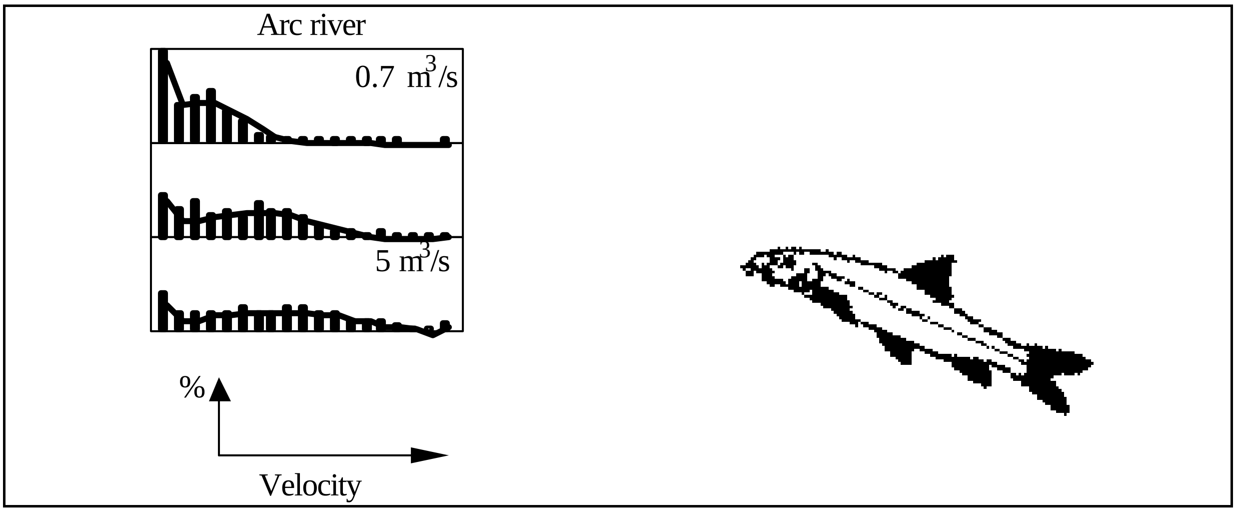
STATHAB/FSTRESS SOFTWARES

HABITAT MODELING USING STATISTICAL HABITAT MODELS



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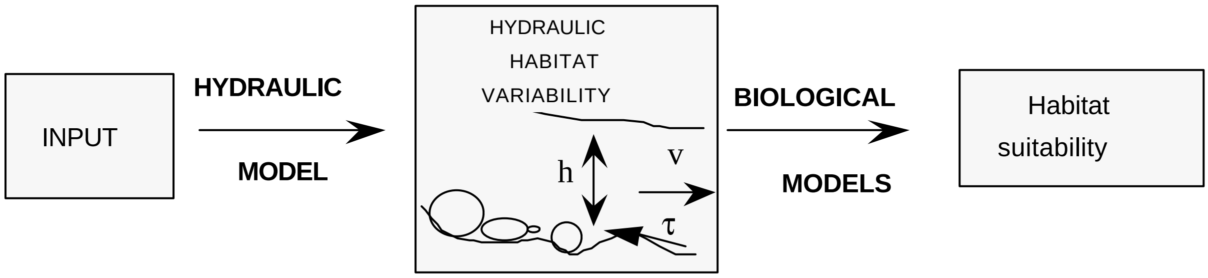
GENERAL DESCRIPTION

Stathab is available for powermacs or windows. It predicts point velocity, depth, and roughness distributions + several species or life stages suitability indices in stream reaches as a function of discharge. FSTress is a derivative of stathab, but predicts shear stress frequency distributions + associated suitability indices. Its particularities are described at the end of this guide.

As classical habitat models (e.g. Bovee 1982), Stathab combines a hydraulic model (describing the hydraulic habitat variability within stream reaches) and biological models (estimating habitat suitability for species, guilds or life stages in such conditions):



The main difference with classical models is that Stathab uses statistical hydraulic models (Lamouroux et al. 1992, Lamouroux et al. 1995, Lamouroux, 1998), which are based on properties of hydraulic variable distributions in stream reaches. Statistical models strongly simplify the input and the use of habitat models (see input description below; Lamouroux, 1995). They apply to a wide range of reaches whose discharge can be modified, but whose morphology is quasi-natural. Reaches must contain at least 1 and preferably several pool/riffle successions (i.e. a length of 10 to 40 times the stream width), and discharge should reasonably remain below 50 m3/s. See references for more details on the validity range of statistical hydraulic models.

Stathab can be used with classical preference curves, the different hydraulic variables being, in the present form of the model, considered independently. However, it can be used with new multivariate preference models (Lamouroux et al., 1998; Lamouroux et al., 1999b) acounting for 1) the local hydraulic variability, 2) covariance between hydraulic variables. In any case, the preference models have to be defined by the user in an input file. The example of multivariate preference models included here is from Lamouroux et al. (1999b).

Simulations using Stathab/FSTress have already been made for invertebrates and fish (Lamouroux, 1999b; Statzner and Borchardt, 1994). In particular, applications in bypassed sections of the Rhone river (French main river where 25 % of the French electricity is produced) led to a first validation of habitat models for fish at the community level (Lamouroux et al., 1999b).

Stathab/FSTress are freely distributed for test/research/applied purposes. The management of errors in input files is not optimized, and such errors can lead to execution problems. Examples of input files are provided to avoid such errors (reach 'ain'). Please inform of any use/problem by mailing to N.Lamouroux (lamourou@lyon.cemagref.fr).

HOW STATHAB WORKS

Statistical hydraulic models estimate, for any discharge, the volumes and surfaces respectively associated with different velocity, depth, roughness classes within the studied reaches. For example, let V_1 to V_3 be volumes associated with 3 velocity classes, H_1 to H_4 be surfaces associated with 4 water depth classes, and G_1 to G_2 be surfaces associated with 2 roughness classes. Let V be the total volume of the reach.

The biological preference models than can be used with stathab calculate, for each species or cohort studied, an abundance index J as a linear combination of the above volumes and surfaces

$$J = aV + b_1V_1 + b_2V_2 + b_3V_3 + c_1H_1 + c_2H_2 + c_3H_3 + c_4H_4 + d_1R_1 + d_2R_2$$

All volumes and surfaces correspond to a fictive length of reach of 1m.

The user will define in different input files, common to all reaches:
* the list of reaches under study (file listriv.txt)
* the velocity, depth and roughness classes (file bornv.txt, bornh.txt, borng.txt)
* the list of species (or cohorts, guilds) under study and the coefficients (a, b1, b2, b3, c1, c2, c3, c4) of the preference model used, for each of them (file pref.txt).

Note that
1) if a=0, ci=0, di=0 and bi are suitabilities between 0 and 1 associated with velocity classes,
-> J is a Weighted Suitable Volume in relation with a velocity preference curve.
2) if a=0, bi=0, di=0, and ci are suitabilities between 0 and 1 associated with depth classes,
-> J is a Weighted Suitable Area in relation with a depth preference curve.
3) if a=0, bi=0, ci=0, and di are suitabilities between 0 and 1 associated with roughness classes,
-> J is a Weighted Suitable Area in relation with a roughness preference curve.
4) If coefficients are those of multivariate models of Lamouroux et al. (1998, sous presse),
-> J is equal to I*V, where I is a species density index, and V the volume of the reach.

The input files required to run statistical hydraulic models, in each reach 'xxx', are:
* simple hydrological information (file xxxdeb.txt)
* hydraulic geometry information, i.e. mean depth and width of the reach for several discharges, at least 2 (file xxxqhw.txt)
* a roughness distribution (file xxxgra.txt)
* a depth distribution at one given discharge (file xxxdis.txt)

STATHAB: INPUT FILES (All files should be text files, separator = tab)

Common to all reaches

1) listriv.txt (list of reaches on which simulations are made)
contains 1 column, k reaches names (1 by line)

2) bornv.txt (velocity classes limits)
contains 1 column, n+1 lines which are the limits of n velocity classes

3) bornh.txt (depth classes limits)
contains 1 column, p+1 lines which are the limits of p depth classes

4) borng.txt (roughness classes limits)
contains 1 column, q+1 lines which are the limits of q roughness classes. For roughness these limits are expressed in class numbers (see the 12 roughness classes definition below)

5) pref.txt (preference models)
contains 1+1+n+p+q columns (species name, constant, and biological preference models coefficients), and e lines (e is the number of species). Preference models predict suitability indices as linear combinations of the weights of hydraulic variable classes.
To use a classical preference curve for a given variable, coefficients for classes of this variable are suitability indices, other coefficients are set to 0.

1 file by reach, xxx being the code of the reach

1) xxxdeb.txt (hydrological information)
contains 1 column with the discharges values for the period under study. Models will be made for several discharges included between the 2 extreme values of this file. Synthetic results will also be given; they correspond to the discharge distribution derived from this file

2) xxxqhw.txt (hydraulic geometry of the reach)
contains 3 columns (discharge, mean depth of the reach, mean width) and at least 2 lines
Power laws (stage- and width-discharge relationships) are fitted to these data

3) xxxgra.txt (substrate size distribution)
contains 1 column with 12 lines, corresponding to frequencies of 12 roughness classes.
Classes are (units in cm)
detritus, clay , fine sand, rough sand, <1, <2, <3, <6, <12, <25, <100,>100

4) xxxdis.txt (the depth distribution at a given discharge)
contains 1 column and 22 lines : the discharge, the mean depth H, and frequencies of 20 regular depth classes ranging from 0 to 5H

STATHAB: OUTPUT FILES

Common to all reaches

1) stathab.txt
summary of the execution, including the fitted depth and width-discharge relationships

2) listesp.txt
contains 1 column with e lines : species names of file pref

3) riv-disa.txt
contains k lines (reaches) and 4+n+p+q columns (discharge (ln of),depth,width,volume,volumes associated with velocity classes, surfaces associated with depth classes,surfaces associated with roughness classes).
These statistics correspond to a length of stream of 1m.
For each reach, values are averages for the period considered in xxxdeb.txt (i.e. they are spatio-temporal distributions)

4) riv-dism.txt/ riv-disx.txt/ riv-disv.txt
similar to riv-dista.txt, but contain the minimum/maximum/variance of values (instead of the average) for discharges of xxxdeb.txt

5) riv-espa.txt
contains k lines (reaches) and e columns (species indices for the volumes and surfaces of riv-disa.txt)
For each reach (supposed 1m long) values are averages for the period considered in xxxdeb.txt (i.e. they are spatio-temporal distributions)

6) riv-espm.txt/ riv-espx.txt / riv-espv.txt
same as riv-espa.txt but minimum/maximum/variance instead of average

1 file by reach, xxx being the code of the reach

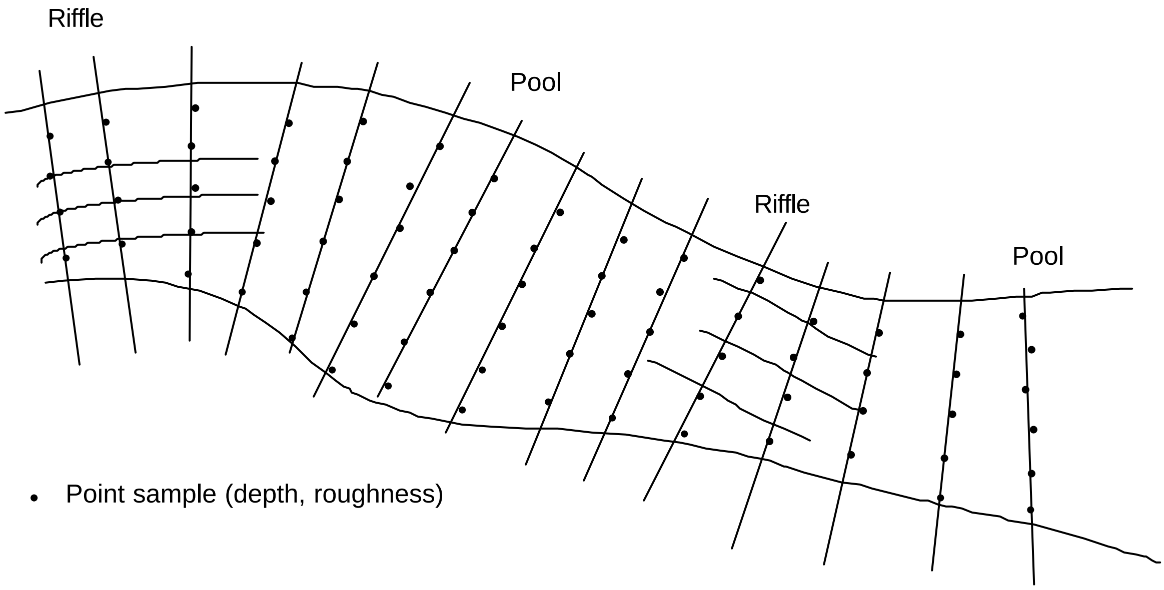
1) xxxrrd.txt
contains 50 lines (increasing discharge classes) and 4+n+p+q columns (discharge (ln of), discharge frequency, depth, area, volumes associated with velocity classes, surfaces associated with depth classes,surfaces associated with roughness classes)
These statistics correspond to a length of stream of 1m. Frequencies of classes can be calculated by dividing the values of the file by the total area or volume (=depth*area) of the fictive 1m reach.

2) xxxrre.txt
contains 50 lines (increasing discharge classes) and e columns (species indices for the volumes and surfaces of xxxrrd.txt)
The reach is supposed 1m long.
For preference curves, species indices are usable volumes WUV (for velocity) or usable areas WUA (for depth) in the fictive 1m long reach. Suitability indices for the reach can be calculated by dividing WUV(or WUA) by the volume (or area) of the reach given in xxxrrd.txt

EXAMPLE OF FIELD SESSION TO COLLECT THE INPUT DATA

For each stream reach, the input data required to run the model is (see above) :
* the mean depth and the mean width of the reach, at a minimum of two different discharges (info needed for file xxxqhw.txt)
* A depth and roughness distribution at a given discharge (needed for files xxxgra.txt and xxxdis.txt).

A stream reach is defined as several pool/riffle successions (at least one, preferably two or more). The simplest mean to collect the input information is to measure, at two different discharges:
-> about 100 depths and roughness sizes, at points regularly spaced along 15-20 regular transects covering the reach. Roughly, 4 to 8 points by transects are enough; the number of points depends on the river width, the distance between points along transects being constant.
-> the widths of the transects.



No precise topography nor velocity/stress measurements are required. Neither transects nor points need to be precisely localised, because these measurements mainly serve to calculate the average depth and width of the reach. Thus, 'step' units can be used to place transects and points. For example, in a reach 300 steps long and roughly 20 steps wide, a transect can be chosen every 15 steps (300/20), and a measuring point every 4 (20/5) steps along the transect.

The measuring discharges should be as different as possible. Indeed, depth-discharge and width discharge relationships for the reach are extrapolated from measurements; these extrapolations are made by fitting the relationships to power laws. Such fittings are more reliable if discharges strongly differ.

Transects and points do not need to be the same for the different measuring discharges. Again, the aim is to get the average characteristics of the reach, not a precise local information.

The time needed for each field session is about 1h or 2h; data collection is easily made by a team of 2 people without particular experience.

FSTRESS

FSTress estimates suitability indices in relation with shear stress distributions. Using FSTress, the input file needed are reduced (information on roughness and depth distribution are useless, as well as the limit of classes). Field measurements necessary are similar to those described for Stathab, excluding roughness measurements :

FSTress: input files - Common to all reaches

1) listriv.txt (list of reaches on which simulations are made)
contains 1 column, k reaches names (1 by line)

2) pref.txt (preference models)
contains 21 columns (species name, 20 suitability coefficients), and e lines (e is the number of species).
The suitability coefficients correspond to preferences for shear stress as estimated by FST-hemispheres n° 0-19 (Statzner and Müller 1989).

FSTress: input files - 1 file by reach, xxx being the code of the reach

1) xxxdeb.txt (hydrological information)
contains 1 column with the discharges values for the period under study. Models will be made for several discharges included between the 2 extreme values of this file. Synthetic results will also be given; they correspond to the discharge distribution derived from this file

2) xxxqhw.txt (hydraulic geometry of the reach)
contains 3 columns (discharge, mean depth of the reach, mean width) and at least 2 lines.
Power laws (stage- and width-discharge relationships) are fitted to these data.

FSTress: output files - Common to all reaches

1) fstress.txt
summary of the execution, including the fitted depth and width-discharge relationships

2) listesp.txt
contains 1 column with e lines : species names of file pref

3) riv-disa.txt
contains k lines (reaches) and 4+n+p+q columns (discharge (ln of),depth,width,volume, frequencies associated with FST hemispheres 0 to 19).
For each reach, values are averages for the period considered in xxxdeb.txt (i.e. they are spatio-temporal distributions)

4) riv-dism.txt/ riv-disx.txt/ riv-disv.txt
similar to riv-dista.txt, but contain the minimum/maximum/variance of values (instead of the average) for discharges of xxxdeb.txt

5) riv-espa.txt
contains k lines (reaches) and e columns (species indices for the volumes and surfaces of riv-disa.txt)
frequencies are averaged for the period considered in xxxdeb.txt (i.e. they are spatio-temporal frequencies)

6) riv-espm.txt/ riv-espx.txt / riv-espv.txt
same as riv-espa.txt but minimum/maximum/variance instead of average

FSTress: output files -1 file by reach, xxx being the code of the reach

1) xxxrrd.txt
contains 50 lines (increasing discharge classes) and 4+20 columns (discharge (ln of), discharge frequency, depth, area, frequencies associated with FST-hemispheres 0 to 19)

2) xxxrre.txt
contains 50 lines (increasing discharge classes) and e columns (average suitability index for the shear stress distributions xxxrrd.txt)

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