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Using Ant Communities for Rapid Assessment of Terrestrial Ecosystem Health

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Measurement of ecosystem health is a very important but often difficult and sometimes fractious topic for applied ecologists. It is important because it can provide information about effects of various external influences like chemical, nuclear, and physical disturbance, and invasive species. Ecosystem health is also a measure of the rate or trajectory of degradation or recovery of systems that are currently suffering impact or those where restoration or remediation have taken place. Further, ecosystem health is the single best indicator of the quality of long term environmental stewardship because it not only provides a baseline condition, but also the means for future comparison and evaluation. Ecosystem health is difficult to measure because there are a nearly infinite number of variables and uncertainty as to which suites of variables are truly indicative of ecosystem condition. It would be impossible and prohibitively expensive to measure all those variables, or even all the ones that were certain to be valid indicators. Measurement of ecosystem health can also be a fractious topic for applied ecologists because there are a myriad of opinions as to which variables are the most important, most easily measured, most robust, and so forth. What is required is an integrative means of evaluating ecosystem health.

All ecosystems are dynamic and undergo change either stochastically, intrinsically, or in response to external influences. The basic assumption about change induced by exogenous antropogenic influences is that it is directional and measurable. Historically measurements of surrogate parameters have been used in an attempt to quantify these changes, for example extensive water chemistry data in aquatic systems. This was the case until the 1980's when the Index of Biotic Integrity (IBI) (Karr et al. 1986), was developed. This system collects an array of metrics and fish community data within a stream ecosystem and develops a score or rating for the relative health of the ecosystem. The IBI, though originally for Midwestern streams, has been successfully adapted to other ecoregions and taxa (macroivertebrates, Lombard and Goldstein, 2004) and has become an important tool for scientists and regulatory agencies alike in determining health of stream ecosystems. The IBI is a specific type of a larger group of methods and procedures referred to as Rapid Bioassessment (RBA). These protocols have the advantage of directly measuring the organisms affected by system perturbations, thus providing an integrated evaluation of system health because the organisms themselves integrate all aspects of their environment and its condition. In addition to the IBI, the RBA concept has also been applied to seep wetlands (Paller et al. 2005) and terrestrial systems (O'Connell et al. 1998, Kremen et al. 1993, Rodriguez et al. 1998, Rosenberg et al. 1986). Terrestrial RBA methods have lagged somewhat behind those for aquatic systems because terrestrial systems are less distinctly defined and seem to have a less universal distribution of an all-inclusive taxon, such as fish in the IBI, upon which to base an RBA.

In the last decade, primarily in Australia, extensive development of an RBA using ant communities has shown great promise. Ants have the same advantage for terrestrial RBAs that fish do for aquatic systems in that they are an essential and ubiquitous component of virtually all terrestrial ecosystems. They occupy a broad range of niches, functional groups, and trophic levels and they possess one very important characteristic that makes them ideal for RBA because, similar to the fishes, there is a wide range of tolerance to conditions within the larger taxa. Within ant communities there are certain groups, genera, or species that may be very robust and abundant under even the harshest impacts. There are also taxa that are very sensitive to disturbance and change and their presence or absence is also indicative of the local conditions. Also, as with the aquatic RBAs using macroinvertebrates, ants have a wide variety of functional foraging or feeding groups, by whose abundance or scarcity an evaluation of the system health may be made. Much of the ground work has been done for useful ant RBAs, but it has primarily been in Australia, Europe, the US desert Southwest, and South America (Australia; Majer and Nichols, 1998, Anderson, 1991, Read, 1996, Lobry de Bruyn, 1999, Majer et al. 1984, Majer 1985, Anderson, 1997, Oliver and Beattie, 1996: Europe; Puszkar, 1978, Gomez et al. 2003: South America; Bestelmeyer and Weins, 1996, Majer, 1992, Kalif et al. 2001, Osborn et al. 1999, Estrada M. and Fernandez C. 1998: SW US and Mexico; Kaspari and Majer, 2000). However, the work already done will transport well to other ecoregions and as has been done with the IBI, it could be adapted with an appropriate investment of time and resources. It would be necessary to establish taxonomic expertise, allocate the local ant fauna to functional groups, and evaluation and modification of metrics and characteristics used to develop indicies in the existing methods. Successful adaptation and application of an ant RBA would provide a cost effective, useful, and robust tool for evaluating the health of terrestrial ecosystems anywhere in the region.

Technical Background Information

1. Rapid bioassessment in general has advantages over other methods to evaluate ecosystem change or health. The primary advantage is that RBAs, by looking at actual communities or functional groups constitute a direct measure of integrated ecosystem health rather than using physical or chemical parameters as surrogates (Barbour et al. 1999). This is true because organisms integrate all parameters within their local immediate habitat, including those that are not obvious or are even unmeasurable at the human scale. In addition, RBA's are a proven concept and have been applied to numerous ecosystems all over the world (Barbour et al. 1999) and are known to be adaptable to regions outside of the area where they were first developed (Paller et al. 1996). Another distinct advantage of RBA techniques is that they can be applied quickly and require minimum laboratory time and equipment so they are therefore exceptionally cost effective.

2. Ant communities are highly responsive to human impact (Folgarait, 1998) and other changes, and even slight modifications to their ecosystem will produce changes in the ant community (Majer, 1983; Andersen, 1997a). These changes can reflect direction and rate of specific impacts, and ants provide a reliable indicator of general change (Andersen, 1997; King et al. 1998). In addition to ecosystem health, restoration, or recovery, ant communities have shown strong correlation to other variables. These variables include total and perennial plant cover (Seymour and Dean, 2002), vegetation type (Burbidge et al. 1992), litter and soil temperature, litter humidity, and forest stand structure (Eltz and Bruhl, 2001), soil faunal richness (Touyama et al. 2002), microclimate (Torres, 1984), and soil, agricultural management, and crop variables (Peck et al. 1998). Finally, ants are widely adopted as indicator organisms as a tool in land management (Andersen and Majer, 2004)

3. Sampling procedures for ants are relatively inexpensive. Pitfall traps, either baited or unbaited, require little effort and resources and so are the most frequently used sampling method (Romero and Jaffe, 1989; Greenslade and Greenslade, 1971; Majer, 1978; Andersen, 1991; Delabie et al. 2000; Greenslade, 1973; Olson, 1991) However, a second method such as litter sifting (Olson, 1991), visual search and hand capture (Romeo and Jaffe, 1989) or other methods (Delabie et al. 2000) found genera and species which were not captured by pitfalls so that pitfalls should be supplemented with at least one other sampling technique.

4. While taxonomy of ants is somewhat complex, all ants are members of family Formicidae within the order Hymenoptera. Living ants are comprised of 11 subfamilies, 297 genera, and approximately 8800 species, with new species being described frequently (Holldobler and Wilson, 1990). However, with only a few hours of training, technicians had identification error rates of less than 13% which rapidly reduce further with experience (Oliver and Beattie, 1992). It has been found that using functional groups, genera and morphospecies make identification to species generally unnecessary for using ants as indicators of ecosystem health (Andersen and Majer, 2004; King et al, 1998)

According to Andersen and Majer (2004) ants are routinely used in diverse land-use situations in Australia, where their experience has been that the monitoring can be greatly simplified without losing its effectiveness. Because of the usefulness of simplified protocols ants can be easily and economically incorporated into environmental monitoring programs. Rapid bioassessment using ant communities can be developed and tested at SRS and regional military bases. Initial work will develop a working regional inventory of ant species and an assessment of sampling procedures as to effectiveness in including most species and all foraging guilds. Based on the species inventory, appropriate identification procedures will be developed. The next step will be adapting the actual assessment protocols to Southeastern ant communities and developing base line data from undisturbed habitats and habitats that have known histories of recovery. The final test of the concept would involve implementation at a wide range of habitat types of varying degrees of disturbance; excellent opportunities for this are available at several near-by military facilities. Investment in the development of an ant RBA will provide significant savings of time and money in future commitments and requirements for environmental impact evaluation and monitoring, restoration necessity and effectiveness, and long term stewardship issues.

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