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Dear Professor Orth,

I am fairly new to the aquatics field. Having majored in Environmental Sciences and Policy with an emphasis in geospatial analysis, I never really made an effort to understand streams or how the aquatic ecosystem worked. After working for nearly two years at Colombia's Biodiversity Research Institute, I got very frustrated of not being able to "sell" the importance of conserving biodiversity as it seemed (and still seems) a very intangible goal. That is when I recognized that I needed to change my paradigm and think more in terms of ecosystem services. It is a very anthropogenic look at nature, but I think that it provides the bridge between development and conservation. There are tradeoffs, and we just have to be aware of that and the consequences of the decisions we take.

I started to become interested in the aquatic/stream field world while working on an ecosystem service modeling exercise while working at the Biodiversity Research Institute. We were creating alternative scenarios for the growth of oil palm in the savannahs of the Orinoco Basin, on the Colombian side. Traditionally (since around 1500s), these natural savannahs have had cattle at very low densities, allowing the natural ecosystem and cattle ranching to coexist. However, recently oil palm plantations have become ubiquitous. We were interested in modeling what an increase in vegetation cover (from grasslands to tree plantation) would do to carbon sequestration and food security. The Orinoco Basin is one of the world's richest in freshwater fish, and many communities living along the Orinoco River and its tributaries depend on fish as a source of protein and income (exportation of ornamental fish). We thought that as oil palm plantations increased, there was going to be less of a flood pulse – an important environmental queue for fish to spawn – and thus affect communities downstream. The project remained as a series of hypothesis as we did not have the resources or know-how to really understand what the impact was going to be.

I arrived to Virginia Tech to work for Paul Angermeier to assess the sustainability of a cultural ecosystem service (freshwater recreational fishing) in the Albermarle-Pamlico Basin in NC and VA. This got me to understand the type of impairments that affect fish: dissolved nutrients, dissolved solids, suspended solids, infrastructure along streams and altered flow regime among others. The responses of fish to disturbance vary by species. A recent review of Poff and Zimmerman (2010) examined the ecological response to altered flow to find that while fish abundance and diversity consistently decreased, riparian vegetation and macroinvertebrate showed mixed results. This finally convinced me that we should not look at biodiversity (number/variety of species) to manage our streams, but instead of ecosystem integrity because it takes into account the functionality of the ecosystem.

A year ago I took Freshwater Ecology with Dr. Jack Webster. I was exposed to the ways waterbodies are formed (glacier, meteor, earthquake, etc.), the behavior of lakes with varying light and heat (isotherm, thermocline, etc), nutrient cycling in streams (hysteresis loops and the sources of nutrients), and stream techniques (measuring flow, sampling for macroinvertebrates, conductivity, suspended solids, nutrient levels). I recall having concentrated more on the ecology of lakes, than on streams. However, I am more interested in learning about streams. This course introduced me to the limnology and limnetic terminology, although there is still much to learn (based on the Knowledge Background Survey). I feel like a novice with many of these topics – where I can look it up and recall how it works – but am far from being an expert.

For my Master's thesis I am studying the ecosystem structure's capacity to regulate floods. I define ecosystem structure as land cover and flood infrastructure. Land cover/use can decrease (if it's impervious cover or agriculture) or increase (forest and wetlands) the capacity to mitigate floods. So does infrastructure – channelization can decrease while dams can temporarily increase the capacity to mitigate floods. Only on small watersheds (<30mi^2) can we see the effect that land cover configuration has on stream flow. On the contrary, flood control infrastructure is placed in higher order streams. Thus, trying to understand how flood control infrastructure and land cover change has impacted flood regime becomes a challenge because we cannot analyze the same watersheds.

The paradigm of managing floods has begun to change (from hard structures such as levees, channelization and dredging, to retention ponds, floodplain and wetland restoration). However, with a changing climate where some places are projected to get more rain, increasing the resilience of the landscape to withstand floods is important –and not just in the places where flooding occurs (along high order streams), but also in the head waters that contribute to that flooding.

For my thesis, I am exploring the relation between land cover change and flood magnitude, duration and flow (defining the flood as the bankfull event, 1.5 - 2 year flood). I have learned on my own how to calculate the bankfull level, the differences in USGS's stream flow data, and to a certain extent the response of flow to different land cover configurations. I thought daily average flows were going to work, but after a quick analysis the data does not give me the resolution needed to capture the flood regime (floods that last for 6 hours get lost in the average data). I am now going to use instantaneous data.

The second part of my thesis is to explore the role of infrastructure on floods (levees, dams, channelization, dredging). I have this objective less developed than the first, and I think this is mainly due to the contradiction between what I have read in the literature and what I see in reality. The literature emphasizes that hard infrastructure in many cases have exacerbated flooding events. However, the management response in some Colombian watersheds has been to dredge and raise levees around streams.

My initial plan was to do a comparative analysis between a watershed (Tundama) in Colombia where massive flooding occurred in 2010-2011 due to la Niña, and around 70 watersheds in North Carolina and Virginia. I have not gotten too far with exploring the NC/VA data, but I spent this summer in Colombia understanding the Tundama watershed, the availability of flow and land cover data, and the land use history. I analyzed satellite derived land cover for 1985, 2000 and 2005 for nine watersheds less than 30mi^2. I found that there has been very little change in land cover, the most prominent use being agriculture (90% of the watershed). I found some aerial photography from the 1930s and 1940s to construct land use/cover back then. However, this analysis is on hold while I can get the funding to purchase the aerial photography. However, another fact to take into account is that the best resolution flow data that exist is average daily flows which might be too coarse to see floods in headwater watersheds.

To understand the history of the Tundama watersheds, I discovered a series of documents at the National Archive. I found correspondence from 1887 between the Governor of Tunja (biggest city in the Tundama watershed) and the Minister of Government where they laid out the plan to channelize, straighten, dry out wetlands and get the boulders out of two main rivers to decrease flood damages. This plan was carried out in 1930. I found another letter from 1901 to the Minister of Government reporting the number of houses that has been damaged by floods. By word of mouth/archive documents, I learned that major floods have occurred in 1887, 1901, 1917, 1937 and 1985 (presumably others between 1937 and 1985); so I am estimating that these floods occur every 20 years.

Natural resource management in Colombia is centered to suit people, not nature. Thus, when managing for floods, the response is not to recover the stream for the native fauna and flora; but to dredge or channelize to keep the dirty stream water away from people’s properties. The high order streams provide a site to irrigate crops, dispose of trash and sewer, instead of a place to drink water, invite recreation and provide habitat for fauna/flora. What I would like to learn more is how to approach stream recovery or restoration in streams that have been highly disturbed. While I see the importance of studying the biology and physical-chemical composition of streams, I see these as mechanisms to monitor impact/recovery efforts, than tools to restore the basic functioning of streams.

My biggest deficiencies are in hydrology, hydraulics and geomorphology of streams. I am interested also in learning stream dynamics in the high-altitude tropics (above 1500 meters) because in comparison to temperate streams, precipitation patterns and seasons are very different.

Some questions:

What is the interaction between ground water and stream water in places where dredging and channelization have occurred?

Is there interaction between ground water and stream water in man-made streams?

What effect does dredging have on floods?

How to know what was before and to what should it be restored to look like?

How to take into account legacy effects?

Floods are driven by climatic events, however given a rainfall event equal in intensity and duration, how does the land cover configuration affect the timing and level of stream flow?

Is bankfull discharge defined the same way in natural and disturbed streams? What happens to this definition when levees are put in?