Eco-informatics: The Encouragement of Ecological Data Management

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Abstract

Purpose – The purpose of this research is to study the ecological developments that are growing rapidly and are complemented by technological developments that make ecology a discipline which is able to collaborate, integrate, and use data for the development of science.

Design/Methodology/Approach – The method involves integration, analysis, and conclusion, drawing knowledge dissemination from heterogeneous ecological data that make the ecological research so complex requiring an approach to simplify the problem.

Findings – The data involved in ecology are very complex and diverse and spread from various sources, which are not mutually integrated so that a structured arrangement is required through the arrangement of computer-based data management.

Research Limitations/Implications – Eco-informatics is one of the options to manage the data, settings, and transform it into information and knowledge.

Keywords Ecological, information, eco-informatics, data, management, knowledge

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1. Introduction

Ecology has grown rapidly and is increasingly transformed into a more extroverted, interdisciplinary, liable, collaborative, and intensive database. Heterogeneous data in ecology has made researchers more interested in finding, integrating, and analyzing huge numbers of complex data into meaningful data on a scale from the gene to the biosphere. One of the models used by researchers is with eco-informatics that offer apparatuses and ways to deal with overseeing information of ecological data and changing information into significant information and knowledge.

Eco-informatics is a fresh discipline and a blend of ecological science, information, and communication technology. So it becomes a new discipline that can acquire, integrate, analyze, store, and be able to access various information about the ecology which is so massive and complex by using various new technologies in the computer science field, such as information-based sensor technology, advanced computational methodologies and database systems, and wireless data network-based biological computation algorithm. These abilities make eco-informatics in solving ecological-related problems and ultimately lead to new inventions of cross-science on an ecological basis. Several studies related to eco-informatics have been conducted, such as eco-informatics, biodiversity, etc. (Bisby, 2000; Canhos *et al.*, 2004; Guralnick and Hill, 2009; Dengler et al., 2011, 2012a, 2012b)

Before eco-informatics elaborated on a part of the ecology, studies were limited to physical portraits and observations of animals. However, after eco-informatics developed the influence of computer-based technology, the ecology is effective in managing huge numbers of datasets and significant and utilizes the advanced technology-weather sensors, wireless data networks, and computational methodologies. Therefore, ecology becomes a new area of science that continues the research. Since the complexity of ecology is necessary to utilize, assess, assimilate, and disseminate information technology for various applications for ecology. As the consequence of revolution in ecosystem services, biodiversity conservation, rural community economies, the information technology has had an impact on ecology through documentary changes and biodiversity in explicit spatial detail, provision of automatic sensors, changes in environmental conditions at specific locations, GPS tags in animals by recording their path movement with precise spatial and temporal precision, etc.

The application of eco-informatics in ecology can help researchers measure ecosystem changes more accurately or predict trends. Many technical processes, in general, can improve the ability of researchers in the subject area of ecology to provide good results to the public especially in this era where the validity and legitimacy of science are often questioned in the media so it requires scientific proof.

One of the most complicated challenges is bargaining between the scope of ecology and variability on a large scale encountered, from microbes, the dynamics of the community, the community of organisms that inhabit a place, plants, etc. Therefore, it requires comprehensive completion and involves various disciplines. The integration, support, and implementation of technology in ecology are needed as part of the ecological manifestation of ecological management due to easily comprehended. As eco-informatics is one answer of many repartees to the problem, it is needed to understand and apply its tools in detecting, evaluating and predicting patterns and processes ecology, complex ecosystem arranging and software engineering for the model of construction and testing. Therefore, one step to address the problem is to build software for ecology and remember the complexity of ecological problems with the aim of initializing the stages of this study. The software built is limited only for the enlargement of taxonomic databases with the aim of generating information that is able to be applied in the enlargement of related knowledge and decision making to ecologies such as in agriculture and industry.

This research is expected to give advantage for biologists and ecological researchers since they confront progressively challenging inquiries that demand huge numbers of information and through various disciplines, space, and time so they are able to be implemented as a capable form of producing ecological information through development exploitation solutions ecological's data management software.

2. Ecology

Ecology is frequently pointed to as the basic science of the environment. Based on their understanding, ecology contains the study of plant and animal populations, plants and animal communities, and their ecosystems. The ecosystems explains the relationships between organisms on different scales. Fulfillment of human needs can be fulfilled by the management of the environment. Through environmental management, there is a mutual relationship between the biophysical and the social environment. This means it has to do with the concept of ecology, especially about interrelated relationships between the biophysical and social environment. Thus, when talking the environment, the ecological concept will always be linked, so that environmental issues are ecological problems.

The current ecology has turned into an informatio-exhaustive science (see Glossary) (Hey *et al.*, 2009; Kelling *et al.*, 2009). A study by Michener and Jones (2012) relied on a large amount of collecting data by two remote sensing platforms (Jensen 2006) and network sensors embedded in the environment (Collins *et al.*, 2006; Porter *et al.*, 2009; Rundel *et al.*, 2009; Benson *et al.*, 2010). Ecology is influenced by changes occurring in the enlargement of science overall. Specifically, researchers, proficient social orders, and research funders recognize the price of data as an outcome of logical undertaking and place upgrading weight on services of data, sharing of data, and support of repetition studies and openness (Hackett *et al.*, 2008; Whitlock, 2010). Expanding the area of ecology in other fields has made ecology is a field that can collaborate widely with other fields and has a broad and team-based network (Michener and Waide, 2009; Peters *et al.*, 2008; Gosz *et al.*, 2010; Michener and Jones, 2012). For instance, research in the USA that focus on long-term ecological research. The study has relationship with the information system as a data sharing facility and data combination for the aim of integration with various disciplines.

3. Eco-informatics

Eco-informatics, sometimes written as eco-informatics or ecological informatics is a governance arrangement and analysis of ecological information and as a facility for research on the ecology of the very large skill through the computer technology application (http//www.ecoinformatics.org). Eco-informatics also has been explained as a framework that supplies the occasion for scientists to develop and produce a new knowledge through innovative tools and methods of approach through the latest discovery, compliance, integrity, analysis, visualization, and protection related to biology, environment, and socio-economic data and information, so that solutions can be developed eco-informatics that support and facilitate any new discovery, analysis, and integrity of ecological data in an effective information management and efficient, user friendly interactions between users and computers.

Recknagel (2006) describes eco-informatics in an editorial as a study across disciplines in understanding the processing of information that starts from genomes to biological communities or ecosystems, the metadata idea for information management ecology, clustering, computational ordination, and predicting on ecological communication are complex and facilitate notified supportability for ecosystem management sustainability. Eco-informatics in establishing a process for a database management to produce a new knowledge that has the infrastructure is given in Figure 1, which is the model component of the following eco-informatics.

(1) *Data:* The ecological data are relatively massive and complex. The data that exist at the first level of the data component has four stages so that they can be applied in the next component, that is, primary data storage, syntactic metadata, access technology, and indexing catalog. The term metadata is data model that describes data and may represent key elements for transforming various datasets that have been placed into useful resources in terms of content, context, structural quality, and accessibility (Michener *et al.*, 1997).
(2) *Information:* The information in eco-informatics infrastructure defines as a link between data and knowledge. Information in Figure 1 can integrate and store existing data in the ecology.
(3) *Knowledge:* Knowledge is the outcome of processing and data analysis so that a collection of important knowledge should be trained and placed in a knowledge base and or it can be an expert system as part of eco-informatics development. The knowledge gained can be represented as logical representation, or it can be as production rules, semantic networks, frames, and characteristic representations.

4. Data life cycle

Data life cycle (DLC) or life cycle data is a sequential stage for management and preservation of data that has the characteristics of each of these stages. DLC is the process for all stages that are able to produce new information and knowledge. The DLC stages are pretty much different and vary rely on the domain and community that use them. For the case of data management of eco-informatics, the DLC used is a data life cycle model proposed by the National Sciences Foundation in collaboration with Data One (Strasser *et al.*, 2011)

Figure 2 illustrates the eight stages of the DLC that can be explained as follows:

Planning is a step to describe the data to be managed and compiled and it can be accessed at any time. *Collecting* is a step taken to obtain data through observation, interviews, or related references either by direct or through other instruments so that the data can be

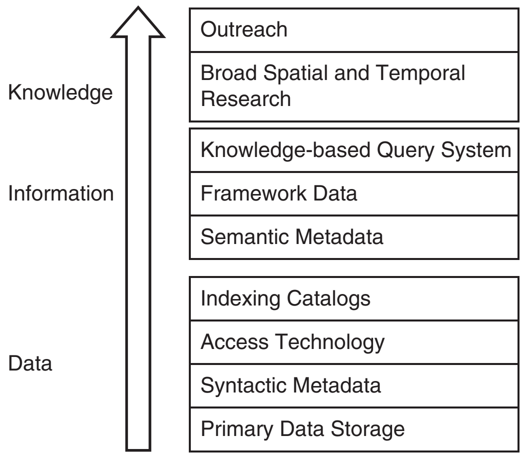

Figure 1.
Component Model of Eco-Informatics Infrastructure (Brunt *et al.*, 2002)

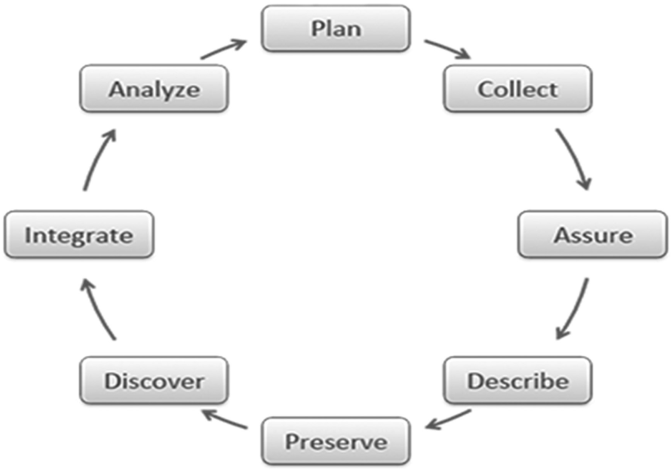

Figure 2.
Eight Stages of Data Life Cycle (Strasser *et al.*, 2011)

placed in the digital form. *Providing assurance* ensures the quality of data collected. Quality assurance can be done through testing and examination; *Explaining* is a step to explain and set out data accurately and comprehensively using metadata with standards that exist in the metadata. *Maintaining* or maintain data is a step in maintaining the data so that it can be applied all the time through storage in the form of archives in accordance with the needs of the period such as the existence of a computerized system, it is possible for the data center. *Finding* is a step in finding potential data and can be applied to obtain relevant information about the data, in this case, is metadata. *Integrating* is a stage of combining data from many and different resources so it is easy to analyze. *Analysis* is to analyze the data.

Through the stages in Figure 2 knowledge can be derived through mastery and proficiency in data management to be able to change it in the information are connected together in a unified frame of scientific facts, principles, and theories that can serve benefits for a research related to informatics-based ecology.

5. Conclusion

Eco-informatics evolved as an area of the ecology and computer discipline that studied the principles of data processing into information in the ecosystem so that it can be applied as a shape of analysis and synthesis in ecosystem forecasting. Eco-informatics also concentrate on the integrated data and sharing data of ecosystem from the genomic level to the scene level on a spatial scale different from GIS, remote sensing, and data warehousing. Eco-informatics has also been able to overcome the very complexity of ecological problems by utilizing computational technologies, such as evolutionary computation, deep learning neural network, and cellular immunology to uncover ecological complexities, and to clarify and estimate ecological system's feedback on habitats and climate change. For the future, it is expected that eco-informatics will be expanded as eco-informatics provide solutions to the ecological problems such as data sharing through the use of internet media and data warehouse, integration, and visualization of field data through GIS and utilization of various methods on data mining for classification, clustering, and prediction of ecological issues.

References

Benson, B.J., Bond, B.J., Hamilton, M.P., Monson, R.K., Han, R. (2010). Perspectives on next-generation technology for environmental sensor networks. *Frontiers in Ecology and the Environment*, 8, pp. 193–200.

Bisby, F.A. (2000). “The Quiet Revolution: Biodiversity Informatics and the Internet”. *Science*, Vol. 289, pp. 2309–2312.

Canhos, V.P., Souza, S., Giovanni, R. and Canhos, D.A.L. (2004). “Global Biodiversity Informatics: Setting the Scene for a “New World” of Ecological Modeling”. *Biodiversity Information*, Vol. 1, pp. 1–13.

Collins, S.L. *et al.* (2006). “New Opportunities in Ecological Sensing using Wireless Sensor Networks”. *Frontiers in Ecology and Environment*. Vol. 4, pp. 402–407.

Dengler, J., Jansen, F., Glo«ckler, F., Peet, R.K., De Ca¨ceres, M., Chytry, M., Ewald, J., Oldeland, J., Finckh, M., Lopez-Gonza¨lez, G., Mucina, L., Rodwell, J.S., Schamine¨e, J.H.J. and Spencer, N. (2011). “The Global Index of Vegetation-Plot Databases (GIVD): A New Resource for Vegetation Science”. *Journal of Vegetation Science*, Vol. 22, pp. 582–597.

Dengler, J., Oldeland, J., Jansen, F., Chytry¨, M., Ewald, J., Finckh, M., Glo«ckler, F., Lo¨pez-Gonza¨lez, G., Peet, R.K. and Schamine¨e, J.H.J. (2012a). *Vegetation Databases for the 21st Century,* Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Hamburg

Dengler, J., Berendsohn, W.G., Bergmeier, E., Chytry¨, M., Jansen, D.J.F., Kusber, W., Landucci, F., Mu«ller, A., Panfili, E., Schamine¨e, J.H.J., Venanzoni, R., von Raab, Eckhard and Straube, R.E. (2012b). “The Need for and the Requirements of EuroSL, an Electronic Taxonomic Reference List of all European Plants”. *Biodiversity and Ecology*. Vol. 4, pp. 15–24.

Gosz, J., Waide, R. and Magnuson, J. (2010). “Twenty-Eight Years of the US-LTER Program: Experience, Results, and Research Questions”. In F. Müller, C. Baessler, C., H. Schubert and S. Klotz. (Eds.), *Long-Term Ecological Research*, Springer, pp. 59–74,

Guralnick, R. and Hill, A. (2009) “Biodiversity Informatics: Automated Approaches for Documenting Global Biodiversity Patterns and Processes”. *Bioinformatics*, Vol. 25, pp. 421–428.

Hackett, E.J., Parker, J.N., Conz, D., Rhoten, D. and Parker, A. (2008). “Ecology Transformed: The and the Ecological Research”. In G.M. Olson, A. Zimmerman and N. Bos (Eds), *Scientific Collaboration on the Internet*, MIT Press, pp. 277–296.

Hey, T., Tansley, S. and Tolle, K. (2009). *The Fourth Paradigm,* Data-Intensive Scientific Discovery. Seattle, Washington: Microsoft Corporation.

Brunt, J.W. *et al.* (2002). “The Future of Ecoinformatics in Long-Term Ecological Research”. In *Proceedings of the 6th World Multi-Conference on Systematics, Cybernetics and Informatics* 14–18 July, Orlando, FL.

Jensen, J.R. (2006). *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Edition, Pearson Education, Prentice Hall, Upper Saddle River.

Kelling, S. *et al.* (2009). “Data-Intensive Science: A New Paradigm for Biodiversity Studies”. *Bioscience*, Vol. 59, pp. 613–620.

Michener, W.K. *et al.* (1997).:Nongeospatial Metadata for the Ecological Science”. *Ecological Application*, Vol. 7, No. 1, pp. 330–342.

Michener, W.K. and Waide, R.B. (2009). “The Evolution of Collaboration in Ecology: Lessons from the United States Long Term Ecological Research Program”. In G.M. Olson, A. Zimmerman and N. Bos. (Eds), *Scientific Collaboration on the Internet*, MIT Press, pp. 297–310.

Michener, W. K. and Matthew B. J. (2012). “Ecoinformatics: Supporting Ecology as a Data-Intensive Science”. *Trends in Ecology and Evolution*, Vol. 27, No. 28, pp. 85–93.

Peters, D.P.C. *et al.* (2008). “Living in an Increasingly Connected World: A Framework for Continental-Scale Environmental Science”. *Frontiers in Ecology and Environment*, Vol. 5, pp. 229–237.

Porter, J.H. *et al.* (2009). "New Eyes on the World: Advanced Sensors for Ecology". *Bioscience*, Vol. 59, pp. 385–397.

Rundel, P.W. *et al.* (2009). "Environmental Sensor Networks in Ecological Research". *New Phytology*, Vol. 182, pp. 589–607.

Strasser, C. *et al.* (2011). "DataONE Promoting Data Stewardship through Best Practices". In Jones, M. B. Jones and C. Gries (Eds) *Proceedings of the Environmental Information Management Conference*, University of California, pp. 126–131.

Whitlock, M.C. (2010). "Data Archiving in Ecology and Evolution: Best Practices". *Trends in Ecology and Evolution*, Vol. 26, pp. 61–65. Available: http//www.ecoinformatics.org (Accesed 18*th* October).

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