

# *HyperNiche*<sup>TM</sup>

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Multiplicative Habitat Modeling

*mjm*  
SOFTWARE

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**Cover:** Ecologically reasonable response surfaces pose difficult challenges to traditional habitat modeling tools. HyperNiche provides tools that can easily find and describe complex response surfaces, such as this hump that combines sigmoid and Gaussian curves.

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# ***What is HyperNiche For?***

HyperNiche is designed to be user-friendly software for nonparametric multiplicative regression (NPMR) – creating habitat models in which predictors are combined multiplicatively rather than additively. We believe this is the most flexible, powerful approach to empirical habitat modeling.

HyperNiche has many potential uses:

- Build habitat models for species presence-absence. Estimate likelihood of occurrence in relation to multiple habitat parameters or other predictors.
- Build habitat models for species abundance. Estimate abundance in relation to predictors.
- Estimate physiological response surfaces in relation to 1, 2, or more environmental parameters.
- Build empirical models of species diversity in relation to multiple predictors.
- Relate community ordination scores to multiple environmental variables.
- Optimize sample stratification.
- Build multiple regression models for any nonlinear response to multiple interacting factors.

# ***The Case for Nonparametric Multiplicative Models***

Ecologists readily accept the concept of complex species response functions to multiple interacting factors. In representing those responses, however, ecologists usually fall back on simplistic statistical models that cannot hope to capture the complexity of a species in relationship to its habitat. The models usually lack interaction terms, are additive, and the default response shapes are typically linear (as in multiple linear regression) or sigmoid (as in logistic regression). Yet the viewpoint most widely accepted among ecologists is that species often have hump-shaped responses to environmental gradients. Furthermore, we expect the shape of the response to one factor to depend on other factors. In other words, factor interactions should be expected.

Linear models may be appropriate in some cases, such as species responses to short environmental gradients. Likewise, logistic response functions are sometimes appropriate. For example, the relationship between probability of occurrence and a successional gradient may be sigmoid. But many other possibilities exist.

The standard ecological concept for the relationship of species to an environmental gradient is a unimodal, hump-shaped curve, such as those popularized by Whittaker. Though widely accepted as a theoretical model, where are the statistical models of single-species response functions that incorporate a unimodal response? These are surprisingly rare in the ecological literature. Even more rare are models where the shape of the unimodal response depends on another variable, yet this kind of interaction should be the norm.

The challenge for habitat modeling is exactly the same as that expressed for data analysis in general by Scott (1992, p. 5): “The modern challenge in data analysis is to be able to cope with whatever complexities may be intrinsic to the data. The data may, for example, be strongly non-Normal, fall onto a nonlinear subspace, exhibit multiple modes, or be asymmetric [all of these are commonly true of species responses]. Dealing with these features becomes exponentially more difficult as the dimensionality of the data increases, a phenomenon known as the *curse of dimensionality*.”

This curse applies to all data sets on species performance in relation to multiple habitat factors. As the number of factors increases, the number of potential interaction terms increases exponentially. The number of transformations or combinations of transformations similarly inflates. The number of possible combinations of factors to include or exclude balloons.

Huston (2002) described well the some of the pointless arguments and faulty conclusions that have emerged from using simple, inappropriate statistical models to represent complex systems of interacting factors. He encouraged us to recognize that, “the interactive effects of multiple limiting factors require new statistical approaches for quantifying ecological processes...”

HyperNiche solves this problem with a new approach: multiplicative models. Nonparametric Multiplicative Regression (NPMR) effectively represents species responses to multiple habitat factors. Factor interactions are accommodated automatically and the overall form of the response surface need not be specified in advance. With a built-in cross-validation procedure to reduce problems of overfitting, NPMR promises models that fit better and are more parsimonious than traditional models.

With multiplicative models, the effect of each variable can depend on the value of other variables. This is conceptually simple but mathematically difficult. A practical solution is provided by adapting nonparametric curve fitting techniques, the components being combined multiplicatively rather than additively – this is NPMR.

The main purpose of HyperNiche is to offer this practical solution. HyperNiche incorporates NPMR into an easy-to-use yet powerful package, complete with 3D and 2D graphics, GIS interface, easy connections to spreadsheets and community analysis, data transformation, and predictions for new cases.

## References

- Huston, M. A. 2002. Critical issues for improving predictions. Pages 7-21 in J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, & F. B. Samson, eds., *Predicting Species Occurrences: Issues of Accuracy and Scale*. Island Press, Washington.
- Scott, D. W. 1992. *Multivariate Density Estimation: Theory, Practice, and Visualization*. John Wiley, New York. 317 pp.

## ***Where is the Manual?***

The full manual is built into HyperNiche, so we have not produced a paper manual. We pass the cost savings on to you. Our context-sensitive Help system can be accessed at any time by pressing F1 or clicking a Help button.

The Help system has two parts, a PDF document and the HyperNiche built-in Help. The PDF document (NPMRintro.pdf) provides:

- an introduction to habitat modeling,
- the rationale for using nonparametric multiplicative regression for habitat models,
- a discussion of some of the major choices in nonparametric multiplicative regression.

## ***How Do I Get Started?***

After you install the software, click on *Help / Contents* in the main menu. Then navigate in the help system:

*Introduction to HyperNiche*

*Getting Started*

*Quick Overview of How to Use HyperNiche*

After reading this section, read the PDF document that comes with HyperNiche:

*Help / Contents / Companion PDF document*

## ***Managing Files and Projects***

Normally you will want to keep your data and results in a folder that is separate from the folder that contains HyperNiche. If you have more than one HyperNiche project, you can keep the files from each project in a separate folder or put them in a



single folder. HyperNiche helps you resume work where you left off with the *File | Open Project* and *File | Save Project* menu items. Details of how HyperNiche manages folders (directories) and file management definitions are given under *Open Project* in the HyperNiche Help system.

When you Install HyperNiche, the HyperNiche icon is inserted in the Programs section of the Start Menu. If you wish to create an icon for a given project, first create a "shortcut" to HyperNiche on your desktop or in a folder (see your Windows help system if you don't know how to do this). Then:

- Rename the shortcut icon to tell you what project it represents. (Right click, rename)
- Now set the working directory for that project. (Right click on the icon, click on properties, click on shortcut tab, then in the "Start in" space, type the path to the folder containing the data files for that project, for example, `c:\forests\edgedata`).

From then on, when you click on this shortcut icon, HyperNiche will look in the folder you specified. It will also remember the history of files, graph options, etc., so that when you start HyperNiche from that icon, you will be right where you left off.

## ***System Requirements***

### **Hardware Required**

- 80486 or higher CPU (including Pentium 4, Athlon, Celeron, etc.)

- 8 MB RAM (more RAM means ability to analyze larger data sets)
- 6 MB of available hard disk space

**Operating System:** Windows 98, NT, ME, 2000, XP, XP 64-bit, or Vista

**Spreadsheet Software Recommended:** A spreadsheet program capable of writing files in \*.wk1, \*.xls, \*.xlsx format is recommended (e.g. Excel). Many statistical software packages also export \*.wk1 files.

## ***Network Environments***

HyperNiche can be run from a file server in a network environment, but you must set up the software correctly. Because network environments vary, your network administrator may need to help you set up HyperNiche. Generic instructions for a typical network setup are given below. These presume that your network administrator has already installed HyperNiche on your network.

1. Right click on some free space on the desktop.
2. Select *New / Shortcut*.
3. For "command line" enter the path for HyperNiche.exe. Your network administrator can provide this path.
4. Click on "Finish." The HyperNiche icon should now be on the desktop.
5. Right click on the HyperNiche icon.
6. Select *Properties / Shortcut*.

7. Under "Start in" enter your working directory (where you will keep your HyperNiche data files and temporary files).

### ***Important points***

1. Each user needs a unique working directory (folder). Call this the "user's directory." The user's directory can be either on a local drive or on a network drive. However, the user's directory must be unique to that user or workstation and the user must have write access to that directory.

2. The "Start in" directory **MUST** be changed to that unique user's directory. Install HyperNiche in the normal way. Then right-click the HyperNiche icon, select "properties", and type the name of the user's directory into the "Start in" box. Conflicts will result if multiple users are writing to the same directory.

### ***Recommended network setup***

1. Executable files are installed in a network directory and shared by multiple users.

2. Users keep data files and temporary files on their own hard disks or on a removable drive (e.g., flash drive or memory key). A user's network drive can also be used, but this is not recommended because network traffic can slow processing considerably.

## ***For class use***

1. Same as above, but each user should copy the data files provided for the class into their own folders.

2. In computer classrooms, users may want to define their "Start in" directory as a removable drive, such as a flash drive. This allows users to preserve their own settings from one session to the next, regardless of which machine they are using. The same thing can be accomplished by having users use their own network drive, if such is available. This is slower than using a local hard drive.

## ***Limitations***

- 30 GIS input files (one file for each predictor variable)
- 100 GIS output files (one for each species or other response variable)
- 246-character file names
- 1000 species or other response variables
- 500 habitat variables or other predictors in the model at once (more can be included as potential variables)
- 32,000 sample units (rows)

# ***Technical Help***

We use email to answer technical questions about the software from registered users. Our software support pertains only to programs obtained directly from MjM Software Design.

If you experience unexpected behavior, often someone else will have detected the same problem and it will already be fixed.

Before you contact us...

- Please download the latest fixes from our website <[www.pcord.com](http://www.pcord.com)>, and determine whether the problem still exists in the latest version.
- Check the Frequently Asked Questions section on the HyperNiche website: [www.pcord.com/nichefaq.htm](http://www.pcord.com/nichefaq.htm)
- Determine which version you are using by selecting *Help / About* in the HyperNiche menu or inspecting the header at the top of your output files. Please include the full version number in your correspondence with us, specifying not just "version 1" but "version 1.03" or whatever exact version you are using.

## **Updates and Fixes**

Fixes will be posted on the web as needed. Click on *Help / Internet Support* for the current web address for downloading fixes, plus other information on HyperNiche. HyperNiche maintenance fixes are free and can be downloaded from the MjM website: <[www.pcord.com](http://www.pcord.com)>.

## Contact Us

**MjM Website:** <http://www.pcord.com>

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## *Using HyperNiche: a Brief Overview*

You can quickly learn the basics of HyperNiche by following four steps:

1. Prepare your data
2. Open HyperNiche and your data files
3. Fit models to your data
4. Explore your models graphically

These are briefly illustrated below.

# 1. Prepare Your Data

For an easy start, follow the instructions in the help system exactly.

- A. Put your data in a spreadsheet (e.g. Excel) with the sample units as rows and variables as columns. Assign a short name to each row and column.
- B. Partition your variables into two worksheets, one with response variables (e.g., presence, abundance, or other measure of performance), and the other with predictors (habitat variables). Copy the row names into both worksheets.

**Habitat models:** place species performance data (e.g. presence-absence or abundance) in the response matrix and environmental variables or other predictors in the predictor matrix.

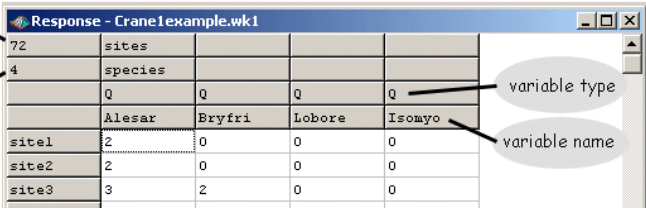
**Physiological response surfaces:** open your physiological variables as the response matrix and your environmental variables as the predictor matrix.

**Species diversity:** place your diversity measures (calculated by **PC-ORD** or a spreadsheet) in the response matrix and predictors (environment, productivity, etc.) in a second matrix.

**Ordination scores:** save your ordination scores in a spreadsheet, then open this as the response matrix. Open your file containing environmental variables or other predictors as the predictor matrix.

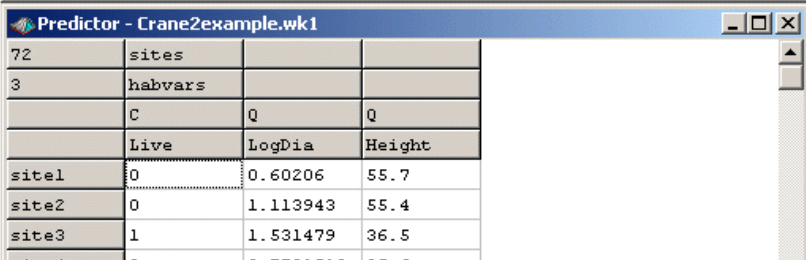
- C. Insert header rows declaring the contents of your response matrix, and whether each variable is quantitative (Q) or categorical (C). Binary (0/1) variables can be

declared as either Q or C variables.



72	sites			
4	species			
	Q	Q	Q	Q
	Alesar	Bryfri	Lobore	Isomyo
site1	2	0	0	0
site2	2	0	0	0
site3	3	2	0	0

D. Set up the predictor matrix in the same way (example below).



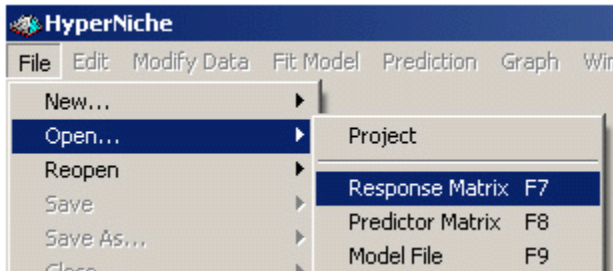
72	sites			
3	habvars			
	C	Q	Q	
	Live	LogDia	Height	
site1	0	0.60206	55.7	
site2	0	1.113943	55.4	
site3	1	1.531479	36.5	

E. Save each of these two worksheets as a separate spreadsheet in \*.wk1 format. In Excel, use *File / Save as*, then in the “*Save as type*” box, select “WK1 (1-2-3) (\*.wk1).” The file can now be opened and analyzed by HyperNiche.



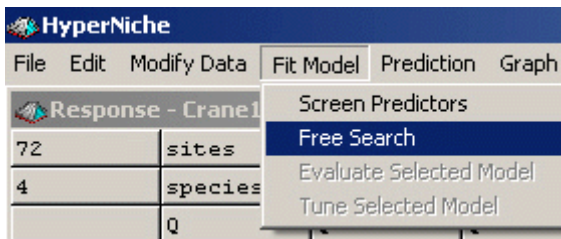
## 2. Open HyperNiche and Your Data Files

Start HyperNiche, then open your response matrix (a \*.wkl file). Open your predictor matrix in the same way.



## 3. Fit Models to Your Data

A. Use *Fit Model / Free Search* with your method of choice. For general purposes we recommend nonparametric multiplicative regression based on a local mean and Gaussian weighting function (LM-NPMR; see next page).



## Free Search Setup



Model Type | Model Options | Output Options

### Model Form

- Local Mean - Uniform (Binary or Quantitative)
- Local Mean - Gaussian (Binary or Quantitative)
- Local Linear (Quantitative)
- Least-squares Multiple Linear Regression (Quantitative)

### Kind of Response

- Binary
- Quantitative

### Cutoff for Binary Conversion

OK

Cancel

Help

B. HyperNiche examines a large number of models (2008 in this case), then lists the results for those models in the Model List window in the upper right corner of your screen. The “Eval” column shows the statistic used to evaluate the model, in this case the cross-validated  $R^2$  (xR2; note: these can be negative!).

Model Number	Response Variable	Cutoff	Form	Eval xR2	Ave Size	Pred Count	Variable 1	Tolerance	Vari
1	Alesar	0.000	LM	-0.0542	35.1	1	Live	0.00000	
2	Alesar	0.000	LM	0.0157	9.4	1	LogDia	0.10923	
3	Alesar	0.000	LM	0.1003	5.5	2	Live	0.00000	Lo
4	Alesar	0.000	LM	0.0115	18.3	1	LogDia	0.21847	
5	Alesar	0.000	LM	0.0585	9.7	2	Live	0.00000	Lo
6	Alesar	0.000	LM	-0.0012	26.1	1	LogDia	0.32770	
7	Alesar	0.000	LM	0.0234	13.3	2	Live	0.00000	Lo
8	Alesar	0.000	LM	-0.0118	32.7	1	LogDia	0.43694	
9	Alesar	0.000	LM	-0.0128	16.5	2	Live	0.00000	Lo
10	Alesar	0.000	LM	-0.0211	38.4	1	LogDia	0.54617	
11	Alesar	0.000	LM	-0.0386	19.2	2	Live	0.00000	Lo
12	Alesar	0.000	LM	-0.0271	43.3	1	LogDia	0.65541	

3. Filter and save the best models for each response variable for each number of predictors. Use *Edit / Delete All But Best For N Predictors*.



This results in 12 retained models. For each of the four response variables, the best 1-, 2-, and 3-predictor models are saved (more are saved if you have more predictors). The model list is then saved by choosing *File / Save As / Unsaved Model List*, then supplying the file name, in this case CraneExample.spx.

4. Choose the number of predictors by evaluating the diminishing returns of adding predictors. Consider the response variable Isomyo, which represents the abundance of this species. Adding a third predictor “Live”, resulted in little improvement in fit (see next page; fit measured by  $xR^2$ , the cross-validated  $R^2$ ). So we chose to pursue the model with two predictors, LogDia and Height.

## 4. Explore Your Models Graphically

You can explore your models with:

- 2D and 3D response surfaces
- Estimated vs. observed values
- Residual plots
- Partial models

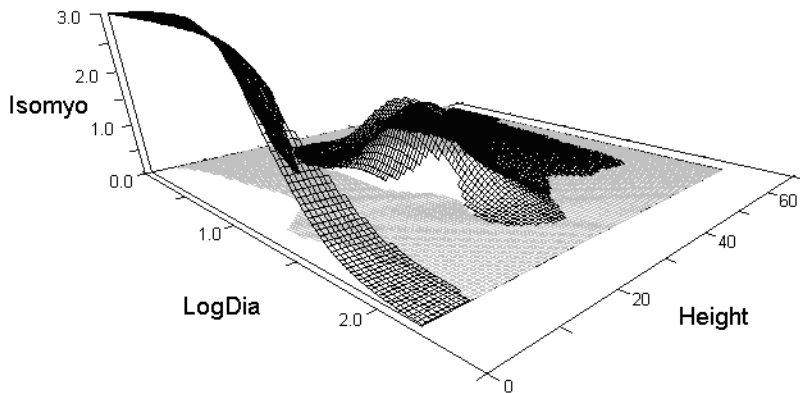
For example, generate a 3D response surface as follows. Click on a model to select it. In this case we chose model number 1540, relating Isomyo to the two predictors LogDia and Height.

Models - CraneExample.spx												
Edit [Icons] Vars: BQC Models: 12 Selected: 1												
Model Number	Response Variable	Cutoff	Form	Eval xR2	Ave Size	Pred Count	Variable 1	Tolerance	Variable 2	Tolerance	Variable 3	Tolerance
32	Alesar	0.000	LM	0.3647	14.2	1	Height	3.23000				
123	Alesar	0.000	LM	0.4640	4.1	2	LogDia	0.10923	Height	12.92000		
94	Alesar	0.000	LM	0.6026	3.5	3	Live	0.00000	LogDia	0.21847	Height	9.69000
506	Bryfri	0.000	LM	0.0825	18.3	1	LogDia	0.21847				
565	Bryfri	0.000	LM	0.2094	5.6	2	LogDia	0.21847	Height	6.46000		
567	Bryfri	0.000	LM	0.2276	3.9	3	Live	0.00000	LogDia	0.32770	Height	6.46000
1094	Lobore	0.000	LM	0.1701	22.6	1	Height	9.69000				
1101	Lobore	0.000	LM	0.2293	11.2	2	LogDia	0.43694	Height	9.69000		
1102	Lobore	0.000	LM	0.1511	5.5	3	Live	0.00000	LogDia	0.43694	Height	9.69000
1566	Isomyo	0.000	LM	0.2160	18.8	1	Height	6.46000				
1540	Isomyo	0.000	LM	0.7144	4.3	2	LogDia	0.21847	Height	3.23000		
1543	Isomyo	0.000	LM	0.7233	3.4	3	Live	0.00000	LogDia	0.43694	Height	3.23000

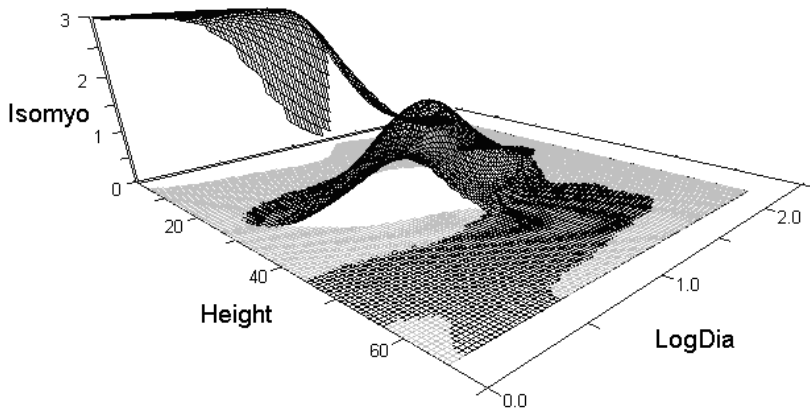
Then click on:

*Graph / Fit Response Curves / 3D Projection*

We get the following graphic:

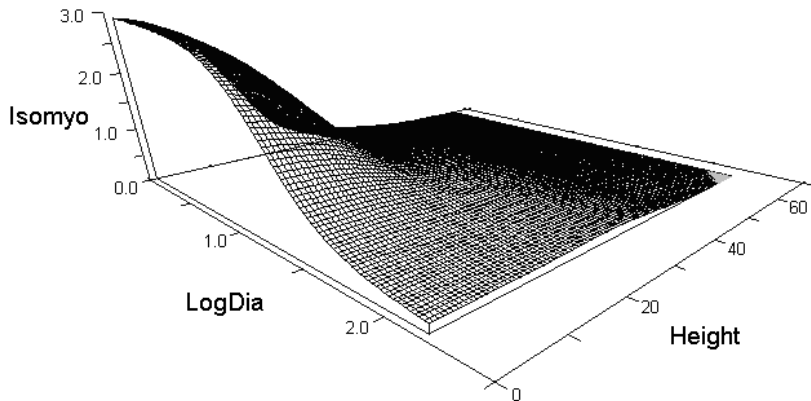


It is a bit difficult to see the full response shape, so let's rotate the graph for a different view. Click on the circle icon for continuous rotation, then the horizontal arrow to rotate horizontally. Click the circle icon again to stop rotation.



The response surface is broken in the areas where there were insufficient data, as set by the minimum average neighborhood size. This parameter was set during the model fitting phase. To achieve a smoother, continuous curve we can increase that parameter from 3 to 10.

The following graphic shows the best 2-predictor model with this stronger smoothing:



That's the essence of it. We hope you will enjoy the power, flexibility, and insights provided by distribution-free multiplicative habitat models. Happy exploring!