“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 in both taxonomic and functional senses (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 (). 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). Spatial and temporal variability in hydrological patterns participate in a complex interplay with fluvial geomorphological processes and vegetation dynamics to generate biogeomorphic heterogeneity within the landscape. 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. For adult plants, rare, extreme floods or periods of low flow are strong selective pressures.

Human changes to hydrology have been and will continue to be extensive. 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.

The impact of flow regulation on riparian plant communities is now being addressed by a growing body of research, under the “environmental flows” banner (Poff Zimmerman 2010 FWB, Merritt 2010). Understanding of taxonomically or regionally specific flow-ecology relationships has grown substantially over the last two decades – although progress has been mainly in North American (see Merritt et al. 2010) and Western European systems (Stella et al. 2013, Gurnell?), and largely describes a small group of taxa, namely *Populus*, *Salix* and *Tamarix*. The hydroecology of North American *Populus spp.* have been well described in a ‘recruitment box’ model that integrates knowledge about seed release phenology and seedling root extension rates with flow stage and water table decline rates (Rood and Mahoney 1998). This model has since been USED TO DESIGN SUCCESSFUL RESTORATION FLOWS (Rood managing river flows) and ALSO adapted for *Salix L.* (Rood et al 2005) and could conceivably be extended to other riparian species with similar recruitment strategies (Shafroth et al). The role of changing hydrologies in precipitating or facilitating weedy invasion has also stimulated interest. Here, the scope of research has extended into New World systems such as Australia (Catford 2014, Stokes , Howell) and New Zealand (??) where rapid escalation of plant invasions now represent significant threats to biodiversity and functioning in riparian ecosystems. Investigations into the potential impacts of climate change on riparian plant communities are still at a fledgling stage, but concepts and understanding from environmental flows research can be applied.

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.

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). Functional traits can form the basis for mechanistic assessments of diversity that describe the range and distribution of ecological strategies within a community. These metrics of functional diversity are highly generalizable and allow us to explore fundamental questions about how hydrology might drive community composition and functionality across broad spatial and ecological scales. 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).

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

WHAT IS THE RELATIONSHIP BETWEEN SPECIES RICHNESS, ECOSYSTEM FUNCTION AND FUNCTIONAL DIVERSITY? – SEE CADOTTE ET AL 2011.

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**