POPULATION TREND MONITORING OF WASHINGTON GROUND SQUIRRELS

(*Urocitellus washingtonii*) IN THE UPPER COLUMBIA BASIN 2012-2017

Progress Report

April 2018

JAMES W. WATSON, *Washington Department of Fish and Wildlife, P.O. Box 43141, Olympia, Olympia, WA 98504-3200*

GAIL S. OLSON, *Washington Department of Fish and Wildlife, P.O. Box 43141, Olympia, Olympia, WA 98504-3200*

Citation: Watson, J.W., and G.S. Olson. 2018. Population trend monitoring of Washington ground Squirrels (*Urocitellus washingtonii*) in the upper Columbia Basin 2012-2017. Progress Report. Washington Department of Fish and Wildlife. Olympia, Washington.

INTRODUCTION

Development of methods to model occupancy of animal populations provides tools for improved survey design and better precision to estimate vital parameters (MacKenzie et al. 2006). These tools are useful for studying characteristics of existing populations as well as their long-term population trends because they allow for estimating changes in populations over time. This is a particularly important for monitoring status of threatened or endangered species, or populations of species that are believed to be unstable or declining.

The Washington Ground Squirrel (*Urocitellus washingtoni*), hereafter "squirrel", is a candidate species for Threatened or Endangered status designation by the State of Washington. The need to understand the long-term population trend of this species is important to supplement what is known about population size and distribution. In 2012 we developed and tested a protocol to assess squirrel population trend in the upper Columbia Basin by surveying potential squirrel sites on public land (Watson et al. 2016). The study recommended repeating the survey at 3-to-5 year intervals to capture potential changes in population dynamics. Here, we report on results of population trend analysis from surveys conducted again in 2017 and analyzed with respect to 2012 results. Our objective was to estimate annual probabilities of local squirrel extinction (ε), colonization (γ), and population growth rate (λ) from the sampled population over the 5-year interval with respect to changing occupancy (ψ). We also examine relationships of site covariates to occupancy, including those sampled both years (study area, and evidence of cattle grazing), and two new covariates sampled only in 2017 (evidence of fire, and badger sign).

METHODS

Surveys

In 2012, we established survey sites across potential and historically occupied squirrel range in the upper Columbia Basin. Sites were selected randomly from among 5 geographic regions (i.e., study areas) within this range. Details of site selection (Watson et al. 2016) included stratification prior to random selection to exclude all private land because of uncertain future access to established sites. Therefore, our results may, or may not be representative of ground squirrel population trends on private lands.

We selected a 2-survey design with removal for multi-season analyses (Watson et al. 2016). Removal design involves removing sites from further visits once squirrels are first detected. The method maximizes survey efficiency by increasing the number of overall sites that can be surveyed when resources are limited (MacKenzie and Royal 2005). Removal sampling is most appropriate where probability of detection is relatively high (MacKenzie and Royal 2005). In 2011 surveys at 166 historic squirrel sites resulted in high estimates of detection probability (p) = 0.97 and occupancy (ψ) = 0.93 (Watson et al. 2016) suggesting a 2-visit survey design would optimize sampling (MacKenzie et al. 2006). Detection probabilities are modeled as constant in a 2-survey design because they are not separately estimable.

Because we modeled detection probability as a constant within years, we attempted to minimize potential influence of three factors on detection including observer inexperience, adverse weather conditions, and squirrel dispersal (Watson et al. 2016). To accomplish that, each survey year WDFW District Biologists were trained to improve detection consistency among biologists. Surveyors avoided weather conditions that were found to affect detection estimates including high wind (i.e., > 23kph), steady rain, and relatively high temperatures (e.g. >32˚C without overcast). Surveys were conducted from 1 March with the initiation of adult activity and prior to 1 June after which time pup dispersal intensified. Second surveys were conducted 1-3 weeks after the first surveys. Seasonal timing conditions of surveys supported the assumption that squirrel populations were closed within each survey year (i.e., no immigration or emigration between the two surveys), an important condition for occupancy estimation. We also assumed that detections were independent, and surveyors accurately determined whether vocalizing squirrels were within bounds of survey sites. Prior occupancy surveys indicated squirrel detections were highest from dawn until mid-day and declined late in the day (Watson et al. 2016). Surveyors were encouraged, but not required to conduct surveys earlier in the day. Median time when surveys were initiated was 11 h.

We limited collection of site covariate information in order to reduce time spent at each site and to maximize survey sample size. In both study years, we collected and analyzed covariates *study area* and *grazing* (evidence of active cattle grazing; yes or no). In 2017, two additional site covariates were documented including *scorching* (evidence of recent fire activity, yes or no) and *badger* (presence of badger burrow, yes or no). We tested the effect of the latter covariates in models using 2017 data only for relevance of including them in future survey efforts. We did not estimate probability of detecting badgers or adjust this covariate based on counts of badger burrows.

Each site consisted of a 400 x 400 m grid centered on the randomly-selected site waypoint. During each survey one surveyor walked 10, 400 m transects within a site using GPS orientation and recorded all signs of squirrel occupancy (active burrow, scat, whistle, or visual). Positive detections were considered to be a minimum of one vocalization or visual sighting, or a combination of scat and burrow use. Surveyors hand-sifted fresh soil around ground squirrel burrows to search for soft, fresh scat. When squirrel calls were heard at <60 m locations of individuals were recorded as inside or outside of the study site. Additional details of site selection and survey protocols are described in Watson et al. (2016).

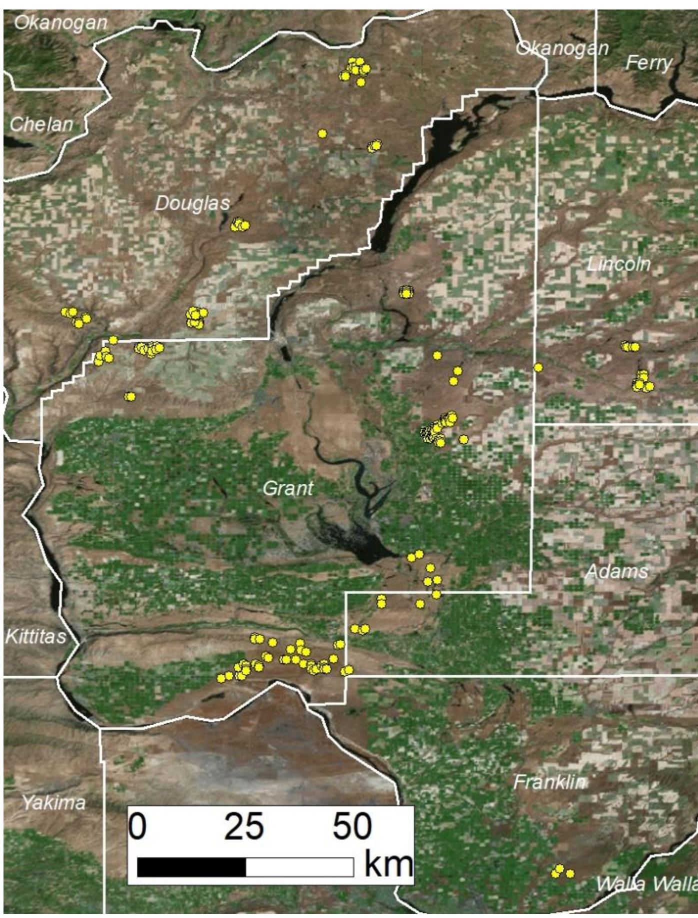
Analysis

We used multi-season modeling in program PRESENCE (version 6.4) to derive parameter estimates for objective 1. PRESENCE identifies the most parsimonious models by calculating AIC scores and ranking models based on differences between the best model and other models (ΔAIC). We considered models having Δ values within 2 AIC units of the top-tier model as strongly supported by the data, and models with Δ values between 2 and 7 AIC units as supportive (Burnham and Anderson 2002). We ran models to compute ε, γ, and λ and alternative parameterizations to compute annual ψ, and to test covariates. We tested all additive and interactive combinations of covariates on occupancy, with detection modeled as constants among years and surveys, and also varying among years (but constant among surveys within years).

We ran single-season occupancy models on 2017 survey data in PRESENCE. This allowed us to test newly-sampled covariates on 2017 occupancy data (objective 2). We ran single-season occupancy models on 2012 and 2017 survey data in PRESENCE to test for potential overdispersion of annual data with goodness-of-fit tests. Testing for overdispersion is not an option in multi-season analyses in PRESENCE, but we tested for overdispersion within individual years to identify and adjust for data sparseness, unexplained heterogeneity, or lack of independence in parameters. Program PRESENCE used the logistic link to transform data to better meet modeling assumptions and constrain the response variable (probabilities) to the interval 0-1. We ran the tests on saturated models by comparison to 1,000 bootstrap estimates. If goodness-of-fit tests indicated a possible lack of fit (i.e., < 0.05 probability that the test statistic was greater or equal to the observed statistic), we changed the over-dispersion statistic ($\hat{c}$) for the ranked multi-season models to the average value of $\hat{c}$ estimated from the two, single-year models. PRESENCE automatically provided the new (Q)AIC model ranking after adjusting standard errors for model parameters.

RESULTS

We analyzed survey data from 202 sites surveyed in both 2012 and 2017 (Fig. 1). Squirrels were detected at 54 sites (27%) on the first visit. Ranking of multi-season models, adjusted for evidence of lack-of-fit, showed *grazing* effect on 2012 occupancy estimate was the best indicator of localized extinction or colonization (Table 1). The un-transformed estimate of grazing was -0.20 (95% CI = -1.19 – 0.79). No other models fell within 2 QAIC units of the top model. *Study area* accounted for only 2% of weights in any subsequent model. *Badger* and *scorching* recorded in 2017 did not enter top models.



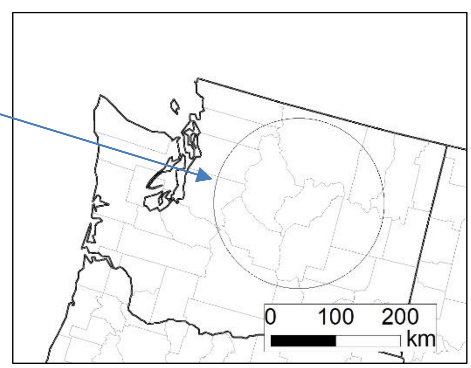


Fig. 1. Location of survey sites for Washington ground squirrels (yellow dots; some overlapping) in eastern Washington.

Table 1. Ranking of top Washington Ground Squirrel multi-season occupancy models used to estimate local extinction and colonization. Ranking is based on the Akaike Information Criterion adjusted for evidence of lack of fit (QAIC). Data were collected in five study areas in eastern Washington in 2012 and 2017. In all models, probability of detection was modeled as constant within years but estimated independently between years.

Model[a]	QAIC	ΔQAIC[b]	Akaike Weights[c]	Likelihood	No. Param.	Deviance[d]
$\psi1(G_{2012}), \gamma, \varepsilon, p$	21.26	0.00	0.92	1.00	6	657.16
$\psi1, \gamma, \varepsilon(A), p$	28.95	7.69	0.02	0.02	10	635.43
$\psi1, \gamma, \varepsilon(A{:}G_{2017}), p$	29.09	7.83	0.02	0.02	10	645.42
$\psi1(A{:}G), \gamma, \varepsilon, p$	29.22	7.96	0.02	0.02	10	654.77
$\psi1(A+G), \gamma, \varepsilon(A+G_{2012}+G_{2017}), p$	33.03	9.31	0.00	0.01	11	608.45
$\psi1(A), \psi2(A), \gamma, p$	32.32	11.49	0.00	0.00	12	621.28

[a]A = study area; G = grazing evidence.
[b] Difference in model QAIC value and the QAIC of the top ranking model.
[c] Akaike weights for the model (i.e., relative explanatory power).
[d]Difference in likelihood of current model and saturated model.

Parameter estimates are provided in Table 2. Probability of local population extinction was estimated to be over twice that of colonization between the two study periods. Overall population growth rate <1 was indicative of a declining population during the study period. Estimates of occupancy indicated a decline in our study population but broad overlap of confidence intervals suggests this decline was not significant. Estimates for probability of detection were also different between two years, and respective non-overlap of confidence intervals suggest this decline in probability of detection was significant between the two years.

Table 2. Real parameter estimates for occupancy, detection, and population trend for Washington ground squirrels in the upper Columbia Basin, Washington. Parameters were estimated in highest ranked multi-season occupancy models. Data were collected in five study areas in eastern Washington in 2012 and 2017.

Parameter	Estimate	95% CI
$\varepsilon_{2012\text{-}2017}$	0.28	0.11 – 0.45
$\gamma_{2012\text{-}2017}$	0.13	0.05 – 0.22
$\lambda_{2012\text{-}2017}$	0.84	0.61 – 1.07
ψ_{2012}	0.53	0.29 – 0.77
ψ_{2017}	0.45	0.27 – 0.62
p_{2012}	0.91	0.84 – 0.97
p_{2017}	0.60	0.40 – 0.80

DISCUSSION

Our analysis is the first attempt to document long-term trend of the Washington ground squirrel population based on the first of what should be multiple 5-year surveys. Although we are uncertain as to the degree our results reflect “natural”, annual fluctuations in squirrel occupancy, we believe the survey effort was effective in describing conditions of the represented population during the 5-year period. Our sample (202 sites) was fairly robust, and previous work has demonstrated a high probability of squirrel detection at historic sites, thus we believe application of the rigorous survey protocol at both historic and unexplored habitats captured real population changes. Although results suggested the squirrel population during this period was at minimum unstable and perhaps trending toward local extinction, we recommend caution in interpreting the relevance in a larger context due to our relatively short (i.e., 5-year) study period and only two sample points to define "trend". Additional sample points will help explain whether data collected in these two years is relevant to understanding long-term trends.

There is an important caveat necessary for interpretation of these conclusions. Because we excluded private land from the sample our results do not reflect population trends for squirrels located on private land that would supplement the larger population. Thus, decline in the sampled population during the study period does not necessarily reflect lambda for the entire population of ground squirrels in eastern Washington.

The negative association of grazing on initial squirrel occupancy may suggest that some of our study plots were overgrazed and that this reduced occupancy, but without more details or potential quantification of grazing intensity the relevance of this finding is unclear. For example, Bylo et al. (2014) documented both positive and negative effects of cattle grazing on ground squirrel occupancy depending on such factors as elevation and habitat characteristics. We recommend continuing to collect survey information on grazing evidence, as well as badger sign and fire evidence if that can be accomplished without compromising integrity of surveys due to time constraints. Future trend surveys (e.g., 2022) should re-analyze these covariate associations for relationship to occupancy.

The causes for different detection probabilities between the two years is unclear. However, lingering snow cover and subsequent standing water in early spring surveys in 2017 surveys were reported by surveyors in some northern sites, particularly in the Coulee City study area. This may have reduced first survey detections in that area. We recommend capturing covariates related to snow cover and standing water in future assessment of squirrel occupancy. Also, late-afternoon surveys (post 14:00 h) were conducted at 14% of sites in 2017 and may have influenced detection rates based on the tendency for reduced late-afternoon squirrel detections noted by Watson et al. (2016). We recommend that future survey protocols avoid surveys late in the day (e.g., after 1400 h).

ACKNOWLEDGMENTS

Funding for analysis of this project was provided through the Wildlife Program in the Wildlife Science Division of WDFW. Matt Vander Haegen provided critical comments that improved this report.

LITERATURE CITED

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd Edition. Springer-Verlag, New York, New York, USA. 488 pp.

Bylo, L. N., N. Koper, and K. A. Molloy. 2014. Grazing intensity influences ground squirrel and American Badger Habitat use in mixed-grass prairies. Rangeland Ecology & Management 67:247-254.

Mackenzie, D. I., and J. A. Royle. 2005. Designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology 42:1105-1114.

_____, D.I, J.D.Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence. Academic Press, Burlington, Massachusetts.

Watson, J.W., R. Finger, and A. Scott Anderson. 2016. Occupancy and trend modeling of the Washington Ground Squirrel population in the upper Columbia Basin, 2008-2012. Draft Report. Washington Department of Fish and Wildlife. Olympia, Washington.