Reconciling Floodplain Reconnection and Agricultural Land Use

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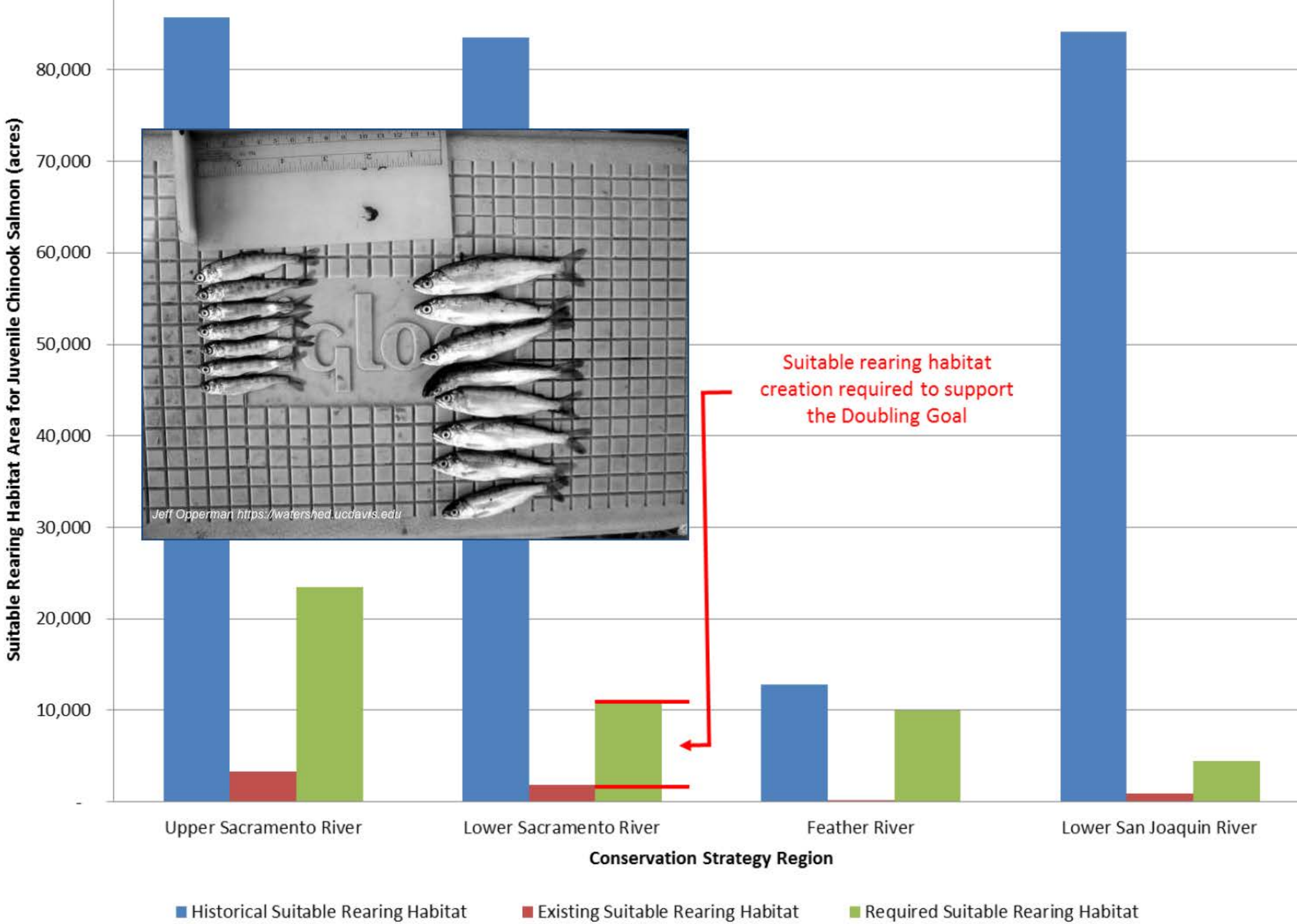
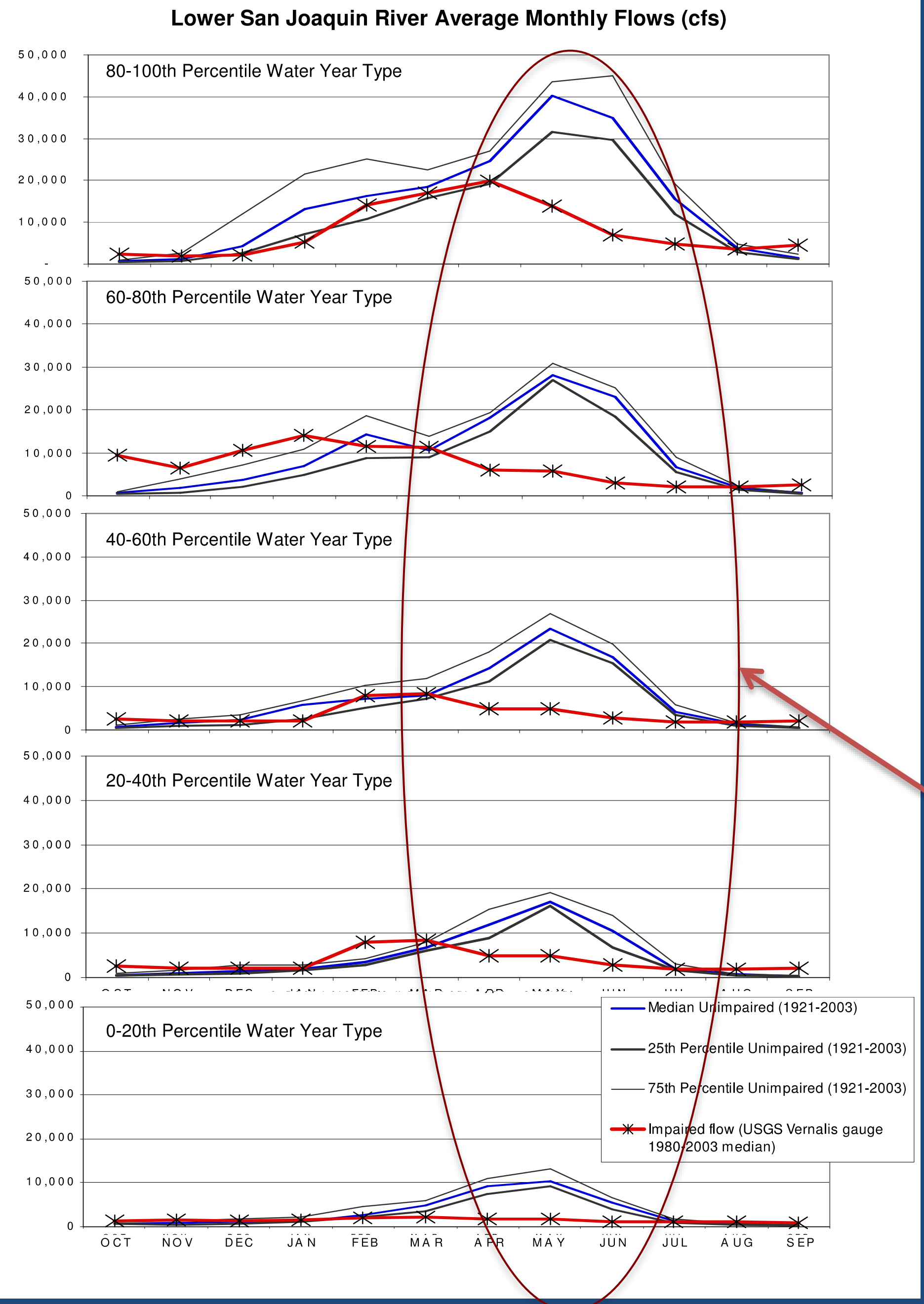

Suitable Rearing Habitat Area for Juvenile Chinook Salmon (acres)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Jeff Opperman https://watershed.ucdavis.edu
Suitable rearing habitat creation required to support the Doubling Goal
Upper Sacramento River
Lower Sacramento River
Feather River
Lower San Joaquin River
Conservation Strategy Region
Historical Suitable Rearing Habitat
Existing Suitable Rearing Habitat
Required Suitable Rearing Habitat



Floodplain area in the lower SJ is limited by

- Levees
- Regulation by upstream reservoirs
- Upstream diversions

American Rivers (2013)

Options for restoring floodplains:

1. Remove or setback levees
2. Increase flows
3. Lower floodplains between levees
4. Raise channel invert*

Raise channel invert

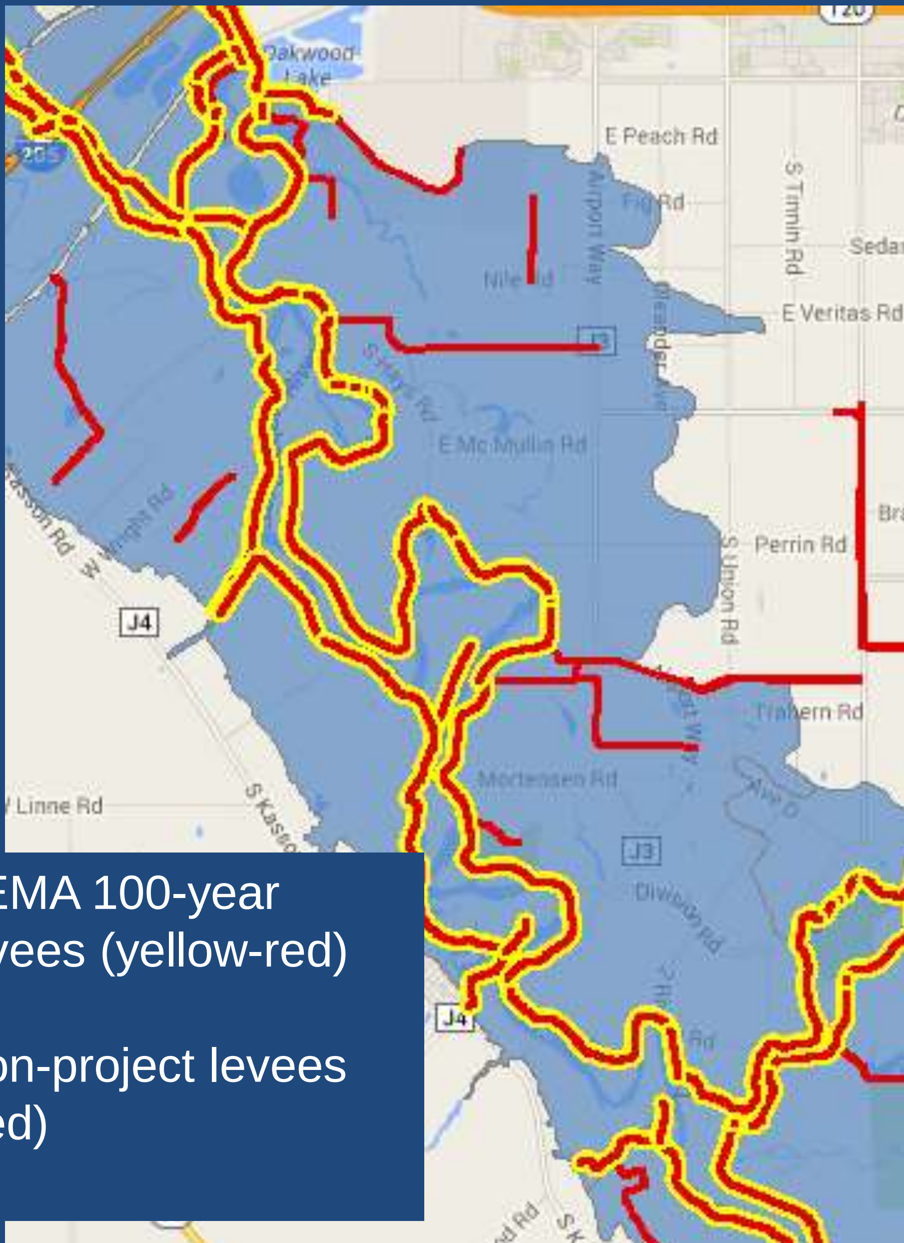
- Raising channel invert not possible within regulatory floodway, thus may require levee setback/removal.

- Would allow for fl… dplain … un… on with significantly less flow…

"ECOLOGICAL POP PER DROP"

http://fishbio.com/projects/honolulu-bar-restoration-and-floodplain-enhancement

Historical Background



FEMA 100-year levees (yellow-red)

Non-project levees (red)

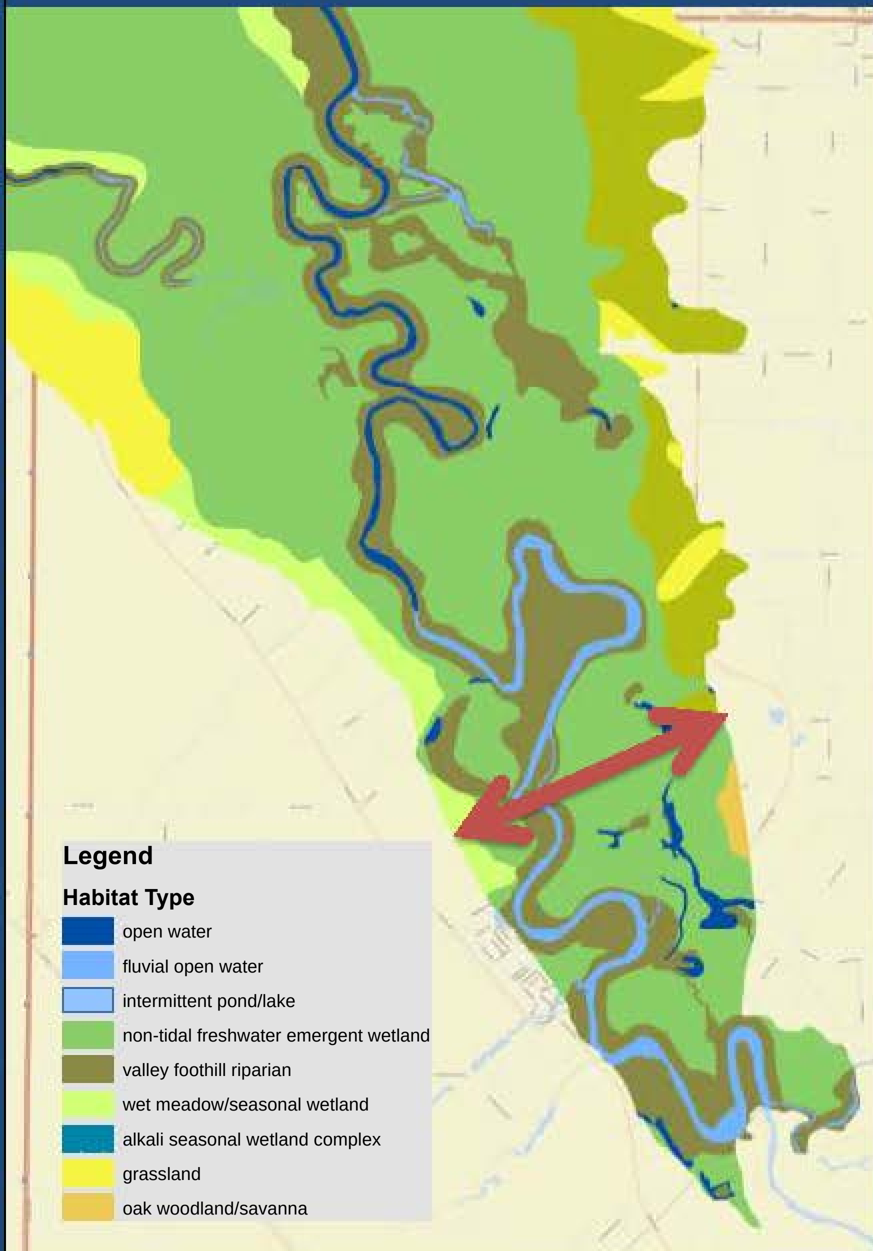
- Levees were built prior to the construction of upstream reservoirs.
- Upstream reservoirs significantly reduce flood frequency.
- Large, infrequent floods continue to create problems such as levee failures and seepage.

Shaded blue denotes area subject to 1% annual chance (100 year event) flood

Historical Ecology

Historical Ecology

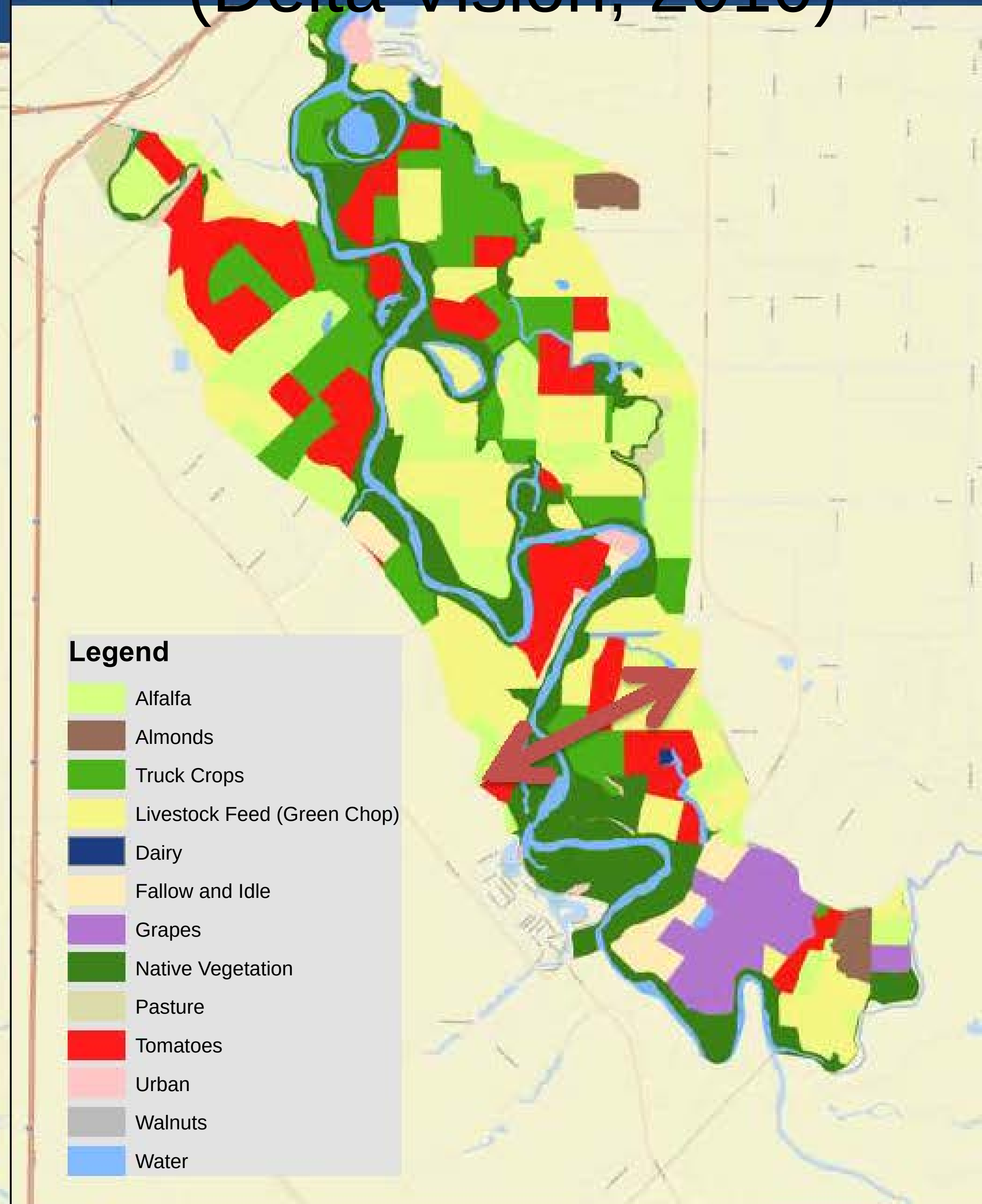
(Whipple, 2012)



Full Setback Area

Crop Map (2010)

(Delta Vision, 2010)



Research Questions

Lower San Joaquin River Bypass

What would be the economic impact to agriculture if there were no levees between Vernalis and I-5?

Conversely…

What economic benefits do the levees provide ?

Method

- We utilized hydrologic model results to generate inundated area maps for different discharge scenarios.
- We adapted the **Estimated Annual Habitat method (EAH)** to quantify probability of inundation for various cultivated crops.
- We then multiplied probability of inundation by crop production value to calculate risk (annualized gross revenue foregone).

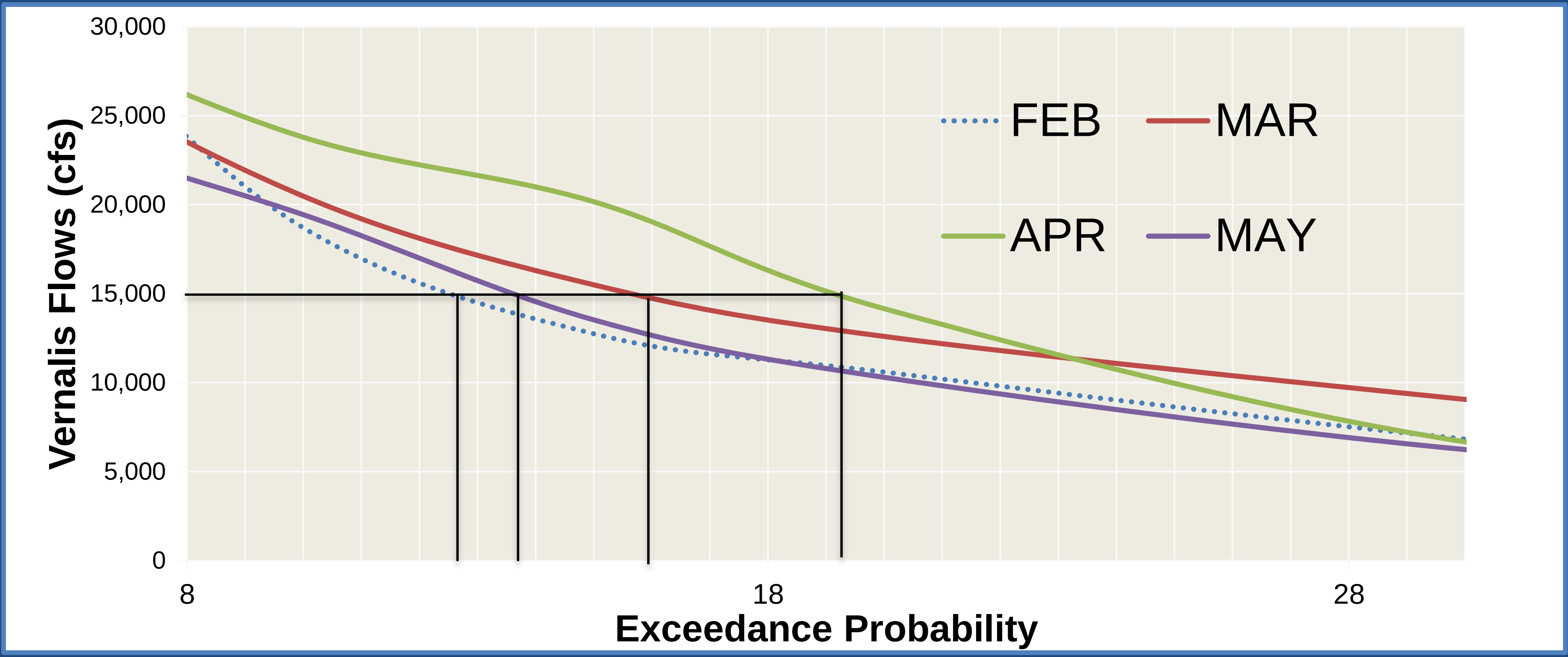
Method

Spatial and temporal characteristics of inundation

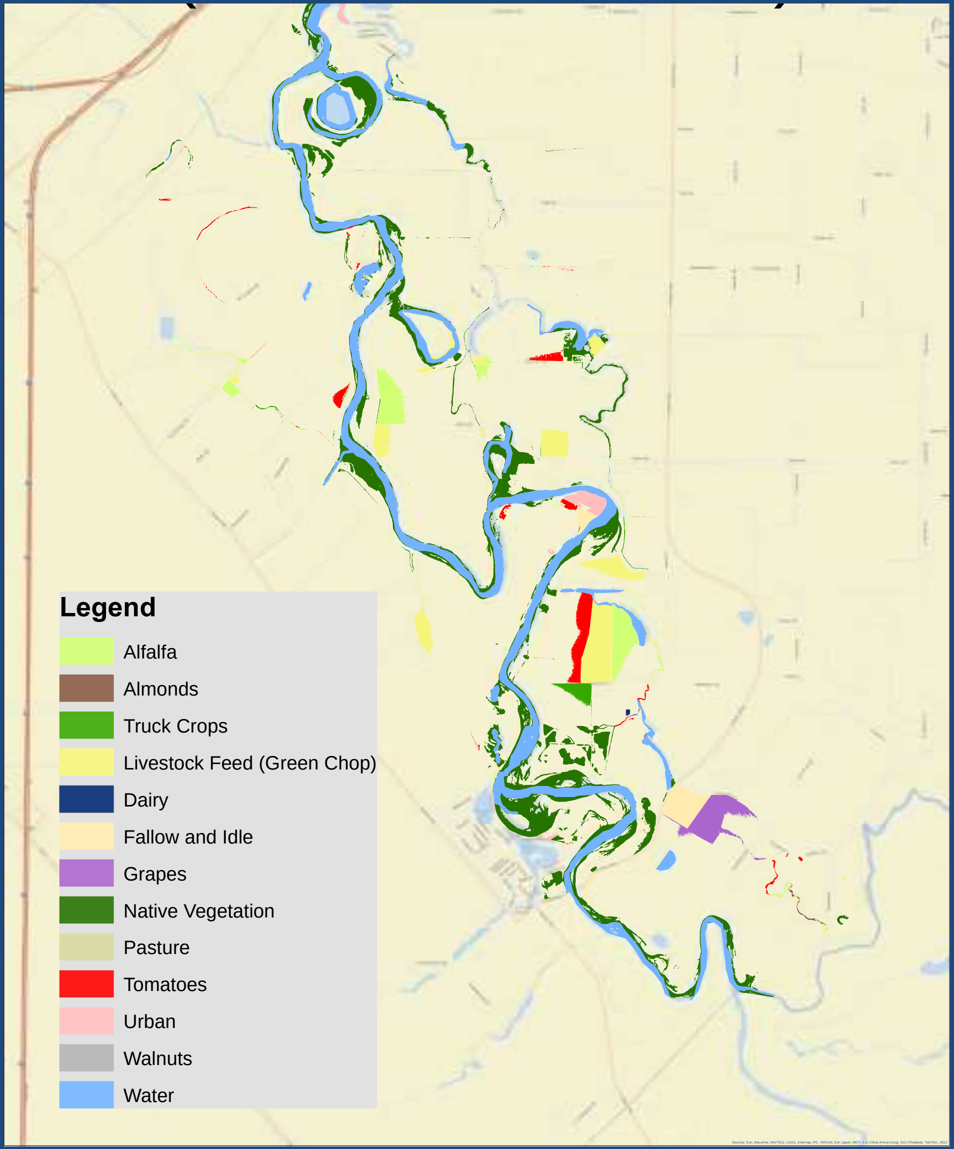
Area
Duration
Frequency

+

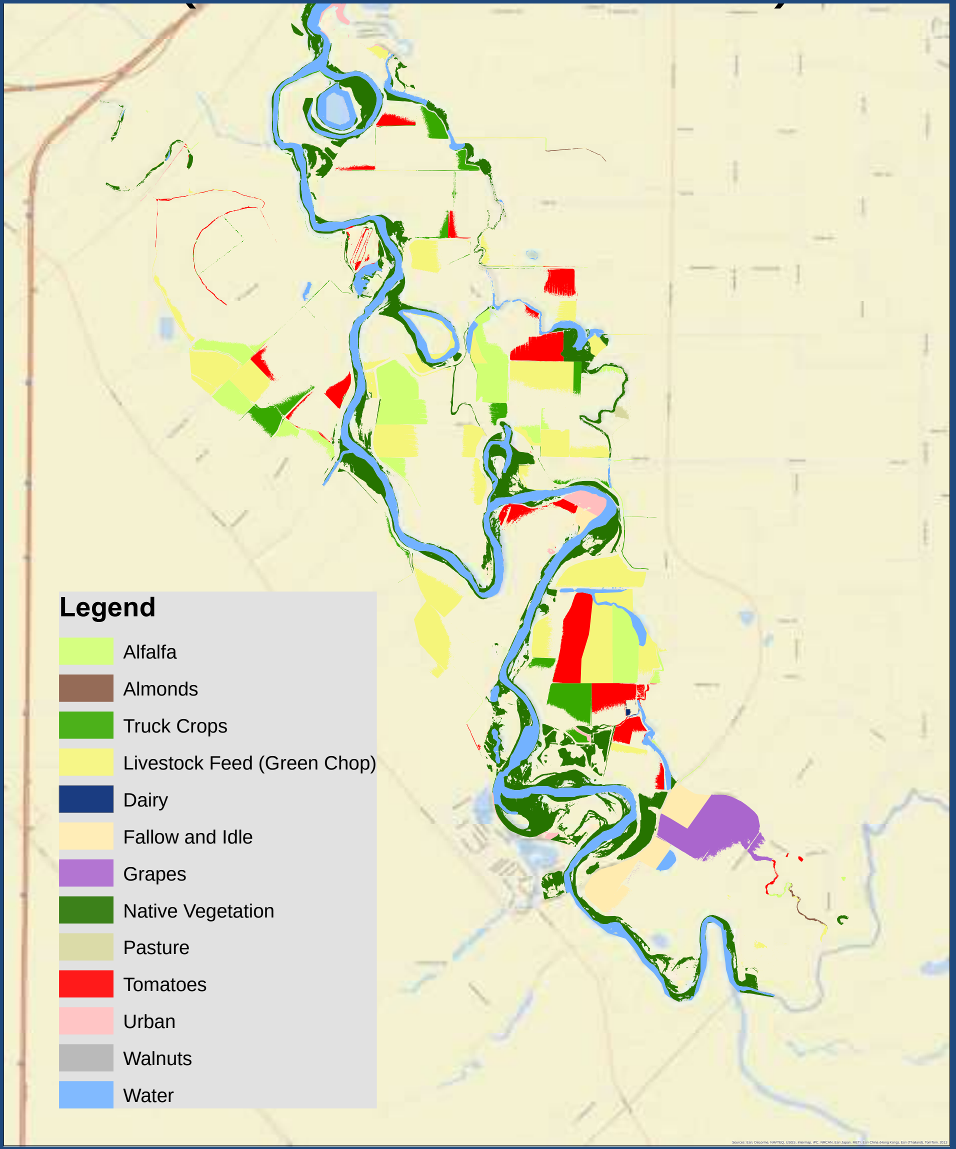
Agronomic information related to crop acreage, planting schedules, flood tolerance, and production value.



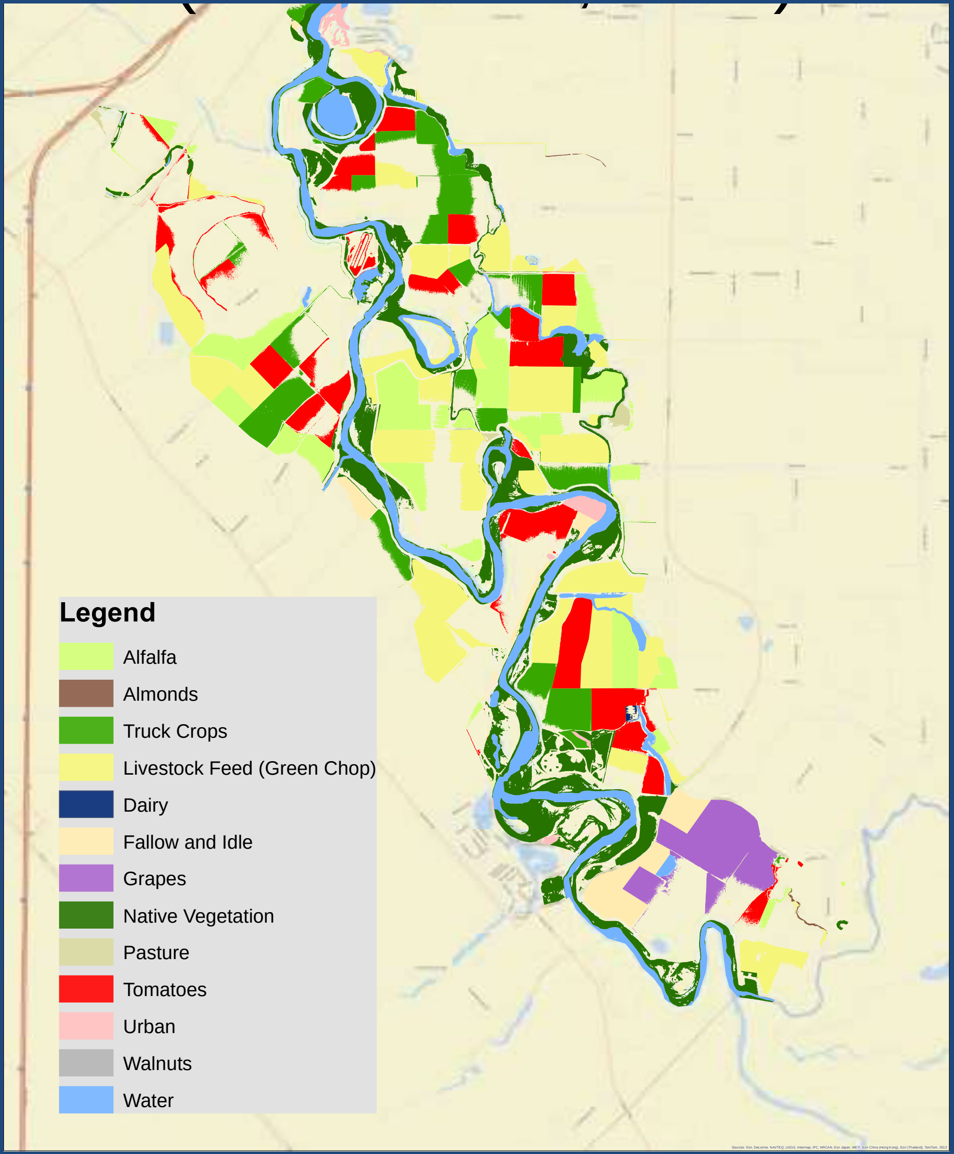
10,000 cfs flow



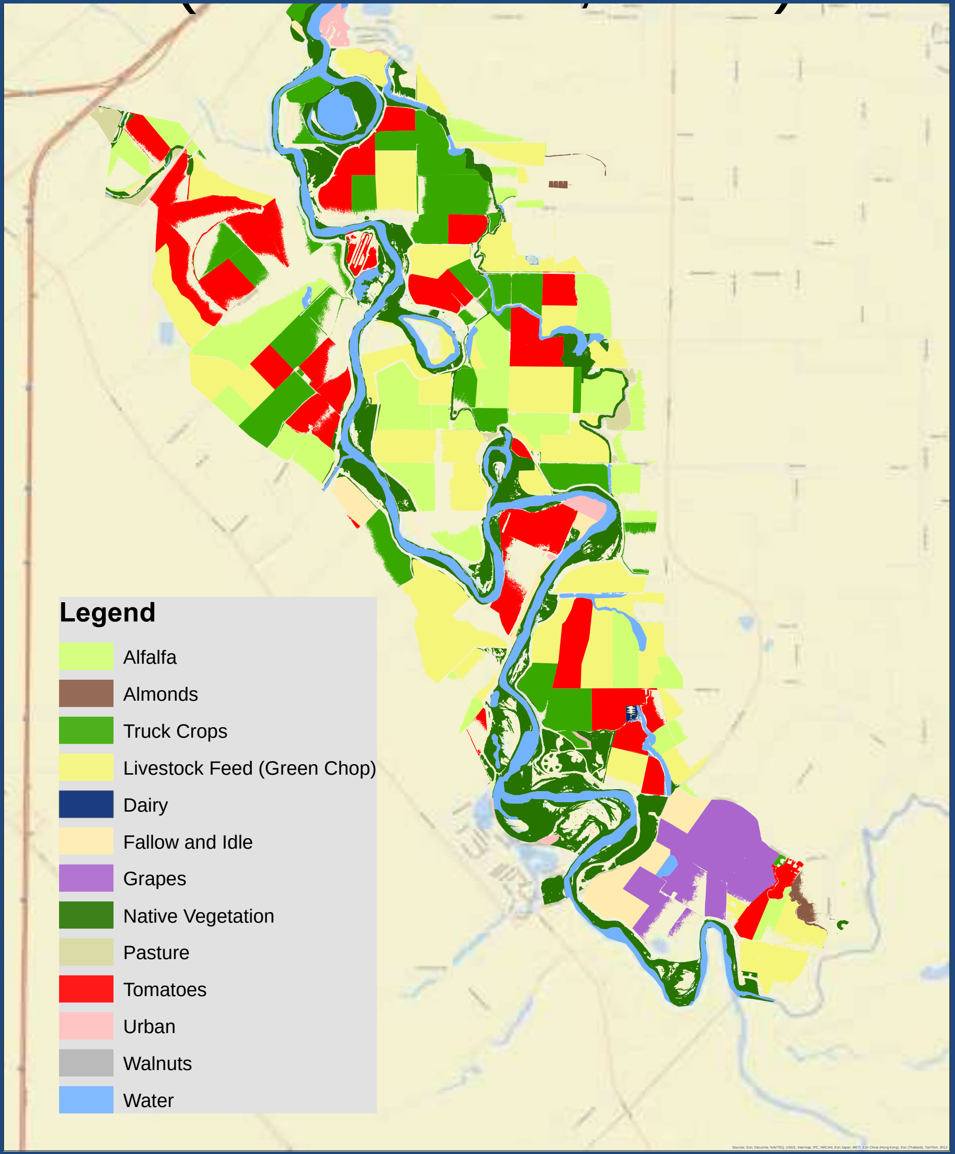
15,000 cfs flow



20,000 cfs flow

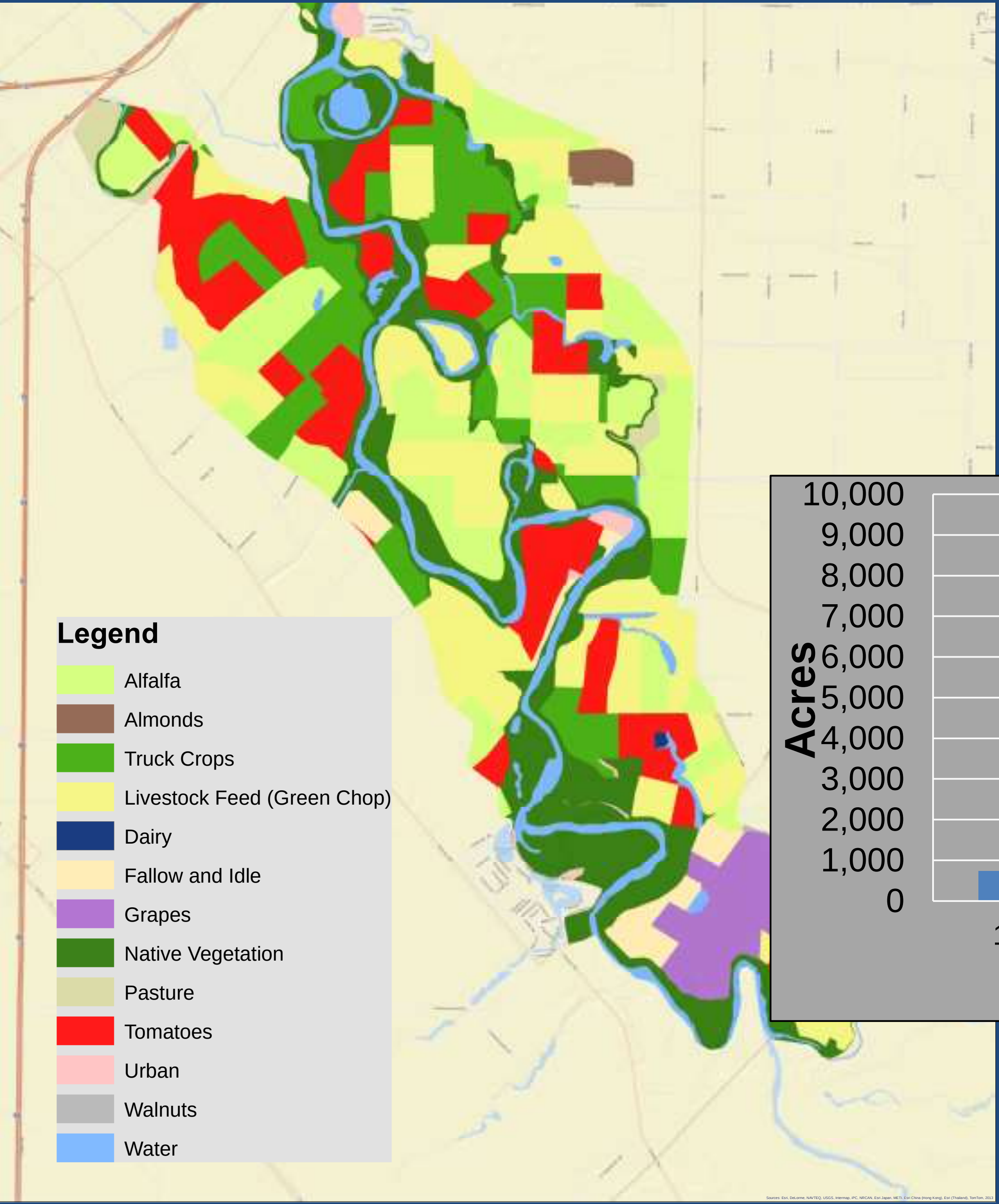


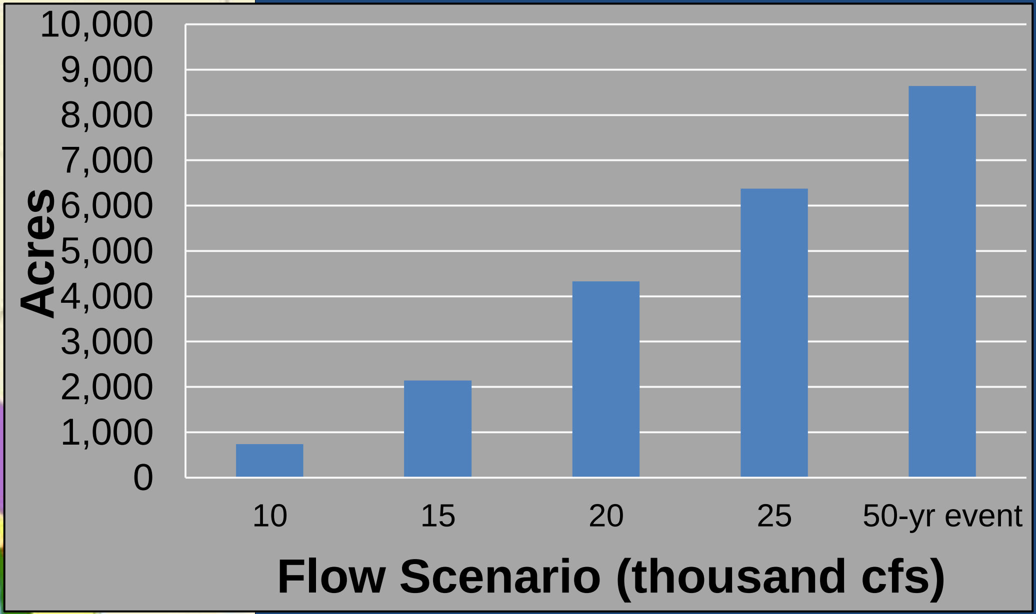
25,000 cfs flow



A 48,500 cfs flow discharge is required to inundate the full setback area.

The 48,500 cfs flow scenario corresponds to the **50-year flood** event, which has a 2% chance of occurring in any given year

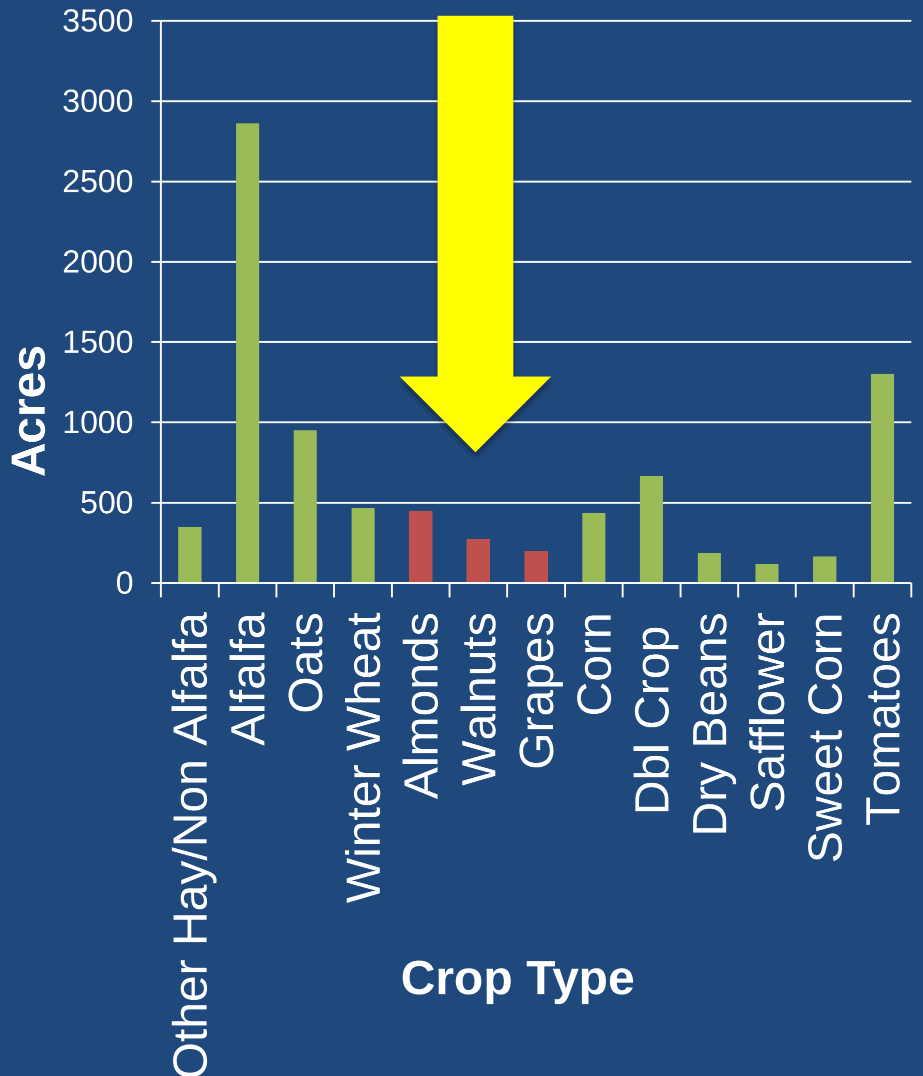




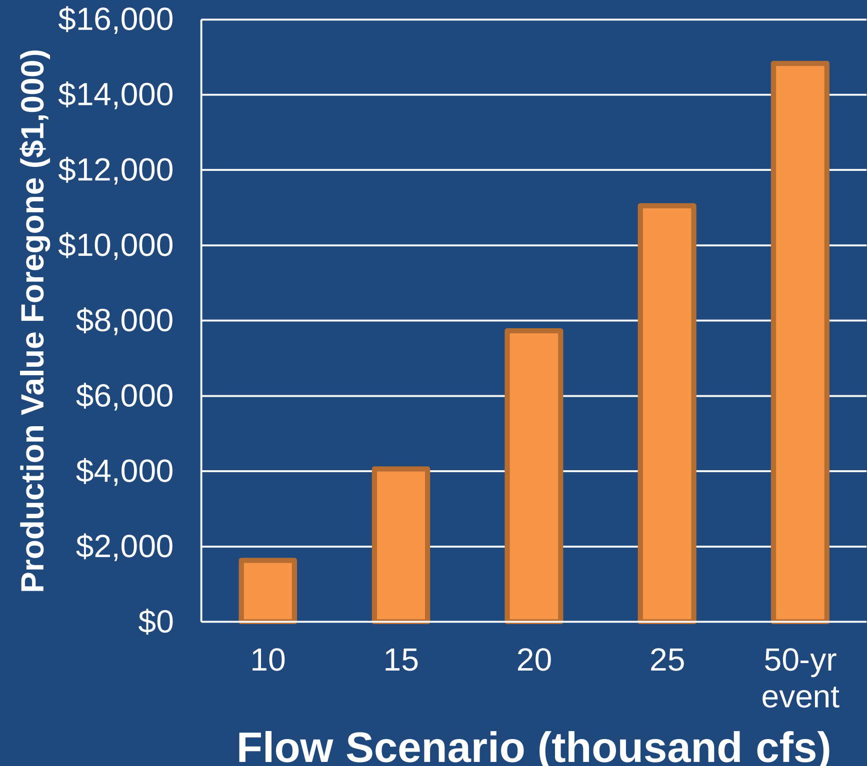
Full setback area (including developed land and open space) is approximately **10,258 acres**.

Crop Acreages in Total Setback Area

Perennials are approximately 10% (2010)



Approximate Production Value Forgone



Annual crops with planting flexibility
(UCCE San Joaquin)

Crop Name	Planting Range
Corn (Silage)	Early April - May
Corn (Sweet)	Early March - July
Dry Beans	May - June
Peppers	Early March - June
Rice	N/A
Safflower	Early February - May
Small Grain Silage	Early February - April
Squash	Early March - June
Sunflower	N/A
Tomatoes (Fresh Market)	Early March - July
Tomatoes (Processing)*	Early March - June

Non-flood risks: frost, rain, and of course … drought!

Yields and Gross Revenues (2012 $) for Selected Crops

Crop type	Yields (Tons/ Acre)	Gross Revenue/Ton ($)	Gross Revenue/Acre ($)
Almonds All	1.03	3740	**3852**
Walnuts English	2.07	2542	**5262**
Corn Grain	5.21	206	1073
Corn Silage	31.62	44	**1391**
Corn Sweet All	7.71	501.01	**3863**
Grapes Table	5.63	224.26	1263
Grapes Wine	5.6	550.56	**3083**
Hay Alfalfa	6.24	255	**1591**
Hay Other Unspecified	3.08	163.01	502
Silage	6.54	34	**222**
Wheat All	2.91	205.37	598
Tomatoes Fresh Market	13.1	400	5240
Tomatoes Processing	40.51	74	**2998**

We then multiplied crop value by the frequency that a given crop area would be inundated to determine risk.

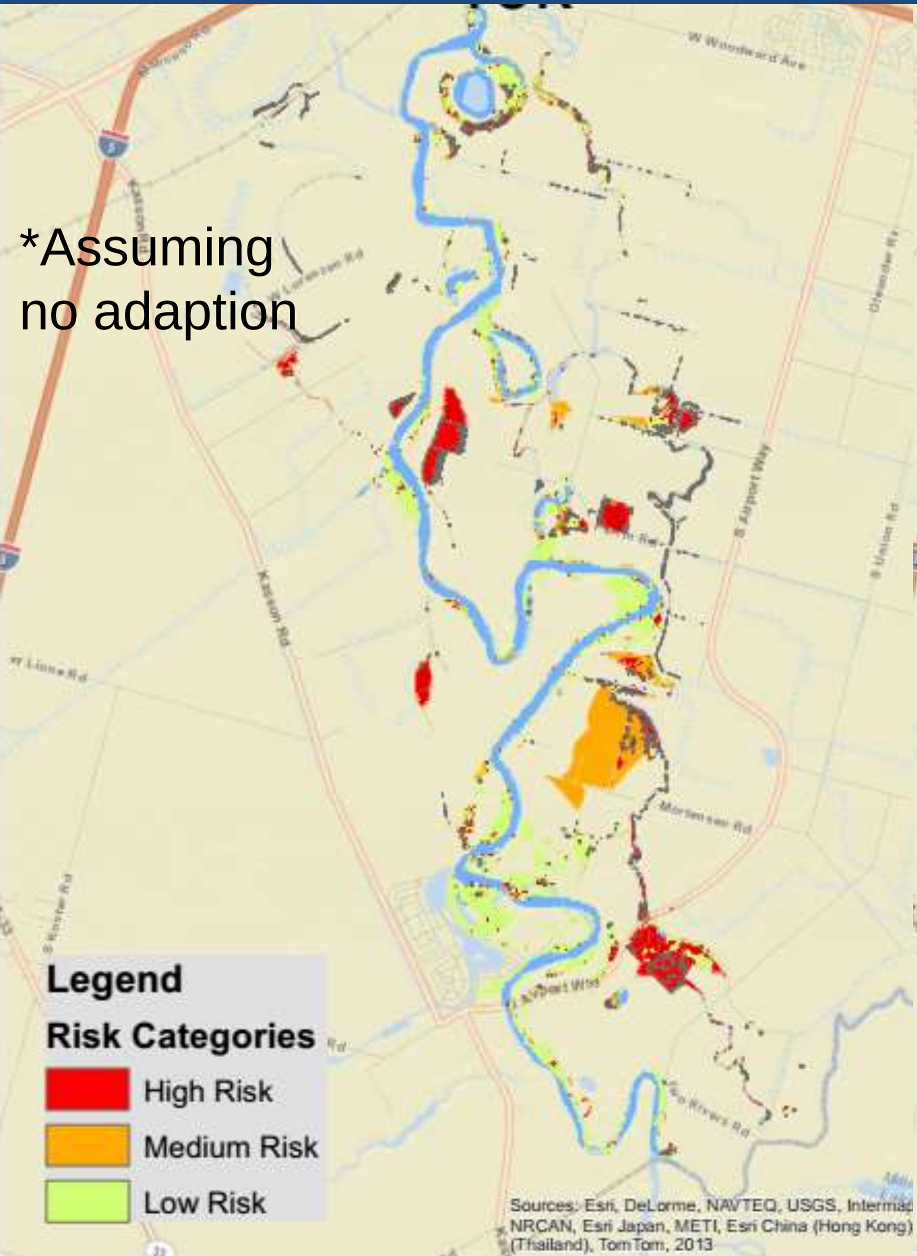
Risk = annualized gross revenue foregone

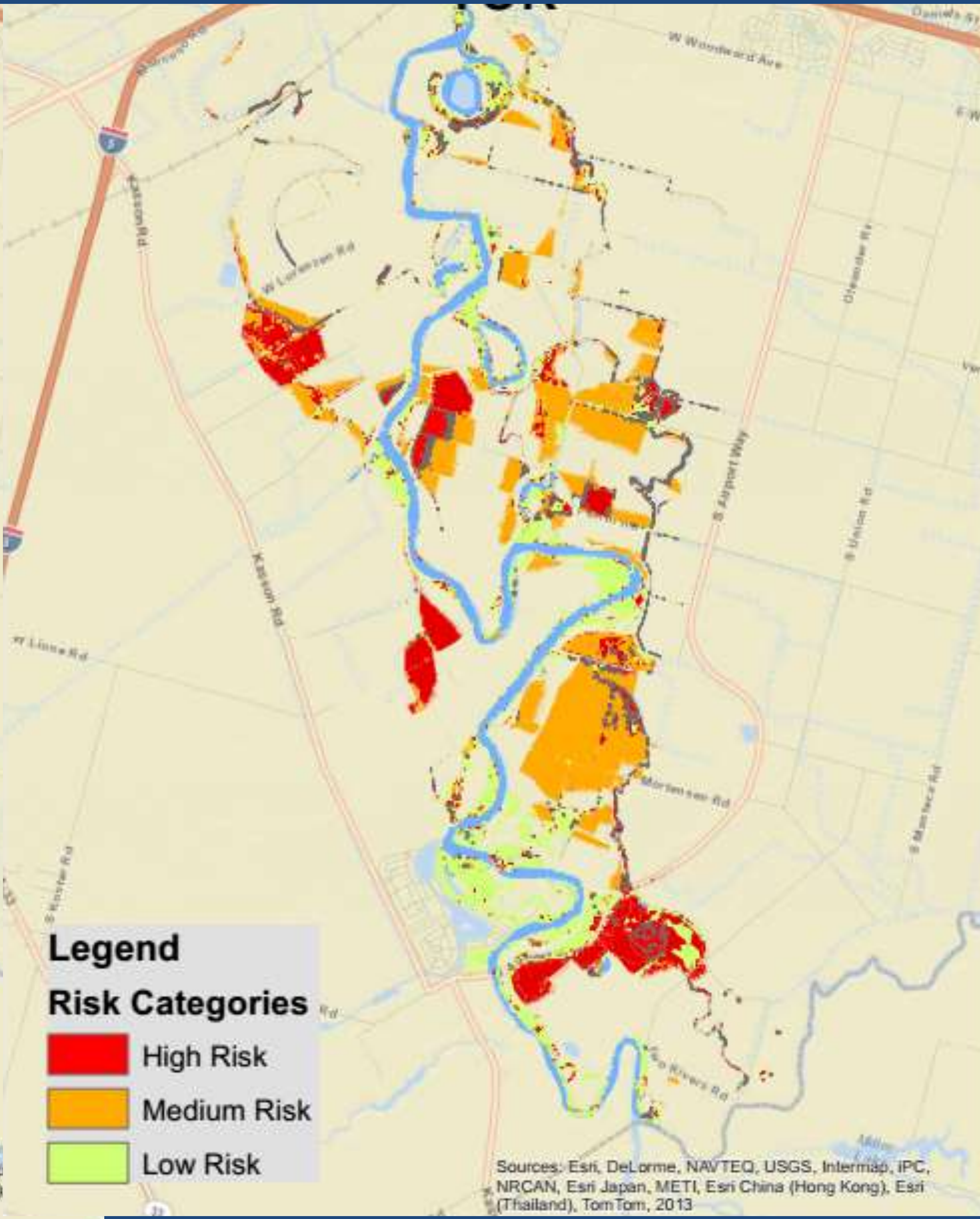
We developed a crop vulnerability index, which conveys the annualized risks associated with planting time for annual crops.

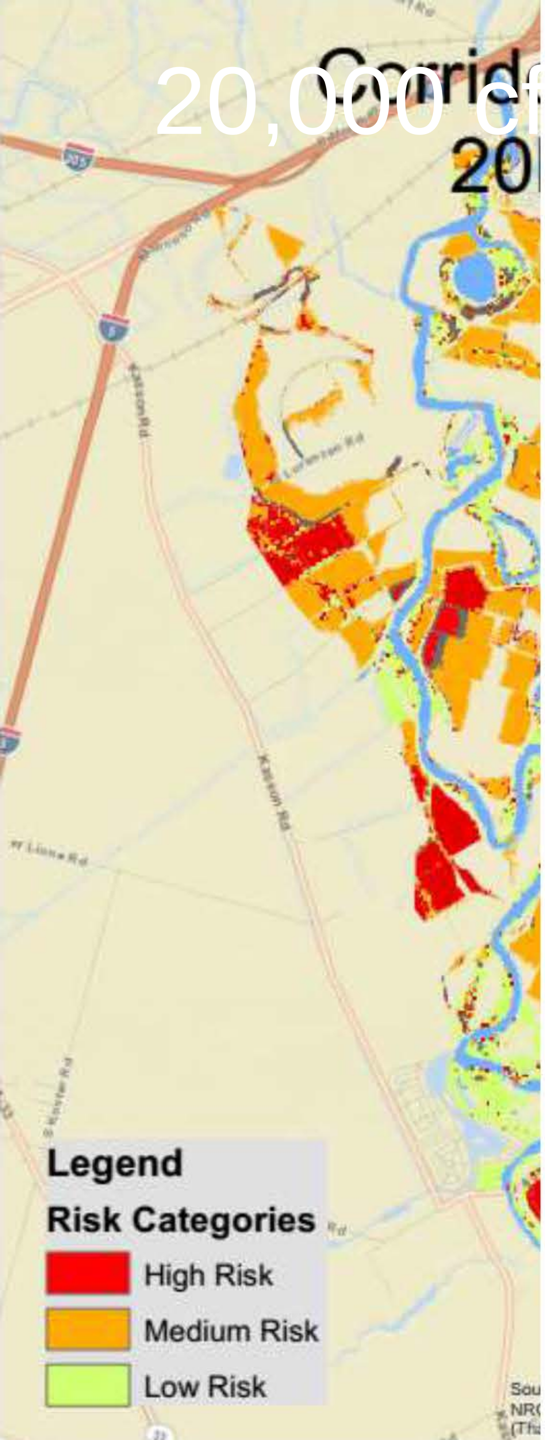
10,000 cfs flow

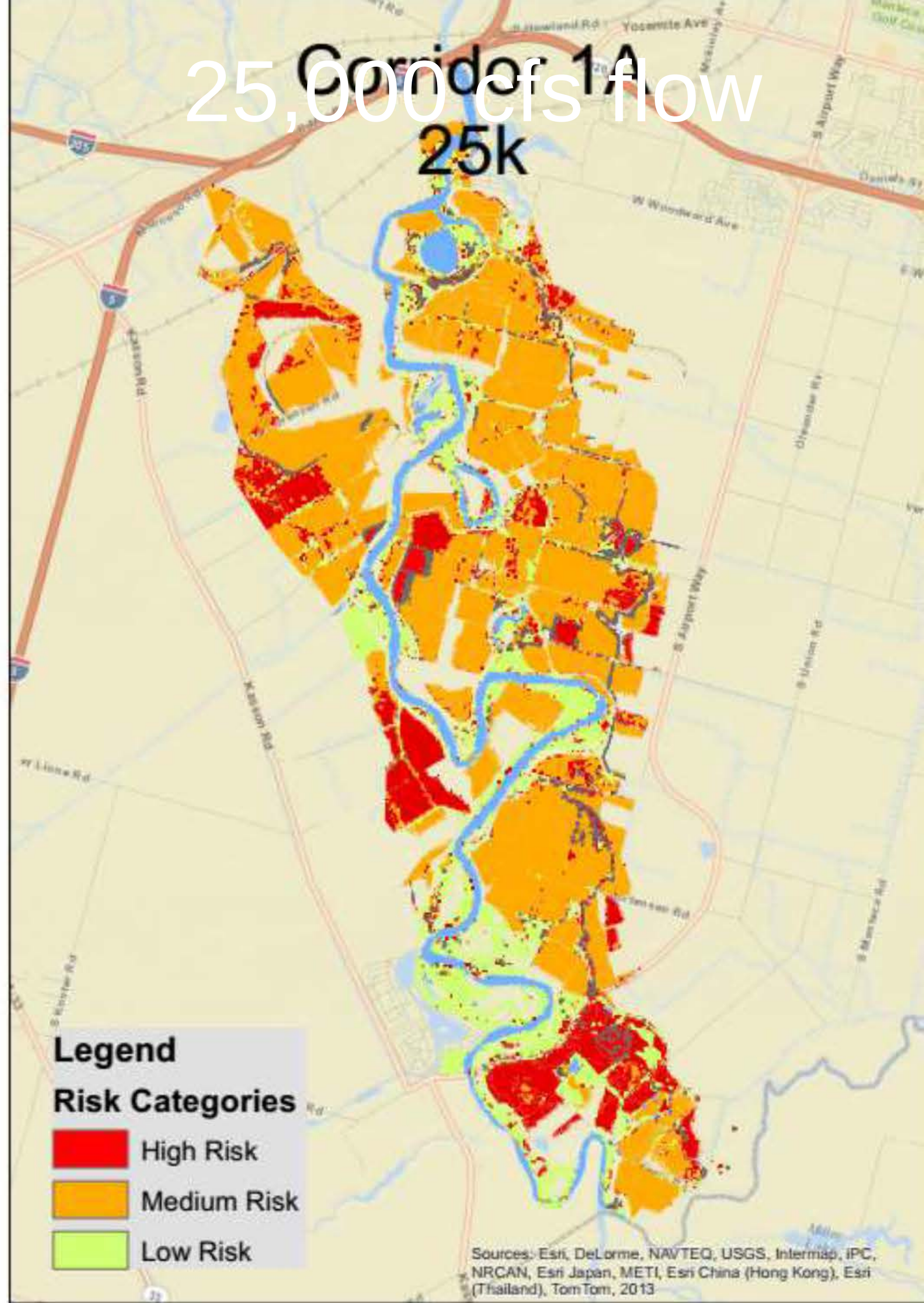
15,000 cfs flow

*Assuming no adaption





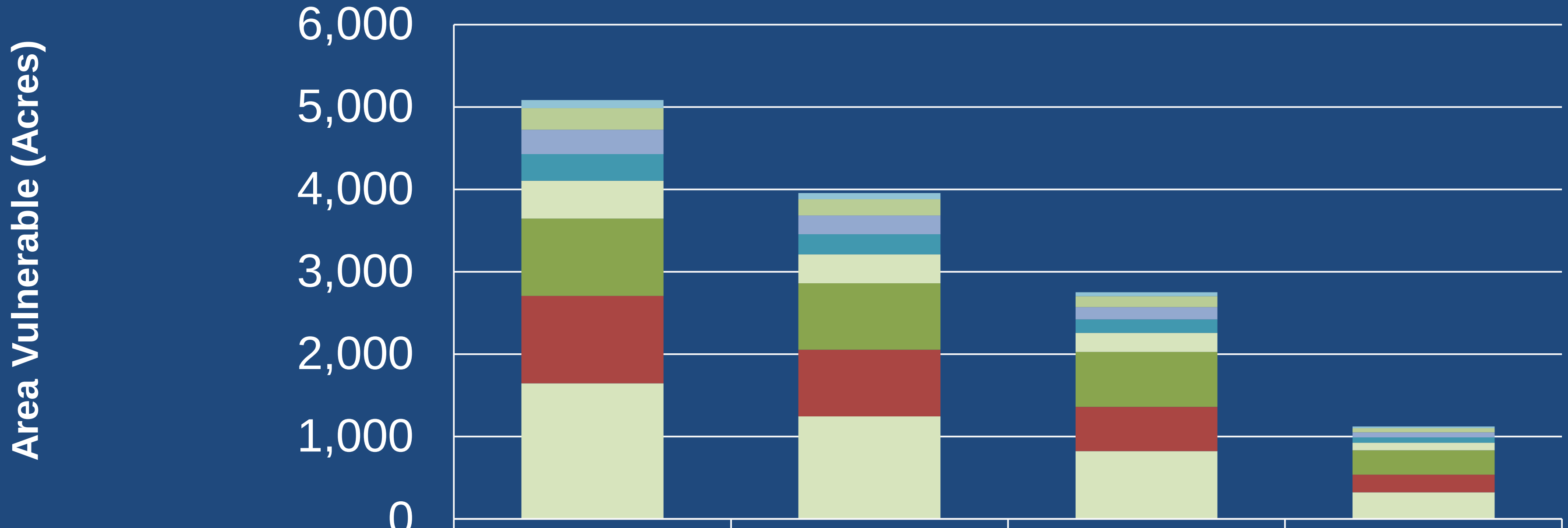

20,000 cf
Corrid
20k
Legend
Risk Categories
High Risk
Medium Risk
Low Risk


25,000 cfs flow
Corridor 1A
25k
Legend
Risk Categories
High Risk
Medium Risk
Low Risk
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

To determine the vulnerability associated with planting annuals in a specific month we calculated vulnerability for that month and then added the crop vulnerability for proximate months when annual planting occurs.

Our assumption being that the risk associated with an early planting of annuals must take into consideration risks of inundation events later in the spring.

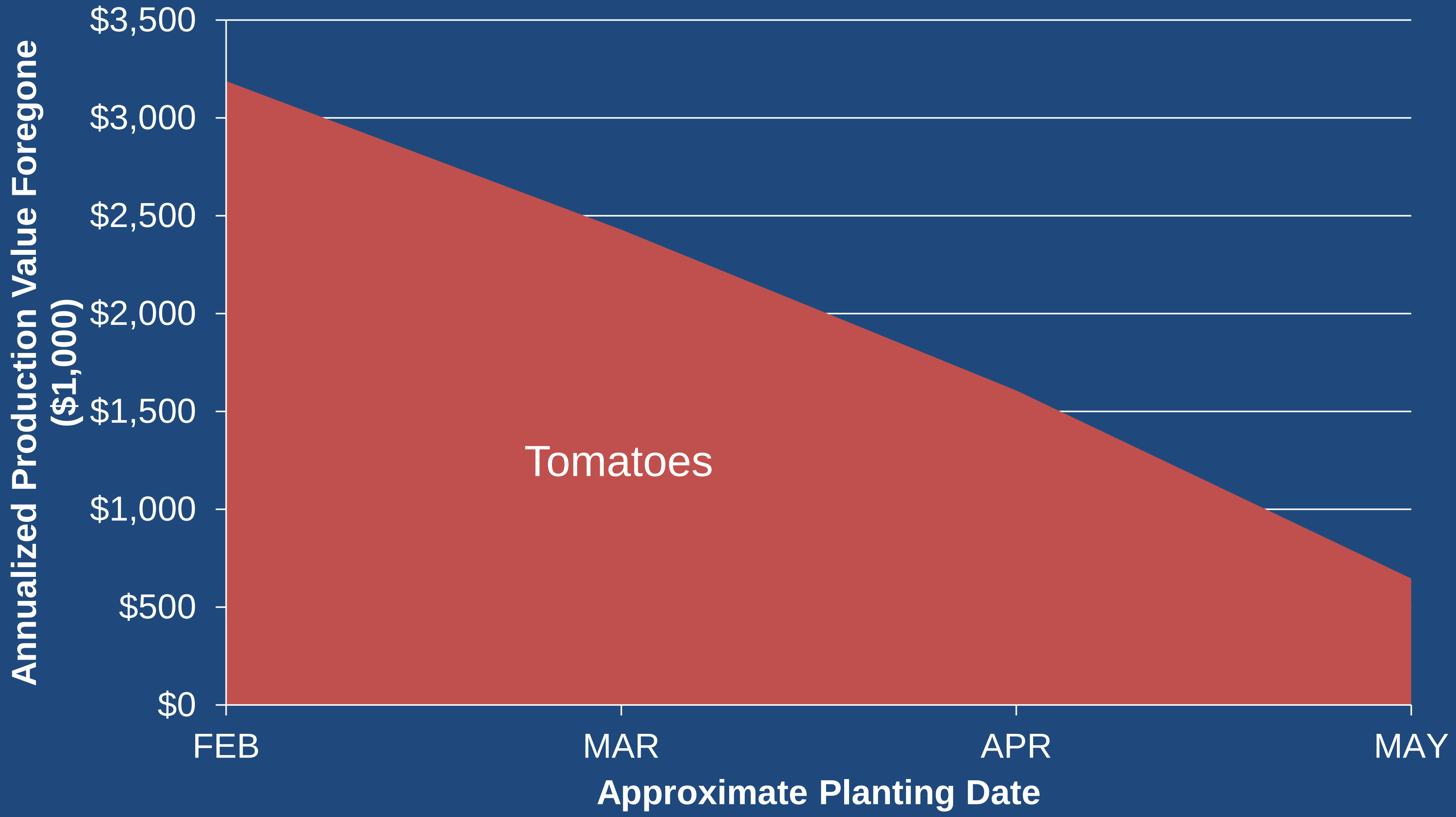
Annual Crops - timing matters a great deal



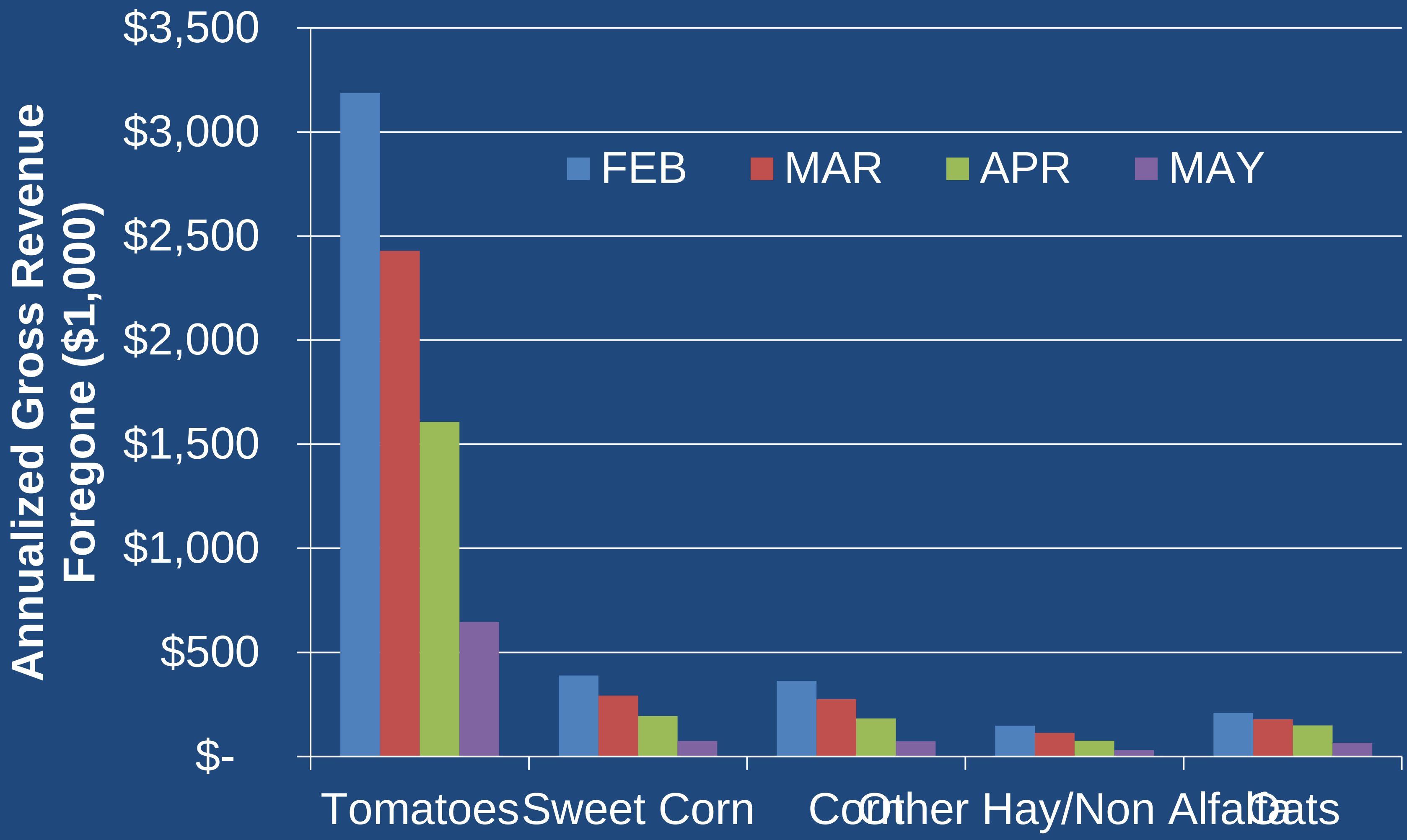
	FEB	MAR	APR	MAY
Sweet Corn	101	76	50	19
Corn	261	198	131	52
Other Hay/Non Alfalfa	295	225	150	60
Winter Wheat	323	247	164	65
Silage (double crop)	458	350	231	93
Oats	939	806	667	294
Tomatoes	1063	810	536	215
Alfalfa	1645	1245	824	324

Risk decreases as the season progresses

Similar to the risk management associated with a early spring frost event.



Expected annualized gross revenue foregone for annual crops by approximate planting date



Example

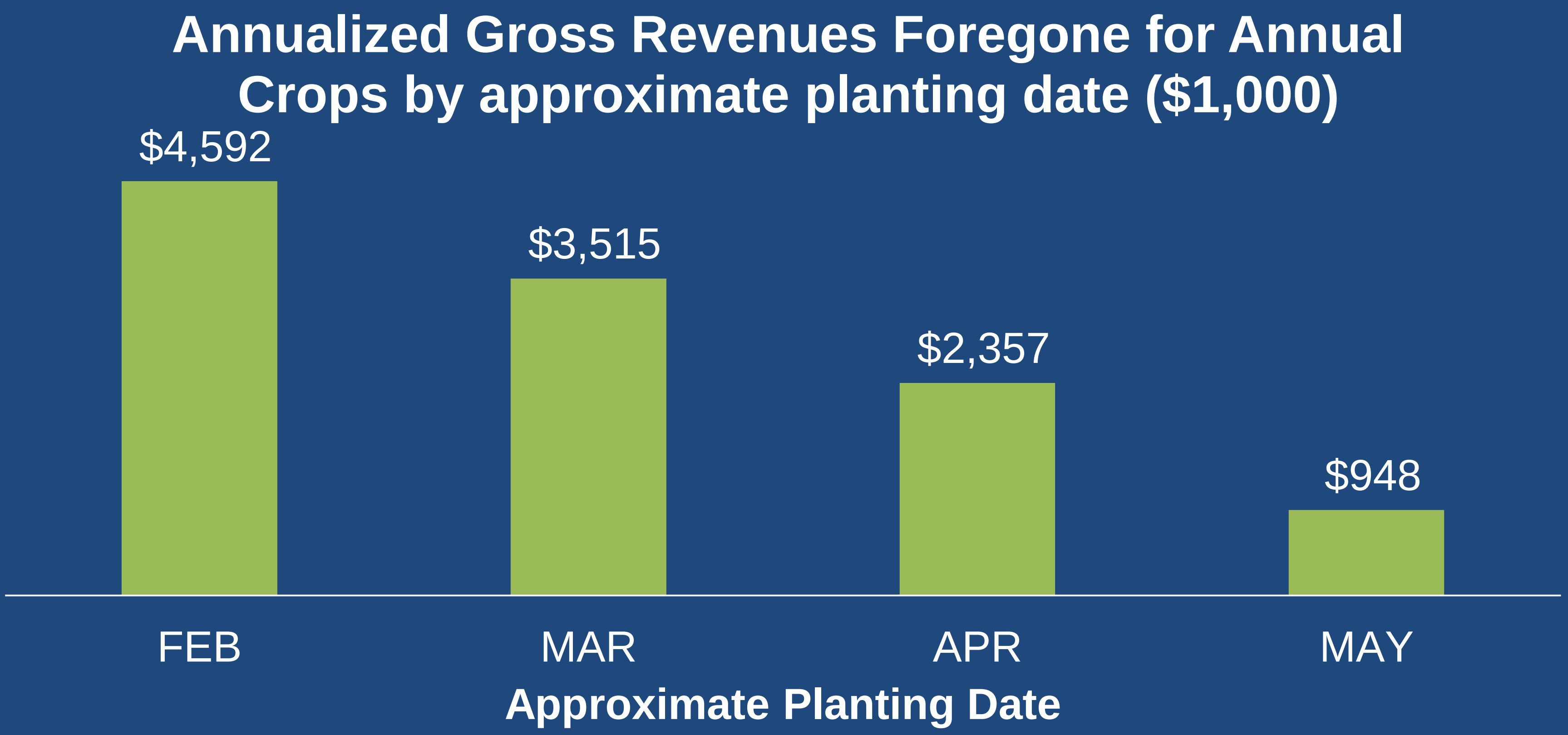
Due to extreme hydrograph alteration by upstream dams, the impact of levee removal on agricultural production value is limited. For example, a late May 15,000 cfs flood event (*occurring approximately 1 in 7 years*) would decrease annual crop production value by **$2.5 million**—slightly under one-tenth of total gross production value (**$27m**) of the total setback area.

*not including **300 acres** of perennial crops are at risk.

The average annual risk to annual crops of a 15,000 cfs May event   ~ **$350,000 per yr**

Results

Additional adaptions, such as planting later into the spring season, have the potential to greatly reduce risks for annual plantings.



Method Underestimates

- Ignores field damages and recovery costs
- 2010 data underestimates extent of perennial crops
- Gross revenue foregone is a rough proxy for broader economic impact (doesn’t include multipliers)

Method Overestimates

- Assumes no crop flood tolerance
- Ignores that growers are currently affected by seepage in wet years
- Assumes full levee removal (vs. strategic)
- HEC-RAS 1D may overextend area of inundation (but seepage confounds)
- Ignores how growers will adapt cropping patterns and planting times (for instance not plant in January…)
- Assumes no seasonal foresight

Conclusion

Probability of large areas being inundated after crops are planted is relatively low due to upstream regulation.

+

Relative low value crops (2010) are being grown in the area frequently inundated.

=

Potential risks of revenue loss is relatively low.

Strategically restore significant areas of floodplain with relatively small impact regional agriculture is high.

Next steps

How do these costs compare to those associated with:

- Existing costs of maintaining and operating levees
  - Flood fighting
  - Levee failure
  - Drainage
  - Pumping
  - Salinity management

Currently looking for these costs…

Next Steps:

Exploring synergies between agroecosystems and floodplain restoration.

How can growers **benefit** from the restoration of natural floodplain function?

HEC-RAS 2D + Hydrospatial modeling
Groundwater recharge

Tradeoff ➡ Compatibility ➡ Synergy

Questions?

Original artwork by Laura Cunningham, 2010.

Special thanks to:

John Cain, Mary Matella, Mark Tompkins, Josue Medellin-Azuara, Rene Henery, Julie Rentner, Chris Unkel, David Doll

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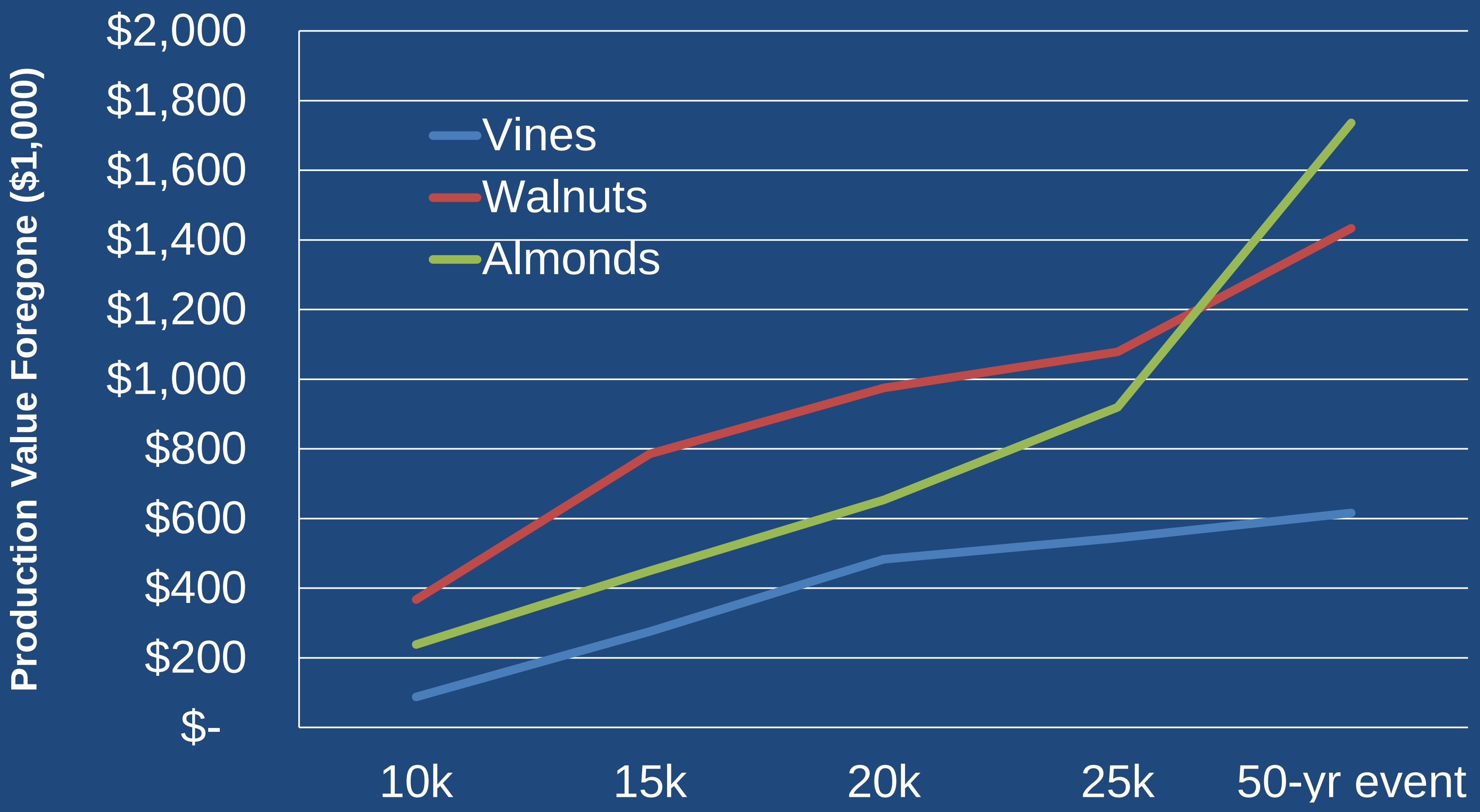
Perennial Crops

Timing does not matter as much

Duration and frequency are more important



Problem:

Floodplain restoration efforts along the San Joaquin are seen as incompatible with ongoing agricultural production.