G Model
ECOHYD-159; No. of Pages 9
ARTICLE IN PRESS

Ecohydrology & Hydrobiology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Ecohydrology & Hydrobiology

journal homepage: www.elsevier.com/locate/ecohyd

Review Article

What is a macrophyte patch? Patch identification in aquatic ecosystems and guidelines for consistent delineation

Jonas Schoelynck [a,*], Stéphan Creëlle [b], Kerst Buis [a], Tom De Mulder [b], Willem-Jan Emsens [a], Thomas Hein [c], Dieter Meire [b,d], Patrick Meire [a], Tomasz Okruszko [e], Stefan Preiner [c], Rebeca Roldan Gonzalez [b], Alexandra Silinski [a,f], Stijn Temmerman [a], Peter Troch [b], Tomas Van Oyen [b,d], Veerle Verschoren [a], Fleur Visser [g], Chen Wang [a,h], Jan-Willem Wolters [a], Andrew Folkard [i]

[a] *University of Antwerp, Department of Biology, Ecosystem Management Research Group, Universiteitsplein 1C, B-2610 Wilrijk, Belgium*
[b] *Ghent University, Department of Civil Engineering, Hydraulics Laboratory, Sint-Pietersnieuwstraat 41 B5, B-9000 Ghent, Belgium*
[c] *WasserCluster Lunz, Biologische Station GmbH, Dr. Carl Kupelwieser Promenade 5, A-3293 Lunz am See, Austria*
[d] *Flanders Hydraulics Research, Flemish Government, Berchemlei 115, B-2140 Antwerp, Belgium*
[e] *Warsaw Agricultural University, Department of Hydraulic Engineering and Environmental Reclamation, ul. Nowoursynowska 166, 02-787 Warszawa, Poland*
[f] *Georg-August-Universität, Institute of Geography Cartography, GIS and Remote Sensing Dept. Goldschmidtstr. 5, 37077 Göttingen, Germany*
[g] *University of Worcester, Institute of Science and the Environment, Henwick Grove, Worcester WR2 6AJ, United Kingdom*
[h] *Satellite Environment Center, Ministry of Environmental Protection of People's Republic of China, Fengde East Road 4, 100094 Beijing, PR China*
[i] *Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, United Kingdom*

ARTICLE INFO

Article history:
Received 29 July 2017
Accepted 17 October 2017
Available online xxx

Keywords:
Landscape ecology
Pattern identification
Plant-flow interaction
Spatial scales
Ecohydrology
Macrophytes

ABSTRACT

Patches are of central interest to many areas of environmental science because they provide a lower limit of structural detail in synoptic studies, and an upper limit of contextual structure for point measurement-based studies. Identification and delineation of macrophyte patches however, is often arbitrary and case-specific. In this paper we propose a widely-applicable set of guidelines for delineating a "patch" and "patch matrix" – the latter implying a collection of interacting patches – which could standardise future research. To support this proposal, we examine examples from eco-hydrological studies, focusing on interactions between plants, water flow, sediment, and invertebrates. We discuss three aspects that are key to the delineation of a patch: (1) constitution (variable(s) whose values define the patch), (2) spatial properties (patch boundaries), and (3) distinction (of isolated single patches from multiple separate-but-interacting patches). The discussion of these aspects results in guidelines for identifying and delineating a patch which is applicable to any aquatic habitat, and covers a broad range of disciplines such as plant and animal ecology, biogeochemistry, hydraulics, and sedimentology.
© 2017 European Regional Centre for Ecohydrology of the Polish Academy of Sciences. Published by Elsevier Sp. z o.o. All rights reserved.

* Corresponding author.
E-mail address: jonas.schoelynck@uantwerpen.be (J. Schoelynck).

https://doi.org/10.1016/j.ecohyd.2017.10.005
1642-3593/© 2017 European Regional Centre for Ecohydrology of the Polish Academy of Sciences. Published by Elsevier Sp. z o.o. All rights reserved.

Please cite this article in press as: Schoelynck, J., et al., What is a macrophyte patch? Patch identification in aquatic ecosystems and guidelines for consistent delineation. Ecohydrol. Hydrobiol. (2017), https://doi.org/10.1016/j.ecohyd.2017.10.005

1. Why do we need these guidelines?

Self-organised patch formation is a process whereby large-scale ordered spatial patterns emerge from disordered initial conditions through local interactions between organisms and their environment (Rietkerk and Van de Koppel, 2008). This process has recently gained increased scientific attention because it has important implications for ecosystem functioning. Patchiness may be interpreted as an early warning sign of tipping points in ecosystems at which a sudden shift to a contrasting regime may occur (Scheffer et al., 2009). Self-organised patch formation can also increase ecosystem productivity as well as resilience and resistance to global environmental change, compared to spatially homogeneous ecosystems (Rietkerk and Van de Koppel, 2008). Patches are also important in facilitating the colonisation of initially bare landscapes and their subsequent bio-geomorphic evolution (Gurnell, 2014; Vandenbruwaene et al., 2011), and they also have a role in regulating fluxes of water (Rietkerk et al., 2004) and sediments (van Wesenbeeck et al., 2008). Correct delineation of patches is therefore extremely important (Li and Reynolds, 1995), especially in multidisciplinary studies where every specialist may define patches differently (O'Hare, 2015).

The term "patch" is commonly used in aquatic ecology to distinguish, for instance: (i) patches of vegetation from surrounding bare areas, e.g. within rivers and lakes (Kleeberg et al., 2010; Naden et al., 2006; Schoelynck et al., 2012, 2014), on river floodplains (Francis et al., 2009; Gurnell, 2014), in riparian wetlands (Opdekamp et al., 2012), or on intertidal floodplains (Bouma et al., 2007, 2009, 2013; Vandenbruwaene et al., 2011), (ii) diatom aggregations from bare tidal mudflats (Weerman et al., 2012); (iii) zones with fine sediment from zones with coarser grain sizes (Gibbins et al., 2007); (iv) nutrient-rich from nutrient-poor zones (Hodge, 2004; Hutchings and Wijesinghe, 2008); (v) zones of high hydrodynamic stress from more quiescent zones (Lancaster and Hildrew, 1993); (vi) coral reefs from sea grass beds (Maldonado et al., 2010); (vii) food-rich from food-depleted locations (Thums et al., 2013), (viii) zones of high variability in populations of soil organisms from zones with less variability (Ettema and Wardle, 2002) and even (ix) areas modified by ecosystem engineers (Wright et al., 2002), from areas not modified in this way. The implication common to all of these examples (and the many others in which the term is used (Townsend, 1989)) is that patches are areas characterised by values of a parameter of interest that are relatively high or low compared to the mean value across the whole area being studied. As such, patches tend to be viewed in two ways. Firstly, in synoptic scale studies, they are identified as the lower limit of structural detail, for example where a landscape is characterised in terms of the size and shape statistics of patches of a certain kind of habitat (e.g. Visser et al. (2015), who used low-altitude imaging to map submerged aquatic vegetation patches). Secondly, in studies executed via point measurements, they are identified as the upper limit of contextual structure, for example where comparisons are made between measurements within and outside of patches. Thus, a patch has a finite spatial extent (distinguishing it from a "point") but is smaller than the entire study area.

2. Examples of macrophyte patches in aquatic environments

In some cases, macrophyte patches are easily and rather unambiguously defined, whereas in many other situations, especially in aquatic habitats, the delineation of patches is less straightforward (Kolasa, 2014). For example: plant patches identified in aquatic environments can be categorised into four groups. In the first category, plant patches are easily recognised (Fig. 1a). These consist of a single species at a relatively high density within patches whose edges are sharp. This category appears especially in subaqueous systems (Fig. 1b). It is also frequently found on mudflats where patches of pioneer plants are formed by the establishment of a few individual plants that then expand clonally (Fig. 1c). In the second category (Fig. 1d), patches still consist of a single species, but the edges are less sharp because the density of shoots does not change quasi-discontinuously as in the first category; instead the patch fades into areas better identified as collections of isolated individual shoots. This configuration is often found in subaqueous systems where a group of individuals emerges from a seed bank (Fig. 1e), and can also occur at the edges of lakes or marshes (Fig. 1f). In the third category (Fig. 1g), patches consist of two or more species. This is common in subaqueous systems where single shoots of different species grow in amongst each other, or where stands of different species are interwoven (Fig. 1h). Finally, in the fourth category (Fig. 1i), two or more patches of the same or of different species grow separately, but interact with each other in such a way that they can be regarded as one under certain circumstances (see later). This category is frequently found in the field (e.g. Fig. 1j), and includes situations where it is difficult to demarcate the outer edges of the region of the patches' mutual interaction with the flow of water, and hence its size. From these four categories, we identify three characteristics of patches which will form the basis of our guidelines: (a) their **constitution** – i.e. the variable(s) whose values define the patch; (b) their **spatial properties** – i.e. identification of patch boundaries; and (c) their **distinction** – i.e. distinguishing multiple separate-but-interacting patches from single patches.

Because patch identification and consistent delineation is very often ambiguous, calculating statistics of patch size and shape can be problematic, and can cause difficulties with determining whether measurement points are truly within or outside of patches. The intention of this paper, therefore, is to review situations in which patches are identified in aquatic environments and provide a clear and widely-applicable set of guidelines for defining the term "patch" using the three identified patch characteristics. This will enable researchers a standardised way of comparing different studies that use this term, or comparing studies that use field measurements, laboratory experiments or numerical models.

Download English Version:

https://daneshyari.com/en/article/8847669

Download Persian Version:

https://daneshyari.com/article/8847669

Daneshyari.com