Intro

Stream ecosystem metabolism is the combination of gross primary production (GPP) and ecosystem respiration (ER). GPP is the fixation of inorganic carbon from carbon dioxide to organic carbon by photoautotrophs which produces oxygen. ER is the reverse of this process and is the mineralization of organic carbon to carbon dioxide which consumes oxygen and represents the use of energy by organisms in the stream (methods stream ecology ch34). Stream metabolism as such is a comprehensive measure which sums the activity of virtually all of the organisms in a stream (Meijia 2019).

A method for estimating stream metabolism that is currently receiving a lot of attention is the single station open diel oxygen method (methods 34). This method assumes that oxygen saturation at time *t* is a function of GPP, ER, the gas exchange rate, and oxygen saturation at time *t-1* (Odum 1956). GPP and ER are often solved for using inverse modeling (Byesian parameter estimation) where the amount of light is assumed to be proportional to GPP and the remaining oxygen deficit is assumed to be ER. This produces a modeled oxygen curve which can be compared to the measured oxygen curve. To do this light measurements and oxygen saturation must be measured frequently (commonly 5-15 minute intervals) along with temperature, salinity, and barometric pressure to calculate 100% saturation. The last remaining parameter required is the gas exchange or reaeration rate often reported as *K*600 in d-1 (600 refers to Schmidt number scaling used for comparison between different gasses).

The *K*600 may be estimated as a free parameter in the inverse modeling technique or measured directly. Estimating *K*600 as part of the model is adequate for streams with low slope and high light availability however it is more accurate to measure gas exchange directly in shaded streams with higher slopes which are typical of headwater streams. Measuring gas exchange is done by diffusing a gas of choice into the stream at high volumes and measuring concentrations downstream from the injection point. This process may however require permits, be cost prohibitive, and the gas may have undesirable effects.

An alternative to measuring the gas exchange directly in headwater streams may be to estimate this value from physical attributes of the stream and relationships reported in the literature. Palumbo (2014) suggests that stream slope is the most accurate variable to include when predicting gas exchange in this way and Hall (2016) reports a *K*600 to stream slope relationship with an *R*2 of 0.89 and similarly in a later study Hall (2018) includes data from gas injections in small headwater streams producing an *R*2 of 0.68. Using this relationship it may be possible to calculate a *K*600 from the slope of the stream which can then be used in the inverse modeling to estimate stream metabolism.

The respiration of all trophic levels contained within the stream will be included in the metabolism estimate (Meijia 2019). The top predators living in streams are most often fish (stream ecology ch6) and in In the Pacific Northwest headwaters these fish are generally trout (Family Salmonidae) (Richardson 2007) These trout will necessarily have their respiration included in the stream ER estimate (Hall 1972) and potentially affect GPP due to a trophic cascade (Young 2008).

In the western USA trout are regionally an important fish for recreational angling which has a sizable economy surrounding it (TCW 2010, Loomis 2012). Although the trout in first and second order headwater systems are not generally the target of anglers, these smaller systems present themselves with a more manageable size of stream to study and smaller streams exhibit connectivity with larger systems (Colvin 2019). A trend or relationship that exists in a small stream may not hold true as the stream widens (Richardson 2007) however it may be a place to begin hypothesis testing.

Many water quality factors have an effect on both stream metabolism and trout presence. Increased nutrients such as nitrate and phosphate is known to increase GPP (Mullholland 2001), ER (Pascoal 2005), and trout biomass (Artigas 2013) and dissolved organic carbon (DOC) is associated with moderate increases in GPP (cite) and larger increases in ER (Bernhardt 2002) but may decrease fish production at least in lakes (Benoit 2016). Light availability is the major stimulant of GPP (Warren 2017) and may also be associated with ER (Parkhill 1999) and trout (Warren 2018). Warming temperatures may also be associated with increased GPP, ER (Hill 2002) while having variable effects on trout (Coutant 2011).

The goal of this study was to use estimates of stream metabolism with a derived gas exchange value to predict trout biomass in headwater streams and to investigate what water quality parameters best predict both stream metabolism and trout biomass.