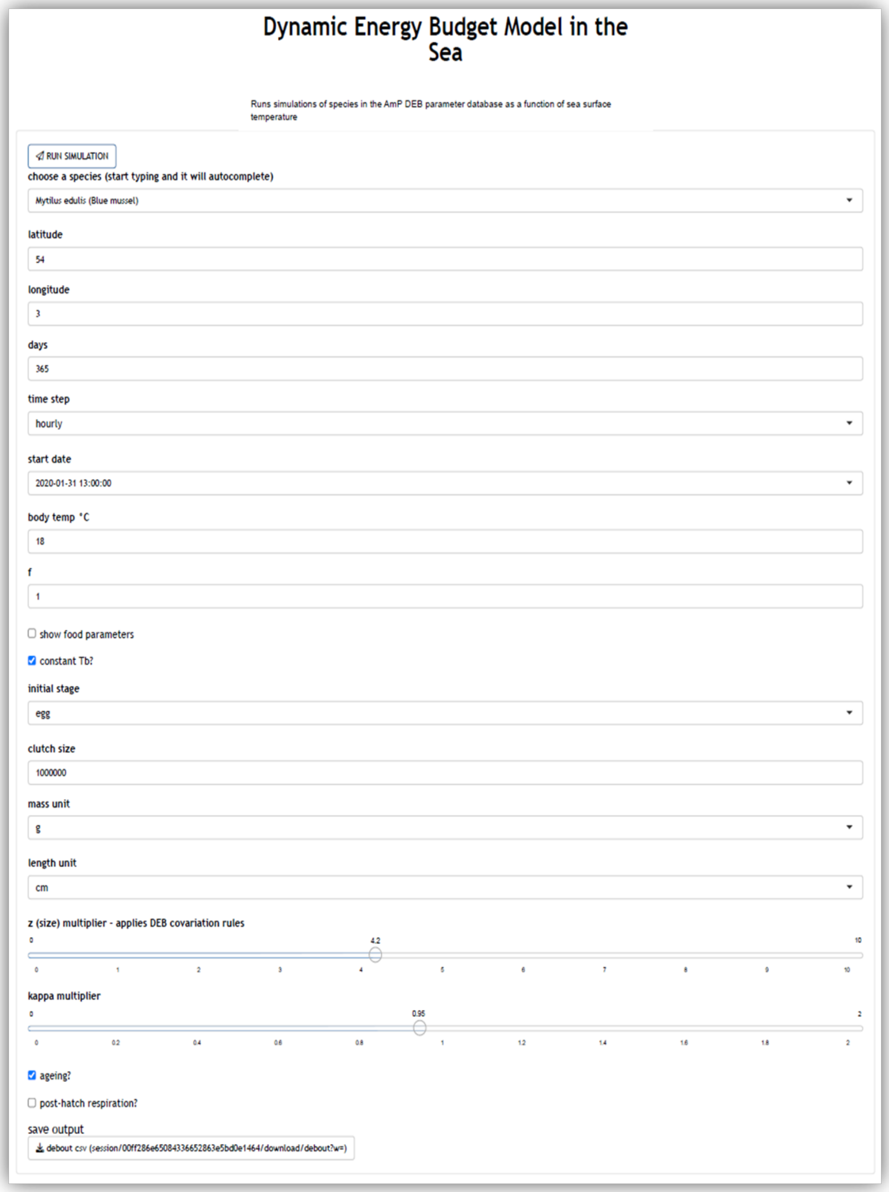
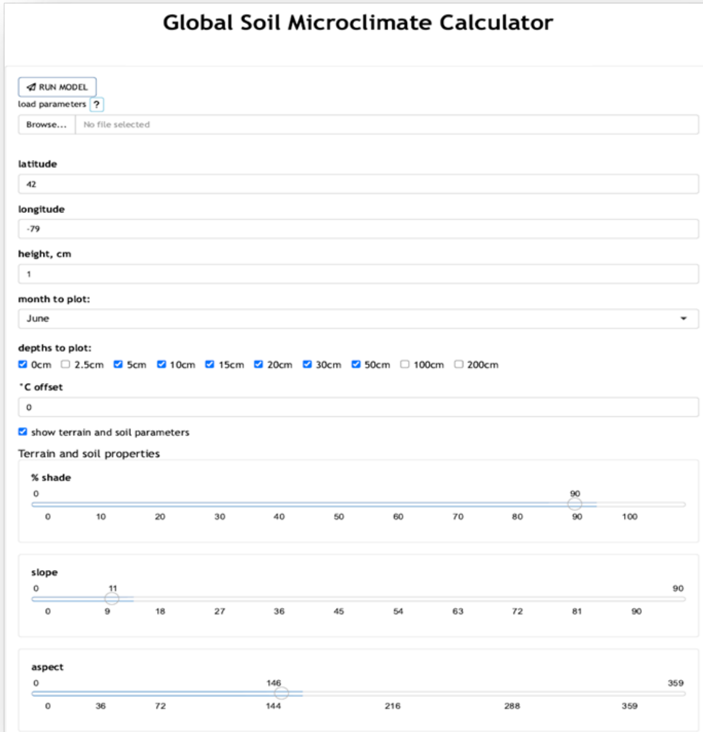
Positive Niche Construction: Incorporating Facilitative Microhabitat into Mechanistic Niche Modeling

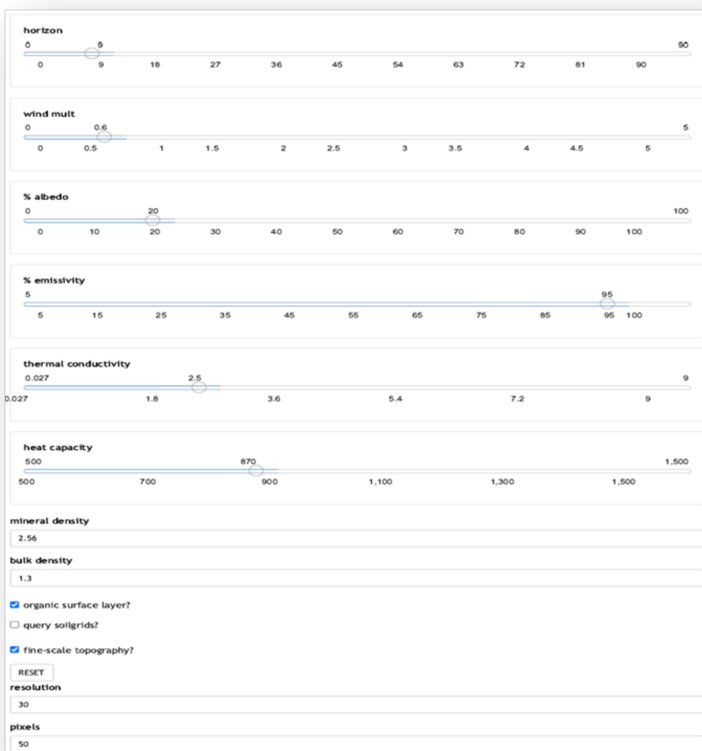
Supplementary Material

https://doi.org/10.26443/msurj.v1i1.216

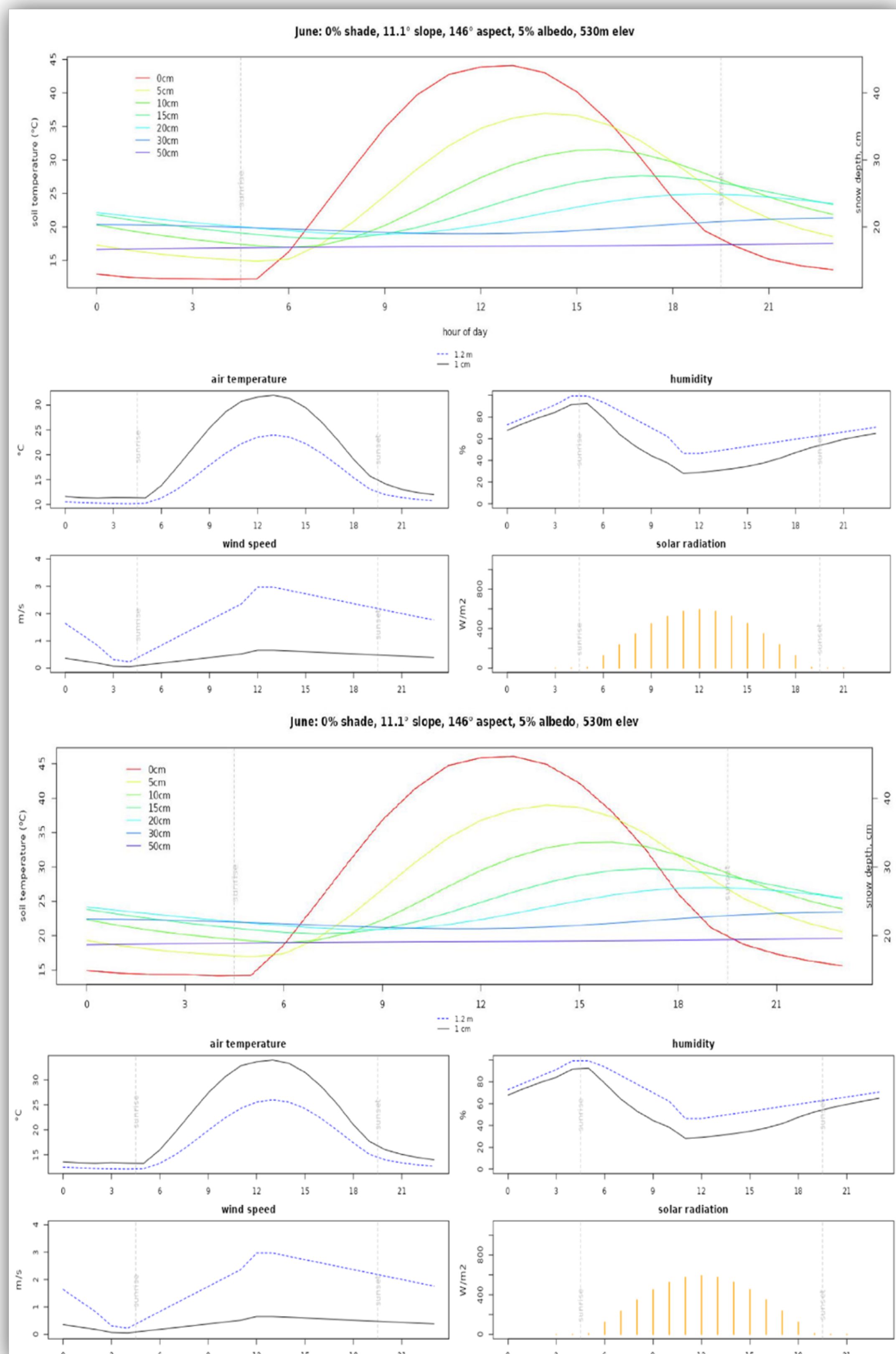


Supplementary Figure 1. Example set up of DEB Model in the Sea simulation web tool.





Supplementary Figure 2. Example set up of Global Soil Microclimate Calculator simulation web tool.



Supplementary Figure 3. Example output of Global Soil Microclimate Calculator simulation web tool.

Supplementary 4: Link to Compiled DEB Parameters for Mytilus Edulis and DEB Model in the Sea Assumptions.

"Figure 4 shows the mass budget scheme used in the DEB theory. The symbol $\dot{J}$ means mass, the symbol $\dot{p}$ represents energy flow (power), and the dot above means a flux (per time). The elemental composition of the different molecules is represented by $n_{1,2}$ where 1 represents the element (C, H, O or N) and 2 represents the 'molecule' (e.g. V for structure or C for CO_2). The fluxes (moles per time) of food, structure, reserve and feces."

$$
\begin{array}{c}
\begin{array}{cccc} \text{Food} & \text{Structure} & \text{Reserve} & \text{Faeces} \end{array} \\
\begin{pmatrix} n_{CX} & n_{CV} & n_{CE} & n_{CP} \\ n_{HX} & n_{HV} & n_{HE} & n_{HP} \\ n_{OX} & n_{OV} & n_{OE} & n_{OP} \\ n_{NX} & n_{NV} & n_{NE} & n_{NP} \end{pmatrix}
\end{array}
\begin{pmatrix} \dot{J}_X \\ \dot{J}_V \\ \dot{J}_E + \dot{J}_{E_R} \\ \dot{J}_P \end{pmatrix}
\begin{array}{l} \text{Food} \\ \text{Structure} \\ \text{Reserve} \\ \text{Faeces} \end{array}
+
\begin{array}{c}
\begin{array}{cccc} CO_2 & H_2O & O_2 & \text{N waste} \end{array} \\
\begin{pmatrix} 1 & 0 & 0 & n_{CN} \\ 0 & 2 & 0 & n_{HN} \\ 2 & 1 & 2 & n_{ON} \\ 0 & 0 & 0 & n_{NN} \end{pmatrix}
\end{array}
\begin{pmatrix} \dot{J}_C \\ \dot{J}_H \\ \dot{J}_O \\ \dot{J}_N \end{pmatrix}
\begin{array}{l} CO_2 \\ H_2O \\ O_2 \\ \text{N waste} \end{array}
=
\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}
$$

$$
\begin{pmatrix} \dot{J}_X \\ \dot{J}_V \\ \dot{J}_E + \dot{J}_{E_R} \\ \dot{J}_P \end{pmatrix}
\begin{array}{l} \text{Food} \\ \text{Structure} \\ \text{Reserve} \\ \text{Faeces} \end{array}
=
\begin{pmatrix} -\eta_{XA} & 0 & 0 \\ 0 & 0 & \eta_{VG} \\ \overline{\mu}_E^{-1} & -\overline{\mu}_E^{-1} & -\overline{\mu}_E^{-1} \\ \eta_{PA} & \eta_{PD} & \eta_{PG} \end{pmatrix}
\begin{pmatrix} \dot{p}_A \\ \dot{p}_D \\ \dot{p}_G \end{pmatrix}
\begin{array}{l} \text{assimilation} \\ \text{dissipation} \\ \text{growth} \end{array}
$$

μ = energy – mass converter, J/C-mol

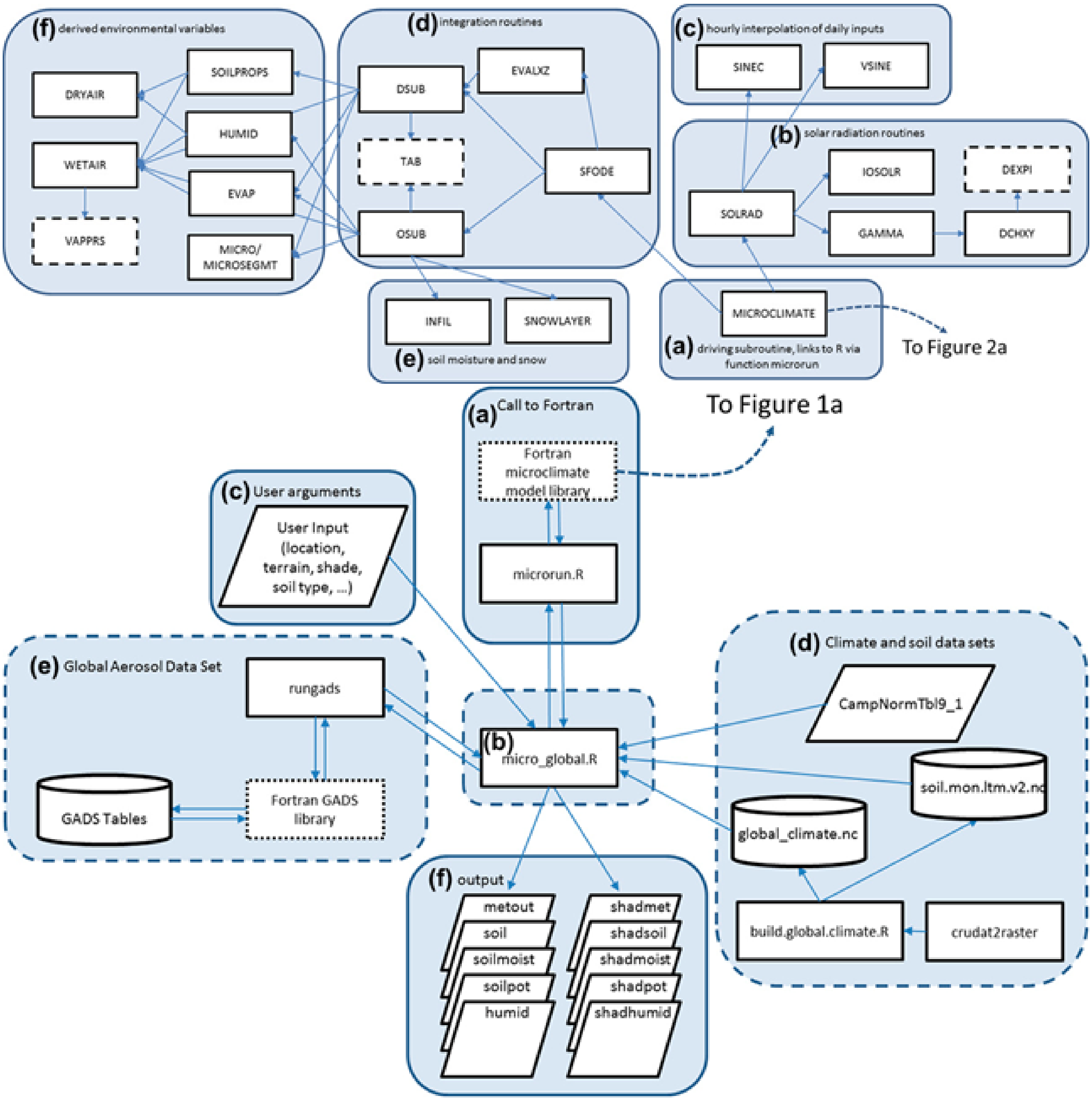
η = mass – energy converter, C-mol/J

Stoichiometric equations of the standard model of Dynamic Energy Budget theory, taken from Kooijman (2010).

Supplementary Figure 4. Overview of stoichiometric equations of the standard model of Dynamic Energy Budget theory, explained by Dr. Kearney in documentation of NicheMapR package[1].

"The first equation in Figure 4 is simply a statement of the conservation of mass; the flows of all the elements in the different metabolic processes, when added together, must sum to zero. The second equation states the relationship between the four organic mass fluxes and the three energy fluxes of assimilation, growth and 'dissipation' (maturation and its maintenance, somatic maintenance, any heating or osmoregulation costs, and reproduction overhead costs), given the conversion coefficient matrix for energy/mass.

The key point is that knowing the energy fluxes, computed from the DEB model as it evolves through time, and the stoichiometric composition of food, structure, reserve and feces, one can compute the oxygen, carbon dioxide, metabolic water and nitrogenous waste fluxes. Although we don't usually have explicit data on these elemental compositions, the default values [based on general estimates of organismal stoichiometry, e.g. Roels (1983)] give good predictions in practice. Thus, by producing a DEB model we can get realistic dynamics of development, growth and reproduction under fluctuating temperature and food scenarios, and we also get estimates of the fluxes of food, feces, metabolic water, respiratory gases and nitrogenous waste production 'for free', as shown in Figure 5 for *Eulamprus quoyii*. This is one of the many pay-offs for abstracting biomass into pools of reserve and structure."



Supplementary Figure 5. Figure 1 (Top). Structure of the Fortran library of the NicheMapR microclimate model. Solid boxes represent Fortran subroutines and dashed boxes represent Fortran functions. Figure 2 (Bottom). Structure of the R functions used to run the NicheMapR microclimate model with the global databases on climate, soil moisture and aerosols. User input data are represented by the trapezoid boxes and databases are indicated by cylinders. Fortran libraries are indicated by dashed boxes. Curved shaded boxes represent scripts specific to the application of the model with the global climate database and can be substituted with user-created R scripts for customization to alternative environmental data sources. From documentation of NicheMapR package[1].

References

1. Kearney, M. R. & Porter, W. P. NicheMapR – an R package for biophysical modelling: the ectotherm and Dynamic Energy Budget models. *Ecography* **43,** 85–96 (2020). https://doi.org/10.1111/ecog.04680