C:\bear\proposals\bearpro8 (Peer-reviewed final draft)[1]

NRPP- USGS Final Research Study Plan (vers. 1/15/01)[1]

LANDSCAPE ANALYSIS OF BLACK BEAR DISTRIBUTION PATTERNS IN OLYMPIC NATIONAL PARK

Prepared By: Kurt Jenkins, USGS, Forest and Rangeland Ecosystem Science Center, Olympic Field Station, 600 E. Park Ave., Port Angeles, WA 98362 (503-565-3041).

OVERVIEW

The Department of Interior proposes to dismantle two dams that have blocked the annual return of anadromous fish to Olympic National Park (NP)'s Elwha Valley for approximately 90 years. Removal of the dams, proposed to begin as early as 2004, will present an unprecedented 'quasi-experimental' opportunity to study influences of restoring anadromous fish to one of Olympic NP's premier riverine ecosystems.

This study will describe broad-scale patterns in seasonal distribution and movements of black bears in Olympic NP prior to dam removal, and will assess methods of monitoring influences of salmon restoration on the park's black bear populations. The study will provide a baseline of information from which to interpret ecological effects of salmon restoration on distribution and abundance of black bears, while also providing key information for managing seasonal conflicts between black bears and human activities in the Elwha watershed and developing an effective monitoring strategy. We will accomplish these objectives by examining distribution and movements of at least 12 radio-instrumented black bears relative to elevation, landscape composition, and phenology during two spring-summer-fall periods. It is beyond the scope of the current funding to completely develop and evaluate monitoring methods for black bears. This study will, however, determine seasonal patterns by which bears use subalpine habitats where Olympic NP plans to monitor productivity of black bears, and of low-elevation riverine habitats, where we will examine the use of remote camera systems to monitor bear use of riparian areas before and after salmon recovery.

My intention is to develop a fully collaborative research project integrating the efforts of USGS, Olympic National Park, and the Wildlife Conservation Society (WCS) to advance understanding of landscape patterns of bear distribution, environmental relationships, and population monitoring tools. USGS will oversee administration of the collaborative research effort and assist with all phases of study design, beginning with preparation of this study plan. Olympic National Park staff will work closely with USGS and WCS in developing study design and facilitating capture, research, and survey operations. The WCS will also have a key role in developing the project within the context of this study plan, in cooperation with USGS and NPS. The WCS is a world leader in carnivore research and currently conducts integrated studies of

[1] Version 8 has been modified to reflect budget changes resulting from meeting of cooperators on 7/2/02.

black bear ecology and management issues in both Yosemite and Grand Tetons National Parks, as well as throughout North America. They are uniquely positioned to work collaboratively with USGS and NPS toward developing a better understanding of long term interactions of bears, humans, and their changing ecosystems at the local, national, and international scales.

This study plan outlines study objectives, general research approaches, and suggested analytical methods. We intend to develop components of the project as a M.S. graduate research project at the University of Idaho. Consequently, the graduate student will provide additional detail in a graduate student study plan. As this study develops, all cooperators will explore opportunities to expand its scope to permit the accomplishment of longer-term research goals associated with research and monitoring the effects of salmon restoration. This study will provide the important baseline understanding of distributional ecology of bears prior to dam removal.

INTRODUCTION

Problem Statement/Justification

For approximately 90 years two dams have blocked the annual return of anadromous fish to over 70 miles of the Elwha River in Washington's Olympic NP. Historically, the Elwha River supported runs of chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), pink, (*O. gorbuscha*), and chum salmon (*O. keta*), and steelhead (*O. mykiss*). The construction of the first of two dams from 1910 to 1913, about five miles the river's mouth, restricted salmon and steelhead to a small fraction of their historic range and excluded them completely from Olympic NP. The second dam, built between 1925-27, 8.5 miles upriver from the first dam, presented yet another impassable obstacle to anadromous fish.

The Department of Interior now proposes to remove both dams to fully restore the Elwha River ecosystem and native anadromous fisheries as authorized by the Elwha River Ecosystem and Fisheries Restoration Act of 1992. Removal of these dams, which could begin as early as 2004, presents an unprecedented opportunity to study influences of restoring anadromous fish to one of Olympic NP's premier riverine ecosystems. Salmon and steelhead runs are estimated to increase by almost 400,000 adult fish following full restoration (NPS 1996). The park has begun establishing baseline values of marine-derived nutrients that are returned to Olympic NP's rivers each year by anadromous fish, to provide the basis for monitoring ecosystem-level influences of salmon restoration on aquatic food webs and nutrient pathways (Winter et al. 2000). Influences of this major modification of nutrient flow and foods to terrestrial carnivores is very poorly understood but has implications for park management of black bear/human interactions and development of bear monitoring protocols.

The purpose of the proposed project is to describe broad-scale patterns in seasonal distribution and movements of black bears in Olympic NP prior to dam removal, and assess methods of monitoring the influence of salmon restoration on the park's black bear populations. From the long-term perspective, the study will provide baseline information by which to assess long-term effects of salmon restoration on park bear populations and distribution. In the shorter term, the study will provide important information for managing seasonal conflicts between black bears and humans using the Elwha Valley and developing an effective monitoring strategy for bears.

The short-term need for information is driven by escalating bear-human conflicts throughout the park, notably in the Elwha Valley. During the last few years, managers at Olympic NP have relocated one bear, destroyed another, and have temporarily closed popular backcountry destinations to overnight use, all in an aggressive campaign to minimize positive conditioning of bears to human food sources. Olympic NP managers have closed a seven-mile stretch of the Elwha Valley, a popular summer hiking destination, to all human use during early summer for the past three consecutive years. It is not know whether increased bear/human conflict is due to an increase in the bear population, variations in natural food supply, increase in habituation and food conditioning or a combination of factors. To help answer these questions, Olympic National Park wishes to develop a program to monitor trends in natural foods, productivity and abundance of bears and seasonal periods of bear/human conflicts in the Elwha Valley. Due to enormous difficulties and costs associated with monitoring bears in this large, inaccessible wilderness, park biologists have considered monitoring the relative abundance and productivity of bears visible on berry-producing subalpine meadows during late summer, or by surveying bears that appear to concentrate in low elevations during late spring-early summer. Park managers have no information to answer the following questions: What proportions of bears use these areas of concentration? How variable are distribution patterns among years? When do bears concentrate in these areas? Further, there are valid concerns that any long-term monitoring of seasonal concentrations of bears could be affected by ecosystem-level changes in nutrient availability caused by salmon restoration activities. Answers to these questions are needed to identify optimum sampling schedules and sampling frames and to evaluate potential influences of salmon restoration on long-term distribution and sampling design.

Previous studies provide an incomplete and tenuous interpretation of what benefits salmon restoration might confer to black bears in Olympic National Park, or how the addition of salmon might influence populations or seasonal distributions of bears, bear/human conflicts in the park, or bear monitoring programs. Contrary to some expectations, salmon have not been reported common in the diets of black bears in Oregon or Washington (Poelker and Hartwell 1973, Cederholm et al. 2001), perhaps reflecting declining populations of salmon, or perhaps seasonal timing of spawning that overlaps considerably with the seasonal denning period of bears. It is also plausible that because fish are highly digestible, they are under-reported when using scat analysis as a basis of determining diet. By contrast, salmon was present in 10% of bear fecal samples collected near spawning sites in coastal California (Kellyhouse, 1975), and movements and distribution of black bears were linked closely to salmon migrations in a southeast Alaskan stream (D. Chi. personal communication reviewed in Cederholm et al. (2001). Further, hand-planted carcasses of salmon were consumed frequently by black bears in selected areas of Olympic NP when carcasses were made available prior to den entry (Cederholm et al. 1989). In a recent thorough review of salmon-wildlife relationships in Oregon and Washington, Cederholm and co-authors (2001) concluded that ‘salmon populations do not represent a predictable food supply to bears in Washington and Oregon….’, but that ‘…if salmon were to be found in substantial and predictable numbers, bears in Oregon and Washington….would also establish traditional use patterns around salmon".

The proposed project is designed to set the stage for long-term 'quasi-experimental' studies of the influences of salmon restoration in Olympic NP on bear population biology and distribution. In the short term, project objectives will be useful for developing a long-term monitoring strategy for bears, predicting seasonal overlap in bear/human use patterns, and developing management prescriptions to reduce bear/human conflicts in Olympic NP.

Study Objectives and Hypotheses

The goal of this study is to describe landscape-scale patterns of black-bear distribution in Olympic NP and evaluate population-monitoring strategies. Because Olympic NP presents such strong challenges in obtaining suitable and representative sample of radio locations of black bears using conventional VHF radio collars, we will use GPS-equipped radio-collars to answer large-scale questions of bear distribution. Therefore, objectives of this study focus on large-scale questions suitable for study using remotely sensed data.

Specific Objectives are to:

- Examine seasonal and spatial variation in home ranges of black bears in Olympic NP.
- Examine seasonal patterns of elevation distribution by black bears.
- Examine seasonal patterns of landscape use.
- Examine correlation's between size and composition of seasonal bear home ranges.
- Examine correlation's between elevational distribution and seasonal phenology.
- Assess observational bias using GPS-radio-telemetry.
- Examine the feasibility of monitoring bear use of low-elevation riparian forests using camera surveys

This research is descriptive rather than experimental. Therefore, the following descriptive hypotheses have been formulated as a tool to guide the analysis and summarization of data:

- Seasonal home ranges of bears are related to composition and productivity of ranges.
- Bears select landscapes and habitats in disproportion to their availability.
- Timing of use of high elevation habitats is related to phenology of berry production.

Research Background

Olympic NP is generally considered to have a large population of black bears, seemingly abundant throughout the park and seen frequently in the backcountry. Yet we know very little about bears within the park. No studies of sex ratios, age-class distribution, movements, density or population estimates and trends have been conducted in Olympic NP. The only research on black bears conducted in the park was a cooperative effort initiated in 1996 between Washington Department of Fish and Wildlife (WDFW) and Olympic NP. In that study, the park was one of three study areas in a statewide effort to understand black bear ecology. Ten bears were radioequipped in Olympic NP and their movements monitored via aerial telemetry on a monthly basis. The park was not one of the primary study areas, so limited information was obtained about park bears. Mean home range size of females (7.8 km^2) was less that that for males (121 km^2) (Koehler 1998), and males ranged widely and unpredictably within the park, occasionally leaving the park. Sampling was not sufficient to delineate or describe seasonal distribution and movement patterns. ‘Park’ bears were older than those captured in study areas outside the park.

We have found that all other wildlife populations that we have studied (e.g. elk, spotted owls) function very differently (social structure, population dynamics and trends) in the park than in managed lands adjacent to the park. Therefore, we assume bear populations inside the park likely function very differently than harvested bear populations in managed landscapes outside the park.

METHODS

Field Methods

Animal Capture: Our objective is to capture and place GPS radio-collars on a minimum of 12 bears (total funding for radio-collars presently) in the Elwha Valley, including 6 females and 6 males. We will begin capture operations in low elevations during May-June during 2002 and 2003, and continue capturing bears at higher elevations during mid to late summer (as needed) to meet these capture goals. After deploying all the GPS collars, we will continue to capture as many additional bears as we are able during May and June fitting each with either a conventional VHF radio-collar or visual collar markers. Each collar, both GPS and conventional, will be coded with unique color combinations and a numeric code repeated along the collar for easy visual identification. We will also mark bears with a numbered color-coded ear tag in each ear.

We will use a combination of capture methods that will be elaborated in detail in an approved Bear Capture Plan, prepared by Olympic NP staff. During May-June we will capture bears at low-elevations in Aldrich foot snares (Johnson and Pelton 1980) and by darting free ranging bears from the ground. We will bait trapsites using salmon obtained from a local fish hatchery. Staff at Olympic NP has previously darted three black bears from the ground in the Elwha Valley during June 1999. During summer we will capture free-ranging bears at high elevations primarily by darting them from the ground. If we have not met our annual capture objectives by late summer, we will dart the remaining bears from a helicopter during late-September. We will anesthetize bears using Telezol™ (teletamine HCl and zolazepam HCl) administered using a Daninject C0-2 remote delivery system (recommended dosage from Kreeger 1997). We will determine gender, weigh, and record morphological measurements and ear-tag each bear. Lastly, we will extract a first upper premolar for age estimation from cementum annuli, and obtain blood, hair and tissue samples for isotopic analysis of dietary sources of nitrogen and carbon. The analysis of stable isotope ratios has been used to determine proportions of terrestrial animal, salmon, and plant material in the diets of bears (Hilderbrand et al. 1996, Hilderbrand et al. 1999, Jacoby et al. 1999). Dietary baselines derived from this study will permit future monitoring and comparisons over time after salmon are restored to the Elwha. Tissue and hair samples will be archived for any future DNA work.

Radio-telemetry: We will fit each immobilized bear with a 950-g Telemetry Solutions GPS-Simplex 1D radio-collar. These collars are programmed to transmit data from remote locations (i.e., on the animal) at scheduled intervals and to drop off at the end of the study. Data will be retrieved at approximately 2 month intervals. We will program radio-collars to attempt to obtain a location fix 5 times daily during spring-summer-fall and once daily during the denning period (1 Dec-31 March).

Although the performance of this particular telemetry transmitter has not been evaluated in Pacific Northwestern forests, similar units used on grizzly bears in Yellowstone National Park generally obtained locations with 70-80% success (C. Schwartz, USGS, Personal Communication). Success rate was as low as 50% in the case of one male bear inhabiting rugged terrain (C. Schwartz, USGS, Personal Communication). Previous studies using different models and configurations of GPS-collars reported that GPS-telemetry collars were successful in acquiring locations about 60% of the time in boreal conifer forests (Moen 1996, Dussault et al. 1999). We expect lower success rates in old-growth conifer forests of Olympic NP. However, biologists in Olympic NP report average success rates of about 50% using telemetry collars on Roosevelt elk in old-growth coniferous forest lowlands of Olympic NP (P. Happe, Olympic NP, Personal Communication). Success rates and potential biases of collars used in this study will be evaluated.

Accuracy and success rates of GPS-telemetry collars: We will examine potential biases and performance of radio-collar packages by placing unused radio-collars at random locations near trail systems in Olympic NP. At each location we will place a radio-collar and Trimble-GPS-Unit configured to mimic the Telemetry Solutions radio-collar for approximately 24 hours. At each site, field crews will measure and record the following independent variables: percent slope, azimuth of slope, elevation, overstory canopy cover, basal area of trees, average height of dominant trees. Over two summers, we anticipate examining the percent location success and accuracy of radio-collars at >100 independent locations and up to 500 fixes (e.g., 5 fixes per day per site), representing the full array of slope, elevation, vegetation conditions used by radio-collared bears, and all times of day.

Seasonal Phenology: We will monitor seasonal phenology of blueberries (*Vaccinium membranaceum* and *V. deliciosum*) within 3 1-km^2 index sites at high elevations in the Elwha Valley. It will be necessary to select these index sites on the basis of accessibility (i.e., hiking access) and availability of berry fields; hence it will not be possible to make inferences on berry production beyond the boundaries of these index sites. Within each index site, we will establish a minimum of 6 5x5-m plots, selected at random from berry patches found within the reference site. We will use pilot data collected during summer 2001 to determine if 6 plots is sufficient to describe mean abundance and phenology scores. Each plot will be 5x5 meters. Within each plot we will establish 3 transects and monitor berry abundance, cover, plant height, and phenological stage of development within 15 0.25-m2 sampling quadrats monthly from June-October (if snow conditions permit) We will monitor abundance by counting ripe and ripening berries in each quadrat. We will assess phenological stage of seasonal development by rating phenological stages as follows (West and Wein 1971, Amstrup and Beecham 1976, Beecham and Rohlman 1994):

Stage1: Winter dormancy
Stage 2: Bud swelling/leafing out
Stage 3: Twigs elongating
Stage 4: Floral buds developing
Stage 5: Flowers growing
Stage 6: Fruit swelling
Stage 7: Fruit turning color
Stage 8: Fruit ripe
Stage 9: Fruit dry or dropping
Stage 10: Plant cured/fall

We understand that the above sampling regimen includes no replication for inferring berry characteristics at the watershed level or describing spatial variation in berry phenology. But the plan is suitable for determining temporal signatures of berry phenology for comparison among seasons and years.

Feasibility of Camera Surveys: It is ultimately the objective of the National Park Service to use information generated from this study to design a program to monitor the influences of fish restoration on the relative distribution and abundance of bears. Therefore a secondary objective of this study is to examine the feasibility of using camera surveys to monitor bear use of low-elevation riparian forests. The study will be designed as a pilot study conducted during the third (last) year of this study. Our focus on the last year of this study will allow us to photograph bears independent of bear trapping efforts that will be conducted during the first two years of study in the same area. Preliminary data collected during the last year of the study and initial assessments of methods will used as a foundation for proposals to continue the development of quantitative monitoring methods.

Camera-based mark-resighting surveys have been used to estimate densities of bears successfully in many areas throughout North America (Mace et al. 1994, Beausoleil 1999, Mortorello et al. 2001). Initial reviews of this proposal, however, pointed out many potential problems of mark/resighting surveys to estimate abundance of bears, including (1) inadequate number of marked bears (2) potential loss of ear tags of bears (3) and lack of population closure due to the unbounded landscapes in Olympic NP and highly individualistic movements of bears. We understand that success of any mark-resighting survey depends upon the density of bears, proportions marked, and resighting probabilities, as well as adherence to methodological assumptions (Skalski and Robson 1993). Therefore, our objectives are to determine approximate capture probabilities associated with camera surveys and adherence to assumptions.

We will have approximately 40 Trailmaster cameras available for the pilot study. Following recommendations of Karanth we will establish camera-sampling stations at the rate of approximately 2 stations per estimated average home range size of females, or approximately 2 cameras per 8-km2. Camera stations will be distributed systematically throughout areas below 2000 feet in elevation (i.e., low-elevation riverine corridors). At each sampling station we will hang salmon bait from a tree in such a manner that bears will not be able to consume the bait, thereby reducing its attraction to other bears. We will establish two cameras at each sample site and program them to shoot a picture every 10 seconds the animal is within view of the camera. We will establish each camera station during May, July and September and maintain each camera for approximately 21 days during each month.

Data Analysis

*GPS-collar Performance:--*We will analyze 4 measures of GPS collar performance: location accuracy, horizontal dilution of position (HDOP), time required to record a successful location (TRRL), and location success, following the lead of Moen et al. (1996). Horizontal dilution of position (HDOP) refers to the optimality of satellite configuration used to derive GPS locations, with lower HDOP indicating better satellite geometry. Time required to record a successful location could prove useful to minimize search times and conserve battery power in the GPS collar. Location success refers to the probability that a location was successfully obtained.

We will determine location accuracy of GPS collars by comparing estimated locations, derived from 150-second communications between satellites and GPS collars, with essentially known locations, derived by averaging differentially-corrected locations obtained from Trimble Geo-explorer-II units. We will test whether GPS-collar locations had a uniform circular distribution around the averaged differentially corrected location using Rayleigh's z statistic (Zar 1984:442). We will use stepwise multiple regression to examine relationships of location accuracy to HDOP and independent environmental variables measured in the field. We will also examine relationships of HDOP and TRRL to independent environmental variables using stepwise multiple regression models.

We will use stepwise logistic regression procedures to model location success (dichotomous variable: (success versus no success) as a function of independent environmental characteristics measured in the field. Significant independent variables will be used to develop a model to predict the probability of successfully obtaining a location (analogous to Samuel et al. 1987 developed for modeling probability of detecting animals from aerial surveys). The model will be used to compare probabilities of successfully obtaining radio-fixes under various forest classes.

Seasonal Home Ranges: We will determine annual and seasonal home ranges of radio-collared bears using two analytical methods: a fixed-kernel home range estimator (Seaman and Powell 1996, Powell et al. 1997, Seaman et al. 1998), and the minimum convex polygon (Garshelis and Pelton 1981). We will examine visually for spatial demarcations of data that delineate biologically meaningful seasons for home range analysis. Barring compelling evidence to do otherwise, we will determine home ranges during spring (den emergence-May 31), breeding (June-July), mid-summer (August) and fall (September-denning) seasons.

We are concerned about the potential influences of variable location success rates on home range analyses. If, for example, locations were twice as likely to be successfully obtained in open subalpine environments than in more closed forests, kernel distributions and inferences of bear activity would be biased toward more open environments. We plan to compute minimum convex polygon (MCP) home ranges primarily because they contain no information about use patterns of bears within home ranges. Consequently, we expect MCP estimates to contain less spatial bias compared to the methods described below based on utilization distributions, provided sample sizes are sufficient to represent spatial use patterns. We expect that numbers of telemetry fixes obtained from GPS collars will be sufficient to estimate MCP home ranges accurately.

We plan to also investigate using the logistic regression models, described above, to reduce biases in estimated bear distribution patterns within fixed-kernel home range estimates. Details of the analysis will be fleshed out with a graduate student research committee, but we anticipate computing for each GPS telemetry location, the probability of its detection (i.e., successful location) as:

$$y = \frac{\exp(u)}{1+\exp(u)}$$

where y is the probability of detection and u is the sightability model derived from logistic regression (Samuel et al. 1987). We will investigate using y as the basis to depopulate a pool of location data as a function of success rate, thereby minimizing the preponderance of data locations in open habitats. We will investigate these concepts more thoroughly in the graduate student research plan.

We will compare the size of seasonal home ranges between seasons (and potentially between genders, depending on sample size) using a general randomized block design with individual collared animals as a blocking factor to control for individual variation across seasonal periods (Kirk 1982).

*Seasonal Patterns of Elevation Distribution:--*We will compute median, quartiles and ranges of elevations used by collared black bears during two-week intervals from den emergence to den entry throughout the study. We will use box-whisker plots to display the median and distributions of elevations used by collared bears of each gender (Waller and Mace 1997). Because we expect vegetation cover and telemetry location success to be confounded with elevation, we will investigate using detection probabilities to minimize bias in much the same manner as described previously for home range analyses.

*Seasonal Patterns of Landscape Use:--*We will investigate seasonal patterns of landscape use at several levels of geographic resolution, both to provide the most complete description of spatial use patterns useful for management and ecological interpretation, but also to accommodate potential interpretation problems associated with location bias of GPS telemetry. Analyses associated with gross scales should be less affected by potential GPS biases.

At a relatively gross scale of resolution, we will begin by summarizing numbers of locations of bears present within two primary physiographic zones of the park, summarized by two-week intervals from den emergence in the spring to den entry in the fall. The two physiographic zones, each of unique management significance to the park, are high-elevation subalpine vegetation and low-elevation riverine corridors. Examining bear use of high-elevation subalpine vegetation is useful because bears are most visible on subalpine meadows where reproductive productivity or relative abundance of bears potentially could be monitored. Examination of bear use of low-elevation riverine corridors is important because bear-human conflicts are most intense in such areas each spring. Knowledge of seasonal use of these areas is presently of interest to those managing human-use patterns, and such data will provide reference for comparisons after salmon populations are restored. We will define subalpine vegetation from Olympic NP's GIS vegetation map as any vegetation >4500 feet in elevation with open overstory (<30% overstory canopy closure). We will define low-elevation riverine corridors as alluvial floodplains and adjoining slopes within 75 vertical m of a third- or fourth-order river below 2000 feet in elevation (e.g., main-stems of major river systems). As described above for displaying seasonal patterns of elevational use, we will plot biweekly median, and quartile scores in the distribution of total numbers of telemetry fixes present in each physiographic zone. Total numbers of locations (standardized for equal numbers of days) should be an unbiased index of broad-scale spatial use patterns to the extent that location success within each physiographic zone does not vary seasonally.

We will also infer important landscape characteristics for black-bears in Olympic NP by examining patterns of landscape selection of individual bears at nested spatial scales, with each level of analysis providing greater spatial resolution to the identification of resource selection patterns (i.e., based on Johnson's [1980] orders of resource selection). At the broadest scale, we will determine factors influencing home range placement (second-order selection process of Johnson 1980) by comparing cover-type composition of landscapes within annual home ranges to that available in the collective area used by the radio-collared sample. We will define this collective area of available habitat as the MCP calculated from the aggregate of all collared bears (Design 2 of Thomas and Taylor 1990, Manly 1993). We will determine vegetation composition of both the available habitat and within annual home ranges of individual bears using the Geographic Information System at Olympic NP (using broad remotely sensed vegetation categories, to be determined). We will examine seasonal selection patterns at a somewhat smaller scale by comparing cover type composition within seasonal home range 'cores' to composition of landscapes available to individual bears annually. Here, we will consider the annual minimum convex polygon home range as habitat available to individual bears annually, and the 50% fixed-kernel home range estimate to define a seasonal core-use area (Design 3 of Thomas and Taylor 1990, Manly 1993). At the finest level of resolution, we will compare cover classes of vegetation at individual telemetry locations of bears to availability of habitat characteristics within seasonal MCP home ranges (Design 3 of Thomas and Taylor, Manly 1993). For each comparison of resource selection and availability we will compute standardized selection ratios described by Manly (1992:40). The graduate student, in consultation with her graduate research committee will determine the best acceptable method to determine statistically significant resource selection patterns for each level of analysis.

One reviewer of an earlier draft of this study plan suggested that we also examine fine-grained selection patterns by following individual bears to determine what foods are investigated and eaten by bears during their daily movements (4th order-selection of Johnson 1980). We strongly endorse close-range observations as a means of interpreting patterns observed from remotely sensed data. Although we are uncertain how frequently such close range observations will be possible with limited personnel on hand, we will collect close-range observations of foraging sites whenever such an opportunity presents itself throughout the study.

*Relationships Between Home Range Size and Composition:--*Within each seasonal period and gender, we will examine correlation's between sizes of both 95% fixed-kernel home ranges and 'cores' and vegetation composition and characteristics. We will use multiple linear regression to examine correlation's between sizes of home range and percent of area in key vegetation classes as well as fractal metrics of home range composition.

Relationships between Elevational use and Phenology:-- Information on seasonal correlation's between use of subalpine vegetation and phenology could prove useful for designing aerial survey methodology. We plan to examine correlation's between biweekly estimates of both mean elevations of bears and total numbers of locations of bears in subalpine vegetation and phenological indices. We will examine all correlations for statistical significance using Spearman rank correlation coefficients or Kendall's tau (Daniel 1978:300-306).

Feasibility of Camera Surveys: --Objectives of the feasibility study are to obtain preliminary information on sampling requirements and adherence to assumptions needed to design an appropriate monitoring strategy. For each of three camera sampling periods, we will compute total numbers of bear photographed (index of relative abundance), proportion of marked bears (index of capture probability), proportion of collared bears retaining ear tags (to evaluate tag losses), and proportion of time collared bears spend in the surveyed area (to evaluate closure assumption). We will explore relationships between total numbers of bears photographed and proportion of time collared bears spend in the surveyed area to examine the potential value of camera surveys to monitor bear use of the riparian corridor.

Data Management

The diversity of spatial and biological data will require the design of numerous databases. All databases will be developed in MS-Access in cooperation with Data Management Specialists at Olympic NP. Spatial data sets will be referenced through Olympic NP's Geographic Information System. All spatial and digital data sets will be archived at USGS Forest and Rangeland Ecosystem Science Center and Olympic NP. We will use a metadatabase template, modeled on the attributes of Metamaker, to reference information on all data sets generated in this study. The resulting metadata will be served through the National Biological Information Infrastructure. All science partners will have access to the completed data and metadata at the end of the project. Data remains property of the USGS and NPS cooperators.

C:\bear\proposals\bearpro8 (Peer-reviewed final draft)[1]

Research Cooperation and Collaboration

As described previously, our goal is to develop a broad, interactive, and collaborative research effort among USGS, Olympic National Park, and the WCS. Principal investigators and research cooperators will interact freely on developing the study plan, implementing the study, and publishing results. Kurt Jenkins, the USGS Principal Investigator will administer this research, develop this study plan, coordinate the roles of all other Principal Investigators and Cooperators, and advise on all aspects of the project.

The WCS will have primary responsibility conducting the research under terms of a cooperative agreement to be established with WCS. The project will be run as a graduate research project under the auspices of the WCS. The graduate student, working under the direction of the Principal Investigators (who will act as thesis advisors), will be responsible for developing a more detailed study plan, data collection, analysis, and report preparation. This work will serve as partial fulfillment of the requirements for a graduate degree.

Olympic National Park, working closely with WCS, will have the primary responsibilities of facilitating field operations under terms of an interagency agreement established at the park. Responsibilities will include developing bear capture protocols, coordinating bear capture operations of WCS with Olympic NP staff, and conducting aerial survey operations. Patti Happe, wildlife biologist at Olympic National Park will also cooperate in all aspects of study planning, implementation, and review.

Project Personnel

Dr. Kurt Jenkins. Research Wildlife Biologist, USGS, Forest and Rangeland Ecosystem Science Center, Olympic Field Station, 600 E. Park Avenue, Port Angeles, WA. Phone: 360-565-3041. Email: kurt_jenkins@usgs.gov

Dr. Patti Happe, Wildlife Biologist, Olympic National Park, 600 E. Park Avenue, Port Angeles, WA. Phone: 360-565-3065. Email: patti_happe@nps.gov.

Dr. John Beecham, Carnivore Research Ecologist, Wildlife Conservation Society, (208)853-1901, jbeecham@hwi.org.

Kim Sager, Graduate Research Assistant

Research Schedule

Year 1: Fiscal Year 2002 (October 2001-September 2002)

October-December 2001

- Research coordination
- Internal/external peer review study plan

January-April 2002

- Prepare cooperative and interagency agreements
- Graduate student selects graduate committee and prepares study plan

- Bear capture protocols/reviews/training

May-June 2002
- Capture bears
- Begin data acquisition as bears are radio-instrumented
- Monitor berry phenology and production

July-October 2002
- Capture bears as necessary
- Monitor berry phenology and production
- Remote data acquisition on telemetered bears
- Test accuracy and performance of GPS collars

Year 2: Fiscal Year 2003 (October 2002-September 2003)

October-December 2002
- Remote data acquisition on telemetered bears
- Graduate student course-work(?)
- Data analysis/reporting

January-April 2003
- Remote data acquisition on telemetered bears
- Graduate student course-work(?)
- Data analysis/reporting

May-June 2003
- Capture bears
- Begin data acquisition as bears are radio-instrumented
- Monitor berry phenology and production plots

July-October 2003
- Capture bears as necessary
- Monitor berry phenology and production
- Remote data acquisition on telemetered bears
- Test accuracy and performance of GPS collars

Year 3: Fiscal Year 2004 (October 2003-September 2004)

October-April 2004
- Remote data acquisition on telemetered bears
- Graduate course-work(?)
- Data analysis/reporting/thesis preparation

May-September
- Camera resighting study
- Data acquisition (including biweekly telemetry flights)
- Final Report

Project Deliverables

There will be several interim and final products from this study:

1. Annual progress reports, prepared by Graduate Assistant and reviewed by all Principal Investigators, will be distributed to NPS and USGS local and regional offices.

2. A student MS thesis and describing landscape-scale distribution of black bears in Olympic National Park.
3. A USGS/NPS Final report derived from student MS thesis. Report will include any management implications pertinent to Olympic National Park's bear management plan.
4. Peer-reviewed publications prepared by graduate research assistant and all principal investigators and cooperators. Potential papers include an assessment of GPS collar performance in Pacific Northwestern coniferous forests and Landscape-scale distribution of black bears in Olympic National Park.
5. Spatially explicit database of bear distribution patterns in MS-Access format with NBII compliant metadata. Records will be accompanied by GIS maps of seasonal bear distribution for educational and interpretive purposes.
6. All Access databases and NBII compliant metadata.

C:\bear\proposals\bearpro8 (Peer-reviewed final draft)[1]

Budget

	FY02	FY03	FY04
NRPP Project Funding Available	**82,000**	**70,000**	**58,000**
Olympic National Park			
Biological Technicians	29,000	19,000	16,000
Perdiem and Travel	2,000	2,000	2,000
Capture Equipment	2,000	1,000	1,000
Radio-collars	8,000		
Fixed-wing Aircraft	4,000	3,000	3,000
Subtotal	**45,000**	**25,000**	**22,000**
University of Idaho			
Graduate Student + Fringe	5,700	14,200	15,000
Indirect Costs (15%)	900	2,100	2,250
Graduate Fees	3,500	4,000	2,000
UI Travel		1,500	2,000
Subtotal	**10,100**	**21,800**	**21,250**
Wildlife Conservation Society			
Co-PI Salary (100 hrs @$27/hr)	2,700	2,700	2,700
Co-PI Travel (two trips @ $400+$120/day)	2,200	2,200	2,200
Veterinarian Salary (40hrs @27/hr)	1,100	1,100	1,100
Veterinarian Travel (1 trip @ $400+$120/day)	1,200	1,200	
Subtotal	**7,200**	**7,200**	**6,000**
USGS			
Radiocollars (@3500 per)	14,000	14,000	6,000
Spare batteries	700		
Telemetry Receiver and GPS Software	5,000		
Vehicle		2,000	2,000
Publication Costs			750
Subtotal	**19,700**	**16,000**	**8,750**
TOTALS	**82,000**	**70,000**	**58,000**
National Park Foundation Funds			
GPS Radio collars @3,2000	6,400		
In-Kind Contributions			
USGS			
K. Jenkins (0.1 FTE)	7,500	7,500	7,500
Olympic National Park			

P. Happe (0.15 FTE)	9,500	9,500	9,500
Capture Equipment	5,000		
Cameras			9,000

Literature Cited:

Amstrup, S.C., and J.J. Beecham. 1976. Activity patterns of radio-collared black bears in Idaho. J. Wildl. Manage. 40:340-348.

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology. 74:1313-1325.

Beecham, J.J., and J. Rohlman. 1994. A Shadow in the forest: Idaho's black bear. Northwest Naturalist Books, Moscow, ID. 245 pp.

Beausoleil. 1999. Population and spatial ecology of the Louisiana black bear in a fragmented bottomland hardwood forest. M. S. Thesis. University of Tennessee, Knoxville.

Cederholm, C.J., D.B. Houston, D.L. Cole, and W.J. Scarlett. 1989. Fate of coho salmon (*Oncorhynchus kisutch*) carcasses in spawning streams. Can. J. Fish. Aquat. Sci. 46(8):1347-1355

Cederholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W.H. Graeber, E.L. Greda, M.D. Kunze, B.G. Marcot, J.F. Palmisano, R.W. Plotnikoff, W.G. Pearcy, C.A. Simenstad, and P.C. Trotter. 2001. Pacific Salmon and Wildlife- Ecological Contexts, Relationships, and Implications for Management. Special Edition Technical Report, Prepared for D.H. Johnson and T.A. O'Neil (Manage. Dirs.), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia.

Daniel. W. W. 1978, Applied nonparametric statistics. Houghton Mifflin Company. Boston. 503 pp.

Dussault, C., R. Courtois, J. P. Ouellet, and J. Huot. 1999. Evaluation of GPS telemetry collar performance for habitat studies in the boreal forest. Wildl. Soc. Bull. 27:965-972.

Eberhardt, L. L. 1990. Using radio-telemetry for mark-recapture studies with edge effects. J. Appl. Ecol. 27:259-271.

Garshelis, D. L. Mark-recapture density estimation for animals with large home ranges. Pages 1098-1111 in D. McCullough (ed.) Wildlife 2000:Populations.

Garshelis, D. L., and M. R. Pelton. 1981. Movements of black bear in the Great Smokey

Mountains National Park. J. Wildl. Manage. 45:912-925.

Hilderbrand G. V., S. D. Farley, C. T. Robbins, T. A. Hanley, K. Titus, and C. Servheen. 1996. Use of stable isotopes to determine diets of living and extinct bears. Can. J. Zool. 74:2080-2088.

Hilderbrand, G.V., T.A. Hanley, C.T. Robbins, and C.C. Schwartz. 1999. Role of brown bears (*Ursus arctos*) in the flow of marine nitrogen into a terrestrial ecosystem. Oecologia 121:546-550.

Hilderbrand, G.V., C.C. Schwartz, C.T. Robbins, M.E. Jacoby, T.A. Hanley, S.M. Arthur, and C. Servheen. 1999. The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. Can. J. Zool. 77:132-138.

Jacoby, M.E., G.V. Hilderbrand, C. Servheen, C.C. Schwartz, S.M. Arthur, T.A. Hanley, C.T. Robbins, and R. Michener. 1999. Trophic relations of brown and black bears in several western North American ecosystems. J. Wildl. Manage. 63:921-929.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Johnson, K. J., and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. Wildl. Soc. Bull. 8:46-54.

Karanth, K. U., and J. D. Nichols. In Prep. Camera trapping big cats: some questions that should be asked frequently. Unpublished.

Kellyhouse, D. G. 1975. Habitat utilization by black bears in northern California. International Conference on Bear Research and Management 4:221-227.

Kirk, R. E. 1982. Experimental Design. 2nd Edition. Brooks/Cole Publishing Company. 911 pp.

Koehler, G. 1998. Progress report: federal aid in wildlife restoration, black bear (*Ursus americanus*) research in Washington. Dec. 1998. Washington Department of Fish and Wildlife, Olympia, WA. Unpublished report. 12 pp.

Kreeger, T. J. 1997. Handbook of Wildlife Chemical Immobilization. International Wildlife Veterinary Services, Inc., Laramie, WY. 342 pp.

Mace, R. D. S. C. Minta, T. L. Manley, and K. E. Aune. 1994. Estimating grizzly bear population size using camera sightings. Wildlife Society Bulletin 22:74-83.

Manly, B., L. McDonald, and D. Thomas. 1993. Resource selection by animals: statistical design and analysis for field studies. Chapman and Hall, London. 177 pp.

Minta, S., and M. Mangel. 1989. A simple population estimate based on simulation for capture-recapture and capture-resight data. Ecology 70:1738-1751.

Moen, R., J. Pastor, Y. Cohen, and C. C. Schwartz. 1996. Effects of moose movement and habitat use on GPS collar performance. J. Wildl. Manage. 60:659-668.

Martorello, D. A., T. H. Eason, and M. R. Pelton. 2001. A sighting technique using cameras to estimate population size of black bears. Wildlife Society Bulletin 29:560-567.

NPS (National Park Service). 1996. *Elwha River Ecosystem Restoration Implementation, Final Environmental Impact Statement.* National Park Service, Olympic National Park, Port Angeles, Washington.

Poelker, R. J., and H. D. Hartwell. 1973. Black bear of Washington. Washington State Game Department. Biological Bulletin No. 14. Olympia, WA.

Powell, R.A., J.W. Zimmerman, and D.E. Seaman. 1997. Ecology and Behavior of North American Black Bears. Chapman and Hall, New York, NY. 203 pp.

Samson, C., and J. Huot. 1998. Movements of female black bears in relation to landscape vegetation type in southern Quebec. J. Wildl. Manage. 62:718-727.

Samuel, M.D., E.O. Garton, M.W. Schlegel, and R.G. Carson. 1987. Visibility bias during aerial surveys of elk in northcentral Idaho. J. Wildl. Manage. 51:622-630.

Seaman, D.E., and R.A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075-2085.

Seaman, D.E., B. Griffith, and R.A. Powell. 1998. KERNELHR: a program for estimating animal home ranges. Wildl. Soc. Bull. 26:95-100.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second edition. Griffin, London, U.K.

Thomas, D. L., and E. J. Taylor. 1990. Study designs and tests for comparing resource use and availability. J. Wildl. Manage. 54:322-330.

Waller J. S. and R. D. Mace. 1997. Grizzly bear habitat selection in the Swan Mountains, Montana. J. Wildl. Manage. 61:1032-1039.

West, N.E., and R.W. Wein. 1971. A plant phonological index. Bioscience 21:116-117.

Winter, B. D., R. Reisenbichler, and E. Schreiner. 2001. The importance of marine-derived nutrients for ecosystem health and productive fisheries. U.S. Department of Interior, National Park Service, Olympic National Park, Elwha Restoration Project Office. 32 pp.

Zar J. R. 1984. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ. 718pp.

C:\bear\proposals\bearpro8 (Peer-reviewed final draft)[1]