

Quantitative food webs to estimate carrying capacity and guide restoration

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Is habitat carrying capacity limiting salmonid production?

- Natal streams are highly altered from historic conditions.
 - Atrophied Structural Functions
 - Channel morphology, complexity
 - Altered Aquatic Food Webs
 - Reduction in marine derived nutrients
 - Competition
 - Hatchery origin
 - Non-native

(ISAB 2015-1; Naiman et al. 2012; ISAB 2011-1; Roni et al. 2019; Stewart et al. 2009; Thompson et al. 2006; Wipfli et al. 2010; Stockner et al. 2003; Gresh et al. 2000; ISAB 2008-4; Sanderson et al. 2009)



Monitoring Gap

• The need to quantify carrying capacity.

(ISAB 20015, Naiman et al 2012, ISAB 2011)

- How do we quantify habitat carrying capacity and associated density dependent conditions?
- How do we estimate the magnitude of competition from nonnative fish?



Carrying Capacity (K) of Stream Habitats



Time ------

K(E) The Energetic Capacity of Streams





Energetic Carrying Capacity Function



Time ____

Restoration in Context of K(E)







Methods to estimate K(E)

Trophic Basis of Production

- Production (annual accrual of biomass)
 - Trophic levels of interest

(Benke and Wallace 1980)

Bioenergetics

• Multiple approaches

(Warren and Davis 1967; Kitchell et al. 1974; Deslauriers et al. 2017)

Construct Energetic Flow Webs

• Display energetic routing

(Bellmore et al. 2013; Cross et al. 2013)







Methods for Estimating Trophic Production

Measuring Secondary Production of Insects and Fish



Population Density = (n-m⁻²)

Biomass = single point in time = (g-DM m⁻²)

PRODUCTION = Biomass * Growth = accrual of tissue over time = (g-DM m⁻² y⁻¹)

Bioenergetic Component



Example of a Quantitative Energetic Flow Web

Track organic energy flows through trophic levels, among communities by taxa

- Series of bio-energetic calculations
- Prey production (aquatic and terrestrial)
- Fish Production
- Fish diets
 - Who is eating who

- Magnitude of energy flow
- Diet overlap
- Magnitude of competition



Research Questions

1) Does habitat restoration increase food production for listed salmonids?

Study Area: Hancock Spring Creek

- 1km long, first order spring creek,
- Tributary to the Methow River
- Highly degraded, uncontrolled livestock
- Non-Native fish (Brook Trout)







Before/After



Monitoring Design



Results:

Total Community Production, Benthic Macroinvertebrates

- Error bars display 95% CI
- No Significant differences between reaches



Top 10 Produced Taxa By Reach - 2013



Reach 2 (Un-Restored) Diets - 2013





Reach 1 Diet Overlap with Brook Trout



Discussion

Todays Results

- Community level BMI production is not significantly different between reaches
- Alignment of consumption of top taxa much higher in the restored reach
- Competition overlap by brook trout is high in the restored reach (1)

Next Steps To Flow Web Completion:

- Complete production estimates for the entire fish community (non-salmonids)
- Include terrestrial insect subsidies
- Construct bioenergetic costs
- Calculate mass/balance relationships

Quantify Brook Trout's contribution to density dependence and carrying capacity

Food Web Analysis Tools (R Packages)

- Aquatic Insects Production Package
 - Inputs
 - Directly from lab
 - Result Outputs
 - Mean annual estimates of abundance, biomass and production.
 - Constructed levels of uncertainty (CI)
 - Output resolution can be adjusted based on study needs



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Conclusion

Quantitative Food Web Applications

Diagnostic

- Estimate habitat energetic carrying capacity
- Identify primary limitations affecting K(E)
- Estimates of non-native competition

Predictive

- Model prey availability at different levels of non-native removals
- Help prescribe restoration treatments chronologically
 - Remove non-natives prior to adding wood or nutrients

Restoration Monitoring

- Quantify separate and additive treatment effects
 - Habitat Complexity
 - Nutrient Augmentation
 - Non-Native and Hatchery removals

Questions



Sponsors







Salmon Recovery Funding Board

WASHINGTON STATE RECREATION AND CONSERVATION OFFICE



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http://www.methowsalmon.org/currentprojects.html