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Managing Water in the West

Vegetation Modeling of the Trinity River between Lewiston Dam and the North Fork Trinity River

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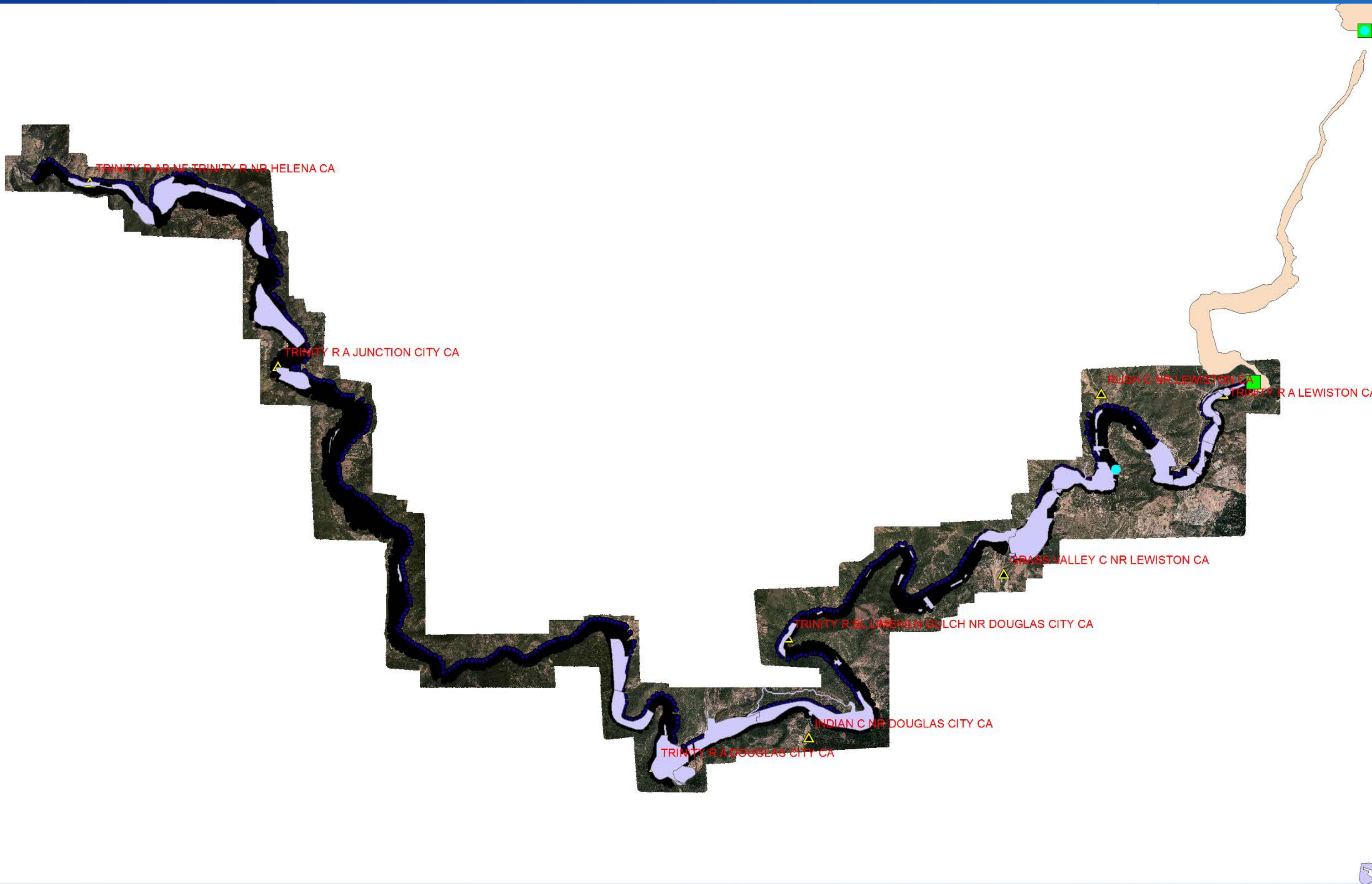
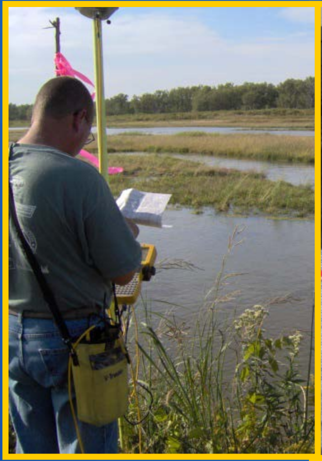
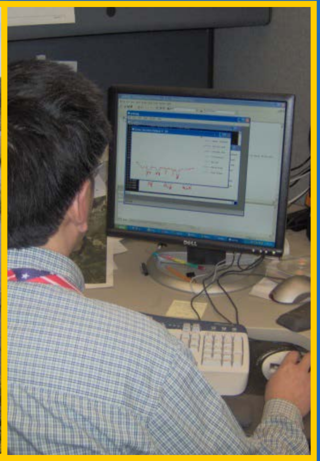
U.S. Department of the Interior
Bureau of Reclamation

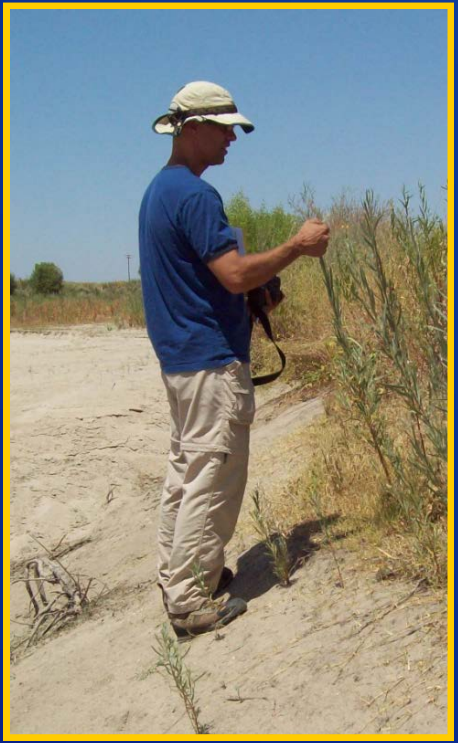


TRINITY R AB NF TRINITY R NR HELENA CA
TRINITY R A JUNCTION CITY CA
RUSH C NR LEWISTON CA
TRINITY R A LEWISTON CA
GRASS VALLEY C NR LEWISTON CA
TRINITY R BL LIMEKILN GULCH NR DOUGLAS CITY CA
INDIAN C NR DOUGLAS CITY CA
TRINITY R A DOUGLAS CITY CA

The Sedimentation and River Hydraulics Group at Reclamation's Technical Service Center has worked with riparian vegetation in 1D models since 1999.







APPLICATIONS

Platte River – SedVeg-Gen3 - EIS alternatives analysis for Habitat

Sacramento River - Development calibrations

San Joaquin River - EIS alternatives analysis

Sacramento River – EIS alternatives analysis

San Joaquin River – Vegetation Restoration Design

Rio Grande – Calibration Study for Habitat and River Management

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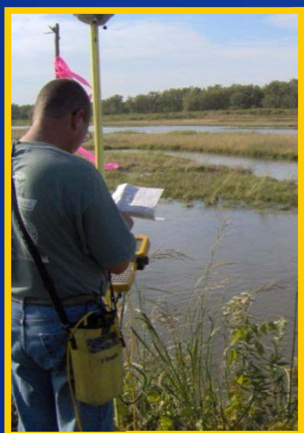
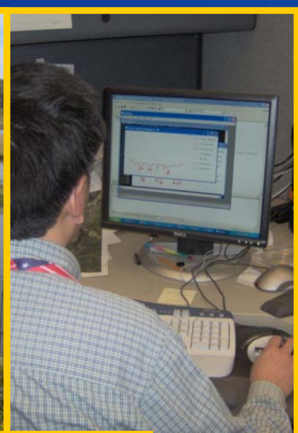
SRH-1DV, is a 1D numerical model, linking physical and ecological processes for the study of management actions





SRH-1D

Physical Processes

Flow hydraulics

Sediment transport

Groundwater elevation

SRH-1DV

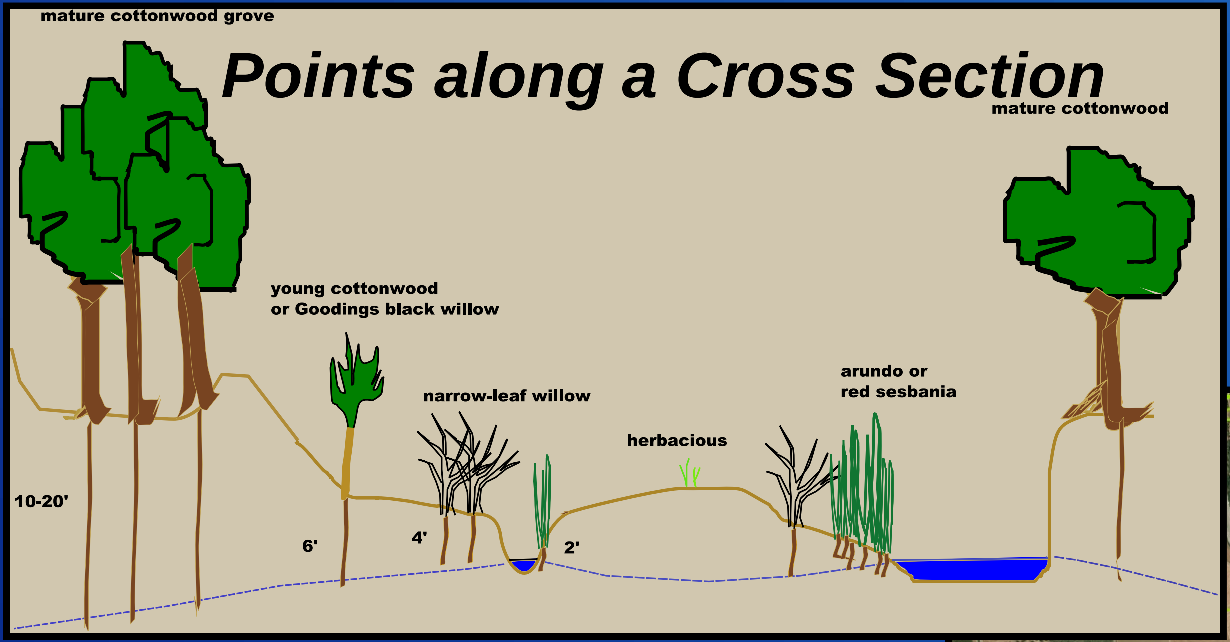
Ecological Processes

Germination, growth and mortality of native and invasive vegetation

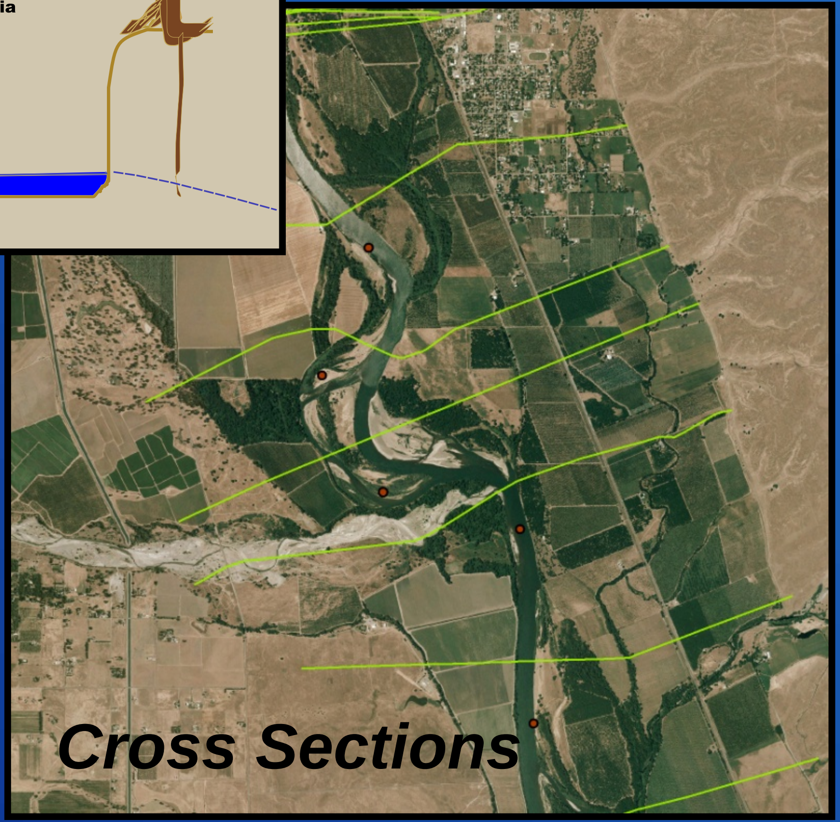
SRH-1D

Flow and Sediment Transport Computations

- SRH-1D is the base model for SRH-1DV
- It is a step-backwater model with steady or unsteady flow capability, computes water surface elevation and hydraulic parameters at specified time steps
- Sediment transport is computed at the specified time step for each grain size at each cross-section providing erosion and deposition, and substrate predictions



One-Dimensional Model (1D)



1D cross section model with vegetation growth potential at each point in the cross section.

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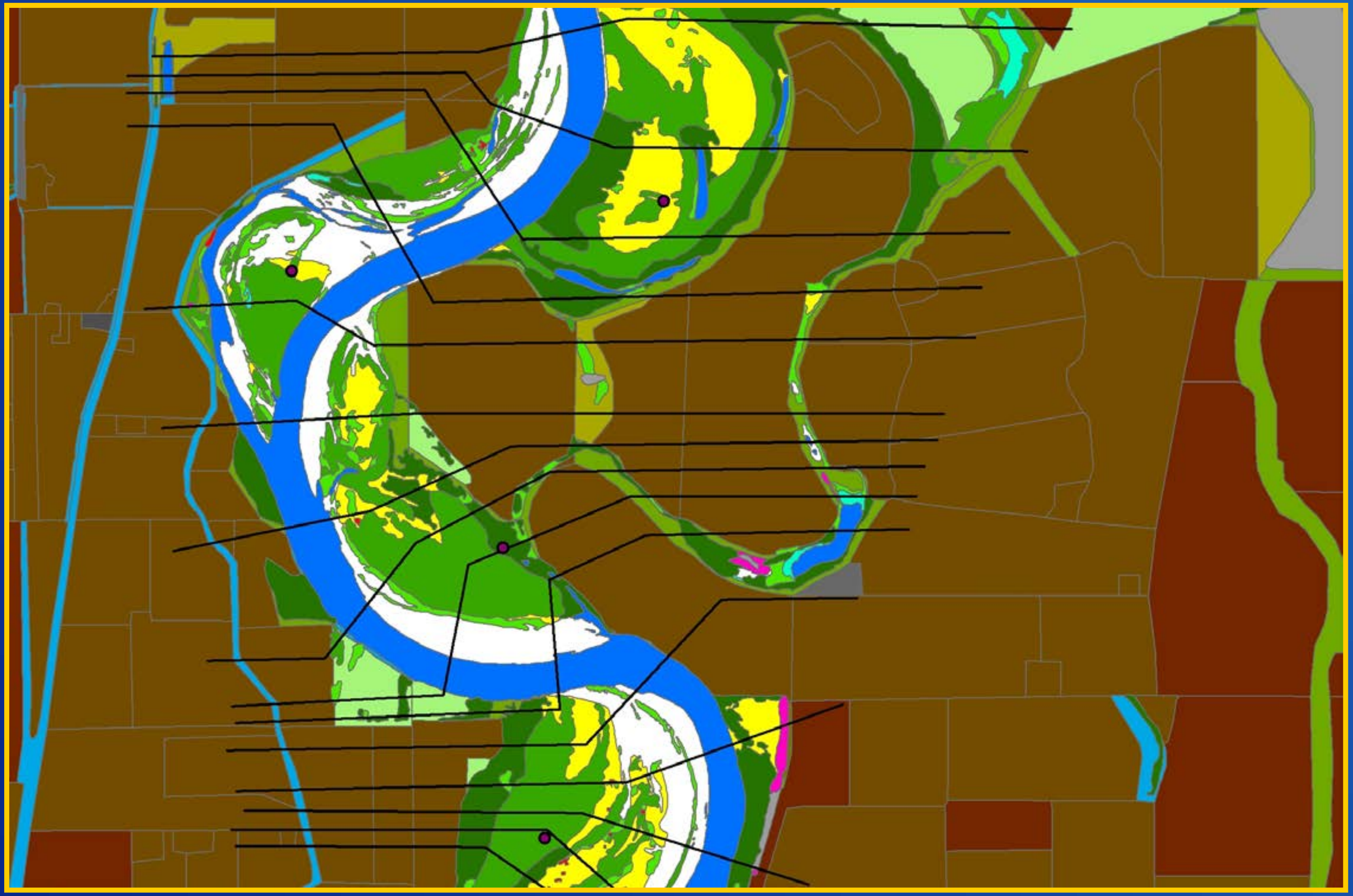
Vegetation modeling begins with input of existing vegetation conditions from GIS mapping



Vegetation Computations

Vegetation subroutines determine establishment, growth, and removal at specified time steps

Vegetation algorithms describe:

- Plant germination by air (natives) or water (invasives)
- Growth of roots (depth), stems (height), and canopy (width)
- Mortality by scour, inundation, desiccation, shading and competition. Options: by burial or management actions
- Describing plant growth requires estimates of the groundwater table
- Established vegetation is input from vegetation mapping

Each Selected Vegetation Type Should be Distinct

- Inhabits it's own niche that can be described by the model.

Vegetation Germination

seeds dispersed by air

or

seeds or plant propagules dispersed by water

Some model parameters:

- germination period,
- seed viability,
- flow depth,
- maximum float distance

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Vegetation Growth

- Model tracks growth of:
  - -plant stem,
  - -roots with respect to groundwater, and
  - -canopy width
- Model estimates groundwater based on river water surface
- Plant growth is limited to specified growing seasons for each vegetation type

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Vegetation Removal

Plant removal (mortality) occurs as a result of:

- flow scour or velocity criteria
- desiccation when root growth does not keep pace with a drop in the water table
- inundation based on assigned maximum time of submergence and water depth over the root cap
- senescence (age)
- burial

A counter in the model tracks the area of plants removed by cause of mortality (scour, desiccation, inundation, competition).

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Mortality by Shading and Competition
(developed for SJRRP)

Shading

Disturbance plants including cottonwood, willow, and arundo require direct sunlight to establish.

Canopies of established vegetation discourage new plant growth or vegetation expansion.

Plant germination for specified vegetation types can be blocked at cross section points located under canopies. Growth rate of canopy width is specified by plant type and age.

Competition

Competition rules are assigned by vegetation type and age, i.e. once established, invasive plants like red sespania and giant cane can out-compete native plants.

Cottonwood requires bare sand to germinate and can not establish in grassed areas.

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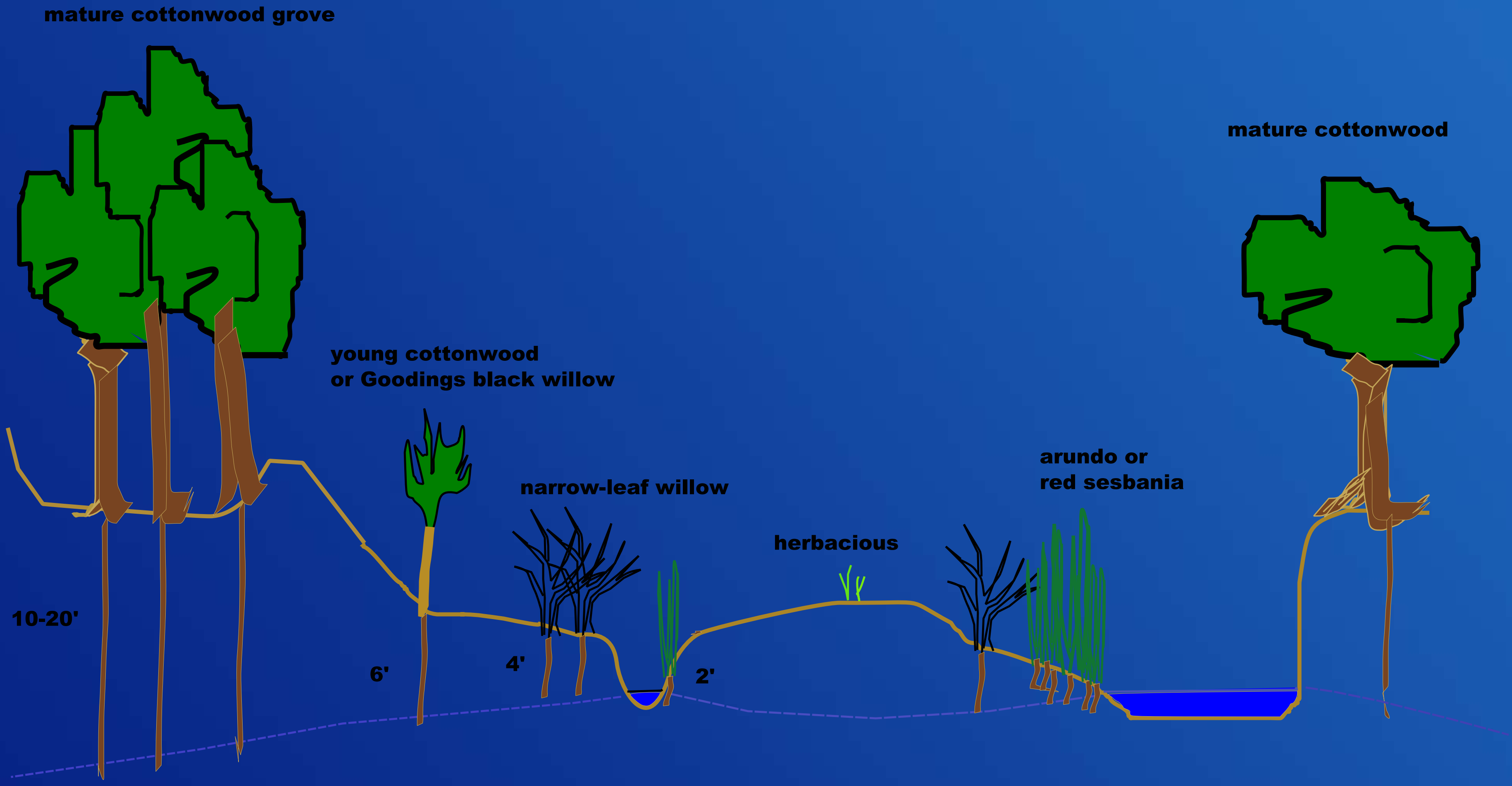
Sensitive to Root depth, seed seasons, desiccation, inundation



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Background

- Trinity River between Lewiston Dam and the North Fork Trinity River
  - Trinity Dam was completed in 1962 (capacity of 2,448,000 acre-feet)
  - Lewiston Dam was completed in 1963 (capacity of 14,660 acre-feet)
- Up to 90% of the annual water yield of the Trinity was diverted for agricultural and urban uses
- These dams regulated the flows and reduced the flow peaks. Historic flows ranging from 100 to 100,000 cfs were regulated to nearly constant flows between 100 to 300 cfs.
- The elimination of the high flow regime reduced the channel dynamics of the river and changed the river into a single channel in most areas, and thus reduced salmonid habitat.

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Input data

- Hydrology

Gage Number	Gage Name	Time Period	comment
11525500	Trinity R a Lewiston CA	1911-10-01 to present	
11525530	Rush C nr Lewiston CA	2002-10-01to present	Tributary
11525630	Grass Valley C nr Lewiston CA	2004-10-01to present	Tributary
11525655	Trinity R bl Limekiln Gulch nr Douglas City CA	1981-04-28 to present	
11525670	Indian C nr Douglas City CA	2004-10-01 to present	Tributary
11525854	Trinity R a Douglas City CA	2002-10-01to present	
11526250	Trinity R a Junction City CA	2002-10-01to present	
11526400	Trinity R ab NF Trinity R nr Helena CA	2005-03-29 to present	

- Cross section geometry based on a 2009 terrain
- Downstream boundary condition:
  - Based on a rating curing developed in a separate study

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Input data

- Groundwater Parameters
  - Hydraulic conductivity
  - Capillary fringe height
  - Drop velocity
  - Maximum groundwater decline below thalweg
- Other Parameters
  - Manning's coefficient 0.045 for channel and 0.08 for overbank
  - Time Steps: 1 hour for flow and 1 day for vegetation

Input data

- 2001 vegetation inventory map, developed by Mcbain And Trush and USDA Forest Service Redwood Sciences Laboratory
- Numerical simulation was performed from November 15 2001 through April 15 2011 with historical flow rates
- compared with 2011 vegetation map (Hoopa Valley Tribe and McBain Associates, 2015)

SRH-1DV

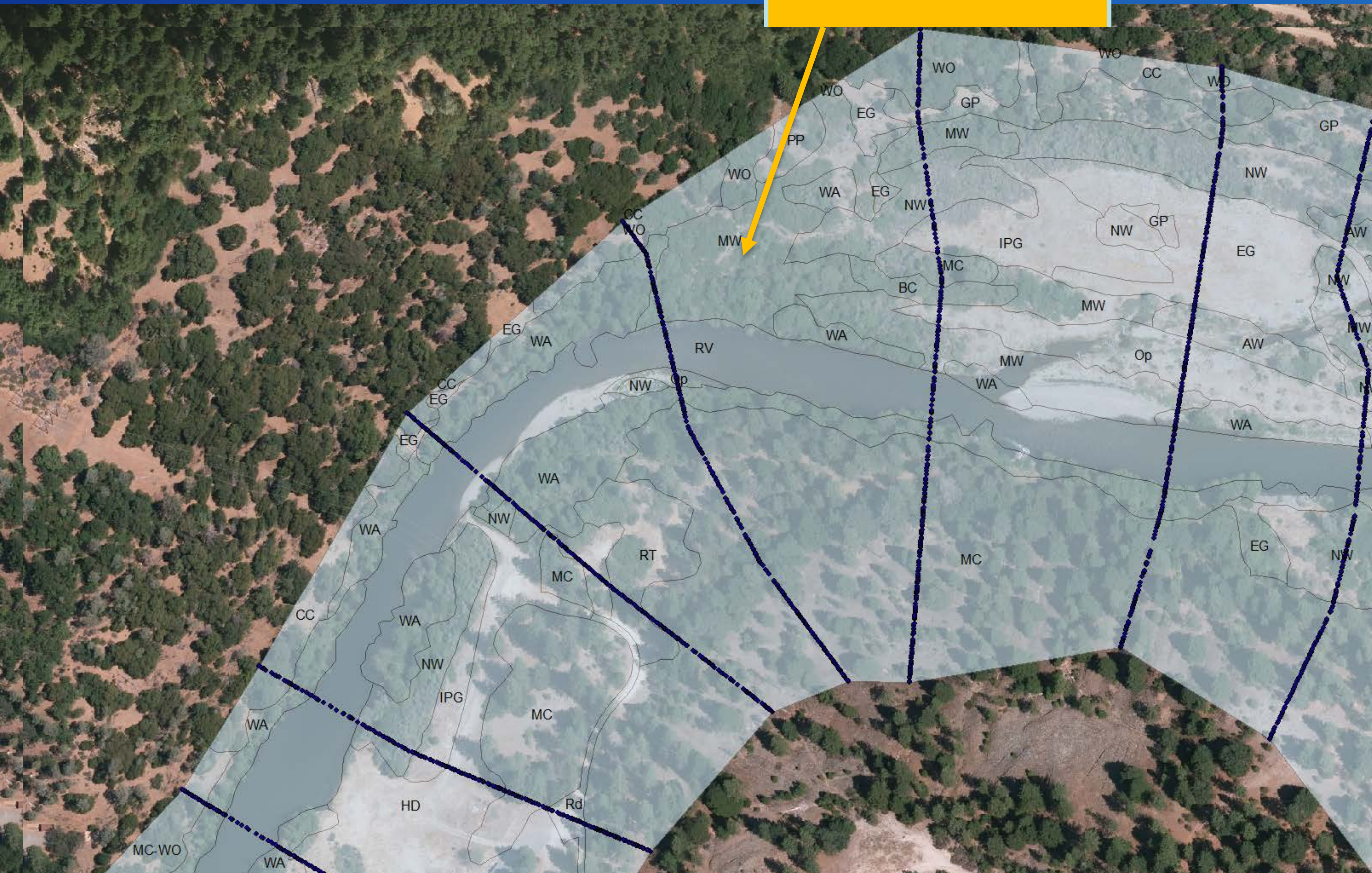
Modeled Vegetation Alliance	Latin Name	Abbreviation
Black Cottonwood Fremont Cottonwood	Populus balsamifera ssp. Trichocarpa Populus fremontii	BKCW
White Alder	Alnus rhombifolia	WHAD
Narrowleaf Willow Dusky Willow	Salix exigua Salix melanopsis	NLWL
Arroyo Willow Shiny Willow Red Willow	Salix lasiolepis Salix lucida ssp. Lasiandra Salix laevigata	OTWL
Others	NA	OTER
No Grow (ag and roads)	NA	NOGR

SRH-1DV

Code	BKCW		WHAD		NLWL		OTWL		OTER		NOGR		Vegetation Community
	a	r	a	r	a	r	a	r	a	r	a	r	
AQEM	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Aquatic Emergent
ARDO	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Mugwort
AW	0	0	0	0	0	0	20	0.75	0	0	0	0.00	Arroyo Willow
BB	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Himalaya Berry*
BC	20	0.75	0	0	0	0	0	0	0	0	0	0.00	Black Cottonwood
BL	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Black Locust*
BM	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Bigleaf Maple
CC	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Wedgeleaf Ceanothus
CG	0	0	0	0	0	0	0	0	10	0.75	0	0.00	California Grape
CL	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Canyon Live Oak
CLE	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Clematis
CT	0	0	0	0	0	0	0	0	1	0.75	0	0.00	Cattail
DAR	0	0	0	0	0	0	0	0	3	0.75	0	0.00	Indian Rhubarb
DF	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Douglas Fir
DW	0	0	0	0	20	0.75	0	0	0	0	0	0.00	Dusky Willow
EG	0	0	0	0	0	0	0	0	1	0.8	0	0.00	California Annual Grassland
ELDER	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Blue elderberry
FC	30	0.75	0	0	0	0	0	0	0	0	0	0.00	Fremont Cottonwood
GP	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Foothill Pine
GP-CL	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Foothill Pine - Canyon Live Oak
GP-WO	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Foothill Pine - White Oak
HD	0	0	0	0	0	0	0	0	0	0	99	1.00	Human Disturbance
IPG	0	0	0	0	0	0	0	0	1	0.8	0	0.00	Introduced Perennial Grassland
JU	0	0	0	0	0	0	0	0	3	0.75	0	0.00	Juncus
MA	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Whiteleaf Manzanita
MAL	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Apple
MC	0	0	0	0	0	0	0	0	20	0.5	0	0.00	Mixed Conifer
MC-MAP	0	0	0	0	0	0	0	0	20	0.53	0	0.00	Mixed Conifer - Mountain Maple
MC-WO	0	0	0	0	0	0	0	0	20	0.53	0	0.00	Mixed Conifer - White Oak
MW	0	0	0	0	20	0.4	20	0.4	0	0	0	0.00	Mixed Willow
NW	0	0	0	0	20	0.75	0	0	0	0	0	0.00	Narrowleaf Willow
OA	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Oregon Ash*
Op	0	0	0	0	0	0	0	0	0	0	0	0.00	Open
OpAQ	0	0	0	0	0	0	0	0	0	0	0	0.00	Open Water
PP	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Ponderosa Pine
Rd	0	0	0	0	0	0	0	0	0	0	99	1.00	Road
RI	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Straggly Gooseberry
RS	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Rose
RS-CG	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Rose-California Grape
RT	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Basket Bush*
RV	0	0	0	0	0	0	0	0	0	0	0	0.00	River
SA	0	0	0	0	0	0	0	0	10	0.3	0	0.00	California Brickellbush
Sd	0	0	0	0	0	0	0	0	2	0.75	0	0.00	Sedge
SW	0	0	0	0	0	0	20	0.75	0	0	0	0.00	Shiny Willow
TH	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Tree of Heaven*
UNK	0	0	0	0	0	0	0	0	10	0.75	0	0.00	Unknown
WA	0	0	30	0.75	0	0	0	0	0	0	0	0.00	White Alder
WA-SW	0	0	30	0.33	0	0	20	0.2	0	0	0	0.00	White Alder - Shiny Willow
WO	0	0	0	0	0	0	0	0	20	0.75	0	0.00	Oregon White Oak

Initial Vegetation

MW: Mixed Willows
40% NLWL, 20 yrs old
40% OTWL 20 yrs old



Simulation

			Vegetation Area (Acres)			
			BKCW	WHAD	NLWL	OTWL
Living	2001 Mapping		36.8	246.6	254.1	129.3
	2011 Mapping		31.6	177.0	262.4	154.5
	2011 Simulated	Total	30.0	185.4	259.3	153.9
		Old	30.0	185.4	136.2	110.6
		New Grown	0	0	123.1	43.3
	Field Change		-14.1%	-28.2%	3.3%	19.4%
	Modeled Change		-18.6%	-24.8%	2.1%	19.0%
Mortal-ity cause	Competition		0	0	12.6	1.6
	Desiccation		1.9	39.3	68.6	6.9
	Drowning		0	20.9	3.1	4.2
	Scour		5.0	1.0	33.6	6.0

Cottonwood at Station 94.35 on 2001 aerial photo

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Cottonwood at Station 96.82 on 2010 aerial photo

white alder at Station 89.43 on 2001 Aerial Photo

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White alder at Station 89.43 on 2014 Aerial Photo

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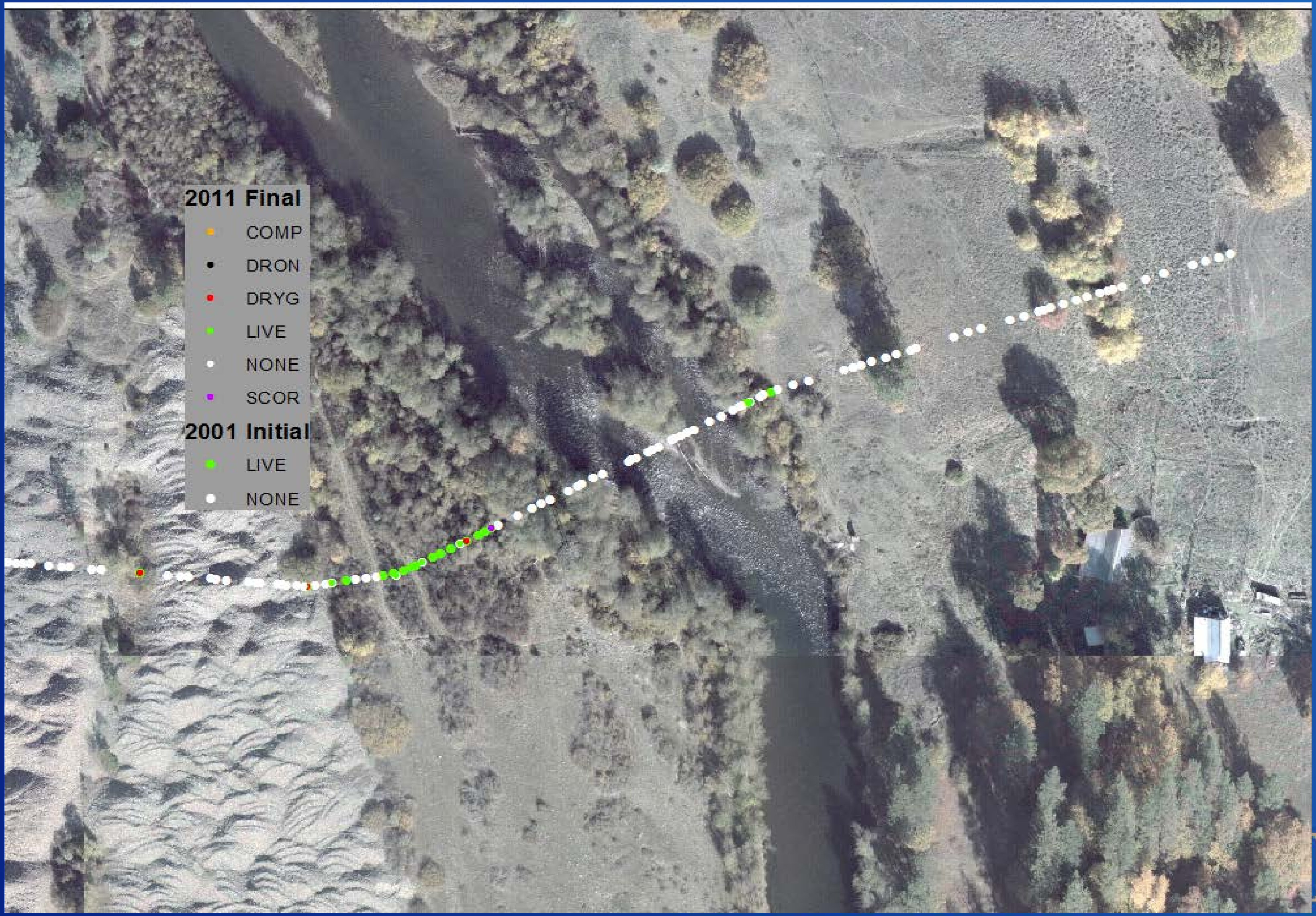
Shrub willows at Station 106.92 on 2001 aerial photo



Shrub willows at Station 106.92 on 2010 aerial photo

Tree willows at Station 93.73 on 2001 aerial photo

Tree willows at Station 93.73 on 2010 aerial photo

Summary

- The model predicts cottonwood establishment and growth; however the field data didn't support this.
  - Why
- The model shows that shrub-type willows and tree-type willows substantially increased in number
- The primary mortality mechanism for both the shrub-type and the tree-type willows was desiccation.

Future works

- Trinity-specific germination, growth, and mortality parameters
- Cottonwood germination
  - A sensitivity analysis could be performed regarding the days to germination after the ground is saturated, the maximum days seed can endure dry conditions, the root growth rate, and the length of time when the root is above the ground water table before desiccation .
- Additional vegetation alliances.
- Increased accuracy with 2D vegetation and 1D flow and sediment.

Acknowledgments

- James Lee of Hoopa Valley Tribe and Trinity River Restoration Program
- John Bair of McBain Associates
- Todd Buxton of Trinity River Restoration Program

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