MAVIS - Documentation

v0.96

# 1 Introduction

The assignment of species compositional data to established vegetation classifications is a well established practice in ecology and conservation ([Maciejewski et al. 2020](#ref-maciejewski2020)). The results of this assignment process are used in various ways, including: informing ecological restoration objectives ([Gann et al. 2019](#ref-gann2019)), assisting in the phase 2 habitat survey (or NVC survey) ([Rodwell 2006](#ref-rodwell2006national)) process, along with establishing an ecological baseline and identifying important ecological features such as protected habitats ([CIEEM 2022](#ref-cieem2022)).

The development of computational methods and programs for the assignment of vegetation survey data to NVC communities began with the development of TABLEFIT ([Hill 1989](#ref-hill1989); [Marrs 2019](#ref-marrs2019)). The most recent program, the Modular Analysis of Vegetation Information System (MAVIS), was originally developed by S. Smart, Goodwin, and Wallace ([2016](#ref-smart2016mavis)) as a Windows application, with the latest version released in 2021.

This R Shiny implementation of MAVIS is the newest program in this series, aiming to provide a web-based and easily operable system which can be updated and improved over time.

# 2 Instructions and Methodology

## 2.1 Survey Data

Three methods for entering data into MAVIS are provided: manual, upload, and example. The manual method allows the user to enter the data directly via editing the cells of the survey data table, or copying the data in. The upload method allows the user to upload the data in one of three formats: long, wide, and matrix. The example method allows the user to load a bundled dataset, in order to demonstrate the functionality of the app (see Section 2.1.2).

### 2.1.1 Accepted Species

The list of species available for entry is currently composed of:

* The vascular plant taxa present in the Botanical Society of Britain and Ireland’s database ([BSBI 2022](#ref-bsbi2022TaxonLists)); filtered to include taxa at the genus, species, hybrid species, and subspecies ranks which have an associated UK Species Inventory (UKSI) Taxon Version Key (TVK).
* The accepted bryophytes present in the UKSI, retrieved from the National Biodiversity Network (NBN).
* The lichens, charophytes, and algae present in the NVC floristic tables.

### 2.1.2 Example Data

Four example datasets are available in MAVIS, which provide a means to explore the applications functionality.

**Parsonage Down**

The Parsonage Down dataset ([Ridding et al. 2020](#ref-ridding2020)) contains the results of a long-term survey of Parsonage Down National Nature Reserve in Wiltshire, which consists of 188ha of calcareous grassland. The site was surveyed in three years: 1970, 1990, and 2016. Four transects were surveyed, containing a total of 115 quadrats. The Domin scale of abundance system was used, with these values being converted into direct percentage estimates for use in MAVIS.

**Leith Hill Place Wood**

The Leith Hill Place Wood dataset represents a subset of the Bunce woodland survey data, described in Wood, Smart, and Bunce ([2015](#ref-wood2015)) and consists of a total of 16 plots surveyed in 1971, 2001, and 2021 ([S. M. Smart et al. 2024](#ref-smart2024)). Leith Hill Place Wood lies in the path of the October 1987 storm track, with Simon M. Smart et al. ([2014](#ref-smart2014)) outlining the positive effect of the storm on species richness between 1971 and 2001. No cover values are currently provided in this example dataset.

**Whitwell Common**

The Whitwell Common dataset is composed of a repeat survey of Whitwell Common, Norfolk - a soligenous mire. Thirty repeat quadrats were surveyed in 1994 and 1997 ([S. M. Smart 2000](#ref-smart2000)). No cover values are currently provided in this example dataset.

**Newborough Warren**.

The Newborough Warren dataset contains the results of a yearly monitoring study at Newborough Warren (Ynys Llanddwyn SSSI, Anglesey) with four dune slacks surveyed over five years: 2014, 2015, 2016, 2017, and 2018 (which contain 18, 19, 18, 24, and 24 quadrats respectively) ([Wallace and Jones 2018](#ref-wallace2018)). No cover values are currently provided in this example dataset.

## 2.2 Survey Data Validation

At present MAVIS is designed to analyse vegetation survey data in the form of grouped quadrats for a single site, with or without cover estimates. However, the user may utilise the “Group” and “Quadrat” columns as desired, for example by using the “Group” column to delineate sites.

Data entered through any of these methods must meet the following conditions.

* Each species value must match a species present in the accepted species list, which can be downloaded in the “Download Options” section (see Section 2.1.1).
* There must be no missing values in the year, group, quadrat, and species columns.
* Each quadrat value must be unique in each year, even if in a separate group.
* Each group value must be unique in each year.
* Each year value must be a four digit integer.
* No quadrat must contain two entries of the same species.

These conditions are checked and can be viewed in the **Survey Data Validation** section, accessed by pressing the “Validate Survey Data” button. Here the user may adjust the species which are not present in the accepted list using the “Species Adjustment Table”, three options are provided:

* Replace a submitted species with a accepted species.
* Ignore a submitted species. This omits the species from the NVC assignment process.
* Remove a submitted species. This removes a species (or entry in the species column) in the survey table.

The user may also combine duplicate observations of a species in quadrats using the “Combine Duplicates” button.

Until these conditions are met MAVIS will not be able to proceed with as the “Run Analysis” and “Generate Report” buttons will be disabled.

## 2.3 NVC Assignment

In MAVIS NVC community similarities are assigned to survey data for the site and each group of plots by year using the Czekanowski index ([Bloom 1981](#ref-bloom1981); [Hill 1989](#ref-hill1989)), which quantifies the similarity between a floristic table composed from survey data plots and the NVC floristic tables, with species absent from the survey data, but present in the floristic tables at a constancy of 0.2 down-weighted to 0.1. The similarity between individual plots and NVC communities are quantified by calculating the Jaccard similarity between the sample plots and pseudo-quadrats generated from the NVC floristic tables. This approach is noted as improving the accuracy of fit relative to the Czekanowski index for samples with low species richness ([Tipping et al. 2013](#ref-tipping2013)).

### 2.3.1 Communities

The NVC communities available in MAVIS are composed from the following sources:

* The original NVC floristic tables as described in Rodwell, Nature Conservancy Council (Great Britain)), and Joint Nature Conservation Committee (Great Britain) ([2000](#ref-rodwell2000)).
* An alternative version of MG4 (MG4v2) and the four MG4 sub-communities described in Prosser, Wallace, and Gowing ([2023](#ref-prosser2023)) and Wallace and Prosser ([2017](#ref-wallace2017)) (MG4a, MG4b, MG4c, and MG4d).
* A new MG6 sub-community (MG6d) ([Wallace and Prosser 2017](#ref-wallace2017))
* An alternative version of MG8 (MG8v2) and the four sub-communities described in Wallace and Prosser ([2017](#ref-wallace2017)) (MG8a, MG8b, MG8c, and MG8d).
* An alternative version of MG13 (MG13v2) ([Wallace and Prosser 2017](#ref-wallace2017)).
* A new MG community (MG14) and two sub-communities (MG14a, MG14b) ([Wallace and Prosser 2017](#ref-wallace2017)).
* A new MG community (MG15) and two sub-communities (MG15a, MG15b) ([Wallace and Prosser 2017](#ref-wallace2017)).
* A new MG community (MG16) ([Wallace and Prosser 2017](#ref-wallace2017)).

### 2.3.2 Options

**Results to View**

Three sets of NVC assignment results are available in MAVIS at present:

* Site, Czekanowski
* Group, Czekanowski
* Quadrat, Jaccard

**Restrict Habitat**

Optionally restrict the NVC assignment process to one or more broad NVC habitat types. This is recommended to increase the assignment speed, but only if the site being analysed unequivocally conforms to the selected NVC habitats.

**Number of Top Results**

Select the number of top-fitted NVC communities to view.

## 2.4 Habitat Correspondence

The **Habitat Correspondence** section provides a means to explore the habitats from alternative habitat classifications which are associated with the top-fitted NVC communities assigned to the survey data.

Habitat correspondence data is drawn from three sources:

1. The Joint Nature Conservation Committee (JNCC) Spreadsheet of Habitat Correspondences ([JNCC 2008](#ref-jncc2008)).
2. UKHab V1.1 ([Butcher et al. 2020](#ref-butcher2020)).
3. For the National Plant Monitoring Scheme (NPMS) data is drawn from ([Pescott et al. 2019](#ref-pescott2019)).

### 2.4.1 Options

**Classification**

The user may select the habitat classification system from which to retrieve associated habitats. At present the following systems are available:

* UKHab - Level 2 ([Butcher et al. 2020](#ref-butcher2020))
* UKHab - Level 3 ([Butcher et al. 2020](#ref-butcher2020))
* UKHab - Level 4 ([Butcher et al. 2020](#ref-butcher2020))
* UKHab - Level 5 ([Butcher et al. 2020](#ref-butcher2020))
* Biodiversity Action Plan Priority Habitats ([JNCC 2008](#ref-jncc2008))
* Phase 1 Habitat Classification ([JNCC 2008](#ref-jncc2008))
* Biodiversity Action Plan Broad Habitats ([JNCC 2008](#ref-jncc2008))
* EUNIS Classification ([JNCC 2008](#ref-jncc2008))
* Vegetation communities of British lakes ([JNCC 2008](#ref-jncc2008))
* EU Habitats Directive Annex 1 ([JNCC 2008](#ref-jncc2008))
* NPMS Broad ([Pescott et al. 2019](#ref-pescott2019))
* NPMS Fine ([Pescott et al. 2019](#ref-pescott2019))

## 2.5 Floristic Tables

To aid in the NVC assignment process and as an exploratory tool the **Floristic Tables** section of MAVIS allows the user to compare a composed floristic table to a chosen NVC floristic table. The facility to match the species in the composed table with the NVC table, two ways, is also provided.

### 2.5.1 Options

**Restrict**

Restrict the NVC communities available to select in the “NVC Table” option to the top-fitted NVC communities.

**NVC Table**

Select a NVC community to display the floristic table for.

**Composed Table**

Select a composed floristic table. The composed tables are formed by calculating the frequency class of each species across all quadrats in each year and year - group combination.

**Match Species**

The user may choose to re-arrange the floristic tables to match the species present in both tables, three options are provided:

* No, the floristic tables are displayed with no re-arrangement.
* Composed to NVC, the composed floristic table is re-arranged to only include species also present in the NVC floristic table and aligned with the NVC floristic table.
* NVC to Composed, the NVC floristic table is re-arranged to only include species also present in the composed floristic table and aligned with the composed floristic table.

## 2.6 Frequency

The **Frequency** section of MAVIS summarises the number of occurrences of each species across all sample plots, the difference between the first year and last year, and a text category describing the change.

## 2.7 EIVs

The Ecological Indicator Values (**EIVs**) section uses the results of the **NVC Assignment** module to calculate cover-weighted Hill-Ellenberg ecological indicator values for the Nitrogen Score (N) ([BSBI 2017c](#ref-bsbi2017ellenbergN)), Moisture Score (F) ([BSBI 2017d](#ref-bsbi2017ellenbergF)), Reaction Score (R) ([BSBI 2017a](#ref-bsbi2017ellenbergR)), Salinity Score (S) ([BSBI 2017b](#ref-bsbi2017ellenbergS)), and Light Score (L) ([BSBI 2017e](#ref-bsbi2017ellenbergL)). Data for bryophytes was taken from BRYOATT ([Hill et al. 2007](#ref-hill2007)).

### 2.7.1 Options

At present six sets of results are available:

* Unweighted Mean Hill-Ellenberg Values, by Site
* Weighted Mean Hill-Ellenberg Values, by Site
* Unweighted Mean Hill-Ellenberg Values, by Group
* Weighted Mean Hill-Ellenberg Values, by Group
* Unweighted Mean Hill-Ellenberg Values, by Quadrat
* Weighted Mean Hill-Ellenberg Values, by Quadrat

## 2.8 Diversity

The **Diversity** section allows the user to view a range of basic diversity metrics.

### 2.8.1 Options

**Results to View**

At present five sets of results are available:

* Site Summary Table, contains the mean alpha diversity, gamma diversity, and beta diversity of the site with years arranged column-wise.
* Quadrat Diversity Indices Table, contains the species richness, Shannon diversity, Simpson diversity, Inverse Simpson diversity, Shannon evenness, and Simpson evenness for each quadrat.
* Species Richness, by Site, contains the species richness of the site with years arranged column-wise.
* Species Richness, by Group, contains the species richness of each group with years arranged column-wise.
* Species Richness, by Quadrat, contains the species richness of each quadrat with years arranged column-wise.

## 2.9 MVA

The Multivariate Analysis (MVA) section of MAVIS aims to allow the user to explore the position of the survey data quadrats in an ordination space constructed by performing a Detrended Correspondence Analysis (DCA) ([Hill and Gauch 1980](#ref-hill1980dca)). The results of a Canonical Correspondence Analysis (CCA) ([Braak 1986](#ref-terBraak1986)), using the pseudo-quadrats as the community matrix and pre-calculated set of unweighted mean Hill-Ellenberg values for each pseudo-quadrat as the constraining matrix, are available for visualising in each MVA plot.

Three MVA methods are provided in MAVIS, which are described below.

### 2.9.1 National Reference

The ordination space in the **National Reference** MVA was constructed by performing a pre-calculated DCA on the pseudo-quadrats from all NVC communities, with the survey quadrats added in passively in MAVIS using the mean of the species scores from the pre-calculated pseudo-quadrat DCA.

By default the top-fitted NVC communities retrieved from the **NVC Assignment** process are displayed.

**Advantages**

* The psuedo-quadrat axis scores are not influenced by the survey quadrats.
* The position of the pseudo-quadrat axis scores are absolute. Adding or removing NVC communities from the plot using the “National Reference Spaces” option does not change the axis scores and position of the other NVC communities or survey quadrats.
* The pseudo-quadrat DCA contains all the species present in the NVC floristic table, in comparison to the **Local Reference (restricted)** method.
* The survey quadrat positions in the ordination space accurately reflect their similiarity with the pseudo-quadrats, and therefore the NVC communities and sub-communities.

**Disadvantages**

* The pseudo-quadrat DCA scores for each sub-community within a community are compressed by the dissimilarity with other communities. Consequently there is a greater degree of overlap between the sub-communities, and the survey quadrats and sub-communities.

### 2.9.2 Local Reference (restricted)

The ordination space in the **Local Reference (restricted)** MVA is constructed by performing a DCA on the top-fitted NVC communities retrieved from the **NVC Assignment** process with the survey quadrats added in passively using the mean of the species scores from the pseudo-quadrat DCA.

**Advantages**

* The psuedo-quadrat axis scores are not influenced by the survey quadrats.
* The pseudo-quadrat axis scores show greater variation due to the absence of highly dissimilar communities, in contrast to the **National Reference** method. Consequently, the (dis)similarity between the pseudo-quadrats and survey-quadrats is emphasised.

**Disadvantages**

* Species present in the survey data but absent in the top-fitted NVC communities are omitted from the survey quadrat axis score calculation. Consequently, the similiarity between the survey quadrats and pseudo-quadrats (and therefore NVC communities and sub-communities) is over-estimated.
* The axis scores and position of both the pseudo-quadrats and survey quadrats varies based on the NVC communities used in the pseudo-quadrat DCA.

### 2.9.3 Local Reference (unrestricted)

The ordination space in the **Local Reference (unrestricted)** MVA is constructed by performing a DCA on the top-fitted NVC communities *and* the survey quadrats.

**Advantages**

* All species present in both the survey quadrats and pseudo-quadrats contribute to the axis scores. Consequently, the (dis)similarity between the pseudo-quadrats and survey quadrats is correctly represented as in the **National Reference** method but the axis scores are not compressed by highly dissimilar communities.

**Disadvantages**

* The inclusion of the survey quadrats in the DCA means that the pseudo-quadrats do not provide a fixed reference as in the **National Reference** and **Local Reference (restricted)** methods where the survey quadrats are added in passively.

### 2.9.4 Options

**Axis Selection**

The user may select any combination of the first three DCA axis scores to be displayed in the MVA plots:

* DCA1 vs DCA2
* DCA1 vs DCA3
* DCA2 vs DCA3

**National Reference Spaces**

Here the user may select any NVC community to display in the **National Reference** MVA plot only.

**Survey Quadrat Selection**

Three methods are available for subsetting the survey quadrats being displayed:

* Select Years, where all the survey quadrats for selected years will be displayed.
* Select Groups, where all the survey quadrats for selected groups will be displayed.
* Select Quadrats, where all the survey quadrats for selected quadrats will be displayed.

**CCA Variables**

At present the CCA axis scores from each combination of Hill-Ellenberg values are available for display in each MVA plot:

* Moisture (F) x Nitrogen (N)
* Moisture (F) x Reaction (R)
* Moisture (F) x Light (L)
* Moisture (F) x Salinity (S)
* Nitrogen (N) x Reaction (R)
* Nitrogen (N) x Light (L)
* Nitrogen (N) x Salinity (S)
* Reaction (R) x Light (L)
* Reaction (R) x Salinity (S)
* Light (L) x Salinity (S)

**Axis Scores**

The following results may be toggled on/off for display in the MVA plots.

* Survey Quadrats, the survey quadrats entered in **Survey Data**.
* Pseudo-Quadrats, all pseudo-quadrats used in the DCA ordination.
* Reference Space, the convex hulls formed around the pseudo-quadrats.
* Species, the species DCA axis scores.
* Unique Survey Species, the species present in the survey quadrats but absent in the top-fitted NVC communities pseudo-quadrats. Displayed in **Local Reference (unrestricted)** only.
* Hill-Ellenberg, the Hill-Ellenberg CCA axis scores selected in the “CCA Variables” option.
* Survey Quadrat Change, arrows showing the direction of travel for individual quadrats in the ordination space.

## 2.10 Report

MAVIS allows the user to generate a downloadable pdf report, which by default contains 1) a table of the MAVIS results selected for inclusion, and 2) tables containing the number of quadrats sampled by year and group.

### 2.10.1 Options

**Author**

A text input where the user is able to enter the name of the person/s using MAVIS.

**Project Name**

A text input where the user is able to enter the project name/name of the site being analysed in MAVIS.

**Report Options**

The user is able to select any of the results visualised in MAVIS for inclusion in the report, displayed in the table below.

Results Group

Results Value

NVC Assignment

Site, Czekanowski

NVC Assignment

Group, Czekanowski

NVC Assignment

Quadrat, Jaccard

Floristic Tables

Site

Floristic Tables

Group

Species Frequency

Species Frequency

EIVs (incl. Mean Hill-Ellenberg)

Weighted, Site

EIVs (incl. Mean Hill-Ellenberg)

Unweighted, Site

EIVs (incl. Mean Hill-Ellenberg)

Weighted, Group

EIVs (incl. Mean Hill-Ellenberg)

Unweighted, Group

EIVs (incl. Mean Hill-Ellenberg)

Weighted, Quadrat

EIVs (incl. Mean Hill-Ellenberg)

Unweighted, Quadrat

Diversity

Summary

Diversity

Quadrat Indices

Diversity

Richness, Site

Diversity

Richness, Group

Diversity

Richness, Quadrat

MVA

National

MVA

Local (restricted)

MVA

Local (unrestricted)

Survey Table

Survey Table

## 2.11 Download

At present the **Download** section of MAVIS allows the user to download:

* A csv file containing the species accepted by MAVIS.
* The data entered into the Survey Table.

# 3 Acknowledgements

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# 4 Reccomended Citation

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}

# 5 Release Log

v0.96

2024/02/XX

* Modifications:
  + Removing site and group Jaccard similarity results.
  + Moving survey data summary information to Survey Data tab.
* Fixes: NA
* New Features: NA

v0.95

2024/01/24

* Modifications:
  + Removing unnecessary upload data checks.
  + Making survey data availability table searchable.
  + Changing nomenclature for releve to plot.
* Fixes:
  + Ensuring report renders correctly using new surveyTableSummary object data.
* New Features: NA

v0.94

2024/01/18

* Modifications: NA
* Fixes:
  + Ensuring the number of quadrats per group is passed to the floristic tables module through the new survey data summary module.
* New Features: NA

v0.93

2024/01/18

* Modifications: NA
* Fixes: NA
* New Features:
  + Adding survey data summary module.
  + Adding quadrat re-grouping tool.

v0.92

2024/01/18

* Modifications: NA
* Fixes: NA
* New Features:
  + Adding Czekanowski index method for Site and Group NVC assignment calculations.

v0.91

2024/01/11

* Modifications: NA
* Fixes: NA
* New Features:
  + Adding privacy policy section

v0.9

2024/01/09

* First release for user testing.
* Modifications: NA
* Fixes: NA
* New Features: NA

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