

# INTEGRATED MAPPING ASSESSMENT PROJECT (IMAP): A SUMMARY OF ACTIVITIES AT THE IMAP LAB OF THE UNIVERSITY OF TORONTO

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**ABSTRACT:** In 2000, the Institute for Environmental Studies (IES) at the University of Toronto and Environment Canada established an Integrated Mapping Assessment Project (IMAP) Lab at the University of Toronto (UofT). IMAP has been engaged in collecting published maps on topics such as climate, severe weather, air quality, human health, woodlots, wetlands, wildlife, land-use, roads and many other themes, and then functionally linking and integrating these map surfaces together on specific issues, such as atmospheric change and biodiversity. The final maps are then assessed spatially at various scales, from local to global, although the initial focus of the study has been on regions of Ontario, where a range of detailed, high-quality maps are already available. This paper details the history of IMAP; IMAP directors; IMAP research projects; IMAP symposia, conferences, workshops and events; IMAP publications; IMAP student support; and IMAP course support. The co-location of Environment Canada scientists at universities has proved successful in the case of the IMAP Lab at the University of Toronto. The authors support continuing partnerships in this area.

**Keywords:** integrated assessment, Canada, science partnerships

## 1. Introduction

In 2000, the Institute for Environmental Studies (IES) at the University of Toronto and Environment Canada established an Integrated Mapping Assessment Project (IMAP) Lab at the University of Toronto (UofT). IMAP has been engaged in collecting published maps on topics such as climate, severe weather, air quality, human health, woodlots, wetlands, wildlife, land-use, roads and many other themes, and then functionally linking and integrating these map surfaces together on specific issues, such as atmospheric change and biodiversity. The final maps are then assessed spatially at various scales, from local to global, although the initial focus of the study has been on regions of Ontario, where a range of detailed, high-quality maps are already available. This regional focus is an important part of the project's goal of bringing national issues, such as climate change, to a level that municipal decision-makers can understand and take action on.

The IMAP office is located at Room 1047A, Earth Sciences Centre, 5 Bancroft Avenue entrance at the University of Toronto's St. George Campus (main campus) in Toronto, Ontario, Canada. IMAP has been administered by four directors (presented alphabetically): Heather Auld, Adam Fenech, Roger Hansell and Don MacIver.

Heather Auld is a meteorologist and climatologist with the Meteorological Service of Canada. Ms. Auld joined Environment Canada in 1979 after obtaining a Bachelor of Science in physics and a Masters of Science in meteorology. She has served as a weather forecaster in the Canadian cities of Edmonton, Vancouver, Toronto, Canadian Forces Base Trenton and has taught weather forecasting to university graduates. She has worked as a climatologist since 1988. For eight of those years, she researched and developed climatic design values for the National Building Code of Canada, building energy codes and other national infrastructure standards. Her current position with Environment Canada is with the Science Assessment and Integration Branch of the Atmospheric and Climate Science Directorate of the Meteorological Service of Canada.

Adam Fenech is a science advisor at the Meteorological Service of Canada, Environment Canada. Mr. Fenech has worked many years in the areas of climate change, air quality and stratospheric ozone depletion. Adam was seconded for two years to Harvard University working on the international Social Learning Research Project. He spent six years establishing the Ecological Monitoring and Assessment Network (EMAN) of Environment Canada. He is currently working on his doctorate in the area of integrated assessment modeling through the Department of Geography and the Institute of Environmental Studies at the University of Toronto. Adam teaches at the University of Toronto in areas of Ecological Economics, Regional Ecology and International Environmental Agreements, as well as at the Smithsonian Institution in their course on Monitoring Biodiversity Change.

Roger Hansell is a professor of Botany at the University of Toronto. He is cross-appointed at the Institute for Environmental Studies where he once served as its Director. Roger has a variety of research interests including vertical gardens and green canopies for urban environments; evolution of complex systems; and the response of the Arctic and tree-line communities to environmental changes.

Don MacIver is the Director of the Adaptation and Impacts Research Group at the Meteorological Service of Canada, Environment Canada. He has worked at a number of agencies as a meteorologist, climatologist, forester, biometrician and (forest) mensurationist. Outside of work, he is a municipal politician (namely, deputy mayor for Amaranth Township), a farmer, an environmental activist, an amateur ham radio operator and a CANWARN volunteer. Don served as a professor at York University from 1972-1981 and as an adjunct professor at the University of Toronto from 1988-1993. He worked as a biometrician and

mensurationist at the Ontario Ministry of Natural Resources from 1981-1986 before joining Environment Canada in 1986 as a forest meteorologist and a climatologist.

## 2. IMAP Research Projects

### 2.1 Atmospheric Hazards in Ontario Website: A New Tool for Planning for Risks and Hazards from Naturally Occurring Events in Ontario

A website was developed at [www.hazards.ca](http://www.hazards.ca) presenting background material and map data about risks and hazards from naturally occurring events in Ontario. The user is presented with various related data sets from the IMAP project, Meteorological Service of Canada and other cited references (for example, the **INFRASTRUCTURE WEATHER IMPACTS** section selects data sets from wind energy; wind loads for design; and severe ice storm loads). The website displays a map of the region with the layers of hazards information selected by the user. The user can then click on the map to "zoom in" to an area and list the values of the parameters there. The purpose was to enable the evaluation of multiple risks and to assist in the preparation of Municipal Emergency Management Programs as required by Bill 148, amendments to the Canadian province of Ontario's *Emergency Management and Civil Protection Act*.

### 2.2 Climate and the West Nile Virus in Ontario

This study traced the spread of the West Nile virus over the summers of 2000 to 2002, applied a risk analysis framework to the virus, and associated climate variables to the spread and severity of the virus across Ontario, Canada. This virus is a member of the Japanese encephalitis virus that can be spread to humans from birds through mosquito transmission. There have been infrequent human outbreaks, but more recently including the first outbreak in North America in New York City in 1999. Using Health Canada maps and a Geographic Information System (GIS), Fenech and Chiotti (this volume) hypothesized that the virus would be exacerbated by warmer winters allowing infected mosquitoes to survive the winter or migrating birds to winter in Ontario; by spring or early summer warmth to support bird migrations from virus infected areas of North America; and by summer heat to allow for virus incubation and transmission. The study concludes that climate is one of many variables affecting the spread and severity of the virus. As the virus has been shown to propagate in temperatures above 30°C, a climate indicator such as a "West Nile Virus Infection Threshold Alert" is recommended to provide early warnings to the public.

### 2.3 Linking Excessive Rainfall to the Walkerton Tragedy

This IMAP study (Liu *et al.*, this volume) focused on the occurrence of excessive rainfall over a five-day period between May 8-12, 2000 that resulted in one of Canada's worst waterborne disease outbreaks killing seven people with thousands becoming ill in Walkerton, Ontario. The five-day cumulative rainfall was unusually high and would, on average, be expected only once every 60 years or more. Drinking water from groundwater wells that are under the influence of surface water can be particularly vulnerable during excessive rainfall events. A study across the United States by Curriero *et al.* (2001) identified that in more than 51 percent of cases, there was a direct relationship between the upper 10th percentile threshold for extreme precipitation events and waterborne diseases. Using a similar approach, the IMAP study revealed that the five-day cumulative rainfall exceeded the 90th percentile of the 30-year rainfall mean for Walkerton. In the future, it may be possible to develop a WellHead Protection Alert System that could provide advisories in advance of the risk of excessive rainfall.

### 2.4 Changing Landscape of Southern Ontario since European Settlement

As European settlement in southern Ontario occurred, land was prepared for agriculture by draining wetlands and removing trees, leading to altered and continually stressed ecosystems. To illustrate the changing landscape, Butt *et al.* (this volume) used a Geographic Information System (GIS) to create a first approximation map of the pre-European land cover of southern Ontario. These were derived from paper survey maps by Finlay (1978) using the notes of the original land surveys of European settlement completed from 1798-1850. When compared to a modern day map of landscape coverage, results show a decrease in forested land from more than 80 percent to less than 20 percent. The implications are decreasing forest diversity and loss of forest cores to support sensitive wildlife species resulting in significant changes in the overall forest ecology.

### 2.5 Toronto: The Climate Change Laboratory

The heart of Toronto, Ontario, Canada is home to two-and-a-half million people with one-third of Canada's human population located within a 160 kilometer radius. Located on the northwest shore of Lake Ontario, Toronto lies within a "battleground" of colliding global air masses; the moderating influence of Lake Ontario; and the self-generating effects of urban heating. These combined effects result in winter mean temperatures that are about 3.3 degrees Celsius higher than those recorded at similar latitudes without the lake effect. Summers in Toronto are also moderated, and thus average July temperatures are 1.7 degrees Celsius cooler than similar locations in continental zones. This IMAP

study examined 123 years of climate data at the downtown Toronto Climate Observatory (43° 40' N, 79° 24' W) as compared to the rural site of Beatrice (45° 8' N, 79° 23' W) from 1878 to 1998. Using the comparative approach illustrated by Munn *et al.* (1999), concurrent data was analyzed for annual maximum, mean and minimum temperatures. Today, the "Toronto warming effect" has resulted in a 4.0 degree Celsius increase in the annual minimum temperatures at the downtown Toronto site since 1878. In contrast, at the rural Beatrice site, the trend is practically non-existent, with an increase of only 0.1 degrees Celsius over the 123 years of record.

## 2.6 Economic Valuation of Landscape Changes at Canada's Biosphere Reserves

Canada's natural environment provides ecosystem services to humans such as pollination, climate regulation, water purification, etc. At present, these ecosystem services are not valued because there is no private, organized market for such services. These services, unlike ecosystem goods such as lumber, do not go into making up a nation's Gross Domestic product (GDP). Nevertheless, their value is very large, if not infinite, since they support life itself. Using historical land surveys, aerial photos or satellite imagery, landscape change studies have revealed significant changes in the land cover across Canada over the years. The economic value of the ecosystem services provided by these land covers can be estimated using contingent valuation methods as applied by Costanza *et al.* (1997). Although difficult and fraught with uncertainties, Fenech estimated the changes in economic value of the economic services provided by landscapes in the North Halton region of the Niagara Escarpment over time. The importance of various approaches to landscape change analysis with respect to economic valuation were studied, and recommendations were made for the best approaches.

## 2.7 Lifestyle Meteorology

This IMAP study developed an internet tool allowing the public to access information on the physical and chemical aspects of the natural environment when seeking a place to live. For example, if you are seeking lower atmospheric pollutant levels, or simply milder temperatures, then the Lifestyle Meteorology internet tool allows you to click on maps and find the place best suited for you in southern Ontario.

## 2.8 Impact of Roads on Natural Areas of Southern Ontario

In a continuing study of roads and their ecological implications, Fenech *et al.* (this volume) focused on areas of southern Ontario with ecological significance and

under threat of human development - the Oak Ridges Moraine, the Niagara Escarpment and Algonquin Park. The major (paved) roads in the Oak Ridges Moraine increased from 126 kilometers in 1935 to 554 kilometers in 1965 to 1016 kilometers in 1995. Most roads, which by 1995 include four multi-lane highways, run north to south creating a series of paved barriers to wildlife movement. The road density on the Oak Ridges Moraine was 0.518 kilometers in 1995, which is about 90 percent of the road density in York County, a typical county in the region. The major roads in the Niagara Escarpment increased from 173 kilometers in 1935 to 567 kilometers in 1965 to 923 kilometers in 1995. What is obvious from the maps is the increasing number of intersections of the natural corridor that the Niagara Escarpment is intended to protect. By 1995, there were 9 points at which multi-lane highways cross the escarpment, presenting a significant barrier for wildlife movement. While no quantitative analysis has been possible for the roads in Algonquin Park, a series of access roads now branch out to reach the Park, creating a "ring of roads" for recreation use at various access points to the Park. The primary concern now is not so much the barrier effect to wildlife but the potential for increases in invasive species and traffic volume into the Park as the number of access roads has increased.

### **2.9 Economic Valuation of the Ecosystem Services Provided by the Landscapes on the Oak Ridges Moraine**

This IMAP project by Morgan (2004) was undertaken to provide an economic valuation of the ecosystem services of the western portion of the Oak Ridges Moraine (where it abuts the Niagara Escarpment) using quantified estimates of landscape types in the region (using remote sensing data), and transferring those estimates into a dollar figure based on the ecosystem services these landscapes provide to humans.

### **2.10 Research on Biodiversity and Frost Hardiness Zones across a Southern Ontario Transect**

This research project (Karsh, this volume) compared expected species lists for the new plant hardiness zones with species lists collected by volunteers in SI/MAB plots along a longitudinal gradient on the Niagara Escarpment from Long Point to Wiarton. Scientists have currently documented 12 families at Long Point and nine families at Wiarton. The expected loss in the number of families at Long Point, as predicted by the new plant hardiness zones, could result in a potential biodiversity crisis for Ontario. Native species diversity could be threatened, especially species growing in the Carolinian Region of Ontario, one of the most diverse areas in Canada. There is a potential to lose native species that have been naturally adapted to our Canadian climates.

## 2.11 Changes in Major Roads of Southern Ontario

Major roads in southern Ontario increased five fold from 1935 to 1995 according to results of a recent University of Toronto study. Roads are important indicators of environmental change as forested lands are cleared and wetlands are drained to make the roads. Roads also open up areas to further human development leading to declining wildlife habitat and increased introduction of invasive wildlife species. This study (Fenech *et al.*, this volume) examined changes in the major roads of southern Ontario every decade from 1935 to 1995. The authors began with a digitized 1995 road map of Ontario and hard copy road maps from the archives for 1985, 1975, 1965, 1955, 1945 and 1935. Using a geographic information system, roads not present on the 1985 map were removed from the 1995 digitized map. This was repeated for every ten year interval map. Further study will examine how these major road changes are related to changes in forested land, agricultural activity, human population and economic development. Additional studies are planned for looking at the impact of major roads on breeding birds, and the relationship between a declining railway network, increased road traffic and climate change.

## 2.12 Heat as a Powerful Trigger in the Natural World, and a Major Influence on Land Use Change in Southern Ontario

Using international biodiversity protocols, this study revealed a link between climate and the family diversity of forest species – a factor that could affect conservation practices in the future. The IMAP lab also explored the possibility that, although a warmer landscape can support greater biodiversity, increases in species will come primarily from exotic or non-native species, similar to the invasions of zebra mussels and purple loosestrife.

# 3. IMAP Symposia, Conferences, Workshops and Events

## 3.1 Leading Edge Conference 2004, St. Catharines, Ontario, March 2004

A special session titled *Understanding the Niagara Escarpment through Integrated Mapping Techniques* was held with papers on *Atmospheric Hazards in Ontario: A New Tool for Planning for Risks and Hazards from Naturally Occurring Events in Ontario*; *Impact of Excessive Rainfall on Waterborne Diseases in southern Ontario: The Walkerton Case*; *The Change in Major Roads Along the Niagara Escarpment 1935-1995: Implications for Wildlife*; *The Change in Landscapes Along the Niagara Escarpment Since 1750: Effects of European Colonization*; *The Change in the Economic Valuation of Ecosystems and Biodiversity Along the Niagara Escarpment 1972-1994: The North Halton Case Study*; *The Spread and Severity of the West Nile*

*Virus Along the Niagara Escarpment 2000-2003: Implications of Climate; and Emerging Environmental Issues for the Niagara Escarpment: The Future Challenges.*

### **3.2 International Society of Biometeorology, Kansas City, November 2002**

Heather Auld presented a paper on excessive precipitation and waterborne diseases.

### **3.3 International Conference on Water and Health, Ottawa, September 2002**

Anthony Liu presented on the research of excessive precipitation and the Walkerton waterborne disease outbreak.

### **3.4 WSSD Day (World Summit on Sustainable Development), University of Toronto, June 1, 2002**

The IMAP Lab celebrated the ten years since the United Nations Conference on Environment and Development (UNCED) held at Rio de Janeiro, Brazil, by hosting a WSSD Day as part of the overall Congress of the Social Sciences and Humanities. The objective of the day was to arrive at a comprehensive, frank and useful review of the past ten years, with some thoughts on future paths to global sustainable development. All of this was in anticipation of the World Summit on Sustainable Development held 26 August to 4 September 2002 in Johannesburg, South Africa. The WSSD Day at U of T, sponsored by the Canadian International Development Agency, the Environmental Studies Association of Canada (ESAC), the Canadian WSSD Secretariat and the Institute for Environmental Studies (IES), consisted of a symposium of speakers, a poster exhibit, a video diary, a youth contest and a special session on faith and the environment. Over 90 registrants attended the symposium which included sessions on emerging environmental issues; youth perspectives on water, faith and interdisciplinary study; biodiversity; NGOs and development; and education, knowledge and history.

### **3.5 Annual Meeting of Canadian Association of Geographers May 2002**

A special full-day session on the *Integrated Mapping Assessment Project (IMAP)* at IES was organized for the 51st Annual Meeting of the Canadian Association of Geographers (CAG). Jointly hosted by the Geography departments at Ryerson Polytechnic University, the University of Toronto and York University, the 2002 CAG meetings took place at the University of Toronto in conjunction with the Congress of the Social Science and Humanities Federation of Canada. The session was an opportunity to showcase to the larger academic community and the general public through the extensive media coverage that the Congress receives. The IMAP session included studies on heat as a powerful trigger in the



natural world, and a major influence on land use change in southern Ontario; major road changes across Canada from the 1930s to the 1990s; changes in major roads in natural areas of southern Ontario from 1935-95; changes in the forested landscapes of southern Ontario since European settlement; Lifestyle Meteorology: the physical and chemical aspects of the natural environment that drive modern human settlement; and changes in the economic valuation of ecosystems changes along the Oak Ridges Moraine over the past 20 years.

### **3.6 Niagara Escarpment, Oak Ridges Moraine, and Algonquin to Adirondack Heritage (NOAH) Workshop, Toronto, April 2002**

A workshop was held to generate a broader interest for the concept of a large-scale wildlife corridor for southern Ontario that includes the Niagara Escarpment, Oak Ridges Moraine, and Algonquin to Adirondack Heritage (NOAH) Area. This workshop was organized by Public Spaces, a not-for-profit environmental organization dedicated to promoting stewardship and fostering a sense of community through the protection, enhancement and celebration of Ontario's public spaces. The NOAH Project emerged from the research and testimony before the Ontario Municipal Board of internationally-renowned ecologist Dr. Reed F. Noss in his attempts to inform decision-makers and the public on the need to maintain linkages between the large-scale natural corridors of southern Ontario. The workshop was co-sponsored by the Integrated Mapping Assessment Project (IMAP) of the Institute for Environmental Studies, the Public Spaces Appreciation Association of Ontario, the City of Toronto, Environment Canada, and Ontario Power Generation.

### **3.7 Leading Edge 2001: Focus on the Biosphere Conference, Burlington, Ontario, October 17-19, 2001**

Members of IMAP presented papers at the fifth in a series of biennial conferences on science and management of the Niagara Escarpment, the *Leading Edge 2001: Focus on the Biosphere Conference*. This conference brought together more than 200 landowners, scientists, environmental interest groups, researchers, corporations, artists, government agencies, and representatives from other World Biosphere Reserves in Canada, USA and Europe. Conference themes included sustainable communities, research, monitoring and conservation. Members of the IMAP Lab were prominently featured in the program with:

- Preeti Ramprasad presenting on the Changing Forest Landscapes of Southern Ontario since European Settlement;
- Adam Fenech presenting on Major Road Changes In and Around the Niagara Escarpment 1935-95: Implications for the Natural Environment;

- Alexis Morgan presenting on Economic Valuation of the Ecosystem Services Provided by the Landscapes on the Oak Ridges Moraine; and
- Researcher and M.Sc. Forestry graduate Marianne Karsh presenting on Research on Biodiversity and Frost Hardiness Zones across a Southern Ontario Transect.

### **3.8 International workshop on Poverty, Development and Natural Capital, Toronto, September 2001**

Along with the World Bank, Environment Canada, the Canadian International Development Agency, the International Development Research Council, U of T's Munk Centre for International Studies, Faculty of Forestry, the Connaught Fund for Symposia/Colloquia, and the Institute for Environmental Studies, IMAP co-sponsored an international conference on Natural Capital, Poverty and Development. Many key questions have emerged during debates on natural capital, poverty and development, which the conference addressed. What are realistic measures of poverty and development? Are there market or non-market mechanisms that can assign a value to natural capital? Can these valuation mechanisms facilitate decision making for poverty alleviation of natural capital based communities? What is the role of institutions in the process of development through natural capital? What are appropriate institutions for sustainable development of natural capital based communities? What are the experiences of donor agencies in designing appropriate institutional arrangements? How can fragile lands be used for poverty alleviation in land resource scarce communities? What are the experiences of developing countries and donor agencies in management of fragile lands? How can eco-tourism and biodiversity conservation programs be used for economic development of local communities? What should be the role of donor agencies in these natural capital based poverty alleviation and economic development programs. The conference was organized around four main themes: 1. Measurement issues in natural capital, poverty and development; 2. Institutions, natural capital and development; 3. Poverty, fragile lands and development; and 4. Ecotourism, biodiversity and development.

### **3.9 Official Launch of the IMAP Lab at UofT, May 17, 2001**

Over 30 interested researchers joined the Institute for Environmental Studies and Environment Canada in officially launching the Integrated Mapping Assessment Project (IMAP) Lab at UofT.

### 3.10 Special Session at EMAN National Science Meeting, January 2000

Over 350 delegates from universities, federal and provincial governments, community groups and the private sector from across Canada attended the 6th annual meeting of Canada's Ecological Monitoring and Assessment Network (EMAN), held in Toronto from January 18 to 22, 2000. EMAN consists of approximately 90 research and monitoring sites located across the country with the objective of understanding what changes are occurring in Canadian ecosystems and why. Environment Canada is the coordinating partner for the network, and co-sponsored the 6th *Annual EMAN Meeting* with the Institute for Environmental Studies, IES. Over 100 research papers, and keynote speeches were presented to illustrate and explain changes occurring in Canadian ecosystems. IMAP Director, Adam Fenech, chaired a special session on Natural Capital: Valuing Ecosystems and Biodiversity. Speakers such as Roger Hansell, Acting Director of IES; Bill Rees from the University of British Columbia; Orié Loucks from Miami University; Mohammed Dore from Brock University; and Ana Isla from the Ontario Institute for Studies in Education at U of T presented the latest views on valuing the earth's natural environment. IMAP Director Don MacIver chaired a special session on Integrated Mapping Assessment. Brent Taylor, M.Sc. Candidate in U of T's Department of Planning, presented the study of the Major Road Changes in Southern Ontario from 1935-95. The presentation has led to potential partnership work in examining road development and wildlife mortality (roadkill); road development and protected/conservation areas; and an expansion of the study of road development across Canada.

## 4. IMAP Publications

### 4.1 Integrated Mapping Assessment. Edited by Adam Fenech, Roger Hansell, Don MacIver and Heather Auld. 2005.

This volume includes papers on IMAP studies including: Emerging environmental issues: the future challenges for Canada and the world by Timmerman *et al.*; The spread and severity of the West Nile virus in Ontario, Canada 2000-2003: implications of climate by Fenech and Chiotti; Excessive precipitation and waterborne diseases in southern Ontario, Canada by Liu *et al.*; The impact of climate changes in the seasonal timing of life cycle events of eastern Canada 1900 to 1920; by Fenech *et al.*; Changes in the landscape of southern Ontario, Canada since 1750: effects of European colonization by Butt *et al.*; Change in the major roads of Southern Ontario, Canada 1935-1995 by Fenech *et al.*; Landscape changes at Canada's Biosphere Reserves: an overview of land change studies by Fenech *et al.*; Social learning in the management of global atmospheric risks: a Canadian example of issue identification by Fenech; and research on biodiversity and plant hardiness zones across a Southern Ontario transect.

#### 4.2 Integrated Mapping Assessment Project (IMAP) Website:

[www.utoronto.ca/imap](http://www.utoronto.ca/imap)

The IMAP Lab launched its Web site where a large collection of published maps on topics such as climate, severe weather, air quality, human health, woodlots, wetlands, wildlife, land-use, roads and many other themes can be found. The site also includes the functional linking and integration of these map surfaces together on specific issues into assessments on atmospheric change and biodiversity; roads and severe weather; climate and land use development; and severe weather and human health. All of these maps are referenced and can be easily downloaded.

#### 4.3 Natural Capital: Views from Many Perspectives. Adam Fenech, Roger Hansell, Ana Isla, Shirley Thompson.

This report of an April 23, 1999 workshop (Environmental Monograph EM-16, Institute for Environmental Studies, University of Toronto) sponsored by the IMAP Lab, the Ecological Monitoring Assessment Network (EMAN), and the World Bank, held at Toronto, Ontario, Canada included over 30 participants from Canadian universities, government and the World Bank. Ideas and views that emerged from the workshop were categorized by the authors into four main themes: 1. measuring the wealth of nations; 2. valuing biodiversity and ecosystems; 3. models for bringing economics and ecology together; and 4. issues of sustainability and risk.

### 5. IMAP Funding

Funding was received domestically and internationally to hire students and run the IMAP Lab through a variety of sources including:

- Environment Canada's Youth Employment Strategy – Science Horizon's Project
- Canada's Climate Change Action Fund (CCAF)
- Canadian International Development Agency (CIDA)
- Environment Canada's Ontario Region
- Environment Canada's Ecological Monitoring and Assessment Network (EMAN)
- The World Bank

Support for the IMAP Lab at UofT from 2000 to 2004 ranged from CAN\$9K to CAN\$50K per annum.

## 6. IMAP Student Support

The following students worked under the auspices of the IMAP Lab at UofT at some time during the period of 2000 to 2004.

- Brent Taylor, MSc, Department of Planning
- Preeti Ramprasad, PhD, Faculty of Forestry
- Ana Isla, PhD, Ontario Institute for Studies in Education
- Shirley Thompson, PhD, Ontario Institute for Studies in Education
- Zoe Meletis, MSc, Department of Geography
- Alexis Morgan, MSc, Department of Geography
- Amar Wahab, PhD, Ontario Institute for Studies in Education
- Erik Sparling, MSc, Department of Geography
- Anthony Liu, PhD, Department of Physics
- Sadia Butt, MSc, Faculty of Forestry
- Mathew Lieberman, BA, Department of Geography
- Kim Snarr, MSc, Department of Anthropology

## 7. IMAP Course Support

IMAP Directors provided teaching for four courses including:

### 7.1 IES1433S Regional Resource Ecology (2000)

This course examined the ecosystems along the Niagara Escarpment including farms, recreation areas, cliffs, streams, wetlands, wildlife habitats, and urban environments. A large number of guest speakers provided a broad exposure to natural resource management issues at various jurisdictional levels.

### 7.2 IES 1433S Natural Capital: Valuing Ecosystems and Biodiversity (2001)

This course brought together the many ideas and views focussing on valuing biodiversity, ecosystems and natural resources from the two perspectives of embedding the economy into the ecological system or embedding the ecology into the economic system. The course presented practical applications for agencies to guide their managers in making decisions and investments in countries around the world on sustaining natural resources. Presentations were organized around four main themes: measuring the wealth of natural resources; valuing biodiversity and ecosystems; models for bringing economics and ecology together; and issues on sustainability. The course was a seminar format with student-led discussions directed by the two moderators.

### **7.3 IES 1433S World Summit on Sustainable Development: A Critical Review of the Outcomes of UNCED Ten Years Later (2002)**

The United Nations Conference on Environment and Development (UNCED), also known as the "Earth Summit," was held at Rio de Janeiro, Brazil, in June 1992. This global conference, held on the 20th anniversary of the first international Conference on the Human Environment, (Stockholm, 1972), brought together policy makers, diplomats, scientists, media personnel and NGO representatives from 179 countries in a massive effort to reconcile the impact of human socio-economic activities on the environment and vice versa. A major achievement of UNCED was Agenda 21, a thorough and broad-ranging international agreement of actions demanding new ways of investing in our future to reach global sustainable development in the 21st century. Other UNCED outcomes included the Rio Declaration, the Framework Convention on Climate Change (FCCC), the Convention on Biological Diversity (CBD), and a Statement of Forest Principles. Ten years later, and time to take a critical look back at UNCED, and aim to arrive at a comprehensive, frank and useful review of the past ten years, with some thoughts on future paths to global sustainable development. Johannesburg 2002: The World Summit on Sustainable Development (WSSD also known as Rio + 10) was held in September 2002 in Johannesburg, South Africa to assess global change since the historic UNCED of 1992. This course examined the outcomes of UNCED in 1992, with a review of global and Canadian progress towards meeting these agreements over the past ten years. Also, the WSSD was examined, including the preparatory process, the issues to be examined, the players involved, and the results to be expected.

### **7.4 IES 2000F International Environmental Agreements: Implications for Canadian Environmental Management (2000, 2001, 2002)**

Canada is signatory to a large number of international environmental agreements that govern environmental management in Canada. These include agreements in the areas of wildlife (Birds, Whaling, International Trade in Endangered Species, Biodiversity), atmosphere (Acid Rain, Climate Change, Stratospheric Ozone Depletion, Toxic Chemicals) and water (Wetlands, Law of the Sea). This course examined the international environmental agreement process of negotiation, terminology of agreements, "guts" of a general agreement, ratification of agreements, responsibilities of signatory nations, and effectiveness of agreements. Specific international environmental agreements examined included the Biodiversity Convention, the Climate Change Convention, the Convention on Long Range Transport of Atmospheric Pollutants, and Agenda '21 - the general agreement of environmental action.

## 8. Conclusions

In 2000, the Institute for Environmental Studies (IES) at the University of Toronto and Environment Canada established an Integrated Mapping Assessment Project (IMAP) Lab at the University of Toronto (UofT). IMAP has been engaged in collecting published maps on topics such as climate, severe weather, air quality, human health, woodlots, wetlands, wildlife, land-use, roads and many other themes, and then functionally linking and integrating these map surfaces together on specific issues, such as atmospheric change and biodiversity. The final maps are then assessed spatially at various scales, from local to global, although the initial focus of the study has been on regions of Ontario, where a range of detailed, high-quality maps are already available. This paper has detailed the history of IMAP; IMAP directors; IMAP research projects; IMAP symposia, conferences, workshops and events; IMAP publications; IMAP student support; and IMAP course support. The co-location of Environment Canada scientists at universities has proved successful in the case of the IMAP Lab at the University of Toronto. The authors support continuing partnerships in this area.

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