“Stable rivers breed dull communities”

“Variety breeds diversity: hydrological variability predicts functional diversity in plant riparian communities “

Riparian ecosystems are biophysically complex and highly diverse taxonomically, structurally and functionally (Naiman, Decamps, & Pollock, 1993; Christer Nilsson & Svedmark, 2002; N. L. Poff, 2002). They provide a disproportionate amount of ecosystem goods and services compared with the fraction of the landscape which they occupy (Capon et al., 2013), and have been disproportionately modified by humans (C Nilsson & Berggren, 2000). In the New World, this modification has taken place rapidly and has resulted in significant degradation and biodiversity loss (). Impoundment and flow regulation has altered the hydrology of river systems globally, resulting in reductions to total discharge, reduced flow variability, dampening of flood peaks and changes to seasonality of flows. As demand for water increases with growing human populations, river systems are likely to become increasingly modified. Changing climatic conditions over the next century are also expected to cause shifts in hydrological patterns. Predictions are regionally specific, but similarly include changes to total discharge, flow seasonality and flow variability. In regions with projected increases in climatic variability, changes to the prevalence and intensity of extreme flooding or drought events can be expected. The combination of flow regulation and alterations to baseline discharges may well produce dramatically different future hydrologies, with significant consequences for the diversity and functional composition of riparian assemblages. An understanding of the processes that generate patterns of diversity and drive ecosystem functioning in riparian ecosystems must inform riverine conservation and rehabilitation efforts.

Riparian environments are characterised by strong fluctuations in soil moisture and repeated flooding disturbance. Accordingly, hydrology is widely considered to be the most important driver of determines community composition and functioning in riparian plant assemblages (N. Poff, Allan, & Bain, 1997). Biogeomorphic heterogeneity in the riparian patch mosaic results from a highly contingent interplay between hydrology, ecology and geomorphology over diverse spatial and temporal scales. Dispersal of propagules, colonisation and establishment of many plant species within the resulting patch mosaic is intimately tied with flooding cycles and temporal variability of flows.

A longstanding goal of community ecology has been to find general rules that explain patterns of ecological diversity. In the riparian environment, it is well established that the intrinsic environmental heterogeneity within these systems fosters heterogeneity in vegetation communities. Vegetation heterogeneity, in turn, can be thought of as a function of structural and taxonomic or functional diversity. A number of studies have looked specifically at the patterns of taxonomic diversity in relation to hydrology. OR JUST LAUNCH INTO EXAMPLES OF HYDRO THEN GEOMORPHIC RELATIONSHIPS WITH SPECIES RICHNESS

DISCUSSION ABOUT DRIVERS OF TAXONOMIC DIVERSITY IN RIPARIAN LANSCAPES

* *Hydrologic heterogeneity* <-> vegetation heterogeneity <-> geomorphic heterogeneity
  + “Biogeomorphic heterogeneity in the riparian patch mosaic results from a highly contingent interplay between hydrology, ecology and geomorphology over diverse spatial and temporal scales.” “A framework for interdisciplinary understanding of rivers as ecosystems”, Corenblit, Gurnell
  + Vegetation heterogeneity = population structure diversity \* functional / taxonomic diversity
  + We know these relationships hold for taxonomic diversity, right?
    - Hydrology - Riparian plant species richness along lateral and longitudinal gradients of water stress and flood disturbance, San Pedro River, Arizona, USA; Landscape structure and diversity in riparian plant communities: a longitudinal comparative study ; The role of riparian corridors in maintaining regional biodiversity ; Huston, M. 1979. A general hypothesis on species diversity. | Biological (species richness), landscape (hab- itat mosaic) and functional (nutrient flux) diversity in the high flood-frequency zone can be maintained or even increased by flood disturbances (Barnes, 1997; Naiman and Décamps, 1997; Hughes et al., 2001;Ward and Tockner, 2001). – from Corenblit 2007
    - Geomorph - Jess paper digging deep for diversity – geomorphic implications for species richness, also see her references in intro re: species richness & geomorphy
* Are riparian systems more resilient than terrestrial systems?
  + To individual disturbances and/or dry periods, yes, due to the nature of rivers as dispersal corridors, and intrinsic ecological heterogeneity providing refugia and a diverse patch mosaic a template for recovery (Naiman decamps Pollock 1993). However, riparian communities can be finely tuned to patterns of disturbance / low flows.
    - See dams literature

Conservation and ecological restoration activities increasingly aim to preserve the ecosystem functions associated with biodiversity (Cadotte 2011, Aerts &Honnay 2011, Montoya et al 2012 – emerging perspectives in the restoration of biodiversity based ecosystem services). Conservation management approaches oriented around patterns of taxonomic diversity may be problematic, however, as relationships between environmental conditions and community species composition can be difficult to generalise across landscapes. Where sites harbour dissimilar species assemblages, comparison becomes problematic. Compressed taxonomic descriptors of communities such as species richness or species-oriented metrics of diversity are widely used to compare communities across landscapes, but are unable to provide information about how elements of a community ARE TYPICALLY WEAK INDICATORS OF influence ecosystem functioning, provision of ecosystem services, or contribute to system resilience. Describing communities in terms of functional traits - any morphological, physiological or phonological feature measurable at the individual level (Violle et al. 2007) - dissolves species distinctions and emphasises ecological strategies: what species do within their community and how they do it. This allows for direct comparisons between communities that do not necessarily contain matching assemblages. In such a manner, communities can be compared in terms of how their component species both respond to and have an effect on their environment (Lavorel & Garnier 2002). A functional trait oriented approach, then, allows us to search for generalities in the influence of hydrology on ecosystem processes and patterns of diversity across disparate riparian plant communities. Merritt et al. (2010) outlined a framework for defining riparian vegetation flow response guilds according to functional traits, and functional traits have been discussed as a means by which to predict riparian community responses to climate change (Catford et al. 2013, Kominoski 2013). To date, however, plant functional ecology remains a novel approach in ecohydrology.

Functional traits can form the basis for mechanistic assessments of diversity that describe the range and distribution of ecological strategies within a community. While species richness (Whitaker 1972) has to date been the most commonly used metric of biodiversity for investigating the relationships between biodiversity and ecosystem functioning (Duffy 2009 – why biodiversity is important to the functioning of real-world ecosystems), functional diversity and composition are able to reveal the mechanisms underlying these relationships (Hooper 2005, Diaz 2001, E.J. O’Gorman, et al. Loss of functionally unique species may gradually undermine ecosystems Proc. R. Soc. Lond. B, 278 (2011)). Assessments of ecosystem service production have also begun to give functional diversity privilege over simple taxonomic metrics of diversity (Diaz et al 2007 – incorporating plant functional diversity effects in ecosystem service assessments).

WHAT DO WE KNOW ABOUT HOW PATTERNS OF FUNCTIONAL DIVERSITY RESPOND TO DISTURBANCE AND STRONG ABIOTIC CONSTRAINTS?

* So what happens to functional diversity in post-disturbance terrestrial systems?
  + What about systems that are just exposed to strong abiotic constraints?
  + Intermediate disturbance hypothesis? (can cite Jess)
* WHAT IS THE RELATIONSHIP BETWEEN SPECIES RICHNESS, ECOSYSTEM FUNCTION And FUNCTIONAL DIVERSITY? – SEE CADOTTE ET AL 2011.

HOW TO WE MEASURE FUNCTIONAL DIVERSITY?

Numerous metrics of functional diversity have been described in the literature; see Schleuter et al. (2010) for an introduction to the field. Typically these metrics have in common that they take multidimensional trait data as an input and output a single value describing the properties of this data.

Two requirements must be satisfied to achieve a functionally informed mechanistic understanding of biodiversity-ecosystem function relationships. Firstly, traits must be selected carefully so as to be representative of the functional variability within a community. Secondly, an appropriate metric of functional diversity must be selected for analysing the community with respect to the chosen traits. Trait selection bounds the ability of any metric of functional diversity to describe a community; thus, selected traits should be

ECOSYSTEM GOODS AND SERVICES, RESILIENCE (talk about needing a good metric of resilience when discussing which FD metrics to use.)

Specifically, the array of plant functional traits present within a community determines ecosystem properties, in terms of the size of pools of resources and rates of flux of these resources.

Ecosystem functioning comprises ecosystem properties (sizes of pools of matter and rates of processes), and the production of ecosystem goods and ecosystem services (Hooper 2005).

Functional redundancy, measured as the is also suggested to contribute to (Standish et al 2014).

In the riparian context, ecosystem functioning must take into account the ability of a community to respond to HYDROLOGY / GEOMORPHOLOGY.

Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona Patrick B. Shafroth, Gregor T. Auble, Juliet C. Stromberg, Duncan T. Patten

Simulated recruitment of riparian trees and shrubs under natural and regulated flow regimes on the Wisconsin River, USA Mark D. Dixon†\* and Monica G. Turner

Managing river flows to restore floodplain forests Stewart B. Rood 1, Glenda M. Samuelson 1, Jeffrey H. Braatne 2, Chad R. Gourley 3, Francine MR Hughes 4, and John M. Mahoney

AUSTRALIA Predicting potential impacts of environmental flows on weedy riparian vegetation of the Hawkesbury–Nepean River, south-eastern Australia Jocelyn Howell† andDoug Benson (see refs for NZ refs)

EUROPE Allocation of River Flows for Restoration of Floodplain Forest Ecosystems: A Review of Approaches and Their Applicability in Europe -Francine M. R. Hughes, Stewart B. Rood (ALSO SEE ABSTRACT – CONTAINS AUS and SA refs)

INVASION

* Exotic invasive black willow (Salix nigra) in Australia: influence of hydrological regimes on population dynamics (Kate E. Stokes)
* Shifting dominance of riparian Populus and Tamarix along gradients of flow alteration in western North American rivers David M. Merritt 1,2,5 and N. Le Roy Poff 3,4
* Water table decline alters growth and survival of Salix gooddingiiand Tamarix chinensis seedlings Jonathan L. Horton, , Janelle L. Clark
* (populus in Canada) Factors affecting the regeneration and distribution of riparian woodlands along a northern prairie river: the Red Deer River, Alberta, Canada
* L. D. Cordes1, F. M. R. Hughes2,\* andM. Getty1
* CATFORD INVASIONS paper? Or later?

“rules are bad” – In the absence of detailed empirical information of environmental flow requirements for rivers, we propose a generic approach that incorporates essential aspects of natural flow variability shared across particular classes of rivers that can be validated with empirical biological data and other information in a calibration process. THE CHALLENGE OF PROVIDING ENVIRONMENTAL FLOW RULES TO SUSTAIN RIVER ECOSYSTEM Angela H. Arthington 1,4, Stuart E. Bunn 1, N. LeRoy Poff 2, and Robert J. Naiman 3

WE KNOW QUITE A BIT ABOUT TAXONOMICALLY OR REGIONALLY SPECIFIC FLOW-ECOLOGY RELATIONSHIPS. C.F. ELOHA, RECRUITMENT BOX MODELS, MEDITERRANEAN, ETC. THIS SORT OF RESEARCH LARGELY COMES FROM NORTH AMERICA OR EUROPE AND IS BASED ON A SMALL SET OF DOMINANT TAXA SUCH AS SALIX, POPULUS AND TAMARIX. THE CHALLENGE NOW IS TO GENERALISE OUR UNDERSTANDING ACROSS REGIONS THAT MAY NOT NECESSARILY HAVE THE SAME SPECIES POOLS (OR FUNCTIONAL ATTRIBUTES?). cue species richness isn’t great argument

The ELOHA framework (Poff et al. 2010) put forth a comprehensive framework aimed at understanding the ecological consequences of hydrological alteration for the purposes of flow management in regulated systems. This framework urges the development of regionally specific models of flow-ecology relationships.

A plethora of statistical metrics can be generated to describe ecologically relevant components of hydrology. Broadly, these can be grouped into five categories, describing the central tendencies and variability of: magnitude, frequency, duration, timing, and rates of change of discharge events.

SEASONALITY OF FLOWS IS IMPORTANT”:

**The importance of seasonal flow timing for riparian vegetation dynamics: a systematic review using causal criteria analysis**

**JOE GREET1,2, J. ANGUS WEBB1,2 andROGER D. COUSENS1**