5-1955

A Management Study of the Cache Elk Herd

Norman V. Hancock
Utah State University

A MANAGEMENT STUDY OF

THE CACHE ELK HERD

by

Norman V. Hancock

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Wildlife Management

UTAH STATE AGRICULTURAL COLLEGE
Logan, Utah

1955

ACKNOWLEDGMENTS

Completion of the study has been possible only through close cooperation and the untiring efforts of many individuals and agencies. I sincerely express my appreciation to Dr. Jessop B. Low for his kind counsel and supervision, encouragement, enthusiasm, and time expended in both field and laboratory phases of the project as well as in the preparation of the final thesis.

Financial aid for the project was supplied by the Utah Cooperative Wildlife Research Unit[1] and the Utah State Department of Fish and Game.

I greatly acknowledge the cooperation and help of the many Utah State Department of Fish and Game personnel who immeasurably facilitated the progress of the study. Wardens LaVere King, G. Morgan Jensen, and Alma M. Argyle particularly aided in the collection of harvest data. Basic information on Hardware elk counts and feeding activities were recorded by Hardware Ranch employees, Lloyd C. Kennington and LaMar Jensen. Supervisor Joseph A. Berger and wife, Inez, will long be remembered for their generosity, hospitality, and cooperation extended throughout the study phases at the Hardware Ranch. In addition, District Game Manager Wallace Jensen participated in several phases of the project. Likewise, the support given by District Warden Ricy H. Anderson is acknowledged.

U. S. Forest Service rangers Jerry W. Hill, Owen M. DeSpain, and Murle J. Markham, together with Assistant Forest Supervisor Orval E. Winkler, were always ready to give assistance to the project and make

1. U. S. Fish and Wildlife Service, Utah State Department of Fish and Game, Utah State Agricultural College, and Wildlife Management Institute cooperating.

available their records on livestock and elk.

The preparation of microscopic slides of elk ovaries by Mr. Earl Johnson and examination of these slides and preserved ovaries by Drs. LeGrand Shupe and Wayne Binns is also acknowledged.

Expressions of appreciation would be far from complete without mentioning my wife, Genivee. It was only through her unselfish devotion to the increased burdens, particularly family responsibilities, brought about through my absence during field investigations and preparation of the following report that the study was completed.

To all students and others who have participated in any phase of the study, I extend my heartfelt appreciation.

Norman V. Hancock

TABLE OF CONTENTS

LIST OF TABLES

Appendix

LIST OF FIGURES

INTRODUCTION

American elk, by virtue of their distribution, were the most cosmopolitan members of the cervid family at the time of white settlement of North America. At this early date elk were present in every major region of what is now continental United States, as well as in northern Mexico. They likewise were abundant in upper and lower Canada, though records do not corroborate their presence too far north on the Atlantic coast. Although generally existent throughout the western states, elk were sparsely distributed in Nevada, southern Utah, and most of Arizona and New Mexico. Paucity of elk was also noted in eastern portions of Washington and Oregon.

A legend most vivid to young and old alike is the vision of vast numbers of elk which once traversed prairie and mountain in hordes at the time of early colonization of America. A corresponding panorama shared by Americans as a heritage of the past is the graphic pageant of elk exploitation and subsequent waning of wapiti numbers in the wake of westward advance of white civilization. As hay falls in contact with the rancher's mower, so did countless numbers of elk and other big game topple as the blade of civilization made contact with them and their habitat.

Like elk of the eastern states, elk of the west were subjected to the same American traditionalism of "exploration, exploitation, and extirpation." By the early 1900 period western elk populations became sorely depleted. Local annihilations of this genus were legion. The horizon of hope for their perpetuation seemed almost nonexistent. Indeed, the chain of distribution for the Rocky Mountain elk had shrunken to encompass

narrow portions of the Rocky Mountain system lying in Colorado, Wyoming, Idaho, Montana, and Canadian provinces to the north. Remnant numbers of Roosevelt elk were present along coastal belts of Washington, Oregon, and northern California; a handful of Tule elk remained in central California, but the type species (Cervus canadensis canadensis) had long been exterminated, as had similarly the Meriam elk of the Southwest; however, limited Manitoba elk still remained.

Indeed, few individuals of this early western period had visionary aspirations for the perpetuation of elk after they had been witnesses to the bizarre annihilation of countless former numbers of bison and elk. In fact, there came an interim when valiant attempts were made to domesticate elk with a principal objective of preserving this fine animal. However, what might well have been the "great tragedy" of the American elk was avoided by the existence of a large sanctuary capable of accommodating and continuing a substantial elk population. This area was the Yellowstone National Park and adjacent lands. Yellowstone Park was set aside as such and free from hunting in 1894. The sanctuary offered elk in this Park was undoubtedly a contributing factor in the perpetuity of this species, for it was from this and adjacent areas that nuclear stocks were obtained to re-establish elk in most of the elk-producing areas today within western states, some eastern states, and some Canadian provinces. True, residual stocks in states, as Montana, Idaho, Wyoming, and Colorado, might have brought about continuance of this major elk species; but this might well have involved a considerable period of time. In Utah and some other western states, it is indeed dubious whether the re-establishment of elk to its former range could ever have been achieved solely through increment from the residual elk stocks which were present at the inception of protective game laws.

Close herd-histories are noted in the reintroduction, increase, and successful re-establishment of many existent western elk herds. In fact, any one history might well express that of many western herds. This history might be recapitulated as procurement of stock from Yellowstone Park and adjacent herds; reintroduction into areas exterminated of elk or having only residual numbers remaining; protection, followed by an increase, culminating in successful re-establishment of the species.

The Cache elk herd, like most Utah herds, is not unique in its re-establishment, for it too pursued the same general characteristic pattern of reintroductions following destruction of native elk. Like many other reintroduced western elk herds, the Cache herd grew and extended its range; and during the interim of years, an overflow of elk occurred involving peripheral areas adjacent to agricultural lands. This extension of range, coupled with subsequent elk predation on agricultural crops, made it evident that a harvest phase must be initiated as a part of management plans. Though limited numbers were removed, the elk population increased until it was demonstrated that elk had reached numbers that were incompatible with good range conditions and other land management uses.

In brief this terse resume of the Cache elk herd had its parallelism in most western elk herds. We no longer are attempting to build elk populations, but in this era are trying to stabilize herd numbers consistent with local range and forage conditions as well as other allied range uses. Similar elk management problems confront most western game managers.

A realization of these factors instills prudent game managers with a singular objective of managing the elk resource in such a manner as will result in the harvest of existing surpluses compatible with management of the range resource and subsequent use of the range by domestic

livestock and big game. Collectively, most game managers today are faced with management objectives dedicated to closer utilization of the present elk resource in order to meet increased hunter demands and produce maximum elk returns per unit of land without materially reducing parent herd or increasing them beyond their present range carrying capacity.

It thus behooves game management agencies to study game herd problems methodically and exploit the field of ideas with the principal objective of not only placing the herd on a sustained yield basis but utilizing the herd resource to its maximum consistent with annual herd increment, range forage, and last but not least of all other range uses, watershed protection. To study the herd problems on the Cache elk herd has been the objective of this study.

Much of the basic information concerning the Cache elk herd was recently released as a result of McCormack's (1951) South Cache elk herd study. The primary features of this investigation were the establishment of herd numbers, definition of elk range, and evaluation of herd losses in the South Cache elk herd. His study has provided information and has aided the present study of the entire Cache unit.

The present study was undertaken to acquire additional management information for both the North and South Cache units. It was recognized that effectiveness of elk management could be increased if such information were available as population data, age composition figures, effectiveness of the winter feeding program, herd productivity and mortality, summer and winter distribution, and the inter-specific role of deer and domestic livestock with the elk.

The present study was commenced during late fall of 1951. Formal field work continued through the spring of 1953, though limited field work extended through the early 1954 winter. The study has been dedicated to

the procurement of elk management information on both the North and South Cache units.

Review of Literature

Early elk literatures were largely confined to historical notes on distribution and relative abundance. Such writings generally evolved from dairies of trappers, explorers, soldiers, and settlers who were then penetrating the western continent. Many of these early writings were fragmentary; some conflicted with others written by different individuals reconnoitering the same general area. Generalizations drawn from observations were many. Ommissions of pertinent elk data appear great, for the student of these early writings indeed becomes mildly confused and divided in respect to the divergent entries of local elk conditions.

Specific emphasis on elk management was not manifested extensively until the mid-1920 period, though natural histories such as Seton (1929) and Caton (1877) did supply many valuable elk data. One of the earliest elk management studies was Preble's Jackson Hole investigation in 1911 (Murie, 1951). However, with the creation of a special Federal Elk Commission in 1926 and the subsequent assignment of field work to the Bureau of Biological Survey, a formal elk study was commenced. Its objective was a comprehensive life history study to be used as a basis for elk management (Murie, 1951). The climax of this extensive study and later allied field investigations is Murie's (1951) "bible" of elk of North America. Big game managers, biologists, students, and other interested peoples are indeed fortunate in having available this comprehensive treatment of distribution, forms, life history, characteristics, and management of North American elk.

It is only natural that early elk writings dealing with management phases should stem from the Northern and Southern Yellowstone herds, for

it was here that elk problems were first manifested as a consequence of the "come back" of western elk populations. One of the initial studies on the Northern Yellowstone herd was made by Rush (1932). His vivid description of life history, breeding and food habits, and summary of elk diseases and parasites gave impetus to the evolution of elk management. Later, a Federal Elk Commission report summarized basic data collected on the Northern herd (Bagley, 1935). Mills (1936) made early contribution to a knowledge of elk reproduction, while Cahalane (1938) attempted an aerial census in connection with a ground survey on the Northern herd. Murie (1931 and 1934) presented much basic information on the Southern Yellowstone herd which is part of the famous Jackson Hole herd.

A gradual increase in elk management information has occurred since these early Yellowstone investigations. As did protected elk populations spiral within Yellowstone Park, so did native and particularly reintroduced herds increase throughout the western states. The mid-1910 elk plants, within western states, resulted in increased populations ready for harvesting in the late 1920 period. As a result, a need for individual herd investigation became evident and an ever increasing amount of literature subsequently became available on elk.

A typical Washington elk herd has been described by Mitchell and Lauckhart (1948) in their report of the Yakima elk herd which stemmed from an early plant resulting in a herd now exceeding its range capacity.

The Roosevelt elk situation on the Olympic Penninsula has been carefully studied by Schwartz and Mitchell (1945). From this study comes an expression of Olympic elk herd sex ratios, herd composition, herd increment, utilization standard for key forage species, parasites and diseases, as well as various natural history data.

Banfield's description (1949) of an irruption of elk in Riding

Mountain National Park in Manitoba has been a source of reproductive data and treatment of elk disease and parasite relationships.

Two comprehensive Utah elk studies have been reported to date. These studies--McCormack's (1951) on the South Cache herd and Rognrud's project (1953) on the Nebo herd--have provided the writer with a source of comparative data. Other Utah elk writings have been reviewed and have been found to contain much basic information on Utah elk management (Standing, 1931; Olsen, 1945; Rasmussen and Doman, 1947; Rasmussen, 1949; and Crane, 1951). A summary of elk reintroductions in Utah has been compiled by Popov and Low (1950).

An additional index to elk productivity has transpired in recent investigations surrounding the anatomical changes of the elk reproductive tract during oestrus, conception, and pregnancy periods. Pioneer work along these lines has been conducted by Cheatum (1949) on white-tailed deer. Cheatum and Gaab (1952) have since utilized Cheatum's ovary analysis method in evaluating elk productivity. Additional elk reproductive studies (Kittams, 1953; Cheatum and Wright, 1951; Conway, 1952; and Coffin and Remington, 1953) have also supplemented present knowledge of elk reproduction. A review of mammalian reproduction and reproductive studies conducted with domestic livestock has also provided the writer with valuable information (Hammond, 1927; Winters and Feuffel, 1936; Winters and Comstock, 1942; and Green and Winters, 1945). Likewise, a background of information and ideas were assembled in reviewing deer productivity and reproduction studies of Robinette and Olsen, 1944; Cheatum and Morton, 1946; Morton and Cheatum, 1946; Robinette and Gashwiler, 1950; Armstrong, 1950; Tolman, 1950; and Harrison and Hamilton, 1952.

Age determination by occular examination of lower mandibular dentition was greatly facilitated by reviewing the works of Murie (1951),

Swanson (1951), and Quimby (1952).

Many other literatures have been reviewed and found to be of practical worth in suggesting new ideas, experimental procedures, and providing comparative data. References to these studies will be contained in appropriate sections of this report.

Description of Area

Location

The Cache elk range, situated in northeastern Utah, lies solely within the counties of Cache and Rich. The area under surveillance comprised approximately 760 square miles of Cache National Forest and privately owned range and forest lands, though limited agricultural lands are contained within the study area. Study area boundaries were expanded and delineated to conform with those utilized by the Utah State Department of Fish and Game in setting hunting regulations on the Cache elk herd. Thus Cache unit was bounded on the west by Highway 91 and the Logan-Avon and South Fork of the Little Bear River Highway, and on the south by the Cache-Weber County line as well as State Highway 39 to Woodruff, while the eastern limit was Highway 3 to Garden City and Highway 89 to the Utah-Idaho State line. The Utah-Idaho line served as the northern boundary. The area thus described appears in figure 1 and contains approximately 1,025 square miles, though only approximately 760 square miles were forest and range lands utilized by elk.

Topography and geology

The Cache area is characteristically composed of rugged mountainous terrain on the western fringe and rolling hills and valleys on the central and eastern portions. Broad-open valleys are present to the east and west of the unit. The area contains three major western drainages; namely, Logan, Blacksmith Fork, and East Fork of the Little Bear. Bear River and

Bear Lake comprise the two major eastern drainages. The streams represented in the area eventually drain into the Bear River which empties into the Great Salt Lake. The Canyons are geologically young and maintain the characteristic steep slopes of rejuvenated streams. Elevational ranges within the study area were from 4,600 to 9,980 feet.

The Cache study area is considered a part of the Wasatch Range. Bailey (1927) described this portion of the Wasatch as:

> The range as a whole consists of broad and shallow syncline and anticline of resistant paleozoic formations, the eastern and central parts of which are in part unconformably overlain with Wasatch conglomerate, limestone and sandstone.

Soils are characteristically heterogeneous and are derived mostly from residual sandstone, limestone, and dolomite formations.

Climate

The area under consideration lies within a semi-arid climatic region of the United States; however, it is locally modified by the presence of the mountainous terrain. Average annual precipitation of approximately 18 inches occurs on the western fringe of the study area, while an average rate of 11 inches is received on the eastern periphery (Alter, 1941). Average precipitation for the Cache summer range is around 30 inches. Most precipitation comes as snow during the late fall and winter periods. Average warm season precipitation is considered 8 inches on the central and eastern portions of the study area (Alter, 1941).

Growing season on the peripheral sites of the Cache unit is approximately 142 days on the west and 72 days on the east (Alter, 1941). Frost-free day ranges are noted as 98 in 1914 and 197 during 1936 (Alter, 1941). Growing season within the optimum Cache elk summer range averages around 100 to 120 days.

Vegetation

Climax associations of vegetation in the area, as expressed by Weaver

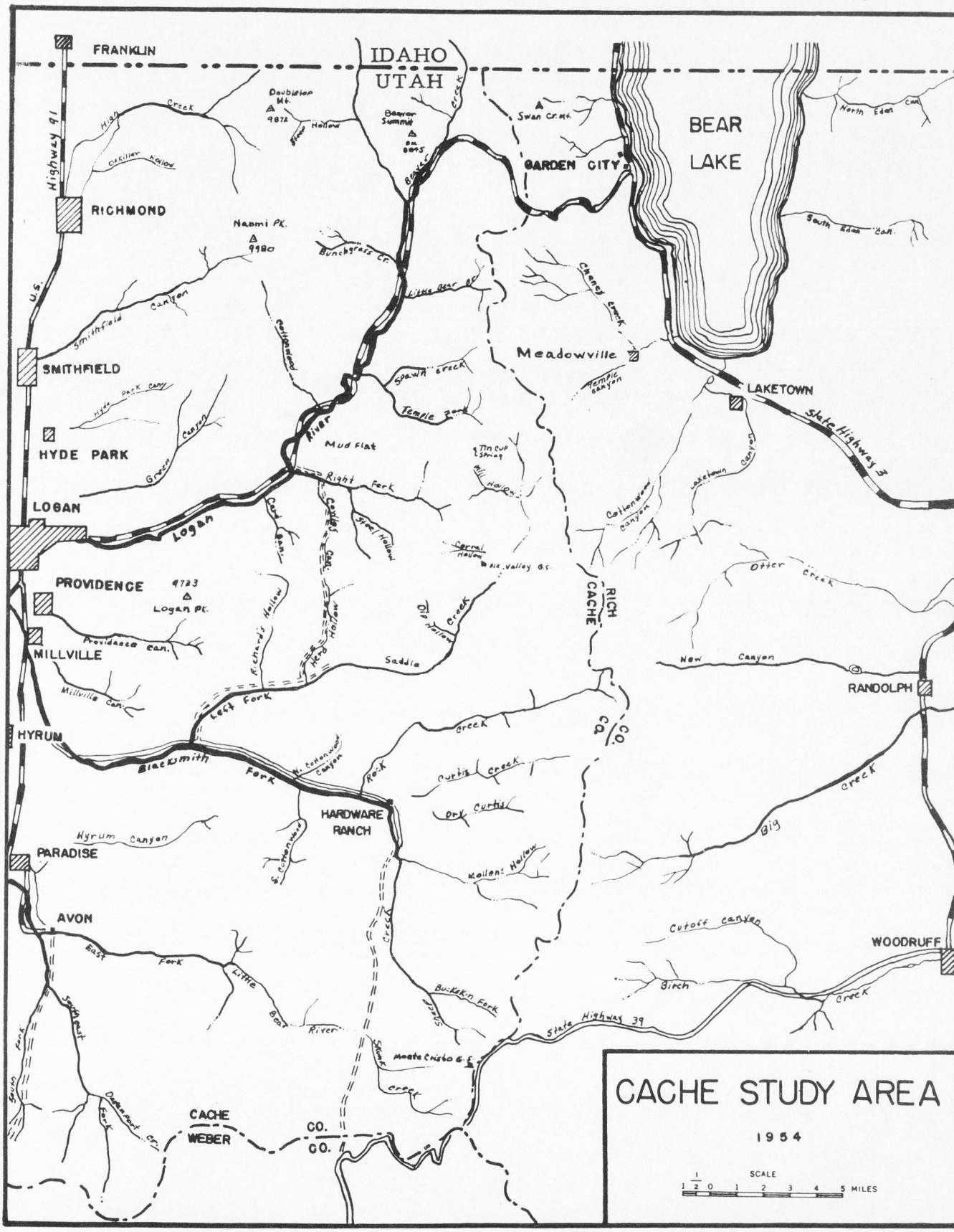


Figure 1. Cache study area

and Clements (1939), are Petran Subalpine and Montane Forests, Woodland, and Basin Sagebrush. The Petran Chaparral is decidedly lacking in this northern Utah situation, though it does extend as far north as the southern edge of Cache Valley.

Five major cover types were apparent within the elevational confines of the study area. They were (1) aspen, (2) conifer, (3) juniper, (4) mahogany, and (5) sage. Integradations of these types were also present. Many plant species are contained within the above described associations and cover types.

Life zones

Life zones represented in northern Utah are (1) Transitional, (2) Canadian, and (3) Hudsonian. Of these the Transitional is most dominant.

Wildlife

Mule deer, Odocoileus hemionus macrotis, was the most prevalent big game species present; while elk, Cervus canadensis nelsoni, ranked second. Other larger mammals noted were the coyote, Canis lestes; bobcat, Lynx uinta; mountain lion, Felis oregonenses hippolestes; and the black bear, Euarctos americanus americanus. In addition, many small mammals and birds were present.

Land use

Range use is the principal land use of the Cache area. Domestic livestock, predominately cattle and sheep; big game, featuring deer and elk, are the representative ungulates utilizing the range resource. Since most lands lie within the Cache National Forest, the Forest Service administers the livestock distribution, period of grazing, and numbers. Deer and elk numbers are controlled through harvest removals authorized by the Utah State Board of Big Game Control and executed by the Utah State Department of Fish and Game.

Further land use was present, such as limited agriculture which primarily featured grain and hay production in the Blacksmith Fork drainage and peripheral sites on eastern and western slopes of the study area. The Cache area also contains important watersheds. They amply supply culinary and irrigational water supplies to surrounding communities and agricultural lands. Hydroelectric plants are also situated on major streams. In addition, timber is produced on a commercial but limited scale.

Recreational use is continually gaining impetus on the Cache National Forest. Many fine recreational and camping sites are available, particularly in Logan Canyon.

HISTORY OF THE CACHE ELK HERD

Native Status

That elk were indigenous to the Cache area is an undisputable reality; for, since Cache Valley's discovery, various reports have described early elk status (Standing, 1931; Hovey, 1936; Olsen, 1943). Olsen (1943), reviewing big game historical literature in Utah, observed that big game were seldom mentioned by early Utah historians except for evidenced hardships of pioneers in search of food. He concluded from these and other tales of privation one would infer that Utah had but little big game in its territorial days; however, the diaries of early trappers and explorers portrayed a somewhat different picture of big game in mountainous areas.

Two informative incidents pertaining to native elk status adjacent to and south of the Cache were related by Murie (1951) from an early trapper's diary:

> . . . on December 20, 1840, on Weaver's (Weber), near Great Salt Lake, Utah, he (Russell[1]) recorded: ". . . we also found large numbers of elk which had left the mountains to winter among the thickets of wood and brush along the river."
>
> On January 10, 1841, while camped near Great Salt Lake, he (Russell) went into the mountains for several days of elk hunting and while at "Ogden's Hole" (Ogden Valley) on Ogden Fork, where the snow was 15 inches deep, wrote: "Towards night the weather cleared up and I discovered a band of about one hundred elk on the hill among the shrubbery."

Undoubtedly, similar references to native Cache elk status would be present in early Cache trapper's diaries were such journals available.

Initial white settlement of Cache Valley was begun by a Mormon

---

1. Osborne Russell, Journal of a Trapper, 1834-43. (Boise, Idaho 1921) 149 pp..

pioneer company sent by Brigham Young to prepare wintering operations for grazing stock during the 1855-56 winter. The selected ranch site was near the present community of Nibly; the ranch was appropriately named the "Elk Horn Ranch" (Hovey, 1936).

The 1855-56 winter proved infinitely severe and ranch personnel were forced to drive the best of 3,000 cattle to the Weber River where all but 420 succumbed (Hovey, 1936). A previous rigorous Cache winter was described by Indian Chief Sagwich who informed settlers of being forced into the Salt Lake Valley by 14-foot deep snow in the winter around 1784. When the Indians returned in the spring, 7 head of buffalo were observed as the sole remaining survivors in the valley (Hovey, 1936). Pioneers on their entry into Cache Valley viewed mute evidence of other big game winter losses as they recorded seeing numerous heaps of elk, buffalo, and deer skeletal remains. Additional severe winters were recorded by pioneers as being 1873-74 and 1879 (Hovey, 1936).

It appears, from a review of available literature and personal interviews of early Cache residents, that elk were plentiful in mountainous areas of eastern Cache County during pre-settler and early pioneer times.

True, limited notes on paucity of elk were recorded by early Cache settlers; however, these reports seem more applicable to elk status in the valley and immediate foot-hill zone rather than the forest interior. One would do well to remember pioneers were at a considerable handicap to explore the hinterland since transportation facilities were limited and antiquated. Additional obstacles precluded ready pioneer access into elk habitats since man-made trails and roads were nonexistent in interior mountainous terrain; but, as mountain roads and trails became prevalent and transportation facilities increased, the tempo of elk utilization reached a climax.

Whatever may have been the former abundance of Cache elk at the time of early settlement, they nevertheless vanished in the years that followed. Periodic extremely rigid winters, combined with tenacious year-long settler use of the elk resource, are believed to be major factors operative in this decline.

Though records of former Cache elk distribution are fragmentary, native elk were known to frequent Strawberry and Elk Valleys, Card and Right Hand Fork of Logan Canyons, chiefly in Ricks Canyon and Steel Hollow. Theurer (1954), early Cache resident and Forest Service ranger from 1905 to 1915, recalled native elk distribution to be centralized in Steel Canyon, Ricks Hollow, and Elk Valley. He affirmed that Elk Valley received its name from former native elk abundance. Steel Hollow and Ricks Canyon were then noted to be "sure bets" for bagging elk

The tempo of Cache elk utilization undoubtedly became accelerated during the late 1800 period in order to meet local settlers' increased food demands, thus finally culminating in a virtual disappearance of Cache elk around the turn of the century. Though the Utah State Department of Fish and Game was established in 1894, no hunting license was required until 1907. A closed elk season was then initiated. McCormack (1951) reports U. S. Forest Service record of last native elk killed to be in 1898 when 5 elk were shot in Card Canyon. Few native elk might well have persisted past this date, but written records affirm not.

Reintroduction

Elk have been brought to the Cache area on four different occasions since the extermination of the native herd. Three of these instances have resulted in known elk releases.

First mention of elk presence after the alleged decimation was that of 2 cows and 1 bull obtained in 1911 by a Logan Canyon citizen (Bagley,

1952). It is assumed that none of these elk escaped to the wild. The herd was killed in the fall of 1914 and the meat sold to Utah residents.

A second group consisting of three elk, 1 bull and 2 cows, was obtained in 1913 by Oliver Nielsen, of Smithfield, from Nielsen's brother-in-law, Osbourne Low, of Afton, Wyoming (Nielsen, 1954). These elk were placed in a Smithfield enclosure and fed hay for the ensuing five-year period. The caring of these elk was discontinued in 1918 or 1919 when 2 elk were sold to the Denver Zoo; one old bull was killed, mounted, and placed in the Utah State Capitol Building, and the remaining eight head (one yearling bull, one mature bull, and six antlerless elk) were released and herded into the hills east of Smithfield. It should be recognized that this release was not the first reintroduction on the Cache area.

Probably kindled by apparent success of the Smithfield group in raising elk and the occurrence of initial central Utah elk plants, Cache Valley sportsmen formulated plans to acquire elk stock, which was then available from the northern Yellowstone Park herd. Thus, during the winter of 1915-16, 25 elk were shipped by rail from Gardner, Montana, to Logan where they were placed within an enclosure and fed hay through the winter. During this period, one spike bull died; and one cow, which was heavily infected with ticks, was killed (Peterson, 1935).

It is evident that the sponsoring organization did not contemplate releasing these elk so speedily; but due to the fear that ticks would be transmitted to livestock and the existence of general unsanitary conditions, these elk were released in 1916 (Peterson, 1935 and Theurer, 1954).

On March 10, 1916 the remaining 23 elk, 4 bulls (2 spikes and 2 mature) and 19 cows and calves, were driven slowly before a small army of horsemen to the mouth of Logan Canyon where the elk crossed the reservoir and filed up the Logan-Dry Canyon ridge (Peterson, 1935; Theurer, 1954).

Peterson (1935) reports that game warden, Sam Ewing, observed these elk established on their summer range at the base of Mount Logan. Theurer (1954) saw upwards of 50 elk in the Mount Logan area a few years after the 1916 release. Nielsen (1954) reports of riding for the elk one year after the 1916 spring release and observed an elk concentration in Spring Hollow, above the former Girl Scout camp in lower Logan Canyon.

Paucity of information on initial wintering sites is noted; however, 9 elk were known to winter in Hyde Park Canyon during the first winter (1916-17), 16 to 18 head were also observed in the same area during the 1917-18 winter, as were 28 and 80 head in 1919 and 1920 winters, respectively (Peterson, 1935).

A third and final plant of 5 elk was consummated on the Cache in 1917 (Popov and Low, 1950) by Smithfield sportsmen who purchased elk from Gardner, Montana, and released them in the mouth of Smithfield Canyon. The sex of these elk was not recorded. No other known reintroductions have been made.

Earliest complaints of elk damage to hay began on the North Cache during the 1922-23 winter (Peterson, 1935). Within a very few years after the 1916 release, elk were also frequenting Providence hay stacks and orchards. There existed considerable damage and nuisance in the Providence area prior to the early 1930 period (Theurer, 1954).

So prevalent were damage complaints that a supervisory Board of Elk Control was established in 1925 in order to expedite Utah elk herd management (Popov and Low, 1950). The board thus authorized 140 either sex permits in 1925 for the first hunt on the Cache area. One hundred and four (104) elk were bagged (Leonard, 1946). No permits were sanctioned for 1926 and 1927. Subsequent hunts were restricted to bull only through the year 1934 (table 17). Nevertheless, elk damage problems throughout

the State increased to such prominence that State legislative action was precipitated in 1927. The State Legislature thus passed a law creating a new organization, the State Game Refuge Committee and Board of Elk Control (Crane, 1951). This board later included all big game problems and the name was changed to the Board of Big Game Control.

Though only bull permits were authorized by the Board through the year 1934, Cache damage problems multiplied to such proportions that it became necessary to remove antlerless elk. Antlerless elk, since 1935, have been included in the harvest in some proportion except in 1937.

Formal investigations were not undertaken on the Cache elk herd until 1949 when McCormack (1951) conducted a population study on the South Cache unit and reported a winter population of slightly over 600 head of elk on this portion of the Cache area.

Present Status

Suffice it to say at this time, the Cache elk winter herd in 1954 numbers approximately 1,000 head and is distributed throughout the North and South Cache portions of the Cache National Forest with most elk occurring on the South Cache section.

CACHE ELK POPULATION CHARACTERISTICS

Census Methodology

Past censuses

Though population estimates were desirable in early Cache elk management, effective census methods were conspicuously lacking. Early enumeration attempts were confined to isolated portions of the area, and hence those results today hold limited significance.

Later efforts were made toward coordinated ground counts which, in an appreciable measure, did give an index to herd population. Earliest use of the aerial census on the Cache area was in 1936 when pioneer work along these lines was attempted by the U. S. Forest Service and the Utah Fish and Game Department (Olsen, 1936). Periodic winter inventories, which since have been conducted, have utilized the aerial survey in part with the exception of the 1948-49 census. One summer census has been conducted on the South Cache division in which the "Strip" or "Belt" transect method was used.

Present inventory

Aerial. Coordinated earial and ground censuses have provided the basis for 1951-52 and 1952-53 Cache elk herd inventories. Feasibility for utilizing ground coverages was suggested from a knowledge of certain adverse topographical features and large winter elk concentrations. A four-place Stinson 145 horse power air-wagon was employed in making the aerial portion of the survey; the pilot and two observers constituted the crew. Actual flight techniques were modified from those used by Colorado technicians (Riordan, 1948) in order to conform to existent topographical features. The principal flight pattern used on the Cache elk

survey can be more accurately described as "contour stripping." Such features as natural barriers, vegetative types, and known elk distribution were used to define counting units. Later, minor modifications of original units were made according to safety factors, maneuverability of plane in relation to topography and air conditions, and discovery of actual aerial counting conditions. The respective counting units were then traversed by contour stripping at 500 to 1,000 feet altitudinal levels. Rolling and flat terrains were covered by a series of parallel flights spaced to provide uniform coverage of the total area.

A more accurate and expedient total count of individual elk bands was achieved when elk were counted from higher altitudes, especially if animals were concentrated. Conversely, elk band composition was more accurately defined when observations were made from around 300 feet altitude. Enumerations of elk within each band were repeated until both observer's counts were in agreement. Compositional counts included bull and antlerless classes only. No attempt was made to differentiate calves from the antlerless herd since in the writer's opinion calves cannot be distinguished accurately from yearling cows in an aerial survey. It should be noted, however, that some workers (Riordan, 1948, and McCormack, 1951) have segregated antlerless fraction into calf and cow complements in their aerial surveys. McCormack's (1951) aerial classification, when compared to ground classification, suggests a higher calf tally than ground counts.

Ground counts were coordinated with aerial coverages; thus, Hardware Ranch elk were counted from the ground at a predetermined time so an aerial coverage of adjacent sites could be made concurrently. Likewise, elk concentrated in the Millville feed ground area were censused from the ground. In addition, ground surveys were also made in areas where aerial accuracy could not be achieved due to adversities such as rugged

topography and spread of vegetative types. The juniper cover presented the most difficult type to census from the air. In the latter situations aerial counts were deleted and ground counts utilized.

Twelve hours of flying time and 66 man hours of ground coverage were consumed in completing the 1951-52 Cache winter elk inventory. Though snow conditions were not as optimum as in the previous winter, the 1952-53 aerial survey was believed to be a good coverage. Twenty-one hours of flying time were utilized in the 1952-53 inventory. From the 1952-53 survey it can be concluded that optimum snow conditions on the Cache area are not imperative for a successful aerial survey, though such conditions do speed up an aerial coverage considerably. The chief advantage of good snow conditions lies in readily locating elk tracks and sign from the air.

Comparative aerial and ground counts were attempted in an effort to assign accuracy to aerial coverage, but under existing conditions sufficient number of comparisons could not be achieved to assure accuracy.

Lincoln index. Tagging operations since 1949 have provided valuable data on the Cache herd. Since all hunters are required to check their kill through checking stations, the examination has provided an insurance of ear tag recovery. However, it was found that limitations to the use of the Lincoln index method were present which curbed its use in computing Cache elk populations from tag returns. Certain basic requirements were not met and the total sample size was believed too small for arriving at accurate population estimates.

Life equation. Cache elk population figures as represented by the 1951-52 and 1952-53 censuses were related to each other through means of herd losses and gains between the two time segments, represented by these annual censuses. Thus, beginning with the 1952-53 enumeration of 877 elk and tabulating in reverse towards the 1951-52 inventory, we arrive

at a population figure (table 1) that can be compared to the 1951-52 count of 817 elk.

Table 1. Cache elk life equation table from 1952 to 1953

Period and Gain or Loss	Cows	Calves	Bulls	Total
Winter census, 1952-53	493	232	152	877
Plus total losses, 1952-53	135	22	122	279
Minimum summer herd, 1952	628	254	274	1,156
Less calves		254		
Minimum parent spring herd in 1952	628		274	902

The difference from the computed 1952 spring population of 902 elk (table 1) when compared to the spring population derived from the aerial and ground census of 1951-52 winter should for the most part be due to the census enumeration. Thus 817 elk were tallied in the 1951-52 aerial census (table 2), but an estimated winter loss of 80 elk (malnutrition section) would leave a remaining parent spring herd of 737 elk.

Therefore, if it were assumed that the 1952 spring herd of 902 (table 1) represented the total herd size, it can be compared to the 737 spring herd actually counted and the maximum per cent effectiveness of the 1951-52 aerial and ground census can be calculated as follows:

$$\frac{100}{902} \text{ as } \frac{x}{737} \text{ or } 81.7 \text{ per cent}$$

If such comparisons are conducted each year, an index to the effectiveness of the previous year's inventory may be established. Then, if a consistency of figures of census effectiveness exist over the years and censuses are comparable, it would be possible to project this maximum accuracy to the current census and assign minimum population estimates

to the spring and summer herd in question.

Bugling census. A mid-September bugling census was conducted in the Elk Valley section in 1952. Bull elk bugling was stimulated with the use of an elk whistle. The general technique employed was a morning and evening coverage of the area by using vantage points where bugling returns could be readily heard.

Herd numbers

Past censuses. Complete aerial and ground censuses for the entire Cache area date back only to the 1951-52 winter, though comparative records are available for the South Cache unit since the 1949-50 inventory. Actual counts made prior to these dates are the results of partial coverages of either the North or South Cache units or both. The extent of early Cache censuses is difficult to ascertain as available file records are incomplete. However, Olsen's and Argyle's (1936) count is believed to be a near total coverage (table 2).

Actual herd counts. Results from coordinated aerial and ground censuses of 1951-52 winters indicate close trend correlation (table 2). A difference of 60 elk was noted between the 1951-52 count of 817 head and the 1952-53 tally of 877 elk (tables 3 and 4).

It is readily admitted that inventories such as these do not account for all elk present on the entire area; however, such censuses do provide trend counts which may be effectively utilized in a management program. It is noted, however, that Wyoming (Hanscum, 1949) base their elk management program on a total estimated population, though in Utah trend counts frequently have been used to maintain desired population levels.

Sufficient ground spot checks could not be executed to enable an accurate comparison of Cache aerial and ground censuses, although the data did suggest a higher ground tally than corresponding aerial counts.

These two types of checks agreed in principle with those made by Cahalane (1938) and LaNoue (1938) in Yellowstone. Buechner, et al. (1951) also found under Washington conditions that the aerial census was 83 percent of the corresponding ground count. Rognrud (1953) similarly reported that an aerial count produced 77 percent of a Nebo elk ground tally. Nevertheless, the aerial count still has its unexcelled merits, which make it a utilitarian method.

Bugling census. Completed September bugling census returns in the Elk Valley section of the Cache study area indicated that 21 mature bulls were present in the area. On the basis of summer herd classifications, the summer Elk Valley population would then be 118 elk; other field investigations indicated a summer population of about 200 head. Eighty-one elk (35 bulls and 46 cows) were killed in the same area one month after the completion of the census.

Many problems incidental to a bugling census were found to exist, which in final analysis precluded a tally of all bulls in a given area. No spike bulls were known to bugle, although on occasions spike bulls assumed a position relative to a return of the bugle call, but no sounds were emitted. Absence of spike bull bugling was also noted in Wyoming (Murie, 1951). Additional factors such as topographical features, adverse affect of sheep utilization on elk distribution, increased wind velocities, elk inactivity during diurnal hours, sound limits, and increased movement of bulls during the earlier rut stages all tended to limit accuracy in the elk bugling census.

Within the described limitations an elk bugling census may be practical in determining trends in summer elk populations in areas having optimum terrain conditions.

Calculated past herd size. Though not absolutely necessary for

Table 2. Summary of Cache elk herd censuses, Utah, 1933-1953

Year	Time	Census			Personnel	Extent of Coverage	Remarks
		aerial	ground	total			
1933	Winter		426	426	?	Apparently Wasatch Face area, Blacksmith Fork north to Smithfield	
1936	March	674	102	776	Olsen and Argyle	Wasatch Face, Avon north to Idaho, Logan Canyon Head of Meadowville Dry and Blacksmith and Left Hand Forks	533 counted on face
1941	Feb. & March	534		534	Olsen	?	
1942	Winter	614		614	Olsen	?	
1946	March	410		410	Feast	Wasatch Face, Blacksmith Fork, Logan Canyon, and Left Hand Fork	292 elk on face
1949	Jan.		544	544	Fish and Game and U.C.W.R.U., Logan	North and South Cache areas	
1950	Jan.	277	239	606	McCormack	Entire coverage South Cache unit	
1952	Feb.	198	619	817	Hancock and Jensen	Entire coverage of North and South Cache units	265 elk on face
1953	Feb.	474	403	877	Ibid.	Ibid.	101 elk on face

Table 3. Summary of Cache elk aerial and ground census, February, 1952

General Location	Total Number	Cows and Calves	Bulls	Bulls 2 point or less	Bulls above 2 point	Unclassified
North Cache						
North Cache - Face	47	40	7	1	6	
North Cache - Logan Canyon	46	37	9	2	7	
TOTAL - North Cache	93	77	16	3	13	
South Cache						
Face-Logan to Blacksmith Fork	176	144	32	12	20	
Face-Blacksmith South past Avon	42	31	11	2	9	
Rich Co. - head of Cottonwood	12	10	2	0	2	
Blacksmith Fork Canyon-Mouth to N. Cottonwood	42	31	10	1	9	1
Left Hand Fork of Blacksmith	18	13	4	1	3	1
Right Hand Fork of Logan River; Temple Fork, Spawn Creek, Little Bear, and Steel Hollow	79	49	27/1	4	15	3
Hardware Ranch	355	330	25/2	16	6	
TOTAL - South Cache	724	608	111	36	64	5
Grand Total	817	685	127	39	77	5

1. Eight of these were identified as bulls but points not verified.

2. Three of these had antlers sawed off from recent trapping operations.

Table 4. Summary of Cache aerial and ground census, February, 1953

General Location	Total Number	Cows and Calves	Bulls	Bulls 2 point or less	Bulls above 2 point	Unclassified
North Cache-face	61	55	6	5	1	
Logan Can. and East Slope	12	2	10	1	9	
TOTAL - North Cache	73	57	16	6	10	
Face-Logan to Blacksmith	40	25	11	2	9	4
Scare Can. and East Fk. of Little Bear	19	16	3	1	2	
Right Fk. Logan River, Temple Fk., Spawn Cr., Little Bear, Steel, Ricks, Cowley, and Card Can.	193	149	28	6	22	16
Left Hand Fk. of Blacksmith, Herd, and Bear Hollow	44	30	7	1	6	7
Mahoganies-Left Hand Fk. of Blacksmith, Main Blacksmith Fk. to N. Cottonwood and over to Left Hand	42	18	24	10	14	
Rock Cr., Pol Hollow, Pleasant Valley, and West Hollow	20	5	15	1	14	
Rich Co. - Head of Cottonwood and Temple Canyon	4		4		4	
Immediately adjacent to Hardware Ranch - Curtis to Rock Creek	39	38	1	1		
Hardware Ranch Feed ground	403	367	36	27	9	
TOTAL - South Cache	804	648	129	49	80	27
Grand Total	877	705	145	55	90	27

management purposes, the use of population size is frequently advantageous. Actual population figures perhaps may never be known, but close approximation may be arrived at.

In attempting herd reconstruction mortality figures aside from actual legal harvest must be included. If consideration is not given to this categorical herd loss, computed population figures become too low or high depending upon the direction of herd reconstruction.

Rate of increase method. Various attempts were made to reconstruct herd numbers through the years. Thus, a reconstructed herd for years preceding the 1952-53 period was attempted, but proved futile beyond 1944 when the computed annual population became lower than field counts. A second attempt was made to define the herd from the time of the original reintroduction to the year 1936 when an extensive count was conducted. When a 1.25 rate of increase was utilized in herd reconstruction (Kelker, 1947), the final population was less than the actual 1936 enumeration. Conversely, a 1.30 rate of increase resulted in too high a population. However, when the rate of increase was computed at 1.27 and both known and conservative estimated losses were allowed, the reconstructed herd size appeared nearly comparable to the actual 1936 herd enumeration of 776 head. A third computation was attempted from the 1936 inventory figures and projected down to 1954. This method utilized an annual rate of increase of 1.22 and included known and estimated losses. In addition to above estimates, herd growth was made by using a 1.30 rate of increase for the original herd. This computation showed that possibly 460 elk were on the Cache area immediately prior to the first Cache elk hunt in 1925.

Current population levels thus computed for the latter period are somewhat higher than those derived from 1951-52 and 1952-53 aerial and

ground censuses. Difficulties in reconstructing a population, as has been attempted herein, are almost solely tied up by lack of information on the annual herd losses. Herd losses, aside from harvest removals, make reconstruction of herd numbers difficult and often not too reliable.

It appears from these computed data, however, that a reconstructed Cache elk herd, from the original plant to date, would roughly approximate that of actual populations. Thus, figures 2 and 3 present calculated annual populations in 2 segments: (1) the period 1916 to 1936, and (2) the 1936 to 1954 period.

Population estimates available from Utah State Fish and Game files show approximately the same trend as the calculated ones except for the 1942-50 period (table 5). Though the season of year for figures shown is not known, it presumably is for the late winter period of that calender year. Figures thus shown are from Utah State Department of Fish and Game files.

Table 5. Estimated Cache elk herd population figures, 1915-1950

Year	Population	Year	Population
1915	24	1940	850
1931	687	1941	900
1932	813	1942	614
1933	856	1943	606
1934	1,000	1944	611
1935	750	1945	650
1936	776	1946	660
1937	800	1947	700
1938	800	1948	750
1939	750	1949	900
		1950	800

Lincoln index. Certain basic requirements must be met in order that the Lincoln index equation be valid (Adams, 1951). In the Cache situation two requisites appeared lacking. They were that the tagged elk were not

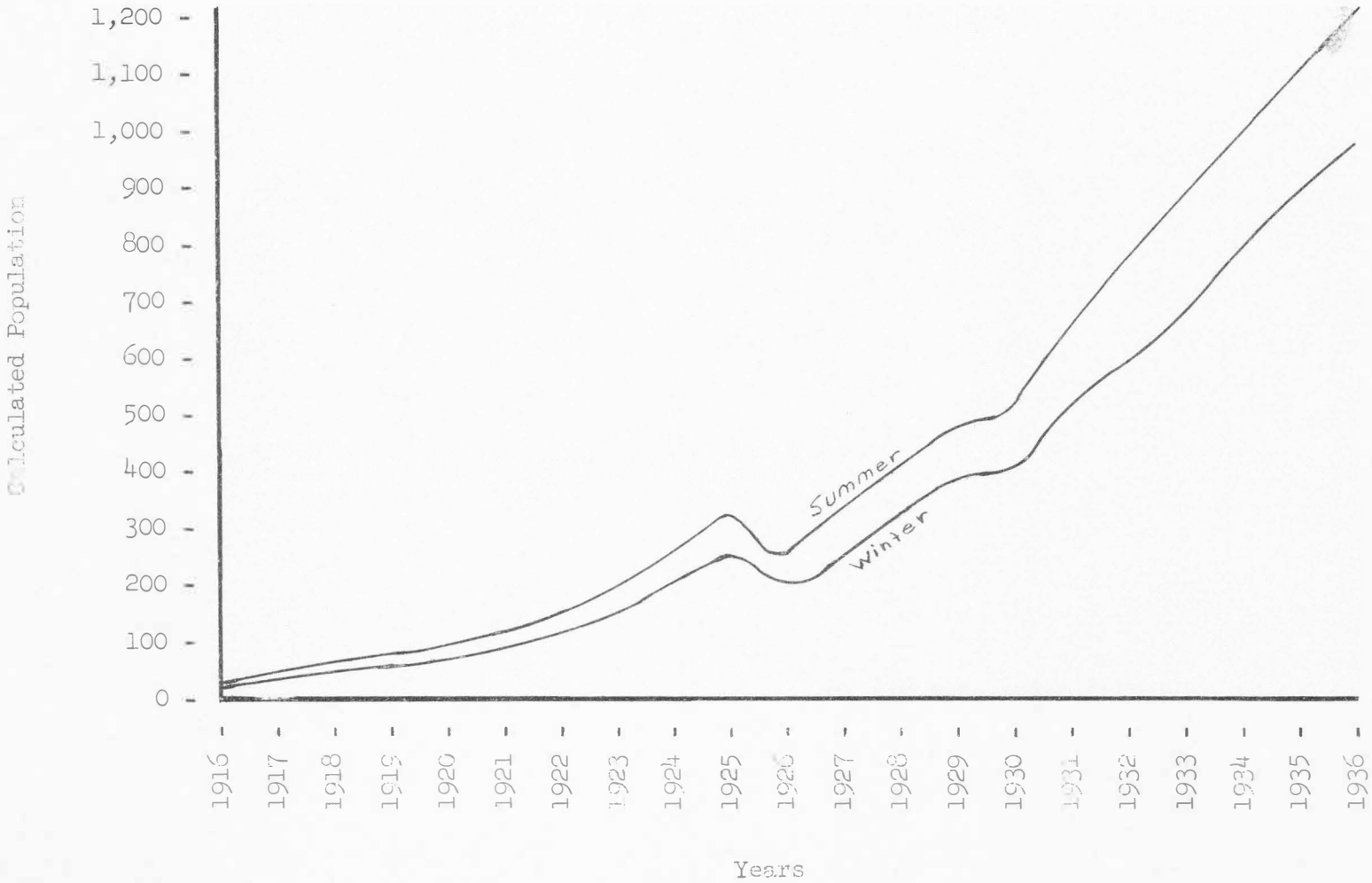


Figure 2. Calculated Cache elk population, 1916-1936

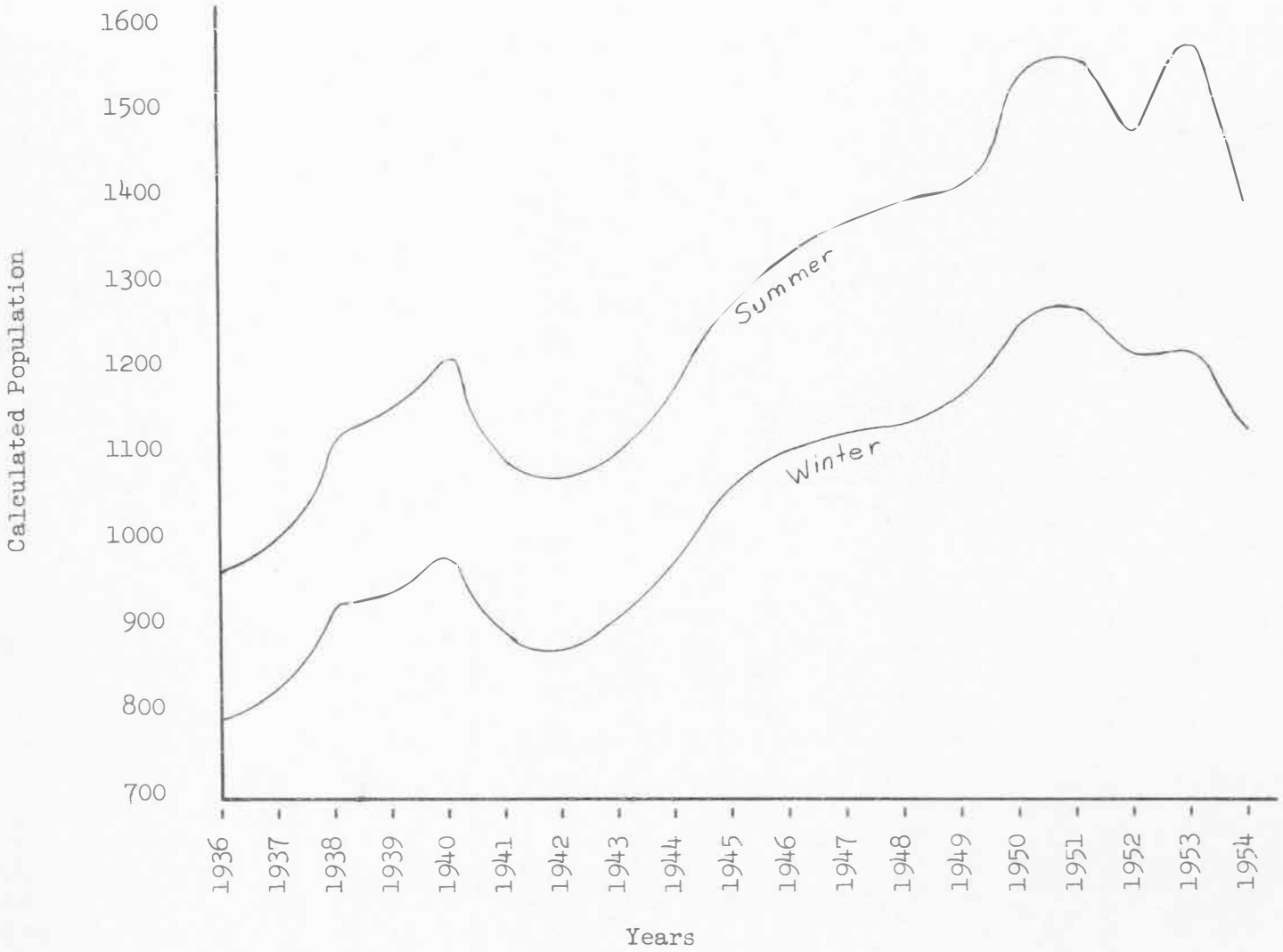


Figure 3. Cache elk population, 1936-1954, calculated from the actual count in 1936

randomly mixed with the untagged ones and the distribution of the sampling effort was not proportional to the number of tagged animals in different parts of the elk range. Another factor that hindered its use on the Cache was that few mature bulls were tagged within the herd. Even so, some results were not too far off possible numbers.

Attempts to reconstruct annual Cache elk populations by the Lincoln index consistently showed higher populations than were obtained by field counts (table 6) Even higher population figures were computed for all years except the first two when cumulative years of taggings were utilized (table 7). The latter calculation indicates that either tag losses or unaccounted losses of tagged elk, or both, have taken place and the cumulative results of these losses reflect in such a way as to produce inflated population estimates computed from the Lincoln index equation. Computations based on a single year's taggings suggest this condition even more dynamically than do those in table 7. North Cache elk kill and tag returns were not included in these calculations; hence population estimates are applicable only to the South Cache portion.

It is interesting to note, however, that there appears a definite trend in annual tag returns, as accumulative returns for the years 1949, 1950, 1951, 1952, and 1953 were 22.8, 14.3, 22.2, 23.3, and 28.1 percents, respectively.

Calculated present herd size. An estimate of a minimum 1953 spring elk population was achieved by defining the upper accuracy limit of the 1951-52 aerial and ground inventory. Thus a maximum effectiveness of the 1951-52 Cache winter survey was computed at 81.7 percent. (See page 22 for derivation of maximum success of survey.) It was assumed that efficiency of the 1952-53 Cache inventory was similar to that of the preceding year; hence a winter Cache elk population was predicted from the known

Table 6. Cache elk populations (P) computed by the Lincoln index method and based on individual year taggings, 1949 to 1953

Year	No. elk tagged prior to hunt (n)	No. tagged elk killed (x)	Total elk kill regular season (k)	Computed summer elk population $p = \frac{kn}{x}$
1949	52	6	135	1,170
1950	102	4	150	3,825
1951	112	22	225	1,145
1952	224	28	181	1,444
1953	68	8	188	1,583

Table 7. Cache elk populations (P) computed by the Lincoln index method and based on cululative years taggings, 1949 to 1953

Year	No. elk tagged prior to hunt (n)	No. tagged elk killed (x)	Total elk kill regular season (k)	Computed summer elk population $p = \frac{kn}{x}$
1949	52	6	135	1,170
1950	146	9	150	2,435
1951	246	30	225	1,845
1952	437	43	181	1,839
1953	459	36	188	2,397

1952-53 enumeration of 877 elk (table 2). This estimate was achieved thusly:

$$\frac{877}{0.817} \text{ equals } 1073 \text{ elk}$$

Thus a minimum 1953 spring population of 1073 elk was computed for the entire Cache herd. The 1953 summer herd was calculated to be 1452 head when the expected 379 calf crop was added to the parent spring herd. The 1953 calf crop of 379 was derived by using an expected summer cow-to-calf ratio of 1 : 0.51 (table 12).

Seasonal Distribution of Population

Summer

Summer elk distribution was delineated during extensive ground coverages of the study area throughout the 1952 summer period and through the distribution of the kill (figure 4 and table 18). Cache elk then displayed a decided preference for the aspen cover type, while coniferous tracts--primarily spruce-fir--were sought secondly as an elk summer habitat. Summer Cache elk range lies within the forest interior from about 6,000 feet to slightly above 9,000 feet with optimum range between 7,000 and 8,000 feet elevation.

Winter

Distribution of Cache elk winter populations can best be outlined from the annual aerial winter census and supplemented by information secured from periodic ground surveys. It is readily apparent that winter distribution of elk or any big game species is largely dependent upon existing late fall and winter weather conditions. Two winters of contrasting weather intensity occured during the present study period. The 1951-52 winter was severe and the 1952-53 winter was open and mild. Elk were forced onto the Wasatch face areas during the severe 1951-52 winter as contrasted to a greater utilization of interior areas during the milder

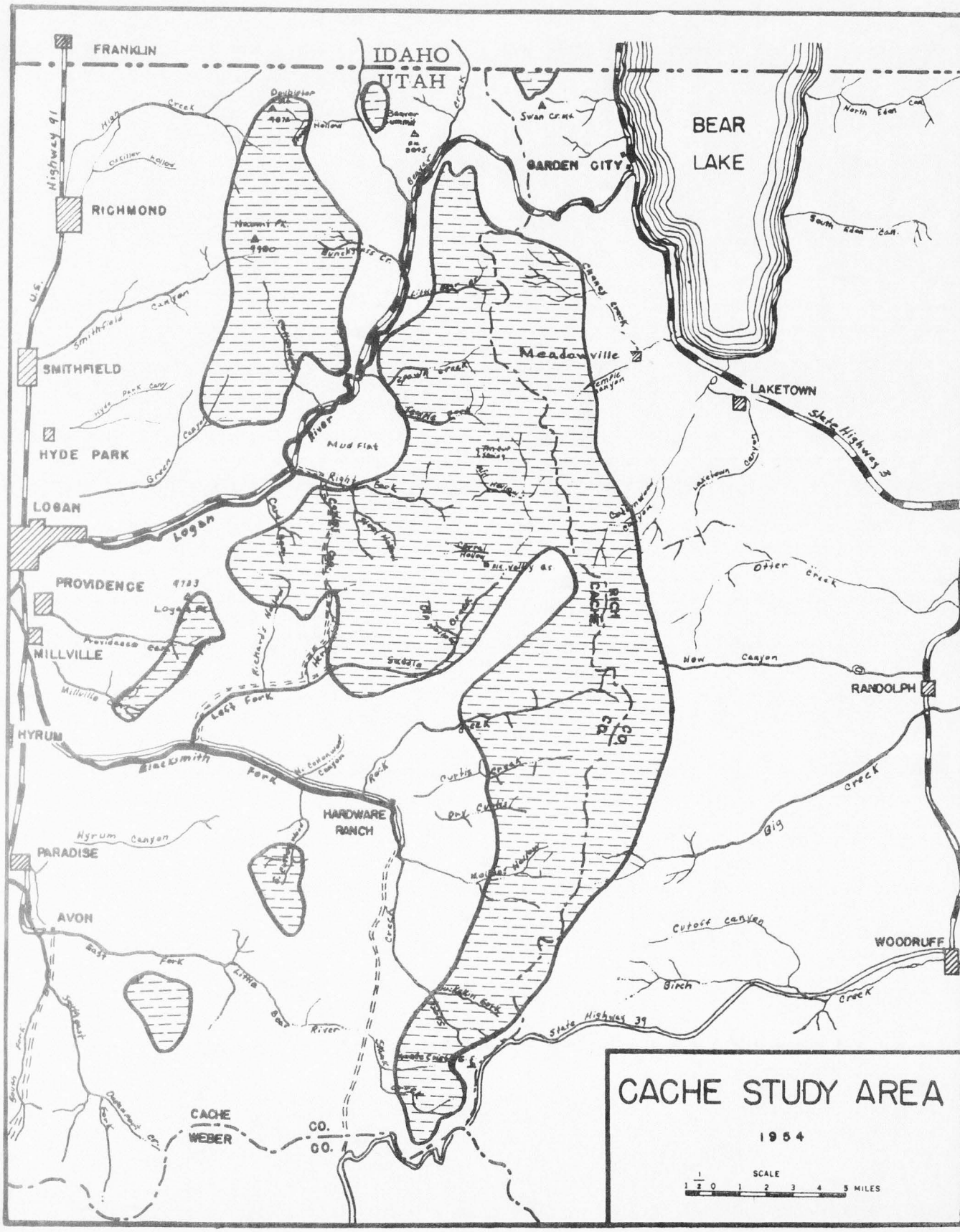


Figure 4. Summer distribution of elk on the Cache area, 1952

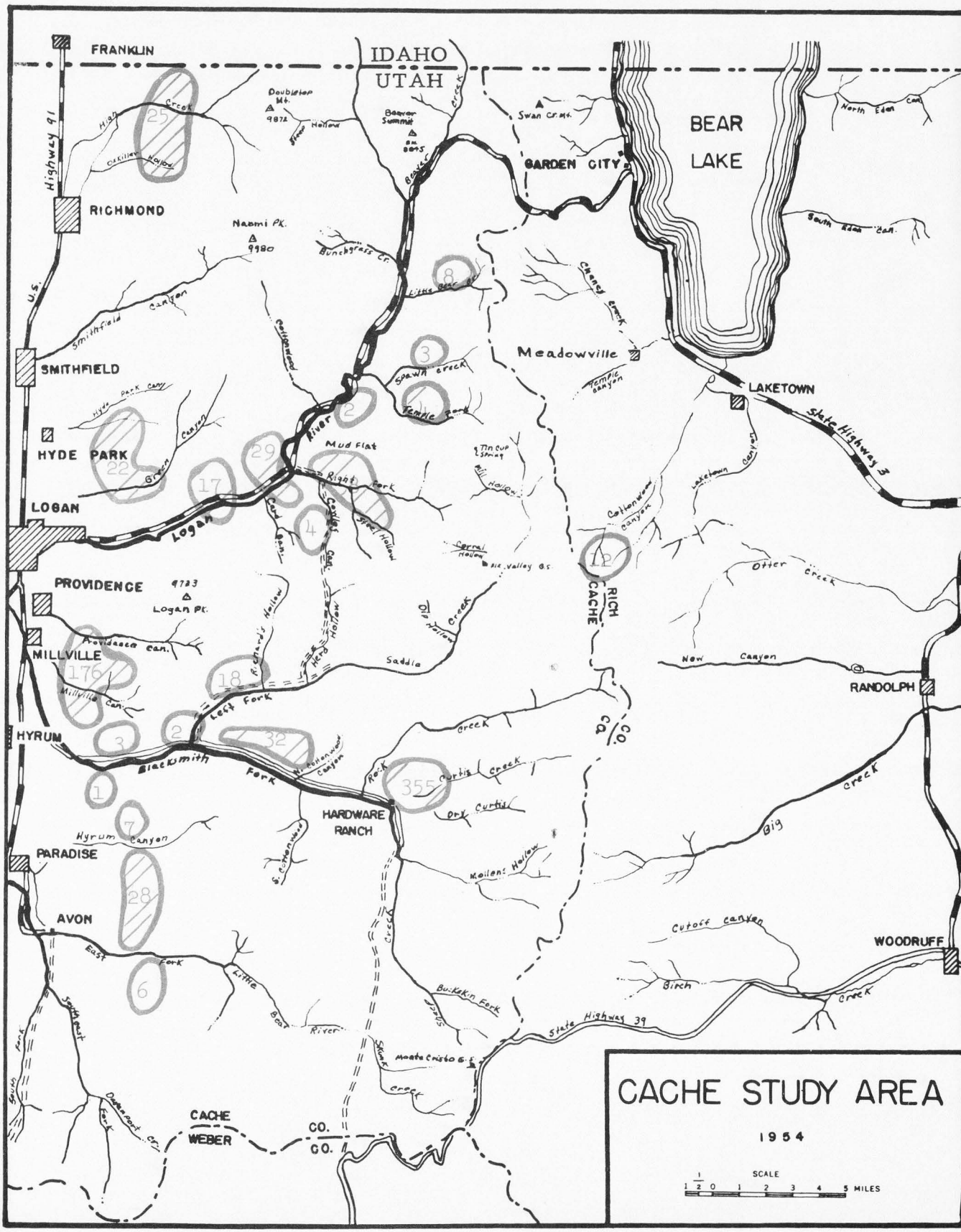


Figure 5. Numbers and winter distribution of Cache elk herd, February 1952

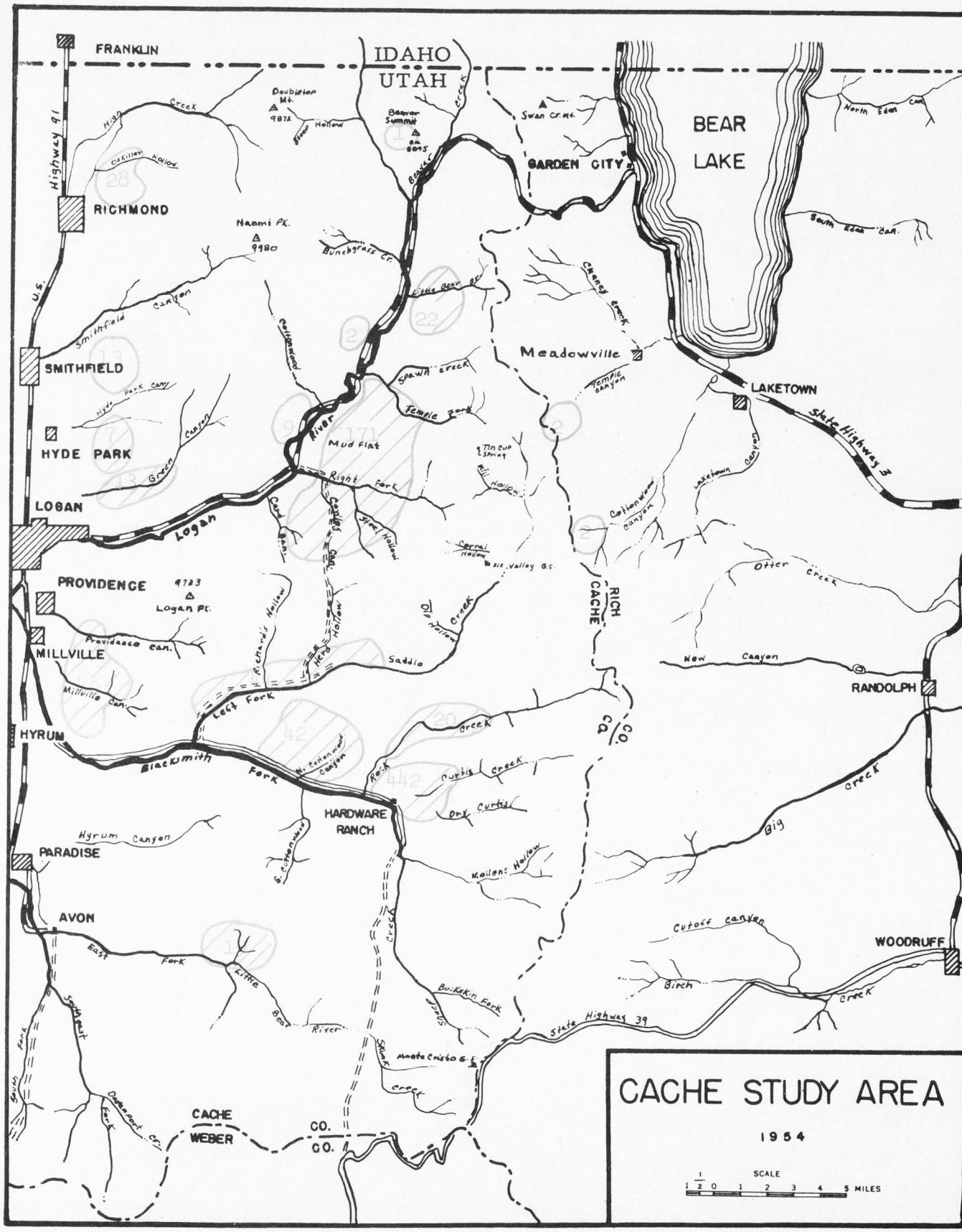


Figure 6. Numbers and winter distribution of Cache elk herd, February 1953

1952-53 winter (figures 5 and 6).

Migration

Migrations from principal wintering ranges were studied by means of aerial surveys and periodic ground checks. Tagged elk returns were also used advantageously in outling elk travel to the summer range.

Earliest movement in 1952 was noted when elk, which had wintered in Little Cottonwood, moved into the Mud Flat section about April 8. Some elk from Spawn Creek and Temple Fork also traveled into the Mud Flat area approximately at the same time. However, chief migrations from the Wasatch face, Blacksmith Fork, and Left Hand Fork areas started about the last week in April. Early arrivals into Elk Valley, a summer elk concentration area, were noted April 27. North Cache elk migration from the mountain face areas occurred at a slower pace and at a somewhat later date, probably because of extensive snow fields in migrational lanes. North Cache migration was comparatively short, consisting of a gradual movement to the mountain tops and followed by a scattering of the animals on the eastern slope.

Cache elk spring migration can best be described by summarizing movement from individual major winter ranges (figure 7).

1. The Hardware Ranch migration has been a subject of no little speculation; however, the general migration pattern from the Hardware appeared to be characterized by a three-phased movement: (a) A gradual drift took place from the feed ground proper to Rock Creek adjacent to the northeast portion of the Hardware; ;his commenced around April 15, 1952 and April 1, 1953. Feeding was discontinued on April 23, 1952 and April 12, 1953. Migration reached a peak during the last week in April of each year. (b) A general movement in and around Rock Creek was noted for a period of 2 to 3 weeks. (c) A final migration from the Rock Creek area occurred into 3 major summering areas: Bear Hollow, Elk Valley, and

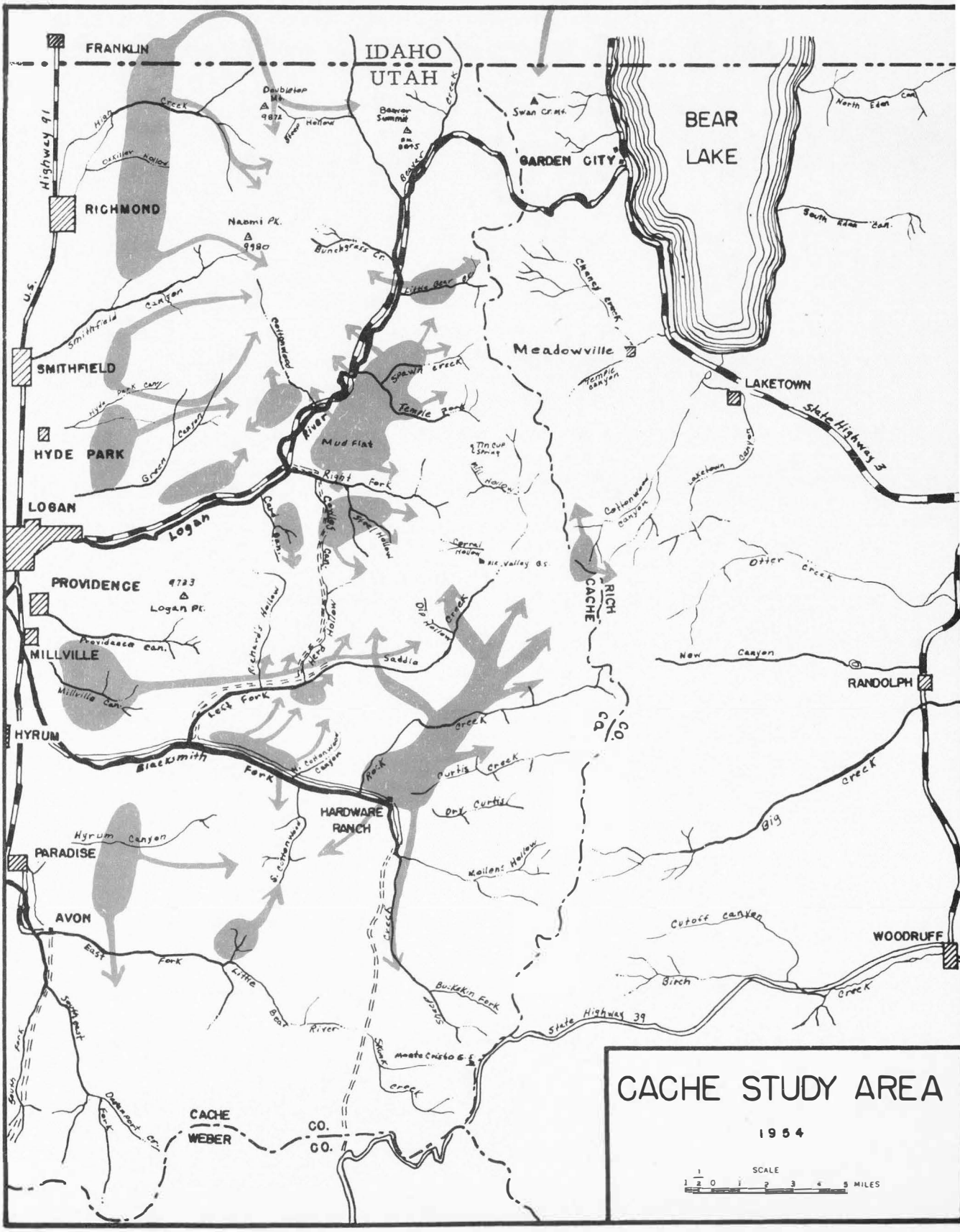


Figure 7. Principal Cache elk migration routes from winter to summer ranges, 1952 and 1953

strawberry Valley-Rock Creek area. Limited numbers migrated between Rock and Curtis Creeks toward Black Mountain. Aerial reconnaissances of 1952 and 1953 did not show any large migration south of the Hardware Ranch, although small numbers of elk did migrate that way.

2. Migration from the area between Logan and Blacksmith Fork Canyons occurred during the last week in April in both 1952 and 1953. Elk traveled to the Millville Canyon-Leatham Hollow ridge and traversed Leatham Hollow paralleling the northern side of Left Hand Fork and broke off in detached units at the mouths of Richard, Herd, and Bear Hollows. A few elk continued up Left Hand Fork past Boulder Mountain, presumably en route to Elk Valley.

3. Spring migration from the Mud Flat and adjacent area was directed to the north and northwest. Elk left the area en route to the North Cache via Chicken Creek-Cottonwood crossing, mouth of Temple Fork-Blind Hollow section, and the Bear Creek trail. Other elk moved up Temple Fork toward Temple Mountain, while some elk journeyed toward Spawn Creek and Little Bear. Limited evidence suggested a possible early migration from the southern Mud Flat area toward Ricks and Steel Hollows as well as Lion Canyon. Additional information relative to Mud Flat elk migration is presented in relation to spring elk use of the reseeded units. (See Mud Flat section of this report.)

4. Elk wintering in the vicinity of High Creek near the Utah-Idaho border utilized two routes to the summer range. The major route was up the right hand fork of High Creek into the White Pine Lake area and the "Kitchen" in the head of Steam Mill. Other elk, probably supplemented by Idaho elk wintering east of Franklin, Idaho, migrated up Deep and Maple Canyons down White Canyon and crossed Franklin Basin toward Beaver Mountain and Wiggler Lake. It is also entirely feasible that elk winter-

ing in Franklin County, Idaho, migrate up the Cub River and south into Franklin Basin.

Spring migration is generally regulated by stage of plant growth and reduction of snow depths. Migration to the winter range is similarly stimulated by lack of available forage in higher areas from freezing temperatures and adverse snow conditions. Fall migrations to winter ranges was observed as a build up of elk at various places followed by a general drifting movement of elk concentrations toward winter ranges. In general, migration to winter ranges was a reversal of the spring migration pattern. In addition, hunting pressure exerts influences, although its role is not fully understood or appreciated. It appeared that most elk movement during the 1951, 1952, and 1953 elk and deer hunting seasons were sporadic adjustments to hunting pressures applied on local elk populations. Little known migration was exhibited except for the premature arrival of an elk vanguard on the Hardware unit around the termination of the deer season.

The elk tagging program initiated in 1949 has been continued each winter through the 1954 season at the Hardware Ranch (table 8). Tag returns thus far have produced valuable information on migrations and local elk movements. Limited tagging has also been done during the calving season. Initial tagging operations began on the Wasatch face area east of the town of Millville. Though objectives of the tagging program have been partially realized through the short span of years of operation, fruits of the project will become increasingly valuable as cumulative data are annually secured. Information to date has aided materially in substantiating migration and seasonal distribution of Cache elk. It is, furthermore, providing a basis for determining aging techniques founded on dentition replacement and wear.

Table 8. Summary of Cache elk tagging data, 1949-1953

Tagging Data Year	No. Tagged	1949		1950		1951		1952		1953	
		Tags Returned	Tags Remaining	Tags Returned	Tags Remaining	Tags Returned	Tags Remaining	Tags Returned	Tags Remaining	Tags Returned	Tags Remaining
1949	57	13	44	5	39	6	33	1	32	3	29
1950	103			5	98	8	90	4	86	2	84
1951	114					24	90	10	80	5	75
1952	236							43	193	24	169
1953	68									9	59
Total	578	13	44	10	137	38	213	58	391	43	416
Accumulated Total		13		23		61		119		162	

From 1949 to 1953, 578 elk have been tagged (table 8). At the end of the 1953 hunting season 162 (28 percent) tags had been returned. Taggings since 1952 have utilized two tags per animal; this procedure minimizes loss of identity of animal through ear tag losses.

McCormack (1951) presented tag-return data on the South Cache elk for the years 1949 and 1950. The present report indicates distribution of tagged elk killed in pre-season and general elk hunts as well as illegally killed ones during deer seasons for the years 1951, 1952, and 1953 (figures 8, 9, and 10). Boulder Mountain and Elk Valley sections have consistently been the areas of highest tag returns. Rock Creek and the eastern ridge of Strawberry Valley had the next highest tag returns. A greater spread in tag returns was more evident in 1953 than the preceding two years. This same dispersion was evident in the Millville and North Cache tag returns (figures 11, 12, 13, and 14). Partial explanation may be that Rich County and North Cache areas were set up as separate units during the 1953 general elk season. However, when tag returns from these special divisions were excluded, there still remains an unexplained spread in tag returns of 1953 as compared to 1951 and 1952.

During the severe winter of 1951-52, 76 elk were trapped on the Wasatch face in the vicinity of Millville canyon. They were tagged and released at the Hardware Ranch. A blue disc was placed in the lower right ear to identify these elk. One cow from this group was observed in the Mud Flat-Temple Fork area on May 17, 1952. Other elk of this group were observed throughout the 1952 summer, particularly in the Elk Valley section. Figures 11 and 12 indicate distribution of tag returns of the Millville elk group during the years 1952 and 1953.

Also in the winter of 1951-52, fifty-two (52) elk were trapped on the North Cache face area immediately north of Green Canyon. Forty-two

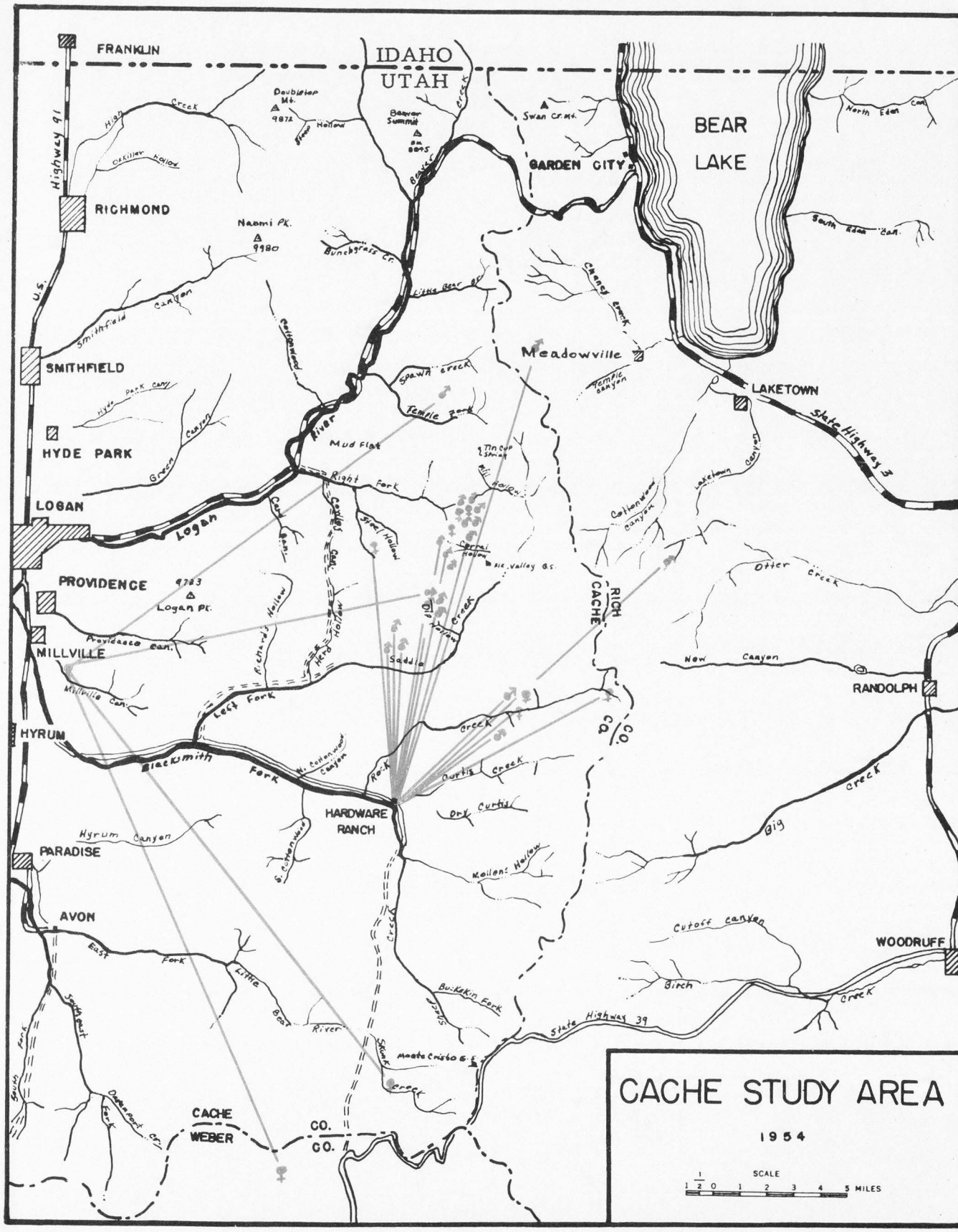


Figure 8. Distribution of tagged elk killed during 1951 pre-season, general elk hunt, and deer season

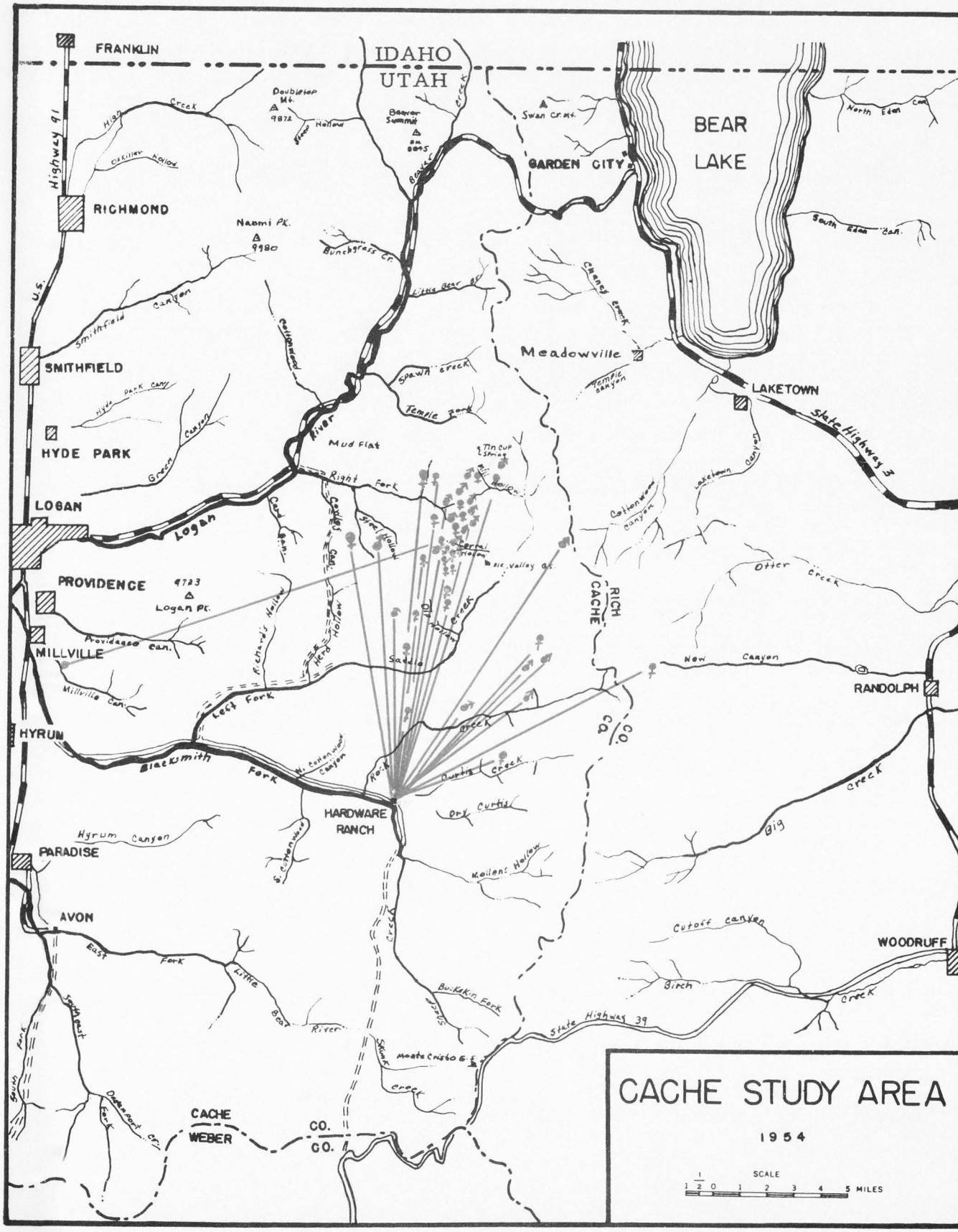


Figure 9. Distribution of tagged elk killed during 1952 general elk hunt and deer season

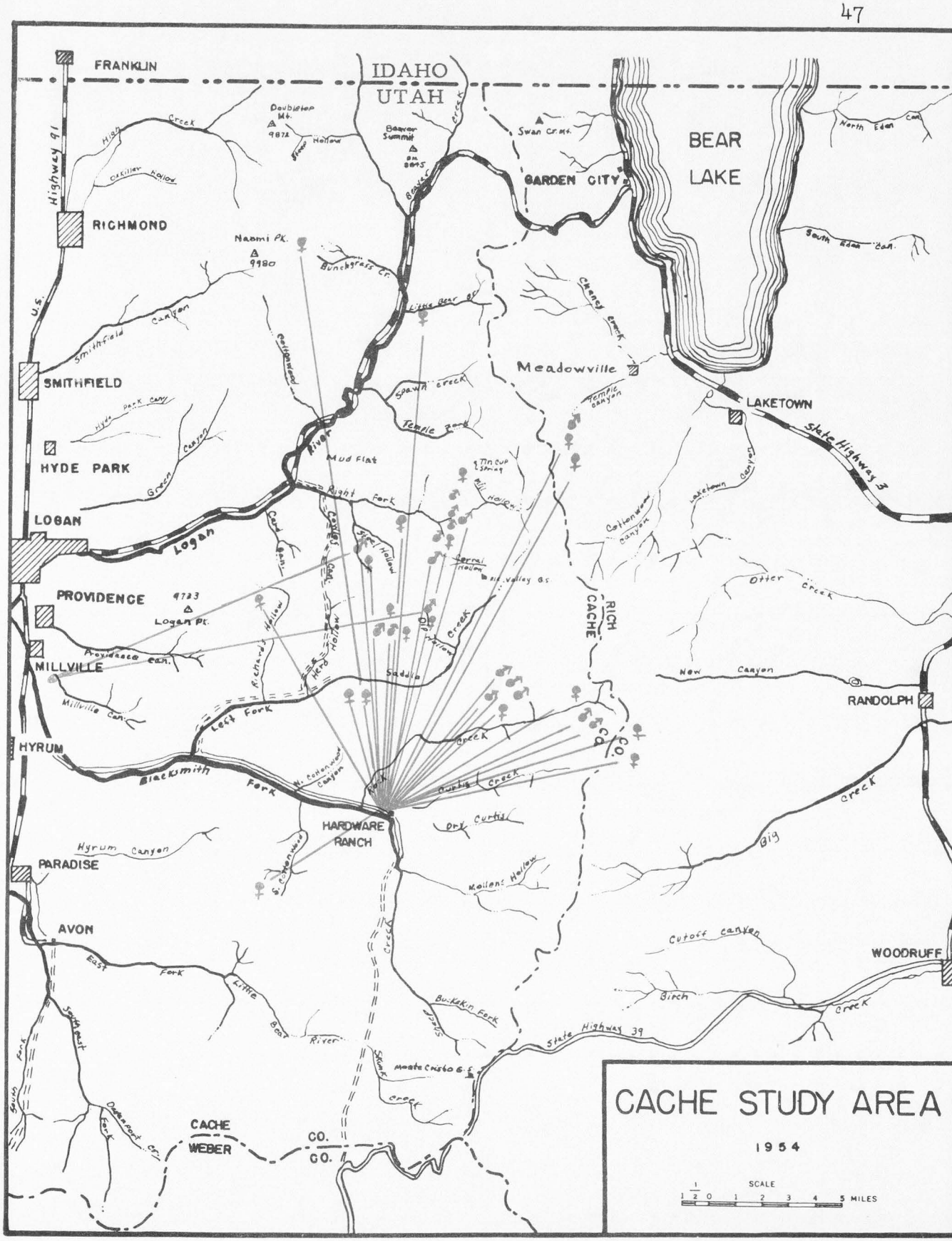


Figure 10. Distribution of tagged elk killed during 1953 general elk hunt and deer season

of these elk were tagged and released at the Hardware Ranch. The remaining 10 head were released untagged at the Hardware. Animals were tagged with two standard cattle-type tags and a yellow disc in the lower right ear. Particular interest was maintained in this group since there was considerable speculation as to whether these elk would return to the North Cache district where they were trapped. A member of this group was first seen on June 6, 1952, one-half mile east of the Elk Valley Ranger Station. Since that time, members of the group were observed frequently in the Elk Valley and Rock Creek sections during the summer of 1952. First indication of these elk migrating back to the North Cache was when two cows of this group were observed on July 7, 1952, in lower Blind Hollow. Additional information was obtained when a cow of this group was killed 3 miles east of the North Cache trapping site during the 1952 post-season hunt. Four tagged cows of this group were also observed March 19, 1953, near the North Cache trapping site. Tag returns from the North Cache group during the years 1952 and 1953 are plotted in figures 13 and 14, respectively. Of particular interest is a tag from a bull of this group killed December 5, 1953, in the right fork of Crooked Creek, 5 miles east of Franklin, Idaho.

These North Cache tag returns are even more significant since no other tagged animals have been seen or killed on the North Cache unit, although slightly less than six hundred elk have been tagged on the entire Cache from 1949 to 1953.

It is the writer's opinion that much migration information yet remains to be discovered for the elk on the North Cache. This information can be disclosed by supplementing the Hardware Ranch taggings through tagging new-born elk calves wherever possible on the North Cache as well as in the Mud Flat section. In addition, should elk concentrate near the

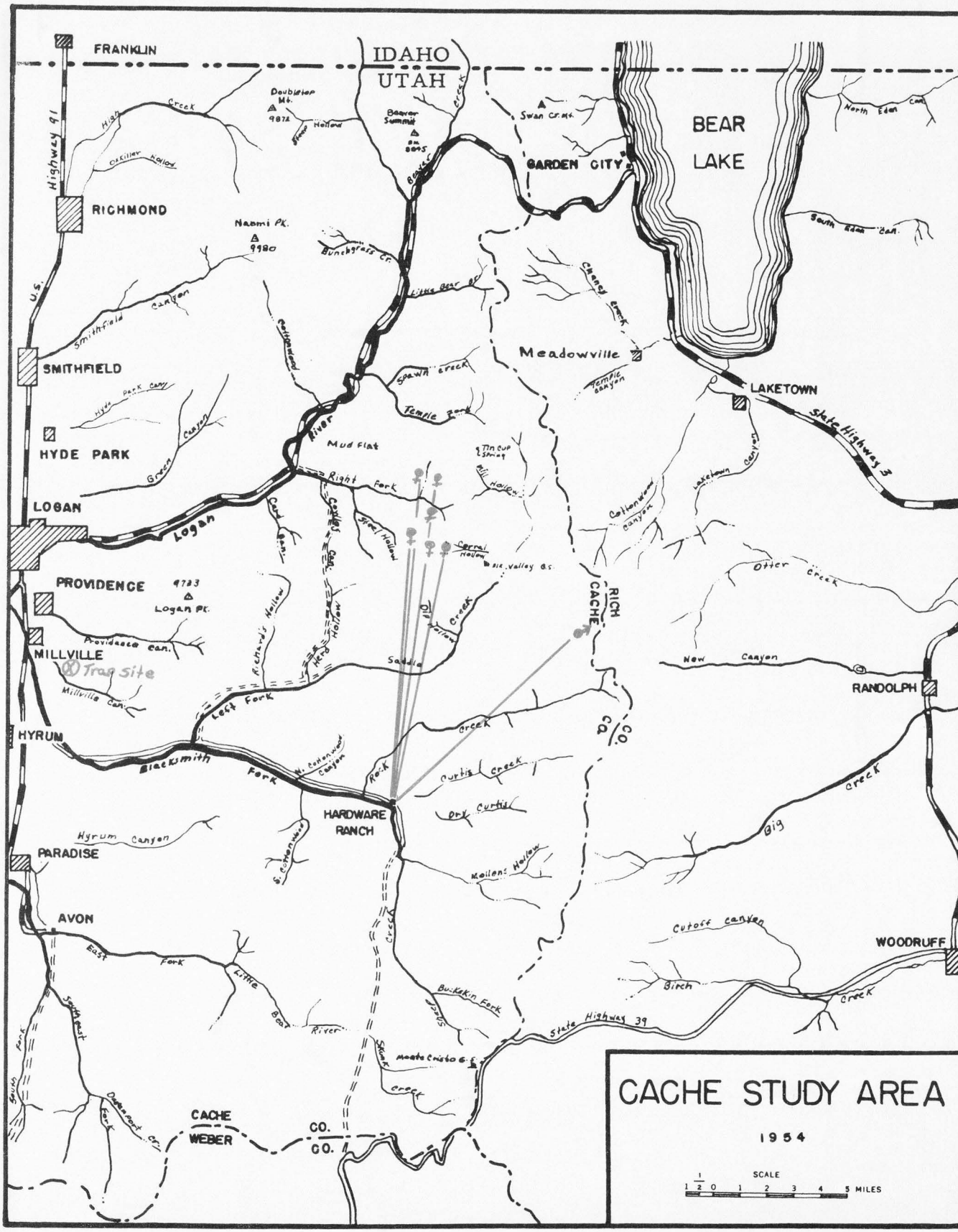


Figure 11. Distribution of elk killed during 1952 general hunting season that had been trapped and tagged at Millville Canyon and released at the Hardware Ranch in 1952.

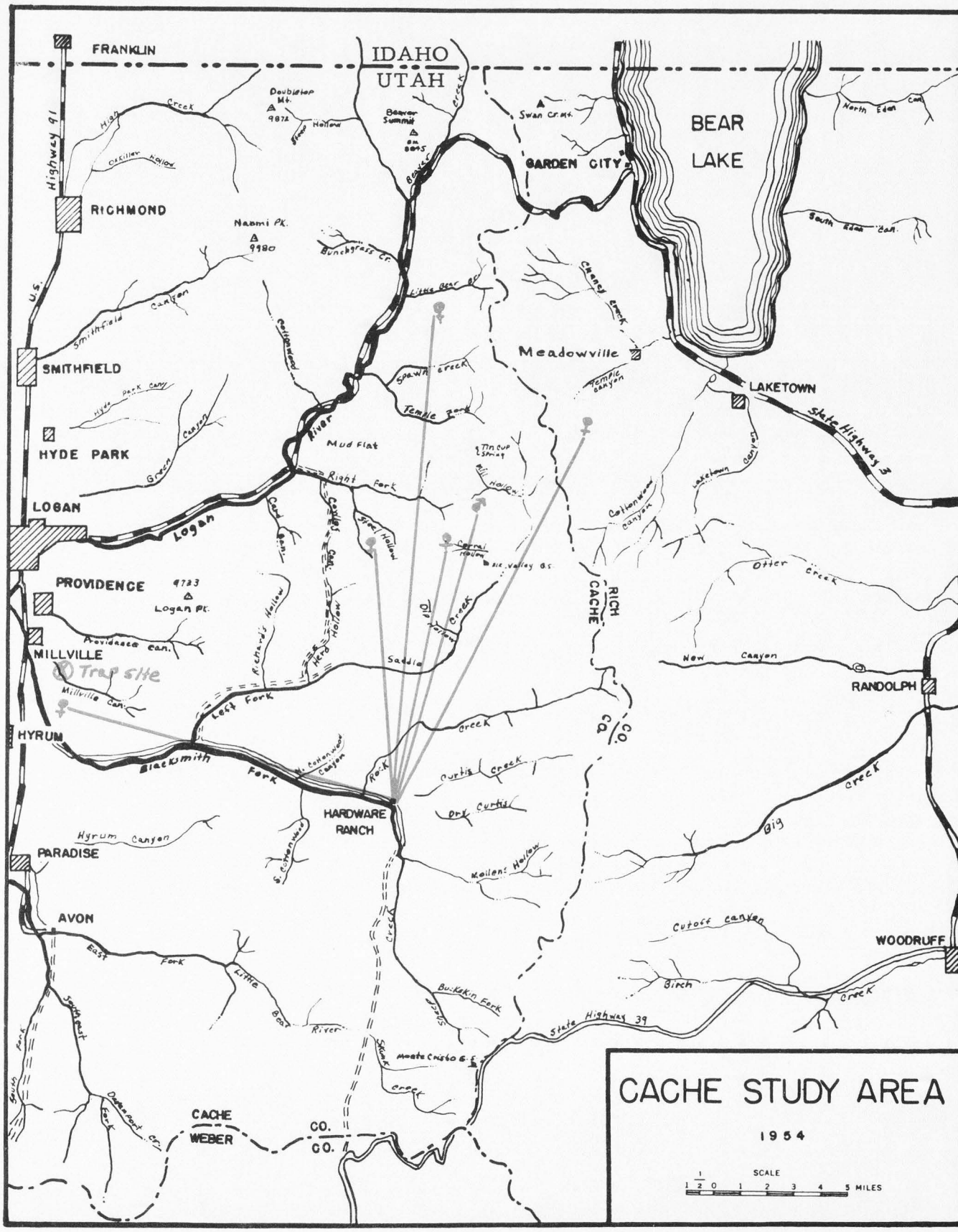


Figure 12. Distribution of elk killed during 1953 hunting seasons that had been trapped and tagged at Millville Canyon and released at the Hardware Ranch in March 1952.

Utah-Idaho border as they did in December, 1951, a cooperative effort should be undertaken by the Idaho and Utah Fish and Game Departments to tag these elk. It was the concensus of opinion that elk congregated near Franklin, Idaho, in 1951, moved into Utah along the North Cache face. Such a proposed tagging endeavor in the Franklin area would undoubtedly clarify the extent of North Cache interstate elk migration.

Herd Sex and Age Composition

Though figures of total elk numbers are of indisputable management value, their worth becomes even increasingly important when the existent herd composition is known. Such a knowledge of herd composition endows the game manager with a reliable index to calf crop, sex ratios, and yearling survival. He is then in a position to better evaluate herd productivity, population status, and necessary harvest removals.

Composition of winter herd

Cache winter herd composition was derived from aerial bull and antlerless counts, and from classified ground cow and calf samples. The antlerless portion recorded from the aerial survey and then divided into its complementary cow and calf groups in the same proportion as observed on the ground. Ground sex ratio counts were not completed since it was found impractical to survey sufficient number of bull wintering sites to insure reasonable sampling accuracy. Aerial census, therefore, provided the basis of the bull complement for computing herd sex ratio. Ground classification counts of 1951-52 and 1952-53 winters resulted in observed cow-calf ratios of 100 : 0:52 and 100 : 0.47, respectively (table 9). Cache cow-calf ratios, when compared to those from other western herds, appear quite narrow; hence tend to indicate a higher calf survival on the Cache.

Winter sex ratios are particularly significant since they reflect,

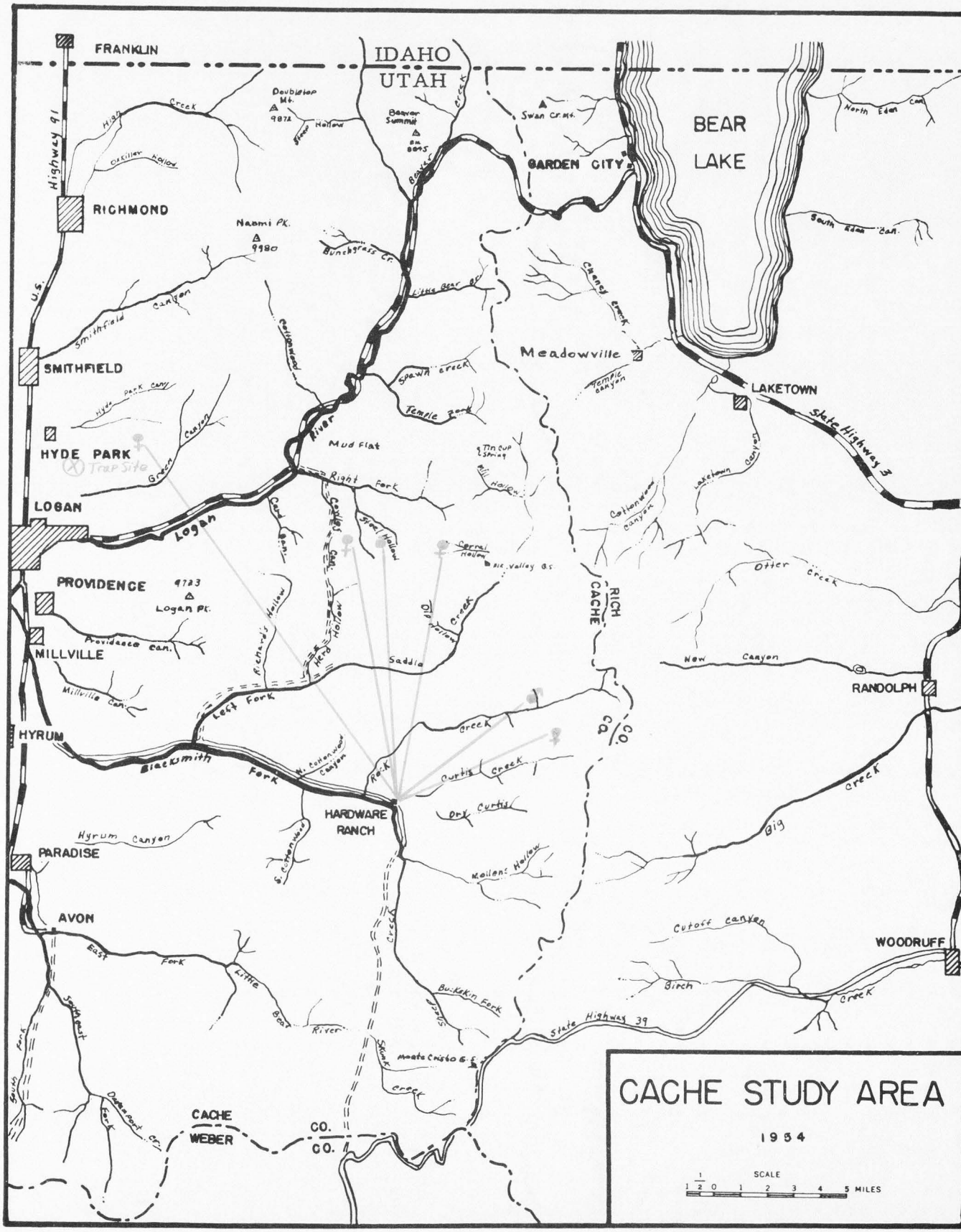


Figure 13. Distribution of elk killed during 1952 hunting seasons that had been trapped at North Logan and tagged and released at the Hardware ranch in February 1952

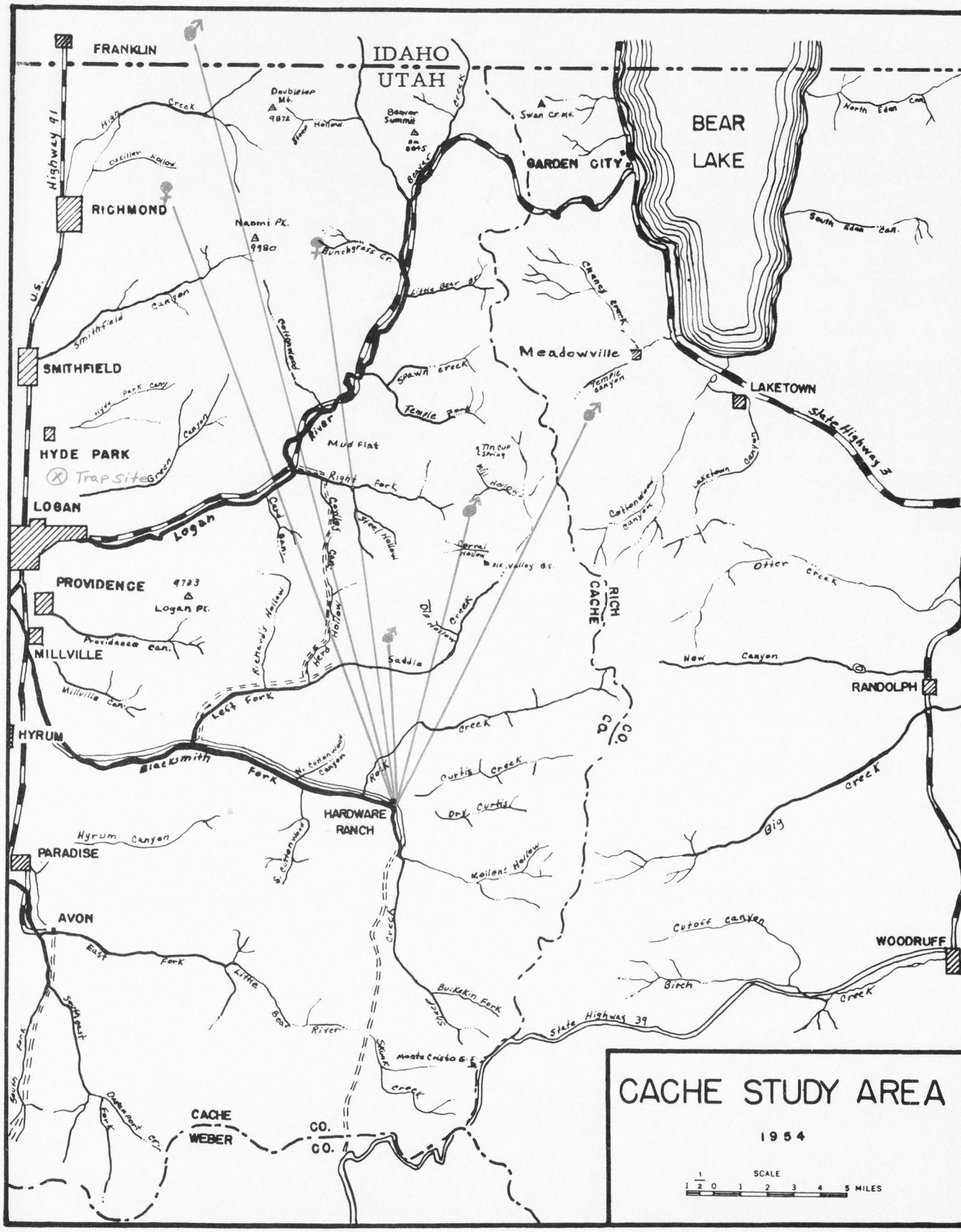


Figure 14. Distribution of elk killed during 1953 hunting seasons that had been trapped at North Logan and tagged and released at the Hardware Ranch in February 1952

to a marked degree, the expectant late summer breeding bull-to-cow ratio. Considerable variation in winter sex ratios among western elk herds is noted in reported literature. Cache winter sex ratios were noted to be remarkedly similar for the 1951-52 and 1952-53 winter herds. Thus, a bull-to-cow ratio of 1 : 3.5 and 1 : 3.3 were recorded, respectively. McCormack (1951) recorded a winter sex ratio of 1 : 2.6 for the South Cache section. Bull-cow-calf ratios in the winter Cache elk herd were observed as 1 : 2 : 1, respectively.

Table 9. Comparative winter cow and calf ratios, Cache elk herd, 1950, 1952, 1953

Winter	Location	Cows	Calves	Total	Cow-Calf	Calf-Cow
1949-50 (McCormack, 1951)	S. Cache (aerial)	104 (57.5)	77 (42.5)	181 (100.0)	100:0.74	100:135
	Hardware Ranch	194 (62.8)	115 (37.2)	309 (100.0)	100:0.59	100:169
1951-52	Hardware Ranch	213 (64.5)	117 (35.5)	330 (100.0)	100:0.55	100:181
	Cache less Hardware Ranch	111 (68.1)	52 (31.9)	163 (100.0)	100:0.47	100:214
	Cache Total	324 (65.7)	169 (34.3)	493 (100.0)	100:0.52	100:191
1952-54	Hardware Ranch	249 (67.8)	118 (32.2)	367 (100.0)	100:0.47	100:211

Adult sex ratio counts at the Hardware Ranch were not representative of the Cache herd since Cache bull elk were conspicuous by their absence. The few bulls wintering here were preponderantly yearling and young bulls.

An inspection of classified Cache winter herd inventory figures reveals an occurrence of 31.7, 28.8, and 26.7 percent calf complements of the entire herds, 1949-50, 1951-52, and 1952-53, respectively (table 10).

Table 10. Comparative classified Cache elk counts for 1950, 1952, and 1953

Winter	Unit	Cows	Calves	Total Bulls	Bulls 2 pt. or less	Bulls above 2 pt.	Bulls unclassified	Grand Total
1949-50	So. Cache	298 (49.2)	192 (31.7)	116 (19.1)				606 (100.0)
1951-52	No. Cache	51	26	16	3	13		93
	So. Cache	400	208	111	36	64	11	719
	Total	451 (55.5)	234 (28.8)	127 (15.7)	39	77	11	812 (100.0)
1952-53	No. Cache	39	18	16	6	10		73
	So. Cache	440	208	129	49	80		777
	Total	479 (56.3)	226 (26.7)	145 (17.0)	55	90		850 (100.0)

The percent of calves in the winter herd has long been used as a basis for defining herd increase or often synonomously called "calf crop." Though differentiation of the terms "rate of increase" and "calf crop" should be made at this time, it shall be reserved for later consideration within the current report. Calf crop, as herein reported, is the percentage composition of the calf complement of the total winter or "after hunting season" herd. Considerable variation is noted in reported calf-crop figures (appendix table 1). However, this is justifiably so since there is distinct heterogeneity in western state harvest programs, which may or may not induce selectivity of sex and age classes in harvest removals; hence, calf crops are numerical values changing with hunting pressure intensities exerted upon the bull, cow, or calf complements.

Composition of summer herd

Cache summer elk herd sampling was commenced during the last week in July and continued through September, 1952. Animals observed in the field were classified according to their respective sex and age groups. No animals were tallied unless all members of the group were classified.

Classification of animals was extremely difficult during this period since elk spent considerable time in the chokecherry understory in aspen groves. Leaf foliage was highly persistent throughout the entire period. Calves in all instances did not heel cows. In addition, classifications also showed a paucity of mature bulls in cow and calf bands. Furthermore, sheep grazing caused considerable movement of elk. More optimum classification conditions prevailed in mid-September through October 1.

Summer classifications of 153 elk were made without any known duplication (tables 11 and 12). For the most part, sex and age composition figures are quite comparable to those obtained by McCormack in 1949 and 1950 (McCormack, 1951).

Table 11. Summer elk herd classifications on the Cache

Location	Year	Mature bull	Mature cow	Yrlg. bull	Yrlg. cow	Calves	Total
S. Cache	1949	44 (20.7)	81 (38.0)	15 (7.0)	18 (18.5)	55 (25.8)	213 (100.0)
S. Cache	1950	45 (17.4)	91 (35.2)	31 (12.0)	27 (10.4)	65 (25.0)	259 (100.0)
Cache	1952	28 (18.6)	62 (40.4)	12 (7.7)	13 (8.5)	38 (24.8)	153 (100.0)

Cache summer bull-cow-calf ratios were roughly 1:2:1 during the study period. The same ratios were noted on the Nebo summer herd (Rognrud, 1953).

Table 12. Cache summer elk herd ratios 1949, 1950, and 1952

Year	All Bulls to All Cows	All Bulls to Breeding Cows	All Cows to All Calves
1949	1 : 1.68	1 : 1.37	1 : 0.55
1950	1 : 1.55	1 : 1.19	1 : 0.55
1952	1 : 1.87	1 : 1.55	1 : 0.51

Composition of harvest

Complete composition data are not available for the 1951 Cache harvest since calves were not differentiated within the antlerless group on the Blacksmith Fork checking station records. However, complete data were recorded for two succeeding seasons (table 13). The low incidence of calves in the total harvest suggests a selectivity in favor of older age classes within the antlerless fraction. In the summer herd, calves made up about one-third of the total antlerless class; while in the 1952

Table 13. Composition of Cache elk legal harvest

Season	Kill									
	Calves				Cows	Antlerless	Bulls			Grand Total
	male	female	unclass.	total			yrlg.	mature	total	
1951						122 (47.2)			137 (52.8)	259 (100.0)
1952	6	9		15 (7.5)	94 (47.2)	109 (54.7)	17 (8.6)	73 (36.7)	90 (45.3)	199 (100.0)
1953	10	11	1	22 (9.0)	103 (42.4)	125 (51.4)	35 (14.4)	83 (34.2)	118 (48.6)	243 (100.0)

and 1953 kills they were 13.3 and 17.6 percent of the total antlerless kill. The calf kill in the Cache harvest is not comparable to the kill of other western herds since Cache hunting permits are specified as to sex. Most other available kill composition is derived from herds where either sex hunting is in vogue. However, Rognrud's (1953) Nebo data on an either sex hunt show a comparable calf kill of 13 and 16.9 percent of the 1951 and 1952 total antlerless kill.

Data for age classes above the calf age, as determined from dental examination of those animals killed during the fall hunting season, are presented in table 14. If consideration is used in expressing accuracy of aging by harvest years, it would appear that yearling and older bull and cow elk up to 5½ years of age comprise approximatly 75 percent of the herd. About 60 percent of these age classes were under 3½ years. A similar age class composition was observed in the 1951 and 1952 Nebo elk harvests by Rognrud (1953). However, Cheatum and Gaab (1952) observed a reversed age class incidence in a Montana elk herd harvest when 68 percent of harvested cows were 5½ years and older. Cache aging data suggest a substantial turnover in the Cache elk population.

Antler-point frequency. Age class and antler-point frequency showed close correlation in the 1952 data; thus, 41.4 percent of bulls aged by dentition were 1½ and 2½ years and 34.2 percent of bulls were four-points and under. However, 1953 age class and antler-point frequencies among bulls 1½ and 2½ years were not in agreement with the 1952 records. In 1953, 63.7 percent of bulls were classified by dentition as being 1½ and 2½ years, while comparable antler-point classification was recorded at 46.3 percent for four-point and younger (table 14). These data suggest that dental age classification in the 1953 bull harvest was biased in favor of the younger age classes. The writer believes that checking

station personnel were sufficiently certain of aging younger age classes through the 2½ year old group, but lacked experience in aging older groups; hence, senior groups were avoided, and yearling and two-year-old bulls were more frequently sought than their normal occurrence in the harvest. This same bias was not represented in female age classifications since lower jaws of all age classes were collected and analyzed in connection with female reproductive tracts obtained.

Productivity

The term "productivity" elicits variable concepts among game workers. Leopold (1933) relates productivity as: ". . . the rate at which mature breeding stock produces other mature stock . . . ." Productivity in common usage has been used synonomously with reproduction, increase, rate of increase, and calf crop. It is referred to herein as representing annual increment to the parent herd.

Female herd reproduction

An index to reproduction was gained through analysis of the female elk reproductive tract. Tracts were obtained through hunter response during the various general and post-season elk hunts held on the study area. Female elk tracts thus collected during the first and second collection periods were tagged and placed in 10 percent formalin immediately at the time received at the checking stations. These uteri collected from early October failed to produce visible membranes or embryos in any appreciable quantity. Various staff members of the Utah State Agricultural College were of the opinion that the recovery incidence of embryological specimens should be more pronounced in elk uteri collected at this date than had been found, as the post-coitus period of some elk would approximate three weeks to one month. It was pointed out by them that under the past collection program there might well have been a rapid degeneration

Table 14. Comparative age classes in Cache elk herd as reflected through October harvest samples for 1951, 1952, and 1953

A. Cows

Season	Age class in percent					Sample size	Total cow kill
	1½	2½	3½	4½	5½ and older		
1951	61.8	17.2	20.6	6.9	3.5	29	approx. 75
1952	27.2	17.0	14.2	17.1	25.5	70	85
1953	20.0	30.0	17.5	7.5	25.0	40	75

B. Bulls

Season	Age class in percent					Sample size	Total cow kill
	1½	2½	3½	4½	5½ and older		
1951	36.9	13.1	13.1	6.5	20.4	46	121
1952	22.3	19.1	12.7	20.6	25.3	63	84
1953	43.3	20.4	13.6	18.2	4.5	44	109

of the delicate embryonic membranes, since a day or more often lapsed between time of kill and fixation of the uteri in formalin.

Techniques were thus modified during 1953, allowing uteri to be analyzed fresh for pregnancy. Analysis then consisted of suspending each disected uterus in a saline bath. If present, embryonic membranes floated freely from the uterus. This technique was utilized by the writer on 1953 Cache and Nebo collections. Though ease of recovery of visible membranes and embryos was greatly enhanced by the latter procedure, no increase in the total recovery incidence was evident. It was concluded from this work that pregnancy status cannot be ascertained in early October collections through normal occular means because of lack of embryological development. Ovulation and pigmented scar incidence were the ultimate findings derived from tracts collected in the early October period.

Tracts so analyzed were placed in a 10 percent formalin and ovaries were later studied for ovulation incidence as determined by the presence of current corpora lutea. Ovaries were sliced longitudinally in 1 to 2 mm. sections, as per procedure of Cheatum (1949) and Cheatum and Gaab (1952). Microscopic examination of ovarian sections was then conducted for current corpora lutea. Corpora luteal scar incidence (pigmented scar) was also listed as a possible index to the former pregnancy period. Though luteal scars in white-tailed deer were demonstrated to be a valid index to the former pregnancy (Cheatum, 1949), similar significance for elk remains to be verified (Cheatum and Gaab, 1952).

Results of ovary analyses

Corpora lutea and pigmented scar incidence is posted for the Cache herd in table 15. The yearling and older female sample from the entire herd in the early October 1952 collections showed a 78.4 percent ovulation frequency, while 96.6 percent of the mature females in the same

sample had ovulated. Comparable ovulation was observed as 93.5 and 100 percents, respectively, in the early October 1953 collection. In the Nebo female herd, 75.7 percent of yearling and older elk had ovulated in October of 1951; while 90.5 percent of the mature females had done so (Hagmud, 1953). The writer found in the Nebo collections for October 1953 that 77.6 percent of yearling and older female ovaries and 92.4 percent of ovaries from the mature female contained current corpora. Ovaries from the Beaston elk herd in northcentral Utah were collected in late October of 1953. These showed an ovulation incidence of 97.3 percent for yearling and older elk, while the mature female fraction experienced 100 percent.

Cache post-season collections made in 1952 and 1953 hunting seasons contained only 9 and 28 cows, respectively; though 4 and 11 complete counts, respectively, were collected. This small population sample is too small to relate ovulation incidence and pregnancy findings to the entire herd.

Very early in the analysis work of elk ovaries the writer observed that the incidence of multiple corpora lutea was high in comparison to that of a single corpus. It was reasoned by some that the occurrence of the smaller corpus in relation to the larger one or ones within a given set of ovaries probably typified a recurrent oestrus cycle in which the animal initially exhibited internal response to the oestrus cycle but failed to be bred. If this were so, then one or more of the corpora would show tissue degeneration.

Ovaries collected in October of 1953 containing single and multiple corpora lutea were thus analyzed histologically in order to ascertain the significance of multiple corpora in relation to the oestrus cycle of elk. Selected sets of ovaries, including those from yearling cows, were

Table 15. Corpora lutea and pigmented scar incidence in Cache elk ovaries collected in early October of 1952 and 1953.

Age Class	No. Analyzed		No. Ovulated		Total No. of Current Corpora		Average No. Corpora		Total Pig. Scars		Average Pig. Scars	
	1952	1953	1952	1953	1952	1953	1952	1953	1952	1953	1952	1953
1½	7	5	0	3	0	3	0	1.0	0	0	0	0
2½	3	3	3	3	6	5	2	1.66	2	0	0.66	0
3½	4	6	4	6	4	10	1.0	1.66	7	4	1.75	0.66
4½	7	1	6	1	6	2	1.0	2.0	8	1	1.33	1.0
5½ Plus	10	7	10	7	18	11	1.80	1.85	15	10	1.50	1.43
Unverified Maternal	6	7	6	7	11	14	1.83	2.0	8	9	1.33	1.28
Unverified Virginal		2		2		3		1.50		0	0	0
Total	37	31	29	29	45	48	1.50	1.65	40	24	1.33	1.00

prepared by standard histological techniques and sectioned, mounted, and examined microscopically.

Current corpora lutea were studied in single and multiple occurrences in order to determine functional status. All corpora, whether single, multiple, or present in yearling cows, appeared functional.

Pigmented scar incidence observed in the $2\frac{1}{2}$ year old age class in the October 1952 collection was 66 percent. Rognrud (1953) reported that $2\frac{1}{2}$ year old Nebo cow age class possessed 22.2 and 10.7 percent incidence in October 1951 and 1953 collections, while he found 33.3 and 25 percent pigmented scar frequency in the same age class in 1951 and 1953 post-season hunts. A 14.2 percent incidence in the $2\frac{1}{2}$ year age group was recorded by Cheatum and Gaab (1952) in the January 1951 North Yellowstone collection. Pigmented scars in $2\frac{1}{2}$ year old elk tentatively suggest breeding as yearlings.

Current corpora lutea incidence of 33.3 and 60.0 percent were found in Cache yearling elk in October 1951 and 1953. The writer found 47.3 percent or 9 out of 19 yearling cows had ovulated in the October 1953 Nebo collections. No Cache yearling elk ovaries collected in the 1952 October or post-season hunts possessed current corpora. Rognrud (1953) also reported that no corpora were observed in yearling elk in the 1952 October collection on the Nebo.

Pregnancy findings

Pregnancy data obtained through analysis of reproductive tracts collected in the general early October season will purposely be deleted for reasons previously enumerated. All 6 of the 6 mature elk uteri collected in January 1953 contained embryos, or fetuses. Likewise, 100 percent of the 11 adult tracts obtained in late January 1954 were gravid. In addition, 3 out of 4 long yearlings collected in the latter situation

possessed fetuses. Admittedly, these data cannot be applied to the total Cache herd with any degree of confidence because of the small population sample (harvest).

However, sufficient uteri from Nebo post-season hunts in December 1951 and January 1953 were collected and analyzed (Rognrud, 1953); thus, 90.5 percent of the 1951 cows of $2\frac{1}{2}$ years and older and 77.1 percent of the 1953 mature elk bore fetuses.

Pregnancy in other elk herds have been described by various writers. The following rates are expressed as percent of mature elk pregnant within the adult female herd, thus pregnancy frequency in the Northern Yellowstone herd has been reported as: 98 percent in 1929, 74.4 in 1935, 91.1 in 1937, 79 in 1950, and 94 percent in 1951 (Rush, 1932; Mills, 1936; West, 1941; and Kittams, 1953). Kittams (1953) summarized that the Northern Yellowstone herd experienced 85 percent average annual pregnancy.

Herd pregnancy ratios are also reported for Banff Park elk; thus Cowan (1947) relates pregnancies of 63 percent in 1942, 76 in 1944, 93 in 1945, and 75 percent in 1946. Green (1950) summarized that Banff Park elk averaged 78 percent annual pregnancy from 1945-48.

In Jackson Hole 334 female elk $2\frac{1}{2}$ years and older were examined in 1936 in a herd reduction program, and 89.2 percent of these were with calf (Murie, 1951). In a similar reduction program in 1943, 90.4 percent of $2\frac{1}{2}$ years and older cows were pregnant (Murie, 1951).

Though pregnancy incidence appears high in the winter female herd, summer cow-to-calf ratios do not affirm such comparable fertility. Rognrud's (1953) Nebo data showed 87.0 percent of the uteri from the total female herd (yearling and older) contained fetuses during December 1951. However, only 54.3 percent of comparable age classes in the 1952 summer period were represented by calves. Murie (1951) was cognizant of

the described incongruency as indicated by the following remarks:

> Inspection of the figures given above (calf crop data) shows that, roughly speaking, about one-third of the ideal calf crop (one calf to each cow of bearing age) reaches the age of about 10 months. What has become of the other two-thirds?

On the South Cache, 67.9 percent of cows 2 years and older were represented by calves in late summer of 1949; similarly, cows of the same corresponding age groups were represented by calves by an incidence of 71.5 percent in the late 1950 summer herd (from McCormack's data, 1951). Calves, likewise, represented 61.3 percent of the above age groups in the late 1952 summer Cache herd. No corresponding pregnancy data are available for winters preceding the latter recorded summer calf incidence.

Cursory examination of Cache elk summer cow-to-calf ratios and limited pregnancy information suggest that the Cache elk herd is normal in respect to fertility.

Yearling pregnancy. Elk cows generally breed at approximately 2 years and 4 months of age (Murie, 1951) and calve at 3. Available literature to date relate the occurrence of pregnancy in but 4 yearling elk cows whose ages were verified by dentition. Mills (1936) first reported a yearling cow bearing a fetus. The incidence was 1 out of 5 yearlings examined from the North Yellowstone herd. One yearling in 14 bore a fetus in a January 1951 collection from this same herd (Cheatum and Gaab, 1952). Rognrud (1953) discovered a pregnant yearling cow in the 1951-52 Nebo winter loss. Among 7 yearling cow elk killed in early January 1952 in the Rocky Mountain National Park, one bore a fetus (Coffin and Remington, 1953).

These limited entries suggest a small fraction of yearling elk breeding; however, during the course of the present Cache study and subsequent field work on the Nebo elk herd, the writer has found 6 pregnant

long yearlings during the 1953 and 1954 post-season collections. Lower jaws were kept on 5 of these for reference. Three of the elk were dressed out by the writer and a local warden. The recorded incidence of yearling fertility was 75 percent out of 4 yearlings on the Cache and 100 percent of 3 on the Nebo. This frequency, as suggested by these small samples, is not believed to mirror any such appreciable pregnancy within the yearling classes of the respective herds. However, these and other records denote a fact that some yearling cow elk become pregnant under northern and central Utah conditions.

As yet frequency of breeding in the yearling age class is not known, though ovulation frequency among yearlings for the years 1951, 1952, and 1953, together with pigmented scar incidence in the $2\frac{1}{2}$ year age class, tend to substantiate that (1) an appreciable number of yearling cow elk are capable of and may be bred successfully, and (2) ovulation and pregnancy among yearling elk occur at a variable annual rate. No yearling elk ovaries examined by the writer in the 1952 season contained current corpora lutea. Rognrud (1953) similarly observed that in 1952 analyses only one Nebo yearling elk out of 30 examined was pregnant, or contained current corpora lutea. The 1952 hunting season followed an unprecedented severe winter.

Pigmented scar incidence in ovaries collected in 1953 from the $2\frac{1}{2}$ year age class, though meager, appear to coincide with the observed pattern of yearling breeding failure in the 1952 season.

These data suggest an additional hypothesis in relation to yearling cow elk breeding; namely, the extent of yearling precociousness, as evidenced by successful breeding, is inversely proportional to the severity and duration of the preceding winter while the animals are then calves. Thus, most yearling cows fail to ovulate following winters of extreme

intensity and duration; while conversely, significant numbers do ovulate when the preceding winter is moderate to light in intensity and short in duration.

In the case of young domestic animals, the plane of nutrition has already been demonstrated to affect pregnancy; thus, in an experiment involving ewe lamb feeding during their first winter, the results showed that the percentage of ewes lambing at two years of age was 64.7 per cent in the group that was fed hay and grain and only 45.5 percent in the group foraging on the range (Esplin, et al., 1940). The authors concluded, "The difference in lambing percentages are too great to be merely owing to chance." In addition, Maynard (1951) stated in respect to farm animals: "Under-nutrition delays puberty in both male and female." It can similarly be reasoned that the described variable yearling elk breeding condition is closely allied with food intake in relation to maintenance and growth requirements of the growing calf throughout the initial year of life. If, for instance, the availability of food and the expenditure of energy are such as usually exist during a severe winter, the young animal utilizes first the nutrients needed for maintenance and secondly the remnant amount for growth. Calf growth requirements in terms of nutrient intake are probably never met adequately in rigorous winters since food availability is curbed and energy expenditure per unit of body surface is high. Adult females do not have this same problem to cope with as the food intake need not be expended to any appreciable extent on growth.

An effort should be made to collect reproductive data during those post-season hunts where sufficient permits are available to assure a statistically sound population sample. Yearling pregnancy could then be evaluated in a clearer perspective to the total female herd.

Twinning. No instance of twinning was recorded for the Cache herd during examination of gravid uteri. Instances of twinning have been reported by a few individuals. However, Kittams (1953) summarized that twinning incidence among elk is below one-half of one percent.

Productivity by indices

Herd increase. Herd productivity can be evaluated quantitatively if such information as summer and winter herd composition and cow-to calf ratios are known. Thus herd increment based on South Cache elk classification in the summer of 1949 showed a 34.8 percent herd increase over the parent spring herd (McCormack, 1951). Similarly, this same study found the 1950 herd increment to be 33.5 percent. Likewise, the 1952 Cache herd increase was 33.0 percent, based on summer herd composition. However, for 1953 calculations were made of the expectant calf crop on the basis of each cow yearling and older averaging 0.51 calf (table 12). This approach indicated the 1953 herd had a 35.3 percent increase. Similarly, the Nebo elk herd was reported to have had a 33.3 percent increase in 1947 (Rasmussen and Doman, 1947) and 33.9 percent average in 1951 and 1952 (Rognrud, 1953).

Cache cow-to-calf ratio in the 1952 summer classified count was 1 : 0.51, or 51 percent, fecund cows (table 12). Likewise, summer classifications in 1949 and 1950 showed 1 : 0.55 cow-to-calf ratio, or 55 percent, for both periods (McCormack, 1951). These ratios when compared to other western herds (appendix table 9) show a slightly higher calf incidence within Utah elk herds.

Productivity has more universely been evaluated in terms of calf crop, which in its strict sense is composition. In Utah the calf crops, as represented by classified summer counts, approximate 25 percent of the classified summer elk herd (appendix table 10); but calf crops as related

in the "before hunting season herds" of Wyoming and Montana were reported considerably less.

Many differences in reported winter and summer calf crop data are noted in available literature, though close intra-regional similarities are observed (appendix tables 9 and 10). Some of these differences may well be the results of differential mortality from adverse weather conditions. Similarly, some areas may experience higher calf mortality through predation. Further disparities may be attributed to the affect of optimum and poor range conditions on fertility, calf crops, and calf survival.

Differences among reported calf crop data can also be attributed to the varied state harvest programs, for there exists a distinct heterogenity among state hunting programs which may or may not induce sex or age class selectivity within the herd. Last, but not least, is the salient point brought up by Murie (1951) who explained: "This is one of the most difficult facts to determine (rate of increase or, as discussed, percent calf composition), and probably in no other phase of game problems is there greater discrepancy in estimates."

Herd increase discussion. Cow and calf ratios appear by far the more constant and accurate means of expressing the relative increase to an elk herd, though unfortunately calf composition in ralation to the total classified herd has now grown through common usage to be the "yard stick" of herd increase measurement. The calf incidence of a certainty bears a definite, constant relationship to the cow fraction; however, calf crops (represented by composition) do not possess the same perspective within the total herd, for, as the bull complement increases, calf composition decreases. It is evident that the tertiary sex ratios do assuredly differ from herd to herd and from state to state.

Convention, however, dictates that herd increase be expressed in terms

of "calf crop" (composition) in the classified summer and winter herd samples. This usage has produced a clouded concept of the true relationship of calf crop (represented by composition), herd increase, and rate of increase. The terms "herd increase", "calf crop", "rate of increase", and "reproduction" are used synonomously in both usage and actual thinking by some big game technicians and wildlife workers. For instance, in the 1952 Cache classified summer herd sample, 38 calves, 75 cows, and 41 bulls were recorded. The "calf crop" as used in its liberal sense of composition was 24.8 percent; however, the actual herd increase was 33.0 percent of the parent herd, and the rate of increase was 1.33. These numerical values make it evident that each should have a particular name, and this study uses a definite term for each numerical sense. Individual workers, however, should develop a true perspective of the relationship of these expressions and terms.

Rate of increase. Rate of increase is a mathematical expression indicating quantitatively how much a herd, or group of animals, increases annually. This expression has the same relationship in showing how an elk or deer herd increases as the rate of interest has in indicating the relationship of the amount of money payed or earned, based on the principal amount borrowed or loaned. For instance, an individual loaned money to another person at 7 percent interest per year. The rate of interest earned by the money loaned would be 1.07 per annum.

Percent of herd increase can be arrived at by moving the decimal point two places to the right in the percent-interest part in the rate-of-increase figure and by dropping the "1". Thus, when the rate of increase is 1.33 for an elk herd, the percent of herd increase would correspondingly be 33 percent.

Maximum rate of increase for an elk herd whose cows have a two-year

delay in initial breeding has been computed at 1.30 (Kelker, 1954). It appears that rates of increase above 1.30 probably reflect yearling cow elk breeding or decreased composition of the bull complement within the herd, or both.

Computed rates of increase for the Cache elk herd were 1.34, 1.33, 1.33, and 1.35 for the years 1949, 1950, 1952, and 1953, respectively. Nebo elk herd rates of increase were 1.33 and 1.34 (Rasmussen and Doman, 1947, and Rognrud, 1953). These figures are based on the summer herd compositions.

The maximum rate of increase for deer having one fawn per doe is 1.36 (Kelker, 1947). Our Cache elk herd, then, seems to have nearly attained this value. Since some cows are sterile or new calves die, the herd has not reached 1.36 but has exhibited the attributes of the mentioned deer herd. The major ways that it can do so are by excessive twinning or by yearling cows becoming pregnant. This latter case, then, is more probably what has happend on the Cache.

Herd Losses

Legal harvest

Legal harvest removals from the Cache elk herd were readily available from checking station records. These records are accurate since Utah elk hunters are required by law to check in and out of designated checking stations regardless of hunting success.

Elk hunting on the Cache unit is restricted to the permit system, as is all Utah elk hunting. Though either sex permits have been available in conjunction with bull and antlerless permits on various annual hunts, only five annual, general season, either sex, Cache hunts have been held since the inception of elk hunting in 1925. More often permits for a specified sex have been authorized.

Permits authorized during the three seasons 1951, 1952, and 1953 have averaged slightly less than 300 per annum. Legal kills of 259, 199, and 243 were taken in the 1951, 1952, and 1953 seasons, respectively, for over-all hunter successes of 86, 80, and 76 percents (table 16). The reduced 1952 seasonal kill is due to the retention of 50 post-season permits to the 1953 season because of mild 1952-53 winter conditions during which elk failed to migrate to their normal wintering sites. These permits involved 10 bulls, 20 antlerless, and 20 either sex. Decreased hunter success in the 1953 season is interpreted to be the result of the belated autumn season during which leaf foliage was highly persistent.

A summary of available Cache harvest data since the inception of renewed hunting in 1925 is presented in table 17. Data prior to 1951 are taken from the files of the Utah State Department of Fish and Game.

Daily elk kill. Distribution of daily kill for the past three years has followed the typical pattern of heavy kills during the first two days. Thus, daily kills of 77.9, 78.6, and 65.4 percents were recorded for the first two days of 1951, 1952, and 1953 seasons, respectively (figure 15).

Distribution of kill. Distribution of elk kill during the regular 1951, 1952, and 1953 October seasons is shown in table 18; distribution units are likewise indicated in figure 16. These units were arbitrarily organized to assign areal kill and do not correspond to any population relationship within the unit. The Elk Valley unit (5) consistently produced slightly in excess of half of the total Cache general elk kill for the years 1951 and 1952, but failed to do so in 1953. This decline was believed to be a reflection of hunting pressures directed to the North Cache and Rich County units when special divisions of the Cache general

Table 16. Summary of 1951, 1952, and 1953 Cache legal elk harvests

Year	Type of Hunt	Permits Author.	Hunters Afield	Hunter Success	Kill cows m.	cows f.	calves uncl.	calves total	antler-less	bulls spike & 2 pt.	bulls above 2 pt.	bulls uncl.	bulls total	Total
1951	Rich Co., E.S., Pre-season	20	20	100.0	8	2		2	10		10		10	20
	Cache general, antlerless	111	111	94.0					104					104
	Cache gen., bull	150	150	80.6									121	121
	N. Cache, antlerless	10	10	80.0	7	1		1	8					8
	N. Cache, bull	10	10	60.0						4	2		6	6
	Total	301	301	86.0	15				122				137	259
1952	Cache general, antlerless	111	110	88.3	85	5	7	12	97					97
	Cache gen., bull	120	120	70.0						14	70		84	84
	N. Cache, E.S., Post-season	20	19	95.0	9	1	2	3	12	3	3		6	18
	Total	251	249	80.0	94	6	9	15	109	17	73		90	199
1953	S. Cache, antlerless	91	91	79.2	59	6	7	13	72					72
	S. Cache, bull	125	124	72.5						25	65		90	90
	Rich Co., E.S.	35	35	74.3	11		1	2	13	4	8	1	13	26
	N. Cache, E.S.	25	25	44.0	5				5	2	4		6	11
	Cache face, E.S., Post-season (Hold-over permits from 1952)	47	44	100.0	28	4	3	7	35	4	5		9	44
	Total	323	319	76.2	103	10	11	22	125	35	82	1	118	243

hunt were set up in indicated units 1, 3, and 12, respectively. It was in the latter three units that hunters failed to hunt in sufficient numbers when they were allowed to select hunting areas of their choice.

Though desirable harvest removals are important in efficient management equally so is the distribution of that harvest. It, therefore, was expedient that harvest plans provide an adequate distribution of kill on the North Cache and Rich County areas. This practice of setting up 3 units on the general hunt has been successful to date. It should not, however, be inferred that elk in these units are distinct population entities for such is not the case.

Crippling loss

Crippling loss for the Cache elk herd was recorded from hunter reports obtained at checking stations and in the field, warden-field observations, and limited organized coverages of elk ranges. Known crippling losses thus constituted 9.8, 5.0, and 8.1 percent of the 1951, 1952, and 1953 general season kill, respectively.

A dire need is exhibited for accurate elk crippling loss information on the Cache and many other western elk herds, though Colorado's experiences have contributed much to our limited knowledge of elk crippling losses (Hunter, 1945 and Riordan, 1949). Even so, the popular method of projecting herd crippling loss from hunter-interview results is subject to considerable error.

McCormack (1951) estimated that South Cache elk crippling losses were 15 and 18 percents during the 1949 and 1950 general hunts. An interview of 50 percent of Cache elk hunters constituted the basis of McCormack's estimate. Olsen (1939) reported a 15 percent crippling loss on Nebo elk. Hunter (1945) revealed a 15 percent crippling loss in Colorado elk herds, while Riordan's (1949) wounding loss survey in Colorado was listed at

Table 17. Summary of harvest data for the Cache elk herd, 1925-1953

	Permits Sold				Legal Kill				
Year	Bull	Antler-less	Either sex	Total	Bull	Antler-less	Unclassified	Total	Hunter Success
1925			140	140	52	52		104	74
1928	46			46	18			18	40
1929	79			79	69			69	87
1931	75			75	54			54	73
1932	62			62	50			50	80
1933	60			60	52			52	87
1934	75			75	57			57	76
1935			100	100	60	24		84	84
1936			85	85	34	35		69	81
1937	50			50	36			36	72
1938	40	35	50	125	44	30	39	113	85
1939			150	150	30	48		78	50
1940	70	70		140	62	71		133	95
1941	75	75		150	69	73		142	87
1942	51	49		100	41	46		87	87
1943	64	61		125	35	40		75	60
1944	47	33		80	35	29		64	80
1945	75	50		125	67	49		116	93
1946	20	20	100	140	50	62		112	80
1947	30	20	100	150	62	76		138	92
1948			180	180	53	87		140	80
1949	75	45	80	200	110	70		180	92
1950	125	60	20	205	110	64		174	85
1951	160	121	20	301	137	122		259	86
1952	120	111	20	251	90	109		199	80
1953	125	91	107	323	118	125		243	76
Total	1,524	841	1,152	3,517	1,595	1,212	39	2,846	Av. 81

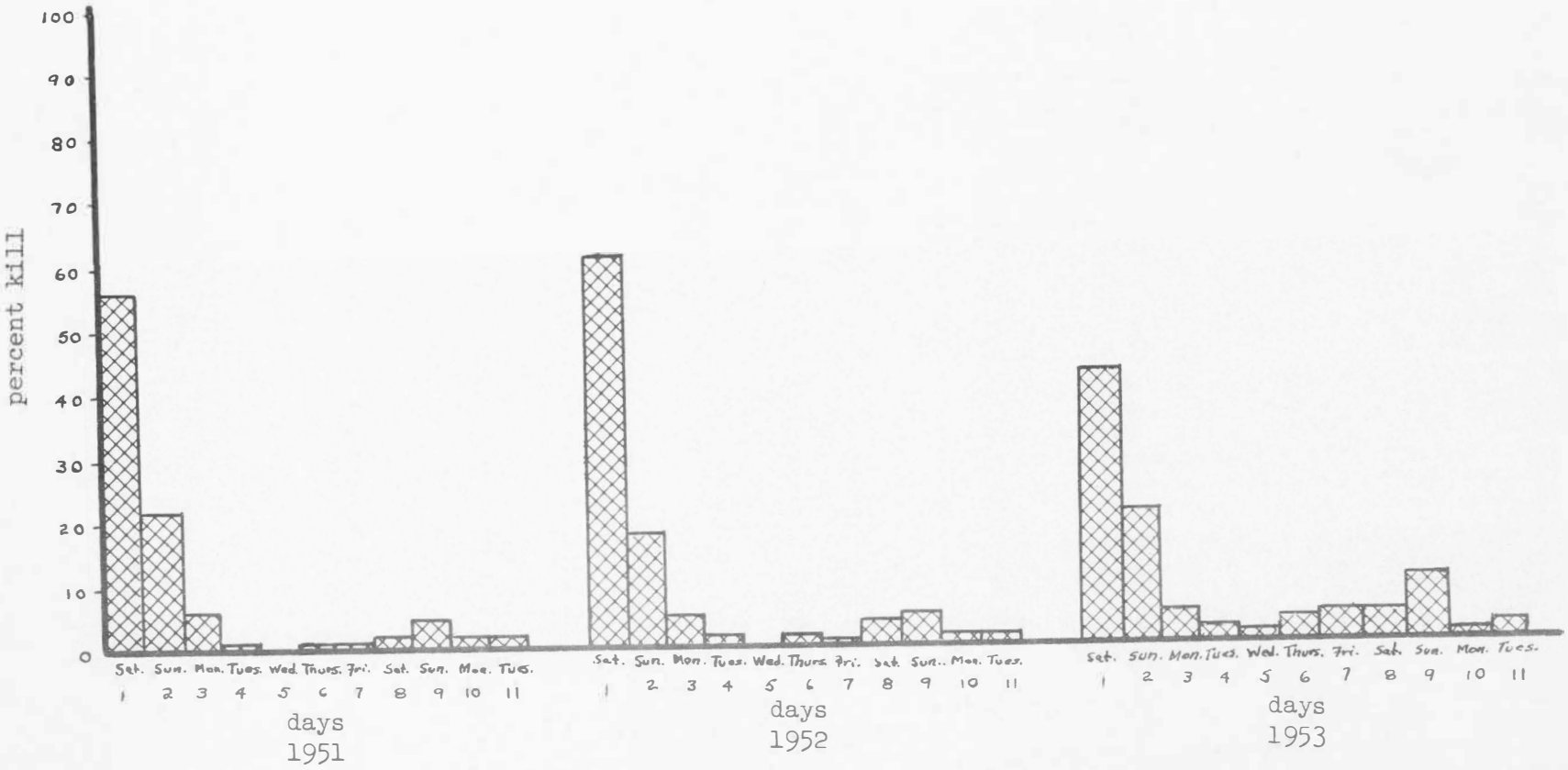


Figure 15. Elk kill, by days, during 1951, 1952, and 1953 Cache general seasons

approximately 10 percent of the legal kill. Present Cache crippling losses probably approximate 15 percent.

Illegal kill

In contrast to McCormack's South Cache findings (1951) and Rognrud's Nebo elk report (1953), illegal kill of elk on the Cache was found to be significant during the present study. The principal component of illegal kill thus found was elk killed during the deer season.

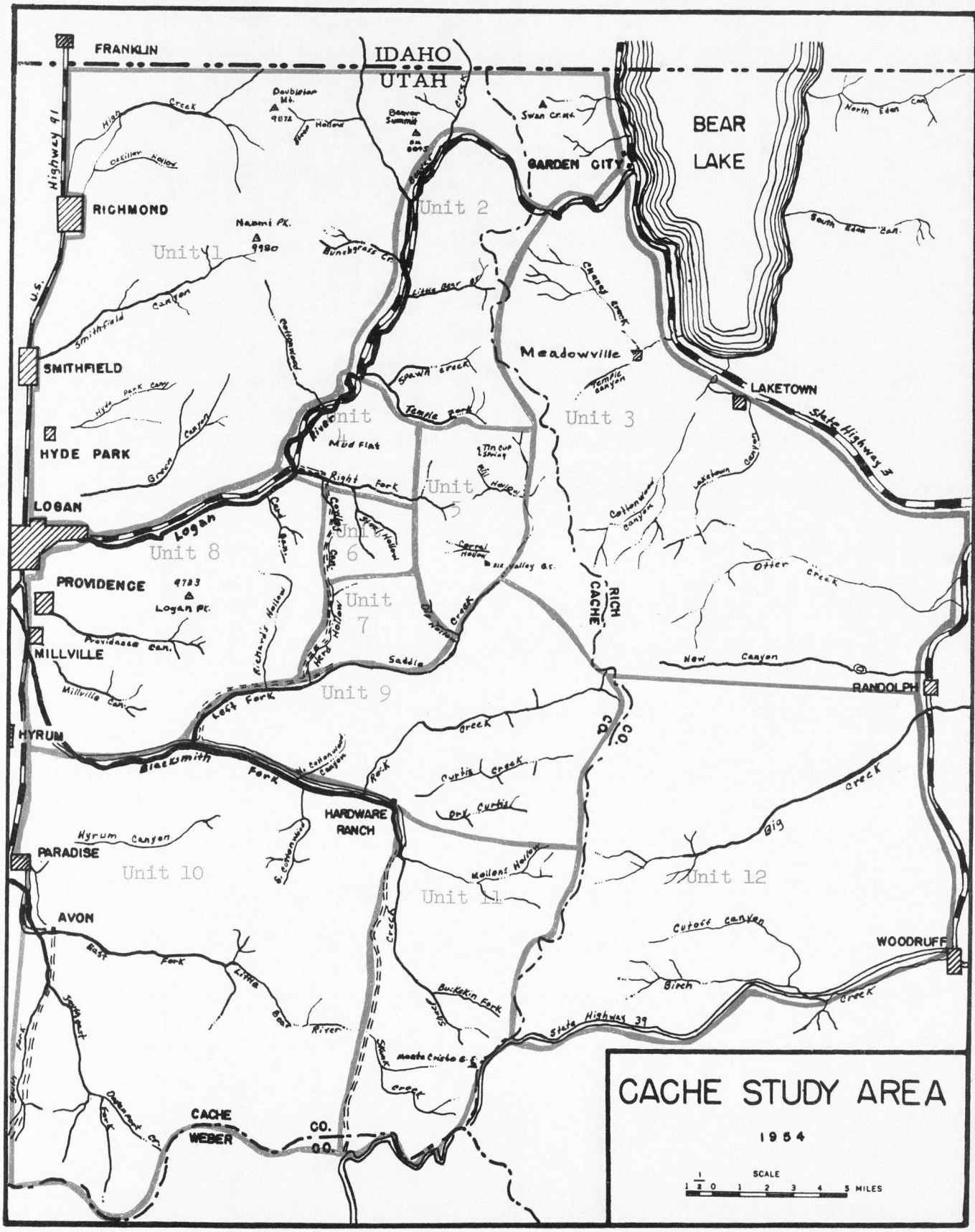
Wherein possible, field verification of illegally killed elk was made. Forty-three (43) illegally killed elk were recorded during the 1952 deer season. Distribution and composition of this kill is presented in figure 17. Composition of this kill was 24 cows, 4 calves, 11 bulls, and 4 unclassified. Seven of this number were salvaged; but inadequate description of kill location and tardiness of reports, combined with warm weather conditions, precluded a successful salvage of most animals.

Complete records of elk illegally killed during prior Cache deer hunts are noticeably absent; however, a 1939 report in the Utah Cooperative Wildlife Research Unit files in Logan tends to substantiate findings of the present study. During the 1939 buck-deer hunt, 34 elk kills were reported to game wardens and deer checking station attendants (Utah Coop. Wildl. Res. Unit file, 1939). Composition of this illegal kill was listed as 9 bulls, 12 cows and calves, and 13 unclassified elk (figure 18). Sixteen of these elk were killed within the boundaries of the newly opened Saddle Creek Game Preserve. This area was closed to deer hunting during the years of the present study. Twenty-five elk were reportedly killed by deer hunters on the Cache in 1940 (Turpin, 1940).

Advocates of the buck-only type of a deer hunt were enthusiastically eager to pronounce the large kill of illegal elk in the 1952 deer season a common feature of an either-sex deer hunt. Their contentions were that

Table 18. Distribution of elk kill - Cache general seasons, October 1951, 1952, and 1953
(See figure 16 for unit designation.)

Unit	Kill									Percent of Kill		
	Bull			Antlerless			Total					
	1951	1952	1953	1951	1952	1953	1951	1952	1953	1951	1952	1953
1	2	1	6	0	0	5	2	1	11	0.90	0.56	5.71
2	8	2	9	1	4	5	9	6	14	4.08	3.36	7.25
3	8	5	8	9	9	12	17	14	20	7.73	7.87	10.35
4	7	7	3	5	4	6	12	11	9	5.45	6.16	4.66
5	73	40	39	58	60	34	131	100	73	59.60	56.30	37.81
6	2	8	6	4	3	4	6	11	10	2.72	6.16	5.19
7	10	9	12	6	11	5	16	20	17	7.28	11.22	8.82
8	1	1	3	0	0	2	1	1	5	0.45	0.56	2.59
9	10	8	15	11	2	12	21	10	27	9.54	5.63	14.00
10	0	2	0	3	1	2	3	3	2	1.35	1.68	1.03
11	0	0	0	2	1	2	2	1	0	0.90	0.56	0.00
12	0	0	3	0	0	2	0	0	5	0.00	0.00	2.59
	121	83	104	99	95	89	220	178	193	100.00	100.00	100.00



Fibure 16. Elk kill distribution units on Cache study area

under the buck-only type of hunt deer hunters would have no logical reason to kill antlerless elk in confusion of buck deer. The unsoundness of this thinking was reflected in the 1939 illegal kill when more cows and calves were killed than bulls during the buck-deer hunt.

Most difficult evaluation of all herd mortality is that resultant from poaching. It does not appear to confine to any designated season, time of day, nor predictable characteristic pattern. Cache elk poaching losses are not believed to be of serious consequence to total herd drain during present times of economic stability. They may, however, reach serious proportions during periods of recessions as indicated by a singular record in Logan files reporting the occurrence of considerable elk poaching during the early 1930 period.

Known poaching in 1951-52 season on the Cache area was restricted to a single incident involving seven head of elk killed from the main highway near the mouth of Temple Fork Canyon. Poaching discoveries of 1952-53 seasons were confined to two bulls killed in August at the head of Cheeney Creek where poachers used a tractor to convey elk to a truck. Part of the frame of a large elk, believed to be a bull, was found in Logan Canyon in February 1953.

Poaching may have well increased some with the advent of the modern deep freeze and its popular use in rural communities. Interviews with a local Round Valley rancher, whose confidence was secured, bear out the fact that a limited amount of poaching takes place in the Round Valley area of Rich County. Elk are reportedly killed in rancher's hay and grain fields. The informant estimated that 20 head of elk are poached each year on the Rich County slope, with the greatest amount of poaching confined to the Round Valley area. Circumstantial evidence tends to support this premise very well.

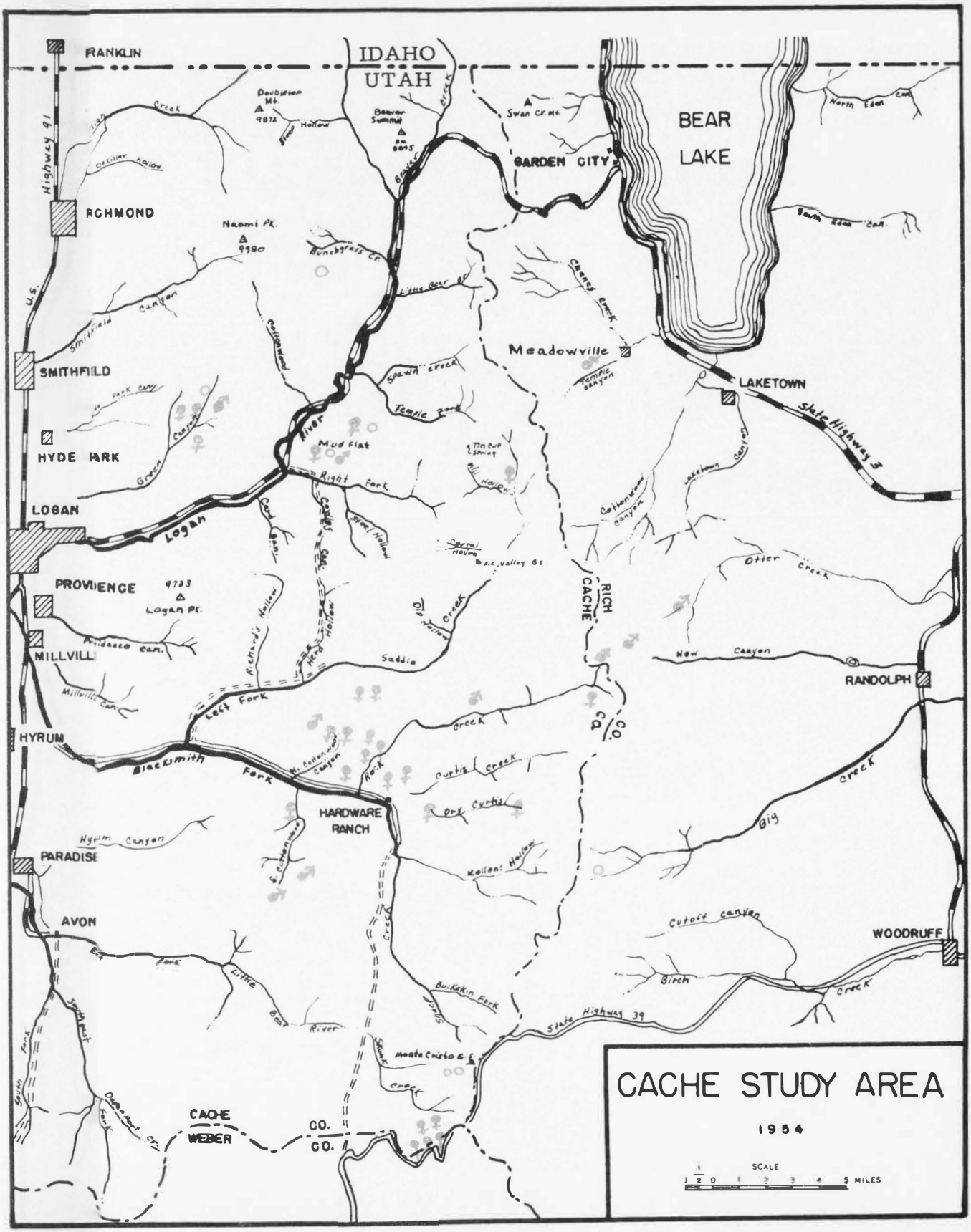


Figure 17. Illegal elk kill during the 1952 deer season (The symbol 0 represents unclassified elk.)

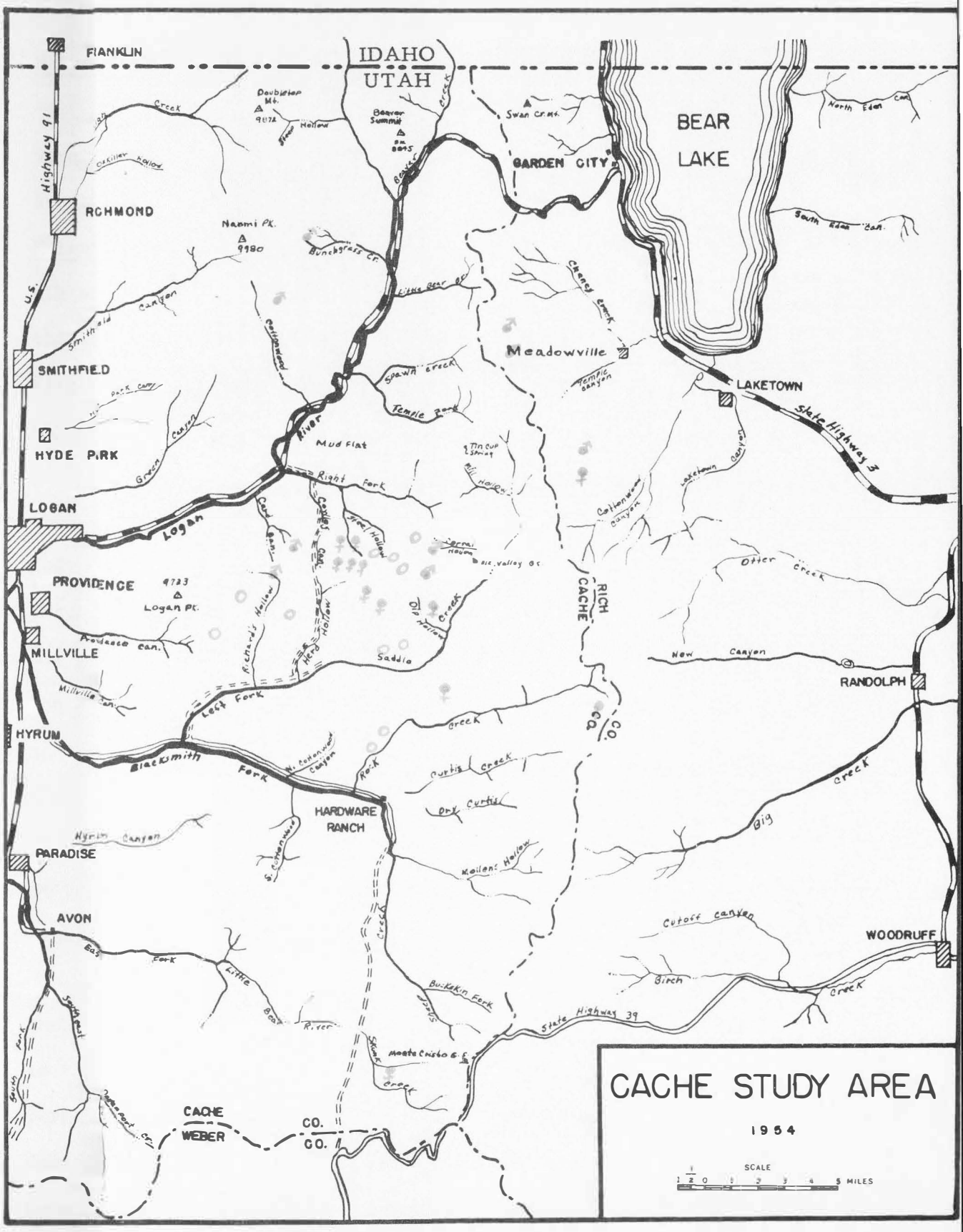


Figure 18. Illegal elk kill during the 1939 deer season (The symbol 0 represents unclassified elk.)

Natural causes

Natural losses occurring from time to time were recorded as they were observed in the field. Malnutrition and other natural losses were sought during a systematic coverage of major elk wintering ranges.

Malnutrition. The severe 1951-52 winter contributed heavily to Cache elk winter loss. Though such a great loss has never been reported for the herd, it was not considered of extreme serious consequence. Fifty-five elk were classified as malnutrition losses as evidenced by bone marrow analysis. Calves contributed 80 percent of all such known losses.

Losses at the Hardware Ranch, where feeding activities continued through late April, were not large in comparison to number of elk being fed. Malnutrition losses amounted to merely 2.6 percent of the winter ranch herd. Overall 1951-52 natural winter herd losses at the ranch were 4.2 percent. Ninety-two percent of the classified malnutrition losses at the Hardware Ranch were from elk trapped on the North Cache and Millville areas and released at this site. This loss alone indicated that future trapping operations of this nature should provide for immediate release of the animals rather than retaining them, thus contributing to an unnecessary expenditure of critically needed energy through milling and fighting the trap.

Known winter mortality accounted for 6.6 percent of the 1951-52 Cache censused winter herd. When the estimated winter loss of 80 head is taken into consideration, the 1951-52 winter mortality would be 9.8 percent of the enumerated winter herd. Minimal winter losses occurred during the mild 1952-53 season; however, no losses were known to stem from malnutrition. Very limited winter losses were also observed during McCormack's (1951) investigation of the South Cache elk.

Disease and parasites. Two parasitic forms were almost universally

present in dead elk in the winter time; however, the winter tick (Dermacentor albapictus) occurred more frequenty than the larvae of the bot fly (Cephenomyia pratti). Both forms, though not lethal, generally conform into the category of contributing or secondary factors in elk deaths.

Blood samples were collected from 4 bulls and 3 cows taken on the 1953 January North Cache hunt. In addition, samples were obtained from 16 cow elk at the Hardware Ranch during 1953 winter ear tagging operations. All 23 blood samples were negative to brucellosis when analyzed by the agglutination test. No agglutination occurred in titers of 1:50, 1:100, and 1:200. Though the results of this limited sample are not conclusive enough to place statistical reliance in the absence of this disease, it is nevertheless believed that the Cache elk herd is free from brucellosis. The high incidence of calves in the herd tends to preclude the existence of such a disease which would, were it present, cause extensive fetal abortions.

An exhaustive survey of diseases and parasites in the Cache elk herd would undoubtedly corroborate the presence of numerous forms; but since diseases and parasites do not appear to be the etiological agents responsible for the limited current natural elk mortality, it appears that management endeavors need not at this time concentrate their efforts in pursuit of such academic discoveries.

Predation. The Cache elk herd is not affected to any extent by predation. This finding is in conformity with a 1949-50 study (McCormack, 1951). Though limited coyote and bobcat kills and one cougar kill were noted on deer within the study area, the writer failed to find a single elk killed. All predator use of elk appeared carrion.

Nuisance elk removal

This type of removal is necessary in most herds whose ranges are co-existent with or peripheral to agricultural lands. Such removals during the present study were limited to the Rich County slope where 11 elk were removed in the Little Creek area near Randolph during December of 1951 and 1 bull was removed from the Round Valley section during August of 1952.

Cripple removal

Removal of crippled animals is another source of herd drain. This procedure is, however, sage since the meat of the crippled elk can generally be used. Experience has shown that winters of moderate intensity generally preclude survival of more badly crippled elk. At the Hardware Ranch such elk also present a public spectacle. Six cows and 2 calves were thus removed on the entire Cache during the 1951-52 winter. It was necessary to remove only 1 cow during the 1952-53 annum.

Miscellaneous losses

Young calf losses were noted in the field. Such losses have been observed by other workers, but, like the writer, they are unable to define the prevalence of this loss in relation to total herd drain.

Summary of herd mortality

A summary of known Cache elk mortality from 1951 to 1953 is presented in appendix tables 4, 5, and 6, and figure 19. Legal harvests quite naturally provide the principal item of herd drain. They accounted for approximately 75 percent of known annual herd mortality during the present study period.

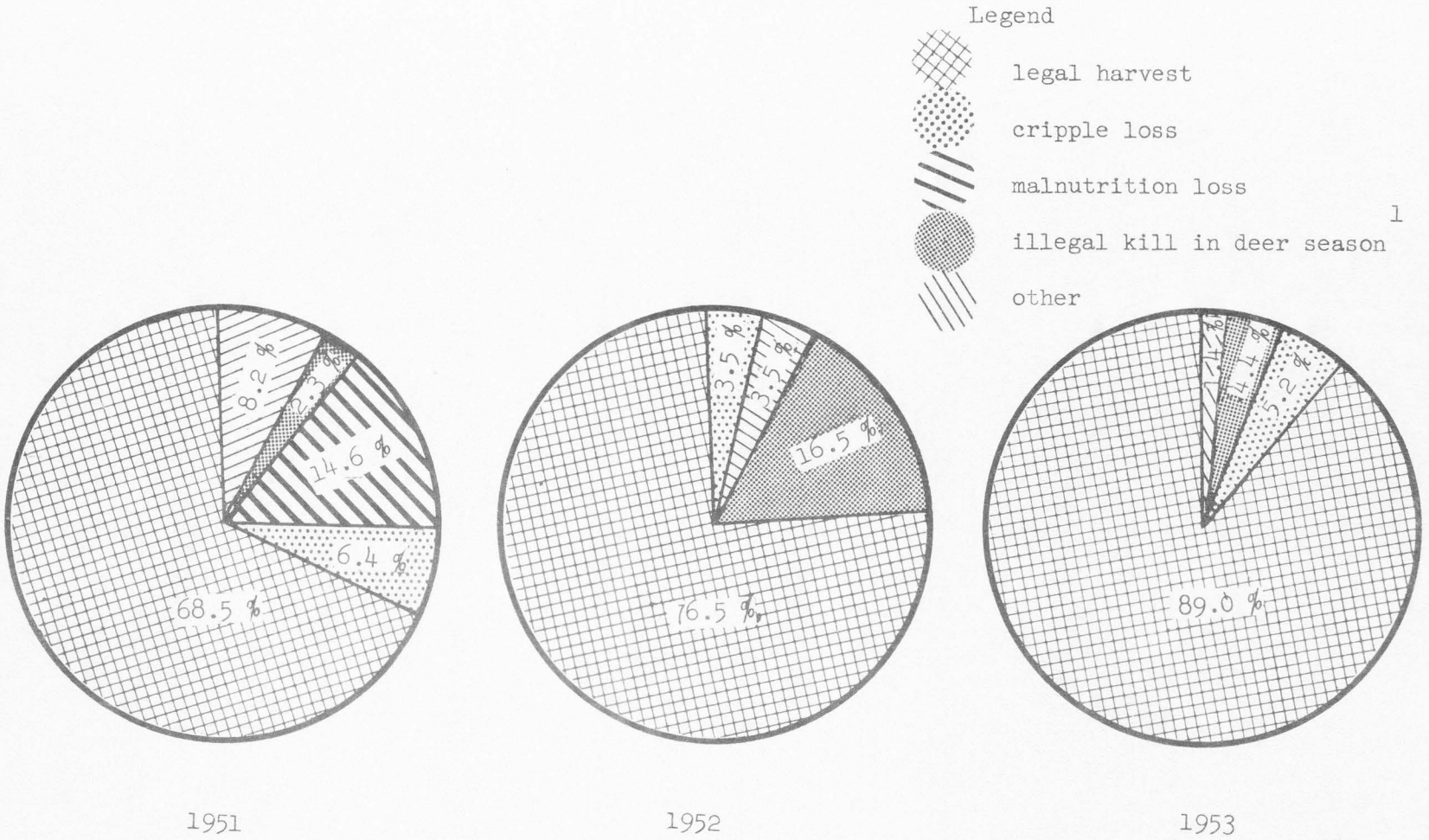


Figure 19. Summary of known elk losses, Cache elk herd, 1951-1953
(1. This loss is not complete for the 1951 and 1953 years.)

CACHE ELK RANGE RELATIONSHIPS

Range Conditions

Winter range

As is the case prevalent throughout the intermountain region, the winter range on the Cache presents the limiting factor in elk and deer production. Present winter range conditions are the cumulative results of early livestock use, sharply increased deer utilization, and persistent local elk use. Principal deer winter ranges are largely confined to the Wasatch face, but extend to an appreciable extent into major drainages; namely, Logan and Blacksmith Fork. In addition, limited winter range is available on the eastern Rich county slope of the Cache unit. Lower elevational limits of elk winter ranges normally coincide with the upper fringe of deer range; upper Cache elk wintering sites are restricted to isolated ranges within the interior of the forest. However, the major elk wintering location for the Cache is at the Hardware Ranch, situated in the headwaters of Blacksmith Fork. See figures 5 and 6 for the elk distribution on winter ranges.

Range conditions are critical throughout the lower portion of the Wasatch face, as they are in many areas in Logan and Blacksmith Fork drainages. Julander, et al., (1950) estimated that 42 percent of the Cache winter range was a big game problem area. Under the present harvest system of either-sex deer hunting and post-season elk hunts held along the critical Wasatch face, this major winter range has received some relief; but the high deer population maintained through the late 1940 period has culminated in an extreme reduction of palatable browse species. Heavy winter deer losses, as reported by Low and Low (1949) during the

1948-49 winter and additional winter losses in 1951-52, surely corroborate reported existence of depleted winter ranges. Elk winter ranges in the Cache interior are largely confined to isolated tracts along ridge tops and southern exposures. Range conditions of such interior sites are generally superior to face areas; however, during extreme winters--like the winter of 1951-52--these ranges become greatly restricted and diminutive localized areas are utilized severely. Such was the situation involving curlleaf mahogany utilization in an interior site during the 1951-52 severe winter (figure 20).

Hardware Ranch big game unit range conditions are discussed in the Hardware Ranch Operation section of the present report.

Summer range

General elk summer range conditions on the Cache National Forest are considered comparatively good. Productive aspen understories and open grass valleys amply supply forage needs of domestic livestock; the range likewise adequately satisfies food demands of elk and deer. It is, however, quite obvious on an area as extensive as the Cache that localized sites may exhibit some deviations from the over-all good range condition. Such instances of localized inferior range conditions within the Cache elk range were largely confined to domestic livestock bedding grounds and watering sites utilized by elk and livestock. Some inferior range conditions were also found on some private lands and few other summer ranges aside from elk ranges. It should be noted that elk distribution generally conformed to the aspen sites which were the most productive forage sites.

Reliable reports of summer range elk damage has, to the writer's knowledge, been restricted to a singular instance. Forest Service officials report that during the late spring elk were noted to do a

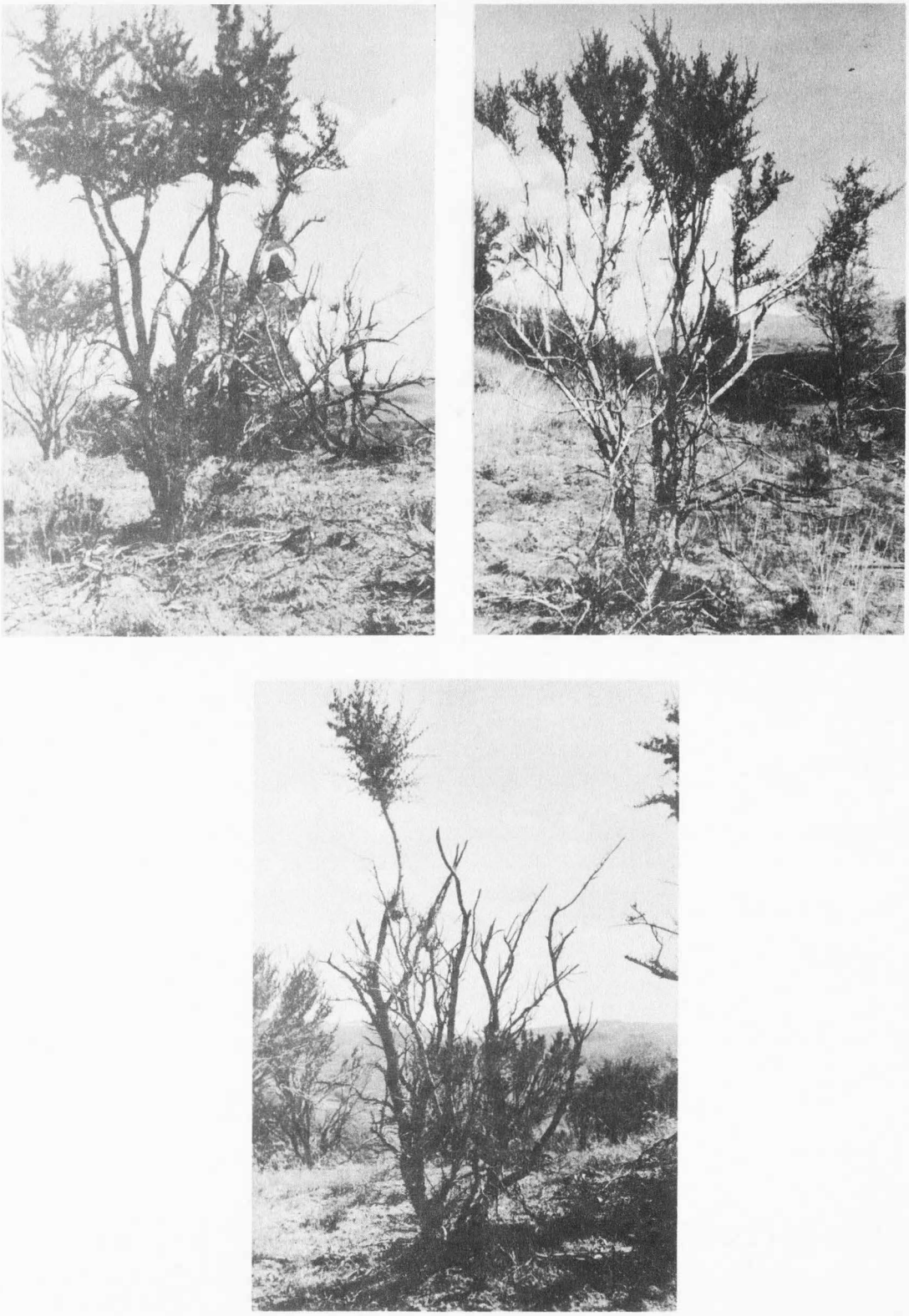


Figure 20. Localized Cache elk utilization of curlleaf mahogany during the 1951-52 severe winter

considerable amount of trampling damage to the range in the head of Corral Hollow, which is situated in the heart of elk summer range. Investigation of this incident by the writer affirmed that a small band of 20 or so elk utilized snow banks therein as a water source. Disturbance of the soil mantel was a characteristic feature incidental to the trek of elk to and from snow-bank sites. Later investigations of the Corral Hollow area showed that elk did not utilize this important drainage of Elk Valley to any appreciable extent after the snow banks had dissipated until they were forced there during the fall elk hunt. No open water source is available in Corral Hollow. It was later observed that elk trampling damages in the vicinity of snow drifts were minimized in those Elk Valley drainages having open water available.

Withstanding these limited local adverse range conditions, the Cache area appears to amply supply livestock and big game forage demands and furthermore still maintain an adequate vegetative cover conducive to good watersheds on ranges commonly used by elk and livestock.

Elk-Livestock Relationships

In most observed instances elk and cattle were compatible on the same range. Elk were observed frequently with cattle at watering sites, salt licks, and in few instances bedding grounds. Elk indeed were tolerant in respect to cattle activity.

Sharply contrasted to the former situation was that of elk being highly intolerant to sheep activity in all instances observed. Sheep activity resulted in a complete shift of elk from the immediate unit. A period approximating two weeks lapsed before elk re-entered an area formerly utilized by sheep.

Elk Valley

Elk Valley consists of two major vegetative types: (1) the open

valley proper, containing sagebrush and grass and sedge meadows, and (2) the hollows featuring continuous aspen (Populus tremuloides) stands. In addition, alpine fir (Abies lasciocarpa) is present in the higher elevation of the aspened hollows. Similarly, Engleman spruce (Picea engelmani), alpine fir, and Douglas fir (Pseudotsuga taxifolia) are present in the higher elevations in Mill Hollow and Bear Wallow. Limited lodge pole pine (Pinus contorta) is also found on the northern exposure of Bear Wallow The aspen type was by far the more productive site for forage production.

Grass species within the aspen understory form the dominant vegetative cover. Forbs are less common in the botanical composition herein than most aspen sites; this feature precludes the area from being an optimum sheep range. Browse species are limited within the understory but occur on exposed sites.

Three major grass species were represented in the aspen type, namely: (1) mountain brome (Bromus carinatus), (2) slender wheat grass (Agropyron trachycaulum), and (3) blue wild-rye (Elymus glaucous). The most prevalent browse species were snowberry (Symphoricarpus vaccinoides) and chokecherry (Prunus virginiana var. melanocarpa). Bitterbrush (Purshia tridentata) and sagebrush (Artemesia tridentata) were present on the more exposed sites. Forbs were represented chiefly by niggerhead (Rudbeckia occidenalis), sawtooth butterweed (Senecio serra), and wild pea (Lathyrus leucantus).

An early entry of elk into Elk Valley were 9 head seen during a May 1, 1952 aerial reconnaissance. A similar coverage on May 14 showed 36 elk to be as far north as Cold Springs. Subsequent ground observations indicated that most resident summer elk had moved into the area by June 1. Initial spring elk utilization was limited to open southern exposures of

valley hollows and the meadow proper; vegetation thereon was considerably advanced than in aspen sites. Major elk activity after June 1 was confined to aspen sites above the valley floor.

Cattle entry began on June 6, 1952. Early cattle use was predominately confined to the open valley. First indication of cattle movement into the aspen hollows appeared on June 28 in the Tragara Hollow section. However, peak cattle movement into the aspen type did not occur until around July 15. The cattle association rider then attempted to maintain cattle numbers within the outlined distribution units as planned by the U. S. Forest Service and shown in figure 21. The open valley unit was reserved exclusively for cattle use throughout the grazing period which ended October 5. Two hundred and seventeen head of cattle were alloted for the open valley unit (figure 21).

As can be appreciated, it is impossible to maintain a static number of cattle on distribution units without fencing. The association rider, however, attempted to carry out distribution plans as outlined in figure 21. Though in most instances observed, more than the allotted cattle (217) were present in the open valley. This was particularly so in the early and late portions of the grazing period. Cattle distribution was noticeably difficult to maintain in the aspen section south of Corral Hollow, as well as the southern meadows of Elk Valley. Principal cattle activity in the aspen type occurred within the Side Hill Canyon-Tin Cup Springs area.

Sheep appeared in the Nielson allotment on July 1, and again July 6 on the Willis Brothers' allotment. Sheep numbers were 1105 and 830, respectively. The sheep utilized the aspen type above the open meadows as shown in figure 22. The grazing season terminated on September 9 and 15, respectively.

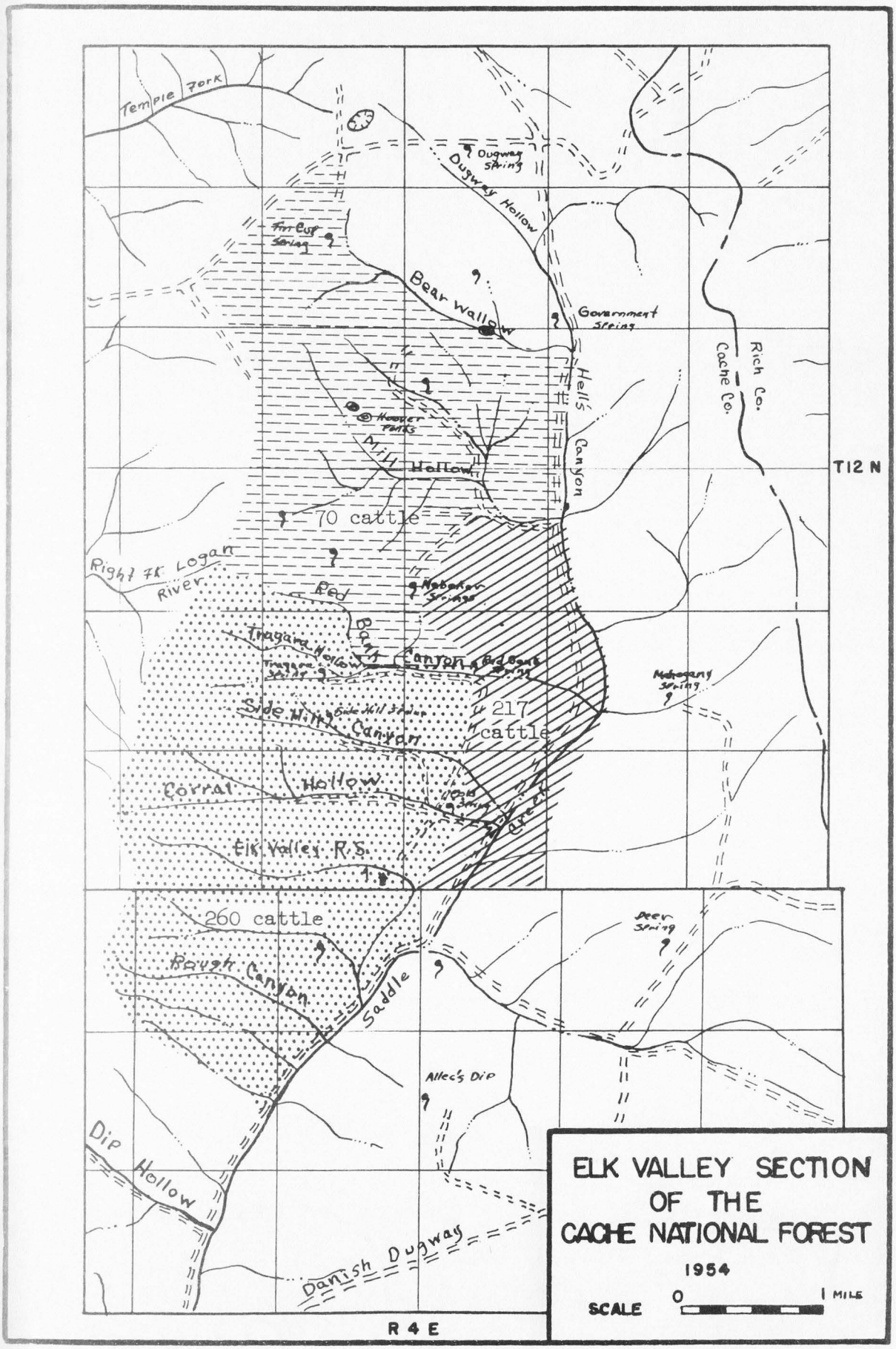


Figure 21. Cattle distribution in Elk Valley, 1952

Competition. Reported information on elk-livestock competition, based on actual field study, is conspicuously meager. More often such criteria as casual observations, local elk food habit information, and reiterated opinions are largely utilized to draw inferences which now reflect the current popular concept of elk-livestock competition. Thus, Haskell (1946) and others create an impression of keen elk-livestock competition by portraying two allegedly opposing trends of progressive reduction of grazing permits on U. S. Forest Service landds concurrent with a sharp increase in elk numbers. Schwan (1945) observed that elk prefer a more varied diet than cattle, and Stoddart and Smith (1943) generalized that " . . . naturally, competition between the two (elk and livestock) is direct."

In so far as the writer is aware, reported elk-livestock competition based on formal field investigation is limited to a singular study. Peculiarly enough, this investigation is confined to an elk-sheep competion situation. Thus Pickford and Reid (1943) and Pickford (1943) cite direct competition between elk and sheep on an eastern Oregon range; however, the range was depleted of choice forage plants before the study began, and vegetative composition consisted of 76 percent weedy species. Sheep were removed from the described summer range because of acute summer range problems. During the summer's absence of sheep, it was found that elk consumed 63 percent of the total forage formerly removed by sheep during the previous summer grazing season.

Much of the reported elk-livestock competition is based solely on recorded forage habits of the animal classes involved. Such factors as area utilized, topography, type of forage available, period of use, and conversion ratios are too often neglected items in the appraisal of competition. Similarly, and to a more prevalent extent, individuals fail to grasp the significance of the present "multiple use concept" or, through

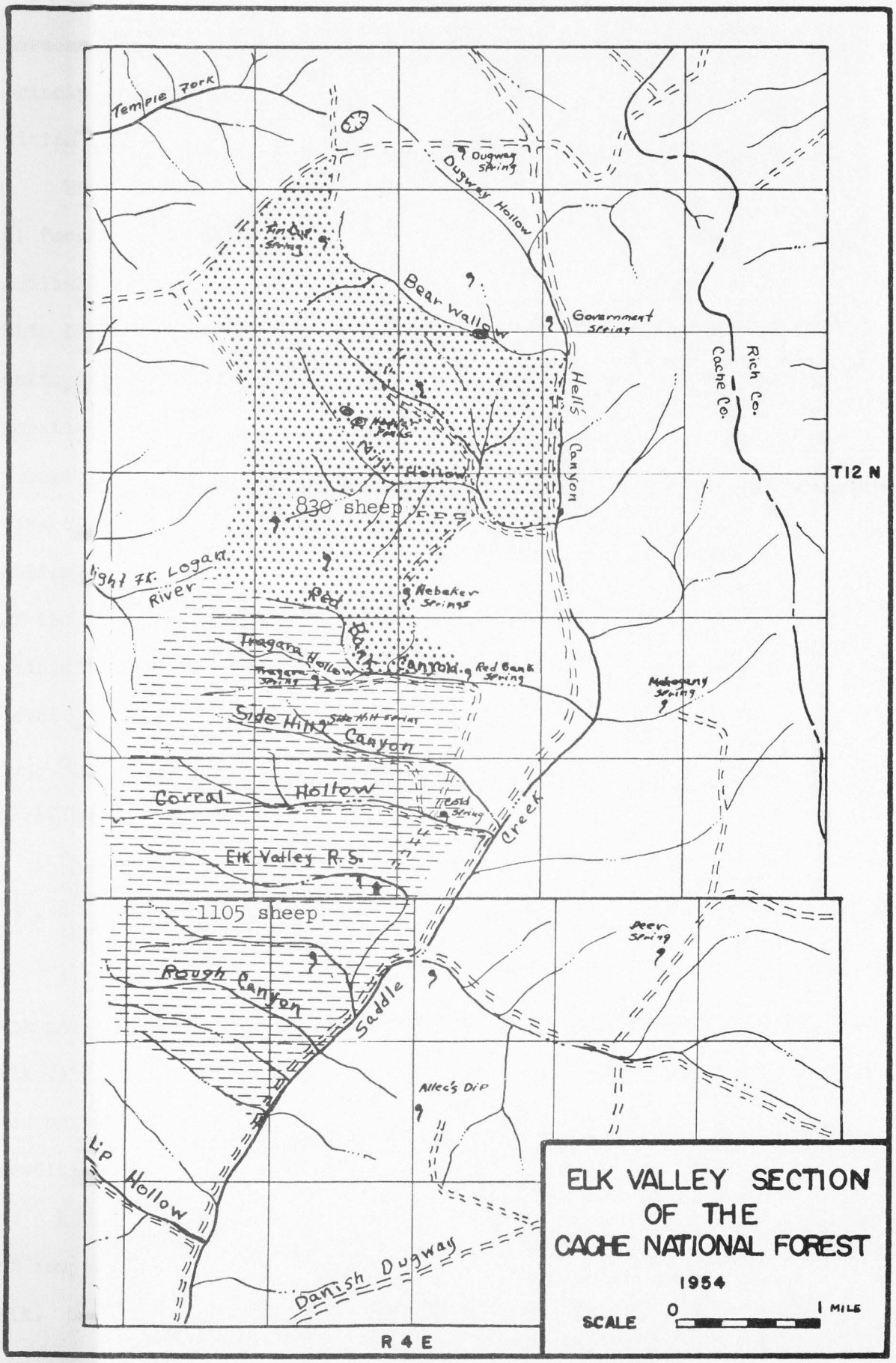


Figure 2. Sheep distribution in Elk Valley, 1952

personal bias, refuse to accept its inferences. The "multiple use principle" is all too often laid aside entirely in considering competition.

The greatest utilization of the range resource consistent with annual forage production and proper utilization can best be achieved more equitably through varied animal class use of the range forage resource. This in essence is partial expression of common use, an appendage to the multiple use principle. Final decision of allotted use should surely consider which animal class or classes is or are best adapted to existing forage conditions, plant composition and production, topography, vegetative types, economics, and other features at hand. If total forage obligation of animal classes involved does not exceed proper utilization of the annual forage production and over-all good range conditions are maintained, it can be concluded that there is very little real competition involved.

Olsen (1945) in defining what constituted competition in utilization of forage by big game and livestock stated:

> There is no conflict as long as there is sufficient forage to meet the needs of both game and livestock, provided dual use doesn't impair vigor of plants. . . . conflict comes only when there isn't enough to go around.

At present stocking levels of domestic livestock and summer deer and elk populations, there appears little real competition for forage in the Elk Valley section; for forage production throughout the aspen understory was more than sufficient to meet forage demands and maintain proper range conditions.

However, competition may be assigned on the basis of popular concept of competition involving range and forage use overlap of livestock and elk. Stoddart and Rasmussen (1945) present a direct method of calculating

competition of this nature. Utilizing their method in the Elk Valley situation, competition can be computed as per the following discussion:

Cattle used approximately 60 percent of the Elk Valley area utilized by elk. Furthermore, cattle used an estimated 80 percent of plants eaten by elk. The "competition index" would then be 60 x 80 or 48 percent. This means that slightly less than one-half of the forage eaten by elk on the area could be consumed by cattle if all the elk were removed. This does not imply that the removal of two elk would permit an addition of one domestic cow, since both animals eat different amounts according to their size. A cow is approximately 1.88 times the size of an elk or an elk is 0.53 the size of a cow (Stoddart and Smith, 1943). Thus, 48 x 0.53 equals 25.4 percent of one elk's food which one domestic cow eats or $\frac{100}{25.4}$ or 3.9 elk that would have to be removed to add one cow. Conversely, 48 x 1.88 equals 1.1 cows that would have to be removed to add 1 elk.

Comparing elk and sheep in the same manner, sheep used approximately 90 percent of the area utilized by elk and only about 30 percent of the plants eaten by elk. The "competition index" would then be 90 x 30 or 27 percent. Since an average sheep weighs approximately 24 percent of an elk (Stoddart and Smith, 1943), it would be necessary to remove 1.5 sheep to permit an addition of 1 elk and 10 elk to permit an addition of 1 sheep.

The foregoing calculations show that on an average 48 percent of the forage consumed by elk would be available for cattle or 27 percent would be avaiable for sheep were all the elk removed from the Elk Valley common use range. Thus, if all elk were removed in Elk Valley, approximately 50 head of cattle and 194 head of sheep could be added on the basis of present elk numbers. Conversely, it is wholely impractical to calculate elk increase above the present carrying capacity of the winter range without adjustments being made in deer numbers.

Mud Flat

History. Initial cattle use of the present Mud Flat area was commenced as early as the 1890 period. Since then, the area has become part of the Cache National Forest. Evidences of excessive past erosion and present plant indicators truly suggest the area has been heavily utilized over a extended period of years. As a result, the Forest Service undertook a grass reseeding project in September of 1941 in an effort to stabalize soil conditions and increase forage production. For seeding purposs the area was divided into smaller units which were placed under control by fencing and were reseeded as monies and materials became available (figure 23).

Pior to the present reseeding project some individuals asserted that ek were responsible for the depleted state of the range. Since its compleion, they have vociferously complained of elk utilizing great amount of grass feed that should be destined for cattle use; they further assert that elk are currently causing considerable damage to the reseeded projec. Elk wintering at the Hardware Ranch were said to immediately proceed in mass to Mud Flat in a spring migration.

Subsequent spring rides of the area have generally shown that up to 85 head of elk made spring use of the Mud Flat area. The existence of this quantity of elk continually added fuel to the fire of antagonism against the elk and particularly against the State Department of Fish and Game.

Present study. A phase of the project was thus organized to study elk utiization of the area. Field investigations were centered around established period of elk use as correlated with stage of plant growth, elk numers, and elk utilization of reseeded areas prior to cattle use. Briefly elk distribution around and on Mud Flat was plotted during the

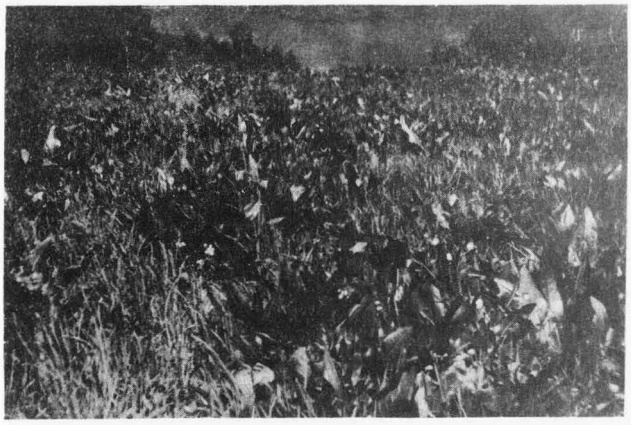
Figure 23. Sketch of Mud Flat reseeding project site

1952 and 1953 winter-aerial census. Subsequent ground checks were made to ascertain movement from adjacent wintering sites to Mud Flat. Periodic checks were then conducted when elk began spring utilization of the area. Two aerial reconnaissances were executed in the 1952 spring and 1 in the spring of 1953 in an effort to define elk distribution on the area and ascertain relative elk numbers.

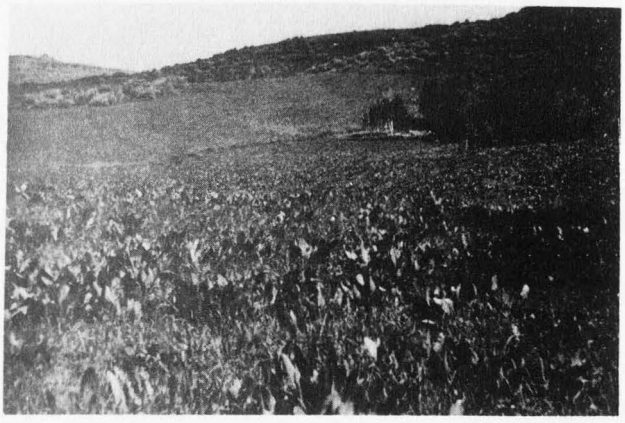
Elk spring migration on the entire Cache, particularly from the Hardware, was likewise studied in an effort to determine correlation to Mud Flat spring use. Utilization checks were periodically made throughout the interum of Mud Flat elk use as were photographs taken to show vegetation growth in respect to elk utilization (figures 24 and 25). Final utilization checks were made prior to cattle entry in the spring of 1952 and 1953 so that elk use of the reseeded areas could be justly assigned. At the termination of the 1952 cattle grazing period, photographs were taken to show general range aspect and cattle utilization (figure 24). Periodic checks were conducted throughout the summer and fall to ascertain elk use of the area.

Results. Earliest arrival in 1952 of elk into the Mud Flat area was noted on April 8. Snows of 3 foot depth still blanketed the reseeded sites. In 1953 elk had moved onto the ridges adjacent to the reseeded areas by April 25, though 69 elk wintered immediately south of Maughn Hollow and north of Chicken Creek reseeded units during the ensuing mild winter.

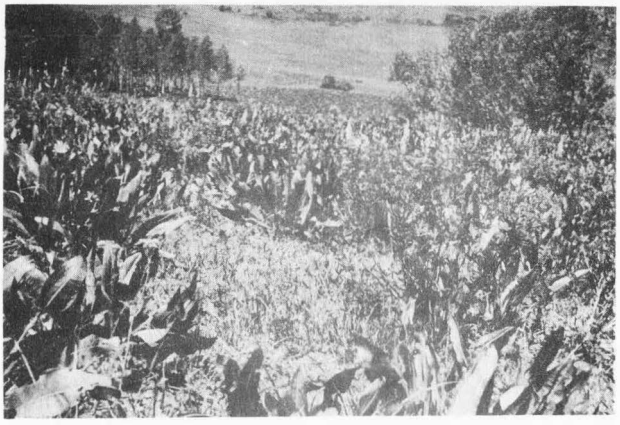
Elk activity through May 12, 1952 was principally restricted to ridge tops adjacent to reseeded units. Grasses and other vegetative growths were noticeably advanced on ridges and slopes in contrast to growth on reseeded units. Some elk commenced utilizing reseeded areas on about May 12, but failed to obtain much feed since average grass height



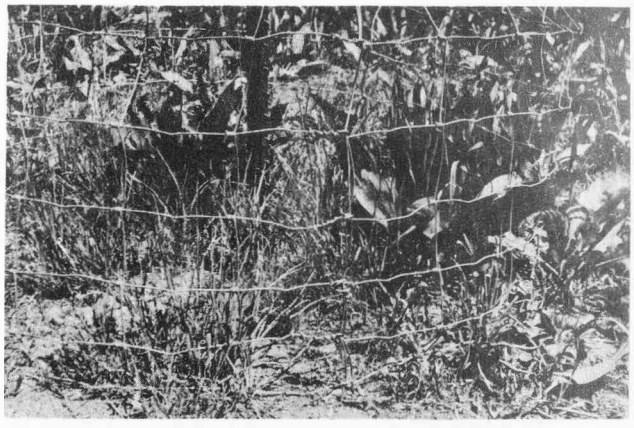
May 31, 1952



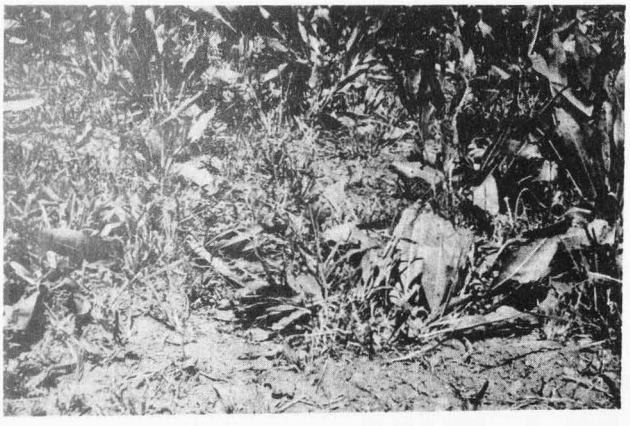
May 31, 1952



July 2, 1952

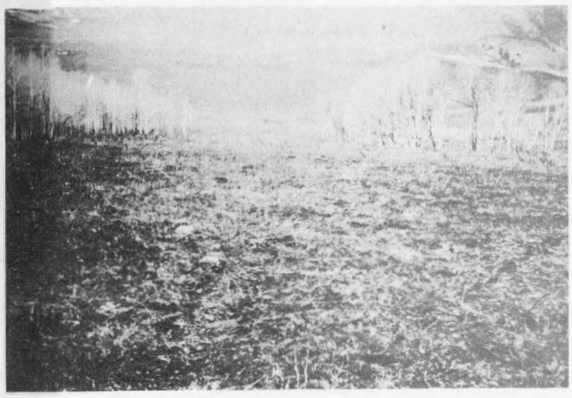


July 2, 1952

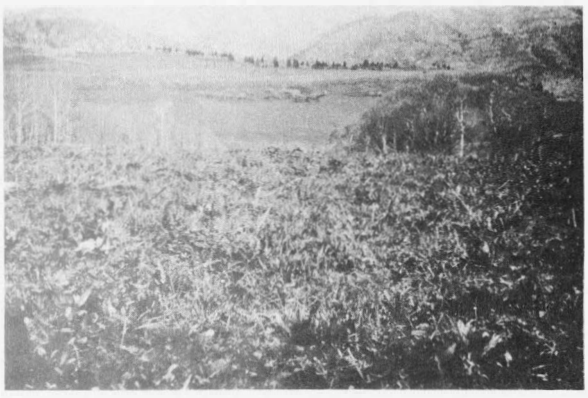


July 2, 1952

Figure 24. Comparative stages of vegetative growth and utilization by cattle - Mud Flat, 1952



May 12, 1953



May 28, 1953

June 8, 1953

May 28, 1953

June 8, 1953

Figure 25. Comparative stages of vegetative growth - Mud Flat, 1953

was approximately 2½ inches. Peak elk numbers observed in the 1952 spring were 50 head; estimated peak numbers were 60 elk. By May 24, 1952, elk were utilizing aspen areas to a decidedly greater extent since vegetative growth in the aspen were superior to that on reseeded units. No elk were seen in the Mud Flat area after May 31, 1952, until mid-September. Comparative stages of plant growth are illustrated in figure 24.

Elk demonstrated definite interest in the reseeded area by May 12, 1953. Their preference, as indicated by plant use, was estimated to be 80 to 90 percent annual and perennial forbs, principally mule's ear (Wyetha) and wild onion (Allium). These forbs were only 1 to 2 inches in height. Grass species on the reseeded areas averaged only 1 inch, though most grasses had not yet commenced growth (figure 25). Extremely dry weather and prolonged cold temperatures below plant physiological growth minimum retarded 1953 vegetative growth by approximately two weeks as compared to 1952 conditions. Peak elk numbers observed in 1953 were 88 head on May 12, while 79 elk were present on May 28. Largest single concentration was 30 elk. One hundred elk were estimated to be the maximum number of elk using the area during the 1953 spring. It is interesting to note that plant growth on reseeded areas was conspicuously retarded even though peak elk use had been apparent for the prior two weeks (figure 25). By June 5, 1953, elk activity had shown a sharp decline; the only elk observed near the area were 19 head one mile north of the Chicken Creek reseeded unit.

Earliest known elk arrival from the Hardware Ranch (identified by colored disc in ear) was noted on May 17, 1952, and June 5, 1953.

Utilization checks on reseeded units made prior to 1952 cattle entry demonstrated a 5 percent utilization for elk and limited deer use. Similarly, utilization checks in the spring of 1953, immediately prior to

cattle use, indicated a 4 percent utilization on grasses on the same areas. Figures 24 and 25 show stages of plant growth immediately prior to cattle use.

Eight hundred cattle were placed on the reseeded units on June 2, 1952, and again June 8, 1953. Cattle utilization during the initial week of grazing in 1952 was estimated to be 20 to 30 percent. Full allotted utilization of vegetation on the reseeded units was accomplished by June 25 in 1952, and cattle were moved to higher ranges commencing July 2. Cattle use was likewise terminated on the reseeded units on July 1, 1953. Utilization of area at conclusion of 1952 cattle grazing season was observed on July 2, 1952 in 2 reseeded units (figure 24).

No elk were seen on or near the Mud Flat area after May 24, 1952 and June 5, 1953 until mid-September of each year. Few elk were then noted in the Chicken Creek drainage and the Roll-Off section. These elk were not utilizing reseeded units.

Summary. A pattern of elk use on the Mud Flat reseeded units can be summarized in view of past two year's observations and experiences. Three phases seemed apparent:

(1) Initial utilization commenced with movement of local elk to the ridges and slopes immediately adjacent to reseeded areas; this generally occurred around mid-April. Elk continued to utilize ridges and slopes in preference to the reseeded areas since plant growth was further advanced and availability of previous year's forage was greater off the reseeded units.

(2) Actual utilization of the reseeded areas commenced around the second week of May and extended for approximately 2 weeks ending near the close of May. Some elk from the Hardware Ranch generally appeared during the latter portion of the utilization but did not make up the bulk of elk

utilizing the area. Forage growth in late May was still further advanced on ridge tops and southern and western exposures than contrasting flat reseeded areas. The inferior stage of vegetative growth on reseeded areas is believed to be a major factor involved in limiting elk utilization which did not exceed 5 percent prior to spring cattle use on the area. Early elk use of vegetation on the reseeded area was primarily confined to mule's ear (Wyethia) and wild onion (Allium).

Trampling seemed the most conspicuous evidence of elk use on reseeded units. However, no visible difference could be ascertained in plant vigor and forage production in elk trampled sites as compared to those not trampled when observed in early June prior to cattle use and termination of growing season.

(3) There appeared a transition of elk numbers into the aspen type during the latter part of May. This is speculated to be (a) preference of aspen sites because of advanced stage of vegetative growth, and (b) the period which coincides with calving season when cow elk become more seclusive. Subsequent elk movement took place within a week's time, thus resulting in elk movement toward the North Cache in Blind, Bear, and Cottonwood Canyons and toward Spawn Creek and Temple Peaks area on the South Cache.

On the basis of present findings, accusations regarding excessive elk utilization of the Mud Flat reseeded area appear ill-founded. Likewise, it appears that a maximum of 100 elk on and near the reseeded area for 3 weeks and 800 cattle for 1 month is hardly a comparable comparison.

Cache general

The Cache summer range, like most mountainous summer ranges, can be used economically in no other way than by grazing livestock and game.

Big game alone cannot fully utilize the vast summer range since the restricted winter range is the factor limiting their production. When due consideration is given the big game-livestock, summer forage utilization question, it can be concluded that common use (big game and livestock) of the range forage resource is the most equitable means of using range lands, provided the status of good range conditions is not jeopardized through excessive utilization by any one or collectively by all animal classes involved. In general, areas on the Cache favored by elk as a summer range and used by livestock during the summer season are in fair condition.

Summer elk distribution is for the most part coexistent with the aspen type (figure 4), which is the most productive type from the standpoint of forage production. Cattle and sheep distribution are shown in figures 26 and 27, respectively.

Some individuals would prefer that all livestock be removed from the Cache and the area be devoted to deer and elk production. Similarly, others would desire that all deer and elk be removed and the total forage production be assigned to livestock use. Advocates of either of these sentiments assuredly possess ulterior, selfish motives. Each fails to realize the basic factors involved. The individual who promulgates total livestock exclusion in support of increasing deer and elk is believed to be wrong; for, in actuality, the facts indicate that present big game numbers could not be increased materially beyond the overburdened and limited carrying capacity of the winter range if all livestock were excluded. Similarly, were all big game removed on the Cache unit, many areas supporting good forage could not be utilized by cattle or sheep.

Between these two extremes of irrational thinking lies a basic concept known to game, livestock, and range managers alike. The principle

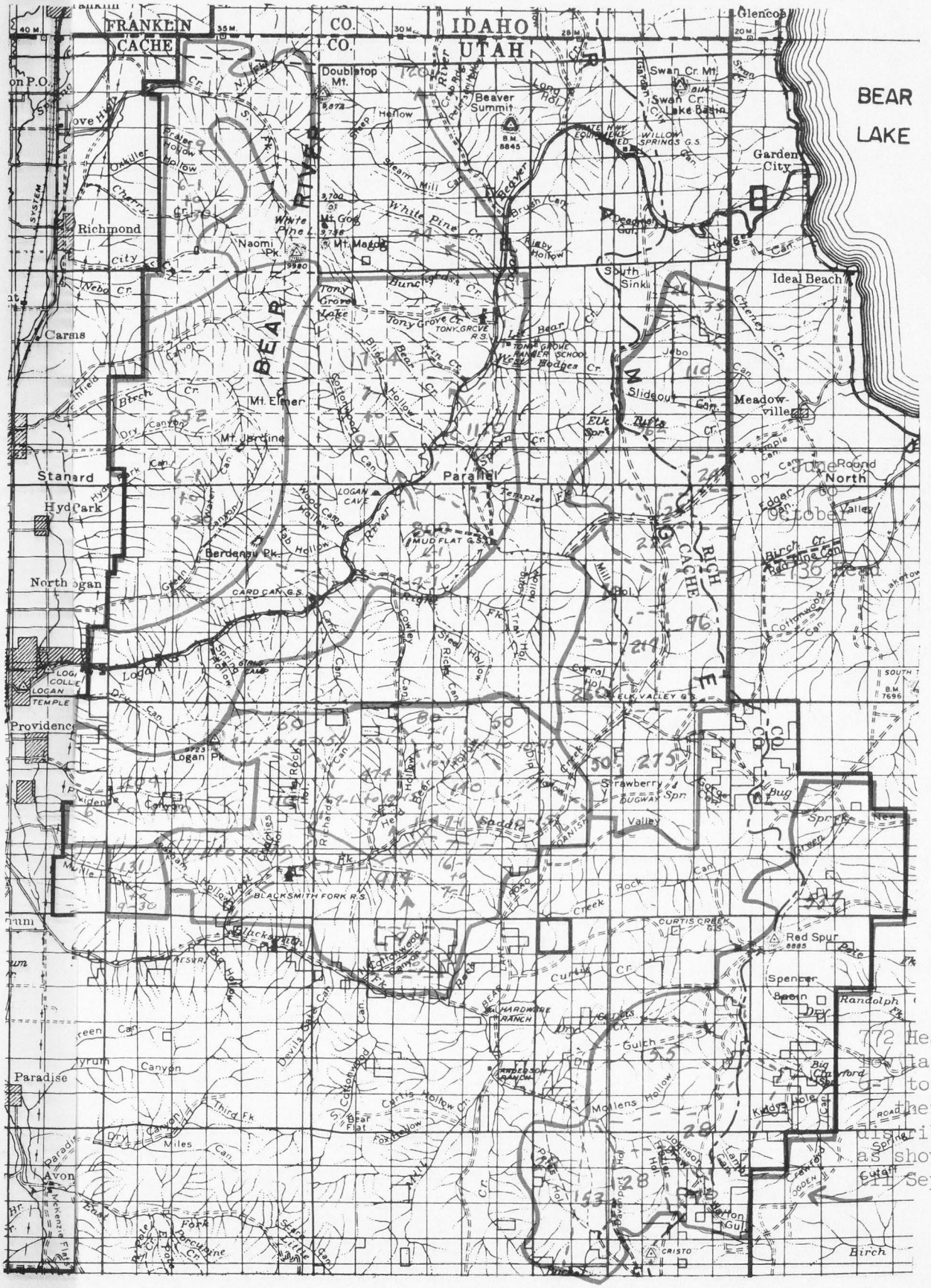
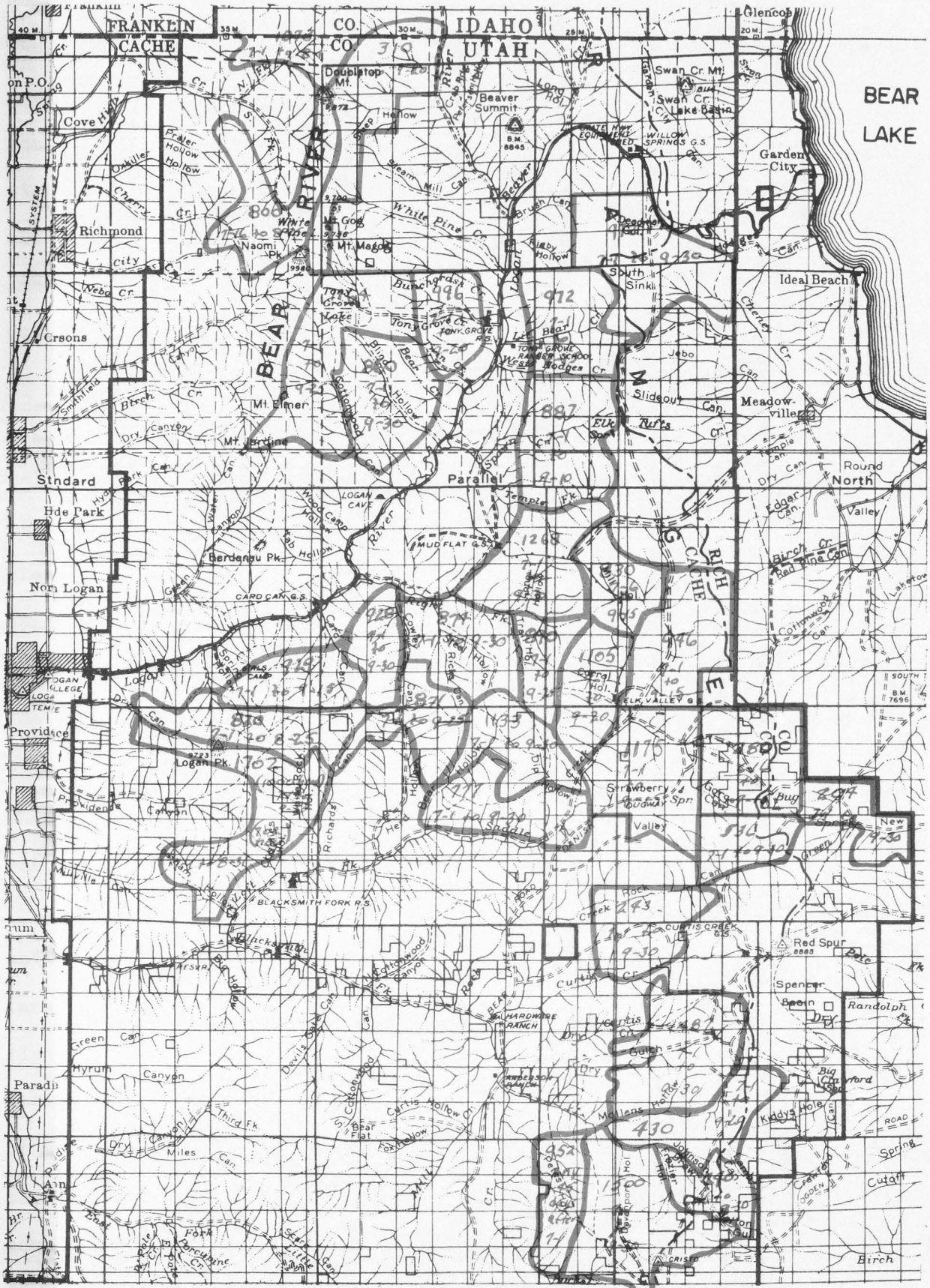


Figure 26. Cattle distribution on the study area portion of the Cache National Forest



Figue 27. Sheep distribution on the study area portion of the Cache National Forest

expressed in this philosophy of equitable use of land is termed "multiple use." In other words, the maximum utility of a unit of land can best be achieved through such combined uses as watershed protection, timber production, recreation, grazing, wildlife, mining, or additional uses according to the availability of resources contained on the land and their proper use. Generally, no single use will provide maximum utility.

There exists in connection with the multiple use principle an appendage applicable to the grazing use feature. This subordinate is called "common use", which in essence asserts that the maximum utility of the range forage resource can best be achieved through varied animal class use according to the adaptability of animal classes to existent topographies and vegetative types for both livestock and big game.

Though the multiple use principle together with the common use feature are generally agreed to be equitable means of providing maximum utility of any given unit of land, disagreements generally occur among interested groups as to what is equitable stocking proportions of deer, elk, sheep, and cattle on federal and state lands.

It was anticipated at the beginning of the present study to include animal months' use of livestock and elk on the study area portion of the Cache National Forest from 1915 to date. However, such a tabulation for livestock use could not be made since the writer could not accurately interpret Forest Service records because he lacked background information to the varied changes which for a surety would affect the trend in livestock numbers on the study area. Changes which conspicuously affected an accurate tabulation of livestock trends were (1) past changes of ranger districts within the national forest, (2) annexation of lands to the forest, (3) withdrawal of land from the Cache to the Caribow National

Forest, and (4) periodic transfer of sheep permits to cattle permits.

Even though a quantitative trend in livestock numbers is not available, it is common knowledge that cattle and sheep month use has decreased substantially, while deer and elk use has increased materially on the Cache National Forest since 1915. Animal months' use of sheep, cows, and elk for the period 1944 to 1954 appear in figure 28. This segment of use, however, does not give a true perspective in regard to animal use trends since elk and cattle use have leveled off throughout the period shown. Likewise, sheep use has stabilized since 1946. Livestock use indicated in figure 28 does not include livestock use of private ranges within the study area that are not waived for administration to the Forest Service. There are 5 such principal townships of which elk frequent but one of these to any appreciable extent.

The increase of elk since 1916 on federal and state lands on the Cache study area can be justified through at least 2 means: (1) in order to satisfy the needs of the greatest number of people; and (2) the maximum utility of the range can best be achieved through elk, deer, sheep, and cattle use of the forage resource.

Realizing full well that the present study could only give but a fraction of the time that a specific study could do in investigating Cache elk-livestock relationships, the writer believes the present Cache elk population is compatible with sheep and cattle production as well as forage utilization on the Cache summer range with the exception of the adjacent Hardware Ranch range situation. Proposed land acquisitions and range use exchanges should equitably eliminate excessive use of the described depleted ranges.

Elk-Deer Range Relationships

As indicated in the present report, forage production on Cache

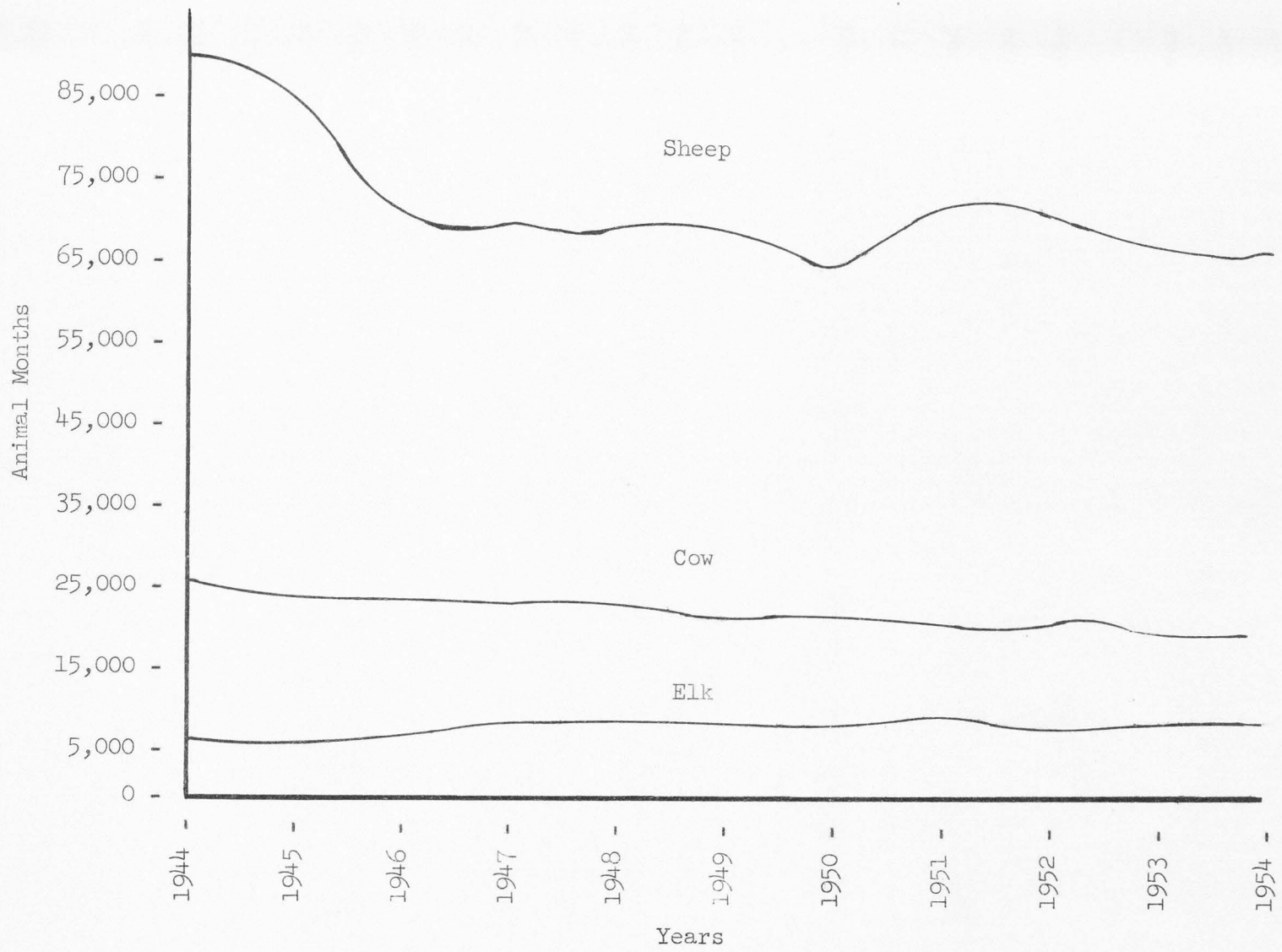


Figure 28. Animal months use on the study area portion of the Cache National Forest

summer elk range was found adequate in satisfying present elk, deer, and livestock forage requirements as well as amply maintaining fair range conditions. However, one fails to muster any such optimistic report in respect to the winter range situation.

Julander, et al., (1950) report that the Cache has approximately 203 square miles of winter range, 86 square miles or 42 percent of which was considered a big game problem area. The big game problem area thus reported almost entirely laid within the confines of the Wasatch face and lower Logan and Blacksmith Fork Canyons; it extended somewhat higher in the latter drainage.

In contrast to deer winter distribution, which normally is continuous and coincides with all of the portions in the described problem area, elk winter distribution is characterized by isolated, localized distributions (figures 5 and 6). Therefore, elk-deer range overlap and resultant competition is subsequently a local issue. Perhaps one of the greatest deer-elk competitive situations took place in the Millville Canyon section on the Wasatch face. Numerous elk wintered in this and adjacent sectors prior to the purchase and operation of the Hardware Big Game Ranch as an elk winter feeding site. Similar elk concentrations were also then observed along the southern exposures of the Blacksmith Fork drainage. Since the initial operation of the Hardware Ranch, elk numbers have been curtailed in the described problem area, thus reducing forage competition materially in favor of the deer population.

It is estimated that elk use overlapped approximately 40 percent of the deer winter range during the moderate winters of 1952-53 and 1953-54 in the Millville Canyon and immediately adjacent sections. However, less than 50 head of elk were involved. Conversely, during the difficult winter of 1951-52 elk utilized approximately 100 percent of the same deer

winter range for about 90 percent of the time spent on the winter range. Around 200 elk were involved in the latter situation.

The Utah State Department of Fish and Game, beginning with the initiation and operation of the Hardware Big Game Ranch, have dedicated management efforts toward conserving forage on critical winter range along the South Cache Wasatch face. Forage production along this belt has been reserved for deer use wherein possible. Post-season elk hunts have been held to curtail elk numbers in the area; in addition, trapping operations are cortemplated if and when it becomes necessary to remove elk from the area, thus reducing the deer-elk competition ratio.

Though elk are present along the Wasatch face on the North Cache, their numbers to date have been compatible with range conditions and deer-elk use.

HARDWARE RANCH OPERATION

Importance

The present population level of the Cache elk herd is largely dependent upon the success experienced in the operation of the Hardware Big Game Ranch Unit. Under circumstances as exist on the Cache area, such as absence of adequate winter ranges remote from agricultural lands and critical winter ranges dedicated to deer production, it virtually became necessary to establish a feeding program if present elk population level was to be maintained. Similar circumstances were noted in the classical example of elk feeding on the National Refuge in Jackson Hole, Wyoming. Murie (1951), in describing this feeding program, stated: "In this instance we can hardly avoid the feeding program. But every effort is being made to lessen its evils."

Location and Description of Ranch Property

The Hardware Ranch Big Game Unit is situated in the Blacksmith Fork drainage of the Cache National Forest and is located some 20 miles southeast of Logan, Utah. Ranch headquarters and irrigated meadow lands are situated in an open valley near the headwaters of the Blacksmith Fork. Present property is composed chiefly of a continuous tract of land with infrequent isolated holdings (figure 29). Elevation at ranch headquarters is 5,586 feet.

Brief History of Ranch

Historical highlights of the ranch include its colorful role as an early Indian and trapper rendezvous. It very early became the scene of a small cattle operation, and its present name, "Hardware Ranch", came from the title of a former owner, the "Box Elder Hardware Company."

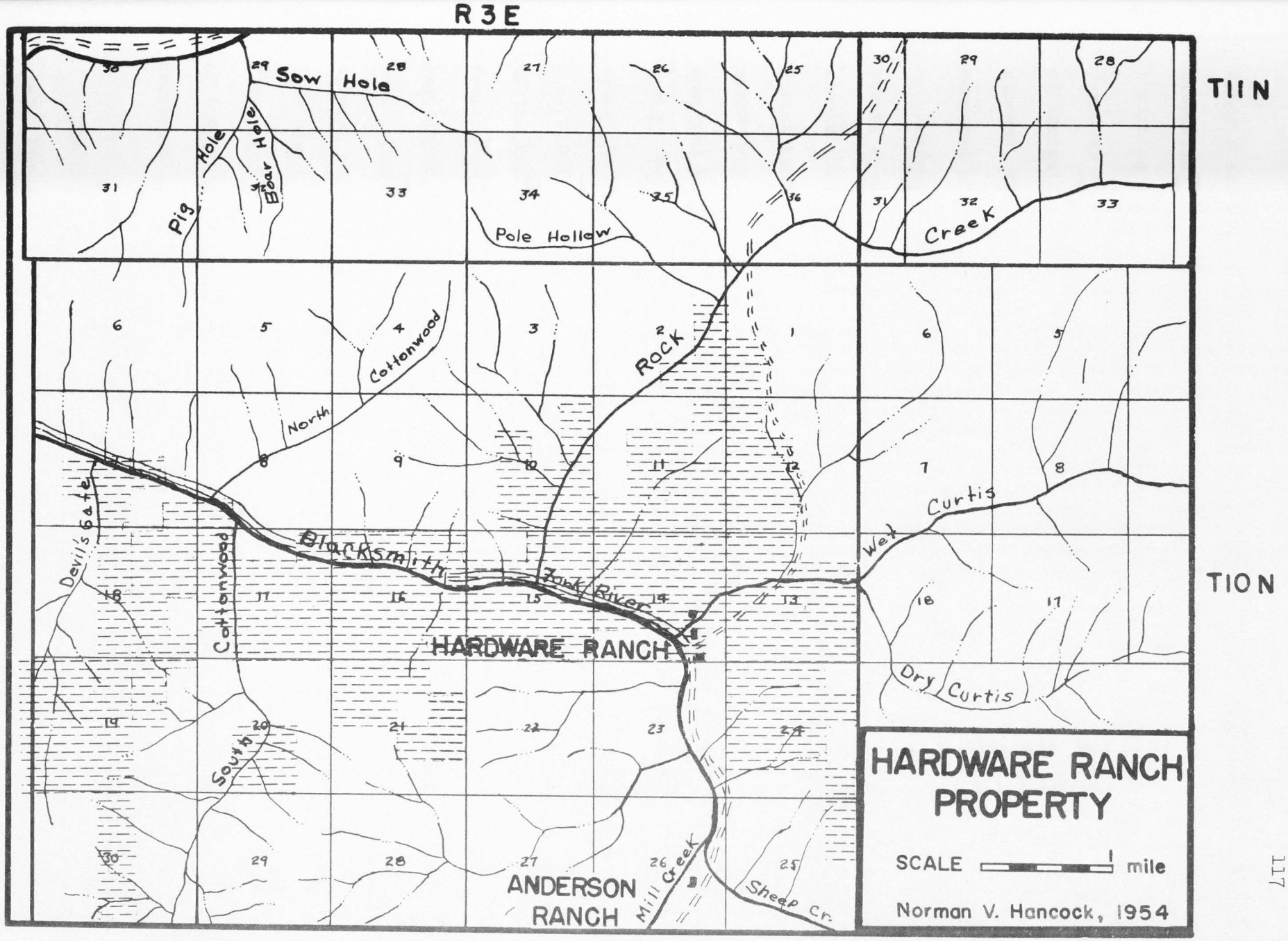


Figure 29. Hardware Ranch property

After a series of changes to individual ownerships, the present Hardware properties were purchased by the Utah State Department of Fish and Game, beginning in 1944 and resulting in the present ranch status embracing 7,454.45 acres of which planted grasses comprise approximately 210 acres of irrigated meadow hay land. Brush-meadow type, principally along streams, make up a total of 284 acres. The remaining acreage is chiefly composed of range land.

Purchase of the Hardware unit was encouraged by the sequence of events stemming from the exclusion of marauding elk from Hardware hay stacks then under private ownership. For, after the fencing of these stacks by the Fish and Game Department in the early 1940 period, elk moved from the ranch and arrived in force on the Wasatch face where they competed heavily with deer for the limited available forage (Turpin, 1954). These elk likewise re-embarked on marauding habits until damage along the Wasatch face in hay stacks and orchards became intolerable.

Since elk were known to originally winter in force in the vicinity of the Hardware Ranch, and inasmuch as their exclusion by haystack fencing merely resulted in their shift to critical deer winter ranges, hay stacks, and orchards along the Wasatch face, Utah State Fish and Game personnel envisioned that the resultant problem could be diminished through the purchase and operation of the Hardware Ranch as an elk and deer winter refuge. Subsequent operations of the Hardware Ranch has confirmed the fulfillment of the original objective; for slightly in excess of 400 elk have been known to winter on the ranch site, and substantial decreases in elk wintering on the Wasatch face have been noted.

Recreational Use

The Hardware Ranch has aptly been called "Little Jackson Hole" of Utah. During the present study period approximately 9,000 people annually

visited the Hardware during the elk feeding period. Each successive year finds an increased recreational use of the Hardware Ranch for the purpose of viewing elk.

Elk Use

Contrary to published reports elk numbers have never exceeded 435 head on the Hardware Ranch. Written reports exceeding this figure are known to be casual estimates. The Ranch was first operated for elk use in the 1946-47 winter. Counts since this time are presented in table 19.

Table 19. Hardware Ranch elk counts, 1946-1954

Winter	Status of winter	Actual maximal count	Source
1946-47		120	Utah F.&G. Bul. 7(11), 1950
1947-48	very mild	375	U.C.W.R.U. files, Logan
1948-49		350	McCormack, 1951
1949-50		339	Ibid.
1950-51		no count	
1951-52	Extremely severe	418*	Author, 1952
1952-53	Mild	435	Author, 1953
1953-54	Extremely mild	318	Hardware Ranch records

* 124 of these elk were trapped at Millville and North Logan and released at the Hardware Ranch.

Composition of Hardware Elk

As previously noted, the composition of the elk wintering at the Hardware Ranch does not mirror the actual Cache herd for mature bulls are conspicuously absent from the hardware, as are yearling bulls to a lesser degree. The greatest frequency of bulls recorded on the feed ground during the present study period was 37 bulls, while 270 cows and

128 calves were concurrently listed.

However, cow and calf ratios realistically represented the entire Cache herd.

Haying Records

One hundred and eighty tons of meadow-grass hay were harvested in 1952, while the total production in 1953 was 156 tons (appendix table 7). The decreased tonage in 1953 stemmed from early season restrictions of irrigation waters. Thus it appears under optimum conditions that the present meadow acreage will produce nearly 180 tons of hay annually.

Feeding

Though the elk vanguard appears on the ranch property generally following the close of deer season around November 1, they prefer to forage out rather than accede to the meadow proper. The major portion of elk arrive in early December and at this time show interest in the feed ground.

It is apparent that the length of the feeding period is largely dependent upon snow and other weather conditions and hence varies from year to year. Available records to date disclose that Hardware elk feeding periods have extended on an average of approximately 137 days, excluding the 1950-51 feeding period of 89 days when "teaser hay piles" were distributed throughout early December; but feeding records were not maintained until daily feeding commenced.

The following tabulation reveals the tenure of recorded feeding periods at the Hardware Ranch:

Winter	Calendar Months	Feeding Period, Days
1947-48	Nov. 3 to April 6	141
1950-51	Dec. 31 to March 28	89
1951-52	Dec. 2 to April 23	144

1952-53	Nov. 15 to April 12	148*
1953-54	Dec. 1 to April 4	125

* Elk were fed only 118 days within this period.

Hay consumption

Complete feeding records were kept throughout winter study periods in an effort to calculate daily hay consumption. These consumptions were computed on the basis of daily feeding records and average monthly and seasonal elk counts. Consumption figures for the 1951-52, 1952-53 and 1953-54 elk feeding periods are presented in table 20. Monthly feeding records are described in appendix table 8.

Table 20. Daily hay consumption of Hardware elk, 1951 to 1954

Month	1951-52 lbs. fed/elk/day	1952-53 lbs. fed/elk/day	1953-54 lbs. fed/elk/day
Nov.		3.41	
Dec.	4.38	2.02	2.98
Jan.	4.60	2.76	3.79
Feb.	4.46	2.68	4.64
Mar.	5.59	2.51	5.03
April	4.52	2.85	Incomplete data
Seasonal Daily Mean	5.13	2.42	4.78

Elk consistently ingested more hay during the difficult winter of 1951-52 than the two succeeding milder winters (table 20). Daily observations also showed that elk placed more reliance on supplemental feed during prolonged cold spells and deep snows. Herd feeding habits at the ranch characteristically consisted of daily feeding on or near the feed ground and nightly foraging into surrounding hills. Daily hay consumption

listed for Hardware elk is believed to approximate their maximal preference for meadow hay in view of existent winter conditions and availability of natural forage species. Amount of hay thus fed to elk was gauged by their adeptness to "clean up" feed without wasting.

Hardware elk do not ingest hay in quantities sufficient to satisfy daily maintenance requirement. In fact, their hay consumption is considerably less than those on similar feed ground operations like those conducted in the Jackson Hole area. Murie (1951) reported that during the 1938-39 winter on the National Elk Refuge in Jackson Hole, Wyoming, the elk consumed about 8 pounds of hay per animal per day under actual feed ground conditions. Hay consumption over a period of years on the same Wyoming refuge was calculated to be 7 to 10 pounds per elk per day (Murie, 1951). It is assumed by the writer that inasmuch as feeding operations on the National Elk Refuge have been present for a considerable length of time (since 1911) that natural forage species, particularly browse, have been eliminated, thus resulting in a greater animal reliance on supplemented feeds. In contrast, feeding at the Hardware has been conducted for a short period of 8 winters; furthermore, natural forage is still available. Four pounds of hay per animal per day was found to be an adequate maintenance ration for Montana elk in areas where moderate browse was available (Cooney, 1952). This situation more closely parellels that at the Hardware Ranch.

If present Hardware hay consumption is not adequately filling the elk's maintenance requirements, what then is the approximate portion which daily feeding is currently meeting? In light of results from reported elk feeding experiments, Hardware elk are consuming hay approximating 20 to 56 percent of their daily maintenance requirements. These figures are based on a herd run individual maintenance requirement of 10 pounds

of air dry forage per animal per day (Murie, 1951 and Hungerford, 1952). The reader may more fully realize the extent to which supplemental feeding is supplying maintenance requirements for Hardware elk by inspecting table 20. When the decimal point contained in poundage figures is moved one place to the right, the resultant figure expresses the percent which supplemental feed is meeting total individual daily elk maintenance requirement.

Feeding cost

Sufficient data were kept through two winter feeding periods to enable a computation of feeding costs. Thus, the average cost per elk for the 1951-52 winter was $16.68; it similarly cost $9.48 to feed each elk during the 1952-53 period. The above costs include only actual value of hay fed and wages paid during the feeding period. Similar computed cost for elk on the National Elk Refuge in Jackson Hole during the 1951-52 winter was $7.95 per head.

These costs, however, do not seem realistic, especially when Hardware Big Game Unit operational expenses are not considered. A more unvarnished evaluation appears when total Hardware unit operational expenditures are charged against the elk feeding cost. Thus, the average feeding cost per elk would be $50.29 during the Winter of 1951-52 and each elk would cost $48.82 to feed during the 1952-53 winter. Comparative average feeding costs were noted for Jackson Hole elk as $18.51 per elk for the 1951-52 winter feeding period. These latter average cost figures are computed on the following basis:

(1) current value of hay fed and tons fed,

(2) operational expenses of unit,

(3) salary costs,

(4) interest at 3 percent on original investment,

(5) 5 percent depreciation on improvements, and

(6) average number of elk fed during the feeding period.

Range

Range use

Though substantial big game use on the eastern portion of the Hardware is restricted to 8 preceding winters, liberal livestock use has been present over most of the unit for approximately 90 years prior to present ownership. Even now substantial livestock use is present on some neighboring ranges northeast of the Hardware Ranch headquarters. Elk utilized these same eastern ranges to the extent of approximately 90 percent of their total winter range use.

Total winter range of about 3,200 acres was used by Hardware elk in 1951-52 and 1952-53 winters. This acreage includes meadow sites. This means approximately 7.6 and 7.3 acres were used per elk for 5 months during the respective winters, or about 1.5 and 1.4 acres per elk month. Murie (1944) states that elk require around 12 acres of good range per herd for a 6 month winter period; this would amount to around 2 acres per elk month.

Deer use on Hardware property is largely confined to areas west of ranch headquarters and section 24, township 10 north, and range 3 east.

Forage types

The range adjacent to the meadow feed ground is a sagebrush type interspersed with stands of bitter brush (*Purshia tridentata*) and limited serviceberry (*Amelanchier alnifolia*), birch-leaf mahogany (*Cercocarpus montanus*), and snowberry (*Symphoricarpus rotundifolia*). Juniper (*Juniperus utahensis*) is sparsely scattered over the area and curlleaf mahogany (*Cerocarpus ledifolius*) is restricted to rocky ridge tops and rock out-croppings. Grass species are becoming relatively abundant in

areas of heavy elk utilization and field mouse infestations. Native Carex and Juncus species are prevalent in moist sites within and surrounding meadow lands which are composed of planted grasses, principally smooth brome (Bromus inermis), timothy (Phleum pratense), and red top (Agrostis alba).

Browse utilization

Low (1948) reported that browse utilization by big game was light during the 1946-47 winter. Bitterbrush, the most heavily utilized species was estimated to be used 10 to 15 percent. However, during this same winter an unprecedentedly high mouse population occurred contiguous to upper meadow hay lands. Mice girdled and killed 75 to 80 percent of larger bitterbrush plants, while 25 percent of sage was killed (Low, 1948).

Occular estimates of the 2 more important browse species adjacent to the Hardware feed ground placed 1951-52 winter use at approximately 80 percent of bitterbrush and 30 percent of sage annual growth. Some localized sage areas experienced correspondingly heavier use. Particularly so was the area immediately adjacent to the east hay field in the vicinity of Curtis Creek. The resultant high incidence of sage mortality in this area remains unparalleled (figure 28a).

Differential utilization was also noted between young and old sage and bitterbrush plants. Young plants, 8 inches or less, in many instances were not eaten though young bitterbrush plants were utilized less frequently than young sage. Snow depths of a foot or more appeared to provide a measure of protection to juveniles of both species.

Range trend

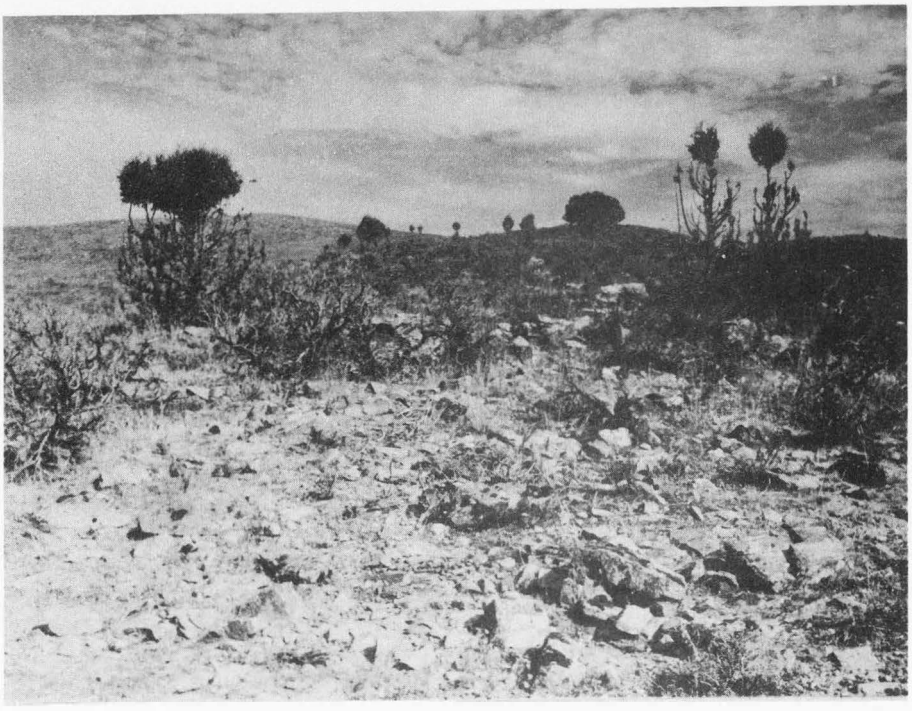
Specific trend data are available for browse species during the 1946-51 period. Low (1953) noted these changes as recorded by use of

photographic and charted vegetative study plots. Plots so studied were in areas of differential use, including a completely protected zone. Low (1953) concluded that sage and bitterbrush increased in all plots except those heavily utilized. Sage was noted to increase double or more under light use. Dead plants increased on all areas of heavy use.

An additional study of plant mortality and dead stem frequency within living plants was suggested when an unusually high incidence of dead sage and bitterbrush plants was noted. Thus, a dead stem count was executed during September 1952. Transect lines were laid out at right angles to the meadow feed ground perimeter. Lines extended one-fourth to one-half miles and were placed so as to radiate from the feed ground.

Significances of dead stem count data, table 21, in respect to apparent range trend point toward a recession of browse species adjacent to the meadow feed ground. These data, however, fail to present the true perspective of sage and bitterbrush seedlings. A surprising amount of sage and considerably lesser bitterbrush reproduction is present in moderately used areas. Heavily utilized portions of the unit, including adjacent private lands where heavy livestock use is present, do show a paucity of juvenile plants.

What, then, is the apparent range trend in the Hardware Unit and immediately adjacent ranges? Successional changes are distinctively apparent in the northeastern section of the unit neighboring the meadow feed ground. These alterations were observed as a transition from browse to perennial grasses (figure 28b). The resultant vegetal changes do not necessarily infer regression inasmuch as perennial cover is present and stable soil conditions still exist. Private ranges to the east are less fortunate since common use has resulted in a downward trend of all perennial vegetation and edaphic conditions are retrogressing.



a

b

Figure 30. Hardware Ranch range. (a) results of heavy utilization of sage and juniper during the 1951-52 severe winter and (b) successional changes resulting in browse reduction and perennial grass increase, 1952

The part native mice populations have played in the elimination of browse species surrounding the meadow cannot be readily placed on a quantitative basis, but it is apparent that early rodent activity during the initial year of the Hardware Big Game Unit operation contributed to large scale elimination of browse species. Elk have since perpetuated this degradation by excessive browse utilization.

The Future of Hardware Elk Wintering Herd

What does the future hold for the Hardware Ranch wintering elk herd? Would that we as game managers could have one short glimpse 20 years hence into the proverbial crystal ball. Basic principles of range and big game management we now have. Limited knowledge of ecological aspects of plant succession is ours. Likewise, we share a knowledge of what has transpired through four decades of elk feeding experience in the world's most classic elk herd. Moreover, limited conclusive corroborating evidence has been further demonstrated in less spectacular elk herd feeding situations the west over. The results of these and other elk winter feeding operations unanimously point toward depleted browse ranges followed by less prevalent but eventual disease or parasitic outbreaks.

Recommended solutions for the elk feed ground problem inevitably center around the axiom of not maintaining the herd in excess of the carrying capacity of the natural winter range. More often two solutions are proposed: (1) increase present size of available winter range and discontinue supplemental feeding, and (2) discontinue artificial feeding and make reductions in conformity with available natural winter range. Increased land use demands for qualified elk winter ranges almost invariably thwart their procurement by game management agencies. Thus, solution number one most generally cannot be put into effect. Number two proposal appears likewise difficult, for increased hunter demand for the elk resource

Table 21. Summary of dead stem count data - Hardware Ranch, 1952

Line	Artemesia tridentata and Artemesia arbiculus (Sage)					Purshia tridentata (Bitterbrush)	
	Dead wood on all live plants	Dead wood on live plants above 8"	Dead plants in total sample	Dead wood in plants above 8"	Dead plants of plants below 8"	Dead wood on all live plants	Dead plants of total sample
A	32.58%	57.21%	43.62%	52.31%	54.71%	50.60%	27.27%
B	23.33	45.22	46.34	63.07	48.88	70.00	46.67
C	29.75	37.05	25.31	33.92	37.76	40.00	21.43
D&D'	40.60	51.61	41.57	54.41	42.00	16.50	37.50
E&E'	32.45	36.93	15.87	23.81	39.62	30.00	33.33
F	38.09	44.06	60.00	66.00	22.73	39.16	25.00
G&G'	33.65	38.42	35.86	43.08	30.76	33.88	0.0
Average	32.51	43.86	38.30	49.75	40.77	43.17	29.11
40 acre sample	N.E. of meadow					54.48	34.00
Grand Average						52.60	33.27

has become so great that herd reductions could at the time be accepted at a disadvantage to the game management agency.

Craighead (1952), among others, has reviewed and weighed the obstacles to successful solution of artificial feeding; he concluded that the ideal solution of maintaining naturally the elk herd (Jackson Hole) at numbers that would meet hunter demands is not feasible, and tenacious demands for such an objective have only hindered more practical approaches. His final proposal was to gradually reduce the herd through increased harvest rather than heavy kills for a few seasons, until the elk herd is brought within the bounds of carrying capacity of the winter range.

It would be all too easy at this time for the writer to prescribe the universal proposal of abandoning feed ground operations at the Hardware and recommending that the Cache herd be reduced proportionately to meet natural winter range carrying capacities on the Wasatch face. To follow such a prescribed course of action, however, would seem equivalent to taking the course of least resistance and failing to face all existing conditions realistically.

A more veritable approach seems that of improving present Hardware operations and, within the scope of limitations, minimizing the apparent evils of the feed ground situation. However, a comprehensive knowledge of inherent evil features accompanying elk feed ground situations should be ever as perceptible as the door to one's home and not hidden behind the camouflage of substituting artificial feeding for winter range.

Two major evils of the feed ground situation are (1) inevitable damage to browse species or the range, or both, and (2) the creation of optimum conditions for transmittal of disease and parasites through concentrating animals. Under many feed ground situations actual damage extends far beyond that of browse species. However, heavy use of browse species

on the Hardware unit proper is resulting in a decrease in browse and an increase in perennial grasses. Portions of the adjacent ranges lying to the east and north of the Hardware are less fortunate in this respect, for common use is eliminating perennial vegetation; thus creating optimum conditions for unstable soils. From range and watershed standpoints such vegetal changes as exist in some portions inside the Hardware property are of no serious consequence in this rolling topography. If only similar conditions existed on adjacent eastern and northern private ranges, the present picture would appear more optimistic. Over-all range conditions and Hardware operation could be greatly enhanced if livestock use of these limited ranges could be reduced.

The all important question in relation to the gradual decrease in browse species on the Hardware is: Can elk curb their appetite for browse in a parallel sequence to the declining browse trend? Their primitive distribution connotes a unique quality of extreme versatility in forage habits. Likewise, reported elk winter food habit studies coincide with the premise that elk modify their food habits to fit the availability of forage types. In Montana some elk herds winter on natural grass types, and substantially all of their winter diet is composed of grass and grass-like vegetation (Smith, 1930; Rush, 1932; and Gaffney, 1941). Similarly, native grasses were reported to make up 97 percent of Jasper Park elk diet (Cowan, 1947).

In light of these and other experiences, it appears that Hardware elk will be capable of meeting transitional changes from browse to grass ranges. However, if range utilization increases so that adequate perennial vegetation cannot exist or accelerated erosion commences, then the fate of the Hardware Ranch elk herd will indeed be questionable.

Whatever optimism we are able to muster toward the future outlook

of Hardware elk and their ecological relationship to the range, we fail to emulate to any degree in relation to disease probabilities. Feeding concentrates elk; concentration establishes optimum conditions for transmittal of diseases. These sober facts cannot be changed from the menacing features they represent.

At present reported elk losses from diseases luckily appear to be confined almost solely to one disease--necrotic stomatitis. The causative organism is a bacterium, Actinomyces necrophorus. This organism was first reported to be confined to moist contaminated soils but has been demonstrated to now be a common parasitic form in the oral cavity of elk and other animals (Drake, 1951, and Murie, 1951). Allred, et al. (1944), indicate that the organism most likely does not multiply outside the animal body but undoubtedly remains viable in the soil for short periods of time such as was demonstrated for 10 months. The organism is world-wide in distribution and has been surmised to have been active in prehistoric mammals as far back as the Pliocene (Murie, 1951). The disease caused by this organism is most generally associated with the elk feed ground situation but has been reported in natural ranges where over-browsing has resulted in an increased consumption of coarser materials by elk (Schwart and Mitchell, 1945).

Ordinarily the necrophorus bacillus is of no pathological consequence, even though prevalent. The etiology of the disease follows a pattern commencing with the entry of the actinomyces into the soft tissues of the mouth and less frequently the stomach and other vital viscera. Entry of the organism is largely confined to locations of mechanical injury or abrasions of the soft tissues of the elk's mouth, cheek, or tongue. Squirrel-tail grass awns are known to be the most common agent causing mechanical injury. This grass is a common constituent of many hays fed

elk.

The necrophorus organism enters the wound and invades the surrounding tissue which becomes greatly inflamed. Subsequent development of the disease may involve presence of ulcers or lesions which may penetrate the tissue and in the case of the jaw bone cause an abnormal bony growth, extosis. The disease is in most all cases fatal. Actual death is generally caused from the poisoning affect caused by toxin secreted by the multiplying bacilli.

It should appear quite evident from the preceding discussion that an ever present potential threat is lurking in the vicinity of any feed ground operation such as the Hardware. Hardware elk will, over the years, do well to remain immune from this disease.

Proposed Land Acquisition or Exchange Range Use

Elk wintering at the Hardware Ranch Big Game Unit are currently using only about 40 percent annually of the total Hardware Ranch range, though, only about 30 percent of the total property is used very extensively. When property purchases were consummated and initial use of the Hardware Ranch unit began, range use and elk migration could only then be speculated. Since this time, elk have demonstrated their preference for ranges to the east and north of ranch headquarters. Similarly, principal migration to and from the ranch involves adjacent ranges lying north of Hardware headquarters.

In view of Hardware elk range use pattern and particularly excessive common use of certain privately owned ranges, it seems advisable to (1) acquire private lands that elk have demonstrated to be using in the course of their normal feeding pattern and (2) dispose of or make range use exchanges of those Hardware properties not being utilized by big game during the winter period. If adequate range conditions and watershed

protection are maintained on adjacent eastern and northern private ranges, excessive common use of these ranges must be discouraged.

Acquisition of those portions of privately owned range lands in sections 12, 13 and southern portion of section 1, township 10 north, range 3 east, should adequately curtail common use on the winter range elk are presently using. Similarly, procurement of private ranges as hereafter described should curtail common use which is now resulting in extensive depleted ranges. Elk used these latter ranges for approximately 3 weeks to 1 month in their 1952 and 1953 spring exodus from the Hardware. The lands thus involved are the northern portions of sections 1 and 2, township 10 north, range 3 east, and southern portion of section 25, township 11 north, range 3 east, together with sections 30 and 31 and western halves of sections 29 and 32 of township 11 north, range 4 east. In addition, U. S. Forest Service lands in sections 26, 35, and northern portion of section 25, township 11 north, range 3 east, are involved as well as state section 36 (figure 29). It seems only fair that range exchange use agreements be made for livestock permittees on Forest Service and state lands involved.

The procurement of approximately 2,500 acres of private range thus proposed and exchange use agreements on about 1,900 acres of Forest Service permitted lands and 640 acres of state land should improve range and watershed conditions and enhance present Hardware Ranch elk operations materially. Proposed acquisition and exchange use acreage slightly exceeds acreage of the Hardware range which is currently not being used by Hardware Ranch elk.

Permanent title to private lands or permanent exchange for Hardware properties appear to be the more desirable solutions to the present problems. Range exchange uses of present Hardware lands and desired

private ranges should be considered only as a secondary expedient to land acquisition since it may set an undesirable precedence in regard to elk use on other private ranges.

Recommendations

Future operation of the ranch would do well to capitalize on 2 objectives: (1) Maintenance of as good range conditions as can be achieved within the limitations of perpetuating present operation; and (2) reduction of conditions conducive to diseases, particularly the feed ground disease--necrotic stomatitis. All activities should supplement these objectives. It is believed that the following suggestions will at this time improve the Hardware operation:

1. A concerted effort should be made to acquire adjacent ranges that elk have demonstrated to be using in the course of their normal feeding pattern and disposing of those properties not utilized.
    a. This would eliminate common use of which the range is incapable of sustaining at the present rate. (See preceding discussion for land acquisition.)
2. Leave meadow grass standing in excess of what is actually needed for elk and livestock plus a liberal reserve.
    a. At present consumption levels, elk will use a maximum of around 130 tons of hay during winters of severe intensities. In normal winters they will consume approximately one-half of this amount (appendix table 8).
3. Segregate bales containing large quantities of foxtail or squirreltail grasses, Sitanion or Hordeum.
4. If a surplus of hay exists and if it is deemed advisable to dispose of such, sell that hay in the lower meadow containing

a large amount of wire grass, Juncus.

5. If substantial stands of foxtail or squirreltail grass become prevalent, formulate plans for its eradication or leave uncut and unused for hay, as the awns, which may cause mechanical injury to the elk mouth, disarticulate at maturity and hence fall off on the ground in the natural state.

6. Continue to scatter hay over a large area when feeding.

7. Continue to feed as much hay as animals will consume without wasting.

8. Maintain daily feeding records and make at least a weekly count so that an index may be had to what part feeding is supplying the elk maintenance requirement over a period of years.

9. If it again is necessary to purchase additional hays, as during the 1951-52 severe winter, extreme precaution should be exercised to avoid hays with foxtail and other coarse irritants.

10. If necrotic stomatitis disease ever becomes evident in the Hardware herd, present feed grounds should be alternated annually with the lower meadow. This would probably involve no little difficulty since the volume of vehicular traffic utilizing the adjacent road would present a problem in retaining elk within the area.

In summary it should be remembered that the Hardware Ranch was put into operation to retain elk in the interior of the Cache away from critical winter ranges on the Wasatch face. The operation in this respect has been highly successful. Even in light of enumerated obstacles the writer looks upon future operation of the Hardware with optimism provided substantial elk increases are not allowed, and proposed land acquisitions or exchange uses are realized.

CONCLUSIONS AND RECOMMENDATIONS

At the termination of the present study in 1954 the Cache elk winter herd probably numbered from 1,000 to 1,100 head, and around 1,300 to 1,400 elk in the summer herd. Aerial and ground censuses accounted for 817 and 877 elk in 1951-52 and 1952-53 wintering herds. These censuses were calculated at best to be 81 percent effective. A combined aerial and ground census is believed to be the most utilitarian method of herd enumeration on the Cache and should be carried out annually.

Legal harvest of 259, 199, and 243 elk were made during 1951, 1952, and 1953 hunting seasons. Total known annual herd mortality, including legal harvests, were 378, 260, and 283 elk, respectively; though illegal elk kill was complete only for the 1952 season.

Very often game managers desire a "cut and dried" workable formula for predicting annual harvest removals consistent with herd stabilization. Realizing the limitations of such calculations, together with existing here variables, the writer believes that an annual Cache harvest removal formula may be utilized as a preliminary guide. Such a formula must be tempered with other changing factors found in the herd. Thus it appears that approximately 70 to 75 percent of the expected calf crop may be removed through legal harvest in normal years. This proposed removal is equivalent to 25 percent of the parent spring herd. This prediction would allow annual harvest removals of around 275 head which should stabilize the herd at the 1954 level of 1,000 to 1,100 head. If the illegal elk kill in deer season can be curtailed, annual harvest removals can be proportionately increased. Likewise, the annual kill can be increased

without reducing the calf crop through greater bull removals.

Increased bull harvests should take place so adult sex ratios could be adjusted to at least a pre-hunt ratio of 1 bull to 4 cows. This suggested adult sex ratio spread cannot be achieved, however, unless the number of bull permits is increased. Hunter success for bulls will be reduced proportionately as the bull permits increase. Such a procedure would produce the same size calf crop and at the same time more efficiently utilize the parent herd.

Though numbers of elk removals are important, distribution of the kill is equally significant. It is therefore recommended that the Rich County and North Cache hunts be maintained as separate divisions of the Cache general hunt as has been the procedure since 1953. Justification for these divisions does not infer that distinct populations exist in these areas aside from the regular Cache elk herd, but inadequate harvests were experienced in these areas when hunters were allowed to hunt the total Cache area according to their choice.

Calves comprised 24.8 percent of the classified 1952 summer herd and represented a 33 percent increase to the parent spring herd or a rate of increase of 1.33. Herd bull composition was 26.3 percent, while cows comprised 48.9 percent of this same herd.

Female elk reproduction appeared normal in the Cache elk herd. Ovulation in the total female complement averaged 78.4 and 93.5 percent in October 1952 and 1953, while 96.6 and 100 percent ovulation frequencies were recorded for the October 1952 and 1953 mature female fractions. Some yearling cow elk are capable of and do breed successfully under northern and central Utah conditions; however, ovulation and pregnancy frequencies among yearlings occur at a variable rate. It is reasoned that the extent of yearling precociousness, as evidenced by successful

breeding, is inversely proportional to the severity and duration of the preceding winter while the animals were then calves.

Pregnancy status could not be ascertained through normal macroscopic examination of elk uteri collected in early October since embryological development was not readily evident. Early October collections offered only ovulation incidence.

The tagging program should be continued with additional emphasis on tagging new-born calves in the Mud Flat and North Cache areas. The most effective time for such tagging is around June 1. In addition, should another build-up of elk occur in the Franklin, Idaho, area liason between the Idaho and Utah Fish and Game Departments should be attempted so these elk could be tagged. These North Cache taggings should supplement the present tagging program by providing additional migration data.

Legal harvests annuallly removed 68 to 89 percent of the known annual herd loss during the study period, though complete illegal elk kill during the deer season was not recorded for 2 of the reported seasons. When due consideration is given the categorical loss of illegal elk kill during deer season, legal harvest on the Cache area represented approximately 70 percent of annual herd mortality.

Illegal elk kill during deer season ranked second in total herd drain. Recorded annual losses of around 40 elk have been noted for 2 years of complete coverage during the deer season. Such a loss is an inexcusable waste and every effort is being made to curtail it through law enforcement and educational media.

On the basis of the present findings, accusations regarding excessive elk utilization of the Mud Flat reseeded area appear ill-founded. Elk demonstrated a 5 percent maximum utilization of grass on this reseeded area prior to cattle entries during 1952 and 1953. Similarly, Hardware

Ranch elk, though found on the reseeded area, were not represented in any appreciable numbers.

It can be concluded that the mountainous Cache summer range can be used economically in no other way than domestic livestock and big game use; and, furthermore, that summer livestock use does not curtail present deer or elk production.

The Hardware Big Game Ranch Unit was successfully filling the objectives of its purchase, for around 400 head of elk have wintered there and substantial decreases in elk numbers on the critical Wasatch face winter range have occurred. Depleted common use ranges were observed on adjacent ranges north and east of the ranch property. In view of the Hardware elk range use pattern and excessive common use on limited private and public ranges, it is recommended that (1) the Utah State Department of Fish and Game acquire, lease, or exchange use on private and public lands that these elk have demonstrated to be using in foraging and migrational activities; and (2) dispose of or make range use exchanges of those properties not being utilized by big game during the winter period.

Competition for natural browse forage exists on some common deer and elk winter ranges on the Wasatch face areas. The management practice of curtailing elk numbers in these critical zones by post-season hunts and trapping activities is a sage one and should be continued, thereby reserving these critical ranges for deer winter use.

It was concluded from the present study that the Cache elk herd was reproducing itself normally and was compatible in respect to range conditions with deer and livestock production on summer ranges, while limited incompatibilities existed on restricted winter ranges and a spring-fall range surrounding the northeastern section of the Hardware Ranch. The Cache elk herd should supply optimum hunting to Utah sportsmen and in

general should compete little with deer and livestock production should elk, deer, and livestock numbers remain regulated to the annual forage production of the respective winter and summer ranges.

SUMMARY

1. A management study of the Cache elk herd was initiated during 1951 and field work extended through the 1953 spring period, though limited field work continued until the 1954 winter. This study has been dedicated to the procurement of elk management information on both the North and South Cache units.

2. The study area, located in northeastern Utah, is about 1,025 square miles in size. However, only approximately 760 square miles of the area is forest and range land which elk inhabit.

3. The Cache area is characteristically composed of mountainous terrains ranging from around 4,600 to 9,980 feet above sea level. Precipitation averages around 30 inches on the summer range and approximately 18 inches on the winter range.

4. Five major cover types were present on the Cache area, namely: (1) aspen, (2) conifer, (3) juniper, (4) mahogany, and (5) sage.

5. The present Cache elk population stemmed from reintroductions of 23, 5, and 8 head of elk in the years 1916, 1917, and 1918, respectively. Since the inception of renewed hunting in 1925, the herd has produced 2,846 legally harvested elk to the year 1953, and has experienced a hunter success of 81 percent.

6. Census of the entire Cache area dates back only to the 1951-52 winter herd. Combined aerial and ground enumerations accounted for 817 and 877 elk in the 1951-52 and 1952-53 herds. An estimate of the effectiveness of the 1951-52 aerial and ground census showed that the census at its best accounted for 81 percent of the wintering herd.

7. Past herd sizes were calculated to be around 460 elk at the initiation of hunting in 1925 and a peak wintering herd of 1,275 in 1951. These figures should be tempered with the fact that the uncertainty of herd losses, aside from harvest removal, makes reconstruction of herd numbers difficult and often not too reliable.

8. Best estimates of the 1953 herd size were 1,073 elk in the winter and spring parent herd and 1,452 elk in the summer herd.

9. Cache elk displayed a decided summer preference for the aspen cover type which was situated around 6,000 to 8,500 fee elevation. Winter ranges 5,000 to 8,000 feet elevation in juniper, mahogany, grass, or combination of these types were similarly preferred.

10. Summer and winter migrations were recorded. Tag kill returns plotted on a base map showed that elk wintering at the Hardware Ranch principally summered in the Elk Valley-Bear Hollow and Rock Creek areas. Five hundred and seventy-eight Cache elk have been ear tagged from 1949 to 1953. At the end of the 1953 hunting season 162 or 28 percent of all tags had been returned. Principal assets realized from the tagging program were aging and migration data.

11. Cache bull to cow ratios established from classified winter counts were 1 : 3.5 and 1 : 3.3 during the 1951-52 and 1952-53 winter periods. Summer sex ratio of 1 bull to 1.87 cows, yearling and older, was recorded during 1952. Calf composition of 24.8 percent of the 1952 classified summer herd was thus observed, while 28.8 and 26.7 percent calf compositions were present in the 1951-52 and 1952-53 wintering herds, respectively. The 1952 summer cow-to-calf ratio on the Cache was 1 : 0.51 .

12. An index to herd reproduction was gained through analysis of the female elk reproductive tract. It was found that 78.4 percent of the total female herd had ovulated in early October of 1952, while 96.6 percent

of the mature female sample had done so. Higher ovulation frequencies of 93.5 and 100 percent were noted in the 1953 collection. Current corpora lutea were recorded for 33.3 and 60.0 percent of yearling elk ovaries collected in October of 1951 and 1953. In addition, 3 yearling elk on the Cache and 3 on the Nebo were found to be pregnant during 1953 post-season hunts, respectively.

13. A perusal of Cache elk summer cow-to-calf ratios and limited pregnancy information bear out that Cache elk herd fertility was normal.

14. Annual herd increase for the 1952 parent Cache spring herd was 33.0 percent. Rates of increase were 1.33 in 1952 and a calculated 1.35 in 1953.

15. Legal harvest removals accounted for 259 elk in 1951, 199 in 1952, and 243 head in 1953. Legal harvest comprised 68.5, 76.5, and 89.0 percent of known annual mortality in the 1951, 1952, and 1953 herds. Illegal elk kill was found to be significant during the present study. The principal component of illegal kill thus found was elk killed during the deer season.

16. Crippling losses of 9.8, 5.0, and 8.1 percent of the legal harvest were recorded in 1951, 1952, and 1953 general elk hunting seasons. It is believed, however, that actual crippling losses probably approach 15 or more percent.

17. Elk and cattle were compatible in respect to tolerance on the summer range, though elk were highly intolerant to sheep activity.

18. The "multiple use concept" is all too often a forgotten principle in considering big game and livestock competition. At present stocking levels of domestic livestock and deer and elk populations, there appears little real competition for summer forage on the Cache area. Competition assigned on the basis of the popular concept of competition

involving range and forage use overlaps indicated that 48 percent of the forage consumed by elk in a popular summer range section of the Cache, would be available for cattle or 27 percent for sheep were all elk removed on that range.

19. The Cache summer range can be used economically in no other way than domestic livestock and big game. Forage production was generally adequate to supply deer, elk, and livestock forage demands on common summer ranges and maintain fair range conditions, though excessive big game and livestock use of adjacent Hardware Ranch range was evident. Proposed land acquisition and range exchange uses should improve this situation.

20. The Hardware Ranch, operated by the Utah State Department of Fish and Game, was succesfully fulfilling the objectives of its original purchase; for slightly in excess of 400 elk were known to winter on the ranch site and substantial decreases in elk numbers wintering on the critical Wasatch face range have occurred.

21. Average daily Hardware elk consumption of grass hays over a seasonal winter period ranged from 2.42 pounds per elk per day in 1952-53 to 5.13 pounds in 1951-52. Average feeding costs were $16.68 per head of elk fed during the 1951-52 winter period and $9.48 per head in the 1952-53 season. These costs include only value of hay fed and wages paid during the feeding period.

22. Results of 8 years of operation of the Hardware Ranch point toward successional changes from browse to perennial grass ranges in adjacent meadow feed ground areas utilized by elk only.

23. Even in light of obstacles enumerated in the body of the present report, the writer looks upon the future operation of the Hardware with optimism provided substantial elk increases are not allowed and proposed land acquisitions or range exchange uses are realized.

LITERATURE CITED

Alter, Cecil J. 1941. Climate of Utah. Climate and man- The yearbook of agriculture. USDA. 1147-1158.

Anonymous. 1939. Illegal Cache elk kill during deer season. Utah Coop. Wildl. Res. Unit Files, Logan.

Adams, Lowell, 1951. Confidence limits for the Peterson or Lincoln index used in animal population studies. Journ. Wildl. Mgt. 15(1):13-19.

Allred, Warren J., Robert C. Brown, and Olaus J. Murie. 1944. Disease kills feedground elk. Wyo. Wildl. 9(2):1-8,27.

Armstrong, Ruth Alison. 1950. Fetal development of the northern white-tailed deer (Odocoileus virginianus borealis Miller). Amer. Midl. Nat. 43(3):650-666.

Bagley, George F. 1935. Federal elk commission report. Trans. N. Am. Wildl. Conf. 13:451-457.

Bagley, Lester. 1952. Elk in captivity. Wyo. Fish and Game. 17(5): 20-26.

Bailey, Reed. 1927. A contribution to the geology of the Bear River Range, Utah. M.S. thesis unpublished, U. of Utah. microfilmed.

Banfield, A. W. F. 1949. An irruption of elk in Riding National Park, Manitoba. Journ. Wildl. Mgt. 13(1):127-134.

Buechner, Helmut K., Irven O. Buss, and Homer F. Bryan. 1951. Censusing elk by airplane in the Blue Mountains of Washington. Journ. Wildl. Mgt. 15(1):81-87.

Cahalane, Victor H. 1938. The annual northern Yellowstone elk herd count. Trans. N. Am. Wildl. Conf. 3:388-399.

Caton, John D. 1877. The antelope and deer of North America. Forest and Stream Pub. Co., New York. 426 pp.

Cheatum, E. L. and Glenn H. Morton. 1946. Breeding season of white-tailed deer in New York. Journ. Wildl. Mgt. 10(3):249-263.

Cheatum, E. L. 1949. The use of corpora lutea for determining ovulation incidence and variations in fertility of white-tailed deer. Cornell Vet. 39(3):282-291.

_____ and Phillip L. Wright, 1951. Reproduction in elk. Mont. Coop. Wildl. Res. Quart. Report. 2(1):4.

_____ and J. E. Gaab. 1952. Productivity of north Yellowstone elk as indicated by ovary analysis. Special report No. 2. Mont. Coop. Wildl. Res. Unit. Mont. State Univ. 5 pp. mimeo.

Cliff, Edward P. 1939. Relationship between elk and mule deer in the Blue Mountains of Oregon. Trans. N. Am. Wildl. Conf. 4:560-569.

Coffin, A. Lynn and Jack D. Remington. 1953. Pregnant yearling cow elk. Journ. Wildl. Mgt. 17(2):223.

Conway, Clinton. 1952. The age at sexual maturity in male elk (Cervus canadensis). Jour. Wildl. Mgt. 16(3):313-315.

Cooney, Robert F. 1952. Elk problems in Montana. Jour. Range Mgt. 5(1):3-7.

Cowan, Iaan McTaggart. 1947. Range competition between mule deer, big-horn sheep, and elk in Jasper Park, Alberta. Trans. N. Am. Wildl. Conf. 12:223-227.

Crane, Harold S. 1951. Restoration and management of elk in Utah. Proc. of Annual Conf. of Western Ass'n of State Game and Fish Comm. 31: 165-167.

Craighead, John J. 1952. A biological and economical appraisal of the Jackson Hole elk herd. New York Zoo. Soc. 31 pp.

DeNio, R.M. 1938. Elk and deer foods and feeding habits. Trans. N. Am. Wildl. Conf. 3:421-427.

Drake, Charles H. 1951. Mistaken diagnosis of actinomycosis for osteo-genic sarcoma in an American elk (Cervus canadensis). Jour. Wildl. Mgt. 15(3):284-287.

Esplin, Alma C., Milton A. Madsen, and Ralph W. Phillips. 1940. Agr. Exp. Sta. U.S.A.C. Bull. 292. 12 pp.

Feast, C. N. 1940. The deer and elk problems in Colorado and its related problems. Proc. of Annual Conf. of Western Ass'n of State Game and Fish Comm. 20:12-17.

Gaab, J. E. 1950. West Gallatin winter elk study 1949-1950. Mont. Fish and Game Comm. Quart. Prog. Report. 10(2):15-22.

Gaffney, William S. 1941. The effects of winter elk browsing, South Fork of the Flathead River, Montana. Jour. Wildl. Mgt. 5(4):427-453.

Green, Hubert U. 1950. The productivity and sex survival of elk, Banff National Park, Alberta. Canadian Field Nat. 64(1):40-42.

Green, W. W. and L. M. Winters. 1945. Prenatal development of the sheep. U. of Minn. Agr. Exp. Sta. Tech. Bull. 169. 36 pp.

Hanscum, Charles. 1949. Elk census techniques. Wyo. Wildl. 13(7):28-30.

Hammond, John. 1927. Physiology of reproduction in the cow. Cambridge Univ. Press, London.

Haskel, E. S. 1946. Livestock and big game on national forests. Nat. Wool Growers. 36(8):12-13.

Harrison, R. J. and W. J. Hamilton. 1952. The reproductive tract and the placenta and membranes of Pere David's deer (Elaphurus davidianus, Milne Edwards). Jour. Anat. Great Britain. 86(2):204-225.

Hovey, Merlin R. 1936. An early history of Cache County. M.A. thesis unpublished. Chamber of Commerce, Logan.

Hungerford, Charles Roger. 1952. The food consumption and weight response of elk (Cervus canadensis nelsoni) under winter conditions. M.S. thesis unpublished Mont. State. 75 pp.

Hunter, Gilbert N. 1945. Crippling loss. Big game kill. Colo. State Game and Fish Comm. 2:10-11.

Julander, Odell, W. Leslie Robinette, Arthur D. Smith, and D. M. Gaufin. 1950. A review of Utah's big game, livestock, and range relationship problems. Intermountain For. and Range Exp. Sta. research paper No. 24. 44 pp. mimeo.

Kelker, George Hills. 1947. Computing the rate of increase for deer. Jour. Wildl. Mgt. 11(2):178-183.

_____ 1954. Unpublished rate of increase figures for big game. Utah State Agricultural College, Logan.

Kittams, Walter H. 1953. Reproduction of Yellowstone elk. Jour. Wildl. Mgt. 17(2):177-184.

LaNoue, Francis D. 1938. Census of the Yellowstone elk herd. Univ. of Idaho Bull. 33(22):42-43.

Leonard, Ross. 1946. Biennial report of the State Fish and Game Comm. of State of Utah. 26:36.

Leopold, Aldo. 1933. Game management. Charles Scribner's Sons, N. Y. 481 pp.

Low, Jessop B. 1948. Game and mice compete for forage on Utah ranges - Rodents eat bark and kill shrubs. Utah State Fish and Game Bull. 4(8):1.

_____ and Blair Low. 1949. Deer losses on the Cache deer herd, winter of 1948-49. Utah Coop. Wildl. Res. Unit. 14(3):1-2.

_____ 1953. Vegetation trends at Hardware Ranch Big Game Unit. unpublished. Utah State Agricultural College, Logan. 28 pp.

Maynard, Leonard A. 1951. Animal nutrition. McGraw-Hill. N. Y. 474 pp.

McCormack, Roger J. 1951. A population study of the south Cache elk herd. M.S. thesis unpublished, U. S. A. C. Library, Logan. 88 pp.

Mills, Harlow B. 1936. Observations on Yellowstone elk. Jour. Mamm. 17:(3):250-253.

Mitchell, Glenn E. and Burton Lauckhart. 1948. Management of the Yakima Rocky Mountain elk herd. Trans. N. Am. Wildl. Conf. 13:401-406.

Morton, Glenn H. and E. L. Cheatum. 1946. Regional differences in breeding potential of white-tailed deer in New York. Jour. Wildl. Mgt. 10(3):242-248.

Murie, Adolph. 1940. Ecology of the coyote in the Yellowstone. U. S. Gov. Print. Office. Bull. No. 4. 206 pp.

Murie, Olaus J. 1930. An epizootic disease of elk. Jour. Mamm. 11: 214-222.

_____ 1931. Big game range. Trans. Am. Game Conf. 18:253-261.

_____ 1934. Studies in elk management. Trans. Am. Game Conf. 20: 355-359.

_____ 1951. The elk of North America. The Stackpole Co., Harrisburg, Pa., and the Wildl. Mgt. Inst., Wash., D. C. 376 pp.

Nielsen, Oliver. 1954. Personal interview. Smithfield, Utah.

Olsen, Orange A. 1939. Letter. Utah State Fish and Game Nebo elk files.

_____ 1936. U. S. Forest Service memorandum concerning Utah elk aerial census. Utah State Department of Fish and Game files.

_____ 1942. Managing Nebo's Wapiti. Trans. N. Am. Wildl. Conf. 7:373-379.

_____ 1943. Big game in multiple use in Utah. Jour. For. 41(11): 792-797.

_____ 1945. Elk below. Stevens and Wallis, Inc., Salt Lake City, Utah. 104 pp.

Peterson, Bud. 1935. Report regarding Cache elk herd. Utah Coop. Wildl. Res. Unit Files, Logan.

Pickford, G. D. 1943. Range management includes big game. Nat. Wool Grower. 33(3):18-19.

_____ and Elbert H. Reid. 1943. Competition of elk and domestic livestock for summer forage. Jour. Wildl. Mgt. 7(3):328-332.

Popov, Boris H. and Jessop B. Low. 1950. Game, fur animals and fish introductions into Utah. Utah State Fish and Game Comm. Misc. Pub. No. 4. : 35-38.

Quimby, Don C. and J. C. Gaab. 1952. Preliminary report on a study of elk dentition as a means of determining age classes. Proc. of Annual Conf. of Western Ass'n of State Game and Fish Comm. 32:225-227.

Rasmussen, D. I. and E. R. Doman. 1947. Planning of management programs for western big game herds. Trans. N. Am. Wildl. Conf. 12:204-211.

_____ 1949. The American elk or wapiti today. Trans. N. Am. Wildl. Conf. 14:513-526.

Riordan, Laurence E. 1948. Sexing of deer and elk by airplane in Colorado. Trans. N. Am. Wildl. Conf. 13:409-430.

_____ 1949. Colorado crippling loss survey. Colo. Game and Fish Comm. Quart. Prog. Report. April. : 43-45.

Robinette, W. Leslie and Orange A. Olsen. 1944. Studies of the productivity of mule deer in central Utah. Trans. N. Am. Wildl. Conf. 9:156-162.

_____ and Jay S. Gashwiler. 1950. Breeding season, productivity and fawning period of the mule deer in Utah. Jour. Wildl. Mgt. 14(4):457-469.

Rognrud, Merle J. 1949. A study of big game in the continental and adjacent units. Final Report, Surveys and Investigations, Proj. 1-R, May, 1950. Montana State Fish and Game Dept. 188 pp. multil.

_____ 1950. Spring elk range inspection in the South Fork of the Flat Head. Mont. Fish and Game Comm. Quarterly Progress Report. 10:58-65.

_____ 1953. The population, range, and productivity of the north Nebo elk herd. M.S. thesis unpub. U.S.A.C. Library, Logan. 168 pp.

Rush, W. M. 1932. Northern Yellowstone elk study. Mont. Fish and Game Comm., Helena. 131 pp.

Seton, Ernest T. 1929. Lives of game animals. Vol. III. Doubleday, Doran and Co., N. Y.

Schwartz, John E. and Glen E. Mitchell. 1945. The Roosevelt elk on the Olympic Penninsula. Jour. Wildl. Mgt. 9(4):295-319.

Schwan, H. E. 1945. Big game and livestock on the western range. Trans. N. Am. Wildl. Conf. 10:219-224.

Smith, Glen A. 1930. The Sun River elk herd. Jour. For. 28:644-647.

Standing, Arnold. 1931. Elk propagation and management in Utah. Utah Juniper. U. S. A. C., Logan. 2:11-14,39.

Stoddart, L. A. and Arthur D. Smith. 1943. Range Management. McGraw-Hill, N. Y. 547 pp.

_____ and D. I. Rasmussen, 1945. Deer management and range livestock production. Utah Agr'l Exp. Sta. Cir. 121, Logan. 17 pp.

Swanson, Carl V. 1951. A technique for age determination of elk (Cervus canadensis). Murrelet. 32(2):19-22.

Theurer, David. 1954. Personal interview. Providence, Utah.

Tolman, Carwin D. 1950. Productivity of mule deer in Colorado. Trans. N. Am. Wildl. Conf. 15:589-596.

Turpin, R. L. 1940. Letter concerning illegal elk kill. Utah State Department of Fish and Game files. Salt Lake City.

_____ 1954. Personal interview. Salt Lake City.

Weaver, John E. and F. E. Clements. 1938. Plant ecology. Hill Book Co., Inc. N. Y. 601 pp.

West, Raymond M. 1941. Elk of the northern Rocky Mountain Region. Field notes on wildlife, U. S. Forest Service, North Rocky Mt. Region. 11(9):1-32.

Winters, Laurence M. and George Feuffel. 1936. Studies on the Physiology of reproduction in the sheep, IV, Fetal development. U. Minn. Agr'l Exp. Sta. Tech. Bull. 118. 20 pp.

_____ and R. E. Comstock. 1942. Prenatal development of the bovine. U. Minn. Agr'l Exp. Sta. Tech. Bull. 151.

Young, Vernon A. and W. Leslie Robinette. 1939. A study of range habits of elk on the Selway Game Preserve. U. of Idaho Bull. 34(16):47 pp.

APPENDIX

Appendix Table 1. Comparative winter calf crop data

Winter	Herd and Location	Percent Calves in Winter Herd	Data Source
1939-40	Colo., general	25	Feast, 1940
1946-47	W. Gallatin, Mont.	17.1 (heavy winter loss)	Gaab, 1950
1948-49	Ibid	25.5	Gaab, 1950
1949-50	Ibid	23.7	Gaab, 1951
1949-50	Continental units, Mont.	14	P.R. Quart., Mont. 1950, April
1949-50	Gallatin, Mont.	23	P.R. Quart., Mont. 1950, July
1920-30	Sun River, Mont.	14	Smith, 1930
1950-51	W. Gallatin, Mont	20.4	Gaab, 1951
general	Manti & Nebo, Utah	25	Rasmussen and Doman, 1947
1939-40	Saprinero, Colo.	34.8	Colo. G. & F. vol. 3, 1940
up to 1932	Blue Mts., Oregon	26.5	Cliff, 1939
1932-39	Ibid	18.4	Ibid
1917-34	Highwood Mt., Mont.	27	Rush, 1934
general	Yakima, Washington	20	Mitchel & Lauckhart, 1948
1941-42	S. Fork Flat Head, Mont.	24	Rognrud, 1950
1945-46	Ibid	30	Ibid
1946-47	Ibid	15	Ibid
1947-48	Ibid	13	Ibid
1948-49	Ibid	14	Ibid
1949-50	Ibid	13	Ibid
1944-48	Banff Park, Canada	17.2	Green, 1950
1946-47	Nebo, Utah	26.6	Rognrud, 1953
1951-52	Ibid	31.2	Ibid
1949-50	South Cache, Utah	31.7	McCormack, 1951
1951-52	Cache, Utah	28.8	Author, 1952
1952-53	Ibid	26.7	Author, 1953
1937	Yellowstone	25.0	Murie, 1940
1938	Teton, Wyoming	20	Murie, 1951
1942-43	Yellowstone (herd reduction)	9	Ibid
1935-36	Ibid	16	Ibid
1935-36	N. Yellowstone E.S. hunt (Mont.)	19.1	Ibid
1936-37	Ibid	34.0	Ibid
1937-38	Ibid	16.0	Ibid
1938-39	Ibid	16.0	Ibid
1941-42	Ibid	15.9	Ibid
1942-43	Ibid	13.9	Ibid

Appendix Table 2. Comparative calf and cow winter ratios

Winter	Herd and State	Calf : Cow	Cow : Calf	Data Source
1948-49	N. W. Montana	100 : 540	1 : 0.18	Rognrud, 1950
1949-50	So. Fk. Flat Head, Montana	100 : 530	1 : 0.19	Ibid
?	Banff Park, Canada[1]	100 : 336	1 : 0.30	Green, 1950
1943-44	N. Powder & Wenaha, Oregon	100 : 248	1 : 0.40	P. R. quart., Oregon, 1944
1939-40	Saprinero, Colo.	100 : 163	1 : 0.61	Colo. Game & Fish vol. 3, 1940
1940-41	Jackson Hole, Wyo.	100 : 264	1 : 0.38	Rasmussen and Doman, 1947
1946-47	Nebo, Utah	100 : 187	1 : 0.53	Rognrud, 1953
1951-52	Nebo, Utah	100 : 160	1 : 0.62	Ibid
1949-50	Cache, Utah	100 : 155	1 : 0.65	McCormack, 1951
1950-51	Cache, Utah	100 : 191	1 : 0.52	Author, 1951
1951-52	Cache, Utah	100 : 211	1 : 0.47	Author, 1952

1. Unbiased herd slaughter.

Appendix Table 3. Some comparative winter elk herd compositions

Winter	Herd and location	Percent Cows[1]	Percent Calves	Percent Bulls	Total Sample	Data Source
1939-40	Saprinero, Colo.	56.9	34.8	8.3	1,159	Colo. G. & F. vol. 3, 1940
1946-47	Banff Park, Canada[2]	63.0	17.2	19.8	?	Green, 1950
1948-49	N. W. Montana	69	14	17	?	Rognrud, 1950
1949-50	S. Fk. Flathead, Mont.	71	13	16	404	Ibid
1946-47	Nebo, Utah	49.5	26.6	23.9	226	Rognrud, 1953
1951-52	Nebo, Utah	50.2	31.2	18.5	799	Ibid
1949-50	S. Cache, Utah	49.2	31.7	19.1	606	McCormack, 1951
1951-52	Cache, Utah	55.5	28.8	15.7	812	Author, 1952
1952-53	Cache, Utah	56.3	26.7	17.0	850	Author, 1953

1. Includes yearling cows.
2. Unbiased herd reduction slaughter.

Appendix Table 4. Summary of known Cache elk mortality from August, 1951 to August, 1952

Mortality Factor	Composition of Loss: North Cache				South Cache						Grand Total
	cow	calf	bull	total	cow	calf	antlerless	bull	uncl.	total	
Legal harvest	7	1	6	14			114	131		245	259
Cripple loss				0	12	4		8		24	24
Cripple removal	2			2	4	2				6	8
Nuisance removal				0	5	5		1		11	11
Illegal kill--deer season[1]		1		1	5	1		2		8	9
Illegal kill-elk season				0				1		1	1
Poaching				0	4	1		1	1	7	7
Malnutrition	2	5		7	7	36		2	3	48	55
Trapping accidents						2				2	2
Pneumonia						1				1	1
Undetermined						1				1	1
GRAND TOTAL	11	7	6	24	37	53	204	146	4	354	378

1. Represents a limited coverage of the Cache.

Appendix Table 5. Summary of known Cache elk mortality from August, 1952 to August, 1953

Mortality Factor	Composition of Loss: North Cache cow	calf	bull	uncl.	total	South Cache cow	calf	bull	uncl.	total	Grand Total
Legal harvest	9	3	7		19	85	12	83		180	199
Cripple loss			1		1	3		5		8	9
Cripple removal						1				1	1
Nuisance removal								1		1	1
Illegal kill-deer season	3	1	1	1	6	21	3	10	3	37	43
Poaching								2	1	3	3
Illegal kill-elk season								1		1	1
Legal kill-meat condemned								1		1	1
Undetermined						1		1		2	2
GRAND TOTAL	12	4	9	1	26	111	15	104	4	234	260

Appendix Table 6. Summary of known Cache elk mortality from August, 1953 to February, 1954

Mortality Factor	Composition of Loss: North Cache cow	calf	bull	uncl.	total	South Cache cow	calf	bull	uncl.	total	Grand Total
Legal harvest	15	1	7		23	88	21	111		220	243
Cripple loss	1		1		2	5		7		12	14
Cripple removal								1	1	2	2
Illegal kill-deer season[1]			1	1	2	4		4	2	10	12
Legal kill-meat condemned								1	1	2	2
GRAND TOTAL	16	1	9	1	27	97	21	124	4	246	273

1. Rich County and Blacksmith Fork loss not included.

Appendix Table 7. Haying records, Hardware Ranch, 1952-53

Unit	1952 Bales	1952 Tons[1]	1953 Bales	1953 Tons[2]
South Meadow	285	7.97	250	7.88
Monument Meadow	515	16.22	476	14.99
Lower Meadow	1,533	48.29	1,687	52.64
East Meadow	3,363	105.93	2,535	79.85
TOTAL	5,696	179.41	4,948	155.36

1. Average weight per bale, 61 pounds.
2. Average weight per bale, 63 pounds.

Appendix Table 8. Summary of elk feeding records, Hardware Ranch, 1950-54

A. Winter 1950-51

Month	Bales Fed	Pounds Fed[1]	Tons Fed
Dec.	7	434	0.22
Jan.	691	42,842	21.42
Feb.	782	48,484	24.24
Mar.	643	39,866	19.93
Total	2,123	131,626	65.81

B. Winter 1951-52

Dec.	712	43,432[2]	21.71
Jan.	935	57,035	28.52
Feb.	873	53,253	26.63
Mar.	1,149	70,089	35.04
Apr.	576	35,136	17.57
Total	4,245	258,945	129.47

C. Winter 1952-53

Nov.	32	2,016[3]	1.01
Dec.	226	14,238	7.12
Jan.	411	25,893	12.95
Feb.	493	31,059	15.53
Mar.	258	16,254	8.12
Apr.	34	2,142	1.07
Total	1,454	91,602	45.80

D. Winter 1953-54

Dec.	396	24,948[4]	12.47
Jan.	519	32,697	16.35
Feb.	568	35,784	17.89
Mar.	439	27,657	13.83
Apr.	24	1,512	0.75
Total	1,946	122,598	61.29

1. Weight of bales estimated at 62 pounds each.
2. Average weight of bales was 61 pounds each.
3. Average weight of bales was 63 pounds each.
4. Average weight of bales was 63 pounds each.

Appendix Table 9. Comparative summer cow and calf ratios in various western elk herds.

Year	Herd and Location	Calf : Cow	Cow : Calf	Data Source
1935	Teton, Wyoming	100 : 261	1 : 0.38	Murie, 1940
1937	Yellowstone	100 : 244	1 : 0.41	Murie, 1940
General	N. Yellowstone, Mont.	100 : 233	1 : 0.43	Rush, 1932
1947	Banff Park, Canada	100 : 237	1 : 0.42	Banfield, 1949
1936?	Olympic Penn. Wash.	100 : 164	1 : 0.45	Swartz, et al, 1945
1938	Selway, Idaho	100 : 135*	1 : 0.74*	Young & Robinette, 1939
General	Nebo, Utah	100 : 178	1 : 0.56	Rasmussen & Doman, 1947
General	Manti, Utah	100 : 189	1 : 0.53	Rasmussen & Doman, 1947
1946	Nebo, Utah	100 : 179	1 : 0.56	Rognrud, 1953
1951	Nebo, Utah	100 : 197	1 : 0.51	Rognrud, 1953
1952	Nebo, Utah	100 : 214	1 : 0.47	Rognrud, 1953
1949	S. Cache, Utah	100 : 180	1 : 0.55	McCormack, 1951
1950	S. Cache, Utah	100 : 181	1 : 0.55	McCormack, 1951
1952	Cache, Utah	100 : 197	1 : 0.51	Author, 1952

* Probably excluded yearling cows.

Appendix Table 10. Comparative summer calf crop and adult sex ratio data

Year	Herd and Location	Percent Calf Crop[1]	Bull : Cow	Data Source
1948	Apache Forest, Ariz.	20	1 : 2.8	P. R. Quart., Ariz. 1950, Jan.
1949	Apache Forest, Ariz.	25.9	1 : 2.8	Ibid
1948	Sitgreaves Forest, Ariz.	24.6	1 : 1.9	Ibid
1949	Sitgreaves Forest, Ariz.	19.4	1 : 1.9	Ibid
1948	Coconino Forest, Ariz.	23	1 : 1.8	Ibid
1949	Coconino Forest, Ariz.	20.7	1 : 1.7	Ibid
1949	S. Cache, Utah	25.8	1 : 1.68	McCormack, 1951
1950	S. Cache, Utah	25.0	1 : 1.70	McCormack, 1951
1952	Cache, Utah	24.8	1 : 1.75	Author, 1952
1946	Nebo, Utah	25.4	1 : 1.57	Rognrud, 1953
1951	Nebo, Utah	26.0	1 : 2.20	Rognrud, 1953
1952	Nebo, Utah	24.8	1 : 2.41	Rognrud, 1953
1947	Nebo, Utah		1 : 1.6	Rasmussen & Doman, 1947
1941	Manti, Utah		1 : 1.8	Rasmussen & Doman, 1947

1. Herd increase expressed as percent calf crop of total summer herd--technically this represents composition only.