Accounting for Wetlands

Improving Data and Management Tools for an Important, but Understudied Water User in California

United States Committee on Irrigation & Drainage (USCID)

Fall 2024 Conference

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Outline

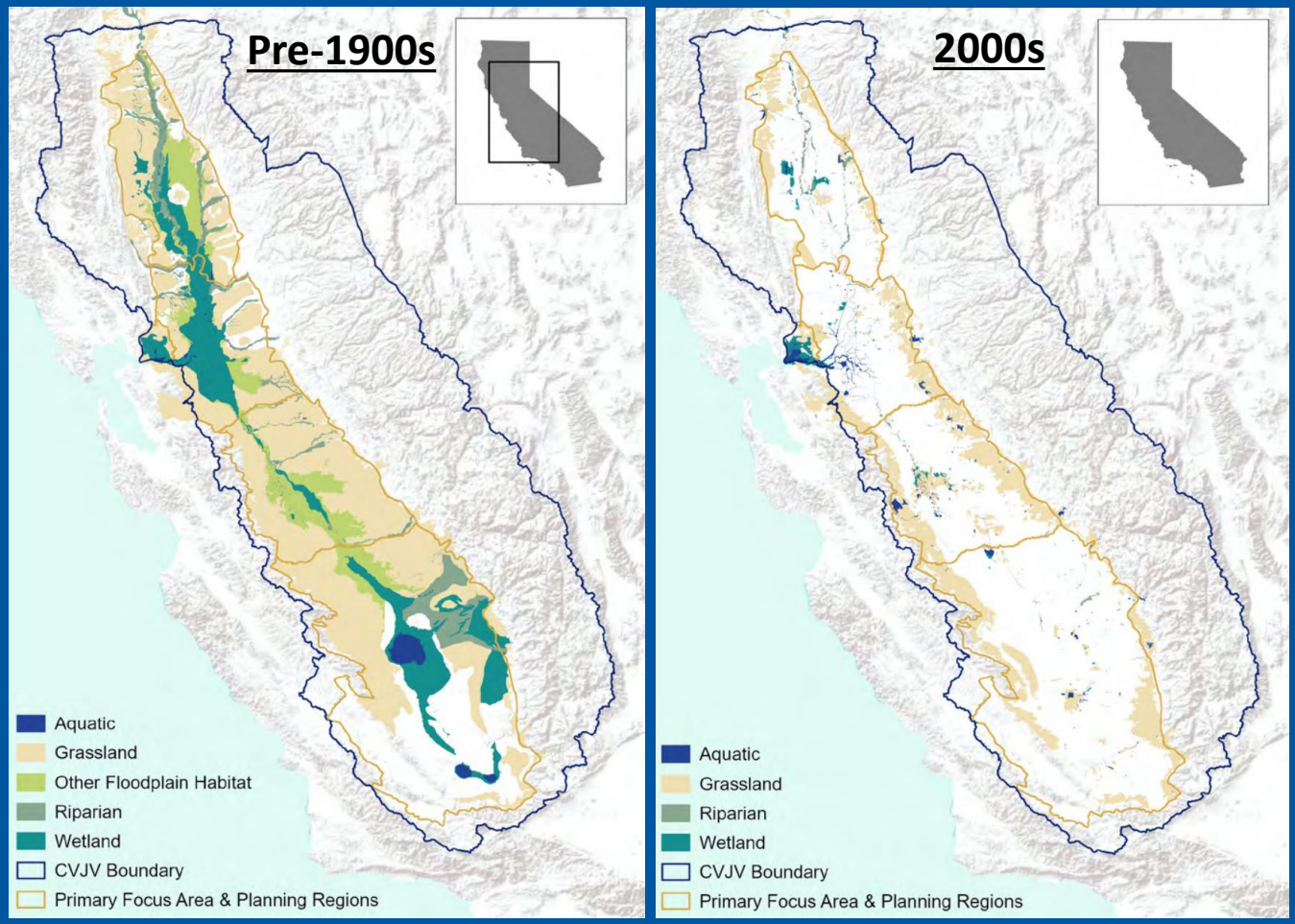
- History & Benefits of Wetlands
- Wetlands Water Budget Tool (WWBT)
- Water Accounting for Wetlands
- Evapotranspiration Study for Wetlands
- Recommended Next Steps
- Questions & Discussion

Cover Image: Naturebridge.org – Merced NWR

History of Wetlands in California

- 1850s: ~4M acres of wetlands
- Present: ~220k acres of wetlands
- ***Loss of nearly 95% of wetlands***

- Today nearly all are managed lands
- The majority are privately owned (hunting clubs), the remainder are public lands (mostly state and federal)



CVJV 2020; Dennis et al. 1984; Frayer et al. 1989; Dahl 1990

Benefits of Wetlands

- Hotspots of biodiversity
  - Migrating waterfowl and shorebirds
  - Anadromous fish
  - Other plant, amphibian, bird species

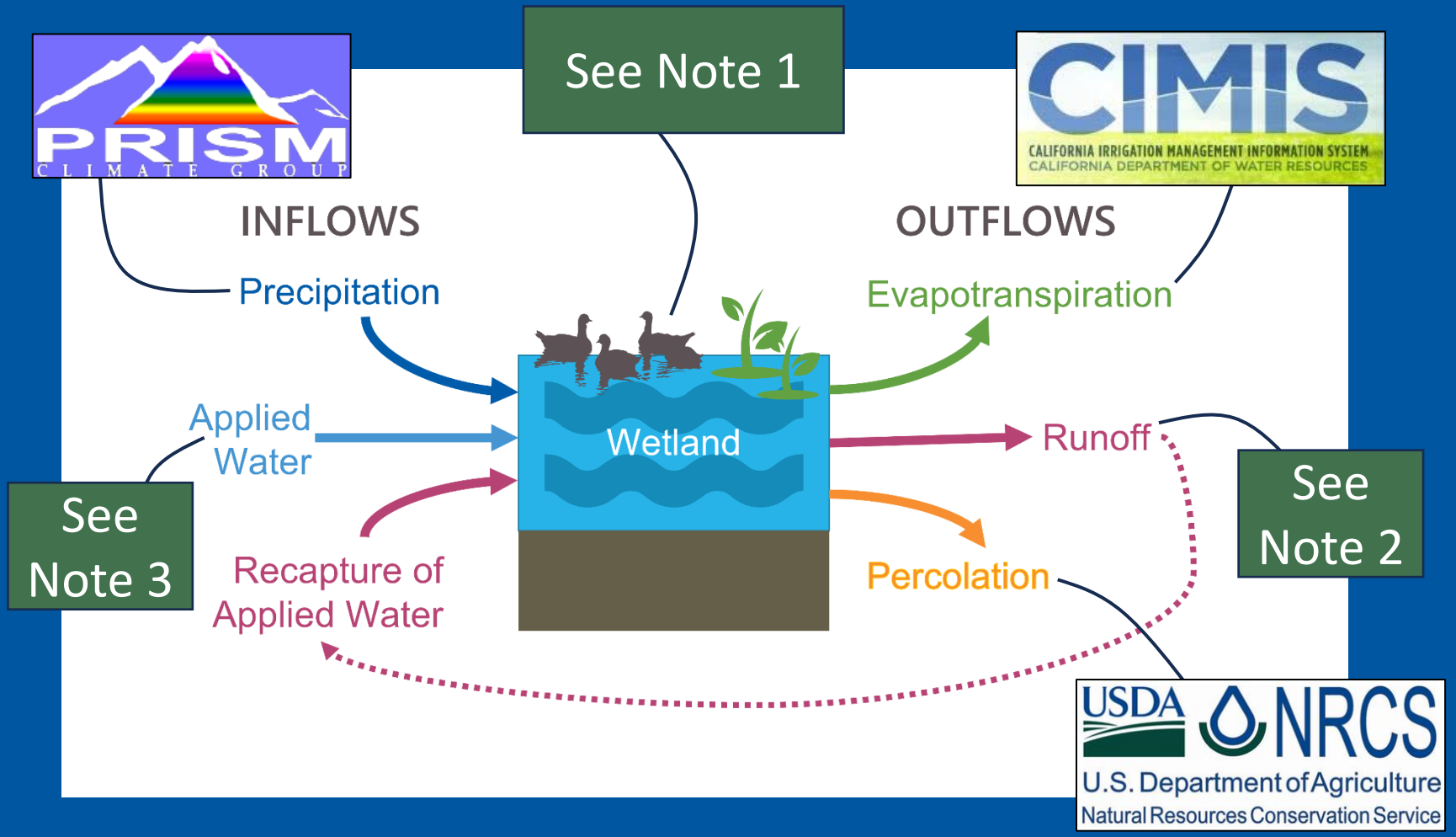
- Flood control
- Water quality improvements
- Recreational opportunities
- Carbon sequestration
- Groundwater recharge

Ducks Unlimited; The New York Times; NOAA

Wetlands Water Budgets? Why?

- Concerns over water supply reliability for the few remaining wetlands areas in California.
- “You can’t manage a resource you don’t measure.”
- Similar to a budget on a checking account, a water budget allows for evaluation of existing inflows and outflows and can inform management.

Wetlands Water Budgets? How?



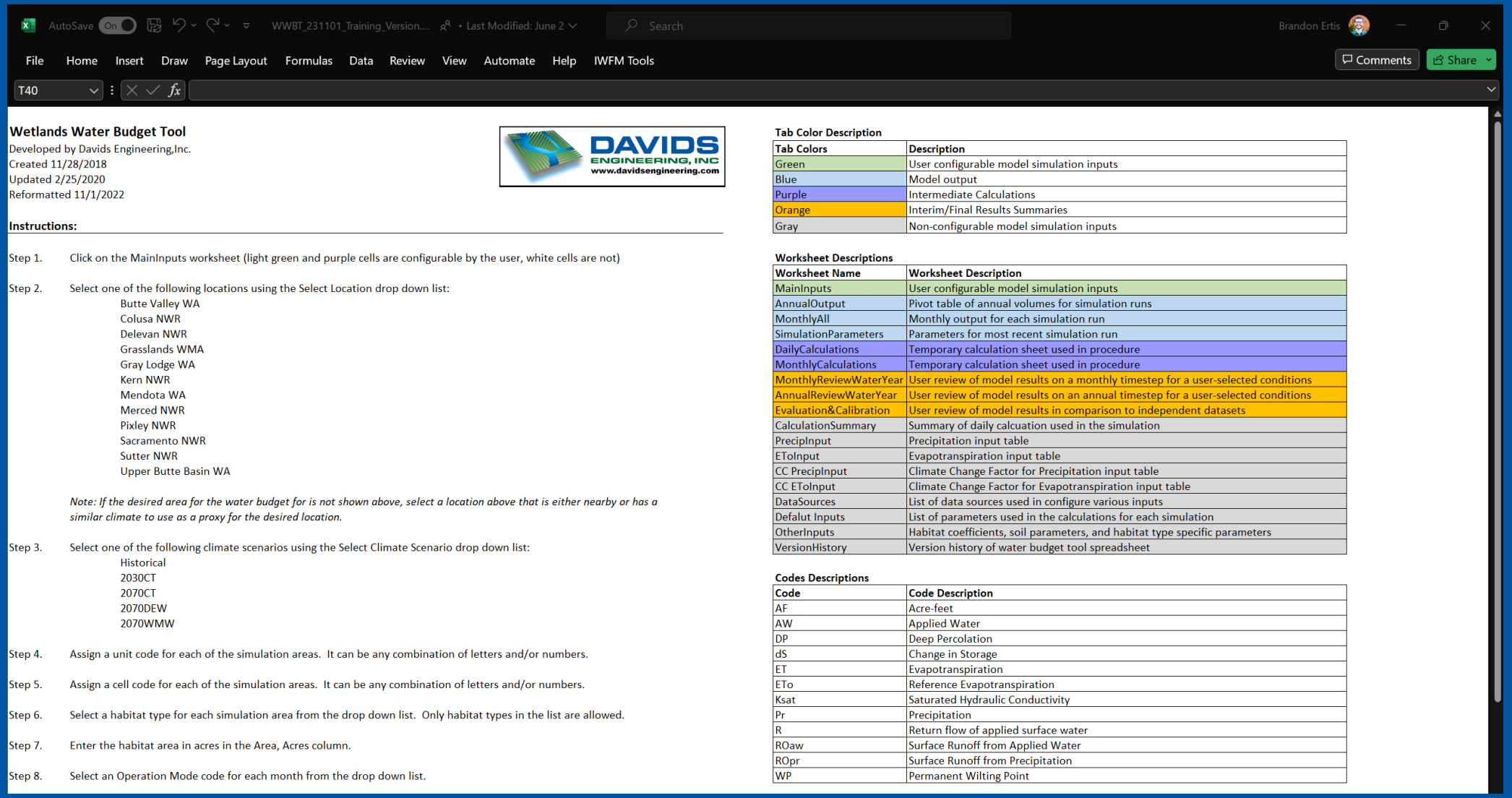
Notes:
1. Coordination with wetlands managers to understand monthly operations and water management practices.
2. Runoff (of precipitation and applied water) and recapture are modeled based on other flow paths, monthly operations, input from wetlands managers, etc.
3. Applied water is closure term, solved by balance of all other flows. Compared to delivery data (if available) for evaluation of water budget results.

Water Budget Tool created in Excel for broad accessibility and use by wetlands managers and others.

Excel

Dybala et al. 2023 (unpublished)

Wetlands Water Budget Tool (WWBT)



Wetlands Water Budget Tool
Developed by Davids Engineering,Inc.
Created 11/28/2018
Updated 2/25/2020
Reformatted 11/1/2022

Instructions:

Step 1. Click on the MainInputs worksheet (light green and purple cells are configurable by the user, white cells are not)

Step 2. Select one of the following locations using the Select Location drop down list:
- Butte Valley WA
- Colusa NWR
- Delevan NWR
- Grasslands WMA
- Gray Lodge WA
- Kern NWR
- Mendota WA
- Merced NWR
- Pixley NWR
- Sacramento NWR
- Sutter NWR
- Upper Butte Basin WA

Note: If the desired area for the water budget for is not shown above, select a location above that is either nearby or has a similar climate to use as a proxy for the desired location.

Step 3. Select one of the following climate scenarios using the Select Climate Scenario drop down list:
- Historical
- 2030CT
- 2070CT
- 2070DEW
- 2070WMW

Step 4. Assign a unit code for each of the simulation areas. It can be any combination of letters and/or numbers.

Step 5. Assign a cell code for each of the simulation areas. It can be any combination of letters and/or numbers.

Step 6. Select a habitat type for each simulation area from the drop down list. Only habitat types in the list are allowed.

Step 7. Enter the habitat area in acres in the Area, Acres column.

Step 8. Select an Operation Mode code for each month from the drop down list.

Tab Color Description

Tab Colors	Description
Green	User configurable model simulation inputs
Blue	Model output
Purple	Intermediate Calculations
Orange	Interim/Final Results Summaries
Gray	Non-configurable model simulation inputs

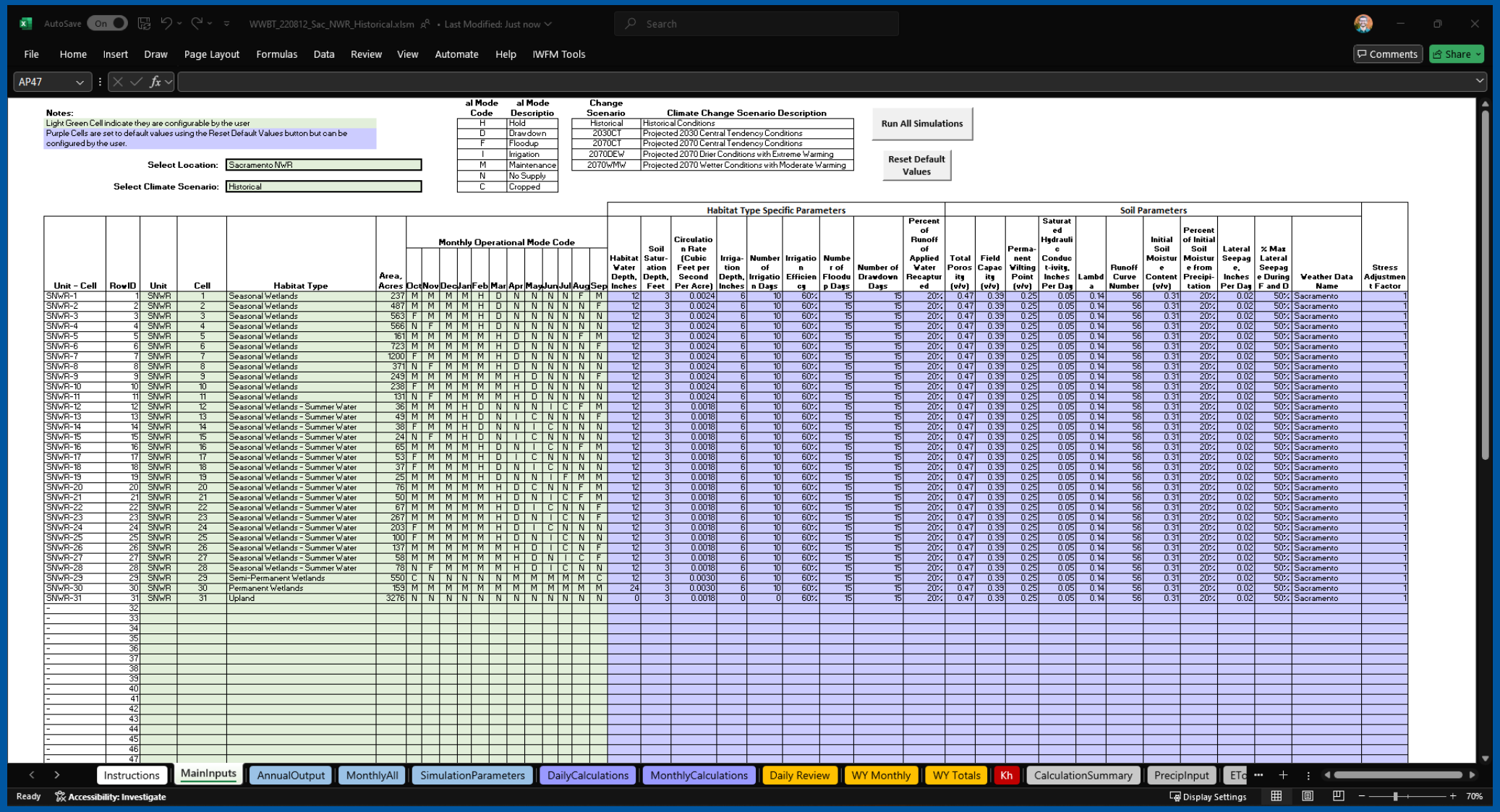
Worksheet Descriptions

Worksheet Name	Worksheet Description
MainInputs	User configurable model simulation inputs
AnnualOutput	Pivot table of annual volumes for simulation runs
MonthlyAll	Monthly output for each simulation run
SimulationParameters	Parameters for most recent simulation run
DailyCalculations	Temporary calculation sheet used in procedure
MonthlyCalculations	Temporary calculation sheet used in procedure
MonthlyReviewWaterYear	User review of model results on a monthly timestep for a user-selected conditions
AnnualReviewWaterYear	User review of model results on an annual timestep for a user-selected conditions
Evaluation&Calibration	User review of model results in comparison to independent datasets
CalculationSummary	Summary of daily calcuation used in the simulation
PrecipInput	Precipitation input table
EToInput	Evapotranspiration input table
CC PrecipInput	Climate Change Factor for Precipitation input table
CC EToInput	Climate Change Factor for Evapotranspiration input table
DataSources	List of data sources used in configure various inputs
Defalut Inputs	List of parameters used in the calculations for each simulation
OtherInputs	Habitat coefficients, soil parameters, and habitat type specific parameters
VersionHistory	Version history of water budget tool spreadsheet

Codes Descriptions

Code	Code Description
AF	Acre-feet
AW	Applied Water
DP	Deep Percolation
dS	Change in Storage
ET	Evapotranspiration
ETo	Reference Evapotranspiration
Ksat	Saturated Hydraulic Conductivity
Pr	Precipitation
R	Return flow of applied surface water
ROaw	Surface Runoff from Applied Water
ROpr	Surface Runoff from Precipitation
WP	Permanent Wilting Point

Wetlands Water Budget Tool (WWBT)



Notes:
Light Green Cell indicate they are configurable by the user
Purple Cells are set to default values using the Reset Default Values button but can be configured by the user.

Select Location: Sacramento NWR

Select Climate Scenario: Historical

Operational Mode Code	Operational Mode Description
H	Hold
D	Drawdown
F	Floodup
I	Irrigation
M	Maintenance
N	No Supply
C	Cropped

Change Scenario	Climate Change Scenario Description
Historical	Historical Conditions
2030CT	Projected 2030 Central Tendency Conditions
2070CT	Projected 2070 Central Tendency Conditions
2070DEW	Projected 2070 Drier Conditions with Extreme Warming
2070WMW	Projected 2070 Wetter Conditions with Moderate Warming

Run All Simulations

Reset Default Values

							Monthly Operational Mode Code												Habitat Type Specific Parameters									Soil Parameters											
Unit - Cell	RowID	Unit	Cell	Habitat Type	Area, Acres	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Habitat Water Depth, Inches	Soil Saturation Depth, Feet	Circulation Rate (Cubic Feet per Second Per Acre)	Irrigation Depth, Inches	Number of Irrigation Days	Irrigation Efficiency	Number of Floodup Days	Number of Drawdown Days	Percent of Runoff of Applied Water Recaptured	Total Porosity (v/v)	Field Capacity (v/v)	Permanent Wilting Point (v/v)	Saturated Hydraulic Conductivity, Inches Per Day	Lambda	Runoff Curve Number	Initial Soil Moisture Content (v/v)	Percent of Initial Soil Moisture from Precipitation	Lateral Seepage, Inches Per Day	% Max Lateral Seepage During F and D	Weather Data Name	Stress Adjustment Factor
SNWR-1	1	SNWR	1	Seasonal Wetlands	237	M	M	M	M	H	D	N	N	N	N	F	M	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-2	2	SNWR	2	Seasonal Wetlands	487	M	M	M	M	H	D	N	N	N	N	N	F	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-3	3	SNWR	3	Seasonal Wetlands	563	F	M	M	M	H	D	N	N	N	N	N	N	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-4	4	SNWR	4	Seasonal Wetlands	566	N	F	M	M	H	D	N	N	N	N	N	N	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-5	5	SNWR	5	Seasonal Wetlands	161	M	M	M	M	H	D	N	N	N	F	M	M	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-6	6	SNWR	6	Seasonal Wetlands	723	M	M	M	M	H	D	N	N	N	N	F	M	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-7	7	SNWR	7	Seasonal Wetlands	1200	F	M	M	M	H	D	N	N	N	N	F	M	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-8	8	SNWR	8	Seasonal Wetlands	371	N	F	M	M	H	D	N	N	N	N	N	N	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-9	9	SNWR	9	Seasonal Wetlands	249	M	M	M	M	H	D	N	N	N	N	F	M	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-10	10	SNWR	10	Seasonal Wetlands	238	F	M	M	M	H	D	N	N	N	N	N	F	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-11	11	SNWR	11	Seasonal Wetlands	131	N	F	M	M	H	D	N	N	N	N	N	N	12	3	0.0024	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-12	12	SNWR	12	Seasonal Wetlands - Summer Water	36	M	M	M	H	D	N	N	N	I	C	F	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-13	13	SNWR	13	Seasonal Wetlands - Summer Water	49	M	M	M	H	D	N	I	C	N	N	N	F	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-14	14	SNWR	14	Seasonal Wetlands - Summer Water	38	F	M	M	H	D	N	N	I	C	N	N	N	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-15	15	SNWR	15	Seasonal Wetlands - Summer Water	24	N	F	M	H	D	N	I	C	N	N	N	N	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-16	16	SNWR	16	Seasonal Wetlands - Summer Water	65	M	M	M	H	D	N	I	C	N	F	M	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-17	17	SNWR	17	Seasonal Wetlands - Summer Water	53	F	M	M	H	D	I	C	N	N	N	N	N	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-18	18	SNWR	18	Seasonal Wetlands - Summer Water	37	F	M	M	H	D	N	I	C	N	N	N	N	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-19	19	SNWR	19	Seasonal Wetlands - Summer Water	25	M	M	M	H	D	N	N	I	F	M	M	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-20	20	SNWR	20	Seasonal Wetlands - Summer Water	76	M	M	M	M	H	D	C	N	N	F	M	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-21	21	SNWR	21	Seasonal Wetlands - Summer Water	50	M	M	M	M	H	D	N	I	C	F	M	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-22	22	SNWR	22	Seasonal Wetlands - Summer Water	67	M	M	M	M	H	D	I	C	N	N	F	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-23	23	SNWR	23	Seasonal Wetlands - Summer Water	267	M	M	M	M	H	D	N	I	C	N	F	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-24	24	SNWR	24	Seasonal Wetlands - Summer Water	203	F	M	M	M	H	D	I	C	N	N	N	F	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-25	25	SNWR	25	Seasonal Wetlands - Summer Water	100	F	M	M	M	H	D	N	I	C	N	N	F	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-26	26	SNWR	26	Seasonal Wetlands - Summer Water	137	M	M	M	M	M	H	D	I	C	N	F	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-27	27	SNWR	27	Seasonal Wetlands - Summer Water	58	M	M	M	M	M	H	D	N	I	C	F	M	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-28	28	SNWR	28	Seasonal Wetlands - Summer Water	78	N	F	M	M	M	H	D	I	C	N	N	N	12	3	0.0018	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-29	29	SNWR	29	Semi-Permanent Wetlands	550	C	N	N	N	N	M	M	M	M	M	M	C	12	3	0.0030	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-30	30	SNWR	30	Permanent Wetlands	159	M	M	M	M	M	M	M	M	M	M	M	M	24	3	0.0030	6	10	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
SNWR-31	31	SNWR	31	Upland	3276	N	N	N	N	N	N	N	N	N	N	N	N	0	3	0.0018	0	0	60%	15	15	20%	0.47	0.39	0.25	0.05	0.14	56	0.31	20%	0.02	50%	Sacramento	1
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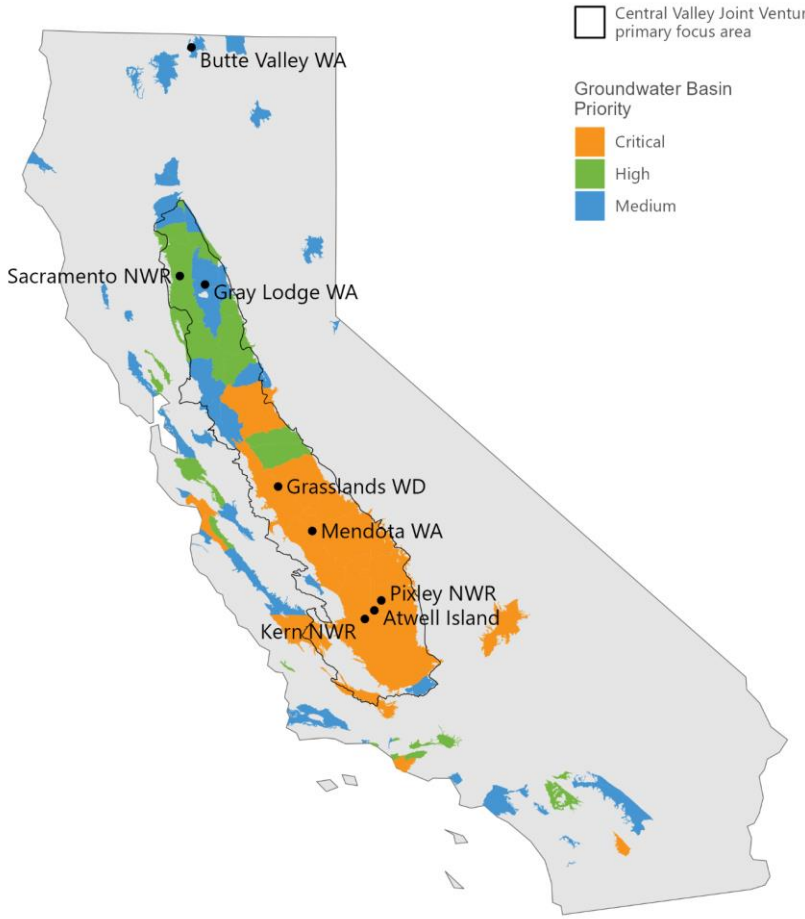
Instructions | MainInputs | AnnualOutput | MonthlyAll | SimulationParameters | DailyCalculations | MonthlyCalculations | Daily Review | WY Monthly | WY Totals | Kh | CalculationSummary | PrecipInput | ETc

Ready | Accessibility: Investigate | Display Settings | 70%

Wetlands Water Budget Tool (WWBT) Results

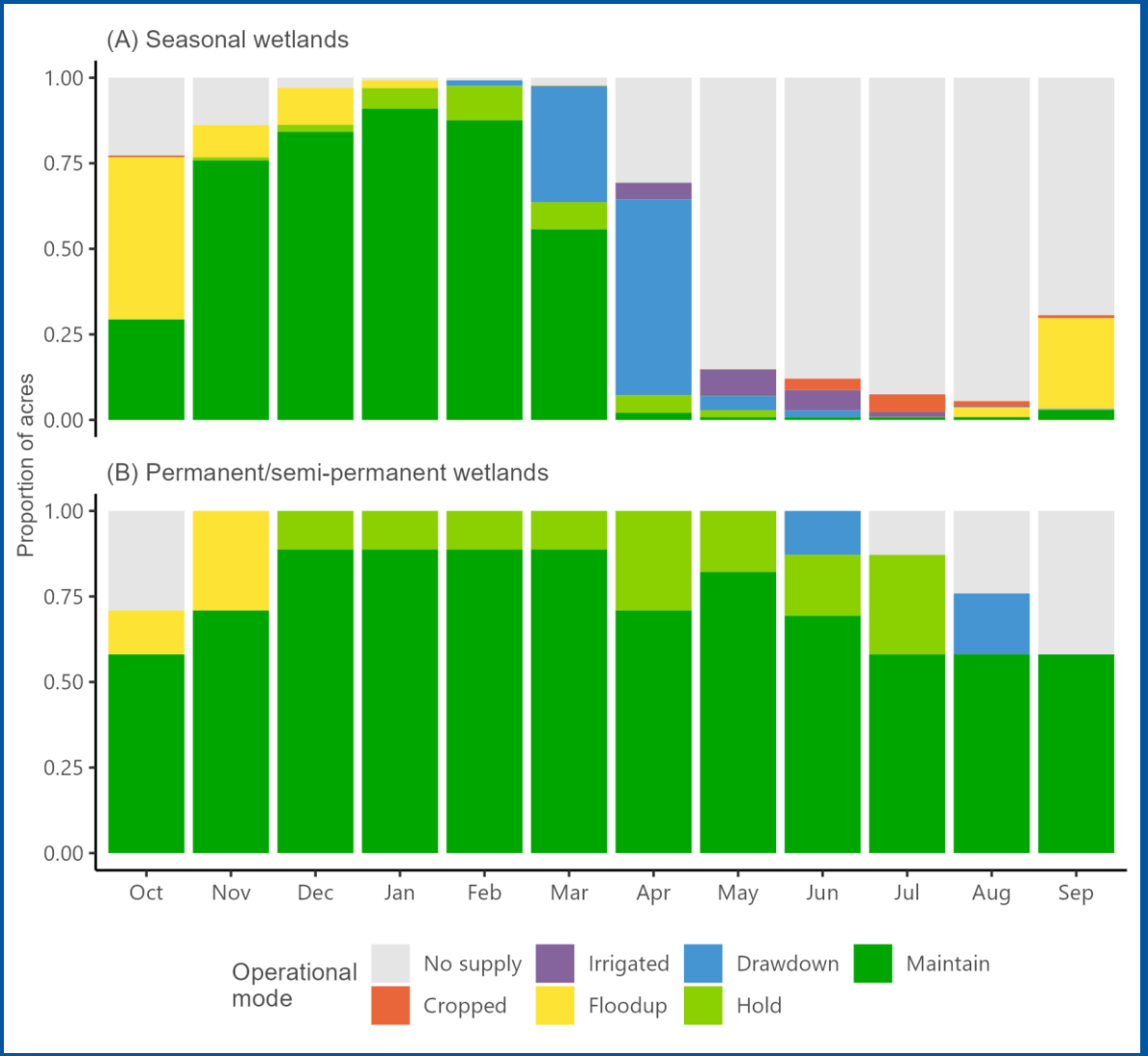


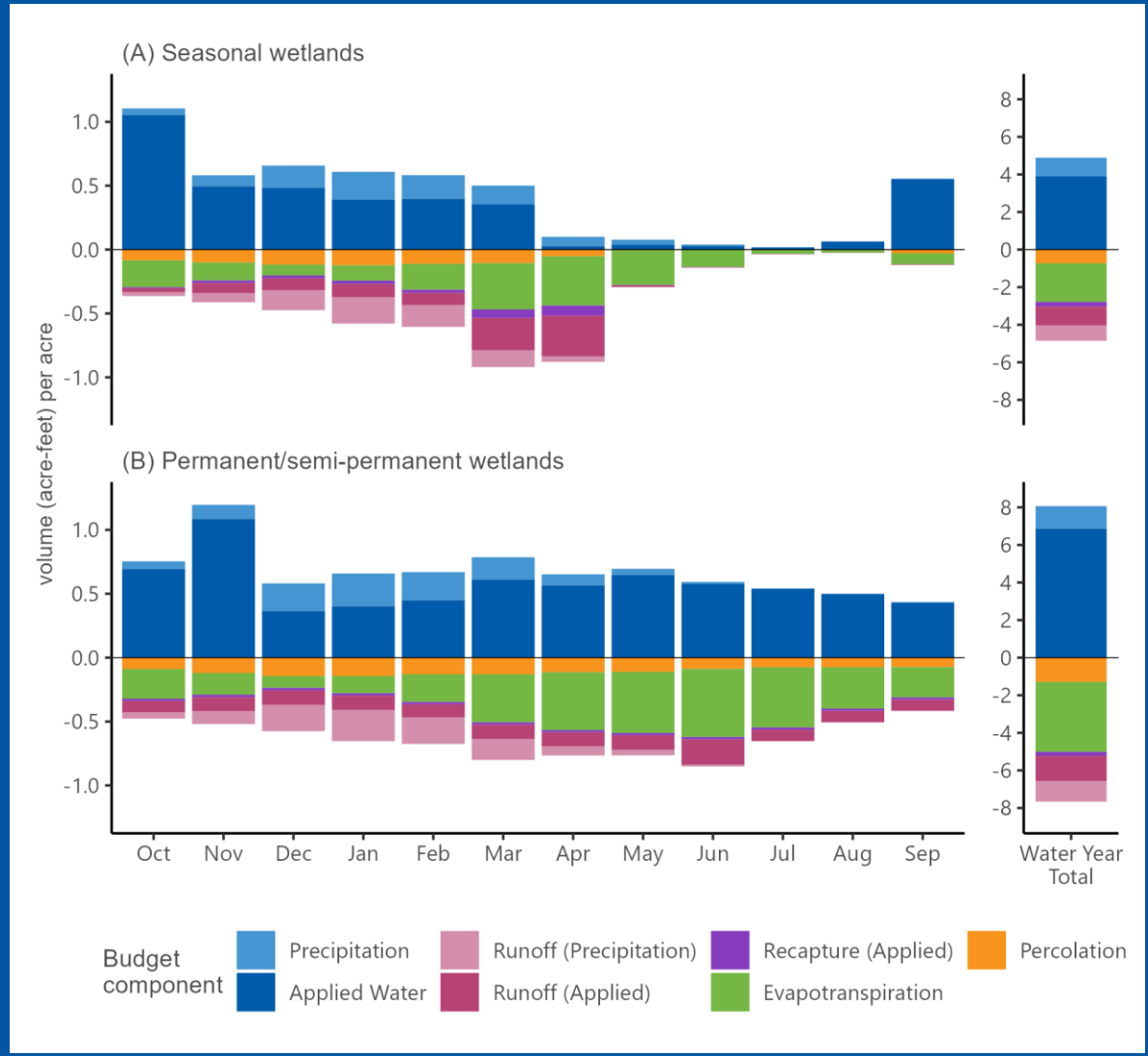
WWBT Applications were developed for a total of 12 unique managed wetland areas.

1. Atwell Island
2. Butte Valley Wildlife Area (WA)
3. Grasslands Groundwater Sustainability Agency (GSA) Area
4. Gray Lodge WA
5. Kern National Wildlife Refuge (NWR)
6. Mendota WA
7. Pixley NWR
8. Sacramento NWR
9. Presley Program Wetlands (4 WWBT Applications)

Dybala et al. 2023 (unpublished)

Wetlands Water Budget Tool (WWBT) Results





Dybala et al. 2023 (unpublished)

Wetlands Water Budget Tool (WWBT) Review

Benefits:

- Utilizes available data to fill a data gap and quantify water use for managed wetlands
- Available in Excel for wide distribution and use among wetlands managers
- Quantifies applied water demands based on other inputs, and how those may change based on habitat, management, or climate change projections

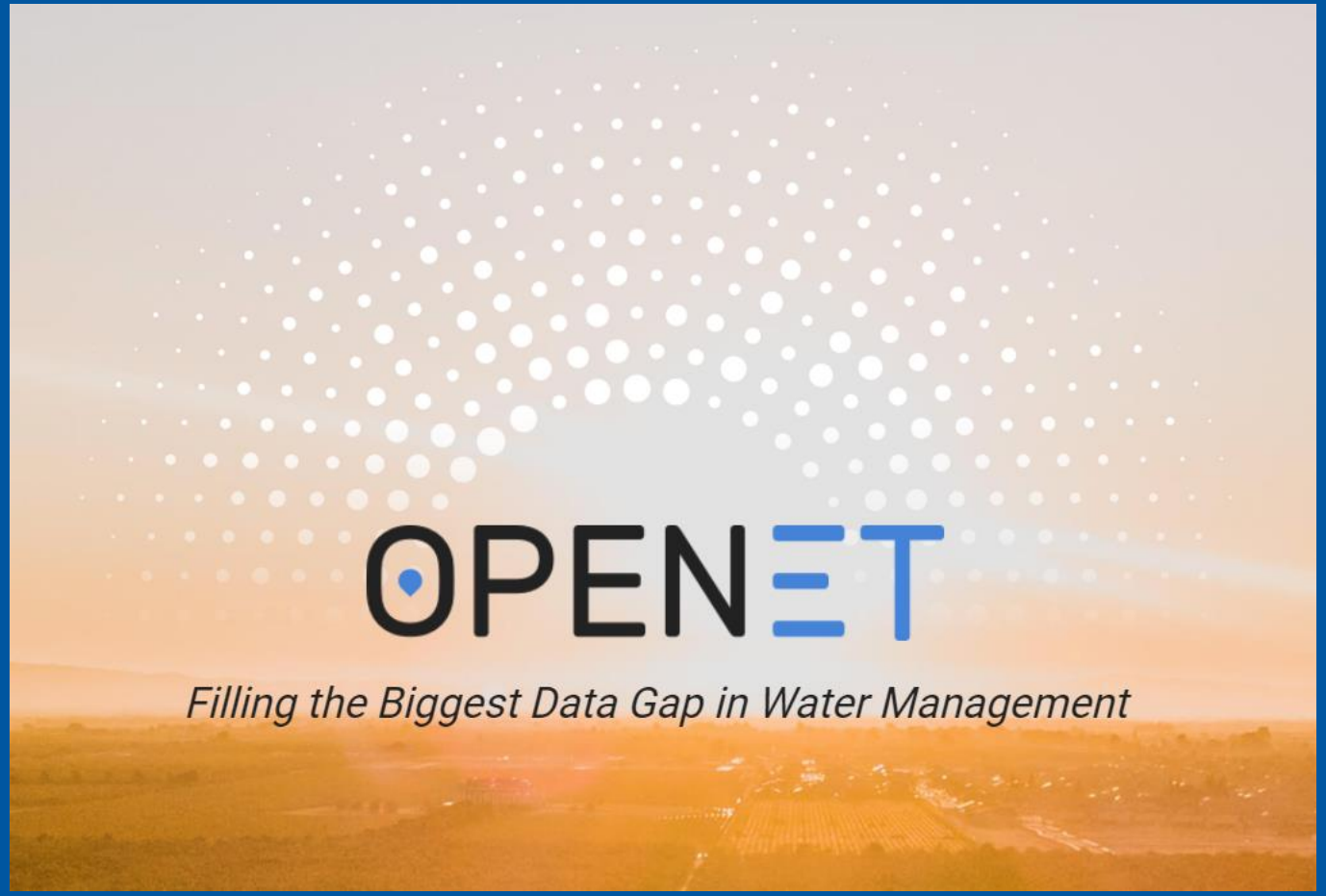
Drawbacks:

- Static habitat and management (in reality these can vary, at times substantially, from year to year)
- Calculates required applied water, does not address scenarios where water supplies may be limited
- Calculates wetlands ET at all wetlands from ETo using a “habitat coefficient” (Kh) developed for Sacramento NWR

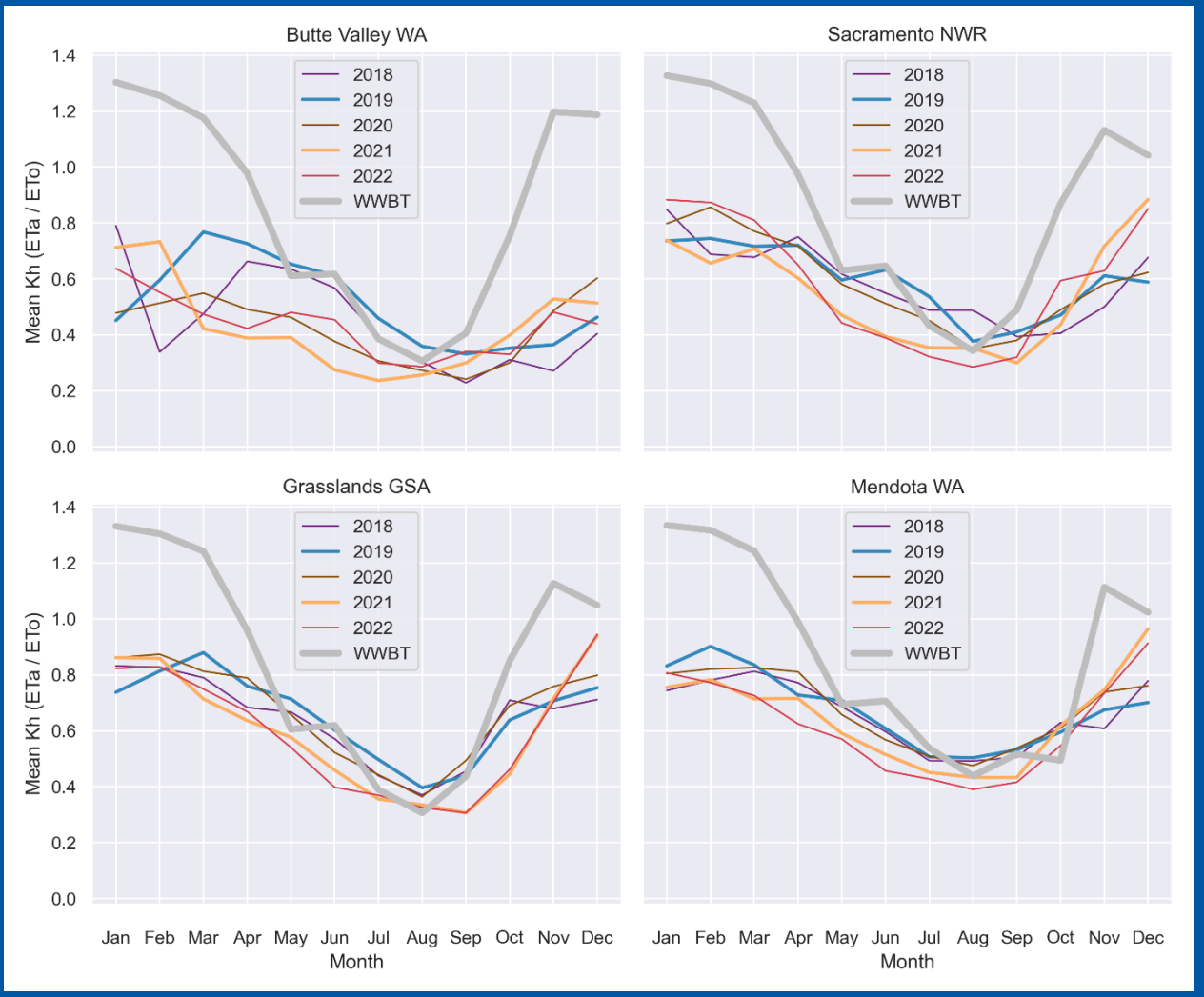
The WWBT is primarily a scenario planning and forecasting tool.

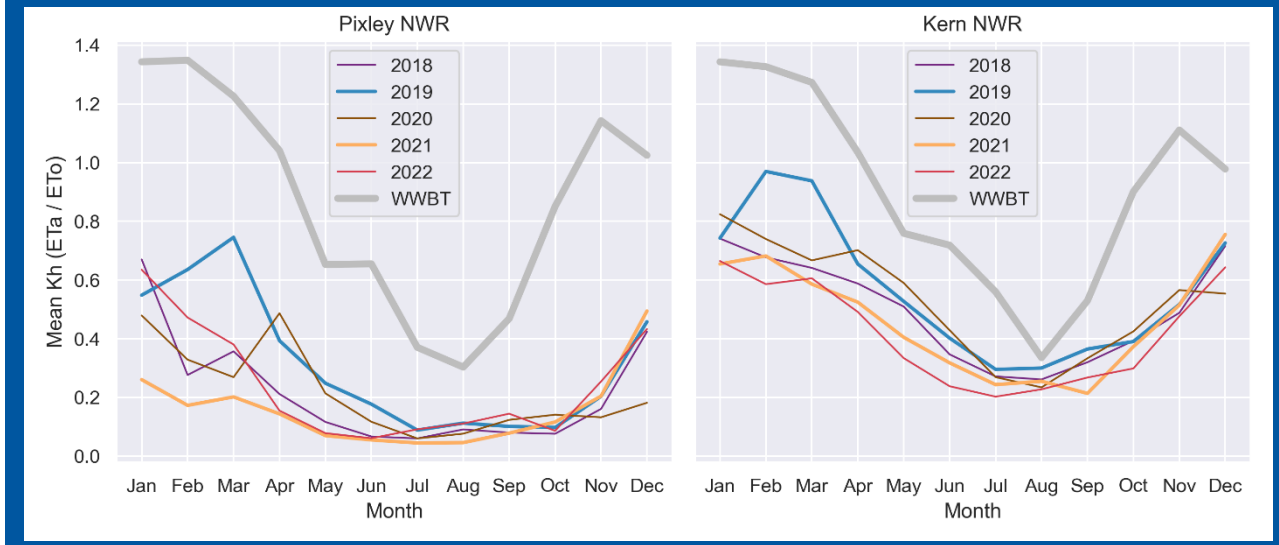
Other Wetlands Water Use Accounting

Evaluating Variability in Evapotranspiration (ET) in Wetlands



Evaluating Variability in Evapotranspiration (ET) in Wetlands





Recommendations

- Continue coordination with wetlands managers to:
  - Expand use and application of WWBT for scenario planning and forecasting.
  - Improve understanding of historical and current variability in water and wetlands management, depending on hydrologic conditions, water supply availability, and other factors.
  - Improve in-field data collection and data management for wetlands.
- Refine WWBT
- Improve wetlands water accounting
  - Understand variability in water supply and use, and related impacts on habitat conditions
  - Improve quantification of groundwater recharge volumes from managed wetlands

Acknowledgments

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The Nature Conservancy

Audubon California

Point Blue Conservation Science

camigratorybirds.org

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Bureau of Reclamation

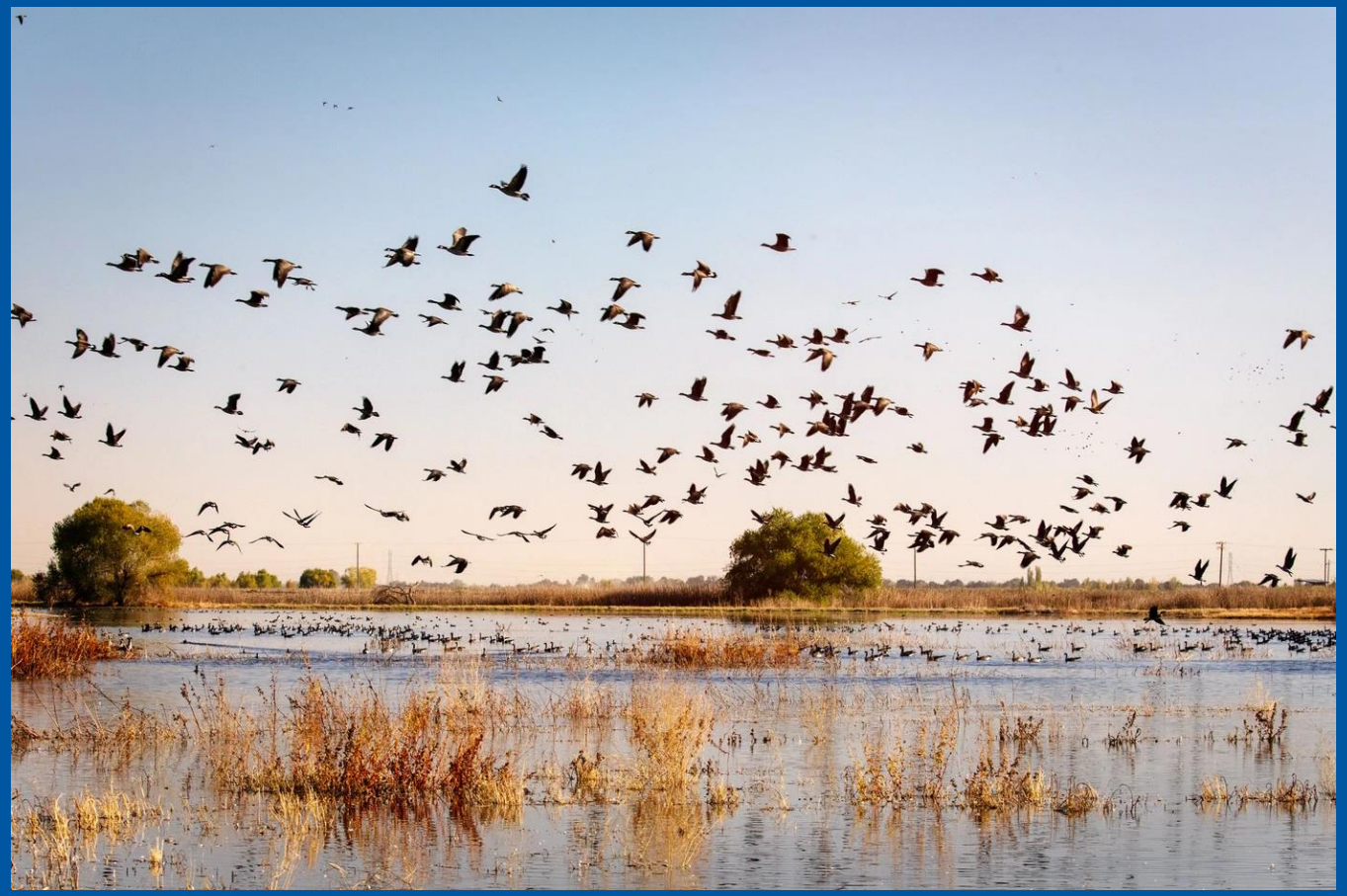
The Conservation Fund

S. D. Bechtel, Jr. Foundation
Stephen Bechtel Fund

Byron Clark, P.E.

(1976-2021)

Thanks! Questions & Discussion



Audubon; California SCC; Natural History Journal

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