Global Positioning System (GPS) Bias Correction and Habitat Analysis of Mountain Goats (*Oreamnos americanus)* in the Cascades of Washington State, USA

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Abstract

Seasonal variation in habitat selection by the mountain goat *Oreamnos americanus* is not well understood due to the difficulties of monitoring animal movement in all months of the year. The use of global positioning system (GPS) wildlife telemetry collars offers an opportunity to overcome this obstacle, however satellite acquisition problems associated with GPS wildlife telemetry collars create an observational bias of animal locations towards areas of favorable signal reception. To correct for this bias in data from GPS collared mountain goats in the Cascades of Washington State, I used an intensive field sampling exercise to model the amount of variation in position acquisition rates (PAR) based on remotely sensed vegetation and topographic landscape characteristics in a geographic information system (GIS) framework. I then derived GIS habitat maps of predicted potential mountain goat habitat in the Western Cascades of Washington.

I used non-linear mixed modeling with Akaike's Information Criteria (AIC) and a generalized estimating equation (GEE), autoregressive correlation structure (m =1), to account for the random effects of the binary clustered GPS bias correction experimental design. I used vegetation data from satellite imagery provided by the Interagency Vegetation Management Project (IVMP) and a 10 m digital elevation model (DEM) to derive a set of predictor variables. I sampled GPS PAR at 543 sites across two study areas, the Western and Eastern Cascades, which covers roughly 5 million hectares. I analyzed the data at two spatial resolutions, 25 m x 25 m and 75 m x 75 m. For both study areas, the 25 m x 25 m resolution yielded the best models with areas under the receiver-operating curve (ROC) of 0.70 and 0.69, for the Western and Eastern Cascades, respectively. Both models fit with expected

ecological patterns. These two models were used to produce a continuous GIS raster map of predicted GPS PAR for the entire mountain range in Washington. This data, used with an inverse weighting scheme, reduced the signal reception bias found in a habitat study of GPS collared mountain goats. The correction factor helped to account for habitats likely used by coastal ecotype mountain goats but unfavorable to GPS satellite acquisition.

Past research into Washington State's mountain goats has not documented well winter habitat selection. These widely overlooked habitats, lower elevation forests with dense canopy cover, may provide critical over-wintering sites for mountain goats. I analyzed data collected over a two-year period from 39 GPS collared mountain goats in the Washington Cascades. The data set included over 86,000 individual locations from 39 animals. Each location was weighted with the inverse of the predicted GPS PAR to account for the GPS bias. I used a weighted logistic regression procedure with Akaike's Information Criteria (AIC) to choose the most parsimonious model out of an *a priori* selected set of models. Predictor variables were derived from vegetation layers developed by the Interagency Vegetation Mapping Project (IVMP) and a 10 m digital elevation model (DEM). Candidate models were developed on the basis of ecological relevance and available GIS data. I partitioned the data into eight datasets, based upon elevation quartiles of mountain goat locations and a northern and southern division of available sites. The individual habitat maps were mosaiced into one map and compared with a map generated with the same models not taking into account the weighting factor. The weighted models classified more terrain as habitat and had slightly higher classification accuracies. I also combined predicted potential habitat maps with proportional use of each elevation band during summer (July-September) and winter (December-April) to examine seasonal differences in habitat use. The final product will assist with management activities, conservation planning and ecological studies of Washington's endemic mountain goat populations.