THE ADVANTAGES OF USING ARTHROPODS IN ECOSYSTEM MANAGEMENT

A brief from the Biological Survey of Canada
(Terrestrial Arthropods)

January 1996

Biological Survey of Canada
Commission biologique du Canada

Published by the
Biological Survey of Canada (Terrestrial Arthropods)
Ottawa
1996

The Biological Survey of Canada (Terrestrial Arthropods) develops and coordinates national initiatives in systematic and faunistic entomology on behalf of the Canadian Museum of Nature and the Entomological Society of Canada.

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The Advantages of Using Arthropods in Ecosystem Management

Summary

- Human society and regional economies are tied to resources produced by ecosystems.
- Realistic information on biological diversity must be integrated into policy planning and management practice if ecosystems are to be managed for use by future generations.
- Arthropods (insects, spiders, mites, & relatives) are the most diverse group of organisms in most ecosystems and many species are well suited to provide ecosystem information.
- Ecosystem baselines that document arthropod species assemblages in a manner comparable in space and time are key to interpretation of arthropod data.
- Government departments, agencies, boards, and private sector companies and organizations with interests in ecosystem management should act to support the acquisition of ecosystem baselines of arthropod biodiversity.
- The acquisition of ecosystem baselines of arthropod biodiversity should be viewed as an integral component in the implementation of Canada's biodiversity strategy.

Introduction

Human society as we know it depends on sound ecosystem management. The provision of food, clothing, and shelter in human society generally relies on renewable resources found within ecosystems. Increasing consumption of these basic necessities results from population growth both locally and globally, and compels governments to either manage resources to ensure supply or deal with the economic, social, and political consequences of resource depletion. Resources are now being consumed at a rate that is without historical precedent and the demand is being met through unsustainable exploitation of ecosystems. Overexploitation, mismanagement, and lack of management of ecosystems have already resulted in ecosystem collapse with loss of one or more resources on a regional scale. Catastrophic ecosystem collapse has occurred twice in Canada in this century, once in the dust bowl of the prairies and more recently in the east coast groundfish fishery. Both were caused by ecosystem mismanagement and were accompanied by loss of biodiversity which led to decimation of regional economies and costly human displacement.

Biodiversity And Ecosystem Management

> *"The biological diversity of the world is almost unbelievably great. We know we are dependent on it. But currently we cannot measure it satisfactorily and our estimates of the loss of biodiversity, our working capital, are therefore conjectural. On this base of ignorance we are planning our future occupation and development of planet Earth." D.L. Hawksworth & L.A. Mound, 1991.*

The management of biological diversity in a sustainable manner is the key challenge now being faced by human societies (Hawksworth and Ritchie 1993). It is biological diversity that interacts with climate and landscape to form ecosystems. The integration of human society with ecosystems has had three principal impacts, namely environmental degradation, ecological fragmentation, and the introduction of exotic biota (Finnamore 1992). Most of our food supply is dependent on exotic species like Common Wheat (*Triticum aestivum* L.) and Cattle (*Bos taurus* L.). The net result is a global reduction of biological diversity. Wilcove (1995) discussed ecosystem management and suggested that it encompass four goals within which human activities are to be accommodated: "(1) maintain viable populations of all native species; (2) protect representative examples of all native ecosystem types across their natural range of variation; (3) maintain evolutionary and ecological processes (e.g. disturbance regimes, nutrient cycles); and (4) manage landscapes and species to be responsive to both short-term and long-term environmental change". Sound ecosystem management is key to sustained resource utilization, healthy regional economies, and long-term maintenance of human populations *in situ*.

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Realistic information on biological diversity must be integrated into the decision-making and management processes. Arthropods (insects, spiders, mites, and relatives) constitute about 64% of known global biodiversity. Biological data entering into the management process are generally obtained from the megafauna and megaflora, the "visible" living things. The "visible" biota (vascular plants and vertebrates) comprise between 2% and 6% of the estimated global biodiversity (Hawksworth and Mound 1991, Hammond 1992). The invertebrates including the arthropod fauna, the microflora and microfauna (bacteria, algae, fungi, protozoa etc.) account for about 95% of biodiversity and collectively form the "invisible" infrastructure that drives ecosystem dynamics. Invertebrates and microorganisms are crucial to the maintenance of biodiversity (Hawksworth and Ritchie 1993). Not only does species richness of arthropods vastly exceed that of vascular plants and vertebrates taken to-

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gether, but biomass of arthropods alone within natural ecosystems can exceed that of vertebrates (Lauenroth and Milchunas 1992, Wilson 1987). It follows that biotic information derived solely from the megabiota presents a skewed view of ecosystem dynamics that can contribute to poor management of resources.

Arthropods are the most diverse group of organisms in most ecosystems. Recent studies suggest Canadian biodiversity is greater than previously realized. Finnamore (1994) estimated between 6 thousand and 8 thousand species of arthropods can occur in a single rich fen, a peatland habitat common in the boreal forests of Canada. We have more species than we thought. Danks and Ball (1993) point out the central position of systematics and the importance of species level names as the link to access and organize information on the extraordinary amount of biodiversity existing in our ecosystems. The arthropods represent a vast resource of ecosystem information that is currently under used. For instance, arthropods can provide information on virtually all macro- and microhabitats within an ecosystem. They cover several size classes (micro-, meso-, and macro-fauna), exhibit a range of ecosystem requirements (highly specific to generalist) and dispersal abilities, exhibit a variety of life cycles and development times, assist in mediating ecosystem functions such as decomposition, assist in maintaining soil structure and soil fertility, regulate populations of other organisms (including arthropods, vertebrates, and plants), respond quickly to environmental changes, and act as "mobile-links" essential to the reproduction of many flowering plants (Danks 1992; Kremen et al. 1993, Wiggins *et al.* 1991). Information derived from arthropod species assemblages can be used to characterize accurately almost any aspect of an ecosystem.

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The use of arthropods as indicator species can provide highly sensitive advance warning of ecosystem changes (Holloway and Stork 1991). Some species react quickly to environmental stressors and are ideally suited to act as bioindicators. Arthropods are environmental bioindicators of habitat disturbance, pollution and climate change (Hawksworth and Ritchie 1993). Arthropods are routinely used in aquatic ecosystems to provide information on environmental quality. The advantage of using arthropod species as indicators or candidates for ecosystem monitoring is that their tremendous ecological diversity provides a wide choice for designing appropriate assessment programs (Kremen et al. 1993) which can be applied for both short-term and long-term monitoring.

The use of arthropods in ecosystem analysis is cost effective. Arthropods are easily, quickly, and cheaply sampled, thereby providing means to obtain timely, cost-effective ecosystem information. Detailed sampling protocols exist for virtually all groups of arthropods in habitats ranging from derived soils in forest canopies to deep groundwater fauna (Marshall et al. 1994). Furthermore, arthropods are generally not in the "public eye" and there are few of the impediments to sampling associated with vertebrates. Species identification of arthropods generally does not have the problems associated with identification of fungi or bacteria where DNA analysis and fatty acid profiles must often be employed. With some training nonspecialists can identify most groups of arthropods to species level where systematic treatments are available. The use of morphospecies further permits the sorting of unworked arthropod groups into meaningful categories by nonspecialists.

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Arthropods are ideal candidates to monitor the subtle effects associated with habitat fragmentation. Fragmentation of ecosystems subdivides populations and imposes barriers to dispersal. These barriers limit gene flow and preclude migration as a response to environmental change (Ledig 1992). The fragmented populations contain only a part of the original gene pool and often are subject to substantial genetic drift and loss of genetic diversity (Brown 1992). Geographically circumscribed species with little genetic diversity have proven highly prone to extinction (Ehrlich 1992). Genetic diversity of arthropod populations in fragmented ecosystems can be measured and the rate of genetic drift assessed with respect to non-fragmented populations. In this way advance warning of ecosystem changes due to fragmentation can be obtained and policy and management practice modified to reduce its impact.

Fossil remains demonstrate that arthropod species are robust over long periods of time, and that, given the opportunity, they migrate with changing conditions rather than evolving new species (Elias 1994). Arthropods are of exceptional value in the reconstruction of paleoenvironments because they are able to provide detailed, precise information on vegetation, soils, water quality, vertebrate species composition, forest composition and degree of stress (Elias 1994). Information on arthropod species derived from present ecosystems is used to place fossils of the same species in ecological perspective and to reconstruct past environments. Shifts of fossil arthropod species assemblages can be used to assess biotic shifts resulting from environmental stressors or long-term climate change, because present ecosystem data can be adjusted to account for recent anthropogenic changes. Such a long-term perspective is necessary for meaningful assessment of eco-system wide biotic shifts. These assessments allow proactive development of policy and the implementation of management practices to reduce the impact of projected climate changes or ecosystem stressors.

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Conclusion

The management of biodiversity for use by future generations is a principle embodied in both the Canadian Biodiversity Strategy and the United Nations Convention on Biological Diversity. Sustainable exploitation of ecosystems is possible if realistic information on biodiversity were to be integrated into policy planning and management practice. Arthropods comprise most of our biodiversity and are well suited to provide detailed information on ecosystems at a small scale thereby complementing information obtained with other organisms.

Many of the barriers to using arthropods in this manner can be resolved through a shift in government priorities to support the acquisition of ecosystem baselines that document spatial-temporal referencing for arthropod species assemblages. Baselines or benchmarks are data sets (specimens and databases) against which similar, usually smaller collections, of data can be viewed in perspective to provide an interpretation that reflects ecosystem reality. On a per species basis arthropods will prove far less costly than in the case, already accomplished, of vertebrates and vascular plants. Moreover, arthropod data will provide much higher ecosystem resolution for the investment. It is in the interests of governments and the private sector to acquire realistic information on biodiversity by acting to support the acquisition of arthropod baselines. The acquisition of ecosystem-based arthropod baselines should be viewed as an integral component in the implementation of Canada's biodiversity strategy and as essential to policy development and management of our ecosystems for use by future generations.

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Thanks to R.S. Anderson, H.V. Danks, D. Marcogliese, and P. Roberts-Pichette for their valuable suggestions and improvements to the manuscript.