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Susitna–Watana Hydroelectric Project
(FERC No. 14241)

Distribution, Abundance, and Habitat Use by Large Carnivores
Study Plan Section 10.8

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Alaska Department of Fish & Game

Anchorage and Palmer, Alaska

and

ABR, Inc.—Environmental Research & Services

Fairbanks and Anchorage, Alaska

June 2014

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
AICc	Akaike's Information Criterion, corrected for small sample size
APA	Alaska Power Authority
ARRC	Alaska Railroad Corporation
CI	confidence interval
CIRWG	Cook Inlet Regional Working Group
CV	coefficient of variation
DSM	density surface model
FERC	Federal Energy Regulatory Commission
GAM	generalized additive model
GIS	geographic information system
GMU	Game Management Unit
H-T	Horvitz–Thompson
ILP	Integrated Licensing Process
ISR	Initial Study Report
MRMCDS	mark–recapture, multiple-covariate distance model
μ	Estimated mode of a detection function
PRM	Project river mile
Project	Susitna–Watana Hydroelectric Project
RSP	Revised Study Plan
SPD	Study Plan Determination

1. INTRODUCTION

On December 14, 2012, the Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP) for the Susitna-Watana Hydroelectric Project No. 14241 (Project), which included 58 individual study plans (AEA 2012a). RSP Section 10.8 described the study of Distribution, Abundance, and Habitat Use by Large Carnivores (Large Carnivore Study). The Large Carnivore Study is a two-year effort that combines desktop analyses of existing data on bears and wolves with new field sampling focused on bears downstream from the proposed Watana Dam. Existing data are from historical studies and recent and ongoing population-monitoring studies by the Alaska Department of Fish and Game (ADF&G). New field sampling for bears is being conducted in riparian areas along spawning streams used by anadromous fish downstream from the proposed dam. RSP Section 10.8 described the goal, objectives, and proposed methods for data collection regarding large carnivores, including brown bear (*Ursus arctos*), black bear (*U. americanus*), and wolf (*Canis lupus*).

On February 1, 2013, FERC staff issued its study plan determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. RSP Section 10.8 was one of the 31 studies approved with no modifications.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)) This Initial Study Report (ISR) on the Distribution, Abundance, and Habitat Use by Large Carnivores has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP (referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The goal of the study is to obtain sufficient information on three species of dominant predators and game animals in the region—brown bear, black bear, and wolf—to use in evaluating Project-related effects and identifying any appropriate protection, mitigation, or enhancement measures. Four primary objectives were established for this study in RSP Section 10.8.1:

1) Estimate the current populations of brown bears, black bears, and wolves in the study area, using existing data from ADF&G.
2) Evaluate bear use of streams supporting spawning by anadromous fishes in habitats downstream of the proposed dam that may be altered by the Project.
3) Describe the seasonal distribution of, and habitat use by, wolves in the study area using existing data from ADF&G.

4) Synthesize historical and current data on bear movements and seasonal habitat use in the study area, including the substantial body of data gathered by radio-tracking during the 1980s, as a continuation of the 2012 wildlife studies (AEA 2012b).

3. STUDY AREA

As established in RSP Section 10.8.3, the study area for spatial modeling of density and population estimation of bears encompasses a large region, including the proposed Project area (reservoir inundation zone, access and transmission corridors, and other Project features) as well as surrounding areas (Figure 3-1). The bear study area includes the entire area of Game Management Unit (GMU) Subunit 13E plus parts of adjacent Subunits 13A, 16A, and 16B, to provide a broad regional context for the analysis of bear densities.

Fieldwork conducted in 2013 under the Study Plan was limited to surveys of bear use of spawning streams used by anadromous fishes in the Middle Susitna River Segment (Middle River, from Project River Mile [PRM] 98 to 184) and its tributaries from the proposed Watana Dam site as far downstream as the confluence of the Susitna River and the Chulitna River (all of which are located within GMU Subunit 13E).

No field surveys were proposed in the Study Plan for wolves. Instead, the study involves office-based analysis of existing ADF&G data on wolves from GMU Subunits 13E and 13A, and from adjacent Subunits 14B, 16A, and 20A, as available.

4. METHODS AND VARIANCES IN 2013

The methods for each of the Distribution, Abundance, and Habitat use by Large Carnivores Study components are presented in this section.

4.1. Bears

4.1.1. Population Estimation

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.1.1.1).

A multi-faceted approach was used to address the need for current information on bears in the Project area. Reanalysis of 1980s data and synthesis with current data from other previous or ongoing ADF&G telemetry studies and other regional management studies provided data on bear populations, movements, and habitat use in the study area (AEA 2012b).

In 2000, 2001, and 2003, ADF&G researchers conducted a distance-sampling survey for brown and black bears in ADF&G's Talkeetna study area (Becker 2001, Becker and Quang 2009), as described in RSP Section 10.8.2.1. That 26,490-km² study area extended from the East Fork of the Yentna River (west of the Project area) to the northeastern portion of the Susitna River drainage and included most of the Project area, although the portion of the reservoir inundation zone located upstream from the mouth of Kosina Creek was not covered in those surveys. The surveys by ADF&G in 2000, 2001, and 2003 provided the source data for the spatial density modeling that was developed to estimate bear population sizes for this study.

Population estimates can be obtained from existing data collected by using complex distance models with a new gamma-like detection function (Becker, in prep.) that is consistent with point independence models (Borchers et al. 2006). By themselves, however, these estimates do not allow detailed inference about the number of bears in areas potentially affected by the Project. The addition of spatial line-transect modeling (Hedley and Buckland 2004) allowed computation of estimates that are both more accurate and more precise. The analytical objective was to obtain density estimates from specialized multiple-covariate, mark-resight distance models (Becker, in prep.) along small transect sections. Combining these model results created a mark–recapture, multiple-covariate distance model (MRMCDS) and the study team modeled these estimates with a detailed density surface model (DSM) (Miller et al. 2013). The DSM incorporated potential explanatory variables such as elevation, aspect, habitat, and east–west and north–south gradients to derive a spatially explicit density model, from which the study team obtained sub-estimates (e.g., parts of both bear survey areas that may be affected by the Project). The study team modified spatial models of Hedley and Buckland (2004) according to recommendations by Miller et al. (2013) to work correctly with the more complex distance models (Becker, in prep.) that were used to model the initial bear densities. The DSM must be robust because of the potential for nonlinearity between the spatial covariates and bear density (Miller et al. 2013) and must also be able to accommodate sparse data.

The analytical work required writing a Geographic Information System (GIS) program to subdivide the 1,238 35-km long transects from ADF&G's Talkeetna study area (Becker and Quang 2009) into 1-km long segments with a width of 450 meters (the width of the detection model) that retained all relevant geospatial information. The study team developed an *R*-based program to fit a spatial model (Miller et al. 2013) to the datasets for black bears and brown bears and then to run this code on the datasets to obtain the population estimates. The study team obtained covariate data from the LANDFIRE database (Wildland Fire Leadership Council 2013), including elevation, slope, aspect, and habitat. Using a GIS, the study team overlaid a 1-km^2 grid on ADF&G's Talkeetna study area to obtain population estimates. Spatial data from the transect database and the LANDFIRE database used the mode of the covariate to calculate the value of the covariate. The study team used restricted maximum likelihood scores to select the best generalized additive model (GAM) (Wood 2006), which was used to construct the DSM. The study team calculated GAM variance using methods detailed in Wood (2006). The study team calculated variance of the MRMCDS model following the methods described by Innes et al. (2002) and used a delta method (Ver Hoef 2012) to combine these variances to obtain the variance of the DSM. The study team constructed confidence intervals (CI) using a log-normal transformation (Borchers et al. 2006).

4.1.1.1. Variances

The Study Plan (RSP Section 10.8.2.1) proposed to use line-transect survey data collected by ADF&G previously in both the Talkeetna study area (Becker and Quang 2009) in 2000, 2001, and 20003, and in a 21,528-km^2 area spanning GMU Subunits 13A and 13B in 2003 and 2004. The study team excluded data from GMU Subunits 13A and 13B from the analysis, however, because of the magnitude of the computational effort required to produce the modeling results and population estimates, which proved to be much more time-intensive than anticipated. The study team concluded that the spatial model of black bears in ADF&G's Talkeetna study area effectively modeled black bears in the Susitna River drainage, so that more information was not required to make inferences about black bear population status in the study area. This change deleted four black bear groups, none of which occurred on hillsides next to the Susitna River. In 2003 and 2004, the study team flew 1,221 30-km transects in GMU Subunits 13 A and 13B and observed only 12 black bear groups, all of which were in GMU Subunit 13A. That result indicated that extending the black bear spatial model for ADF&G's Talkeetna study area into the section of GMU Subunit 13A near the reservoir impoundment zone (east of Kosina Creek and south of the Susitna River; see Figure 3-1) would still allow precise estimation of the number of black bears in that area of marginal habitat. Of the six observations of brown bear groups in the section of GMU Subunits 13A and 13B, all were located far from the Susitna River, the closest being 10 miles away. Because little additional information would be added by analysis of the information from GMU Subunits 13A and 13B, the study team concluded that its exclusion had no appreciable effect on the ability to meet the study objectives.

4.1.2. Downstream Surveys

AEA implemented the methods described in the Study Plan, with the exception of variances explained below (Section 4.1.2.1).

Fieldwork in 2013 focused on surveying bear use of spawning streams used by anadromous fish. The study team conducted a survey of bear use of fish-spawning areas in the Middle River and associated tributaries downstream from the proposed Watana Dam site to the confluence of the Susitna and Chulitna rivers to assess the use of those resources by bears in the Project area. The surveys were designed to obtain samples of bear hair for DNA analysis to quantify the minimum number of bears using the downstream area and for stable-isotope analysis to characterize the diet of bears in the sampled area. Hair-snag stations using modified, nonlethal, single-catch cable snares (Beier et al. 2005) were deployed in documented salmon-spawning areas in the Middle Susitna River. Snares were also deployed in several other locations where bears were regularly seen by local river users. At each site, hair-snags were placed opportunistically along recently used bear trails or other areas where bear sign was present. The placement of hair-snags was constrained by land access limitations (see Section 4.1.2.1 below) and the study team avoided areas of high human traffic by local residents, recreational users, and other researchers associated with the Project. A river boat was used for access to the hair-snag locations.

Following initial deployment of the hair-snags, each site was checked every 11 to 14 days, for a total of five snare check surveys. Researchers removed hair from the snares using tweezers and placed the hair samples in paper envelopes. After all visible hair was removed, the snare was reset and a small butane torch was used to burn any hair remnants from the snare. During the final check (September 24–25), each snare was removed from the field.

Bear-hair samples were provided to laboratories at the University of Alaska Fairbanks for analysis of DNA and stable isotopes. DNA and stable-isotope analyses of the hair samples will provide information on the sex and species of bear, a minimum estimate of the number of different individuals using the area sampled, and stable isotope signatures for diet characterization. The isotopic signature will be used to classify the proportions of the diet composed of salmon, terrestrial meat, and vegetation (Fortin et al. 2007).

The Study Plan includes an evaluation of berry resources in the reservoir inundation zone during the concurrent mapping efforts of the Vegetation and Wildlife Habitat Mapping Study in the Upper and Middle Susitna Basin (Study 11.5) and the Wetland Mapping Study in the Upper and Middle Susitna Basin Study (Study 11.7). Those mapping studies are ongoing and this study component will be addressed after completion of the mapping on which it depends.

4.1.2.1. Variances

Researchers were unable to access Cook Inlet Regional Working Group (CIRWG) and Alaska Railroad Corporation (ARRC) lands in 2013 because land-access agreements were not available at the time of the study. Hence, some documented salmon spawning sites on the Middle Susitna River were inaccessible, including all portions of the Middle River upstream of PRM 146.5 (see Section 5.1.2 below). If access can be obtained in the next year of study, then those sites will be added to the sampling area. Additionally, the study team avoided setting hair-snag snares on private property. Due to concerns about human safety, it was not feasible to set snares at sites experiencing high levels of human activity, however, so those sites will not be sampled in the next year of study. The study team will still be able to produce a minimum estimate of the number of bears using the spawning streams sampled over both years.

4.2. Wolf

AEA implemented the methods described in the Study Plan with no variances.

ADF&G's Division of Wildlife Conservation stated that ongoing ADF&G monitoring work would be sufficient to describe the distribution and habitat use of wolves (ADF&G memorandum to AEA; November 22, 2011), so no additional field surveys were deemed necessary for the Project. Hence, desktop analyses of existing ADF&G data are being used to meet the study objectives for wolves.

The study team reviewed and synthesized historical reports from the original Alaska Power Authority Susitna Hydroelectric Project (APA Project) study, where possible, with data from other recent and current monitoring by ADF&G of wolves in GMU Subunits 13A, 13B, 13E, 14B, 16A, and 20A, as a continuation of AEA's wildlife studies that were begun in 2012 (AEA 2012a). The study team will continue to obtain applicable data for the study area in the next year of study.

4.2.1. Variances

No variances from the methods described for wolves in the Study Plan were necessary in 2013.

5. RESULTS

Because animal location data collected during ADF&G population surveys are restricted under Alaska state statute (AS 16.05.815(d)), the location coordinates of the bears and wolves observed during the previous population surveys analyzed for this ISR (Sections 5.1.1 and 5.2 below) are not included in the ISR data posted on the Project website.

Data developed in support of the downstream bear survey component of this study are available for download in the following file at http://gis.suhydro.org/reports/isr:

- ISR_10_8_LCAR_Data_2013.accdb.

5.1. Bears

5.1.1. Population Estimation

In 2000, 2001, and 2003, ADF&G researchers surveyed 1,238 randomly placed transects, each approximately 35-km long, for a total length of 42,744 km of transects in their Talkeetna study area (Becker and Quang 2009). Areas above 5,000 feet in elevation were not considered to be spring habitat for either bear species, so were excluded from the survey. The data obtained on those surveys were used to develop spatial density models and population estimates for this study.

5.1.1.1. Black Bear

ADF&G researchers detected 373 black bear groups along the transects surveyed in 2000, 2001, and 2003, with the distances from transects to bear groups ranging from 8.4 to 711.8 m. The study team truncated the black bear distance data (Buckland et al. 2001) at 450 m. In addition, the study team excluded distances below 22 m, the minimum distance at which a bear can be seen from the survey airplane (Piper PA-18 "Super Cub") in level flight at 100 m above ground level (E. Becker, ADF&G, unpublished data). This exclusion removed 22 black bear groups from the analysis and left 351 black bear groups with which to build a multiple-covariate distance model (Marques and Buckland 2003) and a subsequent mark–recapture distance model that assumed point independence (Borchers et al. 2006). No black bears were observed above 4,600 feet in elevation, so the study team used that elevation contour to define the upper extent of spring habitat for black bears.

Based on Akaike's Information Criterion statistics adjusted for small sample size (AICc; Burnham and Anderson 2002), the best multiple-covariate distance-sampling model used a two-piece normal detection function (Becker and Christ, in prep.) that included the following covariates: distance (required), an indicator for distance greater than the mode (required to make the distribution gamma-like), the logarithm of search distance for detection distances greater than μ, and pilot search type. Search distance is the distance from the transect to the GPS location denoting the farthest location searched. The pilot search type variable divides the pilots into two groups, with one group searching farther out than the other group. The mode of the detection function ($exp(ln\mu)$) was estimated to be 129.9 m (SE = 1.007) (Table 5.1-1). Estimated detection probabilities that assumed perfect detection at 129.9 m ranged from 0.1510 to 0.9305, with a median of 0.5501.

Based on AICc statistics (Burnham and Anderson 2002), the best multiple-covariate mark–recapture model contained the following covariates: a cubic spline of distance, observer (pilot or backseat), percent snow, percent cover, pilot detection group (two groups), and observer by pilot detection group interaction (Table 5.1-2). The model results coupled with the point independence assumption (Borchers et al. 2006) estimates maximum detection (*MR-pdot*) at the mode of the two-piece normal detection function (129.9 m) to range from 0.4195 to 0.9957, and a median of 0.9493. The estimated probability that a bear group was observed in the survey (Horvitz-Thompson, or H-T, probability) is the product of these probabilities, ranging from 0.0976 to 0.9097, with a median of 0.4930 (Figure 5.1-1).

The study team used a DSM (Miller et al. 2013) utilizing GAMs (Wood 2006) that contain a bivariate smoothing function of *x*- and *y*-axis locations of the centroid of the polygon (Figure 5.1-2), a smoothing function of elevation (Figure 5.1-3), and an interaction smoothing function of slope and aspect (Figure 5.1-4) to predict the number of black bears in 1-km-long polygons searched next to the transects. The study team used the model to predict the number of black bears in 1-km^2 cells (Figure 5.1-5). Model fit diagnostics indicated a good fit. The deviance explained by the model was high (38.1 percent), indicating a good predictive model. The map (Figure 5.1-5) clearly depicts substantial differences in spring distribution of black bears. Much of the eastern part of ADF&G's Talkeetna study area is marginal black bear habitat, with very low densities along the Susitna River from just a few miles east of Devils Canyon up to the "Big Bend" of the Susitna River (just upstream of the Oshetna River mouth). The primary areas of concentration in spring were low-elevation, south-facing slopes west of the Chulitna River (west of the Project area) and the south-facing hills just north of Talkeetna. Using this DSM, the study team estimated that 1,262 black bears (SE = 169.0) inhabited the Project study area during 2000–2003 (95 percent CI: 971.9, 1,638.8; coefficient of variation [CV]=13.4 percent). Figure 5.1-6 depicts a CV map expressing the degree of uncertainty for the estimate of the number of bears in each 1-km^2 cell. Due to instability of the ratio of small numbers, the CV map excludes cells that predict 1/1000th of a bear or less per km^2.

5.1.1.2. Brown Bear

ADF&G researchers detected 153 brown bear groups along the surveyed transects during the spring surveys in 2000, 2001, and 2003, with the distance from transects to bear groups ranging from 35.1 to 1,281 m. The study team truncated the brown bear distance data (Buckland et al. 2001) at 540 m. In addition, the study team excluded distances below 22 m, the minimum distance at which a bear can be seen from the survey airplane (Piper PA-18 "Super Cub") in level flight at 100 m above ground level (E. Becker, ADF&G, unpublished data). This exclusion removed eight brown bear groups from the analysis and left 145 brown bear groups with which to build a multiple-covariate distance model (Marques and Buckland 2003) and a subsequent mark–recapture distance model that assumed point independence (Borchers et al. 2006). The study team used the 5,000-foot contour as the upper elevational limit of brown bear habitat in spring.

Based on AICc statistics (Burnham and Anderson 2002), the best multiple-covariate distance-sampling model used a two-piece normal detection function (Becker and Christ, in prep.) that included the following covariates: distance (required), an indicator for distance greater than the mode (required to make the distribution gamma-like), and the logarithm of search distance for detection distances greater than μ. The mode of the detection function ($exp(ln\mu)$) was estimated to be 127.1 m (SE = 1.007) (Table 5.1-3). Estimated detection probabilities that assume perfect detection at 127.1 m ranged from 0.143 to 0.906, with a median of 0.589.

Based on AICc statistics (Burnham and Anderson 2002), the best multiple-covariate mark–recapture model contained the following covariates: observer (pilot or backseat), pilot detection group (three groups), and observer by pilot detection group interaction (Table 5.1-4). The model results coupled with the point independence assumption (Borchers et al. 2006) estimates maximum detection (*MR-pdot*) at the mode of the two-piece normal detection function (127.1 m) to range from 0.762 to 0.915, and a median of 0.835. The estimated probability that a bear group was observed on the survey (H-T probability) is the product of these probabilities, ranging from 0.109 to 0.829, with a median of 0.485 (Figure 5.1-7).

The study team used a DSM (Miller et al. 2013) utilizing GAMs (Wood 2006) that contain a bivariate smoothing function of *x*- and *y*-axis locations of the centroid of the polygon (Figure 5.1-8), a smoothing function of distance to salmon spawning location (Figure 5.1-9), a smoothing function of slope (Figure 5.1-10), and non-vegetative habitat to predict the number of brown bears in 1-km-long searched polygons next to the transect. The model was used to predict the number of brown bears in 1-km^2 cells (Figure 5.1-11). Model fit diagnostics indicated a reasonable fit. The deviance explained by the model was moderate (14.6 percent), indicating a moderate predictive model. The map (Figure 5.1-11) depicts moderate differences in spring distribution of brown bears, with locations on moderate slopes, especially those classified as non-vegetated, having the most bears. Due to the low slope values for valley floors, the DSM predicts very low spring brown bear densities in those locations. Using this DSM, the study team estimated that 841 brown bears (SE = 161.7) inhabited the study area during 2000–2003 (95 percent CI: 578.7, 1,221.5; CV=19.2 percent). Figure 5.1-12 depicts a CV map expressing the degree of uncertainty for the estimate of the number of bears in each 1-km^2 cell.

5.1.2. Downstream Surveys

A total of 52 hair-snag snares were set in 12 different sampling locations throughout the Middle Susitna River Segment (Tables 5.1-5 and 5.1-6, Figure 5.1-13). Snares were deployed for an average of 49.8 days (range = 11–64; SD = 18.3) between 22 July and 25 September, 2013. Snares were deployed and removed from the field based on observed bear activity and fluctuating water levels. Fifteen snares were deployed during snare checks after the initial deployment because new high-activity bear areas were located. Thirteen snares were removed earlier than planned, five because of low bear activity and eight due to flooding that occurred during August 17–26, 2013 (Table 5.1-5).

The 52 snares were checked between one and five times each for a total 213 snare checks during five field surveys. A total of 106 (49.8 percent) of the snares were tripped when checked and 77 samples (72.6 percent of tripped snares) were collected from 34 different snares at nine sampling locations. Slough 21 and Fourth of July Slough produced the most hair samples (18 and 17, respectively). The snares at Fifth of July and Fourth of July creeks were the most productive, however, based on the total number of active snare days (sum of total days each snare was deployed). The least productive sampling locations were Slough 10 (two samples), Lane Creek (one sample), and McKenzie area, South Indian Slough, and Slough 8A (no samples) (Table 5.1-6). Each of the five snare checks produced between 11 and 21 bear-hair samples, with the most samples obtained during the August 6–7 snare check (20 samples) and the September 10–11 snare check (21 samples) (Table 5.1-5). Only two snares, located at Sloughs 20 and 21, produced a hair sample during each snare check survey. Fifteen snares had multiple (two or three) clumps of hair that were collected in more than one sample envelope. Overall, a total of 96 bear-hair samples were available for laboratory analysis.

In 2013, the study team identified 37 documented salmon spawning sites (i.e., sloughs and tributaries) throughout the Middle Susitna River Segment that were considered to be potentially suitable for deployment of hair snags. Due to land access constraints and areas of high human activity (see Section 4.1.2.1 above), however, the study team was able to deploy snares at 10 of those sites (Figure 5.1-14, Table 5.1-7). The study team also included two other sampling locations (i.e., McKenzie area and South Indian Slough; Figure 5.1-14, Table 5.1-7) in the area sampled, based on observations of bear activity by local residents.

Bear-hair samples were delivered to two analytical laboratories (one for DNA, one for stable isotopes) at the University of Alaska Fairbanks and are currently being analyzed. Analytical results are not yet available at this writing.

5.2. Wolf

Wolf numbers have varied dramatically in GMU 13 over the past half-century as a result of predator control efforts, changing prey populations, and hunting pressure. Wolves were considered common in the area in the 1940s but federal population control decreased their numbers to as few as 12 wolves by 1954. Wolf numbers increased rapidly after federal wolf control ended in 1959 and over 300 wolves were estimated to inhabit GMU 13 until the mid-1970s. Hunting pressure kept the population to an average of 275 wolves. With the discontinuation of land-and-shoot hunting in 1988 (with the exception of 1990–1991), the fall wolf population increased to 525 by 1999–2000. In 2000, wolf control was initiated by the state and in 2004 land-and-shoot hunting was allowed by permit. The wolf population was estimated to be 254 wolves in 46 packs (6.3 wolves/1,000 km^2) in 2007 (Schwanke 2009). The fall population increased to approximately 300 in 2010 before decreasing to 204 in 2011, although the latter population estimate may have undercounted wolf numbers due to poor snow conditions (ADF&G 2013). Annual harvest in GMU 13, including removal due to public wolf control efforts, has ranged from 81 to 159 from 2008 to 2011 (ADF&G 2013). More wolf harvest occurs in alpine tundra where wolves are more visible and easier to track (Schwanke 2009).

6. DISCUSSION

6.1. Bears

6.1.1. Population Estimation

The analysis described in Sections 4.1.1 and 5.1.1 of this study complete the objective to estimate the populations of black and brown bears in the study area using existing data from ADF&G.

The study team concluded that the interpretation of the DSM coefficients is biologically sound. This fact, coupled with the relatively high explained deviance (38.1 percent) and the much lower, more uniform CVs for black bears (Figure 5.1-6) than those calculated for brown bears, indicates solid inferences about the spring distribution of black bears can be made from this model. The DSM can be used to obtain estimates of subpopulations of black bears in specific portions of the study area.

The brown bear DSM had fewer observations (145 groups) than did the black bear DSM (351 groups) and is therefore less accurate. The interpretation of the DSM coefficients makes biological sense for most of the parameter coefficients, with the exception of increasing brown bear density at distances far (60–80 km) from salmon-spawning locations. The study team suspects that the latter part of this smoothing function (Figure 5.1-9) is acting as a surrogate for an unknown variable that was not considered in the analysis. The study team considered distance from paved roads, but that variable was not significant when added to the DSM. The bivariate smoothing of the *x*- and *y*-axis location data put a modeling emphasis on the southwestern portion of the study area (Figure 5.1-8) and left the concentrations of brown bears in the northeastern portion unexplained. It is that section of the study area that benefits from adding the covariate of distance from salmon-spawning location. The study team surmised that brown bears were overestimated in the northeastern portion of the study area, but the overall model is better with distance to salmon-spawning locations than without it. The lower explained deviance (14.6 percent) is indicative of poorer modeling results, mainly at higher elevations, based on the CV map (Figure 5.1-2).

6.1.2. Downstream Surveys

The use of modified, nonlethal, break-away snares as hair snags proved to be effective at collecting a reasonable number of samples of bear hairs in 2013. Compared with a similar study conducted in an area of higher bear density in southeastern Alaska (Beier et al. 2005), the percentage of snares tripped in this study was lower (49.8 percent compared to 65.0 percent), but a greater proportion of the snares tripped in this study produced hair samples (72.6 percent compared to 45.5 percent).

The low number of samples obtained during the late August check was likely the result of high water in the Susitna River that reduced salmon abundance and reduced the number of functional snares. Approximately 11 snares showed signs of having been flooded during that high-water event and the study team removed three snares due to sustained high water levels. Bears appeared to be more abundant in tributaries of the Susitna River than in sloughs. The three stream locations averaged 2.33 samples per snare (n = 9 snares), whereas the slough locations averaged 0.95 samples per snare (n = 41 snares). This difference may have resulted from better fishing success and greater activity by bears in the clearer, higher-gradient waters of the tributaries than in the silty, lower-gradient waters of the sloughs.

Due to land-access constraints and high levels of human activity at some sites (see Section 4.1.2.1 above), the study team was unable to achieve the extent of spatial coverage of the study area that was desired in 2013, which reduced the area in which the study team can produce an estimate of minimum population size. Black and brown bears are highly territorial and tend to use the same high-quality foraging areas throughout a season (Barnes 1990). For this reason, the study team will concentrate on expanding the number of sampling locations in the next year of study to include more of the areas not sampled in 2013 (see Table 5.1-7). Doing so will increase the number of unique samples and provide better information on bear abundance and diet throughout more of the study area. Continued monitoring is important to identify annual variation in the diet of bears. For example, Miller (1987) observed a prevalence of berries in black bear scats along sloughs of the Middle Susitna River, but predicted that salmon constituted an important buffer food during years when berry crops fail.

6.2. Wolf

The study team has made progress in summarizing the knowledge of trends in wolf distribution and population in the study area based on previous studies and current reports summarizing ADF&G research and monitoring activities. That effort will continue in the next year of study to achieve the study objective.

7. COMPLETING THE STUDY

[Section 7 appears in the Part C section of this ISR.]

8. LITERATURE CITED

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9. TABLES

Table 5.1- 1. Multiple-covariate Distance-model Coefficients and Standard Errors for Black Bears.

Parameter	Point Estimate	Standard Error
Intercept	3.556	0.069
Ind(distance > μ)	–11.275	3.414
Ind(distance > μ) ln(SearchDist.)	2.016	0.086
PilotSearch	0.399	0.0256
lnμ	4.867	0.007

Notes:

Intercept = y-intercept of the detection function.

Ind(distance > μ) = Detection-function parameter for distances > μ; zero otherwise.

Ind(distance > μ) ln(SearchDist.) = Detection-function parameter for natural log of Search Distance when distance > μ; zero otherwise.

PilotSearch = Detection-function parameter for the group of pilots that tend to search farther away from the transect.

lnμ = Natural log of the estimated mode of the detection function.

Table 5.1- 2. Multiple-covariate Mark–Recapture Model Coefficients and Standard Errors for Black Bears.

Parameter	Point Estimate	Standard Error
Intercept	0.606	0.624
bs(distance 1)	3.746	1.475
bs(distance 2)	–1.366	0.986
bs(distance 3)	0.673	1.053
Observer	0.031	0.175
(% Cover/20)	–0.546	0.112
(% Snow/20)	–0.373	0.098
Pilot-2Grp	2.460	0.768
Observer x Pilot-2Grp	–1.389	0.413

Notes:

Intercept = y-intercept of the logistic regression model.

bs(distance 1) = Parameter estimate of the slope of the cubic-spline model of distance at the first node.

bs(distance 2) = Parameter estimate of the slope of the cubic-spline model of distance at the second node.

bs(distance 3) = Parameter estimate of the slope of the cubic-spline model of distance at the third node.

Observer = A parameter that shifts the y-intercept for data collected by the backseat observer.

(% Cover/20) = A logistic regression parameter representing the effect of (percent vegetative cover within 10 m of the bear, divided by 20).

(% Snow/20) = A logistic regression parameter representing the effect of (percent snow within 10 m of the bear, divided by 20).

Pilot-2Grp = A logistic regression parameter representing pilots who are more efficient at detecting black bears.

Observer × Pilot-2Grp = An interaction parameter between backseat observers and pilot groups.

Table 5.1- 3. Multiple-covariate Distance-model Coefficients and Standard Errors for Brown Bears.

Parameter	Point Estimate	Standard Error
Intercept	3.838	0.085
Ind(distance > μ)	–14.701	11.049
Ind(distance > μ) ln(SearchDist.)	2.658	0.293
lnμ	4.845	0.022

Notes:

Intercept = y-intercept of the detection function.

Ind(distance > μ) = Detection function parameter for distances > μ; zero otherwise.

Ind(distance > μ) ln(SearchDist.) = Detection function parameter for natural log of Search Distance when distance > μ; zero otherwise.

lnμ = Natural log of the estimated mode of the detection function.

Table 5.1- 4. Multiple-covariate Mark–Recapture Model Coefficients and Standard Errors for Brown Bears.

Parameter	Point Estimate	Standard Error
Intercept	–2.6158	1.101
Observer	1.517	0.638
Pilot-3Grp	1.955	0.616
Observer x Pilot-3Grp	–1.053	0.338

Notes:

Intercept = y-intercept of the logistic regression model.

Observer = A parameter that shifts the y-intercept for data collected by the backseat observer.

Pilot-3Grp = Treating the 3-pilot groups as ordinal, this logistic regression parameter represents the slope effect of pilot group.

Observer × Pilot-3Grp = An interaction parameter between backseat observers and pilot groups.

Table 5.1- 5. Number of Hair-snag Snares Set for Bears, and Samples Collected during Each Field Survey, in 2013.

Survey Dates	Number of Snares Set	Number of Snares Removed	Number of Snares Deployed	Number of Snares Checked	Number of Hair Samples Collected
July 22–24	37	0	37	0	–
August 6–7	8	4	41	37	20
August 15–16	7	0	48	41	11
August 27–28	0	3	45	48	11
September 10–11	0	3	42	45	21
September 24–25	0	42	0	42	14

Table 5.1- 6. Number of Hair-snag Snares Set for Bears, Total Active Days, and Total Samples Collected, by Sampling Location, 2013.

Project River Mile	Sampling Location	Number of Snares Set	Total Active Snare Days[1]	Total Samples Collected
113.7	Oxbow Slough	7	418	6
117.2	Lane Creek	2	50	1
119.4	McKenzie Area	2	50	0
127.3	5th of July Creek	4	194	12
128.7	Slough 8A	1	11	0
134.3	4th of July Creek	3	144	8
134.4	4th of July Slough	10	423	17
136.3	Slough 9A	3	189	5
137.1	Slough 10	7	359	2
141.2	South Indian Slough	2	38	0
143.6	Slough 20	4	225	8
145.2	Slough 21	7	426	18

Notes:

Total active snare days is equal to the total number of days between initial deployment and removal for each snare at that sampling location.

Table 5.1- 7. Potential Salmon Spawning Areas Sampled and Not Sampled in the Middle Susitna River Segment, 2013.

Project River Mile	Salmon Spawning Area[1]	Sampled in 2013?	Reason for Not Sampling
105.1	Whisker's Creek & Slough	No	High level of human activity
110.5	Chase Creek	No	High level of human activity
113.7	Oxbow Slough	Yes	–
114.9	Slash Creek	No	Access to ARRC land restricted
115.0	Gash Creek	No	Access to ARRC land restricted
117.2	Lane Creek	Yes	Limited access due to ARRC land
117.2	Slough 8	No	Access to ARRC land restricted
120.2	McKenzie Creek	No	Access to ARRC land restricted
121.4	Little Portage Creek	No	Access to ARRC land restricted
124.4	Deadhorse Creek	No	Access to ARRC land restricted
124.4	Tulip Creek	No	No bear sign observed
125.7	Slough 8B	No	No bear sign observed
127.3	Fifth of July Creek	Yes	–
128.1	Skull Creek	No	Access to ARRC land restricted
128.7	Slough 8A	Yes	Limited due to high human activity
131.5	Slough 9	No	Difficult to access by boat
132.5	Slough 9B	No	No bear sign observed
134.1	Sherman Creek	No	Access to ARRC land and private property restricted
134.3	Fourth of July Creek	Yes	–
134.4	Fourth of July Slough	Yes	–
136.3	Slough 9A	Yes	–
137.1	Slough 10	Yes	–
138.7	Slough 11	No	High level of human activity
140.1	Gold Creek	No	High level of human activity
142.1	Indian River	No	High level of human activity
142.3	Slough 17	No	High level of human activity
142.5	Slough 18	No	High level of human activity
143.6	Slough 20	Yes	–
145.2	Slough 21	Yes	–
148.3	Jack Long Creek	No	Access to CIRWG lands restricted
152.3	Portage Creek	No	Access to CIRWG lands restricted
155.9	Cheechako Creek	No	Access to CIRWG lands restricted
160.5	Chinook Creek	No	Access to CIRWG lands restricted
164.8	Devil Creek	No	Access to CIRWG lands restricted
179.3	Fog Creek	No	Access to CIRWG lands restricted
184.6	Tsusena Creek	No	Access to CIRWG lands restricted

Notes:

1. Current and historic salmon spawning areas and bear concentration areas documented by one or more of the following references: Barrett et al. (1985), Miller (1987), ADF&G (2012), Link et al. (2013), R2 Resource Consultants, Inc. (2013).

10. FIGURES

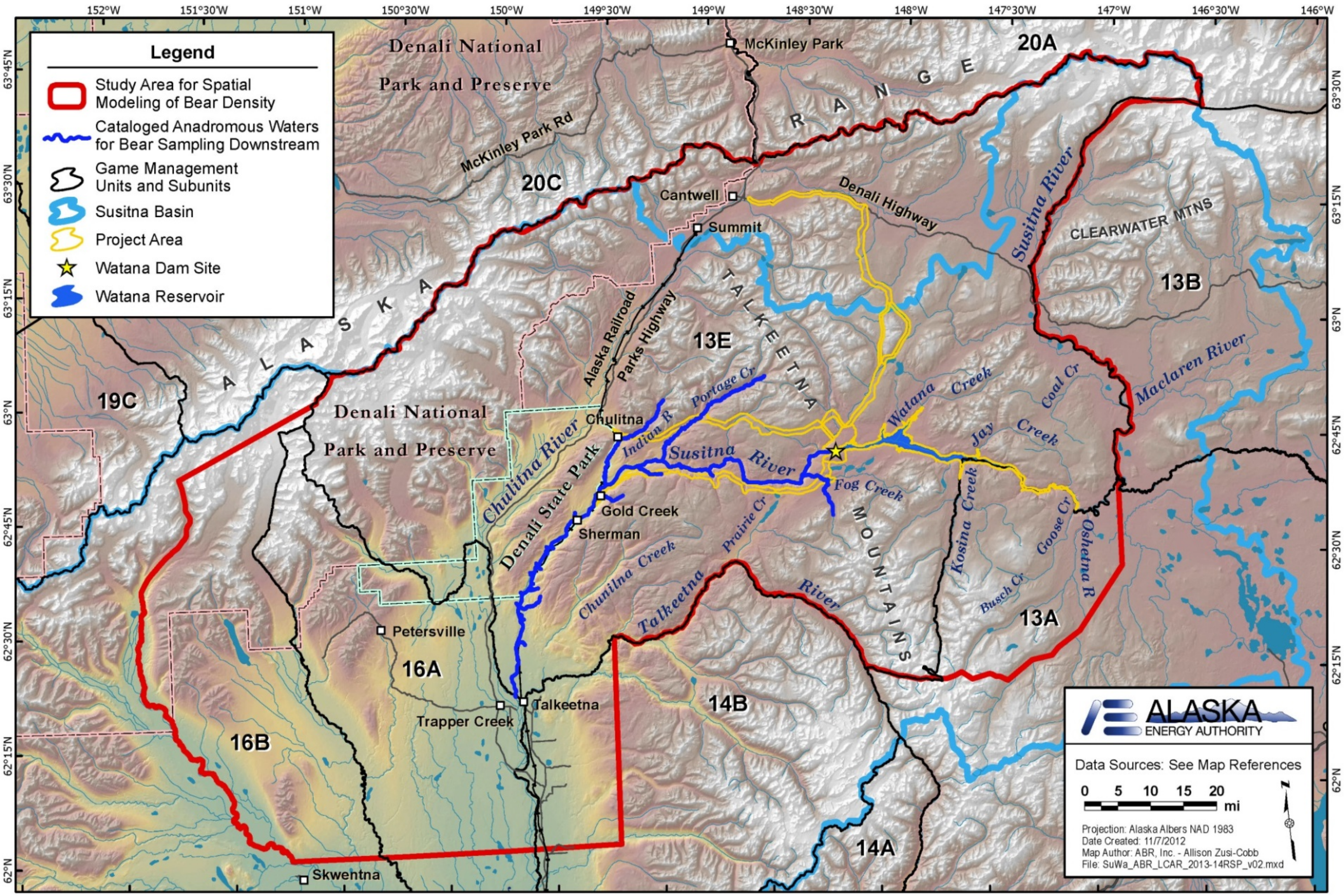

Figure 3- 1. Study Area for Large Carnivores.

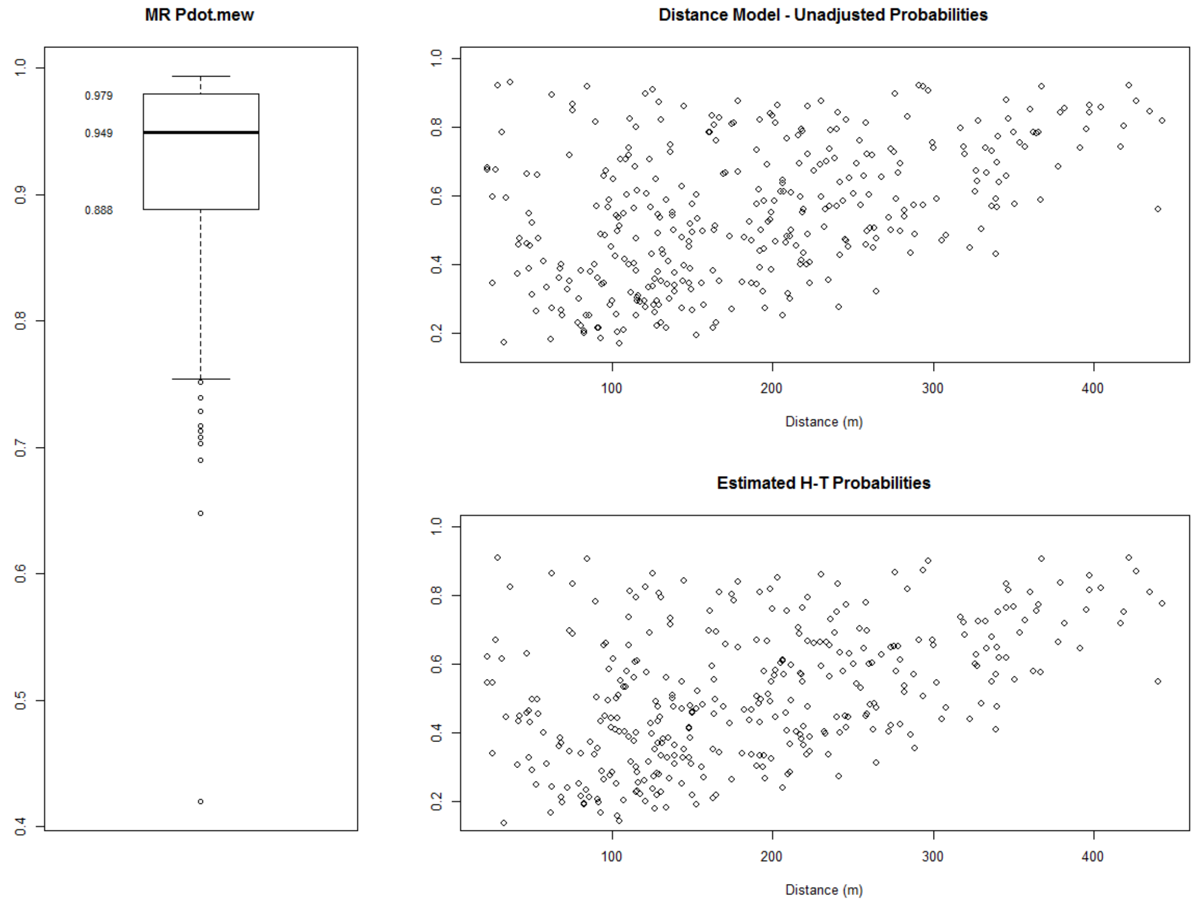

Figure 5.1-1. Distance-sampling Detection Probabilities for Black Bears.

Top Right: Black bear detection probabilities calculated assuming perfect detection at the mode of the detection function (unadjusted probabilities).

Left: Mark and recapture probabilities for various covariate levels calculated at the mode distance, 129.9 m (MR Pdot at μ).

Bottom Right: The final estimated H-T probability of bear detection, which is the product of the unadjusted probability and the MR Pdot at μ.

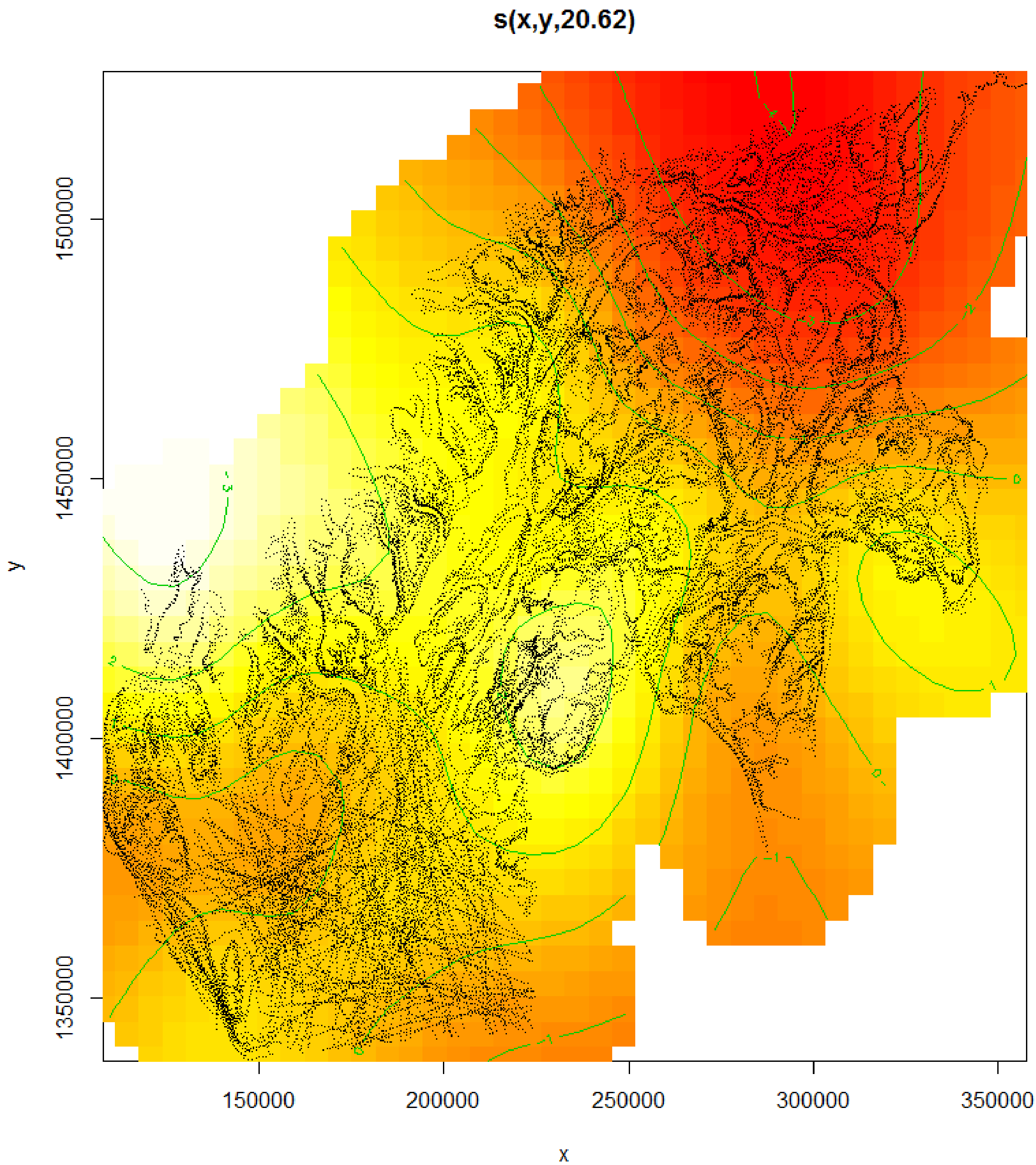

Figure 5.1-2. Bivariate Smoothing of *x* and *y* Coordinates, Estimating a Function of the Number of Black Bears per km^2.

The color scheme uses whitish-yellow to depict the areas that black bears prefer, followed by orange, and then red. The black dots represent the centroid of the transect segments containing the data. Median values for the other DSM covariates are used in this plot.

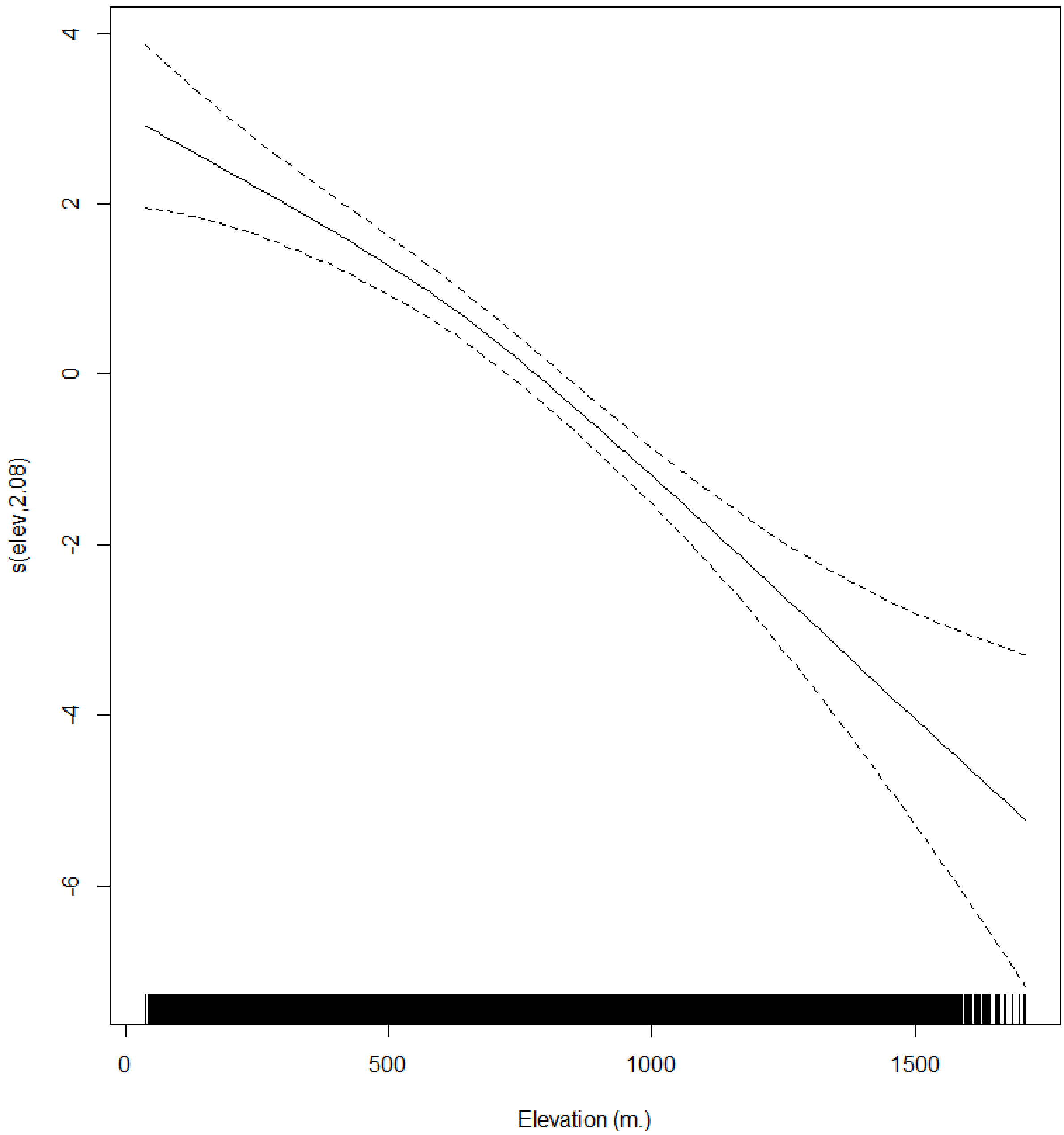

Figure 5.1-3. Univariate Smoothing of Elevation, Estimating a Function of the Number of Black Bears per km^2.

The *y*-axis represents the contribution of the smoothing function on elevation to a function of black bears per km^2. Median values for the other DSM covariates are used in this plot. The bottom of the graph depicts a density plot of the amount of data collected for each elevation.

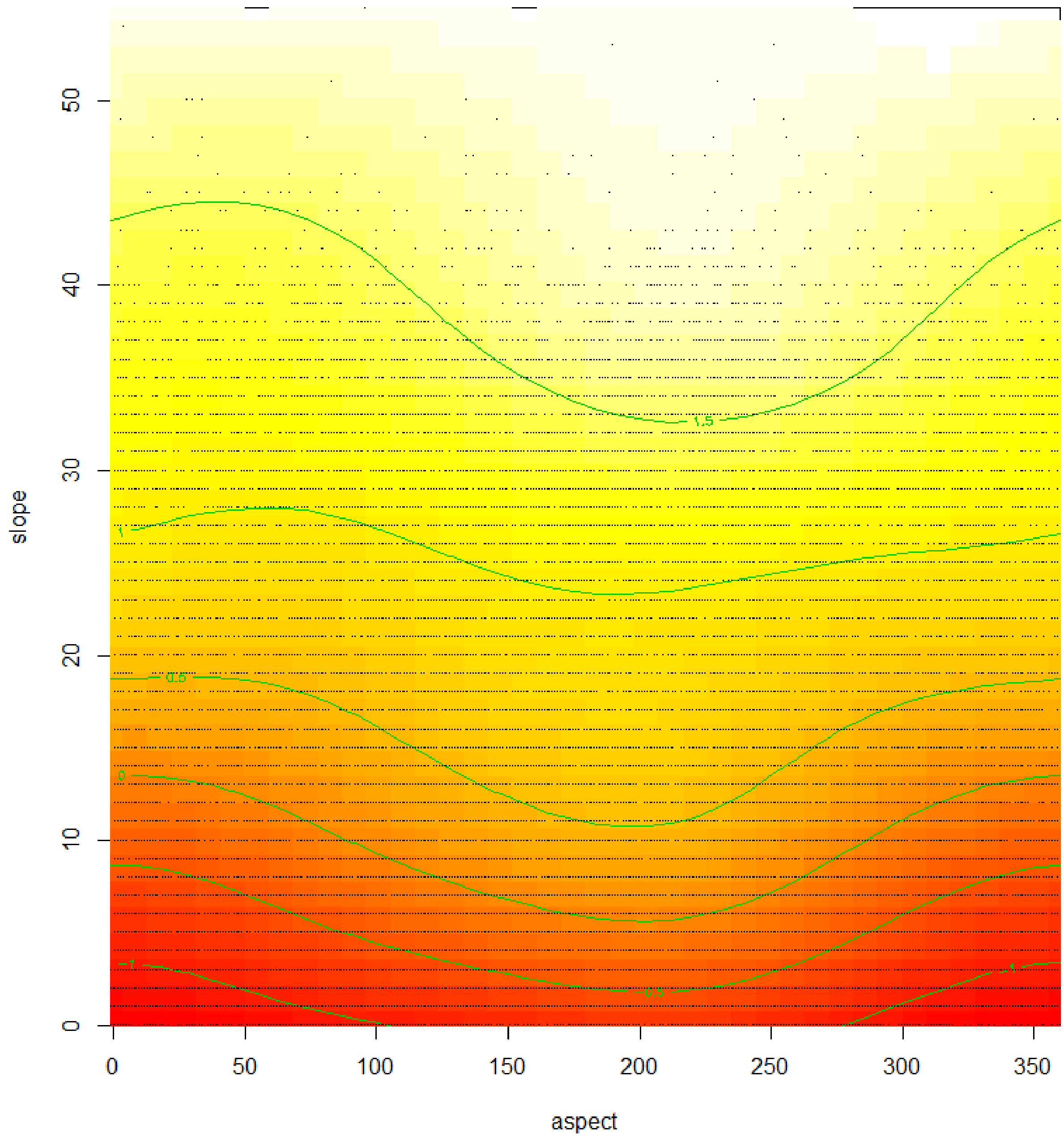

Figure 5.1-4. Bivariate Smoothing of Slope and Aspect, Estimating a Function of the Number of Black Bears per km^2.

Bivariate smoothing of slope and aspect is represented by the number on the contour line. The color scheme uses whitish-yellow to depict the highest concentrations of black bears, followed by orange, and then red. The smoothing function used a cyclic cubic regression spline to ensure that the estimates at aspects of 0 and 360 degrees were the same. Visualize this graph as a tube, by making a cylinder out of the aspect axis. Median values for the other DSM covariates are used in this plot.

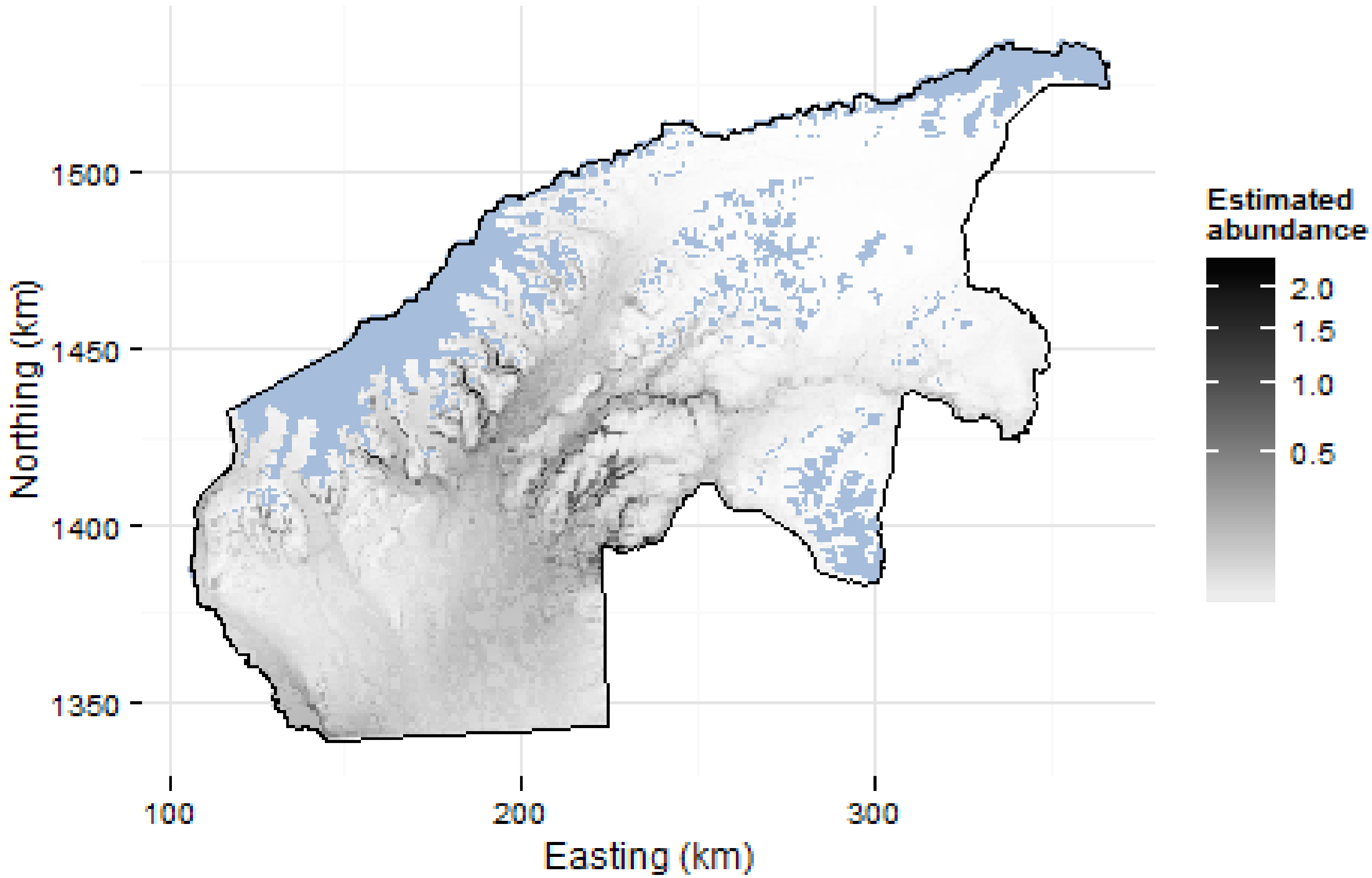

Figure 5.1-5. Density Surface Map of the Estimated Number of Black Bears per km^2.

Gray-blue areas represent areas above 4600 ft in elevation, which are not considered to be spring habitat for black bears.

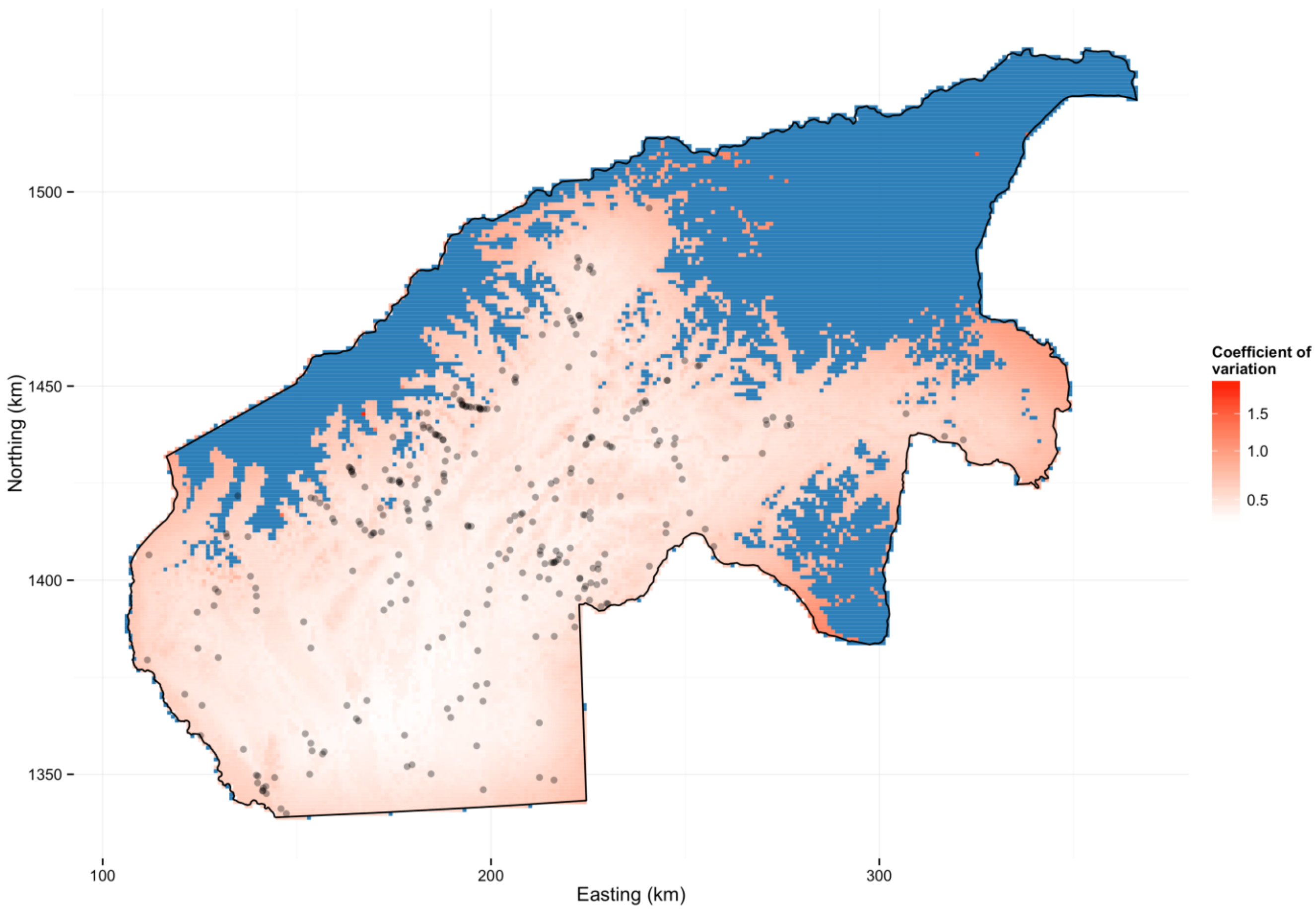

Figure 5.1-6. Density Surface Map of the Coefficient of Variation of the Predicted Number of Black Bears per 1-km^2.

Gray-blue areas represent either areas above 4600 ft elevation, which are not considered to be spring habitat for black bears, or cells that predict 1/1000th of a bear or less per km^2. Black and gray dots represent estimated number of black bears from the distance-sampling models, with darker dots indicating more bears.

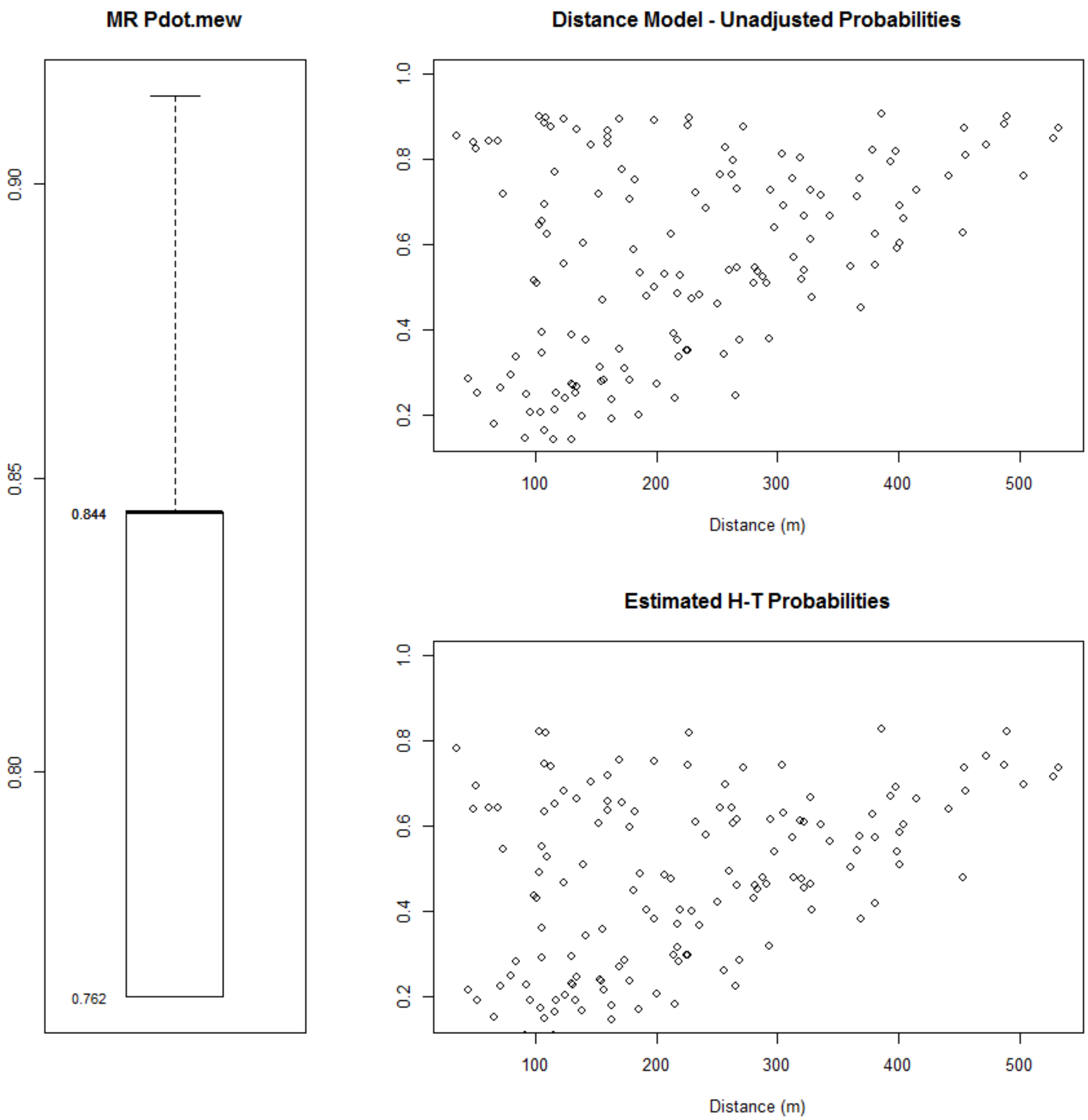

Figure 5.1-7. Distance-sampling Detection Probabilities for Brown Bears.

Top Right: Brown bear detection probabilities calculated assuming perfect detection at the mode of the detection function (unadjusted probabilities).

Left: Mark and recapture probabilities for various covariate levels calculated at the mode distance, 129.9 m (MR Pdot at μ).

Bottom Right: The final estimated H-T probability of bear detection, which is the product of the unadjusted probability and the MR Pdot at μ.

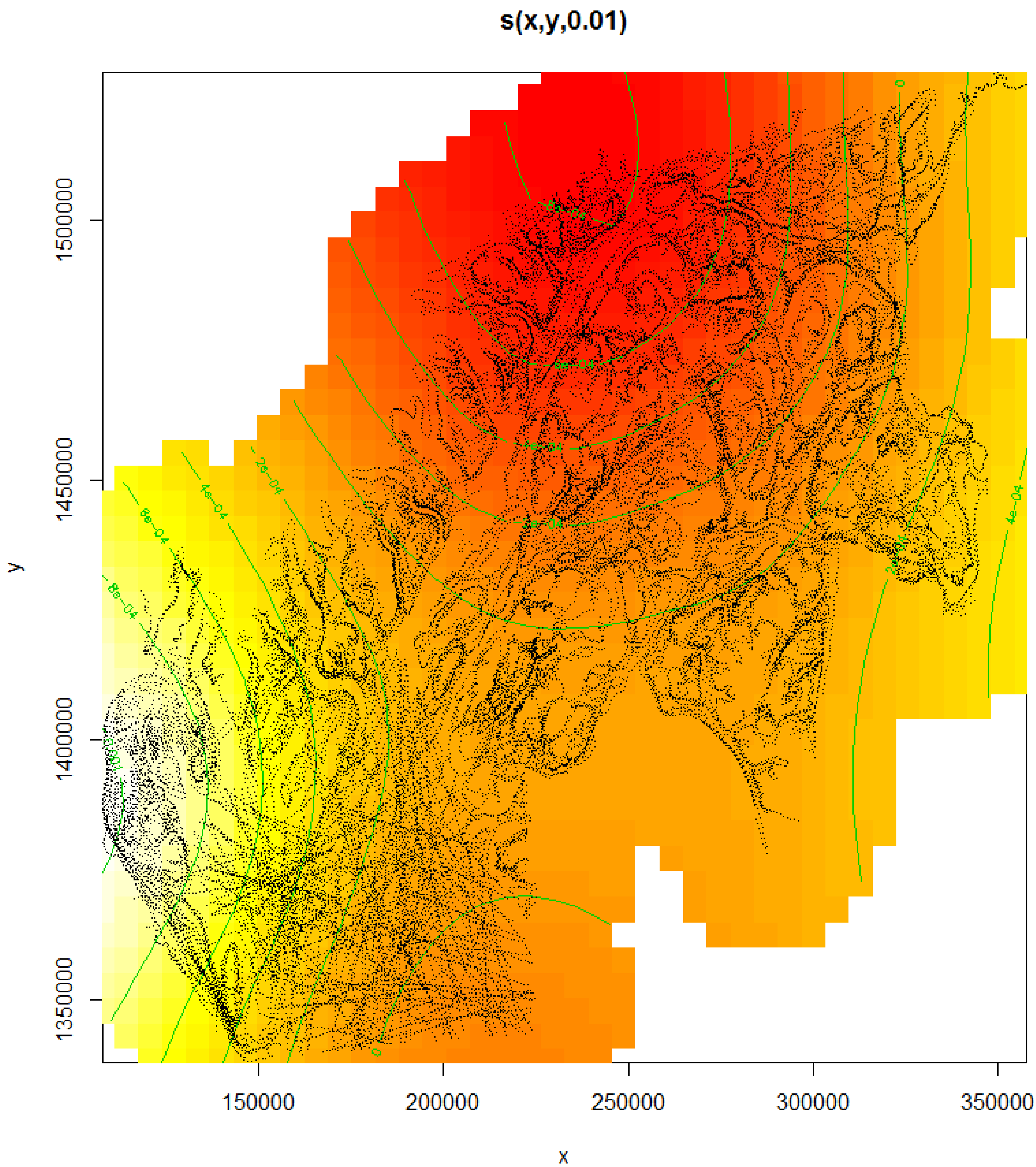

Figure 5.1-8. Bivariate Smoothing of x and y Coordinates, Estimating a Function of the Number of Brown Bears per km^2.

Color scheme uses whitish-yellow to depict the highest concentrations of brown bears, followed by orange, and then red. Black dots represent the centroid of the transect segments containing the data. Median values for the other DSM covariates are used in this plot.

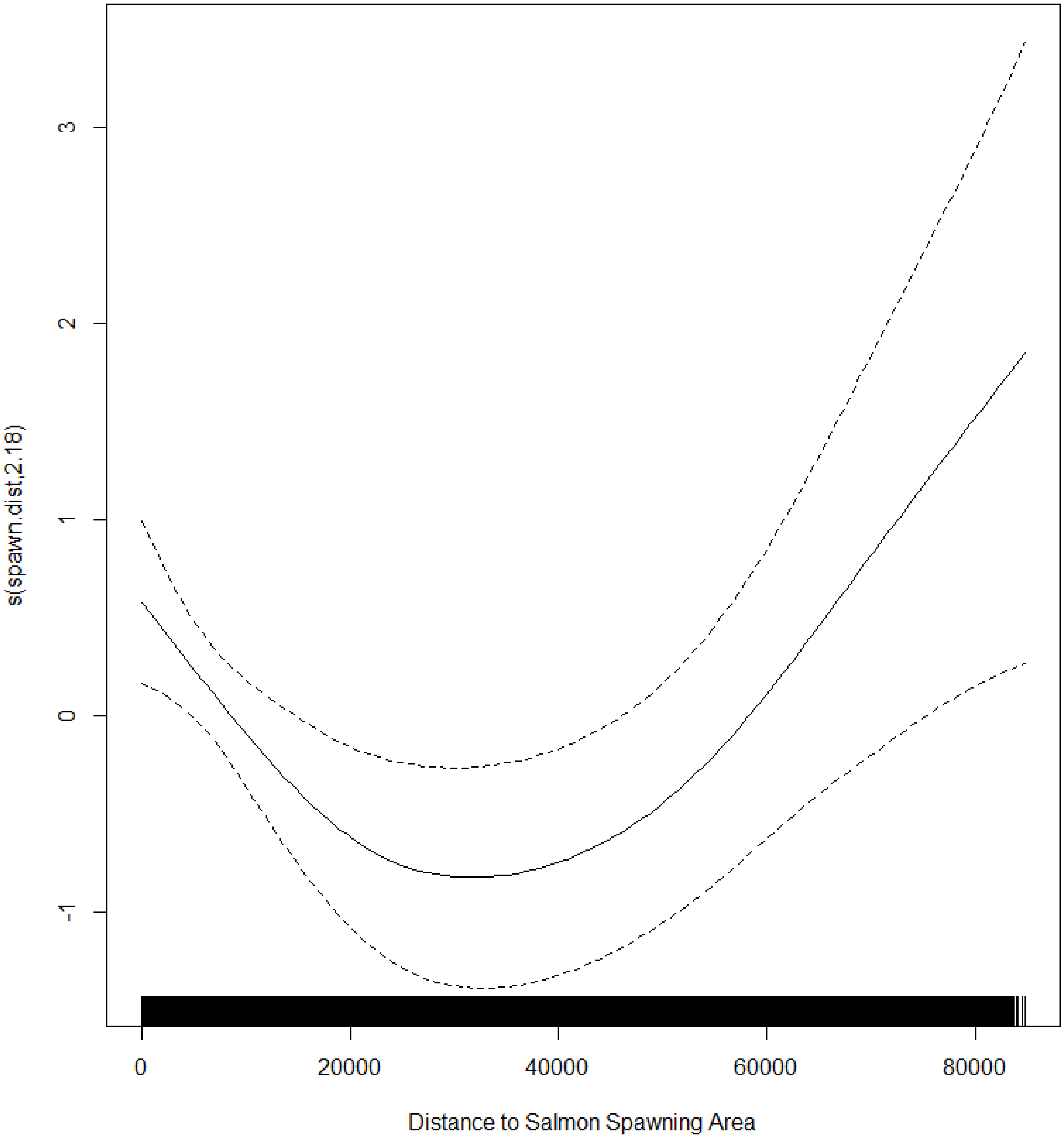

Figure 5.1-9. Univariate Smoothing of Distance to Salmon Spawning Area, Estimating a Function of the Number of Brown Bears per km^2.

The *y*-axis represents an estimate of a function of brown bears per km^2. The bottom of the graph depicts a density plot of the amount of data collected for each distance. Median values for the other DSM covariates are used in this plot.

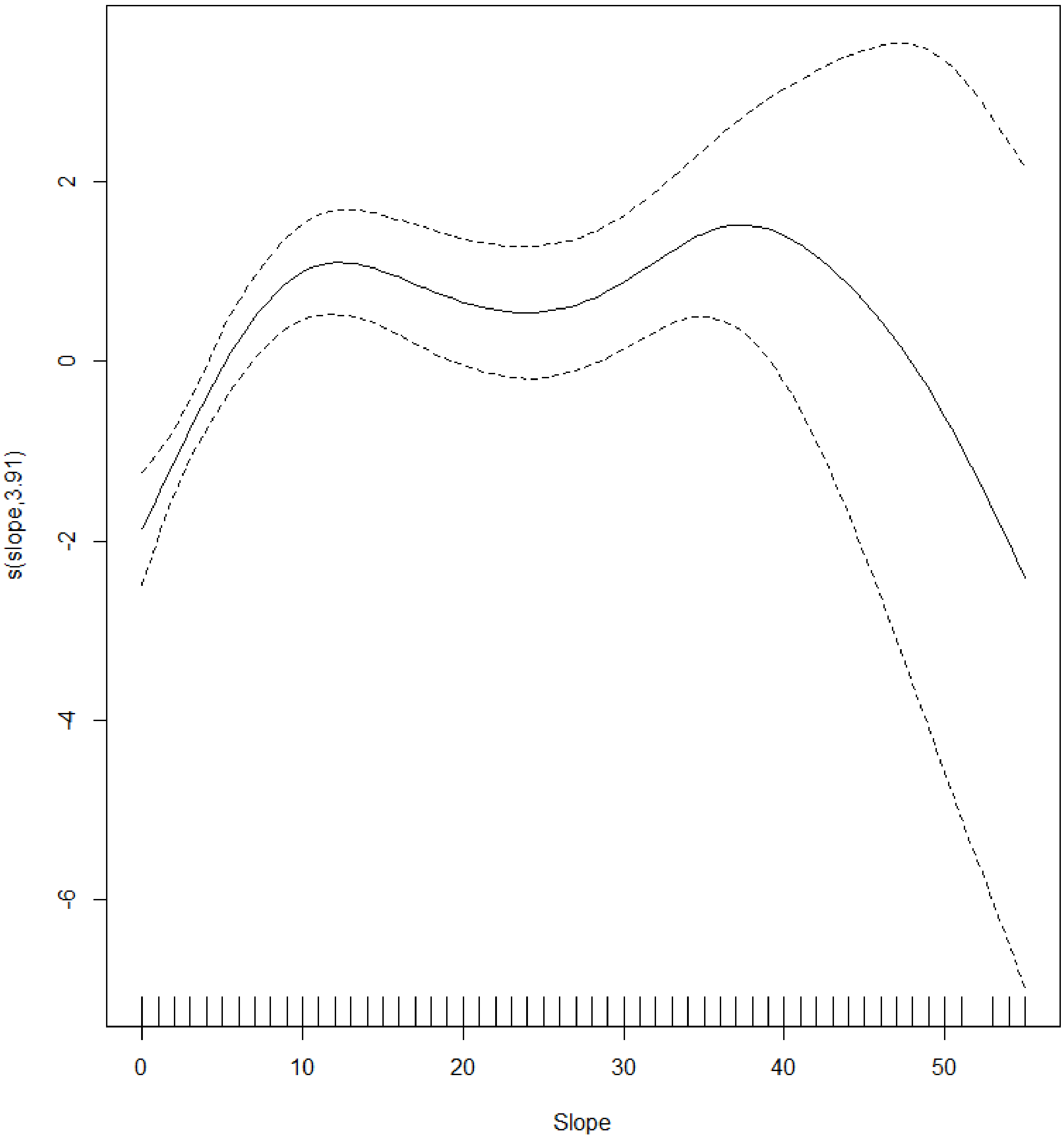

Figure 5.1-10. Univariate Smoothing of Slope, Estimating a Function of the Number of Brown Bears per km^2.

The *y*-axis represents an estimate of a function of brown bears per km^2. Median values for the other DSM covariates are used in this plot.

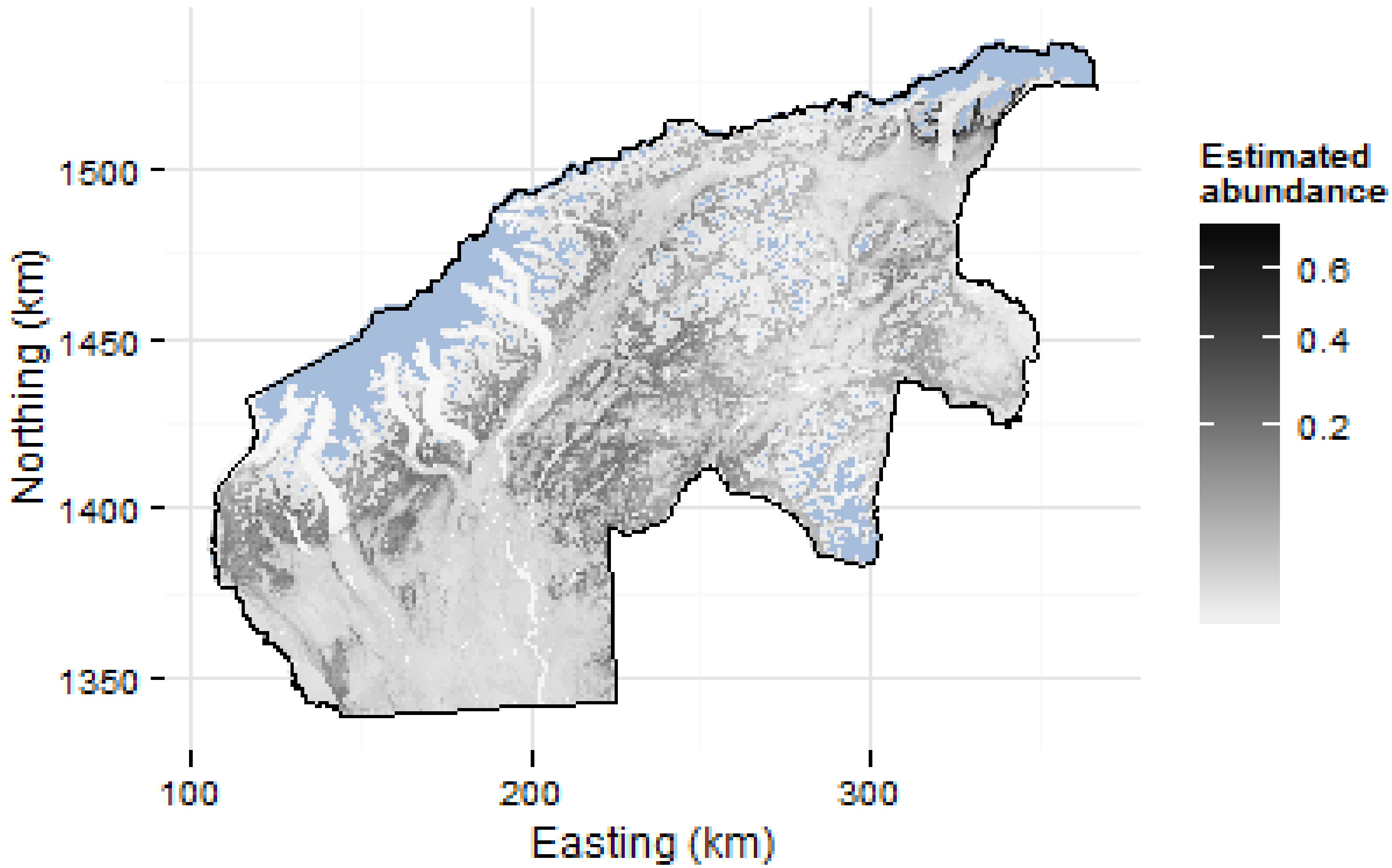

Figure 5.1-11. Density Surface Map of the Estimated Number of Brown Bears per km^2.

Gray-blue areas represent areas above 5000 ft in elevation, which are not considered spring habitat for brown bears.

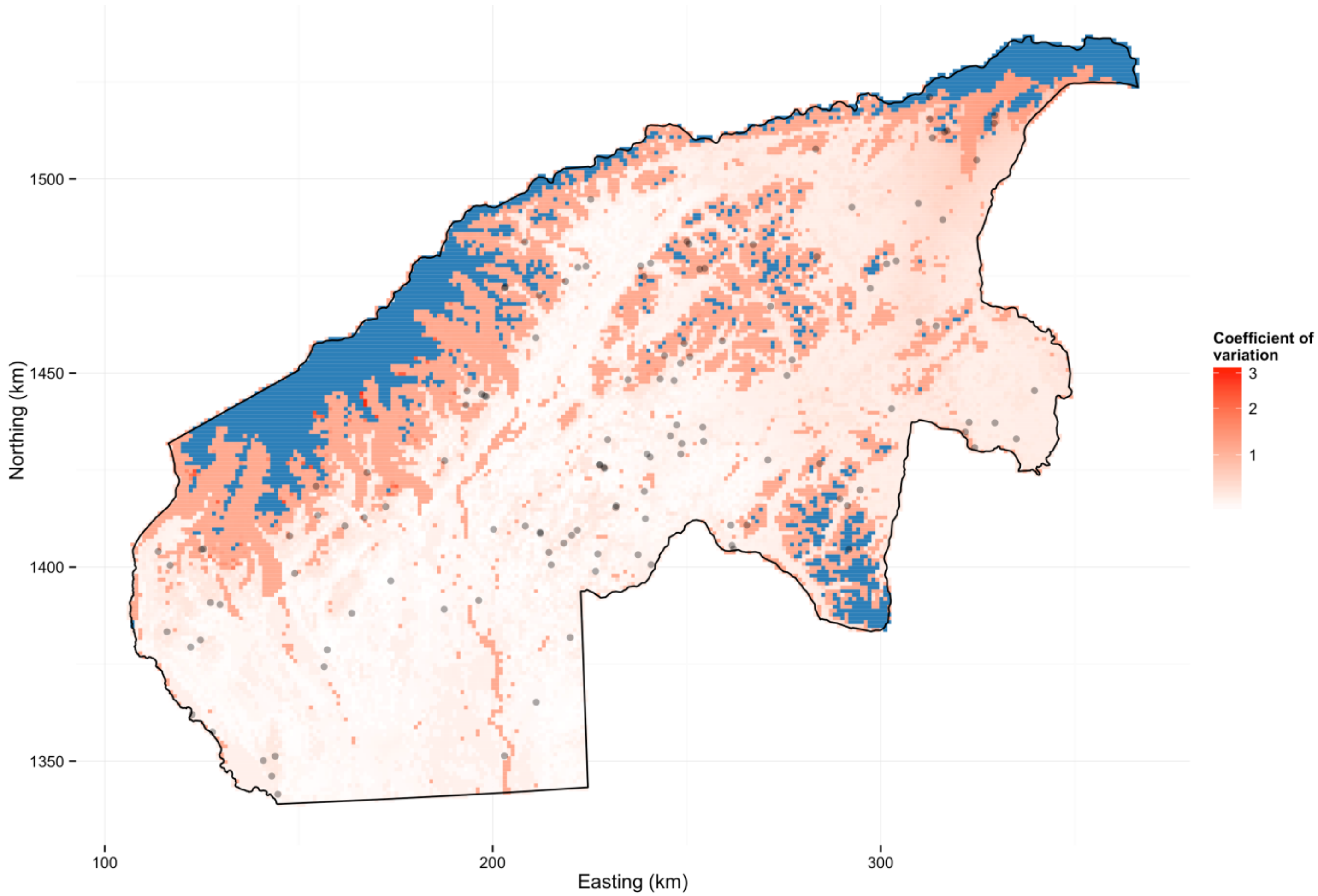

Figure 5.1-12. Density Surface Map of the Coefficient of Variation of the Predicted Number of Brown Bears per km^2.

Gray-blue areas represent areas above 5000 ft in elevation, which are not considered to be spring habitat for brown bears. Black and gray dots represent estimated number of brown bears from the distance-sampling models, with darker dots indicating more bears.

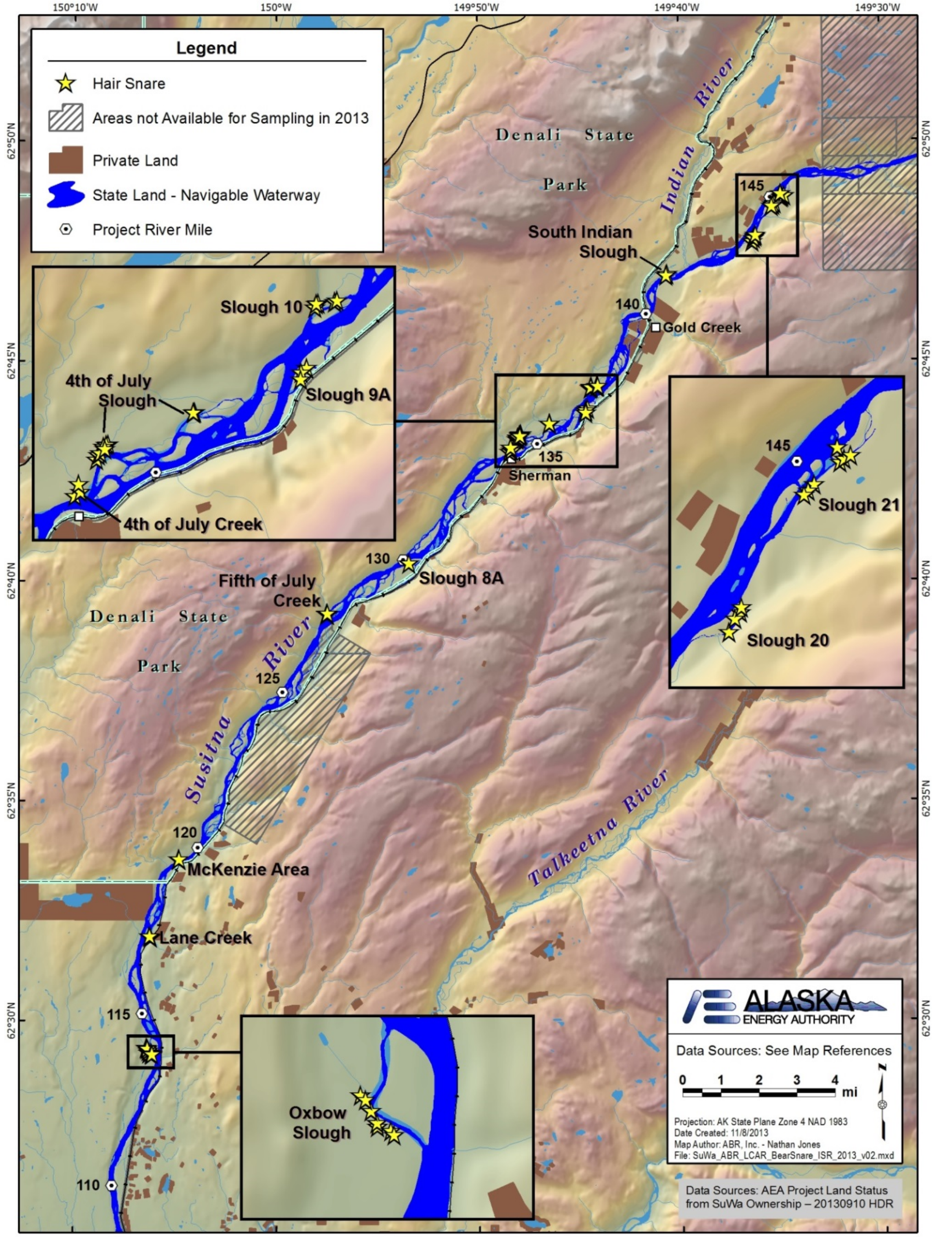

Figure 5.1-13. Locations of Hair-snag Snares for Bears in 2013.

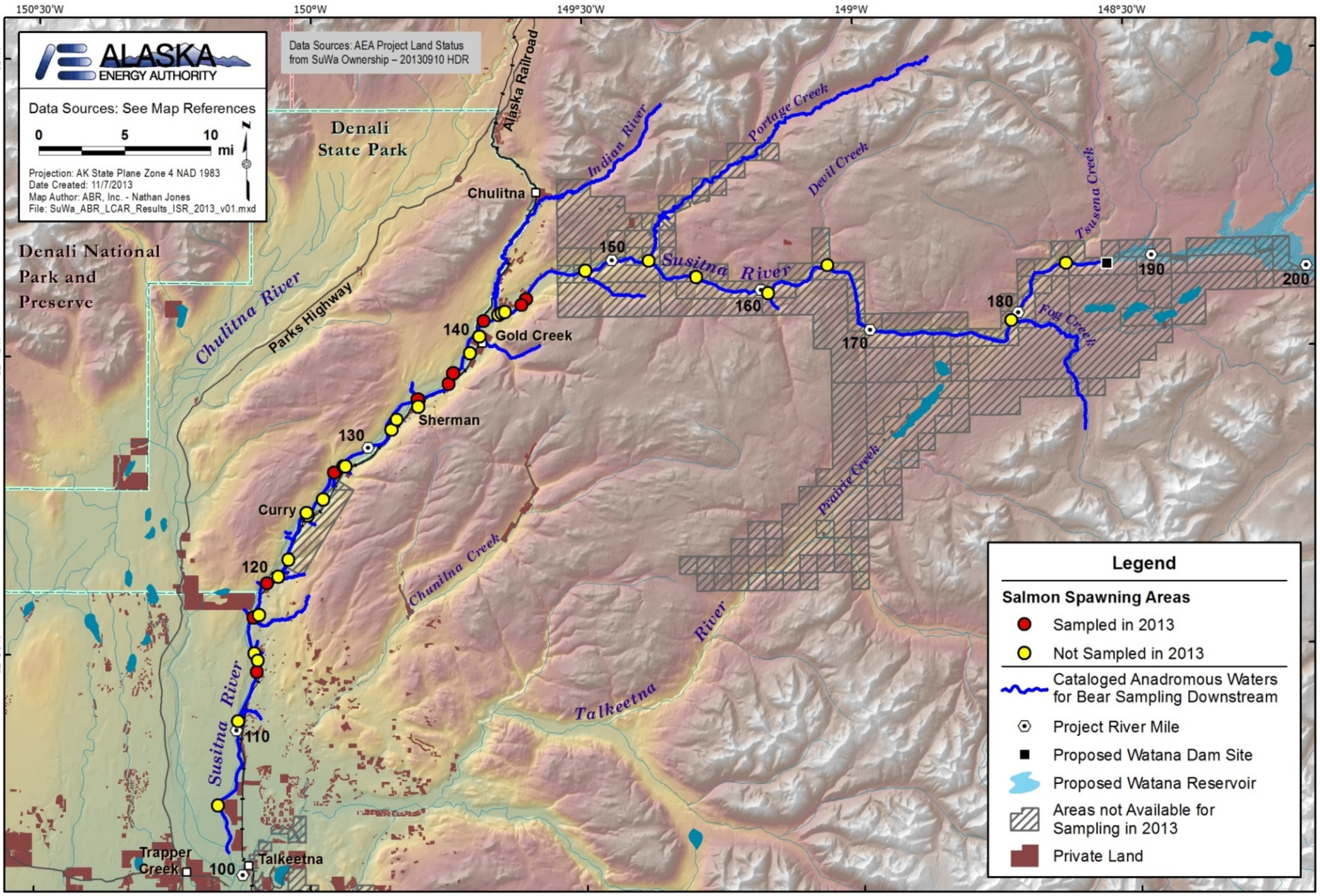

Figure 5.1-14. Potential Salmon-Spawning Areas Identified and Sampled or Not Sampled during Downstream Survey of Bear Use, 2013.