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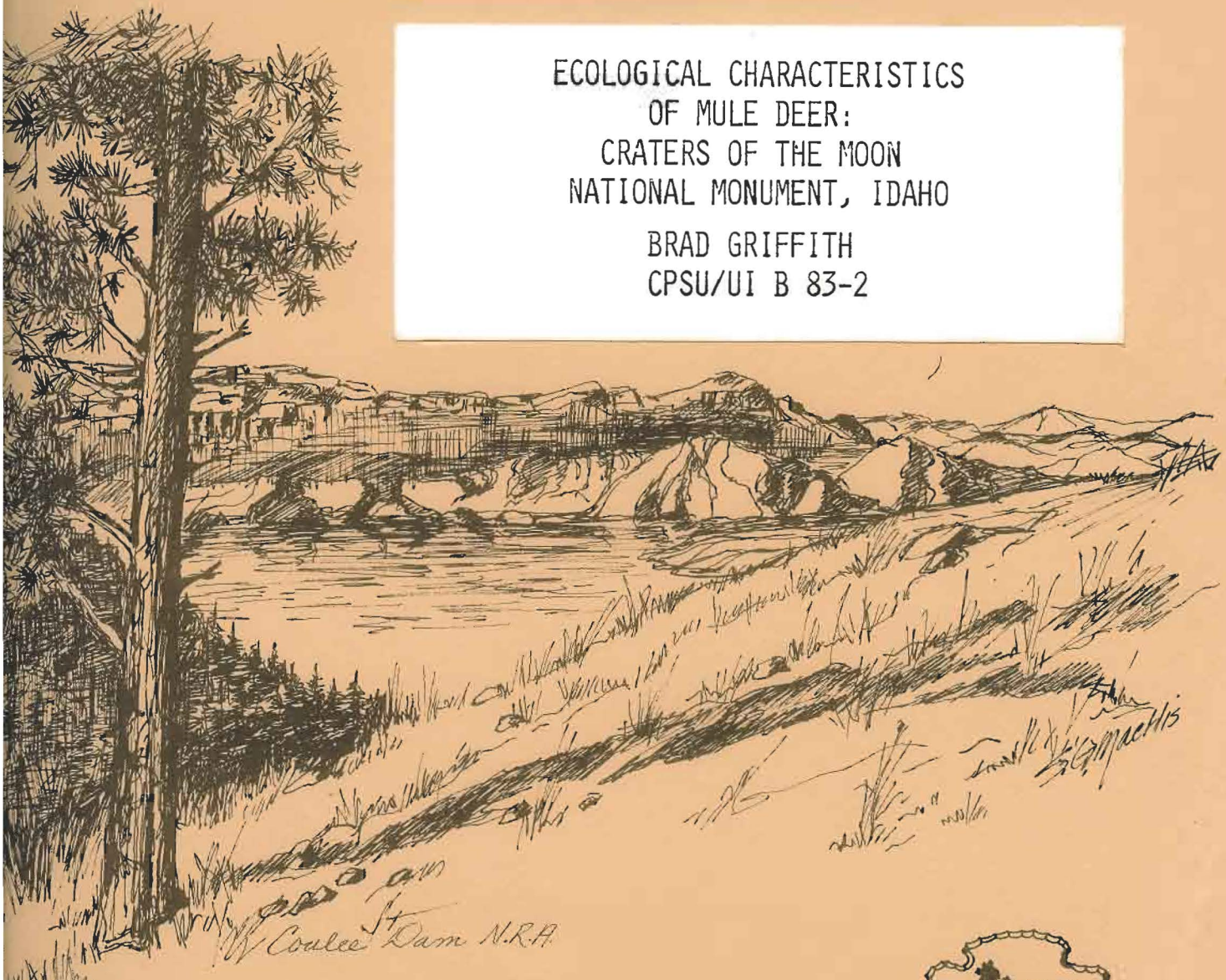
# COOPERATIVE PARK STUDIES UNIT

# UNIVERSITY OF IDAHO

## ECOLOGICAL CHARACTERISTICS OF MULE DEER: CRATERS OF THE MOON NATIONAL MONUMENT, IDAHO

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CPSU/UI B 83-2




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SUMMARY

This section recapitulates the objectives, methods, and major results of a three year study of mule deer on Craters of the Moon National Monument, Idaho. Readers are referred to the body of the report for a detailed presentation of the results.

In response to a request by managers of Craters of the Moon National Monument, a field research project was conducted between May 1980, and November 1982, to investigate characteristics of the mule deer herd which summered on the monument. Observations by managers had suggested that deer were impacting their habitat, and based on earlier reports of high productivity, there was concern that the protected deer herd would multiply sufficiently to damage the habitat.

Specific objectives of the study described in this report were: 1) to describe the area use patterns of deer, 2) to estimate the deer population level, and 3) to investigate aspects of production, mortality, and recruitment as they influenced population dynamics. To accomplish these objectives, 100 deer were marked, released, and their life histories followed. The population estimate was derived from the proportion of marked deer seen on repeated censuses, and area use patterns were described from the analysis of 2381 relocations of marked deer (20 of which were equipped with radio collars). Production, mortality, and recruitment were estimated from documentation of hunting removal, road kills, seasonal and year to year changes in the proportion of the herd in various sex and age classes, and the loss of marked deer. During the study total annual precipitation always significantly exceeded the mean of the most recent 23 years. The year prior to the study had significantly less total precipitation than the average and the summer of 1981 was the fourth driest on record.

Mule deer occupied the monument from April through November; snow depth which reached 150 cm, precluded use during the remaining months. The deer that summered on the monument wintered on at least two separate winter ranges that were on Bureau of Land Management and private lands. One winter range

was 35 km to the north-northeast near the town of Moore, Idaho. The other winter range was 70-100 km to the south-southwest on the Snake River Plain, east of Jerome and north of Burley, Idaho.

Upon arrival on summer range deer dispersed uniformly throughout the vegetated areas of the monument. As a result, from April through late July, 20-25 percent of the herd occupied the part of the monument in the Pioneer Mountains where free water was available. The remainder of the herd occupied the central and wilderness portions of the monument where free water was not available. The central and wilderness area deer were never observed to make watering trips to the Pioneer Mountains during April through mid-July. Analyses of the water requirements of deer and of the water available from forage indicated that these deer could have obtained sufficient water from forage during this period. By late July, however, drinking water would have been necessary for central and wilderness deer to maintain water equilibrium.

In the last week of July, deer which occupied home ranges in the central and wilderness areas of the monument migrated 5-18 km northward within the monument and established new home ranges in the Pioneer Mountains where drinking water and more dense cover was available. During the drought in the summer of 1981, deer migrated 10 days earlier than during the more moist year of 1982. The earlier migration in 1981 could not be totally attributed to drought because fawns were born five to seven days later in 1982, and it is possible that fawns needed to reach a minimum size before they could successfully complete the migration.

The mid-summer migrants remained in the Pioneer Mountains during August and September. Their added presence in the area caused a four fold increase in deer density within the part of the monument north of the highway. Approximately 95 percent of the herd was in the north end during August and September. While there, the deer intensively used the Douglas fir and aspen stands (which only accounted for one percent of the total deer habitat on the monument) for bedding. As a result they

caused noticeable soil disturbance in these areas. The observations of this soil disturbance partially prompted monument managers to request this study. No obvious negative impact on forage communities due to the high densities of deer in August and September was identified in this study.

While in the Pioneer Mountains deer regularly foraged on the irrigated and fertilized visitor center lawns and drank from the sprinkler overflows. Use of the visitor center area required deer to cross the highway and, as a result, about three percent of the herd was killed annually in vehicle accidents. Nearly 70 percent of total road kills occurred during August and September when deer were concentrated in the Pioneer Mountains. Annual variation in road kill was directly correlated with variation in population level but was not correlated with traffic volume.

In late September and early October, following fall rains and a 10°C to 12°C decrease in mean daily high temperature, deer which had migrated northward in mid-summer began returning southward to the same home ranges they had occupied during April-July in southern sections of the monument. They stayed on their southern home ranges for 1-25 days, returned to their northern home ranges for 1-9 days, then returned to their wilderness ranges. Deer made one to four such round trips to southern ranges in the fall. They tended to return to the north end of the monument more frequently and to spend less time in the southern areas during the droughty conditions of 1981 than during the more moist conditions of 1982. In wetter years (1980 and 1982) some migratory deer did not return to the north end in the fall but remained in the wilderness until the herd migrated to winter ranges in late November and early December.

The total population of deer in late August and early September was 478, 515, and 351 for 1980, 1981, and 1982, respectively. The increase in population in 1981 followed a mild winter and the decrease in 1982 followed a severe winter. Following the severe winter of 1981-1982 there were significantly fewer yearling and older females in the

population than in the previous year. The changes in population level were mostly due to differences in overwinter survival. The average fall population of 448 deer consisted of 40 percent fawns, 41 percent yearling and older does, 8 percent yearling males, and 11 percent adult males. The number of adult does in the fall population remained relatively constant (118-142) during the study.

Analysis of fall roadside census data collected over the past 25 years suggested relative stability in the population since 1958. Reports of a numerous and increasing population in 1938 suggested the population may have reached contemporary levels as long as 45 years ago. Based on the three population estimates of this study and the comparable estimate made by Ritchie (1968), the fall population could vary between 277 and 563 deer and not differ significantly ($P \leq .05$) from the long term mean. Since the four estimates which comprised this average were obtained in years of above average precipitation, they may have overestimated the true long term mean.

Birth of fawns peaked during the last week of May and the first week of June following a peak in breeding activity during the first and second weeks of November. Fawns were most easily found in limber pine stands in central and wilderness sections of the monument. Fawn survival to five months of age was good in all years and ranged from at least 66 percent to 86 percent. Following the summer drought in 1981, there were 22 percent fewer fawns per adult doe in the fall than in the previous wet year. This suggested that summer drought lowered fawn survival.

Net fawn crop surviving to the fall was substantial in all years and averaged 1.34 fawns per adult doe. This value slightly exceeded the average number of fawns born per female in many western states. Yearlings comprised an average of 28 percent of the spring doe population and recruitment, the number of female fawns reaching one year of age per breeding doe, averaged 0.6 for the two years when it could be calculated. These statistics identified the Craters herd as one of the most productive mule deer herds on record.

Hunting and winter mortality proved to be the major losses to the herd. Summer mortality of deer older than one year was insignificant. Documented hunting mortality, in each year, accounted for at least 10.6 percent of the fall population. Adding an estimated additional hunting removal, due to crippling and undocumented losses, brought total estimated hunting mortality to 15.1 percent per year. On the average, documented hunting mortality accounted for 4, 57, 68, and 70 percent of annual losses for fawns, does, yearling males, and adult males, respectively, and was the major source of mortality for deer older than one year. This level of hunting harvest approximated that of unprotected herds. On the monument, such a level of hunting mortality was possible due to the heavy hunting pressure around the boundaries in the Pioneer Mountains and the fact that monument deer did not consistently stay within the boundaries. The portion of the herd which returned to the wilderness in the fall was protected from hunting. It is likely that hunting has always removed a significant portion of the Craters herd. Increased enforcement and improved boundary marking in recent years may have actually reduced the proportion of the herd taken by hunters compared to earlier times.

Hunting removed a constant proportion of the population each year. The removal was unequally distributed across sex and age classes. Yearling and adult males were taken 3.9 and 2.8 times as frequently as they occurred in the population. Reductions in these groups of deer were relatively unimportant to population dynamics of the herd. Fawns were only taken by hunters 0.2 times as often as they occurred in the population but there may have been substantial loss of fawns orphaned by the removal of does during the hunting season. Hunting removal of yearling and older female deer was variable during the course of the study. In 1980 does were taken 1.5 times as frequently, in 1981 0.7 times as frequently, and in 1982 0.2 times as frequently as they occurred in the population. Averaged over the three years does were taken only 0.8 times as frequently as they occurred. Hunting loss of yearling and

older does and their associated orphaned fawns tended to dampen population growth.

Overwinter survival of all sex and age classes reflected differing severity of the winters. During the mild winter of 1980-1981 there was negligible mortality of yearling and older deer. Most fawns orphaned during the 1980 hunting season disappeared from the population but classification ratios indicated that essentially all the remaining fawns survived. During the severe winter of 1981-1982, at least 16.3 percent of does, 37.5 percent of males, and 43.9 percent of fawns disappeared from the herd. On the average, winter losses accounted for 34, 37, 25, and 27 percent of all mortality for fawns, does, yearling males, and adult males, respectively. The survival observed during the two winters studied may have bracketed the long term average winter survival expected for the herd.

The potential for increase in the population was evaluated by simulating population dynamics over the course of 30 years using the average survival and production figures obtained in this study. The simulated population increased 10 percent each year and doubled in the seventh year. Such a trend in population was not observed during this study. It is possible that survival of yearling and older females was overestimated causing the discrepancy between the observed and the simulated trend. Alternately, the discrepancy may have been caused by not accounting for dispersal in the simulation exercise. Circumstantial evidence suggested that yearling males dispersed between the ages of 12 and 16 months at an average annual rate of 21 percent. Dispersal of one-third of yearling females would have been sufficient to stabilize a population with production and survival figures observed for the Craters herd. An adequate evaluation of dispersal as a factor in the population dynamics of the Craters herd would require a major radio monitoring study of younger deer.

During the study no consistent evidence emerged to suggest that the herd was damaging the forage base or that the herd was dramatically increasing. In fact, the population declined

during the study. Even though fawn:doe ratios were consistently high in the fall, the combined effects of hunting and winter mortality, and perhaps dispersal, tended to hold the population to about 450 deer. Thus there was little reason to believe that the herd would exceed carrying capacity of the monument summer range and damage the habitat. Any concern for the herd exceeding carrying capacity should probably be focused on the winter ranges. The deer population and habitat monitoring systems established as part of this study will allow documentation of long term trends in population characteristics and eventually allow the results reported here to be placed in long term perspective.

The consistent and substantial levels of hunting harvest and the consistent road kill losses demonstrated that Craters of the Moon National Monument did not serve a true protective function for the herd. These two sources of mortality together removed a number of deer equal to an average of 18 percent of the total fall population each year. If suspected orphaning loss was added, it would bring the total annual removal up to 24 percent of the pre-hunt herd. Any dispersal of yearling deer would further increase this value. The monument does function as an island of high quality habitat and serves as a reservoir of deer which may contribute to recreational use on adjacent lands.

## MANAGEMENT RECOMMENDATIONS

Based on the insights gained in this study, the following recommendations are offered. If carried out they should provide the monument with the data necessary to monitor deer population and habitat trends.

1. Monitor the spring and fall deer population characteristics using the standard operating procedure outlined by Griffith (1983). These procedures will allow evaluation of productivity and winter survival of deer and guage long term trends in health of the herd.

2. Monitor the permanent vegetation transects outlined in the appropriate standard operating procedure (Griffith 1983). The next cycle for reading the transects is during 1986-1988. These transects are the basis for evaluating habitat trend within the monument.

3. Document and record the number, sex, and age of deer killed by vehicle accidents within the monument from April through November each year. The number of road killed deer is one of the two best indicators of population trend evaluated for the Craters herd.

4. Document and record the number of hunter contacts made during deer season and the number, sex, and age of deer killed by hunters each year. The number of deer killed by hunters is one of the two best indicators of population trend for the herd.

5. Communicate the information obtained in items one to four above to the Idaho Department of Fish and Game in Regions Four and Six and to the Shoshone and Idaho Falls District offices of the Bureau of Land Management. The Craters herd falls within the jurisdiction of both these agencies while on winter range, and they should be advised of the status of the herd.

6. Continue to pay rewards for the return of tags from Craters deer. Insure that the date, location and reason for death of the deer is recorded and the file kept current. This process may identify winter ranges which are currently unknown.

7. Maintain the current effective law enforcement program during deer season. This program provides information necessary to properly evaluate trends in numbers of deer.

8. Develop a plan for and begin a program of prescribed burning in the part of the monument north of the highway. This area is critical habitat for the entire herd during August and September. Douglas fir is invading some aspen stands and the area has not burned in so long that continuous fuels exist throughout the area. As a result the probability of a large scale fire, which could be detrimental to watershed quality and deer resting habitat is significant. Prescribed burning in patches will break up fuel continuity and reduce the chance of a large scale destructive fire.

9. Make an effort to reduce the number of vehicle accidents with deer during August and September. There are two ways this might be accomplished. Roadside reflectors could be used to warn deer of approaching vehicles and more explicit signs could be placed along the highway to alert motorists. Alternately, since the visitor center lawns are the attractant which draws deer across the highway in August and September, the lawns could be phased out and the visitor center relandscaped with native vegetation. This would provide the opportunity for an interpretive exhibit. If successful about 10 less deer-vehicle accidents per year would occur.

10. Do not develop additional water sources for deer in the central developed area of the monument. The mid-summer migratory behavior of deer provides an ideal opportunity to study the behavior and physiology of deer in an arid

environment. Water development would likely distrupt the migratory behavior.

## ACKNOWLEDGEMENTS

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# 1.0 INTRODUCTION

Historically, four large native mammals: grizzly bears (Ursus horribilis), bighorn sheep (Ovis canadensis), Rocky Mountain mule deer (Odocoileus h. hemionus) and wolves (Canis lupus) occurred on or near Craters of the Moon National Monument. Around the turn of the century, domestic grazing and subsistence hunting by local gold and silver miners created pressures that depressed the populations of each species. These pressures were eliminated when the monument was established in 1924, but the grizzly bear, bighorn sheep and wolf never recovered and are now extinct within the Monument.

The mule deer, however, survived and may have increased in numbers over the past 55-60 years. Ritchie (1968) reviewed National Park Service (NPS) records available for the period 1921-1967 and concluded that they suggested a population increase during the 46 year period. Deer were reported to be scarce during 1921-26 and geologist H. T. Stearns did not see deer during field work in these summers. By the early 1930's deer were being observed and by 1938 deer were reported to be numerous and increasing. Ritchie (1968) estimated the fall 1967 population to be about 335 deer and increasing.

By the late 1970's park personnel noted that deer were being killed regularly while crossing the highway, were feeding heavily on residence lawns within the monument, and were creating noticeable soil disturbance in forested bedding areas. Ritchie's (1968) concerns that range conditions were deteriorating and the deer population expanding, led monument managers in 1979 to request a new study of the Craters deer herd. Specific requests included development and implementation of deer population and deer habitat monitoring systems that could be carried out through routine park operations, population estimates, and an evaluation of deer use of the wilderness area.

Field research designed to satisfy these requests began in May 1980, and continued through October 1982. The deer population and habitat monitoring systems were developed and

presented by Griffith (1983). Objectives of the field studies presented in this report were: (1) to determine the areas utilized by the deer, (2) to estimate the deer population level, and (3) to investigate aspects of production, survival, and recruitment as they related to population dynamics of the herd. The study population was all of the mule deer which summered on Craters of the Moon National Monument, Idaho, during 1980, 1981, and 1982.

## 2.0 STUDY AREA

### 2.1 General Characteristics

Craters of the Moon National Monument was located on the northern edge of the Snake River Plain, 30 km southwest of Arco, Idaho (Fig. 2.1.1). The 215 $km^2$ Monument (Fig. 2.1.2) encompassed a large volcanic fissure called the Great Rift and a long chain of cinder cones extending southeastward into the Snake River Plain from the base of the Pioneer Mountains. These cones were 35-245 m higher than the surrounding terrain. Large expanses of aa and pahoehoe lava flows in various stages of vegetative succession surrounded the cinder cones. Elevations on the monument ranged from 1627 m along the rift zone to 1817 m at the base of the Poineer Mountains which attained an elevation of 2343 m in the north end of the monument. The most recent volcanic activity occurred about 2,000 years ago (Prinz 1970). Stearns (1928a, 1928b, 1963) and Murtaugh (1961) provided a detailed account of the geology of the monument. Ritchie (1968) summarized soil conditions.

In this report reference is made to three areas of the monument. The northern portion, or north end, of the monument was that part north of U.S. Highway 20/26 (Fig. 2.1.2). The central portion extended from the highway south to the wilderness boundary, and the wilderness was the balance of the area officially designated as wilderness in 1970. The central and wilderness sections of the monument were collectively called the south end. Excluded from the study area was the 15

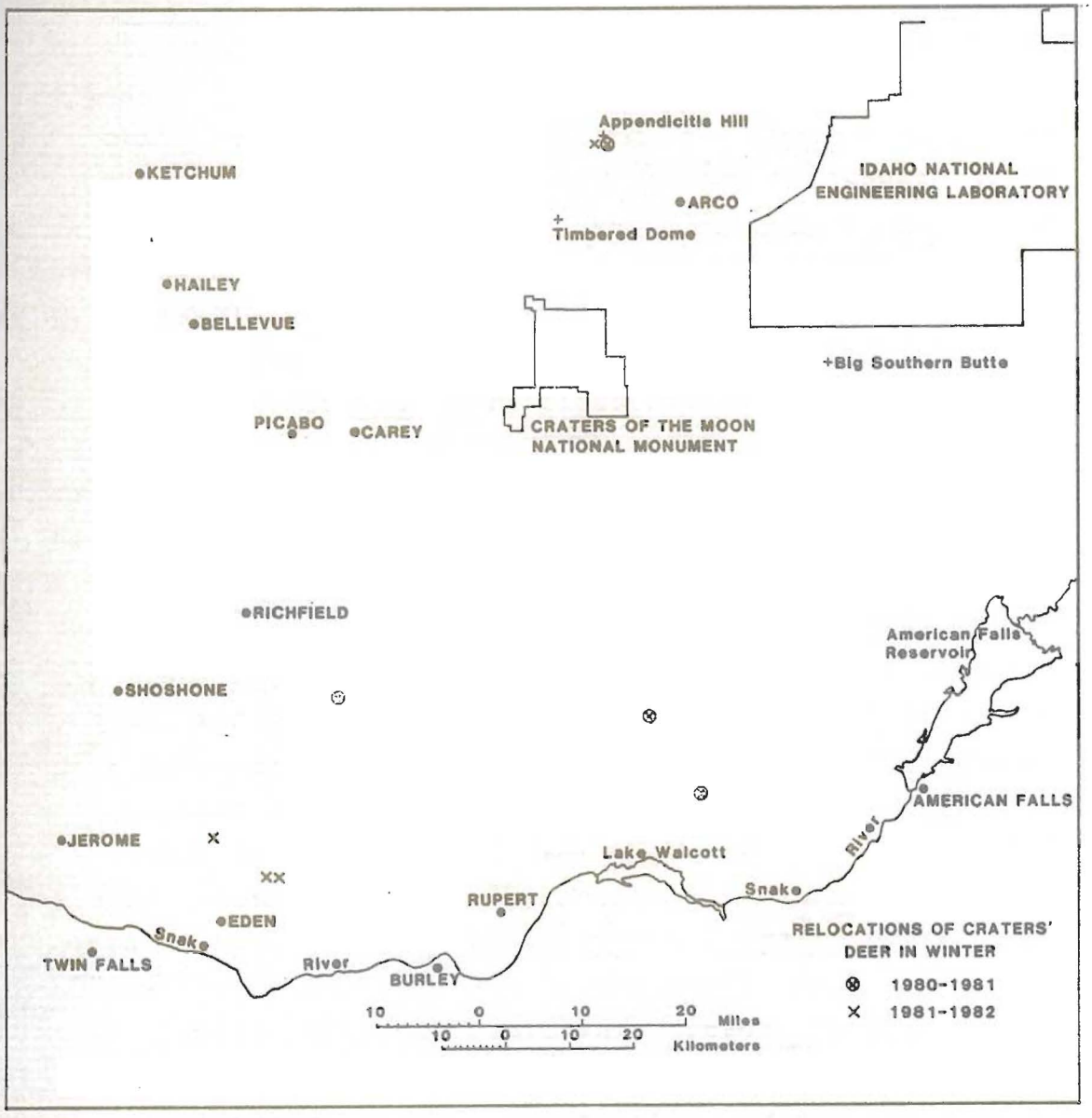



**Figure 2.1.1 Location of Craters of the Moon National Monument, Idaho, and locations of marked Craters' mule deer observed on winter range, 1980-1982.**

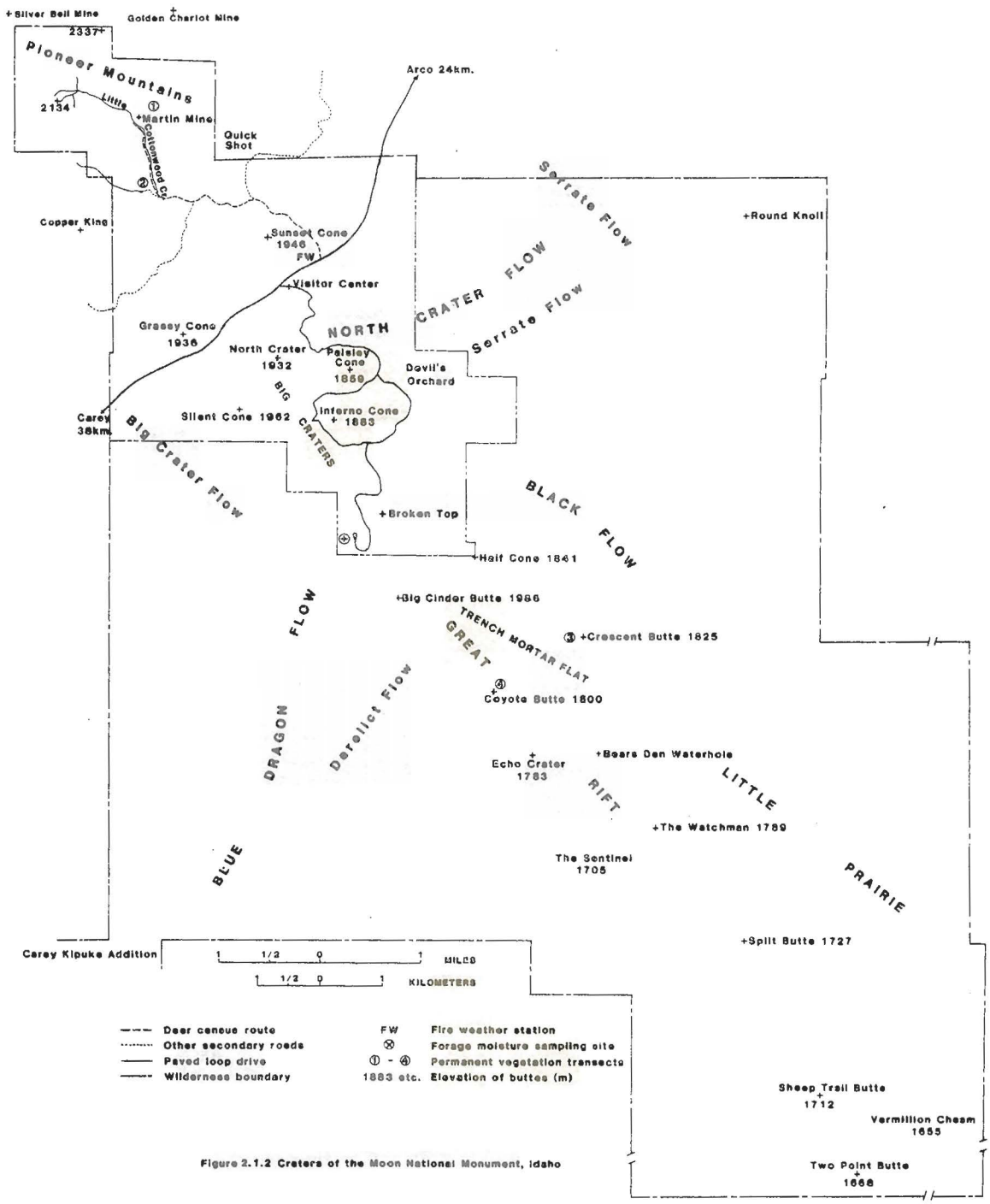



Figure 2.1.2 Craters of the Moon National Monument, Idaho

$km^2$ Carey Kipuka addition made in 1962.

In general, pahoehoe and aa lava flows which were nearly barren or in early stages of succession accounted for 55.6 percent of the total study area. The remaining 89.9 $km^2$ of vegetated area comprised the portion of the Monument that could be considered deer habitat.

## 2.2 Habitat Characteristics of the Central and Wilderness Sections

The chain of cinder cones along the Great Rift was separated from surrounding vegetated areas on the Snake River Plain by barren lava flows which were 3-5 km wide. As a result, the south end of the monument was a patchy, sometimes disjunct, peninsula of habitat extending into a sea of barren lava. Over one-half of the monument south of U.S. Highway 20/26 was covered by barren lava flows having vegetation cover of less than 20 percent. In this southern area, mountain big sagebrush (Artemesia tridentata vasayena) was the dominant shrub, but bitterbrush (Purshia tridentata) was wide-spread, abundant, and in good to excellent condition throughout. Native bunch grasses (Poa sandbergii, Agropyron spicatum, Stipa comota, S. columiana, Oryzopsis hymenoides, Sitanion hystrix) were abundant, and the herb community was diverse. Limber pine (Pinus flexilus) stands were common in the vicinity of cinder cones and on lava flows along the rift. The major vegetation types are listed in Table 2.2.1.

The only consistently available free water in the south end occurred at sprinkler overflows at the visitor center. Due to the porous volcanic substrate in the south end, there were no streams. Pools of water sometimes formed in small rock depressions after rain or snow melt, but these seldom held more than one-half liter of water, and rapidly evaporated. Under certain circumstances, an ice dam formed during winter in the bottom of cinder cones and melting snow was retained for a time in the spring. The waterhole in Sheep Trail Butte was the best example of this periodic phenomenon. On 18 May 1980, it held about 2000 liters of water. By 15 June, the ice dam had melted

TABLE 2.2.1 Vegetation types of Craters of the Moon National Monument, Idaho. Data summarized from vegetation maps of Thomas[a], 1936.

| VEGETATION TYPE | HECTARES[b] | PERCENT |
|---|---|---|
| Barren (<20 percent cover) | 11,156.6 | 55.6 |
| Grassland | | |
| (12.1% with >20<50 percent cover) | 341.1 | 1.7 |
| Shrubland | | |
| (19% with >20<50 percent cover) | 6,360.9 | 31.7 |
| Forested Areas | | |
| Quaking Aspen | 60.2 | 0.3 |
| Douglas Fir | 40.1 | 0.2 |
| Limber Pine (55% with >20<50 percent cover) | 2,106.9 | 10.5 |
| TOTAL | 20,065.8 | 100.0 |

a On file at monument headquarters and does not include Carey Kipuka addition of 1962.

b Includes 1.9 $km^2$ in north end not currently within monument boundaries.

and the waterhole was dry. In 1981 and 1982 no ice dam formed and the waterhole was dry all year. Yellowjacket waterhole was similar in character. In winter, lava tubes below the surface of the terrain collected snow and ice which slowly melted during the summer and provided season-long water. Due to their depth, these lava tubes were unavailable to deer.

Truncated lava tubes which sat on the surface of the terrain, did provide small amounts of water that was seasonally available to deer. Water dripped from the ceilings and collected in tiny pools holding less than one-quarter liter of water. Three such truncated lava tubes were found in the central and wilderness areas. One was near the Sentinel, another near Two-Point Butte, and the third at Amphitheater

Cave. All three locations showed signs of deer use in spring and early summer. The total amount of water available from these sources was extremely limited.

Due to the rough topography and limited water availability, the central and wilderness sections of the monument were infrequently grazed by domestic stock prior to 1924. No domestic livestock grazing has occurred since 1924.

## 2.3 Habitat Characteristics of the North End

The north end of the monument was quite different in character from the central and wilderness areas. Except for two very old cinder cones immediately north of the highway (Fig. 2.1.2) the area was non-volcanic in origin. Terrain was generally steep and elevation increased from 1817 m at the mouth of Little Cottonwood Creek to 2343 m at the monument boundary 2.4 km northward. Douglas fir (Pseudotsuga menziesii) quaking aspen (Populus tremuloides) chokecherry (Prunus virginiana) and cottonwood (Populus trichocarpa) were common on the more moist sites and covered approximately five percent of the area. The balance of the area was primarily shrubland. Big sagebrush, bitterbrush, and snowberry (Symphoricarpos oreophilus) were the principal shrubs. There were isolated patches of buckbrush (Ceanothus velutinus), scattered individual serviceberry (Amelanchier alnifolia) plants, and some willow (Salix sp) along stream courses and on Sunset Cone. The area was entirely vegetated except for rock outcrops and included nearly all the quaking aspen and Douglas fir stands, about 15 percent of the shrubland, and about five percent of the grassland found on the monument (Table 2.2.1). Water was abundant in the north end. There were four developed springs and two permanent streams. These streams disappeared into volcanic substrate soon after exiting Little Cottonwood Canyon.

## 2.4 Habitat Characteristics of the Winter Range Areas

### 2.4.1 Appendicitis Hill

Appendicitis Hill was near the mouth of the Big Lost River

near the town of Moore, 35 km north-northeast of Craters of the Moon (Fig. 2.1.1). Antelope Creek on the north, Champaign Creek on the west, Big Lost River on the east, and the Snake River Plain on the south set the area off from adjacent mountainous areas. The topography was steep, and small water courses were ephemeral. As a result, use by domestic stock in spring was light except at the base of the hill and up the major draws.

Browse transects were established and sampled by the Idaho Falls District Office of the Bureau of Land Management (R.S. McCarty, pers. comm.) in the mild winter of 1979-1980. The key species for 27 of 31 transects was mountain mahogany (Cercocarpus ledifolius). Light grazing (0-25 percent) was characteristic of all transects. Seedling and young shrubs averaged 44 percent of the total. Severely hedged, unavailable, and dead shrub form classes equalled light-moderately hedged, available, and alive form classes (McCarty 1982). These characteristics indicated what might be called acceptable condition of the range.

### 2.4.2 The Southern Winter Range

The southern winter range was approximately 70 to 100 km to the south and southwest of the monument and extended along a broad front from Shoshone and Twin Falls eastward at least to Minidoka, and probably even further eastward (Fig. 2.1.1). The area was a shrub covered plain interspersed with lava flows and buttes. Most Craters deer seen on this winter range were near agricultural areas or on buttes. Snow does not usually accumulate over the region. However, during the severe winter of 1981-1982, snow remained 60 cm deep near Eden for a large portion of the winter. Local residents had not seen such accumulations in 10 years. Approximately 121,500 ha of the southern winter range, which included 1215 ha of critical deer winter range, burned during the summer of 1981. Most of this 1215 ha was reseeded with shrubs, but success of the seedings was uncertain by October 1982 (L. Mangan, pers. comm.).

The impact of fires on deer wintering during 1981-82 must

have been substantial in view of deep and persistent snow. Some benefit to spring range conditions may have occurred. Long term impacts on Craters deer are speculative. Shrubs may return and be more vigorous after the fires, or cheatgrass may come to dominate the areas. Any negative effects of the fires would be more pronounced in severe winters.

## 2.5 Climatic Conditions

Total annual precipitation during 1959-1982 averaged 42.2 cm (Table 2.5.1). May and June were the wettest summer months. The monument receives about 1.5 times as much precipitation as surrounding areas on the Snake River Plain. (Lovejoy 1980). This greater precipitation is due to the rise in topography associated with the Great Rift. The northwest-southeast alignment of the rift lies perpendicular to the prevailing southwest winds. This alignment causes a rise in intercepted air masses with subsequent cooling and resultant precipitation. These same characteristics produce an abnormal amount of ground fog compared to surrounding areas.

During the study, total annual precipitation for 1980, 1981, and 1982, was 58.6 cm, 53.9 cm, and 59.3 cm, exceeding the 20 year mean by 39, 28, and 41 percent, respectively. Most precipitation occurred during the winter months, and there were usually spring rains in May and June. Spring precipitation equalled or exceeded the 20 year mean in all years of the study. In 1981 precipitation from June through September was abnormally low (Table 2.5.1).

Average high temperatures on the monument ranged from 28.7 ℃ in July to -1.7 ℃ in January (Table 2.5.2). Mean high temperature for April, to some degree an indicator of the arrival of spring conditions, was above average in 1980 and 1981 and slightly below average in 1982 (Table 2.5.2). The character of early summer weather for each year was most graphically displayed by fuel moisture values (Fig. 2.5.1) which reflect the combined effect of temperature and relative humidity.

TABLE 2.5.1 Mean monthly and yearly total precipitation (cm) 1959-1982, and deviation from the mean, 1979-1982, Craters of the Moon National Monument, Idaho.

| YEARS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959-1982: | | | | | | | | | | | | | |
| MEAN (cm) | 6.45 | 3.86 | 3.28 | 3.25 | 4.42 | 3.40 | 1.50 | 2.11 | 2.41 | 2.26 | 3.84 | 5.82 | 42.62 |
| STANDARD ERROR | 1.32 | 0.58 | 0.43 | 0.61 | 0.64 | 0.56 | 0.33 | 0.48 | 0.46 | 0.33 | 0.58 | 0.97 | 2.24 |
| DEVIATION FROM MEAN[1] | | | | | | | | | | | | | |
| 1979 | -3.4 | -0.3 | -3.8 | -4.8 | -2.3 | -3.9 | +3.6 | +9.8 | -3.8 | +9.8 | -3.9 | -3.0 | -4.8 |
| 1980 | +7.3 | +1.8 | -0.6 | -0.8 | +14.9 | -1.6 | +3.8 | -0.1 | +3.6 | -4.4 | -3.1 | -2.2 | +7.2 |
| 1981 | +1.2 | -2.8 | +3.6 | +7.6 | +4.2 | -3.6 | -3.2 | -4.1 | -4.5 | +4.8 | +8.9 | +2.9 | +5.0 |
| 1982 | -2.3 | -0.4 | +9.0 | +8.4 | -1.2 | +8.8 | +15.4 | -1.5 | +1.4 | +5.3 | -3.1 | +2.0 | +7.5 |

1 Number of standard errors above (+) or below (-) mean.

Difference significant at $P \leq 0.05$ if deviation exceeds ±2.07

Difference significant at $P \leq 0.01$ if deviation exceeds ±2.81

TABLE 2.5.2 Mean daily high temperature (°C), 1959-1982, and deviation from mean, 1979-1982, Craters of the Moon National Monument, Idaho.

| | HIGH TEMPERATURE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEARS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| 1959-1982: | | | | | | | | | | | | |
| MEAN (°C) | -1.7 | 0.1 | 4.3 | 10.9 | 17.6 | 22.7 | 28.7 | 27.2 | 21.3 | 14.5 | 4.6 | -0.8 |
| STANDARD ERROR | 0.5 | 0.8 | 0.5 | 0.6 | 0.4 | 0.4 | 0.3 | 0.4 | 0.6 | 0.4 | 0.4 | 0.4 |
| DEVIATION FROM MEAN[1] | | | | | | | | | | | | |
| 1979 | -12.7 | -1.3 | -1.6 | -0.3 | +1.5 | +3.6 | +1.2 | -1.8 | +7.4 | +6.5 | -2.8 | +4.2 |
| 1980 | +3.8 | +5.1 | +0.2 | +6.3 | -4.2 | -0.6 | -1.4 | -2.0 | +0.7 | +2.5 | +2.5 | +5.8 |
| 1981 | +8.8 | +2.2 | +8.9 | +5.4 | -1.8 | Ø | +3.4 | +11.0 | +5.4 | -4.8 | +3.2 | +3.6 |
| 1982 | +3.3 | -4.2 | +1.7 | -3.0 | -0.6 | -0.9 | -11.8 | +1.6 | -2.2 | -5.1 | -8.9 | +0.8 |

1 Number of standard errors above (+) or below (-) mean.

Difference significant at P≤0.05 if deviation exceeds ±2.07.

Difference significant at P≤0.01 if deviation exceeds ±2.81.

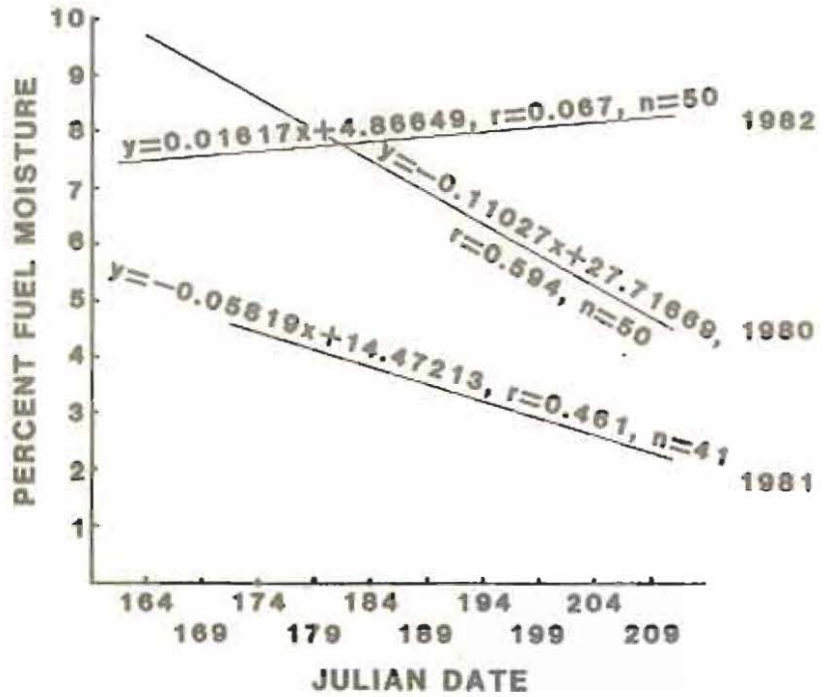



**Figure 2.5.1 Percent fuel moisture, 1980-1982, Craters of the Moon National Monument, Idaho.**

2.6 Evaluation of Present Habitat Conditions

In each year, four clusters of six 15-meter permanent line intercept transects (Canfield 1941) were sampled. These four clusters of transects, two in the wilderness and two in the north end, (Fig 2.1.2) were established as the long term habitat monitoring system (Griffith 1983). The general condition of the habitat was noted for areas where deer were frequently seen throughout the years. A subjective estimate of the degree of browsing evident on bitterbrush and an evaluation of the growth form of the plants was made. No systematic measurements were made of utilization.

Plant communities in the central and wilderness portions of the monument appeared to be near pristine in vegetative composition and condition. Overall, shrubs showed slight utilization, native bunch grasses were abundant and in excellent condition, and the forb community was diverse.

Mountain big sagebrush was the dominant shrub throughout (Windward and Tisdale 1977). Bitterbrush was an important secondary component of the shrub community, and appeared early in the successional sequence on cinder cones. It formed extensive stands on younger substrates. In these instances, gray rabbitbrush (chrysothamnus nauseosus) often constituted about one-half of the shrub cover. Serviceberry was uncommon, scattered throughout central and wilderness sectors, and always severely hedged. The decadent appearance of this shrub was most likely a function of its rarity and preferential browsing by deer.

Bitterbrush rarely showed evidence of use by deer in most locations in the southern sectors. In the wilderness, the percent of bitterbrush plants in seedling and young age classes exceeded the percent in the decadent age class (Table 2.6.1). Some plants in prime fawning areas were severely hedged, but plants adjacent to these hedged individuals often showed no evidence of use.

In southern areas, limber pine stands provided overhead

TABLE 2.6.1 Age distribution of bitterbrush and sagebrush on permanent vegetation transects, Craters of the Moon National Monument, Idaho, 1980-1982.

| TRANSECT | YEAR | SEEDLING | YOUNG | MATURE | DECADENT | TOTAL NUMBER |
|---|---|---|---|---|---|---|
| | | PERCENT TOTAL - BITTERBRUSH | | | | |
| North end | 1980 | 0 | 7.3 | 43.9 | 48.8 | 41 |
| | 1981 | 5.4 | 2.7 | 73.0 | 16.2 | 37 |
| | 1982 | 0 | 0 | 87.1 | 12.9 | 31 |
| Wilderness | 1980 | 20.6 | 5.9 | 73.5 | 0 | 34 |
| | 1981 | 12.5 | 12.5 | 71.9 | 3.1 | 32 |
| | 1982 | 0 | 6.3 | 81.3 | 12.5 | 16 |
| Combined | 1980 | 10.8 | 7.7 | 66.2 | 15.4 | 75 |
| | 1981 | 7.5 | 7.5 | 74.6 | 10.4 | 69 |
| | 1982 | 0 | 2.1 | 85.1 | 12.8 | 47 |
| | | PERCENT TOTAL - SAGEBRUSH | | | | |
| North end | 1980 | 11.5 | 11.5 | 52.5 | 24.6 | 61 |
| | 1981 | 4.3 | 7.2 | 79.7 | 8.7 | 69 |
| | 1982 | 0 | 5.7 | 83.0 | 11.3 | 53 |
| Wilderness | 1980 | 0 | 1.9 | 83.0 | 15.1 | 53 |
| | 1981 | 0 | 0 | 69.8 | 30.2 | 53 |
| | 1982 | 0 | 12.0 | 72.0 | 16.0 | 50 |
| Combined | 1980 | 6.1 | 7.0 | 66.7 | 20.2 | 114 |
| | 1981 | 2.5 | 4.1 | 75.4 | 18.0 | 122 |
| | 1982 | 0 | 9.5 | 81.0 | 9.5 | 103 |

thermal cover and appeared to be favored fawning habitat. Attempts to hand capture fawns were most successful in these stands. In mid-day limber pine stands were the best places to find deer anytime they were utilizing the southern area.

Based on an evaluation of permanent vegetation transects sampled from 1967 through 1982 (Griffith 1983), the major components of the plant community appeared to be stable and in healthy condition. A notable exception was cheatgrass (Bromus tectorum) which declined in frequency in the wilderness as well

as in the north end. Decreases in the proportion of bare soil and increases in vegetation and litter components of cover also indicated a stabilizing trend in soil as would be expected with little site disturbance.

There was a qualitative difference in the growth form of bitterbrush in the north end compared to central and wilderness areas. Bitterbrush on cinder based soils in southern areas had a luxuriant growth form, but in the north end did not exhibit the same profusion of leader growth. The older parent material and finer soils in the north end may have been less favorable for bitterbrush or there may have been two ecotypes of the species on the soils of different origin.

A qualitative evaluation showed that bitterbrush use by deer in the north end was slightly higher than in southern areas. In the north end, bitterbrush was periodically exposed to deer densities up to four times greater than wilderness areas. Even so, it did not appear over-utilized and, although some plants within 25 m of aspen and Douglas fir stands and along travel lanes were severely hedged, most plants appeared lightly to moderately hedged with good productivity.

In contrast to the south, the proportion of bitterbrush in seedling and young age classes did not exceed the proportion in the decadent age class in the north end (Table 2.6.1). It is not known if this was due to site characteristics or browsing by deer. Transect evaluations suggest that site characteristics were the most important. Small patches of cinder based soil in the north end supported bitterbrush with the luxuriant growth form seen in central and wilderness areas. Other trend indicators in the north end suggested stability in plant communities (Griffith 1983). Frequency of forbs and grasses except cheatgrass showed no decreasing trend and the percent of ground covered by vegetation and litter tended to increase over the past 16 years (Griffith 1983).

## 3.0 METHODS

The data obtained in this study are presented as the mean

± standard error where applicable. Statistical comparisons were made by t-tests, linear regression, or as delineated by Zar (1974:295-298) in the case of proportions.

### 3.1 Deer Marking

To determine area utilization and estimate the population level it was necessary to individually identify deer of various sex and age classes. A capture and marking program was therefore conducted each year. A total of 28 fawns were hand captured, 74 deer were caught in modified Clover traps (Clover 1954, McCullough 1975) and 8 deer were immobilized with Anectine (Liscinsky et al. 1969). The 100 deer captured included 47 fawns, 10 yearling males, 9 yearling females, and 34 adult females (Appendix A).

Newborn (1-21 day old) fawns were hand caught during the first week of June in each year. In 1980, doe-fawn groups were observed until the fawns bedded then the fawns were captured. In 1981 and 1982 systematic ground searches in prime fawning areas were conducted with a crew of four to six people. The 1980 procedures were more efficient in terms of manpower but the method used in 1981 and 1982 allowed easier capture of older fawns due to extra personnel present.

Age of fawns at capture was estimated from weight at capture based on regression equations presented by Robinette et al. (1973). Dates of conception were estimated by assuming a mean gestation period of 203 days as reported by Robinette et al. (1973). In 1980, every effort was made to minimize disturbance of the fawns. Small, 2.5 x 4.0 cm plastic ear tags were used to minimize visual cues to the marked fawns, sagebrush scent impregnated gloves were used by the person handling and tagging them, and the fawns were not moved. Subsequent observations of all but one of the eight fawns captured (this one was ill when marked), suggested that rejection by does was not a significant concern nor were predators keying on human scent. Consequently, newborn fawns tagged in 1981 and 1982 were sexed and weighed. Excluding fawns that were obviously unhealthy at capture, three of nine

fawns from 1981 and three of eleven fawns from 1982 were never seen again. This suggested that increased handling in 1981 and 1982 lowered hand captured newborn fawn survival. White et al. (1972) have reported similar reductions in survival for marked fawns.

Adult and yearling deer and fawns one month old and older were captured in eight modified Clover traps. Blocks of trace mineralized salt were used for bait and traps were most effective during extremely hot and dry weather. Deer caught were subdued by hand, hobbled, and blindfolded to reduce stress. Age was assigned as adult, yearling, or fawn based on tooth development and wear (Robinette et al. 1957a). Lactation status of females and the overall appearance of health was noted for each individual. A large, 6.3 X 7.3 cm numbered plastic tag and a 3 X 30 cm colored vinyl streamer was attached to each ear of trap caught deer. Six colors each of tags and streamers allowed each marked individual to have a unique color combination. Eight deer died as a result of trapping; most succumbed to spinal column trauma.

Garrott and White (1982) have reported an apparent selectivity for male fawns in traps which operated similarly to those used in this study. In this study female fawns predominated (10:7) in trap caught fawns while males predominated in fawns caught by hand (19:8).

An additional eight yearling and older deer were darted with immobilizing drugs (Liscinsky et al. 1969). Dry powder injections of Anectine were used; 14 mg of the drug was required to immobilize adult or yearling deer in the spring and 18 mg was required to immobilize deer in the fall. These eight deer were marked in the same manner as trap caught deer. Three additional deer died as a result of darting; one died from inappropriate dart placement, one from cardiac arrest, and one from respiratory depression.

Hamlin et al. (1982) reported no decrease in productivity for trapped or darted female deer. Interviews with the four hunters who shot marked Craters deer revealed that ear tags did not increase visibility and therefore reduce survival. Thus,

no influence on survival or productivity due to marking was suggested for yearling or older deer.

Twenty of the 100 marked deer were equipped with radio collars (Appendix A). Transmitters in the collars had a frequency in the 164 MH band and relocations were made using an AVM-LA-12 receiver equipped with a Telonics RA-2C two element collapsible hand held antenna.

3.2 Census Techniques

A roadside early morning census route was chosen as the standard long-term population monitoring system. Pellet group transects, counts of deer tracks crossing roads, and roadside spotlite censuses were also considered. Pellet group transects and track counts were not chosen due to the assumed large observer to observer variability that would be associated with using different untrained observers in subsequent monitoring programs. Spotlite counts yielded many fewer deer per census than either morning or evening roadside censuses. In addition, the inability to confidently sex and age deer on spotlite counts eliminated valuable information.

The standard 4.2 km census route shown in Figure 2.1.2 was sampled in the early morning and in the evening throughout each field season. The route was always censused from south to north. Morning censuses began within 30 minutes after sunrise. Earlier starts within this time frame did not necessarily increase the number of deer observed. Little Cottonwood Canyon (Fig. 2.1.2) was in shadow, which reduced visibility of deer, until approximately 1.5 hours after sunrise. The important consideration was to complete the censuses within two hours of sunrise. Similarly, evening censuses were begun no sooner than two hours before sunset. Deer were less active and therefore less visible before this.

Additional censuses on the standard route, censuses on spur roads off the main census route, and walking censuses in the wilderness area of the monument and in inaccessible portions of the north end of the monument supplemented the standard censuses. All deer seen were classed as adult males,

yearling males, females, fawns, or unknown. All sex ratios were expressed as males:females. The unknown category only accounted for 7.0 percent of 13,271 classifications during the three years. As a result, unknowns were excluded from sex and age ratio calculations. Based on age determinations of hunter killed deer, all two point and spike antlered males were classed as yearlings; all other males were considered to be adults. Only in 1982 did any known 2.5 year old male have two point antlers. These antlers were large, however, and small antlered yearling males could still be distinguished in classification counts.

In May and June 1980, in April-June 1981, and in May and June 1982, females were further classified as yearlings or adults based on body size and the ratio of ear length to lower jaw length. Deer with ears longer than the lower jaw were classed as yearlings; deer with lower jaw longer than the ear were classed as adults. From 1 July onward, it became difficult to separate growing yearling females from adults and the two were classed only as females.

Prior to antler development in early spring, many yearlings could not be sexed, particularly in 1981. Yearling sex ratios determined later in the spring were used to apportion the yearling deer of unknown sex to the appropriate class.

In addition to standard and supplemental censuses one helicopter census was conducted in the fall of 1980 and 1981. The 1980 flight (1.5 hours, 19 September) covered the area from Big Cinder Butte northward and the 1981 flight (1.5 hours, 30 September) commenced at The Watchman and The Sentinel and proceeded northward including the same area sampled in 1980.

### 3.3 Population Estimates

A mark-recapture population estimator (Schumacher and Eschmeyer 1943, Caughley 1973, Overton 1969) was used in this study (Appendix B). In the method, a known number of animals are captured from a population, marked in some unique manner, and released. The percentage of marked animals seen in

subsequent samples is assumed to represent the percentage of the total population seen in those samples. A number of samples may be taken and averaged to obtain a population estimate and establish a confidence limit. Strandgaard (1967) reported that the mark-recapture technique was not a reliable population estimator for roe deer (Capreolus capreolus) in a forest environment unless about two-thirds of the animals were marked. His data, however, show that once 10-15 percent of the herd was marked, the confidence interval of all subsequent estimates, with an increasing proportion of marked deer, overlapped one another. This suggested that marking 10-15 percent of the herd may be sufficient. Experience gained in this study supported this concept. Highly variable estimates were obtained in 1980 when only 7.1 percent of the yearling and adult females were marked. In 1981 and 1982, with 15.5 and 27.1 percent of the does marked, population estimates were more consistent (Appendix B).

Only the yearling and adult female segment of the population was directly estimated from mark-recapture data because fawns and males were not marked in proportion to their occurrence in the population in any year (Table 3.3.1). It is possible to use a stratified mark-recapture estimator to account for disproportionate marking (Overton 1969). The number of males and fawns with large tags and streamers was judged too small to be of value and a stratified estimator was not used.

Four assumptions are implied in the use of the Schumacher and Eschmeyer (1943) technique (Caughley 1973):

1) The population size is constant during the period of study.
2) There is no death or emigration.
3) There is no birth or immigration.
4) Marked and unmarked animals in the population are equally likely to be seen on subsequent samples.

By restricting population estimates to the mid-August to late September period the first 3 assumptions were basically satisfied. Mid-summer migration into the sample area was

TABLE 3.3.1 Sex and age distribution of marked mule deer and existing population, Craters of the Moon National Monument, Idaho, 1980-1982.

| | | PERCENT IN SEX AND AGE CLASS | | | | |
|---|---|---|---|---|---|---|
| YEAR | SAMPLE | FEMALES[a] | YEARLING MALES | ADULT MALES | FAWNS | TOTAL NUMBER |
| 1980 | Marked deer | 39.4 | 6.1 | 0 | 54.5 | 33 |
| | Existing[b] population | 38.3 | 7.3 | 9.2 | 45.2 | 478 |
| 1981 | Marked deer | 57.4 | 16.4 | 1.6 | 24.6 | 61 |
| | Existing population | 43.9 | 10.5 | 10.7 | 35.0 | 515 |
| 1982 | Marked deer | 63.9 | 4.9 | 8.2 | 23.0 | 61 |
| | Existing population | 41.0 | 9.1 | 11.4 | 38.5 | 351 |

a Includes adults and yearlings.
b Fall pre-hunt population.

complete, hunting mortality had not reduced the population, and mortality of adult deer could reasonably be assumed to be negligible. Over the course of three years only eight yearling and adult females were killed by vehicles from the time of marking until the population estimate was complete. Up to 35 percent of yearling females may disperse by the time they reach 16 months of age (Robinette 1966). If dispersal of this magnitude occurred at Craters, there would have been an average loss of 10 percent of all females from marking until the population estimate. This would have caused an overestimate of population size. Assumed equal dispersal of marked and unmarked yearlings would have tended to negate this bias. Only

yearling and adult female deer with large tags and streamers were used for population estimates and none of these deer lost enough marks tags to render it untagged.

The Schumacher and Eschmeyer (1943) method allows a verification of the fourth assumption. Regression of the proportion of all deer seen on a sample that were marked against the total number of deer marked and potentially observable at each sample should be linear through the origin with a slope equal to the reciprocal of estimated population size if the assumption is met. The calculated regression indicated the assumption was satisfactorally met (n=43, r=0.463). The 95 percent confidence interval on the slope of the regression line overlapped the reciprocal of the estimated average population size.

Samples for population estimates were collected on the standard roadside census route and included the helicopter census in 1980. The total population was estimated by adding an appropriate number of fawns, yearling males, and adult males to the female population as estimated from mark-recapture data. The addition was based on classification ratios. The classification ratio used for fawns was the mean of August-November ratios for 1980 and 1981. Due to insufficient sampling in late August and no sampling in November 1982, the mean of September and October was used for 1982. The classification ratio used for yearling males was the mean of all early morning standard censuses in 1980 and 1981. In 1982, the October classification ratio was used. These conventions gave the highest yearling male:doe ratios obtainable. The highest ratio was used because yearling males are suspected of being underestimated in routine classification counts (Connolly 1981).

The 1980-82 trend in average total number of deer observed on standard censuses, average number of females seen on standard censuses, mark-recapture population estimates, documented hunter kills, documented road kills, and helicopter censuses were compared to verify consistency between techniques.

3.4 Area Utilization

Area utilization of Craters mule deer was determined from analysis of relocations of the 100 uniquely marked deer. During the course of the study these deer provided 21,475 marked-deer-days and yielded 2381 relocations (Appendix A). On the average a marked deer was relocated once every 8.9 days. Individuals varied widely from this average. Nine fawns with small ear tags and two adult does with large tags and streamers were marked and never relocated; others were relocated almost daily.

Radio-collared deer were located more frequently than non-collared deer. Collared deer accounted for only 16.7 percent of all marked deer days but provided 50.8 percent of all relocations. An attempt was made to locate collared deer at least every other day. In actuality, the frequency of relocation varied from twice a day to once in 10 days. Less frequent relocations were generally confined to deer using the wilderness area, particularly those using the southern reaches of the wilderness. On the average collared deer were located once every 2.9 days during the time their collars were functional.

The precision of radio telemetry relocations of collared deer was subject to constraints peculiar to the study area and associated logistical problems. For example, the dissected nature of topography and signal blocking ridges allowed telemetry relocations to be assigned to specific draws in the north end with ease. The elevation within a draw could not be accurately determined without climbing the draw, a process that could take two hours per collared deer. Similarly, use of signal blocking ridges, and assuming deer were in vegetated areas rather than on barren lava flows, allowed wilderness relocations to be assigned to a particular exposure of a butte. To obtain a 90 degree intersecting bearing would often require walking several miles across rough lava fields. In practice either few precise relocations or many less precise relocations could be obtained in a given amount of time.

The strategy of obtaining many less precise locations was chosen for this study. Each observation of a marked animal or telemetry relocation was assigned to one of 121 sectors. The sector boundaries delineated small draws or other relatively small scale physiographic features such as the north side of a butte or a vegetated area surrounded by barren lava. Size of sectors varied from approximately 0.5 km to 9.5 km and averaged 0.8 km . Minimum convex polygon home ranges (Harvey and Barbour 1965) were delineated by assuming that deer were located in the center of the sector at each relocation and connecting the outside points. Separate home ranges were constructed for both northern and southern portions of the monument because there was temporally distinct use of the two areas. Although the relatively large size of the sectors precluded precise specification of home range size, it allowed attainment of study objectives.

A sequential tabulation of all relocations was made for each marked deer. From this, home range, season of area use, and movement patterns were summarized. The daily pattern of area use by deer which were frequently relocated was used to infer the basic pattern of deer which were relocated less often.

Winter range areas of marked deer were determined from sightings, radio relocations, and reports received through Bureau of Land Management (BLM) and Idaho Fish and Game (IFG) offices.

### 3.5 Mortality Estimates

Deer mortality was documented during each year. Rewards were offered for the return of the tags of any marked deer and the rewards were advertized in regional newspapers and through other government agencies. Daily NPS highway litter patrols during the summer season (June-August) found road kills and notified research personnel. Outside these months, daily ranger patrols located road kills. During hunting seasons a concerted effort was made to document all deer taken by hunters around the periphery of the north end of the monument where

most hunting pressure occurred. Daily patrols were made, hunters contacted, and reports of killed deer investigated. Other dead deer found during the study were classed as either dying from unknown or natural causes. Whenever possible dead deer were sexed, a necropsy performed, body condition rated (Kistner et al. 1980), a jaw collected for age estimation, and pellet groups collected. Over winter mortality was estimated from the year to year change in classification ratios and the year to year change in the population of marked deer. All fawns associated with hunter killed or winter killed does were assumed to leave the population either through death or dispersal. The assumed winter loss of orphaned fawns or fawns of winter killed does was calculated as the estimated number of does lost times the mean fawn:doe ratio for the previous fall.

3.6 Production and Recruitment

Initial production was the number of fawns born per adult female. In 1980 this was estimated from the maximum number of fawns trailing 11 marked adult females during the summer. Adult females were those which were two years old on June first of the year being studied. Since the maximum and minimum number of fawns observed trailing marked adult does did not differ in 1981 or 1982, this method could not be used to estimate initial production in these two years.

Net production in the fall was the number of fawns per adult female surviving to the August-November period in 1980 and 1981. Because late August and November field sampling was not conducted in 1982, net fall production was estimated as the number of fawns per adult female surviving to September/October in that year. Data from each month in the appropriate period each year were combined as there was no significant difference in ratios between months. The number of fawns per adult female in fall was derived from the mean fawn:doe ratio each year. The percent of does which were adult was estimated from spring classification ratios, and fall fawn:adult doe ratios were then estimated as (number of fawns per doe) / (proportion of does which were adult).

This convention assumed no differential mortality between yearling and adult females during the summer and no dispersal of yearling females from spring to fall. The first assumption probably held but the second may not have held. Robinette (1966) has reported dispersal of 35 percent of female mule deer during their second summer in Utah. Net fall production would be overestimated if yearling dispersal occurred. Dispersal of does older than yearlings, also reported by Robinette (1966), would tend to counteract this effect. Data presented subsequently in this report suggests average yearling male dispersal rates of 21 percent at Craters of the Moon. Robinette (1966) suggested that yearling females may disperse 58 percent as frequently as yearling males. In such a case the degree of inflation in net fall productivity estimates caused by yearling female dispersal would have averaged less than five percent. This was a relatively insignificant bias, especially if dispersal of does older than yearlings counteracted some of the effect.

Recruitment (net production of yearlings) is the most biologically relevant measure of productivity and in this report is defined as the ratio of the number of female young reaching sexual maturity (one year old) to the number of females which produced them. This convention was chosen because the female segment of the population is the key to population dynamics in polygamous ungulates. Recruitment is often expressed as the ratio of yearling females to adult females in the spring. This convention consistently underestimates recruitment because adult females in the spring include a variable component of two year olds which did not produce fawns the previous year. An accurate estimate of recruitment requires knowledge of the proportion of three year old and older females in the spring female population. Recruitment was therefore estimated as (yearlings:adult doe in spring) X (proportion of yearlings that were female) X (1-proportion of females that were yearlings the previous spring). This convention also assumed no differential mortality or

dispersal of yearling females. If female yearlings dispersed, the equation used would have underestimated recruitment.

3.7 Forage Moisture

The percent water in living vegetation was estimated from 18 June through 13 October, 1982. Primary samples were collected between 1400 and 1500 MDT. Supplemental samples were collected at dawn. The sampling site (Fig. 2.1.2) was at 1790 m elevation with an eastern exposure. Bitterbrush and gray rabbitbrush dominated the site. Samples were taken from bitterbrush, Thurber's needle and thread grass (Stipa thurberiana), bottlebrush squirreltail (Sitanion hystrix), and desert parsley (Cymopterus terrebinthinus). Enough material was collected to fill a one liter airtight plastic container with each species on each occasion. Material was collected from at least four plants for each species. Only current year's growth of bitterbrush was collected. Samples from all aspects of each bitterbrush plant were included in each sample. Grasses were clipped at three cm above ground level and samples included seed heads. Desert parsley was also clipped at three cm above ground level. Containers with fresh material were weighed to the nearest .01 g within one hour. The container lids were then removed and the material dried at 60-65 °C for 48 hours in a convection oven. Containers with dry contents were then reweighed, dry material removed and the containers weighed. Weights of fresh and dry materials were obtained by subtraction and percent water was expressed as:

(fresh weight - dry weight) / (fresh weight)

Regression procedures were used to describe change in percent water over the season.

3.8 Weather Variables

Daily temperature, precipitation, and 10-hour fuel moisture values were obtained from a NPS operated weather station located at the visitor center. In 1982, two sheltered

recording hygrothermographs were operated between 8 July and 16 October. One was located at the fire weather station and another at the forage moisture sampling site. At the end of the study the hygrothermographs were cross-calibrated during a one-week cycle when they were situated within one m of each other.

### 3.9 Food Habits

Monthly food habits were determined from micro-histological analysis of fecal pellets. The work was performed by the Composition and Analysis Laboratory, Colorado State University, using techniques described by Sparks and Malechek (1968). Samples from each month were pooled across years to yield sufficient sample sizes for each month. Sufficient pellet groups were available for the month of June in both 1980 and 1982 to allow that month to be compared between years. Each sample consisted of 10 pellets taken from a fresh group. Fresh pellets were those with a mucous coating detectable by hand. Samples for May-July and October-November were collected in central and wilderness areas; samples for August and September were collected in the north end reflecting the distribution of deer in these months.

The samples for each month were combined and homogenized. Five slides were prepared for each month and 20 fields read per slide yielding 100 data fields per month. Results were expressed as percent relative density which is roughly equivalent to percent dry weight (Sparks and Malecheck 1968). Forbs are probably under represented in the results as has been noted by Anthony and Smith (1974), Vavra et al. (1978), and Leslie (1982).

## 4.0 RESULTS

### 4.1 Food Habits

#### 4.1.1 Summer Range

The composition of Rocky Mountain mule deer diets in spring and summer is variable across the western United States.

Kufeld et al. (1973) summarized results of 17 spring and 16 summer studies from Montana, Colorado, California, and Arizona. In spring, shrubs averaged 48.9 (range 6-92) percent, forbs averaged 24.6 (range 0-43) percent and grasses averaged 26.3 (range 4-64) percent of the diet. In summer, percent of diet averaged 49.1 (range 19-94) for shrubs, 46.4 (range 3-77) for forbs, and 3.2 (range 0-11) for grasses.

Based on frequency and volumetric analysis of rumen samples from 11 deer collected between May and October, Ritchie (1968) found shrubs to be the most important food class of Craters deer. During 1980-1982, shrubs were the predominant forage class used by Craters deer in all months (Table 4.1.1, Fig. 4.1.1). Lowest shrub use (79.5 percent of diet) occurred in May and the proportion of shrubs in the diet gradually increased to 95.5 percent in October/November. Bitterbrush was the most important shrub throughout the summer and was rivaled only by currant (Ribes sp.) in May and June. Grasses approached 10 percent of the diet in May but accounted for less than one percent in all other months. Forbs were most important in May, June, and July, but even then only accounted for an average of 14.3 percent of the diet. Thereafter, forbs averaged only 5.7 percent of the diet.

Craters deer thus used a greater proportion of shrubs and a lower proportion grasses and forbs throughout spring and summer seasons than reported for the average Rocky Mountain mule deer (Kufeld et al. 1973). Of all forages, browse best meets the nutrient requirements for gestation and lactation for cattle and sheep under range conditions in terms of digestible protein, phosphorus, and carotene (vitamin A) (Cook et al. 1977). Bitterbrush reaches a maximum in percent protein and 10 other nutrients in spring and summer (Short et al. 1966) and although browse does not meet all of the energy requirements for gestation and lactation, energy is probably not limiting in summer (Cook et al. 1977). In view of White's (1978) proposal that the single most important factor limiting herbivore abundance is relative shortage of nitrogenous food the emphasis on browse as a diet item for Craters deer is not surprising.

TABLE 4.1.1 Mean percent relative density ($\bar{x}$) and standard error (se) of discerned plant fragments from mule deer fecal samples collected on Craters of the Moon National Monument, Idaho, 1980-1982. Mean value based on 100 fields per sample.

| SPECIES | PERCENT RELATIVE DENSITY OF DISCERNED PLANT FRAGMENTS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MAY 1980 - 1982 | | JUNE 1980 | | JUNE 1982 | | JULY 1980 - 1982 | | AUGUST 1980 - 1982 | | SEPTEMBER 1980 - 1982 | | OCTOBER & NOVEMBER 1980 - 1982 | |
| | $\bar{x}$ | se | $\bar{x}$ | se | $\bar{x}$ | se | $\bar{x}$ | se | $\bar{x}$ | se | $\bar{x}$ | se | $\bar{x}$ | se |
| SHRUBS: | | | | | | | | | | | | | | |
| Amelanchier alnifolia | 3.40 | 0.84 | 0.79 | 0.25 | 1.32 | 0.21 | | | 1.17 | 0.68 | | | | |
| Artemesia | 1.76 | 0.51 | 1.40 | 0.06 | 1.32 | 0.21 | 1.11 | 0.24 | | | 0.97 | 0.20 | 2.30 | 0.16 |
| Chrysothamnus nauseosus | 0.80 | 0.57 | 0.28 | 0.14 | | | 0.35 | 0.17 | | | | | 0.28 | 0.15 |
| Ribes | 30.42 | 5.62 | 23.38 | 2.03 | 42.76 | 1.98 | 4.29 | 0.78 | 1.82 | 0.69 | 1.71 | 0.61 | | |
| Populus | | | | | | | | | 0.31 | 0.18 | | | | |
| Prunus | | | | | | | | | 1.49 | 0.66 | 0.33 | 0.16 | 0.27 | 0.14 |
| Purshia tridentata | 41.49 | 1.74 | 55.78 | 2.06 | 35.29 | 1.94 | 79.53 | 2.08 | 85.71 | 4.05 | 89.26 | 0.71 | 92.12 | 0.40 |
| Salix | 1.65 | 1.16 | | | | | | | | | 0.26 | 0.12 | | |
| Symphoricarpos | | | | | | | | | 3.21 | 1.35 | 0.90 | 0.30 | | |
| SHRUB TOTAL | 79.52 | | 81.63 | | 80.69 | | 85.28 | | 93.71 | | 93.43 | | 94.97 | |
| GRASSES: | | | | | | | | | | | | | | |
| Agropyron | 8.67 | 5.08 | | | | | | | | | | | | |
| Festuca | | | | | 0.38 | 0.15 | | | 0.32 | 0.19 | | | | |
| Poa | | | | | 0.90 | 0.21 | | | 0.28 | 0.17 | | | | |
| Stipa | 0.63 | 0.45 | | | | | 0.37 | 0.18 | | | | | 0.32 | 0.17 |
| GRASS TOTAL | 9.30 | | 0 | | 1.28 | | 0.37 | | 0.60 | | 0 | | 0.32 | |
| FORBS: | | | | | | | | | | | | | | |
| Arabis | | | 0.85 | 0.29 | 0.43 | 0.17 | | | | | | | 0.58 | 0.19 |
| Astragalus | 1.38 | 0.61 | | | | | | | | | | | | |
| Balsamorhiza | | | | | | | | | | | 0.39 | 0.19 | | |
| Compositae | | | | | | | | | | | | | 0.31 | 0.16 |
| Cryptantha | | | | | | | | | | | | | 0.59 | 0.19 |
| Descurainia | | | | | | | | | | | 1.55 | 0.25 | | |
| Eriogonum | 8.70 | 1.76 | 17.31 | 1.11 | 17.60 | 0.95 | 11.31 | 1.28 | | | | | 0.95 | 0.33 |
| Lupinus | | | | | | | 2.69 | 0.14 | 5.69 | 1.14 | 4.37 | 0.80 | 1.74 | 0.36 |
| Mentzelia | | | 0.21 | 0.11 | | | | | | | | | | |
| Phlox | 0.55 | 0.39 | | | | | | | | | | | | |
| FORB TOTAL | 10.63 | | 18.37 | | 18.03 | | 14.0 | | 5.69 | | 6.31 | | 4.17 | |
| OTHER: | | | | | | | | | | | | | | |
| Pinus | 0.55 | 0.39 | | | | | | | | | | | | |
| Opuntia | | | | | | | | | | | | | 0.27 | 0.14 |
| Seed | | | | | | | 0.35 | 0.17 | | | | | | |
| Number of pellet groups in sample | 10 | | 20 | | 34 | | 20 | | 15 | | 22 | | 18 | |

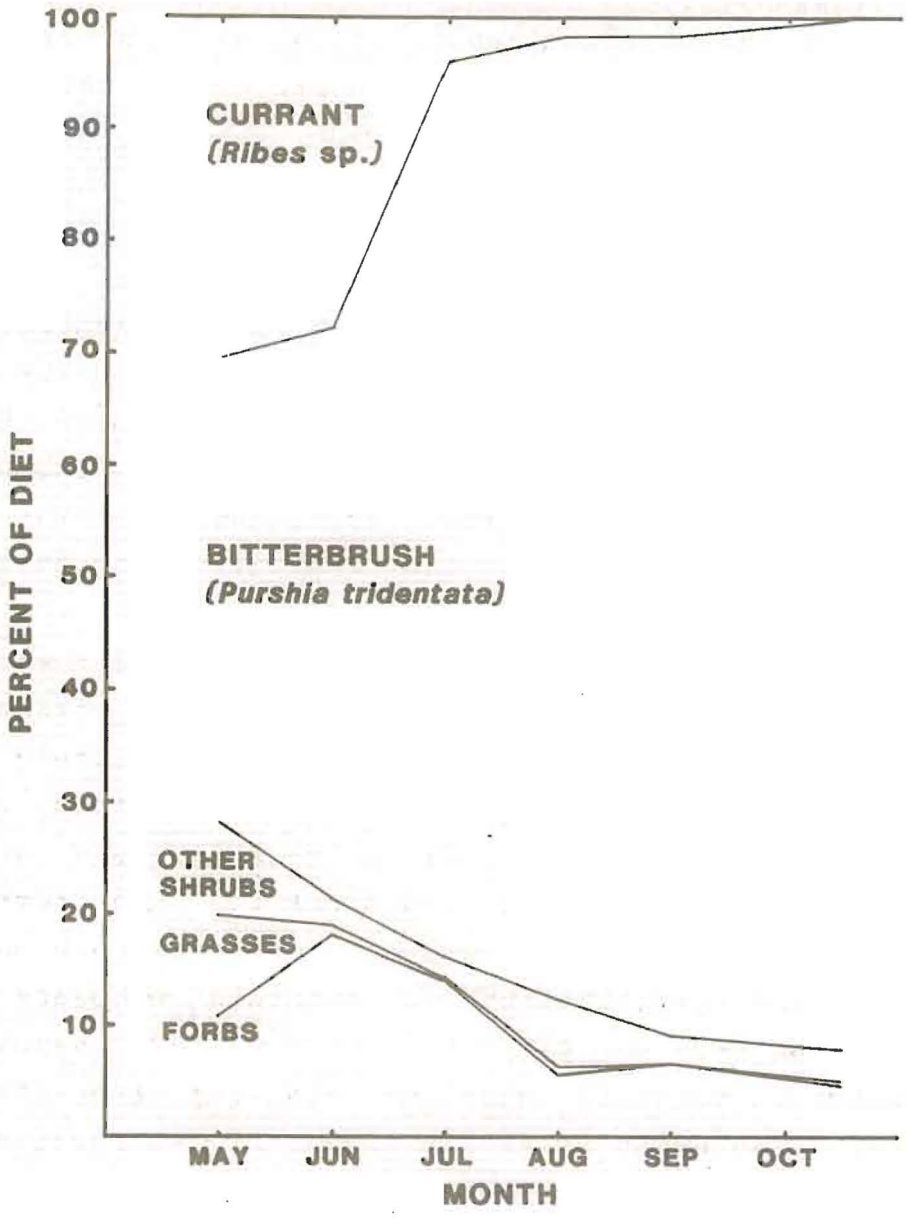



**Figure 4.1.1 Seasonal diet of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.**

Craters deer are able to emphasize bitterbrush as a diet item because it is so abundant and in excellent condition. Both these properties probably reflect the long term absence of domestic livestock from the monument.

4.1.2 Winter Range

No winter range food habits data were available for Craters deer using areas immediately north of the Snake River.

In the mild winter of 1979-1980, fecal pellets were collected on the Appendicitis Hill winter range in November, December, February, and March (McCarty 1982). This is the period of major use of the area as winter range. The fecal pellets were analyzed for the BLM by the Composition and Analysis Laboratory of Colcrado State University using micro-histological methods described by Sparks and Malechek (1968). The data, reproduced with permission in Table 4.1.2, showed that shrubs were the most important component of the winter diet. Mountain mahogany was most important followed by big sagebrush and bitterbrush.

Shrub use on Appendicitis Hill (McCarty 1982) was higher than the average of 73.1 percent (range 27-100) obtained from 26 studies of winter food habits reported by Kufeld et al. (1973). The BLM data showed that use of mountain mahogany decreased noticeably in March, bitterbrush use was quite low throughout the winter, and big sagebrush was used increasingly throughout the winter. Increased use of sagebrush may have reflected reduced availability of mountain mahogany due to depletion of the forage. Carpenter et al. (1979) hypothesized that sagebrush is taken in quantity only when alternate forage is exhausted. Sagebrush is highly digestible (Carpenter et al. 1979, Wallmo et al. 1977), but contains essential oils which may impair digestability of cellulose (Nagy et al. 1964). Powell (1970) observed lower oil content in dormant sage in spring and Carpenter et al. (1979) suggested that deer may adjust to oil content and be able to select sagebrush with low oil content. Thus, the influence of a high proportion of sagebrush in the winter diet of Craters deer in March is not

TABLE 4.1.2 Percent relative density of discerned plant fragments in fecal pellets of mule deer, Appendicitis Hill, Butte County, Idaho, 1979-1980 (McCarty 1982)[a].

| SPECIES | PERCENT RELATIVE DENSITY NOVEMBER | DECEMBER | FEBRUARY | MARCH |
|---|---|---|---|---|
| Mountain mahogany | 79.5 | 58.2 | 70.7 | 19.0 |
| Bitterbrush | 5.5 | 14.3 | 2.0 | 5.5 |
| Big sagebrush | 9.0 | 14.9 | 25.3 | 72.5 |
| Forbs | 5.0 | 10.0 | 1.0 | 2.0 |
| Grasses | Trace | 0.25 | Trace | 0.5 |
| NUMBER OF SAMPLES | 2 | 8 | 3 | 2 |

a Data reproduced with permission of Idaho Falls District Office, Bureau of Land Management, Idaho Falls, Idaho.

clear. Carpenter et al. (1979) found weight reductions in deer consuming more than 30 percent sagebrush. However, the high yearling:doe ratio and high fawn production of Craters deer the following year suggests that it was not particularly detrimental.

## 4.2 Area Utilization

Deer generally arrived at Craters in April and remained until they returned to winter range during late November or early December. By 23 April 1980, backpackers had reported deer from as far south as The Watchman. On 18 April 1981, an ear tagged doe (YGYP) and her ear tagged fawn (YPYG), both marked on the Monument in 1980, were observed crossing the highway north to south, near the visitor center. During 1982, fresh deer tracks were first observed in the north end in early April. In 1983, deer did not return to the monument until the first week of May.

Winter relocations of deer marked during the previous summer have shown that deer which summered on the monument came from at least two separate winter ranges. One winter range was approximately 35 km to the north-northeast in the Big Rocky Canyon area of Appendicitis Hill (Fig. 2.1.1). Ritchie (1968) first identified this winter range when he found marked Craters deer in this canyon. In February of 1981 and 1982, deer marked during the summers of 1980 and 1981 at Craters were found in the same canyon. Of the eight marked yearling or adult deer which were located on winter ranges in 1981, five were on Appendicitis Hill. A second winter range was first identified for the Craters herd in 1981 and confirmed during 1982. The area was approximately 70-100 km south-southwest of the monument along a broad front which extended from Ranges 19E through 27E and encompassed Townships 6 through 9 south (Fig. 2.1.1). Three of the eight marked deer located on winter ranges in February and March 1981 were found in this area. In February and March of 1982, marked deer were seen near farms in the vicinity of Eden for the first time. The severe winter of 1981-1982 may have forced deer further south than during the previous winter.

During April through July, deer on the monument were dispersed throughout the north end and the central and wilderness areas in vegetated areas. In the central and wilderness portions of the monument, deer were most commonly seen in the vicinity of cinder cones and limber pine stands. These areas provided excellent protection from the sun and wind and in general had excellent stands of bitterbrush nearby. In the north end, concentration areas were not as evident. As determined from walking surveys, deer density along a north-south gradient in the monument was fairly uniform during April-July. Based on the percent of total deer habitat (vegetated areas with greater than 20 percent cover) in the north end, central, and wilderness areas, this suggested that from April through July approximately 20 percent of the deer were in the north end, 10 percent were in the central area, and 70 percent were in the wilderness.

Analysis of relocations of deer which were tagged during April through July in 1981 and 1982 supported this pattern of spring distribution. Only females one year old and older which had been marked the previous year were considered. This insured that deer were marked during the entire spring/early summer period. Of 32 such does with large ear tags, eight were seen only in the north end indicating that 25 percent of the herd did not use central or wilderness areas. The difference between this estimate and the one based on percent of total Craters deer habitat in the north end (20 percent) was slight. Any use of habitat outside the monument boundary would have increased the proportion of north end habitat compared to the total. Observations of marked deer confirmed that the Craters herd used areas outside the north end boundaries during spring, early summer, and fall. Marked deer were seen outside the boundaries east of the Quick Shot area, in the aspen draws on the northeast side of the Poineer Mountains, in the shrub flats northeast of the Pioneer Mountains, and in the draws on the northwest flank of the Pioneer Mountains. Marked Craters deer were killed by hunters in each of these areas except the aspen draws on the northeast side of the Pioneer Mountains.

Most deer in the vicinity of the monument, whether marked or not, appeared to be concentrated within the monument boundaries. On a helicopter census conducted in late September of 1980, only 21 percent of all deer seen were outside the boundaries even though approximately 34 percent of the total area sampled was outside the boundary. On a similar flight in 1981 only four percent of deer were seen outside the boundary while 28 percent of the sample area was outside the boundary. The concentration of deer within the monument was best exemplified by the rate of deer observation on a single helicopter flight conducted on both BLM and NPS lands in September 1980. During 1.5 hours over BLM lands adjacent to the monument, deer were seen at the rate of 23 per hour. During 0.25 hours on the monument, deer were seen at the rate of 232 per hour.

Once on the monument, deer established home ranges as is

typical for migratory deer (Gruell and Papez 1963, Leckenby 1971, Zalunardo 1965). Two home range patterns were evident at Craters. Sedentary deer established home ranges in the north end and remained there from April through November. Mid-summer migrants established spring home ranges in central and wilderness areas, migrated to the north end in the hottest and driest part of the year, then returned to central and wilderness home ranges in the fall. There was reasonable fidelity of deer to the same home ranges from year to year among both mid-summer migrants (Figs. 4.2.1 through 4.2.4) and sedentary north end residents (Fig. 4.2.5). Relocations of other marked deer supported this concept. The home ranges shown (Figs. 4.2.1 through 4.2.5) are examples.

The character of year to year home range use for doe YYYY departed somewhat from that observed for adult females. As a radio collared yearling in 1981, YYYY used an extensive area in the north end (Fig. 4.2.1). In 1982, as a two year old with her first fawn, she restricted her home range to one corner of the area used the previous year (Fig. 4.2.1). Ozoga and Verme (1982) have noted that two year old white-tailed deer (Odocoileus virginanus) does in Michigan established ranges adjacent to that of their mothers when having their first fawn. A similar phenomenon may have been displayed by deer YYYY.

Deer which occupied central and wilderness areas in spring and summer generally used the same areas from year to year (Figs. 4.2.1 through 4.2.4). Since relocations in the wilderness were obtained less frequently than in the north end, some apparent variance in year to year home range use may reflect sampling variation (Fig. 4.2.3).

Deer in central and wilderness portions of the monument remained on their home ranges through late July, then migrated 8-15 km northward and established new home ranges (Figs. 4.2.1 through 4.2.4) in the north end. This migration occurred in each year of the study. The new north end home ranges overlapped and were of similar size as those of sedentary north end residents (Fig. 4.2.5) and the mid-summer migrants showed year to year fidelity to north end home ranges (Figs. 4.2.1

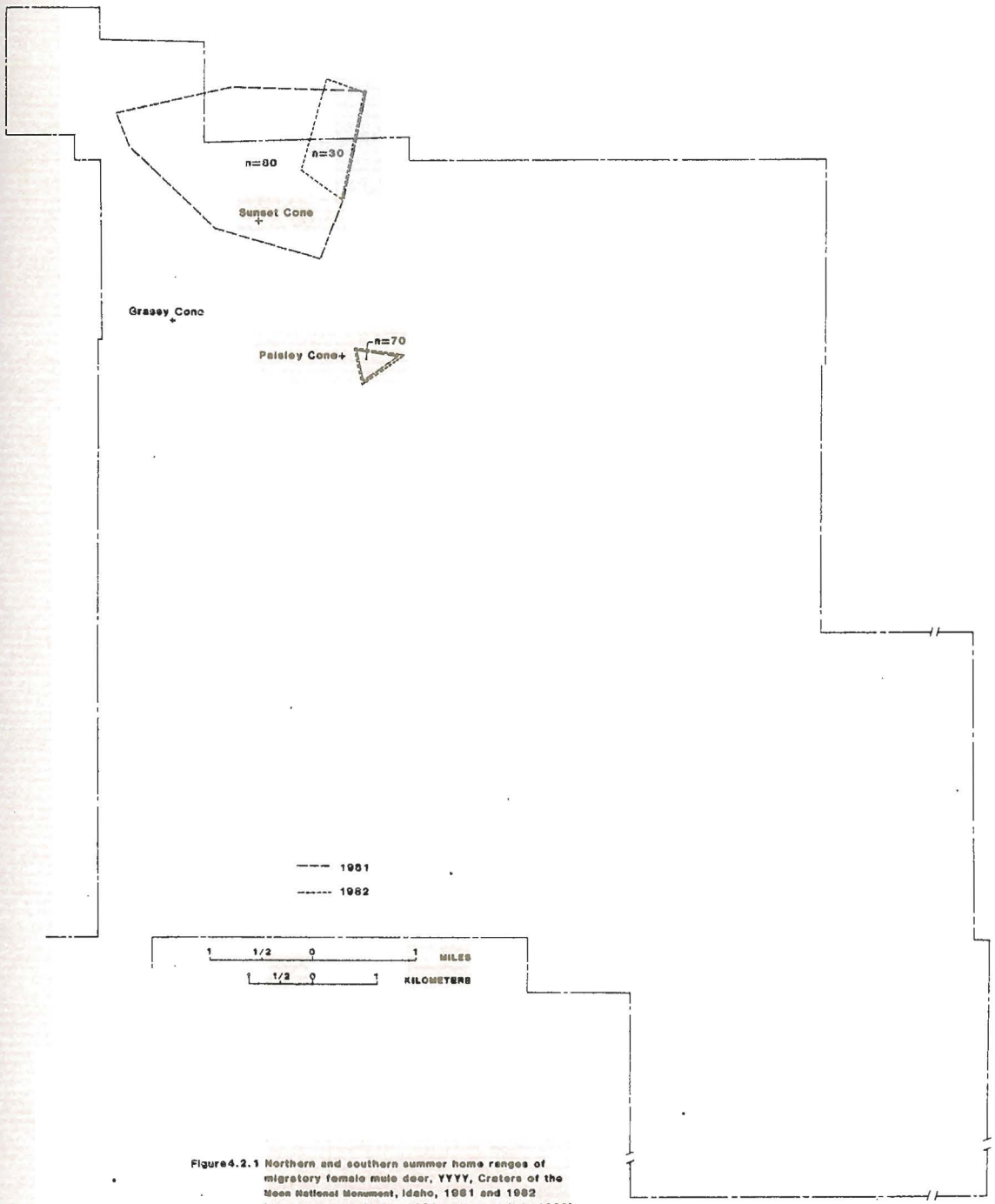



Figure4.2.1 Northern and southern summer home ranges of migratory female mule deer, YYYY, Craters of the Moon National Monument, Idaho, 1961 and 1962 (deer was a yearling in 1961 and an adult in 1962).

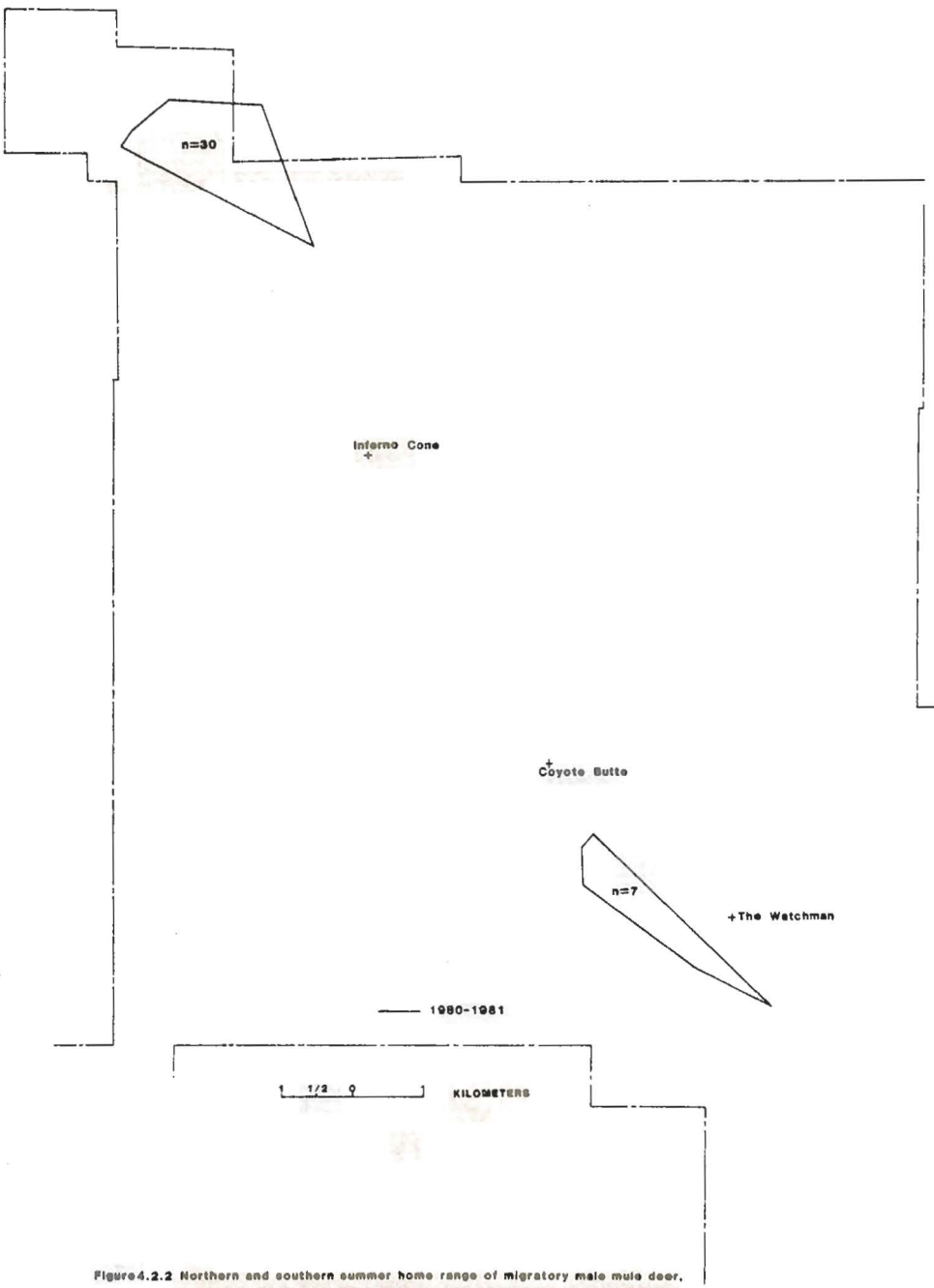



Figure4.2.2 Northern and southern summer home range of migratory male mule deer, YGYC, Craters of the Moon National Monument, Idaho, 1980-1981. (Deer was a yearling in 1980 and an adult in 1981).

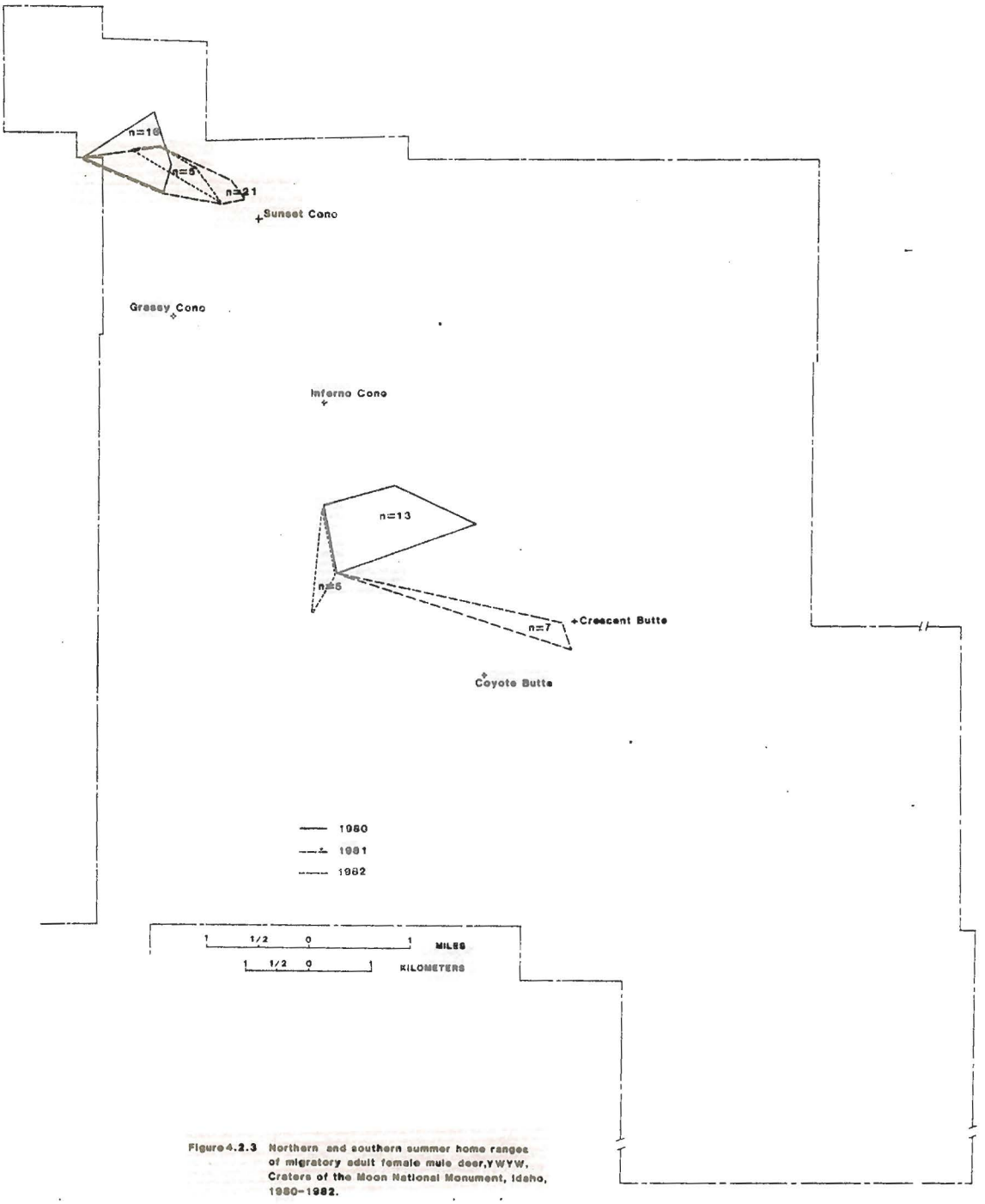



Figure 4.2.3 Northern and southern summer home ranges of migratory adult female mule deer, YWYW, Craters of the Moon National Monument, Idaho, 1980-1982.

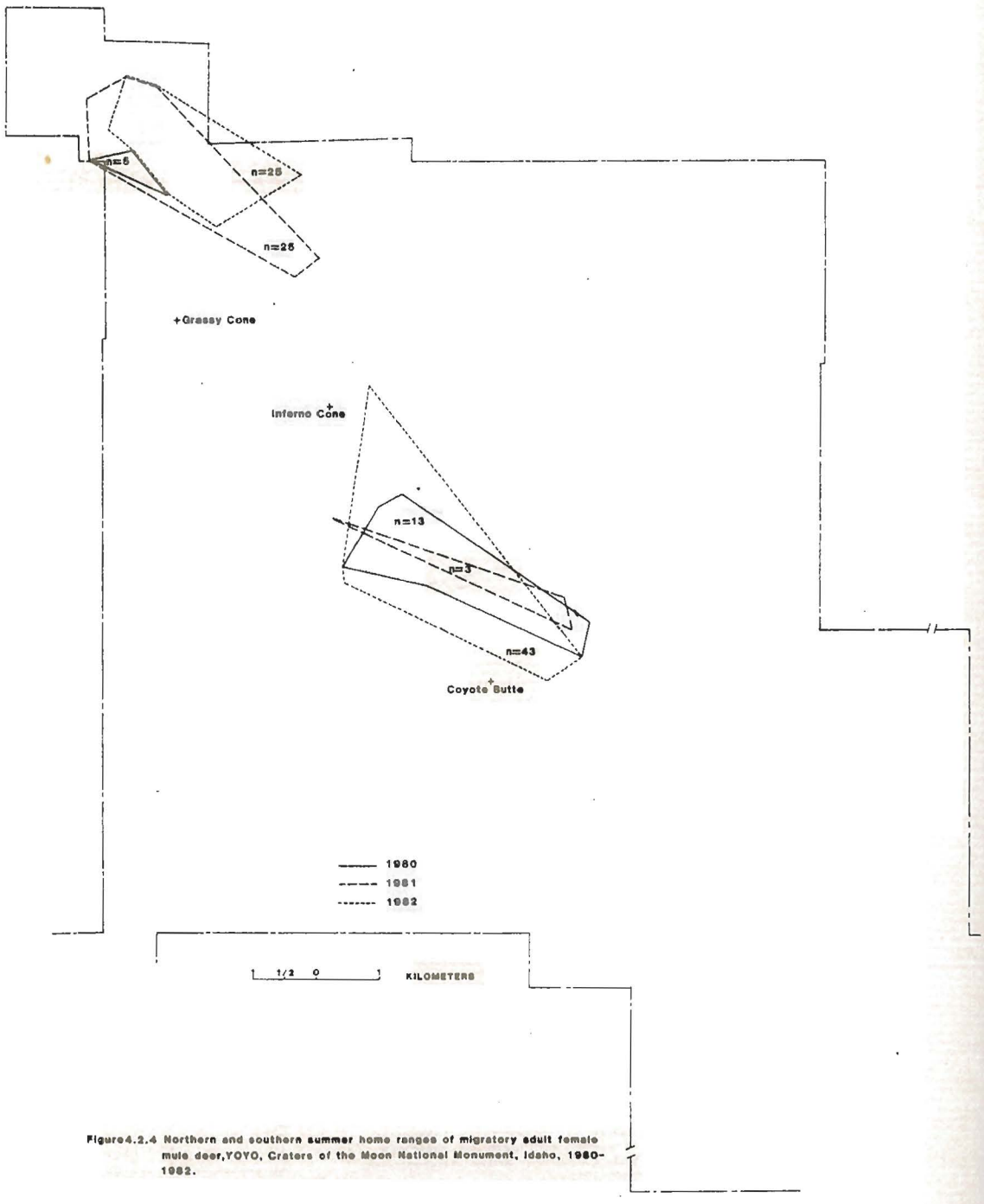



Figure4.2.4 Northern and southern summer home ranges of migratory adult female mule deer,YOYO, Craters of the Moon National Monument, Idaho, 1980-1982.

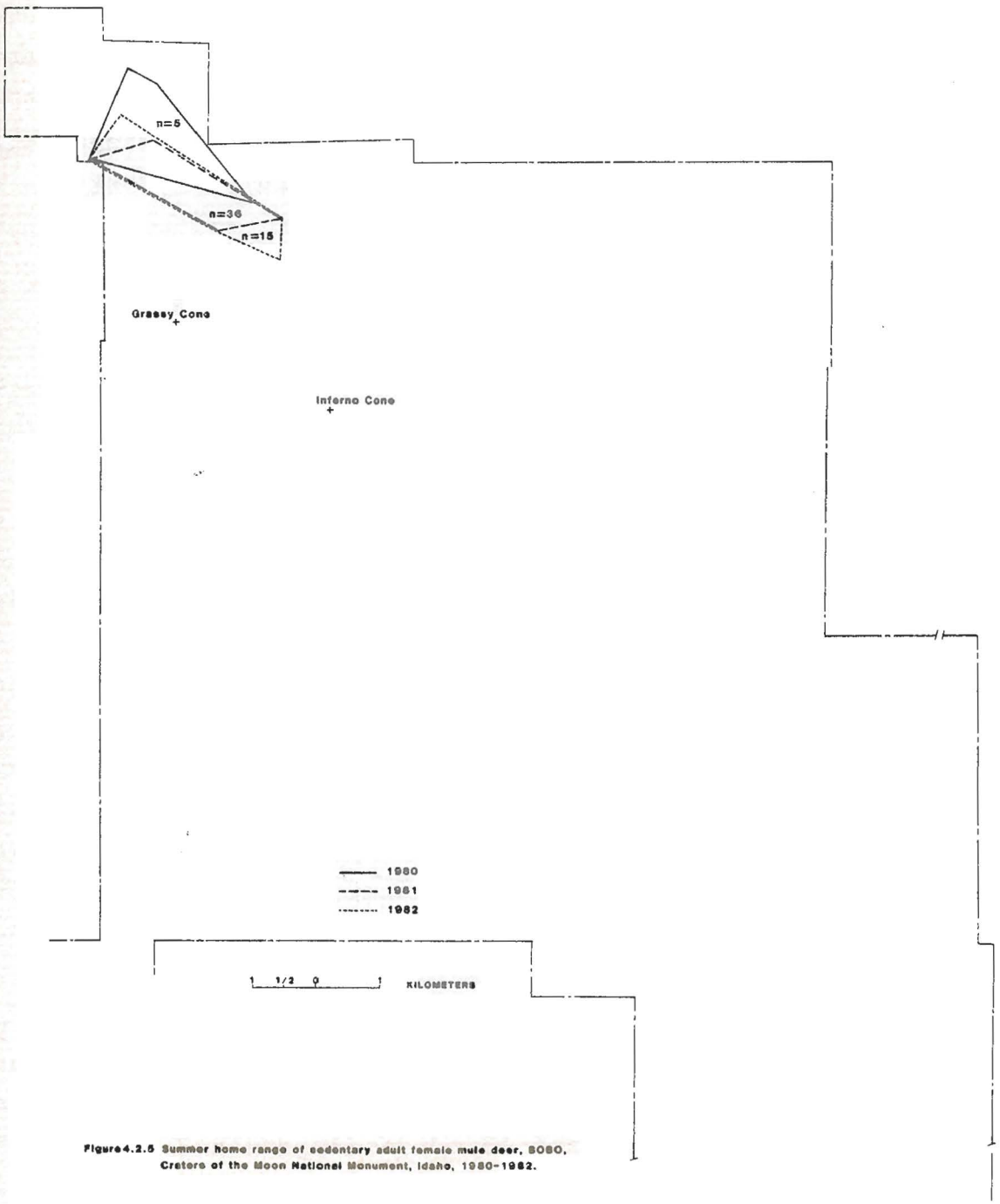



Figure 4.2.5 Summer home range of sedentary adult female mule deer, SOSO, Craters of the Moon National Monument, Idaho, 1980-1982.

through 4.2.4).

All 20 deer which were radio collared (Appendix A) occupied the central and wilderness areas during April-July. None of these deer remained in central and wilderness areas throughout August and September in any year. Relocations of other ear-tagged deer in April-July and August-September indicated that almost all of the deer in the central and wilderness areas migrated northward in late July and established residence in the north end.

A few deer evidently remained in the vicinity of Big Cinder Butte after the end of July in each year. This was the only place in the southern area where there were dense aspen stands and this butte also had the most dense stands of limber pine. Track count stations at the northern edge of Big Cinder Butte revealed only two or three deer per day going north and south in late August of 1981 and 1982. On the helicopter survey conducted on 19 September 1980, 94 percent of 254 deer were seen in the north end. The remaining six percent were located in the vicinity of Big Cinder Butte, Broken Top, Inferno Cone, and Silent Cone.

South of Big Cinder Butte, fresh deer sign was virtually nonexistant during August and early September. On walking censuses in the wilderness in 1980, 1981, and 1982 no deer were seen during August and early September. From April through mid-July each year, fresh deer tracks were abundant and 20-40 deer per day were seen on similar censuses in the wilderness.

Although some deer migrated northward as early as the end of June or as late as the end of August, the bulk of the migration from the wilderness to the north end was abrupt and essentially complete within 6-13 days (Appendix C). Migration date was defined as the first date a marked deer was seen in the north end after having been seen in central or wilderness areas that same spring. This convention may have overestimated the migration date but field observations suggested that mid-summer migrants were seen in the north end within two or three days after their arrival. The mean northward migration date for all marked deer varied between July 20-28 throughout

the three years of the study (Appendix C). Ten deer which were marked both in 1981 and 1982 migrated northward 9.8 days ($P \leq .05$) earlier in 1981 (Table 4.2.1). The two deer which could be compared in 1980 and 1981, migrated 9 days earlier in 1981. Does with two fawns tended to migrate northward 2-3 days earlier than does with one fawn and does with no fawns tended to migrate last (Table 4.2.2). Males tended to migrate northward the earliest (Table 4.2.2).

No radio collared or ear-tagged deer was ever observed to make exploratory or watering trips from central and wilderness areas to the north end from April through late July in any year even if the distance to water was within the physiologically reasonable foraging radius of 10 km calculated by Pennycuick (1978) for a 60 kg ungulate.

Once deer migrated northward and established new home ranges they remained there through late September with only one documented exception. This exception occurred during a period of exceptionally high fuel moisture in mid to late August of 1980. Adult doe YOYO was observed in the north end on 8 August. On 21 and 22 August she was observed at two locations within her southern home range. On 25 August she was observed traveling northward and was next observed in the north end on 28 August. She was next observed on her southern home range on 12 September, and in five subsequent relocations she remained there through 19 November. Similar behavior for this doe was not observed in 1981 or 1982 even though she carried a functioning radio collar during 1982. No other radio collared deer exhibited such behavior although adult doe OYOY was suspected to have behaved similarly in 1980. The return of doe YOYO to her southern home range during a period of high fuel moisture suggested that moisture stress may have caused the northward migration.

On the average, the mean northward migration date was the day following 12 (range 11-13) days when both the daytime high temperature exceeded 27 °C and the nighttime low temperature exceeded 10 °C. Over the course of the study, this variable was the best predictor of mid-summer migration. Other factors

TABLE 4.2.1 Yearly variation in mid-summer northward migration date of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| | | JULIAN DATE OF MIGRATION[a] | | | | |
|---|---|---|---|---|---|---|
| DEER | SEX | 1980 | DIFFERENCE | 1981 | DIFFERENCE | 1982 |
| YWYW | F | 209 | -9 | 200 | +11 | 211 |
| YOYO | F | 210 | -9 | 201 | + 3 | 204 |
| BBBG | F | | | 197 | +18 | 215 |
| OYOY | F | | | 215 | +10 | 225 |
| YYYY | F | | | 215 | +28 | 243 |
| YPYB | F | | | 193 | + 9 | 202 |
| BBBB | F | | | 186 | +15 | 201 |
| O-OY | M | | | 193 | -11 | 182 |
| GPGP | F | | | 197 | 0 | 197 |
| WPWW | F | | | 213 | +17 | 230 |
| OBOB | F | | | 187 | + 8 | 195 |
| MEAN DIFFERENCE | | | -9 | | +9.8* | |
| STANDARD ERROR | | | --- | | 3.1 | |

a Julian date 200 = 19 July.

* Significantly different than 0, ($P<.05$).

TABLE 4.2.2 Julian date of northward mid-summer migration and number of fawns of mule deer, Craters of the Moon National Monument, Idaho, 1981 and 1982.

| | JULIAN DATE OF MID-SUMMER MIGRATION[a] | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | | 1982 | | |
| NUMBER OF FAWNS: | 0 | 1 | 2 | 0 | 1 | 2 |
| | 215[b] | 200 | 201 | 182 | 211 | 204 |
| | 195 | 197 | 195 | 195 | 243 | 215 |
| | 176 | 215 | 193 | 225 | 197 | 195 |
| | 200 | 187 | 186 | 215[b] | 206 | 202 |
| | 197 | 193 | 201 | | 165 | 201 |
| | 193 | 197 | | | 206 | 200 |
| | | 198 | | | 225 | 195 |
| | | | | | 200 | 215 |
| | | | | | | 216 |
| | | | | | | 201 |
| MEAN MIGRATION DATE | 192.2 | 198.1 | 195.2 | 200.7 | 206.6 | 204.4 |
| STANDARD ERROR | 4.2 | 3.2 | 2.8 | 12.7 | 8.0 | 2.6 |

a Julian date: 6/30 = 181, 7/31 = 212, 8/31 = 243.

b Denotes yearling female. Others without fawns were yearling or adult males.

considered were fuel moisture, other temperature variables, and precipitation patterns preceeding migration. Forage moisture may have influenced the migration and will be discussed in a separate section.

In mid to late September, mid-summer migrants began to return to the same spring home ranges they had occupied earlier that year and in previous years. Mean date of southward migration in the fall is shown in Appendix D and was more variable than the mid-summer migration northward. By the time deer began moving southward in late September, mean daily high

temperature had fallen 10 °C to 12 °C below the high of July, and continued to decline thereafter.

Although most deer returned to the same southern home ranges in the fall, they did not remain there consistently. In 1980, marked deer which returned to their southern ranges remained there until migration to winter range. In 1981 and 1982, however, they made repeated trips back and forth between their southern and northern home ranges until migrating to winter range in late November. Length of stay on southern ranges for radio collared deer in the fall of 1981 averaged 8.3 days (Table 4.2.3). Length of stay in the north end on return trips averaged three days. The four radio collared deer made an average of three trips to the wilderness in the fall of 1981. In the fall of 1982 deer tended to make fewer round trips to the wilderness and stayed longer once there (Table 4.2.3).

Departures from fidelity to southern area home ranges in the fall came primarily from deer with southern home ranges on Inferno Cone (Fig. 2.1.2). This area, which was an important fawning area with high deer density in the spring, was not reoccupied in the fall. Marked does which lived there in the spring either remained in the north end until migration to winter range (BBBB, GWGW, PWPW) or moved much farther south to the Little Prairie area in the fall (GPGP, YYYY). Doe YYYY actually remained in the north end in the fall of 1981 as a 1.5 year old, and as a 2.5 year old in the fall of 1982 on two occasions was located within Little Prairie and near Fissure Butte in the fall. The reason for abandonment of Inferno Cone in the fall was unclear. High densities of deer during fawning may have utilized most of the preferred forage rendering the area less suitable in the fall.

## 4.3 Population Characteristics

### 4.3.1 Physiological Characteristics

General health of individual deer was excellent. Evidence of parasites and disease was minimal. Deer trapped in August occasionally had light infestations of ticks. Dipteran larvae

TABLE 4.2.3 Mean number of trips, and length of stay for mule deer making at least one round trip to the wilderness after 1 October, 1981 and 1982, Craters of the Moon National Monument, Idaho.

| DEER | AGE | SEX | RADIO COLLARED | MINIMUM NUMBER OF ROUND TRIPS 1981 | 1982 |
|---|---|---|---|---|---|
| WOBP | A | F | -- | 1 | -- |
| PYPP | A | F | -- | 1 | 1.5 |
| WYWO | Y | F | -- | 1 | -- |
| YPYB | A | F | 81,82 | 1.5[a] | .5 |
| GPGP | A | F | 81 | 3 | -- |
| OYOW | A | F | 81 | 3 | -- |
| YOYO | A | F | 82 | 1 | .5 |
| YWYW | A | F | -- | 2 | .5 |
| GYGY | A | F | -- | 1 | -- |
| BPWP | A | F | -- | -- | 1 |
| WYPG | A | F | -- | -- | 1 |
| PYGP | A | F | 82 | -- | 2.5 |
| BYBW | A | F | -- | -- | 1.5 |
| PGPG | Y-A | F | 81,82 | 4 | 1.5 |
| O-OY | Y | M | -- | 1 | -- |
| GYGB | Y-A | M | -- | 1 | -- |
| OGOW | A | M | -- | -- | 1 |
| COLLARED DEER ONLY: | | | | | |
| MEAN NUMBER OF TRIPS | | | | 2.9 | 1.2 |
| MEAN LENGTH OF STAY (DAYS) | | | | 8.3 | 13.0 |

a Numbers ending in 5 signify deer which eventually remained in the wilderness.

(probably Cephenomyia sp.) were infrequently noted in the nasal passages of road killed deer. A number of deer carried wart-like growths (papillomas) caused by filterable viruses. Some of these warts were as big as a softball but deer carrying them appeared healthy. One doe which died in a trap had abcesses in tissues in her neck. No eyeworms were ever detected and tapeworms were only detected in one necropsy of a road-killed deer.

Three of 28 (10.7 percent) hand captured fawns displayed signs of ill health. One was feverish and had a dry nose. Although given a one cc prophylactic injection of antibiotic it was not seen again. One fawn appeared uncoordinated when it ran off after tagging and was never seen again. A third fawn had a dislocated left rear leg. The leg was splinted and the fawn recovered. Six weeks later it was observed without the splint in good health eight km from its capture site and was seen repeatedly thereafter.

4.3.2 Fawn Production and Survival

Although the capture of spotted fawns in late September indicated that some fawns were born as late as mid-July, fawning peaked during the last week of May in 1981 and during the first week of June in 1982 (Table 4.3.1). These dates indicate a mean conception date of 4 November in 1980, and 11 November in 1981, respectively. Later conception in 1981, and later birth in 1982 ($P \leq .10$), may have been influenced by a larger component of two year old does in 1982, or by reduced nutritional status of does during the summer drought of 1981 prior to conception.

Bischoff (1958), has reported that breeding occurs three to four weeks later for yearling than adult deer, but since only 9 percent more of the does were two year olds in 1982 compared to 1981, the effect would not have been large enough to cause the 7 day shift in birth dates observed. Alternately, the drought during the summer of 1981 and the ensuing severe winter may have nutritionally stressed the does resulting in lower fawn weight at birth in 1982. Because fawn age was

TABLE 4.3.1 Birth weight (kg), estimated age at capture, estimated birth date, and age at migration of hand captured mule deer fawns, Craters of the Moon National Monument, Idaho, 1981 and 1982.

| DATE | SEX | WEIGHT (kg) AT CAPTURE | ESTIMATED AGE (DAYS) | BIRTH DATE | MIGRATION DATE | AGE AT MIGRATION (DAYS) |
|---|---|---|---|---|---|---|
| 1981: | | | | | | |
| 6/1 | F | 4.8 | 4 | 5/27 | 7/5 | 39 |
| 6/1 | M | 4.5 | 2 | 5/30 | 7/5 | 36 |
| 6/2 | M | 5.2 | 4 | 5/29 | --- | -- |
| 6/3 | M | 5.7 | 6 | 5/28 | --- | -- |
| 6/3 | M | 6.8 | 10 | 5/24 | --- | -- |
| 6/3 | M | 7.0 | 11 | 5/23 | --- | -- |
| 6/7 | M | 7.9 | 14 | 5/24 | --- | -- |
| 6/7 | F | 8.6 | 21 | 5/17 | --- | -- |
| 6/7 | F | 6.1 | 10 | 5/31 | --- | -- |
| MEAN | | | | 5/26 | | 37.5 |
| STANDARD ERROR (DAYS) | | | | 1.5 | | 1.5 |
| 1982: | | | | | | |
| 6/5 | M | 4.2 | 1 | 6/4 | 7/20 | 46 |
| 6/5 | M | 3.9 | 0 | 6/5 | 7/20 | 45 |
| 6/5 | M | 7.4 | 12 | 5/24 | --- | -- |
| 6/5 | F | 4.8 | 5 | 5/31 | --- | -- |
| 6/5 | M | 5.7 | 6 | 5/30 | --- | -- |
| 6/5 | M | 7.9 | 14 | 5/22 | --- | -- |
| 6/6 | F | 4.5 | 4 | 6/2 | 7/20 | 48 |
| 6/6 | F | 4.6 | 4 | 6/2 | 7/20 | 48 |
| 6/7 | M | 3.0 | 0 | 6/7 | 7/14 | 37 |
| 6/7 | F | 2.8 | 0 | 6/7 | 7/14 | 37 |
| 6/8 | M | 4.2 | 1 | 6/7 | --- | -- |
| 6/8 | M | 4.8 | 3 | 6/5 | --- | -- |
| MEAN | | | | 6/2 | | 43.5 |
| STANDARD ERROR (DAYS) | | | | 1.5 | | 2.1 |

estimated from weight at capture, lighter fawn weight at birth would have resulted in a later estimated birth date. Assuming an 11 percent lower birth weight for fawns after the severe winter of 1981-1982, as suggested by Robinette et al. (1957b), only accounted for about 2 days of the difference in birth date between 1981 and 1982. McGinness and Downing (1977) found that the only variables which were significantly correlated with white-tailed deer fawn birth dates were those that could result in does reaching estrus in better condition, and Verme (1965) and Robinette et al. (1973) have likewise reported later conception in nutritionally stressed deer. Since the cause of later birth must effect conception date for the entire population of females to produce the large shift in birth date observed, it appears that nutritional stress of all does prior to conception, most likely due to the drought of 1981, was the main cause of later birth in 1982.

Although male fawns predominated in hand caught samples (19:8) and female fawns predominated in trap caught samples (10:7) the sex ratio of all captured fawns was essentially equal for 16 fawns in 1980 (1:1) and for 14 fawns in 1981 (1.33:1). More males were found (2.5:1) in the sample of 14 fawns captured in 1982. Over the three years the sex ratio did not differ significantly from 1:1 (n=44). Male fawns have predominated in other studies with large sample sizes (Robinette et al. 1957b).

In 1980 an indirect minimum estimate of initial production (the number of live fawns born per sexually mature doe) was obtained as the maximum number of fawns trailed by 11 marked adult (two years or older in June) females. These 11 does were initially accompanied by 21 fawns which indicated minimum initial production of 1.91 fawns per adult female. One of these does was not seen with her fawn until 12 October so initial production may have been higher. Triplets were occasionally observed in 1980. Jensen and Robinette (1955) reported 12 percent triplet fetuses for an excepticnally productive herd (1.86 fawns per adult doe) on good summer range in Utah. High initial production is occasionally reported for

prime age (three years old and older) deer on high quality summer range (Julander et al. 1961), but it is the exception.

In 1981 and 1982, estimates of initial production were not possible because marked does were not seen with fawns until too late in the season. Since most neonatal fawn mortality occurs during the first month of life (Connolly 1981, Cook et al. 1971, Trainer et al. 1981) the number of fawns trailing does in 1981 and 1982 was assumed to represent neonatal survival rather than initial production.

Net production is defined in this report as the number of fawns surviving per adult female in the fall. The fall fawn:doe ratios shown in Table 4.3.2 were averaged as described previously and adjusted to reflect fawn:adult doe ratios shown in Table 4.3.3 by dividing the fawn:doe ratio by the estimated proportion of all females which were adult in the same year. The purpose of this adjustment was to relate production to sexually mature does and exclude the generally nonproductive yearling does.

Net fall production was high in all years (Table 4.3.3) averaging 1.34 fawns per adult female surviving to the fall. This value slightly exceeded the average number of fawns born (1.31 per adult doe) for the six herds summarized by Connolly (1981:293). Net fall production in 1980 was exceptionally high (1.62 fawns:adult doe) but declined by 22 percent in 1981. Net fall production for 1981 and 1982 were essentially equal (Table 4.3.3).

The fawn:adult doe ratio for marked adult females in the fall always slightly exceeded the equivalent ratio derived from general classification counts (Table 4.3.3). This may have been due to a tendency to watch marked does longer than unmarked does and thus observe fawns that would have been missed in the unmarked population.

A direct estimate of neonatal fawn mortality was obtained only in 1980. The 11 marked does had lost at least three of their 21 fawns by fall suggesting a minimum mortality rate of 14.3 percent from birth to about five months of age. If the birth rate in 1981 was equal to 1980 (based on good forage

TABLE 4.3.2 Monthly mule deer classification ratios, Craters of the Moon National Monument, Idaho, 1980-1982.

| | CLASSIFICATION RATIO | | | | | | |
|---|---|---|---|---|---|---|---|
| MONTH | ADULT FEMALE[a] | YEAR-LING FEMALE | YEAR-LING MALE | ADULT MALE | FAWN | UN-KNOWN | TOTAL CLASSI-FIED |
| 1980: | | | | | | | |
| MAY/JUN | 100 | 38 | 35 | 10 | 38 | 7 | 322 |
| JUL | 100 | -- | 17 | 11 | 89 | 0 | 117 |
| AUG | 100 | -- | 14 | 7 | 120 | 5 | 514 |
| SEP | 100 | -- | 12 | 21 | 115 | 5 | 577 |
| OCT | 100 | -- | 26 | 40 | 122 | 18 | 407 |
| NOV | 100 | -- | 18 | 34 | 113 | 22 | 331 |
| 1981: | | | | | | | |
| APR-JUN | 100 | 59 | 61 | 11 | 6 | 98 | 612 |
| JUL | 100 | -- | 36 | 26 | 53 | 9 | 365 |
| AUG | 100 | -- | 23 | 14 | 78 | 7 | 2431 |
| SEP | 100 | -- | 25 | 23 | 89 | 11 | 1645 |
| OCT | 100 | -- | 17 | 14 | 74 | 24 | 945 |
| NOV | 100 | -- | 14 | 21 | 74 | 86 | 865 |
| 1982: | | | | | | | |
| MAY/JUN | 100 | 22 | 25 | 21 | 11 | 18 | 414 |
| JUL | 100 | -- | 9 | 21 | 68 | 7 | 666 |
| AUG | 100 | -- | 6 | 21 | 75 | 3 | 815 |
| SEP | 100 | -- | 12 | 29 | 90 | 8 | 1203 |
| OCT | 100 | -- | 22 | 28 | 98 | 9 | 1042 |
| | | | | | TOTAL | | 13,271 |

a During July and later adult female column includes both yearling and adult females.

TABLE 4.3.3 Population characteristics of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| POPULATION CHARACTER-ISTICS | 1980 SPRING | 1980 FALL | 1981 SPRING | 1981 FALL | 1982 SPRING | 1982 FALL |
|---|---|---|---|---|---|---|
| Yearlings per adult doe | 0.73 | | 1.20 | | 0.47 | |
| Proportion male | 0.48 | | 0.51 | | 0.53 | |
| Proportion female | 0.52 | | 0.49 | | 0.47 | |
| Proportion of does-adult | 0.72 | | 0.63 | | 0.82 | |
| Fawns per doe | | 1.18 | | .80 | | .94 |
| Fawns per adult doe | | 1.62 | | 1.26 | | 1.14 |
| Fawns per tagged adult doe | | 1.64 | | 1.35 | | 1.29 |
| Yearling males per doe | | 0.19 | | 0.24 | | 0.22 |
| Adult males per doe | | 0.24 | | 0.24 | | 0.28 |

conditions prior to conception, a mild open winter and slightly early spring), the 1.26 fawns per adult doe remaining in the fall of 1981 (Table 4.3.3) would suggest a maximum mortality of about 34.0 percent prior to five months of age for fawns of 1981. If production in 1981 was lower than 1980, due to lowered productivity following a year of high fawn survival (Clutton-Brock et al. 1982, Verme 1967, Mundinger 1981), then in 1981 neonatal mortality would have been less than the estimated maximum of 34 percent.

If initial production in 1982 was lower than the two previous years due to weather conditions (i.e. a drought prior to breeding, a severe winter, and a late spring during gestation), then the 1.14 fawns:adult doe remaining in the fall would suggest that mortality to five months of age in 1982 was probably lower than 1981 and higher than 1980 and would fall between 14.3 and 34.0 percent. Considering winter severity and

the late spring, neonatal mortality for 1982 was probably toward the upper end of this range. The survival rate to five months of age during the three years, expressed as 1-mortality rate, thus probably varied between at least 66 percent and 86 percent. The median of these two survival values (75 percent) was the best estimate of average survival to five months of age that could be obtained in this study.

Deer entered the winter of 1980-1981 in excellent shape. Even fawns had deposited substantial amounts of fat and the mean body condition (Kistner et al. 1980) was 32 for six road killed fawns from August and September, 1980. Male fawns had three cm antlers in September. Adults and yearlings were in excellent condition as well. No thin deer were seen in the fall and yearling males carried large two point antlers. A very mild open winter ensued and mortality of females 17 months old or older was probably low. All marked does, except one that was poached on winter range, returned to Craters in the spring of 1981. Yearling:adult doe ratios (1.2:1) in the spring of 1981 were essentially equal to the fawn:doe ratios in the fall of 1980 (1.18:1), indicating negligible overwinter mortality of fawns. The sex ratio of yearlings in the spring of 1981 (1.04:1.0) was essentially equal as it had been for fawns captured in the early summer of 1980 (1:1). This indicated no differential mortality between male and female fawns during the mild winter of 1980-1981.

Deer appeared to enter the winter of 1981-1982 in poorer condition than they entered the winter of 1980-1981. Thin does were seen well into the fall and antlers of yearling males were only about one-half the size seen in 1980. Body condition ratings of road killed fawns were not obtained from enough samples for a meaningful estimate. The winter of 1981-82 was severe (Robinson 1982) and yearling:adult doe ratios in the spring of 1982 were 40.5 percent lower than fawn:doe ratios the previous fall (Table 4.3.3). However, at least 16.3 percent of marked yearling and adult females also disappeared during the winter and the fawns associated with these does were probably lost too. Assuming the additional loss of fawns of winter

killed does indicated overwinter survival of only 56 percent of fawns of 1981. Following this substantial first year mortality, the spring sex ratio of yearlings in 1982 was 1.13:1 compared to the 1.33:1 ratio at birth. This suggested differential loss of male fawns during stressful winter conditions as has been reported elsewhere by Taber and Dasmann (1954) and Robinette et al. (1957b).

Survival to one year of age for fawns of 1980 and 1981 was calculated as the product of the individual survivals from neonatal, road kill, hunting, orphaning, and winter losses. Survival to one year of age for fawns of 1980 was 62 percent; 59 percent of total mortality was due to assumed loss of orphans of hunter killed does and 32 percent of mortality was due to neonatal losses. The balance was due to road kills. Free ranging mule deer seldom exhibit first year survival as high (Connolly 1981). Only about 29 percent of the fawns born in 1981 survived to one year of age. Winter losses accounted for 47 percent of all mortality, 32 percent was due to neonatal losses, 10 percent was due to assumed orphaning, and the remainder was due to hunting and road kills. When mortality from all three summer and fall seasons and the two winters were averaged they indicated that only 48 percent of fawns survived their first year of life.

The survival of marked fawns to one year of age appeared to be slightly less than for the fawn population at large. Only 56 percent of 18 fawns marked in 1980 lived to one year of age compared to 62 percent of fawns at large. Only 20 percent of 15 fawns marked in 1981 reached one year of age compared to about 29 percent of fawns at large. Thus an unmarked fawn may have had a 1.10 to 1.45 times greater chance of surviving than if it had been marked.

### 4.3.3 Yearling and Older Females

Due to the variance in first year survival, the percentage of yearling females in the total doe population fluctuated (Table 4.3.3). Free ranging yearlings do not generally bear fawns (Taber and Dasmann 1957) (none of the nine yearling does

captured during this study was lactating). From age 13 months onward yearlings were indistinguishable from adult does at Craters and they caused production estimates based on fawn:doe ratios alone (Table 4.3.3) not to accurately represent productivity of sexually mature does. For example, fawn:doe ratios depicted in Table 4.3.3 showed a 32 percent decrease in production from 1980 to 1981 and a 18 percent increase in production from 1981 to 1982, while fawn:adult doe ratios indicated a 22 percent decrease and 10 percent decrease respectively. The yearling bias carried into the next year when these does had their first fawns at age two. The average of six studies summarized by Connolly (1981:293) showed primaparous does (those having their first fawn) to carry only 43 percent (range 32-67) as many fetuses as older age classes. Similar results were observed in the Craters herd. In 1982, the only year with sufficient data, marked two year old females retained an average of 0.56 fawns each in the fall. This ratio was only 35 percent as great as the ratio of 1.60 fawns each observed for older marked deer.

Recruitment following the mild winter of 1980-1981, was 0.82 females per adult female, and following the severe winter of 1981-1982, was 0.35 females per adult female; the average was 0.59. Thus, a doe which first bred at 17 months of age would have had to fawn twice to replace herself.

Primary sources of mortality for does older than fawns throughout the three years were hunting (57 percent) and winter losses (37 percent). The balance was accounted for by road kills. Total estimated hunting mortality removed 24, 10, and 3 percent of the doe population in 1980, 1981, and 1982, respectively. Although winter losses were a major component of average annual mortality, over-winter loss of marked deer was negligible during the mild winter of 1980-1981. One marked doe (YBWB) was evidently poached on the Appendicitis Hill winter range. The hunting season closed before Craters deer arrived on this range but the marked doe's tags were found near a road in the area and had been cut off. All other marked does leaving for winter range in 1980 returned the next year.

In contrast, during the severe winter of 1981-1982, eight percent of 12 marked yearling does and 19 percent of 21 marked adult does failed to return to Craters from winter range. The average over-winter loss of 16.3 percent of marked females may represent both mortality and dispersal since the individuals were not found dead but disappeared from the marked population. Since the number of females predicted for the spring of 1982 (Table 4.3.4) tended to be about 30 percent greater than the number observed in the fall, it is possible that winter mortality of does was actually greater than the 16.3 percent estimate derived from marked individuals.

4.3.4 Yearling and Older Males

More than twice as many males were seen in morning as in evening censuses in 1980 and 1981 (Table 4.3.5). This may have reflected a difference in period of greatest activity for males and females. Males may have begun their activities later in the evening and have been seen less frequently due to falling darkness.

The monthly classification ratios for 1980, 1981, and 1982, depicted in Table 4.3.2, showed a slight increase in adult male:female ratios during the fall. This was presumably due to increased activity by males as rutting behavior began. Yearling male:doe ratios also reflected this trend in 1982 (Table 4.3.2) when the population was lowest. In 1981, when the population level was highest, the ratio dropped off in October and November (Table 4.3.2). This may have reflected dispersal of yearling males from a relatively crowded situation.

An analysis of population characteristics presented in Table 4.3.3 provided circumstantial evidence that there was dispersal of yearling males during their second summer and that the dispersal rate was related to population size. The yearling male:adult doe ratio in the spring was calculated as the yearling:adult doe ratio times the proportion of yearlings which were male. The yearling male:adult doe ratio in the fall was calculated as the yearling male:doe ratio in the fall

TABLE 4.3.4 Population dynamics of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| POPULATION SEGMENT | MAY-AUG ROAD KILL | ESTIMATE FALL 1980 | SEP-NOV ROAD KILL | OBSERVED HUNTER HARVEST | OTHER[a] HUNTER HARVEST | WINTER MORTALITY | PREDICT SPRING 1981 | MAY-AUG ROAD KILL | ESTIMATE FALL 1981 | SEP-NOV ROAD KILL | OBSERVED HUNTER HARVEST | OTHER HUNTER HARVEST | WINTER MORTALITY | PREDICT SPRING 1982 | MAY-AUG ROAD KILL | ESTIMATE FALL 1982 | SEP-NOV ROAD KILL | OBSERVED HUNTER HARVEST | OTHER HUNTER HARVEST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ... NUMBER OF DEER | | | | | | | | | | | | | | | | | | |
| Total Females | | 183 | -1 | -31[b] | -13 | -0 = 138 | 216 | (1) | 226 | -2 | -16 | -7 | -33 = 168 | 205 | (3) | 144 | -1 | -3 | -1 |
| (0.95 Confidence Interval) | | (105-707) | | | | | | | (191-277) | | | | | | | (117-186) | | | |
| Adult Females | | 133 | | | | | 138 | | 142 | | | | | 168 | | 118 | | | |
| Yearling Females | | 50 | | | | | 78 | | 84 | | | | | 37 | | 26 | | | |
| Fawns[c] | (5) | 216 | -5 | -37 | -15 | -0 = 159 | -- | (3) | 181 | -7 | -22 | -10 | -63 = 79 | -- | | 135 | -2 | -5 | -1 |
| Yearling Males | (2) | 35 | -1 | -6 | -3 | -0 = 25 | 81 | (1) | 54 | -1 | -20 | -9 | -9 = 15 | 42 | | 32 | -2 | -17 | -7 |
| Adult Males | | 44 | | -15 | -6 | -0 = 23 | 48 | | 54 | -1 | -10 | -4 | -15 = 24 | 39 | | 40 | -2 | -14 | -6 |
| TOTAL POPULATION | | 478 | | | | | | | 515 | | | | | | | 351 | | | |

a Assumes 30 percent of total hunter harvest was undetected.

b Includes 1 deer poached on winter range.

c Fawn loss includes assumed loss of all fawns which were orphaned.

TABLE 4.3.5 Mean number of mule deer seen and classification ratios obtained from morning and evening censuses, Craters of the Moon National Monument, 1980 and 1981.

| TIME | ADULT MALE | YEARLING MALE | FEMALE | FAWN | UNKNOWN | TOTAL |
|---|---|---|---|---|---|---|
| 1980 | | | | | | |
| MORNING | | | | | | |
| Mean ratio | 24.0 | 18.8 | 100.0 | 110.6 | 2.9 | --- |
| Mean number | 5.0 | 3.9 | 20.8 | 23.0 | 0.6 | 53.4 |
| Standard error | 0.9 | 0.6 | 2.3 | 2.4 | 0.4 | 4.8 (n=11) |
| EVENING | | | | | | |
| Mean ratio | 2.6 | 12.8 | 100.0 | 111.3 | 1.5 | --- |
| Mean number | 0.5 | 2.5 | 19.5 | 21.7 | 0.3 | 44.5 |
| Standard error | 0.3 | 0.8 | 1.4 | 2.2 | 0.3 | 3.6 (n=6) |
| 1981 | | | | | | |
| MORNING | | | | | | |
| Mean ratio | 24.2 | 23.9 | 100.0 | 79.1 | 8.4 | --- |
| Mean number | 8.1 | 8.0 | 33.5 | 26.5 | 2.8 | 78.9 |
| Standard error | 1.0 | 1.0 | 3.5 | 2.5 | 0.8 | 7.0 (n=23) |
| EVENING | | | | | | |
| Mean ratio | 8.8 | 16.6 | 100.0 | 68.9 | 5.1 | --- |
| Mean number | 2.6 | 4.9 | 29.6 | 20.4 | 1.5 | 59.1 |
| Standard error | 0.7 | 0.7 | 2.9 | 2.3 | 5.6 | 5.7 (n=17) |

a Includes yearling and adult deer.

divided by the proportion of does which were adult. If there was no dispersal, the calculated spring and fall yearling male:adult doe ratios should have been equal but they were not. The fall yearling male:adult doe ratio was 26 percent less, 38 percent less, and 8 percent greater than the spring ratio for 1980, 1981, and 1982, with total population levels of 478, 515, and 351, respectively. If yearling females dispersed, the differences in these ratios would have been underestimated. It is possible that yearling males were less visible in the fall after having been excluded from the doe groups in the spring. Connolly (1981) has noted that yearling males may be underestimated in classification counts and Leckenby (1971) and King and Smith (1980) have noted that males tend to use higher elevations. Since most classification data in this study were collected from roadside censuses at lower elevations, the proportion of males may have been underestimated. An attempt

to avoid this possible bias was made by using the highest yearling male:doe ratio logically obtainable for the fall estimates. If the change in ratios from spring to fall was caused by changing observability, it seems likely that the fall ratios would have been consistently less than spring ratios at an equivalent magnitude. Since the decrease in ratio was greatest at the highest population level, and the spring and fall ratios were essentially equal at the lowest population level, dispersal seems a more likely cause for the observed differences. Averaged over the three years, the spring- fall differences in yearling male:adult doe ratios suggest an average dispersal rate of 21 percent. Robinette (1966) has reported dispersal of 60 percent of yearling male mule deer during their second summer in Utah. Since the two dispersals of marked yearling deer at Craters were to areas both within and outside the monument, the three year average change in spring-fall ratios may underestimate dispersal of yearling males.

Most mortality of yearling and older males was due to hunting (69 percent) and winter mortality (26 percent). The balance was due to road kills and natural causes. One radio collared yearling male (BGBY) was evidently killed and consumed by a bear in late September 1981. Total estimated hunting mortality removed 48, 26, and 53 percent of adult males, and 26, 26, and 80 percent of yearling males during 1980, 1981, and 1982, respectively.

The only marked yearling male which entered the winter in 1980 returned to Craters in 1981. In 1981, eight marked yearling males entered the winter and five returned in 1982 for an overwinter survival of 62.5 percent. The 37.5 percent loss may have included both death and dispersal. Since no adult males were marked during the winter of 1981-1982, they were assumed to have the same loss rate as yearling males. The overwinter loss due to death or dispersal was four times greater for yearling males than for yearling females during the winter of 1981-1982. In a study that only addressed known mortality of mule deer, Robinette et al. (1957b) found the

opposite situation.

4.3.5 Hunting Mortality

Hunting was a significant source of mortality for Craters of the Moon National Monument mule deer during 1980-1982. Each year, documented hunting mortality (Table 4.3.6) accounted for 10.6 ($\pm$0.6, $P \leq .05$) percent of the total pre-hunt population. Throughout the west the illegal kill and crippling loss as a percent of the legal harvest varies widely. Connolly (1981:309) tabulated estimates from three intensive field studies (Stapley 1971, Costley 1948, and Robinette et al. 1977) which compared crippling and illegal losses in buck only and in any deer seasons. These studies showed that documented harvest averaged only about 70 percent of the total harvest. Since the deer hunt around the monument had both buck only and any deer segments in the 25 day season, these results were used to estimate illegal and crippling loss for the Craters herd. Adding estimated illegal and crippling losses to documented harvest would suggest an annual total loss of 15.1 percent of the pre-hunt population. Since portions of the herd were in the protected wilderness during hunting season, harvest rate for deer in the north end may have been even higher. Over the course of the study only six percent of marked deer were known to be taken by hunters. The reason for the lower take of marked deer was unclear.

Documented hunter harvest accounted for a constant proportion ($r=1.0$, $P \leq .01$) of the herd even though hunting pressure as indexed by the number of hunter contacts on routine patrols declined from 200 to 150 to 95 during the three years of the study. Hunter success, estimated as the documented harvest divided by the number of hunter contacts, was 26 percent, 37 percent, and 38 percent for 1980, 1981, and 1982, respectively. Although long term records have not been kept, hunting has likely always been an important source of mortality for the Craters herd.

Although total documented hunter harvest removed a constant fraction of the pre-hunt population, the harvest was

TABLE 4.3.6 Age and sex distribution of documented hunter harvest and of pre-hunt population of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| YEAR | SAMPLE | FEMALES | YEARLING MALES | ADULT MALES | FAWNS | UNKNOWN | TOTAL |
|---|---|---|---|---|---|---|---|
| 1980 | HARVEST | | | | | | |
| | # | 25 | 5 | 13 | 0 | 8 | 51 |
| | % | 58.1 | 11.6 | 30.2 | 0 | --- | 100 |
| | PRE-HUNT | | | | | | |
| | # | 183 | 35 | 44 | 216 | --- | 478 |
| | % | 38.3 | 7.3 | 9.2 | 45.2 | --- | 100 |
| 1981 | HARVEST | | | | | | |
| | # | 15 | 18 | 9 | 8 | 5 | 55 |
| | % | 30.0 | 36.0 | 18.0 | 16.0 | --- | 100 |
| | PRE-HUNT | | | | | | |
| | # | 226 | 54 | 55 | 180 | --- | 515 |
| | % | 43.9 | 10.5 | 10.7 | 34.9 | --- | 100 |
| 1982 | HARVEST | | | | | | |
| | # | 3 | 16 | 14 | 2 | 1 | 36 |
| | % | 8.6 | 45.7 | 40.0 | 5.7 | --- | 100 |
| | PRE-HUNT | | | | | | |
| | # | 144 | 32 | 40 | 135 | --- | 351 |
| | % | 41.0 | 9.1 | 11.4 | 38.5 | --- | 100 |

a Percent of known sex and age hunter harvest.

not uniformly distributed across sex and age classes (Table 4.3.6). Over the three years, adult males were taken by hunters 2.8 times more frequently than they occurred in the population ($P \leq .01$), and yearling males were taken 3.8 times more frequently ($P \leq .01$). Fawns were only harvested 0.2 times as often ($P \leq .01$) as they occurred in the population. Averaged over the three years does were only harvested 0.8 times as frequently as expected ($P \leq .01$) but in 1980 they were killed 1.5

times as frequently ($P \leq .01$) as they occurred in the population.

One aspect of hunting mortality of concern is the fate of fawns of hunter killed does. By the time of hunting season, fawns were about 4.5 months old and weaned. It is unlikely that they would have immediately starved to death if orphaned. Woodson et al. (1980) reported that orphaned 4-6 month old non-migratory white-tailed deer fawns did not suffer increased mortality, but they suggested that migratory deer might not fare so well. Inconsistencies in predicted and observed yearling:doe ratios in the spring of 1981 and 1982 suggested that fawns orphaned at the monument in the fall did not return the following spring. By subtracting known and estimated fall and winter losses from the number of deer in the population prior to the hunting season (Table 4.3.4) and calculating classification ratios on the remaining individuals, spring yearling:doe ratios were predicted. Assuming no loss of orphans yielded a prediction of 1.53 yearlings per doe in the spring of 1981, compared to a predicted ratio of 1.15 yearlings per doe if all orphaned fawns were assumed lost. The observed ratio of 1.2:1.0 was much closer to the prediction that assumed loss of orphans. The same feature held true in 1982. The predicted yearling:doe ratio was 0.58:1.0 assuming no loss of orphans, and was 0.47:1.0 assuming total loss of orphans. The observed ratio was 0.47:1.0. The apparent loss of these orphaned fawns may have been evident due to the migratory nature of the Craters herd. Since deer may learn much of their behavior from association with older animals (Dasmann and Taber 1956), fawns may have survived but not learned the migration route and thus have failed to return the following spring.

### 4.3.6 Vehicle Accidents

Vehicle accidents removed an average of 2.9 percent of the total pre-hunt population each year. Total road kills each year were significantly correlated ($r=1.0$, $P \leq .01$) with estimated total pre-hunt population level. Variation in vehicle traffic was not significantly correlated with ($r=0.13$, $n=3$) the variation in road kill. On the average, one deer was

killed for every 18,436 vehicles that passed the visitor center on U.S. Highway 20/26. The proportion of the total road kill accounted for by fawns and adult males was not significantly different from the proportions of these two classes in the fall population. Yearling males tended to be killed more frequently than they occurred (Table 4.3.7) but the difference was not significant. Adult and yearling does were killed significantly less often ($P \leq .05$) than they occurred in the population. Does were evidently more cautious on the highway.

Deer were killed while crossing the highway when migrating into the monument and when migrating to winter range, but the largest portion of the road kill mortality occurred when deer were concentrated in the north end in August and September. Seventy percent of documented road kills occured during these two months which only accounted for 33.5 percent of total vehicular traffic from May through November. During this period deer made repeated trips across the highway at night to forage on the irrigated and fertilized visitor center lawns and to drink at the sprinkler overflows.

### 4.3.7 Yearly Variation in Total Population

The total population increased from 478 in 1980 to 515 in 1981 then declined to 351 in 1982 (Table 4.3.4). The 36.3 percent decline in estimated number of females in 1982 was significant ($P \leq .05$). The confidence interval on the number of females in 1980 was wide primarily due to the low proportion of marked deer. As a result there was no significant difference between the female population in the fall of 1980 and either other year.

Since the total population estimate, documented hunting removal, and total road kill were directly correlated ($P < .01$) and independent, the mark-recapture method of estimating the population appeared reliable. Although fall roadside censuses properly identified the direction of trend in population level, they both overestimated the proportional increase and underestimated the proportional decrease compared to the mark-recapture population estimate (Table 4.3.8). These biases

TABLE 4.3.7 Age and sex distribution of mule deer killed in vehicle accidents and of pre-hunt population, Craters of the Moon National Monument, Idaho, 1980-1982.

| | PERCENT OF TOTAL IN SAMPLE | | | | | |
|---|---|---|---|---|---|---|
| | FEMALES[a] | YEARL. MALES | ADULT MALES | FAWNS | UNKNOWN | TOTAL NUMBER |
| Total vehicle accidents | 22.4 | 15.9 | 8.9 | 48.4 | 4.4 | 39 |
| Average pre-hunt population | 41.1 | 9.0 | 10.3 | 39.6 | 0 | 448[b] |

a Includes adults and yearlings.

b Mean pre-hunt population for 1980-1982.

TABLE 4.3.8 Population trend indicators of mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| TREND INDICATOR | 1980 | 1981 | PERCENT CHANGE | 1982 | PERCENT CHANGE |
|---|---|---|---|---|---|
| Total population estimate | 478 | 515 | + 7.7 | 351 | -31.8 |
| Total known hunting removal | 51 | 55 | + 7.8 | 36 | -34.5 |
| Total road killed deer | 14 | 15 | + 7.1 | 10 | -33.3 |
| Total deer seen - | | | | | |
| Helicopter census | 253 | 279 | +10.3 | -- | -- |
| Roadside census | 44 | 62 | +40.9 | 50 | -19.4 |
| Population estimate - | | | | | |
| females only | 183 | 226 | +23.5 | 144 | -36.3 |
| Roadside census - | | | | | |
| females only | 19 | 29 | +52.6 | 24 | -17.2 |

may have reflected continually increasing efficiency of the single observer in detecting deer on the same census route over the course of three years.

Density estimates varied concurrently with total population, the distribution pattern of deer, and definition of the area used by deer. Spring pre-fawning density ranged from 2.4 to 3.8 deer/$km^2$ during the three years. Prior to mid-summer migration, but after birth and postnatal loss of fawns there were between 3.8 and 5.8 deer/$km^2$. When deer were concentrated in the north end in August and September, densities would have ranged from 19.0 to 28.4/$km^2$ during the three years. These figures were based only on the area within the monument boundary. Adding 20.7 $km^2$ outside the boundary in the Pioneer Mountains, which might reasonably have been used by Craters deer, would have lowered these estimates by about 23 percent when the deer were dispersed and by about 47 percent when they were concentrated in the north end in late summer.

The post fawning densities of 3.8-5.8 deer/$km^2$ were within the range expected for intermountain mule deer herds on good range. The August-September densities were high due to the concentration of deer. Substantially higher densities have been reported for sedentary black-tailed deer in California (Dasmann and Taber 1956) and migratory mule deer in Utah (Robinette et al. 1977).

## 5.0 DISCUSSION

### 5.1 Area Utilization

#### 5.1.1 Dual Summer Home Ranges

The most unique aspect of the Craters deer herd was the use of two distinct summer home ranges by wilderness and central area deer. Although mule deer are often migratory (Gruell and Papez 1963, Leckenby 1971, Zalunardo 1965, and Robinette et al. 1977) between summer and winter ranges, they typically remain on a single home range on each seasonal range. No other published accounts of multiple summer or winter home

ranges have been found.

Craters deer had a strong affinity for their early summer home ranges in the central and wilderness areas. This was shown by year to year fidelity to these areas and the propensity to return to these areas in the fall even though they stayed only a few days at a time (Table 4.2.3). These phenomena posed 2 questions: 1) what were th costs and benefits of using the wilderness? and 2) why did deer leave the wilderness?

Benefits of wilderness use included the dense shrub cover in vegetated areas. This provided excellent hiding cover for fawns. Average relief of southern areas was less steep than in the north end, facilitating newborn fawn movement. Limber pine stands were scattered throughout the wilderness and provided hiding cover for does. Use of this cover would have reduced the chance that a doe would reveal the location of her fawn to a predator. In addition, coyotes were rare in the wilderness. As evidenced by the high fawn:doe ratios in the fall, coyotes did not take significant numbers of newborn fawns.

Forage in the wilderness was luxuriant. Bitterbrush was abundant and healthy throughout the area. Forbs and grasses were diverse and abundant. In addition, the wilderness was slightly lower in elevation than the north end. Temperatures were warmer earlier in the spring and phenology of plants was thus advanced. The sooner a pregnant female can obtain highly nutritious new growth in the spring the better are her chances for producing a healthy fawn (Verme 1977, Clutton-Brock et al. 1982).

In fall, during hunting season, short term survival would have been increased for all deer which frequented the protected wilderness. Illegal hunting was probably non-existant due to the isolation provided by surrounding lava flows.

The costs of wilderness use would have involved the risks associated with migration and the lack of free water. Migration from an area of intimate familiarity would expose animals to increased mortality. The most obvious source of this mortality for mid-summer migratory Craters deer was

vehicle accidents as described above.

Since free water was not consistently available in the wilderness, the other major cost of wilderness use would have been the risk of early season drought. Conditions which maintain plant succulence may reduce mortality by prolonging a high nutritional plane for fawns (Picton 1979), and drought could cause premature senescence of forage plants and reduce the nutritional value of forage. Since lactation requires both nutritious and succulent forage for the doe (Short 1981), drought could cause substantial early fawn mortality and may reduce deer deer population levels (Anthony 1976). Spring/summer droughts have been recorded in three of the past 24 years on the monument, and A major reduction in fawn crop once every eight years would be a significant cost of wilderness use.

If benefits of wilderness use outweighed the risks, population characteristics such as production and survival would have been expected to be greater for central and wilderness deer. Unfortunately, valid estimates of these parameters for sedentary and migratory segments of the herd were not available as most of the marked sedentary does were younger and retained fewer fawns to the fall than older does. Mixing of the two herd segments in late summer and fall precluded valid estimates of differences in mortality rates.

If productivity and survival were higher for mid-summer migrants, spring density should have been higher in central and wilderness areas. Neither the general impression of density nor the proportion of marked does which were migratory supported this. Approximately 75-80 percent of the Craters deer habitat was in central and wilderness areas and 75 percent of marked does used these areas. Thus no evidence for long term advantage to wilderness use was evident. This suggested that lack of free water and vehicle accidents may have negated the habitat benefits of the southern areas.

### 5.1.2 Mid-Summer Migration

Deer are generally assumed to require free water to

survive (Short 1981), and when observed to drink water in desert situations can consume nearly six liters at a session (Elder 1954). Some authors (Hanson and McCulloch 1964) have suggested that deer will not travel more than 2.5 km to water, yet deer do exist in areas without obvious free water. Deer use of the wilderness area of Craters of the Moon National Monument is the most relevant example in the northern Great Basin. Deer reproduced and reared their fawns through the peak of lactation demand in an area where the only drinking water came from dew, fog, or ephemeral puddles in rocks, yet evidently did not make trips to obtain drinking water in spring and early summer. Relocations of marked deer were made in early mornings and late evening during times that Elder (1956) has reported to be the peak in drinking activity by desert deer. If deer made trips to water in the spring and early summer they should have been detected as they were in the fall.

Deer were routinely located in areas of the monument up to 16 km from free water. Based on the relationships presented by Pennycuick (1979), the daily foraging radius of a 60 kg deer would be about 10 km. Deer from as far south as Coyote Butte conceivably could have made round trips to the Pioneer Mountains for water, yet they evidently did not. Because virtually no free water was available for wilderness deer two hypotheses were suggested: 1) deer satisfied their water requirements from April through mid-July from food, dew, and opportunistic water sources, and 2) deer migrated out of the wilderness because they were unable to maintain water balance.

The ability of desert ungulates to survive on the water obtained from forage has been documented for peccaries (Dicotyles tajuca) by Zervanos and Day (1977) and for the oryx (Oryx besia) and eland (Taurotragus oryx) by Taylor (1969). Leopold (1933) presented anecdotal evidence that mule deer could survive for a time at least on succulent forage and Krausman (1978) noted that water obtained from succulent forage may be quite important to deer in areas without free standing water.

To estimate whether enough water to sustain mule deer could be obtained from forage at the monument it was necessary to estimate water requirements, forage consumption rates, and the amount of water obtained from forage tissues and from metabolic water obtained by oxidation of food.

Water flux, the amount of water entering and leaving an animal in equlibrium, is proportional to the 0.8 power of body weight (Richmond et al. 1962). The relationship applies to animals of various sizes kept in a relatively thermoneutral environment with drinking water available. The quantity of water that an animal requires increases as body size (Richmond et al. 1962), lactation demands (Short 1981), and environmental temperatures increase (Zervaros and Day 1977, Schmidt-Nielsen 1964, Longhurst et al. 1970).

In winter, water flux may drop below values predicted by the interspecific formula of Richmond et al. (1962). Free ranging peccaries (Zervanos and Day 1977) and captive Columbia black-tailed deer (Odocoileus hemionus columbianus) (Longhurst et al. 1970), respectively, showed 23.5 percent and 13.9 percent reductions from predicted water flux during winter measurements.

In summer, an increase above predicted water flux would be expected due to increased thermoregulatory demands. Zervanos and Day (1977), however, observed water flux of free ranging peccaries in summer to equal the predicted value based on body weight. Longhurst et al. (1970) and Knox et al. (1969) observed water flux rates 1.69 and 1.23 times the interspecies predictions for captive Columbian black-tailed deer and Rocky Mountain mule deer at a median daily temperature of 18.5 °C and at a relatively constant temperature of 21 °C, respectively. In both cases constantly available drinking water was provided. Knox et al. (1969) noted elevated flux rates in more closely confined deer and cautioned against broad application of their results due to possible confinement bias. Longhurst et al. (1970) used much larger pens but made no mention of shade being available for their animals. It seems likely that a free living animal would seek shade to minimize thermoregulatory

stress. To cope with restricted water intake an animal may reduce its water flux and extend the time before it becomes lethally dehydrated. Peccaries, for example, reduce water flux by 66 percent when on restricted water intake (Zervanos and Day 1977).

To estimate water requirements of Craters deer (Fig. 5.1.1) it was assumed that the water flux rates reported by Knox et al. (1969) and Longhurst et al. 1970) were biased upward by confinement. Accordingly, water flux in mid-June with a median daily temperature of 14.2 °C was assumed to equal the flux predicted by the interspecies equation of Richmond et al. (1962). The flux was allowed to rise directly with median daily temperature which increased to 16.6 °C by mid-August (Fig. 5.1.1). This produced a 17 percent increase in estimated water flux throughout the two months.

Lactation places an additional water demand on female ungulates (Short 1981). The demand peaks six to eight weeks after birth (Robbins and Moen 1975, Moen 1978) and declines thereafter. The added water demand due to lactation necessary for one and two fawns (Fig. 5.1.1) was estimated from milk consumption rates reported for white-tailed deer fawns by Robbins and Moen (1975). A single fawn was assumed to consume milk at the maximum rate reported and two fawns were each assumed to consume the amount reported for the lower consumption rate. Lower weight gains for twin versus single fawns (Verme 1967) suggest siblings may individually consume less than a singleton. Water content of milk was assumed to be 76 percent (Robbins and Moen 1975).

Water available from forage was estimated from the seasonal diet of Craters deer, the percent water in the forage, the average forage consumption rates for male and female mule deer in summer (26.45 gm/kg) presented by Alldredge et al. (1974). Lactating females were assumed to consume 1.26 times this average in summer. This adjustment was interpolated from information presented by Moen (1978). Water content of shrubs was estimated by bitterbrush, of grasses by the mean of Sitanion hystrix and Stipa thurberiana, and of forbs by the

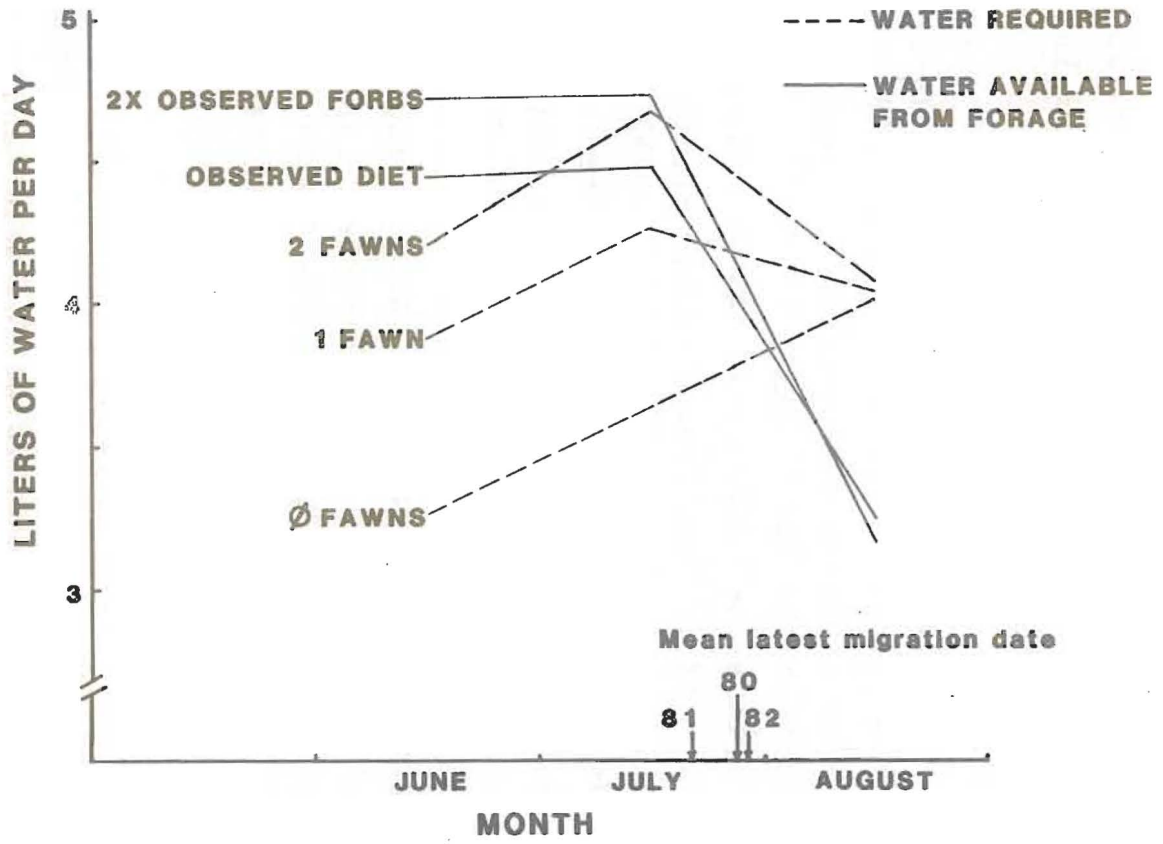



**Figure 5.1.1** Water required for a 60kg mule deer with 0, 1, and 2 fawns; and water available from forage at observed diet and if forb component doubled, Craters of the Moon National Monument, Idaho.

water content of Cymopterus terrebinthinus (Fig. 5.1.2). Craters deer fed primarily in early morning and late evening. Comparison samples collected at dawn and at 1400 MDT on the same days showed that the percent water in shrubs was 10.7 (+2.3) percent greater ($P<.05$) at dawn than in early afternoon. Accordingly, water content of shrubs was assumed to be 10.7 percent higher than the values measured at 1400 MDT and depicted in Figure 5.1.2. Grasses and forbs were not significantly wetter at dawn. The increase in percent water at dawn included both very light and noticeable dew. Heavy dew would increase percent water of vegetation appreciably. Taylor (1968) has documented that desert vegetation reaches maximum percentage water during nighttime conditions of low temperature and high relative humidity and that oryx preferentially feed at these times of maximum water content of forage.

Metabolic water obtained from oxidation of food was calculated from the proportion of shrubs, grass and forbs in the diet, and estimated forage consumption rates presented by Alldredge et al. (1974). Digestabilities were obtained from Short (1981). As the season progressed, digestability was allowed to decrease to the average of new and old growth. This assumed some selectivity by deer in choosing the most nutritious forage. Metabolic water obtained was estimated as (forage consumed) X (digestability) X ( 0.54 g $H_2O$/g forage digested). The value 0.54 was the weighted average of metabolic water conversions presented by Schmidt-Nielsen (1964) and assumed a diet of 15 percent protein and 85 percent carbohydrates. Fats were assumed to be negligible. The effect of this assumption was to slightly underestimate metabolic water as fats produce more metabolic water than either carbohydrates or protein (Schmidt-Neilsen 1964).

To estimate total water available from food, the water in forage tissues and metabolic water were summed and plotted (Fig. 5.1.1).

Based on the water requirement and water availability functions hypothesized (Fig. 5.1.1), at the observed diet Craters deer would have been able to derive sufficient water

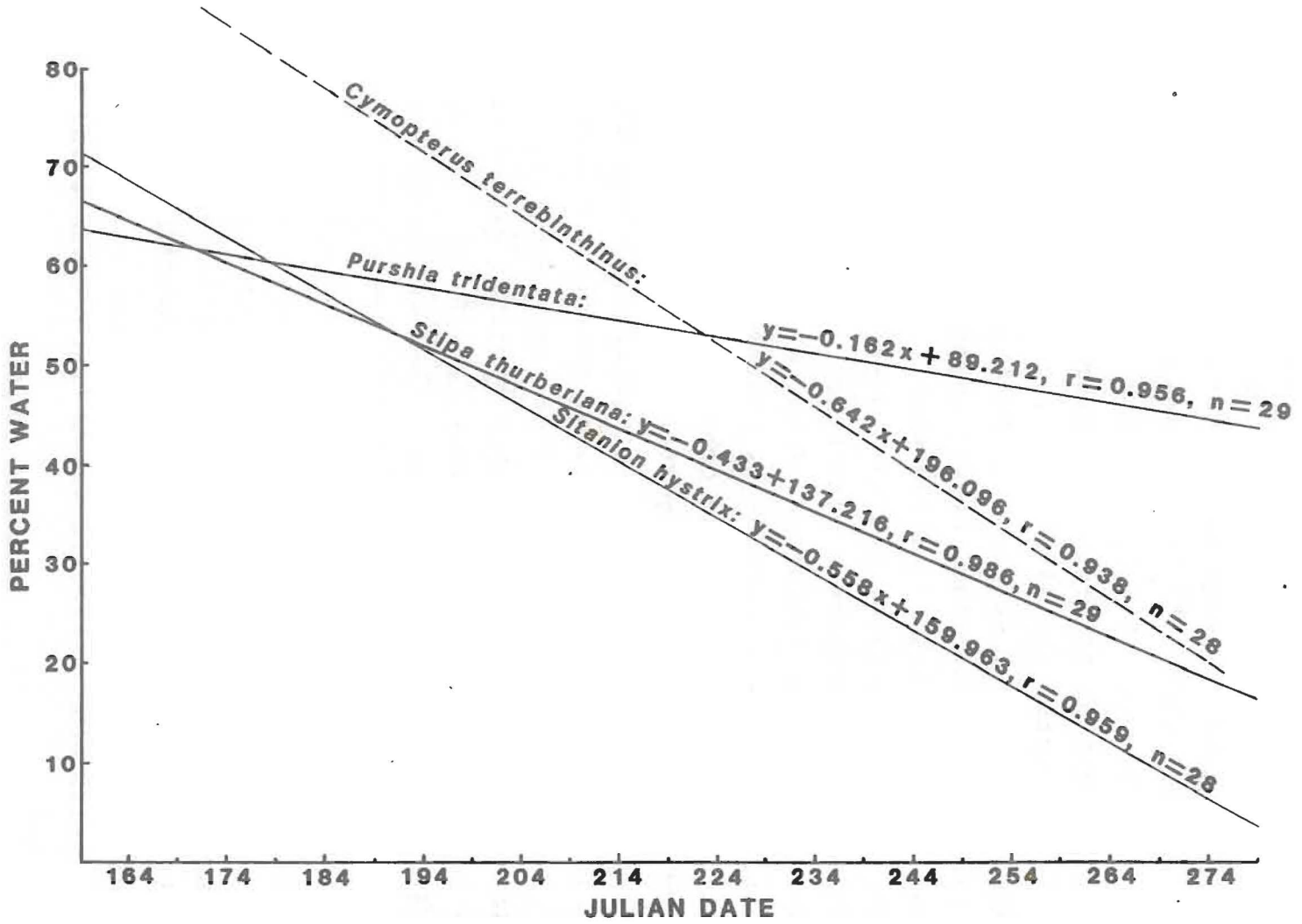



**Figure5.1.2 Percent water in forage, Craters of the Moon National Monument, Idaho.**

from forage through the end of June. By the first week of August, deer would have entered negative water balance and by mid-August would have had a daily water deficit of about 0.8 liters per day. It is quite unlikely that they could have satisfied this deficit in the hot and dry conditions in the southern areas of the monument during August and early September. The fact that deer occupied the southern areas when sufficient water was available from forage and did not occupy the area when there was insufficient water in forage supports the hypothesis that the migration was caused by water stress. Hoskinson and Tester (1980) have suggested that the water content of forage may act as a stimulus for the onset of fall migration in pronghorn (Antilocapra americana) on the northern edge of the Snake River Plain in Idaho as well.

Variation in percent water in forage actually consumed by deer or variation in the proportion of the diet composed of shrubs, grasses, and forbs can affect the hypothesized water availability depicted in Figure 5.1.1. For example, forbs have higher water content than grasses or shrubs in spring and early summer (Fig. 5.1.2) and may be underrepresented in fecal pellet microhistological analyses of herbivore diets (Anthony and Smith 1974, Vavra et al. 1978, and Leslie 1982). Since some forb species which were known to be eaten regularly by deer at Craters (Lomatium sp. and Delphinium sp.) did not appear in microhistological analyses of fecal pellets (Table 4.1.1), a second estimate of water availability was calculated which assumed the proportion of forbs in the diet was actually twice the observed value and the proportion of shrubs was reduced accordingly. This adjustment was in accordance with known levels of detection for microhistological methods (T. Foppe, pers. comm.).

Under the conditions of this exercise, all deer would have entered negative water balance in the latter one-half of July when the migration actually occurred (Fig. 5.1.1). Since the percent water in forage was based on whole plant measurements for grasses and forbs and included stems for shrubs, deer could have selected the more moist parts of plants and have produced

a similar effect. Behavioral minimization of water requirements also could have delayed entry into negative water balance.

According to the functions hypothesized in Figure 5.1.1, does with two fawns should have entered negative water balance earlier than does with one fawn and non-lactating individuals should have entered negative water balance last. Does with two fawns did tend to migrate out of the wilderness 2.5 days earlier than does with one fawn (Table 4.2.2), but the migration date for deer without fawns did not fit the suggested pattern. The two does without fawns did migrate after the mean migration date for does with fawns, but the males tended to migrate three to four days ahead of lactating deer. Male ungulates accumulate fat much earlier than females (Clutton-Brock et al. 1982) and undergo antlerogenesis in the spring and early summer, but it seems unlikely that these physiological demands would have exceeded demands of lactation. Behavioral differences between sexes may have been involved.

The tendency for males to migrate earlier than females suggested that fawns may in some way delayed the migration of their dams. The tendency for fawns to be born 5-7 days ($P \leq .10$) later in 1982, coincident with a 10-day ($P \leq .05$) later migration, would support the hypothesis that fawns influenced the exact timing of migration. Water stress as the ultimate reason for migration would remain unchanged, however. Carroll and Brown (1977) noted that white-tailed deer fawns in areas with adequate ground cover did not regularly follow their dams until about 46 days of age. Mean age at migration for eight fawns at Craters was 42 days (range 36 to 48 days). The 5-18 km migration to north end ranges in late July was a major trip, and does may have been able to sense the ability of their fawns to successfully complete the trip and have delayed accordingly.

Since mid-summer migration date was best predicted by the number of days with combined daytime high temperatures above 27 °C and nighttime lows above 10 °C, the effect of environmental heat load on water requirements of mule deer must have been quite important. The fact that deer returned to the wilderness

in the fall when mean high temperatures had dropped 10 °C - 12 °C, suggested that during the fall they were able to survive for a few days at a time without free water. As evidenced by the repeated trips back to the north end in fall (Table 4.2.3) supplemental water may have been periodically necessary as during drier periods the trips tended to be more frequent and the stay in the south end shorter (Table 4.2.3).

Since the hypothesized water availability functions did intersect the hypothesized water requirement functions in July when migration occurred (Fig. 5.1.1), the assumptions underlying the relationship of water supply and demand were supported. The assumptions used were not necessairly validated, but deer apparently behaved in a manner such that the net effect was similar. In particular, crepuscular feeding by deer, behavioral minimization of water requirements for thermoregulation, or perhaps some type of selectivity for more moist forage would have been necessary to allow deer to remain in water equilibrium in the wilderness until late July. These aspects of mule deer behavior and physiology are worthy of further investigation.

### 5.1.3 Distribution Patterns

Mid-summer migratory behavior of Craters deer caused seasonally variable use of different portions of the monument. From mid-April through the end of July, about 75 percent of the herd was dispersed in central and wilderness sections of the monument. The remaining 25 percent occupied the north end and some adjacent non-monument lands. This period encompassed the latter stages of gestation, fawning, and the first six to eight weeks of lactation.

When central and wilderness deer migrated to the north end in late July they caused an approximate four fold increase in density north of the highway. During August and September at least 95 percent of the herd occupied the north end. A few deer (about five percent of the herd) may have continued to utilize the central area and have periodically obtained drinking water from the north end or visitor center. Of the

nine marked deer which used the visitor center lawns during this study, six used the central and wilderness areas in spring and fall. However, these six did not use the lawns until they had migrated to the north end. Earliest use of the lawns was during the first week in July and most use occurred in August and September. Each year residents of the visitor center started reporting deer on the lawns in mid-July which was consistent with observations of marked deer.

During August and September, the aspen and Douglas fir stands in the north end were important habitat components providing thermal cover and security. Although these stands accounted for only about one percent of the total vegetated area, nearly every deer in the herd eventually used them. The north end was thus a seasonally preferred habitat for the Craters herd and was evidently the best available habitat during August and September. Only there did crown closure in forested stands consistently exceed 50 percent. Leckenby (1971) has noted that this much crown closure is required to effectively moderate environmental stress. When the moisture in forage no longer met the needs of deer, they could have either obtained supplemental water in the north end or have reduced water requirements by using the shaded habitat there. Both factors probably contributed to water equilibrium maintenance.

By late September, when southern deer began to return to their central and wilderness home ranges, the importance of the north end habitat diminished. When temperatures decreased in October, the free water and moderated thermal environment offered in the north end may not have been as critical. Since return to southern areas began before hunting season opened, the deer must have been seeking reduced social pressure, a more favorable forage base, or some other habitat attribute.

Since deer did not consistently remain in southern and wilderness areas in the fall it was difficult to adequately describe distribution in October and November. The sedentary deer remained in the north end throughout the fall, but some migrants made repeated trips back and forth to the southern

areas. Since some migratory deer did not return to southern areas until early November, migratory deer may have spent only one-half their time from October through November in southern areas. Thus, in October and November only about 60-65 percent of the herd would have been north of the highway on any day. The 35-40 percent which used southern areas would have been free of potential hunting mortality during these two months.

## 5.2 Population Characteristics

### 5.2.1 Production

Estimates of population characteristics from this study were obtained during a continous period of above average total annual precipitation (Fig. 5.2.1), During 1980-1982, the number of fawns per adult doe in the fall was consistently high (Table 4.3.3). In 1980, at least 1.91 fawns were born per adult doe, a value exceeding the maximum recorded rate of 1.86 fawns:adult doe (Jensen and Robinette 1955) for free ranging mule deer. The fall fawn:doe ratio for the Craters herd in 1967 (1.29:1.0) (Ritchie 1968) was even higher than equivalent ratios (Table 4.3.3) recorded during 1980-1982. At least in wetter than average years, the Craters herd appeared unexcelled in production of fawns to five months of age. The age structure of the herd reflected this high production and concomitant turnover rate. At least 77 percent of 64 deer which were not fawns and which died from various causes during this study were less than five years old.

The apparently lower fawn:adult doe ratio in the fall of 1981 than in 1980 indicated that fewer fawns were born in 1981, the fawns had lower survival, or a combination of the two. Since deer apparently entered the breeding season and mild winter of 1980-1981 in good condition and suffered negligible over winter mortality, birth rates in 1981 might have been expected to be at least as good as 1980. Ovulation, conception, and pregnancy rates are highest for does in good nutritional status (Connolly 1981) and nutritional status during pregnancy is positively correlated with weight cf young at birth and their subsequent survival (Thorne et al. 1976,

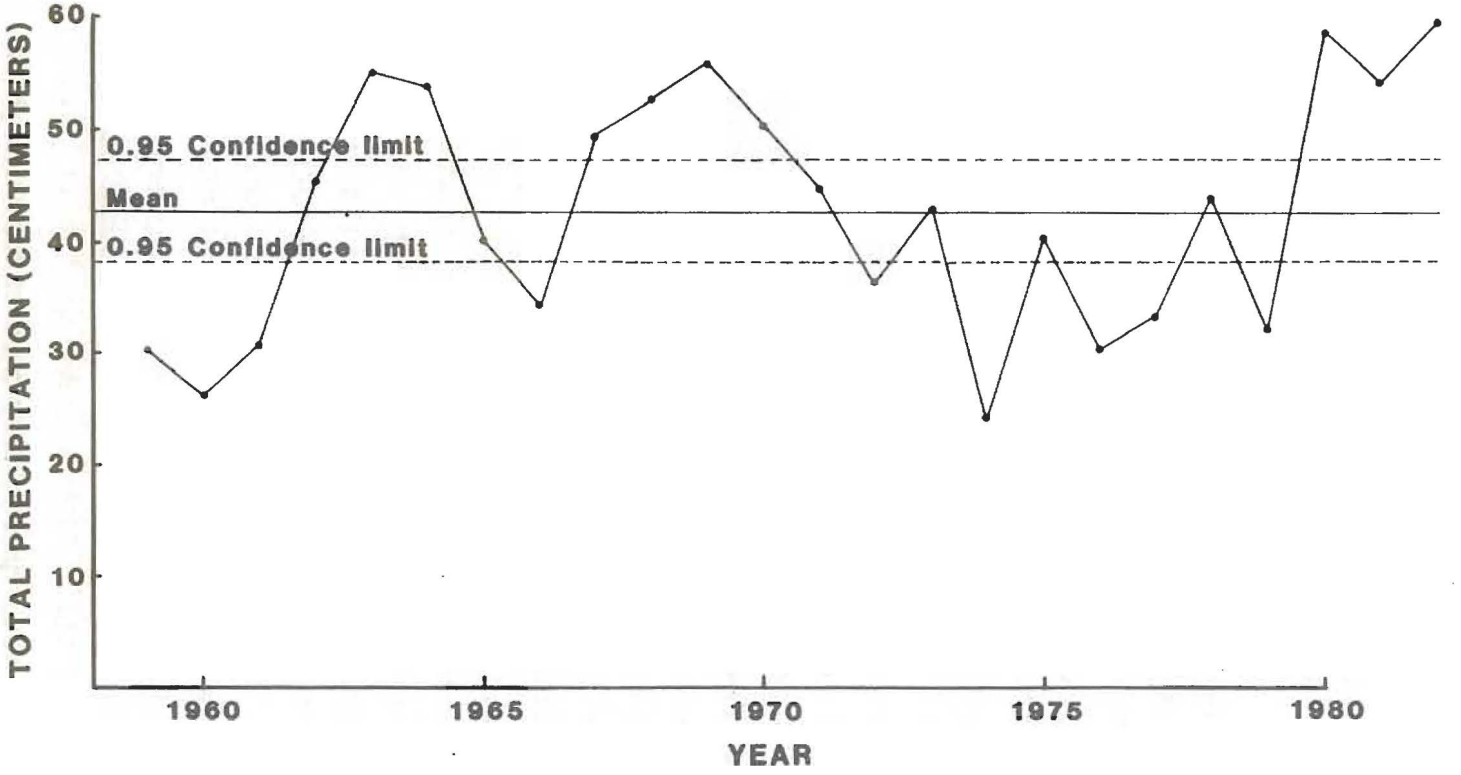



**Figure 5.2.1** Total yearly precipitation, 1959-1982, Craters of the Moon National Monument, Idaho.

Murphy and Coates 1966, Robinette et al. 1973, Verme 1963, 1967). Although Craters deer gave every indication of being on a high nutrional plane during the breeding season cf 1980, and were evidently not severely stressed during the following winter, there was a possibility that because a high proportion had successfully raised fawns in 1980, the does were nutritionally stressed and were thus less productive in 1981. Clutton-Brock et al. (1982) noted lowered productivity of female red deer (Cervus elaphus) in the year following successful rearing of a calf, Mundinger (1981) noted that white-tailed deer in Montana tended to successfully raise a fawn only every other year, and Verme (1967) observed lowered productivity of white-tailed deer the year following successful rearing of fawns. In these cases the demands of lactation were evidently severe enough that females could not regain optimum condition by conception, remained in poorer shape throughout the gestation period, and produced fewer fawns the next year.

It is also possible that does and fawns were nutritionally stressed during the droughty summer of 1981, and this resulted in lower fawn survival and the lower fawn:adult doe ratios observed in the fall of 1981. Diminished antler growth of yearling males and the observations of thin does in the fall of 1981 suggested nutritional stress compared to 1980. Reduced nutritional status of the forage could have been due to low winter precipitation from October 1980 through February 1981, and the fourth driest summer (June-September) on record in 1981. Deer populations have been reported to be lower following drought (Anthony 1976) and fawn:doe ratios may be lower following drought during the fawn rearing season (Zeigler 1978). Smith and LeCount (1979) have demonstrated a direct relationship between the previous winter's precipitation and spring forb production on mule deer range in Arizona. Since adequate nutrition during the last one-third of pregnancy is particularly important to fawn survival (Verme 1963), it is not surprising that winter precipitation was also related to fawn:doe ratios the following fall (Smith and LeCount 1979).

The equivalent fawn:doe ratios observed in the falls of

1981 and 1982 suggest that the effect of a dry winter followed by a summer drought on net production of fawns to five months of age may be equal to the effect observed when deer breed in suboptimal condition and then experience a severe winter and slightly late spring.

5.2.2 Mortality

During the study, on the average less than one-half of the fawns and bucks and about 80 percent of the does survived each year (Table 5.2.1). These survival figures were within the range reported for stable herds in the western states (Connolly 1981:338). For fawns, neonatal losses were the single largest source of mortality followed closely by winter losses. Hunting did not directly account for much fawn mortality but, if the hypothesized loss of orphaned fawns occurred, was an important indirect source of mortality. Although winter losses accounted for substantial portions of total annual mortality for deer older than one year, hunting losses accounted for the largest portion of annual mortality for both bucks and does.

Total estimated hunting mortality was 15.1 percent of the herd per year. Since only 60-65 percent of the herd was subject to hunting pressure during October and November, harvest, as a percent of the deer available, may have approached about 25 percent. Even a hunting removal of 15.1 percent of the herd is significant and approaches or exceeds the harvest rate on unprotected herds. Robinette et al. (1977) reported a sustained average annual harvest of 23 percent over 10 years in Utah for a mule deer herd which had average fall fawn:doe ratios only 71 percent as high as the Craters herd. It would appear that the Craters herd could sustain the documented or estimated total harvest indefinately barring significant changes in the environment.

As the data in Table 4.3.6 show, hunters clearly selected for bucks ($P<.01$) and against fawns ($P<.01$). Differences in hunting season regulations and in the abundance of yearling males appeared to be related to the harvest of does. Yearling bucks were 1.6 times as abundant in 1981 as 1980 and may have

absorbed hunting pressure from does. If a hunter was more likely to see a buck he was probably less likely to take a doe. In 1982 only bucks could be legally taken during the first 7 days of the 25 day season. In both other years, any deer was legal during the first five days of the season. Probably many hunters which would have taken does in 1980 and 1981, took bucks during the first week of the 1982 season. When any deer was legal during days 8-12 of the season in 1982, many hunters had already taken an animal and the does had probably become more wary and less susceptible to being killed.

Harvest of does has the greatest potential for population limitation. Nelson and Peek (1982) have noted that survival of sexually mature females is the most important determinant of rate of increase for elk (Cervus elaphus) and a similar response for mule deer is likely. Consistent harvest of females at the rate observed in 1980 (24 percent) would most likley depress the population. The extremely mild winter of 1980-1981 probably offset much of the effect of this harvest and allowed an increase in deer numbers from 1980 to 1981. The 12 percent average estimated total harvest of does was not large enough, however, to cause a decline in population levels. There is therefore no reason to seek curtailment of doe hunting around the monument boundary. If at a later date the herd should be deemed excessive, liberalization of doe hunting around the monument could be used as a management tool to reduce the population level and/or growth rate.

### 5.2.3 Potential for Population Increase

Since this study encompassed a mild and a severe winter and an unusually dry and an unusually wet summer, the production (Table 4.3.3) and survival (Table 5.2.1) values obtained may have represented the performance expected from the herd. When population dynamics were simulated over the course of 30 years, using the average production and survival values, the herd grew at 10 percent per year and doubled after seven years. Such a trend was not evident during the course of the study, however (Table 4.3.4). It is possible that yearling and

TABLE 5.2.1 Mean survival rate of mule deer and percent of total mortality accounted for by known sources, Craters of the Moon National Monument, Idaho, 1980-1982.

| DATES: MORTALITY SOURCE | MEAN SURVIVAL RATE | | | | PERCENT OF TOTAL MORTALITY | | | |
|---|---|---|---|---|---|---|---|---|
| | FAWNS | FEMALES | YEARLING MALES | ADULT MALES | FAWNS | FEMALES | YEARLING MALES | ADULT MALES |
| 1 Jun - 1 Sep: | | | | | | | | |
| Neonatal[a] | 0.76 | 1.00 | 1.00 | 1.00 | 37 | 0 | 0 | 0 |
| Road Kills | 0.99 | 0.99 | 0.98 | 1.00 | 2 | 3 | 2 | 0 |
| Entire Period | 0.75 | 0.99 | 0.98 | 1.00 | 39 | 3 | 2 | 0 |
| 1 Sep - 1 Jun: | | | | | | | | |
| Road Kills | 0.97 | 0.99 | 0.96 | 0.98 | 4 | 3 | 5 | 3 |
| Hunting[b] | 0.97 | 0.88 | 0.56 | 0.58 | 4 | 57 | 68 | 70 |
| Orphaning[c] | 0.87 | -- | -- | -- | 19 | -- | -- | -- |
| Winter | 0.78 | 0.92 | 0.81 | 0.81 | 34 | 37 | 25 | 27 |
| Entire Period | 0.64 | 0.80 | 0.58 | 0.46 | 61 | 97 | 98 | 100 |
| Entire Year | 0.48 | 0.79 | 0.44 | 0.46 | 100 | 100 | 100 | 100 |

a Neonatal survival calculated as the median of the observed rate in 1980 (0.86) and the estimated minimum rate of 1981 (0.66).

b Hunting losses of unknown sex and age classes were proportionately distributed across known sex and age classes. Total hunting loss was estimated as documented loss ÷ 0.7.

c Assumes all fawns of hunter killed does were lost.

older female survival was overestimated as the predicted and observed populations in 1982 suggest (Table 4.3.4). Alternately, the simulated and observed trends in population level may have differed because dispersal was not accounted for in the simulation. Because yearling and adult females were indistinguishable in late summer and fall it was not possible to estimate yearling female dispersal rates. However, the circumstantial evidence for yearling male dispersal at Craters and Robinette's (1966) report of dispersal of both sexes during their second summer suggested that yearling females may have dispersed also. Dispersal of one-third of yearling females would have been sufficient to stabilize a population with survival and production values obtained in this study. Although not proven, it appears that dispersal may have been an important hidden parameter in population dynamics of the Craters herd.

### 5.2.4 Population Trend

Throughout the west, populations of mule deer appear to have reached a low point during the late 1800's and early 1900's (Mackie 1981). During the 1920's populations began to increase (Denny 1976 in Connolly 1981). The increase, which continued through the 1940's into the 1960's (Mackie 1981), was followed by a decline during the 1960's and early 1970's with signs of recovery during the late 1970's (Connolly 1981).

The scenario of deer numbers presented by Ritchie (1968) for the Craters deer herd during the period of 1921-1967 paralleled the hypothesized westwide trend. Since the Craters herd is subject to influences occurring outside the monument, it seems reasonable that factors affecting the increase in mule deer since the turn of the century would have influenced the monument population. Factors favoring the increase have included decreases in human and domestic livestock populations and establishment of effective game policy in the 1930's (Connolly 1981).

Since 1958 at the latest, however, there has been no

convincing evidence for a consistent increasing or decreasing trend in the Craters herd. All of the late summer and fall counts reported by Ritchie (1968, pers. comm. 1980) fell within the range of standard late summer and early fall roadside censuses conducted during 1980-1982. Ritchie (1968) reported counts ranging from 39 to 100 during the period 1958-1967; during 1980-1982, with total prehunt populations of 351 to 515, similar counts ranged from 16 to 157. The fact that deer were reported to be numerous and increasing as long ago as 1938 (Ritchie 1968) may indicate that the population had reached contemporary levels as long as 45 years ago. Due to their crepuscular habits and distribution in the wilderness, deer were not seen by NPS personnel with the frequency that would have indicated the substantial populations present during 1980-1982. A report of a numerous and increasing deer population in 1938 (Ritchie 1968) therefore suggested a substantial population by that time.

The fall population estimate of 335 total deer obtained by Ritchie (1968) in 1967 and the three prehunt population estimates of 478, 515, and 351 obtained in this study provide the best estimate of fall population levels during the past 15 years. These estimates averaged 420 deer with a 95 percent confidence interval of ± 143. Thus, pre-hunt populations could fall within the range of 277-563 animals and not differ significantly from this average. Yearly variation in weather, through effects on phenology and nutritional content of forage (Verme and Ozoga 1977, 1981), limits on forage availability (Wallmo et al. 1977), and resultant energy available for maintenance, gestation and growth will probably have the greatest influence on year to year variation in population level within this range. Since both this study and the work of Ritchie (1968) took place during periods of above average total annual precipitation, the average population calculated from these years may overestimate the true long term mean.

## 5.3 Habitat Condition

From 1967 through 1982 the grass and forb components of

the vegetative communities at Craters have shown indications of relative stability. Variation between years, particularly in the frequency of forbs, most likely represented year to year variations in precipitation. Increases in vegetation and litter components of cover and decreases in the proportion of bare ground, through the 13 years of 1967-1980 indicated maturation of grass and herbaceous components of vegetation (Griffith 1983). Since grass and forbs constituted a minor portion of the diet of Craters deer (Table 4.1.1), it is not surprising that these two groups remained in excellent condition.

Since shrubs, particularly bitterbrush, predominated in the diet of Craters deer (Table 4.1.1), the age distribution, growth form and frequency of occurrence of bitterbrush is the most likely key to the condition of summer forage base at Craters. During 1980 and 1981 the proportion of seedling and young age class bitterbrush (Table 2.6.1) remained relatively constant. In 1982 seedling and young age classes declined dramatically (Table 2.6.1). It cannot be determined if the decline in young age classes was due to a different observer in 1982, the drought during the summer of 1981 causing mortality of the young plants, or if the high deer population in 1981 browsed the young plants and removed them from the population. Drought seems most important since the summer of 1981 was the fourth driest in 24 years.

If the hypothesis of a relatively stable population level during the past 25 years is valid, then the current good to excellent overall condition of the forage base suggests a population at or below long term carrying capacity on summer range. Within the limits of this concept, deer may still influence their forage base but the effect is viewed as a short term habitat alteration. For example, the high population during the drought year of 1981 probably did influence the forage base to some degree in the north end. If similar conditions existed year after year, habitat alteration might be expected. However, as shown by population fluctuations observed during this study, factors unrelated to the monument

did depress the population and reduce pressures on the habitat. The nutritional content of forage (as influenced by moisture availability) rather than forage quantity, and sufficiently shaded resting sites in late summer may be the attributes of the summer habitat which are limiting to the Craters herd.

## 5.4 Perspective

Although moisture stress has long been known to influence the distribution and abundance of deer, most of the research addressing the specifics has come from the arid southwest. Data which suggest the specific conditions that may cause moisture stress in free ranging mule deer in the northern Great Basin are limited or non-existant, however. The Craters deer, by migrating in mid-summer, have identified some of the conditions of environmental temperature and forage moisture that are likely to cause physiological stress in free ranging Great Basin mule deer in summer. From a practical point of view, the best predictor of stress was the total number of days with combined daytime temperatures above 27 °C and nighttime lows above 10 °C. The behavior of Craters deer suggested that when more than 12 such days accumulate in open habitat in summer (which would include the entire Snake River Plain) that deer distribution and perhaps abundance may be enhanced by water development.

The consistently high proportion of fawns in the fall did not imply a consistently increasing population. Caughley (1974) suggested this would be the case based on population simulation, and the fluctuating population levels observed during 1980-1982 (Table 4.3.4), demonstrated this characteristic for the Craters herd. Even though the herd had high production, it remained stable or declined. Hunting, winter losses, and perhaps the loss of orphans and dispersal tended to depress the population growth rate. Thus there was little reason to believe that the herd would exceed carrying capacity of the monument summer range and damage the habitat. The current good to excellent condition of the habitat suggested a herd at or below carrying capacity on summer range.

The soil disturbance seen in aspen and Douglas fir stands in the north end was primarily a result of the entire herd bedding there for two months in late summer. Any concern for Craters deer exceeding carrying capacity should probably be focused on the winter ranges and Protection of winter range would be the only real reason for limiting the number of Craters deer. Even then, the Craters herd probably does not constitute the major portion of the herd on either winter range.

The consistent and substantial levels of hunting harvest and the consistent road kill losses demonstrated that Craters of the Moon National Monument did not serve a true protective function for the herd. These two sources of mortality together removed a number of deer equal to an average of 18 percent of the total fall population each year. If suspected orphaning losses were added they would bring the total annual removal up to 24 percent of the pre-hunt herd. Any dispersal of yearling deer would further increase the contribution of the monument to the harvestable population of Snake River Plain mule deer.

The monument does function as an island of high quality habitat; and, as such, it serves as a reservoir of deer which may contribute to recreational use on adjacent lands.

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# APPENDICES

APPENDIX A. Sex, age, capture date, capture location, capture method, radio collar status and number of relocations of marked mule deer, Craters of the Moon National Monument, Idaho, 1980-1982.

| TAG COLORS | TAG NUMBERS | AGE[a] | SEX | CAPTURE DATE | CAPTURE LOCATION | CAPTURE METHOD | RADIO COLLARED | NUMBER OF LOCATIONS 1980 | 1981 | 1982 | TOTAL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YY | 02,01 | F | M | 5/31/80 | Inferno | Hand | --- | 4 | -- | -- | 4 | Road kill 8/29/80 |
| YY | 01,02 | F | M | 5/31/80 | Inferno | Hand | --- | 3 | 2 | -- | 5 | >siblings |
| YY | 03,03 | F | ? | 6/1/80 | Inferno | Hand | --- | 1 | -- | -- | 1 | Sickly when marked |
| YY | 04,04 | F | M | 6/1/80 | Inferno | Hand | --- | 4 | -- | -- | 4 | Road kill 9/1/80 >siblings |
| YY | 05,05 | F | M | 6/8/80 | Martin Mine | Hand | --- | 6 | 2 | -- | 8 | One of twins, hunter killed 10/19/81 behind Broadie's |
| YY | 06,06 | F | F | 6/21/80 | L. Cottonwood | Hand | --- | 4 | 7 | 7 | 18 | |
| YY | 07,07 | F | M | 6/21/80 | L. Cottonwood | Hand | --- | 4 | -- | -- | 4 | >siblings |
| YOYO | 46,47 | A | F | 6/21/80 | Broken Top | Trap | 80,82 | 20 | 29 | 80 | 129 | |
| WWWW | 19,23 | Y | M | 6/22/80 | Split Butte | Dart-12mg | 80 | 18 | -- | -- | 18 | Hunter killed 11/6/80, Syd's crossing |
| YWYW | 33,34 | A | F | 6/24/80 | Big Cinder | Dart-14mg | 80 | 37 | 28 | 10 | 75 | |
| YYYY | 39,40 | F | F | 7/26/80 | Inferno | Trap | 81,82 | 3 | 107 | 108 | 218 | |
| YGYG | 12,16 | Y | M | 7/31/80 | L. Cottonwood | Dart-14mg | 80,81 | 31 | 16 | -- | 47 | Study mortality 9/28/81, Quick Shot |
| OGOG | 15,16 | Y | F | 7/31/80 | Martin Mine | Trap | 80 | 20 | 5 | -- | 25 | |
| OYOY | 21,22 | A | F | 8/3/80 | YCC Canyon | Trap | 80 | 16 | 53 | 12 | 81 | |
| WGWG | 21,22 | F | ? | 8/3/80 | YCC Canyon | Trap | --- | 5 | -- | -- | 5 | Fawn of OYOY, disappeared 11/80 |
| WOWO | 13,14 | A | F | 8/4/80 | Martin Mine | Trap | 80,81 | 35 | 41 | -- | 76 | |
| WYWY | 17,18 | F | F | 8/4/80 | Martin Mine | Trap | --- | 10 | -- | -- | 10 | Fawn of WOWO |
| WYWO | 15,16 | F | F | 8/5/80 | Martin Mine | Trap | --- | 6 | 14 | 3 | 23 | One of triplets |
| OBOB | 12,14 | A | F | 8/10/80 | Martin Mine | Trap | 80 | 15 | 7 | 13 | 35 | |
| BWBW | 05,16 | F | F | 8/10/80 | YCC Canyon | Trap | --- | 9 | 4 | 1 | 14 | |
| BOBO | 04,03 | A | F | 8/22/80 | YCC Canyon | Trap | --- | 8 | 36 | 13 | 57 | |
| YGYP | 25,26 | A | F | 8/23/80 | YCC Canyon | Trap | --- | 6 | 29 | 6 | 41 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YPYG | 19,20 | F | M | 8/23/80 | YCC Canyon | Trap | --- | 6 | 3 | -- | 9 | Fawn of YGYP |
| BGOW | 01,01 | A | F | 8/26/80 | L. Cottonwood | Trap | --- | 9 | -- | -- | 9 | Died fall 1980, Big Cinder Butte |
| OPBG | 03,01 | F | M | 8/26/80 | YCC Canyon | Trap | --- | 1 | 23 | 10 | 34 | |
| RWRW | 01,02 | A | F | 8/31/80 | L. Cottonwood | Dart-14mg | --- | 3 | 1 | -- | 4 | Hunter killed 10/14/81, outside monument on Lava Creek |
| OPRG | 05,04 | F | M | 9/3/80 | YCC Canyon | Trap | --- | 3 | -- | -- | 3 | Still spotted when captured |
| YBWB | ---- | A | F | 9/7/80 | YCC Canyon | Trap | --- | 2 | -- | -- | 2 | Poached winter 1980-1981 Big Rocky Canyon, Appendicitis Hill |
| RORO | 05,06 | F | F | 9/10/80 | Martin Mine | Trap | --- | 5 | -- | -- | 5 | Fawn of WOWO |
| OWOP | 02,06 | F | F | 9/17/80 | Martin Mine | Trap | --- | 3 | 1 | 4 | 8 | Fawn of OGOO |
| OGOO | 03,05 | A | F | 9/18/80 | Martin Mine | Trap | --- | 2 | 13 | -- | 15 | |
| BBBG | 304,08 | A | F | 9/25/80 | Martin Mine | Trap | 80,82 | 15 | 13 | 59 | 87 | |
| OBOP | 07,08 | F | F | 9/25/80 | YCC Canyon | Trap | --- | 2 | 3 | -- | 5 | |
| YY | 01,02 | F | F | 6/1/81 | Inferno | Hand | --- | -- | 6 | -- | 6 | Fawn of BBBB, died spring 1982 southern winter range |
| BGBG | 134,135 | F | M | 6/1/81 | Inferno | Hand/trap | --- | -- | 7 | -- | 7 | Fawn of BBBB |
| OO | 01,02 | F | M | 6/2/81 | Inferno | Hand | --- | -- | 8 | -- | 8 | Sibling of RBRB |
| RR | 01,02 | F | M | 6/3/81 | Crescent | Hand | --- | -- | 2 | 2 | 4 | |
| BB | 01,02 | F | M | 6/3/81 | Crescent | Hand | --- | -- | 1 | -- | 1 | |
| WY | 03,03 | F | M | 6/3/81 | Crescent | Hand | --- | -- | 1 | -- | 1 | |
| WO | 04,03 | F | M | 6/7/81 | Inferno | Hand | --- | -- | 1 | -- | 1 | One of twins, missed sibling |
| WR | 05,03 | F | F | 6/7/81 | Inferno | Hand | --- | -- | 1 | 3 | 4 | One of twins, missed sibling |
| WB | 06,03 | F | F | 6/10/81 | L. Cottonwood | Hand | --- | -- | 15 | -- | 15 | |
| BGBY | 21,22 | Y | M | 7/2/81 | Broken Top | Trap | 81 | -- | 58 | -- | 58 | Predator (bear?) killed 9/28/81 |
| YPYB | 29,30 | A | F | 7/3/81 | Broken Top | Trap | 81,82 | -- | 36 | 14 | 50 | |
| RBRB | 10,11 | F | M | 7/3/81 | Inferno | Trap | --- | -- | 21 | -- | 21 | Sibling of OO, road kill 11/81 |
| GYGB | 115,116 | Y | M | 7/4/81 | Tree Molds | Trap | 81 | -- | 46 | 4 | 50 | |
| BBBB | 132,133 | A | F | 7/5/81 | Inferno | Trap | --- | -- | 9 | 24 | 33 | |
| WBWY | 101,102 | A | F | 7/5/81 | Broken Top | Trap | --- | -- | 17 | 9 | 26 | |
| O-OY | 124,125 | Y | M | 7/10/81 | Tree Molds | Trap | 81 | -- | 55 | 24 | 79 | |
| GPGP | 113,114 | A | F | 7/12/81 | Inferno | Trap | 81 | -- | 86 | 21 | 107 | |
| OYOW | 122,123 | A | F | 7/17/81 | Martin Mine | Trap | 81 | -- | 43 | 5 | 48 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OWW- | 127,104 | F | F | 7/18/81 | Martin Mine | Trap | --- | -- | 5 | -- | 5 | |
| WPYB | 105,305 | Y | F | 7/19/81 | Broken Top | Trap | 81,82 | -- | 23 | 46 | 69 | |
| GWWO | 118,108 | Y | F | 7/19/81 | Martin Mine | Trap | --- | -- | 23 | 7 | 30 | |
| GWOW | ---,130 | A | F | 7/20/81 | Martin Mine | Trap | --- | -- | 10 | 6 | 16 | |
| OOBB | 128,136 | Y | M | 8/1/81 | L. Cottonwood | Dart-14mg | --- | -- | 18 | -- | 18 | |
| GYGY | 119,120 | A | F | 8/2/81 | Martin Mine | Trap | --- | -- | 14 | 28 | 42 | |
| WWOO | 111,131 | Y | M | 8/3/81 | L. Cottonwood | Dart-14mg | --- | -- | 13 | 12 | 25 | Hunter-killed 11/12/82 Big Rocky Canyon |
| OOBB | 137,129 | Y | F | 8/6/81 | Martin Mine | Trap | --- | -- | 6 | 5 | 11 | |
| BWBY | 138,139 | A | F | 8/7/81 | Martin Mine | Trap | --- | -- | 8 | -- | 8 | |
| WOBP | 109,140 | A | F | 8/12/81 | L. Cottonwood | Trap | --- | -- | 13 | 13 | 26 | |
| WBWP | 107,108 | A | F | 8/13/81 | Martin Mine | Trap | --- | -- | 13 | 9 | 22 | |
| GWOO | 117,126 | Y | F | 8/15/81 | Martin Mine | Trap | --- | -- | 9 | 8 | 17 | |
| YPYB | 32,31 | F | M | 8/17/81 | Martin Mine | Trap | --- | -- | 9 | -- | 9 | Lost right ear tags in recapture |
| YYWP | 45,23 | F | F | 8/18/81 | L. Cottonwood | Trap | --- | -- | 28 | -- | 28 | Fawn of OYOY |
| WYYO | 110,48 | F | F | 8/26/81 | Martin Mine | Trap | --- | -- | 9 | 21 | 30 | Only yellow tag in right ear remaining by 11/82 |
| YYYO | 43,44 | Y | F | 8/29/81 | Visitor Center | Trap | --- | -- | 7 | -- | 7 | |
| YYYG | 41,42 | F | ? | 8/31/81 | Martin Mine | Trap | --- | -- | 5 | -- | 5 | |
| YYYG | 49,50 | Y | F | 9/5/81 | Martin Mine | Trap | --- | -- | 4 | 7 | 11 | |
| PGPG | 159,160 | Y | F | 9/12/81 | L. Cottonwood | Dart-18mg | 81,82 | -- | 33 | 70 | 103 | |
| OGOW | 09,10 | Y | M | 9/15/81 | Second Gate | Dart-18mg | --- | -- | 8 | 12 | 20 | |
| PYPP | 157,158 | A | F | 9/15/81 | W. Boundary | Dart-18mg | --- | -- | 11 | 8 | 19 | |
| YO | 04,04 | F | M | 6/5/82 | Inferno | Hand | --- | -- | -- | 3 | 3 | Fawn of BBBB |
| YB | 05,08 | F | M | 6/5/82 | Inferno | Hand | --- | -- | -- | 2 | 2 | |
| OY | 05,06 | F | M | 6/5/82 | Inferno | Hand | --- | -- | -- | 3 | 3 | Fawn of BBBB |
| OB | 06,04 | F | F | 6/5/82 | Inferno | Hand | --- | -- | -- | 1 | 1 | Uncoordinated |
| RW | 07,09 | F | M | 6/5/82 | Inferno | Hand | --- | -- | -- | 1 | 1 | Bedded with OB |
| RB | 09,07 | F | M | 6/5/82 | Inferno | Hand | --- | -- | -- | 1 | 1 | |
| BY | 06,07 | F | F | 6/6/82 | Crescent | Hand | --- | -- | -- | 7 | 7 | Splinted dislocated leg, fawn of PWPP |
| BO | 05,07 | F | F | 6/6/82 | Crescent | Hand | --- | -- | -- | 7 | 7 | Sibling of BY, fawn of PWPP |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YY | 08,09 | F | M | 6/7/82 | Echo Crater | Hand | --- | -- | -- | 7 | 7 | |
| WW | 07,08 | F | F | 6/7/82 | Echo Crater | Hand | --- | -- | -- | 7 | 7 | >Twin fawns of OBOB |
| PR | 154,4 | F | M | 6/8/82 | Base of Echo | Hand | --- | -- | -- | 1 | 1 | Large eartag left ear |
| PP | 155,156 | F | M | 6/8/82 | W. of Echo | Hand | --- | -- | -- | 1 | 1 | Large eartags |
| BGBY | 301,302 | Y | M | 6/28/82 | Tree Molds | Trap | --- | -- | -- | 14 | 14 | |
| GWGW | 171,172 | A | F | 6/28/82 | Inferno | Trap | 82 | -- | -- | 69 | 69 | |
| YGYG | 301,302 | Y | F | 6/30/82 | Tree Molds | Trap | --- | -- | -- | 11 | 11 | |
| PGPY | 152,153 | A | F | 6/30/82 | Broken Top | Trap | --- | -- | -- | 1 | 1 | Compound fracture, right rear leg |
| PWPW | 150,151 | A | F | 6/30/82 | Inferno | Trap | --- | -- | -- | 10 | 10 | |
| PYPY | 147,148 | A | F | 7/6/82 | Broken Top | Trap | --- | -- | -- | 2 | 2 | |
| WPBP | 177,303 | Y | M | 7/7/82 | Tree Molds | Trap | --- | -- | -- | 18 | 18 | |
| BPWP | 314,183 | A | F | 7/8/82 | Tree Molds | Trap | --- | -- | -- | 13 | 13 | |
| WYPG | 180,142 | A | F | 7/9/82 | Tree Molds | Trap | --- | -- | -- | 17 | 17 | |
| PWPP | 144,145 | A | F | 7/9/82 | Inferno | Trap | --- | -- | -- | 10 | 10 | |
| PYGP | 149,163 | A | F | 9/8/82 | L. Cottonwood | Trap | 82 | -- | -- | 32 | 32 | |
| PGWY | 146,182 | A | F | 9/8/82 | YCC Canyon | Trap | --- | -- | -- | 5 | 5 | |
| PWYW | 143,316 | F | M | 9/9/82 | L. Cottonwood | Trap | --- | -- | -- | 6 | 6 | |
| BYBW | 305,306 | A | F | 9/10/82 | YCC Canyon | Trap | --- | -- | -- | 9 | 9 | |
| BYGG | 304,164 | A | F | 9/12/82 | YCC Canyon | Trap | --- | -- | -- | 1 | 1 | |
| WBGP | 181,170 | F | M | 9/21/82 | Martin Mine | Trap | --- | -- | -- | 3 | 3 | |
| | | | | TOTAL | | | 20 | 316 | 1119 | 946 | 2381 | |
| | | | | Number of Marked Deer Days | | | | 3873 | 8730 | 8872 | 21475 | |
| | | | | Locations per Marked Deer Day | | | | 0.082 | 0.128 | 0.107 | 0.111 | |

a A = Adult; F = Fawn, Y = Yearling.

APPENDIX B. Schumacher and Eschmeyer (1943) estimates of yearling and adult female mule deer population size (N), Craters of the Moon National Monument, Idaho, 1980-1982.

| DATE | $M^a$ | $n^b$ | $m^c$ | mM | $nM^2$ | $m^2/n$ | m/n |
|---|---|---|---|---|---|---|---|
| 1980: | | | | | | | |
| 8/17 | 6 | 19 | 1 | 6 | 684 | .0526 | .0526 |
| 8/21 | 6 | 13 | 2 | 12 | 468 | .3077 | .1538 |
| 8/28 | 9 | 24 | 2 | 18 | 1944 | .1667 | .0833 |
| 8/31 | 10 | 16 | 1 | 10 | 1600 | .0625 | .0625 |
| 9/1 | 10 | 6 | 3 | 30 | 600 | 1.5000 | .5000 |
| 9/3 | 10 | 16 | 1 | 10 | 1600 | .0625 | .0625 |
| 9/12 | 11 | 33 | 1 | 11 | 3993 | .0303 | .0303 |
| 9/15 | 11 | 24 | 2 | 22 | 2904 | .1667 | .0833 |
| 9/19 | 11 | 110 | 5 | 55 | 13310 | .2273 | .0455 |
| 9/27 | 13 | 21 | 1 | 13 | 3549 | .0476 | .0476 |
| 9/29 | 13 | 20 | 1 | 13 | 3380 | .0500 | .0500 |
| 9/30 | 13 | 44 | 2 | 26 | 7436 | .0909 | .0455 |
| SUM | | | | 226 | 41468 | 2.7648 | |

$N^d$ = 183; 0.95 confidence interval = 105-707

APPENDIX B. Continued.

| DATE | M | n | m | mM | $nM^2$ | $m^2/n$ | m/n |
|---|---|---|---|---|---|---|---|
| 1981: | | | | | | | |
| 8/12 | 28 | 45 | 7 | 196 | 35280 | 1.0889 | .1566 |
| 8/13 | 28 | 44 | 3 | 84 | 34496 | .2045 | .0682 |
| 8/14 | 29 | 24 | 3 | 87 | 20184 | .3750 | .1250 |
| 8/16 | 30 | 22 | 1 | 30 | 19800 | .0455 | .0455 |
| 8/17 | 30 | 41 | 5 | 150 | 36900 | .6098 | .1220 |
| 8/18 | 30 | 37 | 6 | 180 | 33300 | .9730 | .1622 |
| 8/19 | 30 | 40 | 5 | 150 | 36000 | .6250 | .1250 |
| 8/20 | 30 | 36 | 4 | 120 | 32400 | .4444 | .1111 |
| 8/20 | 30 | 18 | 5 | 150 | 16200 | 1.3889 | .2778 |
| 8/26 | 30 | 32 | 6 | 180 | 28800 | 1.1250 | .1875 |
| 8/27 | 30 | 21 | 2 | 60 | 18900 | .1905 | .0952 |
| 8/27 | 30 | 48 | 4 | 120 | 43200 | .3333 | .0833 |
| 8/31 | 31 | 13 | 5 | 155 | 12493 | 1.9231 | .3846 |
| 9/1 | 31 | 27 | 4 | 124 | 25947 | .5926 | .1481 |
| 9/1 | 31 | 31 | 4 | 124 | 29791 | .5161 | .1290 |
| 9/3 | 31 | 28 | 4 | 124 | 26908 | .5714 | .1429 |
| 9/3 | 31 | 10 | 2 | 62 | 9610 | .4000 | .2000 |
| 9/4 | 31 | 34 | 5 | 155 | 32674 | .7353 | .1471 |
| 9/8 | 32 | 26 | 5 | 160 | 26624 | .9615 | .1923 |
| 9/11 | 32 | 12 | 1 | 32 | 12288 | .0833 | .0833 |
| 9/12 | 32 | 35 | 4 | 128 | 35840 | .4571 | .1143 |
| 9/13 | 33 | 25 | 3 | 99 | 27225 | .3600 | .1200 |
| 9/15 | 33 | 22 | 2 | 66 | 23958 | .1818 | .0909 |
| SUM | | | | 2736 | 618818 | 14.1861 | |

N = 226; 0.95 confidence interval = 191-277

APPENDIX B. Continued.

| DATE | M | n | m | mM | $nM^2$ | $m^2/n$ | m/n |
|---|---|---|---|---|---|---|---|
| 1982: | | | | | | | |
| 8/12 | 35 | 22 | 6 | 210 | 26950 | 1.6364 | .2727 |
| 8/13 | 35 | 42 | 10 | 350 | 51450 | 2.3810 | .2381 |
| 8/13 | 35 | 30 | 4 | 140 | 36750 | 0.5000 | .1333 |
| 8/14 | 35 | 22 | 8 | 280 | 26950 | 2.9091 | .3636 |
| 8/15 | 35 | 47 | 11 | 385 | 57575 | 2.5745 | .2340 |
| 8/15 | 35 | 24 | 7 | 245 | 29400 | 2.0417 | .2917 |
| 8/16 | 35 | 31 | 7 | 245 | 37975 | 1.5806 | .2258 |
| 8/16 | 35 | 24 | 7 | 245 | 29400 | 2.0417 | .2917 |
| 9/7 | 35 | 19 | 2 | 70 | 23275 | .2105 | .1053 |
| 9/8 | 35 | 20 | 2 | 70 | 24500 | .2000 | .1000 |
| 9/9 | 37 | 19 | 4 | 148 | 26011 | .8421 | .2105 |
| 9/10 | 37 | 12 | 6 | 222 | 16428 | 3.0000 | .5000 |
| 9/11 | 38 | 21 | 10 | 380 | 30324 | 4.7619 | .4762 |
| 9/12 | 38 | 18 | 3 | 114 | 25992 | 0.5000 | .1667 |
| 9/13 | 39 | 10 | 2 | 78 | 15210 | 0.4000 | .2000 |
| SUM | | | | 3182 | 458190 | 25.5794 | |

N = 144; 0.95 Confidence Interval = 117-186

a M = number of marked yearling and adult female deer in population
b n = total number of yearling and adult female deer seen in sample
c m = number of marked yearling and adult female deer seen in sample
d N = estimated number of yearling and adult female deer in population

$N = \frac{nM}{mM}$; see Schumacher and Eschmeyer (1943) and Caughley (1973) for confidence interval calculation procedures.

APPENDIX C. Dates of migration of marked mule deer from central and wilderness ranges to northern ranges, Craters of the Moon National Monument, Idaho, 1980-1982.

| DEER | AGE[a]/SEX | MIGRATION NORTHWARD 1980 | 1981 | 1982 |
|---|---|---|---|---|
| YWYW | A/F | 7/20-7/28[b] | 6/2-7/19 | 7/20-7/30 |
| YOYO | A/F | 7/22-7/29 | 7/9-7/20 | 7/21-7/23 |
| BBBG | A/F | Unknown | 7/14-7/16 | 8/2-8/3 |
| OYOY | A/F | Unknown | 7/18-8/3 | 7/21-8/13 |
| OBOB | A/F | Unknown | by 7/6 | 7/14 |
| OGOO | A/F | Unknown | 5/22-7/12 | --- |
| WOWO | A/F | Unknown | 4/28-7/14 | --- |
| YGYP | A/F | Unknown | 5/8-7/12 | Unknown |
| YYYY | F/F | Unknown | 7/20-8/3 | 8/15-8/31 |
| OBOP | F/F | Unknown | 5/17-8/13 | --- |
| WWWW | Y/M | 7/22 | --- | --- |
| YGYG | Y/M | Unknown | 6/23-7/14 | --- |
| YPYG | F/M | Unknown | 5/8-6/25 | --- |
| 0102 | F/M | by 7/31 | Unknown | --- |
| 0201 | F/M | by 7/31 | --- | --- |
| YPYB | A/F | --- | 7/8-7/12 | 7/21 |
| BBBB | A/F | --- | 7/5 | 7/6-7/20 |
| GPGP | A/F | --- | 7/14-7/16 | 7/2-7/16 |
| WPWW | A/F | --- | 7/20-8/1 | 8/16-8/18 |
| PYPP | A/F | --- | Unknown | 6/2-7/25 |
| GYGY | A/F | --- | Unknown | 7/14-7/19 |
| WOBP | A/F | --- | Unknown | 6/12-6/14 |
| OYOW | A/F | --- | by 7/17 | Unknown |
| WBWY | A/F | --- | 7/5-7/20 | Unknown |
| PGPG | Y/F | --- | Unknown | 7/21-7/25 |
| GWOO | Y/F | --- | Unknown | 5/29-8/13 |
| YYYG | Y/F | --- | Unknown | 6/2-7/25 |
| WYYO | F/F | --- | Unknown | 6/2-7/14 |
| BGBG | F/F | --- | 7/4-8/29 | --- |

APPENDIX C. CONTINUED:

| DEER | AGE /SEX | MIGRATION NORTHWARD 1980 | 1981 | 1982 |
|---|---|---|---|---|
| BGBY | Y/M | --- | 7/14-7/19 | --- |
| GYGB | Y/M | --- | 7/4-7/16 | Unknown |
| O-OY | Y/M | --- | 7/10-7/12 | 6/28-7/1 |
| RBRB | F/M | --- | 7/3-8/1 | --- |
| GWGW | A/F | --- | --- | 7/18-7/19 |
| PWPW | A/F | --- | --- | 7/9-7/14 |
| BPWP | A/F | --- | --- | 7/8-8/3 |
| WYPG | A/F | --- | --- | 7/25-8/4 |
| PWPP | A/F | --- | --- | 7/9-7/20 |
| YGYG | Y/F | --- | --- | 7/14-8/3 |
| BGBY | Y/M | --- | --- | 6/28-7/14 |
| WPBP | Y/M | --- | --- | 7/7-8/13 |
| MEAN MIGRATION DATE | | 7/28 | 7/20 | 7/26 |
| STANDARD ERROR (DAYS) | | 1.7 | 2.6 | 3.1 |
| SAMPLE SIZE | | 5 | 23 | 26 |

a Age when marked; A = Adult, F = Fawn, and Y = Yearling.

b Last date seen in wilderness and first date seen in north end.

APPENDIX D. Dates of first movement of marked mule deer from northern ranges to central and wilderness ranges, Craters of the Moon National Monument, 1980-1982.

| DEER | AGE[a]/SEX | FIRST MOVED SOUTHWARD 1980 | 1981 | 1982 |
|---|---|---|---|---|
| YGYP | A/F | Unknown | Unknown | 9/12-9/22 |
| YOYO | A/F | 8/28-9/12[b] | 9/27-9/30 | 9/17-9/22 |
| YWYW | A/F | 9/4-9/12 | 9/24-9/25 | 9/19-10/8 |
| OYOY | A/F | 9/19-9/30 | 11/7-11/8 | 9/13-9/22 |
| WOWO | A/F | 11/7-11/11 | not by 11/8 | --- |
| BGOW | A/F | 9/30-11/11 | --- | --- |
| BBBG | A/F | 10/18-11/11 | Unknown | not by 10/29 |
| OBOB | A/F | 9/17-10/1 | Unknown | not by 10/16 |
| WYWO | Y/F | Unknown | 10/29-10/31 | Unknown |
| YYYY | F/F | Unknown | Unknown | 10/17-10/21 |
| RORO | F/F | 10/18-11/11 | --- | --- |
| WYWY | F/F | 10/18-11/11 | --- | --- |
| WGWG | F/- | 8/3-9/30 | --- | --- |
| WWWW | Y/M | 9/30-11/6 | --- | --- |
| YGYG | Y/M | 10/18-11/11 | --- | --- |
| YPYB | A/F | --- | 9/25-9/27 | 10/8-10/11 |
| GPGP | A/F | --- | 10/10-10/15 | not by 10/13 |
| OYOW | A/F | --- | 9/25 | not by 10/10 |
| GYGY | A/F | --- | 9/26-10/15 | not by 10/16 |
| WOBP | A/F | --- | 9/27-10/9 | not by 10/21 |
| PYPP | A/F | --- | 9/26-9/30 | 9/22-10/6 |
| PGPG | Y/F | --- | 9/24-9/25 | 9/17-9/22 |
| WPWW | Y/F | --- | Unknown | 10/17-10/21 |
| WYYO | F/F | --- | 9/26-10/15 | not by 10/16 |
| YYWP | F/F | --- | 11/7-11/8 | --- |
| GYGB | Y/M | --- | 9/29-9/30 | Unknown |
| O-OY | Y/M | --- | 9/29-10/9 | not by 10/30 |
| OGOW | Y/M | --- | Unknown | 10/23 |

APPENDIX D. CONTINUED:

| DEER | AGE /SEX | FIRST MOVED SOUTHWARD 1980 | 1981 | 1982 |
|---|---|---|---|---|
| PYGP | A/F | --- | --- | 9/22-9/23 |
| WYPG | A/F | --- | --- | 10/6-10/8 |
| BYBW | A/F | --- | --- | 9/22-10/12 |
| BPWP | Y/M | --- | --- | 9/11-9/22 |
| MEAN DATE OF FIRST MOVEMENT SOUTHWARD | | 10/21 | 10/10 | 10/5 |
| STANDARD ERROR (DAYS) | | 7.4 | 3.6 | 3.3 |
| SAMPLE SIZE | | 12 | 15 | 14 |

a Age at capture; A = Adult, F = Fawn, and Y = Yearling.

b Last date seen in north end and first date seen on central or wilderness range.