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Comparison of Ordination and model-
affinity approaches for assessing
Impacts on Communities

BY:

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Comparison of ordination and model-affinity approaches for assessing impacts on communities

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Abstract

Environmental assessments that incorporate surveys of ecological communities require that the methods used to summarize and test impact-related hypotheses have a reasonable chance of correctly declaring a community (un)impacted when it really is. In this study, we used simulated data of known characteristics to evaluate the ability of three ordination methods (non-metric multidimensional scaling, NMDS; principal components analysis, PCA; correspondence analysis, CA) and model affinity (MA) to classify unimpacted and impacted ecological communities. Our simulations included both long and short ecological gradients and four levels of noise in species abundances. NMDS, PCA, CA and MA were equal in their ability to correctly classify unimpacted communities, but were not always equal in their ability to classify impacted communities. PCA and MA tended not to perform as well as CA and NMDS when the ecological gradient was long and when the species abundances were as noisy as is typically found in real faunal survey data.

Introduction

Ecological communities are often used as endpoints in monitoring and assessment programs to determine ecological condition (Rees et al., 1990; Davis and Simon, 1995). Typically, variations in composition among reference communities are used to judge the ecological significance of effects on communities from impacted locations. When the composition at a test (impacted) site falls outside of the normal range of variation of reference communities, the test site is declared impacted (Kilgour et al., 1998).

There are several general ways to summarize ecological community composition when comparing test and reference sites including: (1) biotic indices, (2) clustering, (3) ordination, (4) multivariate analysis of variance, and (5) model-affinity (MA) approaches. Biotic indices, ordination axes, and model-affinity endpoints are more useful than clustering because they can be more readily applied in hypothesis testing procedures, and because they give quantitative results allow for estimating the degree of impact. Biotic indices such as the Index of Biotic Integrity (IBI) for fish (Karr, 1981) and for benthic macroinvertebrates (Kerans and Karr, 1994) are usually derived to present a summary of the tolerance of the community to degraded conditions. Biotic indices do, however, require prior calibration, and tend to be subjectively derived. They are also typically calibrated to detect specific kinds of stresses (e.g., the Biotic Index by Hilsenhoff, 1988, was designed to detect nutrient status). As such, indices may not detect impacts resulting from unusual stresses.

Multivariate analysis of variance is appropriate for assessing impacts on biological communities, but only when the number of communities (sites) is well in excess of the number of taxa encountered in the survey. Ordination methods are often used to reduce the high number of taxa (variables) into a reduced set of synthetic variables (axes) that summarize similarities in composition among sites. These ordination axes can be used in hypothesis testing procedures like any other variable (Hotelling, 1933; Green, 1979; Gauch, 1982a:143; Gray et al., 1988; Warwick et al., 1988). Ordination methods filter noise (Gauch, 1982b) and have been shown to result in more sensitive assessments of impacts on biological communities (Warwick et al., 1988). Ordination methods can, however, distort the true underlying similarities among communities. As such, there is potential for ordination methods to misclassify true reference and impact sites.

Given the potential for distortion with ordination methods, some (e.g., Novak and Bode, 1992; Barton, 1996; Bailey et al., 1998) have proposed using model-affinity (MA) approaches instead of

ordination. With MA approaches, the average composition of all reference communities is used to represent the expected reference community. The similarity of communities to this expected reference condition is then used as the biological response. The variation in similarity values of reference sites to the average reference community is then used to characterize the normal range of variation in composition of reference communities. Hypothesis testing can also be performed (Barton, 1996). With MA, similarity (or dissimilarity) can be measured as any ecological distance measure such as Percent Similarity of Community, PSC, the Bray-Curtis distance measure or Jaccards Coefficient of Community for presence/absence data (Barton, 1996; Bailey et al., 1998). In contrast to ordination methods, model-affinity approaches do not filter noise. As such, model-affinity approaches may not be as sensitive to impacts on communities.

In environmental assessment, it is important that we use analytical methods that are unbiased and have a good likelihood of leading us to the correct conclusions of the degree of impairment. To date, no studies have examined the effect ordinations have on the probability of a correct conclusion. Nor has anyone done a full examination of the performance of MA approaches. Given the potential for ordinations to distort underlying structure, one would assume that ordinations may overestimate the degree of impairment and incorrectly classify reference sites as impacted. In contrast, because model-affinity methods do not filter noise, they may not detect impacts when they truly occur. The objective of this paper is to compare the performance and ordination and model-affinity approaches for detecting impacts on biological communities. In this paper, we evaluate three ordinations: (1) principal components analysis (PCA); (2) correspondence analysis (CA); and (3) non-metric multidimensional scaling (NMDS). These ordination methods were chosen to represent the basic variety of techniques that exist: other methods tend to be derivatives of these three techniques.

This paper differs from other papers that have evaluated ordination techniques in the past. Typically, comparison papers use simulated data to construct a set of species distributions across a theoretical ecological gradient. Then communities are "sampled" at specific locations on the gradient. The resulting sampling pattern is used to represent a sampling grid in ecological space (Austin, 1976; Kessel and Whittaker, 1976; Gauch et al., 1977; Feoli and Feoli-Chiapella, 1980; Gauch et al., 1981; Kenkel and Orloci, 1986). Those techniques shown to give an ordination diagram that re-creates the sampling pattern are then considered successful. In this analysis, we care little if the ordination method accurately portrays

the underlying structure so long as the method detects impacts when they occur. As such, this analysis focuses on establishing the probability of correctly classifying sites as either impacted or unimpacted using the four analytical tools (i.e., MDS, PCA, CA, MA).

Methodology

Simulations

Environmental monitoring programs generally incorporate either site-specific (Green, 1979; Hodson et al., 1996) or regional- reference (Hughes, 1995) locations against which to judge presumed impacted locations. Regional-reference data are usually used to evaluate the ecological significance of observed differences (Reynoldson et al., 1998). Consequently, in this analysis, we simulated scenarios analogous to those incorporating regional-reference locations into study designs.

We used COMPAS (Minchin, 1987) to simulate an impact gradient and to vary the nature of species distributions across the impact gradient. COMPAS is a DOS-based algorithm that simulates species abundance curves across theoretical gradients. The software allows users to specify a variety of distributional characteristics for individual species as well as for sets of species.

The ability of an ordination to successfully portray the true underlying similarities among samples is influenced in part by beta diversity or the degree of differences in community composition from across a gradient. Gradients with high beta diversity have large changes in composition across the gradient. Typically, high beta diversity results in species curves across "long" gradients that follow Gaussian curves. Such high beta-diversity systems are more optimally ordinated by CA or MDS because these ordinations do a better job of re-creating the underlying structure (similarities among samples, Austin, 1976; Fasham, 1977; Ter Braak and Prentice, 1988). In contrast, gradients with low beta diversity have many species in common across the gradient. Low beta diversity generally results in species abundances that vary in a linear fashion across the "short" gradient. Such low beta-diversity systems are more optimally ordinated with PCA because PCA is designed to ordinate variables (taxa) that are linearly related (Ter Braak and Prentice, 1988). Given the importance of gradient length, we simulated both a short gradient (0.5 half changes) and long (4 half changes) ecological gradient. Representative species curves are shown in Figure 1.

In addition to gradient length (beta diversity), noise also influences the ability of an ordination to

successfully portray the underlying similarities among communities. We therefore varied the amount of noise in species abundances. Without any object means to quantify noise, we simulated species abundances with no noise, as well as low, medium and high noise. Noise parameters in COMPAS were specified as given in Table 1. The high noise simulation was selected based on an apparent similarity between species abundance distributions in the simulated data and species abundance distributions observed from field collections of fish in southern Ontario (Figure 1).

We used a single sampling pattern to "collect" communities from the eight simulated gradients. The sampling pattern included 100 "reference" communities (samples) collected randomly from a sub-space of the ecological gradient. An additional 20 "test" communities (samples) were collected at equally spaced positions across the simulated gradient (Figure 2). Sampling positions within the reference community space was determined from a normal distribution. As a consequence, we could use an estimate of the limits of the normal range of variation to denote which samples we would expect to consider impacted and unimpacted. Those inside the normal range of variation for the reference communities would be considered unimpacted, while those outside the normal range of variation would be considered impacted (Kilgour et al., 1998).

Ordinations

Each data set was ordinated with PCA, CA, and NMDS. Bray-Curtis dissimilarities were used as the input matrices to the NMDS ordinations. NMDS ordinations used initial configurations base on a principal-coordinates ordination. NTSYS-pc software (Rohlf, 1993) was used to perform the ordinations. With each ordination technique, the data analyst must at some point decide how many axes will be used in subsequent hypothesis tests. However, with the exception of PCA, there are few guidelines for selecting significant axes (Jackson, 1993). In this analysis, we therefore examined the probability of incorrectly classifying communities based on retaining both one, two and three ordination axes.

Model Affinity

For each data set, the average reference community was calculated by averaging the abundances of each taxon found in the reference samples (Novak and Bode, 1992). Bray-Curtis distances (dissimilarities) to

the average reference community, were calculated for each sample (Novak and Bode, 1992). NTSYS-pc software (Rohlf, 1993) was used to calculate these similarities/dissimilarities.

Classifying Communities

As above, communities that fell inside the envelope of reference community space were considered unimpacted, while those falling outside the envelope were considered impacted. For each ordination, and for the model affinity approach, we estimated the true underlying effect size for each of the 100 reference communities and 20 test communities observations using:

$$ES = \frac{\bar{X}_{ref} - test}{S_{ref}}$$

where \bar{X}_{ref} was the mean position of reference communities, S_{ref} was the standard deviation of reference-community positions and $test$ was the position of any individual community along the ecological gradient. As before, these positions are in ecological space, not physical space and so represent the true relative ecological distances between communities.

Kilgour et al. (1998) define the normal operating range of reference communities as the region enclosing 95% of the reference population. Others have defined the normal range of variation as the region enclosing 75% reference population (Yoder and Rankin, 1995) or 99% of the reference community (Reynoldson et al., 1998). These limits can be expressed in standardized units such as the number of standard deviations from the mean of the reference (i.e., Z-scores for univariate responses) or as generalized distances from the centroid of the reference population (for multivariate responses). For univariate responses, the limits of the 95% region lie at 1.96σ (standard deviations). We evaluated the ability of each ordination method and the model affinity approach to correctly classify both impacted and unimpacted communities based on this definition for normal ranges.

Evaluating Performance

Based on known positions along the ecological gradients, we knew whether or not a site truly did lie inside the defined normal range. To evaluate each of the analytical approaches, we then

determined the proportion of communities that were correctly classified as being within or outside the limits of the normal range. For example, based on an analysis using the model affinity approach, we estimated the ecological distance of each community from the average reference community (in standard deviations, SD). Those communities falling within 1.96 SD of the mean of the reference communities were classified as being unimpacted, while those >1.96 SD from the mean of the reference community responses were classified as impacted. We compared the observed frequencies of impacted and unimpacted with the predicted frequencies, to estimate the proportion of times that classifications were incorrect. These distances were expressed as either Z-scores (for single axis solutions and model affinity results), or as generalized distances for two-axis ordination solutions. Equation [1] above was used to estimate observed effect sizes for single axis responses and for model affinity responses. As above, communities with observed effect sizes in excess of the critical effect sizes were declared impacted. When two or more ordination axes were retained, the observed effect size, or generalized distance (D) for each of the 120 sites was estimated using:

$$D = \sqrt{(\bar{X}_r - Imp)' S_r^{-1} (\bar{X}_r - Imp)}, [2]$$

\bar{X}_r is the centroid (vector of sample mean responses) of the reference locations, Imp is the vector of response at the impact location, and S_r^{-1} is the inverse of the variance-covariance matrix for the

reference locations (Owen & Chmielewski, 1985). The limits of the normal range lie at $\sqrt{X^2(x,p)}$ generalized distances from the population centroid, where $X^2_{(x,p)}$ is the xth percentile of a chi-square distribution for p variables (Rode & Chinchilli, 1988; Kilgour et al., 1998). The 95th percentile lies at 2.45 generalized distances for two axis solutions, and at 2.79 generalized distances for three axis solutions. These limits were therefore used to classify communities based on two- and three-axis ordination solutions.

Based on these classifications, we determined the probability of falsely declaring an unimpacted reference site impacted, and of falsely declaring an impacted site unimpacted. Ninety-five percent confidence limits for these proportions were calculated using equations for binomial distributions given

in Zar (p 378, 1984). Murtaugh (1996) recommends this overall approach for evaluating the performance of an ecological endpoint or methodology.

Results

How well were unimpacted communities classified?

There were no apparent differences in analytical methodologies in classification probabilities. In general, the probability of incorrectly classifying truly unimpacted communities varied between about 2 and 10% (Figures 3 and 4). Differences in ecological gradient length and noise level had no apparent effects on the probability of a correctly classifying a true reference community. Increasing the number of ordination axes on which to base the assessment, tended not to change the probability of incorrectly classifying a community, particularly with the longer gradient (Figures 3 and 4).

How well were impacted communities classified?

Classification probabilities of truly impacted communities did tend to vary with method used, but also varied with noise level, and length of the gradient. With an increase in noise level, there was an apparent increase in the probability of an incorrect classification (i.e., impacted communities were classified as unimpacted). This was true for both short and long ecological gradients (Figures 3 and 4). Regardless of noise, an increase in gradient length resulted in an increase in the probability of correct classification. With the short ecological gradient, there was no apparent improvement in classification probabilities with an increase in the number of ordination axes. In contrast, with the longer ecological gradient, inclusion of the second and third ordination axes markedly increased the probability of a correct classification (Figures 3 and 4). With the long gradient, poor classification of truly impacted communities occurred as a result of an apparent distortion of the underlying pattern. Figure 2 shows the apparent distortion that occurred for communities that were truly very different from the reference condition. Using just the first axis results, it was apparent that the estimated effect size was an underestimate. By inclusion of the second and third ordination axes, the magnitude of effect was more appropriately estimated, thus the likelihood of a correct classification was improved.

How did the model affinity approach compare to ordination methods?

The model-affinity approach performed about as well as the ordination methods under certain situations. When the ecological gradient was short, the model-affinity approach tended to perform as well as the ordinations (Figures 3 and 4). When the ecological gradient was long, the model-affinity approach tended to do as well as ordinations only if the ordination was based on a single axis. In contrast, when the ecological gradient was long and when two ordination axes were used to estimate effect size, CA and NMDS had higher classification probabilities than the model affinity approach (Figures 3 and 4).

With all analytical tools, the probability of declaring a community impacted increased with the magnitude of the impact (Figure 5). As such, errors are only likely to be made for those communities that are relatively close to the critical effect size. For CA, there was a higher probability of incorrectly declaring a community unimpacted when it lay between 1.96 and 2.2σ . In contrast, errors with NMDS were made between 1.96 and 3σ , and with PCA and MA were made between 1.96 and 5σ . CA appeared to inflate observed effect sizes to a much greater degree than did NMDS, especially for large effects in excess of 3σ (Figure 5).

Discussion

Environmental assessments that incorporate surveys of ecological communities require that the methods used to summarize and test impact-related hypotheses have a reasonable chance of correctly declaring a community (un)impacted when it really is. This study, using simulated data of known characteristics, demonstrated that NMDS, PCA, CA and MA are equal in their ability to correctly classify unimpacted communities, but not always equal in their ability to classify impacted communities. PCA and MA tend not to perform as well as CA and NMDS when the ecological gradient is long and when the species abundances are relatively noisy.

With the exception of the long-gradient, high-noise simulation, all three ordination methods were reasonably good at classifying impacted communities. This finding is in some contrast to recommendations that PCA be used to ordinate short gradients while CA be used to ordinate long gradients (ter Braak and Prentice, 1988). The main concern when using PCA to ordinate long ecological gradients is the potential for an arch effect (see the CA ordination, Figure 2). With arch effects, communities at opposite ends of the primary gradient are shown to be more similar than they really are, relative to the spread of

communities in the middle of the primary axis. Although arch effects were evident with CA, and to some extent PCA with the long gradient (Figure 2), the arch had no apparent effect on the probability of correctly classifying impacted communities so long as multiple ordination axes were used to calculate observed effect sizes. The concern over arch effects, therefore, seems unwarranted. As an analytical approach, MA has recently received considerable attention in the benthic macroinvertebrate literature. Novak and Bode (1992) used the approach to demonstrate impacts of mines on benthic organisms, while Barton (1996) used the approach to characterize impacts of agricultural practices on benthos in southern Ontario, Canada. Our results show that the MA approach tended not to perform as well as the ordination methods with the longer ecological gradient, regardless of the level of noise. With no or moderate noise, MA had difficulty classifying impacted communities lying between 1.96 and 2.5σ (Figure 5). Such errors were eliminated with each of the ordination methods, but only if multiple ordination axes were used to make the assessment. The use of ordination analyses have the advantage that there are multiple axes that potentially add information.

How many ordination axes should be incorporated into an estimate of effect size? This is a good question. For now, there are rules on selecting significant axes only for PCA (Jackson, 1993). With CA, Lebart et al. (1984) provide guidance on whether the first axis is significant, but not later axes. There are no rules for axis selection in NMDS. One possibility for selecting significant axes in both CA and NMDS would be the use of randomization tests to determine if the observed variance (un)explained by a given axis was unusual compared to a null distribution of variance (un)explained for each axis (Jackson, 1993). Such randomizations with CA and NMDS would, however, require customized algorithms. The disadvantage to using multiple ordination axes is that additional axes use up degrees of freedom in hypothesis testing procedures. If budgets for faunal surveys permit the collection of communities from only a few sites, the use of multiple ordination axes in hypothesis testing procedures may become problematic because there may be too few error degrees of freedom.

Some perceive ordination methods as primarily noise-filtering procedures (Gauch, 1982). The results from this study show that this ability to filter noise did not always improve the ability to classify impacted communities. With the short ecological gradient, none of the ordination methods had a great ability to correctly classify impacted communities when any amount of noise in species abundances was present. Noise, in the case of the short gradient, was apparently stronger than the underlying signal with the result that none of the ordination methods was able to adequately classify impacted communities (Figures 3 and 4). In contrast, in the case of the long gradient, both CA and NMDS had high probabilities of correctly classifying impacted communities regardless of noise level. With the high-gradient, high-noise

simulation, MA had a low probability of correctly classifying impacted communities, demonstrating the inability of MA to filter noise. Although MA is attractive in that it avoids the potential for distortion that can occur with any ordination method, distortion (as discussed above) appears not to be a valid concern. As a result, the inability of MA to recover pattern from noisy species distributions should make this analytical approach less attractive in relation to CA and NMDS. Ordinations (particularly CA and NMDS) are more likely to provide correct classifications of impacted communities regardless of the underlying gradient length or level of noise in species distributions.

Other characteristics of CA and NMDS may be considered in any selection between the two methods. In these simulations, NMDS accounted for a greater amount of the total variation in the data sets than did CA (Table 2). NMDS also appeared to inflate the underlying effect sizes less than did CA (Figure 5). Estimated effect sizes with NMDS should, therefore, give us a better understanding of the degree of impact of a community. In contrast to this benefit with NMDS, CA has the advantage that the species themselves are automatically ordinated. Such species ordinations give an understanding of the faunal differences between communities, usually aiding our understanding of the nature of the impact and therefore of potential rehabilitative measures.

All simulation experiments have constraints. With this study, we perceive at least three major constraints that should be considered. First, none of the simulations included rare taxa that tend to distort ordination diagrams in CA. The possibility exists that CA may perform poorer (may not classify impacted communities as well as shown here) when rare taxa are included in a data set. Second, the maximum size of impacts simulated in this study were just over 5σ . We targeted impacts of this size because we hoped to observe the performance of the various methods near the critical effect size of 1.96σ , and because it is rare for impacts to exceed 5σ in aquatic ecological impact studies (Kilgour, 1997; Reynoldson et al., unpublished data). Finally, in this set of simulations, impacted communities were sampled on both sides of the reference community (Figure 2). This impact scenario represents a relatively complex pattern that may not always exist in the real world. Typically, we think of impacts as occurring in a single direction from the reference community. For example, we might think of organic enrichment in streams as increasing the number of worms and decreasing the numbers of mayflies, stoneflies etc. However, the nature of the taxonomic change in communities do tend to vary with the kind of stress. As a result, observing impacts in more than one direction from the reference community is not necessarily unreasonable.

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Table 1. Characteristics of the eight simulations used to evaluate ordination methods and model affinity.

Question	response
Characteristics of Species Distributions	
(1) # of ecological gradients	1
(2) # of species in group 1	200
(3) Frequency distribution for modal abundances	uniform random
• minimum value for the uniform random distribution	1 (default)
• maximum value for the uniform random distribution	100 (default)
(4) Frequency distribution for ranges (r) on the first gradient	normal (Gaussian) (default)
• mean value for the normal distribution	100 (default)
• standard deviation for the normal distribution	30 (default)
(5) Frequency distribution for modal coordinates (m) on the first gradient	uniform random (default)
• minimum value for the uniform random distribution	-95 (default)
• maximum value for the uniform random distribution	195 (default)
(6) Frequency distribution for alpha and gamma on gradient 1	uniform random (default)
• minimum value for the uniform random distribution	0.5
• maximum value for the uniform random distribution	3.5
(7) Modes of major species adjusted to a more even spacing?	No (default)
(8) Do you want to introduce interspecific interaction?	No (default)
(9) Do you want to introduce a systematic trend in total abundance?	No (default)
Qualitative Noise Characteristics	
(10) Do you want to introduce qualitative noise?	No (no noise) Yes (low, medium and high noise)

(11) Frequency distribution for modal probabilities (P0)	uniform rectangular (default)
• minimum value for uniform random distribution	low noise = 0.8 (default) medium noise = 0.5 high noise = 0.2
• maximum value for uniform random distribution	low noise = 1.0 (default) medium noise = 1.0 (default) high noise = 1.0 (default)
(12) Multiplier for alpha and gamma values to be used for qualitative response functions	0.2 (default)
Quantitative Noise Characteristics	
(13) Do you want to introduce quantitative noise	No (no noise) Yes (low, medium and high noise)
(14) Select frequency distribution for random deviations	normal (default)
(15) Method for determining values of the standard deviation for the noise distribution as a function of the original (noiseless) abundance values (A):	value proportional to the square root of abundance (default)
(16) Constant of proportionality to be used in computing values of the standard deviation	low noise = 0.1 (default) medium noise = 1.0 high noise = 10

Table 2. Ordination results showing the variance (un)explained by axis.

Simulation Characteristics			NMDS (variance unexplained with solution based on 1, 2 or 3 axes)			PCA (variance explained by axis)			CA (variance explained by axis)		
Gradient Length	Noise	# Species	1	2	3	1	2	3	1	2	3
short	none	115	<0.01	<0.01	<0.01	0.86	0.13	0.82	0.74	0.19	0.04
	low	113	0.65	0.54	0.48	0.1	0.08	0.08	0.13	0.06	0.05
	medium	112	0.73	0.64	0.57	0.1	0.08	0.07	0.07	0.07	0.06
	high	112	0.84	0.76	0.71	0.09	0.07	0.06	0.05	0.04	0.04
long	none	199	0.03	0.01	0.01	0.58	0.27	0.08	0.43	0.31	0.13
	low	186	0.12	0.1	0.09	0.33	0.18	0.06	0.33	0.24	0.12
	medium	186	0.21	0.19	0.17	0.2	0.12	0.06	0.24	0.18	0.10
	high	170	0.56	0.52	0.49	0.09	0.07	0.05	0.07	0.07	0.06

Figure Captions

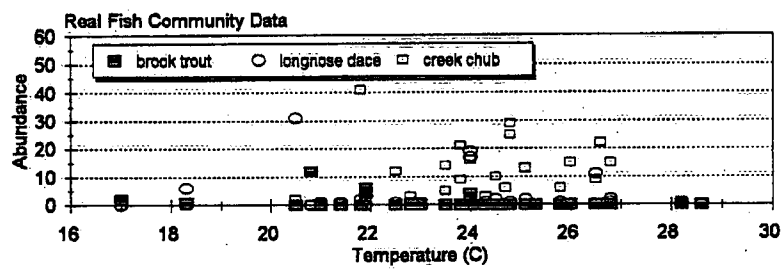
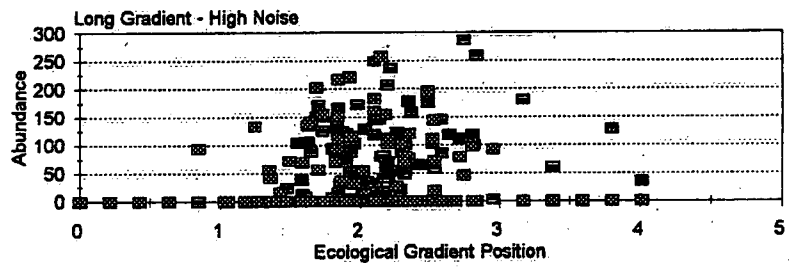
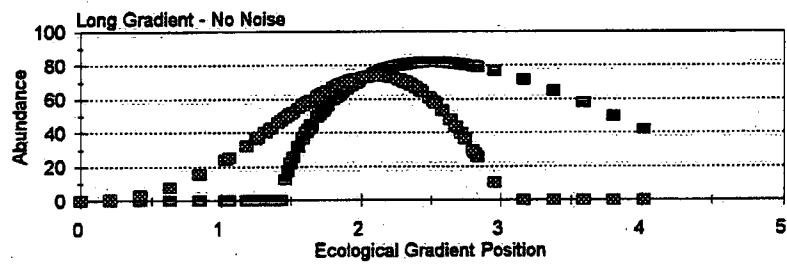
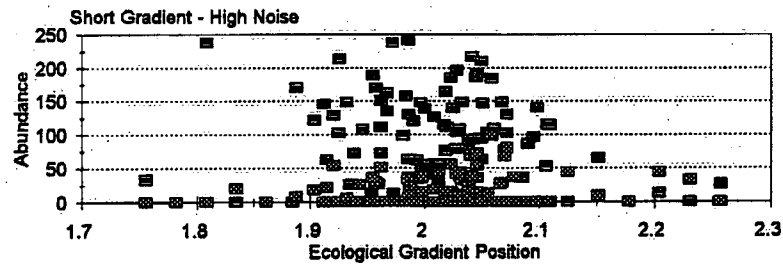
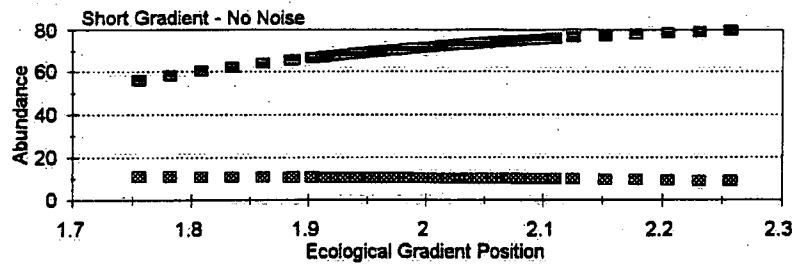
Figure 1. (a) Examples of species abundance curves with varying levels of noise. (b) Abundances of four fish species across thermal gradient in streams in southern Ontario (data from Barton et al., 1985).

Figure 2. Distribution of reference and test communities across the simulated ecological gradient, and ordination diagrams (first two axes only) for NMDS, PCA and CA for the long-gradient with no noise. These diagrams show the underlying distortion. An optimal diagram would portray the distribution of communities as given in the distribution of reference and test communities..

Figure 3. Probability of incorrectly classifying unimpacted communities as impacted with long and short ecological gradients and four levels of noise in species abundances.

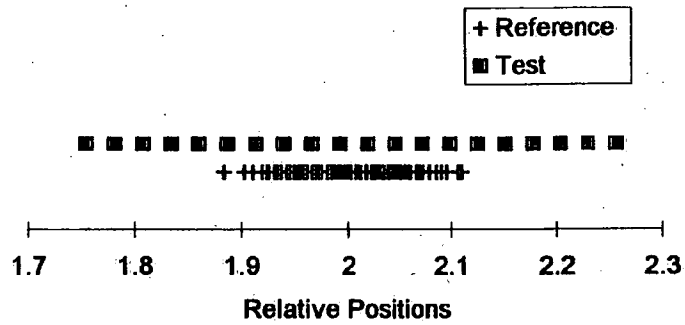
Figure 4. Probability of incorrectly classifying impacted communities as unimpacted with long and short ecological gradients and four levels of noise in species abundances.

Figure 5. Relationship between actual and observed effect size for each of the four analytical methodologies. Effect sizes calculated with the ordination results were based on the retention of three axes. Critical observed effect sizes are 1.96σ (dotted line) and 2.76σ (solid line) Results shown pertain to the simulation with a long gradient with high noise.

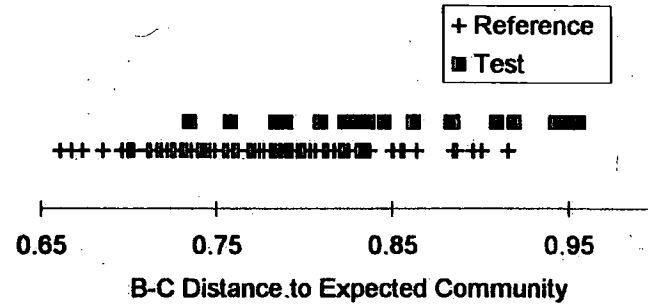


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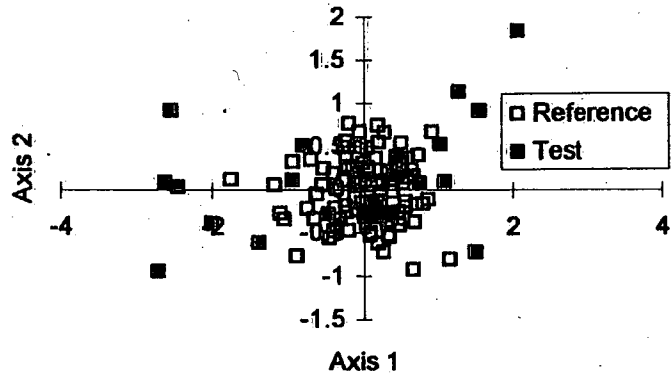
Underlying Structure



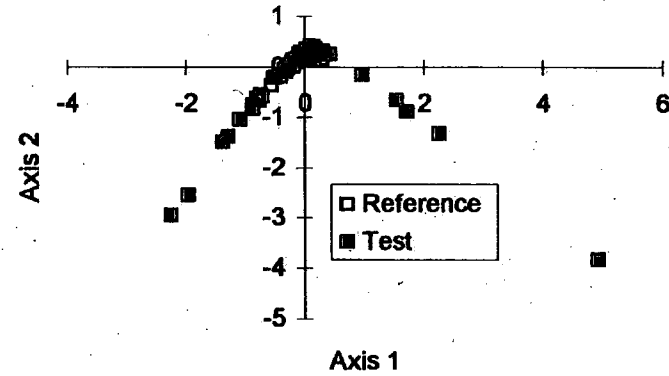
Model Affinity



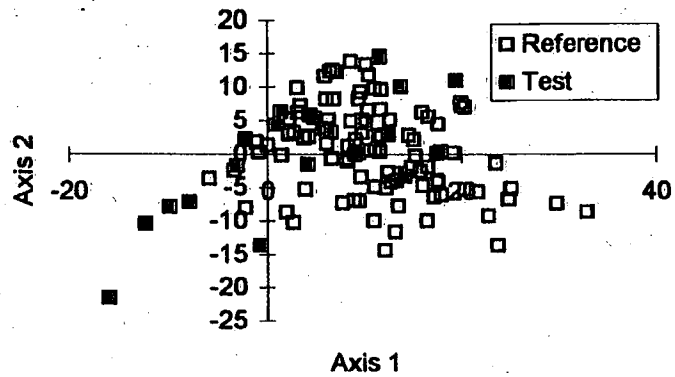
Non-Metric Multidimensional Scaling



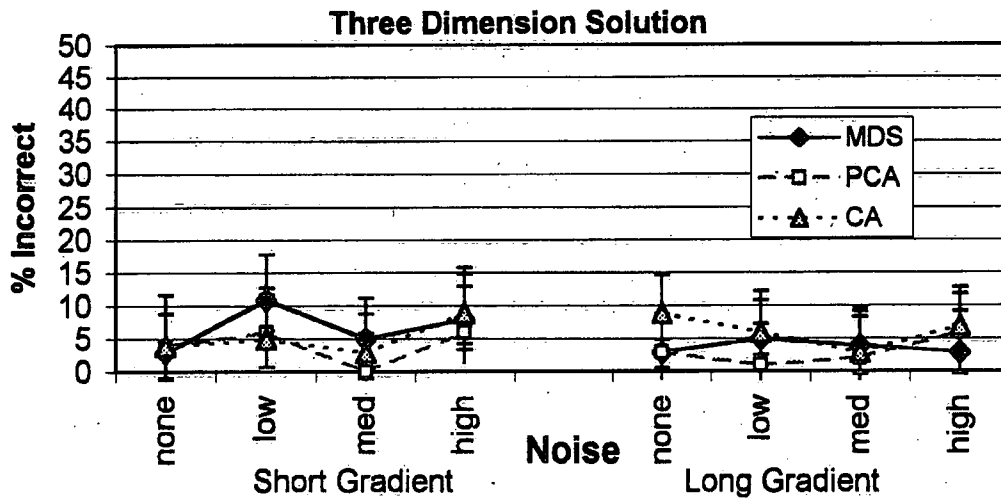
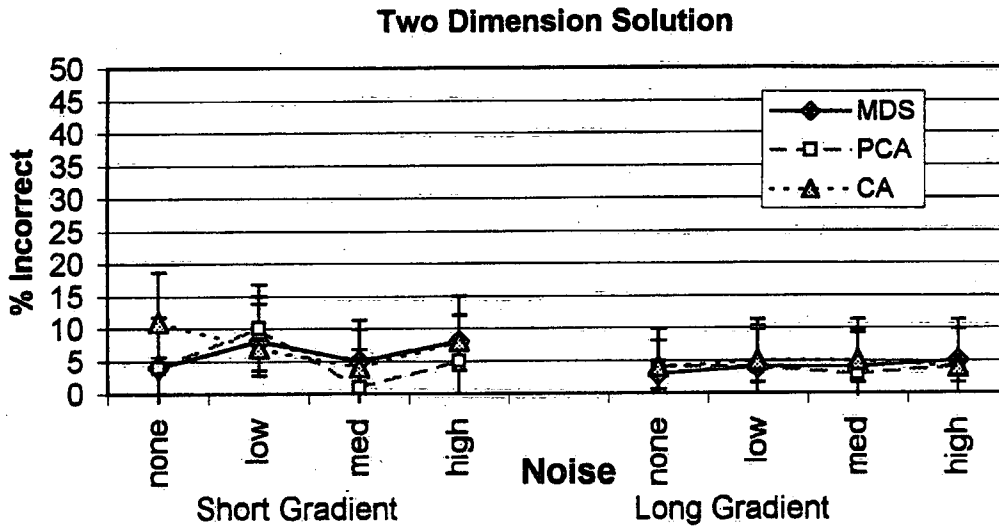
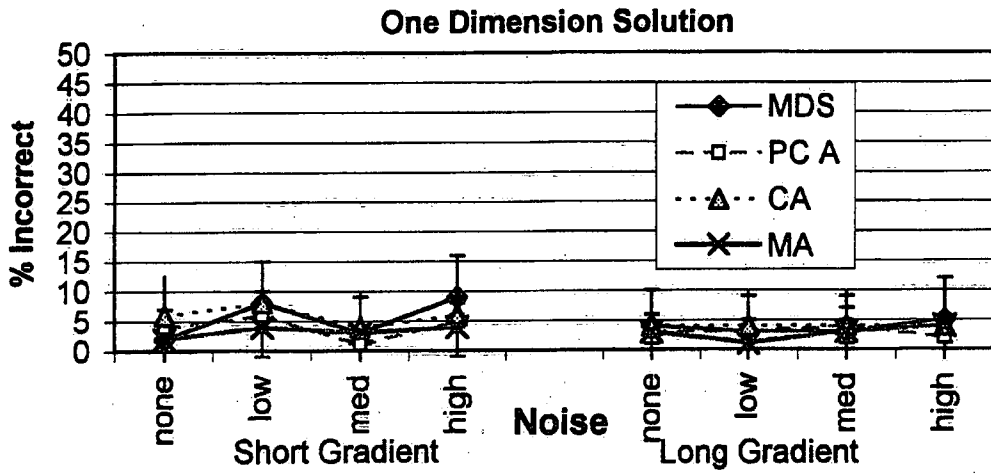
Correspondence Analysis

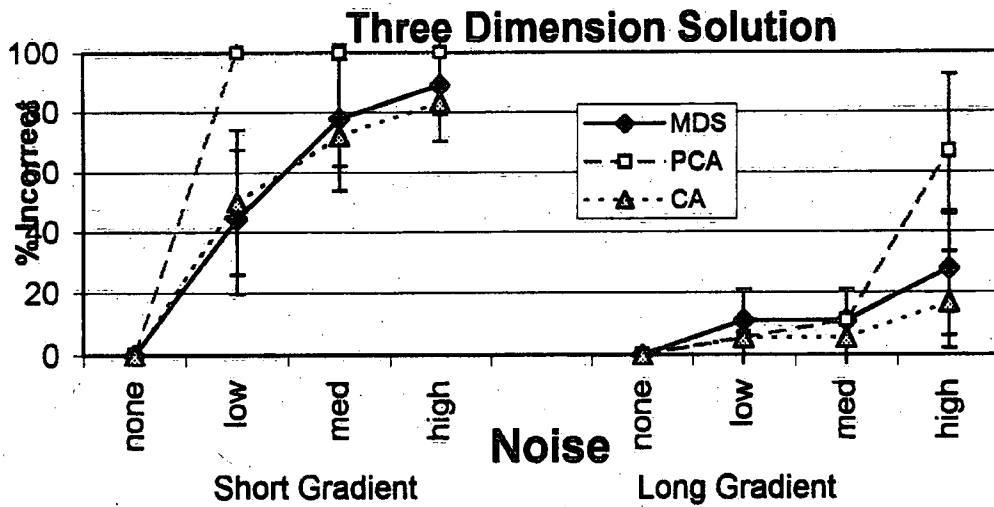
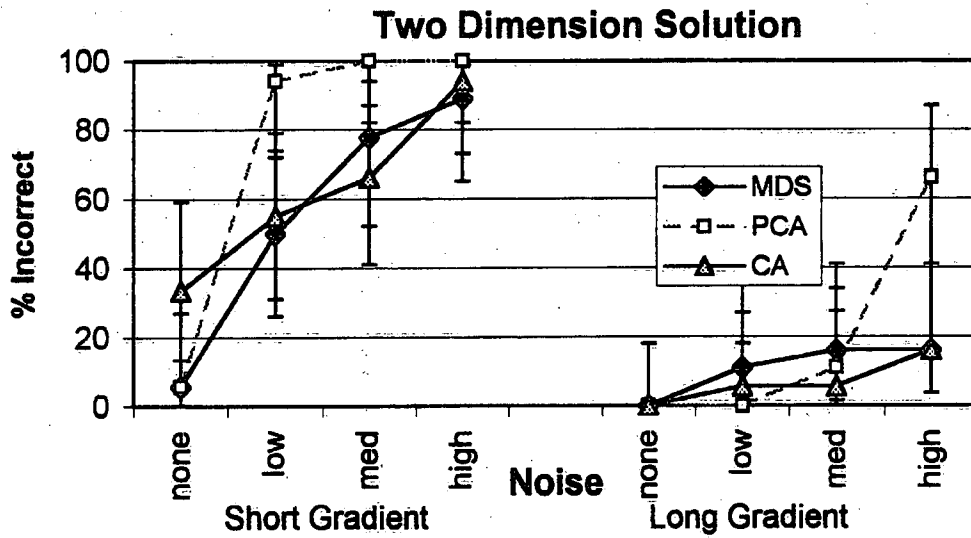
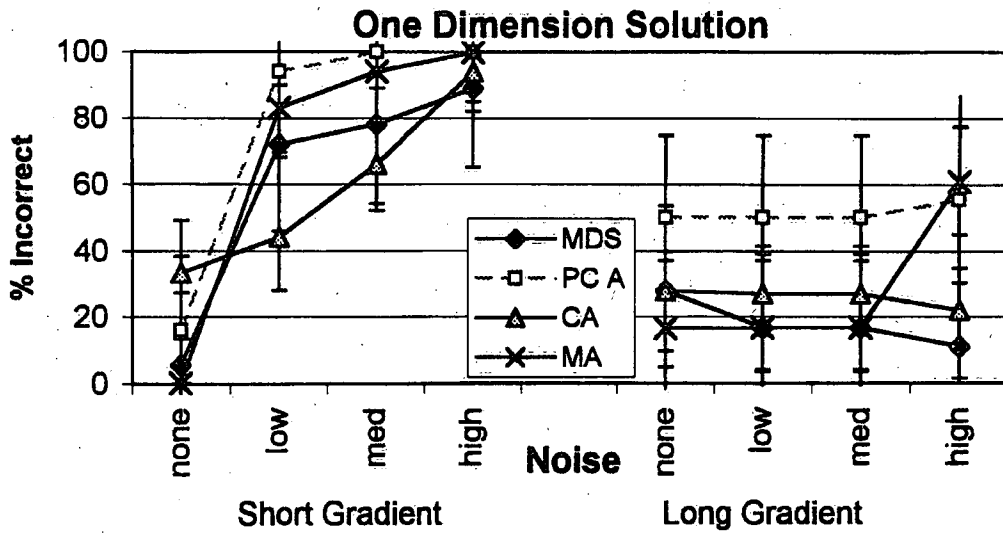


Principal Components Analysis



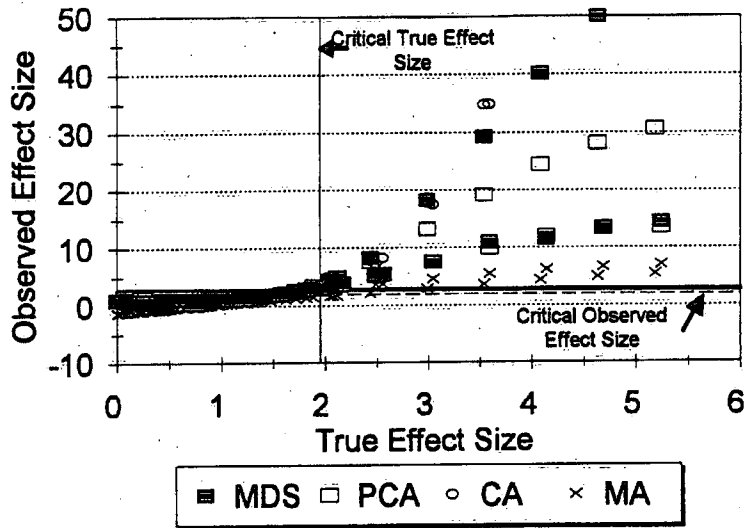
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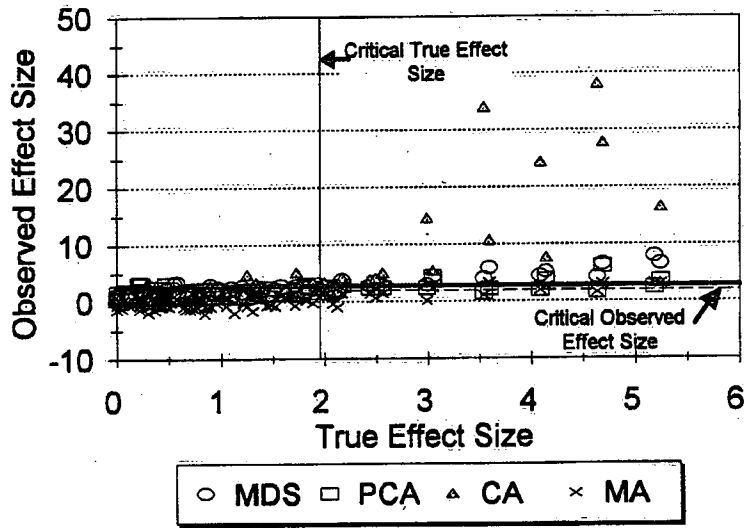


4

Long Gradient - No Noise



Long Gradient - High



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MANAGEMENT PERSPECTIVE

- Title** Comparison of ordination and model-affinity approaches for assessing impacts on communities
- Authors** Bruce W. Kilgour, R.C. Bailey, T.B. Reynoldson, and K.M. Somers
- NWRI Publication No:**
- Citation:** Journal N. American Benthological Society
- EC Priority/Issue:** The department has been in the process of developing a *Reference-Condition Approach* for aquatic ecosystem health assessment through major projects on the Great Lakes (biological sediment guidelines) and the Fraser River (FRAP). This is also being promoted as the basis for a *National Aquatic Ecosystem Health Programme*. The reference-condition approach offers a powerful alternative because sites serve as replicates rather than the multiple collections within sites that are the replicates in traditional designs using inferential statistics. With the reference-condition approach, an array of reference sites characterises the biological condition of a region; a test site is then compared to an appropriate subset of the reference sites, or to all the reference sites with probability weightings.
- Current status:** This research was conducted through a post-doctoral fellowship sponsored in part by the Science Horizons programme. One of the major problems in assessing ecosystem health is establishing effect sizes. Current thought at NWRI uses a multivariate approach for setting numeric ecosystem targets (BEAST). However, other researchers had expressed some reservations concerning the ordination methods being used. This paper compared a number of ordination methods including that being used in current software developed by the Institute. The findings of this paper supported the approach taken in the BEAST.

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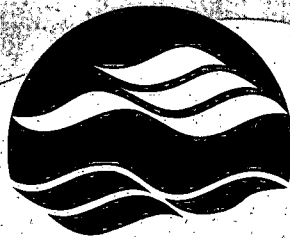
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