Reach hydromorphology: a crucial environmental variable for the occurrence of riverine macrophytes

Willem Kaijser1

Daniel Hering1,2, \*

Armin W. Lorenz1,2

1University of Duisburg-Essen, Faculty of Biology, Aquatic Ecology, Universitätsstraße 5, D-45141

Essen, Germany

2University of Duisburg-Essen, Centre for Water and Environmental Research, Universitätsstraße 5, D-45141

Essen, Germany

\*corresponding author (daniel.hering@uni-due.de)

Table S1: Exemplified calculation of substrate coarseness

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Substrate type** | **Fine organic matter – FPOM**  **(FPOM)** | **Agryllal – loam and clay**  **(< 0.063 mm)** | **Psammal - sand**  **(0.063-2 mm)** | **Akal - small gravel**  **(0.2-2 cm)** | **Mikrolithalgravel**  **(2-20 cm)** | **Mesolithal cobbles**  **(20-30 cm)** | **Makrolithal large stoenes**  **(30-40 cm)** | **Megalithal bedrock/very large stones**  **(>40 cm)** |
| **Substrate class** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Fraction** | 0 | 0 | 0 | 0 | 0.1 | 0.4 | 0.4 | 0.1 |
| **Substrate class \* Fraction** | 0 | 0 | 0 | 0 | 0.5 | 2.4 | 2.8 | 0.8 |
| **Sum/number classes** | 6.5/8 = 0.81 | | | | | | | |

A picture containing text, crossword puzzle, receipt

Description automatically generated

Figure S1: P-PO4 concentrations at sites with different Kohler scales (from 1 = lowest to 5 = highest abundance) for the individual species.

Chart, box and whisker chart

Description automatically generated

Figure S2: (A) Boxplot of the Kohler scale for *F. antipyretica*, *L. minor* and *S. pectinata*. (B) Occurrence of *F. antipyretica*, *L. minor* and *S. pectinata* along the P-PO4 gradient.

A picture containing graphical user interface

Description automatically generated

Figure S3: Full models without recursive elimination.

Table S2: Full species names with corresponding abbreviations.

|  |  |
| --- | --- |
| **Full name** | **Abbreviation** |
| Amblystegium fluviatile | A. fluv |
| Berula erecta | B. erec |
| Callitriche obtusangula | C. obtu |
| Callitriche platycarpa | C. plat |
| Callitriche stagnalis | C. stag |
| Ceratophyllum demersum | C. deme |
| Chiloscyphus polyanthos | C. poly |
| Elodea canadensis | E. cana |
| Elodea nuttallii | E. nutt |
| Fontinalis antipyretica | F. anti |
| Glyceria fluitans | G. flui |
| Iris pseudacorus | I. pseu |
| Lemna gibba | L. gibb |
| Lemna minor | L. mino |
| Lemna minuta | L. minu |
| Myosotis scorpioides | M. scor |
| Myriophyllum spicatum | M. spic |
| Nasturtium officinale | N. offi |
| Nuphar lutea | N. lute |
| Platyhypnidium riparioides | P. ripa |
| Potamogeton berchtoldii | P. berc |
| Potamogeton crispus | P. cris |
| Potamogeton natans | P. nata |
| Ranunculus peltatus | R. pelt |
| Sagittaria sagittifolia | S. sagi |
| Sparganium emersum | S. emer |
| Sparganium erectum | S. erec |
| Spirodela polyrhiza | S. poly |
| Stuckenia pectinata | S. pect |
| Veronica beccabunga | V. becc |

Text, letter

Description automatically generated

Figure S4: Partial Dependency Plots of species along substrate coarseness excluded in Figure 3.

Text

Description automatically generated

Figure S5: Partial Dependency Plots of species along distance from river source excluded in Figure 3.

A picture containing text

Description automatically generated

Figure S6: Partial Dependency Plots of species along the flow velocity classes excluded in Figure 3.

Table S3: Models applied on all species in various combinations. First column indicates which part of the dataset, second column which variable combination, third and fourth column OOB accuracy and Cohen’s kappa with recursive elimination and fifth and sixth without recursive elimination.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **With recursive elimination** | | **Without recursive elimination** | |
| **Dataset** | **Variable combination** | **Accuracy** | **Cohen’s kappa** | **Accuracy** | **Cohen’s kappa** |
| **Total [30 species]** | Hydromorphology + physical and chemical | 74% (min = 64% and max = 87%) | 0.25 (min = 0.08 and max = 0.52). | 74% (min = 64% and max = 87%) | 0.25 (min = 0.08 and max = 0.52). |
| Hydromorphology | 72% (min= 61%; max= 87%) | 0.22 (min= 0.07 ; max = 0.49) | 72% (min= 62%; max= 87%) | 0.22 (min = 0.07 and max = 0.49). |
| Physical and chemical | 64% (min=54%; max= 73%) | 0.11 (min = 0.03; max = 0.29) | 64% (min= 53%; max= 73%) | 0.1 (min = 0.03; max = 0.26) |
| **Lowland [10 species]** | Hydromorphology + physical and chemical | 66% (min=61%; max= 76%) | 0.21 (min =0.08; max = 0.36) | 0.66 (min=66%; max=76%) | 0.21 (min =0.07; max = 0.35) |
| Hydromorphology | 64% (min=57%; max= 77%) | 0.19 (min = 0.07; max = 0.38) | 0.63 (min=56%; max=76%) | 0.18 (min=0.01; max=0.37) |
| Physical and chemical | 57% (min=48%; max= 69%) | 0.19 (min = 0.08; max = 0.28) | 58% (min=51%; max= 68%) | 0.1 (min = 0.00; max = 0.23) |
| **Mountainous siliceous + calcareous streams [5 species]** | Hydro-morphology+ physical and chemical | 66% (min=58%; max=73%) | 0.27 (min = 0.19; max = 0.33) | 66% (min=58%; max=71%) | 0.25 (min = 0.16; max = 0.35) |
| Hydromorphology | 62% (min=55%; max= 71%) | 0.19 (min = 0.08; max = 0.28) | 60% (min=55%; max= 71%) | 0.16 (min = 0.10; max = 0.28) |
| Physical and chemical | 62% (min=56%; max= 69%) | 0.18 (min = 0.12; max = 0.30) | 62% (min=57%; max= 71%) | 0.19 (min = 0.13; max = 0.29) |

A picture containing graphical user interface

Description automatically generated

Figure S7: First approach including a random variable with a value between 0-1.

A picture containing graphical user interface

Description automatically generated

Figure S8: Second approach including a variable consisting only of the number 1.