

MoRPh Indices (revised January 2020)

There are 14 high-level MoRPh indices:

CHANNEL CHARACTERISTICS

- INDEX 1: Number of present/extensive flow types**
- INDEX 2: Highest energy present/extensive flow type**
- INDEX 3: Number of present/extensive bed material types**
- INDEX 4: Coarsest present/extensive mineral bed material type**
- INDEX 5: Average alluvial bed material size (phi units)**
- INDEX 6: Average alluvial bed material size class**
- INDEX 7: Extent of superficial bed siltation**
- INDEX 8: Channel physical habitat complexity**
- INDEX 9: Number of aquatic vegetation morphotypes**

RIPARIAN CHARACTERISTICS (BANK FACE AND BANK TOP)

- INDEX 10: Riparian physical habitat complexity**
- INDEX 11: Riparian vegetation structural complexity**

HUMAN PRESSURES AND IMPACTS

- INDEX 12: Degree of human pressure imposed by bank top land cover**
- INDEX 13: Channel reinforcement**
- INDEX 14: Non-native invasive plant extent**

The indices are calculated as follows:

INDEX 1: Number of flow types

The number of flow types recorded as P or E (total flow types is 10, but only 9 are mutually compatible and thus the maximum number feasible, probable maximum is 6)

INDEX 2: Highest energy present/extensive flow type

The highest energy flow type recorded as P/E (i.e. in the order Freefall > Chute > Broken standing wave > Unbroken standing wave > Upwelling > Chaotic flow > Rippled > Smooth > No perceptible flow > Dry).

INDEX 3: Number of bed material types

NumBedMat: Number of channel bed natural materials sediment types (from section 4.1 (Bedrock, Boulder, Cobble, Gravel, Sand, Silt, Clay, Organic, Peat): the number of types that are P or E – possible maximum is 9, probable maximum is 6).

INDEX 4: Coarsest present/extensive bed material type

Excluding, organic and peat, the coarsest bed material recorded as P or E (i.e. one of the following in the order Bedrock > Boulder > Cobble > Gravel-pebble > Sand > Silt > Clay)

INDEX 5: Average alluvial bed material size (phi units) and INDEX 6: Average alluvial bed material size class

Use observations of the following 6 bed material sizes: Boulder, Cobble, Gravel-pebble, Sand, Silt, Clay. For each record the abundance as 2 for T, 19 for P, 67 for E.

Average alluvial bed material size (phi units) = ((-9*Boulder abundance) + (-7*Cobble abundance) + (-3.5*Gravel abundance) + (1.5*Sand abundance) + (6.5*Silt abundance) + (10*Clay abundance)) / (Boulder abundance + Cobble abundance + Gravel abundance + Sand abundance + Silt abundance + Clay abundance)

Note that modules where only bedrock is present or where the bed is not visible cannot be calculated (the equation divides by 0).

The index is expressed in approximate phi units. To aid interpretation, these units translate into approximate particle sizes (**Average alluvial bed material particle size class**) as follows:

| Particle Size Description | Minimum size (phi) | Maximum size (phi) | Approx. Mid Point (phi) |
|---------------------------|--------------------|--------------------|-------------------------|
| Clay | | ≥ 9 | 10 |
| Silt | < 9 | ≥ 4 | 6.5 |
| Sand | < 4 | ≥ 1 | 1.5 |
| Gravel-pebble | < - 1 | $\geq - 6$ | -3.5 |
| Cobble | < - 6 | $\geq - 8$ | -7 |
| Boulder | < - 8 | | -9 |

INDEX 7: Extent of superficial bed siltation

Using the following table of abundance scores add the scores for 'continuous silt layer' and 'patchy thin silt layer' to give an overall indication of the 'extent of superficial bed siltation' (maximum possible value is 100 so divide total score by 10)

| | T | P | E |
|------------------------|---|-----|------|
| Patchy thin silt layer | 1 | 9.5 | 33.5 |
| Continuous silt layer | 2 | 19 | 67 |

INDEX 8: Channel physical habitat complexity

The index value ranges from 1 (minimal complexity) to 10 (extremely high complexity) and is calculated as a weighted average of 4 sub-indices as follows (round down to nearest integer value):

NumBedMat (i.e. Index 3): Number of natural channel bed material types (from section 4.1: the number of types that are P or E – possible maximum is 9, probable maximum is 6)

NumFlow (i.e. Index 1): Number of water surface flow types (from section 4.2: the number that are Present or Extensive – possible maximum is 9, probable maximum is 6)

NumBedFeat: Number of types of natural bed features (from section 4.3, subsection 'Channel bed - Natural physical features': score 1 for each that is observed as P or E or count>0 – possible maximum is 11, probable maximum is 6)

NumVegInteraction: Number of ways in which vegetation is interacting with wetted channel (from section 4.4, subsection 'Vegetation interacting with the wetted channel': score 1 for each that is observed as P or E apart from large wood dams and fallen trees entirely/predominantly which score 2 if count>0 – possible maximum 8, probable maximum is 6)

The probably maximum value for the total of the above four indicators is 24, suggesting a denominator of 2.4.

Channel physical habitat complexity = ((NumBedMat + NumFlow + NumBedFeat + NumVegInteraction)/2.4)

INDEX 9: Number of aquatic vegetation morphotypes

This index illustrates the number of aquatic vegetation morphotypes that are present. The index value is an integer ranging from 0 (no aquatic vegetation) to 10 (all aquatic vegetation morphotypes are present). Score 1 each for every plant morphotype that is P or E (maximum 10 types, ranging from liverworts/mosses/lichens to filamentous algae) based on observations (i) on the channel bed sheet (section 4.4, subsection 'Vegetation within wetted channel') and (ii) the bank face sheet (section 3.4, subsection 'Aquatic vegetation at the bank-water margin', where 5 of the types can also be recorded). Only score each morphotype once.

INDEX 10: Riparian Physical Habitat Complexity

This index represents the number and extent of riparian physical habitats found within the survey site, accumulating those related to wood, water-related features on the bank top, physical features on the bank face and water's edge, and natural bank profiles. The index value ranges from 0 (extremely low complexity) to 10 (extremely high riparian physical habitat complexity across both banks). It is made up of the following components:

WoodHab: is the extent of wood-related habitat features calculated for each bank separately (i.e. *LeftBankWoodHab*, *RightBankWoodHab* and is the total of the scores from the following table, summed for the bank top (section 2.2, subsection 'Terrestrial vegetation') and the bank face (section 3.4 'Terrestrial vegetation on bank face'). Maximum possible score = 22 for each bank and maximum probable score is 14. Divide each bank score by 1.4 to give a final score in the range 0 to 10 for each bank.

| Feature | P | E |
|---|---|---|
| Large wood (sections 2.2 and 3.4) | 2 | 4 |
| Fallen trees (sections 2.2 and 3.4) | 2 | 4 |
| Exposed tree roots (section 3.4) | 2 | 4 |
| Discrete organic accumulation (section 3.4) | 1 | 2 |

BankTopWatFeat: is the number and extent of water-related habitats on the bank top. It is calculated for each bank separately (i.e. *LeftBankTopWatFeat*, *RightBankTopWatFeat* and is the total of the scores on the following table from the bank top (section 2.3). Maximum probable score = 4 for each bank. Therefore divide each bank score by 0.4 to give a final score in the range 0 to 10 for each bank.

| Feature | P | E |
|--------------------------------------|---|---|
| Pond (disconnected) | 1 | 2 |
| Pond (connected) | 1 | 2 |
| Side channel | 1 | 2 |
| Wetland (short non-woody vegetation) | 1 | 2 |
| Wetland (tall non-woody vegetation) | 1 | 2 |
| Wetland (shrubs and trees) | 1 | 2 |

BankFaceNatFeat: is the number and extent of natural physical features on the bank face and along the water's edge. It is calculated for each bank separately (i.e. *LeftBankFaceNatFeat*, *RightBankFaceNatFeat* and is the total of the scores on the following table from the bank face (section 3.3 – Natural physical features). Maximum possible score is 27 for each bank, maximum probable score = 10, so no transformation needed to give a final score in the range 0 to 10 for each bank.

| Feature | P | E |
|--|---|---|
| Vegetated side bar (> 50% veg cover) | 1 | 3 |
| Unvegetated side bar (< 50% veg cover) | 1 | 3 |
| Toe | 1 | 3 |
| Berm | 1 | 3 |
| Bench | 1 | 3 |
| Stable cliff (> 0.5 m) | 1 | 2 |
| Eroding cliff (> 0.5m) | 1 | 3 |
| Animal burrows | 1 | 1 |
| Marginal backwater | 1 | 3 |
| Tributary confluence | 3 | |

BankNatProfile: is the number and extent of natural bank profiles. It is calculated for each bank separately (i.e. *LeftBankProfile*, *RightBankProfile*). Assign a score of 3 to each natural bank profile type that is E and 1.5 to each that is P (section 3.1, only score natural profiles, i.e. vertical (V), vertical with top overhang (Vo), undercut (Vu), vertical with toe (Vt), steep (St), gentle (Gt), composite (Cm)). If both dominant and subdominant profiles are natural, the maximum possible score is 6 for each bank and so divide by 0.6 to give a final score in the range 0 to 10 for each bank.

The above scores are combined into an integrated index of Riparian Physical Habitat Complexity (with a denominator of 6 rather than 8 to allow for the fact that it is very unlikely that any module would score highly in all aspects and, furthermore, bank top WoodHab and WatFeat are to some degree mutually exclusive):

Riparian Physical Habitat Complexity = (*LeftBankWoodHab* + *RightBankWoodHab* + *LeftBankTopWatFeat* + *RightBankTopWatFeat* + *LeftBankFaceNatFeat* + *RightBankFaceNatFeat* + *LeftBankProfile* + *RightBankProfile*)/(6)

INDEX 11: Riparian Vegetation Structural Complexity

This index represents the number of riparian vegetation morphotypes found with an abundance of P or E within the survey site. Count each vegetation structural component (i.e. mosses/lichens, short/creeping herbs/grasses, tall herbs/grasses, scrub or shrubs, saplings or trees) that is P or E on each bank top and bank face and add the scores for the two banks.

The maximum possible and probable score is 20 so the total is divided by 2

INDEX 12: Degree of human pressure imposed by bank top land cover

The index indicates the degree of human pressure imposed by land cover on the bank tops. The index value is rounded down to an integer ranging from 0 (minimal modification/pressure) to 10 (high modification/pressure). Score the artificial ground cover recorded on each bank top by summing the dominant and subdominant cover (section 2.1) according to the following table.

| | | P | E |
|----|--|---|----|
| Fp | Pedestrianised, footpath | 2 | 4 |
| Tr | Transport infrastructure | 5 | 10 |
| Ic | Buildings (commercial / industrial) | 4 | 8 |
| Re | Buildings (residential) | 4 | 8 |
| Sy | Storage area | 4 | 8 |
| Ld | Landfill area | 5 | 10 |
| Ar | Arable agriculture / allotments | 3 | 6 |
| Pv | Permanently vegetated agriculture (e.g. pasture, orchard) | 1 | 1 |
| Pr | Permanently vegetated recreation (e.g. playing fields, parks, gardens) | 1 | 1 |
| Pw | Plantation woodland | 1 | 1 |
| Ow | Artificial open water (e.g. canal, reservoir) | 1 | 1 |

If dominant and subdominant artificial cover types are present, the maximum score = 20 for each bank. Sum the scores for the two banks (maximum 40, probable maximum 20) and divide by 2 to give a final score in the range 0 to 10.

INDEX 13: Channel reinforcement

The index indicates the extent and strength of reinforcement of the river banks and bed. The index ranges from 0 (no reinforcement) to 10 (fully reinforced with CC, CB, BR or SP).

A common set of weightings is used for reinforcement of different types whether on banks or bed (section 3.2, subsection 'Bank face reinforcement', section 4.1, subsection 'Channel bed reinforcement'):

| | Dominant reinforcement type | Weighting (for T, P, E) |
|----|--|-------------------------|
| CC | Concrete | 3 |
| CB | Concrete & brick / laid stone (cemented) | 3 |
| BR | Brick / laid stone (cemented) | 3 |
| SP | Sheet piling | 3 |
| WP | Wood piling | 2 |
| RR | Rip-rap (large laid stone, uncemented) | 2 |
| GA | Gabions | 2 |
| BW | Builders Waste | 1 |
| WO | Washed out | 1 |
| WS | Willow spiling | 0 |
| RE | Planted reeds | 0 |
| BC | Biotex / coir | 0 |

BankReinfLeft, BankReinfRight: For bank reinforcement, the above materials weighting for the dominant reinforcement material only, is multiplied by one of the following weightings for the horizontal and vertical extent of the reinforcement (i.e. 2, 19, 67 for W and 0.5*2, 0.5*19, 0.5*67 for T or B):

| Reinforcement vertical extent | Reinforcement horizontal extent | | |
|-------------------------------|---------------------------------|-----|------|
| | T | P | E |
| T (top only) | 1 | 9.5 | 33.5 |
| B (bottom only) | 1 | 9.5 | 33.5 |
| W (whole bank face) | 2 | 19 | 67 |

The above gives a maximum score of 201 for each bank:

BedReinf: For bed reinforcement, the above materials weighting for the dominant reinforcement material only, is multiplied by the following weightings: T=2, P=19, E=67. This gives a maximum possible score of 201.

The maximum possible score for both banks plus bed if both extensively reinforced with CC, CB, BR or SP is 603. Therefore to give a range from approximately 0 to 10, the total reinforcement scores are divided by 60:

Channel reinforcement = $(BankReinfLeft + BankReinfRight + BedReinf) / 60$

INDEX 14: Non-native invasive plant species extent

The index indicates the number and extent of invasion by the 4 most common non-native invasive plants along British rivers. The index value ranges from 0 (no nuisance plants) through 5 (extensive invasion) to approximately 10 (extensive and diverse invasion).

The 6 species may be recorded on the bank top (section 2.2), bank face (section 3.4) and channel bed (section 4.4). This gives 5 possible locations (2 bank tops, 2 bank face, bed) for 6 possible species. In each location, each species is scored T=2, P=19, E=67. As it is impossible for all 6 species to be extensive at a location, the maximum, but unrealistic, total score is 1260 (E,E,P,P,P,P at all 5 locations). In reality, no more than one species is likely to be extensive and one present in each of the three locations, giving a maximum probable score (E,P) across all 5 locations (2 bank tops, 2 bank faces, bed) of 430.

Therefore, the index is calculated by adding scores of 2 (for T), 19 (for P) and 67 (for E) for the extent of each species at each of the 5 locations (*BankTopNNIPSRight*, *BankTopNNIPSLeft*, *BankFaceNNIPSRight*, *BankFaceNNIPSLeft*, *ChannelNNIPS*) and then adding the scores for all 6 species together and dividing by 40 to give a score of 0 (no species at any of the 5 locations) to approximately 10 (intensely invaded). In practice, if one species is extensive in any single location (score $67/40=1.7$), then the invasion is significant.