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Occupancy estimation as a tool to test and refine a predictive species distribution model for the Sacramento Valley red fox (*V.v.patwin*)

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Introduction

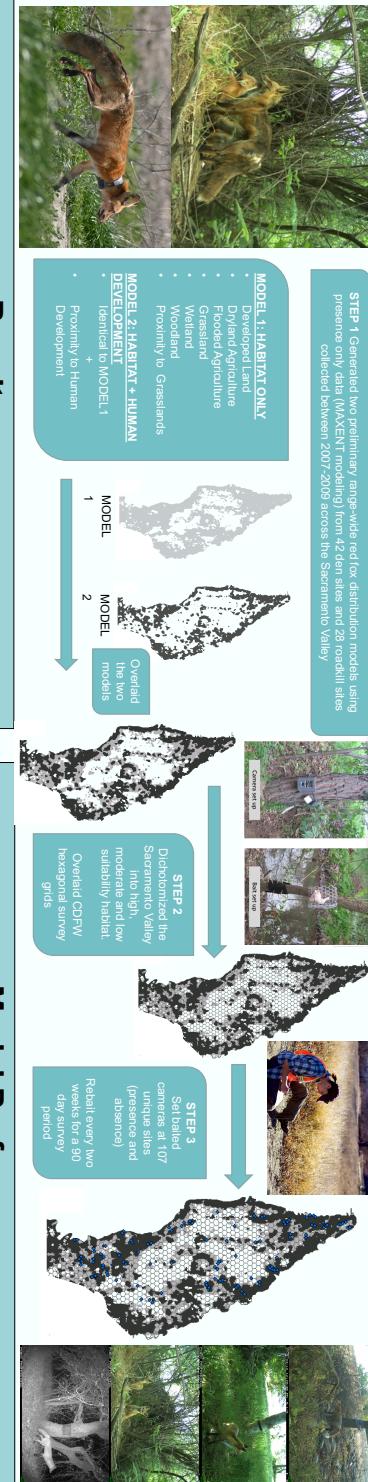
The Sacramento Valley red fox (*SVRF*, *Vulpes patwin*) is endemic to the northern Central Valley of California. It was only recently (2007) identified as native and distinct from the more widely distributed nonnative population of red foxes that currently occupies large portions of California's lowlands (Sacks 2010, Statham 2012; Sacks et al. 2016). Recently, the California Department of Fish and Wildlife (CDFW) listed the SVRF as a Species of Special Concern (SSC) due to the apparent decline in abundance from historic levels, the recognition of its low genetic effective population size ($n = 50$) as well as its restricted and sparse distribution, and the limited amount of information on its current ecological status. Presently, habitat loss and hybridization with non-native red foxes present the most significant threats to the persistence of the SVRF. A preliminary distribution model was generated (using presence only data) in order to guide future survey efforts. This study sought to build upon the original model using systematic camera surveys and occupancy modeling, which incorporates presence and absence data.



Objectives

1. Test utility of a presence only (MAXENT) modeling tool
2. Determine availability of suitable red fox habitat throughout the Sacramento Valley
3. Estimate abundance of Sacramento Valley red fox throughout its range

Methods Flowchart



Model Performance

Model averaged occupancy of the Sacramento Valley 32.76%
Sacramento Valley is ~12,000km²
There is ~4,000km² of suitable red fox habitat
4km² - 10km² territory size of SVRF breeding pair
ESTIMATED 400-1,000 breeding pairs of SVRF

Conclusions

1. Our detection results during the occupancy survey in each of the three MAXENT classifications (high (35.6%), moderate (32.3%), low (0%) probability of detection) support the utility of the original model.
2. Using the model averaged results from our occupancy survey we were able to determine that ~33% of the Sacramento Valley is occupied by the SVRF. This number likely corresponds to the availability of suitable habitat.
3. Though we do not yet have home range estimates for the SVRF, using predicted home range sizes from other red fox subspecies, we estimate the abundance of SVRF to be between 400-1,000 breeding pairs.

References

We thank David Wright and Canh Nguyen of the California Department of Fish and Wildlife (CDFW) for cooperation and assistance as well as the many private landowners who granted us access to conduct research activities on their property. This work was funded by the UC, Davis Veterinary Genetics Laboratory, United States Fish and Wildlife Service, and CDFW. For more information about our research or to report a red fox sighting, please visit <http://foxsurvey.ucdavis.edu>.

Table 1. Model selection table for top 4 (ΔAICc < 4) models, with null model shown for reference. ΔAICc is Akaike's Information Criterion corrected for overdispersion ($\delta = 20.44$) and small sample size ($n = 100$). ΔAICc is the relative difference in AICc between the top ranked model. Covariates shown in blue indicate a negative response variable, while covariates shown in red indicate a positive response variable, and those in grey indicate the covariate was not included in that model. Covariates denoted with a * indicate the 95% confidence intervals of the beta coefficients did not overlap zero (i.e. significant directional relationship)

	Woodland	Dry Agriculture	Development	Human Density	Distance to Grassland	Distance To Development
Model 1	*	*	*	*	*	*
Model 2	*	*	*	*	*	*
Model 3	*	*	*	*	*	*
Model 4	*	*	*	*	*	*
Model 5	*	*	*	*	*	*
Model 6	*	*	*	*	*	*
NULL						



Acknowledgements

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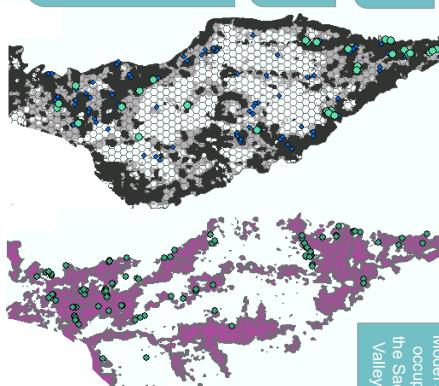


Figure 1. Selection indices. Still need to write out this caption. Basically update these selection indices to reflect the 6 covariates in the table below.

Figure 2. Showing final dichotomized predictive surface based on predicted average probability of occurrence. The gray dots show independent covariates not used in the generation of this model that further show the relative accuracy of this updated model.

