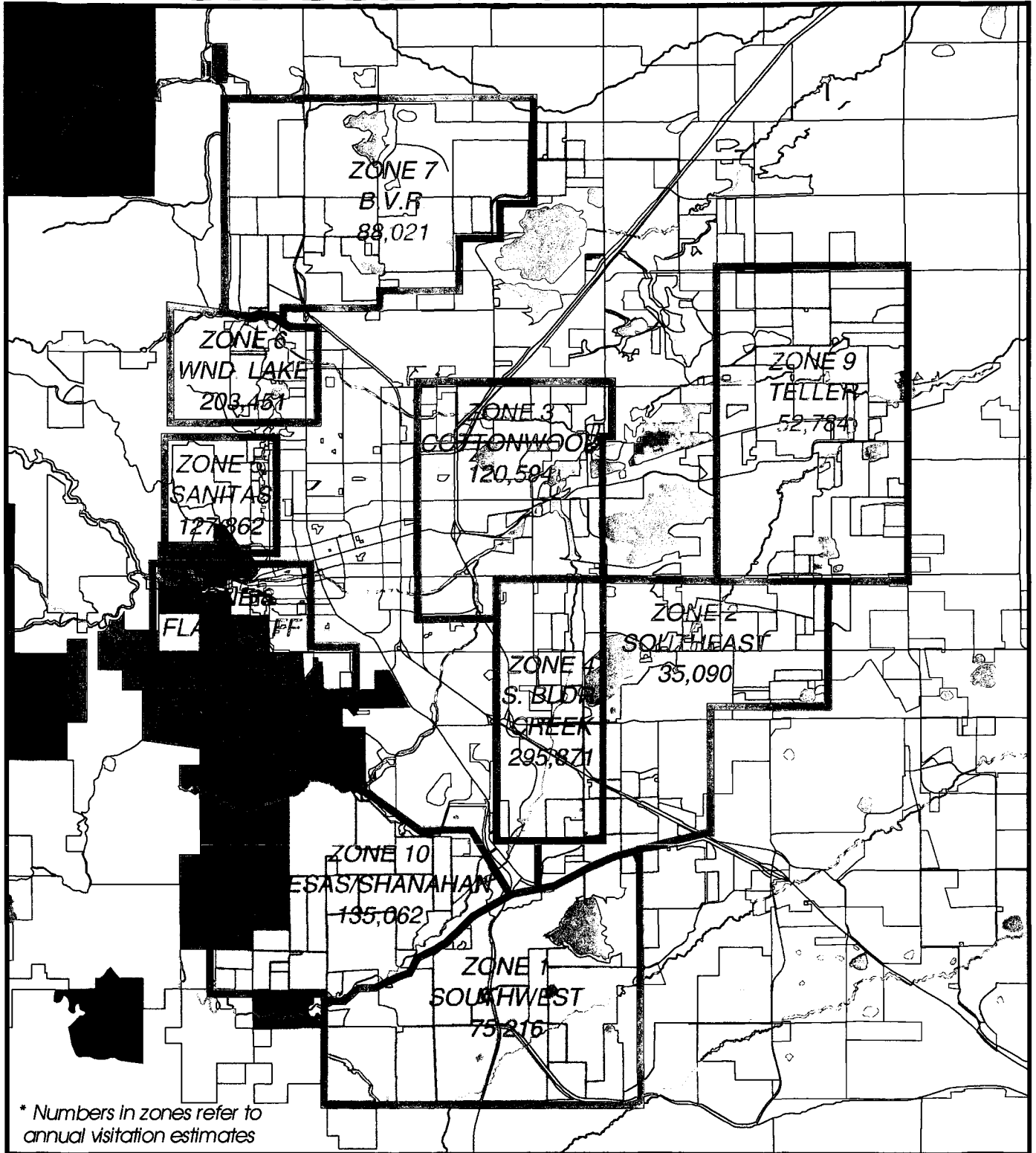
During a subset of time within each sampling period, staff recorded non-respondent data. Subjects who did not respond were counted and interviewed. Information collected in the non-response check was treated as a separate stratum in data analysis.

SAMPLING STRATEGY

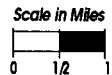
The study's primary stratification was between respondents and non-respondents. The respondent stratum was sampled with self-administered registration cards at exit points, while the non-respondent stratum was sampled by on-site observation and interviews. In a paired sampling procedure, observation sample periods were selected within the self-administered registration periods.

The sampling frame of the self-administered registration study was all 48-hour time periods of the study year crossed with the 10 geographic zones created for the study. The units sampled were the 48-hour periods within individual zones. During the 12-month study period, each of the geographic zones was sampled 8 times, with scheduling determined by a random draw. The measurements taken on each sample unit included date, site, number of parties registering, party-size and composition, length-of-stay, place-of-residence, and activities of respondents.

CITY OF BOULDER OPEN SPACE VISITOR USE STUDY ZONE MAP



- | | | | |
|--|----------------------|--|-------------------|
| | City Open Space | | City Parks |
| | OS Restricted Access | | Other Public Land |
| | County Open Space | | City Limits |
| | Mountain Parks | | Creeks |
| | Federal/State Lands | | Study Zones |



Map produced from the City of Boulder's Open Space/Real Estate Geographic Information System. Computer Cartography - J. Holland/T. Stonich, 11/9/93. Original fieldwork completed on PSCD 1:400 1984 orthographic aerial photography, digitized and assembled in AutoCAD. Map created from DXF output in Corel Draw. For further information, revisions or comments please contact the City of Boulder Open Space GIS Lab at 66 S. Cherryvale Road, Boulder CO 80303 (441-4495).

The sampling frame of the non-respondent observation/interview study was all 4-hour time periods of the study year crossed with the 10 study zones. The units sampled were 4-hour time periods within the time/zone stratum which was sampled for registration. During each 48-hour sample period, 3 sample points were selected randomly for monitoring. Each was monitored for 4 hours. Measurements taken on each sample unit included date, site, proportion of parties completing registration cards, party-size and composition, length-of-stay, place-of-residence, and activities of non-respondents who were interviewed.

Within the respondent/non-respondent stratification, 3 additional stratifications were created for the purpose of reducing the variance of the total annual visitation estimate. The 10 study zones formed a geographic stratification; zone sampling was conducted proportionately to available time. Weeks were divided into weekday and weekend strata, which were sampled equally rather than proportionately. The study year was stratified seasonally (June-August, September-November, December-February, March-May); the 4 seasonal strata were sampled proportionately to available time.

IMPLEMENTATION OF THE STUDY

Field administration

The registration instrument used in the study was a 5 by 8 inch card designed to be completed by visitors as they exited an Open Space area (Figure 2, p. 10). Cards identified the sponsoring agency, briefly stated the purpose of the study, and provided spaces for date, length of visit, party size and composition, and place of residence of party members. In addition, cards provided a check list for activities engaged in by the party. Space for comments was provided on the reverse side.

During each sampling period, registration boxes were installed at designated sample points within a geographic zone. Boxes contained an upper compartment for pencils and blank registration cards and a lower compartment with a deposit slot for completed cards. Boxes were mounted on posts which also displayed signs identifying the sponsoring agency and encouraging participation in the study.

Observation of non-response occurred during 4-hour periods when registration boxes were on site. Observers viewed subject response/non-response from a unobtrusive position. They then used one of two strategies to collect information about non-respondent parties. Parties that could be approached without undue intrusion were asked to complete a non-respondent card. For parties that were difficult to approach, e.g., bicyclists and runners, observers completed a non-respondent card "by proxy" without direct contact. This non-contact process allowed observers to record exit point, date, party size, and activity, but length-of-stay and place-of-residence could not be recorded.

Pretest results

In April 1992, the combined survey methodology was pretested for 5 days on a geographic zone containing both densely-settled neighborhoods and more remote areas. The behavior of test subjects led to four adjustments in the final study design:

- Since frequent visitors to the test area objected to the burden of a 5-day sample period, the sample period length was shortened to 48 hours.
- Since the presence of observers near registration boxes resulted in artificially high response rates while observers were on site, observers were instructed to use unobtrusive positions during the final study.
- Since non-respondent bicyclists and runners provided difficult to approach for non-response interviews, observers were instructed to complete non-response cards "by proxy" for these two types of parties.
- The design and language of the registration card were modified after the pretest to improve ease of use.

Secondary data

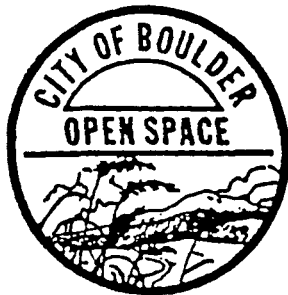
In order to test a predictive model for use in succeeding years, secondary data in the form of vehicle counter and trail counter tallies were collected on the same schedule as the primary survey data. Data analysis determined relationships between counter tallies and overall use estimates.

Please observe the following guidelines when completing this form:

- Complete only one survey form per group and deposit in green registration box.
- Complete the card only upon final exit from the area.
- Complete the survey for all trips, regardless of the length of the trip.

1. Please indicate the month/day/year of this visit to Boulder Open Space. _____
2. Approximately how much time did you spend in the area during this visit? (hours/minutes) _____
3. Including yourself, how many people were in your party during this visit? _____
4. Where do members of your party reside? (please indicate the residence of all members of your party)
 Boulder: _____ people Boulder County: _____ people Other Colorado locations: _____ people
 Denver metro area: _____ people Outside Colorado: _____ people
5. How would you describe the composition of your group? (check one)
 Family _____ Friends _____ Family and friends _____ Alone _____ Organized group _____
6. Which activities did members of your group participate in during this visit? (check all that apply)
 Technical mountain climbing _____ Bouldering _____ Hiking _____
 Remote control gliders _____ Photography _____ Fishing _____
 Wildlife viewing _____ Hang gliding _____ Jogging _____
 Exercising pet(s) _____ Parasailing _____ Bicycling _____
 Horseback riding _____ Picnicking _____ Other (specify) _____

(over)



City of Boulder Open Space Department
AREA USE SURVEY

Your views are important to us, and we appreciate your taking time to help with this survey. Please use the space below to record any comments or questions you may have about the Open Space system. Then fill out the back of this form. If you would like an immediate response to a question or concern, please call 441-3440 or 494-2194.

Thank you.

(opt.) Name & Address/Phone: _____

(over)

Figure 2 The Boulder Open Space Visitation Study registration instrument (actual size 5 by 8 inches).

WHAT WAS SURVEYED?

It is important to recognize that the survey methodology was not suited to measuring all types of recreational visitation and not all types of uses or areas of the open space system could be surveyed. For the most part, the areas or uses not included in the survey were judged to have relatively little impact on total visitation and a high cost associated with attempting to survey them. However, while these areas or uses may receive little visitation, they may require a disproportionate allocation of management resources. The Department has identified approximately 8,360 acres which were not directly surveyed or were added to the system subsequent to the start of the study including Eldorado Mountain, Varra and areas adjacent to Boulder Reservoir.

Five holiday periods (Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas) were also excluded from the sample. The study estimates assume use during the holiday periods was similar to use during other periods. This assumption may have resulted in underestimation for some of the holiday periods. The decision to exclude holiday periods was based on staffing considerations and the unusual visitation patterns occurring on some holidays (e.g. heavy night-time use on Independence Day).

In addition, there are several other categories of visitation for which there is no estimate of usage. These include horse boarding, agricultural lessee activities, vehicle use at trailheads, and illegal use of restricted areas of the system. Also not measured as part of the project were special project visits such as those occasioned by the Gerrity Oil and Peak Power project which create special management requirements. Estimates of these types of visitation may be developed in the future as resources become available to utilize alternative survey designs and techniques.

DATA ANALYSIS

Recreation survey data are often characterized by extreme variability (the range or spread of individual values around their mean), which leads to wide confidence intervals for use estimates. The effects of variability can be reduced and confidence intervals tightened when data can be separated into mutually exclusive strata for which measures are less variable than are measures for data set as a whole.

To address this problem, the calculation of estimates and confidence intervals employed 4 levels of stratification: 1) respondents/non-respondents, 2) weekday/weekend periods, 3) seasons of the year, and 4) geographic zones. After results were calculated for each stratum, they were assembled into system-wide estimates by weighting each stratum according to the proportion of the study it represented.

As a simplified example of how weights were developed, consider a hypothetical one-year study using 48-hour observation periods which are stratified between weekends and

weekdays. The study year is comprised of 182 48-hour periods, 52 occurring on weekends, 130 occurring on weekdays. The 10 weekend periods sampled in this study represent 10/52 of all weekend use, while the 10 weekday periods sampled represent 10/130 of all weekday use. Thus when computing overall use estimates, weekend and weekday observations must be weighed differently. Assuming the mean number of persons observed during weekend periods is 200, estimated total weekend visitation is

$$(200 \text{ persons per period}) * (52 \text{ weekend periods}) = 10,400 \text{ persons.}$$

Assuming the mean number of persons observed during weekday periods is 100, estimated total weekday visitation is

$$(100 \text{ persons per period}) * (130 \text{ weekday periods}) = 13,000 \text{ person;}$$

and estimated total visitation is

$$10,400 \text{ persons} + 13,000 \text{ person} = 23,400 \text{ persons.}$$

This logic underlies the formulae below, which were used to apply the appropriate weight to each stratum used in the Boulder Open Space Department Visitation Study.

Formulae

Using a simple random sample within each stratum, estimates were calculated using formulae available in Scheaffer, Mendenhall, and Ott (1990):

1. Estimates of population means are

$$\bar{y}_{st} = \frac{1}{N} \sum_{i=1}^L N_i \bar{y}_i$$

Where y_{st} is the estimated population means where a stratified sample is used:

N is the total number of sampling units in the population;

L is the number of strata, any one of which can be denoted I ;

N_i is the number of sampling units within stratum i ; and

y_i is the mean for stratum i .

2. The estimated variance of a population is

$$\hat{v}(\bar{y}_{st}) = \frac{1}{N^2} \sum_{i=1}^L N_i^2 \left(\frac{N_i - n_i}{N_i} \right) \left(\frac{s_i^2}{n_i} \right)$$

where \hat{v} is the estimated variance of the population mean, \bar{y}_{st} ;

n_i is the sample size for stratum i ; and

s_i is the variance estimate for stratum i .

Estimates and confidence intervals

Results of this study are presented as population means, totals, or proportions with confidence intervals. Confidence intervals cover the range of estimates that might have occurred if the study had been replicated. That is, a 95% confidence level covers the range within which 95 out of 100 estimates would fall.

The spread or width of a confidence interval is influenced by the inherent variability of the phenomenon being estimated and by the sample size used for the estimate. As discussed above, recreation participation is highly variable. Stratified sampling reduces, but does not eliminate the effects of this variability. Large sample sizes also reduce the effects of variability, but at considerable cost. Consider a hypothetical area with 40 entrances which are to be sampled for 12 weeks during 21 time blocks each week. Using formulae available in Scheaffer, Mendenhall, and Ott (1990), and assuming visitation ranging between 0 and 150 persons per time block, a confidence interval of +/- 5 persons requires sampling 220 time periods. Tightening the confidence interval to +/- 3 persons requires sampling 588 time periods, a 167% increase in sampling effort and cost.

Adjusted data

Problems in the data collection process led to two adjustments in the data used for final calculations. As data collection began in June 1992, staffing limitations led to the use of one-hour observation/interview periods for non-respondent monitoring rather than the standard 4-hour periods used during the remainder of the study. Non-respondent data from the 4 non-standard sampling periods have been weighted to be equivalent to data collected during standard monitoring periods.

Because non-respondent data for many joggers and bicyclists was entered without interviews, length-of-visit, place-of-residence and party composition data for those parties was often missing. The missing data reduced the effective non-respondent sample size for those variables. Data obtained was assumed to be representative of missing data, and estimates for these variables were calculated using the full sample size.

Vandalism did not require data adjustments. During the 7 cases of known tampering, boxes were inoperative primarily during nighttime. Comparison of data from affected periods to data from unaffected periods on a site-by-site basis revealed no discernible loss of data.

Adjusted estimates

Since the sampling and stratification method used to estimate system-wide visitation was incompatible with stratification for zone level estimates, zone visitation estimates were calculated indirectly. Estimates of the proportion of visitation within each zone were applied to system-wide totals. Because this two stage estimating process was used, confidence intervals were not calculated at the zone level.

A systematic error in the entry of party composition data led to under-estimation of non-respondent parties consisting of families, friends, or organized groups. When non-respondent data for joggers and bicyclists was entered without interviews, one person parties were coded as "alone", while data for larger parties was, of necessity, left missing. This missing data caused the underestimation of all party types except the "alone" category. The underestimation has been adjusted by weighting derived from the party size results, since party size results were not subject to the same distortion.

APPENDIX B

PREDICTIVE MODEL

A predictive model was developed to explore whether or not information from an indirect measure of use could be used to estimate visitation. The model assumed a linear relationship between data from vehicle and trail counters and estimates of visitation obtained in the registration and observation study.

Data Collection

Data for developing the predictive model were collected using vehicle and trail counters on the Open Space System. So that counter data could be tested against the results of the registration and observation study, counters were read at the beginning and end of each 48-hour registration period.

Underground induction-cable vehicle counters were used at trailhead parking lots with single entrances. Infrared temperature-sensing counters or reflector counters were used to count individuals on trails where vehicle counters could not be used.

Two criteria were developed and employed by Boulder Open Space Department staff in selecting installation sites. First, sites were selected where visitation patterns were assumed to be consistent with visitation for the zone as a whole. Second, logistic problems such as ease of installation and protection from vandalism were considered. Of the 17 counters installed, 10 were ultimately used in testing the predictive model (see table, p. 39).

Ideally, 8 pairs of visitation estimates and counter readings would have been recorded for each of the 10 zones, providing a total of 80 valid observations. However, installation problems and counter malfunctions caused by severe weather, vandalism, and mechanical problems reduced the valid number of observations to 63. Valid observations by zone ranged from a high of 8 data pairs in zones 1, 4, and 7 to a low of 3 data pairs in Zone 6.

Results of Counter Data Collection by Site and Counter Type, Boulder Open Space, 6/1/92-5/31/93.

Installation Site	Counter Type	Results
105 Flatirons Vista	Vehicle	3 valid observations, not tested or used in model
107 Greenbelt Plateau	Vehicle	7 valid observations, tested but not used in model
109 Marshall Mesa	Infrared	8 valid observations, tested and used in model
204 Dry Creek	Vehicle	4 valid observations, tested and used in model
303 Cottonwood	Reflector	5 valid observations, tested and used in model
401 Bobolink	Infrared	8 valid observations, tested and used in model
401 Bobolink	Reflector	1 valid observation, not tested or used in model
503 Sanitas Valley	Infrared	7 valid observations, tested and used in model
603 Fthls. Nature Ctr.	Infrared	3 valid observations, tested and used in model
612 Wonderland Dam	Infrared	1 valid observation, not tested or used in model
706 Foothills Trlhd.	Infrared	8 valid observations, tested and used in model
706 Foothills Trlhd.	Vehicle	1 valid observation, not tested or used in model
801 Arapahoe & 3rd	Infrared	7 valid observations, tested and used in model
907 N. Teller Farm	Vehicle	0 valid observations, not tested or used in model
908 S. Teller Farm	Vehicle	6 valid observations, tested and used in model
1009 S. Mesa Trlhd.	Reflector	7 valid observations, tested and used in model
1009 S. Mesa Trlhd.	Vehicle	6 valid observations, tested but not used in model

Data Analysis

Multiple regression analysis was used to establish the relationship between counter readings and the results of the registration and observation study. The data were tested using the multiple regression equation shown below:

$$Y' = a + b_1X_1 + b_2X_2$$

where Y' is estimated visitation during a 48-hour period on a zone;

X_1 is time of week (weekday = 0, weekend = 1);

X_2 is the count recorded on a vehicle or trail counter; and

a , b_1 , and b_2 are values calculated in analysis from a set of visitation estimates and counter readings recorded in the field.

The model allows a visitation estimate, Y' , to be computed from known counter data, X_2 , and time of week, X_1 . The more consistent the relationship between counter data and visitation, the more accurate the model is in estimating visitation. If counter readings always changed in a manner consistent with visitation, all estimates calculated using the model would be perfect.

The accuracy of the model is expressed as a statistic called R^2 . R^2 can take on any value between 0.0 and 1.0. An R^2 value of 1.0 indicates that counter results could be used to estimate visitation without error. In contrast, an R^2 value of 0.0 indicates that there is no relationship between counter data and visitation. This model was tested against data collected during the study.

Results

The test of the model using data collected during the registration and observation study produced an R^2 value of 0.6, demonstrating a moderate ability to estimate visitation accurately. When the model was used to estimate visitation for the year the study occurred, that estimate was 1,144,157 persons, 3.5% below the estimate obtained in the registration and observation study. Based on these results, the model is recommended for estimating annual visitation in future years.

Recommendations for Use

Use of the model for estimating visitation will require data collection and analysis paralleling the processes used to develop and test the model. Detailed instructions and a worksheet for calculating estimates have been provided to Boulder Open Space Department in a technical memorandum. Below is an overview of data collection and calculation of estimates.

Data should be collected during 48-hour time blocks in each of the 10 study zones, following a schedule as similar as possible to the schedule used during the original study. In the technical memorandum already delivered, Boulder Open Space Department was provided a counter-reading schedule for 1993-1994 and detailed guidelines for scheduling counter-reading in succeeding years.

After counter readings have been obtained, the calculation of annual visitation estimates require 2 steps. First, visitation estimates are calculated for each 48-hour period using counter readings and the regression equation. Second, separate weekday and weekend estimates for the year are calculated and added together.

In the first step, estimates for each 48-hour period are calculated using the equation in the following form:

$$EV = 55.0 + (238.7 * TOW) + (1.13 * CR)$$

where EV is estimated visitation for a 48-hour period;

TOW is time of week during which the counter reading was taken, using 0 for weekday periods and 1 for weekend periods; and

CR is the counter reading for the 48-hour period.

In the second step, separate weekday and weekend estimates for the year are calculated, then added together. To compute an annual weekday visitation estimate, all 48-hour weekday estimates are first added together. Because there are 130 weekday periods per year and 10 zones, the sum of the weekday estimates is multiplied by 1300, or $130 * 10$. This value is then divided by the total number of valid weekday counter readings, resulting in an estimate of annual weekday visitation.

In a similar manner, all 48-hour weekend estimates are added together. Because there are 52 weekend periods per year and 10 zones, this sum is multiplied by 520, or $52 * 10$. This value is then divided by the total number of valid weekend counter readings, resulting in an estimate of annual weekend visitation. The overall annual visitation estimate is the sum of the weekday and weekend estimates.