SUSITNA HYDROELECTRIC PROJECT

PHASE I FINAL REPORT

BIG GAME STUDIES

Volume VI BLACK BEAR and BROWN BEAR

Sterling D. Miller

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ALASKA DEPARTMENT OF FISH AND GAME

Submitted to the Alaska Power Authority

March 1982

PREFACE

In early 1980, the Alaska Department of Fish and Game contracted with the Alaska Power Authority to collect information useful in assessing the impacts of the proposed Susitna Hydroelectric Project on moose, caribou, wolf, wolverine, black bear, brown bear and Dall sheep. This information, along with information on furbearers, small mammals, birds, and plant ecology collected by the University of Alaska, is to be used by Terrestrial Environmental Specialists, Inc. of Phoenix, New York, in preparation of exhibits for the Alaska Power Authority's application for a Federal Energy Regulatory Commission license to construct the project.

The studies were broken into phases which conformed to the anticipated licensing schedule. Phase I studies, January 1, 1980 to June 30, 1982, were intended to provide information needed to support a FERC license application. If the decision is made to submit the application, studies will continue into Phase II to provide additional information during the anticipated 2 to 3 year period between application and final FERC approval of the license.

Wildlife studies did not fit well into this schedule. Data collection could not start until early spring 1980, and had to be terminated during fall 1981 to allow for analysis and report writing. (Data continued to be collected during winter 1981-82, but could not be included in the Phase I report.) The design of the hydroelectric project had not been determined. Little data was available on wildlife use of the immediate project area, although some species had been intensively studied nearby. Consequently, it was necessary to start with fairly general studies of wildlife populations to determine how each species used the area and identify potential impact mechanisms. This was the thrust of the Phase I Big Game Studies. During Phase II, we expect to narrow the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

Therefore, the Final Phase I Report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on big game.

The reports are organized into the following eight volumes:

Volume I.	Big Game Summary Report
Volume II.	Moose - Downstream
Volume III.	Moose - Upstream
Volume IV.	Caribou
Volume V.	Wolf
Volume VI.	Black Bear and Brown Bear
Volume VII.	Wolverine
Volume VIII.	Dall Sheep

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I. SUMMARY OF PERTINENT FINDINGS-BEAR STUDIES

Projected impacts of proposed hydroelectric development on upper Susitna River populations of brown and black bears were investigated in 1980 and 1981. The preliminary investigations for Phase I of the impact assessment that are reported here were designed to reveal the kinds of impacts which might result from the proposed project, quantitative assessments of actual impacts were, in most cases, postponed until Phase II of the assessment studies scheduled to begin in 1982.

In Phase I a sample of both species was radio-collared and periodically monitored in order to identify the patterns of use of areas that would be impacted by the proposed project. This analysis was based primarily on a total of 518 brown bear and 724 black bear locations in the study area, collected between April 1980 and October 1981 for black bears and between April 1980 and 1 September 1981 for brown bears. These termination dates represent analytical deadlines, data collected subsequently are being analyzed.

The sample of radio-collared adult brown bears was considered representative in terms of age structure but biased against males. In comparison with other North American brown bear populations, the study area population appeared highly productive and moderately dense. An estimate of 1 bear/41-62 km^2, obtained in 1979 in a nearby study area, was considered the best available approximation of brown bear density in the study area.

Brown bear harvests by hunters have averaged 64/year in 1973-1980 in Game Management Unit 13 (range 44-84), 15/year in the project study area (9-24). Improved access and increased human populations during project construction and operation are expected to result in substantially increased hunting effort and harvest.

The mean elevation of 29 brown bear den sites was 4,818 feet (range=2330-5150 feet). No brown bear den discovered to date would be inundated by the proposed impoundments but some were in areas where disturbance during project construction or operation could result in abandonment or avoidance of den sites.

Brown bear home ranges were highly variable between individuals and years. The mean home range of 11 bears in 1980 was 422 km^2, 487 km^2 in 1981. Home range sizes varied from 50-2655 km^2. Larger home ranges in 1981 relative to 1980 may have resulted from a relatively poor berry crop in 1981. Brown bears captured along the Susitna River ranged over a total area of 8,473 km^2. This represents a minimum estimate of the area in which brown bears would be affected by the proposed impoundments.

The period of peak use of areas directly impacted by the proposed impoundments was in spring and early summer. During this period 62% of radio-collared brown bears were located within 1 mile of the proposed impoundment in 1981, 50% in 1980 (excludes females with newborn offspring). In both years 30% of all observations of these bears were within this, conservatively defined, impoundment impact zone. We suspect that brown bears tend to move to lower elevations near or in the impoundments in early spring because of the relatively earlier availability of vegetable forage in these areas; prey, especially moose calves, may also be more available in this impoundment impact area. This pattern was not followed by females with newborn cubs, these bears tended to remain at high elevations away from the impoundments. Perhaps this avoidance of areas where other bears concentrate is adaptive in minimizing intraspecific predation on their cubs.

This same pattern was verified by statistical analyses of locations of brown bears within 3 nested regions of the study area: The actual impoundment, within 1 mile of the impoundment shoreline, and 1-5 miles from the shoreline. Here observed use in the actual impoundment area was greater than would have been expected on the basis of the relative size of the impoundment area. This difference was especially marked in the spring when observed use was 4 times greater than expected under the null hypothesis of no selectivity.

This same pattern was evident in analyses of the habitats where relocated brown bears were found. Use of spruce habitats which occur primarily in the vicinity of the impoundments was significantly higher in the spring than during the rest of the year.

Data on availability of different vegetation types based on the type maps prepared by the Plant Ecology Subtask were not partitioned in a way that would permit meaningful analyses of selectivity of these different vegetation types for the area mapped at the 1:63,360 scale. Appropriate partitioning of these data were available for the actual area that would be flooded by the proposed impoundments, however. Analyses of these data suggested that brown bears tended to select for mixed conifer-deciduous forest types in the Watana impoundment area.

Brown bear movements to areas of seasonally reoccurring food abundance may be blocked or inhibited by the proposed impoundments. Such movements may include movements to Prairie Creek or downstream along the Susitna to fish for salmon (both have been documented), or movements to moose or caribou concentration areas such as calving grounds (movements to caribou concentrations were also documented). Movements to Prairie Creek by bears from an area of 5,773 km^2 were documented in this study, these movements required crossing the impoundments and the proposed access roads.
Brown bear predation rates were intensively monitored (once/day) in spring 1981. A kill rate of 1/10.2 days was observed, substantially lower than has been recorded in more intensive studies conducted in 1978 in nearby areas. The observed kill rate was suspected to be biased because of relatively infrequent moni-

toring and relatively poorer visability caused by more dense vegetation in the study area.

More accurate data on predator-prey relationships based on intensive monitoring of radio-collared moose and caribou calves are proposed for Phase II of these investigations. More intensive brown bear food habits studies based on feces analysis are also proposed for Phase II, these studies should concentrate on spring and early summer uses of impoundment-impact areas.

A summary of expected impacts on brown bear populations caused by the proposed impoundments include: 1. Reduction of habitat, especially habitats used selectively in spring and early summer; 2. Increased human presence which would result in increased hunting, defense of life and property kills, and disturbance; 3. Inhibition or blockage of seasonal movements to areas of food concentration; 4. Disturbance of den sites; 5. Indirect impacts through reduction of availability of important prey items including moose, caribou, and downstream salmon; and 6. Climatic changes which alter the availability or abundance of food resources, especially early in the spring.

The sample of radio-collared adult black bears was considered representative in terms of sex ratio and age structure. In comparison with other North American black bear populations, black bears in the study area appeared to be productive although possibly having an older age of reproductive maturity and higher rate of cub mortality than an intensively studied population on the Kenai Peninsula. No good density estimate was obtained for the study area although a rough estimate of 1 bear/4.1 km^2 was obtained in one relatively open area based on aerial observations of marked and unmarked bears.

Black bear harvests have averaged 66/year in 1973-1980 in Game Management Unit 13 (range=48-85), 8/year in the project study area (1-15). Improved access and increased human population during project construction and operation are expected to result in substantially increased hunting effort and harvests. These changes alone could easily eliminate black bears resident in the highly constricted post-impoundment forested habitat remaining in the vicinity of the upper impoundment.

Fourteen black bear den sites used in 1980/81 were located and measured, an additional 19 dens being used in 1981/82 have been tentatively located from the air. All but one den was below 3,000 feet elevation, most were in the immediate vicinity of the proposed impoundments. Of 13 dens found in the vicinity of the proposed Watana impoundment, 9 will be flooded at an impoundment elevation of 2,200 feet, the mean elevation of these dens was 2,177 feet (1,800-2,750 feet). In the vicinity of the proposed Devils Canyon impoundment, 1 of 16 known dens would be flooded at an impoundment elevation of 1450 feet, the mean elevation of these dens was 2,178 feet (1490-4340 feet). A higher proportion of black bears in the study area den in natural cavities and re-use den sites than has been recorded in other Alaskan studies suggesting relative scarcity and competition for acceptable den sites in the study area. The impact of the Watana impoundment on black bear denning areas is expected to be severe, based on these data. Much less impact is expected for the Devils Canyon impoundment.

Black bear home ranges were significantly larger in 1981 (mean= 251 km^2, range=19-1051) than in 1980 (mean=31 km^2, range=3-136). We suspect the increased movements observed in 1981 reflect, for the most part, the relatively poor berry crop which forced bears to move greater distances in search of forage. The total area encompassed by movements of radio-collared black bears was 4,196 km^2; much of this area away from the river was considered unacceptable or poor black bear habitat.

Acceptable black bear habitat in the study area was largely confined to a narrow finger of forested habitat along the Susitna River; these are the areas which will be the most impacted by the proposed impoundments. In late summer many black bears moved to shrubland habitats adjacent to these spruce forests to forage for ripening berries, generally returning to the forested habitats to den in September. Such shrubland habitats that are also adjacent to forested escape habitat are limited in extent and would be impacted by construction facilities (such as the current site of Watana Camp), borrow areas D and F, and access roads.

Analysis of the location data within the 3 nested zones of the study area (impoundment area, 1 mile from impoundment shoreline, and 1-5 miles from the shoreline) revealed exceptionally high selectivity by black bears. In the area that would be flooded by the proposed Watana impoundment, black bear use was 2-4 times higher than expected based on the relative area of this zone, use was also higher than expected in the zone 1 mile from the impoundment shoreline. For the Devils Canyon impoundment observed use exceeded expected values in the area within 1 mile of the impoundment shoreline. These analyses verify that each impoundment would have a major direct impact on habitats used by black bears, and that this impact would be much more severe in the vicinity of the upper impoundment than in the vicinity of the lower impoundment.

Analyses of selectivity for the different vegetation types mapped at the 1:63,360 scale by the Plant Ecology Subtask could not be accomplished as discussed for brown bear. However, as for brown bear, such analyses were possible in the area that would actually be flooded by the Watana Impoundment. Here use varied significantly from values expected under the hypothesis that black bears were randomly using all vegetation types. Open birch and closed birch habitats appeared to be the most favored types. A high proportion of these 2 vegetative types would be inundated by the proposed impoundments.

Three radio-collared black bears moved downstream below the Devils Canyon damsite in 1981. These movements were suspected to be motivated by spawning salmon in this region. It is not known whether these movements occur also in years of normal berry production. However, dam-related changes in the abundance of salmon downstream of Devils Canyon would impact these bears as well as black and brown bears that are resident in this area. Given the probability of major impacts on spawning salmon downstream of Devils Canyon, downstream bear studies are needed in Phase II of impact assessment studies.

As discussed for brown bears, relatively low predation rates by black bear on moose calves were observed. Biases resulting from relatively infrequent monitoring and poor sightability of kills are expected to account for the low observed predation rates. Predation rate studies based on radio-collared calves are needed in Phase II to document the indirect effects of reduction of moose and, perhaps, caribou populations on black and brown bears. Black bear food habits studies based on fecal analysis are also needed in Phase II.

A summary of expected impacts on black bear populations caused by the proposed impoundments include: 1. Inundation of scarce denning habitats (especially in the upper impoundment area), 2. Habitat elimination through inundation, 3. Increased human disturbance and hunting resulting from project construction, operation, and improved access, 4. Increased predation by brown bears resulting from decreased availability of berry-rich shrublands which are also adjacent to forested escape habitat, 6. Reduction of prey items (downstream salmon, moose calves and, perhaps, caribou), 7. Impoundment related climatic changes which alter the availability or abundance of food resources.

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V. INTRODUCTION

Black bear (*Ursus americanus*) and brown bear (*U. arctos*) are widely distributed and abundant in Alaska. Black bear distribution in Alaska coincides closely with the distribution of forests, with the most abundant populations occurring in "open" forests rather than heavy timber; extensive open areas are usually avoided. Brown bears seem best adapted to open areas of tundra or grasslands although, like black bears, they inhabit a variety of different habitats in Alaska.

Taxonomically there is only one species of brown-grizzly bear. In common usage the term brown bear is utilized to refer to southern ~~and coastal populations of~~ this species and grizzly bear refers to northern and interior populations. Typically "brown" bears are larger and darker than "grizzly" bears. The brown-grizzly bears along the Susitna River described in this report are, most appropriately, referred to as brown bears.

Black bears in Alaska tend to be smaller than in many areas of the contiguous United States, adults commonly weigh 100-200 lbs. Several color phases of black bears are known, the Susitna population includes individuals that are black, cinnamon, and dark brown.

In Alaska, both species of bears spend the winter in dens. Black bears use a variety of den sites including excavations on hillsides or under logs and trees and natural cavities in rock-piles, caves or hollow trees. Brown bears most commonly den in well excavated holes on high mountain slopes. The denning period for both species typically runs from October through April or May but annual, geographic, and individual variations are common. In the Susitna area available observations suggest that black bears enter dens earlier and emerge later than brown bears.

Brown bears are more aggressive and dangerous to man than black bears, this may be the result of evolution in a more open environment without trees to serve as escape habitat and the corresponding need for more aggressive behavior to protect themselves and their offspring (Herrero 1972). The corresponding danger to man combined with the increased vulnerability to hunting associated with more open habitats, has led to great reductions in brown bear distribution and abundance in the contiguous United States. Except in Alaska and parts of Canada, the species is currently classified as endangered. Black bears, on the other hand, are still abundant throughout most of their original range.

Both species have evolved generalist and opportunist strategies and are, correspondingly, biologically compatible with many kinds of man-caused disturbances of their habitat. However, experience has amply demonstrated that brown bear abundance is usually incompatible with increasing human presence except in a few parks where bears are given a legal priority over human developmental activities. Both species of bears are omnivorous, eating a wide variety of grasses, sedges, other herbaceous plants, roots and berries as well as animal protein when available. Populations with access to salmon may heavily utilize this resource during portions of the year. Brown bears have recently been shown to be significant predators on moose calves in the upper Susitna-Nelchina Basin area (Ballard et al. 1980).

Brown bear research has been undertaken since 1978 in the Nelchina and Susitna River Basins. This research has concentrated on the magnitude and effects of brown bear predation on moose but considerable life history data were also collected (Ballard et al. 1980, Spraker et al. 1981). In this region, federal predator control programs conducted from 1948 to 1953 are suspected to have reduced bear populations to low levels.

In the last 20 years brown bear populations have increased and the current population appears to be abundant, young and productive. Fall harvests in the period 1973-1980 averaged 64 bears/year (30-84 bears/year) in Alaska's Game Management Unit (GMU) 13. This level of harvest is suspected to be less than the maximum sustainable yield of this population. In 1980 and 1981 a May 10-25 bear season was held in addition to the normal 1 Sept. - 31 Oct. season. In 1982 the spring season will be extended to 25 April - 25 May.

The abundance of black bears and relatively light hunting pressure in these areas permits a year-long open hunting season and an annual bag limit of three bears. An annual average of 66 black bears have been taken in GMU 13 from 1973-1980 (58-85 bears/year). Relative to brown bears, black bears are more productive and this population could sustain higher levels of harvest. Black bear research has not been previously conducted in the Susitna or Nelchina River Basins. The only ongoing Alaskan black bear research project is on the Kenai Peninsula, this project is being conducted by C. Schwartz (ADF&G). A Forest Service black bear denning project in southeastern Alaska is being conducted by A. Erickson (U. of Washington, Seattle).

The overall objectives of black bear and brown bear studies mandated by proposed hydroelectric development on the Susitna River are:

> "To determine the distribution and abundance of black and brown bears in the vicinity of proposed impoundment area; seasonal ranges, including denning areas, and movement patterns of bears; and seasonal habitat use of black and brown bears."

In Phase I of these studies, emphasis has been placed on determination of relative abundance and seasonal distribution of the two species, in the vicinity of proposed impoundments, and on collection of baseline information on basic biology of impact-area bears in order to compare Susitna-area populations with populations elsewhere. With these kinds of data available, Phase II investigations can concentrate on quantification of the levels of potential impacts and on the reasons for them.

Acknowledgements

Many individuals have contributed in meaningful ways to this study. Karl Schneider (ADF&G) deserves special mention for his help and support in the office and in the field. Other Su-Hydro project staff (ADF&G) also assisted in various ways including: W. Ballard, C. Gardner, J. Westlund, K. Pitcher, P. Arneson, R. Modafferi, J. Dau and S. Albert. Especially valuable assistance was provided by the Su-Hydro data processing, biometrics, and geoprocessing staff: D. Anctil, S. Miller, and L. Van Daele. Danny Anctil, in particular, was important in his skillful and dedicated efforts to apply a new technology, geoprocessing, to our data. Important contributions were also made by other ADF&G staff including: S. Eide, J. Faro, C. Schwartz, E. Goodwin, L. Miller, L. Glenn, A. Franzmann, R. Tobey, T. Spraker, R. Kramer, H. Reynolds, M. Chihuly, P. Martin and P. Mendes. Our office staff (C. Reidner, L. Lewis, S. Lawler, P. Miles, and A. Fridman) were helpful in the preparation of these difficult reports. Karl Schneider and G. Bos (ADF&G) reviewed the manuscript.

Our helicopter pilots (V. Lofstedt and C. Lofstedt) and fixed-wing pilots (A. Lee, K. Bunch, B. Lofstedt, M. Hauke, D. Wilson, R. Halford, and C. Allen) deserve special mention for the safe, efficient and skillful services they provided. Additional assistance was provided by several helicopter pilots on contract to Acres at Watana camp. Two Fish and Wildlife Protection officers also assisted in 1980: Mike Mayberry and Dan Bunselmeier.

Thanks go to the Denali Mining Company for allowing us to use their strip at Susitna Lodge and to Adventures Unlimited for fuel storage and accommodations.

Numerous members of Acres and TES staff provided assistance in various ways; Granville Couey (Acres), the Watana Camp Manager, was especially cooperative. Dr. Richard D. Taber (TES consultant) provided many helpful suggestions and valuable advise.

The Department of Natural Resources (DNR) provided access to their geoprocessing hardware and software and assisted our staff in our data analysis chores on their computer. Additional equipment and geoprocessing support was provided by G. Cook and C. Barnhart of the Habitat Protection Section (ADF&G).

VI. METHODOLOGY

Brown and black bears were captured by procedures described in Spraker et al. (1981) and Ballard et al. (1980). In brief, fixed-wing aircraft (PA-18) were used to search for bears and bears were immobilized from a helicopter (Bell 206B). Drugs utilized included Phencyclidine hydrochloride (Sernalyn), etorphine (M99) and its antagonist Diprenorphine (M50-50), Ketamine hydrochloride (Vetelar), and xylazine (Rompun).

Standard morphological measurements were taken of immobilized bears. When terrain conditions permitted, weights were obtained by means of a scale suspended from the helicopter or a hand-held scale. Specimens of blood and hair were collected to assess physiological condition. Identifying marks applied to bears included: lip tattoos, ear tags, and ear flags. In 1981 collared flags were attached to these radio-collars (red for males, white for females) and ear flags were not utilized. Individual bear numbers referred to in this report represent tattoo numbers preceded by a "G" for brown bear and a "B" for black bears.

Bears judged to have completed 80 percent or more of their growth were fitted with radio-collars which transmit in the range of 148.0-153.9 MHz. Most transmitters had mortality sensors which halve the pulse rate when the collar is stationary for 2 hours, this permits recognition of when a collar has been shed or the bear is dead and also prolongs battery life by reducing electrical draw when bears are in dens.

Bears were captured on 10 April-7 May and 18-19 August, 1980 and on 5-9 May and 6-7 August, 1981. Two yearling black bears accompanied by their radio-collared mothers were captured and marked in their 1980/81 dens. The August tagging efforts were designed primarily to capture black bears on mid-summer habitats, away from their winter dens. These summer captures avoided den-site selectivity biases which may have resulted had only spring-captured bears been followed to their dens. A chronological list of all bears handled is presented in Tables 1 & 2.

Attempts to locate radio-collared animals were made on approximate 10 day intervals in 1980 and weekly in 1981. Actual flights varied from this schedule depending on weather conditions and aircraft availability. Most radio location flights were made in a Cessna 180 based in Anchorage and refueled at Susitna Lodge or Talkeetna. Flights in 1980 were made on: 14, 22 and 29 May, 4, 12 and 23 June, 2, 10, 18 and 22 July, 4, 14, 22 and 27 August, 9 and 29 September and 9, 13, and 27 October. Flights in 1981 were made on: 7 and 21 April, 5-10, 15, 21 and 29 May, 10, 18 and 21-23 June, 1, 22 and 29 July, 4, 6-7, 17 and 24 August, 1, 9, 16 and 22 September, and 1, 7, 16 and 30 October. In addition, from 21 May - 23 June 1981 daily monitoring was conducted of selected individuals to evaluate predation rates; the majority of these daily bear observations were collected concurrently with intensive monitoring of moose & wolves by Glennallen Su-Hydro staff (Ballard, Gardner and Westlund). Additional radio-locations were made in conjunction with flights to locate other species in the Susitna study area. Reasonable efforts were made to visually observe all radio-located bears. The locations of all non-marked bears spotted during radio-location flights were also recorded. Locations were plotted on US Geological Survey maps (scale 1:63,360) and information on habitat type, behavior, associations, topography, etc. were recorded.

In 1980 the habitats in which bears were observed was recorded in the following 17 habitat types:

1. Sparse tall spruce
2. Mod. tall spruce
3. Mod. tall spruce (riparian)
4. Sparse med. spruce
5. Mod. med. spruce
6. Dense med. spruce
7. Sparse low spruce
8. Mod. low spruce
9. Dense low spruce
10. Riparian willow
11. Upland willow
12. Willow birch
13. Aspen
14. Riparian hardwood
15. Marsh
16. Alder
17. Rock/ice

In 1981 these habitat types were expanded to include:

18. Sedge-grass tundra
19. Alpine herbaceous tundra
20. Shrub tundra (mostly dwarf birch, *Betula nana*)
21. Mat & cushion tundra
22. gravel bar
23. Mixed spruce/birch.

This expansion of habitat-types was designed to coordinate classifications with the vegetation-type categories being utilized by the Su-Hydro vegetation analysis team from the U. of Alaska, Agricultural Experimental Station. The tundra classifications utilized in 1981 would have been classified as upland willow or willow-birch in 1980.

Sufficient numbers of observations have not yet been collected to make all 23 of these classification-types meaningful. Therefore, for the gross comparisons of habitat use frequencies discussed in this report, these types were lumped as follows:

SPRUCE: Types 1 - 9,
RIPARIAN: 10, 13, 14, 22, and 23,
SHRUBLANDS: 11, 12, 16, and 20,
TUNDRA: 18, 19, and 21, and
OTHER: 15 and 17.

As mentioned above, the "tundra" categories were not used for the 1980 observations and will be underrepresented in the data presented, especially since, for brown bears, the data are compiled only through 1 September 1981. The "other" category includes a few marsh observations but primarily represents observations on rock and ice. Habitat classifications were made from the aircraft for a total of 518 brown bear observations and 724 black bear observations. For 81(16%) of the brown bear observations and 227(31%) of the black bear observations, 2 habitat categories were recorded when the observation was made (the bear was in an ecotone or a mixed association). When 2 habitat hits were recorded, each was treated independently in our analyses. This resulted in more habitat hits than observations. Brown bears had a total of 599 habitat hits and black bears 951.

Preliminary habitat utilization analyses were conducted in two ways. The first analysis was based on the above-listed habitat categories recorded when the observation was made. No analysis of habitat-availability was possible on the basis of this analysis. The second habitat analysis was based on a physical overlaying of point-locations where bears were found on the 1:63,360 scale vegetation maps developed by the Agricultural Expt. Station. Vegetation types on these maps were interpreted from air photos within an approximate 5 mile strip on each side of the river. Availability information for these vegetation-types on this map are available for portions of the study area. Availability for the actual impoundment area vegetation types was taken from 1:24,000 scale maps, elsewhere the 1:63,360 scale was used. Many bear locations fell outside of the area mapped at this scale.

In 1981, each observation was categorized by the level of accuracy by which the location could be plotted on a 1:63,360 scale map: High=0-0.01 mi^2, moderate=0.01-0.05 mi^2, (low=0.05-0.20 mi^2), very low = >0.20 mi^2.

All data recorded during flights plus the above habitat data calculated subsequently were entered on computer data files by ADF&G Su-Hydro biometrics and data-processing staff. Point-locations were transferred to digetized point-locations and analyzed for home range sizes, distances between points and movement rates from these data using geoprocessor software (ALARS) on the Data General computer system maintained by the Department of Natural Resources. Plotting routines associated with this system were utilized to produce most of the maps and illustrations utilized in this report. Many of the data generated by the geoprocessor were entered for analysis onto the computer data file for observation information. For a more thorough discussion of these analytical procedures see the section on biometrics and data processing in the first annual report of ADF&G Su-Hydro big game studies (Miller and Anctil 1981).

Bear use of areas in the proximity of the Susitna River was examined by comparisons of use in 3 concentric zones: Within the actual impoundment area (159.3 km^2 for Watana and 28.9 km^2 for Devils Canyon), within a 1 mile zone surrounding each impoundment (incorporating about 486.6 km^2 for Watana and 193.7 km^2 for Devils Canyon, including the impoundment zone), and within a 5 mile zone surrounding each impoundment (incorporating 1,795.6 km^2 for Watana and 958.2 km^2 for Devils Canyon, including the 1 mile impoundment zone) (Fig. 3). The 5 mile polygons for each impoundment overlap by 151 km^2. The calculated values for the areas of the Watana and Devils Canyon impoundments respectively were 99.4% and 124.6% of the values reported for these impoundments in the subtask report for Plant Ecology prepared by the Agricultural Expt. Station, University of Alaska, (see Table 22 of this report). These differences doubtless reflect errors resulting from the different scales at which area calculations were performed. Proximity analyses were approached in two ways.

First the area of each individual bear's home range that overlapped each proximity polygon was calculated and expressed as a percentage of that individual's total annual home range. These percentage figures can exceed 100% when a portion of the home range overlaps the area of intersection of the polygons surrounding both impoundments; the percentage value would be 200% if an individual's home range was entirely within this area of intersection. Such individuals are in the zone of impact of each dam.

The second type of proximity analysis examined the proportion of locations within each of these 3 proximity zones. The null hypothesis that bears were randomly using these three concentric zones would be rejected if the number of locations in each zone was not in the same proportion as the area of that zone. The areas of the 1 and 5 mile zones for this analysis were, respectively, 327 km^2 and 1,234 km^2 for the Watana impoundment and 165 km^2 and 690 km^2 for the Devils Canyon impoundment. The area of overlap between the 5 mile polygons was divided at the Watana dam site so that half of the overlap area was subtracted from the 5 mile polygon for each impoundment. Similarily, point locations that fell within the zone of overlap or outside of any proximity polygon were divided so that each point was only counted once. The dividing line was a north-south line bisecting the overlapped area, points to the west of this were counted in the Devils Canyon analysis and those to the east in the Watana analysis. This analysis understates bear use of the riparian habitat along the Susitna River as many points near the river that are outside of the 5 mile polygons (because they are upstream or downstream of the impoundment zone) are not recognized as being near the river. Some bias also entered into this analysis because of insufficient numbers of data points to conduct the analysis on a seasonal basis.

Some biological significance to the 1 and 5 mile impact zone figures was obtained by comparisons with the "average home range diameter" (AHRD) of each species. "Home range diameter" was calculated by assuming that the calculated home range of each individual was circular in shape, the diameter of this circle was used in calculating AHRD. This is a minimal estimate of true home range diameter as a circle is the minimal way of encompassing any area. The AHRD for brown bears was 16.4 miles (range 8.5-45.0 miles) and for black bears it was 8.3 miles (1.9-19.5 miles). By these criteria the 1 and 5 mile proximity figures represent, respectively, 6% and 30% of the AHRD for brown bears and 12% and 60% of the AHRD for black bears. These calculations clearly indicate that a 5 mile proximity polygon is a very conservative estimate of the actual impact zone, especially for brown bears. For statistical purposes, however, it was considered necessary to use these minimal estimates of impact zones in making comparisons of bear use of concentric impoundment proximity zones.

Blood samples were analyzed for condition indices by Pathologists Central Laboratories, Seattle. Hair samples are stored for potential trace element analyses. Teeth were collected for aging according to procedures described by Stoneberg and Jonkel (1966) and Johnson and Lucier (1975). Feces collected during capture are stored for food habits studies (anticipated for Phase II), and thin layer chromatographic techniques are being tested on these specimens for potential utility in separating field-collected feces of brown bears from those of black bear (Appendix 6). This is an essential element of any food habits study based on fecal analyses in areas where both species are sympatric.

Den locations of radio-collared bears were marked on the ground in winter 1980/81 and were visited 27 May-1 June at which time den measurements were taken and den characteristics recorded. Corresponding marking and measurements have not yet been accomplished for 1981/82 den sites, correspondingly, the data presented for these dens are preliminary (based on aerial locations only) and subject to change once dens are marked and visited in 1982.

VII. THE STUDY AREA

Captured bears were located along the Susitna River and its tributaries between Devil Creek (T32N/R8W, Talkeetna Mts. Quad) and the Vee site or gaging station (T30N/R10E, Talkeetna Mts. Quad). The most distant bear captured south of the Susitna River was G293 (upper Tsisi Creek), 25 km south of the Susitna River. The most distant bear captured north of the Susitna River was G312 (T21S/R4W, Healy Quad), about 30 km north of the Susitna River. All black bears and about half of the brown bears were captured within 5 km of the Susitna River.

Based on movements of radio-collared brown bears, the study area was expanded to include upper Chunilna Creek, the whole of Prairie Creek, the height of land separating upper Susitna drainages from Talkeetna River drainages, Kosina Creek, and drainages of the Susitna as far east as the Oshetna River, and upper Jay, Watana, Deadman and Tsusena Creeks. One subadult male brown bear (G342a) emigrated to the Petersville area outside of the illustrated study area. The total area encompassed by movements of radio-collared brown bears (excluding G342a) included approximately 8,473 km^2 (Figure 1). Because of the difficulty of radio-monitoring this large area, most monitoring efforts were concentrated on a core area within 15 km either side of the main Susitna River, encompassing an area of only about 1,000 km^2. Bears ranging outside of this core area were radio-located less frequently than bears with a greater portion of their home ranges within the core area.

Within this study area, black bears were much less ubiquitous than brown bears. The main black bear study area was southeast and east of Devil Mountain to Tsusena Creek (T31-32N/R5-7W), an area which would be impacted by construction of the Devil Canyon dam. A secondary black bear study site, which would be impacted by the Watana dam, was centered around Deadman Creek or (T32N/R4-5W). The most upstream radio-collared black bear was upstream of the confluence of the Susitna and Tyone Rivers in late summer 1981; this bear moved back downstream in the fall. Two black bears moved downstream to the vicinity of Gold Creek in late summer 1981, one of these returned to the primary study area to den. The black bear study area is indicated in Figure 2. The area incorporated by connecting the outermost points of recorded black bear observations (Fig. 2) was 4,198 km^2. Over half of this area, however, was not considered acceptable black bear habitat.

VIII. RESULTS AND DISCUSSION - BROWN BEAR

VIII. - A. SEX AND AGE COMPOSITION OF STUDY ANIMALS - BROWN BEAR

The number of brown bears captured in connection with Su-Hydro studies in 1980 and 1981 totaled 53. This total includes 11 recaptures of bears in order to replace radio-collars. Six bears, primarily males with large necks, shed their radio-collars (G277, G279, G214, G295, G309, and G347), and 4 bears were known to have

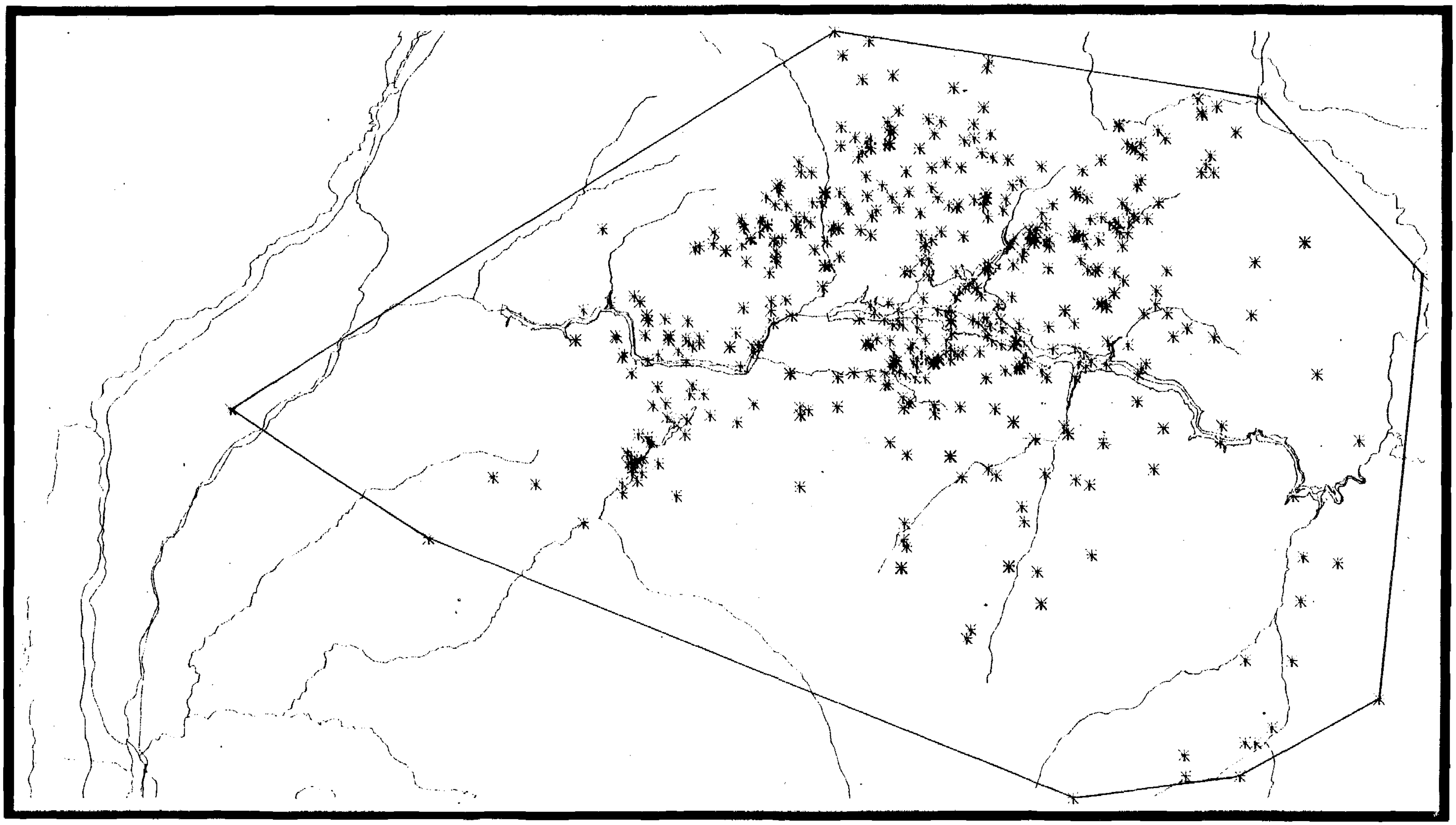

Figure 1. Brown bear study area (8473 sq. km). 513 brown bear locations are illustrated. (1 cm=7250 meters)

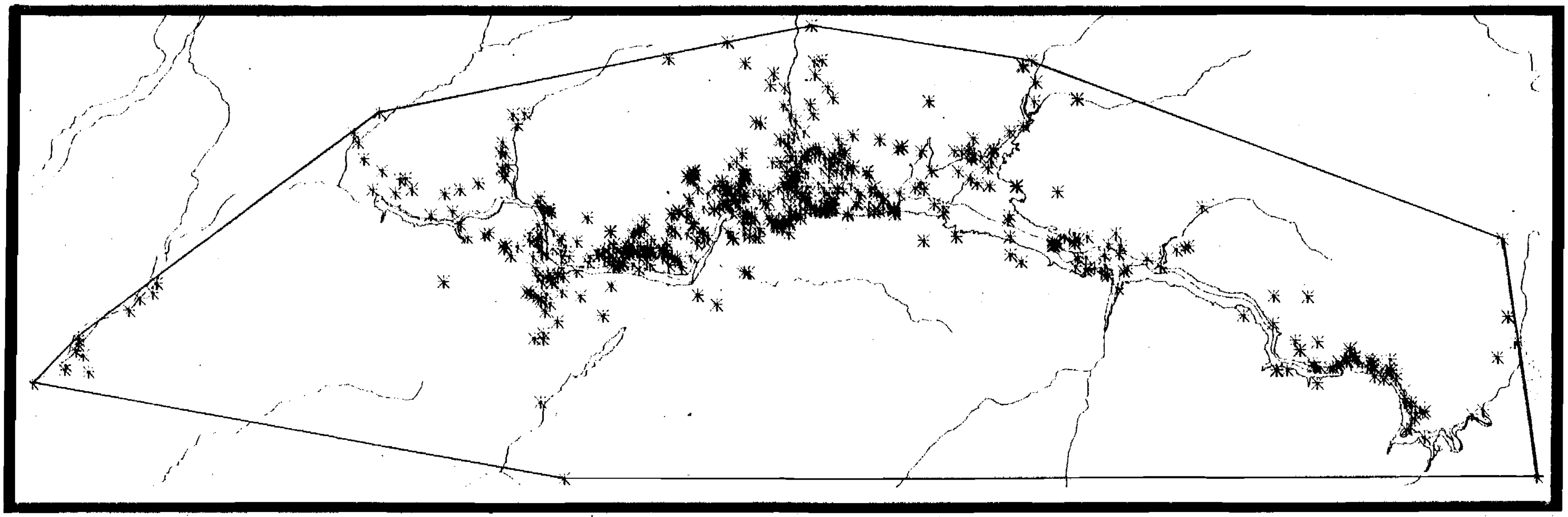

Figure 2. Black bear study area (4196 sq. km). 722 black bear locations are illustrated. (1 cm=6000 meters)

been shot by hunters (G297, G311, G284, G333). Four bears died during capture or recapture efforts (G278, G345, G308B, and G294). At present, 15 brown bears have active radios, although one of these (G334) has been missing since September 1981 and may have been shot, one bear (G342a) emigrated out of the primary study area, and another (G293) is a wide-ranging bear that is seldom found in the primary study area. A chronological list of bears captured and their current status is presented in Table 1.

Five or more radio-locations were obtained for 5 male and 14 female black bears. Numbers of radio-locations for each individual, and current status, are given in Table 2. Primarily, because of large males shedding radio-collars, the numbers of radio-locations for males (109) have been fewer than for females (422). Part of this disparity also resulted because 7 females were intensively monitored in Spring 1981 (114 locations) compared to only 1 male (14 locations) (Table 2). Sex and age structure of captured bears is given in Table 3.

The age structure of bears captured for Susitna Hydro studies is essentially equivalent to that of intensive 1979 studies in the Upper Susitna, to 10 years of GMU 13 harvest data, and to the subsample of radio-collared individuals (Table 4). As mentioned, however, the subsample of radio-collared individuals is biased in favor of females (Table 4).

These data indicate that the sample of study animals is reasonably representative in terms of age structure, but biased in terms of sex ratios.

VIII. - B. SPORT HARVESTS-BROWN BEAR

ADF&G harvest data for brown bear in GMU 13 are given in Table 5. From 1973-1980, harvests averaged 64/year (44-84). During this period, the bag limit has been one bear/hunter every 4 years. In

Table 1. Brown bears captured in Susitna Dam Studies as of November 1981

Tattoo	Sex	Capture Age	Capture Wt.	Capture Date	Frequency	Flags	Ear Tags	Comments
(277)	F	10.5	225*	4/10/80		orange	1065/1066	w/2 ylgs, not marked, collar shed 80/81 den
(278)	M	9.5	375*	4/19/80		--	-- --	Capture mortality
(279)	M	9.5	400*	4/20/80		orange	1100/1099	Collar shed by 6/12/80
280	M	5.5	300*	4/20/80		orange	1097/1098	Recollar next spring
(214)	M	4.5	300*	4/22/80		blue	1072/1071	Collar shed 9/9/80
281	F	3.5	250*	4/22/80		orange	16175/15950	Not turgid
282	M	4.5	325*	4/22/80		orange	1079/1080	
283	F	12.5	280*	4/22/80		orange	690/689	w2 @ 2.5: 284 & 285
(284)	M	2.5	180*	4/22/80		white	1074/1073	w/283 see 5/5/81 recapture
285	M	2.5	180*	4/22/80		green	687/688	w/283
286	M	3.5	264	5/1/80		orange	1081/1082	
292	F	3.5	174	5/2/80		green	1322/1321	Turgid
293	M	3.5	277	5/2/80		white	1116/1115	
(294)	M	10.5	607	5/2/80		white	-- --	see 8/6/81 recapture
(295)	M	12.5	589	5/3/80		green	1303/1304	Collar shed by 5/4/80
299	F	13.5	285	5/4/80		green	1109/1110	w/2 ylgs, turgid
(297)	M	1.5	65	5/4/80		orange	(1301/1302)	w/299, shot by hunter on 9/18/81
298	M	1.5	65	5/4/80		orange	1318/1317	w/299
306	F	3.5	163	5/4/80		white	1319/1320	Turgid
308A	M	6.5	480	5/6/80		white	1126/1125	--
(308B)	F	5.5	240	5/6/80		white	1096/1095	Turgid(?)-see 8/6/81 recapture
(309)	M	12.5	600	5/6/80		orange	1117/1118	Collar shed by 5/14/80
312	F	10.5	319	5/7/80		orange	1312/1311	w/311
(311)	M	2.5	227	5/7/80		orange	-- --	shot on 9/16/80
313	F	9.5	286	5/7/80		orange	1119/1120	w/314 @ 2.5
314	F	2.5	154	5/7/80		orange	1049/1050	w/313
315	F	2.5	90*	5/7/80		green	1127/1128	alone
(284#)	M	3.5	125	5/5/81		red CF	1074/1073	near 283 w/2c, shot by hunter on 5/18/81
331	F	6.5	172	5/5/81		white CF	1296/1295	w/332 & 333
332	M	2.5	79	5/5/81		--	1215/1216	w/331 & 333
(333)	M	2.5	67	5/5/81		--	(1240/1239)	w/331 & 332, shot by hunter on 9/3/81
334	F	10.5	325	5/5/81		white CF	1292/1291	w/335, estrus
335	F	2.5	194	5/5/81		--	1220/1219	
281#	F	4.5	--	5/6/81		white CF	1201/1202	estrus?
283#	F	13.5	261	5/6/81		white CF	1089/1090	w/338 & 339
338	M	0.5	12	5/6/81		--	1224/1223	w/283 & 339, not drugged
339	F	0.5	13	5/6/81		--	1222/1221	w/283 & 338, not drugged
312#	F	11.5	280	5/6/81		white CF	1300/1299	w/2c @ 0.5-not captured
313#	F	10.5	284	5/6/81		white CF	1120/1119	w/336
336	F	0.5	--	5/6/81		--	1237/1238	w/313, not drugged (abandoned)

(continued on next page)

Table 1. Brown bears captured in Susitna Dam Studies as of November 1981 (cont'd)

Tattoo	Sex	Capture Age	Capture Wt.	Capture Date	Frequency	Flags	Ear Tags	Comments
337	F	13.5	321	5/6/81		white CF	1294/1293	w/3c (2 captured subsequently not ear-tagged) reunited on 5/9/81
340	F	3.5	190	5/6/81		white CF	1225/1218	not estrus
280#	M	6.5	394	5/7/81		red CF	1097/1267	w/F 341
341	F	6.5	224	5/7/81		white CF	1208/1207	w/M 280
299#	F	14.5	291	5/7/81		white CF	1109/1110	w/2 @ 2.5 (297 & 298-not recaptured), not estrus
342A	M	2.5	220	5/7/81		red CF	1228/1227	alone
344	F	5.5	--	5/8/81		white CF	1204/1203	w/2 cubs subsequently
(345)	M	7.5	495	5/8/81		--	-- --	capture mortality
(308B)#	F	6.8	--	8/6/81		--	-- --	recapture mortality
299#	F	14.8	--	8/6/81		white CF	1109/1110	collar replaced
293#	M	4.8	--	8/6/81		red CF	1115/1116	collar replaced
(294#)	M	11.8	--	8/6/81		red CF	-- --	recapture mortality
(347)	M	14.8	500*	8/6/81		red	1234/1233	collar shed 9/81

* Weight estimated, ( ) indicates shed collar or dead bear, # recapture, collar or mark replaced subsequently

Table 2. Number of radio-locations of radio-collared brown bears for Su-Hydro studies, 1980 and 1981.

Bear ID	Year of initial capture (age)	No. of radio-locations 1980	No. of radio-locations 1981*	No. River Crossings 1980	No. River Crossings 1981	Comments
MALES						
342A	1981 (2)	-	8	-	1	Active, moved downstream
293	1980 (3)	8	11	2	0	Active, wide-ranging
214	1980 (4)	11	-	0	-	Collar shed, originally captured in 1978
280	1980 (5)	10	24	2	10	Active
308A	1980 (6)	4	-	0	-	Missing**
279	1980 (9)	2	-	0	-	Collar shed
294	1980 (10)	14	8	1	0	Recapture mortality
295	1980 (12)	2	-	1	-	Collar shed
309	1980 (12)	3	-	0	-	Collar shed
347	1981 (14)	-	4	-	0	Collar shed
	All Males	54	55	6	11	
FEMALES						
335	1981 (2)	-	34	-	0	Active
281	1980 (3)	13	40	1	6	Active
340	1981 (3)	-	39	-	6	Active
308B	1980 (5)	15	13	5	7	Recapture mortality
344 (w/2c 1981)	1981 (5)	-	21	-	0	Active
331 (w/2c 1979)	1981 (6)	-	24	-	4	Active
341	1981 (6)	-	28	-	9	Active
313	1980 (9)	14	24	0	0	Active
277 (w/2 ylg 1980)	1980 (10)	6	-	0	-	Collar shed
312 (w/2c 1981)	1980 (10)	12	24	0	0	Active
334	1981 (10)	-	31	-	0	Missing*
283 (w/2c 1981)	1980 (12)	12	19	0	0	Active
299 (w/2 ylg 1980)	1980 (13)	10	23	2	2	Active
337 (w/3c 1871)	1981 (13)	-	19	-	0	Active
	All Females	82	339	8	34	
	TOTAL BOTH SEXES	136	394	14	45	
Observations of unmarked bears		24	32	-	-	
	TOTAL	160	426	14	45	

* Includes radio-locations after 9/1/81 not dealt with in this report.

** Possible unreported hunter kill, collar failure, or emigration

Table 3. Sex and age composition of brown bears captured for Su-Hydro studies, 1980-1981.[a]

Age at first capture	Not radio-collared or <5 observations			Radio-collared with >5 observations		Total Captures		
	Males	Females	Sex?	Males	Females	Males	Females	Sex?
0-1	1	2	7	0	0	1	2	7
1-2	2	2	2	0	0	2	2	2
2-3	5	0	0	1	1	6	1	0
3-4	1	2	0	1	2	2	4	0
4-5	1	0	0	1	0	2	0	0
5-6	0	0	0	1	2	1	2	0
6-7	1	0	0	0	2	1	2	0
7-8	1	0	0	0	0	1	0	0
8-9	0	0	0	0	0	0	0	0
9-10	2	0	0	0	1	2	1	0
10-11	0	0	0	1	3	1	3	0
11-12	0	0	0	0	0	0	0	0
12-13	2	0	0	0	1	2	1	0
13-14	0	0	0	0	2	0	2	0
14-15	1	0	0	0	0	1	0	0
Totals	17	6	9	5	14	22	20	9

[a] Includes offspring observed with radio-collared adults but not captured in the "sex?" column (age is that when first observed).

Table 4. Average spring ages of Susitna area brown bear subpopulations. (Includes only bears of known sex and age that are 3.0 or older, spring age calculated as xx.5).

	Males			Females				
Subpopulations	Average Spring Age (Years)	(Range)	n	Average Spring Age (Years)	(Range)	n	Avg. Both Sexes (Years)	% Males
GMU 13 fall harvests, 1970-1980	8.0	(3.5-23.5)	208	7.7	(3.5-28.5)	191	7.9	52
1979 Upper Susitna studies (Miller & Ballard 1980)	7.4	(3.5-21.5)	17	7.4	(3.5-16.5)	15	7.4	53
1980-'81 Susitna Hydro studies*	7.7	(3.5-14.5)	14	7.9	(3.5-13.5)	15	7.8	48
Su-Hydro studies radio-collared bears w/ ≥ 5 locations*	6.0	(3.5-10.5)	4	8.6	(3.5-13.5)	13	8.0	24

* Average of age at first capture

Table 5. Summary of Brown bear harvest from Alaska's Game Management Unit 13, 1973-1980.

Year	Total Sport Take	Average Age (N)			% Total Harvest Taken in Fall[a]			% of Total Take By Non-Residents
		Males	Females	Both	Males	Females	Both	
1973	44	6.9(25)	7.3(15)	7.1(40)	100	100	100	59
1974	72	6.3(39)	7.3(28)	6.7(67)	100	100	100	47
1975	80	7.2(40)	7.7(31)	7.4(71)	100	100	100	46
1976	59	6.8(28)	5.0(25)	5.9(53)	100	100	100	39
1977	38	6.1(28)	7.1(6)	6.3(34)	100	100	100	32
1978	63	6.1(32)	6.5(24)	6.2(56)	100	100	100	44
1979	73	6.5(34)	8.1(28)	7.2(62)	100	100	100	42
1980	84	5.0(39)	5.8(31)	5.4(70)	79	85	82	30
73-80	513	6.3(265)	6.8(188)	6.5(453)	96	97	97	42
Fall Only -		6.3(255)	6.9(183)	6.5(438)				
Spring Only -		7.7(10)	6.2(5)	7.2(15)				

[a] Only fall seasons prior to 1980

1980, the first year with a spring season, males constituted 67% of the spring harvest, males constituted 58% of the total fall harvests from 1973-1980. Even with spring seasons, most of the harvest still occurs during the fall when bears are taken incidental to moose or caribou hunts. This pattern may change with the longer spring season planned for 1982, and with better spring hunting conditions. During the period 1973-1980, 42% of the brown bear harvest in GMU 13 has been taken by non-residents (Table 5).

The mean age of brown bears taken during the period 1973-1980, has been 6.5 years (6.3 for males and 6.8 for females) (Table 5). This relatively young age suggests that many GMU 13 hunters are not selecting for large trophy bears. Of 656 bears that have been harvested and aged in GMU 13 during the period 1970-1980, 10% were yearlings, 29% were 2 years-old or less, 41% were 3 years-old or less, and 52% were 4 years-old or less (unpublished ADF&G data). In 1980, one Unit 13 hunter even attempted to seal a cub bear. In recent years, sport hunters have applied pressure to extend brown bear seasons and bag limits in Unit 13. This pressure has largely resulted from research showing that brown bears are significant predators of moose calves (Ballard et al. 1980, 1981). Research suggesting a harvestable surplus of brown bears in the unit has also contributed to the pressure (See Appendix 3).

Recorded brown bear harvests in the Susitna Hydro-project study area, 1973-1980, have averaged 15/year (9-24/year) (Table 6). Hunting in the study area is largely by aircraft, including some hunting by guided hunters, although many bears are taken from the Denali Highway. Indeed, the largest proportion of study-area brown bears are taken from subregions that include the Denali Highway (Table 6). Improved access to highway hunters resulting from hydro-project access routes will doubtless greatly increase brown bear hunting in the study area. This increased hunting effort combined with liberalized seasons and bag limits (encour-

Table 6. Brown bear sport harvests by subregion within Su-Hydro study area, 1973-1980.

Location	1973	1974	1975	1976	1977	1978	1979	1980	Totals
Susitna R., Talkeetna-Indian R.						1		2	3
Susitna R., Indian R.-Watana Dam	1					2			3
Susitna R., Watana Dam-Vee Canyon	2	1	4	7		1	2	2	19
Susitna R., Vee Canyon-Denali Hwy incl. Tyone, Oshetna, etc.	3	6	6	2	5	9	7	1	39
Susitna R., Denali Hwy.-N & W to Ak. Range, Butte Lk. & Brushkana (not including McClaren R.)		4	12	5	2	5	5	7	40
Stephan Lk. area	2	2		2				1	7
Chunilna Ck., Disappointment Ck.	1		1			1	2	1	6
Unspecified location within study area.		3	1		1		2		7
Yearly totals	9	16	24	16	8	19	18	14	124

aged by some for Unit 13) could result in local overharvests of brown bear subpopulations in the study area. Most likely this overharvest would result in a reduction in bear density and a lowering of age structure rather than in an elimination of populations.

Brown bear kills in defense of life and property situations will also doubtless increase during project construction and operation. This is an inevitable result of increased human populations in the study area.

VIII. - C. POPULATION BIOLOGY AND PRODUCTIVITY-BROWN BEARS

Brown bears in the study area appear to be healthy and highly productive. Based on 9 litters with newborn cubs observed with marked adults since 1978, the mean litter size was 2.3 (range= 1-3). An unmarked bear with 4 cubs was also observed. Based on 16 litters of yearlings with marked females, the mean litter size was 1.6 (1-2), and based on 9 litters with 2 year-old offspring, it was 1.8 (1-2). Some of these litters represent the same individuals observed in successive years. This mean litter size of newborn cubs is equivalent to highly productive bear populations on Kodiak Island and the Alaska Peninsula, and is higher than has been found in a relatively unproductive population in the Brooks Range (Table 7).

Of 10 cubs in 5 litters produced in 1981, 3 (in 3 litters) were lost during the summer of 1981 (Table 8). One of these losses (to G313) may have been capture-related although Tait (1980) has suggested that abandonment of litters of single cubs may be an adaptive strategy for brown bears. Physical evidence (lactation) suggests that another bear (G308b) may have had a litter in 1981, but cubs were never observed; they may have been lost prior to the recapture of this bear in summer 1981. Two cubs in a litter of 3 were lost in 1979 studies (to G321) as were 2 yearlings or

Table 7. Brown bear litter sizes reported in various North American studies.

		Average litter size (No. of litters observed)		
		Age of litter		
Source	Area	0.5	1.5	0.5-1.5
Pearson 1975	Southwestern Yukon Territory	1.7(11)	1.5(11)	1.6(22)
Martinka 1974	Glacier Natl. Park, Montana	1.7(35)	1.8(30)	1.7(65)
This study	Nelchina Basin, Alaska	2.3(9)	1.6(16)	1.7(10)
Reynolds 1976	Eastern Brooks Range, Alaska	1.8(13)	2.0(7)	1.9(20)
Reynolds 1980*	Western Brooks Range, Alaska	2.0(33)	1.9(21)	2.0(54)
Mundy 1963	Glacier National Park, B. C.	1.9(81)	1.8(45)	1.9(126)
Klein 1958	Southeastern Alaska	2.2(25)	1.9(35)	2.0(60)
Glenn et al. 1976	McNeil River, Alaska	2.5(41)	1.8(69)	2.1(110)
Glenn 1976 & updated	Black Lake, Alaska Peninsula	2.1(19)	2.1(51)	2.1(70)
Hensel et al. 1969	Kodiak Island, Alaska	2.2(98)	2.0(103)	2.1(201)
Craighead et al. 1976	Yellowstone National Park	2.2(68)	-	-

* My calculations from data presented in Table 3 of Reynolds (1980)

Table 8. Brown bear offspring survivorship and weaning, Game Management Unit 13 studies. (Excludes bears transplanted in 1979.)

Mother Bear's ID (age)[1]	year first captured	STATUS 1978	1979	1980	1981
207 (11)	1978	3 cubs, April-Oct.	1 ylg. survived, May-Sept, other 2 lost survived by May (in den?)	no data	no data
220 (5)	1978	1 ylg., May-Oct.	1 @2y weaned in June, bred	no data	no data
221 (8)	1978	2 ylgs., May-Oct.	2 @2 in May, radio failure	no data	no data
204 (7)	1978	2 @2y in May, weaned in June and bred.	no data	no data	no data
321 (12)	1978	Bred	2 of 3 cubs lost in June, 1 survived April-Sept.	no data	no data
299 (13)	1980			2 of 2 ylgs. survived, May-Oct.	Weaned 2 @2y in May and bred
312 (10)	1980			Weaned 1 @2y in May, breeding not observed	1 of 2 cubs lost in June, other survived May-Oct.
313 (9)	1980			Weaned 1 @2y in May, bred	1 of 1 cubs lost in May, possibly capture-related
283 (13)	1980			Weaned 2 @2y in June, bred	1 of 2 cubs lost in August, other survived April-Oct.
277 (10)	1980			2 of 2 ylgs. survived April-August, collar shed in den	no data
331 (6)	1981				2 @2y weaned in May and bred
334 (10)	1981				Weaned 1 @2y in May and bred
337 (13)	1981				3 of 3 cubs survived May-Oct.
344 (5)	1981				2 of 2 cubs survived May-Oct.

[1] Age = age at first capture

cubs in a litter of 3 (to G207) in the same year (Table 8). No other losses from yearling or 2 year-old litters were observed suggesting that offspring mortality is concentrated on cub classes.

Causes of cub losses have not been determined although predation by male brown bears is considered most probable. A wolf was sighted near G312 at about the time her cub was lost in 1981. Hunters have sealed a total of 66 brown bears aged as yearlings during the period 1970-1980 (10% of the total harvest, unpublished ADF&G sealing data) even though yearlings are protected by state law. Doubtless some of these harvested yearlings have been lone animals, unaccompanied by their mothers who have been shot or who weaned their offspring early; we captured one lone yearling (G315) in the early spring of 1980.

Brown bear females in the study area typically accompany their offspring through their yearling year and wean them as 2 year-olds in May or June of the following year (Table 8). As yet, no cases of a female entering a den with a litter of 2 year-old offspring have been observed in Unit 13 studies (Table 8). Many of the females breed again soon after weaning (as evidenced by association with another bear); in all 3 cases where the subsequent year's data are available, this breeding was successful as evidenced by newborn cubs (Table 8). For these 3 bears, the reproductive interval was 3 years, doubtless additional data will reveal a mean reproductive interval for adult females between 3 and 4 years. An estimate of 3.3 years was used in productivity calculations (Table 9.)

Typically, female brown bears in the study area first breed at 3 or 4 years of age and produce their first litter when they are 4 or 5 years-old. Observed litters were produced when the mother was 4 years-old in 4 cases, when she was 5 years-old in 2 cases and when she was 6 years-old in 1 case (possible litter by G308b, aged 6, not included) (Table 10). Five barren females at age 4,

Table 9. Reproductive rates of grizzly bear populations (First four data sets, and analytical procedure, are slightly modified from that presented by Reynolds 1980).

Area	Mean Age at 1st Production to Maximum Age of Breeding	Potential Reproduction Life ' Reproductive Interval		Litter Size		Potential Production of Cubs*	$\bar{x}$ Reproductive Rate (No. cubs/ adult female/year)
Yellowstone Park (Craighead et al. 1976)	6.3 - 24.8	18.5 years / 3.40	x	2.24	=	12.2	0.66
Alaska Peninsula (Glenn et al. 1976)**	6.3 - 24.8	18.5 years / 3.77	x	2.50	=	12.3	0.66
Eastern Brooks Range (Reynolds 1975)**	10.1 - 24.8	14.7 years / 4.24	x	1.78	=	6.2	0.42
Western Brooks Range (Reynolds 1980)	8.4 - 24.8	16.4 years / 4.03	x	2.03	=	8.3	0.50
Nelchina Basin (this study)	5.2 - 24.8	19.6 years / 3.3	x	2.3	=	13.7	0.70
Nelchina Basin (this study)	5.2 - 14.4***	9.2 years / 3.3	x	2.3	=	6.4	0.70

* This potential may be close to actual in lightly hunted populations in Yellowstone and the Brooks Range, it probably over estimates productivity of heavily hunted population (Ak. Peninsula).

** Reynold's (1980) analysis of data presented by others.

*** Maximum age based on mean age of 30 females ($\geq$ 12 years) in the sport harvest 1970-1980.

Table 10. Reproductive intervals of female brown bears captured for Su-Hydro studies and previous Nelchina Basin studies.

Bear ID	Spring age of female when first observed litter was produced	Season first captured	YEAR IN WHICH OFFSPRING WERE PRODUCED AS CUBS [1]						
			1976	1977	1978	1979	1980	1981	1982
SU-HYDRO STUDIES									
(277)	9.5	spring, 1980				2X[b]			
283	10.5	spring, 1980			2M[c]			1M, 1F[a]	
299	12.5	spring, 1980				2M[b]			
312	8.5	spring, 1980			1M[c]			2X[a]	
313[2]	7.5	spring, 1980			1F[c]			1F[a]	
331	4.5	spring, 1980				2M[c]			
334	8.5	spring, 1980				1F[c]			
337	13.5	spring, 1981						3X[a]	
344	5.5	spring, 1981						2X[a]	
NELCHINA BASIN STUDIES (Spraker, et al. 1981)									
207	11.5	spring, 1978			1M, 1F, 1X[a]				
213[3]	9.5	spring, 1978		1X[b]		2M[a]			
204	6.5	spring, 1978	1F, 1X[c]						
220	4.5	spring, 1978		1X[b]					
221	7.5	spring, 1978		2X[b]					
231	13.5	spring, 1979				3X[a]			
206	14.5	spring, 1979				3X[a]			
234	4.5	spring, 1979		2X[b]					
240	4.5	spring, 1979			1M, 1F[b]				
244	5.5	spring, 1979			1F[b]				
251	9.5	spring, 1979			2M[b]				
254	8.5	spring, 1979			2M[b]				
261	6.5	spring, 1979			2M[b]				
269	15.5	spring, 1979			2F[b]				
274	10.5	spring, 1979			1M[b]				

1 Litter size followed by: M=male, F=female, X-unknown sex
2 Second offspring lost, capture-related
3 First offspring lost, capture-related

a Litter first observed as cubs
b Litter first observed as yearlings
c Litter first observed as 2.0+ years old
( ) Bear shot by hunter, collar shed, or otherwise inactive

4 barren females at age 5 (one of these also included at age 4), and 1 barren female at age 6 (G308b not included) have been captured in Unit 13 studies since 1978. Although these data sets are not directly comparable, they suggest that about 44% of the 4 year-old females produce litters, 33% of the remaining barren 5 years-old, and 50% of the remaining barren 6 years-olds. Obviously some of the 5 and 6 years-old barren females could have previously produced, but lost, litters.

All of the barren females aged at 4-6 years when captured (n=10) were in estrus; estrus did not lead to parturition for at least one bear (G209) who was barren again the subsequent year (1979) at age 5. At age 4, this bear was observed numerous times with another bear indicating probable breeding activity. Interestingly, 3 of the 6 barren females aged at 3 years-old that have been captured were in estrus. If this estrus led to successful breeding (not determined) it would yield the 50% parturition rate suggested above for 4 year-old females. In 1981, a large 2 year-old female (G335, not noticeably in estrus) was captured with her mother (G334), was subsequently weaned and was observed frequently with a larger, presumably adult male, bear through the summer of 1981 (no copulation behavior was observed). If G335 produces cubs in 1982, this would reveal at least one case of successful breeding at 2 years-of-age, 1 year younger than indicated above. However, the companion of G335 could have been an uncaptured sibling.

All seven or eight year-old females that have been caught were either with litters or showed evidence of having had a litter previously. Based on these data, it appears that for every 100 females (≥4 years), about 44 will produce their first litter at age 4, 20 at age 5, 19 at age 6 and 18 at age 7 (these estimates are slightly more conservative (less productive) than indicated by available data). Based on these calculations, the mean age at which these 100 hypothetical females produce their first litter is 5.2 years.

The length of time female brown bears in the study remain productive is more difficult to determine. The oldest female captured was G269; this bear had 2 yearlings with her when captured at age 16 in 1979. Two 14 year-old (G206 and G299) and three 13 year-old females (G283, G206, G231) have been captured; all had litters. The oldest aged female in the sport harvest since 1970 was aged at 28 years-old, only 10% of the female sport harvest has been aged older than 12.0 years during this period. The average age of females older than 12.0 taken in the sport harvest was 14.4, compared to 13.6 years for the 7 females older than 12.0 years that have been captured during Unit 13 research efforts since 1978. The best figure to use in calculating the period females are reproductively active would be the mean expectation of life of females older than 4.0, however, data are currently inadequate to calculate this. Therefore, the productive life span of females was bracketed using the mean from other studies (24.8 years) and the average age of females older than 12.0 years from the sport harvest data (14.4 years).

These parameters were used to compare the productivity of the study area population with those elsewhere utilizing the procedures, and data from other populations that were presented by Reynolds (1980) (Table 9). The only change made from Reynolds' presentation of this data was that "maximum age of breeding" was standardized at the mean of 24.8 years instead of fluctuating from 22.5 to 26.5 years in different areas; insufficient data are available to reasonably identify differences in maximum breeding age between different areas, so it was considered more realistic to hold this parameter constant.

The study area productivity data are clearly preliminary as insufficient data are available for this population. Also, these productivity data should not be used in estimating allowable harvest, as they compare potential productivity. Actual productivity is dependent on the age structure of the female segment of the population (heavily harvested populations would have a relatively lower mean female reproductive life) and recruitment (a function of offspring losses prior to weaning). Longer term data on other estimated parameters are also needed prior to calculation of productivity estimates that have reasonable levels of confidence. With these limitations clearly in mind, however, it is evident that the available data strongly indicate that the study area population has a high potential productivity relative to populations in Yellowstone and elsewhere in Alaska (Table 9). This largely results from the lower age of first litter production in the study area.

Preliminary data suggesting that the brown bear populations in the study area may produce pulses of cubs every 3 years are shown in Table 11. With a 3 year reproductive interval and many females becoming reproductively mature at 3 years of age, an especialy large crop of cubs in one year might result in pulses of cub production every 3 years. This model is hypothetical at this point.

VIII. - D. POPULATION DENSITY - BROWN BEAR

Determination of the number of bears in the Susitna study area was defined as a major objective of this study. Bear population estimates are exceptionally difficult and expensive to obtain and an accurate estimate was not achieved with the funds available for Phase I bear studies. An imprecise estimate may be ultimately obtainable from radio-tracking determinations of home range size coupled with an estimate of the proportion of the population which is radio-collared. The precision of such estimates increases as the proportion of the population which is radio-collared increases. Because of the apparent abundance of brown bears in the Susitna study area and because of the large home range sizes of Nelchina brown bears (average=570 km^2, range= 192-1,380 km^2, Ballard et al. in press), it will be expensive to obtain a precise estimate.

Table 11. Annual production of brown bear litters in Game Management Unit 13. (Represents data collected during studies from 1978 through 1981 on litters observed with radio-collared and newly-captured bears, extrapolated back to the year litter was produced).

	YEAR LITTER WAS PRODUCED						
	1976	1977	1978	1979	1980	1981	TOTALS
No. litters observed	1	3	11	6	1	5	27
% of total	4%	11%	41%	22%	4%	19%	101%
No. offspring observed	2	5	19	13	2	10	51
% of total	4%	10%	37%	25%	4%	20%	100%

Above data based on observations of litters of:	cubs	yearlings	2 y-olds
No. of litters (%)	9 (33%)	13 (48%)	5 (19%)
No. of offspring (%)	21 (41%)	23 (45%)	7 (14%)

An imprecise estimate of brown bear density was obtained from intensive trapping and mark-recapture techniques conducted in the Susitna River headwaters in 1979 (Miller and Ballard 1980) (see Appendix 3). This estimate is compared with other North American estimates in Table 12.

Based on a density estimate of 1 bear/41 km^2, the Susitna study area of 8,473 km^2 would have a population of 206 brown bears. It is our subjective evaluation that brown bear density in the Susitna study area is more likely to be higher than that estimated in our earlier study, rather than lower. However, using this estimate, it can be seen that only about a fifth of the bears inhabitating the study area have been captured and that only 7 percent are currently radio-collared. An accurate density estimate may be obtainable only when many more of the brown bears utilizing the study area have been captured and marked.

VIII. E. HOME RANGE AND MOVEMENTS - BROWN BEARS

1. Home Ranges - Brown Bear

Home range sizes for brown bears radio-collared for Su-Hydro studies are given in Table 13, these data are compared with results of nearby 1978 studies (Ballard, et al. in press) in Tables 14 and 15. Significant differences between 1978, 1980, and 1981 data sets were obtained only for females which had smaller home ranges in 1980 than in either 1978 ($P<0.05$) or 1981 ($P<0.10$) (Table 15). Plots of the home range of each individual in this study with 5 or more relocations are presented in Appendix 1.

Brown bear home ranges appeared larger in 1981 than in 1980, although the differences were not significant because of large variances (Table 15). This difference was present even though the 1981 data are analyzed only through 1 September. One male

Table 12. Reported brown bear densities in North America.

mi^2/bear	km^2/bear	Location	Source
0.6	1.6	Kodiak Island, AK	Troyer and Hensel 1964
6.0	15.5	Alaska Peninsula, AK	Unpublished data (Glenn pers. comm.)**
8.2	21.2	Glacier Nat. Park, Montana	Martinka 1974*
11.0	28.5	Glacier Nat. Park, B. C.	Mundy and Flook 1973*
9-11	23-27	SW Yukon Territory	Pearson 1975*
16-24	41-62	Upper Susitna R., AK	Miller and Ballard 1980
88 (16-300)***	288 (42-780)***	Western Brooks Range (NPR-A), AK	Reynolds 1980
100	260	Eastern Brooks Range, AK	Reynolds 1976

* Taken from Pearson 1975.

** Data refer to a 1,800 mi^2 intensively studies area of the central Alaska Peninsula.

*** Mean is for the whole of the Nat. Pet. Reserve, AK, the range represents values for different habitat types in this reserve where the highest density occurred in an intensively studied experimental area.

Table 13. Home range sizes for Su-Hydro study area brown bears. (Includes individuals with 5 or more relocations).

Bear ID (age @ capture)	1980 Observation Period (No. of locations)	1980 Home Range (km^2)	1981* Observation Period (No. of locations)	1981* Home Range (km^2)	Home Range (km^2) 1980 & 1981	Comments
MALES						
342a (2)	---	---	May-September, (5) no den*	1774**	---	dispersed
293 (3)	May-October (8) no den	1409	May-September, (9) no den*	2655	4135	wide-ranging
214 (4)	April-September (11)	975	---	---	---	shed collar
280 (5)	April-October (10)	499	April-July, (21) no den*	427	743	
294 (10)	May-October (14)	495	May-August (8)	100	611	recapture mort.
	$\bar{x}$ (all males) = (10.8)	845	(10.8)	1239	1830	
	S.D. = --	439	--	1190	--	
	range = (8-14)	495-1409	(5-21)	100-2655	611-4135	
FEMALES						
335 (2)	---	---	May-September, (28) no den*	179	--	weaned in 1981
281 (3)	April-October (13)	189	April-September (35) no den*	330	330	single
340 (3)	---	---	May-September, (33) no den*	613	--	single
308b (5)	May-October (15)	142	May-August (13)	110	191	recapture mort.
344 (5)	---	---	May-September, (15) no den*	246 (w/2c)	--	
331 (6)	---	---	May-September, (18) no den*	1136	--	weaned 2@2 in '81
341 (6)	---	---	May-September, (23) no den*	536	--	breeding
313 (9)	May-October (14)	82	May-September, (18) no den*	196	218	lost 1c in May '81
277 (10)	April-October (6)	147 (w/2@1)	---	--	--	shed collar in den
312 (10)	May-October (12)	140	May-September, (19) no den*	163 (w/2c)	280	
334 (10)	---	---	May-September, (29) no den*	111**		weaned 1@2 in '81

(continued)

Table 13. (cont'd)

Bear ID (age @ capture)	1980 Observation Period (No. of locations)		1980 Home Range (km^2)	1981* Observation Period (No. of locations)		1981* Home Range (km^2)	Home Range (km^2) both 1980 & 1981	Comments
283(12)	April-October	(12)	233	April-September, no den*	(14)	50(w/2c)**	323	weaned 2@2 in '80
299(13)	May-October	(10)	188(w/2@1)	May-September, no den*	(18)	356**	585	weaned 2@2 in '81
337(13)	---		--	May-September, no den*	(14)	270(w/3c)**	--	
$\bar{x}$ (all females)=		(11.7)	160		(21.3)	330	321	
S.D.=			48		--	293	141	
range =		(6-15)	82-233		(13-35)	50-1136	191-585	
$\bar{x}$ (all males and females)=		(11.4)	409		(18.8)	544	824	
S.D.=		--	422		--	698	1257	
range =		(6-15)	82-1409		(5-35)	50-2655	191-4135	

*1981 relocation data have been compiled only through September 1, subsequent relocations including 1981 dens will change these results.

**Not included in statistical comparisons (Table 15)

Table 14. Comparisons of mean home range size of brown bears radio-collared in 1978 (Ballard, et. al. in press), 1980, and 1981 studies in Unit 13. Includes all bears 3 years of age or older.

	MALES			FEMALES			BOTH SEXES		
	1978	1980	1981*	1978	1980	1981*	1978	1980	1981*
Mean Home range size(km^2)	769	845	1061	408	160	343	572	409	487
S.D.	396	439	1390	222	48	302	356	422	660
Range	282-1381	495-1409	100-2655	193-734	82-233	50-1136	193-1381	82-1409	50-2655
n	10	4	3	12	7	12	22	11	15
Mean age of sample	6.9	5.5	7.0	8.8	8.9	8.4	7.9	7.6	8.1
Range=	3-11	3-10	4-11	4-13	3-13	3-14	3-13	3-13	3-14
Mean No. relocations/ bear=	16.2	10.8	12.7	24.9	11.7	20.8	21.0	11.4	19.1
Range=	8-29	8-14	8-21	12-33	6-15	13-35	8-33	6-15	8-35
% Males							45	36	20
% of Females w/newborn cubs				8	0	33			

* Includes data through September 1, 1981 only, actual 1981 home range sizes will be larger when all 1981 points are included in analysis.

Table 15. Values of the T test statistic for testing for differences in mean brown bear home range sizes in 1978, 1980 and 1981.

COMPARISON	$\bar{x}_1$	$\bar{x}_2$	T	D.F.	P(x)
1978 males vs 1980 males	769	845	0.30	12	.62
1978 females vs 1980 females	408	160	2.77	17	0.99*
1978 both sexes vs 1980 both sexes	572	409	1.01	31	0.84
1978 males vs 1981 males	769	1061	0.63	11	0.73
1978 females vs 1981 females	408	343	0.62	23	0.73
1978 both sexes vs 1981 both sexes	572	487	0.51	36	0.69
1980 males vs 1981 males	845	1061	0.30	5	0.61
1980 females vs 1981 females	160	343	1.41	18	0.91**
1980 both sexes vs 1981 both sexes	409	487	0.20	25	0.58

* significant, P<0.05
** significant, P<0.10

(G293) and 5 females (G281, G313, G312, G283, and G299) were relocated 5 or more times in both 1980 and 1981 during roughly equivalent portions of the year (Table 13). The 1981 home ranges were larger (P>0.10) for 5 of these bears in 1981 ($\bar{x}$=740 km^2, S.D.=1074) than in 1980 ($\bar{x}$=402 km^2, S.D.=565); the mean percentage increase in home range for these 5 bears was 81% (range = 16%-139%). The bear with the smallest increase in home range size (G312, +16%) had newborn cubs in 1981 as did the bear (G283) that showed a decrease in home range size (-79%) between 1980 and 1981.

In comparison with studies in other portions of Alaska, Canada and Montana, brown bears in the Su-Hydro study area have relatively large home ranges (Table 16). Only in northwestern Alaska, a relatively unproductive population, have larger home ranges been reported (Table 16). All of these populations are also more densely populated than the study population, except for the northwestern Alaskan population (Table 12). Although, a clear relationship has not been established, we suspect that home range size and bear density are inversely related and that both are a function of the distribution and abundance of food resources. The relatively large home ranges and low densities of study-area brown bears may reflect, therefore, relatively low primary productivity of food items important to brown bear in the study area; these data may also reflect a patchy and wide-spaced distribution of important food items in addition to or instead of low primary productivity. Supporting this relationship are observations indicating that in areas of Alaska where salmon represent a primary source of food, home ranges tend to be smaller and densities higher such as on Kodiak Island and the Alaska Peninsula (Tables 16 and 12). Confounding this apparent relationship, however, is the apparent high productivity of study-area brown bear populations (see Section VIII-C this report). If food were limiting this population, a relatively lower reproductive potential, such as has been found in northwestern Alaska, would be expected.

Table 16. Comparison of reported home range sizes of brown/grizzly bears in North America (adapted from Reynolds 1980).

Area	Sex	Sample size	Mean home range (km^2)	Source
Kodiak Island, Ak.	M	7	24	Burns et. al. 1977
	F	23	12	
Yellowstone National Park	M	6	161	Craighead 1976
	F	14	73	
Southwestern Yukon	M	5	287	Pearson 1975
	F	8	86	
Northern Yukon	M	9	414	Pearson 1976
	F	12	73	
Western Montana	M	3	513	Rockwell et al. 1978
	F	1	104	
Nelchina Basin	M	14	790	This study (1978 & 1980 results only)
	F	19	316	
Northwestern Alaska	M	8	1350	Reynolds 1980
	F	18	344	

During the period of den selection many brown bears typically move to higher elevations, outside of their normal home ranges during non-denning seasons. This is reflected in comparisons of home range sizes which include and exclude locations at or in dens for 8 brown bears in 1980. The mean increase in home range size for these bears when den locations were included was 30% (0-151%). Doubtless these data will change once data for the 1981 den sites are compiled.

Mean elevation by month of observation of radio-collared brown bears is given in Table 17. Females with newborn cubs have a significantly higher mean elevation than other bears ($T=9.94$, $P<0.001$). Typically bears were at the lowest mean elevation in June-August (Table 17).

The area of overlap of brown bear home ranges with the impoundment area and with the area enclosed by polygons constructed 1 mile and 5 miles from the proposed impoundment shorelines were determined (Figure 3). The mean overlap with the impoundment area was 5% (0-25%), with the 1 mile polygon it was 15% (0-48%), and with the 5 mile polygon it was 52% (0-100%) (Table 18). As discussed in the Methods section, these data underrepresent the amount of use of the area in, and in the vicinity of, the proposed impoundments because the home range figure used in calculating percent overlap was the total annual home range, seasonal use by many brown bears was more intensive (see following section on seasonal movements). Regardless, these data clearly demonstrate that even the minimal impoundment-impact area represented by a 5 mile polygon would influence a mean of over 50% of the home range area occupied by the study population. As discussed in the Methods section, the 5 mile polygon represented only 30% of the "Average Home Range Diameter" calculated for brown bears, for this reason it is a minimal approximation of the impact-area of the proposed impoundments. A 5 mile polygon was used not because it represented a biologically meaningful

Table 17. Mean elevation by month of radio-collared brown and black bears.

Month	Females with newborn cubs (ft)	S.D.	N	Females w/o newborn cubs (ft)	S.D.	N	Males (ft)	S.D.	N	Males and Females w/o newborns (ft)	S.D.	N
BROWN BEARS (data through 1 Sept. 1981 only)												
May	4357	423	25	2877	840	93	2436	855	24	2787	858	117
June	3473	447	10	2773	557	94	2577	773	22	2736	605	116
July	3423	548	9	2757	470	40	2301	498	17	2621	518	57
August	3016	472	11	2786	494	39	2259	441	17	2626	534	56
September	3219	329	4	3090	570	14	2546	718	7	2908	659	21
Oct.-April	4842	52	3	3786	1103	19	2950	832	13	3446	1071	32
whole year	3791	730	62	2884	724	299	2488	727	100	2785	744	399
BLACK BEARS (all 1980 and 1981 points)												
May	1963	308	8	2048	309	42	2233	409	84	2166	386	132
June	2177	302	12	2221	271	44	2341	442	74	2296	390	118
July	2153	196	8	2338	326	31	2394	265	44	2371	291	75
August	2076	286	17	2165	307	48	2234	459	67	2202	402	116
September	2217	347	15	2284	332	45	2088	624	46	2185	508	91
Oct.-April	2194	355	4	2022	382	14	1953	340	12	1990	351	27
whole year	2131	302	64	2189	327	231	2248	456	327	2223	408	559

Table 18. Areas of intersection of brown bear annual home ranges with each impoundment and with 1 and 5 mile impoundment proximity polygons. (Home range data from Table 13).

Bear ID (age)	Home Range(km^2)	Area of Intersection with Impoundment			Area of Intersection + 1 mile			Area of Intersection + 5 miles		
		Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped
MALES										
342a(2)	1774	0	16.3	0.9	0	120.9	6.8	63.4	629.4	39.1
293 (3)	4135	155.4	0.8	3.8	451.2	10.5	11.2	1349.1	172.8	36.8
214 (4)	975	49.5	0	5.1	256.4	0	26.3	523.7	0	53.7
280 (5)	743	83.6	0	11.3	197.7	0	26.6	486.0	0	65.4
294(10)	611	0	13.7	2.2	0	77.3	12.7	29.9	320.7	57.4
FEMALES										
335 (2)	179	0	0	0	0	0	0	15.1	0	8.4
281 (3)(w/cubs in '81)	330	82.7	0	25.1	158.4	0	48.0	296.8	5.7	91.7
340 (3)	613	61.0	0	10.0	168.4	0	27.5	488.6	0	79.7
308b(5)	191	0	14.4	7.5	0	82.3	43.1	0	189.1	99.0
344 (5)	246	0	0	0	3.5	0	1.4	174.9	0	71.1
331 (6)	1136	50.4	0	4.4	112.5	0.2	9.9	388.3	80.1	34.2
341 (6)	536	43.1	0	8.0	126.4	0	23.6	309.5	0	57.7
313 (9)	218	0	0	0	0	0	0	84.6	34.9	54.8
277(10)	147	0	0	0	0	0	0	0	0	0
312(10)(w/cubs in '81)	280	1.4	0	0.5	11.0	0	3.9	93.9	0	33.5

(Continued)

Table 18. (Cont'd)

Bear ID (age)	Home Range(km^2)	Area of Intersection with Impoundment: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Area of Intersection + 1 mile: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Area of Intersection + 5 miles: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped
334(10)(w/cubs in '81	111	0	0	0	0.3	0	0.3	53.7	0	48.4
283(12)	323	0	12.9	4.0	0	76.3	23.6	59.1	263.7	99.9
299(13)	585	54.7	0	9.4	108.1	0	18.5	343.4	3.3	58.7
337(13)(w/cubs in '81)	270	0	0	0	0	0	0	6.5	0	2.4
	mean =			4.9			14.9			52.2

* Percentage figures do not accuratley portray impoundment-related habitat losses as home range size used reflects total annual home range, percentage figures based on seasonal home ranges would be higher especially during spring and early summer.

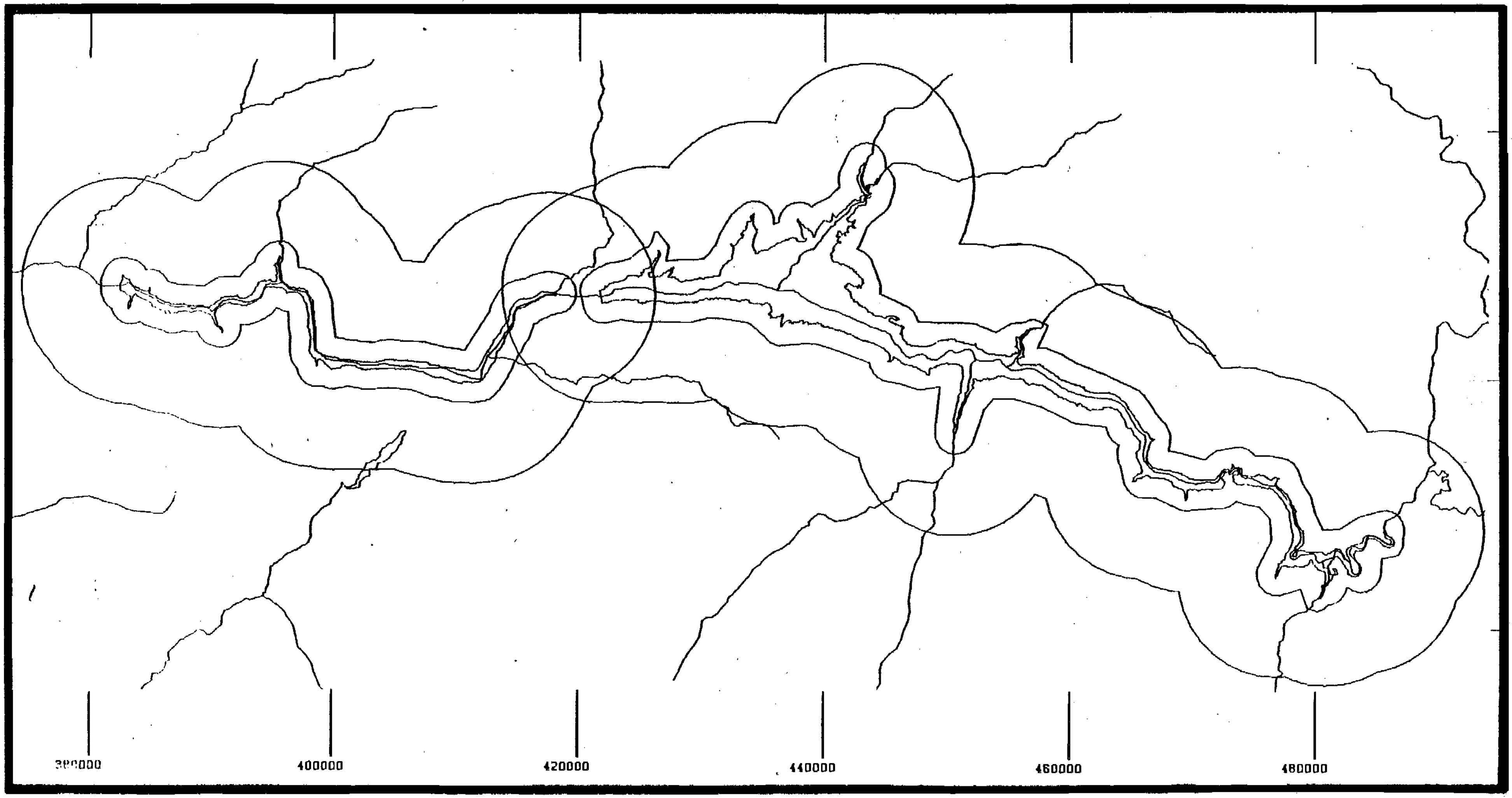

Figure 3. Illustration of proximity polygons that are one mile and five miles from the shoreline of proposed Watana and Devils Canyon Impoundments.

estimate of the impoundment-impact area, but rather because of statistical needs associated with proximity analyses (see section VIII-E-5 of this report).

2. Brown Bear Movements to Fishing or Hunting Sites

Prairie Creek which flows from Stephan Lake to the Talkeetna River is well known as an area where brown bears concentrate in July and August to feed on salmon, especially king salmon. Alaska Department of Fish and Game sport fisheries biologists characterize Prairie Creek as having one of the highest concentrations of spawning king salmon in the Cook Inlet region (Larry Engle, pers. comm.).

Radio-collared brown bears moved to Prairie Creek to fish for salmon in both 1980 and 1981. Unfortunately, bad flying conditions in 1981 prevented complete documentation of how many bears made this movement. At a minimum, 4 bears (G308b, G293, G294) moved to Prairie Creek in 1980 (of 11 with active radio-collars) and 2 (G293, G294) in 1981 (of 18 with active radio-collars). The longest distance moved by a bear to Prairie Creek was 58 km (G293 in 1981), after leaving Prairie Creek this bear was located 94 km from this fishing site. For 4 of these 6 known movements to Prairie Creek, a crossing of the proposed impoundment areas was documented (no crossings were documented for G294 and G293 in 1981). The annual home ranges of the 6 bears known to have moved to Prairie Creek is presented in Figure 4. Connecting the outermost points of these observations enclosed an area of 5,773 km^2, the documented minimum area from which bears are attracted to Prairie Creek.

The Prairie Creek salmon resource is doubtless more widely utilized by study area brown bears than these data indicate; poor weather which results in missed flights and relatively infrequent monitoring would yield an underdocumentation of actual use. Local residents have reported seeing 20 bears at one time on

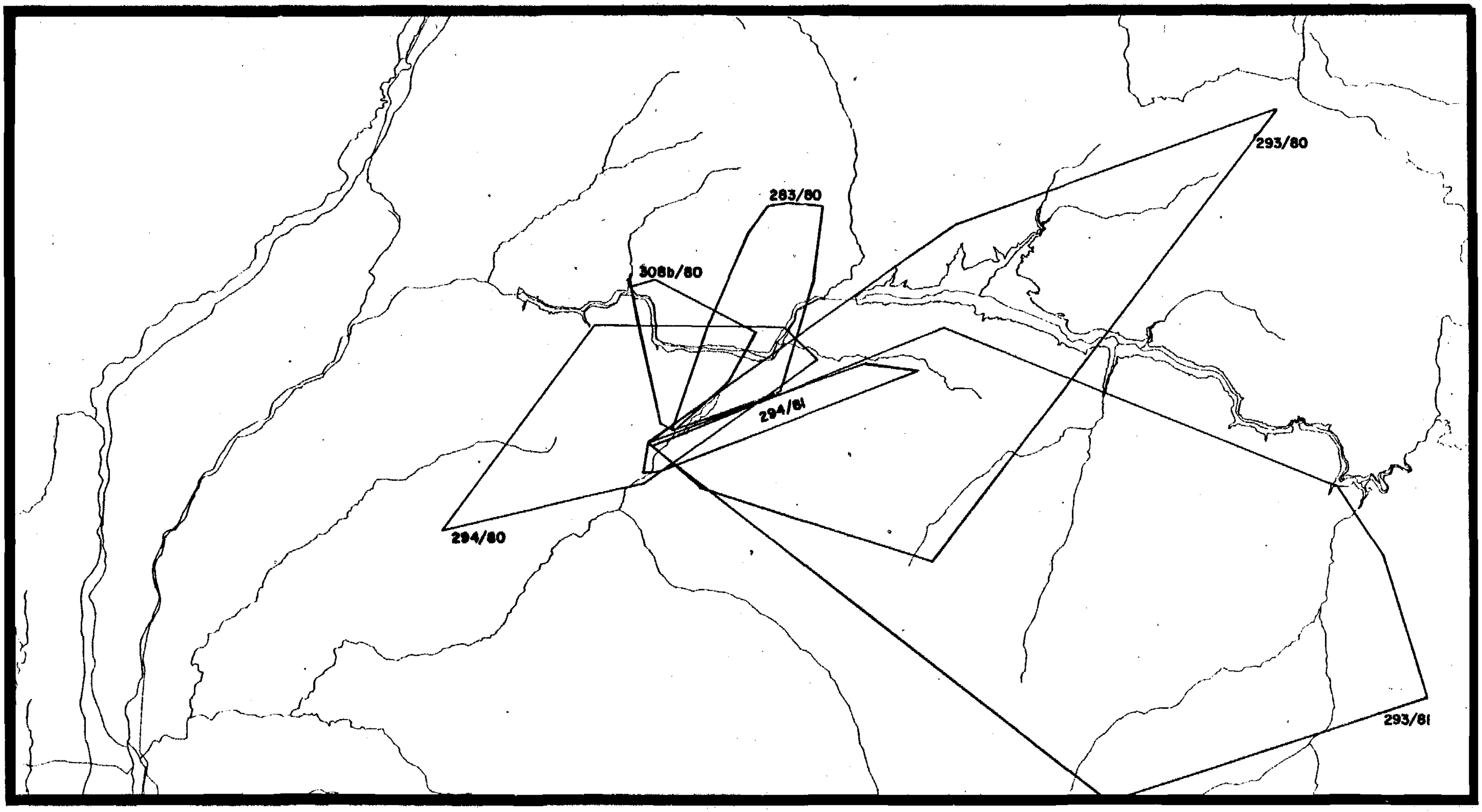

Figure 4. Annual home ranges of 6 brown bears with documented movements to Prairie Creek to fish for salmon in July and August, 1980 and 1981. Prairie Creek attracts bears from a documented area of 5773 sq. km. (1 cm=7250 meters)

Prairie Creek. On 10 August 1980, past the king salmon peak, we saw 13 brown bears at one time on Prairie Creek. We estimated that 30-40 individual brown bears fished in this area in the summer of 1980.

The importance of the Prairie Creek salmon run to study area brown bears will be difficult to evaluate. Other studies (Miller and Ballard, Appendix 3), indicate that moderately dense brown bear populations exist in the Nelchina Basin without access to salmon. However, it is possible that the availability of this interior run of salmon might provide nutritional benefits that result in local bear populations that are more dense or less nutritionally stressed than adjacent populations without access to a salmon run. Prairie Creek salmon may also be an important buffer during years when other sources of forage are limited. Preliminary conversations with sport fish biologists (ADF&G) suggest that Prairie Creek salmon runs are unlikely to be negatively affected by the proposed impoundments, however specific salmon studies will not be completed for 5 years. Assuming the proposed dams have no impact on the strength of the salmon run in Prairie Creek, the main impact the proposed construction might have on bear movements would be a physical blocking of seasonal movements to or from Prairie Creek.

All of the radio-collared bears seen at Prairie Creek had portions of their home ranges north of the Susitna River and therefore had to cross the river enroute to or from Prairie Creek. The maximum number of times an individual brown bear was known to have crossed the Susitna River was 10 (Table 2). It is unknown whether the bodies of water in the proposed impoundments would, in themselves, represent a significant barrier to bear movements, however, this possibility cannot be discounted. In addition, the strangeness of mud banks created by fluctuating water levels (if such occurs in midsummer) might represent an equal or greater barrier, perceived or real, to bear movements across the impoundment. Heavily traveled access roads to the impoundment might also inhibit or block bear movements across these roads; any access road built from the Parks Highway to the Watana damsite would have to be crossed by some bears moving between the Susitna River and Prairie Creek. Observations of homing brown bears being deflected, both permanently and temporarily, by large strange river beds and highways have been reported in Alaska (Miller and Ballard in press).

Seasonal movements of brown bears to areas where moose or caribou congregate, as on calving grounds, are difficult to document. For moose calving areas, which are poorly defined in any case, bear movements to lowland areas to prey on calves in the spring cannot readily be distinguished from movements to these same areas which may be motivated by the presence of relatively more abundant early spring forage. For 4 bears, however, apparent directional movements to or from caribou calving grounds were observed. A 3 year-old male (G293, Fig. 17) and a 6 year-old female (G331, Fig. 23) were sighted in early spring 1981 in close association with the Nelchina caribou herd on their 1981 calving grounds on the upper Oshetna River. G331 made an obvious directional movement to this area from upper Clark Creek, previous locations in spring 1981 were not obtained for G293. In similar fashion, G280 (a 4 year-old male, Fig. 14) and G299 (a 13 year-old female with 2 yearlings, Fig. 19) moved to upper Kosina Creek in spring 1980.

ADF&G biologists conducting caribou surveys (S. Eide, R. Tobey, and K. Pitcher, pers. comm.) regularly report seeing many brown bears associated with the Nelchina herd. For example, in early July 1980, these biologists made incidental observations of 22 brown bears in approximately 260 mi² of survey area during caribou surveys on the upper Oshetna River. This represents a minimum bear density of 1 bear/12 square miles during this seasonal concentration of bears. Since only a fraction (perhaps a third) of the bears present were likely to have been seen by biologists concentrating on caribou, the actual local bear density in this area may have been much higher. In illustration of this observability bias, in 1981 these biologists conducting the same survey in about the same area saw no bears even though some radio-collared individuals were present as discussed above.

3. Dispersal

Dispersal both to and from the study area by subadult brown bear is probably common. Unlike black bears, brown bear populations in the study area are in the middle of a large area of natural brown bear habitat and their dispersal behaviour here is probably typical of the species.

Male G214 was originally tagged as a 2 year-old in 1978 on the Susitna River and Valdez Creek (north of the Denali Highway). In spring 1980, this bear was captured, and radio-collared, near Clarence Creek (between Vee Canyon and Jay Creek) on the Susitna River. Although this bear ranged north a considerable distance prior to shedding his radio-collar (Fig. 12), it appeared that he dispersed to the study area as a subadult from his 1978 capture site.

Male G342a (2 years-old, Fig. 29) was captured near Deadman Creek in the middle of the study area in spring 1981. He was located on Portage Creek shortly thereafter and apparently then moved about 55 miles down the Susitna River to Moose Creek (Talkeetna Quadrangle B1) by mid June. In the fall, this bear moved back upstream to Indian Creek (Talkeetna Mountains Quadrangle D6) and then downstream and denned between Sherman and Curry (Talkeetna Mountains Quadrangle C6). This is apparently a long dispersal downstream followed by a partial return (during the salmon run in the fall). This bear may now be resident between Sherman and Curry.

4. Seasonal Use of Impoundment Impact Areas - Brown Bears

In our first annual report, we suggested that brown bear use of the impoundment area was most prevalent and important in early spring, soon after bears emerge from their winter dens. We hypothesized that these movements were motivated by relatively earlier melt-off of snow, especially on south-facing slopes, which made these the first areas where overwintering berries could be found and also the first areas where new growth was available. Winter-killed or weakened ungulates might also be prevalent in these areas of ungulate winter range.

Overwintered berries were common in scats of bears captured in spring 1980 especially for bears captured along the river. The lack of protective snow cover in the winter of 1980/81 apparently prevented successful overwintering of berries and bears appeared to be eating more ground squirrels in spring 1981. Regardless, the available data strongly support the theory that early spring is the period when many brown bears are most intensively utilizing the impoundment-impact area (conservatively defined, for this analysis, as within 1 mile of the high water mark of the proposed impoundments).

Of 12 bears radio-collared in spring 1980, 6 were located in the impoundment-impact area at least once (Table 19). The mean elevation of these observations was 1984 feet for the Watana area and 1971 feet for the Devils Canyon area (Table 19), below proposed high water lines for the former but not for Devils Canyon. Thirty percent of all 1980 spring observations of radio-collared brown bears were in impoundment-impact areas (Table 19).

Even without prevalent over-wintering berries, the same pattern was evident in spring 1981. Excluding females with newborn cubs which tend to remain at high elevations throughout the year, 8 (62%) of the radio-collared bears were located in impoundment-impact areas in spring 1981 (47% including females with newborn

Table 19. Early spring use[1] of Devils Canyon and Watana impoundment areas by radio-collared brown bears.

BEAR ID (age)	Bear visited impoundment area?[1] (No. observations in/total observations) Spring 1980	Spring 1981	Mean elevation of observations in impoundment area (S.D.) 1980	1981
MALES				
G342 (2)	---	no (0/4)	--	--
G293 (3)	no (0/4)	no (0/1)	--	--
G214 (4)	yes (2/4)(to Watana)	---	2038(-)	--
G280 (5)	no (0/3)	yes (10/16)(to Watana)	--	2030(331)
G308a (6)	no (0/2)	---	--	--
G294 (10)	yes (4/4)(to Devils)	no (0/3)	1721(344)	--
sub totals	(6/17)	(10/24)		
FEMALES				
G335 (2)	---	no (0/20)	--	--
G281 (3)	yes (3/5)(to Watana)	yes (9/26)(to Watana)	2025(-)	2119(254)
G340 (3)	---	yes (9/26)(to Watana)	--	2083(301)
G308b (5)	yes (1/5)(to Devils)	yes (6/7)(to Devils)	1350(-)	1863(309)
G344 (5)*	---	no (0/6) w/2 cubs	--	--
G331 (6)	---	yes (1/8)(to Watana)	--	1850(-)
G341 (6)	---	yes (12/17)(to Watana)	--	2160(474)
G313 (6)	no (0/5)	no (0/10)	--	--
G277 (10)	no (0/4)	---	--	--
G312 (10)*	yes (1/4)(to Watana)	no (0/10) w/2 cubs	1750(-)	--
G334 (10)	---	yes (1/22)(to Watana)	--	2525(-)
G283 (12)*	yes (3/5)(to Devils)	no (0/9) w/2 cubs.	2500(-)	--
G299 (13)	no (0/2)	yes (4/10)(to Watana)	--	2063(103)
G337 (13)*	---	no (0/7) w/3 cubs.	--	--
sub totals	(8/30)	(42/178)		
total	(13/37)	(52/202)		

1 Defined as within 1 mile of impoundment prior to 19 June.

* Females with newborn cubs tend to remain at high elevations throughout the summer.

cubs) (Table 19). Of these 8 bears, 7 utilized the Watana impact area and 1 the Devil's Canyon area (Table 19). The mean elevation of the spring observations within the Watana impact area was 2101 feet, below the high water line of the proposed Watana impoundment (Table 19). Excluding females with cubs, 52 of the 170 spring locations (31%) in 1981 were in impoundment-impact areas, the same percentage as in 1980.

These data represent minimal values for early spring use of impoundment-impact areas by brown bears in the study area. Other bears could also have utilized these areas without having been found there during weekly monitoring flights. This is particularly true for bears relocated relatively infrequently in the spring. For example, G280 was not found in the impact area during three 1980 spring observations but was on 10 of 16 spring observations in 1981, a similar pattern was evident for G299 (Table 19).

Lumping both years, these minimal values of brown bear spring use of impoundment-impact areas (conservatively defined) indicate that 14 of 25 bears (56%) utilized impoundment-impact areas and that 66 of 217 observations (30%) made in the spring were in impoundment-impact areas. Ten of these 14 bears used the Watana impact area (71%). The mean elevation of these observations was below the proposed Watana impoundment elevation (2200 feet) suggesting that the Watana impoundment will have a relatively greater impact on spring brown bear habitat than the Devils Canyon impoundment.

Females with newborn cubs tend to remain at high elevations, away from the impoundments, during the whole year. Two bears (G283 and G344) that were alone in 1980 but had newborn cubs in 1981 used impoundment-impact areas in 1980 but not in 1981 (Table 19). Two other bears (G337 and G344) with newborn cubs in 1981 also avoided impact areas in 1981, these bears were not radio-collared in 1980. We suspect that in 1982 when the cubs of these females will be yearlings, these bears will return to using impoundment areas in early spring. A possible reason for this behavior by females with newborn cubs is to avoid the areas where other bears concentrate thereby reducing the possibility of intra-specific predation on their cubs. Females with young have been reported to be highly intolerant of other bears, especially males, at McNeil River, AK. (Egbert and Stokes 1976).

5. Proximity Analysis - Brown Bear

Point locations falling within the area of the proposed impoundments, 1 mile from the impoundment shoreline, and 1-5 miles from the shoreline were tabulated (Table 20 & Figure 3). The area of each of these 3 zones was determined (see methods section). The null hypothesis that the number of points that fell in each zone was in the same proportion as the relative area of each zone was tested by Chi square analysis in order to evaluate bear selectivity for each zone (Table 20). One assumption of Chi square analysis was violated in this test as the observation were not independent of each other as the data set was composed of multiple locations of the same individuals. Regardless, these data verify the use patterns discussed elsewhere. As mentioned above, female brown bears accompanied by newborn cubs tend to remain at high elevations away from the impoundments and were excluded from this analysis (Table 20).

Lumping data for all seasons the null hypothesis was rejected ($p<0.005$) for each impoundment and for both impoundments considered together. In all cases observed use in the actual impoundment area was greater than expected (Table 20). Similarly, observed use was less than expected in the outermost (1-5 mile) zone (Table 20). This pattern held also for each of the 2 seasons considered, but was much more marked in spring (1 May-30 June) than during the rest of the year (Table 20).

Table 20. Number of observations of radio-collared brown bears within nested impoundment proximity polygons. Expected values given in parenthesis.

	Within impoundment zone	Within 1 mile but outside impoundment zone	1 - 5 miles	Totals	> 5 miles	Chi Square (2 d.f)
DEVILS CANYON IMPOUNDMENT						
area (km^2)	28.92	164.78	689.01	882.71	--	
%	3.28	18.67	78.06	100.00	--	
Females w/o cubs						
7/1-4/31	1	1	16	18	14	
5/1-6/30	3	7	8	18	11	
Males						
7/1-4/31	0	0	6	6	19	
5/1-6/30	2	4	3	9	3	
subtotal	6 (1.67)	12 (9.52)	33 (39.81)	51	47	13.05*
Females with cubs	0	0	2	2	10	
WATANA IMPOUNDMENT						
area (km^2)	159.32	327.07	1233.51	1719.00	--	
%	9.26	19.02	71.72	100.00	--	
Females w/o cubs						
7/1-4/31	7	8	29	44	36	
5/1-6/30	25	15	56	96	62	
Males						
7/1-4/31	6	1	14	21	8	
5/1-6/30	10	3	11	24	10	
subtotal	48 (17.13)	27 (35.19)	110 (132.68)	185	116	61.41*
Females with cubs	0	1	17	18	32	
BOTH IMPOUNDMENTS						
area (km^2)	188.24	491.85	1922.52	2,602.61	--	
%	7.23	18.90	73.87	100.00	--	
Females w/o cubs						
7/1-4/31	8	9	45	62	50	
5/1-6/20	28	22	64	114	73	
Males						
7/1-4/31	6	1	20	27	27	
5/1-6/30	12	7	14	33	13	
subtotal	54 (17.06)	39 (44.60)	143 (174.33)	236	163	86.32*
Females with cubs	0	1	19	20	42	
Males and females w/o cubs						
7/1-4/31	14 (6.43)	10 (16.82)	65 (65.74)	89	77	11.69*
5/1-6/30	40 (10.63)	29 (27.78)	78 (108.59)	147	86	89.82*

* Significant, $P < 0.005$

These analyses reveal brown bear selectivity for the impoundment area throughout the year, this selectivity was especially evident in the spring when observed use was 4 times greater than expected values under the null hypotheses.

6. Impact of Borrow Areas--Brown Bears

Brown bear populations or movements will be influenced by some of the proposed borrow areas. This impact would result from the disturbance which borrow area excavation would cause to individual bears as well as from losses of habitat used by some individuals. Borrow area C (upper Tsusena Creek) would have the greatest impact on brown bears as it occurs in the center of prime brown bear habitat in an area utilized by some individuals especially during the spring and late summer. Other individuals using Tsusena Creek as a north-south transportation corridor would also be displaced. Borrow areas A, H, D, F, and B would also cause some displacement of individual brown bears whose home ranges overlap these sites. Borrow area E (in the riverbed downstream of Tsusena Creek) is in a spring foraging area and would result in displacement of some brown bear during the period of excavation disturbance; over the long run the habitat in this area would likely be vacated by brown bears regardless of the borrow area because of its proximity to the Watana dam site and flooding by the Devils Canyon Dam.

VIII. F. HABITAT RELATIONSHIPS - BROWN BEAR

1. Aerial Classifications

The vegetation type where a bear was found when located from the air was recorded. These data do not show selectivity because no index of availability of the vegetation classifications types was made. However, these data are useful in contrasting different groupings of bears by seasons, sexes, or family status.

Vegetation type was classified into 1 of 23 classification categories (see materials and methods section) for 518 brown bear locations made from the air. For 81 of these locations (16%), 2 vetation type categories were recorded yielding a total of 599 vegetation type hits for brown bears. These data were lumped into 5 gross habitat categories to facilitate interpretation based on this small sample of hits. These data by month of observation are given in Table 21. Table 21 also includes 85 vegetation type observations for uncaptured bears observed during radio-tracking flights.

Brown bear use of spruce vegetation types, which are concentrated around and in the proposed impoundments, was highest in May and June (Table 21). Bears tended to move to shrublands at higher elevations later in the summer. In winter (October-April) 71% of the observations were in the "other" category (Table 21); these were mostly snow or rock.

These observations were lumped to contrast vegetation type use in the "spring" (1 May-30 June) with those during the rest of the year in order to examine the hypothesis that brown bears use the spruce types near the impoundments relatively more at this time than during the rest of the year. The relatively higher use of spruce vegetation types in the spring was significant (Chi square= 10.3, 1 d.f., $p \leq 0.005$). This pattern would have been even more significant if females with newborn cubs were excluded from the analysis. As mentioned above, these bears tend to remain at high elevations away from the impoundment throughout the year following birth of their litter; of 68 vegetation type hits for such bears only 1 was in spruce (49% were in shrublands, 35% in other, 10% in tundra, and 4% in riparian).

Table 21. Number of aerial brown bear observations by month in each of 5 habitat categories.

Habitat	May	June	July	August	September	Oct.-April	Row Total(%)
Spruce	44	50	17	16	9	5	141
Row %	31.2	35.5	12.1	11.3	6.4	3.5	(25.0)
Column %	31.0	29.6	19.3	17.6	25.0	13.2	
Riparian	16	26	22	20	4	1	89
Row %	18.0	29.2	24.7	22.5	4.5	1.1	(15.8)
Column %	11.3	15.4	25.0	22.0	11.1	2.6	
Shrubland	39	75	46	52	21	5	238
Row %	16.4	31.5	19.3	21.8	8.8	2.1	(42.2)
Column %	27.5	44.4	52.3	57.1	58.3	13.2	
Tundra	12	14	1	1	0	0	28
Row %	42.9	50.0	3.6	3.6	0	0	(5.0)
Column %	8.5	8.3	1.1	1.1	0	0	
Other	31	4	2	2	2	27	68
Row %	45.6	5.9	2.9	2.9	2.9	39.7	(12.1)
Column %	21.8	2.4	2.3	2.2	5.6	71.1	
Column Total	142	169	88	91	36	38	564
(%)	(25.2)	(30.0)	(15.6)	(16.1)	(6.4)	(6.7)	(100.0)

2. Vegetation Map Classifications - Brown Bear

Theoretically, the vegetation maps prepared by the Ag. Expt. Station under contract to TES should permit analyses of bear selectivity for different types. This is because the area of each vegetation type can be determined from these maps and frequency of bear occurrence in each type can be compared with the relative availability of this type (Table 22).

As discussed in the methods section, data on bear occurrence in these vegetation types were obtained by overlaying the location data on the 1:63,360 scale vegetation maps. When a point fell on the border between two types, both were recorded as hits; this yielded more vegetation type hits than observations. These data are presented in Table 23a.

These data were not statistically analyzed because the only availability information for the 1:63,360 scale maps did not subdivide the study area. The availability data shown in Table 22 lumped all types throughout the study area, from the Indian River on the west to the confluence of the Tyone River and Tyone Creek on the east. Large differences in availability of different types occur over this distance. Spruce and deciduous trees, for example, are much more prevalent in the western portion while tundra and shrubland types are more prevalent in the eastern portion. Calculated values for expected frequency of occurrence, correspondingly, would not be meaningful. An attempt to appropriately partition the vegetation map to obtain meaningful availability data using a sampling scheme on the vegetation maps is underway and will be reported later. Even once this is done, however, the analysis may not be particularly useful because of the likelihood that the vegetation types that are meaningful to persons making maps from air photos may not correspond with the habitat types that are meaningful to bears or other wildlife.

Some statistical analysis was possible based on vegetation types

Table 22. Availability of different habitat types (hectares) based on vegetation maps prepared by Plant Ecology subtask (Ag. Expt. Station, Univ. of Alaska).

	1:63,360[1]			1:24,000 scale [2]			
				Devils Canyon Impoundment		Watana Impoundment	
TYPE (Code #)	Hectares	% total area	TYPE	Hectares	%	Hectares	%
TUNDRA							
Mat and cushion (3)	63,633	13.76		0	0	0	0
Sedge-grass* (4)	27,505	5.95		0	0	0	0
Sedge-shrub* (5)	20,073	4.34		0	0	0	0
Wet sedge-grass (6)	3,517	0.76		12	0.33	100	0.63
Subtotal	114,728	24.81		12	0.33	100	0.63
CONIFER FOREST							
Open black spruce (7)	28,304	6.12	Woodland				
Woodland black spruce (8)	62,993	13.62	spruce (8 & 10)	162	4.50	4766	30.09
Open white spruce (9)	10,460	2.26	Open Spruce				
Woodland white spruce (10)	13,291	2.87	(7 & 9)	862	23.92	3854	24.33
Conifer subtotal	115,048	24.88		1024	28.42	8620	54.42
DECIDUOUS FOREST							
Closed birch (11)	2,324	0.50		470	13.04	491	3.10
Open birch (12)	1,498	0.32		73	2.03	318	2.01
Closed poplar (13)	571	0.12	Poplar (13 &				
Open poplar (14)	-	-	14)	17	0.47	2	0.01
Deciduous subtotal	4,393	0.95		560	15.54	811	5.12
MIXED FOREST							
Closed conifer-decid. (15)	13,226	2.86		758	21.04	869	5.49
Open conifer-decid. (16)	9,639	2.08		300	8.33	1329	8.39
Mixed subtotal	22,865	4.94		1058	29.36	2198	13.88
Forest subtotal	142,346	30.78		2642	73.33	11,629	73.42
SHRUBLANDS							
Closed tall (17)	15,767	3.41	Tall shrub				
Open tall (18)	15,524	3.36	(17 & 18)	19	0.53	580	3.66
Birch (19)	42,880	9.27		58	1.61	474	2.99
Willow (20)	8,230	1.78		16	0.44	55	0.35
Low shrub (21)	94,863	20.52		6	0.17	785	4.96
Shrubland subtotal	177,264	38.34		99	2.75	1894	11.96
GRASSLAND (22)	1,079	0.23		-	-	-	-
VEGETATED TOTAL	435,377	94.16		2753	76.4	13,623	86.01

(continued)

Table 22. (cont'd)

	1:63,360[1]			1:24,000 scale[2]			
				Devils Canyon Impoundment		Watana Impoundment	
TYPE (Code #)	Hectares	% total area	TYPE	Hectares	%	Hectares	%
OTHER							
Rock (1)	16,603	3.59		14	0.39	63	0.40
Snow and ice (2)	249	0.05		-	-	-	-
Lakes (23)	5,891	1.27	Lakes & Rivers				
Disturbed (24)	24	0.01	(23 & 25)	836	23.20	2153	13.59
River-gravel bar (25)	4,236						
Herbaceous (26)	18	0.01		--	--	--	--
Other subtotal	27,021	5.84		850	23.59	2216	13.99
TOTAL AREA MAPPED	462,398	100.00		3,603	100.00	15,839	100.00

[1] Data available permit no breakdown by impoundment, area mapped includes an approximate 5 mile strip on either side of the river along the whole study area. Smallest map unit at 1:63,360 is 7-8 hectares.

[2] Smallest map unit at 1:24,000 is about 4 hectares. Area to be inundated by proposed impoundments mapped at this scale.

Table 23a. Number of radio-collared brown bear observations in different vegetation types mapped at the 1:63,360 scale. Statistical analyses based on these data were not conducted because of absence of appropriately partitioned availability information (see text).

Vegetation type	No. brown bear hits
TUNDRA	
Mat and cushion (3)	42
Sedge-grass (4)	19
Sedge-shrub (5)	14
Wet sedge-grass (6)	4
CONIFER FOREST	
Open black spruce (7)	51
Woodland black spruce (8)	46
Open white spruce (9)	22
Woodland white spruce (10)	17
DECIDUOUS FOREST	
Closed birch (11)	2
Open birch (12)	2
Poplar (13 & 14)	0
MIXED FOREST	
Closed conifer-decid. (15)	28
Open conifer-decid. (16)	8
SHRUBLANDS	
Closed tall (17)	9
Open tall (18)	39
Birch (19)	48
Willow (20)	13
Low shrub (21)	83
GRASSLANDS (22)	1
OTHER	
Rock (1)	19
Snow and ice (2)	0
Lakes (23)	1
Disturbed (24)	0
River-gravel bar (25)	2
Herbaceous (26)	1
Total	471
No. observations with 2 hits (% of observations)	140 (42%)
No. observations outside area mapped at 1:63,360 (% of observations)	134 (29%)

in the actual impoundment area as the availability data presented by the Plant Ecology Subtask presented these data separately for each impoundment (Table 22). Some errors are inherent in this analysis as this availability data was derived from 1:24,000 scale maps. At this scale higher resolution was possible than for the bear use data which was derived from the 1:63,360 scale maps.

In the area flooded by the Watana impoundment, significant brown bear selectivity for the vegetation types categories mapped was revealed by this analysis (Chi square = 6.0, 4 d.f., $P < 0.10$) (Table 23b). The mixed conifer-deciduous forest types was the only category utilized more than expected based on availability (Table 23b). Only 63 vegetation type hits were recorded in the Watana impoundment, to be meaningful the number of observations must be large enough to avoid extreme lumping of different types and also large enough to permit separate analyses by season.

VIII. - G. DEN AND DENNING CHARACTERISTICS-BROWN BEAR

1980/81 den sites were located and measured for 13 radio-collared brown bears, an additional 3 dens were located for unmarked individuals (Table 24). 1981/82 den sites have been tentatively located, from fixed-wing aircraft, for 13 brown bears. Locations of brown bear dens are shown in Figure 5.

Brown bear den sites ranged in elevation from 2,330 to 5,150 feet, the average elevation of 29 dens was 4,181 feet (S.D.=757 feet). Typically brown bears in the study area denned on moderately sloping southerly exposures (Table 24, Figure 6). Their dens were dug in gravelly soil and no evidence of reuse of the previously used den was observed (Table 24). No radio-collared brown bear dens observed to date would be inundated by the proposed impoundments.

Table 23b. Brown bear use of vegetation types in Impoundment areas.

HABITAT TYPE	Watana Impoundment: % occurrence on 1:24,000 scale	Watana Impoundment: No. hits observed (1:63,360)	Watana Impoundment: No. Hits expected	Devils Canyon Impoundment: % occurrence on 1:24,000 scale	Devils Canyon Impoundment: No. hits observed	Devils Canyon Impoundment: No. hits expected
(Other, not included)		(2)	--		(1)	--
7 & 9 (Open Spruce)	28.50	15	18.00	31.45	2	
8 & 10 (Woodland Spruce)	35.24	21	22.2	5.91	0	
Conifer Totals	63.74	36	40.20	37.36	2	--
11-14 (Deciduous Forest)	6.00	2	3.8	20.43	1	--
15-16 (Mixed Forest)	16.25	17*	10.2	38.60	3	--
Decid & Mixed Totals	22.25	19*	14.0			
17-21 (shrublands)	14.01	8	8.8	3.61	0	--
TOTALS	100 % (13523 ha)	63	63	100% (2741 ha)	6	--

* Observed greater than expected suggests positive selection.

Table 24. Characteristics of brown bear dens in the Susitna study area during winter of 1980/81.

	Den No.	Bear ID No.	Age at Exit	Elevation (Feet)	Slope (Degrees)	Aspect (True N.)	Vegetation	ENTRANCE Ht. (cm.)	ENTRANCE Width (cm.)	CHAMBER Ln. (cm.)	CHAMBER Width (cm.)	CHAMBER Ht. (cm.)	Total Length (cm.)	Previously Used? (Yes/No)	Comments
DUG DENS															
FEMALES															
With offspring (@ exit)															
w/2 cubs	14	G283(sp.)	13	3900	28	192	Tussock grass	–	83	–	138	–	196	No	Spring den/collapsed
w/2 cubs	16	G283(wt.)	13	3725	26	210	Willows	76	64	239	203	92	291	No	Winter den
w/1 cub	22	G313	10	5150	35	166	Tussock/rock slide	–	–	–	104	–	410	No	Collapsed
w/3 cubs	24	G337	13	4825	31	252	Tussock/lg. rocks	57	69	–	152	90	219	No	
w/2 cubs	30	G344	5	4760	–	153	–– –	–	–	–	–	–	–		Collapsed/not visited
w/2 cubs	31	G312	11	4900	–	145	Tundra/rock	–	–	–	–	–	–	–	Collapsed/not visited
w/2 ylg.*	25	G277	11	4925	45	93	Moss/rock slide	–	–	–	165	–	207	No	Collapsed
w/2 @2yr.	28	G299	14	4660	25	138	Tundra/rock	–	–	–	–	–	–	No	Collapsed
w/o offspring	23	G281	4	4700	39	142	Tussock/rock slide	–	61	–	–	–	–	No	Collapsed
	5	G308b	6	2330	26	358	Alder	69	82	112	112	110	230	No	
MALES															
	1	G280	6	3950	32	158	Tundra/grass/rock	48	86	–	231	–	269	No	Collapsed
	15	G284?	3	3990	23	216	Tundra/grass	56	83	135	154	77	239	No	ID uncertain
	29	G294	11	2650	30	146	Alder/grass	52	80	–	157	89	188	No	Partially collapsed
UNK. SEX/ID															
	17	–	–	3925	33	192	Willow	61	62	154	162	122	220	No	
	26	–	–	4090	29	162	Willow/grass	73	65	–	–	–	171	No	Partially collapsed
	27	–	–	4125	26	140	Willow/grass	–	58	–	–	68	–	No	Partially collapsed

* Entered den with 2 yearlings, shed collar in den so exit not observed.

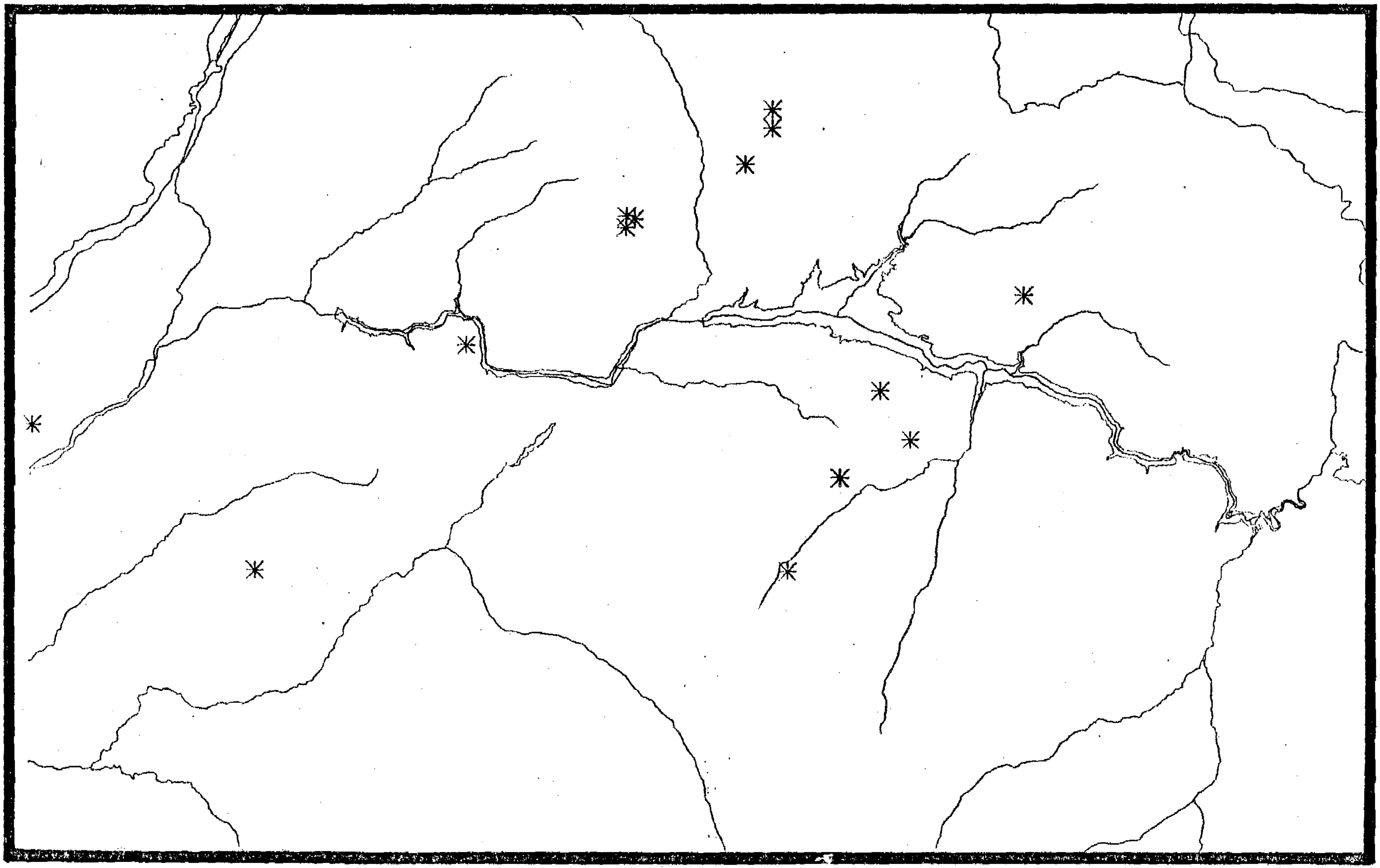

Figure 5. Locations of all brown bear dens found in Su-Hydro bear studies, 1980. (scale: 1 cm = 6250 meters)

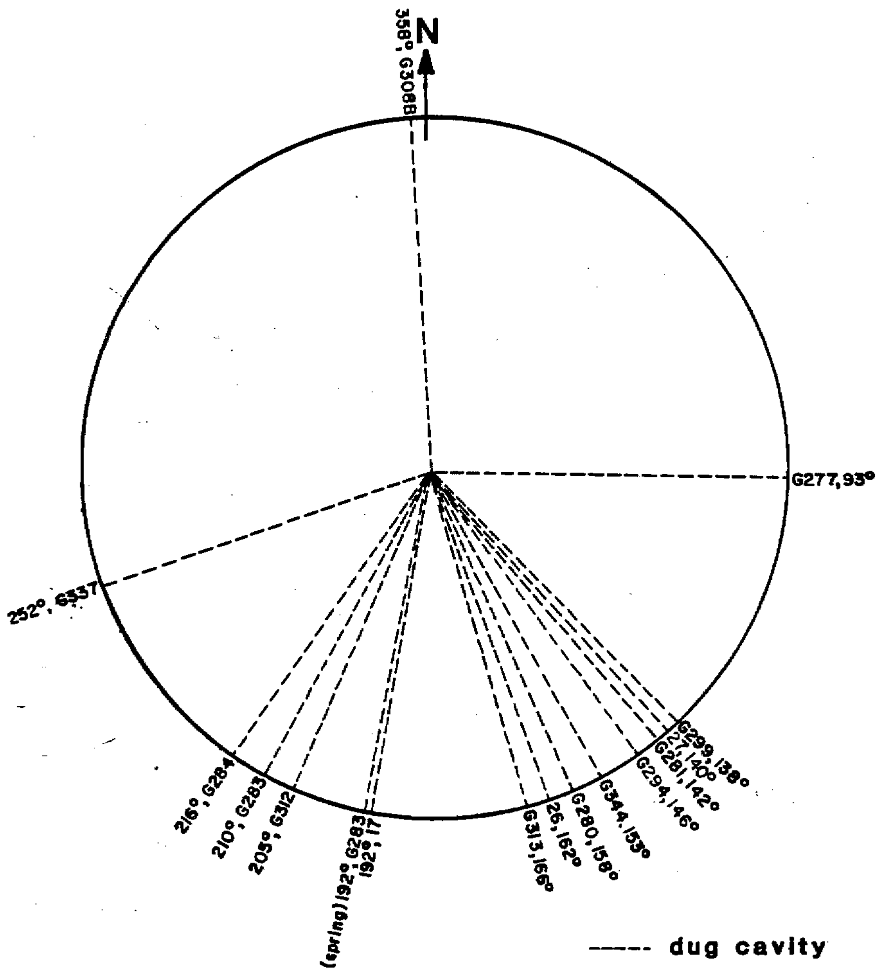

Figure 6. Aspect of brown bear dens in the Su-Hydro study area, 1980/81.

Den sites for 8 brown bears were found in both years of the study, the mean distance between dens utilized by the same individual was 4.4 miles (range=1.9-8.9, S.D.=2.7 miles) (Table 25). No brown bear reutilized the same den site but one individual (G337 with/3 cubs) apparently visited her 1981 den prior to denning elsewhere in 1981/82.

For the 14 brown bear dens we visited in summer 1981, the mean slope was 31° (range=23-45°, S.D.=6°). (Table 24). Of these 16 dens, 13 (81%) were within 45° of due south (135-225°) (Table 24).

Radio-collared brown bears in the study area entered dens in October and exited dens, in 1981, in late April-early May (Table 26). Based on earliest and latest possible den entrance and exit dates of radio-collared individuals, brown bears spent a median period of 187 days in 1980/81 dens (Table 27), 51% of the year. In 1981, brown bears appeared to enter dens earlier than they did in 1980 (Table 26), this may have resulted from the apparent relatively poor berry crop in 1981; fall weather conditions appeared essentially equivalent in 1980 and 1981. Reportedly, brown bears remain out of their dens into December on the Toklat and Shushana Rivers (just north of Denali National Park) in order to take advantage of a late run of 50,000 chum salmon (M. Chihuly, pers. comm.). If so, this suggests that den entrance dates may be a function of food availability.

The primary impact of the proposed project on brown bear denning appears, at this point, to be an indirect one resulting from increased disturbance of den sites by construction activities, access routes, transmission line corridors, and increased human activity. Craighead (discussion in Lentfer et al. 1972) points out that in Yellowstone National Park, brown bears avoid selecting dens in areas where human activity is substantial. Disturbance can also cause bears to abandon their dens (Reynolds et al. 1976). It is probable that brown bears in the Susitna

Table 25. Distance between den sites utilized by radio-collared brown bears in 1980/81 and in 1981/82 and approximate elevations of 1981/82 dens.

Bear ID/sex/age 1981	Distance (miles)	Approx. Den elevation (ft.) (1981/82)
G283/F(w/1c)/13	3.2	4300
G281/F/4	1.9	4900
G280/M/6	8.1	3850
G312/F(w/1c)/11	2.1	4950
G313/F/10	4.4	4750
G299/F/14	8.9	3400
G337/F(w/3c)/13**	3.4	4900
G344/F(w/2c)/5**	3.1	4350
G335/F/2**	?	3800
G342/M/2**	?	2350*
G341/F/6**	?	4400
G340/F/3**	?	4700
G331/F/6	?	4000

* Emigrated outside of main study area

** Not radio-collared in 1980, den site either not known or found during early spring 1981 capture

Table 26. Den entrance and emergence of individual radio-collared brown bears, in both 1980 and 1981.

Bear ID/sex	1980 den entrance*	1981 den entrance*	1981 entrance earlier or later than 1980	1981 * emergence
G280/M	10/13-10/27	9/22-10/1	earlier	4/7-4/21
G281/F	10/13-10/27	10/1-10/7	earlier	4/7-4/21
G283/F	10/9-10/27	10/1-10/7	earlier	4/30-5/5
G293/M	10/9-?	9/22-?	-	?-5/30
G299/F	10/13-10/27	10/1-10/7	earlier	4/7-4/21
G312/F	9/29-?	10/1-10/16	-	4/30-5/6
G313/F	9/29-10/9	10/7-10/16	Later ?	4/21-4/24
G331/F	---	10/7-10/16	---	---
G334/F	---	---	---	---
G335/F	---	10/1-10/7	---	---
G337/F	---	10/1-10/7	---	---
G340/F	---	10/7-10/16	---	---
G341/F	---	10/1-10/7	---	---
G342/M	---	?-10/30	---	---
G344/F	---	10/7-10/16	---	5/8-5/15
G277/F	?-10/27	---	---	---
G294/M	?-10/27	---	---	4/21-4/30
G308b/F	10/13-10/27	---	---	4/30-5/5

* Dates indicate last observation away from den and first observation at the den, large gaps, especially in 1980, reflect flights missed due to poor flying conditions.

Table 27. Den entrance and emergence dates of radio-collared bears, Susitna Hydroelectric Project. ("S" is an index of variability calculated identical to a standard deviation).

Bear ID	Sex	1980 Entrance*	1981 Emergence*	Possible Days in 80/81 Den			Comments
				Minimum	Maximum	Midpoint	
BROWN BEARS							
G280	M	13 Oct.-27 Oct.	7 April-21 April	162	190	176	
G281	F	13 Oct.-27 Oct.	7 April-21 April	162	190	176	
G283	F	9 Oct.-27 Oct.	30 April-5 May	185	208	197	2 cubs in 1981
G294	M	prior to 27 Oct.	21 April-30 April	176	?	-	
G299	F	13 Oct.-27 Oct.	7 April-21 April	162	190	176	with 2 @ 2 yr. in 1981
G308 b	F	13 Oct.-27 Oct.	30 April-5 May	185	204	195	
G312	F	29 Sept.-?	30 April-6 May	?	?	-	2 cubs in 1981
G313	F	9 Sept.-9 Oct.	21 April-24 April	194	207	201	1 cub in 1981
G277	F	prior to 27 Oct.	?	?	?	-	collar shed in den
			$\bar{x}$ =	175	198	187	
			"s"=	13	9	12	
BLACK BEARS							
B287	M	9 Sept.-29 Sept.	3 April-5 May	186	238	212	
B289**	F	9 Sept.-29 Sept.	8 May-15 May	221	248	235	3 cubs in 1981
B290	F	1 Oct.-9 Oct.	5 May-10 May	208	221	215	
B301**	F	29 Sept.-13 Oct.	9 May-29 May	208	242	225	2 cubs in 1981
B303	M	?	30 April-5 May	?	?	-	
B304	M	?	5 May-10 May	?	?	-	
B317	F	9 Sept.-29 Sept.	5 May-15 May	218	248	233	with 2 ylgs. in 1981
B318	F	29 Sept.-13 Oct.	30 April-5 May	199	218	209	with 1 ylg. in 1981
B319	M	29 Sept.-13 Oct.	30 April-5 May	199	218	209	
B321	F	9 Sept.-29 Sept.	10 May-15 May	223	248	236	2 cubs in 1981
B322**	M	9 Sept.-13 Oct.	?	?	?	-	collar shed in den
B323**	M	29 Sept.-13 Oct.	6 May-8 May	205	228	217	
B324	M	29 Sept.-13 Oct.	30 April-5 May	199	218	209	
B325	F	29 Sept.-9 Oct.	?	?	?	-	collar shed in den
B327**	F	9 Sept.-29 Sept.	8 May-10 May	221	243	232	with 2 ylgs. in 1981
B328	F	9 Sept.-29 Sept.	21 May-29 May	234	262	248	2 cubs in 1981
			$\bar{x}$ =	210	236	223	
			"s"=	14	15	13	

* Range given for entrance is the last observation outside den and first observation inside den, visa versa for emergence

** Black bears denning in the impact area of the Watana Dam site, others within the Devils Canyon impact area.

area will be similarly displaced from some areas where denning currently occurs as a result of the increased human presence during and following construction of the proposed impoundments. These data on brown bear denning sites generally correspond with studies elsewhere in Alaska (Lentfer et al. 1972, Reynolds et al. 1976, Spencer and Hensel 1980). On Kodiak Island and in northeastern Alaska, however, some dens were found in natural rock chambers or caves (Spencer and Hensel 1980). Additional data in the study area may reveal similar dens.

VIII. - H. PREDATION RATES-BROWN BEAR

Brown bears were shown to be significant predators of moose calves in a 1978-1979 study conducted in the headwaters of the Susitna River and nearby study areas (Ballard et al. 1981). Of 123 calves with normal cow-calf bonds subsequent to collaring, 55% died of natural causes (including predation). Of these deaths, brown bear predation accounted for 79%, wolf predation for 3%, unknown predation for 4.5%, and miscellaneous causes for 13.5%. In related studies of 23 radio-collared brown bear intensively monitored twice/day in spring 1978, 14 (61%) were observed on at least 1 calf moose kill (maximum=9 calf moose kills) (Spraker et al. 1981, Ballard, et al. 1981). In this study, a total of 37 calf moose, 28 adult moose, 4 unidentified moose, 3 caribou, and 6 other species were taken by brown bears yielding a total of 1 kill/5.6 observation-days (1 moose/6.3 observation-days) (op. cit.). The maximum kill rate was 1/2.2 observation-days for a 12 year-old solitary female bear. No significant differences between kill rate and age or family status of the individual bears could be shown (op. cit.).

The results of this study are compared with the results of intensive (daily) spring monitoring of 8 brown bears in the Susitna study area in Table 28. During this period monitored brown bears killed 3 moose calves (all by the same bear, a subadult female),

Table 28. Comparison of radio-collared brown bear predation rate data in the Nelchina and upper Susitna River Basins from 26 May to 1 November 1978 and from 21 May to 23 June 1981. (1978 data from Spraker, et al. 1981).

Bear Number	Sex-age(yr)	Family Status	No. of observation days	Prey: Moose calves	Adult moose	Unidentified moose	Adult caribou	Beaver	Misc.[a]	Total	Obs. days/kill
1978 Study											
200	M-7.5	single	5							0	0
201	M-10.5	single	20	2	1					3	6.7
202	F-8.5	single	25	5	1					6	4.2
204	F-8.5	w/2(1.5 yrs)	25	2	1					3	8.3
205	M-4.5	single	29	3	6					9	3.2
206	F-13.5	single	31	2	2					4	7.8
207	F-11.5	w/3(0.5 yrs)	23	1					1	2	11.5
208	F-12.5	single	33	9	4		1		1	15	2.2
209	F-4.5	single	22			2				2	11.0
211	M-4.5	single	16		1					1	16.0
212	F-10.5	single	17							0	0
213	F-10.5	single	16	1	1					2	8.0
216	M-10.5	single	10	1						1	10.0
217	M-3.5	single	17	3	1					4	4.3
219	F-4.5	single	12		1		1			2	6.0
220	F-5.5	w/1(1.5 yrs)	29	1		1		2		4	7.3
221	F-8.5	w/2(1.5 yrs)	28	5	1					6	4.7
222	M-11.5	single	11	1	2	1				4	2.8
225	M-4.5	single	25	1	2				2	5	5.0
227	M-9.5	single	8		1					1	8.0
228	M-7.5	single	11		1					1	11.0
231	F-12.5	single	19		1		1			2	9.5
234	F-5.5	w/2(1.5 yrs)	5		1					1	5.0
		Total	437	37	28	4	3	2	4	78	5.6
1981 Susitna Study											
299	F-14	single	6							0	0
340	F-3	single	19	3					2	5	3.8
331	F-6	single	6							0	0
281	F-4	single	13							0	0
280	M-6	single	9							0	0
341	F-6	single	12						1	1	12.0
335	F-2	single	18		2				2	4	4.5
334	F-10	single	19							0	0
		Total	102	3	2				5	10	10.2

[a] Includes small mammals and unidentified species in 1978, possible and unknown species kill in 1981.

2 adult moose (by another subadult female) and 3 species-unknowns during a total of 102 visual observation-days (Tables 28 and 29). Brown bears were strongly suspected to be on kills in an additional 3 cases (Tables 28 and 29). Even using these suspected kills, the observed predation rate (1/10.2 days) was lower than in the 1978 study. Including all brown bear observations, radio-collared bears were seen on 4 calf moose, 4 adult moose, 1 adult caribou, and 3 unknown species, and were observed in 5 additional cases where a kill was suspected but not observed.

These data doubtless underrepresent actual predation rates because of relatively infrequent monitoring (daily instead of twice daily in the spring) and decreased visibility of kills (because of relatively thicker vegetation in the Susitna study-area). The importance of moose calf predation to brown bears, black bears, and to moose populations should be established through studies of radio-collared moose calves in Phase II of this study.

IX. RESULTS AND DISCUSSION-BLACK BEARS

IX - A. SEX AND AGE COMPOSITION OF STUDY ANIMALS-BLACK BEAR

The number of black bears captured in connection with Su-Hydro studies in 1980 and 1981 totaled 53. This total includes 5 recaptures of bears to replace radio-collars, and 2 recaptures of bears that previously shed their collars (B302 and B325). Two bears shed their radio-collars (B288 and B322), hunters killed 6 bears (B305, B307, B316, B320, B326, and B342b), 4 bears died of unknown causes (B291, B300, B319, B330), 1 bear died during capture efforts (B296), and the collar was not replaced on one bear during recapture because of an infected neck (B290). At present, 19 black bears have active radio-collars. A chronological list of bears captured and their current status is presented in Table 30.

Table 29. Predation rates of black and brown bears intensively monitored in May and Jume, 1981, Susitna Hydro Project.

	date, May 1981										date, June 1981																					% visuals
Bear ID/sex/age	21	22	23	24	25	26	27	29	30	31	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	21	22	23	
B302/M/9				R	V	V	V	V	V		<u>V</u>	V		R		<u>V</u>	V	V	V	<u>V</u>	<u>V</u>	V	V	R	V	<u>V</u>	R	R		R		17/23=74%
B327/Fw/1@1/6	V		R				V	V			V	R	V	V	V	R	V	R	R	R	V	R	R		R		V	R	V	V		12/22=55%
B342/M/5	V	V	V	V[1]	V	V	V	V		R	V	V[2]	V	R	R	V		R	V	R	R	V	V	V	<u>V</u>	R	R	R	<u>V</u>	R		18/28=64%
																								BLACK BEAR TOTALS						=		47/73=64%
G299/F/14														<u>V</u>		<u>V</u>	<u>V</u>		V			R		<u>V</u>			V		R			6/8=75%
G340/F/3	V		V	V	V	V	V	R		V[3]	V[3]	V[3]	<u>V</u>	V	V	V		V[4]	V	V	R	V	R[4]	V	V							19/22=86%
G331/F/6																								V	V	V		<u>V</u>		V	V	6/6=100%
G281/F/4	<u>V</u>	<u>V</u>	<u>V</u>	V	<u>V</u>	V	V	V	R	R	V	V	R			V	V	R	R		<u>V</u>		R				R		R	R		13/22=59%
G280/M/6	V				<u>V</u>	<u>V</u>	V							V		V		R	V			R	<u>V</u>	R			R	R		<u>V</u>		9/14=64%
G341/F/6	<u>V</u>	<u>V</u>		<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	R		<u>V</u>						<u>V</u>	R	R		<u>V</u>[5]						<u>V</u>			<u>V</u>		12/15=80%
G355/F/2		V	V	V	V[5]	R	V	<u>V</u>		<u>V</u>			V[6]		V[4]	V			V[6]				V	V	<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>		<u>V</u>		18/19=95%
G334/F/10		<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>			V			<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	R	<u>V</u>	<u>V</u>	<u>V</u>	<u>V</u>	R	R				<u>V</u>	<u>V</u>	V	V		19/22=86%
																								BROWN BEAR TOTALS						=		102/128=80%
																								ALL BEAR TOTALS						=		149/201=74%

1 Adult caribou kill, on same kill thru 5/27

2 Calf moose kill, on same kill on 6/3

3 New kill of calf moose

4 Suspected kill (specied unknown)

5 Kill of unknown species

6 Kill of adult moose

_ with another bear, not including own offspring=possible breeding

R = Bear not seen, located by radio signal only

V = Bear observed visually

Table 30. Black bears captured in Susitna Dam Studies as of November 1981

		Capture						
Tattoo	Sex	Age	Wt.	Date	Frequency	Flags	Ear Tags	Comments
287	M	10.5	225*	5/1/80		white	1083/1084	
(288)	F	10.5	125*	5/1/80		white	1095/1083	w/2 ylgs, turgid, collar shed by 8/27/80
289	F	9.5	130*	5/2/80		white	1103/1104	w/2 ylgs, turgid, had 3 cubs in 1981
(290)	F	8.5	103	5/2/80		blue	1306/1305	w/2 ylgs, turgid, see 8/6/81 recapture
(291)	M	(3.5)	73	5/2/80		orange	-- --	Post-capture mortality
(296)	M	(10.5)	227	5/3/80		--	-- --	Capture mortality
(300)	M	(7.5)	274	5/4/80		orange	-- --	Post-capture mortality
301	F	7.5	115	5/4/80		green	1043/1044	w/1 ylg, turgid, had 2 cubs in 1981
(302)	M	8.5	287	5/4/80		blue	1106/1105	collar shed by 8/4/80
303	M	8.5	217	5/4/80		green	1055/1056	--
304	M	10.5	235	5/4/80		orange	1315/1316	--
(305)	M	(9.5)	217	5/5/80		green		Shot by hunter 8/30/80
(307)	M	2.5	105	5/5/80		orange	1123/1124	Shot by hunter on 5/17/81
310	M	2.5	85	5/6/80		blue/green	1122/1121	--
(316)	F	(12.5)	150*	5/7/80		blue	-- --	w/1 newborn & 1 ylg. shot by hunter 8/28/80
317	F	7.8	133	8/18/80		white	1195/1196	w/2 cubs
318	F	5.8	126	8/18/80		white	1046/1045	w/1 cub, also immobilized in den on 3/81
(319)	M	3.8	174	8/18/80		orange	1194/1193	Died summer 1981
(320)	M	(4.8)	200*	8/18/80		orange	-- --	Shot by hunter 9/9/80
321	F	10.8	175*	8/18/80		white	1243/1244	had 2 cubs in 1981
(322)	M	4.8	154	8/19/80		orange	1087/1088	w/324, collar shed in 80/81 den
323	M	2.8	122	8/18/80		orange	1200/1199	
324	M	5.8	190	8/19/80		orange	1252/1251	w/322
325	F	11.8	164	8/18/80		white	1191/1192	Collar shed in 80/81 den, see 8/6/81 recapture
(326)	F	(5.8)	125	8/19/80		white	-- --	w/2 cubs, shot by hunter 8/28/80
327	F	5.8	118	8/19/80		white	1247/1248	w/2 cubs, also immobilized in den on 3/81
328	F	6.8	150	8/19/80		white	1246/1245	w/303, had 2 cubs in 1981
303#	M	8.8	260	8/19/80		orange	-- --	recapture
329	F	1.3	15*	3/23/81		white	1266/1265	w/327 & sibling, w/heavy collar
(330)	M	1.3	31	3/25/81		orange	1276/1275	w/318, died summer 1981
(342B)	M	(5.5)	165	5/7/81		red CF	1206/1205	cinnamon color, shot on 9/15/81
343	M	5.5	184	5/7/81		red CF	1214/1213	alone, Devil Mountain
346	M	9.5	175*	5/9/81		red CF	1226/1184	alone, gaging station
302#	M	9.5	300*	5/9/81		red CF	1257/1105	alone, old collar previously shed
(290#)	F	9.8	160+*	8/6/81		--	1306/1279	neck infected, collar not replaced
304#	M	11.8	--	8/6/81		red CF	1286/1316	collar replaced
325#	F	12.8	150*	8/6/81		white CF	1191/1192	old collar previously shed
303#	M	9.8	250*	8/7/81		red CF	1055/1056	collar replaced
287#	M	11.8	200*	8/7/81		red CF	1083/1084	collar replaced
348	M	9.8	300*	8/6/81		red CF	1131/1132	alone
349	F	4.8	170*	8/6/81		white CF	1326/1325	alone

* Weight estimated ( ) shed collar or dead bear, # recapture

Five or more radio-locations were obtained for 14 male and 11 female black bears. Numbers of radio-locations for each individual, and current status, are given in Table 31. Of the total of 619 radio-locations of collared black bears, 52% were of males (Table 31), comparable to the proportion of males in the study area sample (Table 32). The age structure of the sample of radio-collared individuals (Table 33) was comparable to that of captured bears in the study area but somewhat older than the subsample of black bears taken by sport hunters in Unit 13 (Table 32). We suspect this resulted from hunter selectivity for younger, less experienced bears relative to the more random capture techniques used to capture study-area animals. It is also possible that black bear hunters along the road system, where much of the harvest occurs, are sampling a more heavily harvested and, therefore, younger population than exists in the study area. A heavily hunted population being studied on the Kenai Peninsula by C. Schwartz (ADF&G) averaged younger than the Susitna study animals, especially for females (Table 32). Males represented a smaller proportion of study area individuals than they did in hunter kills in Unit 13, probably because of greater vulnerability of males, which range greater distances, to hunters.

These data suggest that black bears marked for Susitna Hydro studies are reasonably representative of the existing black bear population.

IX. - B. SPORT HARVESTS-BLACK BEAR

ADF&G harvest data for black bear in GMU 13 are given in Table 34. From 1973-1980, harvests have averaged 66/year (range 48-85) during a 365 day season with a bag limit of 3 bears (cubs and females with cubs excluded from legal bag limit). Males have constituted 74% of spring harvests and 65% of fall harvests. Most of the harvest, (74%) occurs in the fall season when bears

Table 31. Number of radio-locations of radio-collared black bears for Su-Hydro studies, 1980 and 1981.

Bear ID	Year of initial capture (spring age)	No. of radio-locations 1980	No. of radio-locations 1981	No. River Crossings 1980	No. River Crossings 1981	Comments
MALES						
330	1981 (1)	w/318	14	-	0	Inactive, died summer 1981
323	1980 (2)	6	18	2	4	Active
319	1980 (3)	6	9	4	3	Inactive, died summer 1981
291	1980 (4)	7	-	0	-	Inactive, died summer 1980
322	1980 (4)	5	-	0	-	Collar shed in den
320	1980 (4)	2	-	1	-	Shot by hunter fall '80
324	1980 (5)	6	19	0	4	Active
342b	1981 (5)	-	40	-	0	Shot by hunter, fall '81
343	1981 (5)	-	16	-	3	Active
300	1980 (7)	3	-	-	-	Died summer 1980
302	1980 (8)	7	36	0	12	Active, collar shed in 1980 but recaptured subsequently
303	1980 (8)	15	18	2	0	Active
305	1980 (9)	9	-	2	-	Shot by hunter fall, '80
346	1981 (9)	-	16	-	2	Active
348	1981 (9)	-	7	-	2	Active
287	1980 (10)	17	15	0	2	Active
304	1980 (10)	15	19	0	0	Active
	All Males	98	227	11	32	
FEMALES						
329	1981 (1)	w/327	19	-	2	Active
349	1981 (4)	-	6	-	0	Active
318 (w/1c 1980)	1980 (5)	6	20	0	0	Active
326 (w/2c 1980)	1980 (5)	3	-	0	-	Shot by hunter, fall 1980
327 (w/2c 1980)	1980 (5)	6	34	1	8	Active
328 (w/2c 1981)	1980 (6)	6	18	0	0	Active
301 (w/2c 1981)	1980 (7)	20	14	2	0	Active
317 (w/2c 1980)	1980 (7)	6	18	0	0	Active
290	1980 (8)	18	14	4	0	Inactive, collar not replaced, neck infected
289 (w/3c 1981)	1980 (9)	14	19	4	0	Active
288	1980 (10)	16	-	0	-	Collar shed
321 (w/2c 1981)	1980 (10)	6	14	0	2	Active
325	1980 (11)	6	8	0	2	Active, collar shed in den but subsequently recaptured
316 (w/1c 1980)	1980 (12)	4	-	0	-	Shot by hunter, fall 1980
	All Females	111	184	11	14	
	TOTAL BOTH SEXES	209	411	22	46	
	Observations of unmarked bears	49	54	-	-	
	TOTAL	258	465	22	46	

Table 32. Average spring ages of black bear subpopulations in the Susitna area and Kenai Peninsula. (Includes only bears of known sex and that are 2.0 years or older, spring age calculated as xx.5). Data from the Kenai Peninsula from C. Schwartz, ADF&G, pers. comm.

Subpopulations	Males: Average Spring Age (Years)	Males: (Range)	Males: n	Females: Average Spring Age (Years)	Females: (Range)	Females: n	Avg. Both Sexes (Years)	% Males
GMU 13 harvests* 1973-1980	5.6	(2.5-18.5)	115	5.9	(2.5-11.5)	60	5.7	66
1980-1981 Su-Hydro studies**	6.6	(2.5-10.5)	19	8.1	(4.5-12.5)	13	7.2	59
Su-Hydro studies radio-collared bears w/ ≥ 5 relocations**	6.9	(2.5-10.5)	14	8.0	(4.5-11.5)	11	7.4	56
Kenai Peninsula studies 1978-1981***	6.2	2.5-12.5	45	5.0	2.5-10.5	42	5.6	52

* Includes all bear (≥ 2 years) aged and sexed, in recent years not all teeth have been sectioned and read

** Represents age at first capture

*** Based on total bears known to be alive in each of the years of the study (same bear counted more than once). This procedure should yield a relatively older mean age than the procedure used in calculating mean age in Susitna studies

Table 33. Sex and age composition of black bears captured for Su-Hydro studies, 1980 and 1981.

Age at first capture	Not radio-collared or <5 observations			Radio-collared with >5 observations		Total captures		
	Males	Females	Sex?	Males	Females	Males	Females	Sex?
0-1	0	0	17[a]	0	0	0	0	17[a]
1-2	0	0	8[a]	1[b]	1[b]	1[b]	1[b]	8[a]
2-3	2	0		1	0	3	0	
3-4	1	0		1	0	2	0	
4-5	2	0		0	1	2	1	
5-6	0	1		3	2	3	3	
6-7	0	0		0	1	0	1	
7-8	1	0		0	2	1	2	
8-9	0	0		2	1	2	1	
9-10	1	0		2	1	3	1	
10-11	1	0		2	2	3	2	
11-12	0	0		0	1	0	1	
12-13	0	1		0	0	0	1	
TOTALS	8	2	25	12	12	20	14	25

[a] Includes offspring observed with radio-collared adults in 1980 and 1981.

[b] Two radio-collared yearlings were also included as unidentified-sex cubs the preceding year.

are taken incidental to moose or caribou hunts. A mean of only 23% of the GMU 13 black bear harvest has been taken by non-residents.

Black bear do not appear to be a highly prized game animal by GMU 13 hunters. The current harvest is well below the sustainable harvest level. At present it appears that few hunters sufficiently prize black bear meat or pelts from GMU 13 to charter an aircraft to hunt black bear off the road system; only 35% of the hunters taking black bear during 1973-1980 recorded aircraft as their primary means of transportation (Table 34). However, it is probable that the increasingly restrictive seasons and conditions for moose and caribou hunting in GMU 13 will result in increased black bear hunting in this area, especially as more hunters become aware of the existence of substantial black bear populations in the unit.

Recorded black bear harvests in the Susitna Hydro-project study area, 1973-1980, have averaged 8/year (1-15) (Table 35). In the study area, as in GMU 13 as a whole, black bear harvests have been increasing in recent years with the largest recorded annual take occurring in 1980. In the study area, the largest harvests have occurred in the most downstream region, on the Susitna River between the Talkeetna and Indian Rivers, the only portion of the study area currently accessible by river boat or highway vehicle. Improved access for highway vehicles and boats resulting from access routes open to the public will doubtless increase sport harvests in the study area. Substantially increased hunting pressure will also result from hunting by project personnel during construction and operation of the proposed projects. In downstream portions of the study area this increased hunting is not anticipated to have significant impacts on black bear populations. However, upstream of Devil Creek where acceptable black bear habitat is highly constricted along the main Susitna River corridor, increased hunting will doubtless greatly reduce and could eliminate black bear populations.

Table 34. Summary of reported black bear harvests from Alaska's Game Management Unit 13, 1973-1980. (Season=365 days throughout period.)

Year	Total Sport Take	Mean Age (n)			% Males			% Total Harvest Taken in Fall			A	B	C
		Males	Females	Both	Spring	Fall	Both	Males	Females	Both			
1973	70	5.9(39)	5.2(20)	5.6	NA	63	63	100	100	100	49	14	--
1974	48	5.7(26)	7.8(14)	6.4	86	64	67	81	93	85	21	25	--
1975	67				75	75	75	67	67	67	19	36	--
1976	63	5.2(5)			63	70	67	63	55	62	21	26	55
1977**	58	5.1(26)	4.8(12)	5.0	81	64	69	66	82	71	19	26	52
1978***	70	5.4(13)			80	63	68	64	81	69	20	7	64
1979***	70				68	50	55	64	79	70	11	18	73
1980	85				77	74	75	67	71	69	24	32	67
'73-80	531	5.6(121)	5.9(58)	5.7	74	65	68	71	79	74	23	184	63
	Fall only	5.5(88)	5.9(49)	5.6									
	Spring only	5.7(33)	6.3(9)	5.8									

* Mean age given only when n $\geq$ 5.
** Only fall bears aged.
*** Only spring bears aged.
A % of total take by non-residents
B Number taken by hunters reporting aircraft as primary source of transportation
C % of total where meat was salvaged for food.

Table 35. Black bear sport harvest* by subregions in the Su-Hydro project study area, 1973-1980.

Location	1973	1974	1975	1976	1977	1978	1979	1980	Totals
Susitna River, Talkeetna to Indian River.		1	2	4	3	6	6	2	24
Susitna River, Indian River to Watana Dam Site Incl. High Lk.	3				1		4	4	12
Susitna River, Watana Dam Site to Big Bend of Susitna.	1		6	1	1		1	5	15
Fog Lakes-Stephan Lk.	9		1		1	3	1	2	17
Specific Subregion uncertain	1				2	1		2	6
Totals	14	1	9	5	8	10	12	15	74

* Values are minimal, many hunters inaccurately report the location of their kill.
Data compiled from ADF&G sealing records.

IX. - C. POPULATION BIOLOGY AND PRODUCTIVITY-BLACK BEAR

Black bear populations in the study area appeared to be productive and healthy in the first 2 years of this study. this was somewhat surprising because the study area is situated on the northern limit of black bear distribution (south of the Alaska Range). Apparently, the habitat is adequate even though limited in extent.

Eight litters with a total of 16 black bear cubs were observed with radio-collared females in 1980 and 1981, 5 of these litters were not first observed in early spring and may have experienced some losses by June-August when first observed (Table 36). Neglecting this, the observed litter size was 2.0 (1.3) cubs/litter (Table 36). The observed litter size for 7 litters of yearling black bears was 1.9 (Table 36).

On the Kenai Peninsula, 7 radio-collared females had a mean litter size of 1.9 upon emergence from natal dens (compiled from Schwartz and Franzmann 1980 and 1981). erickson (1964) reported a mean litter size of 2.15 Michigan and 1.96 in Alaska. Litter sizes presented by Jonkel & Cowan (1971) ranged from 1.6 for an unproductive population in Montata to 2.6 for a highly productive wild population in Virginia.

In the Susitna study area, 1 cub in a litter of 2 was lost in May 1981 (with B328), 1 was lost from a litter of 3 (with B289) and both were lost from a litter of 2 (with B321) in August 1981 (Table 36). Counting only the 4 litters initially observed by June, 4 of 9 cubs (44%) were lost (all in 1981) (Table 36). On the Kenai Peninsula no losses to cub litters have been observed (Schwartz and Franzmann 1980 and 1981).

This high rate of cub loss relative to the Kenai study has several possible explanations:

Table 36. Black bear offspring survivorship [1] and weaning [2], Su-Hydro studies.

Bear ID	Age when first litter observed	1980 Age of litter	1980 Apr	1980 May	1980 June	1980 July	1980 Aug	1980 Sept	1981 Age of litter	1981 Apr	1981 May	1981 June	1981 July	1981 Aug	1981 Sept
288	10	ylg.	3/3	3/3	3/3	3/3	3/3	*							
289	9	ylg.	2/2	W	0	0	0	0	cub	3/3	3/3	3/3	3/3	2/3	2/3
290	8	ylg.	–	2/2	W	0	0	0						*	
301	7	ylg.	–	1/1	W	0	0	0	cub	2/2	2/2	2/2	2/2	2/2	2/2
317	7	cub[3]	–	–	–	–	2/2	2/2	ylg.	2/2	2/2	W	0	0	0
318	5	cub	–	–	–	–	1/1	1/1	ylg.	1/1	W	0	0	0	0
326	5	cub[3]	–	–	–	–	2/2	*							
327	5	cub	–	–	–	–	2/2	2/2	ylg.	2/2	W(1)	1/2	W(1)	0	0
328	7								cub	2/2	1/2	1/2	1/2	1/2	–
321	all								cub	–	–	2/2	2/2	0/2	0/2
Totals (cubs)							7/7	5/5		7/7	6/7	8/9	8/9	5/9	

1 # survivors/litter size
2 W=weaned in that month (# weaned)
3 Female 326 shot on 8/28/80, remote possibility that cubs were adopted by B317
* Shed collar or dead bear, no further data

1. Increased cub vulnerability to brown bear predation (brown bears are relatively rare in the Kenai study area and escape habitats are more widespread).

2. Maximum density of black bears in the Susitna relative to possible submaximum (possibly resulting from greater hunting pressure) on the Kenai. This might yield relatively greater intra-specific predation on the Susitna. It might also mean relatively lower recruitment potential because of more saturated habitats and absence of acceptable surrounding dispersal habitats in the study area.

3. 1981 cub mortalities observed were atypical, possibly caused by the apparent relatively poor 1981 berry crop in the Susitna study area (however, no Kenai cub mortalities occurred in 1981 either, Schwartz, pers. comm.).

4. Relatively poor black bear habitat in the Susitna area (this is doubtful because the population appears to have a high reproductive potential based on available information on litter sizes, reproductive intervals, and age of first maturity).

Three black bears with apparent yearling offspring were captured in 1980 (offspring were not captured); 2 of these weaned these offspring in 1980 and produced new cubs in 1981 (Tables 36 and 37), a reproductive interval of 2 years. The third bear (B290) relocated its den in April 1980. Perhaps its original den collapsed killing its litter; no similar den relocations were observed for other bears. If a 2 year reproductive interval is standard in the study area, B318, B327, and B317 should produce cubs in 1982 (Table 37). A 2 year reproductive interval is the minimum, doubtless additional data will indicate a mean interval of between 2 and 3 years. The mean reproductive interval for an

Table 37. Reproductive intervals of female black bears radio-collared for Su-Hydro studies.

Bear ID	Spring age of female when first observed litter was produced	season first radio-collared	YEAR IN WHICH OFFSPRING WERE PRODUCED AS CUBS [1] 1979	1980	1981	1982	1983
(288)	9.5	spring, 1980	2X[b]				
289	8.5	spring, 1980	2X[b]		3X[a]		
(290)	7.5	spring, 1980	2X[b]				
301	6.5	spring, 1980	1X[b]		2X[a]		
(316)	11.5	spring, 1980	1X[b, 2]	1X[a]			
318	5.5	fall, 1980		1M[a]			
(326)	5.5	fall, 1980		2X[a]			
327	5.5	fall, 1980		2X[a]			
321	11.5	fall, 1980			2X[a]		
328	7.5	fall, 1980			1F, 1X[a]		
317	7.5	fall, 1980		2X[a]			

1 Litter size followed by M=male, F=female, X=unknown sex

2 This bear was captured near its den site on 7 May 1980 with one newborn and one larger bear suspected to be a yearling (this could happen if 316 bred in 1979 and adopted a cub that year so it would have had a yearling and a cub in spring 1980. The suspected yearling could also have been a 2 year-old bear that denned with or nearby its mother. One year intervals have been reported when lactation is interrupted (Erickson 1964, Baker 1912).

( ) Bear shot by hunter or collar shed, currently inactive

a litter first observed as cubs

b litter first observed as yearlings

unproductive Montana population was over 3 years and the percentage of adult females accompanied by cubs was low (15.6%) (Jonkel and Cowan 1971).

Three bears produced litters at 5 years of age and 1 bear at 6 years of age (Table 37). Assuming no previous litters and correct aging, these bears became reproductively mature and successfully bred at 4 and 5 years respectively. Only 1 female (ages 2-6) without offspring was captured (B349, age 4, captured in August 1981); this bear will likely have cubs in 1982 if she became sexually active at age 4. On the Kenai Peninsula, 7 females (aged at 4 years) had cub litters (Schwartz and Franzmann 1980 and 1981), suggesting that reproductive maturity may be reached a year earlier on the Kenai. More data are needed to verify this difference, especially considering the imprecision of aging techniques based on tooth cementum lines. For an unproductive population in Montana, no females were observed in estrus prior to 4.5 years of age and no bears successfully produced litters at less than 6-7 years (Jonkel and Cowan 1971).

Available data are inadequate to calculate productivity of the Susitna-area black bear population, but available data on productivity parameters suggest it does not have quite the reproductive potential of the Kenai population (based primarily on an older age of reproductive maturity) and may have a lower recruitment rate (based primarily on higher rates of cub losses). Relative to the unproductive Montana population, however, the Susitna population appears highly productive, equivalent to productive populations in the midwest. These comparisons are highly speculative at this point.

IX. - D. POPULATION DENSITY - BLACK BEAR

No reliable black bear density estimates are available from the study area or adjacent areas. Our subjective impression is that portions of the study area were very densely populated by black bears relative to other Alaskan habitats. The poor berry crop in 1981 and corresponding lack of bear movements for many bears to more open country prevented the aerial census originally planned for August 1981. The only available data that permit even a crude density estimate come from sightings of marked and unmarked black bears during the August 1980 tagging operation.

In 1½ days of spotting effort (August 18-19, 1981), 35 bears were seen in approximately 259 km^2 of search area, four of these were marked. A radio-tracking effort on August 14 verified the presence of seven radio-collared black bears in the search area. A straightforward Lincoln Index on these observations yields an approximation of 61 bears in this area or 1 bear/4.1 km^2. An "adjusted" index (Ricker 1975) yields an estimate of 58 bears (s.d.=19). These estimates should be viewed cautiously as there are many possible sources of bias in the technique and it covers only a small portion of the study area during only 1 season.

Regardless, the density estimate of 4.1 km^2/bear falls roughly at the mid-point of reported black bear densities in North America and is only slightly lower than the most intensively studied nearby population (Kenai Peninsula, Schwartz and Franzmann 1981) (Table 38). Our subjective evaluation is that further studies in the Susitna study area are more likely to reveal that the above density approximation is too high in upstream areas and perhaps too low in downstream (Devils Canyon) portion of the study area.

A highly speculative estimate of the number of black bears in the study area is possible from this estimation. Assuming that one-third (1,400 km^2) of the study area (Fig. 2) is acceptable black bear habitat, this density would yield a population estimate of 341 black bears in the study area. This estimate must be improved by additional studies, if correct it suggests that only 14% of the black bears in the study area have been captured and that only 6% are currently radio-collared.

Table 38. Densities of black bears as estimated in studies conducted in different localities (modified from Modafferi 1978).

Source	Location	mi^2 Per Bear	km^2 Per Bear
McIlroy (1972)*	Alaska (coastal population)	0.1	0.3
Lindzey and Meslow (1977)	Washington (an island population	0.3	0.8
Poelker and Hartwell (1973)	Washington (mainland population	0.7-1.0	1.8-2.6
Piekielek and Burton (1975)	California	0.8-1.0	2.1-2.6
Beecham (1980)	Idaho (Councial area)	0.8	2.1
	Idaho (Lowell area)	0.9	2.3
Jonkel and Cowan (1971)	Montana (Bear Creek)	0.8-1.7	2.1-4.4
LeCount (1980)	Arizona	0.8	2.1
Pelton and Burghardt (1976)	Tennessee	0.5-1.0	1.3-2.6
Kemp (1972)	Alberta	1.0	2.6
Modafferi (1978)	Prince William Sound, Alaska	1.2	3.1
Schwartz and Franzmann (1981)	Kenai Peninsula, Alaska	1.5	3.9
Erickson and Petrides (1964)	Michigan	3.4	8.8
Spencer (1955)	Maine	5.6	14.5
Clarke (1977)	New York (Adirondacks)	2.6	6.7
	New York (Catskill)	3.7	9.6
	New York (Allegany State Park)	10.0	25.9

* Probably estimated during season concentration.

IX. E. HOME RANGE AND MOVEMENTS-BLACK BEARS

1. Home Ranges

Home range sizes for Su-Hydro study area radio-collared black bears are given in Table 39 for individuals with 5 or more relocations. These home ranges are illustrated in Appendix 2. In 1980, the mean home range for all bears was 31 km2 (16 km2 for females and 46 km2 for males) compared to 218 km2 in 1981 (200 km^2 for females and 234 km2 for males). Mean home ranges in 1980 and 1981 for bears older than 2.0 years are given in Table 40. The data for these two years are not completely comparable as different individuals were observed during different seasons (Table 39). Regardless, it appears that these home ranges tend to be larger than has been recorded for black bears on the Kenai Peninsula: 16.7 km2 for females and 98 km2 for males (Schwartz and Franzmann 1981). However, in the Kenai study, a more conservative method was used to calculate home range sizes. As can been seen by reference to the home range plots in Appendix 2, the home range sizes reported in this study include, for many bears, large areas where no observations were made. This is especially true for the 1981 data when many bears moved long distances in late summer to foraging sites; these home ranges could be viewed as 2 seasonal home ranges connected by a narrow transportation corridor rather than as one home range.

Larger home ranges in 1981 relative to 1980 were observed for all groupings of individuals but were significant only for males (Pℓ0.01) and both sexes lumped (Pℓ0.05) (Table 41). Some of this increase was doubtless caused by the greater number of observations per bear in 1981 (Table 40) but it is evident that home ranges in 1981 were much more variable and larger than in 1980 (Table 40). We suspect that the greater movements in 1981 reflect the apparent relatively poor 1981 berry crop which necessitated greater movements to find acceptable foraging areas. Steve Buskirk (U. of Alaska, pers. comm.) informed us that ber-

Table 39. Home range sizes for Su-Hydro study area black bears. (Includes individuals with 5 or more relocations).

Bear ID (age @ capture)	1980 Observation Period	1980 (No. of locations)	1980 Home Range (km^2)	1981 Observation Period	1981 (No. of locations)	1981 Home Range (km^2)	Home Range (km^2) 1980 & 1981 lumped	Comments
Males								
330 (1)	---	--	---	May-October	(14)	10	--	
323 (2)	August-October	(6)	20	May-October	(18)	383*	383	
319 (3)	May-July	(6)	67	May-July	(9)	43	146	Bear died
291 (4)	May-July	(7)	20*		-	--	---	Bear died
322 (4)	August-October	(5)	10		-	--	---	Colar shed in den
324 (5)	August-October	(6)	29	May-October	(19)	248*	400	
342B(5)	---	--	---	May-September	(40)	611*	---	Shot by hunter
343 (5)	---	--	---	May-October	(16)	289*	---	
302 (8)	May-July	(7)	4	May-October	(36)	326*	326	Collar shed in '81 recaptured in '82
303 (8)	May-October	(15)	95*	May-October	(18)	92*	142	
305 (9)	May-August	(9)	48*	---	-	--	---	Killed by hunter
346 (9)	---	--	---	May-October	(16)	62*	---	
348 (9)	---	--	---	August-October	(7)	388	---	
287(10)	May-October	(17)	136*	May-October	(15)	268*	292	
304(10)	May-September	(14)	34*,**	May-October	(19)	37*	51*	
	$\bar{x}$(all males)=	(9.2)	46		18.9	230	248	
	S.D. =	--	42		18.9	185	135	
	range =	(5-17)	4-136		(7-40)	10-611	51-400	

(Continued)

Table 39. (Cont'd)

Bear ID (age @ capture)	1980 Observation Period	(No. of locations)	1980 Home Range (km^2)	1981 Observation Period	(No. of locations)	1981 Home Range (km^2)	Home Range (km^2) 1980 & 1981 lumped	Comments
FEMALES								
329 (1)	---	--	---	May-October	(19)	15	--	weaned in June 1981
349 (4)	---	--	---	August-October	(6)	36	--	
318 (5)	August-October	(6)	25(w/1c)	May-October	(20)	1036*	1051	weaned 1@1 in '81
327 (5)	August-October	(6)	3(w/2c)	May-October	(34)	31*	32	weaned 2@2 in '81
328 (6)	August-October	(6)	4	May-October	(18)	28*(w/2c)	30	
301 (7)	May-October	(20)	18*	May-October	(14)	12*(w/2c)	26	weaned 1@1 in '80
317 (7)	August-October	(6)	4(w/2c)	May-October	(18)	14*	19	weaned 2@1 in '81
290 (8)	May-October	(18)	45*	May-August	(14)	116*	163	weaned 2@1 in '81 not recollared in '81 as neck was infected.
289 (9)	May-October	(14)	43*	May-October	(19)	26*(w/3c)	47	weaned 2@1 in '80, had cubs in 1981.
288(10)	May-August	(16)	7	---	--	---	---	collar shed
321(10)	August-October	(6)	3	May-October	(14)	771*(w/2c)	774	lost cubs in August and made big movement.
325(11)	August-October	(6)	8	August-October	(8)	117	146	Collar shed in 80/81 recaptured in Aug. 1981.
	$\bar{x}$(All Females)=	(10.4)	16		(16.7)	200	254	
	S.D.=		16		---	355	383	
	Range=	(6-20)	3-45		6-34	12-1036	19-1051	
	$\bar{x}$(All Males & Females)=	(9.8)	31		(17.9)	215	251	
	S.D.=	---	35		---	273	293	
	Range=	(5-20)	3-136		(6-40)	10-1036	19-1051	

* Included in statistical comparisons, Table 41.

** Excludes atypical location of 80/81 den, with den home range for 1980 & 1981 was 104 km^2.

Table 40. Comparisons of mean home range size of black bears radio-tracked in 1980 and 1981 studies in Unit 13. Includes all bears 2 years of age or older.

	MALES			FEMALES			BOTH SEXES		
	1980	1981	1980 & 1981	1980	1981	1980 & 1981	1980	1981	1980 & 1981
Mean Home range size(km^2)	46	250	153	16	219	117	31	235	136
S.D.	42	180	167	16	368	274	35	278	223
Range	4-136	37-611	4-611	3-45	12-1036	3-1036	3-136	12-1036	3-1036
n	10	11	21	10	10	20	20	21	41
Mean age of sample	6.3	7.4	6.9	7.8	8.1	8.0	7.1	7.7	7.4
Range	2-10	3-11	2-11	5-11	4-12	5-12	2-11	3-12	2-12
Mean No. relocations/ bear=	9.2	19.4	14.5	10.4	16.5	13.5	9.8	18.0	14.0
Range	5-17	7-40	5-40	6-20	6-34	6-34	5-20	6-40	5-40
% Males							50	52	51
% of Females w/newborn cubs				30	40	35			

Table 41. Statistical comparisons between 1980 and 1981 mean black bear home range sizes. (Only individuals with comparable data in each year are included, see Table GG).

Comparison	Mean Home Range (km^2) 1980(n)	1981(n)	T	d.f.	P(X)
males	66(5)	257(9)	2.34	12	0.98*
females	35(3)	254(8)	0.91	9	0.81
females (w/o cubs)	35(3)[1]	299(4)[2]	.91	5	0.80
both sexes	55(8)	255(17)	1.95	23	0.97**
males 303, 287, and 304***	88(3)	102(3)	0.6	4	0.71
female 290	45(1)	116(1)	---	--	---

* Significant at P<0.01

** Significant at P<0.05

*** Equivalent data available for both years for these 3 bears, similar comparisons not feasible for females (301 and 289) because of presence of cubs in one of these years.

[1] Includes females 301, 290, 289.

[2] Includes females 318, 327, 317, 290.

ries were relatively infrequent in martin scats in 1981 relative to 1980 and he also believes that a berry crop failure occurred in 1981. In 1981, black bears were observed north of the Denali Highway near Susitna Lodge (R. Halford pers. comm.), a relatively rare occurrence which also supports the theory that 1981 was a year of atypically large black bear movements.

Black bears usually den within seasonal home ranges. The sizes of home ranges including observations at or in dens averaged only 0.4% larger (0-2%) than home ranges which excluded observations at dens. B304 was excluded from this analysis, his 1980/81 den was in an atypical high-elevation location which resulted in a 105% increase in home range size when this den location was included in calculation of his home range.

Unlike brown bears, data on mean elevation of black bear observations (Table 17) reveal few patterns. Females with cubs maintain a lower mean annual elevation than other bears ($T=2.22$, $P \leq 0.001$). The mean elevation of all observations of radio-collared black bears is at the high water mark of the proposed Watana impoundment (2200 feet) (Table 17).

The areas of overlap of black bear home ranges with the impoundment area and with the area enclosed by polygons constructed 1 mile and 5 miles from the proposed impoundment shorelines were determined (see Methods Section). The mean overlap with the impoundment area was 14% (0-45%), with the 1 mile polygon it was 50% (0-100%), and with the 5 mile polygon it was 122% (56-195%) (Table 42). Values over 100% were obtained when a large portion of the home range occurred in the area overlapped by the 5 mile polygons for each dam, the 1 mile polygons did not overlap (Figure 3). These data clearly demonstrate the close association of black bear distribution with the immediate vicinity of the proposed impoundments.

Table 42. Area of intersection of black bear annual home ranges with each impoundment and with 1 and 5 mile impoundment proximity polygons. (Home range data from Table 39).

Bear ID (age)	Home Range(km^2)	Area of Intersection with Impoundment			Area of Intersection + 1 mile			Area of Intersection + 5 miles		
		Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped
MALES										
330 (1)	10	0	0	0	0	3.5	35.0	1.6	10.0	106.0
323 (2)	383	1.0	21.7	5.9	10.3	138.9	39.0	84.7	371.1	119.0
319 (3)	146	0	14.1	9.7	0	77.1	52.8	0.5	145.8	100.2
291 (4)	20	0	1.6	8.0	0	9.9	49.5	19.3	19.5	194.0
322 (4)	10	2.5	0	25.0	9.0	0	90.0	9.6	2.3	119.0
324 (5)	400	0.4	9.8	2.6	9.9	75.2	21.3	39.0	250.2	72.3
342B(5)	611	141.4	0	23.1	352.7	0	57.7	569.9	13.7	95.5
343 (5)	289	0	11.8	4.1	0	74.6	25.8	0	162.1	56.1
302 (8)	326	98.0	0	30.1	199.7	0	61.3	325.4	0	99.8
303 (8)	142	0	3.1	2.2	8.2	28.4	25.8	82.9	140.2	157.1
305 (9)	48	0	0	0	0	0	0	39.3	11.1	105.0
346 (9)	62	14.8	0	23.9	53.1	0	85.6	61.6	0	99.4
348 (9)	388	34.3	2.0	9.4	85.9	30.9	30.1	170.2	281.3	116.4
287(10)	292	6.3	2.5	3.0	22.8	42.1	22.2	87.0	258.1	118.2
304(10)	104	0	0	0	0	4.3	4.1	57.2	62.2	114.8
FEMALES										
329 (1)	15	6.8	0	45.3	11.9	0	79.3	14.7	10.9	170.7
349 (4)	36	0	11.2	31.1	0	31.5	87.5	0	35.9	99.7

(Continued)

Table 42. (Cont'd)

Bear ID (age)	Home Range (km^2)	Area of Intersection with Impoundment: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Area of Intersection + 1 mile: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped	Area of Intersection + 5 miles: Watana (km^2)	Devils Canyon (km^2)	Total % over-lapped
318 (5)	1051	113.5	4.3	11.2	336.2	35.3	35.3	922.2	124.2	99.6
327 (5)	32	14.1	0	44.1	22.3	4.8	84.7	32.0	24.9	177.8
328 (6)	30	0	0.9	3.0	5.6	10.8	54.7	28.9	29.5	194.6
301 (7)	26	7.0	0	26.9	26.0	0	100.0	26.5	0	101.9
317 (7)	19	0	0	0	0.9	5.8	35.3	13.7	19.3	173.7
290 (8)	163	0	10.6	6.5	0	69.6	42.7	8.6	163.4	105.5
289 (9)	47	21.3	0	45.3	37.6	4.2	88.9	46.9	27.3	157.9
288(10)	7	0	0	0	0	3.7	52.9	0	7.4	105.7
321(10)	774	92.9	5.4	12.7	279.1	46.1	42.0	697.5	154.4	110.1
325(11)	146	9.8	3.3	9.0	41.8	28.8	48.4	109.3	83.9	132.3
	mean =			14.15			50.1			122.3

* Percentage figures do not accurately portray impoundment-related habitat losses as home range size used reflects total annual home range, percentage figures based on seasonal home ranges would be higher especially during spring and early summer.

2. Seasonal Movements

As mentioned in our first annual report, in 1980 many black bears made seasonal movements in late summer (late July-August) to the tablelands between the spruce forests along the Susitna River and the mountains north of the river (see Figure 7 and Appendix 2). We suspect these movements were motivated by ripening berries which may be more abundant in these relatively open areas than in the spruce forests where black bears are more commonly found during the rest of the year. Similar movements were evident in 1981 but many bears moved much greater distances in this year. We suspect the apparent 1981 scarcity of berries in the tablelands relative to 1980 prompted these more extensive movements which are reflected in comparisons of annual home range sizes (Table 39). These movements are likely motivated by searches for better foraging or fishing areas, but actual motives could not be determined. Details of these, apparently atypical, movements follow for selected individuals.

In August-October 1980, female 318 (with 1 cub in 1980) remained in the vicinity of Tsusena Creek. After weaning her yearling and apparently breeding in 1981, this bear moved upstream in late July about 80 km to the vicinity of the confluence of the Tyone and Susitna Rivers, returning to Tsusena Creek in mid-September and entering her den in late September (Fig. 44).

In August-October 1980 and early summer 1981, female 321 (with 2 cubs in 1981) remained in a small home range east of Devil Mountain and west of Tsusena Creek. In early August 1981 she lost her cubs and then moved about 64 km upstream to Tyone Creek, returning to her original home range by 9 September and entering her den between 16 and 22 September (Fig. 46).

The same pattern was apparent for female 325 who had a 1980 home range east of Devil Mountain and west of Tsusena Creek but was found upstream in the tablelands between Watana and Kosina creeks

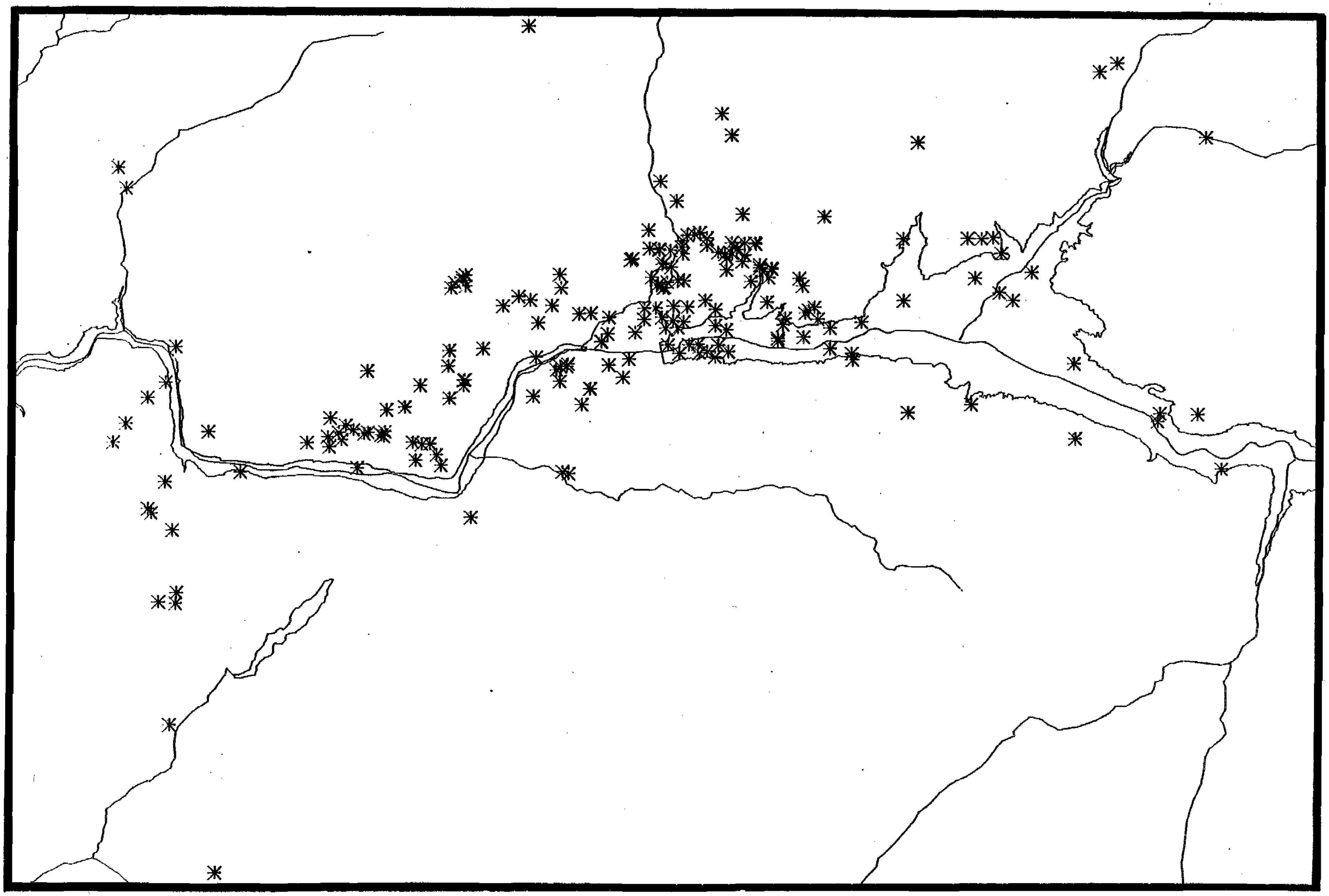

Figure 7. Distribution of 204 black bear locations obtained between 16 July and 4 September. During this period many black bears utilize a berry-rich shrubland habitat adjacent to the spruce forests.

in August 1981. She returned in early September 1981 and entered her den in late September (Fig. 50). This bear shed her collar in her 1980/81 den and so her movements early in 1981, prior to her recapture in August, were not known.

Female 290 (with 1 yearling in early 1980) spent the whole 1980 season and early summer 1981 in a small area north of Stephan Lake. In early August she moved upstream about 25 km to the Tsusena Creek vicinity (Fig. 36). This bear was recaptured in August 1980 but was not recollared because of an infected neck so her 1981/82 den location was not determined.

Male 342b (a large cinnamon-colored bear) made similar upstream movements in 1981, from Tsusena Creek to Vee Canyon in August-September 1981 (Fig. 55). This bear was shot by a hunter in September while it was apparently returning.

Male 346 spent most of the summer of 1981 just west of Vee Canyon, moved west almost to Jay Creek in late July and then moved back east almost to Goose Creek in August, returning to den just west of Vee Canyon. These movements suggest that an initial westward movement to find better foraging was unsuccessful and was followed by a more successful movement upstream (Fig. 57).

Male 323 was found between Tsusena and Deadman Creeks in fall 1980, moved to the High Lake-Portage Creek area in spring 1981 but came back in fall 1981. This bear denned at about the same place (at the proposed Watana dam site) in both years (Fig. 48). The reason for the westward movement in spring 1981 is unclear. It is likely, however, that the bear was foraging for berries on the upstream tablelands in the late summer of both years.

Three males moved downstream from the main study area in fall 1981, apparently to fish for salmon downstream of Devils Canyon. B343 moved from a home range centered on Devil Creek in early 1981 downstream to about mile 250 on the Alaska Railroad

(Talkeetna Mts. Quadrangle C-6) in late July and denned in this same general area. The calculated home range of this bear (Fig. 56), Table 39) cuts diagonally across the Chunilna hills instead of following the Susitna River as the bear doubtless did. In fall 1980, B324 (Fig. 49) was found in the tablelands between Tsusena and Deadman Creeks, denned and spent the early summer 1981 between Stephan Lake and east of Devil Mountain. In late July 1981 this bear moved downstream to the same area as B343 but returned to its same den site in late September (interestingly, this den was apparently occupied by female B325 and B324, obligingly, found another den elsewhere). Male 348 (Fig. 58) was captured on the tablelands around Watana Creek early August 1981 but moved west to Portage Creek in early September and denned on Portage Creek. Perhaps this bear found his traditional late-summer berry foraging area inadequate and moved west to fish for salmon as a replacement.

It appears that female black bears with newborn cubs do not make movements as extensive as other bears even during years of berry scarcity. Two females that were observed from May through October both 1980 and 1981 had smaller home ranges in 1981 when they had cubs than they did in 1980 when they were alone (B289 and B301, Table 39). A third bear (B321), as mentioned above, remained in a small 1981 home range until her cubs were lost and then made an extensive movement upstream. The pattern of larger home ranges in 1981 compared to 1980 appeared to be reversed for females with newborn cubs (Table 39), although sample sizes remain too small to be conclusive. If 1981 was indeed a poor year nutritionally for black bears, relatively high losses of the surviving cubs in their 1981/82 dens might occur.

The pattern of black bear movements based on available data and supposition can be summarized as follows. In years of normal or acceptable berry crops, many bears move to somewhat higher country adjacent to the spruce habitats along the river in late summer, returning to their spring and early summer home ranges near the river to den. Most of these late summer movements are upstream (east) and a bit north. In years of subnormal berry crops most individuals make more extensive movements and many of these move long distances upstream or downstream in search of acceptable foraging areas or areas where salmon are available. These movements occur both upstream and downstream along the main Susitna River which becomes a main transportation corridor. Some of the individuals making these extensive movements do not return to their former home ranges, but most do. Females with newborn cubs are exceptions to this rule, making less extensive movements than other bears or than themselves in years when they do not have cubs, regardless of the berry crop. In late summer and fall, especially in poor berry years, the more extensive movements of black bears may bring them in closer contact with areas frequented by brown bears at time and this may result in increased mortality of black bears through inter-specific predation.

3. Proximity Analysis - Black Bear

Proximity analyses for black bear locations falling within the area of the proposed impoundments, 1 mile from the proposed impoundment shoreline, and 1-5 miles from the shoreline were conducted in the same manner as discussed for brown bear (section VIII-E-5 this report). These data are presented in Table 43.

In all cases the null hypothesis that bears were using these 3 zones in proportion to the areas of these zone was rejected (Pℓ0.025) (Table 43). For the Watana impoundment, both the impoundment area and the area within 1 mile of the impoundment were used markedly more than expected (Table 43). For the Devils Canyon impoundment the zone within 1 mile of the impoundment shoreline showed the highest use relative to expected values (Table 43). The outermost zone most distant from the proposed

Table 43. Number of observations of radio-collared black bears within nested impoundment proximity polygons. Expected values given in parenthesis.

	Within impoundment zone	Within 1 mile but outside impoundment zone	1 - 5 miles	Totals	> 5 miles	Chi Square (2 d.f)
DEVILS CANYON IMPOUNDMENT						
area (km^2)	28.92	164.78	689.01	882.71	--	
%	3.28	18.67	78.06	100.00	--	
Females w/o cubs						
9/1-7/15	2	45	47	94	0	
7/16-8/31	1	10	18	29	0	
Males						
9/1-7/17	1	56	49	106	10	
7/16-8/31	1	4	22	27	7	
Females with cubs						
9/1-7/15	0	9	8	17	0	
7/16-8/31	0	7	1	8	0	
Total	5 (9.22)	131 (52.46)	145 (219.35)	281	17	144.7*
All Bears						
9/1-7/15	3 (7.12)	110 (40.51)	104 (169.39)	217	10	146.8*
7/16-8/31	2 (2.10)	21 (11.95)	41 (49.96)	64	7	8.5**
WATANA IMPOUNDMENT						
area (km2)	159.32	327.07	1233.51	1719.90	--	
%	9.26	19.02	71.72	100.00	--	
Females w/o cubs						
9/1-7/15	31	23	17	71	1	
7/16-8/31	16	14	6	36	0	
Males						
9/1-7/15	36	41	35	112	6	
7/16-8/31	8	14	36	58	1	
Females with cubs						
9/1-7/15	12	9	3	24	0	
7/16-8/31	5	6	4	15	0	
Total	108 (29.26)	107 (60.10)	101 (226.64)	316	8	318.1*
All Bears						
9/1-7/17	79 (19.17)	73 (39.37)	55 (148.46)	207	7	274.3*
7/16-8/31	29 (10.09)	34 (20.73)	46 (78.17)	109	1	57.2*

* Significant $P < 0.005$, ** Significant $P < 0.025$

impoundments was used only about half as much as expected under the null hypothesis for both impoundments (Table 43).

On a seasonal basis the lowest variation from expected values occurred in the late summer (16 July-31 August). This corresponded with the observation discussed above that at this season many black bears tend to move to berry-rich tablelands more distant from the impoundments. Even in the late summer, however, selection for the immediate impoundment vicinity was significant (Table 43).

The restriction of black bear distribution in the study area to the immediate vicinity of the proposed impoundments is clearly evident in this analysis. Only 25 locations (4%) were outside of the 5 mile impoundment-proximity (Table 43). Most of these 25 locations were in the vicinity of the Susitna River but were either upstream or downstream of the 5 mile polygon (see Figure 2 and Figure 3), only a few were actually over 5 miles distant from the Susitna River.

This analysis clearly shows that the direct impact from flooding on the area utilized by the existing black bear population will be severe in the vicinity of the proposed Watana impoundment.

4. Dispersal

Dispersal of bears from the study area may contribute to bear populations in other areas. Some black bears may also disperse to the study area but the reverse is probably more common because of the constricted, and apparently saturated, nature of black bear habitat in the primary study area near the proposed impoundments. Dispersal to the impoundment area cannot be documented because individuals from distant subpopulations have not been radio-collared. Some cases of dispersal of marked bears from the study area, however, have been documented. More dispersal from the study area likely occurs than has been documented; problems with placing radio-collars on subadult bears, the most likely dispersers, results in minimal documentation of actual dispersal frequency. Of 4 documental dispersals, 3 have been westward and 1 southward.

A 2-year old male (B307) was captured on Clark Creek (west of Tsusena Butte) in May 1980. This subadult was marked but not radio-collared. One year later this bear was shot by a hunter near Hurricane on the Parks Highway, about 30 miles west of its capture site. This represents a probable natural dispersal of a subadult bear.

A 4-year old male (B320) was captured in August 1980 north of the Susitna River and east of Devil Mountain. Without any intervening relocations, this bear was shot 1 month later on the Sheep River, 45 miles south. Guide Ed Stevenson who returned the radio-collar and provided information on the kill location had seen this bear 5 times earlier in September in the upper Sheep River. This represents a dispersal of an adult black bear from the study area, but the possibility that trauma associated with capture contributed to this behaviour cannot be discounted. Similar behaviour, however, has not been seen for other handled bears.

As discussed above, 3 adult black bear males in 1981 moved downstream of the Devils Canyon dam site from upstream areas in the vicinity of the proposed impoundments. Two of these bears (B343 and B348) denned downstream. As discussed, these movements may have been prompted by a scarcity of upstream forage in 1981 but, regardless, represent apparent dispersals from the study area.

The implications of these black bear movement patterns relative to the proposed construction of Su-Hydro dams include the following:

1. Actual impoundment areas and impoundment-impact areas will have a negative impact on black bear denning habitats and spring-early summer habitats when bears are concentrated along the river in spruce-vegetated habitats.

2. Late summer and fall foraging habitats on the adjacent tablelands will be adversely affected by access routes proposed through them and by construction facilities and borrow areas. A primary tableland area is between Tsusena and Deadman Creeks, the site of the current Watana Camp and the probable site of expanded quarters for construction staff.

3. During poor berry years movements downstream of the proposed dams by black bear to forage for salmon below Devils Canyon may be unsuccessful because of reduced or eliminated natural salmon spawning between Talkeetna and Devils Canyon (a needed buffer in bad berry years may not be available). These movements may be typical of some individuals even in moderate to good years, but have not so far been seen except in 1981.

4. Transportation corridors for movements upstream and downstream by bears in the project area may be blocked or constrained by the impoundments themselves, this may be especially important during poor berry years when these corridors are most utilized. Any such impediment would limit seasonal movements to foraging areas including movements to areas where moose calves may be important prey.

5. Climatic changes resulting from the impoundments may alter (either beneficial or deleterious effects are possible) the abundance or distribution of berries on the tablelands used by bears in the late summer.

Similar climatic influences in the immediate vicinity of the impoundments may alter the availability of forage utilized early in the spring, this effect would doubtless be negative.

6. Reduction of the number of dispersing bears to adjacent habitats (long-range).

5. Impact of Borrow Areas--Black Bear

Black bear populations or movements will be affected by some of the proposed borrow areas.

The greatest impact will be in borrow area D (west of Deadman Creek) which is in the tablelands area used by black bears foraging for berries in late summer. As mentioned, in the late summer these tableland areas are used both by local resident black bears as well as by bears moving to these areas from downstream locations. The plant ecology study (subtask 7.12) prepared by the Agricultural Experimental Station, University of Alaska indicates the size of Area D as 228 hectares of which 48% is low mixed shrub and 32% is birch shrub (op. cit., Table 4, page 23). Bog blueberry (*Vaccinium uliginosum*), crowberry (*Empetrum nigram*) and Mt. cranberry (*V. vitis-idaea*) were especially common in these shrub types according to this study. Borrow area D encompasses 0.02% of the low mixed shrub type found in the entire upper Basin and 0.22% of the birch shrub type (op. cit.). From the perspective of a black bear, however, these low percentages are misleading as the proximity of these types to escape cover (especially forests) governs their use by black bears. Borrow area D encompasses a much higher percentage of these types which are also found in close proximity to escape cover. The same type of impact would result from Borrow area F (mid-Tsusena Creek) which is 77% comprised of the low shrub type.

Borrow areas B (mouth of Deadman Creek), A (Fog Lakes), H (south of Fog Creek), and the north part of E (mouth of Tsusena Creek) are in forested areas where some individual black bears are resident. Of these, area A would have the least impact on black bears and area H the greatest based on available data. These borrow areas would reduce the amount of black bear habitat available in the study area. Borrow area C would have negligible impact on black bear.

IX. F. HABITAT RELATIONSHIPS-BLACK BEAR

1. Aerial Classifications

Vegetation type was classified into 1 of 23 classification categories for 724 black bear locations made from the air. For 227 of these locations (31%), 2 vegetation type categories were recorded yielding a total of 915 habitat hits for black bears. Of these 798 were obtained from radio-collared individuals. These data were lumped into 5 gross habitat categories as discussed above for brown bears. These data by month of observation are given in Table 44.

Black bear use of spruce habitats, concentrated in the vicinity of the proposed impoundments, was common throughout the year but was least prevalent in late summer. In August black bears were more commonly found in shrubland habitats adjacent to the spruce forests (Table 44). As mentioned, we suspect this late seasonal movement was motivated by the relative abundance of ripening berries on these shrubby tablelands.

The hypothesis that spruce habitats were used less frequently in late summer (16 July-31 August) was tested by contrasting occurrence in spruce habitats during this season (36% of 251 observations) with the rest of the year (44% of 547 observations) for radio-collared individuals. The difference was significant (Chi

Table 44. Number of aerial black bear observations by month in each of 5 habitat categories.

Habitat	May	June	July	August	September	Oct.-April	Row Total (%)
SPRUCE	82	95	54	68	44	15	358
Row %	22.9	26.5	15.1	19.0	12.3	4.2	(39.4)
Column %	50.3	46.3	35.8	31.8	30.8	46.9	
RIPARIAN	23	33	23	18	23	1	121
Row %	19.0	27.3	19.0	14.9	19.0	.8	(13.3)
Column %	14.1	16.1	15.2	8.4	16.1	3.1	
SHRUBLAND	50	70	69	119	71	9	388
Row %	12.9	18.0	17.8	30.7	18.3	2.3	(42.7)
Column %	30.7	34.1	45.7	55.6	49.7	28.1	
TUNDRA	3	3	3	6	2	0	17
Row %	17.6	17.6	17.6	35.3	11.8	0	(1.9)
Column %	1.8	1.5	2.0	2.8	1.4	0	
OTHER	5	4	2	3	3	7	24
Row %	20.8	16.7	8.3	12.5	12.5	29.2	(2.6)
Column %	3.1	2.0	1.3	1.4	2.1	21.9	
Column Total	163	205	151	214	143	32	908
(%)	(18.0)	(22.6)	(16.6)	(23.6)	(15.7)	(3.5)	(100.0)

square = 4.7, 1 d.f., P<0.05). There was a significant difference between males and females in late summer use of spruce habitats (Chi square = 4.4, 1 d.f., P<0.05). In the late summer 43% of 126 female observations were in spruce habitats compared to 30% of 125 male observations. Although sample sizes are small, this difference does not appear to reflect differences between females with newborns (12 observations in spruce out of 30 in the late summer) and females without newborns (25 observations in spruce out of 95 in the late summer (Chi square = 1.88, 1 d.f., P>0.10).

2. Vegetation Map Classifications - Black Bear

The techniques and problems involved in use of the vegetation maps prepared by the Plant Ecology subtask to show bear selectivity for different types are described in the brown bear portion of this report (Section VII-F-2). The same problems exist for the black bear data which are presented in Table 45a. As discussed for brown bears, statistical analyses of these data based on existing information on availability of these vegetation types would be inappropriate.

As was done for brown bears, however, some analysis of black bear selectivity for different vegetation types within the actual impoundment area was possible for the Watana impoundment. Within the area flooded by the proposed Watana impoundment, use of vegetation types varied from expected values that were based on availability (Chi square = 68.1, 4 d.f., P<0.005) (Table 45b). Deciduous forests and shrublands were used more than expected in the flooded area and the other types were used less than expected (Table 45b).

In the deciduous category all use was in closed birch (17 hits) and open birch (12 hits). It is noteworthy that 35% of the area of these 2 types will be flooded by the impoundments (calculated

Table 45a. Number of radio-collared black bear observations in different vegetation types mapped at the 1:63,360 scale. Statistical analyses based on these data were not conducted because of absence of appropriately partitioned availability information (see text).

Vegetation type	No. black bear hits
TUNDRA	
Mat and cushion (3)	13
Sedge-grass (4)	9
Sedge-shrub (5)	5
Wet sedge-grass (6)	9
CONIFER FOREST	
Open black spruce (7)	34
Woodland black spruce (8)	122
Open white spruce (9)	21
Woodland white spruce (10)	51
DECIDUOUS FOREST	
Closed birch (11)	30
Open birch (12)	21
Poplar (13 & 14)	0
MIXED FOREST	
Closed conifer-decid. (15)	107
Open conifer-decid. (16)	33
SHRUBLANDS	
Closed tall (17)	14
Open tall (18)	32
Birch (19)	125
Willow (20)	7
Low shrub (21)	98
GRASSLANDS (22)	0
OTHER	
Rock (1)	9
Snow and ice (2)	0
Lakes (23)	1
Disturbed (24)	0
River-gravel bar (25)	0
Herbaceous (26)	0
Total	741
No. of observations with 2 hits (% of observation)	216 (41%)
No. of observations outside area mapped at 1:63,360 (% of observation)	93 (15%)

Table 45b. Black bear use of vegetation types in impoundment areas.

HABITAT TYPE	Watana Impoundment % occurrance on 1:24,000 scale	Watana No. hits observed (1:63,360)	Watana No. hits expected	Devils Canyon Impoundment % occurrence on 1:24,000 scale	Devils Canyon No. hits observed	Devils Canyon No. hits expected
(Other, not included)		(2)	--		(0)	--
7 & 9 (Open Spruce)	28.43	17	42.1	31.45	0	--
8 & 10 (Woodland Spruce)	35.24	52	52.2	5.91	0	--
CONIFER TOTALS	63.74	69	94.3	37.36		
11-14 (Deciduous Forest)	6.00	29*	8.9	20.43	0	--
15-16 (Mixed Forest)	16.25	18	24.1	38.60	5	--
Decid & Mixed Totals	22.25	47*	33.0			
17-21 (Shrub-lands)	14.01	32*	20.7	3.61	0	--
TOTALS	100% (13512 ha)	148	148.0	100% (2741 ha)		--

* Observed greater than expected suggests positive selection.

from Table 22). Doubtless the proportion of these two types that will be flooded in the vicinity of the Watana impoundment is much higher than 35%, however, this cannot be calculated because data on availability outside of the flooded area has not been calculated separately for each impoundment.

XI. - G. DEN AND DENNING CHARACTERISTICS-BLACK BEAR

1980/81 den sites were located and measured for 14 radio-collared black bears, 2 additional approximate den locations were recorded but the actual dens were not found (Table 46). 1981/82 den sites have been tentatively located from fixed-wing aircraft for 19 black bears, 14 of these are from the same individuals whose dens were found the preceding year (Table 47). More precise data for these 1981/82 dens will be available in summer 1982. Locations of dens are given in Figure 8.

Black bear den sites ranged in elevation from 1,300 feet to 4,340 feet, however, only one bear denned at an elevation above 3,000 feet (B304 in 1980/81). Typically black bears in the study area denned at elevations between 1,500 and 2,500 feet elevation. Of 16 den sites found in the vicinity of the proposed Devils Canyon impoundment, only one will apparently be flooded at an impoundment elevation of 1,450 feet (Tables 46 and 47); the average elevation of these 16 dens was 2,178 feet (range=1,490-4,340 S.D.=686 feet). Of the 13 den sites found in the vicinity of the proposed Watana impoundment, 9 would apparently be flooded at an impoundment elevation of 2,200 feet (Tables 46 and 47); the average elevation of these 13 dens was 2,177 feet (range=1,800-2,750; S.D.=281 feet). Two black bears denned downstream of the Devils Canyon site in 1981 (Table 47).

These data suggest that the direct impacts resulting from inundation of black bear dens sites will be very high for bears denning in the vicinity of the Watana impoundment and low for those denning in the vicinity of the Devils Canyon impoundment.

Table 46. Characteristics of black bear dens in the Susitna study area during winter of 1980/1981.

	Den No.	Bear ID No.	Age at Exit	Elevation (feet)	Slope (Degrees)	Aspect (True N)	Vegetation	% Canopy Tree Coverage	ENTRANCE Ht. (cm.)	ENTRANCE Width (cm.)	CHAMBER Ln. (cm.)	CHAMBER Width (cm.)	CHAMBER Ht. (cm.)	Total Length (cm)	Previously Used? (Yes/No)	A	B	C
NATURAL CAVITIES																		
FEMALES w/offspring (at exit)																		
w/2 cubs	8	B321	11	2825	42	208	Alder	0	79	26	127	68	71	610	Yes	2	No	–
w/2 cubs	19	B328	7	1950	40	218	Alder	0	41	93	–	–	–	–	Yes	4	No	–
? collar shed in den	6	B325	12	1490	30	178	Birch/alder/spruce	50	49	27	100	74	55	113	Yes	2	No	–
MALES																		
	7	B287	11	1700	46	170	Cottonwood/willow/birch	50	62	44	122	89	42	–	Yes	2	No	–
	9	B324	6	2240	30	88	Alder	0	38	34	137	70	45	–	Yes	3	No	–
	10	B303	8	1690	50	48	Willow/alder/aspen	–	93	36	108	82	94	869	Yes	1	No	–
	13*	B304*	11	4340	24	52	Rock pile/tundra	0	–	–	–	–	–	–	?*	–	No	–
	18*	B322*	5	1840	53	158	Alder/rock slide	0	–	–	–	–	–	–	?*	–	–	Yes
DUG DENS																		
FEMALES w/offspring (at exit)																		
w/2 cubs	2	B301	8	2065	34	191	Alder/birch	90	49	43	97	92	51	151	Yes	3	–	Yes
w/3 cubs	4	B289	10	2000	18	211	Alder/willow/spruce	70	39	72	142	127	55	290	No	1	–	Yes
w/2 ylgs.	11	B317	8	2050	36	86	Alder	0	27	41	93	93	78	128	No	3	No	–
w/1 ylg.	12	B318	6	2725	24	122	Dwarf birch/moss/tundra	0	24	42	95	84	40	145	No	5	No	–
w/2 ylgs.	21	B327	6	2000	35	379	Alder/birch	80	22	59	163	203	116	198	?	4	–	Yes
MALES	20*	B323*	3	1950	46	176	Alder/birch	–	–	–	–	–	–	–	?*	–	–	Yes
SPECIES UNK.	3	–	–	2340	35	(254)	Dwarf birch	0	50	54	–	–	–	170	No	–	–	No

* Actual den site not found or too difficult to enter.
A Subjective characterization of quality, 1 = highest and 5 = lowest.
B Will be flooded by Devil's Canyon?
C Will be flooded by Watana Impoundment?

Table 47. Distance between den sites utilized by radio-collared black bears in 1980/81 and in 1981/82. (81/82 data are preliminary as den sites have not been located on the ground as yet).

Bear ID/sex/age (1981)	Distance (miles)	Approx. Den elevation (1981/82)	1981/1982 den will apparently be flooded by: Devils	Watana
B287/M/11	0 (same)	1,700	no	--
B289/F(w/3c)/9	0 (same)	2,000	--	yes
B301/F(w/2c)/8	0.5	2,450	--	no
B303/M/9	0 (same)	1,690	no	--
B304/M/11	9.0*	1,850	no	--
B317/F/8	0.7	1,950	no	--
B318/F/6	2.7	2,000	no	--
B321/F/11	1.4	2,200	no	--
B323/M/3	1.3	2,000	--	yes
B324/M/6	6.8**	1,500	yes?	--
B325/F/12	2.7**	2,240	no	--
B327/F/6	3.0	2,750	--	no
B329/F/1	0.4***	1.900	--	yes
B328/F(w/1c)/7	0.2	2,100	no	--
B343/M/5****	?	1,300	Gold Creek	
B346/M/9****	?	2,350	--	no?
B348/M/9****	?	1,600	Portage Ck.	
B349/F/4****	?	2,550	--	no
B302/M/9	?	2,100	--	yes

* B304 denned in very atypical high-elevation den in 1980/81.

** B325 is apparently denning (in 81/82) in same den utilized by B324 (in 80/81). B324 was located near, or at, this same den (occupied by B325 since 16 Sept.) on 1 October, but subsequently moved to another den site.

*** This bear denned with its mother (B327) in 1980/81.

**** Not radio-collared in 1980.

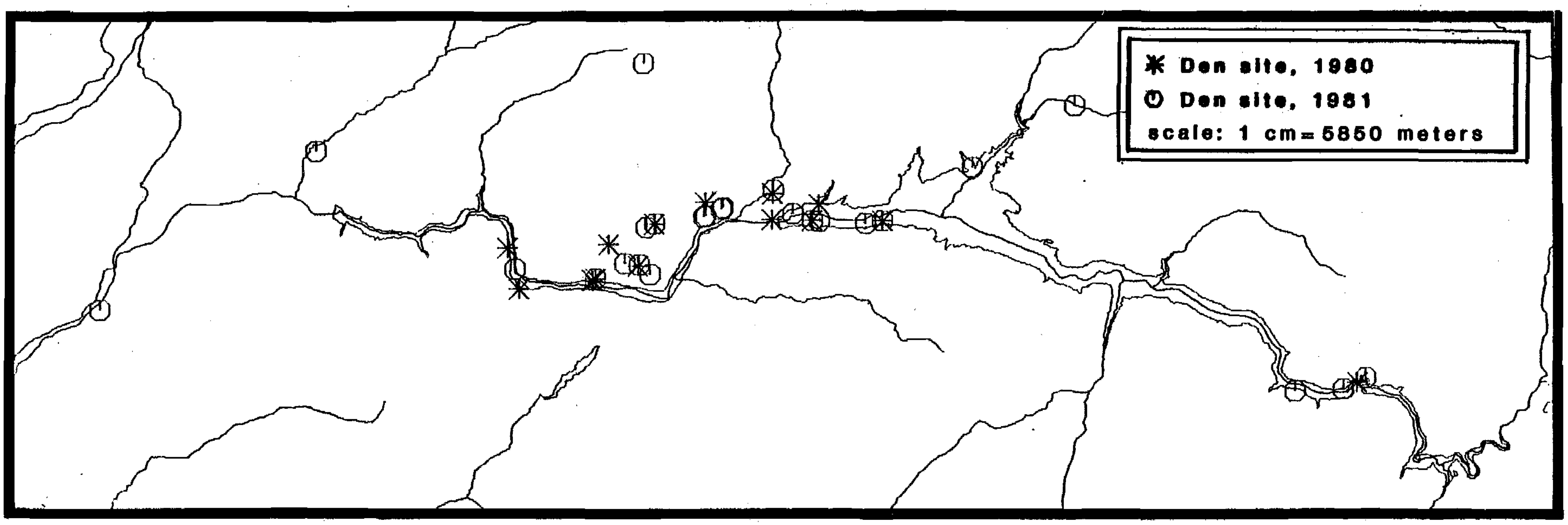

Figure 8. Locations of all black bear dens found in Su-Hydro bear studies, 1980 - 1981.

The distribution of known black bear den sites indicate that study-area black bears tend to den in steep terrain along the main Susitna River or feeder streams (Fig. 8). Proceeding upstream through the study area, the band of acceptable denning habitat apparently becomes progressively narrower and more confined to the immediate vicinity of the Susitna River, much the same pattern as seen for black bear overall distribution. This explains the greater impact of the upper impoundment relative to the lower impoundment.

Of the 14 dens used in 1980/81 that have been located on the ground, 8 were in natural cavities or caves and 6 were excavated. All of the natural cavity dens examined (n=6) and 1 of the dug dens examined (n=4) had apparently been previously utilized based on evidence found at the den site; a determination of previous use could not be made for 4 dens. Four of the dens examined in 1981 are apparently being utilized again in the winter of 1981/82 by radio-collared black bears, 3 of these by the same individual that utilized the den the preceding year (Table 47). These data on reuse of den sites may indicate scarcity of acceptable denning sites in the study area or they may just indicate habituation. Of 18 den sites examined on the Kenai Peninsula, 8 had been previously used and 10 were newly constructed; only 1 bear reused the same den in successive years (Schwartz and Franzmann 1981). Relative to this Kenai study, reuse of den sites appears higher in the Susitna area. All of the dens in the Kenai study were excavated (Schwartz pers. comm.) compared to 43% in the Susitna area. The average distance between dens utilized by the same bear (n=14) in successive years was 2.1 miles (range=0-9 miles, S.D.=2.7 miles). Comparison data for black bear dens in Prince William Sound are given in Appendix 5. Here reuse was also lower than in the Susitna area and many bears denned in hollow trees.

For 15 black bear dens visited in summer 1981, the mean slope was 36° (range=18-53°, S.D.=10°). The mean slope of excavated dens

($\bar{x}$=39°, S.D.=10°, n=8) was essentially equivalent to that of dens in natural cavities ($\bar{x}$=33°, S.D.=9°, n=7). Half of the dens visited were within 45° of True South (135-225°) (Table 46 and Figure 9).

Radio-collared black bears in the study area entered dens from mid-September through mid-October and exited dens, in 1981, from early April to mid-May (Table 48). Based on earliest and latest possible den entrance and exit dates of radio-collared individuals, black bears spent a median period of 223 days in 1980/81 dens, 61% of the year. In 1981, black bears appeared to enter dens about 2 weeks earlier than they did in 1980 (Tables 48 and 49). This may have resulted from the apparent relatively poor berry crop in 1981; fall weather conditions appeared essentially equivalent in 1980 and 1981.

IX. - H. PREDATION RATES-BLACK BEAR

Black bear predation on moose calves is prevalent on the Kenai Peninsula (Franzmann et al. 1980). Black bears killed 34% of 47 radio-collared moose calves, compared to 6% by wolves, 6% by brown bears (low density), 2% unknown predation, and 8% accidental deaths or unknown causes. Of known predator-caused deaths of moose calves in this study, black bears caused 70% (op. cit.). Most black bear predation on the Kenai occurred when calves were small, less than 1 month old. High levels of black bear predation of elk calves in Idaho have also been reported (Schlegel 1976).

Of 23 radio-collared black bears followed in the Kenai study, 5 (22%) were known to have preyed on moose calves (Schwartz and Franzmann 1980, in press). No predation occurred in areas where moose browse rehabilitation had occurred, all predation occurred in uncrushed areas of regrowth vegetation resulting from a 1947 forest fire (op. cit.). If this same model holds in the Susitna

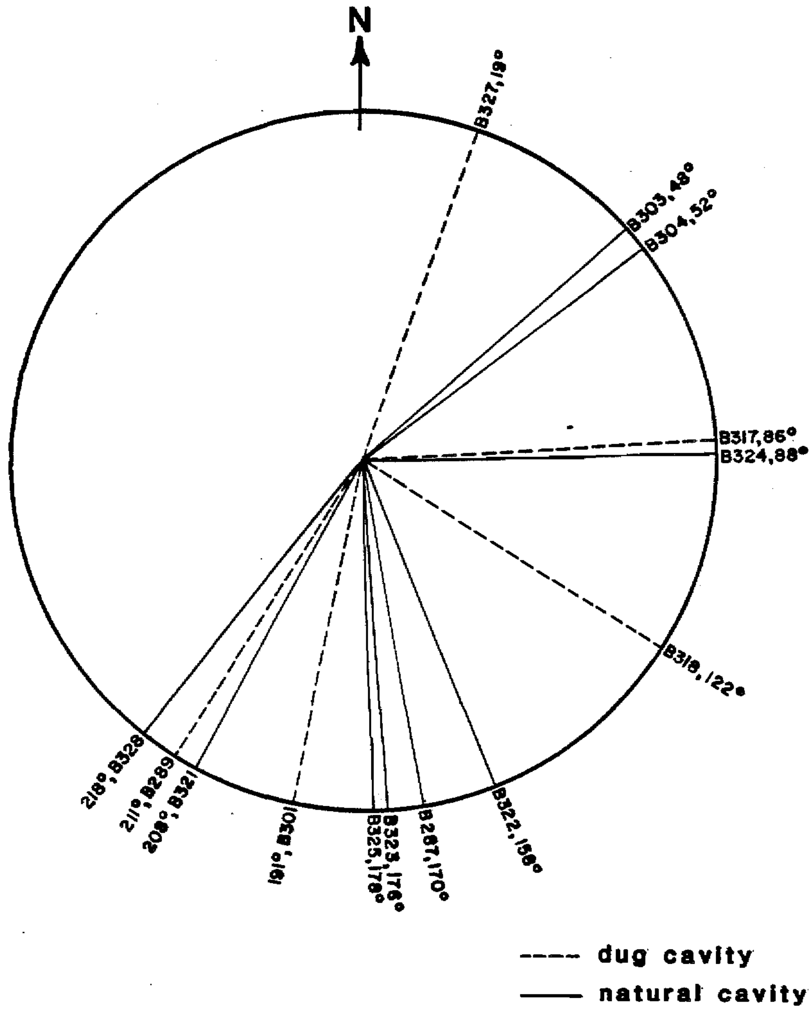

Figure 9. Aspect of black bear dens in the Su-Hydro study area, 1980/81.

Table 48. Den entrance & emergence of individual radio-collared black bears, in both 1980 and 1981.

Bear ID/sex	1980 den entrance*	1981 den entrance*	1981 entrance earlier or later than 1980	1981* emergence
B287/M	9/9-9/29	8/24-9/9	earlier	4/3-5/5
B289/F	9/9-9/29	9/23-10/1 (w/3c)	?	5/8-5/15
B301/F	9/29-10/13	9/16-9/22 (w/2c)	earlier	5/9-5/29
B317/F	9/9-9/29 (w/2c)	9/9-9/16	?	5/5-5/15
B318/F	9/29-10/13 (w/1c)	9/16-9/22	earlier	4/30-5/5
B321/F	9/9-9/29	9/16-9/22**	?	5/10-5/15
B323/M	9/29-10/13	9/22-10/1	?earlier?	5/6-5/8
B324/M	9/29-10/13	10/1-10/7	?	4/30-5/5
B325/F	9/29-10/9	9/9-9/16	earlier	---
B327/F	9/9-9/29 (w/2c)	9/16-9/22	?	5/8-5/10
B328/F	9/9-9/29	9/16-9/22	?	5/21-5/29
B290/F	10/1-10/9	---	---	5/5-5/10
B319/M	9/29-10/13	---	---	4/30-5/5
B322/M	9/9-10/13	---	---	---
B303/M	---	9/16-9/22	---	4/30-5/5
B304/M	---	9/16-10/1	---	5/5-5/10
B329/F	---	9/22-10/1	---	---
B343/M	---	9/16-9/22	---	---
B346/M	---	9/9-9/16	---	---
B348/M	---	9/16-9/22	---	---
B349/F	---	9/9-9/16	---	---
B302/M	---	9/16-9/22	---	---

* Dates indicate last observation away from den and first observation at the den, large gaps, especially in 1980, reflect flights missed due to poor flying conditions.

** 2 cubs lost in mid July.

Table 49. Comparison of radio-collared Black Bear den entrance dates, 1980/81 and 1981/82. (Poor weather resulted in some missed and incomplete flights in 1980).

Time Period	8/22-8/28	8/29-9/5	9/6-9/12	9/13-9/19	9/20-9/26	9/27-10/3	10/4-10/10	10/11-10/17
1980 date flown	8/27	-	9/9	-	-	9/29	10/9	10/13
1981 date flown	8/24	9/1	9/9	9/16	9/22	10/1	10/7	10/16
	Number of bears at den site/Number of bears found*							
1980	0/14	?	0/14	?	?	6/13	8/8	14/14
1981	0/9	0/18	1/19	5/19	15/18	19/19	19/19	19/19

* Number of bears found includes bears found and those missed during that flight that were previously and subsequently observed at the same den site, does not include those missed during that flight that were not at the den site during the previous flight.

study-area, which is comprised of vegetation in a relatively undisturbed state, high levels of predation on moose calves by black bears would be expected.

Daily monitoring of 3 black bears in the Susitna study area during the period 21 May-22 June, 1981 resulted in 73 point locations (Table 29). One black bear (B342, a 5 year-old male) was observed on 1 calf moose kill and 1 adult caribou kill during this period (Table 29). This bear was also observed on a kill of an adult radio-collared moose on 22 July. No other predation was observed during the period of intensive monitoring. Regular monitoring of black bears resulted in no additional known kills of ungulates, although one black bear was seen on a hunter-killed moose in September (B318).

We suspect that calf moose are more important spring prey than indicated by these data. Many kills were doubtless missed because of relatively infrequent monitoring, difficulty of spotting kills in heavy vegetation, and low numbers of intensively monitored black bears. Importance of moose calf predation to black bear populations, as well as to moose populations, should be established by studies of radio-collared moose calves in Phase II.

X. SUMMARY OF PROJECT IMPACTS.

A. Brown bears.

Anticipated project impacts on brown bears are similar in type for both impoundments but are likely to be more severe in degree for the Watana impoundment than for the Devils Canyon impoundment. This is because the upper impoundment is in prime brown bear habitat while the lower impoundment appears to grade into habitat which is relatively better for black bears and poorer for brown bears. In order of suspected degree of impact, the proposed project is likely to influence brown bear populations in the following ways:

1. Reduction in the amount of lowland habitats along the river utilized by many bears early in the spring and by a few bears throughout the year. These habitats are the first to be cleared of snow in the spring (especially on south-facing slopes) and overwintered berries as well as early spring growth are available in these habitats relatively earlier than elsewhere. Nutritionally, early spring is likely to be the most critical period for bears. Much of the area used in the early spring will be inundated by the impoundments. Areas more distant from the impoundment shoreline may be affected by climatic changes caused by the impoundment (particularly delay of spring green-up).

2. Increased human presence during construction and operation of the dams will result in increased disturbance and hunting pressure which will lead to corresponding displacements and reductions of brown bear populations in the study area. Increased frequency of bears killed in defense of life and property situations is also an inevitable result of an increased human population; this can be minimized by proper preventative regulations during construction and operation.

3. Inhibition or blockage of directional seasonal movements to areas of reoccurring food abundance. Routes followed in these movements will be intersected by the impoundments, by access routes, by borrow areas, and by construction and operation facilities and activities. The areas affected include caribou and moose concentration areas (especially calving areas), salmon fishing areas (especially Prairie Creek), and sites where vegetable forage is seasonally available.

4. Disturbance, but probably not much direct inundation, of brown bear den sites.

5. Indirect impacts through reduction of availability of salmon in Prairie Creek and downsteam of Devils Canyon. Based on available evidence, Prairie Creek salmon runs are unlikely to be significantly affected and there is little documentation, as yet, that many brown bears in the existing study area make seasonal movements downstream of Devils Canyon to fish. Brown bear populations that are resident downstream of Devils Canyon, however, are likely to be impacted by the anticipated project-related reduction or elimination of salmon spawning between Talkeetna and Devils Canyon.

6. Reduction of ungulate prey. This potential is listed last only because the importance of ungulate prey to bear populations was not part of the Phase I study plan. Studies elsewhere, including the upper Susitna River, suggest that predation on moose calves by brown bear in the spring is very common. Indirect evidence suggests that brown bear predation on caribou, especially on caribou calving grounds, may also be frequent.

B. Black bears.

Upper Impoundment Residents and Transients

Black bears using the upper impoundment area can conveniently be broken into resident and transient subpopulation. The most affected subpopulation will be residents that have all or most of their annual home ranges upstream of the Watana Dam site, it is our suspicion that this group will be essentially eliminated by the proposed project through a combination of the following factors (listed in order of suspected degree of impact):

1. Inundation of den sites and scarcity of acceptable post-construction alternative den sites.

2. Elimination of habitat through inundation. Acceptable spring, summer, and denning black bear habitats in this area appear largely limited to the impoundment area and immediate vicinity, much of these habitats will be flooded.

3. Increased hunting and disturbance. Black bears in this area are currently very vulnerable to hunting by virtue of the constricted nature of their primary habitat (spruce forests along the river), this vulnerability will increase as the impoundment further constricts acceptable upstream spruce habitats. At present black bears are little hunted in this area because of its remoteness and difficulty of access; this pattern will change as project construction and operation improves access and augments the human population resident in the area.

4. Reduction of availability (through disturbance, habitat destruction, and/or climatic changes) of tableland areas used for forage in late summer and early fall. The tablelands between the spruce forests along the Susitna River and the adjacent mountains north of the river appear seasonally important for black bears. Access roads, borrow areas and construction facilities which transect these tablelands are anticipated. These habitats in the vicinity of the upper impoundment are used both by bears resident in the upper impoundment area and by many transient bears that are resident in the vicinity of the lower impoundment earlier in the year.

5. Climatic changes. The nature, extent, and direction (deliterous or beneficial) of climatic changes resulting from the impoundment are uncertain. It is considered likely, however, that establishment of winter snow cover will be delayed by a warm-body effect of the mass of water behind the dam. This, in turn, may reduce the potential for berries (suspected important food in the early spring) to

successfully overwinter because of the absence of a protective snow cover in the fall and early winter (this apparently happened naturally during the winter of 1980/81 when snow cover was abnormally slight and delayed). The warm impoundment waters may also cause some early winter precipitation to fall as rain rather than snow and may increase the amount of precipitation because of increased local humidity. Climatic impacts from the impoundment may be more serious in the spring when breakup may be delayed because of a possible cold-body influence of the frozen impoundments. This may retard the phenology of plants important to bears as early spring forage at the most vulnerable portion of the bear's annual life cycle (immediately following den emergence). Finally, climatic changes resulting from the impoundment (temperature changes, precipitation changes, etc.) may alter the distribution or abundance of berries (suspected critically important late summer and early spring foods) or other forage plants. *Vaccinium spp.* production, for example, appears naturally variable from year to year and appears to correlate with bear behavior; perhaps years of low *Vaccinium* production correlate with winter conditions or climatic conditions during pollination (increased spring precipitation may inhibit pollination). Although the types of climatic change which may result from the proposed impoundments are uncertain, as are the impacts of any such changes on bears, it is noteworthy that black bears in this area are on the northern limit of their natural distribution south of the Alaska Range and are, correspondingly, likely to be in a somewhat precarious balance with their environment.

6. Elimination or reduction of salmon runs downstream of the Devils Canyon impoundment may eliminate an important alternative food source for upstream bears. This alternative may be important only during years when berry crops are subnormal. Based on available data the number of Watana

impoundment-area residents that move downstream to fish for salmon during poor berry years may be small but has been documented (see discussion and range maps for B348 and B343).

7. Increased interspecific competition with brown bear including increased predation by brown bears. It is likely that the constricted distribution of black bears in the spruce forests along the river is adaptive to black bears in limiting the degree and effectiveness of brown bear predation, black bears can climb trees and brown bears cannot. If this is true, decreases in the amount of forested habitat could result in increased predation by brown bears, especially in the early spring when the two species are most sympatric.

8. Indirect impacts through reduction of ungulates, especially moose calves, that may be important prey items in early spring. This potential factor is listed last because of the lack of adequate data to reveal the level of predation that exists as well as uncertainties relative to the project's impact on moose populations. If such predation is important to black bear populations and if moose populations are markedly affected, this factor may rank first or second in importance.

The transient bear population, usually resident in the vicinity of the lower impoundment but moves to the upper impoundment in late summer to forage, will be affected in the upper impoundment area, by the same factors listed above in approximately the following order:

1. Reduction of availability of tableland areas used for forage in late summer and early spring (see #4 above).

2. Increased hunting and disturbance (see #3 above).

3. Climatic changes (see #5 above).

4. Reduction of downstream salmon runs (see #6 above).

5. Reduction of escape habitat on late-summer foraging grounds (see #7 above).

Lower Impoundment

The proposed Devils Canyon impoundment will doubtless have less severe impacts on local black bear populations than the Watana impoundment but impacts will be marked regardless. The topography of the lower impoundment area as well as the wider distribution of forested habitats downstream, will result in loss of a relatively lower proportion of acceptable black bear habitat downstream. In order of suspected degree of influence the anticipated impacts of the lower impoundment are:

1. Elimination of important early spring habitats through inundation and associated impacts of climate (retardation of spring phenology) on spring forage.

2. Reduction of the availability (through disturbance and/or climatic changes) of tableland area used by Devils Canyon-area black bears are upstream in the vicinity of Tsusena-Deadman-Watana Creeks. Impacts on these areas were discussed in points 4 and 5 above for bears resident in the upper impoundment area.

3. Increased hunting and disturbance (discussed in point 3 above).

4. Elimination or reduction of downstream salmon runs (point 6 above). This factor is of relatively greater importance to the black bears resident near the Devils Canyon impoundment

because of their closer proximity to these runs. In late summer 1981 three radio-collared bears resident in the Devils Canyon impoundment area moved downstream, apparently to fish for salmon.

5. Inundation of den sites.

6. Reduction of ungulate prey. As noted above the importance of this factor is unknown which is why it is listed last. Potentially this could be the #1 or #2 impact on this subpopulation of black bears.

Downstream impacts

The above predicted changes in black bear population density in the vicinity of the proposed impoundments may affect adjacent populations as well. The most likely source of this type of impact would be through reduction in the number of bears dispersing from the reduced population in the study area to adjacent areas, mostly to the west. As mentioned above, some documentation of such dispersals has been obtained in this study. However, the significance of this to adjacent populations is unknown. On the short-term, activities and disturbance associated with project construction and perhaps project operation as well could force some individuals to disperse. Some of the larger movements and dispersals observed to date could, arguably, be interpreted as resulting from the increased human activity associated with Phase I activities conducted during the last 2 years, this is considered unlikely however. Over the long-term, it would be more significant if the project area was a source of dispersing individuals moving to adjacent areas.

Available data collected by Su-Hydro fisheries biologists indicate that salmon spawning in mainstem Susitna between Talkeetna and Devils Canyon will be greatly reduced or eliminated as a result of the proposed project. If so, this would be likely to have a major negative impact on black bear populations in this area that may depend on salmon for food. Reduction of periodic flooding of downstream riparian habitats which would result from the project may also reduce the availability of early-successional stage forage which may be particularly important in the spring. These possibilities are conjectual as downstream bear studies were not conducted in Phase I, they should be a part of any Phase II studies.

XI. PHASE II STUDY NEEDS AND OBJECTIVES

The two-phase format of Susitna game studies was designed to identify the kinds of impacts the project was likely to have in Phase I and, should the decision be made to proceed with a license application, information on the magnitudes as well as more precise documentation of the actual impacts would be obtained in Phase II. Assuming a license application is submitted to FERC, the following Phase II studies are needed to quantify the impacts of the proposed project on bear populations.

A. Brown Bear

1. Continued documentation of brown bear utilization patterns of the study area with particular emphasis on early spring utilization by many bears of areas that will be directly inundated or affected by the proposed impoundments. Secondary emphasis will be placed on further documentation of what proportion of the brown bear population in the study area utilize the impoundment area throughout the year. These studies will require continued radio-collaring of new individuals and replacement of radio-collars on existing study animals. As the number of radio-collared animals in the study area increases, a corresponding more precise estimate of brown bear density in the study area will also be obtained. These studies will also help clarify the relationship between the two bear species and what impacts on one species would mean to the other.

2. Intensive studies of sites where project construction facilities are likely to conflict with bear use of these same areas. Preliminary analyses of these impacts based on the tentative

locations of borrow sites, access roads, and camp facilities have been discussed in this report. Transmission line impacts have not yet been addressed. Of primary importance to brown bears based on this preliminary analysis is a disturbance of den sites caused by project access roads. Once the locations and extent of these sites have been more firmly established, more intensive studies are needed to quantify the degree of impact and to clarify procedures to minimize these impacts.

3. Determination of essential brown bear niche-elements which will be lost or reduced by the proposed project. The primary concern in these studies will be determination of the foods utilized in the spring by many bears and throughout the year by those bears that use the impoundment-impact area and the availability of these foods relative to other areas and seasons. The technique proposed to determine utilization is feces analysis, transect sampling will be used to determine availability. During Phase I the feasibility of the feces analysis technique was established through development of a procedure to chemically identify black and brown bear feces (Appendix 6).

4. Determination of the importance of moose calf and other predation to brown bear populations in the study area. Some information on the relative importance of moose calves in brown bear spring diets, and ungulates in general in year around diets, will be obtained from the feces analysis described in point 2, above. However, Phase I of this study, as well as previous work (Ballard, et

al. 1979, Franzmann et al. 1980, Gasaway et al. 1977, and Schlegel 1976) have clearly demonstrated that predation-rate information gathered by observations of radio-collared predators underestimates the importance of this predation to populations of both predators and prey. Relative to other areas of Alaska where predator-prey relationships have been studied, the Watana area is unique because of the presence of 3 major predators (brown bear, black bear and wolves) and 2 major ungulate prey (moose and caribou). For this reason, it would not be reasonable to extrapolate results from other areas to the project study-area. Any one of these 5 species could be markedly impacted by project impacts on the other (except caribou-black bear relationships are unlikely to be significant). An accurate appraisal of overall project impacts must consider species interactions, not just individual species by themselves. In addition to direct impacts on predators, the proposed project has potentially large impacts on both ungulate species which, if such impacts should develop, would in turn likely have significant indirect impacts on all 3 species of predators. These predator-prey relationships should be studied in cooperation with ongoing Phase II ungulate investigations.

B. Black Bear

1. Continued documentation of black bear utilization patterns in the vicinity of the proposed impoundments in order to quantify losses to black bear habitats and populations. Continued emphasis will be placed on direct losses to black bear denning habitats. The possibility that reductions in

brown bear density as a result of project impacts could benefit black bear populations may also be clarified by these studies. These studies will require the continued radio-collaring of new individuals and replacement of radio-collars on existing study animals. As the number of radio-collared animals in the study area increases, a corresponding more precise estimate of black bear density in the study area will be possible. More precise estimates of density should also be obtained through aerial surveys in August when black bears are concentrated on relatively open habitats.

2. Intensive studies of sites where project construction facilities, borrow areas, access roads, and transmission lines will conflict with bear use of these same areas. Preliminary assessments of these conflicts based on tentative locations of these construction sites have been discussed in this report. Important impacts on black bears are expected to result from displacement from berry-rich habitats used by black bears in late summer as a result of borrow areas and camp facilities. Access roads and transmission line corridors are expected to impact black bear populations also, especially through disturbance of den sites and improved access to the general public. Once the locations and extent of these sites have been established, more intensive studies are needed to quantify the degree of impact that can be expected and to clarify the procedures that can be implemented to minimize these impacts.

3. Determination of essential black bear niche-elements which will be lost or reduced by the

proposed impoundments. As discussed for brown bear, above, these studies will concentrate on food habits and food availability. Fecal analysis techniques will be utilized. Black bear predation-rates on ungulates will also be studied as outlined for brown bears above.

4. Downstream black bear studies. During Phase I studies the potential for significant impacts on bear populations downstream of the proposed impoundments were not fully appreciated. Results of Phase I work, however, clearly identify the potential for substantial downstream impacts on bear populations through two mechanisms:

   a. Indirect impacts through reduction or elimination of mainstem Susitna River and associated slough spawning of salmon. The results of Su-Hydro fisheries studies clearly demonstrate the likelihood that the proposed downstream flow regimen will reduce or eliminate salmon spawning in upstream portions of the main Susitna River and adjoining sloughs and tributaries. This effect would be most marked in that section of the river upstream of Curry to Devils Canyon (T. Trent, C. Estes, W. Trihey, pers. comm. on 18 Nov. 1981). The impact this would have on the bear population is unclear. Su-Hydro fisheries biologists report that bears of both species, but particularly black bears, appeared to be especially prevalent along this section of the river when salmon were spawning (late August-through September) in 1981 (B. Barrett and K. Delany, pers. comm.). They reported that of 15 radio-transmittered salmon, 2 (27%) were taken by bears, overall they estimate that 4% of their marked salmon were taken by bears. Their observations suggest that bears repeatedly used the same preferred fishing sites on islands and gravel bars to fish and to scavenge for salmon carcasses. They also noted well-developed bear trails paralleling the river. Highbush cranberry as well as salmon were common in bear feces found along the river by these researchers. These observations coincide with movements 3 radio-collared black bears that moved in downstream August from the impoundment area, evidently to take advantage of this salmon resource. One subadult brown bear made a similar movement in May but this was considered a probable natural dispersal. Perhaps such movements of upstream black bears are particularly important during years, like 1981, when upstream berry crops are subnormal. Local residents of the Talkeetna area are well aware of the seasonal concentration of bears along the river during salmon spawning and frequently hunt bears at this time from riverboats.

This apparent concentration of bears along the river and their apparent reliance on a salmon resource which is threatened by the proposed impoundments makes an expansion of the bear studies to include this area essential in Phase II of Su-Hydro impact studies.

b. Indirect impacts on downstream bear populations through alteration of periodic flooding patterns and corresponding vegetation changes should also be investigated during downstream Phase II bear work. This kind of impact is equivalent to that being investigated for moose populations in Phase I of this study. Like moose, both species of bear may be especially dependent on early-successional stage vegetation that results from periodic flooding of downstream habitats (Singer 1978); this dependence, if it exists, would likely be more prevalent in the early spring because these riparian habitats are the most phenologically advanced in the spring. Adequate spring foraging is particularly important for bears, which have spent the preceding 6 months fasting in their winter dens. The Su-Hydro fisheries study team did not report noticing concentrations of bears along the river in the early spring, but such foraging might easily have gone unnoticed.

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APPENDIX 1. BROWN BEAR DISTRIBUTION MAPS

Figure 10. Composite of all brown bear home ranges, 1980 - 1981. (scale: 1 cm=6250 meters)

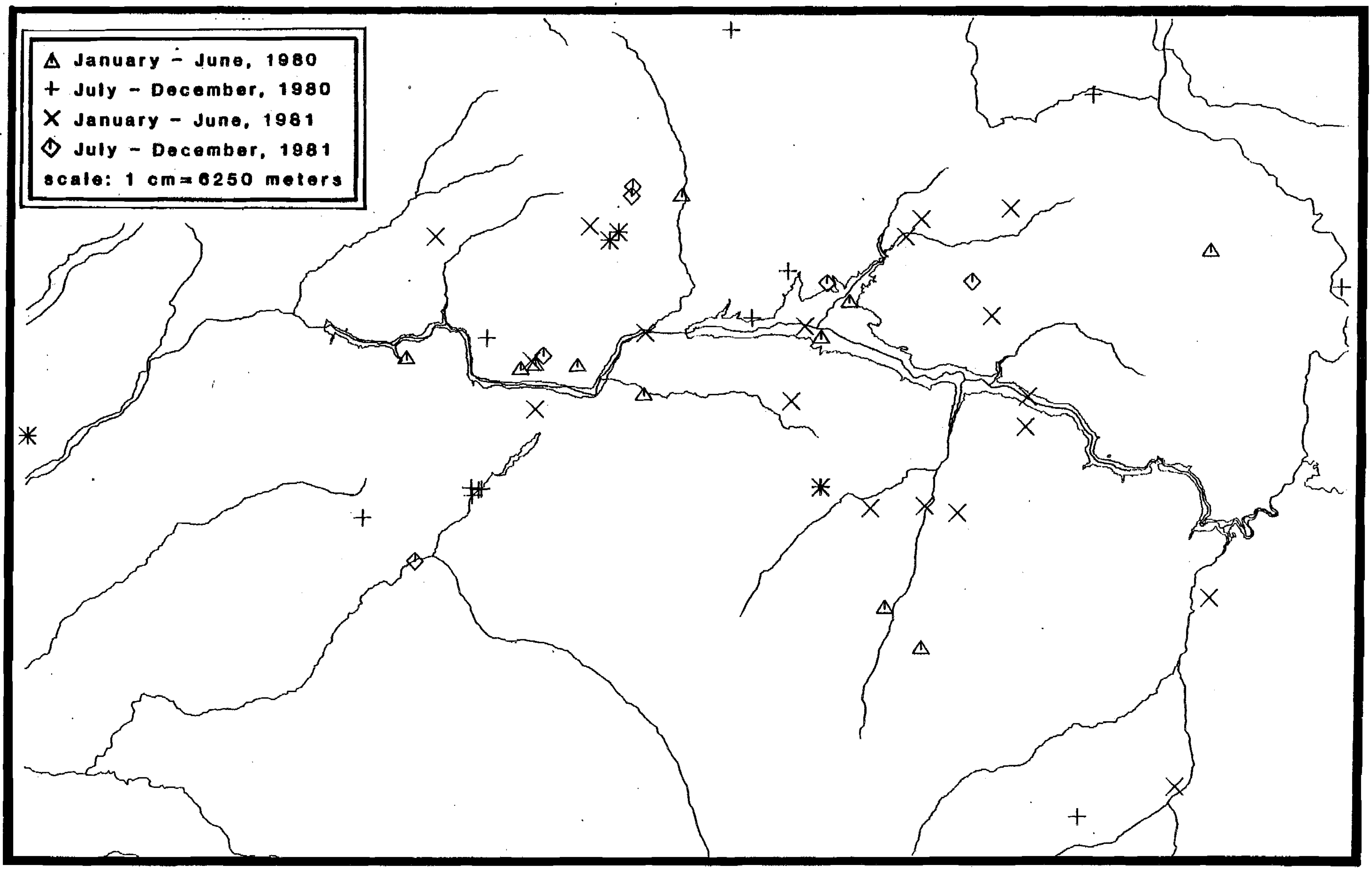

Figure 11. Locations of all unmarked brown bears observed during radio-tracking efforts, 1980 - 1981.

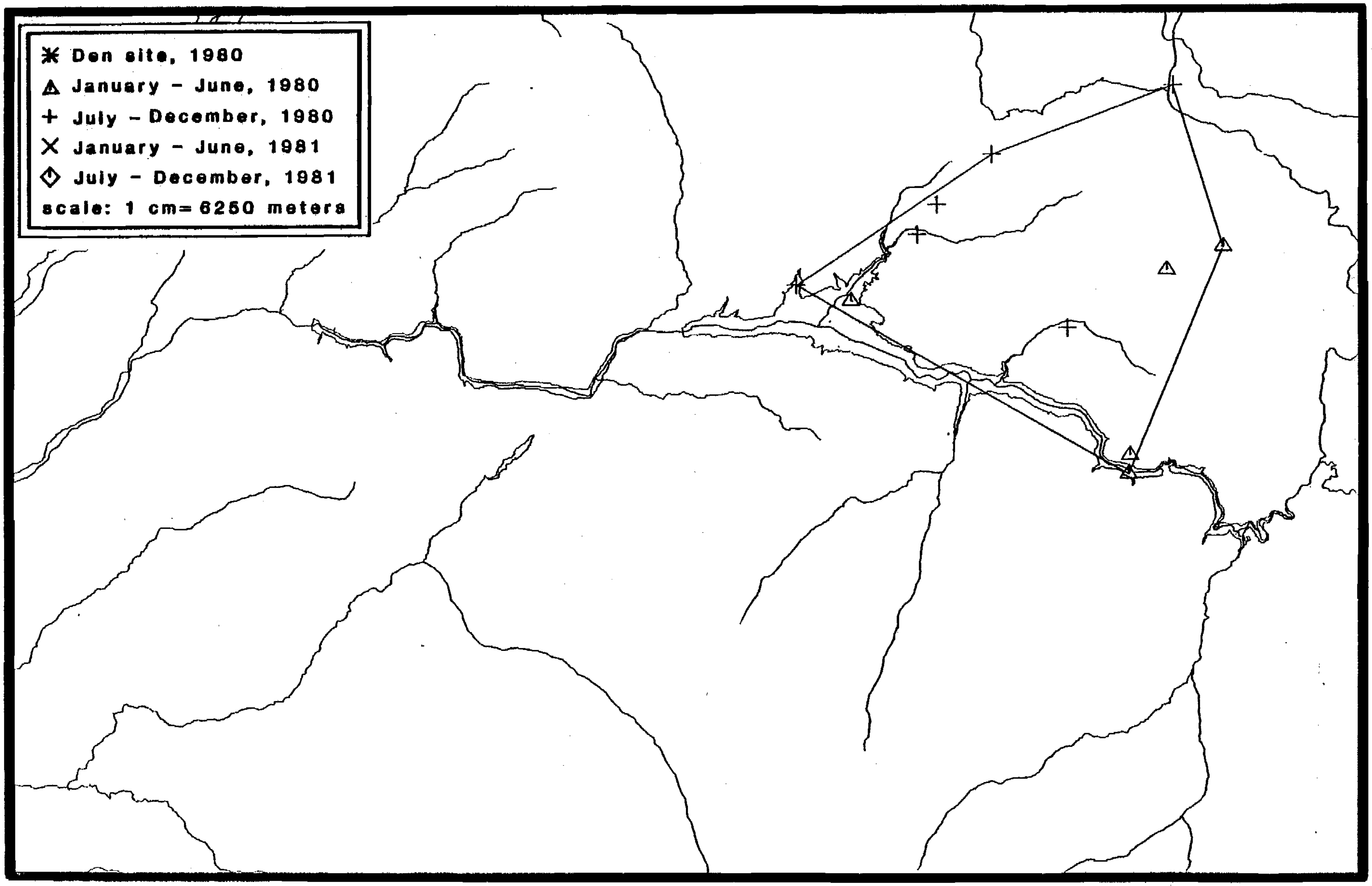

Figure 12. All point locations and complete known home range for brown bear 214.
(includes locations only through 9/1/81)

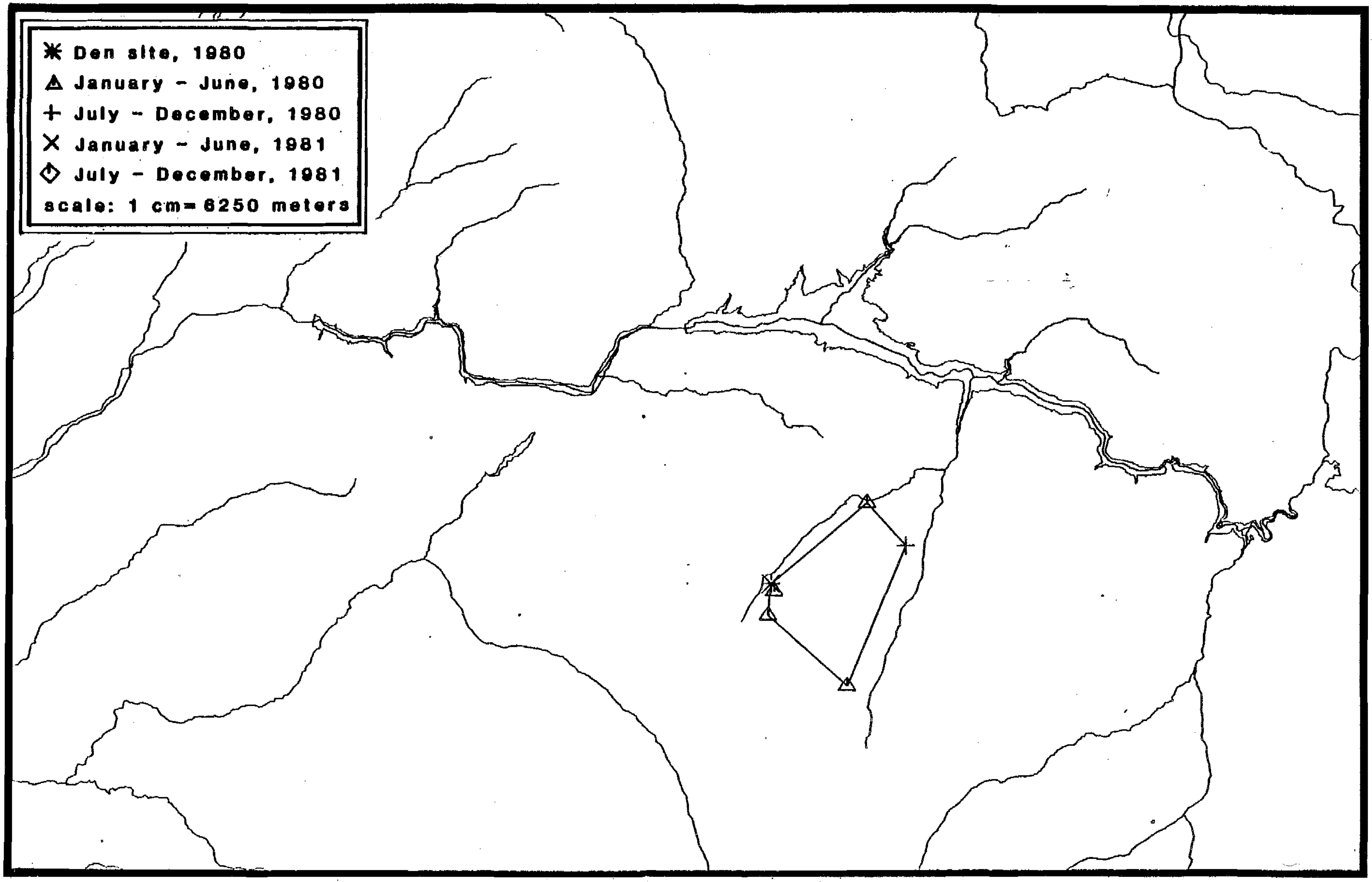

Figure 13. All point locations and complete known home range for brown bear 277.
(includes locations only through 9/1/81)

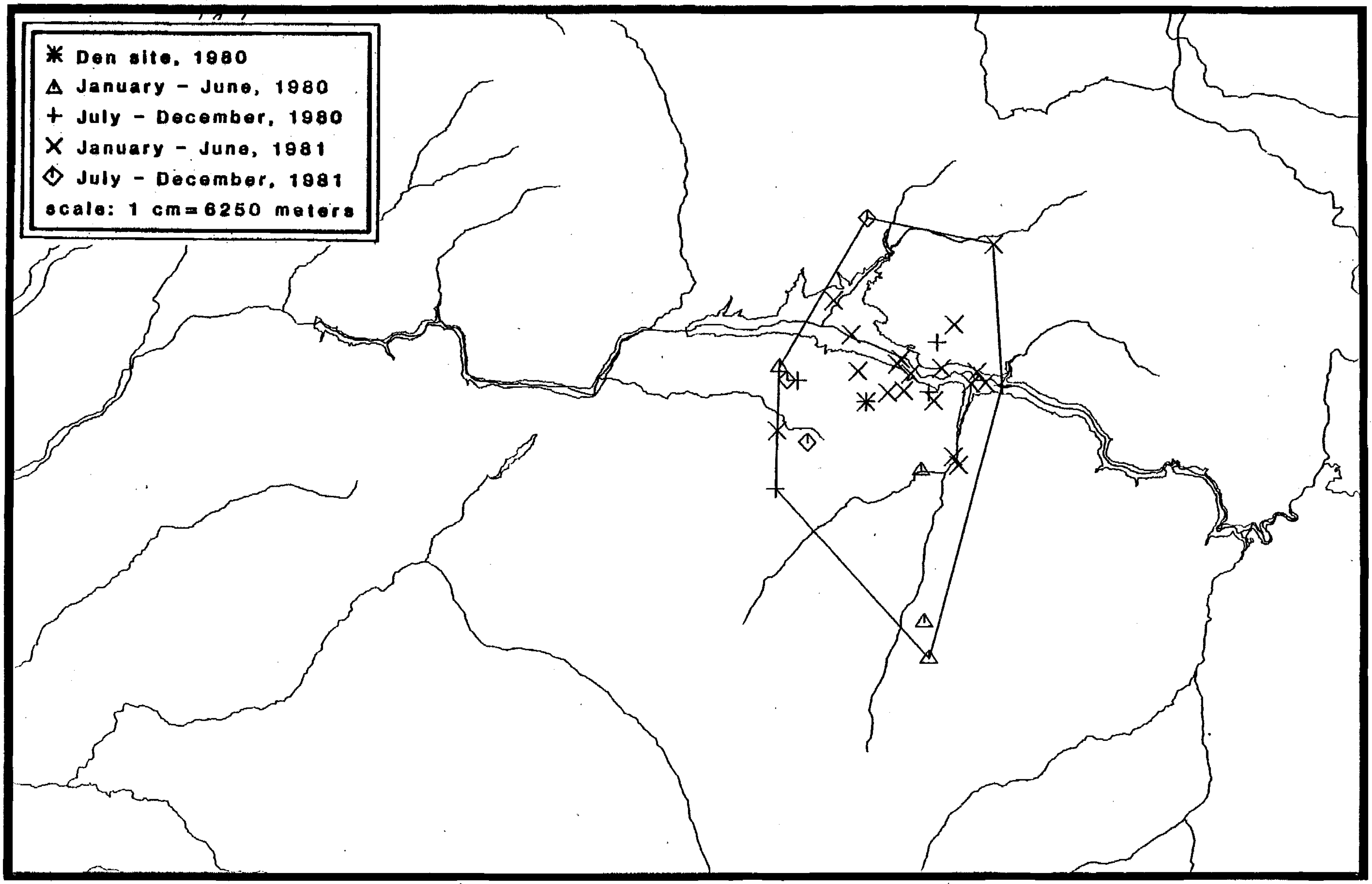

Figure 14. All point locations and complete known home range for brown bear 280. (includes locations only through 9/1/81)

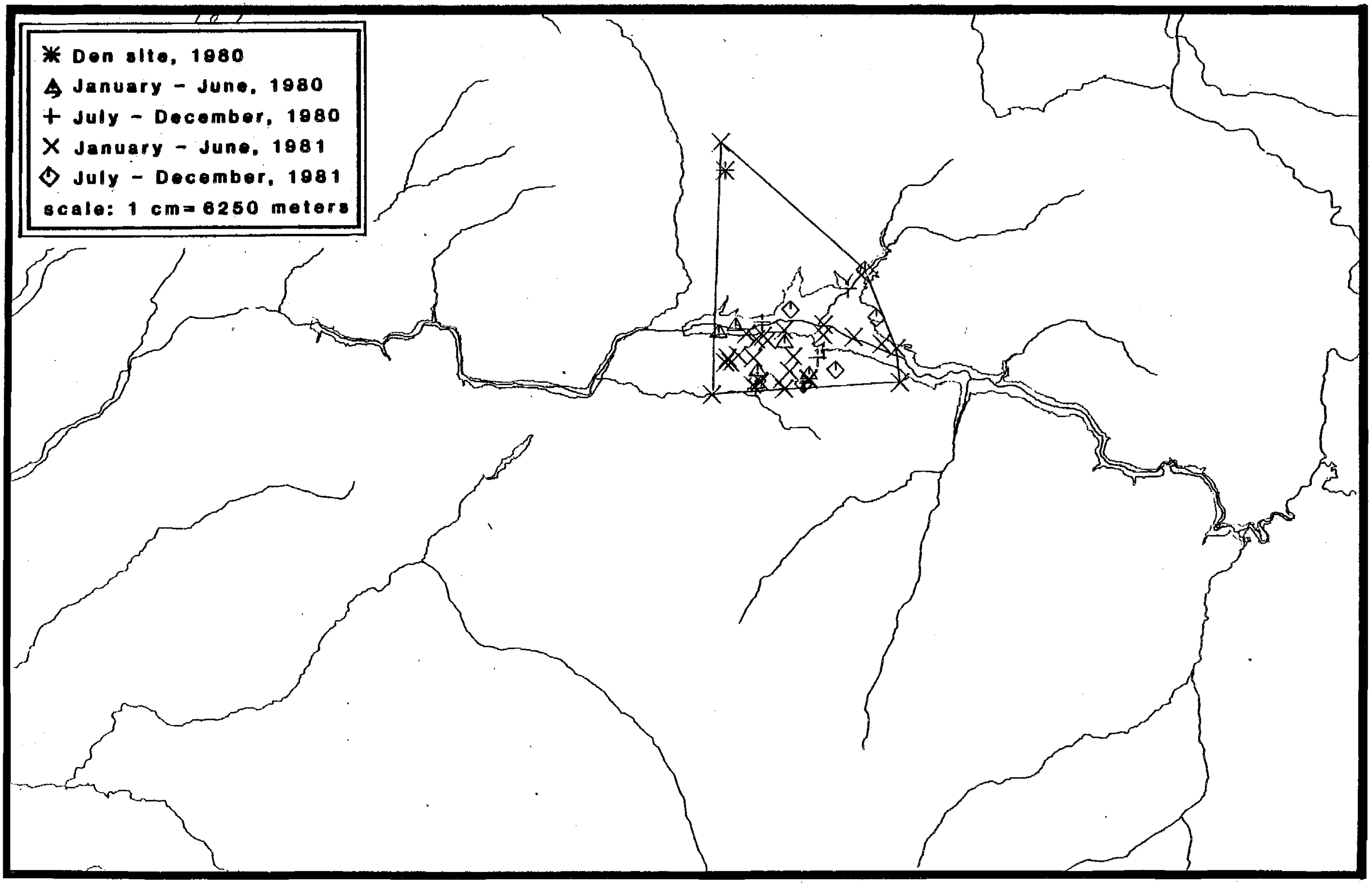

Figure 15. All point locations and complete known home range for brown bear 281. (includes locations only through 9/1/81)

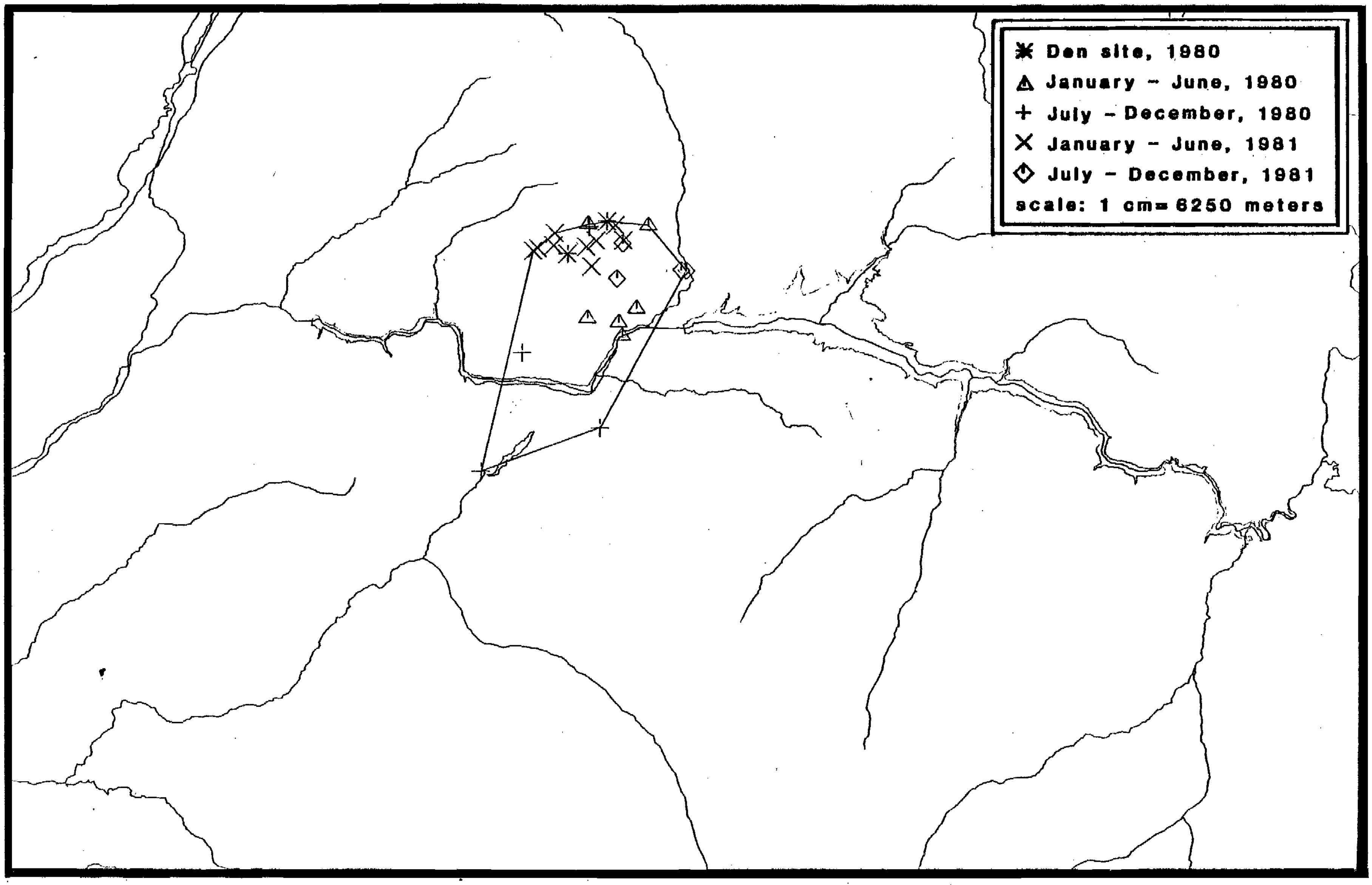

Figure 16. All point locations and complete known home range for brown bear 283. (includes locations only through 9/1/81)

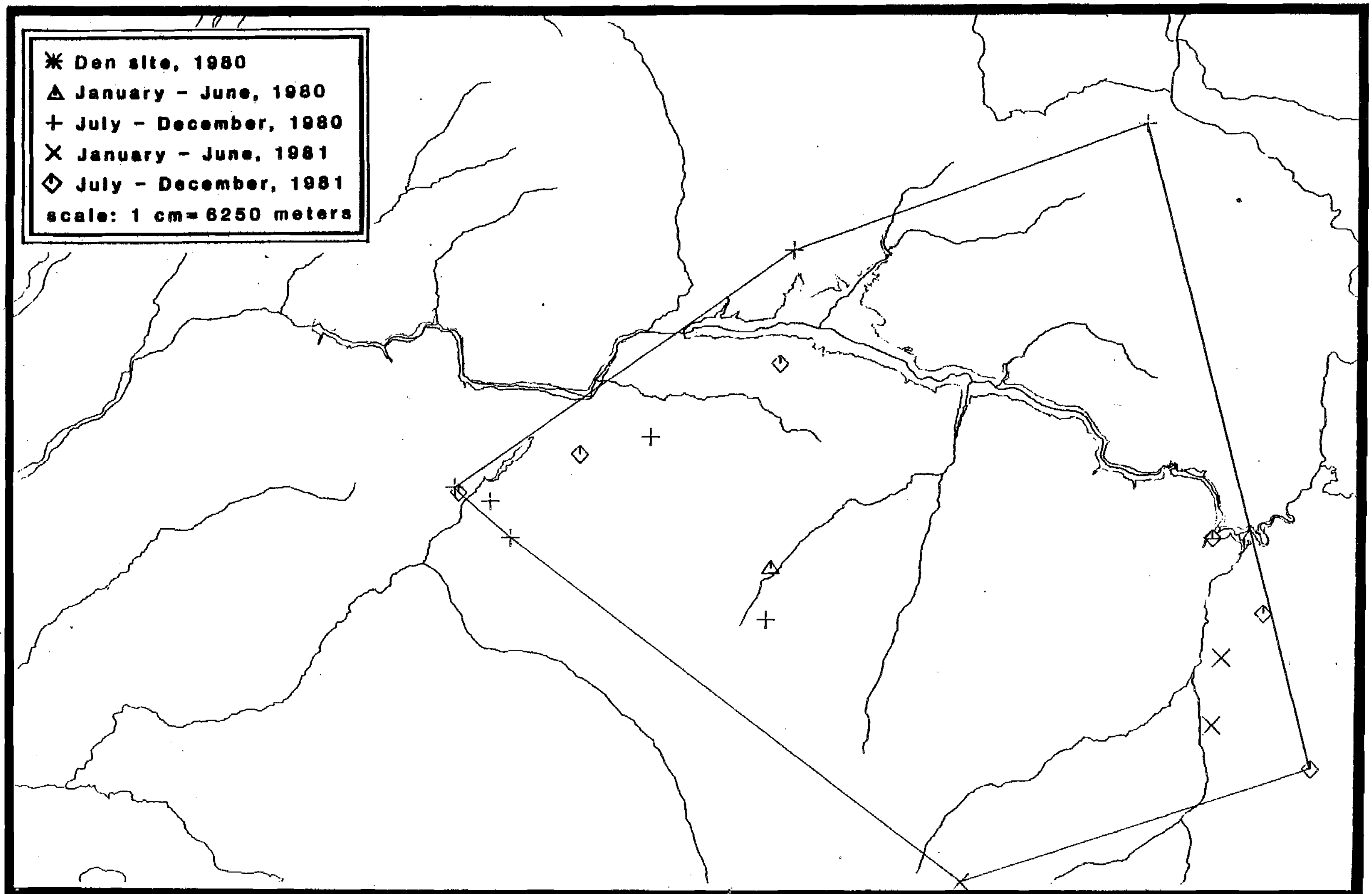

Figure 17. All point locations and complete known home range for brown bear 293. (includes locations only through 9/1/81)

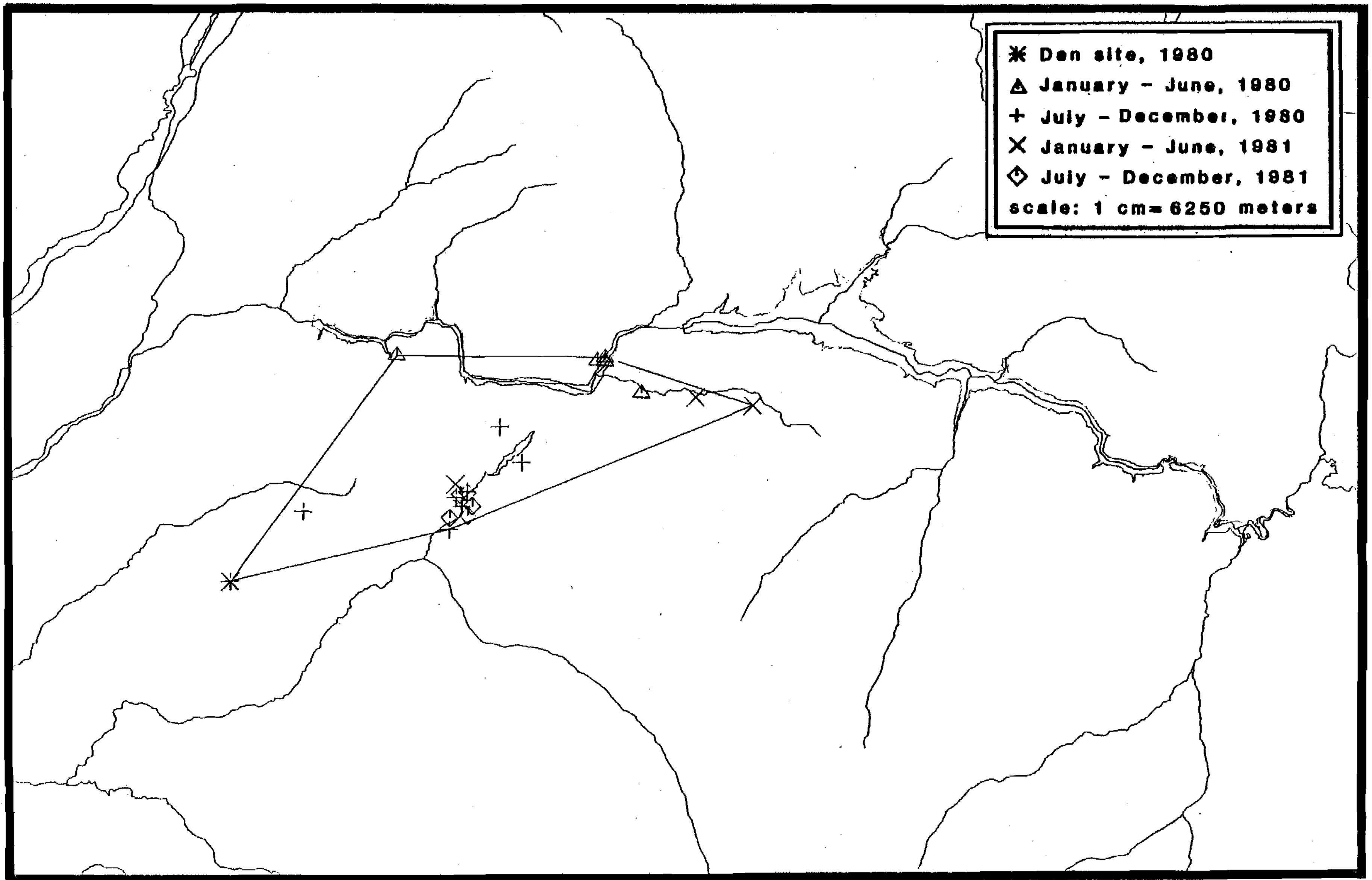

Figure 18. All point locations and complete known home range for brown bear 294. (includes locations only through 9/1/81)

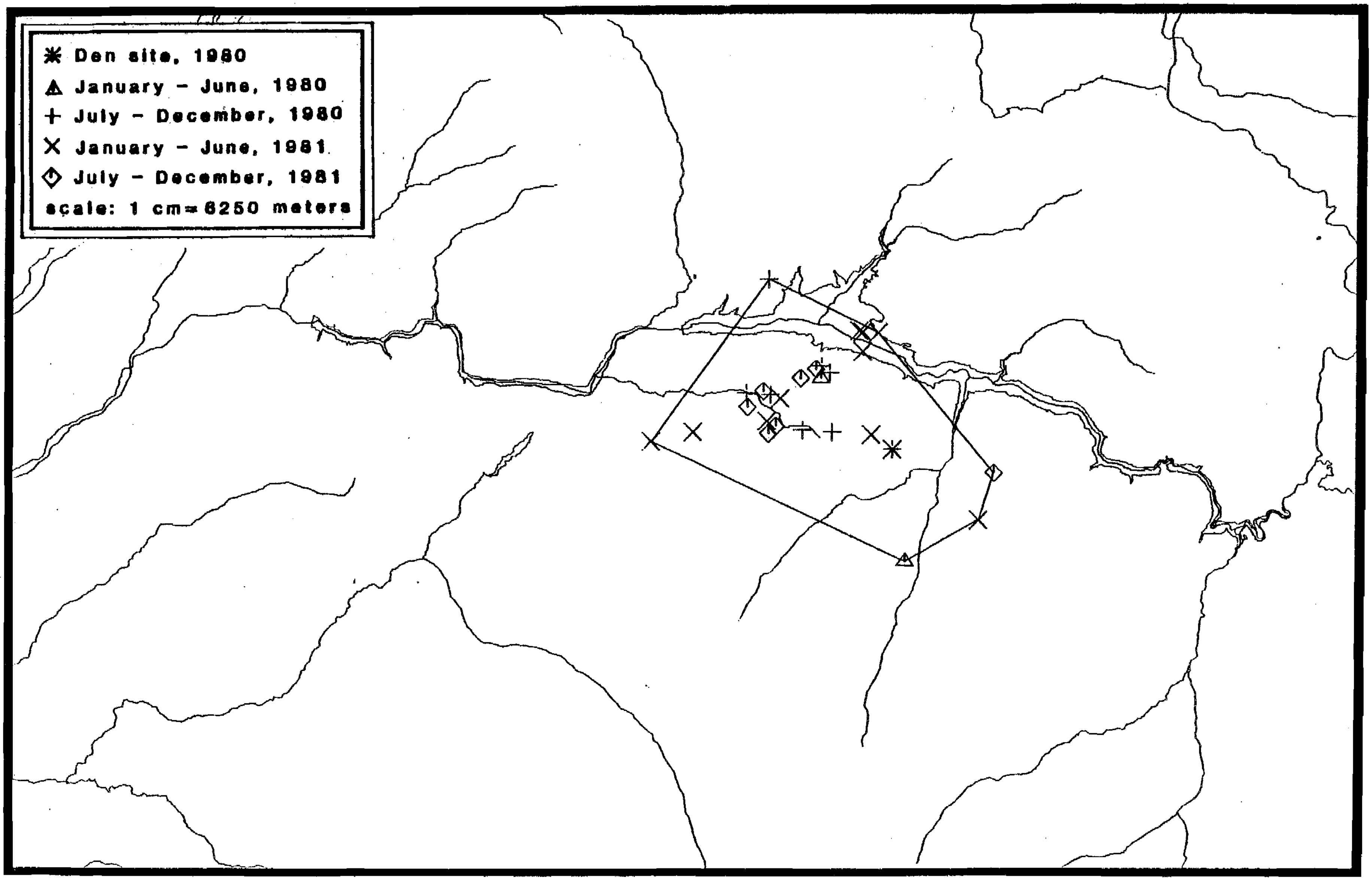

Figure 19. All point locations and complete known home range for brown bear 299.
(includes locations only through 9/1/81)

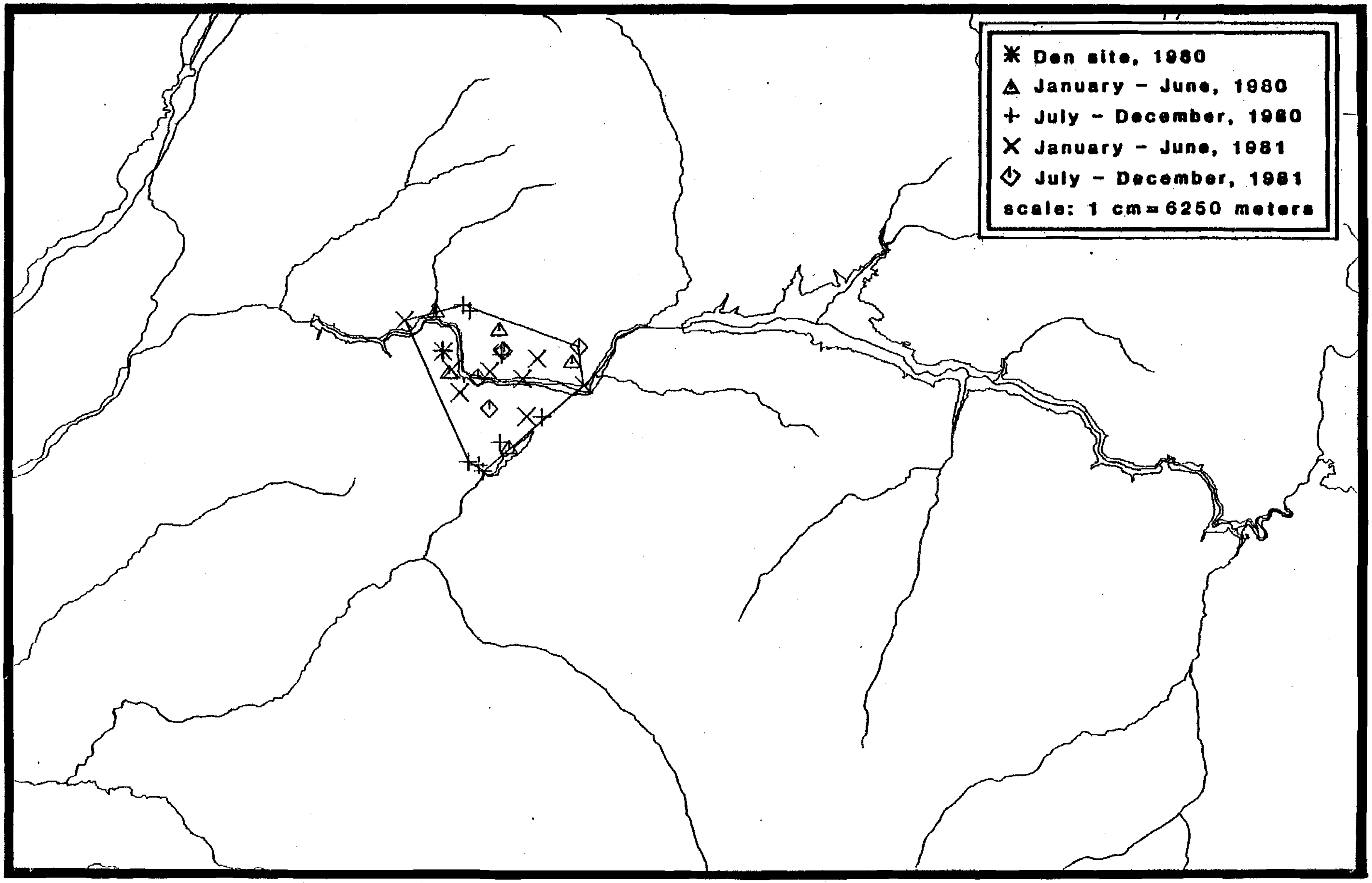

Figure 20. All point locations and complete known home range for brown bear 308b. (Includes locations only through 9/1/81)

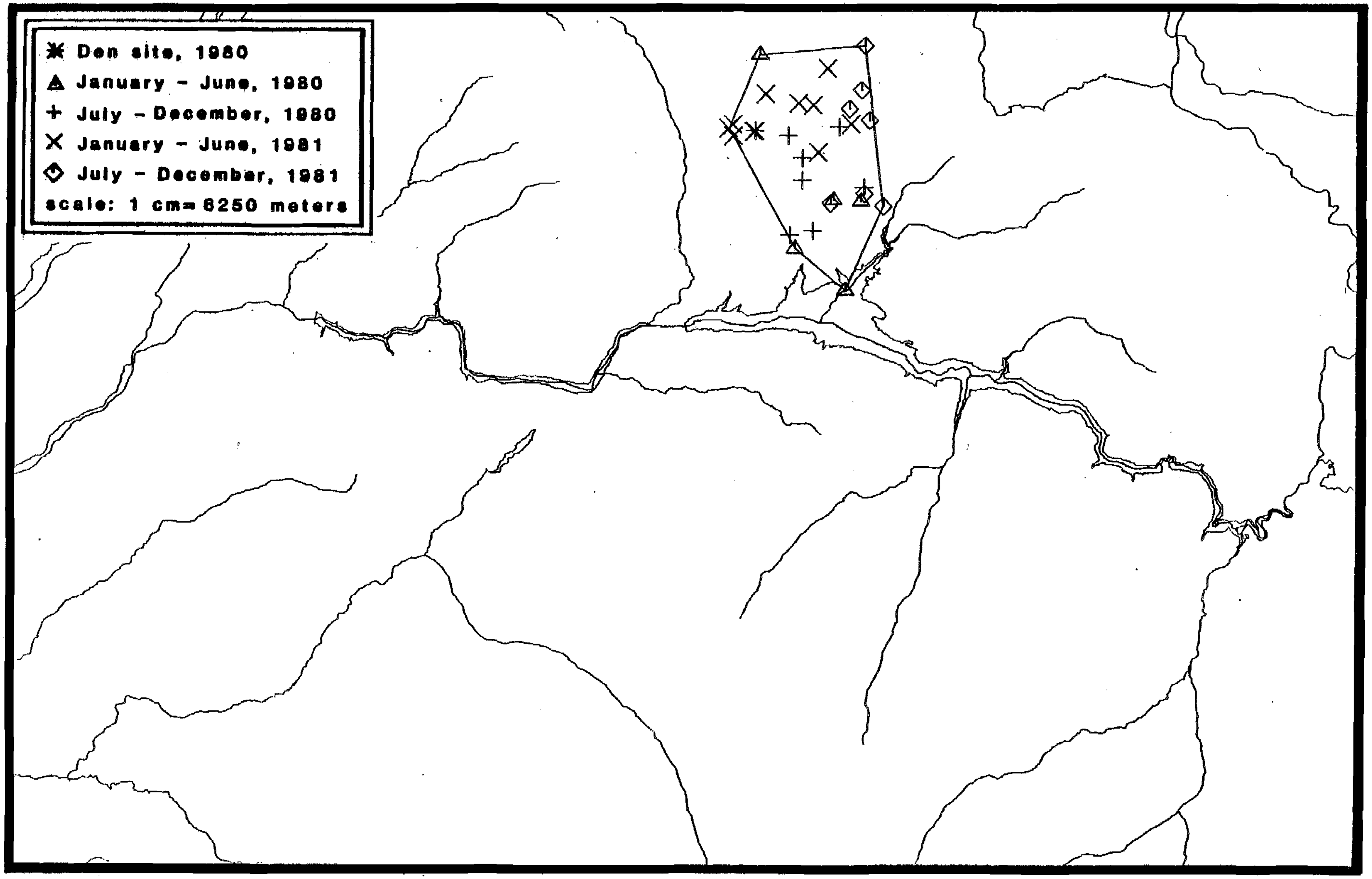

Figure 21. All point locations and complete known home range for brown bear 312.
(includes locations only through 9/1/81)

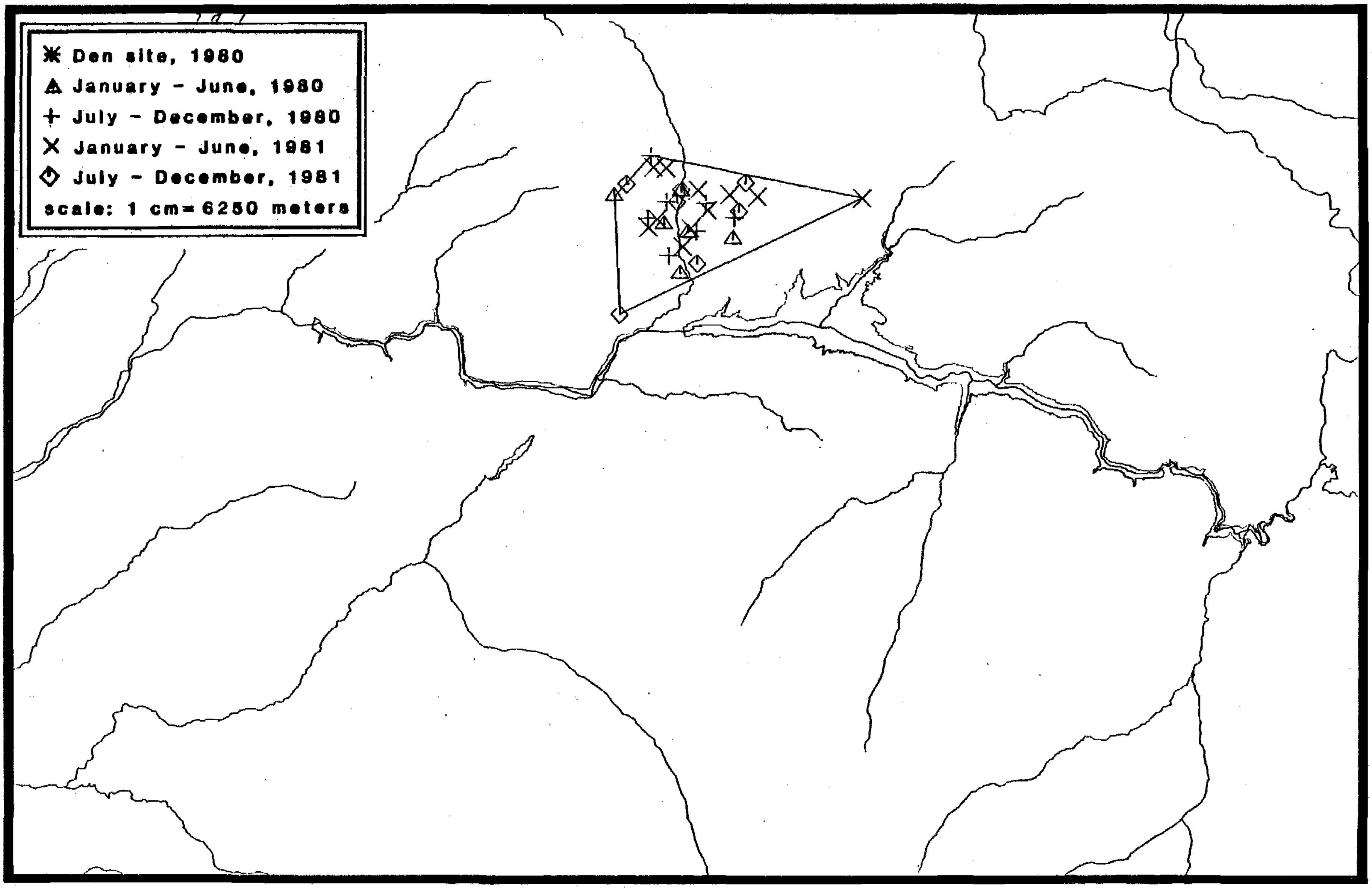

Figure 22. All point locations and complete known home range for brown bear 313.
(includes locations only through 9/1/81)

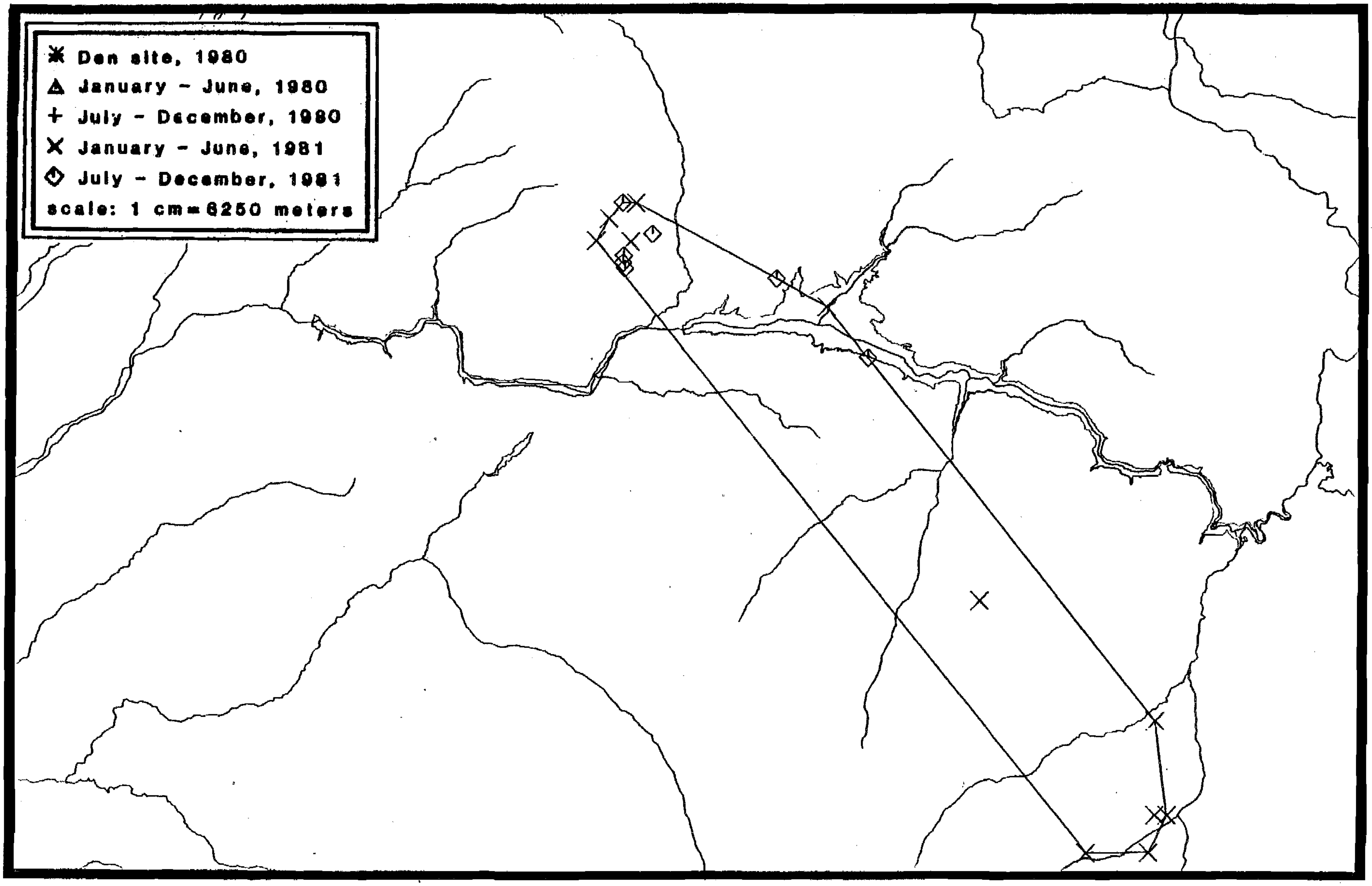

Figure 23. All point locations and complete known home range for brown bear 331. (Includes locations only through 9/1/81)

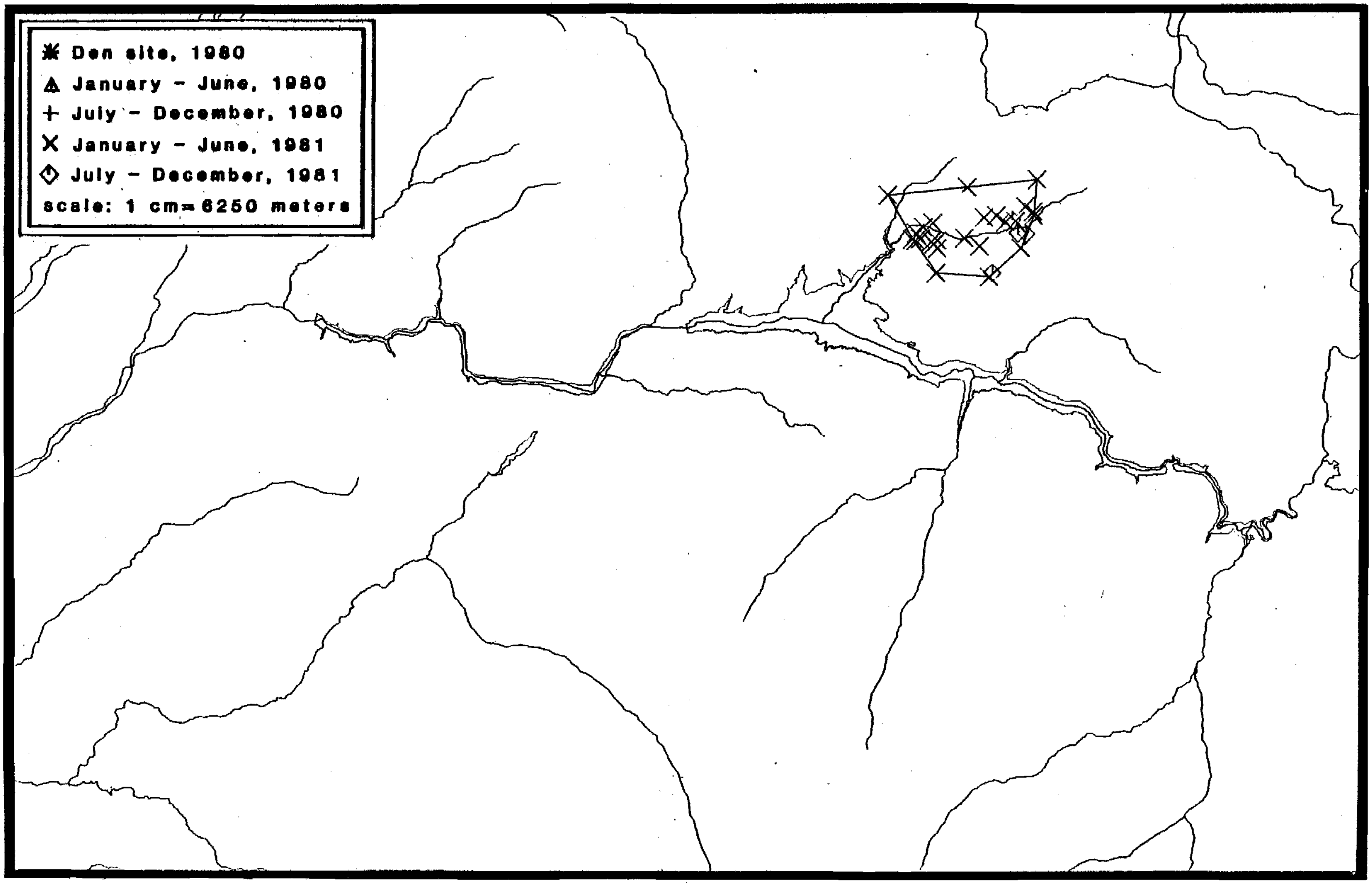

Figure 24. All point locations and complete known home range for brown bear 334. (Includes locations only through 9/1/81)

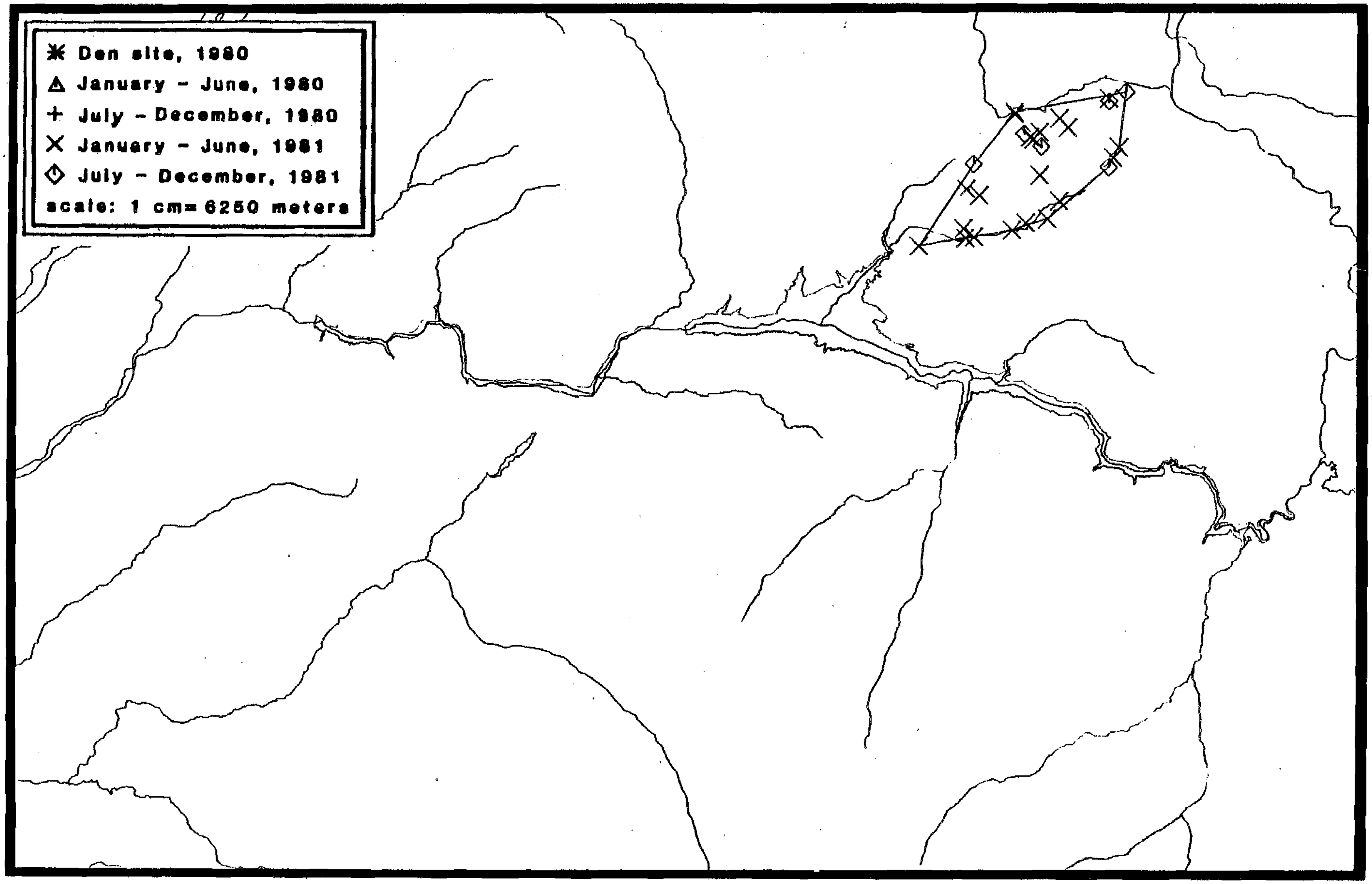

Figure 25. All point locations and complete known home range for brown bear 335.
(includes locations only through 9/1/81)

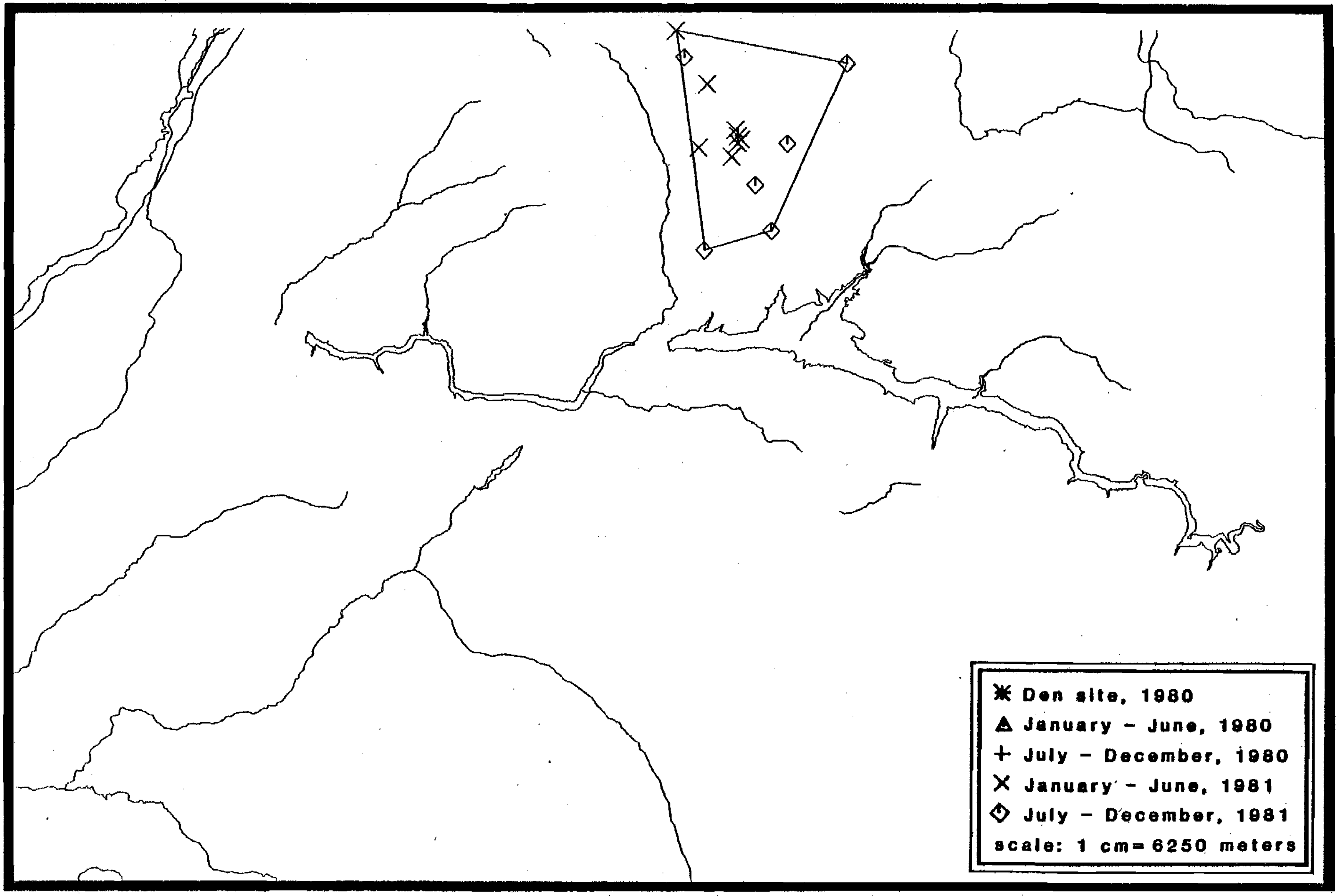

Figure 26. All point locations and complete known home range for brown bear 337. (includes locations only through 9/1/81)

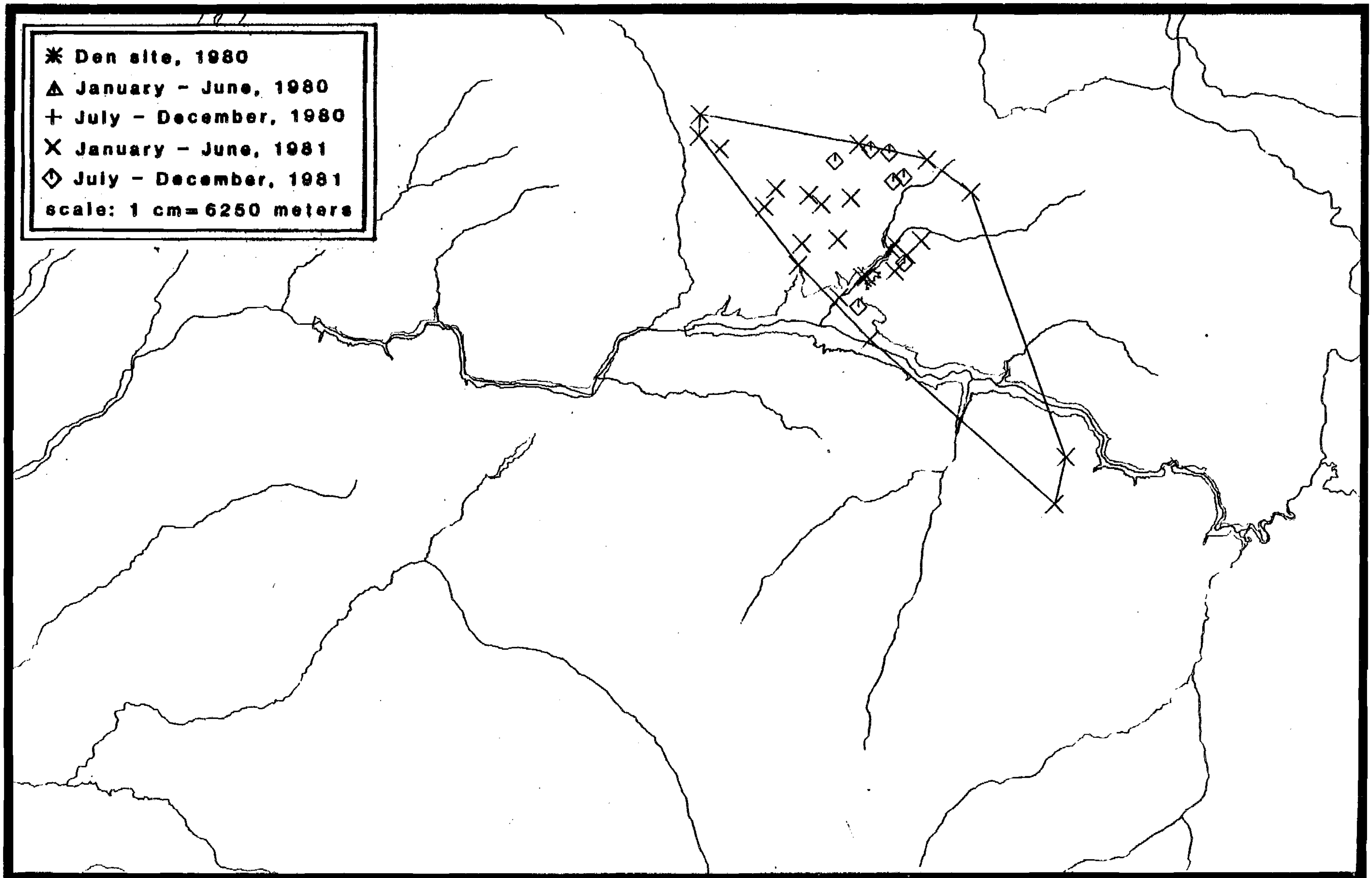

Figure 27. All point locations and complete known home range for brown bear 340. (includes locations only through 9/1/81)

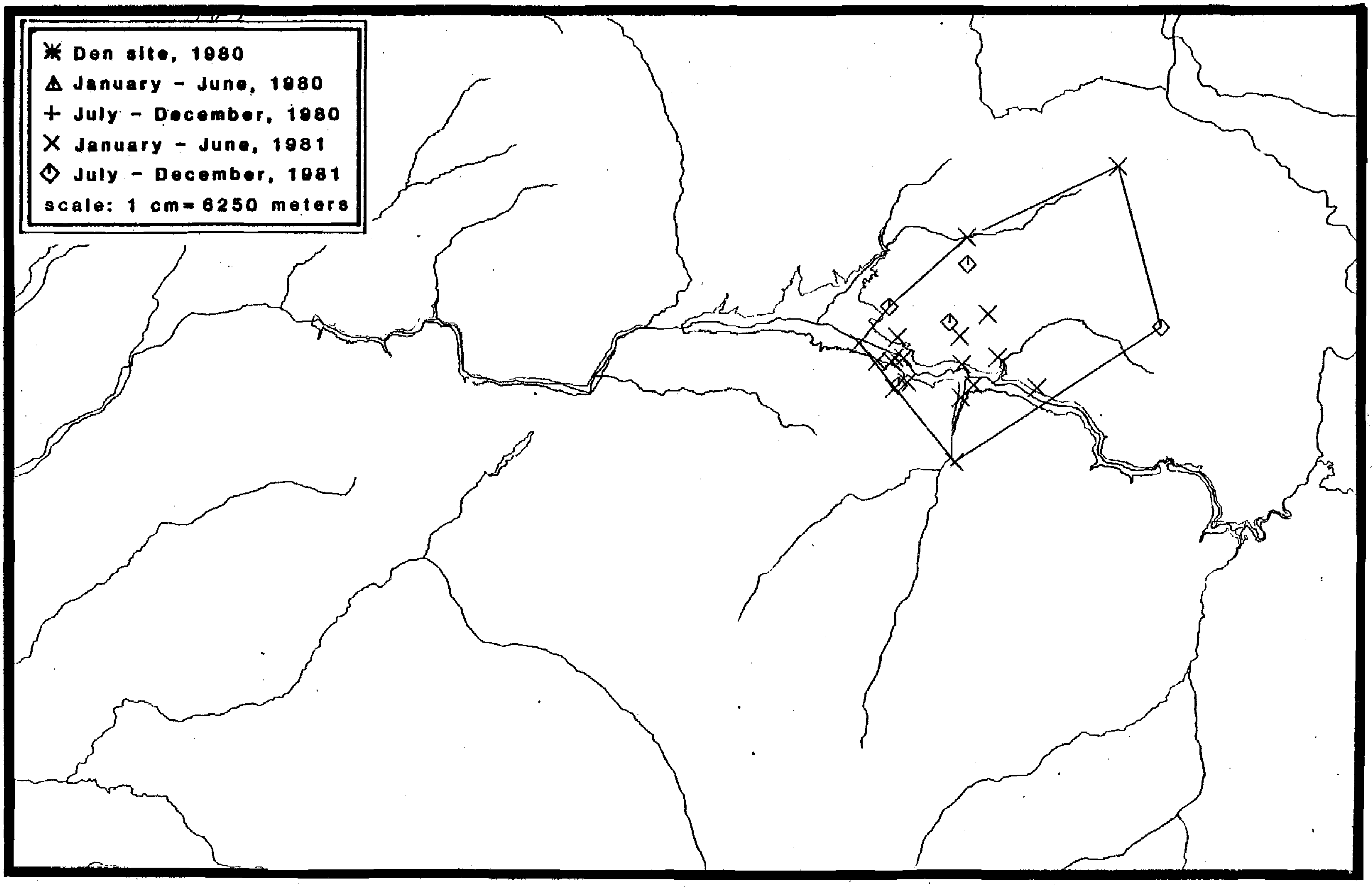

Figure 28. All point locations and complete known home range for brown bear 341. (Includes locations only through 9/1/81)

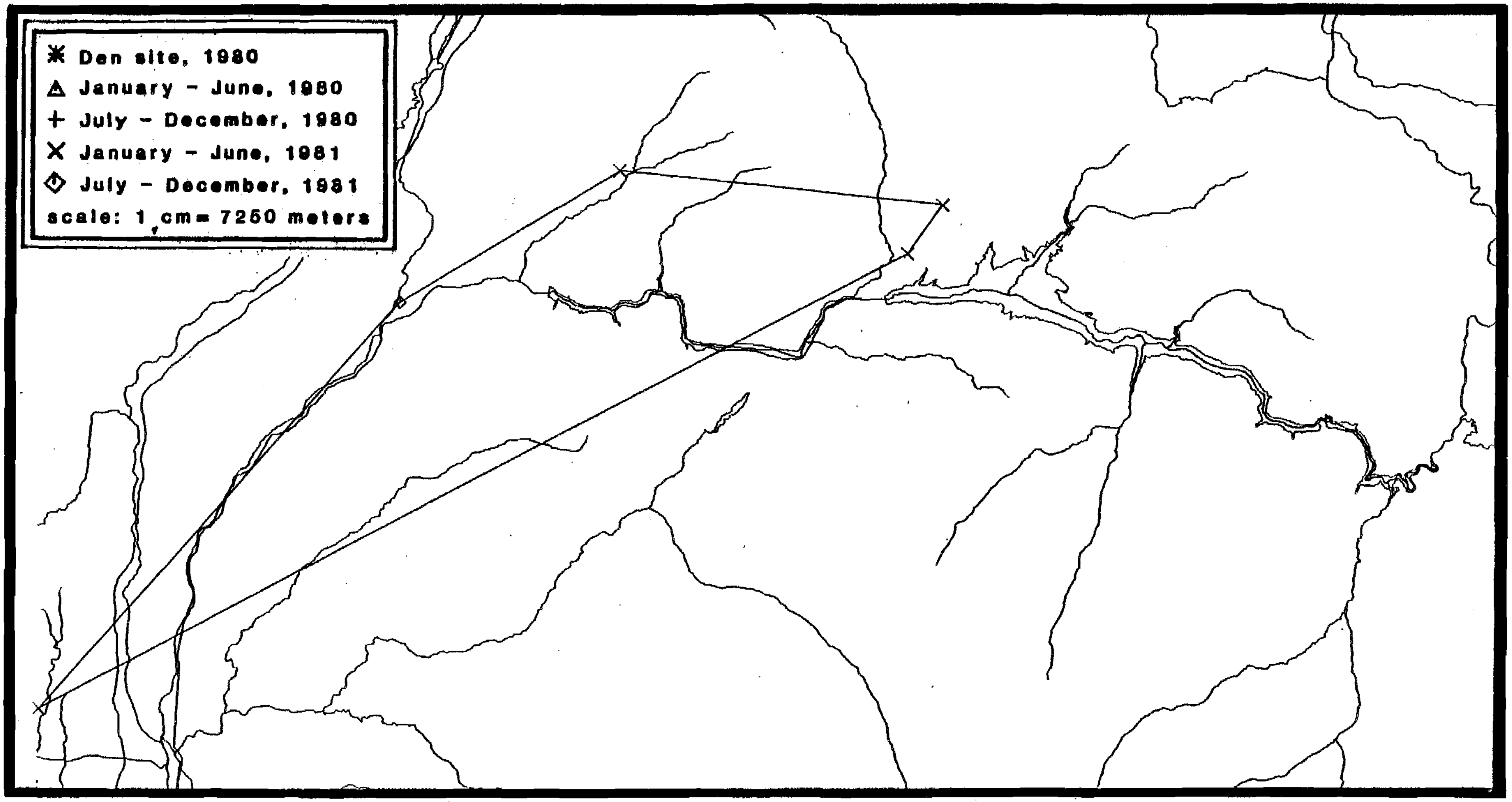

Figure 29. All point locations and complete known home range for brown bear 342a. (includes locations only through 9/1/81)

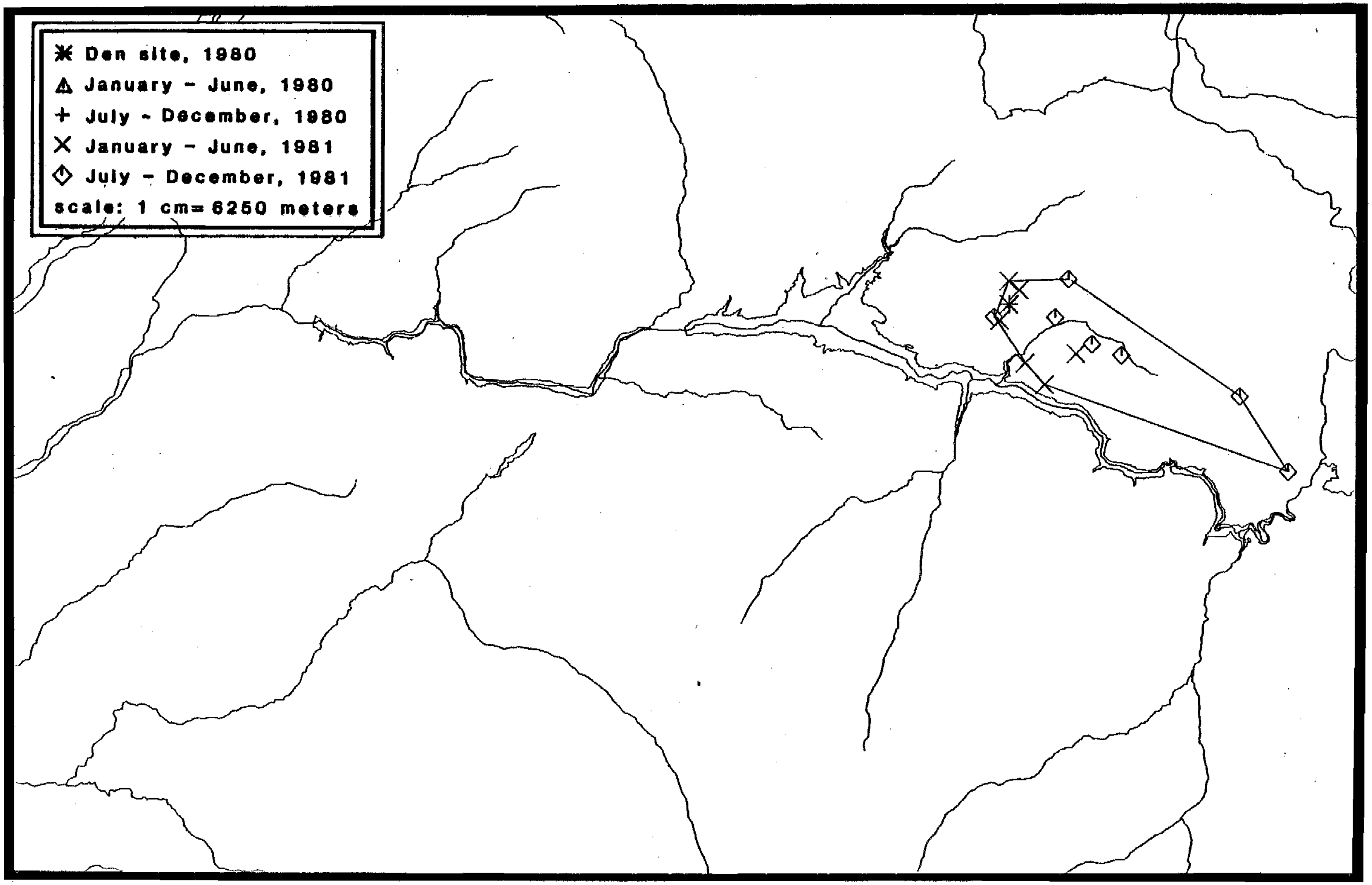

Figure 30. All point locations and complete known home range for brown bear 344. (Includes locations only through 9/1/81)

APPENDIX 2. BLACK BEAR DISTRIBUTION MAPS

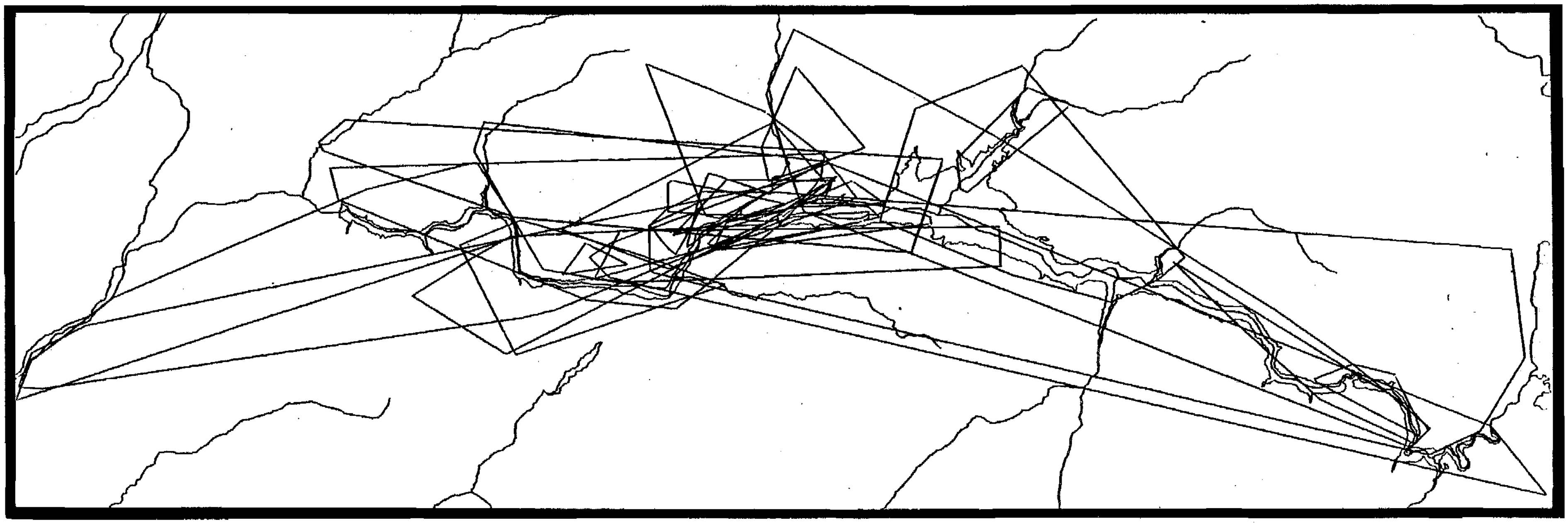

Figure 31. Composite of all radio-collared black bear home ranges, 1980 - 1981. (scale: 1 cm = 5850 meters)

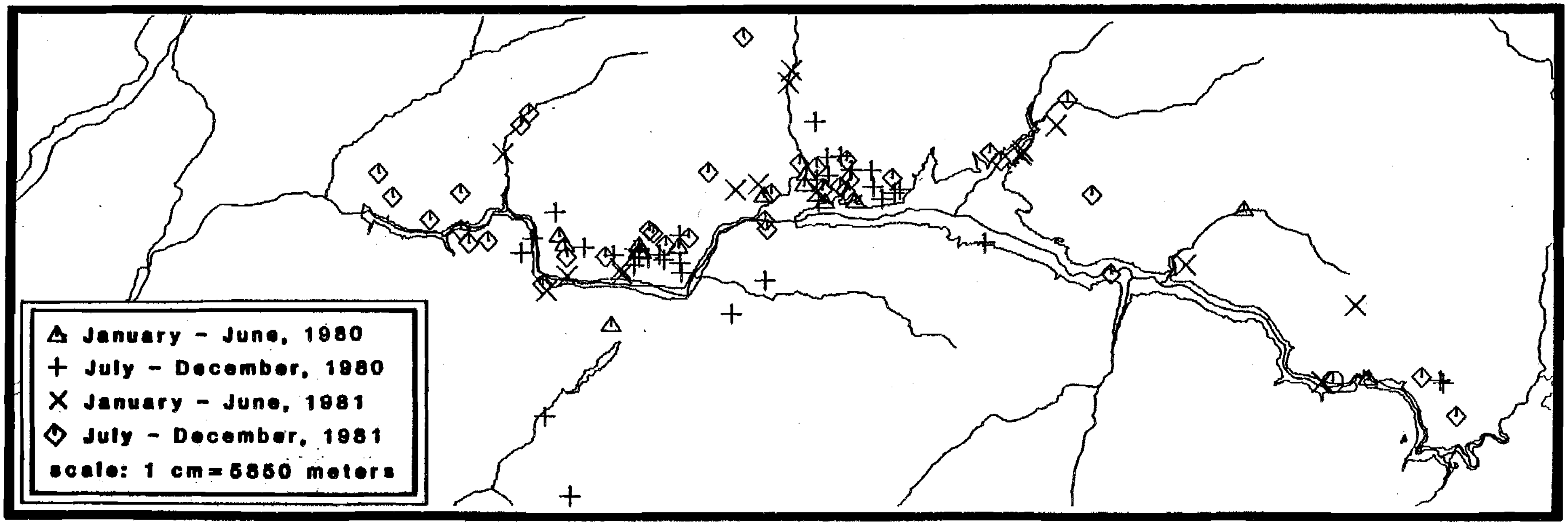

Figure 32. Locations of all unmarked black bears observed during radio-tracking efforts, 1980 - 1981.

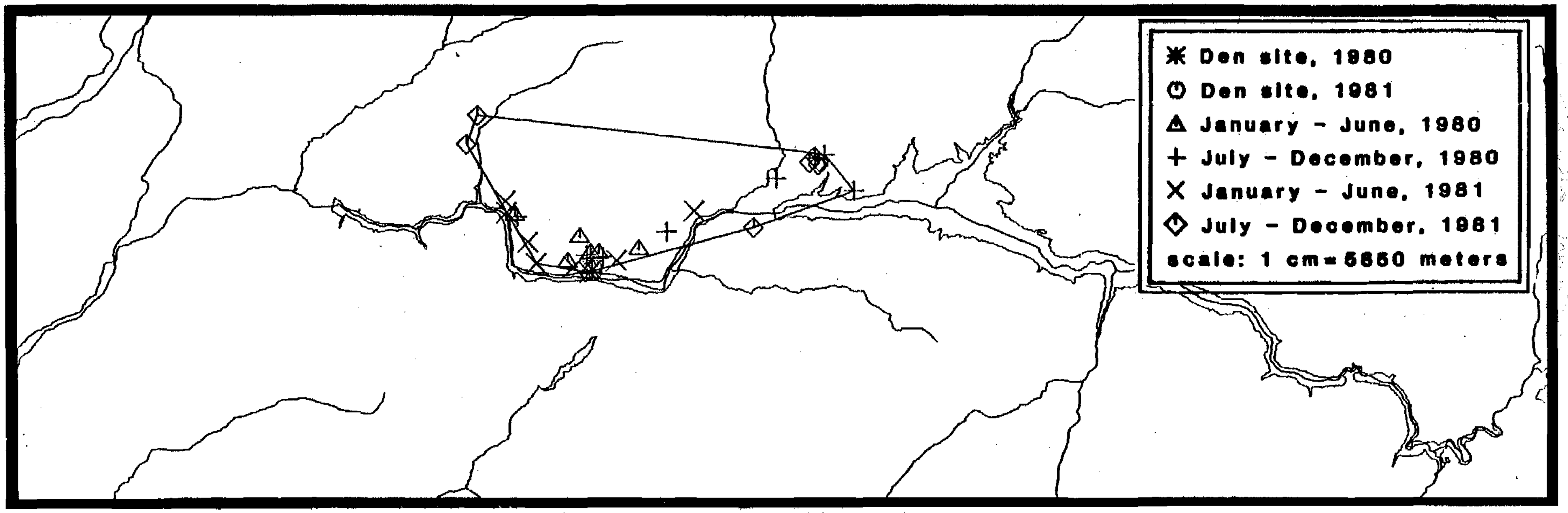

Figure 33. All point locations and complete known home range for black bear 287.

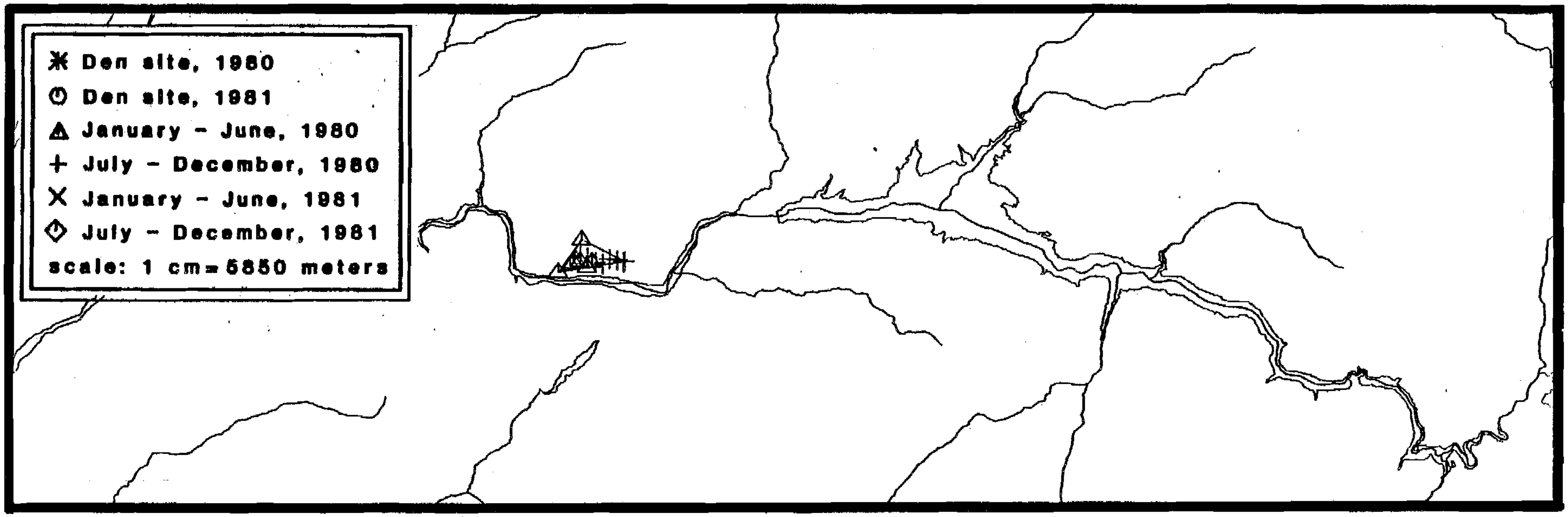

Figure 34. All point locations and complete known home range for black bear 288.

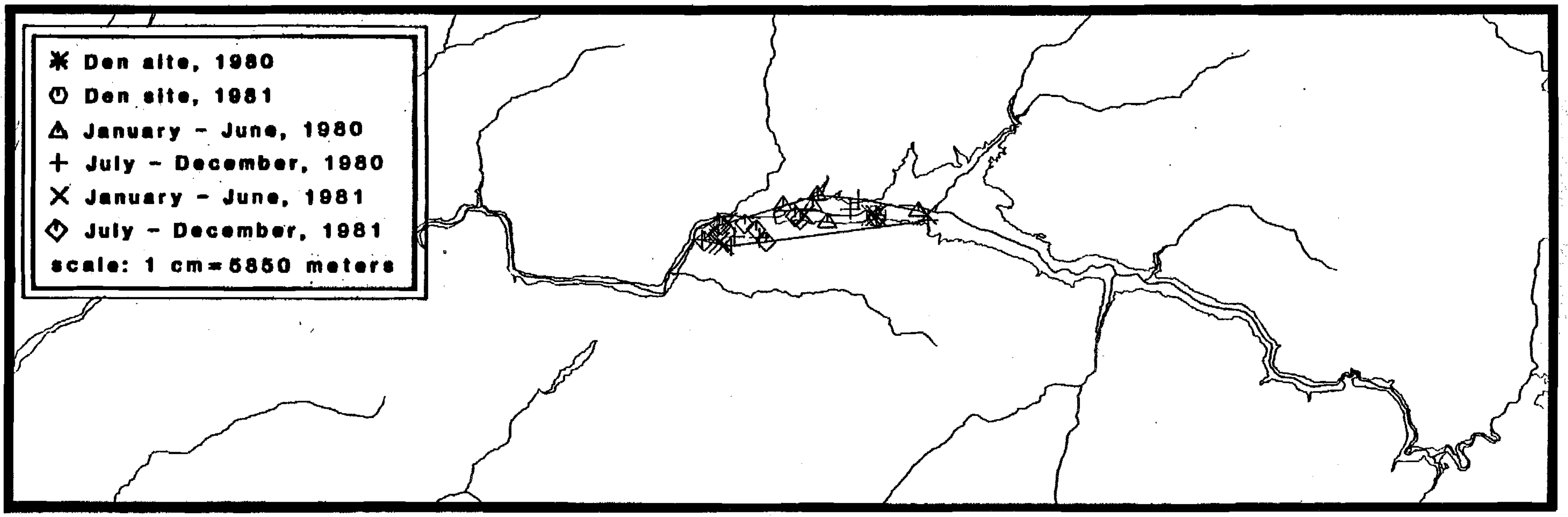

Figure 35. All point locations and complete known home range for black bear 289.

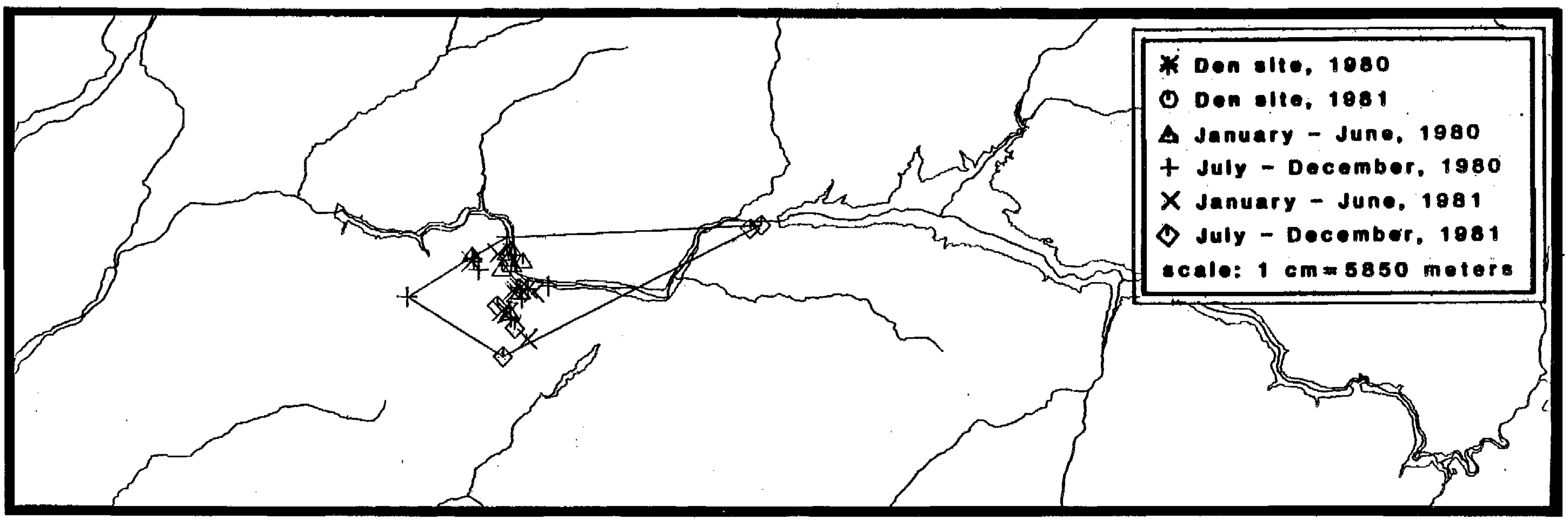

Figure 36. All point locations and complete known home range for black bear 290.

Figure 37. All point locations and complete known home range for black bear 291.

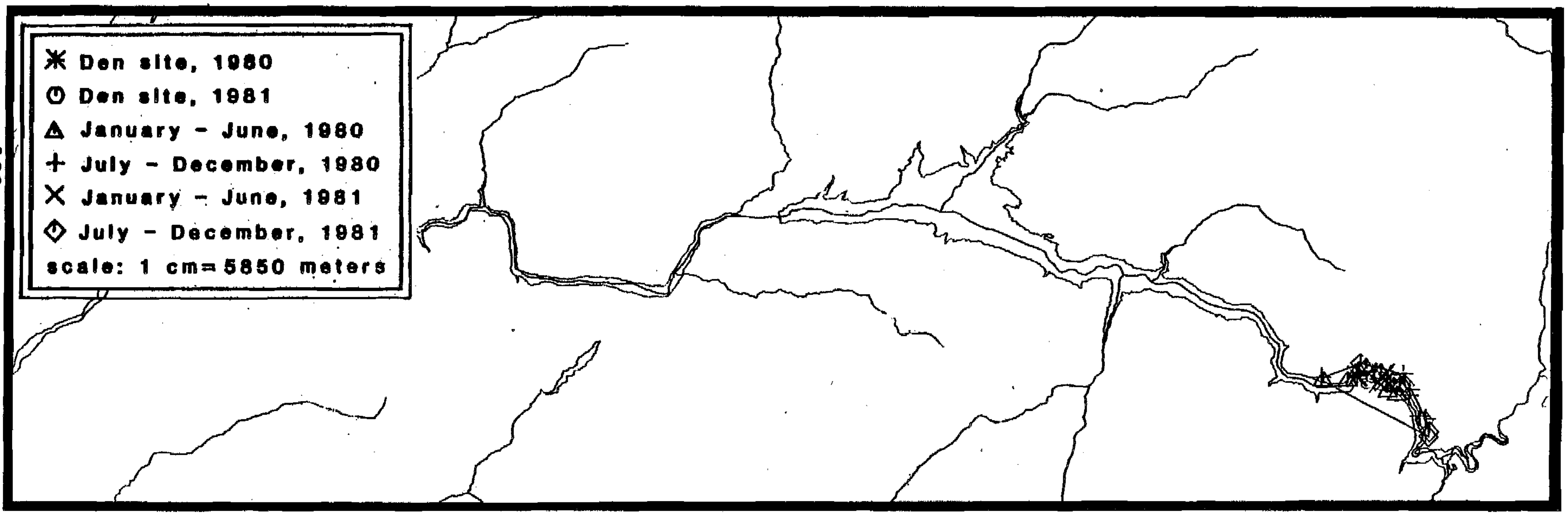

Figure 38. All point locations and complete known home range for black bear 301.

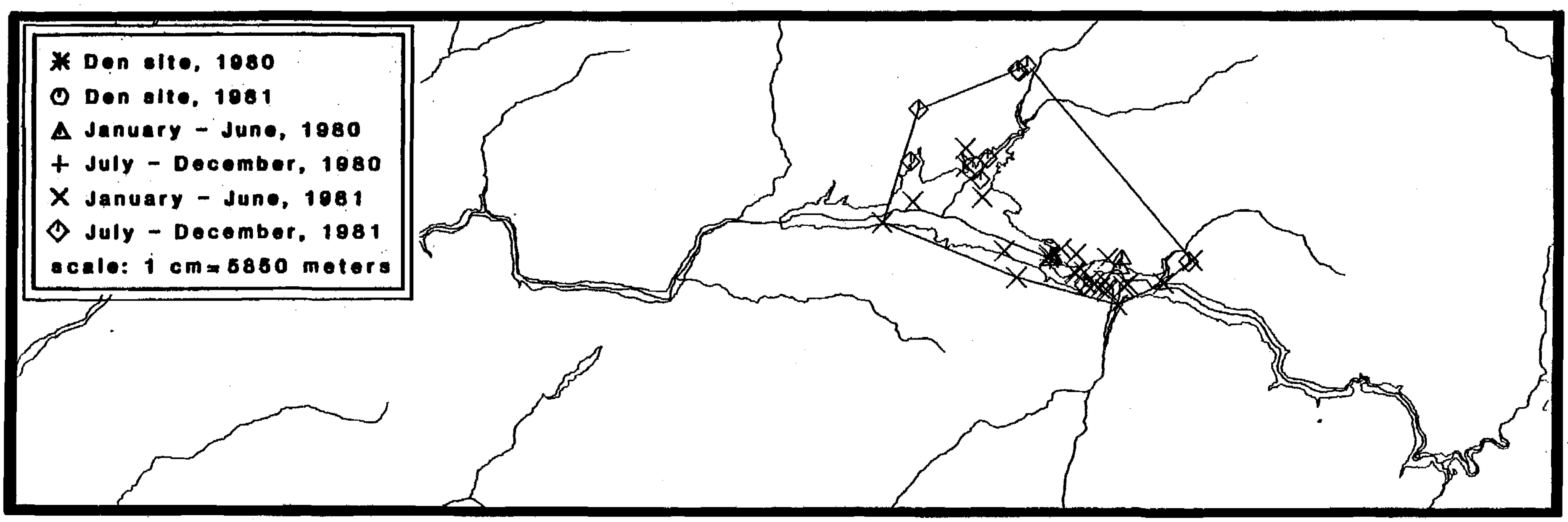

Figure 39. All point locations and complete known home range for black bear 302.

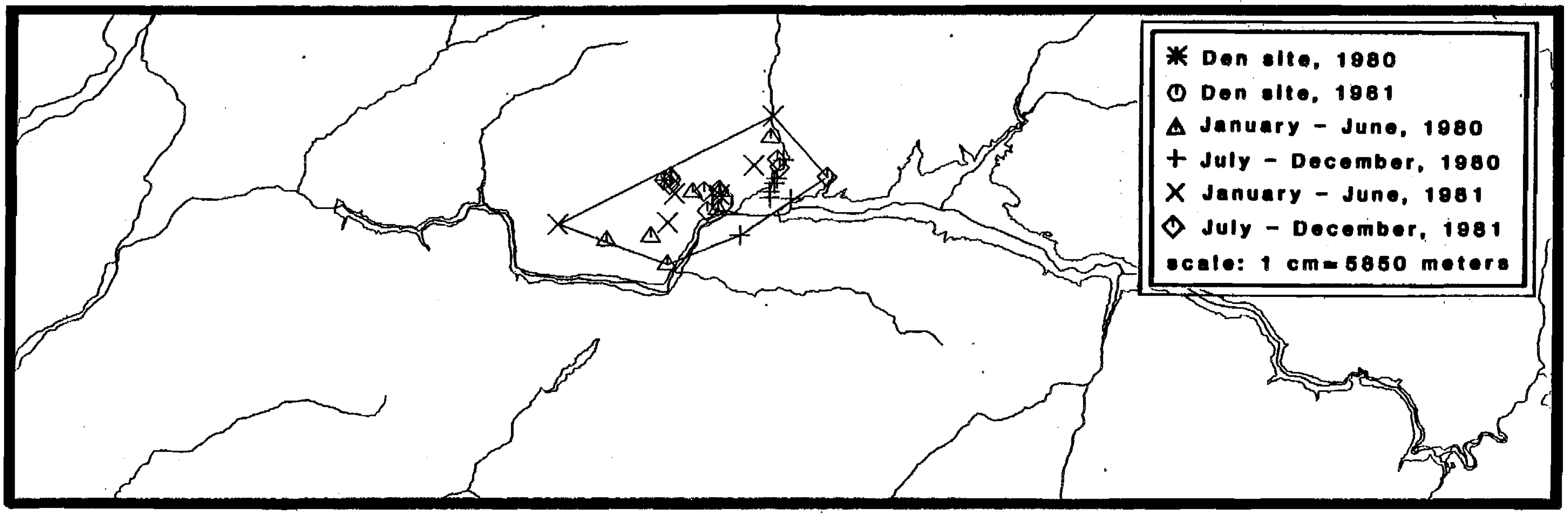

Figure 40. All point locations and complete known home range for black bear 303.

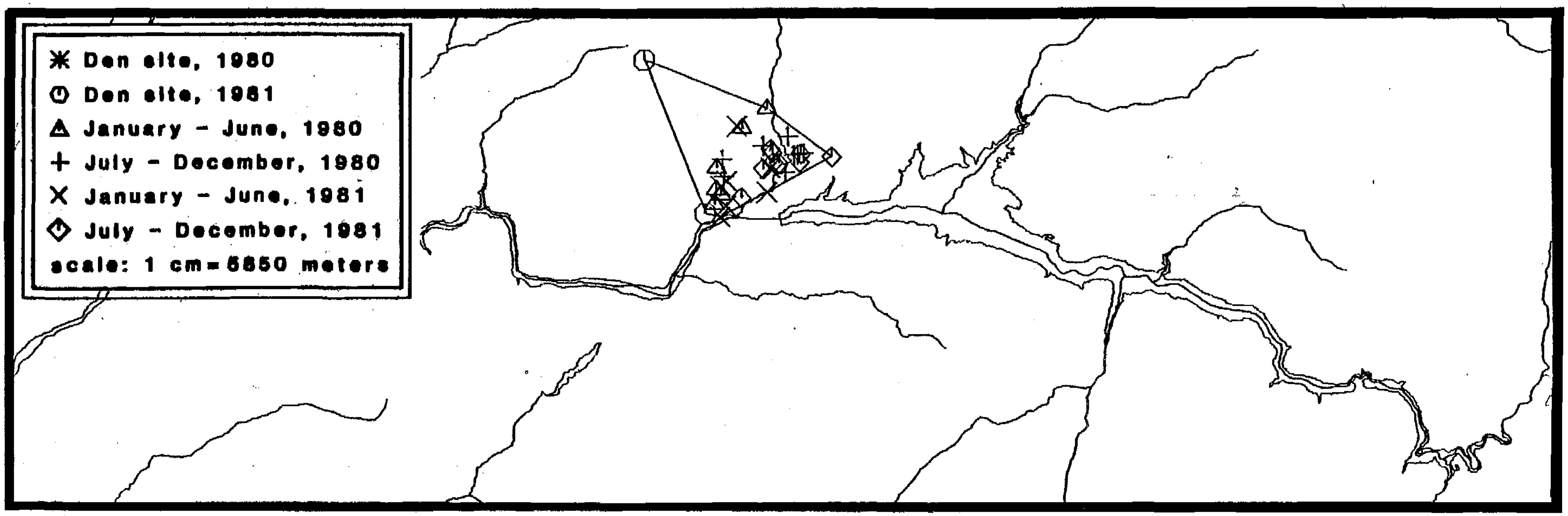

Figure 41. All point locations and complete known home range for black bear 304.

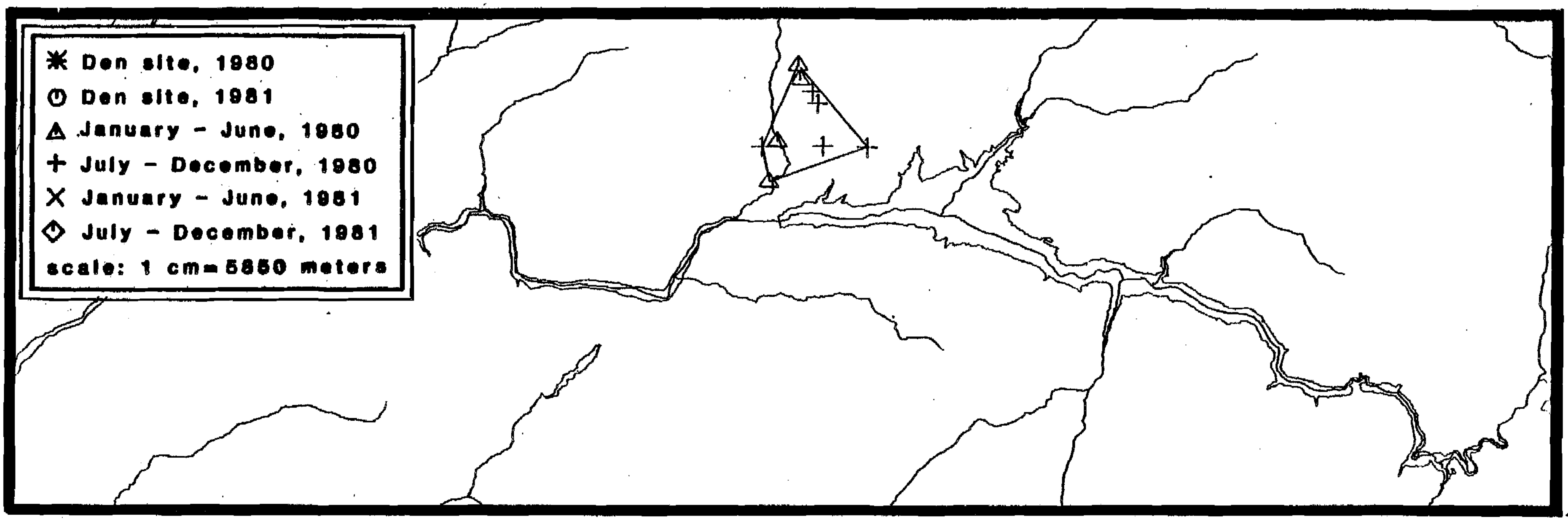

Figure 42. All point locations and complete known home range for black bear 305.

Figure 43. All point locations and complete known home range for black bear 317.

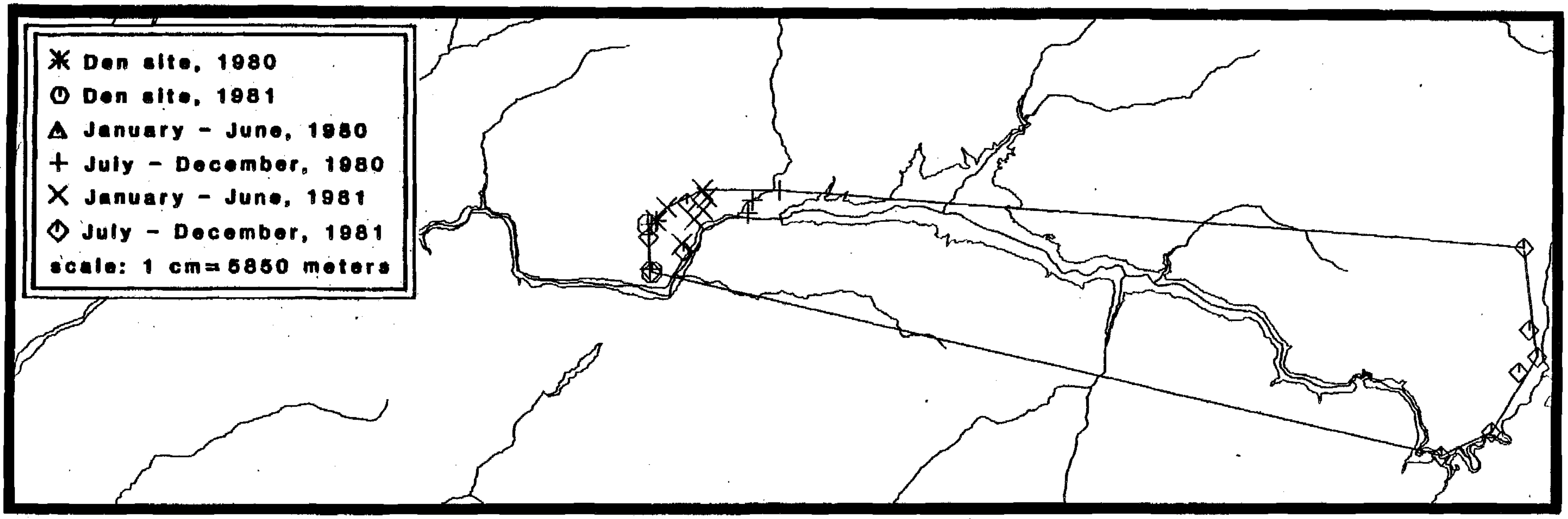

Figure 44. All point locations and complete known home range for black bear 318.

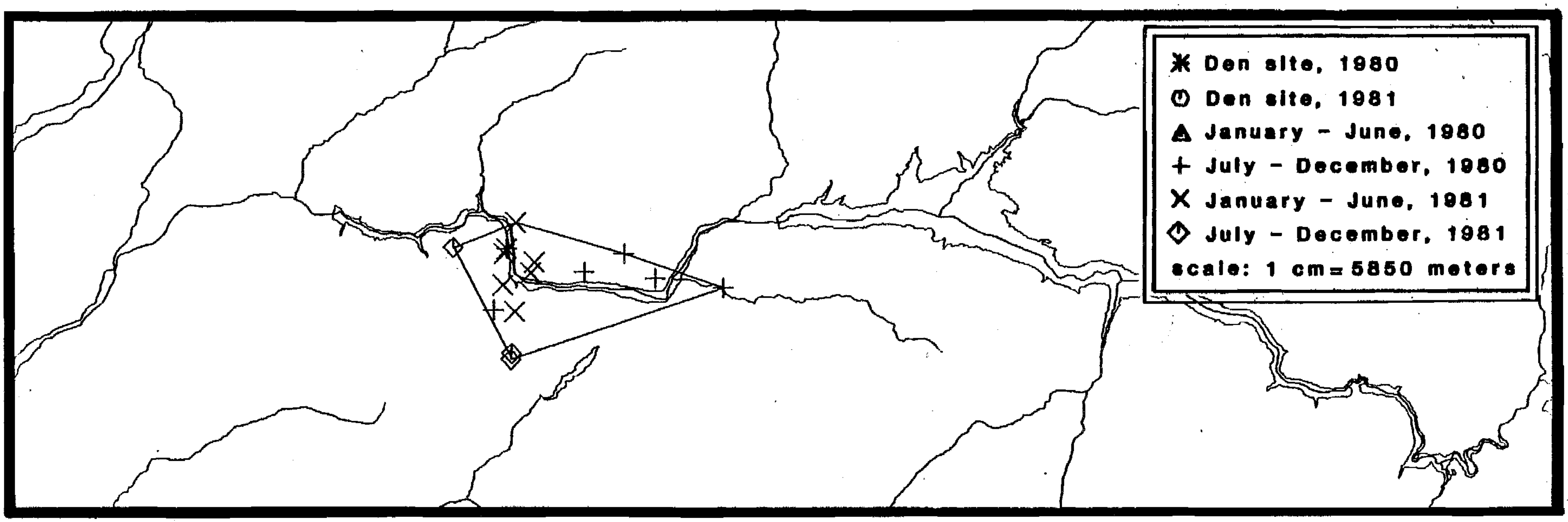

Figure 45. All point locations and complete known home range for black bear 319.

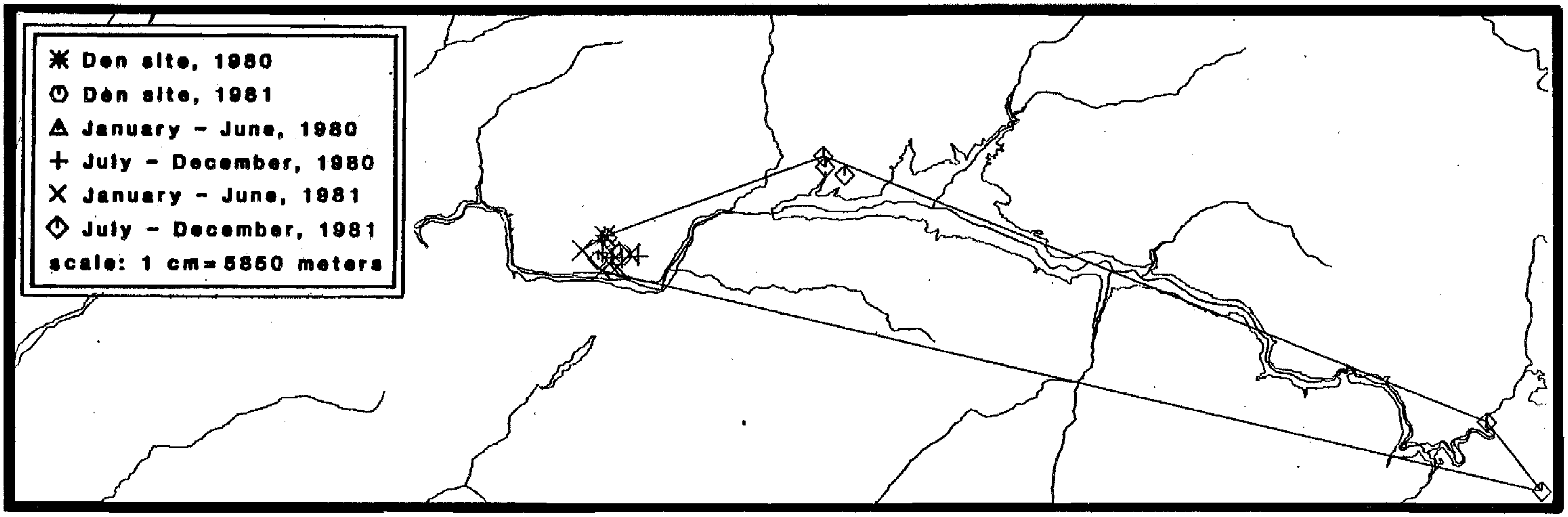

Figure 46. All point locations and complete known home range for black bear 321.

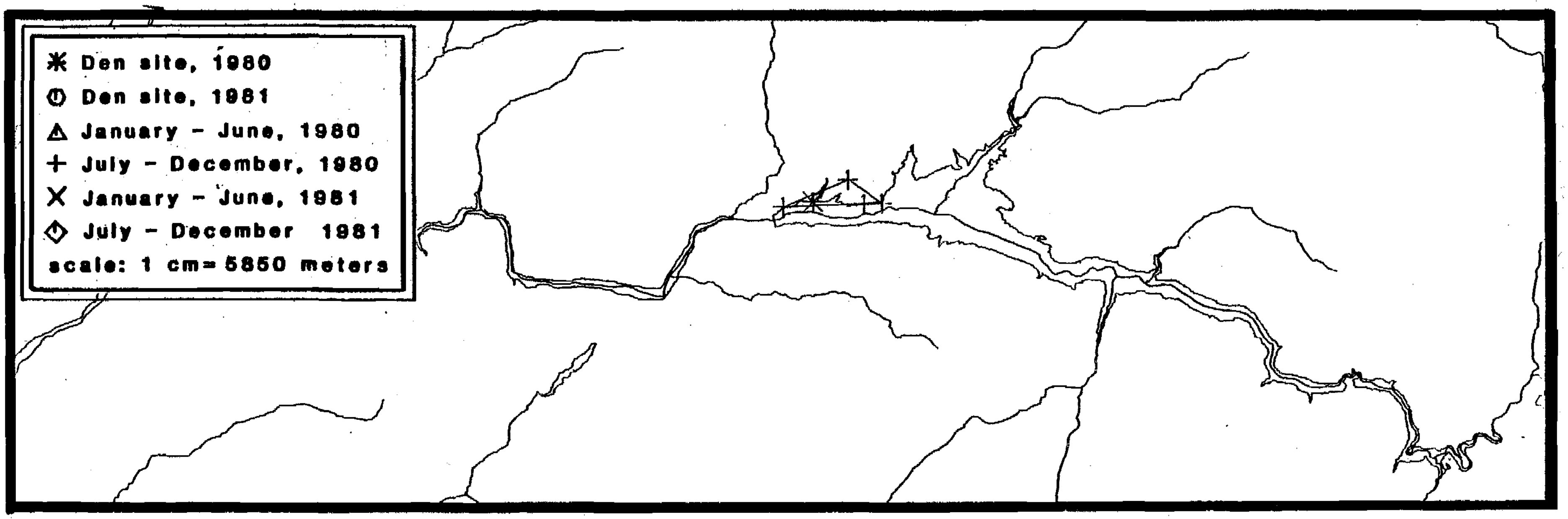

Figure 47. All point locations and complete known home range for black bear 322.

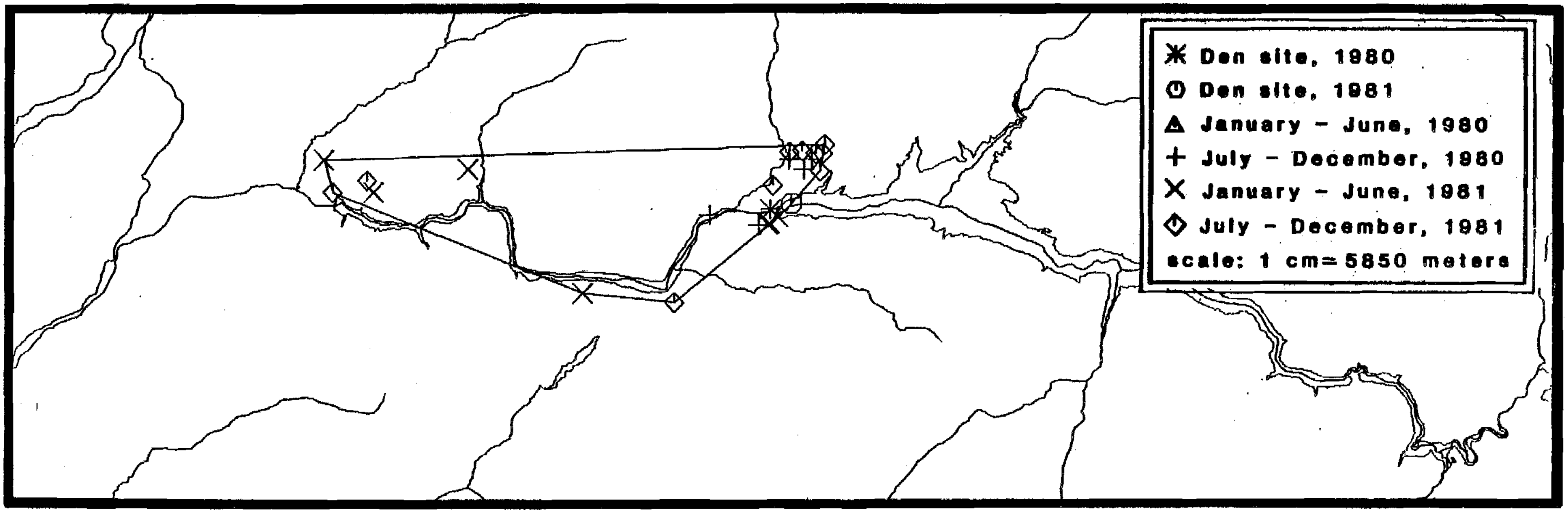

Figure 48. All point locations and complete known home range for black bear 323.

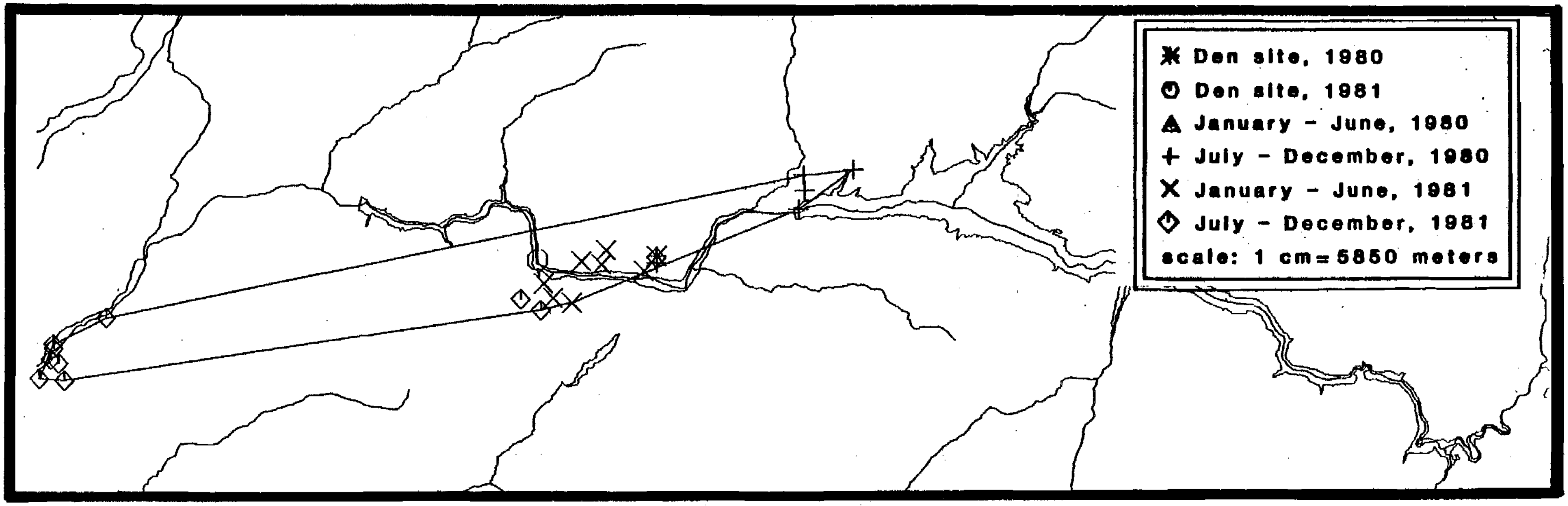

Figure 49. All point locations and complete known home range for black bear 324.

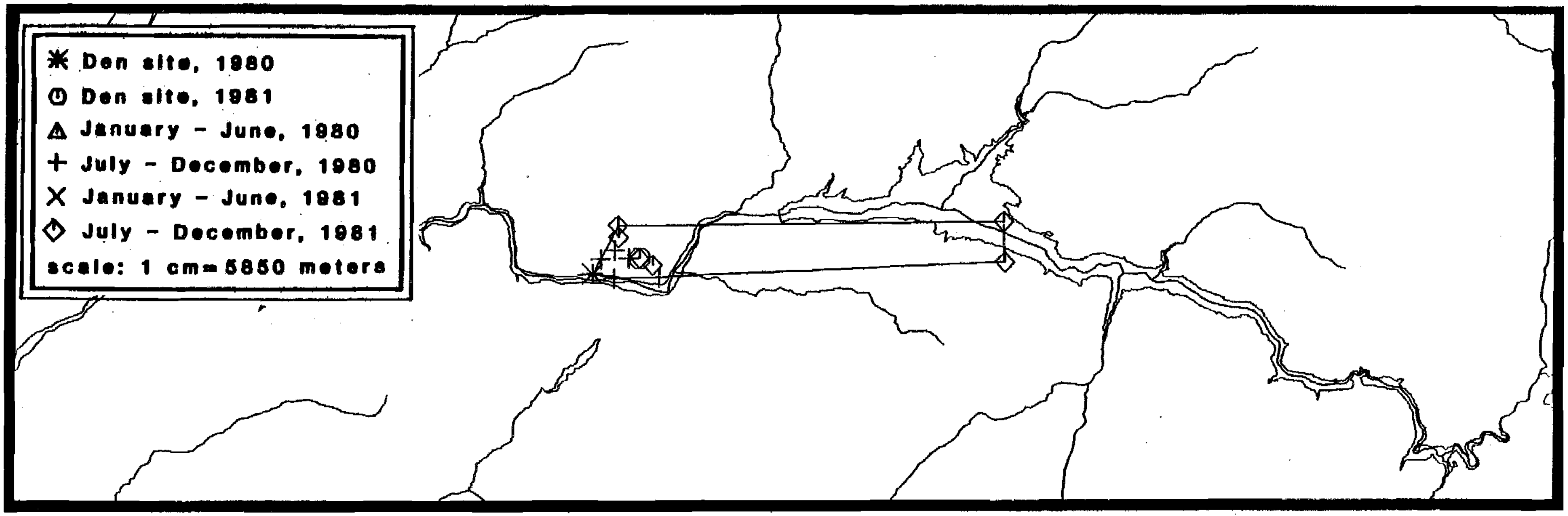

Figure 50. All point locations and complete known home range for black bear 325.

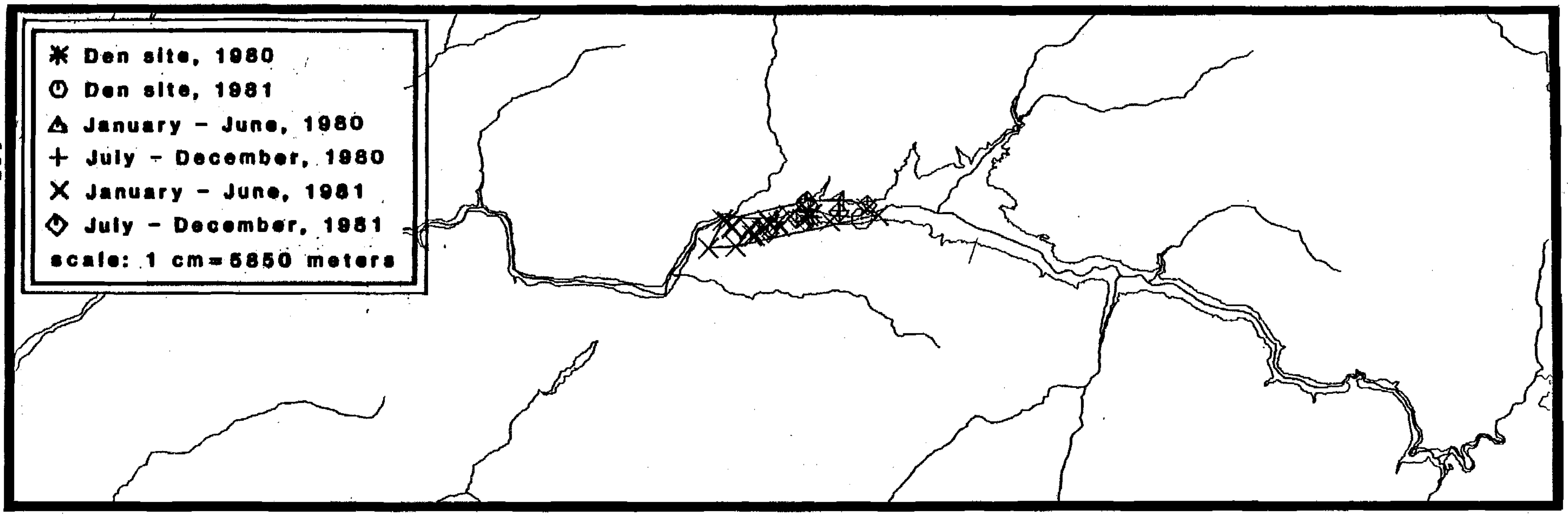

Figure 51. All point locations and complete known home range for black bear 327.

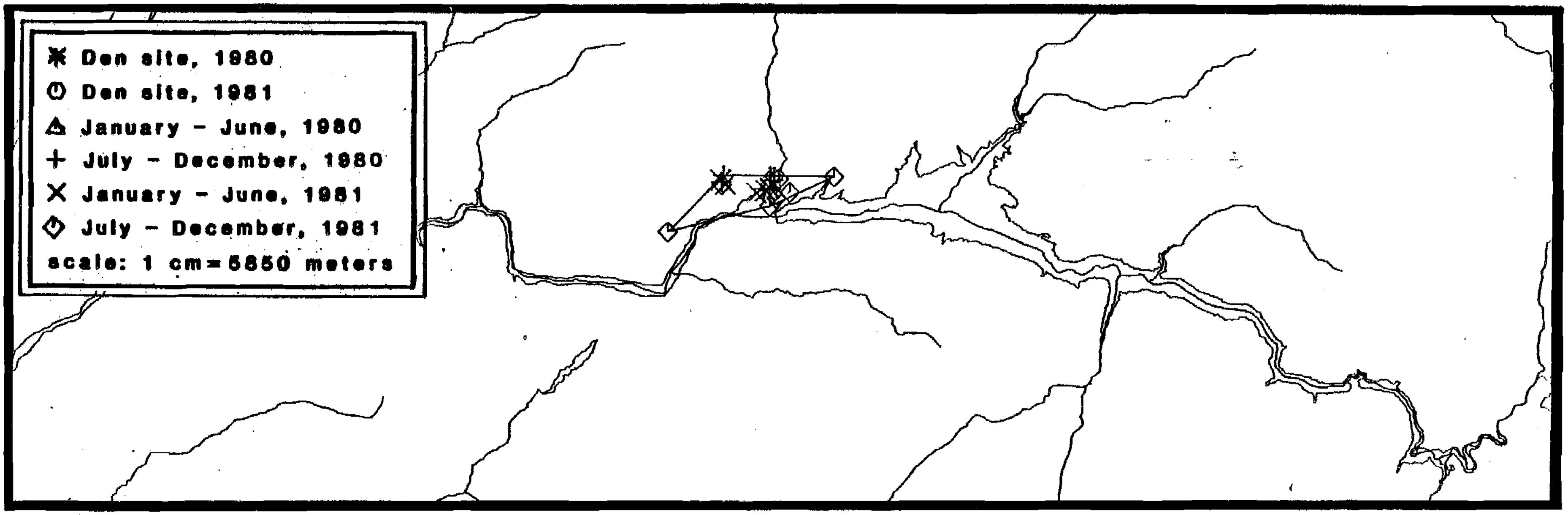

Figure 52. All point locations and complete known home range for black bear 328.

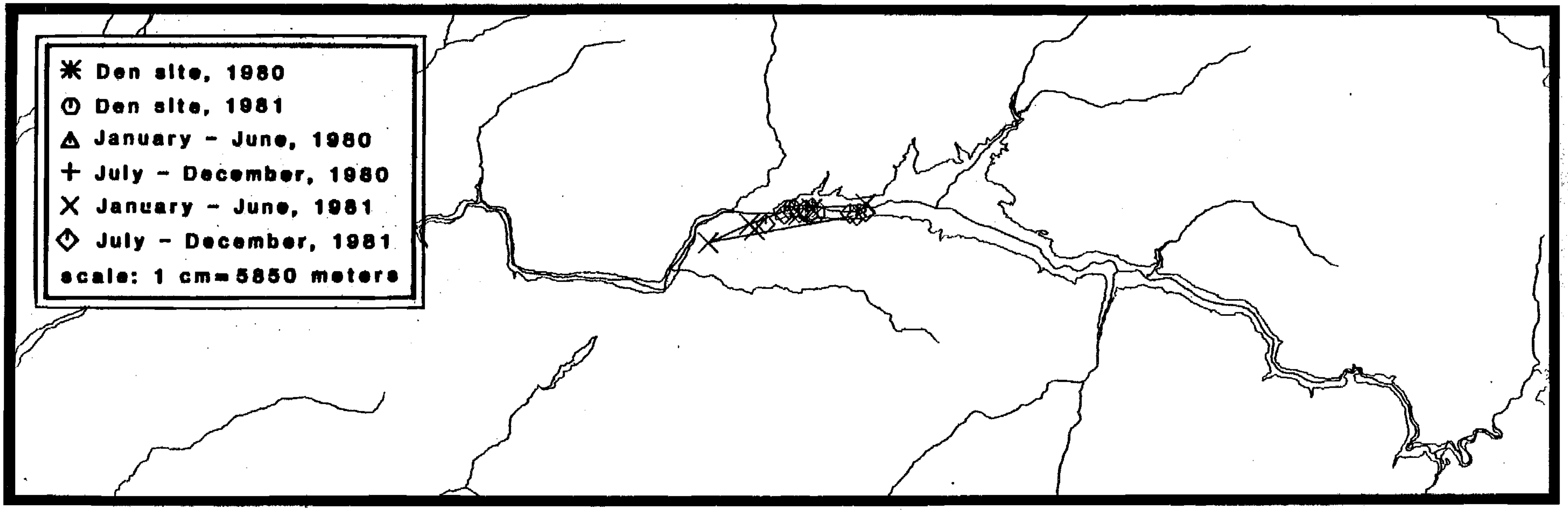

Figure 53. All point locations and complete known home range for black bear 329.

Figure 54. All point locations and complete known home range for black bear 330.

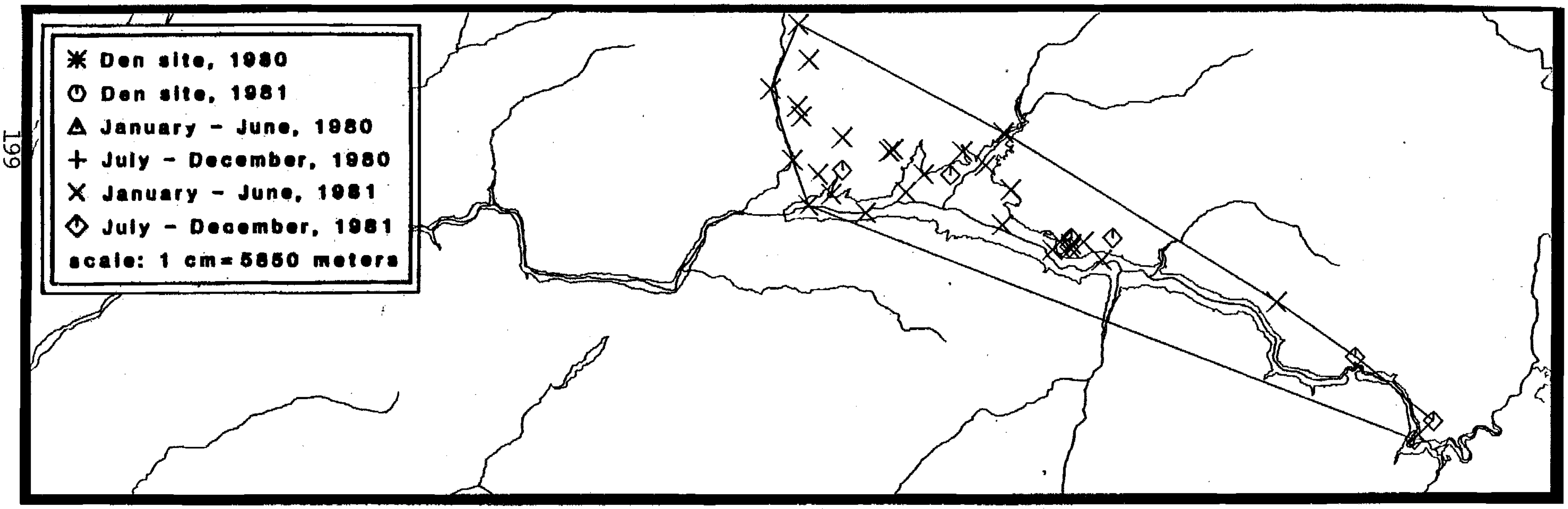

Figure 55. All point locations and complete known home range for black bear 342b.

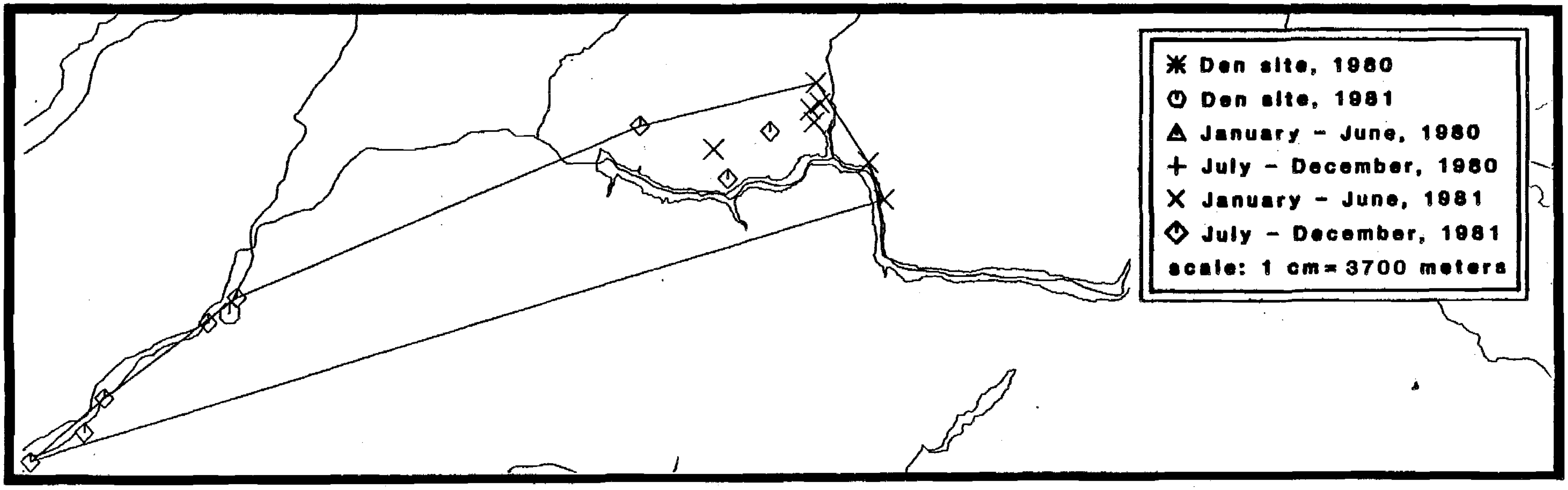

Figure 56. All point locations and complete known home range for black bear 343.

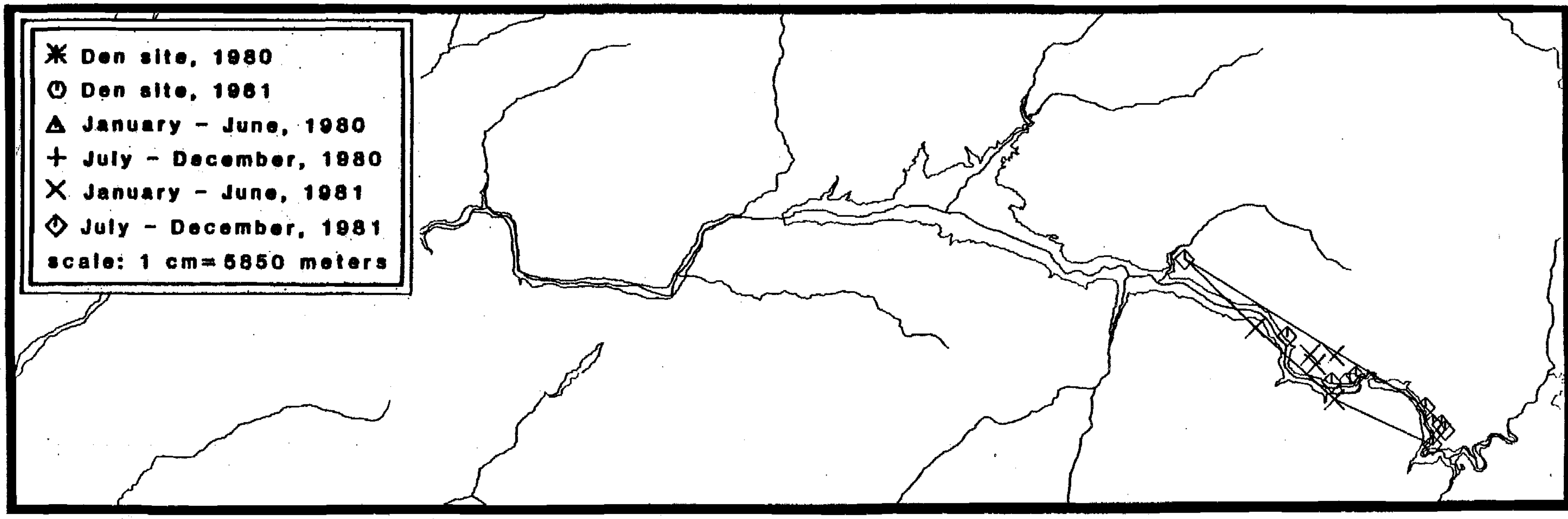

Figure 57. All point locations and complete known home range for black bear 346.

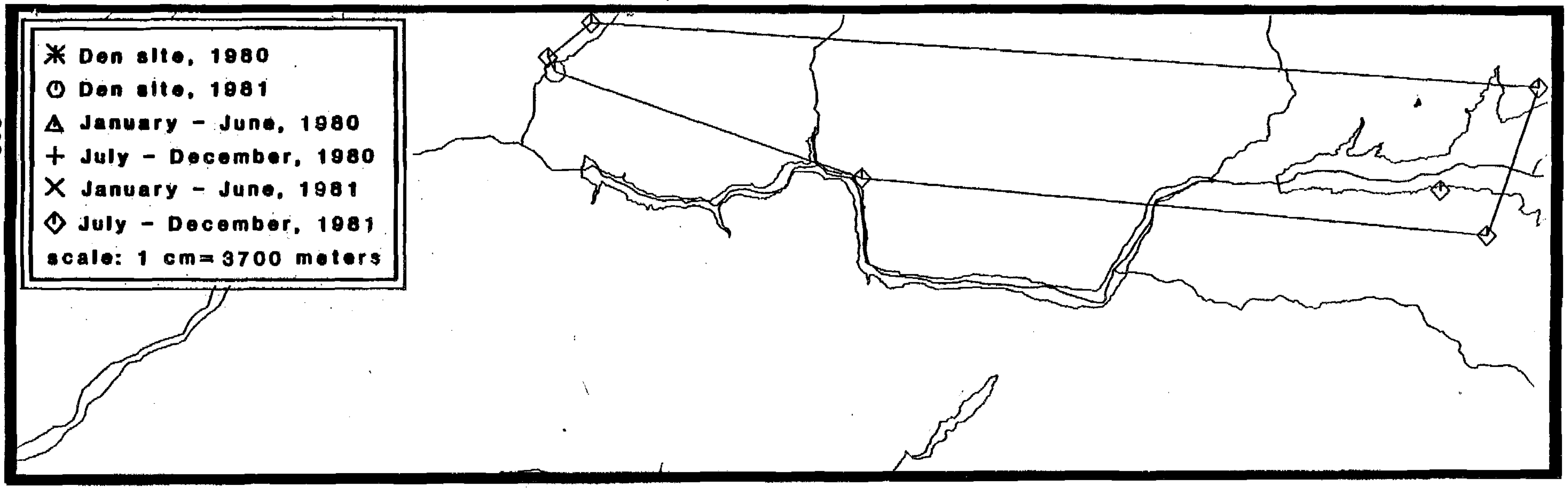

Figure 58. All point locations and complete known home range for black bear 348.

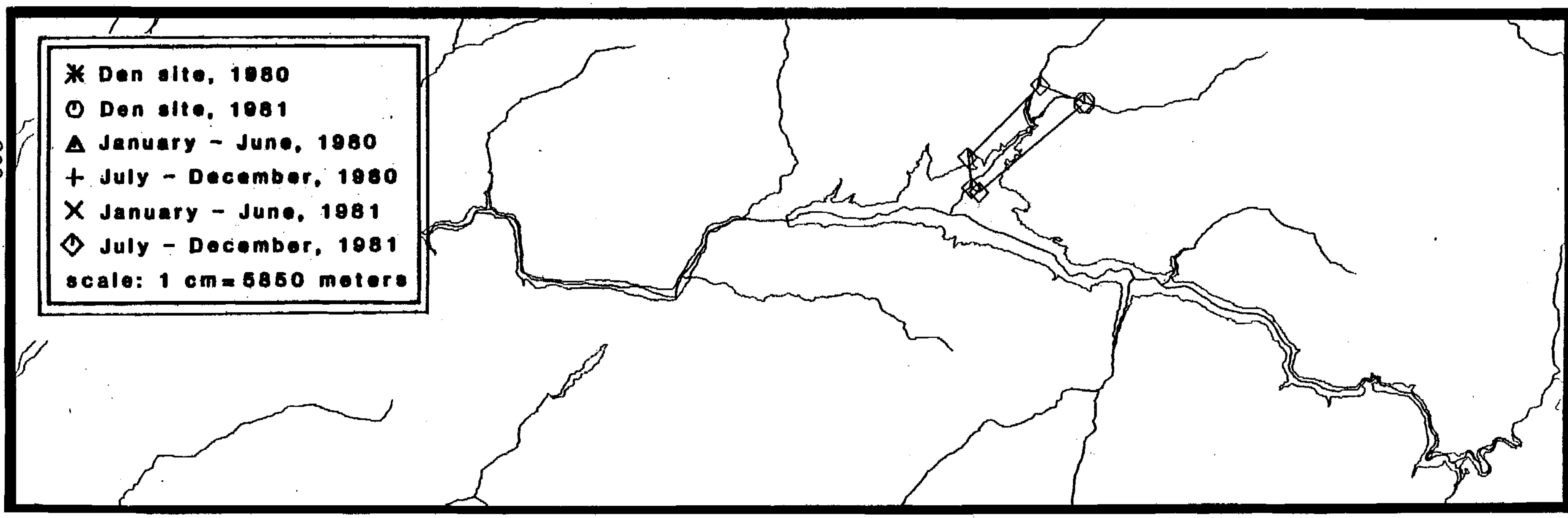

Figure 59. All point locations and complete known home range for black bear 349.

XIII. APPENDIX 3

DENSITY AND BIOMASS ESTIMATES FOR AN INTERIOR ALASKAN BROWN BEAR POPULATION

Sterling Miller[1] and Warren B. Ballard[2]
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Miller, Sterling and Warren B. Ballard. 1982. Density and biomass estimates of an interior Alaskan brown bear population. Canadian Field-Naturalist 97( ): - .

Abstract: Intensive capture efforts for an interior Brown Bear (*Ursus arctos*) population in southcentral Alaska permitted calculation of a minimum density estimate of 1 bear/61 km^2 based on the total number of captured and observed bears. Petersen technique (mark-recapture) estimates on the same data, corrected for biases, yielded an estimate considered more accurate of 1 bear/41 km^2. Females with newborn cubs were identified as having lower probabilities of capture than other bears. Brown bear biomass in the study area was estimated at 262 kg/100 km^2.

Keywords: Brown Bear, Grizzly Bear, *Ursus arctos*, density, biomass, Petersen technique.

Accurate bear density estimates have been difficult for wildlife managers and researchers to obtain. Direct counts are seldom possible because of low observability and generally low densities; indirect estimates based on scats or tracks are seldom attempted because of the infrequent and highly variable distribution of these signs in both time and space. Reliable density estimates have been derived primarily from intensive marking and radio-tracking studies wherein essentially all bears in a well-defined area have been captured and monitored over a period of years. Except for such studies, most reported bear densities represent little more than a guess on a number of bears divided by the area of some unit of management significance. Although such estimates have value in some circumstances, lack of definite procedures make replicate studies difficult and density comparisons between areas questionable.

The purpose of this paper is to report a Brown Bear density estimate in a portion of interior Alaska where no previous density estimates have been made. The opportunity to investigate Brown Bear population densities in this region arose as a result of an effort by the Alaska Department of Fish and Game (ADF&G) to experimentally reduce Brown Bear numbers, by transplant, in order to evaluate the response of Moose (*Alces alces*) calves to relief from Brown Bear predation (Ballard et al. 1980). These studies were conducted in an area where Brown Bear home ranges and movements had been previously documented (Ballard et al. in press).

The design of these studies permitted a bear density estimate through use of a standard population estimation technique (the Petersen estimate).

Potential sources of bias and assumptions implicit in Petersen estimates have been widely reported (e.g. Seber 1973). Although all of the potential sources of bias could not be adequately tested or adjusted, we feel that the procedures reported in this study provide a bear density estimate that is based on objective numerical procedures, is replicable in other areas or at other times to provide directly comparable estimates, and, at least in relatively open areas with moderate to high bear densities, may prove to be quicker and less expensive than intensive, long-term, radio-tracking studies designed to provide density estimates. We further believe that the density estimate that resulted from these studies is realistic.

STUDY AREA AND METHODS

The bear removal area encompassed 3,436 km² centered on the headwaters of the Susitna River in southcentral Alaska. The study area was bordered on the north by the Alaska Range, on the east by the Clearwater Mountains and on the southwest by the Talkeetna Mountains. Between these mountains is a broad, flat plateau known as Monahan Flats (823 meters elevation) crossed in several places by the braided glacial tributaries of the upper Susitna River.

The vegetation in the study area was predominently shrubs composed of dwarf birch (*Betula nana*) and willow (*Salix spp.*). Local areas of spruce (*Picea glauca* and *P. mariana*) are found along river courses and areas of poor drainage. Vegetation at higher elevations is open tussock grasslands.

Bears were located by 2 fixed-wing aircraft (Piper Super Cub PA-18) each with a pilot and observer. Once located, bears were darted from a helicopter (Bell 206B) and removed from the area as described by Miller and Ballard (in press). Fates of transplanted bears were described elsewhere (op. cit.).

Ages of adult bears were based on sections of the first premolar similar to the methods described by Mundy and Fuller (1964); ages of cubs and yearlings were based on size and tooth replacement. Ages of the spring-captured bears were standardized as years plus

(0.5). Weights were obtained using a hand-held spring scale with a capacity of 91 kg or a spring scale with a capacity of 680 kg mounted on a boom affixed to the front of a pickup truck.

Forty-seven bears were captured from 22 May to 7 June 1979. Additional efforts on 21-22 June resulted in the capture of one additional bear and the recapture of one returning bear. All observed bears were captured, except for one unmarked individual.

Search efforts were not uniform throughout the experimental area, but rather were concentrated in its central portion. Some bears were located at moose kill sites, including kills of radio-collared moose calves equipped with mortality-sensor radio collars (Ballard et al. 1980). Of the bears captured the preceding year (1978), only two retained functioning radio collars; both of these animals were radio-tracked and recaptured on the first day of the removal effort.

Twelve Brown Bears marked in 1978 were in the experimental area; these served as the basis for adjusted Petersen estimates of population size. In this estimate it was assumed that all 12 of the marked bears were still alive and present in the experimental area in 1979. Mark-recapture calculations were made separately for each sex and included all bears older than 3 y in 1979. This age restriction was utilized because no yearlings were marked in 1978, so no marked 2.5 y-old bears could have been present in 1979. The probability of capture of 2.5 y-old bears in 1978 was assumed equivalent to that of 3.5 y-old bears in 1979, therefore no need to correct for recruitment into the 1979 sample of bears 3.0 y or older was necessary.

The Chi square test statistic was utilized to compare subpopulations on the basis of sex ratio. The equation utilized in Petersen estimate calculations was (Ricker 1975):

$$N = \frac{(M+1)(C+1)}{(R+1)}$$

In this equation: M = number marked in 1978, C = number captured in 1979 and R = number of recaptured bears in 1979.

RESULTS AND DISCUSSION

The number of captures/day ranged from 0 to 8 (0-4 for adult bears). Daily capture rates for the 17-day continuous removal effort were highest in the first 6 days (4.5 bears/day), lowest in the middle 5 days (0.8 bears/day), and intermediate in the last 6 days (2.7 bears/day). This pattern of capture probably resulted from normal seasonal movements of Brown Bears from high elevation den sites on the periphery of the study area to the flat central portion where search efforts were concentrated.

The possibility that this pattern of capture resulted from immigration into the study area was rejected on the basis of analyses of sex and age composition as related to time or location of capture. For this purpose a periphery zone was defined as the area within one average home range radius inside of the search area, 15.7 km for males and 11.5 km for females (Miller and Ballard in press).

Sex ratios of captured bears were not significantly different in any of three different groupings of consecutive time periods (six 3-day intervals, three 6-day intervals, and two 9-day intervals) (P©0.30). The sex ratio in the center of the area throughout the capture period was skewed in favor of males (8:7); this was not significantly different from the sex ratio in peripheral areas during the last half of the removal period (3:2 in favor of males) (P©0.2).

A similar lack of evidence for immigration existed in age ratio data. The seven males captured in the last half of the capture period were younger (x=5.8 y) than the 12 males captured in the first half (x=7.6 y), however, excluding one exceptionally old
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bear (21.5 y) no differences in male ages were apparent (5.8 y and 6.2 y, respectively). No differences were apparent in the average age of eight females captured early (x=7.1 y) relative to seven captured later (x=7.6 y).

These analyses provide no reason to reject the assumption that the bear population in the study area was "closed" (Seber 1973) with respect to immigration or emigration. Rigorous examination of this assumption would be less necessary under experimental designs where captured bears were not being removed from the population.

Minimum Population Estimate

The number of bears actually captured was 48. In addition, eight bears were known to have been missed in the removal effort (2 of unknown sex which were observed in June and July, 2 others observed in August, and 4 from 1978 which were not recaptured in 1979, 2 males and 2 females). These bears were individually identified on the basis of pelage, size and the absence of ear flags or other marks. Therefore, the study area population contained a minimum of 56 bears. This number appeared to be a reasonable minimum estimate as some bears which were missed in the capture effort were doubtless also missed during subsequent monitoring flights. Furthermore, the rate at which bears were being captured in the last days of the removal effort clearly indicated that not all bears had been captured.

Mark-Recapture Population Estimates

Seven male bears were captured and marked in the study area in spring 1978 (Ballard et al. in press). Of these, all were recaptured in spring 1979 except for two, both 3.5 y in 1978. Both of these bears were doubtless in the study area in 1979, as each was verified in or near the experimental area in 1980. One of these bears had a functioning radio collar in 1978 and was relocated 15 times in the center of the removal area that year. On this basis it was concluded that both of the previously marked males not found in 1979 were present. One of the 1978 captured males still had a functioning radio collar in 1979. This bear was, correspondingly, easily tracked and captured in 1979 and therefore was excluded from Petersen estimate calculations.

Five female bears were captured and marked in the study area in spring 1978 (Ballard et al. in press). Three of these were recaptured in spring 1979. One of the recaptured females still had a functioning radio collar and was, correspondingly, excluded from Petersen estimate calculations as trap-prone. The two females not recaptured in 1979 were 10.5 and 4.5 y-old in 1978, both were in estrus when captured in 1978 and therefore likely had newborn cubs in 1979. The older bear was observed mating in 1978, and the younger bear was observed in the company of another, presumably male, bear in 1978. Both of these females had functioning radio collars in 1978 and were well-documented experimental area residents. Both females were assumed present during the 1979 intensive capture effort.

Excluding the trap-prone bears described above, adjusted mark-recapture calculations (Ricker 1975) were made for each sex using the total number of bears 3.0 years or older captured in 1979 (16 males and 14 females) and the recaptures of bears marked in 1978 (4 of 6 males and 2 of 4 females). This process yielded population estimates of 24 males and 25 females older than 3.0 years (Table 1). By lumping sexes, Petersen calculations independently provided an estimate of 49 bears older than 3.0 years (Table 1). Because of the low numbers of marked individuals, the numerical confidence intervals (Ricker 1975) for these estimates were large (Table 1).

Corrections to Mark-Recapture Estimates

The mark-recapture estimates were based on the assumption that the probabilities of capture were equal and remained constant through both 1978 and 1979 capture efforts. This assumption may be incorrect for females as there were indications that females with newborn cubs had lower capture probabilities. Only two females with newborn cubs were located during capture efforts conducted during 1978, 1979, and 1980 in the study area and adjacent areas. One of these females was trap prone because of her functioning radio collar applied the previous year. The other, from a nearby study area, was captured with three newborn cubs in 1978. The following evidence indicates trap shyness by females with newborn cubs relative to the capture techniques utilized in this study:

1. In both 1978 and 1979 only one female with newborn cubs was encountered although females with yearlings were relatively numerous in 1978 (1 with cubs:5 with yearlings), 1979 (1:7), and 1980 (0:2). This suggests that the low capture rates of females with newborn cubs were not likely due to low reproductive rates.

2. The two females marked in the study area in 1978 that were not recaptured in the 1979 removal effort, both likely had cubs in 1979. Both were in estrus in 1978 and were seen either copulating with or in the company of another bear in 1978.

Females with newborn cubs have been reported to remain in the vicinity of their den sites longer than other bears (Glenn and Miller 1980; Craighead and Craighead 1972). On the Alaska Peninsula, females with newborn cubs were seldom captured in the spring because they tended to remain in mountainous terrain and near protective cover (Glenn and Miller 1980). Observations in 1978 of a female accompanied by three newborn cubs, indicated that she tended to remain in thickly forested habitats and, consequently, was less frequently observed than other radio-collared bears (Ballard et al. in press).

In recognition of this apparent capture bias, the above capture-recapture estimate was adjusted upwards for the female segment to correct for "trap shyness" of females with newborn cubs. A conservative adjustment was derived by assuming that the number of females with newborn cubs was equal to the number of captured females with yearlings (7). This adjustment increased the female segment estimate to 33 bears older than 3.0 y (Table 2). This is still probably conservative because it is unlikely that all females with yearlings were captured. However, it should be noted that probable females with newborn cubs were used both in the Petersen estimate and in the correction to this estimate.

Sex ratio of captured bears (older than 3.0 y) was 113 males:100 females. In an exploited population where hunters tend to selectively harvest males (because males range greater distances, females accompanied by offspring are legally protected, and hunters tend to select large bears), a population with a sex ratio skewed towards females would be expected (Bunnell and Tait 1978). Unpublished harvest data from Alaska's Game Management Unit 13, which includes the study area, reveal that from 1970 to 1979 males represented 52% of the harvest of bears older than 3.0 y. The "corrected" mark-recapture estimate has a sex ratio (bears older than 3.0 y) of 73 males:100 females; this sex ratio more closely corresponds with the model proposed by Bunnell and Tait (1978) than does the observed sex ratio of captured bears.

The number of newborn cubs also required adjustment in a similar manner as the number of females with cubs. Seven females accompanied by 12 yearlings were captured in 1979 yielding an average litter size of 1.7 yearlings/female with yearlings. The assumption that there were at least as many newborn cubs present as yearlings captured, yielded a conservative correction for newborn cubs (Table 2). This was conservative because a high rate of cub mortality likely occurs (Glenn et al. 1976) and because all females with yearlings were probably not captured.

With these adjustments to the female and cub classes, the "corrected" Petersen population estimate was 83 bears, of these 57 were bears 3.0 y or older (Table 1).

Population Density Estimates

To arrive at density estimates using the above population estimates, the area occupied by the removed bears must be determined. Some of the bears captured had portions of their 1978 home ranges outside of the search area, suggesting the total area from which bears were removed was larger than the area searched. However, it appeared reasonable to assume that for each such bear captured, another bear which was only partially resident in the search area was not captured. Assuming that bears with home ranges that are not completely included within the search area have a probability (P) of being captured (where [P] is equivalent to the proportion of their home ranges which is within the search area) and a probability of being missed of (1-P), it is reasonable to use just the search area in making density estimates. Making this assumption and utilizing the search area (3,436 km^2) combined with the above estimates of bear populations yielded bear density estimates (Table 1) for each of the above population estimates.

The accuracy of the "corrected" mark-recapture density estimate was supported by 1978 home-range data in the study area (Ballard et al. in press). The total area occupied by seven bears (older than 3.0 years) was 1,560 km^2 (overlaps counted only once). A simple proportional extrapolation to the experimental area yielded an estimate of 15 bears aged 3.0 y or older. This figure must be corrected for the presence of unmarked bears. Of the 32 adult bears caught in 1979, only eight (25%) were marked.

If it is assumed that the above estimate of 15 bears represents the same proportion of the total population, than the population of bears older than 3.0 y would be 60 bears. This figure is only slightly larger than the "corrected" Petersen estimate (Table 1) and adds credence to this estimate.

The "corrected" Petersen density estimate was compared to Brown Bear density estimates elsewhere in North America (Table 2). The estimated density fell about where subjectively expected, lower than in portions of Alaska where Brown Bears have access to salmon or than in more southern areas of good habitat, but higher than in the Alaskan Brooks Range (Table 2).

Biomass Estimation

Density estimates provide a measure of comparison between different geographic areas within species' range. A more meaningful comparison in terms of relative habitat capacities is biomass which combines density estimates with information on the size of individuals in the population. This parameter has been infrequently reported in the literature although, commonly, data are available to calculate biomass.

Measured weights were available from 88 Brown Bears captured from 1978 through 1980 in the study area and adjacent areas (Table 3). All bears were captured in the spring (April-June). For each sex, the density estimate lumped bears 3.0 y or older. Therefore, it was necessary to calculate average weights in the same age categories (Table 3). Similarily, sexes were lumped in calculation of average weights of cubs, yearlings, and 2 y-old bears (Table 3).

Combining these weights with the "corrected" mark-recapture density estimate (Table 2) yielded a Brown Bear biomass estimate of 262 kg/100 km^2 (1,493 lbs/100 mi^2).

ACKNOWLEDGEMENTS

Financial support for this study was provided by the Game Division, Alaska Department of Fish and Game (ADF&G). Comparison data reported for 1980 studies were collected during Susitna Dam impact assessment studies financed by the Alaska Power Authority.

We gratefully acknowledge the assistance of many employees of the Game Division (ADF&G) in capturing and transplanting the Brown Bears, data reduction and tooth sectioning. K. Schneider, D. McKnight, C. Schwartz and C. Gardner (all ADF&G) and D. E. N. Tait reviewed earlier drafts of the manuscript and offered constructive comments.

We especially acknowledge the participation of T. Spraker (ADF&G) who assisted in the bear transplant, and provided technical assistance and advice throughout the project.

Much of the success of the bear capturing phase of this project was due to the skills and cooperative attitudes of our spotter plane pilots: Ken Bunch, Al Lee, and Rick Halford, and to the skill and cooperative attitude of our helicopter pilot, Vern Lofstedt.

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Table 1. Summary of Brown Bear population and density estimates, upper Susitna River, Alaska.

	No. of Captures	Captured Plus Known Missed bears	Uncorrected Petersen Estimate (95% CI)	"Corrected" Petersen Estimate
BEAR POPULATION				
Males (3.0 y+)	17*	21**	24 (9-96)	24
Females (3.0 y+)	15*	19**	25 (8-280)	33
Both Sexes (3.0 y+)	32	40	49 (23-136)	57
Offspring (0.5-2.5 y)	16	16	--	26
All Bears	48	56	--	83
BEAR DENSITY (km^2/bear)				
Both Sexes (3.0 y+)	107	86	70	60
All Bears	72	61	--	41

* Includes one trap-prone bear that was excluded from mark-recapture calculations.
** The four adult bears of unknown sex not captured were assigned as two males and two females.

Table 2. Reported brown bear densities in North America.

km^2/bear	Location	Source
1.6	Kodiak Island, AK	Troyer and Hensel 1964
16	Alaska Peninsula, AK	Unpublished data (Glenn, pers. comm.)*
21	Glacier Nat. Park, Montana	Martinka 1974
28**	Glacier Nat. Park, B.C.	Mundy and Flook 1973
23-27	SW Yukon Territory	Pearson 1975
41	Upper Susitna R., AK	This study
288(42-780)***	Western Brooks Range, AK	Reynolds 1980
148-260****	Eastern Brooks Range, AK	Reynolds 1976

* Data refer to a 1800 mi^2 intensively studied area of the central Alaska Peninsula.

** Estimated density, minimum was 1/18 km^2.

*** 1/288 km^2 is mean density for the whole of the Nat. Pet. Reserve, Ak, the range represents values for different habitat types in this reserve where the highest density occurred in an intensively studied experimental area (Reynolds, pers. comm.).

**** Highest density (1/148 km^2) was in an intensively-studied area of relatively high quality habitat, region-wide density was estimated at 1/260 km^2.

Table 3. Measured weights (kg) of spring-captured Brown Bears by sex and age, southcentral Alaska.

Age (Years)	Males				Females				Both Sexes			
	n	$\bar{x}$	S.D.	Range	n	$\bar{x}$	S.D.	Range	n	$\bar{x}$	S.D.	Range
0.5	3	5.0	-	-	1	5	-	-	4	5.0	-	-
1.5	10	38.2	14.4	21-63	4	34.7	11:6	21-45	14	37.2	13.3	21-63
2.5	6	89.9	30.0	61-140	3	80.0	13.3	70-95	9	86.6	25.1	61-140
3.5	5	113.3	19.3	93-139	4	81.5	10.7	74-97	-	-	-	-
4.5	7	133.4	25.7	100-181	5	88.6	12.8	72-101	-	-	-	-
5.5	3	181.3	61.1	115-236	4	118.9	19.0	106-147	-	-	-	-
6.0+	16	255.9	20.4	217-289	12	120.6	23.4	86-145	-	-	-	-
3.0+	31	198.0	68.0	93-289	25	107.6	25.2	72-147	-	-	-	-

XIII. APPENDIX 4

Ballard, W. B., S. D. Miller, and T. H. Spraker. Home range, daily movements, and reproductive biology of Brown Bear in southcentral Alaska. Canadian Field - Naturalist 95( ): 000-000.

Abstract: Twenty-three radio-collared adult Brown/Grizzly Bears (*Ursus arctos*) were studied in the Nelchina Basin of southcentral Alaska during 1978 and 1979. Radio-collared bears were seen on 85.4% of 644 radio locations. Home ranges of adult females averaged 408 km^2, while those of adult males averaged 769 km^2. Daily movement of males averaged 7.7 km/d. while females averaged 7.0 km/d. Most bears entered dens in late October and emerged between 9 April and 12 May and therefore were active for half of the year.

Most females became reproductively mature at 4.5 y; in three cases females successfully bred at 3.5 y. A reproductive interval of 1 y was reported in one case following loss of a yearling offspring. Typical breeding intervals were 3 y. Average size of 17 cub and yearling litters was 1.9: high rates of cub loss were observed. Breeding activity was concentrated in May and June.

Relative to most other North American Brown Bear populations, Brown Bears in Interior Alaska had larger home ranges, females reached sexual maturity at younger ages, and weaning of litters occurred earlier.

XIII. APPENDIX 5

Den Site Characteristics of Prince William Sound Black Bears.
by Sterling Miller, Charles Schwartz and Dennis McAllister

Black bear dens utilized in winter 1980/81 by bears radio-collared in connection with population identity studies in Prince William Sound (Modafferi, in prep.) were located, marked and measured in 1981. Den sites for these same bears in 1981/82 were approximately located by fixed-wing aircraft in January 1982. The purpose of this work was to provide baseline data on characteristics of Prince William Sound black bear den sites. Such data are valuable in light of increased developmental activities anticipated in the area, especially logging. These observations also provide comparison data to that being collected on the Kenai Peninsula (Schwartz and Franzmann 1981) and along the upper Susitna River (Miller and McAllister in prep).

All radio-collared bears were in dens when bears were located by fixed-wing aircraft on 15 April 1981. However, 2 bears, both males, had left their dens by 23 April 1981 when dens were marked; only approximate locations and elevations are available for the dens of these 2 males (as well as for all 1981/82 dens). Nine bears, all females, were still in dens on 23 April 1981 and these dens were marked with radio-collars, flagging and/or evident topographic features. 1981/82 dens will be similarly marked if time and available funds permit.

Marked dens were visited in summer 1981 and their characteristics were noted and dens were measured. The measurements followed those outlined by Schwartz and Franzmann (1981) with the addition of a subjective characterization of relative quality on a scale from 1 (poor) to 5 (excellent). These data are presented in Table 1 and Fig. 1.

Of the 9 measured dens, 5 were in mature hemlock (*Tsuga spp.*) forests, a forest type likely to be heavily exploited by increased logging efforts. Hollow trees were used as dens by 3 bears denning in hemlock forests (Table 1). In 1981/82 all 10 dens tentatively located were in hemlock forests or hemlock associations (Table 2).

Interestingly, 8 of the 9 dens examined in 1981 were in natural cavities (3 in trees, 3 in rock caves, and 2 under large boulders on talus slopes (Table 1); only 1 den was excavated by a radio-collared black bear.

In 7 cases a determination or reasonable guess could be made on whether an examined den had been previously used by a black bear. In 4 of these previous use by black bears was evident or suspected (Table 1).

Frequency of reuse of the same den by the same individual appeared low, although individual bears tended to den in the same general vicinity in successive years. None of the dens visited in 1981 was reused by radio-collared bears in 1982, although one bear (144) denned close enough to its previous den (0.25 miles) to be within the range of radio-tracking and plotting errors (Table 2). Den site locations prior to 1980/81 are available for only a few individuals (Modafferi, pers. commun.). Female 101 apparently used the same den in 1977/78 when she entered the den with a single cub as she did in 1980/81 when she entered with 3 cubs; she probably used the same den in 1979/80 but denned elsewhere in 1980/81, and apparently, in 1976/77. No den location was recorded for this bear in 1978/79. Two bears with radio-tracking histories (106 and 143) used different dens, 1-6 miles distant, in earlier years when den sites were approximately located (1977/78 and 1979/80 for 106 and 1977/78 for 143). The mean distance between dens for 10 individuals in 1980/81 and 1981/82 was 0.9 miles (0.25-1.88) (Table 2).

The time bears spent in 1980/81 dens could not be determined as the last flight in 1980 was on 29 September at which time all bears were still out. Emergence from dens seemed concentrated in the first 2 weeks of May for females and the last two weeks of April for the 2 males (Table 3).

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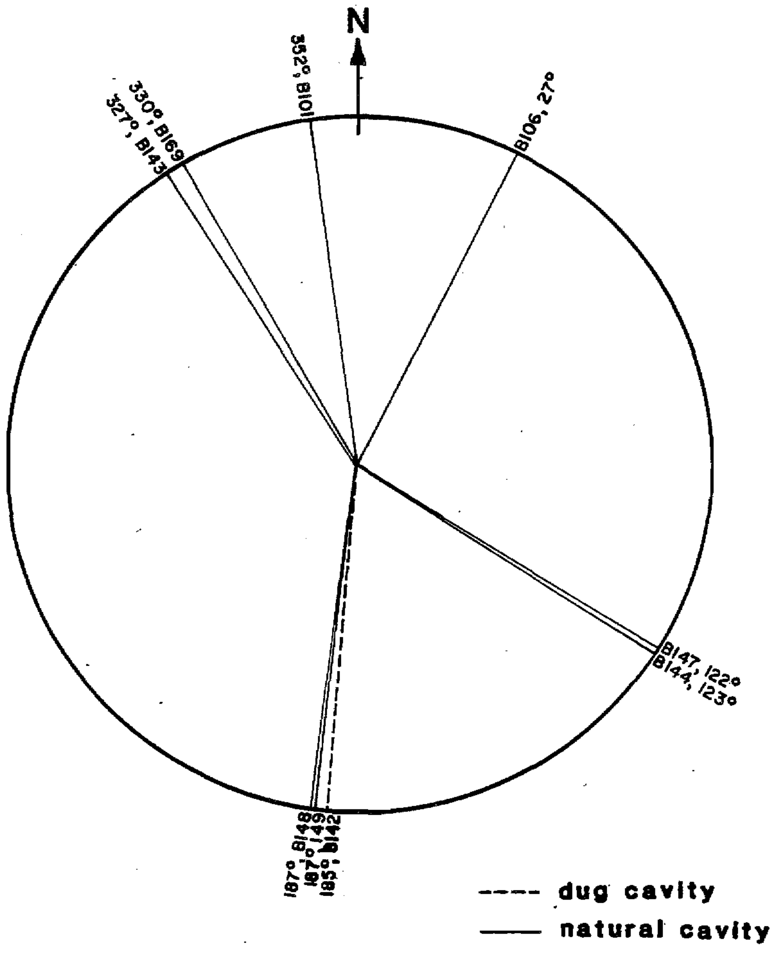

Figure 1. Aspect of 1980/81 black bear dens in Prince William Sound, Alaska.

Table 1. Characteristics of Black Bear Dens in Prince William Sound, 1980-81.

Den No.	Bear No.	Age @ exit	Elevation ft.	Slope (degree)	Aspect (True N)	Vegetation	% canopy tree cover	Entrance Ht. (cm)	Entrance Width (cm)	Chamber Ln. (cm)	Chamber Width (cm)	Chamber Ht. (cm)	Total length (cm)	Prev. Used?	"Quality" **	Location & type
NATURAL CAVITIES																
Female w/offspring (at exit) w/3 yearlings																
1	101	9	375	10	352	Alpine tundra	0	38	47	216	160	96	800	Yes*	3	Blackstone Bay Rock talus
Females w/o offspring																
2	106	19	450	14	27	Hemlock	30	65	55	71	80	90	94	No?	4	Blackstone Bay Hollow tree
3	143	7	500	45	327	Hemlock	60	46	26	88	71	74	198	No?	2	Cochrane Bay Hollow tree
5	144	7	600	40	123	Hemlock	30	37	48	67	62	-	89	-?-	4	Cochrane Bay Hollow tree
6	169	14	300	26	330	Hemlock	20	55	104	175	126	67	308	Yes	3	Cochrane Bay Rock cave
7	148	3	400	50	187	Alder/Salmon-berry	0	34	71	73	134	65	122	-?-	3	Culrose Passage Rock cave
8	147	17	900	55	122	Hemlock	80	178	42	128	114	118	980	Yes	3	Culrose Passage Rock talus
10	149	11	1250	60	187	Alpine tundra	0	43	59	86	86	53	268	Yes?	3	Cochrane Bay Rock cave
Males																
11	165	7	250 approx	-	-	Spruce	slight	-	-	-	-	-	-	-	-	Cochrane Bay (den not marked as bear out by 23 April)
12	146	9	350 approx	-	-	Alder(?)	0	-	-	-	-	-	-	-	-	Kings Bay (den not marked as bear out by 23 April)
DUG CAVITIES																
Females w/o offspring																
9	142	12	1300	52	185	Alder	0	36	52	70	129	92	80	No	3	Cochrane Bay

* Same bear used the den in 77/78 (w/1 ylg.), and probably in 79/80; not in same den in 76/77, unknown den location in 78/79.
** Subjective characteristics of quality, 1=poor and 5=excellent.

Table 2. Characteristics of black bear dens in Prince William Sound, 1981/82. (Based on locations from fixed wing aircraft on 4 Jan. 1982).

BEAR ID		Distance from 80/81 den (Table 1) (Miles)	Approximate Elevation (ft.)	Aspect	Slope	Habitat
101		0.81	450	NW	Steep	Hemlock-alder-rock
106		0.94	10	Flat	Flat	Alder-hemlock
143		0.53	80	NW	Moderate	Hemlock
144		0.25	750	SE	Steep	Hemlock-alder
169		1.88	400	NW	Steep	Hemlock-alder-rock
148		0.44	400	SW	Moderate	Hemlock-alder
147		1.19	650	S	Moderate	Hemlock
142		1.75	500	SE	Steep	Hemlock-alder
149		0.81	850	N	Steep	Hemlock
146		0.60	300	SE	Moderate	Hemlock
165		Not located in 1982.				
	Mean	0.92	439			
	S.D.	0.54	269			
	Range	0.25-1.88	10-850			

Table 3. Den entrance and emergence dates of radio-collared Black Bears in Prince William Sound, winter of 1980/81.

Bear ID	Sex	Age @ exit	1980 Entrance *	1981 Emergence *
101	F	9	29 Sept.- ?	29 April - 14 May
106	F	19	29 Sept.- ?	29 April - 14 May
143	F	7	29 Sept.- ?	27 April - 29 April
144	F	7	29 Sept.- ?	29 April - 14 May
169	F	14	29 Sept.- ?	14 May - 22 May
148	F	3	29 Sept.- ?	29 April - 14 May
147	F	17	29 Sept.- ?	29 April - 14 May
149	F	11	29 Sept.- ?	29 April - 14 May
142	F	12	29 Sept.- ?	23 April - ?
165	M	7	29 Sept.- ?	15 April - 23 April
146	M	9	29 Sept.- ?	15 April - 23 April

* Last flight in fall was on 29 September when all bears were out of dens.

** Range represents last observation in den & first observation outside den.

XIII. APPENDIX 6

Preliminary results testing technique to chemically differentiate between scats of black and brown bear.

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A technique for identification of field collected carnivore scats by recovery of bile acids through thin-layer chromatography (TLC) has recently been developed (Major et al. 1980). This method was applied to known samples of brown bear and black bear feces, two types of scats which cannot be distinguished visually. Samples from two brown bears and three black bears were used in the preliminary experiment. Samples were prepared for TLC according to Major et al. (1980) and the plates were examined under long-wave (366 nm) and short-wave (254 nm) ultraviolet light as well as visually under white light. Because of the lack of bile acid standards, along with other limitations due to the preliminary testing aspect of the experiment, results obtained were necessarily tentative. Nevertheless, results indicate possible differences between the two scat types. Further experimentation to fully delineate the nature of bile acid differentiation between brown and black bear fecal samples is recommended.

Three compounds with Rf values (ratio of the distance the solute moved to the distance traveled by the solvent front) comparable to Rf values of known bile acids (Major et al. 1980) were found on the test TLC plates. These were lithocholic acid (Rf = 0.75), chenodeoxycholic acid (Rf = 0.47) and cholic acid (Rf = 0.15). Two other unidentified compounds located on the bear scat test plates had Rf's comparable to unidentified compounds listed by Major et al. (1980): Rf = 0.87 (brown and black bear) and Rf = 0.72 (brown bear). In addition, all samples tested showed a compound with an Rf value of 0.06, and both brown bear samples showed a compound with an Rf of 0.97.

Of the components corresponding in Rf value to those of known bile acids, the black bear samples showed lithocholic acid; brown bear samples showed chenodeoxycholic acid, and both types showed cholic acid. Further testing is needed to determine what, if any, variation exists within species, and also to determine if the above indications are independent of diet. Tentative results indicate that the presence of chenodeoxycholic acid in brown bears and the presence of lithocholic acid in black bears may be a key to identification.

Brown bear samples showed a component (Rf = 0.97) which did not appear in the black bear samples. While Major et al. (1980) stated that compounds traveling above lithocholic acid (Rf = 0.75) were probably not bile acids, this component may still provide an identification key if found to be constant within the species and absent within black bears.

The differences between the two scat types are presented in Table 1. The most striking aspects between brown and black bear samples tentatively appear to be the presence of chenodeoxycholic acid (Rf = 0.47) and two unidentified compounds (Rf = 0.72 and 0.97, respectively) in brown bears with a corresponding absence in black bear; and the presence of lithocholic acid (Rf = 0.75) in black bears with a corresponding absence in brown bear scats.

Summary of TLC results on bile-acid and unidentified steroid recovery, brown and black bear fecal samples.

	Rf	Brown Bear	Black Bear
Unidentified	0.06	X	X
Cholic Acid	0.15	X	X
Chenodeoxycholic Acid	0.47	X	
Unidentified	0.72	X	
Lithocholic Acid	0.75		X
Unidentfied	0.87	X	X
Unidentified	0.90	X	X
Unidentified	0.97	X	

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