

# Least Bell's Vireo Habitat Suitability Model for California

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# Least bell's Vireo (LBVI) Presentation Outline

- Background & Purpose
- Modeling approach
- Environmental Grids – So Ca & CA
- Calibration & Evaluation Datasets
- Model Results
- Habitat Relationships
- Model Refinements
- Exploring Model Predictions



# Background

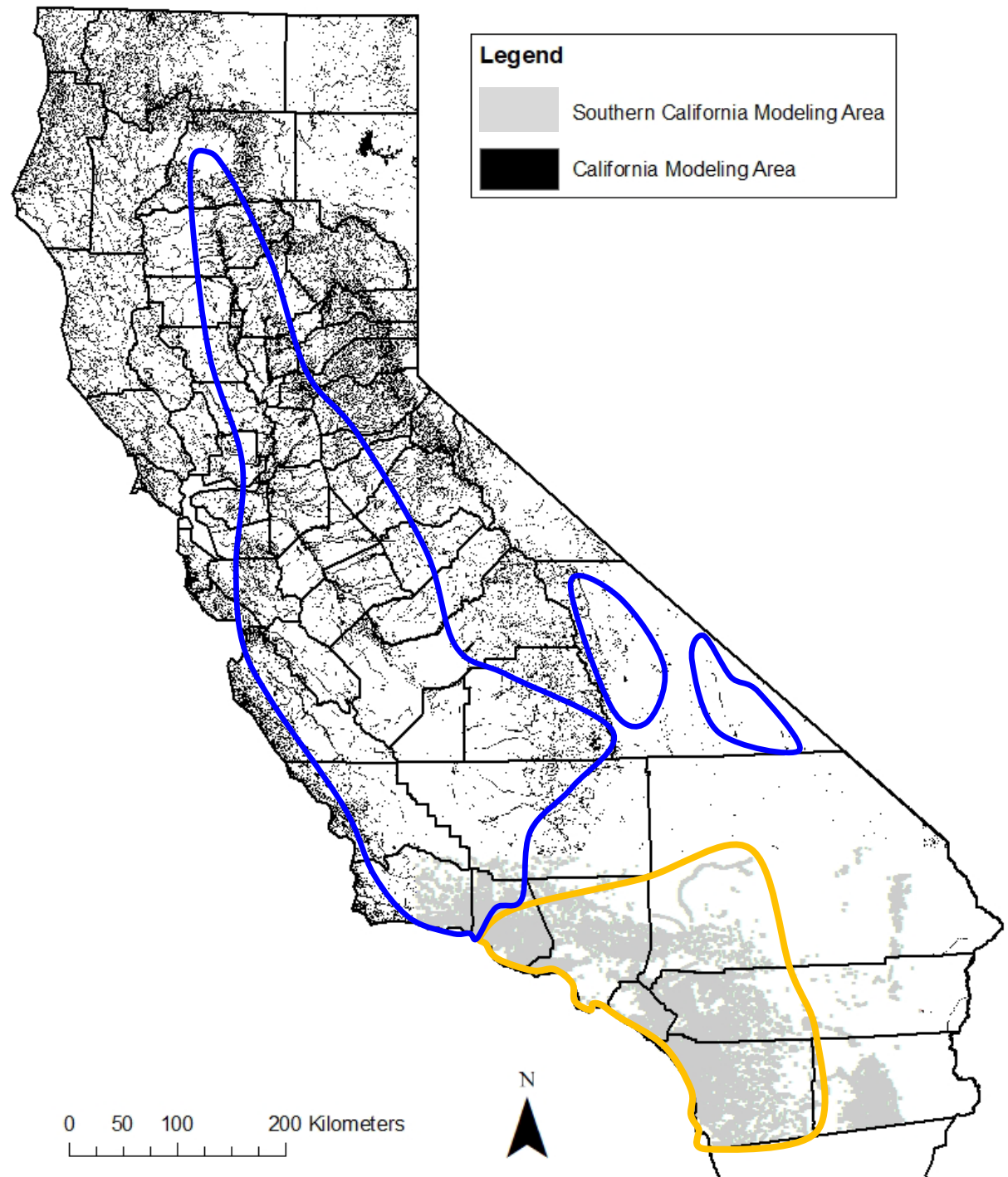
- LBVI formerly abundant in CA riparian habitats:
  - ✓ Central Valley
  - ✓ Sacramento Valley
  - ✓ Coast south of Bay Area
  - ✓ So CA
- Steep popn decline:
  - ✓ “Current” range = So CA
- Popn mgmt & conservation in So CA
  - ✓ Recent limited expansion into “historic” range





# Least Bell's Vireo California Range

- Blue - Historic Range
- Orange - Current Range



# LBVI Recovery Criteria



- Stable or ↑ popns:
  - ✓ So Ca (11 key popns)
  - ✓ Salinas River
  - ✓ San Joaquin Valley
  - ✓ Sacramento Valley
- Threats eliminated (BHCO & habitat loss/degradation)



# Purpose of Model → Contribute to Recovery

- ID habitat to survey in “historic” range
- ID habitat enhancement opportunities to support key popns
- Habitat relationships - historic vs current range



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# Least Bell's Vireo Habitat Model

Predicts high & very  
high habitat  
suitability



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# Least Bell's Vireo Habitat Model

- Model created from obs. in “current” So CA range
- Predicts potential habitat across CA including “historic” range



This is not easy to do!

# Partitioned Mahalanobis D<sup>2</sup> Approach

- Model calculates similarity of each point in landscape to multivariate mean of variables at vireo locations
- Partition full model into separate additive components
- Components represent independent combinations of species-habitat relationships

*Rotenberry et al. 2002, 2006*

*Knick et al. 2013*

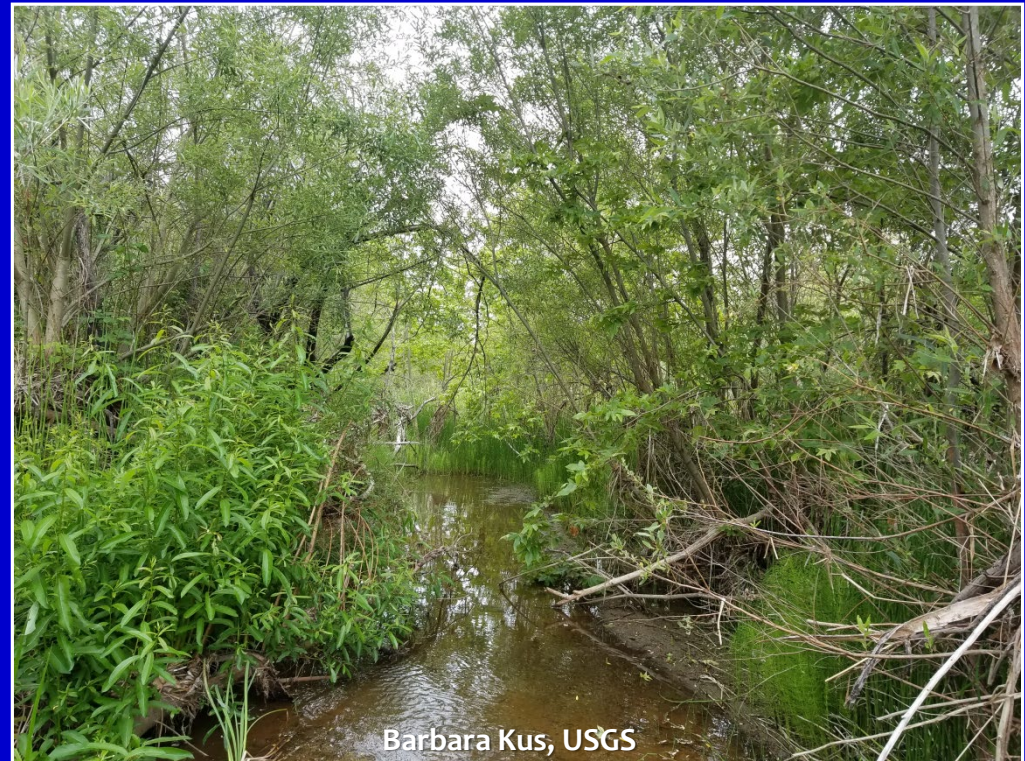


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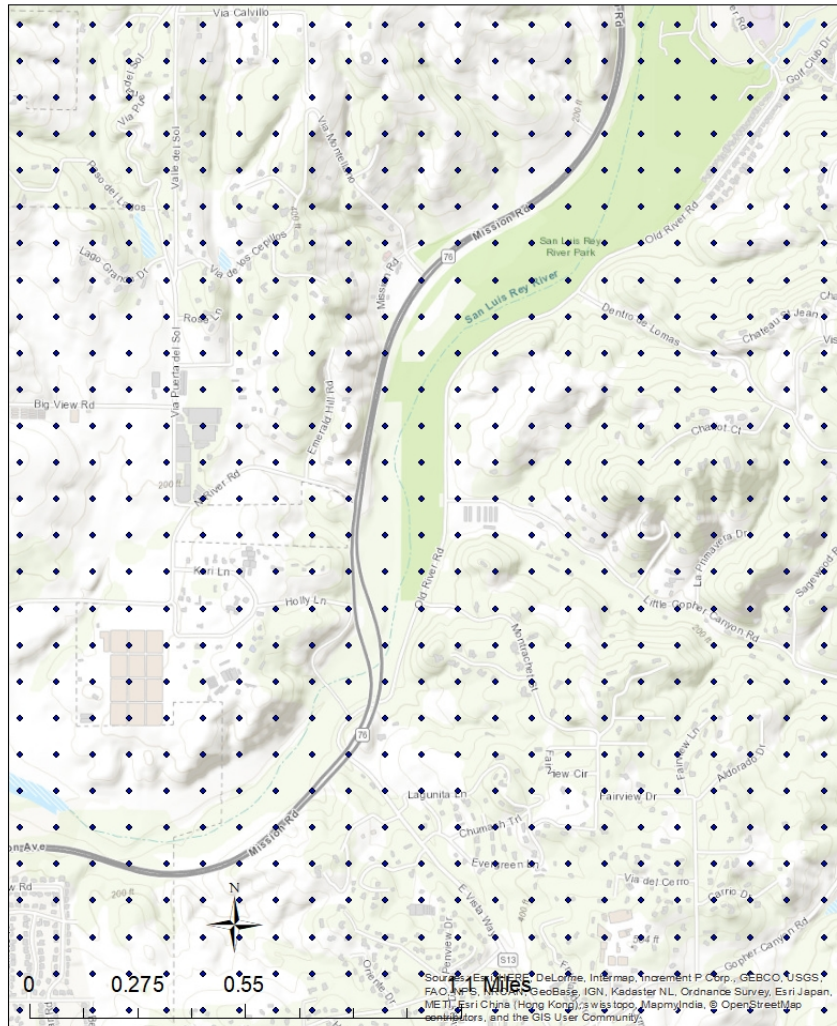
# Partitioned Mahalanobis D<sup>2</sup> Approach

- Environmental variables with wide range of values where species occur are less informative than those maintaining consistent value (limiting)
- This approach works well when predicting habitat in novel or changing conditions

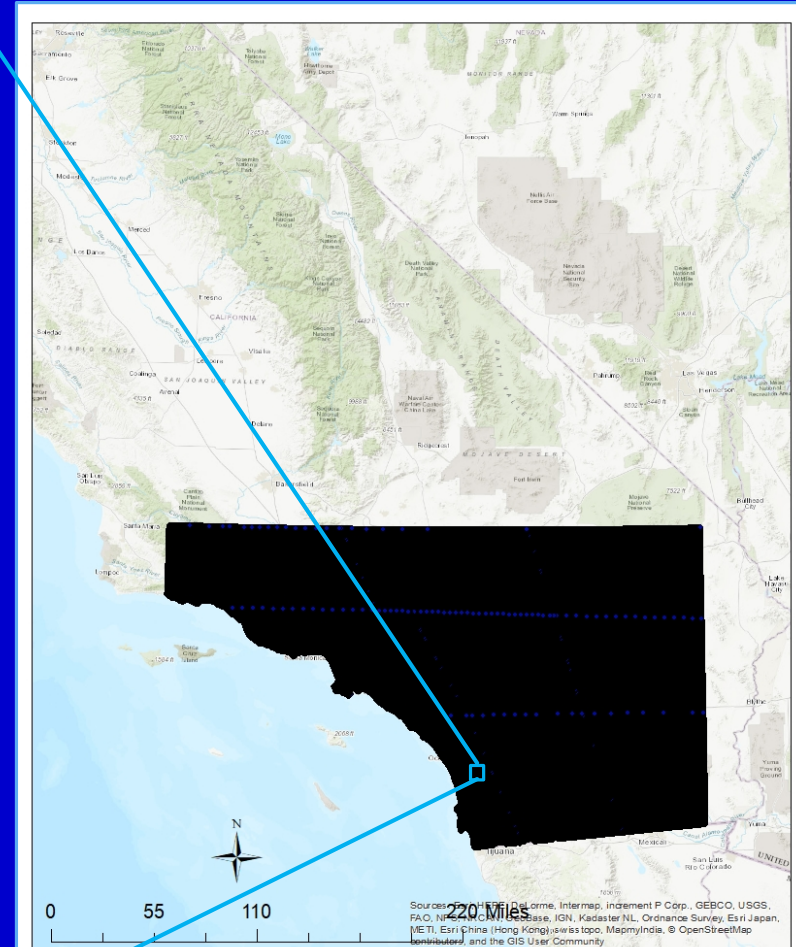




# So CA Modeling Grid (~3.8 million grid pts)



Close-up Least Bell's Vireo Southern California Modeling Area

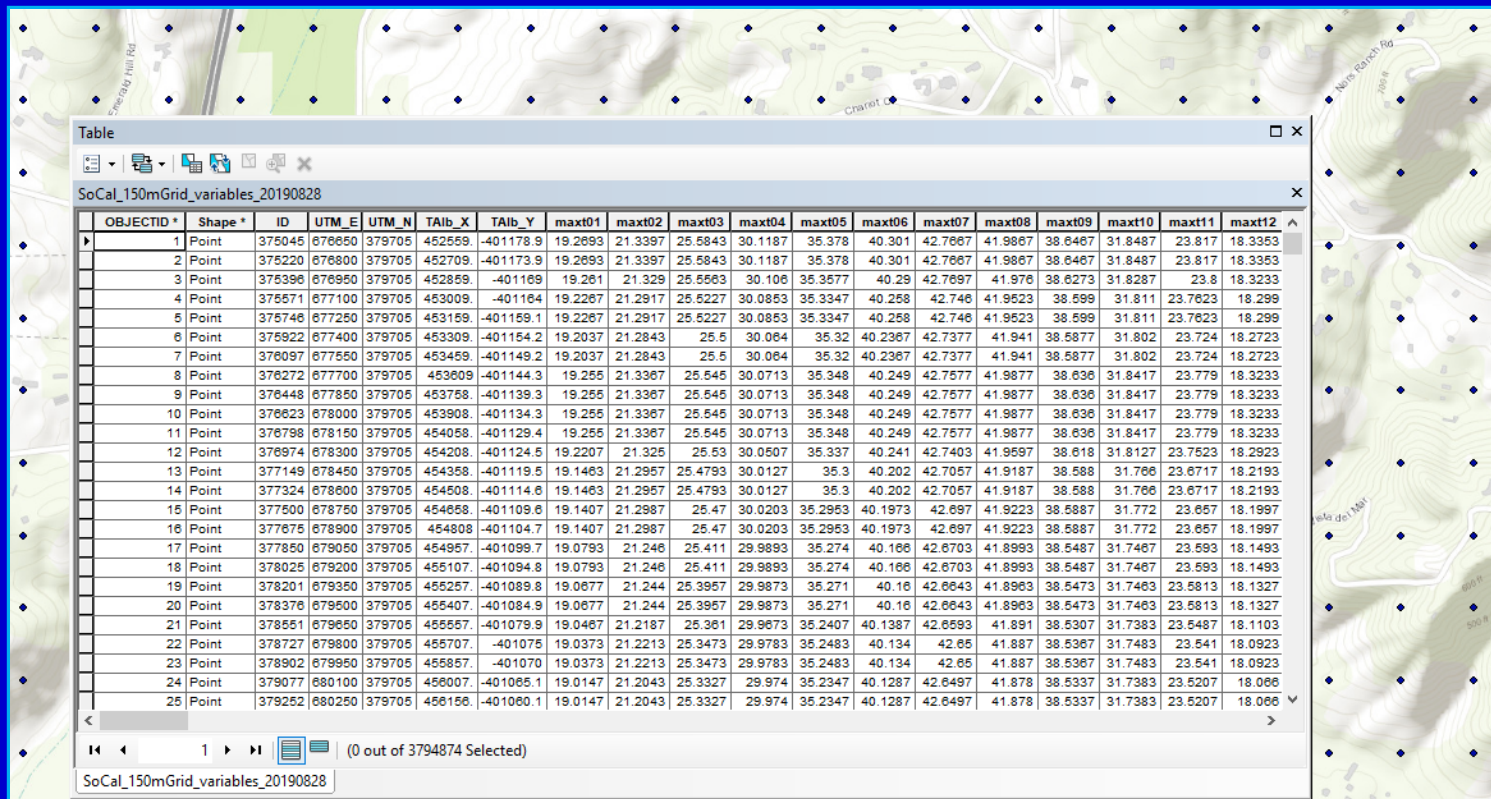


Least Bell's Vireo Southern California Modeling Area



# Variables Calculated at Each Grid Point

- Climate
- Topography
- Riparian vegetation
- Land use
- Normalized Difference Vegetation Index (NDVI)



Table

SoCal\_150mGrid\_variables\_20190828

OBJECTID *	Shape *	ID	UTM_E	UTM_N	TAIB_X	TAIB_Y	maxt01	maxt02	maxt03	maxt04	maxt05	maxt06	maxt07	maxt08	maxt09	maxt10	maxt11	maxt12
1	Point	375045	676650	379705	452559	-401178.9	19.2693	21.3397	25.5843	30.1187	35.378	40.301	42.7667	41.9867	38.6467	31.8487	23.817	18.3353
2	Point	375220	676800	379705	452709	-401173.9	19.2693	21.3397	25.5843	30.1187	35.378	40.301	42.7667	41.9867	38.6467	31.8487	23.817	18.3353
3	Point	375396	676950	379705	452859	-401169	19.261	21.329	25.5563	30.106	35.3577	40.29	42.7697	41.976	38.6273	31.8287	23.8	18.3233
4	Point	375571	677100	379705	453009	-401164	19.2267	21.2917	25.5227	30.0853	35.3347	40.258	42.746	41.9523	38.599	31.811	23.7623	18.299
5	Point	375746	677250	379705	453159	-401159.1	19.2267	21.2917	25.5227	30.0853	35.3347	40.258	42.746	41.9523	38.599	31.811	23.7623	18.299
6	Point	375922	677400	379705	453309	-401154.2	19.2037	21.2843	25.5	30.064	35.32	40.2367	42.7377	41.941	38.5877	31.802	23.724	18.2723
7	Point	376097	677550	379705	453459	-401149.2	19.2037	21.2843	25.5	30.064	35.32	40.2367	42.7377	41.941	38.5877	31.802	23.724	18.2723
8	Point	376272	677700	379705	453609	-401144.3	19.255	21.3367	25.545	30.0713	35.348	40.249	42.7577	41.9877	38.636	31.8417	23.779	18.3233
9	Point	376448	677850	379705	453758	-401139.3	19.255	21.3367	25.545	30.0713	35.348	40.249	42.7577	41.9877	38.636	31.8417	23.779	18.3233
10	Point	376623	678000	379705	453908	-401134.3	19.255	21.3367	25.545	30.0713	35.348	40.249	42.7577	41.9877	38.636	31.8417	23.779	18.3233
11	Point	376798	678150	379705	454058	-401129.4	19.255	21.3367	25.545	30.0713	35.348	40.249	42.7577	41.9877	38.636	31.8417	23.779	18.3233
12	Point	376974	678300	379705	454208	-401124.5	19.2207	21.325	25.53	30.0507	35.337	40.241	42.7403	41.9597	38.618	31.8127	23.7523	18.2923
13	Point	377149	678450	379705	454358	-401119.5	19.1463	21.2957	25.4793	30.0127	35.3	40.202	42.7057	41.9187	38.588	31.766	23.6717	18.2193
14	Point	377324	678600	379705	454508	-401114.6	19.1463	21.2957	25.4793	30.0127	35.3	40.202	42.7057	41.9187	38.588	31.766	23.6717	18.2193
15	Point	377500	678750	379705	454658	-401109.6	19.1407	21.2987	25.47	30.0203	35.2953	40.1973	42.697	41.9223	38.5887	31.772	23.657	18.1997
16	Point	377675	678900	379705	454808	-401104.7	19.1407	21.2987	25.47	30.0203	35.2953	40.1973	42.697	41.9223	38.5887	31.772	23.657	18.1997
17	Point	377850	679050	379705	454957	-401099.7	19.0793	21.246	25.411	29.9893	35.274	40.166	42.6703	41.8993	38.5487	31.7467	23.593	18.1493
18	Point	378025	679200	379705	455107	-401094.8	19.0793	21.246	25.411	29.9893	35.274	40.166	42.6703	41.8993	38.5487	31.7467	23.593	18.1493
19	Point	378201	679350	379705	455257	-401089.8	19.0677	21.244	25.3957	29.9873	35.271	40.16	42.6643	41.8963	38.5473	31.7463	23.5813	18.1327
20	Point	378376	679500	379705	455407	-401084.9	19.0677	21.244	25.3957	29.9873	35.271	40.16	42.6643	41.8963	38.5473	31.7463	23.5813	18.1327
21	Point	378551	679650	379705	455557	-401079.9	19.0467	21.2187	25.361	29.9673	35.2407	40.1387	42.6593	41.891	38.5307	31.7383	23.5487	18.1103
22	Point	378727	679800	379705	455707	-401075	19.0373	21.2213	25.3473	29.9783	35.2483	40.134	42.65	41.887	38.5367	31.7483	23.541	18.0923
23	Point	378902	679950	379705	455857	-401070	19.0373	21.2213	25.3473	29.9783	35.2483	40.134	42.65	41.887	38.5367	31.7483	23.541	18.0923
24	Point	379077	680100	379705	456007	-401065.1	19.0147	21.2043	25.3327	29.974	35.2347	40.1287	42.6497	41.878	38.5337	31.7383	23.5207	18.066
25	Point	379252	680250	379705	456156	-401060.1	19.0147	21.2043	25.3327	29.974	35.2347	40.1287	42.6497	41.878	38.5337	31.7383	23.5207	18.066

(0 out of 3794874 Selected)

SoCal\_150mGrid\_variables\_20190828

# So CA Environmental Grid

- **Climate**

- ✓ annual & seasonal precip
- ✓ min and max temps
- ✓ cumulative water deficit

- **Topography**

- ✓ median elev, slope & topo heterogeneity - 150m
- ✓ % flat land - 150 & 500m
- ✓ Distance to stream (m)



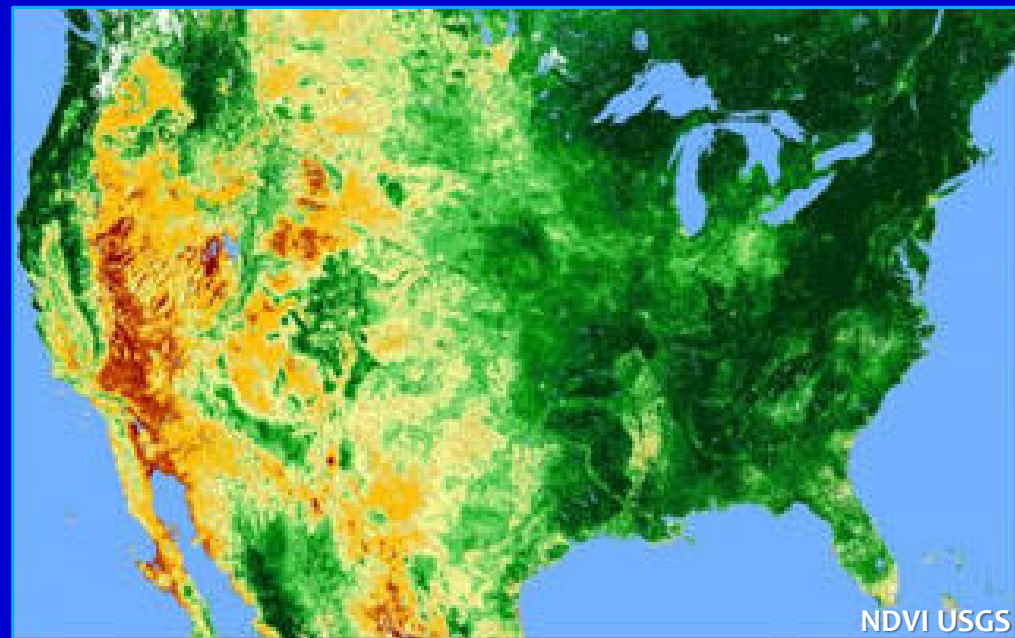
# Riparian Vegetation (150, 500 & 1000 m scales)

Multiple Veg Maps Cross-Walked & Merged:

- Various detailed veg maps for So CA
- Fire Resource Assess Prog 2015 Veg Map
- Klausmeyer et al. 2016 Groundwater Dependent Ecosystems Map

# So CA Environmental Grid

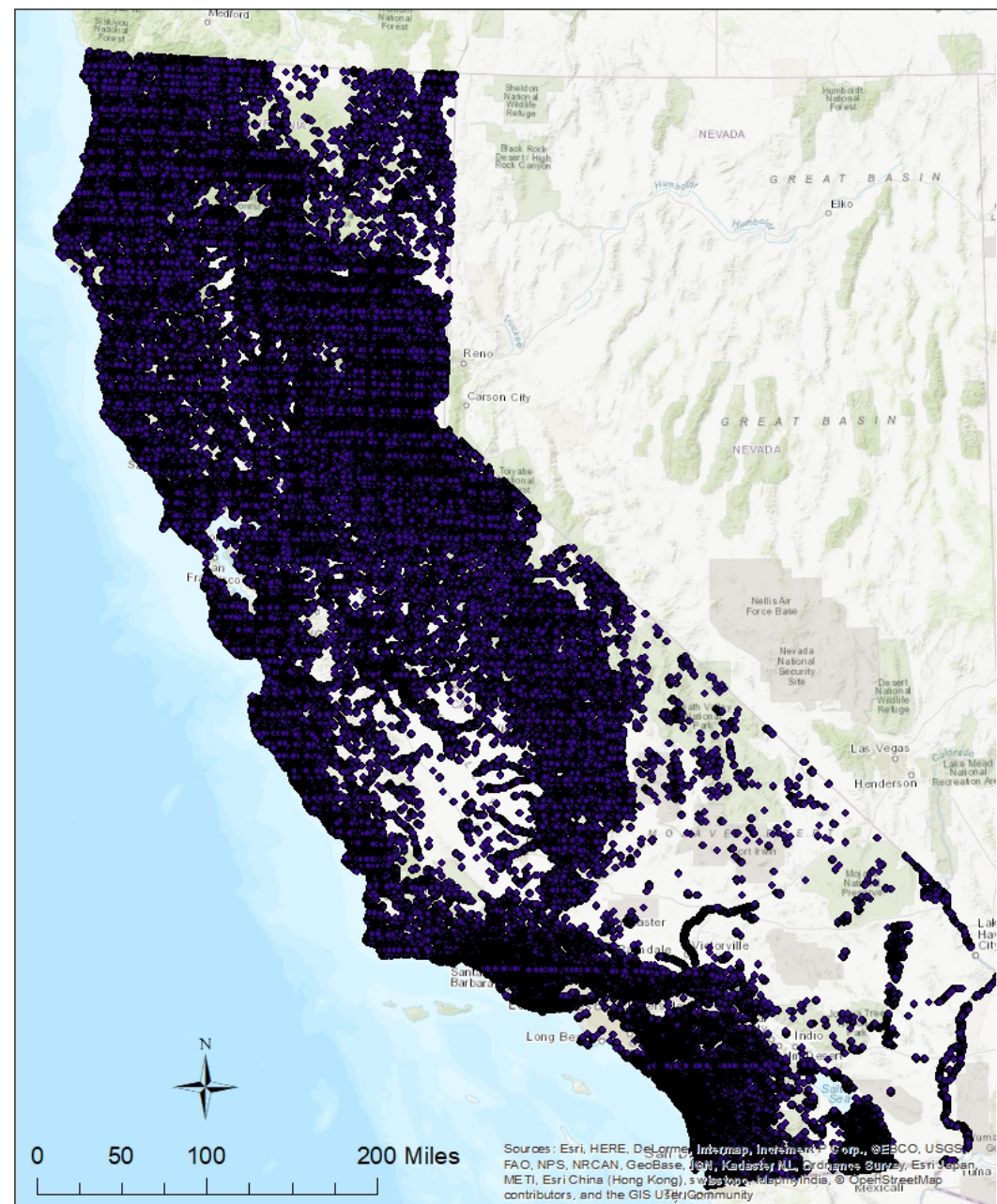
- Land use (% urban 150, 500 & 1000m scales)
- Normalized Difference Vegetation Index (NDVI)
  - ✓ NDVI mean, Max at 150 & 500m scales
  - ✓ NDVI % 150m  $\geq 0.25$ , 0.40 & 0.56





# CA Environmental Grid

- Calculated variables for entire state (~14 million grid pts)
- Clipped to riparian with 500m buffer (~2.5 million grid pts)



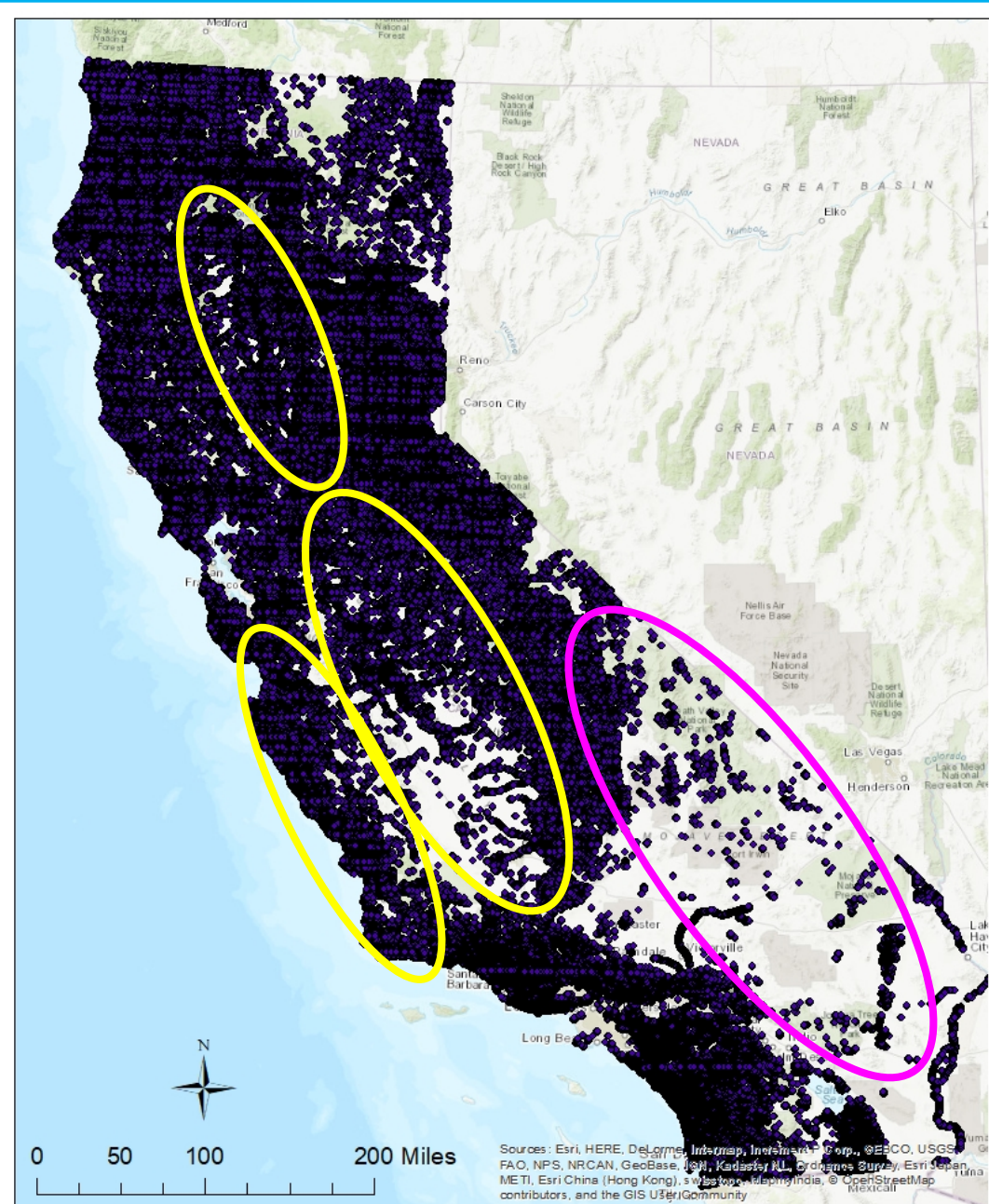
California Riparian Modeling Area



Preliminary Information-Subject to  
Not for Citation

# Historic Range

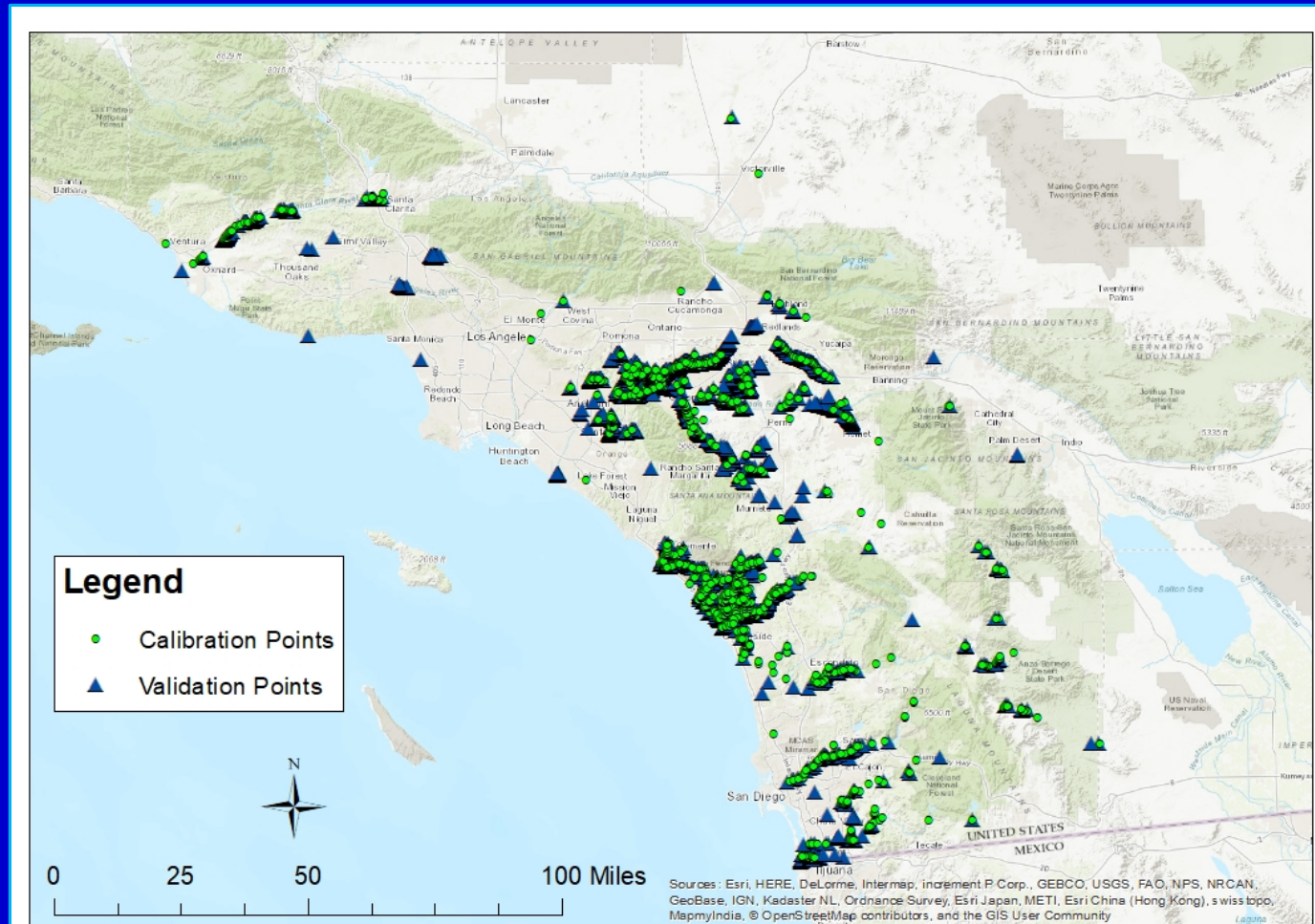
- Not all of CA = LBVI historic range
- Historic range =
  - ✓ Sacramento Valley
  - ✓ Central Valley
  - ✓ Central Coast
- Subspecies taxonomy of eastern popns uncertain





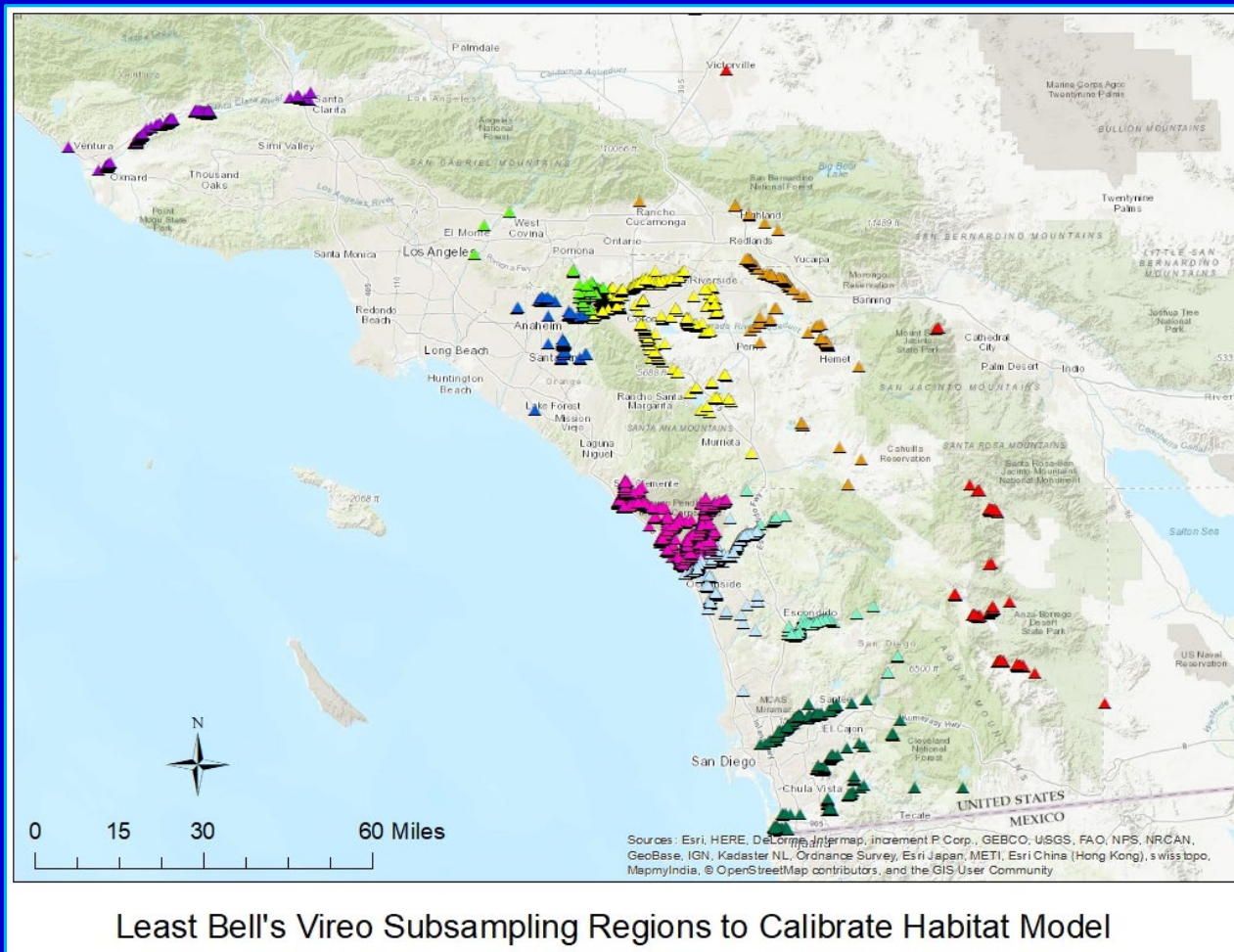
# Creating & Evaluating So CA Habitat Model in Current Range

- 2,270 so CA vireo locations → calibrate models
- 3,530 so CA vireo locations → evaluate models



Least Bell's Vireo Location Records Used for Model Calibration & Validation

# Subsampling Strategy (Knick et al. 2013)



- 70 randomly selected/ 10 subregions → **create** model
- repeat **1,000** iterations & **average** results across models



# So CA Model Approach

- Construct & evaluate alt Mahalanobis  $D^2$  models
- Predictions = Habitat Similarity Index (HSI):
  - ✓ 0 - 1.0 (Low to Very High suitability)
- Compare Model HSIs - calibration & validation datasets
- Calculate HSIs for all points in model grid



# So CA Model Evaluation

- **Validation Datasets:**
  - ✓ Randomly selected
  - ✓ 2016, 2017 & 2018 - ave, above ave & below ave rainfall
- 3,530 presence locations & 3,566 pseudo-absences → calculate Area Under Curve (AUC)
  - ✓ Measures how well model predicts classes
  - ✓ AUC ranges from 0-1.0;  $<0.5$  = poor, 1.0 = excellent



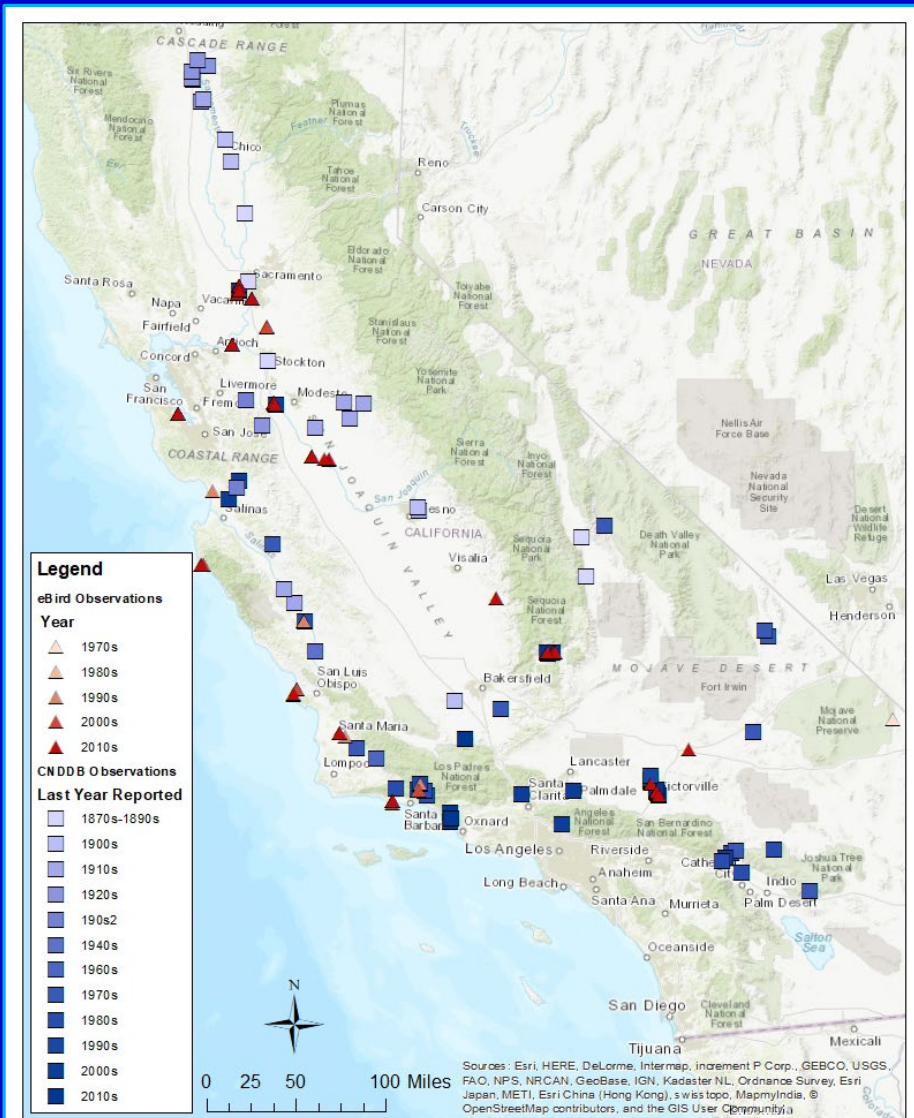


# Evaluating Model Predictions Outside So CA

## Model Grid

Inspect predictions & environmental variable statistics at historic & recent vireo locations:

- 70 historic & recent CNDDDB locations
- 131 eBird locations



Historic & Recent Least Bell's Vireo Observations Outside the Southern California Range

# LBVI TOP MODELS





Model Number	Model 30 Selected Local scale topography, riparian, dist to Water	Model 29 Selected Local scale topography, riparian, dist to Water & CWD	Model 22 Pre-Breed Climate & Local Scale Topography, Land Use, Dist to Water & CWD	Model 18 Breed Climate & Local Scale Topography & Land Use	Model 27 Selected Local scale topography, riparian, NCVI25_pe, dist to Water &
<b>Environmental Variables</b>					
NDVImean15 (150 m)					
NDVImean50 (500 m)					
NDVImax150					
NDVIMax500					
NDVI025_pe (500 m)					X
dem150m			X	X	
slp150m	X	X	X	X	X
topo150m			X	X	X
Ripkla150P	X	X	X	X	X
Ripkla500P					
Urb150mPer			X	X	
Urb500mPer					
flat150mpe	X	X	X		X
WaterDistrm	X	X	X		X
PREC_OD_AV					
PREC_JM_AV			X		
PREC_AJ_AV				X	
PREC_ANN_T					
MINT_OD_AV					
MINT_JM_AV			X		
MINT_AJ_AV				X	
MAXT_OD_AV					
MAXT_JM_AV			X		
MAXT_AJ_AV				X	
CWD_ANN_TO		X	X		X
<b>Model Results</b>					
Number of Partitions	4	5	11	8	7
Selected Partition	1	2	1	1	1
Eigenvalue Selected Partition	2.198	0.996	3.159	2.443	2.763
<b>AUC</b>	<b>0.976</b>	<b>0.969</b>	<b>0.967</b>	<b>0.977</b>	<b>0.979</b>
Median Selected Partition Calib HSI	0.699	0.749	0.730	0.706	0.710
Median Selected Partition Random (All Rainfall) Valid	0.697	0.776	0.711	0.712	0.704
All SNR Validation Points (n = 3,530)					
Median Selected Partition Pres Valid HSI	0.647	0.662	0.716	0.716	0.659
Pseudo-absences (n = 3,565)					
Median Selected Partition Abs Valid HSI	0.000	0.000	0.000	0.000	0.000



Preliminary Information-Subject to Revision.  
Not for Citation

# Take Home Point

**Simple model is best!!!**

Complex So CA models don't extrapolate well to rest of CA





Model Number	Model 30 Selected Local scale topography, riparian, dist to Water	Model 29 Selected Local scale topography, riparian, dist to Water & CWD	Model 22 Pre-Breed Climate & Local Scale Topography, Land Use, Dist to Water & CWD	Model 18 Breed Climate & Local Scale Topography & Land Use	Model 27 Selected Local scale topography, riparian, NCVI25_pe, dist to Water &
Environmental Variables					
NDVI <sub>mean15</sub> (150 m)					
NDVI <sub>mean50</sub> (500 m)					
NDVI <sub>max150</sub>					
NDVI <sub>max500</sub>					
slp150m	X	X	X	X	X
topo150m			X	X	X
Ripkla150P	X	X	X	X	X
Ripkla500P					
flat150mpe	X	X	X		X
WaterDistm	X	X	X		X
Model Results					
Number of Partitions	4	5	11	8	7
Selected Partition	1	2	1	1	1
Eigenvalue Selected Partition	2.198	0.996	3.159	2.443	2.763
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# LBVI Habitat Suitability Model

- Current range
  - ✓ 846,241 ha modeled
  - ✓ 47,171 ha (5.6%) suitable
- Historic range
  - ✓ 2,468,491 ha modeled
  - ✓ 145,146 (5.9%) suitable



# Important Variables in LBVI Model

- **% Riparian 150m-scale**

Occupied ave.  $\pm$  STD =  $64\% \pm 30$

- **% Flat Ground 150m-scale**

Occupied ave.  $\pm$  STD =  $62\% \pm 29$

- **Median slope 150m-scale**

Occupied ave.  $\pm$  STD =  $2.6\% \pm 4.3$

- **Distance to water (m)**

Occupied ave.  $\pm$  STD =  $133.7 \pm 230$

**Table 2.** Environmental variable means and std calculated for the least Bell’s vireo calibration dataset and for riparian modeling grids in the historic and current ranges. Values highlighted in gray are those for which the historic and/or current range falls outside 95% of observations in the calibration dataset (mean ± 2 std).

Environmental Variables	Mean ± std		
	Historic range	Current range	Calibration dataset
Sample size	601,118	319,443	2,270
NDVImean150	0.60 ± 0.13	0.53 ± 0.17	0.50 ± 0.13
NDVImean500	0.59 ± 0.12	0.53 ± 0.16	0.47 ± 0.12
NDVImax150	0.92 ± 0.08	0.66 ± 0.17	0.66 ± 0.11
NDVIMax500	0.96 ± 0.05	0.76 ± 0.14	0.73 ± 0.09
dem150m	223.56 ± 342.74	530.19 ± 424.31	140.73 ± 163.14
slope150m	5.89 ± 8.81	14.14 ± 11.31	<b>2.65 ± 4.33</b>
topo150m	306.57 ± 284.54	600.23 ± 174.95	400.08 ± 257.10
riparian150p	0.09 ± 0.20	0.08 ± 0.19	<b>0.64 ± 0.30</b>
riparian500p	0.09 ± 0.44	0.08 ± 0.13	0.44 ± 0.26
urban150p	0.06 ± 0.20	0.17 ± 0.34	0.10 ± 0.20
urban500m	0.06 ± 0.17	0.18 ± 0.29	0.17 ± 0.21
flat150m	0.57 ± 0.44	0.18 ± 0.29	<b>0.62 ± 0.29</b>
waterdistm	204.56 ± 256.64	257.50 ± 296.59	<b>133.73 ±230.14</b>
prec OD av	163.58 ± 74.00	108.75 ± 41.56	86.48 ± 14.94
prec JM av	271.89 ± 105.03	263.11 ± 105.15	204.06 ± 38.13
prec AJ av	58.83 ± 28.53	40.64 ± 16.05	31.50 ± 5.08
prec anntot	504.30 ±206.90	424.31 ± 162.17	329.11 ± 55.08
minT OD av	6.0 ± 1.44	7.91 ± 2.51	8.65 ± 1.10
minT JM av	4.53 ± 1.54	5.80 ± 2.56	6.99 ± 1.08
minT AJ av	10.44 ± 1.94	16.03 ± 2.76	17.49 ± 1.22
maxT OD av	19.09 ± 1.49	21.60 ± 2.41	22.82 ± 0.91
maxT JM av	16.12 ± 1.61	18.39 ± 2.61	19.97 ± 0.73
maxT AJ av	26.12 ± 2.65	35.79 ±3.94	34.50 ± 4.05
cwd anntot	907.20 ± 169.35	1085.41 ± 126.85	1119.42 ± 59.33



# Important Variables in LBVI Model – Suitable vs Unsuitable Habitat across California

- **% Riparian 150m-scale**

Suitable significantly more (64% vs 4%)

- **% Flat Ground 150m-scale**

Suitable significantly more (62% vs 25%)

- **Median slope 150m-scale**

Suitable significantly less (3% vs 13%)

- **Distance to water (m)**

No significant difference

**Table 3.** Assessment of historic and recent least Bell’s vireo observations (CNDDDB 2018 and eBird 2019) and R30-P1 model performance in California’s historic range. Aerial photographs were used to assess conditions on the ground to determine the status of vireo observations and accuracy of riparian vegetation mapping at observation areas.

Obs. Status	No. of Obs.	Developed	Small amount riparian	Undeveloped but not riparian	Available riparian	Riparian mapping adequate	Riparian mapping too restrictive	Riparian mapping too expansive	Model performs poorly	Model performs marginally	Model performs well
Extirpated	8 (13%)	8	0	0	0	6	0	2	2	0	6
Potentially extirpated	31 (49%)	0	21	0	10	23	4	4	1	6	24
Extant or potentially extant (vireo observed after 1990)	24 (38%)	0	11	2	11	13	5	6	0	10	14
Total	63	8 (13%)	32 (51%)	2 (3%)	21 (33%)	42 (67%)	9 (14%)	12 (19%)	3 (5%)	16 (25%)	44 (70%)



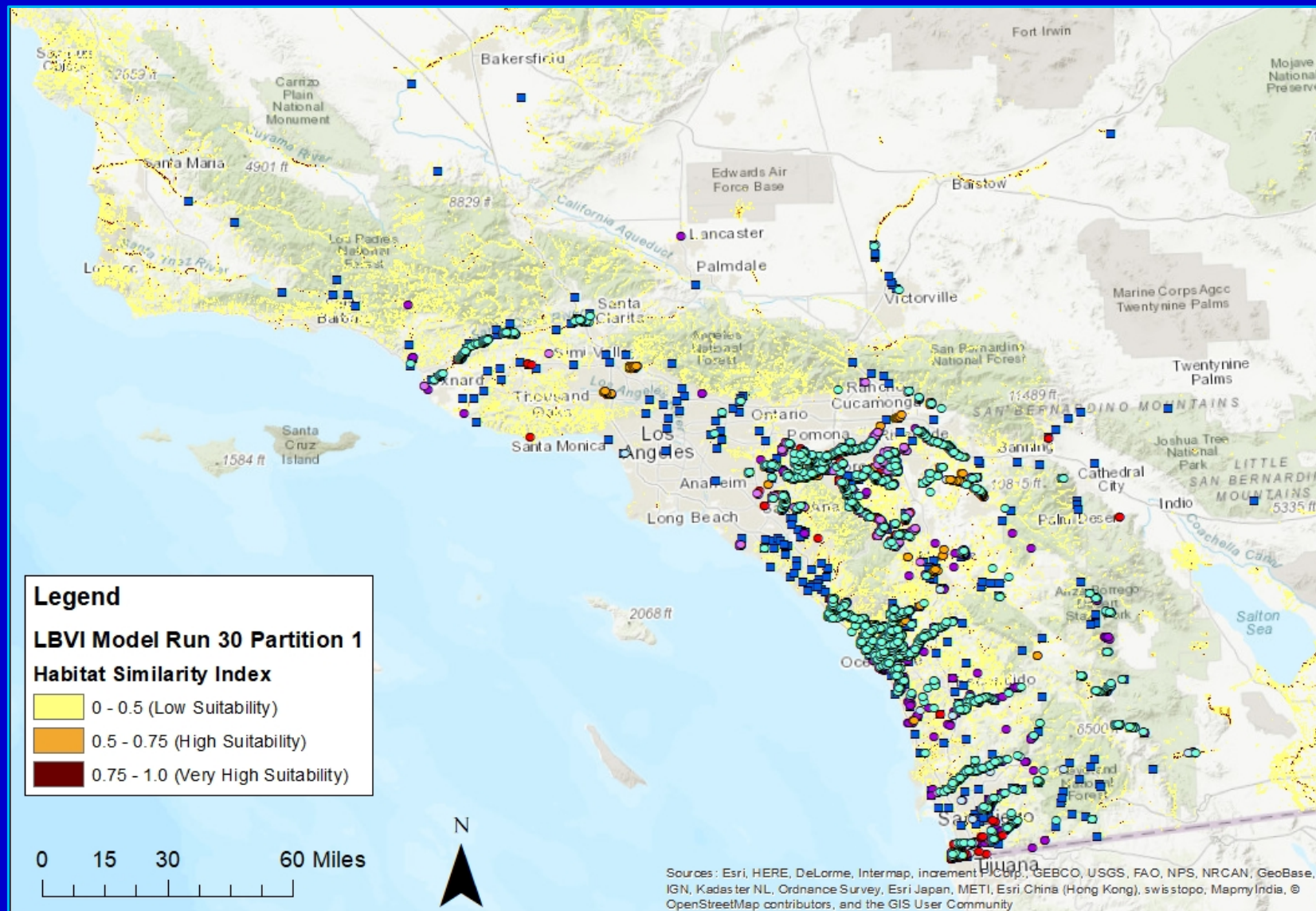




## Least Bell's Vireo Predicted Habitat Suitability for Southern California



Preliminary Information-Subject to Revision.  
Not for Citation



## Least Bell's Vireo Historic & Current Observations & Predicted Habitat Suitability for Southern California



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Not for Citation



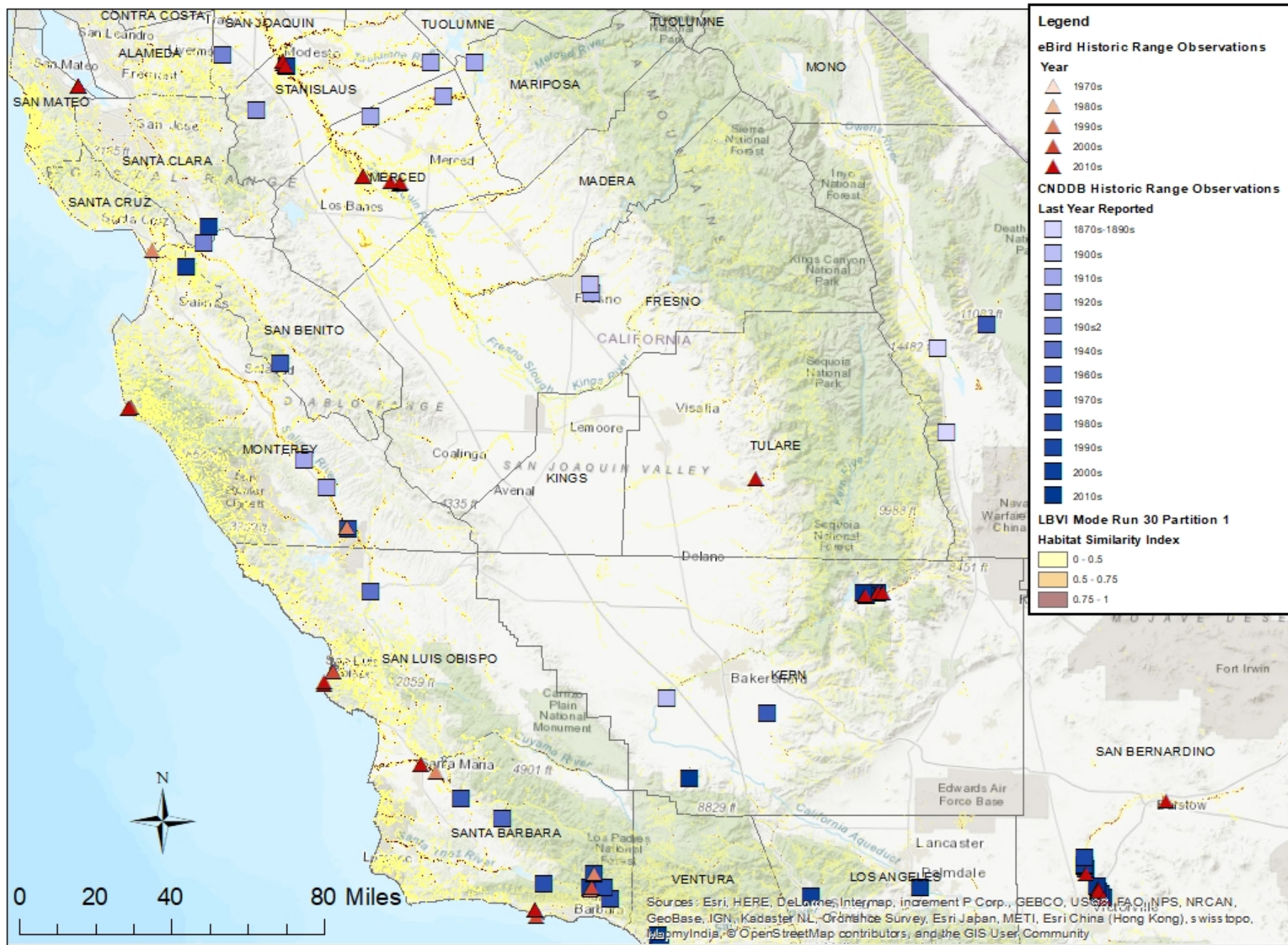


Least Bell's Vireo Predicted Habitat Suitability for California









Least Bell's Vireo Habitat Suitability in Central California

# Models are Hypotheses

- Models ≠ “Truth”
- Represent current understanding of habitat relationships
- Iterative - can be improved with more information



# Using Habitat Model for Surveys

- In evaluating model performance we can't rely on vireo occupancy
  - Vireos do not occur in most of historic range
- We can get feedback from surveys on habitat characteristics to refine model for historic range
- Prioritize surveys for areas with significant amounts of suitable habitat
- In these areas - survey stream reaches & collect simple field data at both High, Very High & Low suitability points

# Refining Model for Entire State

- Vegetation mapping issues
  - ✓ Dynamic system
  - ✓ Inconsistent veg classification & mapping across CA
- Dist to Stream may vary across state relative to so Ca
  - ✓ Wide floodplain systems in historic range (vs So CA)
- Collect LBVI location & habitat data in historic range to refine future models



# Information to Collect During LBVI Surveys to Refine Model in Historic Range

**Field Data to Evaluate Least Bell's Vireo (LBVI) Predicted Habitat Suitability**

Site: \_\_\_\_\_ Date: \_\_\_\_\_ Surveyors(s): \_\_\_\_\_

Point #: \_\_\_\_\_ Coordinates: Easting: \_\_\_\_\_ Northing: \_\_\_\_\_

Coordinate System/Datum: \_\_\_\_\_ / \_\_\_\_\_

LBVI Detected? Yes / No # obs. \_\_\_\_\_ Sex(es): \_\_\_\_\_ Breeding? \_\_\_\_\_

Rank up to three vegetation groups within 75m radius of the survey point in order of dominance (1-3). Record top three tree/shrub species in order of dominance.

<u>Vegetation Type</u>	<u>Dominance</u>	<u>Species</u>
Riparian Woodland	_____	_____
Riparian Scrub	_____	_____
Non-Native Dominated Riparian	_____	_____
Other (list): _____	_____	_____
Other (list): _____	_____	_____

Potential to Support LBVI? (circle one & explain in notes)    Low            Moderate            High

Notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Photo Numbers: \_\_\_\_\_


Preston, K.L., Kus, B.E., and Perkins, E.E.,  
2019, Least Bell's vireo habitat suitability  
model for California (2019): U.S. Geological  
Survey data release

[HTTPS://DOI.ORG/10.5066/P90T9WT2](https://doi.org/10.5066/P90T9WT2)



Preliminary Information-Subject to Revision.  
Not for Citation





**Thank You!!!!  
Questions?**



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Not for Citation

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