FLOODPLAINS REIMAGINED

Secondary (zooplankton) productivity and export potential suitability criteria

August 2023

cbec eco engineering

SFEI AQUATIC SCIENCE CENTER

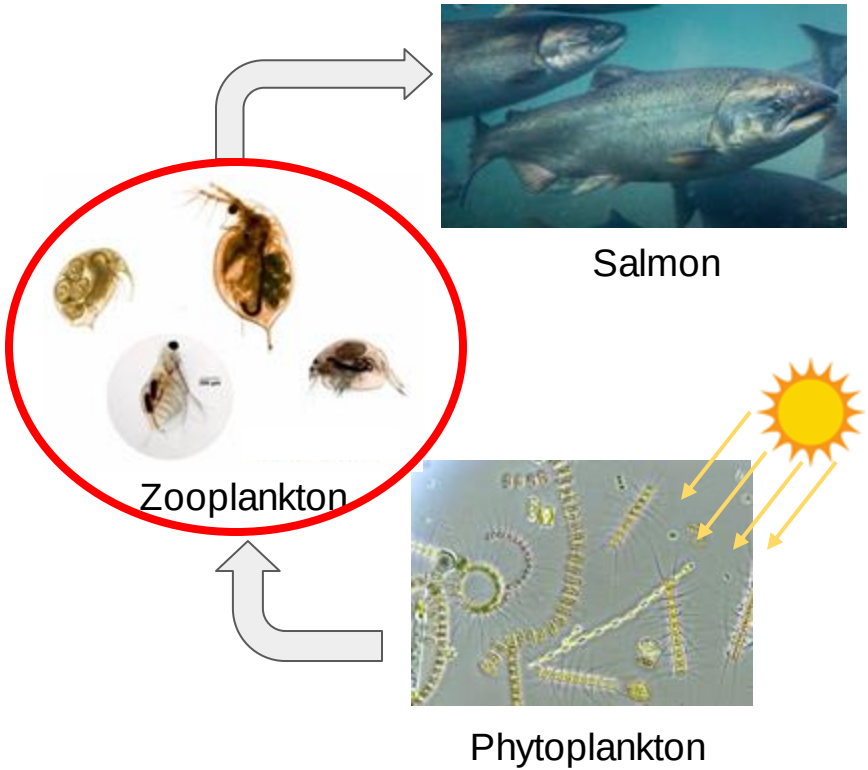
Outline

- Goals
- Development process
- Proposed criteria
  - Productivity Suitability
  - Export Potential
- Caveats and assumptions
- Application of criteria: Initial results
- Discussion:
  - Potential Future Studies
  - Feedback from AC
  - Recommendation to move forward (with any changes based on feedback)

Goal for criteria

Evaluate “productivity” and “productivity export” potential as part of the suite of benefits evaluated

1. *Productivity*: Suitability of zooplankton production
2. *Export*: Releasing of productive water downstream



Floodplains Reimagined Objective: Increase the frequency, duration, and spatial extent of inundation within the FR geographic areas **to stimulate production of invertebrates to provide high quality habitats** for rearing when juvenile salmon are migrating through the area.

Criteria development process

- Outlined spatially-resolved suitability analysis approach similar to that applied for juvenile salmon rearing floodplain habitat criteria
- Reviewed the literature to establish parameters and possible criteria values
- Held several informal discussions with technical experts (Carson Jeffres, Eric Holmes, Bjarni Serup)
- Incorporated feedback from internal Technical Team (Keith Marine) to refine criteria based on model assumptions, behavior, and outputs

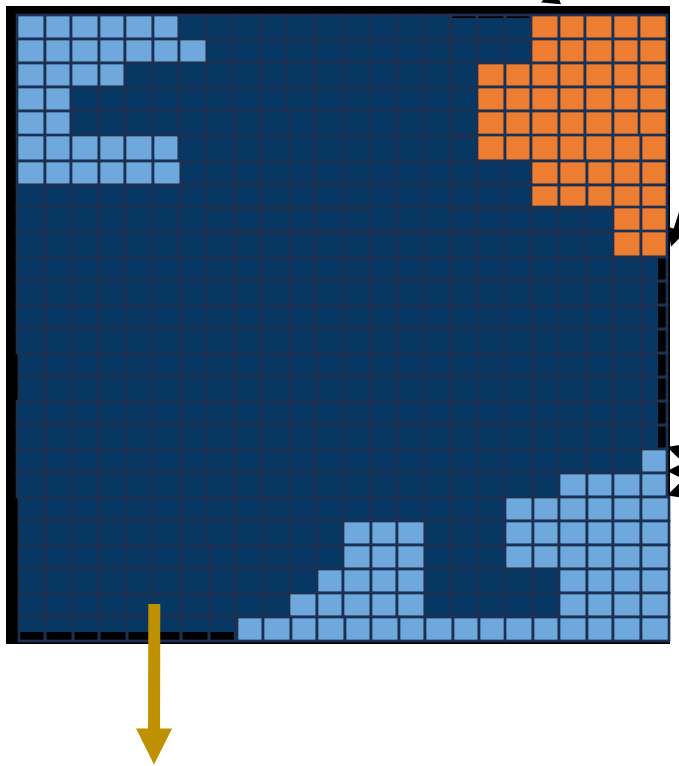
Proposed zooplankton productivity suitability criteria

Parameter	Criteria	Value	Source
Velocity (water age)	>0.1 m/s (0.33 ft/s)	0	Sommer et al. 2004 (some support for ~0.4 m/s); Opperman 2008; used model to set
	0 - 0.1 m/s (0.33 ft/s)	1	
Duration (water age)*: applied after velocity (high velocity event resets duration), also resets after drying*	1-9 days	0.66	Baranyi et al. 2002; Groscholz & Gallo 2006; Keckeis et al. 2003; Opperman 2008 [synthesis]; Gorski et al. 2013
	>10 days	1	
Cover type	Marsh, Managed Wetlands, & Rice	1	Caitlin et al 2016; Gorski et al 2013; Corline et al. 2021
	Forest, Shrub, Grassland, & Other ag	0.66	
Depth	Wetted (depth >0)	1	
	Dry	0	

Note: applied on a cell-by-cell basis

Approach: Productivity (zooplankton) suitability

On a given day:



1

Suitable Areas

>0

Non-suitable Areas (=0)

Field Outlet

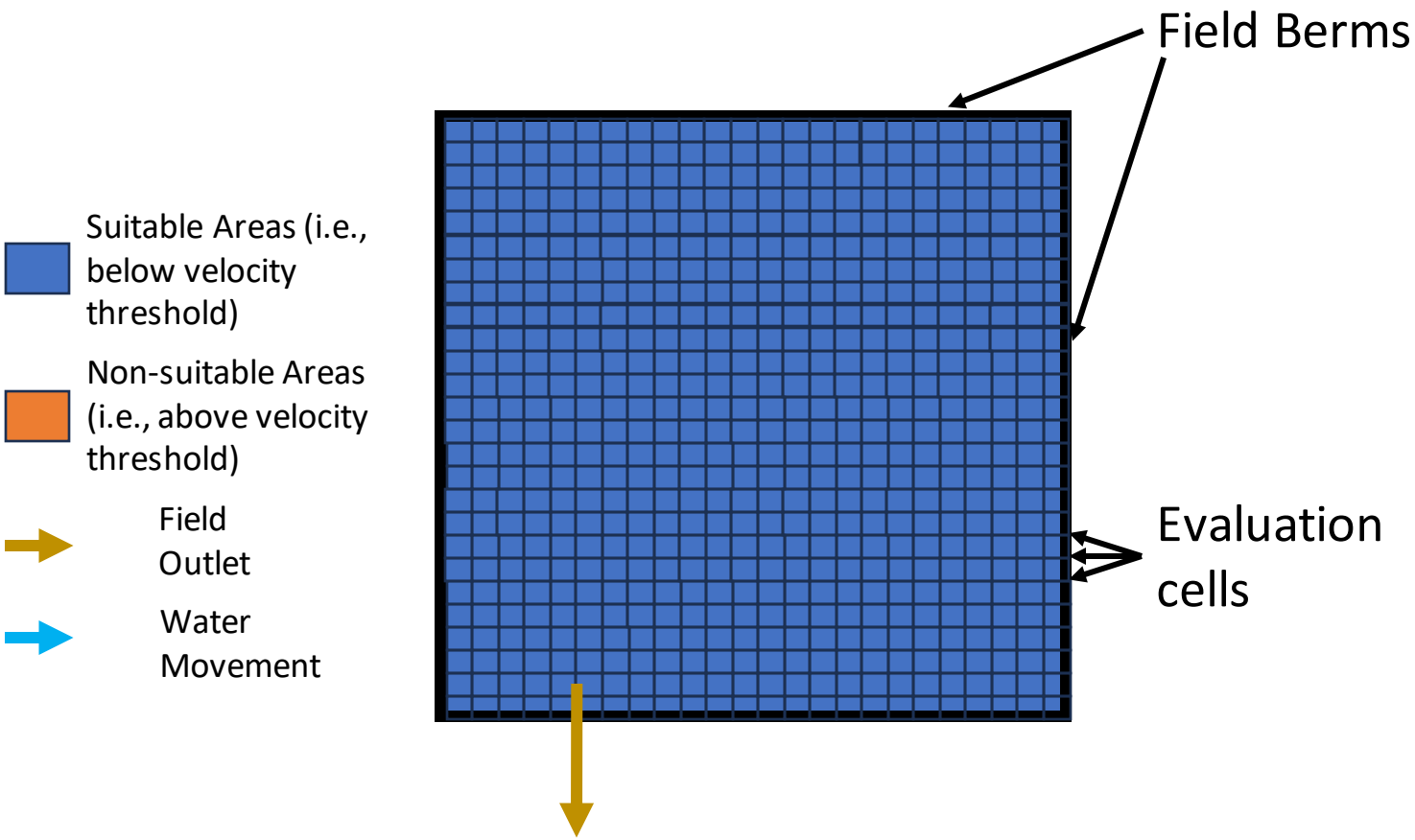
Water Movement

For each cell, productivity is determined using depth, velocity, and cover based on criteria

Proposed zooplankton productivity export potential criteria

Condition	Criteria	Value
Managed - applied at field scale	no downstream connection	0
	if berm overtopping directly connected to downstream	[ac-ft * productivity suitability] Volume of water per cell exceeding velocity threshold on first Berm Overtopping day * productivity suitability one day prior of those cells
	if connected through outlet weir with downstream connection	[ac-ft * productivity suitability] Daily export volume through outlet structures or total field volume on prior day, whichever is lower * area weighted productivity suitability one day prior
Unmanaged - applied at cell scale	unmanaged areas	[ac-ft * productivity suitability] Daily suitability-weighted volume of cell on previous day when velocity threshold is exceeded

Approach: Productivity export potential



Approach: Productivity export potential

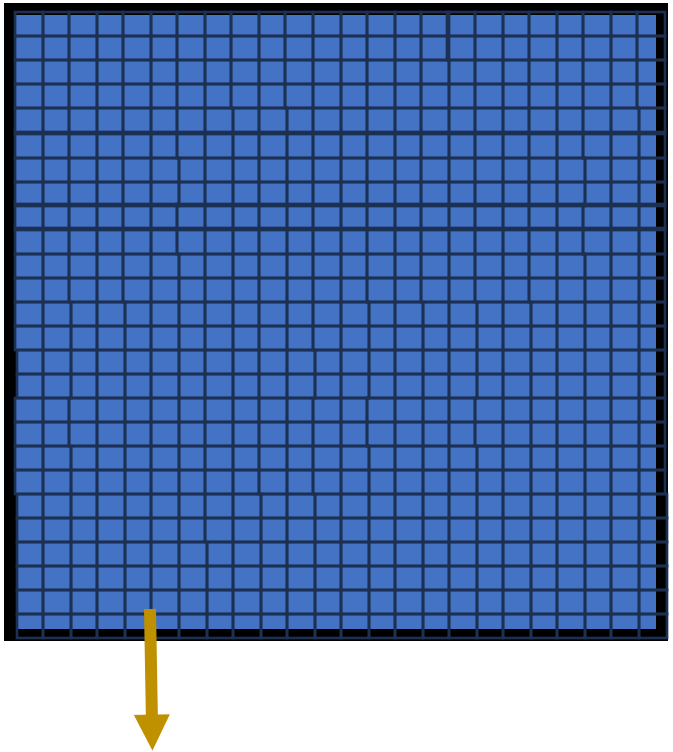
Baseflow

Suitable Areas (i.e., below velocity threshold)

Non-suitable Areas (i.e., above velocity threshold)

Field Outlet

Water Movement



Field holding managed inundation at managed depth

- No Berm OT occurring
- Little to no water movement

Approach: Productivity export potential

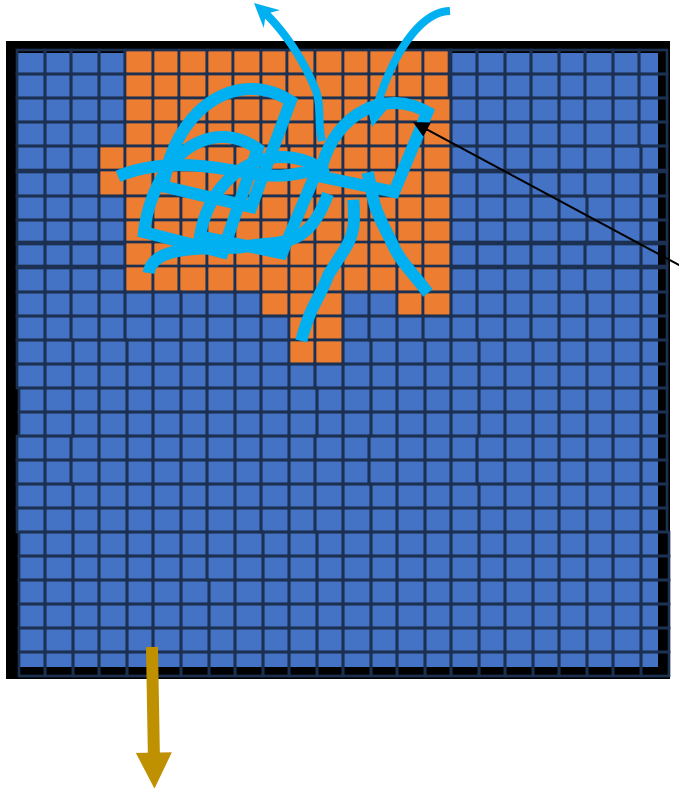
Berm overtopping (OT) export

Suitable Areas (i.e., below velocity threshold)

Non-suitable Areas (i.e., above velocity threshold)

Field Outlet

Water Movement



Berm OT forces **part of field** above velocity threshold – only **this part** is assumed to be exported

$Number\ of\ non-suitable\ cells\ on\ day\ t$: $n_{exd,t}$

$Cell\ area$: a

$Depth\ in\ cell\ j\ on\ day\ (t-1)$: $d_{j,t-1}$

$Productivity\ HSI\ in\ cell\ j\ on\ day\ (t-1)$: $P_{j,t-1}$

$Berm\ OT\ Export\ Volume\ on\ day\ t$: $x_{bot,t}$

$$x_{bot,t} = a * \sum_{j=1}^{n_{exd,t}} P_{j,t-1} * d_{j,t-1}$$

Approach: Productivity export potential

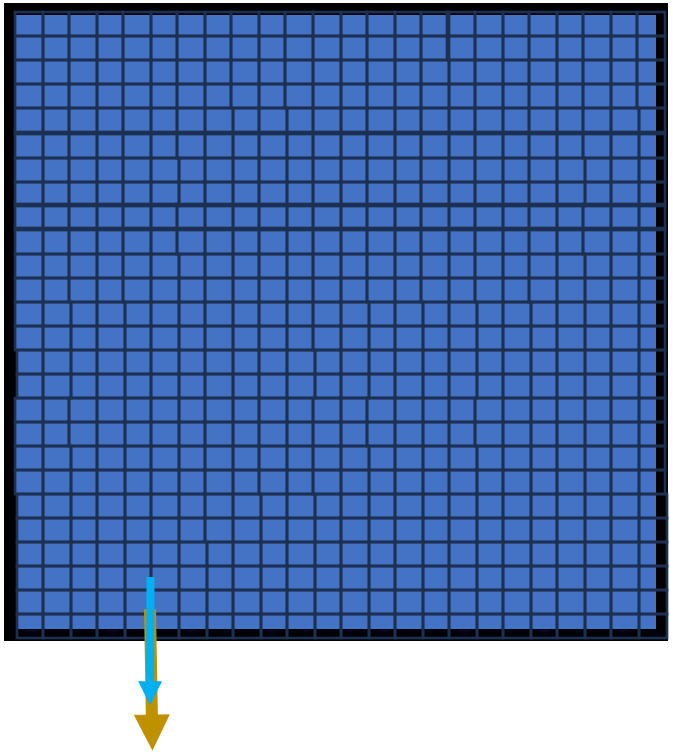
Outlet structure export

Suitable Areas (i.e., below velocity threshold)

Non-suitable Areas (i.e., above velocity threshold)

Field Outlet

Water Movement



Majority of field back below velocity, outlet structure exporting

Convert outlet structure flow on day t (Q_t, cfs) *to volume* $(V_{out,t}, ac\ ft)$

Field average Productivity HSI on day $(t-1)$: P_{t-1}

Field Productivity HSI weighted volume on day $(t-1)$: $V_{f,t-1}$

Outlet Export Volume on day t: $x_{out,t}$

$$x_{out,t} = \min(V_{out,t} * P_{t-1}, V_{f,t-1})$$

This minimum ensures field does not export more water than is available to export on the previous day

Approach Assumptions

- Approach quantifies **relative effects** of floodplain inundation **on secondary production (zooplankton) and export**
- Increase in productivity → more juvenile fish food → more juvenile fish growth → better outmigration/early ocean period survival
- **However, this should not be used to represent direct fisheries benefits**
    - Food availability does not guarantee fish will benefit
    - The distance to main river channel and complexity of canals and infrastructure affects whether the food is actually used
    - Fish may not be present
    - Food may not be a limiting factor

Questions

Specific Criteria Caveats & Assumptions

- Duration & velocity is representative of water residence time
- Maximum velocity threshold based on model results
    - Represents flood events that reset productivity and keeping water slow enough for zooplankton production
    - Limited published literature to inform this threshold
- Duration does not vary spatially (e.g., source water and antecedent conditions)
- Export means water leaves fields and other floodplain areas, not tracking all the way to river entry
- Water temperature, light availability, and daylength not accounted for in this analysis
- Antecedent conditions (e.g., soil moisture, periodicity, duration between events) are not accounted for in this analysis due to complexity

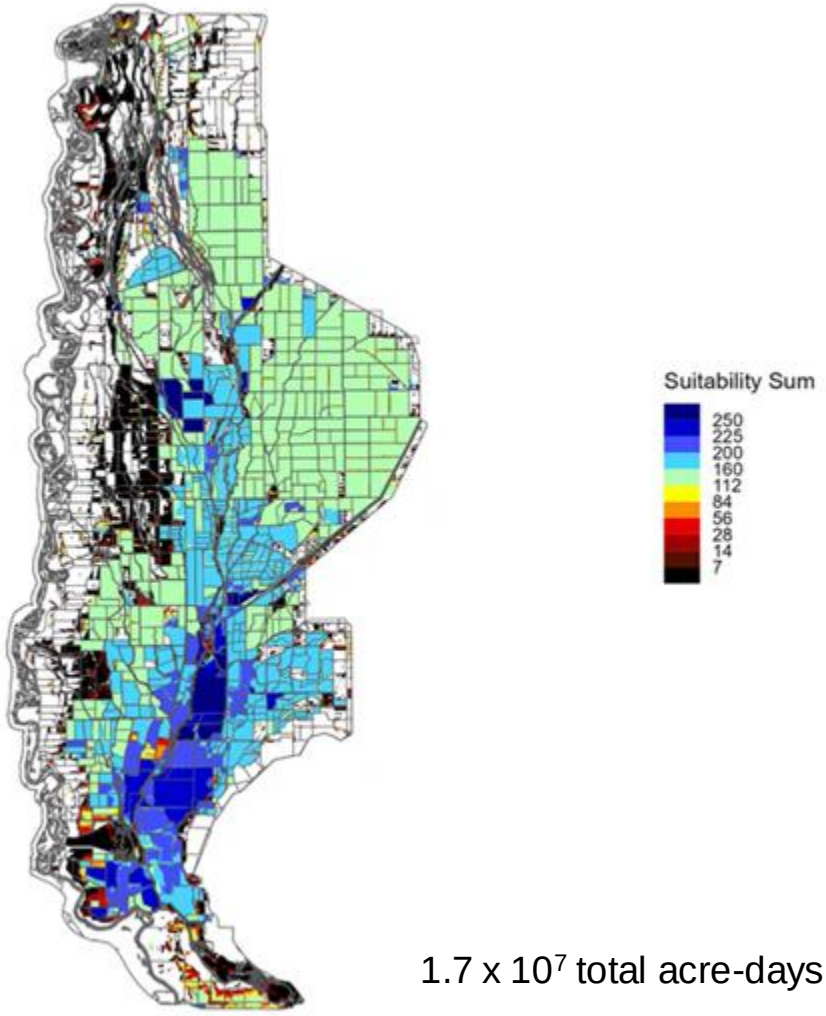
Productivity suitability

Suitability sum for the 2019 Water Year

- Daily productivity suitability values summed across the water year

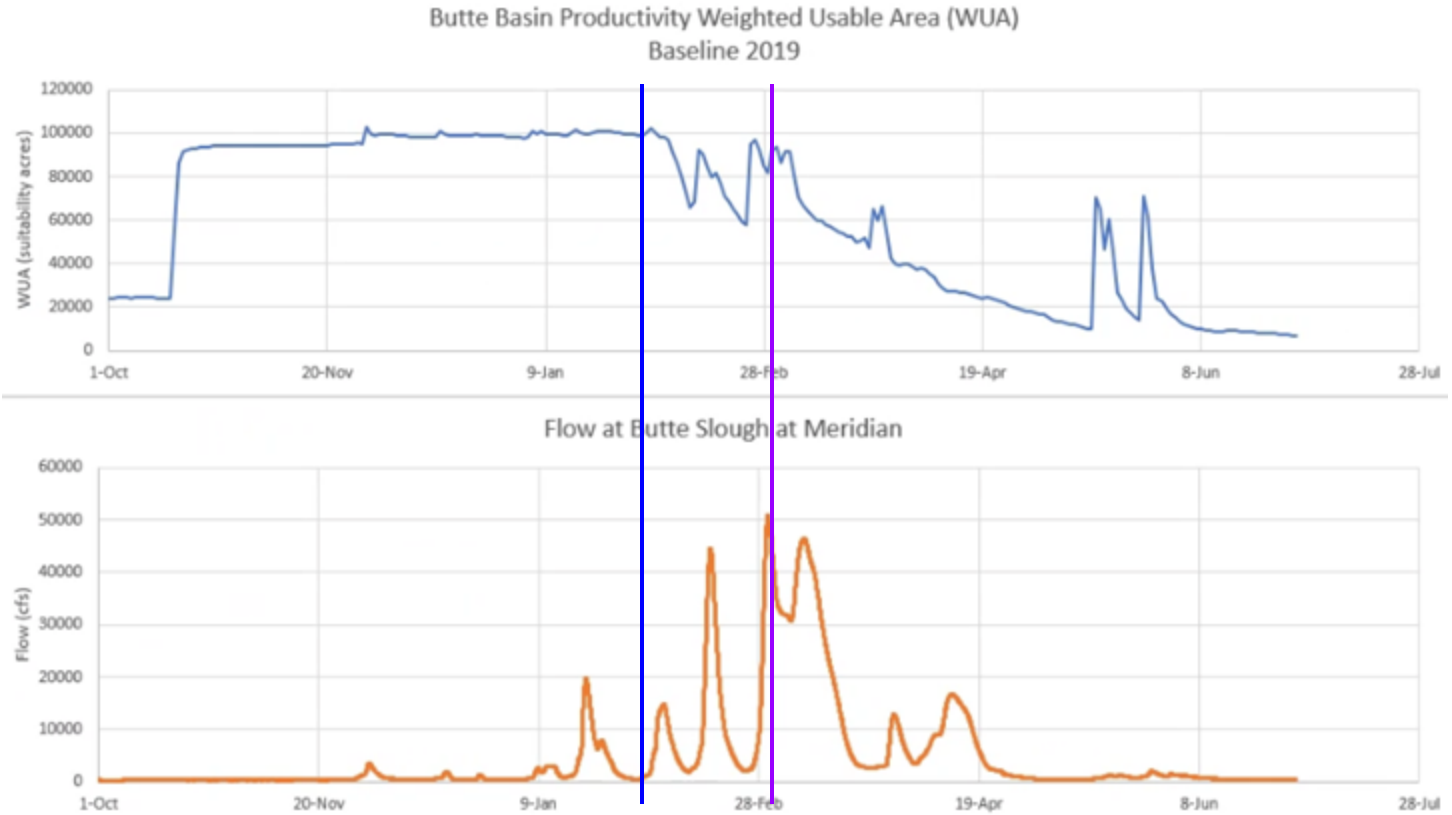
Observations

- Wetter areas (with longer inundation periods below the velocity threshold) have higher overall suitability
- Fields farther from channel have lower productivity

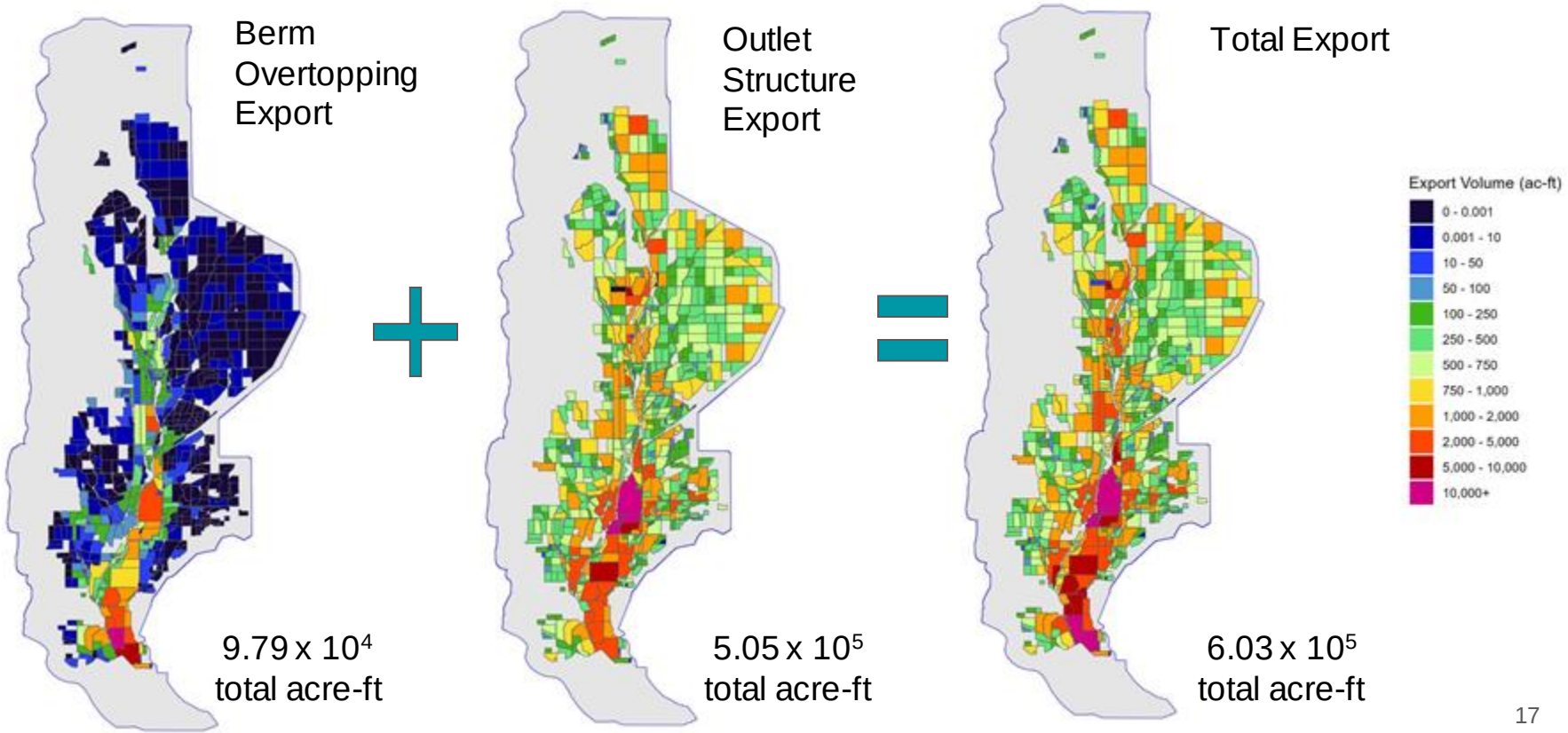


1.7 x 10^7 total acre-days

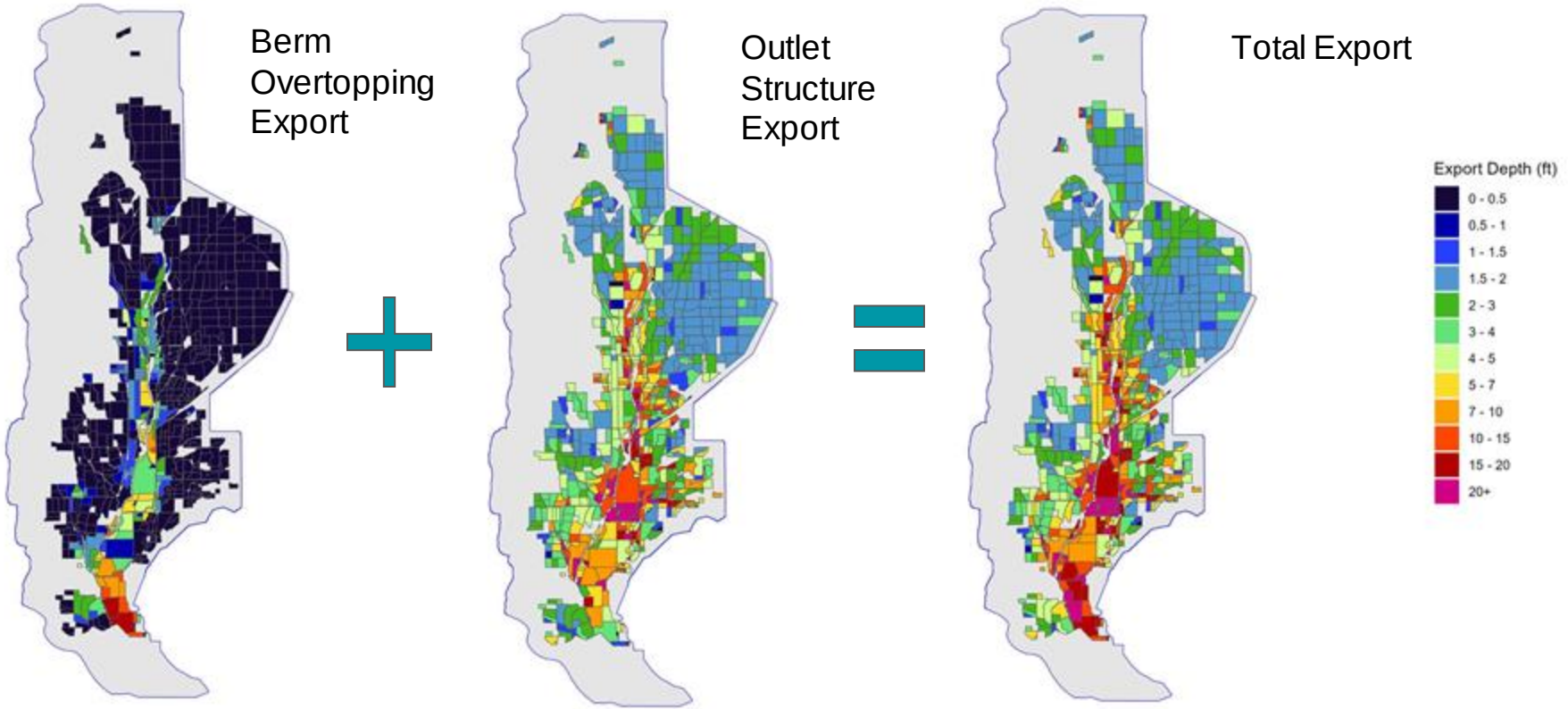
2019 productivity suitability - time series



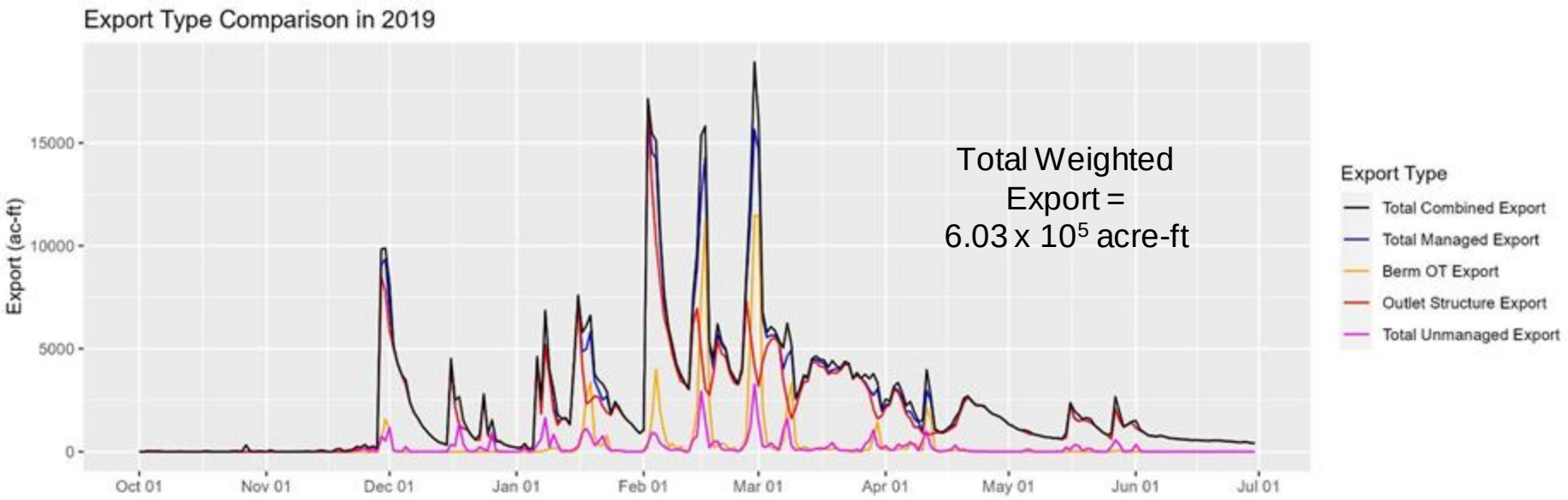
Export potential: Productivity-weighted export volume for 2019 water year

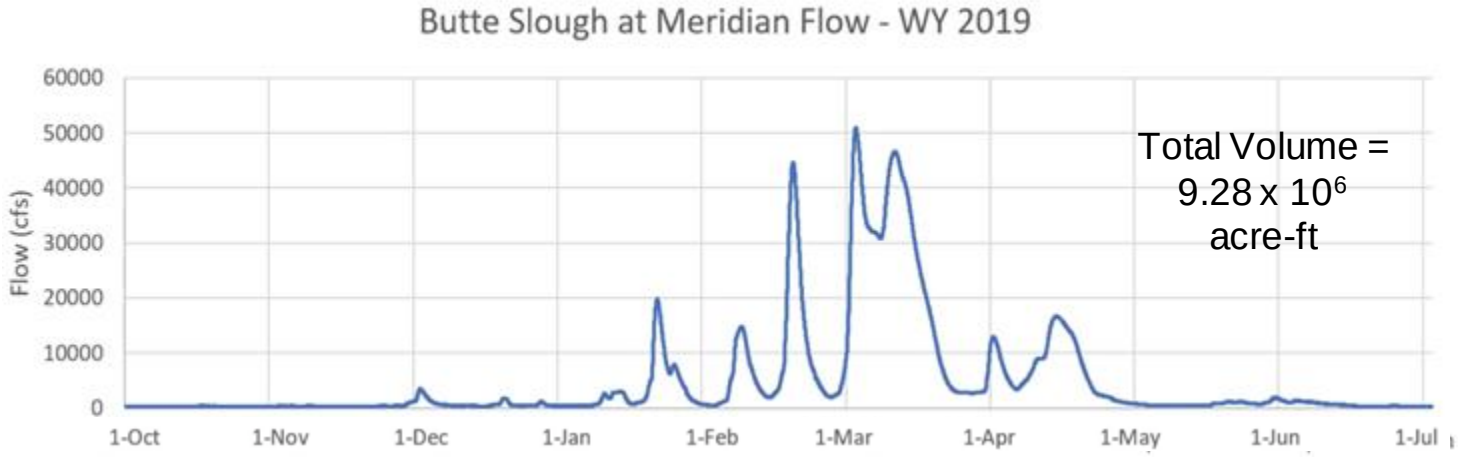


Export potential: Proportion of field area exported for 2019 water year

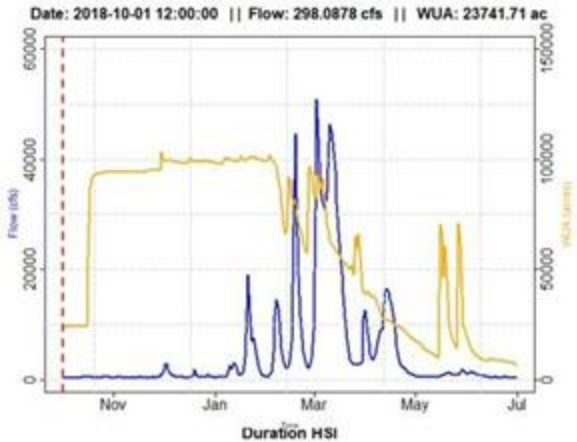


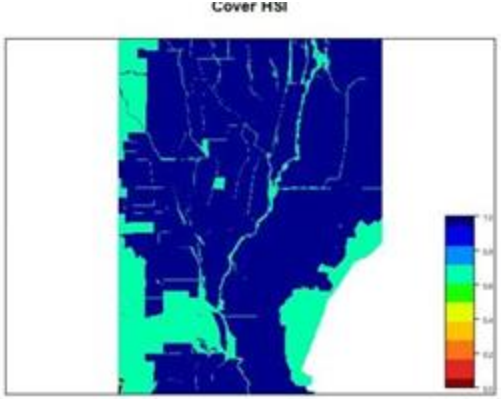
Export depth (ft) = Weighted Export Volume (ac-ft) / Field area (ac)

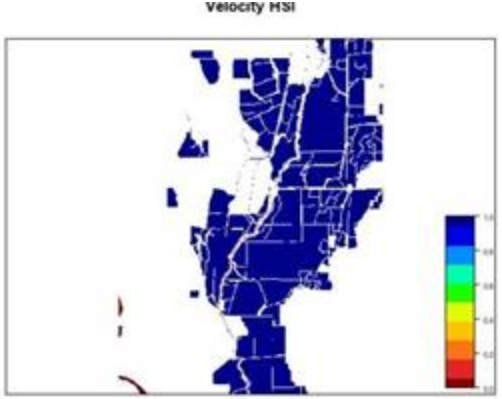

Export Type Comparison in 2019
Export (ac-ft)
15000
10000
5000
0
Oct 01
Nov 01
Dec 01
Jan 01
Feb 01
Mar 01
Apr 01
May 01
Jun 01
Jul 01
Total Weighted Export = 6.03 x 10^5 acre-ft
Export Type
Total Combined Export
Total Managed Export
Berm OT Export
Outlet Structure Export
Total Unmanaged Export

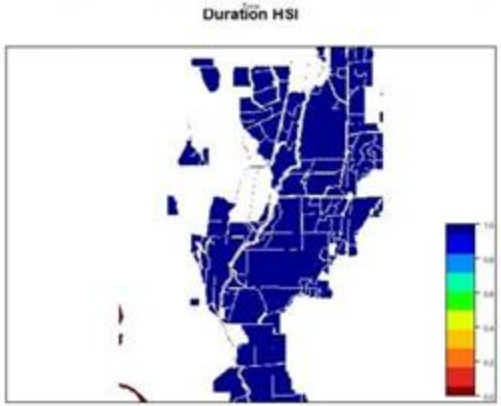

Butte Slough at Meridian Flow - WY 2019
Flow (cfs)
60000
50000
40000
30000
20000
10000
0
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
Total Volume = 9.28 x 10^6 acre-ft

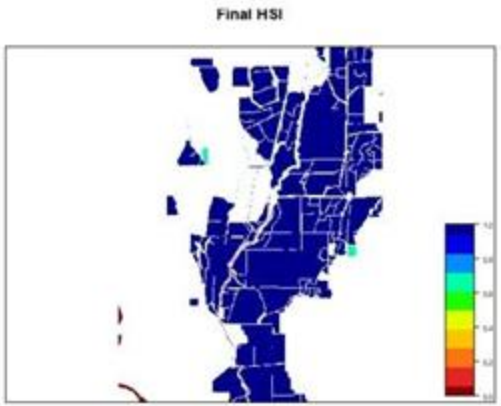
Animation: 2019 Water Year



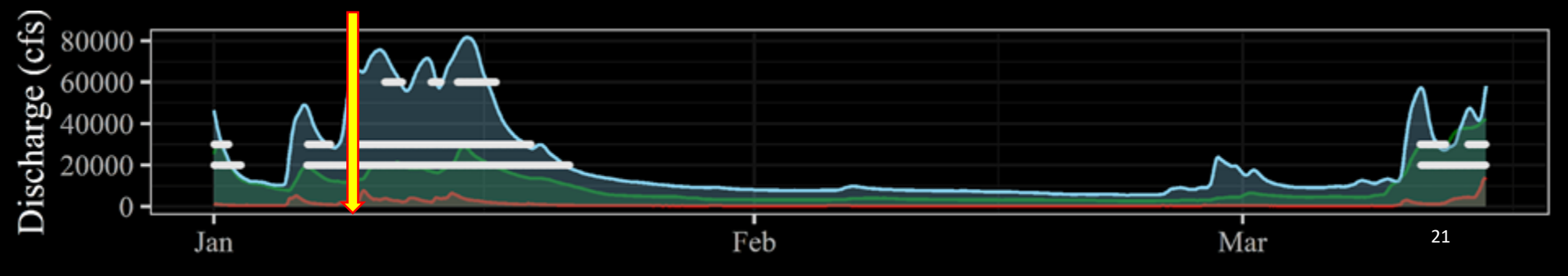








Source: Eric Holmes, UC Davis Center for Watershed Sciences



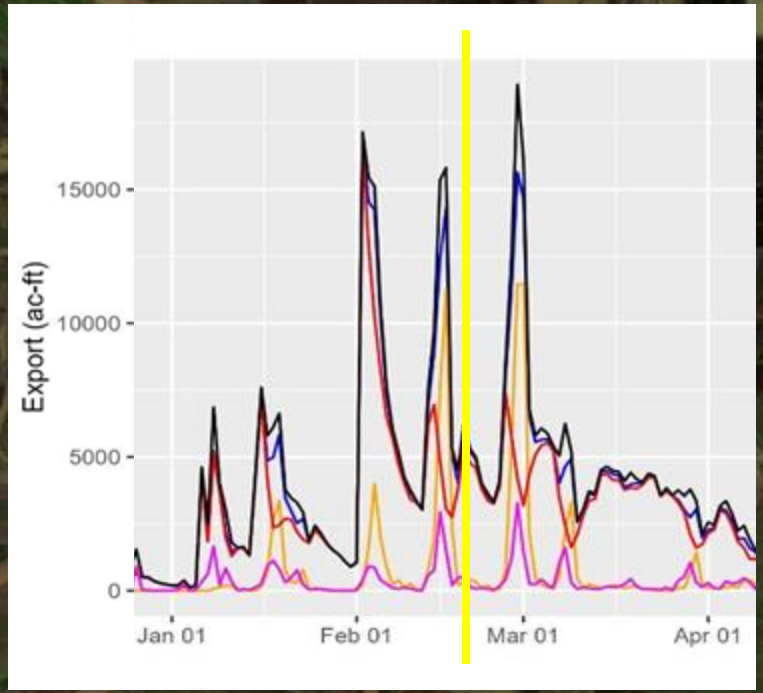
Source: Eric Holmes, UC Davis Center for Watershed Sciences

Bypass banding

- Brown water coming from the river with high turbidity
- Darker water represents wetland water
  - Low turbidity
  - Extremely high zooplankton

Feb 19, 2019 Imagery

Natural Color from Sentinel 2



Colusa

West Butte

Potential Future Study

- Validate approach using field data
- Field-based study to compare productivity across cover types
  - Rice fields versus natural cover types
  - Managed inundation versus unmanaged
- Add time of year to criteria to help account for daylength and temperature
- Consider role of turbidity and how it might be accounted for
- Develop more specific criteria to account for distance to river and/or complexity of canal network for export potential, supported by field-based research

Recommendation of the AC

Are the criteria and approach adequate to capture zooplankton productivity suitability and export potential for use in comparing scenarios?

- Are there any changes you would suggest?
- Are there additional assumptions and caveats that you think are important to include?

RECAP: Proposed zooplankton productivity suitability and export potential criteria

Zooplankton productivity			
Parameter	**Criteria**	**Value**	**Source**
Velocity (water age)	>0.1 m/s (0.33 ft/s)	0	Sommer et al. 2004 (some support for ~0.4 m/s); Opperman 2006; used model to refine
	0 - 0.1 m/s (0.33 ft/s)	1	
Duration (water age)	1-9 days	0.66	Baranyi et al. 2002; Opperman 2008 [synthesis]; Groscholz & Gallo 2006; Keckeis et al 2003
	>10 days	1	
Cover type	marsh/managed wetland/rice	1	Caitlin et al 2016; Gorski et al 2013; Corline et al. 2021
	grassland/other ag/shrub/forest	0.66	
Depth	Wetted (depth >0)	1	
	Dry	0	

Export potential	
Criteria	**Value**
if berm overtopping directly connected to downstream	[ac-ft * productivity suitability] Volume of water per cell exceeding velocity threshold on first Berm Overtopping day * productivity suitability one day prior of those cells
if connected through outlet weir with downstream connection	[ac-ft * productivity suitability] Daily export volume through outlet structures or total field volume on prior day, whichever is lower * area weighted productivity suitability one day prior
no downstream connection	0
unmanaged areas	[ac-ft * productivity suitability] Daily suitability-weighted volume of cell on previous day when velocity threshold is exceeded