Planning Tools for Recovery Efforts:
Columbia Basin Examples

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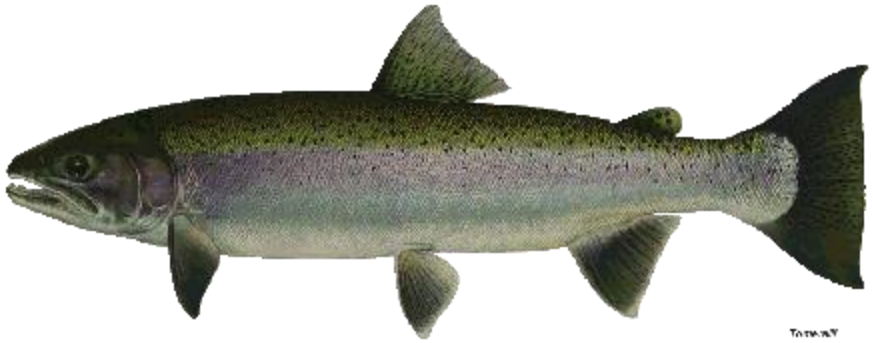
National Marine Fisheries Service



Topics

- Life history modeling tools (Columbia Basin examples)
  - Initial recovery planning tools
  - ICTRT/NWFSC matrix model applications
  - Current efforts: Life Cycle Modeling project
- Why quantitative models given uncertainties and data gaps?
  - Linking results to assumptions
  - One method for framing adaptive management
- Models: focusing on analyses rather than predicted numbers
- Implications for Puget Sound efforts

Table 1. Populations belonging ESUs listed under the Endangered Species Act in the Interior Columbia basin in this report.

ESU	MPG	Population	Habitat condition (from McClure et al. 2004)
Snake River spring/summer Chinook	Middle Fork Salmon River	Marsh Creek	Very good (minimal impacts)
	South Fork Salmon River	South Fork Salmon mainstem	Moderate (some areas with probability of significant impacts)
	Grande Ronde/Imnaha	Catherine Creek	Poor (substantial probability of high impacts)
Upper Columbia spring Chinook	East Cascades	Wenatchee	Moderate (some areas with probability of significant impacts)
Snake River steelhead	Salmon River	Little Salmon River	Poor (substantial probability of high impacts)
Mid-Columbia steelhead	Umatilla-Walla Walla	Umatilla River	Poor (substantial probability of high impacts)

Life Cycle Models

- Model types
  - Conceptual
  - Quantitative
    - Simple PVA
    - State-dependent
    - Genetic
    - Meta population models
    - Linked models

Life Cycle Models

- Assumptions: explicit and implicit
- Key uncertainties: O. mykiss life cycle models
  - Relative smolting rates: role of genetic component
  - Spawning timing: overlap between anadromous and residents in a watershed
  - Juvenile capacity: degree of interaction, segregation in time and depth??
  - Local area summer refuges
  - Downstream migration survival
  - Applicable SARs

Population Level: Spatial Structure Considerations

- Spatial Structure refers to the geographic distribution of a population and the processes supporting that distribution.

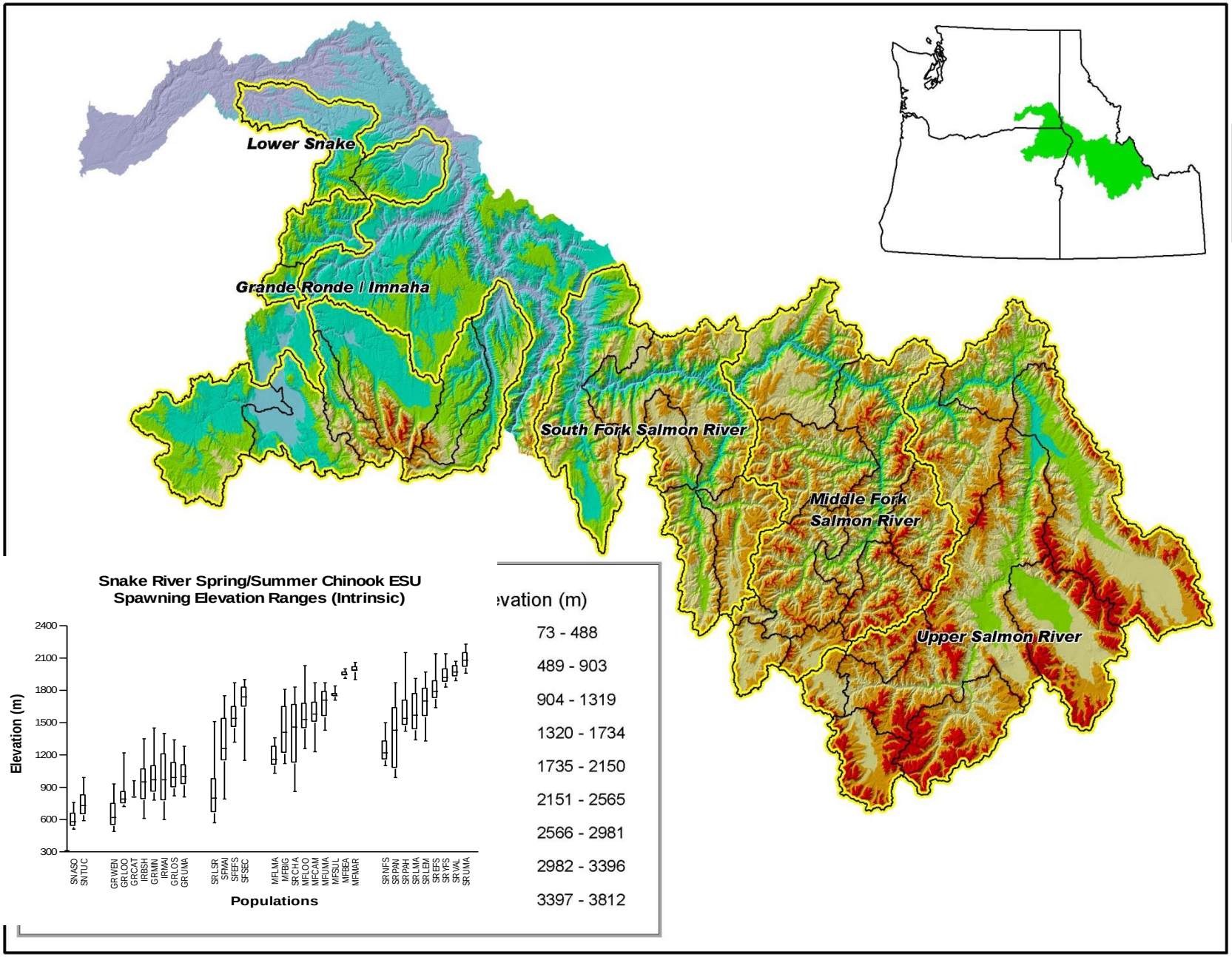
- Basic rationale:
  - Multiple spawning reaches within a population provides protection against local catastrophic loss
  - Some production areas may be inherently more productive than others – potentially serving as sources to a broader range of areas after prolonged periods of low survival, etc.

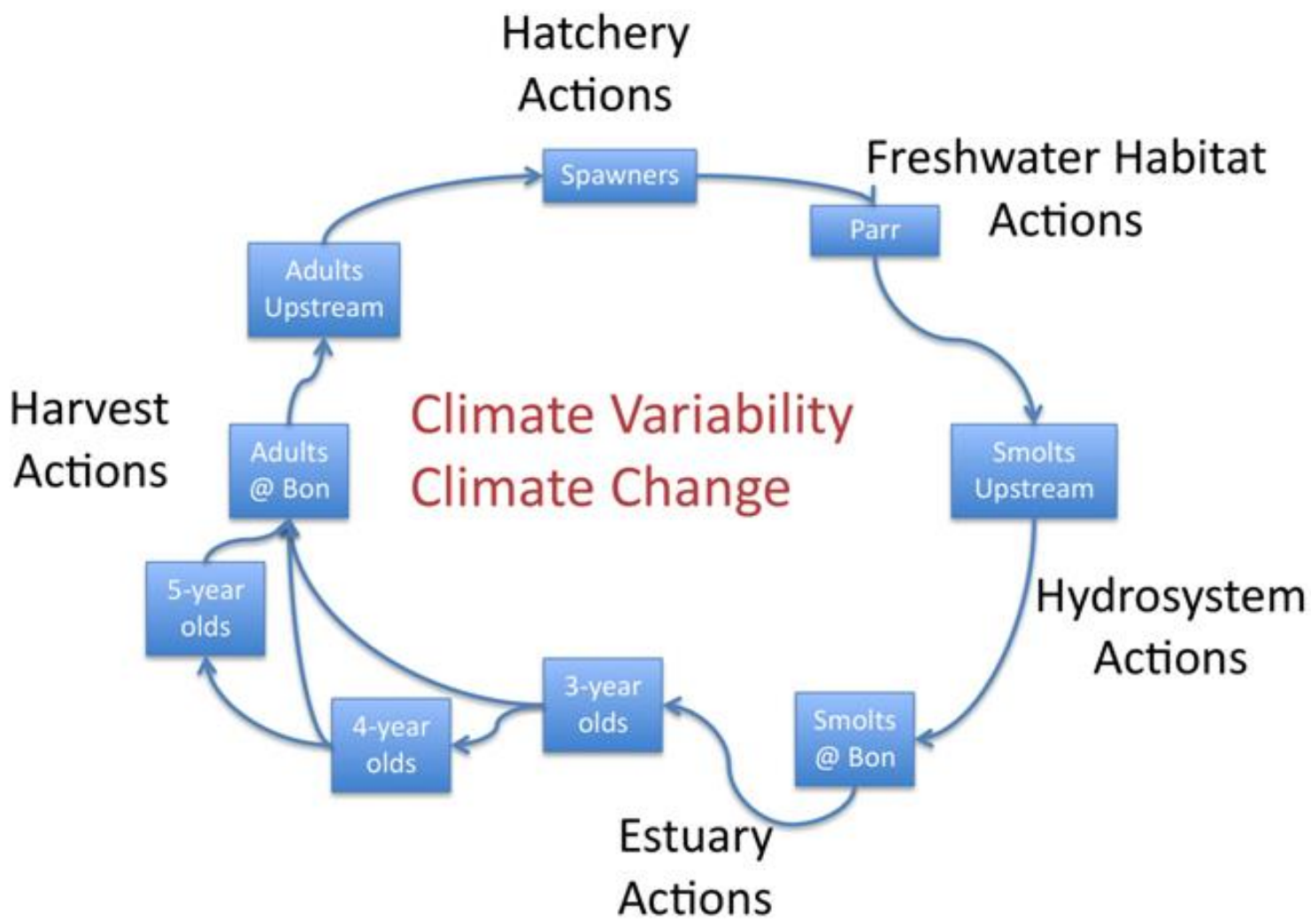
Population Criteria: Diversity Considerations

- Traits and Life History strategies
  - Loss of major life history strategies
  - Reductions/changes in traits
- Genetic Characteristics
  - Direct measures
  - Indirect: Influences of artificial production
- Dispersal and Gene Flow Effects
  - Gaps in spawning
  - Selective effects of human activities
  - Spawning distribution vs habitat types

ICTRT: Recovery plan review questions

1. Framework questions - for application to each planning sector (H), and across the plan as a whole.
    a. Cohesiveness – Is there a clearly articulated rationale linking action plan to population, MPG, and ESU objectives, limiting factors and threats?
    b. Models and Analysis
        i. Are one or more independent models or analyses used to assess fish response to recovery actions?
        ii. What is the support for models and assessment conclusions – are the conclusions logical?
    c. Population Specific Data - use of empirical data from the target population. Is lack of specific data treated appropriately?
    d. Empirical support – Is there empirical evidence that the proposed actions will have the desired effect relative to existing environmental conditions?
    e. Does the plan cite examples of responses to action consistent with plan expectations?
    f. Is the component/plan part of an integrated strategy at the population level, the MPG or ESU level?

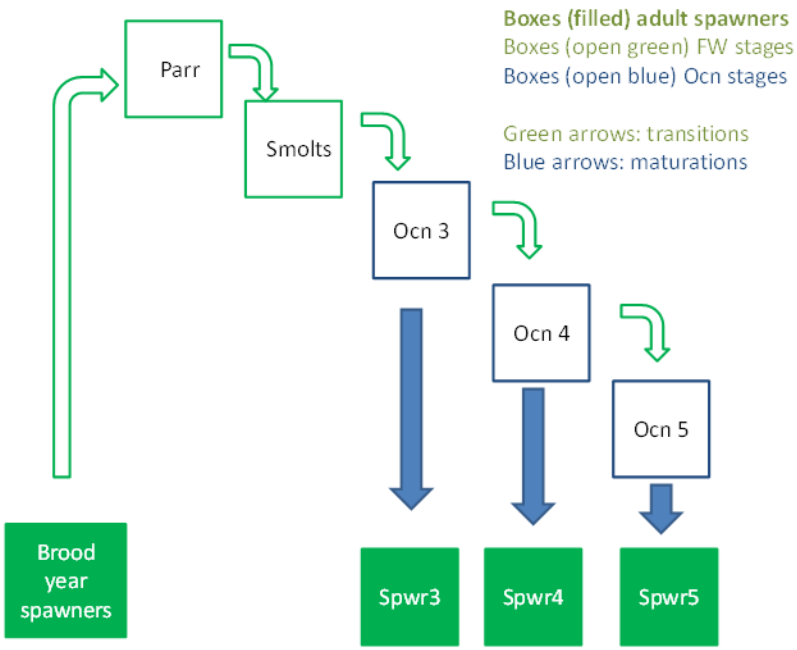

Lower Snake
Grande Ronde / Imnaha
South Fork Salmon River
Middle Fork
Salmon River
Upper Salmon River
Snake River Spring/Summer Chinook ESU
Spawning Elevation Ranges (Intrinsic)
Elevation (m)
2400
2100
1800
1500
1200
900
600
300
SNASO
SNTUC
GRWEN
GRLOO
GRCAT
IRBSH
GRMIN
IRMAI
GRLOS
GRUMA
SRLSR
SFMAI
SFEFS
SFSEC
MFLMA
MFBIG
SRCHA
MFLOO
MFCAM
MFUMA
MFSUL
MFBEA
MFMAR
SRNFS
SRPAN
SRPAH
SRLMA
SRLEM
SREFS
SRYFS
SRVAL
SRUMA
Populations
evation (m)
73 - 488
489 - 903
904 - 1319
1320 - 1734
1735 - 2150
2151 - 2565
2566 - 2981
2982 - 3396
3397 - 3812


Hatchery Actions
Spawners
Freshwater Habitat Actions
Parr
Adults Upstream
Harvest Actions
Adults @ Bon
Climate Variability
Climate Change
Smolts Upstream
5-year olds
Hydrosystem Actions
3-year olds
4-year olds
Smolts @ Bon
Estuary Actions

Matrix Model (cohort) based framework

$$\mathbf{A}(t) = \begin{matrix} 0 & 0 & 0 & b_4 \cdot s_A \cdot F_4(t) & s_A \cdot F_5(t) \\ s_2 & 0 & 0 & 0 & 0 \\ 0 & s_3(t) & 0 & 0 & 0 \\ 0 & 0 & (1-b_3)\cdot s_o & 0 & 0 \\ 0 & 0 & 0 & (1-b_4)\cdot s_o & 0 \end{matrix}$$

Simple (e.g. Chinook) example



Steelhead

more complex (and we haven't specifically incorporated resident interactions yet!)

Year t

Year t+1

	fw1	Fw2	fw3	fw4	O1	O2	OW
fw1							F
fw2	s_{fw2}						
fw3		$(1-sm_2)$ $\cdot s_{fw3}$					
fw4			$(1-sm_3)$ $\cdot s_{fw4}$				
O1		sm_2 $\cdot s_d \cdot s_{O1}$	sm_3 $\cdot s_d \cdot s_{O1}$	$s_d \cdot s_{O1}$			
O2					$(1-b_1)$ $\cdot s_{O2}$		
OW					$b_1 \cdot s_A$ $\cdot s_{ow}$	S_A $\cdot s_{ow}$	

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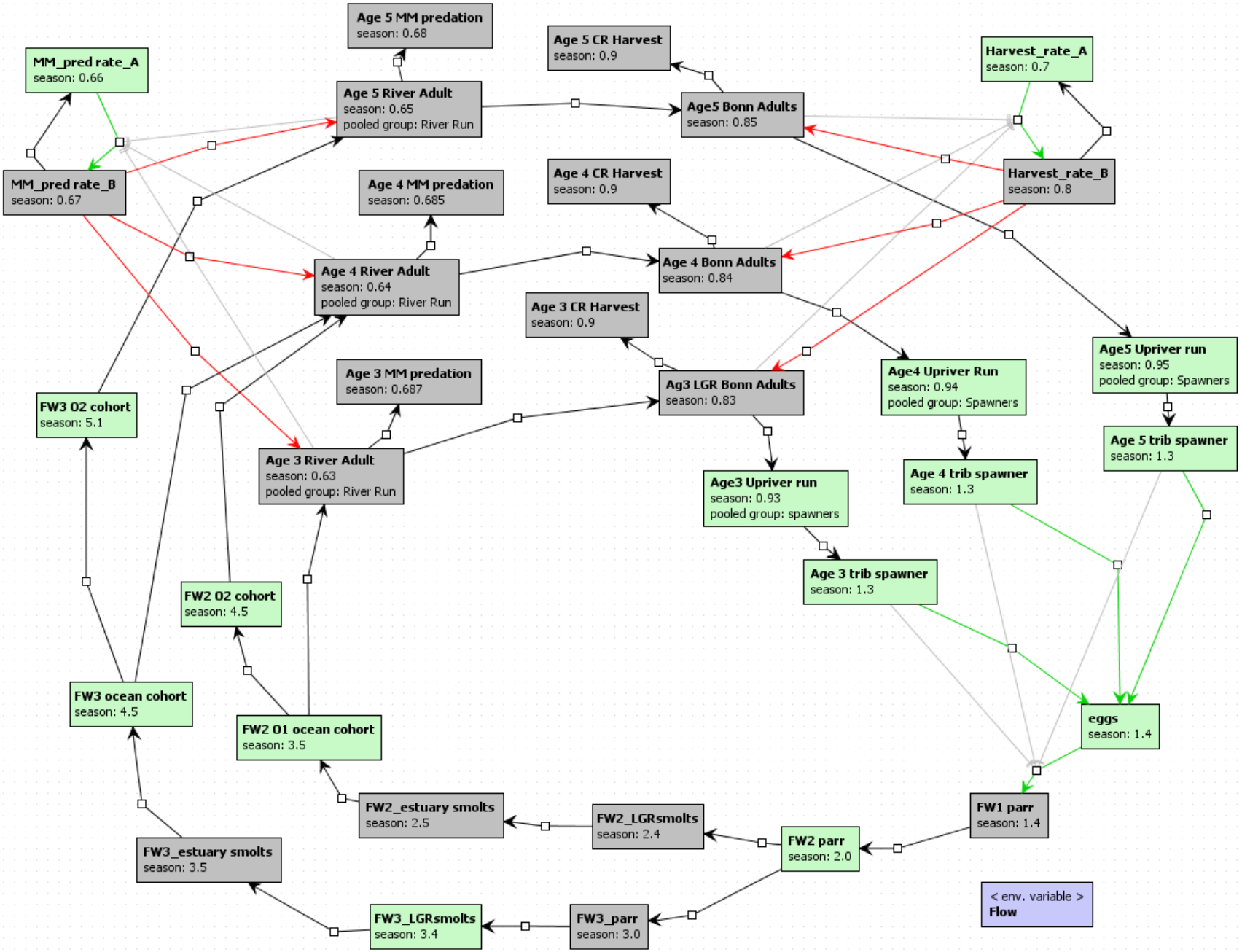
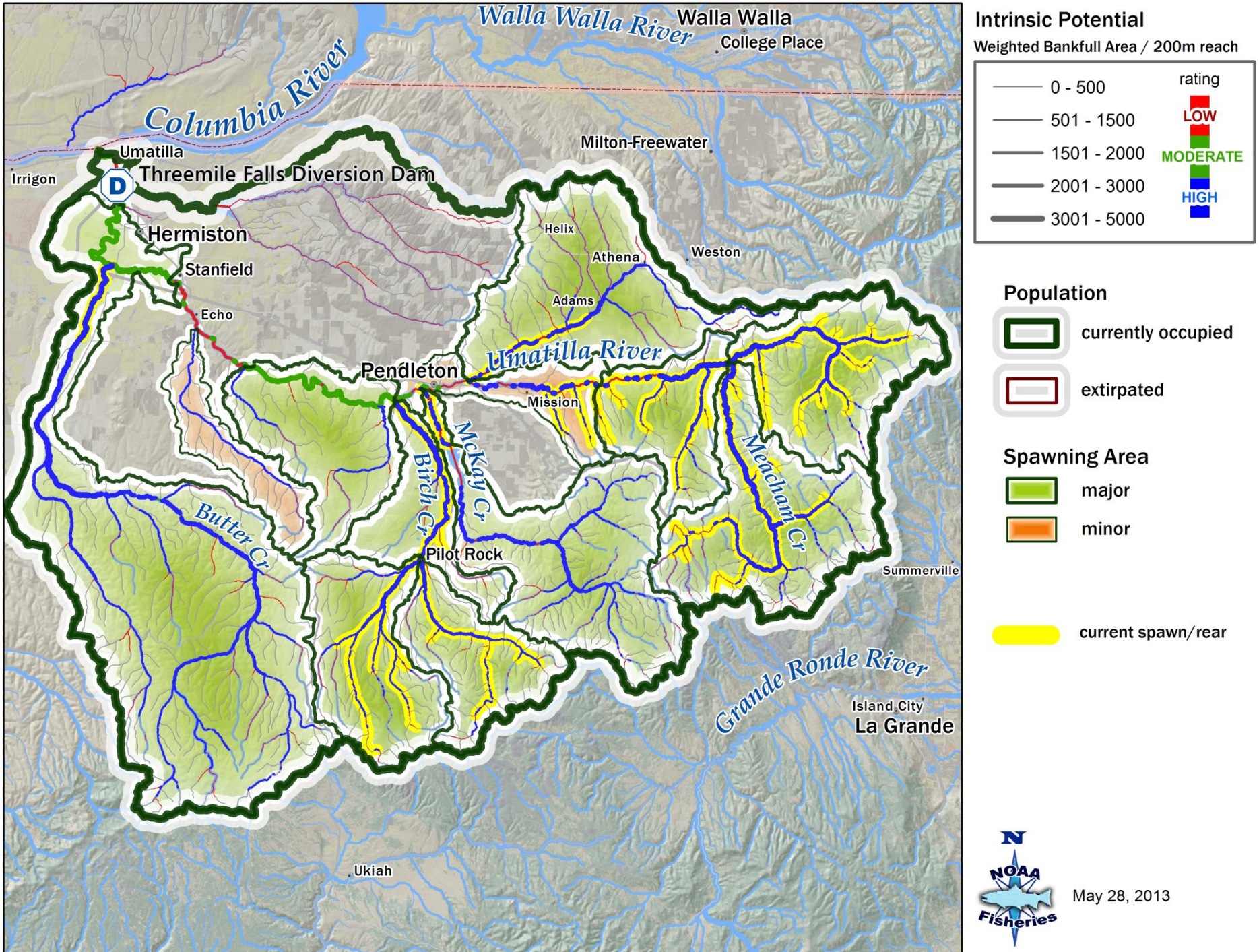
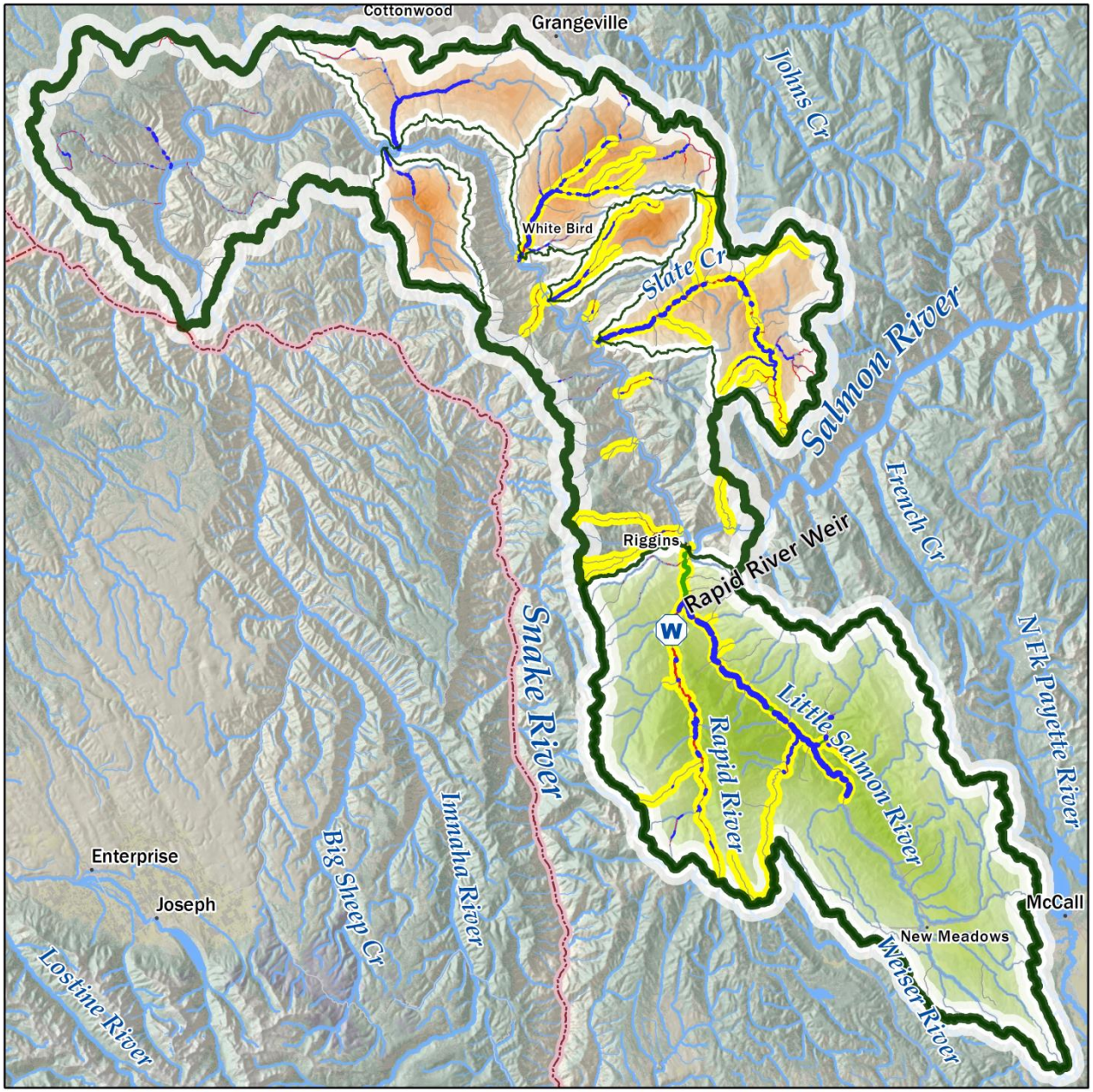


Umatilla River Summer Steelhead



Little Salmon River Summer Steelhead



Intrinsic Potential

Weighted Bankfull Area / 200m reach

	rating
0 - 500	LOW
501 - 1500	
1501 - 2000	MODERATE
2001 - 3000	
3001 - 5000	HIGH

Population

- currently occupied
- extirpated

Spawning Area

- major
- minor

- current spawn/rear

N

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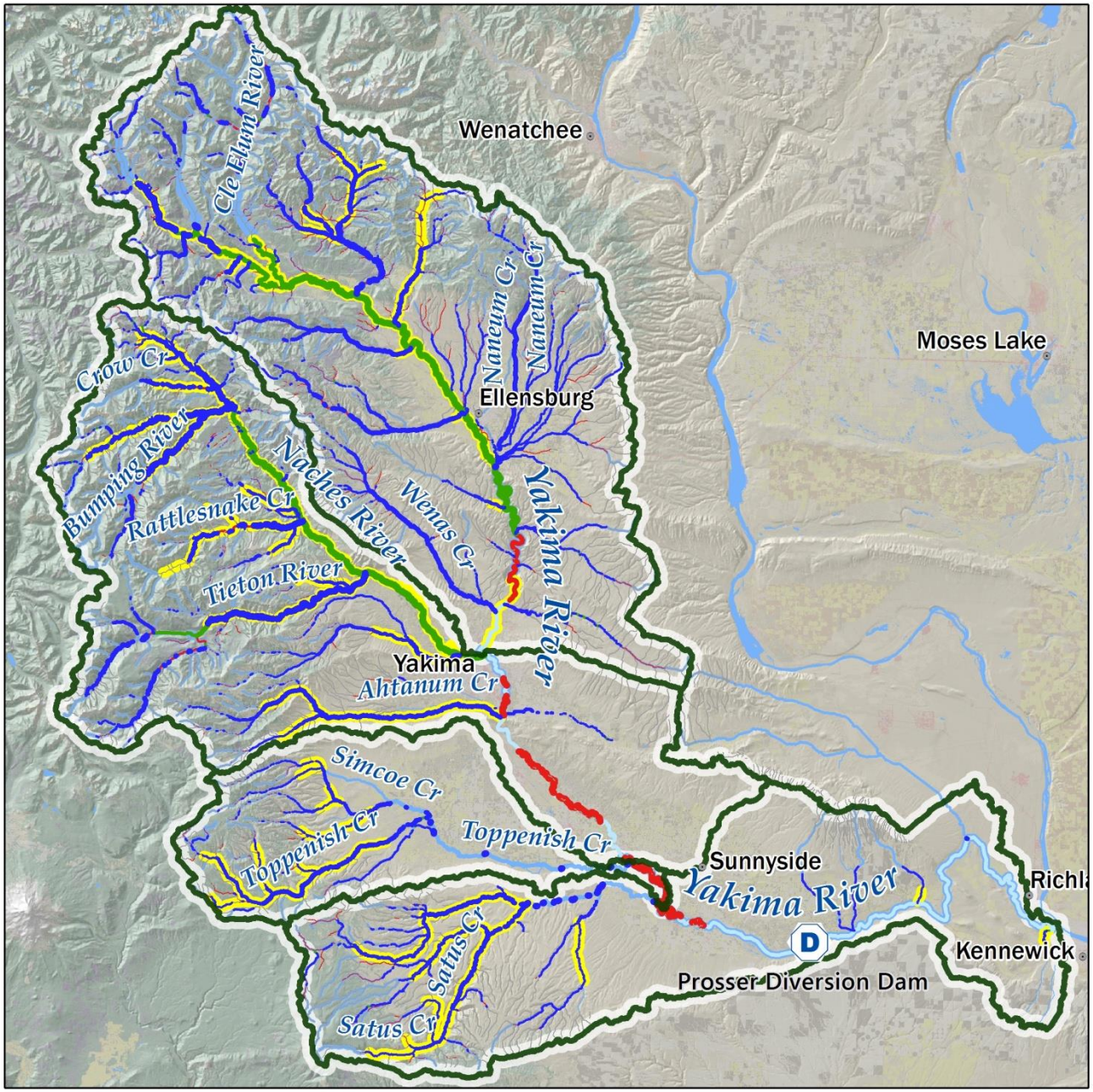
Yakima River MPG



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current spawn/rear

N

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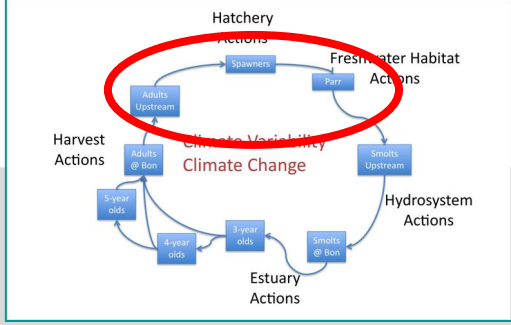
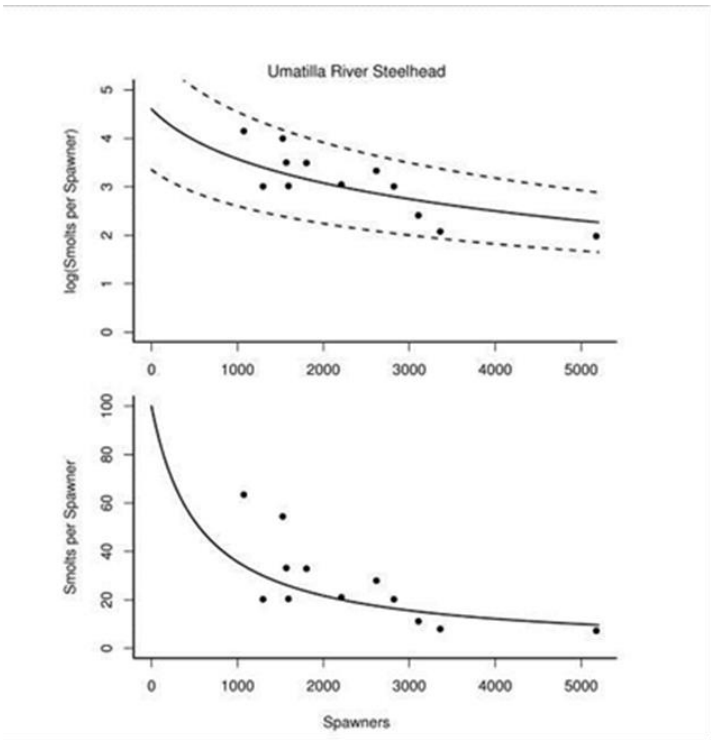
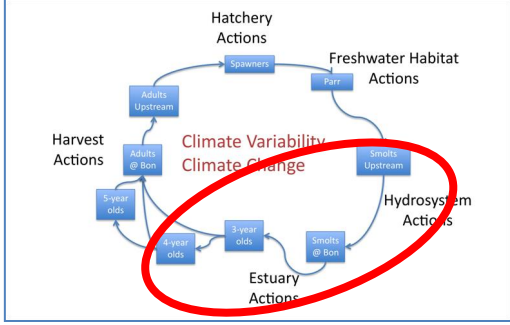
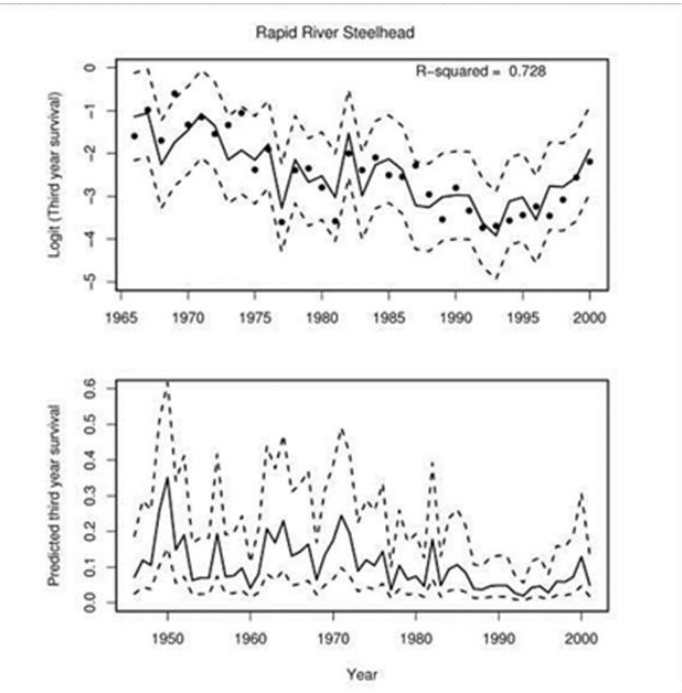


Parameter	Little Salmon River (Rapid River)	Umatilla River
Beverton-Holt "a"	200	200
Beverton-Holt "b"	0.06254	0.00402
σ^2_1	0.307	0.0165
ϕ (variance term)	0.0	2.0
Freshwater survival year 2 (s_{fw2})	1.0	1.0
Freshwater survival year 3 (s_{fw3})	1.0	1.0
Freshwater survival year 4 (s_{fw4})	1.0	1.0
Propensity to smolt at age 2 (sm_2)	0.0	0.908
Propensity to smolt at age 3 (sm_3)	0.6	1.0







Lower Granite outmigrant smolts
(Brd yr +2/3)

(1-Pt)*Si+Pt*St*D
System survival
functions

Estuary yearling smolts
(Brd yr +2/3)

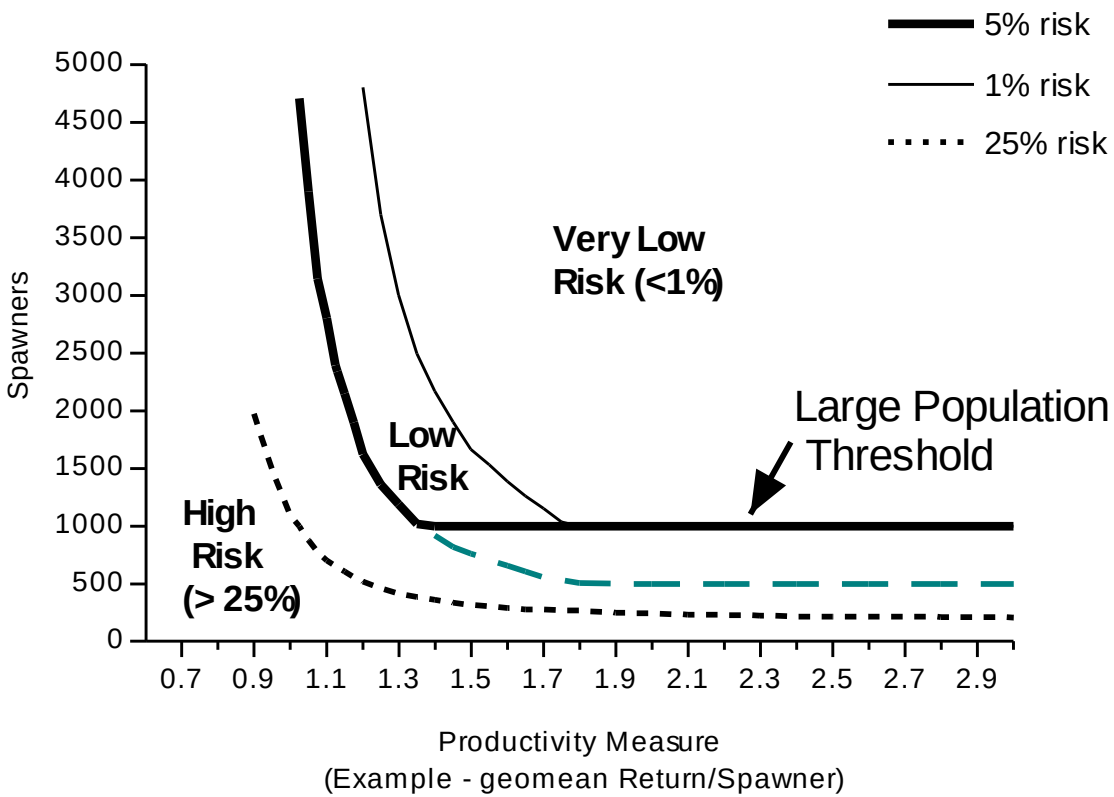
S3 fitted function
LGR wild agg vs
PDO, WTT, Upwell

SO1 = -0.985 -0.0405 (WTTSnake)+0.664(PDOApr)-0.939(PDOMay)-0.0149(UpwellSep)

Ocean (age 2/3 juveniles)
(Brd yr +2/3)

Ocean annual survivals: PSC
model assumptions
Maturation rate: stock specific
cohort analysis

Example Viability Curve: ICTRT



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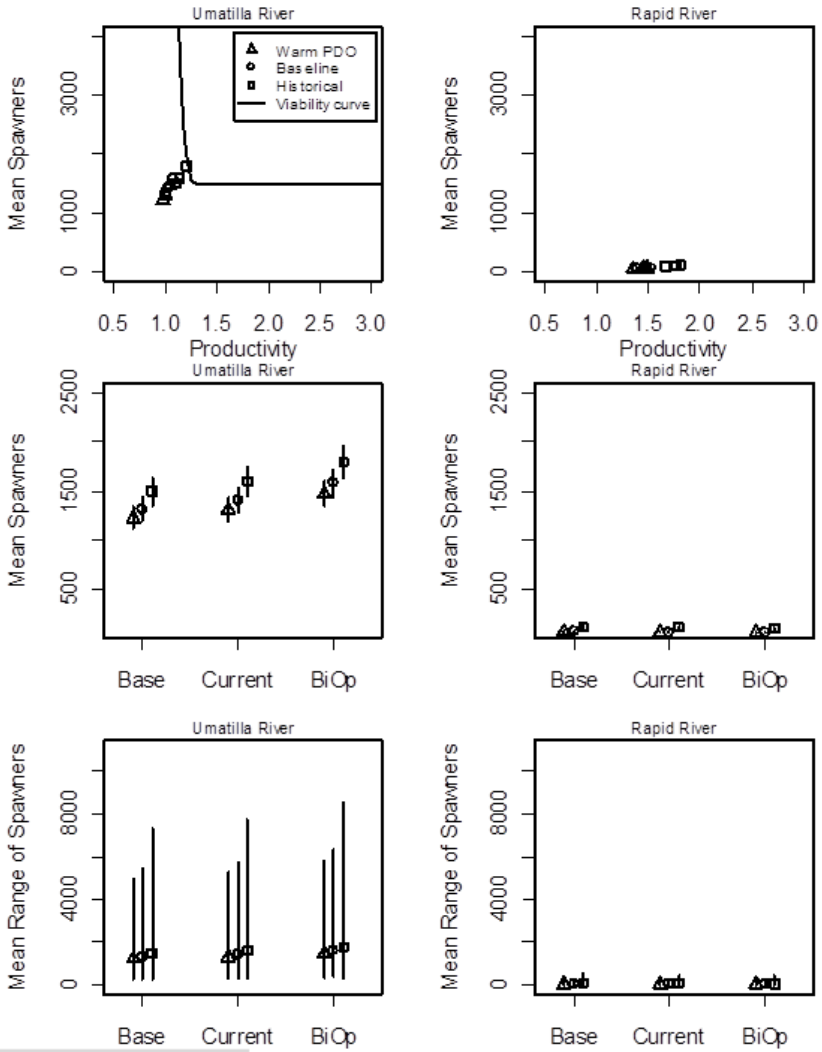

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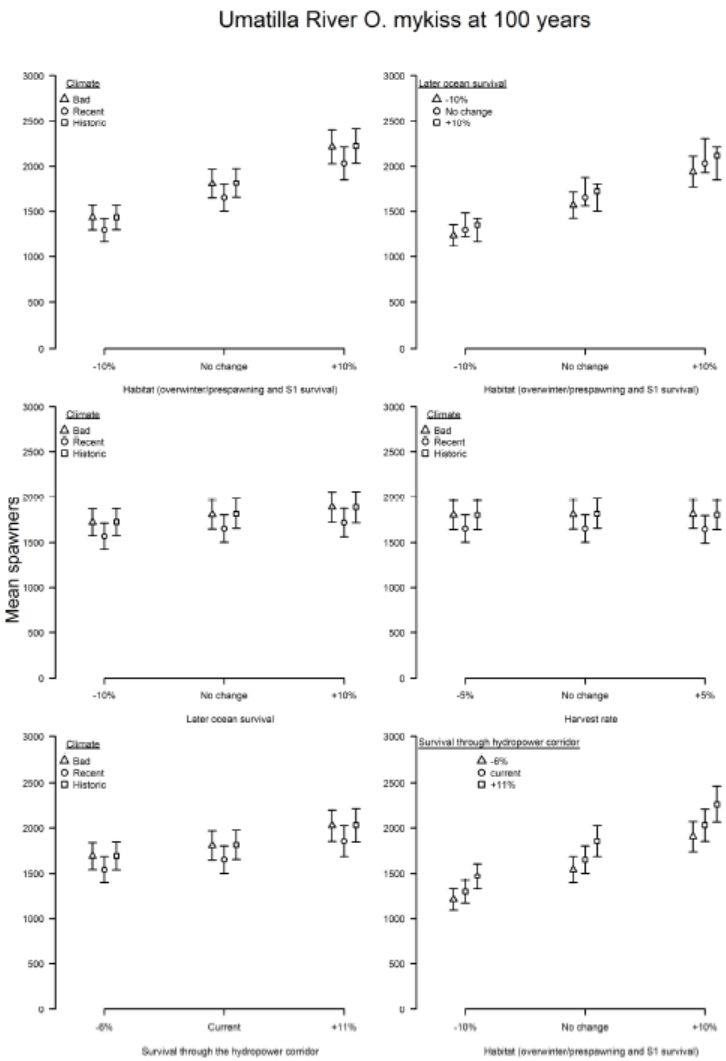
Figure 2.7.3. Mean spawners for steelhead populations under various climate, habitat, hydropower corridor survival, later ocean survival, and harvest rate change scenarios predicted after 100 years by the life-cycle model. Error bars represent standard deviations.



Next Steps

- Compare results from modeling approaches
  - Cohort based smolt reconstructions
  - State dependent modeling (e.g. Satterthwaite et al., 2010)
  - Parr density based modeling
- Key sensitivity analyses
  - Juvenile density models: size based habitat partitioning, temperature and flow assumptions
  - Alternative assumptions/data on migrant production and survival rates

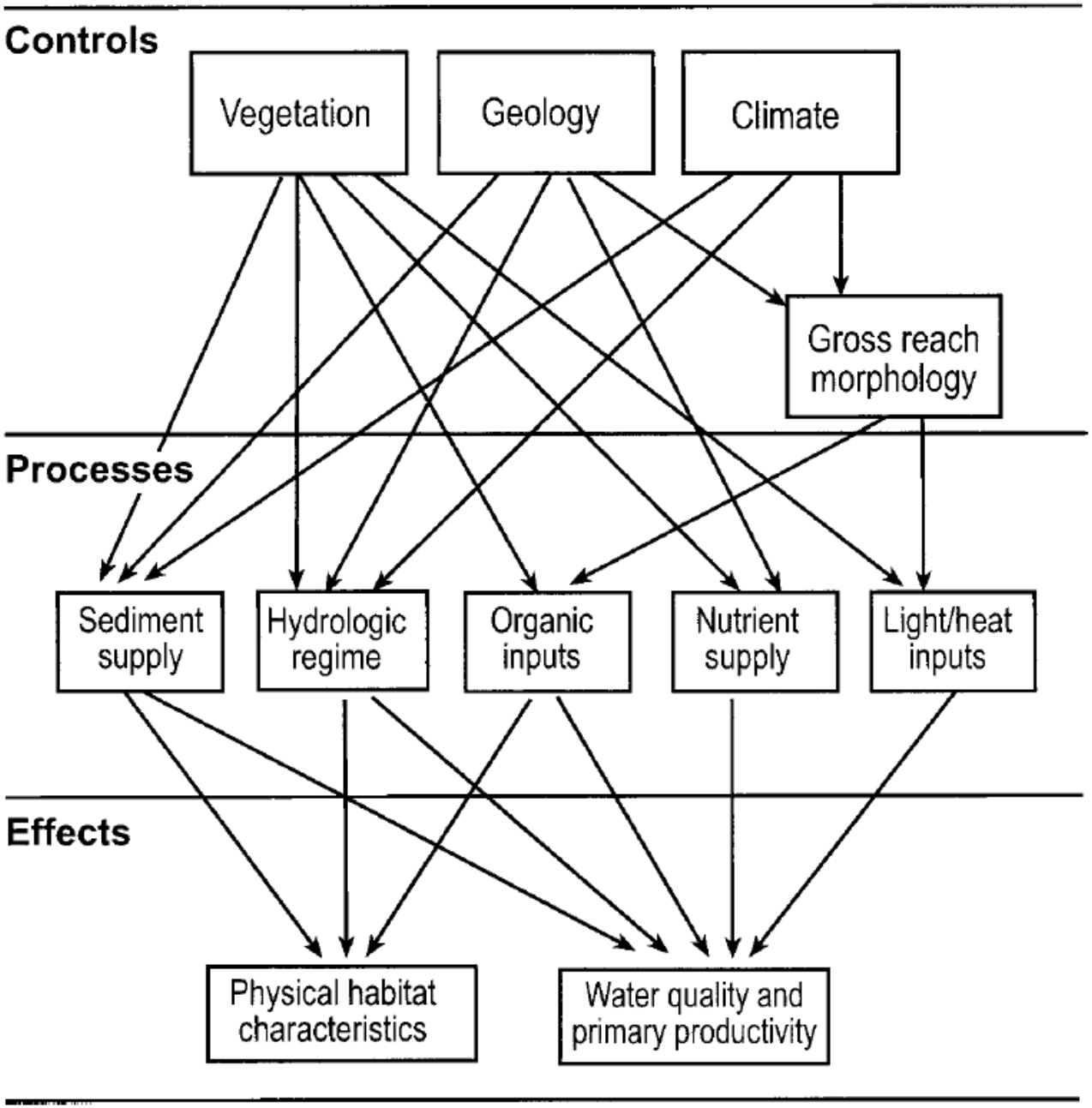
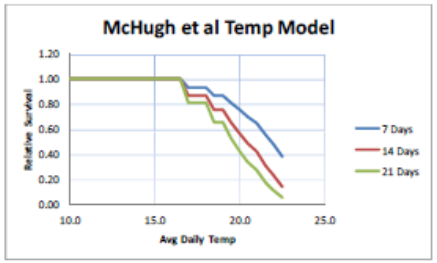
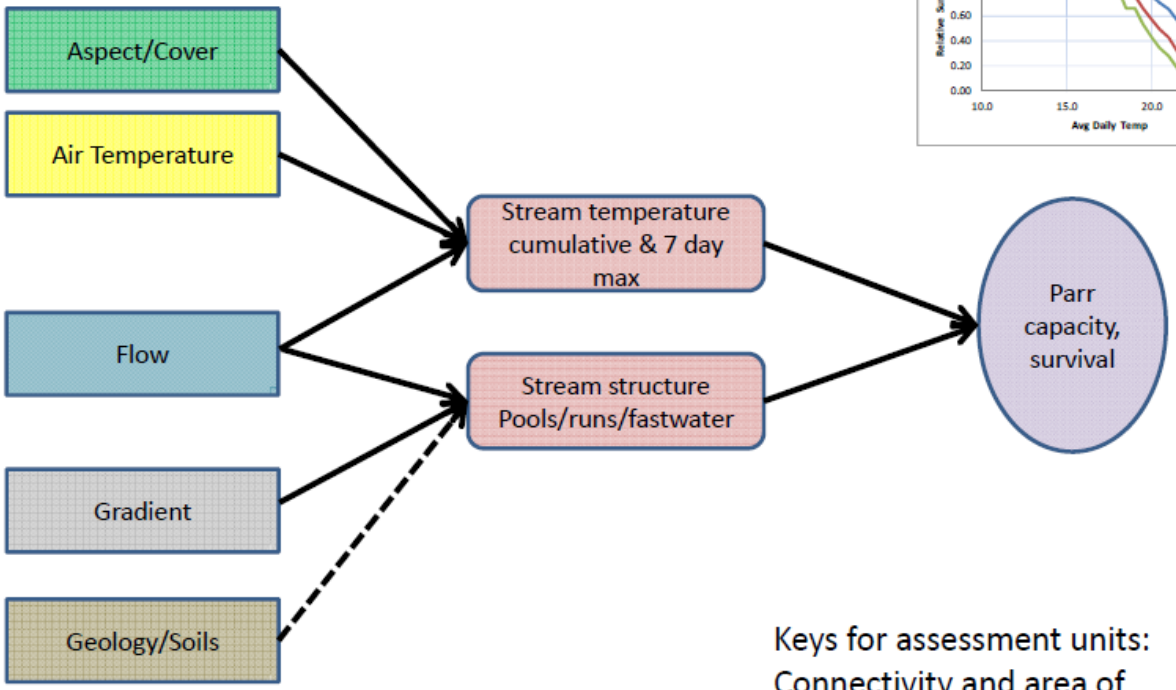


FIGURE 1.—Schematic diagram of linkages between landscape controls on habitat-forming processes and between habitat-forming processes and effects on habitat conditions.

Linking habitat conditions to model parameters (Grande Ronde Chinook example)

Fry to Outmigrant Stage





Keys for assessment units: Connectivity and area of suitable (depth and temp) pools for parr to pre-smolt rearing

Translating Actions into habitat changes

Oregon MU Mid-Columbia Steelhead example

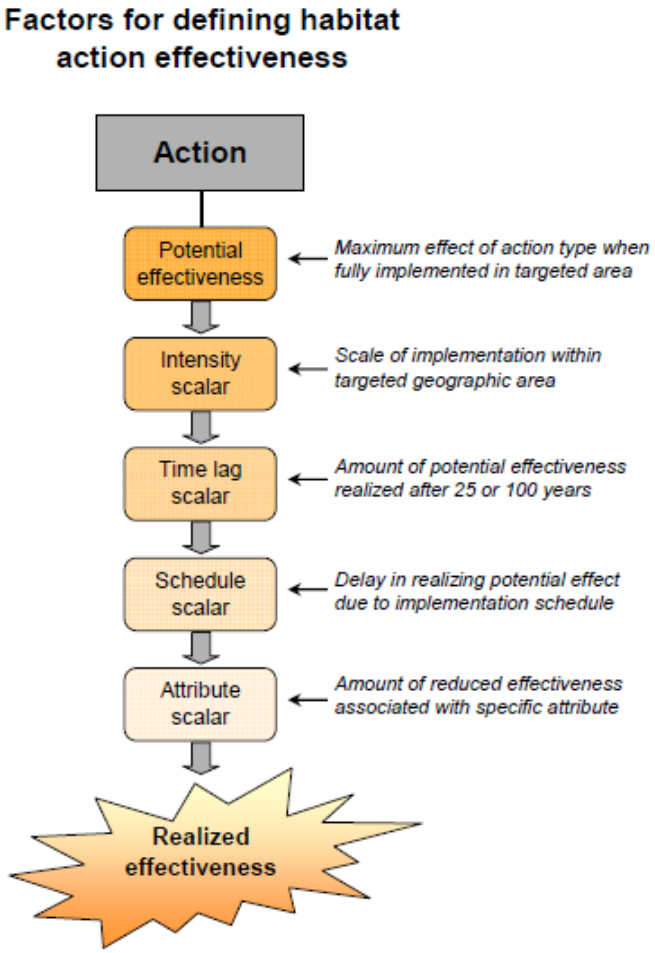


Figure 10-3. Action effectiveness elements.

Key Questions

- Spawning timing
- Emergence
- Age 0 density dependent interactions
  - Growth
  - Mortality
- Age 1 density dependent interactions
- Smolts and SARs
  - Smolting rates as a function of parentage
  - Relative SARs as a function of parentage
  - Downstream mortalities: natural vs anthropogenic

More detailed O. mykiss life history models: opportunities, limitations and applications

- Adapt to regional settings
  - State dependent life history models
  - Cohort reconstruction paired with juvenile production
- Treat as hypothesis frameworks, primary use is to ‘test’ rule sets behind viability benchmarks and indices
- Identify and pursue opportunities for validating results at either the component or population level
- Contribute to recovery planning – tributary habitat protection/restoration