Predicting relative risk of invasion in river networks under different scenarios of climate change and dam operations in the western U.S.

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Knowledge to Go Places

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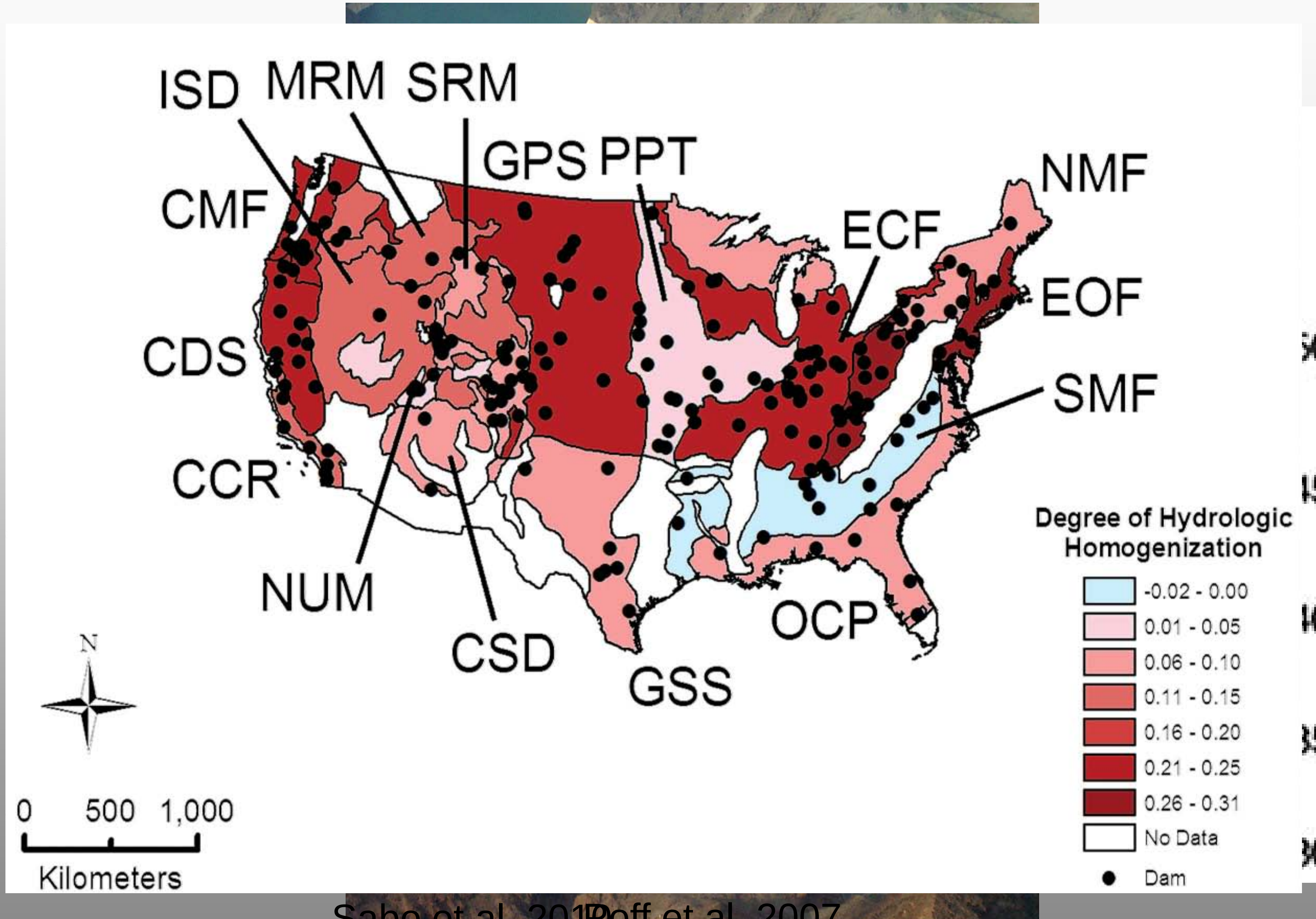
Problem Statement

How will climate change and human infrastructure alter flow regimes to influence invasion by saltcedar and NZ mudsnails?

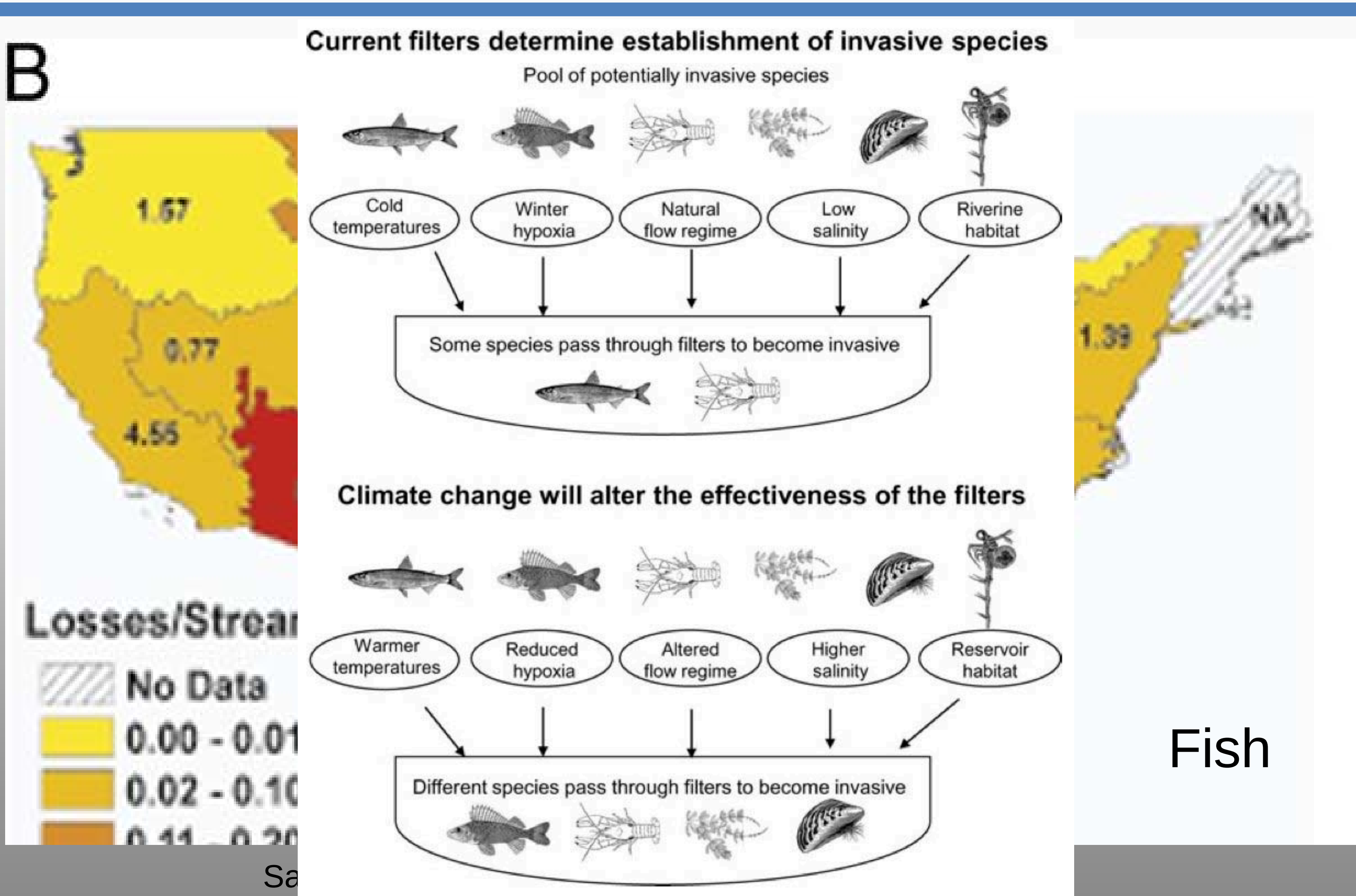
System Background

Western Rivers: Altered Structure & Function



Sabo et al. 2010 Poff et al. 2007

Western Rivers: Species Invasions



Sa

Rahel & Olden 2008

Species of Concern: New Zealand Mudsnail
(Potamopyrgus antipodarum)

- VERY high production
  - Hall et al. (2003, 2006)
- Usurp basal resources at expense of native consumer species
- Low quality prey for native and recreational fishes
- Favored by stable flows (low disturbance) and warmer water temperatures

Species of Concern: Saltcedar or Tamarisk *(Tamarix ramosissima)*

- Widespread, sometimes dense monotypic stands
- Undesirable interactions with native vegetation & wildlife?
- Undesirable effects on channel form, water supply?

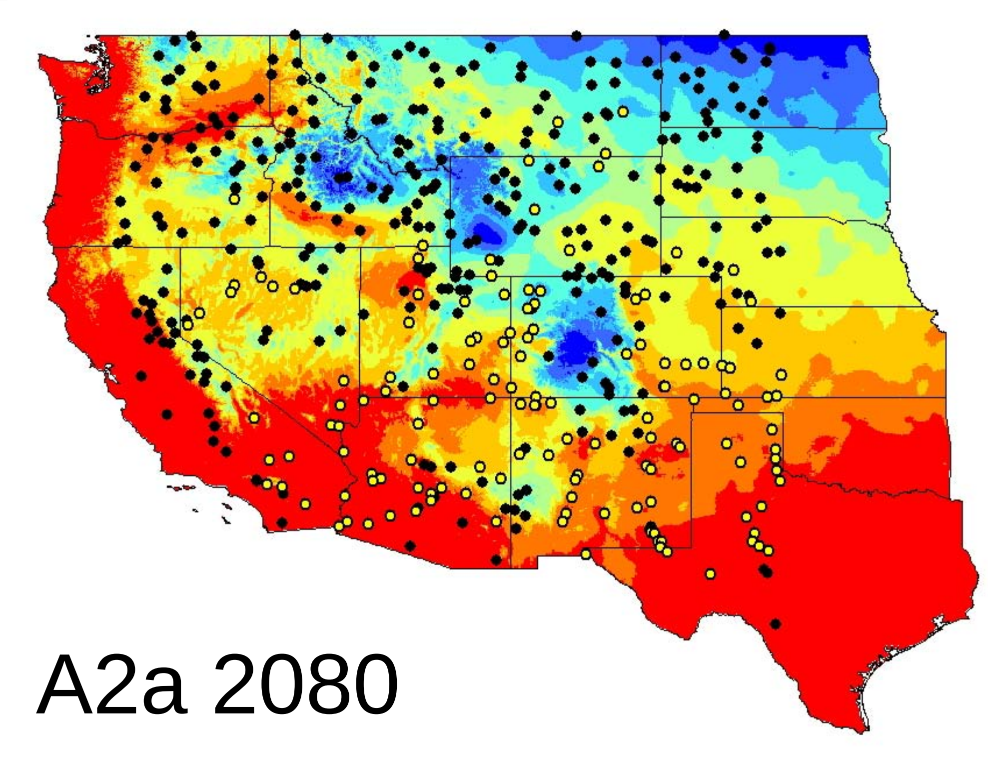
photos: D. Auerbach

Tamarisk: Thermal Controls on Distribution

Tam.

P

A



Ann.Min.T

-35°C

>0°C

"Frost sensitivity, therefore, may limit northward expansion of saltcedar in North America." –Friedman et al. 2008

Tamarisk: Hydrologic Controls on Distribution

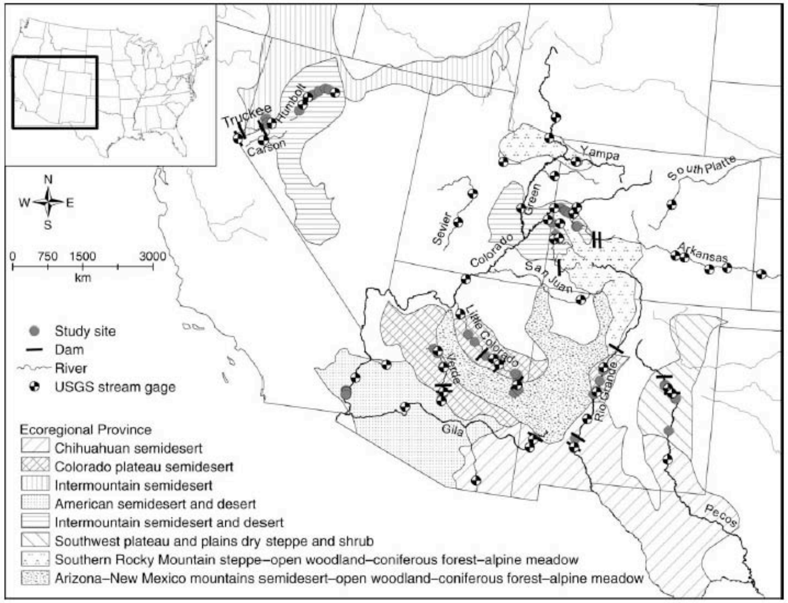
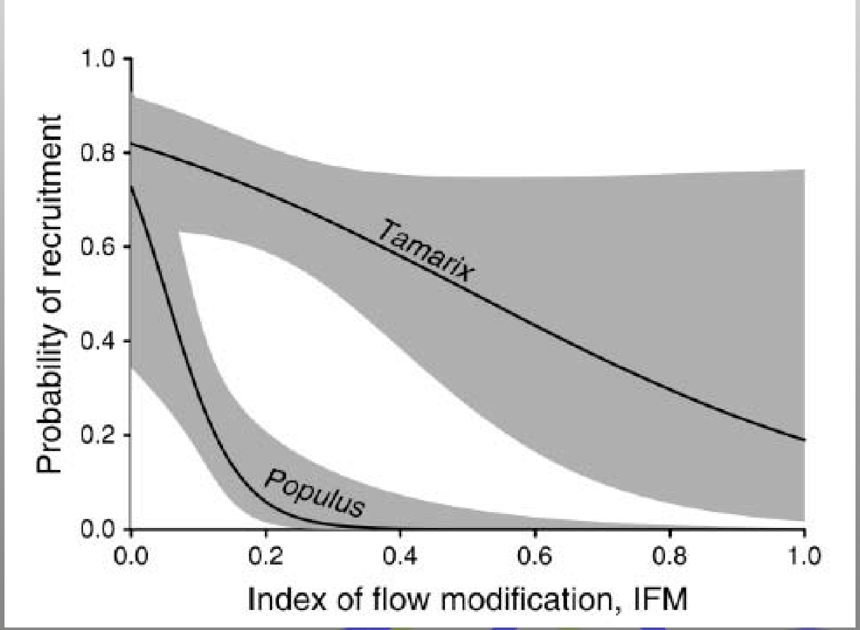


FIG. 2. Study-site map showing the western United States. Only rivers included in the analysis are included in the diagram. USGS stream flow gages are indicated with black and white symbols, dams are indicated by black lines normal to streams, and gray dots indicate *Tamarix* sampling sites.

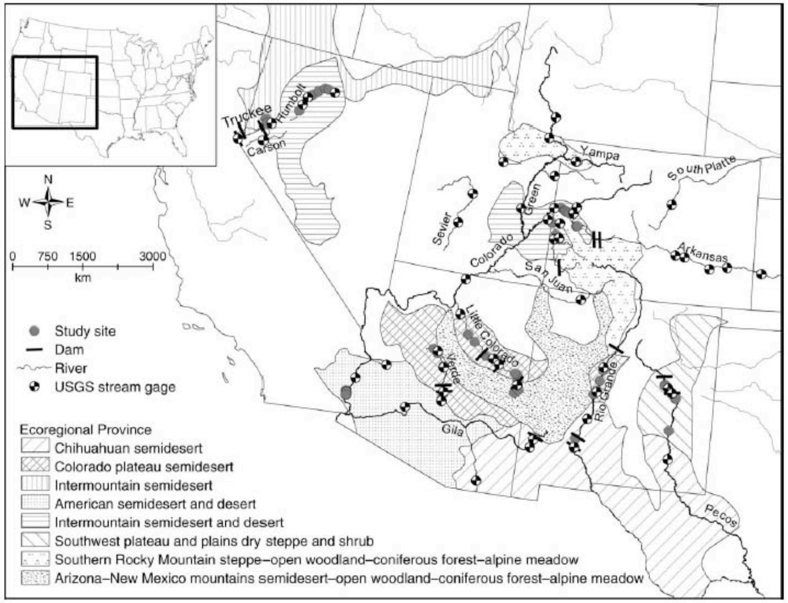
Merritt & Poff 2010

Location of 64 sites along 13 western rivers having different degrees of river regulation and flow alteration.

Recruitment (seedlings)



Tamarisk: Hydrologic Controls on Distribution



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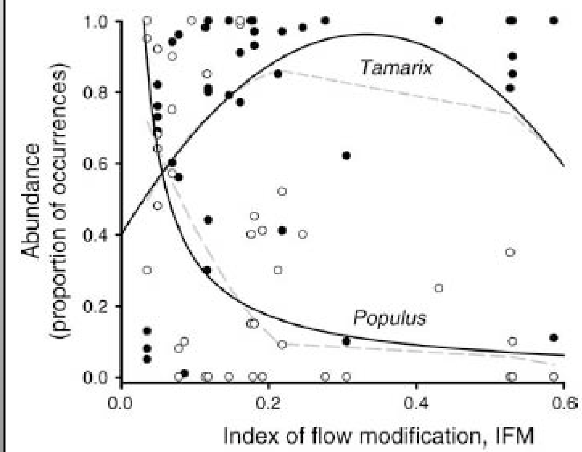
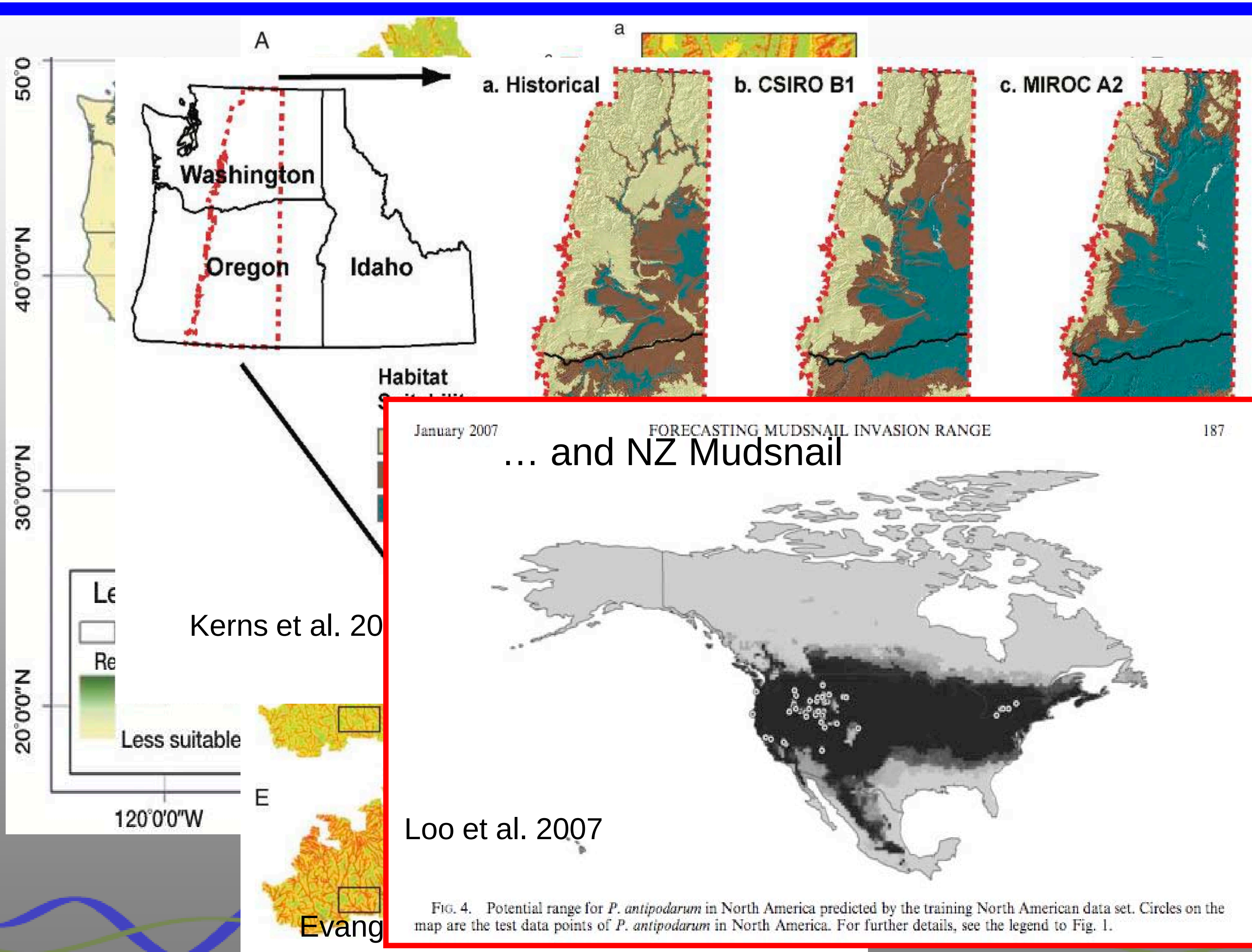


FIG. 5. Models of *Populus* and *Tamarix* abundance as a function of index of flow modification (IFM). Loess regression was used to determine the form of the functions (grey dotted curves, smoothing parameter = 1). The nonlinear power function fitted to *Populus* was significant (solid black line, $P < 0.0001$), indicating that *Populus* abundance declines as a function of flow modification. The polynomial regression fitted to *Tamarix* abundance was also significant ($R^2 = 0.12$, $P = 0.02$), indicating that *Tamarix* abundance is highest at intermediate levels of flow modification. Solid circles represent *Tamarix* and the open circles show *Populus*.

Abundance of non-seedlings

Tamarisk Habitat Suitability Precedents

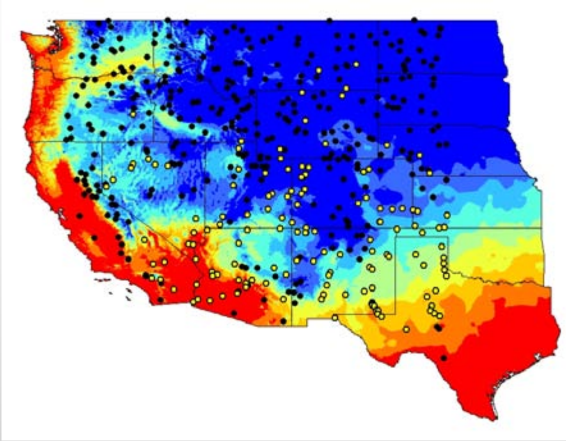


Working hypothesis:

Within thermally suitable envelope …**local invasion success** will be dictated by habitat suitability and dynamics (hydrologic, geomorphic) and by biotic factors, which can be modeled at the ecologically relevant scales.

<u>Goals:</u> Explain current distribution of key invasive species in terms of thermal and hydrogeomorphic setting and build mechanistic models to project invasion risk throughout river networks in response to future climate change and human water infrastrcture management.

Toward Fluvial Processes…Tamarisk



Current Tamrisk Distribution

Create climate classification tree

Subset of thermally suitable sites

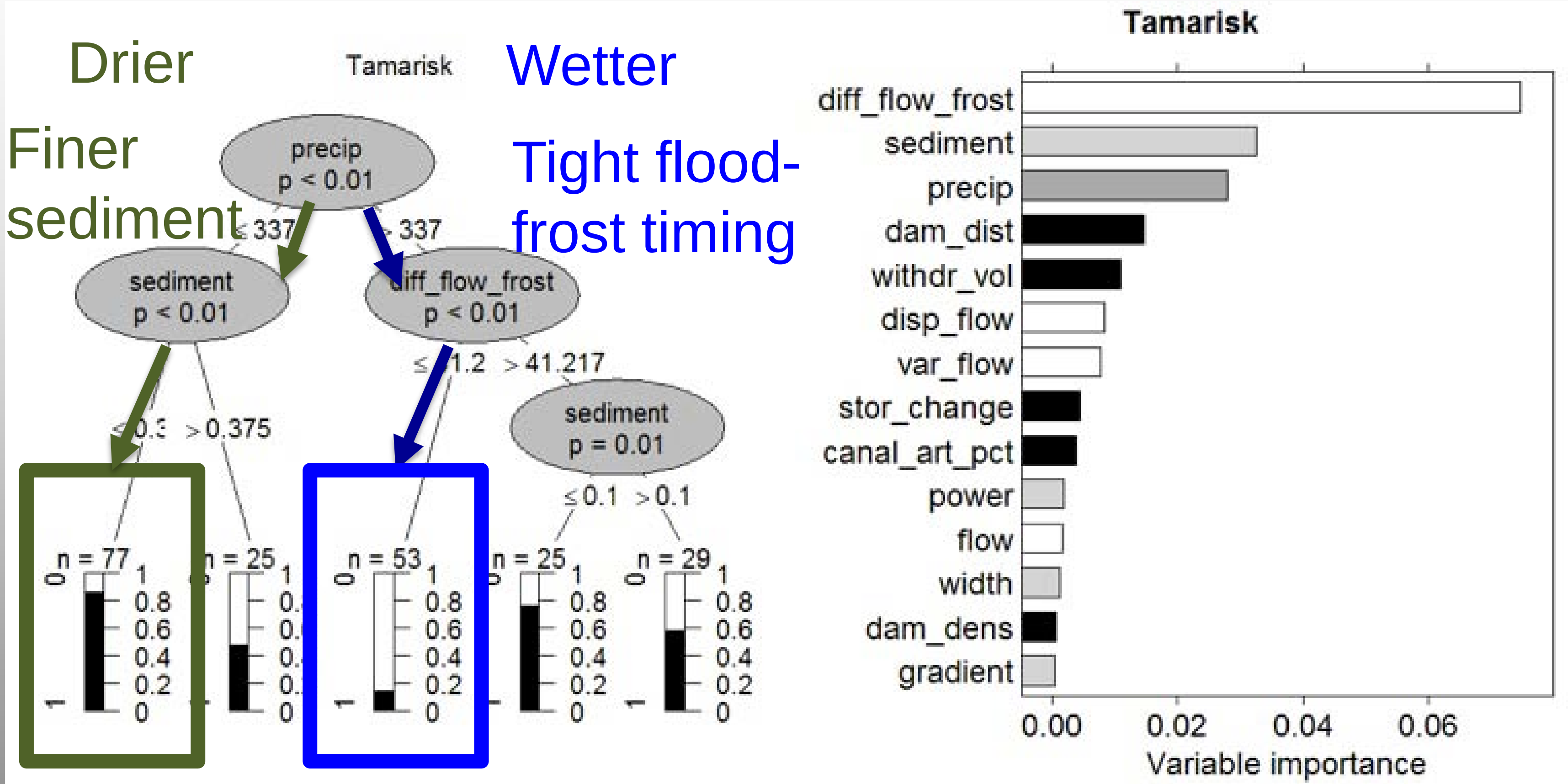
Re-classify

Hydrologic & geomorphic predictors of presence

McShane et al. *in prep.*

Toward Fluvial Processes…Tamarisk

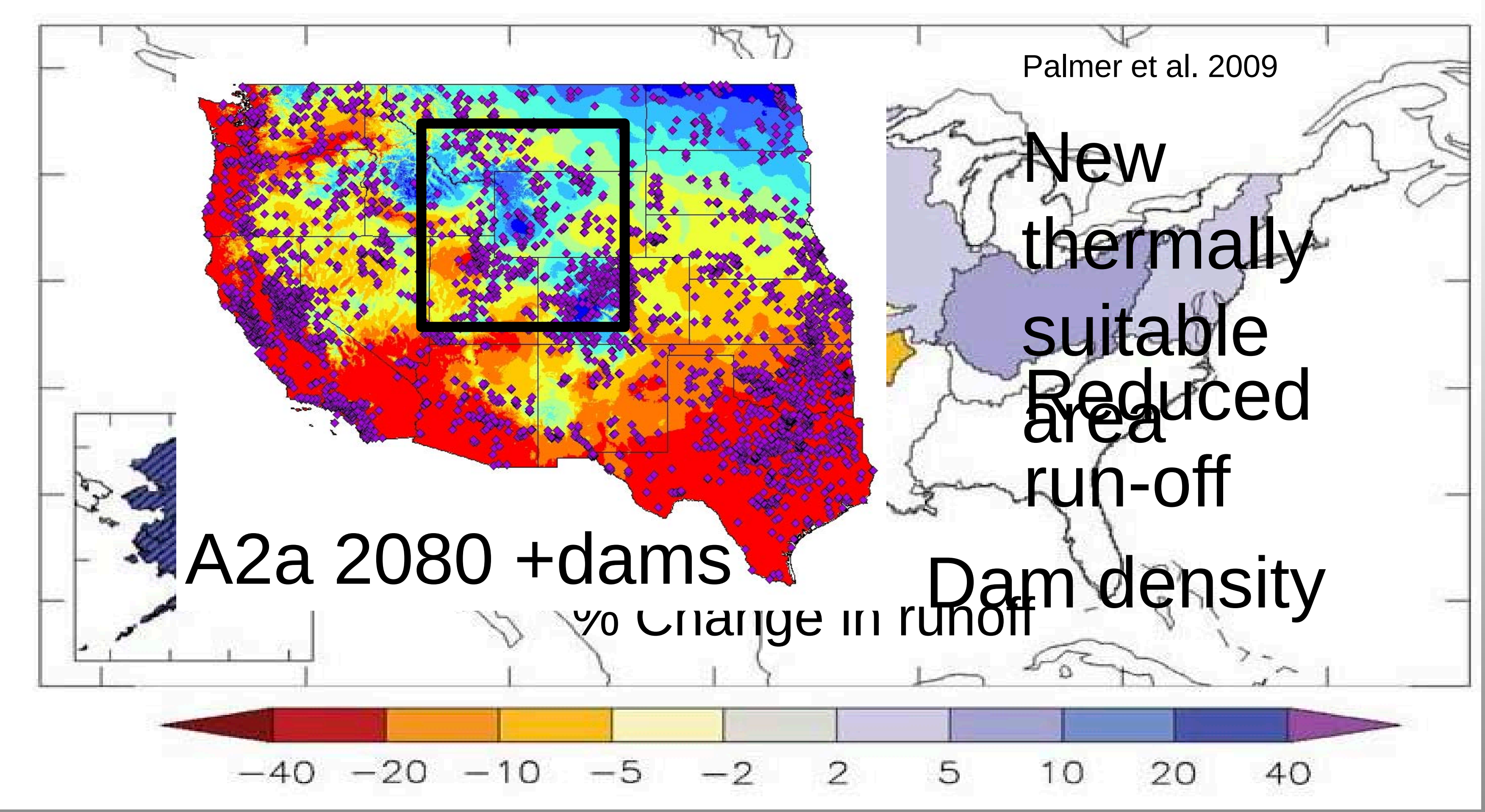
For sites that are thermally suitable …



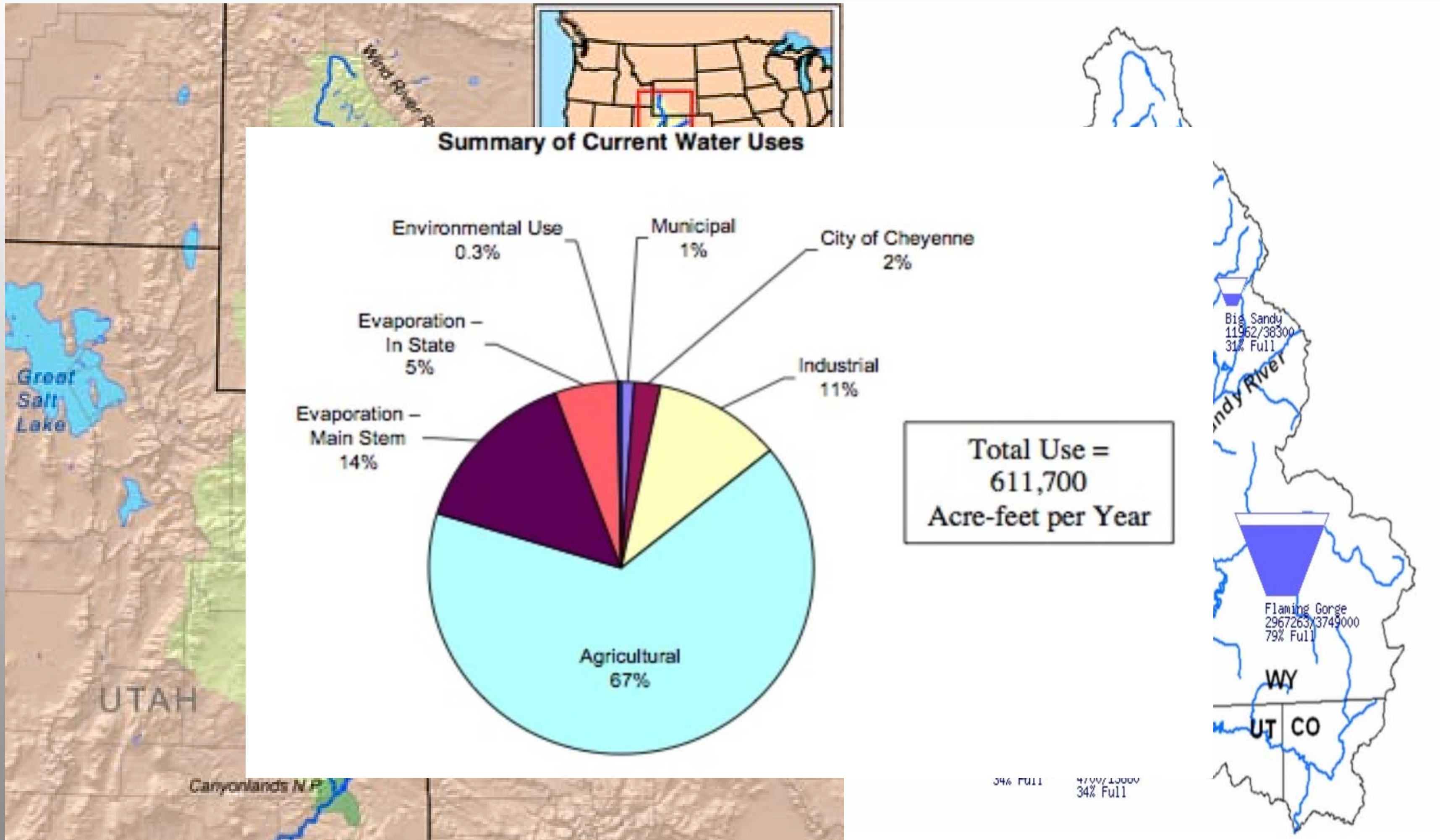
McShane et al. *in prep.*

Upshot: Difficult to capture appropriate *dynamics* with easily obtained landscape environmental variables

Modeling combined processes for invasion



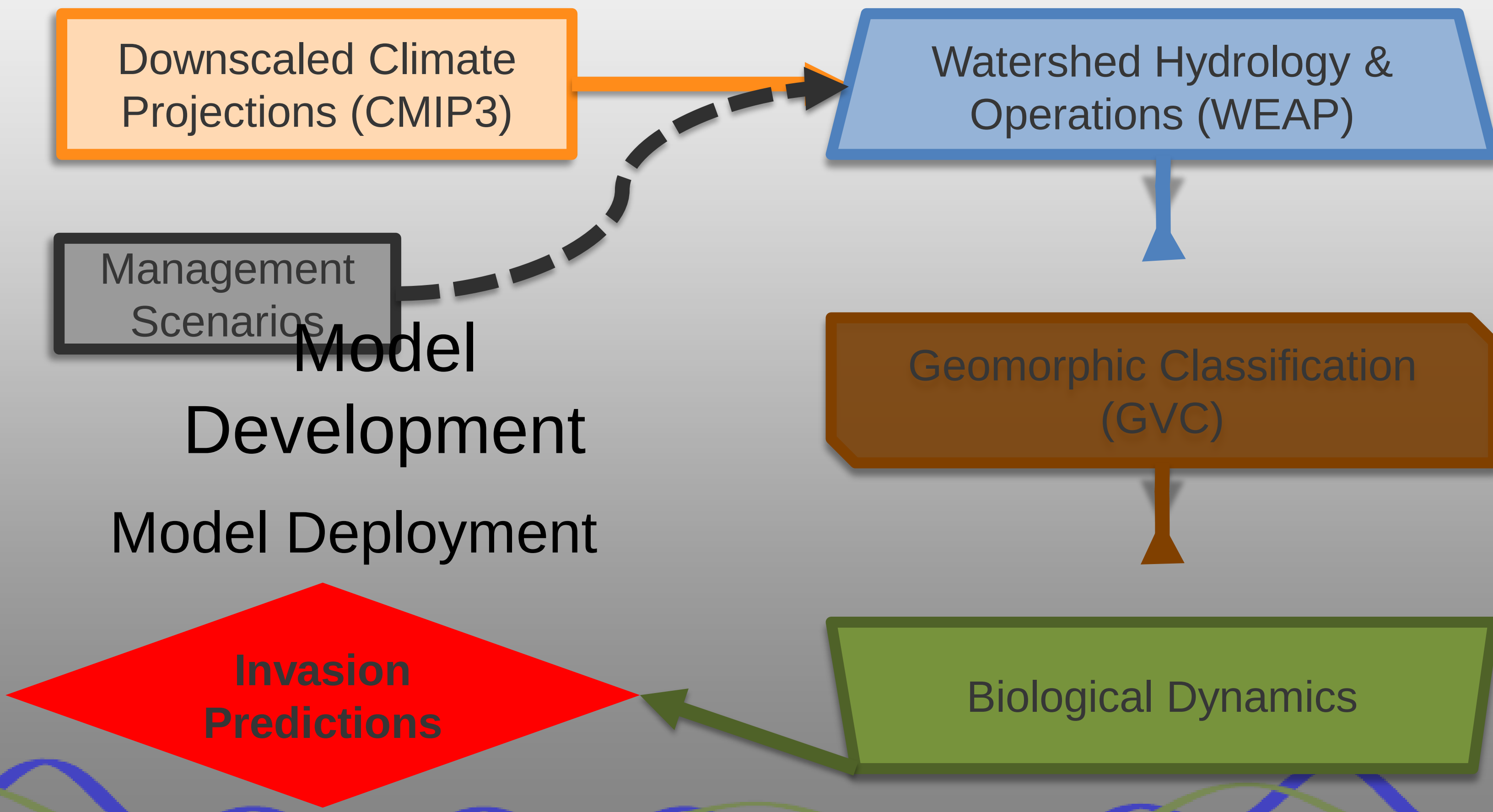
Upper Green River



Project Implementation: Hydrogeomorphic Models for Tamarisk

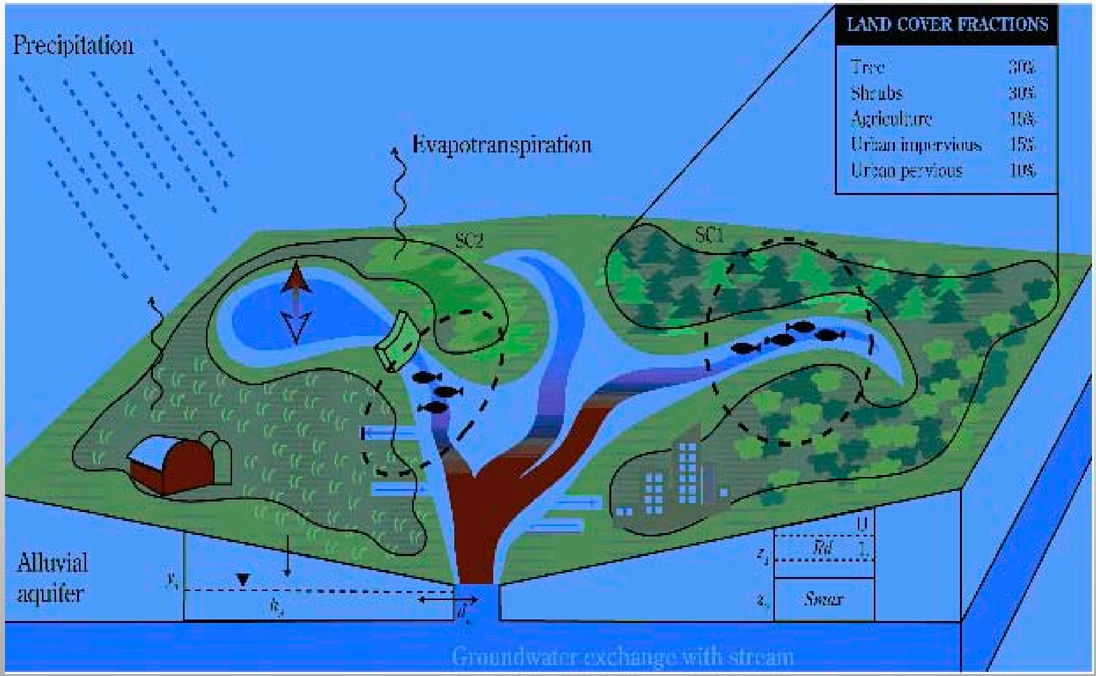
Framework

Capture main fluvial and biological processes that are spatially distributed through network and assess sensitivity to climate change and water management



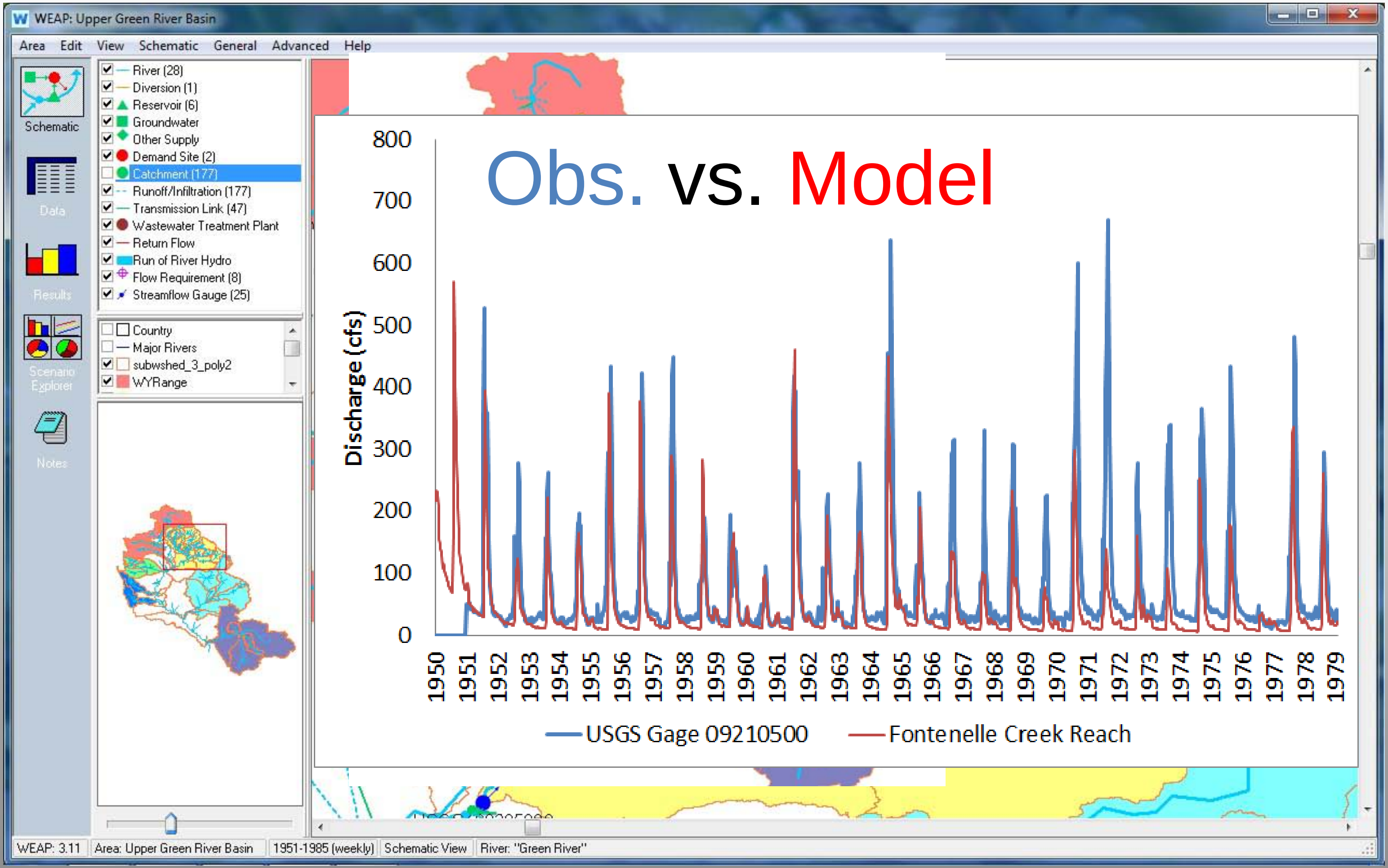
WEAP: Overview

Watershed **E**valuation **A**nd **P**lanning System (http://weap21.org)



Rainfall-Runoff Model based on spatially distributed land use/land cover types and climatic inputs to catchment; operational rules of water management infrastructure are incorporated to generate hydrographs throughout network.

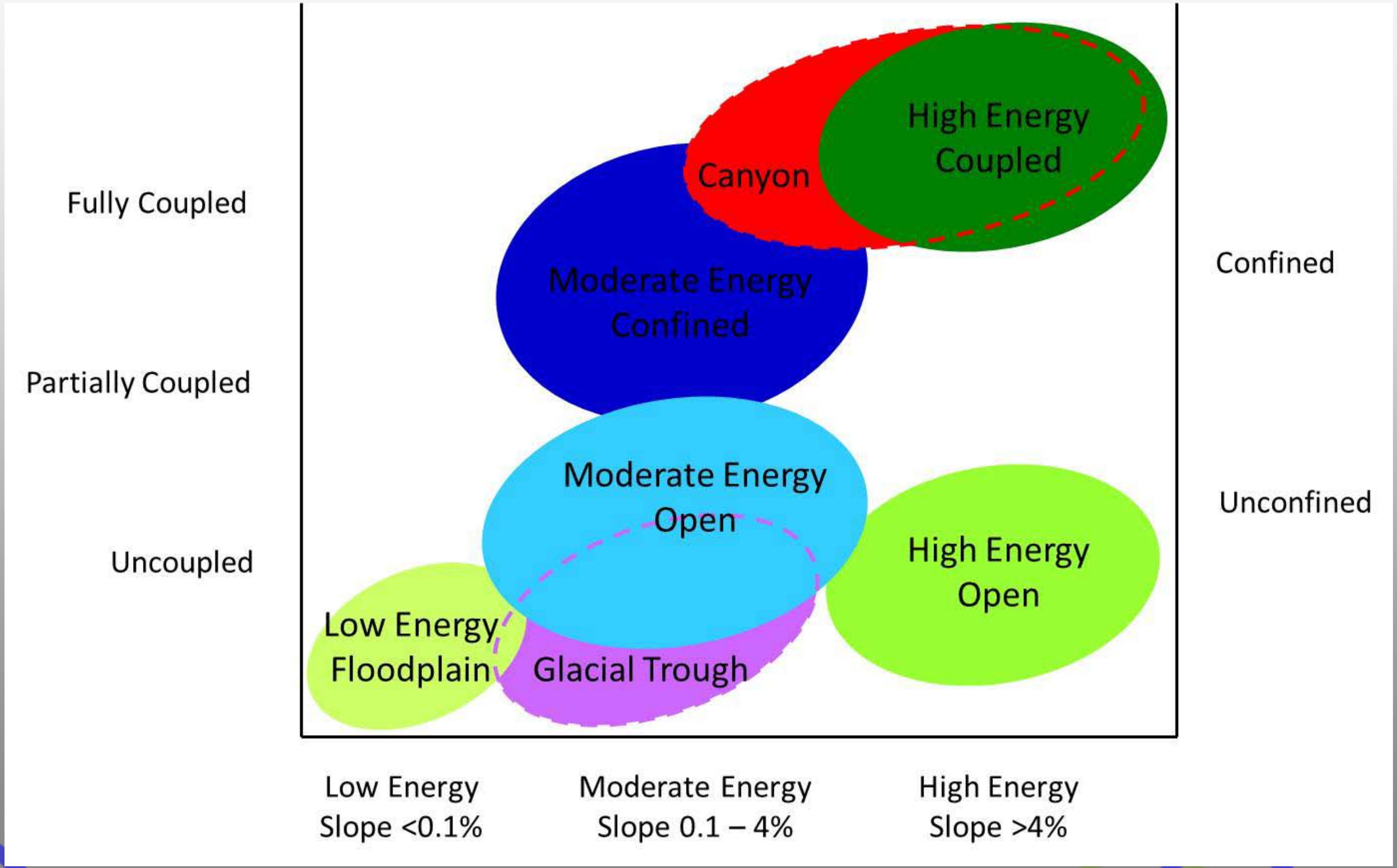
WEAP



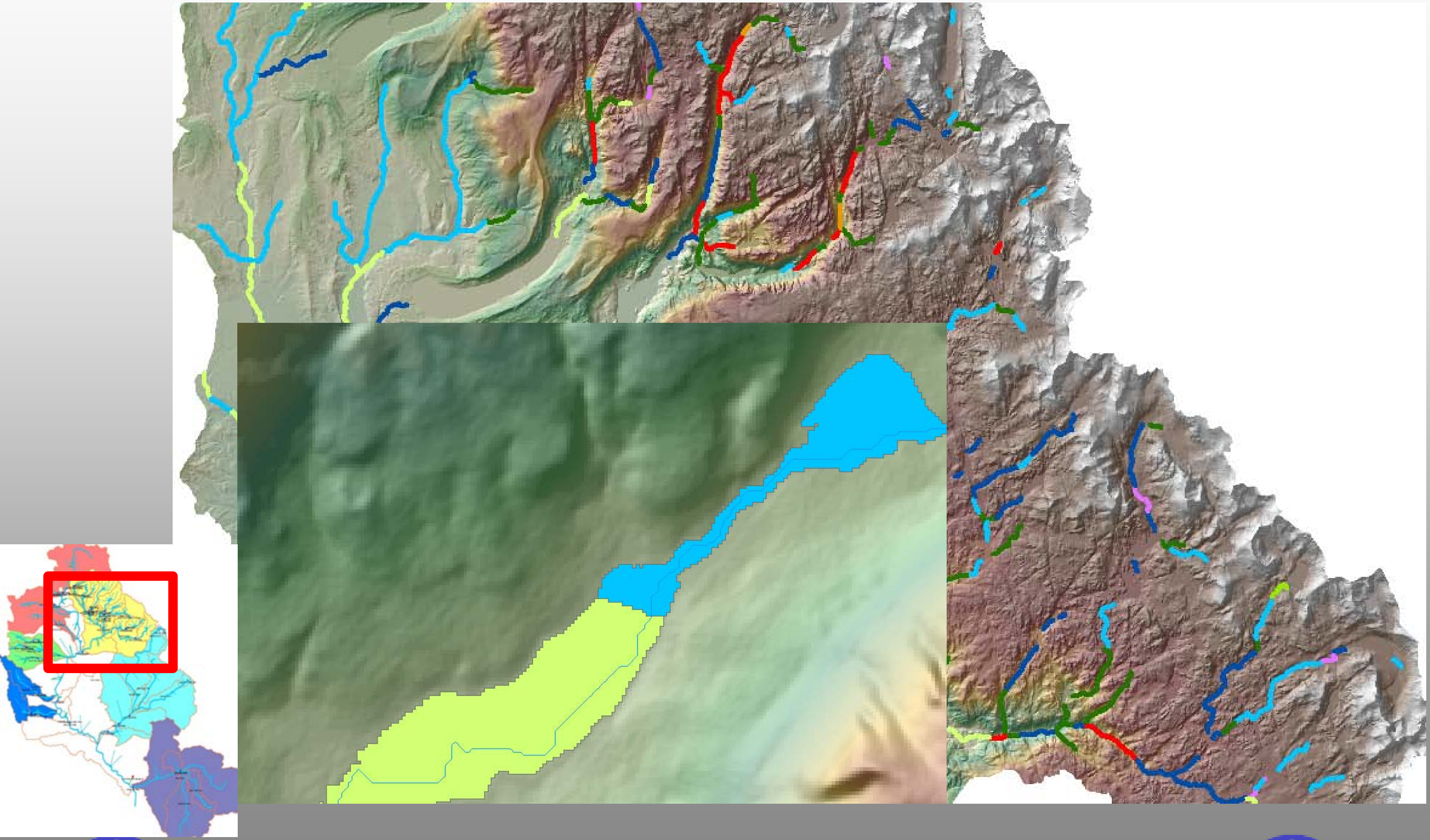
WEAP: Upper Green River Basin
Area Edit View Schematic General Advanced Help
Schematic
Data
Results
Scenario Explorer
Notes
River (28)
Diversion (1)
Reservoir (6)
Groundwater
Other Supply
Demand Site (2)
Catchment (177)
Runoff/Infiltration (177)
Transmission Link (47)
Wastewater Treatment Plant
Return Flow
Run of River Hydro
Flow Requirement (8)
Streamflow Gauge (25)
Country
Major Rivers
subwshed_3_poly2
WYRange
Obs. vs. Model
Discharge (cfs)
800
700
600
500
400
300
200
100
0
1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979
USGS Gage 09210500
Fontenelle Creek Reach
WEAP: 3.11
Area: Upper Green River Basin
1951-1985 (weekly)
Schematic View
River: "Green River"

GVC: Overview

Geomorphic **V**alley **C**lassification

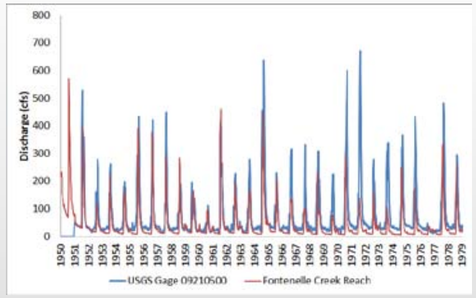


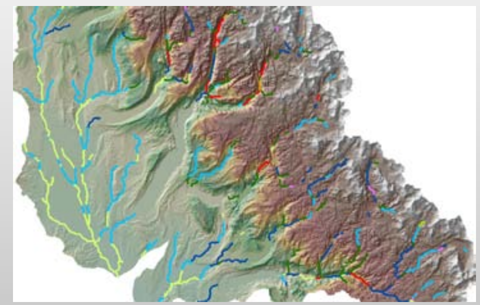
GVC – mapping reaches at watershed scale

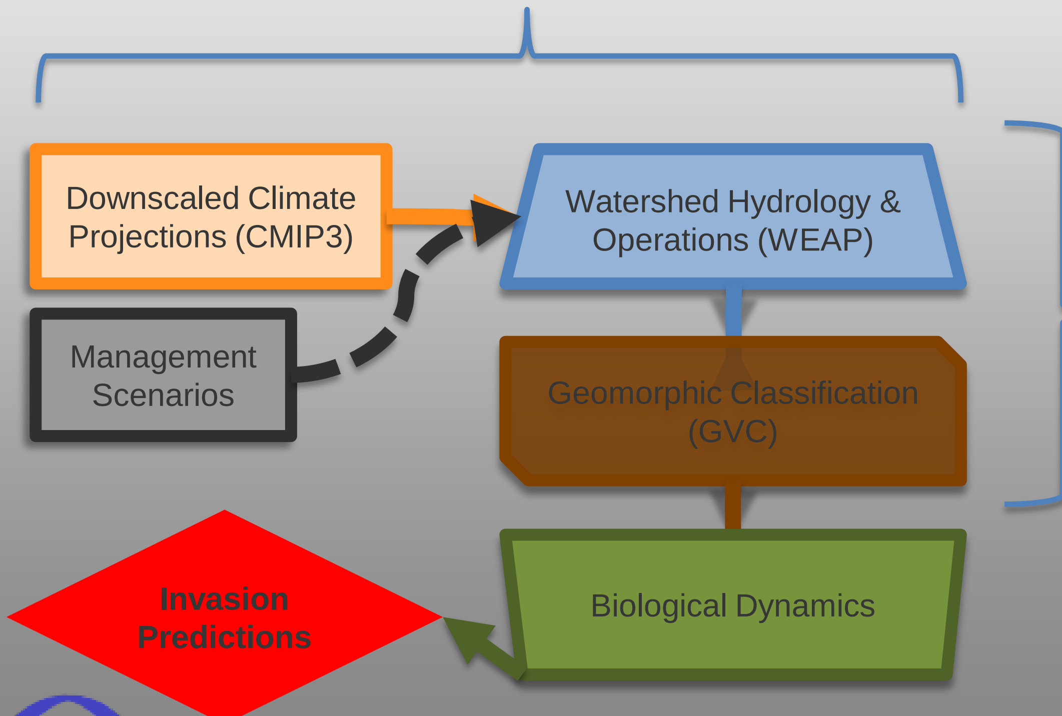


Model framework: present and next steps

Future flow regime scenarios at hundreds of nodes within watershed

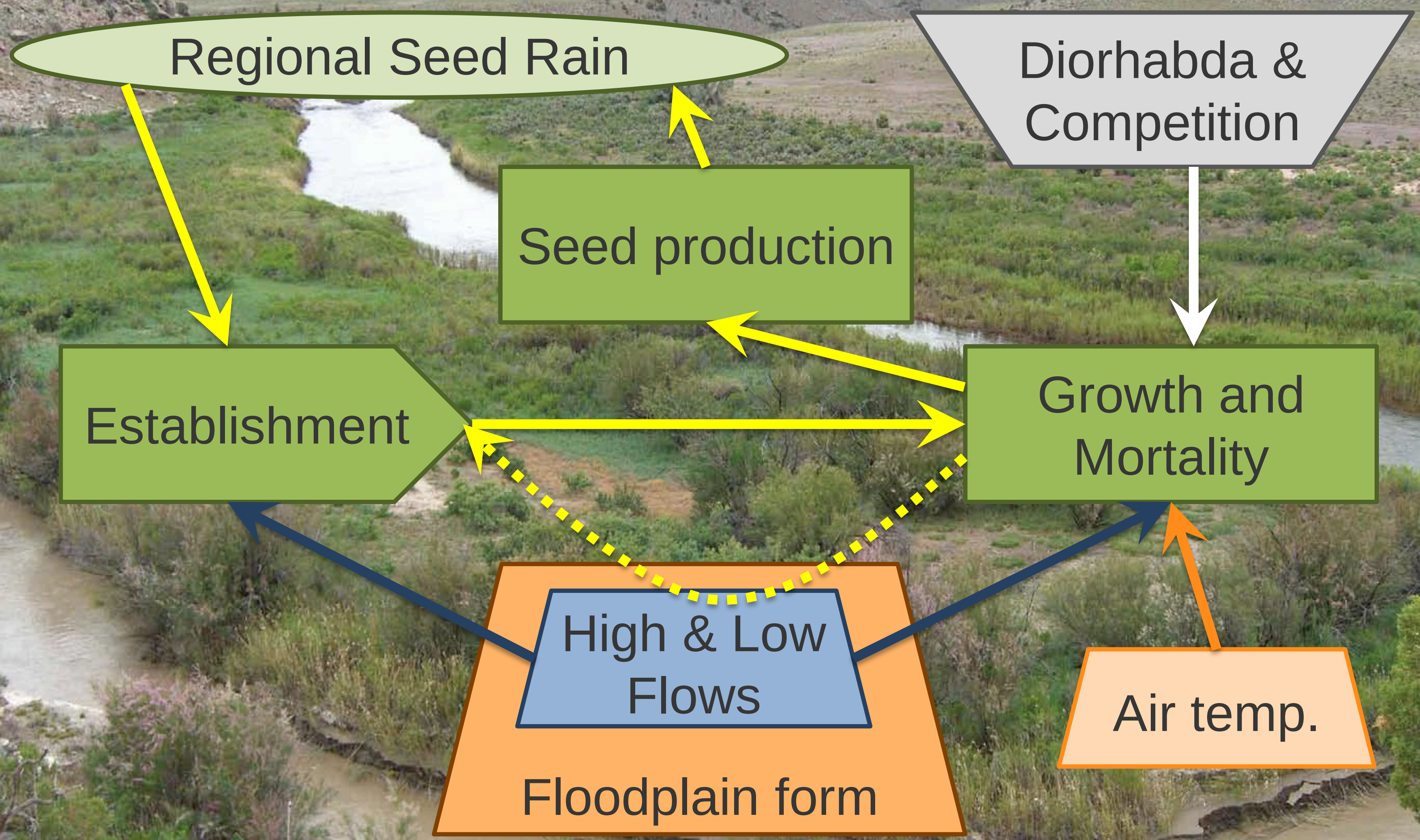




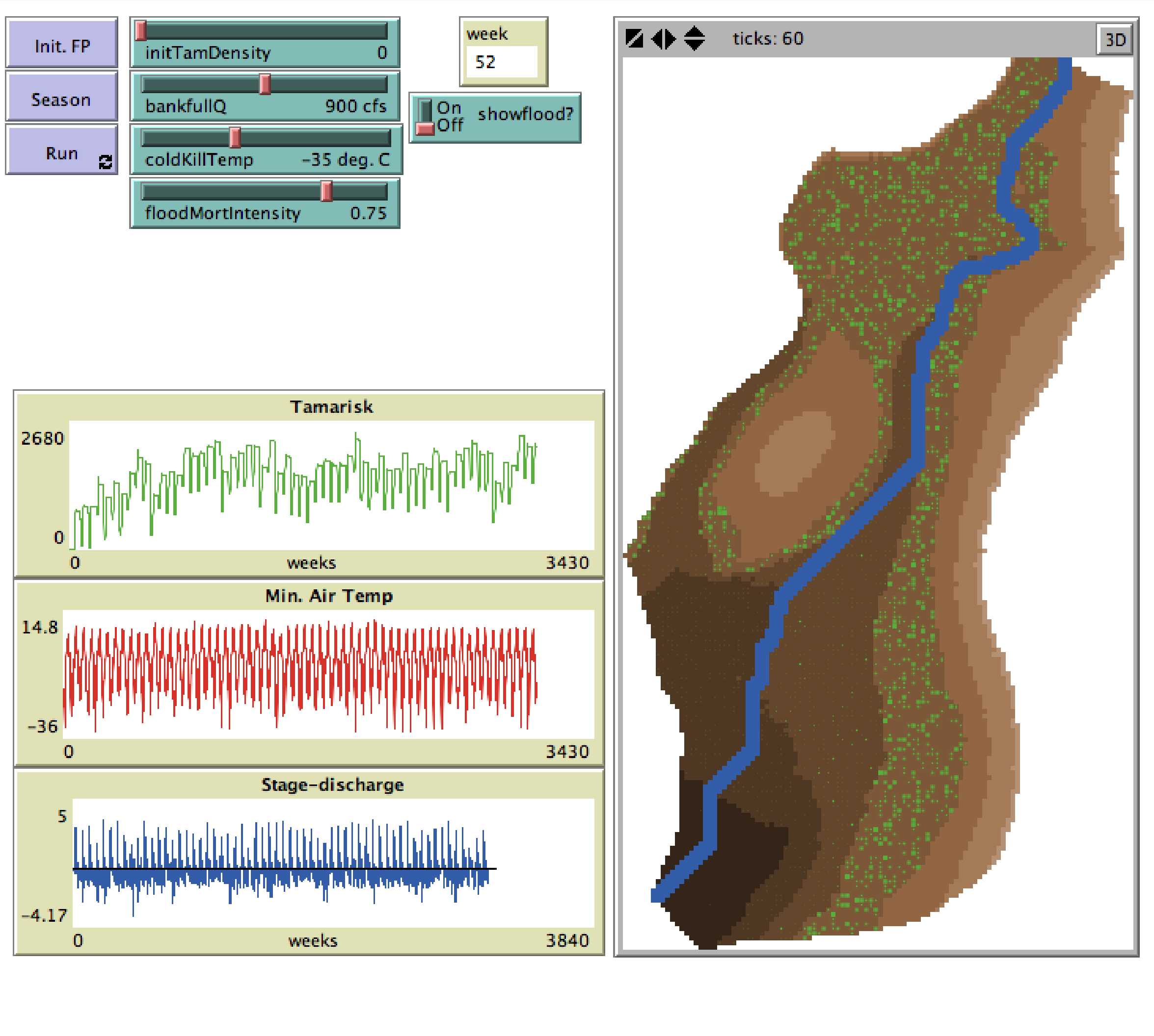


Spatially explicit hydro-geomorphic dynamics throughout channel network

Modeling Local Biological Dynamics



Agent-Based Floodplains



Expected Outcomes

- More mechanistic (dynamic) and appropriately scaled basis for projecting invasion risk of riverine species and/or responses of native species to future hydrogeomorphic change.
- Risk map - decision support system given high uncertainties in multiple, linked models. (Not precise point predictions)
- Framework for thinking about the spatial distribution of threats and how to contemplate proactive management. (Not make precise predictions)
- Future extension to capture social processes to examine cost-benefits of spatially-distributed water management?