Integrating Remote-Sensing and Ecological Forecasting into Decision-Support for Wetland Wildlife Management and Ecosystem Services in the Central Valley of California: Optimizing Across Multiple Benefits (NNX17AG81G)

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NASA Biodiversity and Ecological Forecasting Team Meeting

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Project Team

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Central Valley has <10% wetlands remaining
Wetland habitat is dynamic – driven by weather and management

Dybala et al. 2018

Reiter et al. 2015
Coordinated Data-Driven Decision Support Optimizes Water Management to Achieve Multiple-Benefits for today and 100 years from now

Where to put water and when to maximize multiple benefits?

Biological Targets
- Waterfowl
- Shorebirds
- Giant Garter Snake

Ecosystem Service Targets
- Groundwater Recharge
- Freshwater Biodiversity

Groundwater Recharge
Objectives and Decisions

Within-year forecasts of biological and ecosystem services targets

- TNCs dynamic conservation program – BirdReturns
- Annual wetland water management planning (Federal, State, Private)

Long-term forecasts (50-100 years) of biological and ecosystem services targets under multiple scenarios

- Strategic implementation of Central Valley Joint Venture habitat goals
- Habitat restoration potential maps for USFWS
Our Workflow

Year 1-2: Spatial Covariates
Year 1-2: Species Distribution Models
Year 2-3: Driver covariate forecasts
Year 2-3: Forecast Species & Services
Year 3: Optimize
Year 3-4: Decisions
Water

Open Water Data
2000-2018
(Landsat 5 & 8)

Surface Water Probability

July 1-15

Spatial Covariates

Source(s): PRBO Conservation Science, The Nature Conservancy of California

Reiter et al. 2018
Hotspots of Change in Drought

Managed Seasonal Wetland

Proportion Open Water

- Non-drought
- Drought
- Extreme Drought

Change Dry
-0.1 - 0.75
-0.75 - 0.5
-0.5 - 0.25
-0.25 - 0
0 - 1

Spatial Covariates

Reiter et al. 2018
Habitat Quantity / Quality

Landsat 5 & 8
2007-2017

Wetland Vegetation Type

- Swamp Timothy: 32,369 ha ± 2,524 ha
- Watergrass/Smartweed: 13,012 ha ± 1,384 ha

Spatial Covariates

Crop Productivity

Swamp Timothy

Watergrass/Smartweed

Point Blue

USGS

The Nature Conservancy

NASA
Significantly more swamp timothy and less productivity in critical drought years across the Central Valley, public and private lands.

Byrd et al. In prep
What are the key drivers?

- Bird data (Point Blue structured surveys/filtered eBird)
- Snake capture data
- Boosted Regression Trees
- Identify key drivers for forecasting
- Assessed Real-Time versus Long-Term Average
- Drought vs. Non-Drought Years
Suitability varies by species

AUC: 0.89 0.92 0.93 0.89
Suitability is seasonally dynamic
Suitability is dynamic among years.
Giant Garter Snake

**Covariates**

Average (2001-2017) of flooding for two week periods and the period March 1-Oct 15

Fraction of landscape that is growing rice, fallow rice and post-harvest flooded rice

**Density of canals at 300m, 1000m, and 3000m**

Density of streams at 300m, 1000m, and 3000m

Average and standard deviation (across 2001-2016) of day of year of maximum greenness

Average and standard deviation (across 2001-2016) of maximum NDVI
Variable Importance

Species Distribution Models

- DUNL
- DOWI
- AMAV
- BNST
Forecasting – Within Year

- Forecast of where to put water to achieve objectives
  - April

- Revised forecast based on observed productivity metrics
  - Sept - April_{t+1}

- Final forecast incorporates observed flooding patterns and allocations to wetlands through December
  - January_{t+1}

Driver covariate forecasts
Forecasting Water – Within Year

Model forecast accuracy varied by month... wetter months were harder to forecast

Accuracy → 80-90%

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Time Period</th>
<th>Source</th>
<th>Importance</th>
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</thead>
<tbody>
<tr>
<td>10-year average water (pixel)</td>
<td>10-year</td>
<td>Landsat 8</td>
<td>66-95%</td>
</tr>
<tr>
<td>Basin</td>
<td>NA</td>
<td>CVJV</td>
<td>3-11%</td>
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<tr>
<td>Water Supply Index</td>
<td>WSI forecast monthly</td>
<td>CA DWR</td>
<td>7-16%</td>
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<tr>
<td>Months in the future</td>
<td>NA</td>
<td>calculated</td>
<td></td>
</tr>
<tr>
<td>Month predicted to</td>
<td>NA</td>
<td>calculated</td>
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Water Tracker
www.pointblue.org/watertracker
Forecasting – Future

WEAP-CV (Matchett and Fleskes 2017)

LUCAS (Wilson et al. 2016)

Spatially Explicit Projections
Forecasting Recharge Benefits

Climate
- Hot Dry
- Hot Variable
- Historic

Vegetation

Water Management
- Unimpaired
- 2000-2017 Average
- Conservation Flooding

Basin Characterization Model
Spatially Explicit Water Balance Model

Recharge Maps
2000-2100 by scenario

Site specific estimates of recharge across scenarios

Natural recharge (acre-ft/month)
Managed recharge (acre-ft/month)

- Natural (left y-axis)
- Rice flooding (right y-axis)
- Extended flooding (right y-axis)
Thank You