**Introduction**

Regime shifts in ecological research is defined in numerous ways are can be defined as changes in either the structure or underlying functioning of a system. Identifying historic ecological regime changes is achieved using post-hoc analytical approaches, and many have been tested and verified in multiple systems. Methods for reliably forecasting and predicting these changes are less common. Although numerous quantitative methods exist for detecting ecological regime shifts, new methods are proposed for achieving this aim ata XXX rate (\*insert figure of number of papers per year with new methods\*). These methods have proven useful in detecting shifts in atmospheric and fisheries catch data, and in systems that are well-described by a few state variables, or can be modelled reliably with matheamtical equations. Because ecological comunities are more complex than, say, a simple Lotka-Volterra predator prey system, the set of reliable regime shift detection methods narrows.

Ecological and social-ecolgical systems havemany unpredictable and variably interacting components. Systems analyses, including Dynamic Bayesian Networks, network models, and food webs are designed to handle these complexities, yet obtaining enough information to feed these models seems less feasible in ecosystem research and management. A survey of the methods available for detecting ecological regime shifts in high dimensional data is timely. Recent reviews of regime shift indicators (Andersen et al, the others) are outdated, are not comprehensive (include only a subset of the available RSDMs), and do not provide recommendations for which events, systems, or data characterstics are appropriate for these methods.

Some RSDMs are proposed for and are subsequently applied to data having specific characteristics, while others are proposed to be useful in multiple systems and on data of varying characterstics (e.g., Karunithi et al; Mayer 2007; Eason). This review provides a summary of the available methods and evaluates the appropriateness of these methods to data of varying character, quality, and quantity.

This paper aims to identify, describe, and critique quantitative RSDMs that have been used or proposed to detect regime shifts in ecological data. We discuss the relevant characteristics of the data/information that are required for each method, and how these characterstics may help or hinder the ecologists' interpretation of the analytical results. We pay special attention to the RSDMs that are most appropriate for analysis of high dimensional and noisy ecological data.

**Methods**

We present a concicse overview of the proposed ecological regime shift detection methods. Although many methods (XX% of those here) are ubiquitous in ecological regime shift literature, some methods have been proposed in rather specific publication outlets, or have been applied only a handful of times, thus not making it into the commonly-used and commonly-known list of methods. We conducted a systematic literature review to identify these less known methods. We used SCOPUS and Web of Science to identify these methods, using the search terms (see Appendix A for a list of the search results and Booleans specific to each database).

*Procedures for filtering searches.* We removed duplicate titles after combining the results from Scopus and Web of Science. We then read the titles and abstracts of each paper to determine whether the article introduced a new method into the literature, or was simply an application of a previously introduced method. If the method was not new, we noted the method used and the original reference (if given).

*Data gathered from papers*. We read the full text of the papers remaining after the filtering process to gather the following data:

* If this paper was an application of a method, we noted the method, and identified the orignal source for the method (if possible)
* Identify characteristics of the method
* It is model-based?
* Does it require a mathematical model?
* Does it require \*a priori\* knowledge of the regime shift
* Does it forecast or provide predicitons?
* Assumptions required (e.g., discontinuity, step functions, normality of response vars)
* Identify requirements for the data input
* Require equal spacing b/w observations?
* Minimum # data points required to use?
* Minimum # of state variables required?
* Identify the characteristics of the data USED to demonstrate the method
* Spatial resolution and extent
* Temporal resolution and extent
* Number of state variables
* System type
* Whole-system vs. selected variables?
* Experimental system or observational/passive
* Note the number of times the paper has been cited

This review is not meant to fully explore all applications of these methods, therefore twe do not present an exhaustive list of the applications of and advances in these methods. We do, however, provide references for the reader to explore further applications of these methods (see Appendix B for a list of later applications of the methods reviewed in this study).

**Results**

**Potential figures**

X = year Y = number of publications for \*new\* RSDMs in the ecol/env literature

X = year Y = # pubs for new RSDM appropriate for multidimensional systems

**Discussion**

Major findings of the review.

What major assumptions are we currently making about the data and the system that we need to know more about moving forward? i.e., where are the gaps in knowledge?

How has or how can we take advantage of unstructured or semi-structured data to ID regime shifts?

How can or should we adapt our monitoring schemes to better suit these (or at least the seemingly helpful) analyses?

What about identifying the drivers behind the shifts?

Which methods posit they can identify the, or potential, drivers of the state changes? Which have shown it?

Potential text:

Climate change is expected to induce an increase in both the intensity and frequency of rapid ecological change or disturbance, impacting social systems, potentially to the detriment of human communities most vulnerable. Identifying and forecasting these changes is critical for community and ecological planning, management, and disaster mitigation.

Because ecological and social systems are tightly coupled, we have used indicators in the environment and in wildlife communities to identify change and potential changes that may impact our social communities.

Many regime shift analytical papers suggest that, using multiple quantitative methods to provide for evidence for a regiem shift in a specific data set is necessary or is acceptable. Although this proposition is valid, comparing results within a single system using multiple methods has often yielded varying results. Managing systems using quantitative methods that yield different results may yield improper management techniques and objectives.