**Project overview:**

We are investigating how riparian forest structure influences stream light availability and how that in-turn influences potential bottom up drivers of stream ecosystem processes. We are using stand age/stage as a proxy for structure with old-growth forests having more gaps and mid/early succession forests having a more uniform structure. We are particularly interested in how forest gaps influence local and larger scale processes in headwater streams (1st to 3rd order).

Hypothesis: Old-growth riparian forests will allow more light to reach the stream benthos than second-growth riparian forest resulting in increased primary production leading to increased nutrient demand, greater secondary production, biomass, and growth rates (with a primary focus on vertebrate - cutthroat trout).

**Premise for study:**

Studies have shown riparian clear-cuts can result in a substantial increase in solar radiation which can lead to increased primary production, increased grazer biomass and greater predator biomass…..

HOWEVER these forest management practices also lead to:

* Increased stream temperature, impacting waters locally and downstream.
* Reduced Large Wood (LW) loading over time
* Reduction of in-stream habitat and spawning habitat for salmonids
* Dense forest regrowth, which can quickly close canopies and reduce light & primary production in small streams
* Increased sedimentation and turbidity

Overall long-term negative impacts that outweigh the short-term increases in primary and secondary production

Old-Growth Forests typically have better habitat for salmonids due to the high abundance of large wood and associated deep pool and complex structure. Many researchers and managers tend to focus on the instream habitat and wood but do not consider the importance of the canopy gaps created when that wood fell into stream. We believe these canopy gaps, with increased solar radiation, create local productivity hotspots with increased primary production, increased nutrient demand and biogeochemical cycling with the potential for greater secondary production without the negative effects associated with clearcutting. But are these gaps big enough to have a noticeable effect beyond the localize area of increased light, and do these “hotspots” actually lead to greater whole stream production? These are the questions that we are hoping to answer in this research.

**Increased Light**

*The first step in this study was to evaluate the fundamental hypothesis that headwater streams with old-growth riparian forests have more light than headwater streams with second-growth riparian forests.*

Vials of the photodegrading dye Fluorescein were placed every 5 m for 160 m in paired reaches of the same stream but different riparian forests (old-growth versus second growth riparian forests)

Figure 1: STREON site Fluorescein Vial Data



Figure 2: McRae Tributary Fluorescein Vial data



Figures 3 & 4: Photosynthetically Active Radiation (PAR) sensor data from McRae Tributary. Left: Figure 3 illustrating the variability of light reaching stream in Old-Growth Site. Right: Figure 4 depicting two locations with similar accumulated light with high light events occurring at different times during day.

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Note that old-growth forest reaches have greater light on average but also much greater variability in light than the second-growth forest reaches.

**Primary Production**

Our next step was to see if increased light resulted in greater Chlorophyll a and periphyton Ash Free Dry Mass, both indicators of increased primary production.

Figure 5: McRae Tributary fluorescein loss in vials. Box indicates where periphyton samples were collected.- capturing the transition from a gap to a closed canopy second of the old-growth stream.



Figure 6: Periphyton Chlorophyll a., Ash Free Dry Mass and their ratio plotted against light measured with fluorescein vials.



**Nutrient Cycling**

*We then asked whether increased light with an associated increase in primary production lead to differences in stream nutrient cycling? We focus here on Nitrate uptake during the day versus uptake during the night to explicitly evaluate the role of primary producers on nutrient demand.*

Figure 7: Uptake velocity data from day/night nutrient releases on McRae Tributary



**Increased Vertebrate Predators**

*We then ask the question: Does greater primary production lead to measurably greater secondary production?*Note: it is a LOT of work to truly measure secondary production so we are using measures of the abundance and biomass of top predators as a proxy/first-cut look at a potential relationship between forests structure and secondary production

Figure 8: Vertebrate biomass estimates at two paired reaches

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Figure 9: Vertebrate population estimates at two paired reaches

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Table 1: Average sizes of Cutthroat and Salamanders in paired reaches.

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| --- | --- | --- | --- | --- |
| Average Biomass (g) | McRae Trib 2nd G | McRae Trib OG | STREON 2nd G | STREON OG |
| Cutthroat Total | 8.74 | 8.30 | 8.77 | 12.25 |
| Cutthroat >50 cm | 10.51 | 10.76 | 17.08 | 18.29 |
| Cutthroat <50 cm | .255 | .33 | .15 | .17 |
| Salamanders | 7.65 | 7.25 | 19.86 | 21.39 |

One of the issues here is that these streams also have differences in habitat, which have been shown to affect the abundance and biomass of fish. So – we are also looking at fish growth and at the isotopic signature of young of year (fry) fish from these streams.

**Fish Growth**

Fish are implanted with PIT tags allowing us to individually mark fish and measure growth over the summer. Will cutthroat growth rates be higher in old-growth reaches vs. second-growth reaches?...Ask me in a few weeks.

**Stable Isotopes Signatures**

Carbon fixed in the terrestrial environment has a different 13C:12C ratio than carbon fixed in aquatic environments. If the base of the stream food-web is truly different in streams with different forest types, we should be able to see that in the 13C:12C signature of young of year fish. Why are we focusing on YOY fish? Because fish move in winter in these systems. The isotope signature in muscle tissue integrates food resources and we therefore don't know how much of the signal is a product of where we caught the fish. In these systems, however, we are expecting limited YOY movement through the summer. When looking at these fish in the fall, we can therefore assume that most of their current signature is a product of the food resources that they had available over the summer where we caught them (old-growth versus second-growth reaches). Will we see a result suggesting greater influences of in-stream production on fish from with old-growth versus second-growth riparian forest reaches? Ask me in a few months. . .