

A Conceptual View for Advancing Monitoring and Assessment of Land Resources in the Mexican State of Jalisco

Celedonio Aguirre-Bravo, Research Coordinator for the Americas, Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO

Abstract—This paper addresses key elements of a conceptual view for advancing monitoring and a variety of applications to land resources and environmental management in the state of Jalisco, Mexico. Fundamental to this conceptual view is what we know about the structure and functioning of nature: the spatial and temporal dynamics of processes (for example, objects, outcomes), the multirelational matrix of cause-effect relationships, the uncertainty of location and duration of outcomes, and the power of human intelligence that can alter the structure of order in nature. Because knowledge is constantly evolving, we discuss why a new vision of monitoring is needed and how to implement it so through the appropriate use of changing technologies. Articulation of this evolving vision in order to make it operational across the actors and players of the sustainability equation is perhaps the most defining challenge that individuals and institutions face now and in the years to come. The Jalisco Monitoring Pilot Project, an ongoing process of intellectual discovery for practical applications, has provided the fertile ground and multidisciplinary environment for structuring and advancing this conceptual multirelational view of monitoring and assessment of ecological and economic systems.

Introduction

Most forms of human interaction with the natural environment are increasingly challenged by the growing complexity of systems interdependence (for example, ecological, social, economic, cultural) at multiple geographical scales. Because human activities and impacts transcend geopolitical boundaries (for example, nations, states, counties, property rights), orthodox distinctions between matters of individual, local, regional, national, and global significance are taking a new direction, one that is guided by sustainability principles that cut across natural and human systems. While a variety of conceptual sustainability views have gained worldwide political support, as indicated by the proliferation of accords between and among national governments, making them operational has been and will be one of the most serious institutional challenges in the twenty first century.

Information and knowledge is central to understanding the multi-relational physical nature of sustainability. No complete and uncompromising theory about sustainability, whether scientifically-based or not, exists and will ever be proposed to the scrutiny of the human world. What one knows about sustainability is also a multi-relational process where cultural contexts condition to a large

extent what one perceives, recognizes, sees, measures, and understands. Cultural contexts by themselves are also multi-relational processes. Recognizing their uniqueness is central to how they measure, understand, improve, and maintain the sustainability of ecological, economic, social, cultural, and political systems. There is no such thing as one way road towards sustainability science and its supporting research and monitoring processes.

When formulating a conceptual approach to monitoring and assessment one has to take into account the multi-relational reality of nature in space and time. For example, nowhere and at no time is what we can or can not recognize and measure exactly the same; nothing remains the same as it was originally created. Material (for example, objects, structures, things) and non-material things (for example, energy, thoughts, decisions, knowledge, etc.) are under flux, at different dynamics, therefore taking place at different locations and times, and at distinctive spatial and temporal resolutions. Life forms (for example, micro-organisms, plants and animals, populations, communities, landscapes, ecosystems, etc.), their attributes and health, and all other components (for example, soils, landforms, etc.) and processes (for example, water, climate, fire, etc.) of their physical environment are subject to the uncertainty of how causal forces (potential energies) converge in space and time.

Human processes, whatever their nature (for example, government, policy, the economy, social, educational, cultural, cities, corporations, individuals, etc.), no matter the geography of their location, they are also subject to the same principles and laws of nature.

Given the multi-relational nature of the world we inhabit we can expect a myriad of responses with respect to questions of monitoring and assessment of ecological and economic systems. Each response will be different in terms of perceiving, recognizing, measuring, assessing, and understanding the causal structure of problems and issues and the multi-relational dimension of their nature. For example, what is the current extent and condition of land resources, particularly forests and agricultural lands? Were the question asked by a government institution, it would generate a chain reaction of response processes across the hierarchies of the human dimension. Few will be interested in listening to the response of a farmer who lives in the remote Sierra Madre Occidental in Mexico. How that person perceives the question would be different from an intellectual in Mexico City, or from a German Green Peace activist. Scientists, particularly statisticians, may never agree on how best to monitor and assess what the question implies. However, they are expected to reach a consensus about a sampling strategy. In a multi-relational world, where the potential becomes the real, the design of monitoring and assessment programs must always take into account the probabilistic framework of how events and processes in nature occur in the dynamic matrix of space and time.

The success of monitoring and assessment programs will be determined in terms of their dynamic performance as to how significant and meaningful their outputs are to answer, describe, and explain the multi-relational nature of the question's object of study, but most importantly, the probabilities and uncertainties associated to their spatial and temporal dynamics. Global estimates to address these questions are useful, but they are powerless when accurate spatial and temporal information is needed to address local sustainability problems and issues, at fine resolution levels. This paper addresses these and other institutional challenges encountered while formulating a conceptual framework for inventorying and monitoring the land resources of the state of Jalisco in Mexico.

Why a New Vision

It is in the nature of the multi-relational world we live in that nothing we do will ever be the same. Each time a knowledge quantum leap takes place it has served the purpose of its time. Creativity process then takes care of evolving that knowledge towards higher levels of

enlightenment so that we can understand its dynamic multi-relational nature. In a way, knowledge is the past, while new discoveries are the present, thereby creating new dynamic conditions for exploring and understanding the future. Decades ago, for example, there was a sort of a revolution in the scientific and technical domains of agriculture, forestry, natural resources, and the environment. New sampling and statistical analysis methods and approaches for inventorying and monitoring forest and natural resources came to be and served well the needs and challenges of their time. In today's world, that knowledge and technology represents the past; it is powerless to address the multi-relational nature of needs and challenges of today and future generations.

Change has brought us to a new dynamic condition so that institutions and people can begin to address complex needs and challenges of their time. Nature in the myriad forms of how it comes to be and perceived it is never the same. Welcome to the "Knowledge Age Era," the time of knowledge workers, where more and more people are being enabled to understand the complexity of living in a dynamic multi-relational world of physical processes, the foundation of systems sustainability, whether they are ecological, economic, social, cultural, political, unified, or nondenominational. It is at the intersection of these systems, in each spatial and temporal point of the world geometric grid, where processes of multi-relational nature converge to bring about what we can perceive and recognize (for example, things, objects, structures, information, knowledge), and perhaps measure, the ultimate condition where information and knowledge exists in dynamic unified form. When we function at this level of knowledge resolution, which is the fertile ground for sustainability science and policy, then the voids that separate facts and actions dissolve, and the "what is" can then be perceived, recognized, measured, improved, maintained, and sustained within the changing framework of their spatial and temporal dynamics. From this dynamic multi-relational vision of the world, a seamless web of cause-effect relationships—and options for investigating and acting upon them—become clearer for advancing research, monitoring and assessment, as well as policy and decision making for sustainability.

How this vision is articulated to advance monitoring and assessment of land resources in the Mexican state of Jalisco will significantly impact the scientific and economic utility of products and outcomes to support policy, planning, and decision making processes. The vision implies that fundamental changes have to take place in the current technical and scientific establishment that is responsible for how monitoring and assessment programs are designed and carried out. Important issues and considerations to take into account include the

following: (1) things in nature are the resulting events of convergent multi-relational processes; (2) things in nature have their own spatial and temporal dynamic framework; and (3) things in nature have a probabilistic pattern of spatial and temporal distribution. Everything that has “matter matters massively (Schearer 2004)” as far as these considerations for advancing monitoring and assessment strategies and programs.

Technology to Make it So

Knowledge has become the most fundamental organizing principle driving technological progress into the 21st century. New ways of generating, presenting, and distributing information and knowledge to institutions and people are significantly changing how we learn, create, plan, decide, work, and live. Today, we live in a multi-relational world that is being rapidly transformed by advances in high-speed computing, communications, and information technologies. Better and more powerful technologies are connecting people-to-people, scientist-to-scientist, resource manager-to-scientist, people-to-digital libraries and instruments, and people-to-institutions and markets around the world. In this technological revolution, connectivity and networking have become common denominators of ongoing multi-relational processes, at all geographical scales. Now the human dimension is like a global virtual mind that is empowering people throughout the world to become effective stakeholders in the pursuit of knowledge for multiple applications.

What is happening today is just a glimmer of the rich possibilities of the Knowledge Age that is emerging. Quantum leaps in computational power, connectivity, and user-friendly technologies to improve learning and creativity processes are now part of our multi-relational reality. Many of these astonishing developments will experience significant improvements in the near future. In many ways, they are significantly enhancing our ability to explore, discover, collect, analyze, represent, transmit, and apply information, thereby improving the way we generate knowledge for planning, decision making, scientific research, engineering, education, business, management, and policy making. The common goal that seems to fuel this technological explosion is to create networked systems that can make all kinds of knowledge available to everyone, located anywhere, at any time. As this emerging paradigm continues to unfold, it becomes clear that its outputs could become powerful multipliers of progress in a wide range of scientific, educational, social, and economic endeavors.

Driven by these transformations, people and institutions around the world are continuously reassessing

and redirecting their programs and capabilities. Central to these processes is how to handle and interpret the enormous amounts of data and information that accumulate at increasing rates, and how to transform them into knowledge that is meaningful to users spatially. Knowledge that has no connection to location and context has limited value to people and society. However, the magnitude of these challenges pales in comparison to the socioeconomic and cultural challenge of transforming more and more people around the world into Knowledge Workers. New strategies for representing and distributing spatial knowledge are not only essential for advancing human intellectual progress, but also for confronting complex economic and environmental sustainability problems. Enabling people and institutions to be effective stakeholders through the power of spatial and temporal knowledge is the greatest sustainability challenge facing institutions in the 21st century.

Harnessing the power of the Knowledge Age is essential for ensuring the well being of future generations. The great technological transformations of this new era are now making it possible to represent knowledge within a geo-spatially explicit framework, at any spatial and temporal scale, and to distribute it to society throughout the world via a variety of electronic means. Spurred by this technological evolution, the development of Geo-Spatially Explicit Knowledge (GSK) may be the most defining technological innovation of the early 21st century. Potential uses and applications of GSK are seemingly endless. The growth in the content, capacity, connectivity, and flexibility of technologies to represent and communicate GSK is so powerful that it is dramatically reshaping relationships among people and organizations, and quickly transforming our processes of discovery, learning, exploration, cooperation, and communication. Realizing this potential is an essential response to a 21st century that is being shaped by science and rapidly changing technologies.

How to Articulate this Vision

Today, because we know more about the workings of the human mind and the nature of our multi-relational world, have the technological capabilities to collect and generate tremendous amounts of spatial and temporal data, and have learned the lessons of failed scientific and technical paradigms, there is a growing understanding that there exists an opportunity to simultaneously improve the human condition and the sustainability of ecological systems.

Through modern psychology, we have gained a greater understanding of how the human brain works and how

information is received, processed, and retained. It is known that people have the ability to absorb billions of bits of information instantly. When the brain receives information that is in an isolated form and disconnected from a larger multi-relational context, its significance is analogous to that of a single piece of a jigsaw puzzle. Any one piece has very little meaning in and of itself. However, when each of the individual pieces of the puzzle is seen in the context of the adjacent pieces, a picture begins to form which is recognizable and has meaning. Historical means of information transfer have presented information as an individual puzzle. Future methods and approaches will have to present the information in a complete contextual, multi-relational, and integrated framework.

Spatially explicit model representations of the multi-relational nature of things and processes are analogous to a time series of high resolution digital pictures taken of a forest site. As pictures, spatial models are means to aid and improve how people best acquire, retain, analyze, synthesize, and utilize geo-spatial information for multiple applications. Fundamental to articulating this conceptual view is the consideration of the value of any bit of information in its spatial and temporal multi-relational contextual location. Each information bit takes on greater meaning when it can be viewed in relation to its position in space and time relative to neighboring bits. Higher utility is achieved when it is possible to view the change of each bit as a function of time or other relational variable. Technological advances in geo-spatial sciences provide us with a flexible and adaptable approach to acquire, analyze, model, visualize, and disseminate spatially- and temporally-explicit information and knowledge to wider audiences quickly and efficiently.

A fundamental revolution is taking place in the geo-spatial sciences with tremendous implications in fields as diverse as those related to sustainability science and applications. Historically, for example, modern medicine has taken the approach that people are generic and that those with similar conditions or ailments constitute a common human landscape to be prescribed similar medicines and/or treatments. Under the traditional paradigm, the human population is treated homogeneously without regard for the unique attributes of each individual. Visionaries see the day when medicines and prescriptive treatments will be developed on a person-by-person basis (in the language of geo-spatial sciences, on a pixel-by-pixel basis). In other words, the correct prescription for a person with a certain ailment will be tailored to reflect the unique genetic, chemical, and other multi-relational features of that individual. The logical extension of this thinking is expected to be the anticipation and treatment of medical problems well in advance of their arrival. For

example, a 30 year old person will be treated with an individually designed medicine for a cancer that has not yet appeared but will develop at about age 50 and be fatal to the person at about age 60. Analogous thinking can be applied to the design of new geo-spatially monitoring strategies for the assessment of ecological and economic systems sustainability.

Historically, research and monitoring have been conducted on a landscape type and as a result vast generalities were identified that were then applied to all other similar landscapes. However, in this model, little or no consideration was made of the multi-relational nature of the landscape (for example, climate, soil chemistry, air quality, human impact, hydrology, etc.) and its temporal and spatial dynamics. A more enlightened approach to sustainability science will have to evaluate natural systems on a pixel-by-pixel basis for their unique social and environmental circumstances. Then, unique management prescriptions can be made to reflect both societal and environmental needs. With the advent of geo-spatial sciences, a variety of spatial and temporal information layers are able to be developed which allow for the accounting of the myriad relational variables that influence the expected outputs in each point (pixel) of the space-time matrix of a given geographical area. As such, land resource management prescriptions can be made which reflect the multi-relational nature of a landscape in the same way that future medicines will reflect the unique traits of a person.

Conclusion

It is now clear to a growing number of people throughout the world that a new paradigm in sustainability science is emerging. At the center of this new way of thinking is how research and monitoring methods need to be adapted to the technical and scientific challenges of providing the appropriate data and information to advance the understanding of ecological and economic sustainability and its spatial and temporal dynamics, at multiple resolution levels. No longer will it be satisfactory to disseminate information and knowledge to stakeholders in forms that are obscure and interpretable only to those familiar with the technical or scientific arcana. Disappearing are the days when it was acceptable to make policy and management decisions derived solely from general information that is not multi-relational to a particular geographical landscape.

In the 21st century, the geo-spatial knowledge era of sustainability science, it will be necessary to ask what is the solution to the problem that is found on a particular landscape having a certain set of time-dependent

multi-relational processes and features, and define the solution at a resolution of one pixel (regardless of the pixel size). Solutions of this type will not result from traditional monitoring and assessment approaches that were developed and used throughout most of the 20th century. Though useful, it is now part of the past. Furthermore, solutions of this type will not be developed by people who are trained in a certain discipline and lack the ability to work with people who can utilize the entire spectrum of analytical tools and procedures that constitute the body of knowledge of modern geo-spatial sciences. Ernst Mach's legacy (Malin 2001), "it is theory which decides what we can observe," has no place in this new paradigm that fosters freedom from the known. The most successful problem solvers in the 21st century will be those who can think multi-relationally and free themselves from

the mental conditioning of theories, methods, and technologies. Individuals who have this mental potential can easily work with interdisciplinary and multidisciplinary teams that can apply the tools of geo-spatial sciences in an integrated, multi-relational, cohesive, unconditioned, and seamless fashion to the solution of unique sustainability problems.

References

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