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Insights and Applications from International Studies of Earth Systems Science

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"Biosphere Sustainability Project"

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Preface

The "Biosphere Sustainability Project" is an SSHRC-supported inquiry, more formally called "Citizen Engagement in Governance for Socio-Ecological Sustainability: Concepts and Case Studies". Its purpose is to [a] draw together concepts and insights, along with case study applications, from three rapidly developing areas of academic enquiry – complex open systems, sustainability of social-ecosystems, and civil society roles in governance -- and [b] determine (through consultations with examples) the potential application and usefulness of some of these concepts and insights for people associated with biosphere reserves in Ontario.

Biosphere reserves were chosen mainly because of the stringent criteria they must meet to receive this designation of recognition from UNESCO. The criteria include local organizational arrangements to be in place for developing collaborative capacities to address local and regional issues about the ecological, economic and ethical components of enhancing the sustainability for local communities and individual livelihoods. People associated with these local organizations are informed and committed to the ideals of sustainability and thus are in a good position to identify which perspectives, from among a range of concepts and examples from the academic literature, could be especially appropriate to the situations they are in and are striving to improve.

Introduction

In 2001, an “Earth System Science Partnership” (ESSP) was formed as a formal alliance of four international global change research programs associated with the International Council of Science. The ESSP’s purpose is to foster collaboration on scientific questions at the scale of the entire planet, including the various biophysical dynamics operating at a planetary scale and the effects of human driving forces on them. This initiative is a major component of the International Geosphere Biosphere Program (IGBP) as it was re-organized in 2003 for its second decade. The ESSP acknowledges the world to be “a coupled interactive human-environment system” which is to be studied by a new integrative research project currently being planned: the “Analysis, Integration, and Modeling of the Earth System (AIMES)” (e.g. IGBP 2004; Brasseur, Steffan and Noone 2005).

At the same time, new intergovernmental arrangements are being negotiated to implement a 10-year strategy for developing the “Global Earth Observation System of Systems (GEOSS)”. This international program was endorsed by some 60 governments (including Canada) in February 2005 to “…improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth System” (Earth Observation Summit II 2004; Group on Earth Observations 2005).

These two initiatives, and others that are related to them, build upon at least two decades of international collaboration through programs sponsored, or co-sponsored by United Nations Specialized Agencies along with research programs sponsored, or co-sponsored by international networks of sciences coordinated in part through the International Council of Science (ICSU – formerly called the International Council of Scientific Unions). ICSU represents a number of international associations of particular scientific disciplines, most of them also associated with national academies of sciences in their home countries. The new initiatives reflect the considerable progress made in recent years by research on biophysical processes that has enabled increasingly sophisticated models of them to be constructed and calibrated.

This working paper is an overview of some background and related events behind these initiatives. It also notes Canadian participation in them that provides both case examples and on-going programs that are relevant to biosphere reserves. Conversely, some activities underway in biosphere reserves may take on greater significance when placed within these

larger contexts of international collaboration for understanding and responding to global environmental changes, and assessing the implications for “sustainable development”.

The programs and events deemed most appropriate for this review are ones that can be associated quite directly with the environment and development debate that has been underway for at least 30 years. It is convenient to enter it through the 1992 “United Nations Conference on Environment and Development” held in Rio de Janeiro on the occasion of the 20th anniversary of the UN Stockholm “Conference on the Human Environment”. The Rio events were informed by extensive work in the decade prior to 1992, notably that of the Brundtland Commission (WCED 1987); the Commission was responsible for the deliberately ambiguous phrase “sustainable development” which has been debated ever since. Three new Conventions emerged from the 1992 Conference: the UN Framework Convention on Climate Change, the Convention on Biodiversity, and the UN Convention on Combating Desertification. The first two were of special interest in Canada.

A somewhat parallel set of programs and events is associated with ICSU, and its Scientific Committee on Problems of the Environment (SCOPE). ICSU served as one co-sponsor of the four programs that have come together as the core of the ESSP. Both formal and informal cooperation is maintained among these and the UN sponsored programs, especially those backed by formal Conventions. The UNESCO “Man and the Biosphere” Program (MAB), the international sponsor of the world “network” of biosphere reserves, has also been involved in some of these cooperative arrangements.

A cautionary note is in order. The great number, diversity, and to some degree overlapping of international organizations and programs that have evolved over the years makes it a challenge for any “outsider” to fully understand. There is always a question of where to draw some boundary for what to include in an overview. There is a jungle of acronyms to interpret, and a vast array of scientific literature and governmental documents to consider. Only a few are cited here as examples or leads into more extensive details. Apologies are extended in advance to whoever was inadvertently omitted, or included in a context that would not be of their choosing. The same cautionary note is applied to the array of governmental and NGO programs in Canada.

The Rio Conventions

Climate change

In 1988, at about the same time as the “Toronto Conference on the Changing Atmosphere” called for a global reduction of 20% of the 1988 volume of CO_2 emissions by 2005, the Inter-governmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The Panel brings together a wide range of scientists from a number of countries to review and assess the state of knowledge of the global climate systems, evidence for climate change, and risks these changes pose. The IPCC has three working groups: WG I to assess the scientific understanding of climate systems; WP II to consider questions about impacts, vulnerabilities, and adaptations; and WG III to address options for mitigation measures to reduce emissions of the “greenhouse gasses (GHG)”.

The IPCC issued its first assessment report in 1990 which showed that human activities had increased the concentration of GHG in the atmosphere and that the resulting increase of the greenhouse effect has lead to a general warming. This assessment was endorsed at the Second World Climate Conference by ministerial level representatives from 137 States and the European Union (EU). The Conference agreed on general principles for dealing with climate change and these became the basis for intergovernmental negotiations under UN auspices. At the 1992 Rio Conference, a United Nations Framework Convention for Climate Change (UNFCCC) was signed by 154 States, including Canada, and the EU; the UNFCCC entered into force in 1994. Its stated goal was to stabilize GHG concentrations in the atmosphere at levels that would prevent serious disruption to agricultural production or to major ecosystems so as to allow sustainable development to occur.

The second IPCC assessment report in 1995 gave evidence that climate had changed over the past century and the balance of evidence suggested that human activities had influenced this change. This assessment was the basis for agreeing upon the Kyoto Protocol by 84 countries in 1997. The Protocol sought to stabilize and reduce GHG emissions to designated target levels in 2012 by mitigation measures using technological improvements, changes in land use that result in better management of carbon reservoirs and sinks, and initiation of a global carbon credits market. Many details had to be negotiated before the Protocol took effect in 2005 (without US endorsement).

The third assessment in 2001 concluded that most of the warming over the past 50 years is attributable to human activities, and that climate change was impacting detrimentally on human and natural systems. The mitigation and adaptation measures needed to deal with this depend critically upon “alternative development paths”. This assessment report is used as a scientific reference for continued negotiations over the Kyoto Protocol as well as for looking ahead to a post-2012 longer-term global climate change regime. Negotiations for this latter are to be initiated at the Montreal Conference on Climate in late 2005. The fourth assessment report of the IPCC is due in 2007. (WMO and UNEP 2004; Government of Canada 2005). The Johannesburg Plan of Implementation from the 2002 World Summit on Sustainable Development (WSSD) includes a continuing commitment to the UNFCCC.

The IPCC has become a model for international scientific collaboration to assess the state of scientific and technical knowledge about global issues. Its assessment reports along with numerous other special reports are based on peer-reviewed publications in the scientific literature throughout the world, and its own multi-authored technical reviews are also peer-reviewed. Debates are mainly associated with the inherent uncertainties and indeterminacies in climate system dynamics, different methods for analyzing and modeling climate systems and scenarios based on them, and on the relative importance of the many causal factors and their interactions which drive changes, especially factors arising from human activities. This is a particular challenge for working groups II and III whose subject matter is embedded in socio-economic contexts where policies for sustainable development are likely more important determinants of mitigation and adaptation than climate policies alone. These issues are being discussed by members of both working groups in preparation for the fourth assessment report (IPCC 2005).

Biodiversity

Concerns about the loss of biodiversity were raised for a number of years, notably by the IUCN (now the World Conservation Union). IUCN with UNESCO, FAO (the UN Food and Agriculture Organization), and the WWF (World Wildlife Fund for Nature) issued a widely distributed World Conservation Strategy in 1980 which argued that conservation of biodiversity, and sustainable uses of it, were essential for maintaining the “carrying capacity” of the planet for humans; the statement was subsequently up-dated and enlarged in its scope in 1991. In 1987,

UNEP created a working group of scientific, legal, and other experts to develop what became the working draft of the UN Convention on Biodiversity (UNCBD).

The UNCBD was officially opened for signature at the Rio Conference in 1992. Canada signed on at the time and ratified it in December 1992. The Convention came into force in December 1993 (after being ratified by 30 countries) and it now has about 188 countries in support of it (but excluding the US). The permanent Secretariat of the Convention was located in Montreal in 1995, and as a host country, Canada committed (in 2004) some $11 million in support over 10 years.

The overall goal of the UNCBD is to reduce significantly the rate of loss of global biodiversity by the year 2010. The three main objectives are conservation of biodiversity, sustainable use of biological resources, and the fair and equitable sharing of the benefits coming from the use of genetic resources. The goal and objectives were specified more directly in a Strategic Plan for the Convention adopted in 2002 (10 years after Rio); this Plan articulated quite general indicators to assess progress in its implementation. A Cartagena Protocol on Biosafety was adopted in 2000 as a supplementary agreement to address issues of protecting biodiversity from possible risks arising from genetically-modified organisms produced by the biotechnology industry.

A number of difficulties have been encountered in implementing the Convention. They include scientific issues of systematics and nomenclature to define various groups of biota; realization that most species of flora and fauna (other than vascular plants and vertebrate animals) remain to be discovered; a need to reconcile and harmonize provisions in the UNCBD with other international agreements (e.g. the World Heritage Convention and the Ramsar Convention for wetlands) as well as other agreements about the sustainable use of biological resources; insufficient financial and other support from governments; and difficult political issues about access to, and sharing of genetic resources, and provisions in the Cartagena Protocol (e.g. UNEP 2005a; ENB 2005).

The three Rio Conventions together cover interrelated issues such as biodiversity and climate change (Gitay and others 2002) that require further attention. There are also numerous links with commitments identified in the voluminous Agenda 21 requirements agreed upon at Rio in 1992 for enhancing sustainable development. All of these came up for consideration at

the WSSD in 2002, and the Johannesburg Plan of Implementation includes a continuing commitment to the purpose of the UNCBD (UNEP 2005b).

Millennium Ecosystem Assessment (MEA)

The MEA was a four-year (2001-2005) collaborative assessment of the linkages between ecosystem change and human well-being, on a global and regional scales. In 2000, the Secretary-General of the United Nations deemed the MEA to be a priority action to help meet the Millennium Development Goals during the early decades of the 21st century, and it was endorsed by the WSSD in 2002. The organization for the MEA was modeled on the IPCC, but without the same direct involvement of governments. The MEA had direct involvement from Parties to the UNCBD, the Convention on Combating Desertification, and the Ramsar Convention. It also had a multi-stakeholder governance structure that, besides the Convention representatives, drew upon representatives from UN institutions such as the World Bank, UNESCO, FAO, UNDP (United Nations Development Program), UNEP, WHO (World Health Organization) and the GEF (Global Environment Facility); from government agencies, business and private foundations; and from INGOs such as the Business Council for Sustainable Development, Indigenous Peoples' Biodiversity Information Network, Max Planck Society, World Economic Forum, and the Third World Academy of Sciences. Altogether, some 1,300 scientists from 95 countries were reported to have contributed to the MEA.

The MEA developed a conceptual framework to be applied at global, regional, and local scales. It has four major interconnected compartments. Demographic factors, along with actions arising from the political economy, technology, values, and institutions, constitute "indirect drivers of change" that set conditions of "human well-being and poverty reduction" while also leading to "direct drivers of change" in resource extraction, land use practices, and pollution. These in turn impact on "ecosystem services" which then affect human well-being. Policy interventions are possible for most of these interconnections. (World Resources Institute 2003).

Ecosystem services are grouped into four categories: "provisioning" such as food, fibre and water; "regulating" such as water purification, climate regulation; "cultural" such as recreational, spiritual, sense of place; and "supporting" such as the basic ecological processes of soil formation and primary production. The services interpretation, rather than biodiversity

conservation, facilitates the inclusion of ecosystemic considerations into discourses about sustainable development.

The MEA had four working groups: (1) Sub-global assessments to conduct or stimulate a number of local, national, and regional assessments that used the MEA framework – this group had also to deal with issues raised by multi-scale and multi-epistemological assessments (Reid 2004) and it drew extensively upon people from developing country institutions to help; (2) Conditions and trends for major categories of ecosystems, such as terrestrial, freshwater, and marine – the UNEP World Conservation Monitoring Centre assisted with this; (3) Ecosystem scenarios to review international literature about diverse possible trajectories of development patterns and their possible impacts on ecosystem services – ICSU/SCOPE assisted here; and (4) Response options to identify policy, institutional, legislative or technological changes that could help restore and maintain ecosystem services – this also drew upon knowledge of people from developing countries with widely different institutional arrangements.

The MEA reported its four main findings in March 2005: (1) "Over the past 50 years humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history…This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth"; (2) The changes to ecosystems "…have contributed to substantial net gains in human well-being and economic development…but at growing costs in the form of degradation…increased risks of non-linear changes and the exacerbation of poverty for some groups of people"; (3) "The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals"; and (4) "The challenge of reversing the degradation of ecosystems while meeting demands for their services…involve significant changes in policies, institutions, and practices that are not currently under way…" (MEA 2005).

Canadian Participation and Responses to the Rio Commitments

Climate change

A Canadian Climate Program Board (CCPB) had been set up in 1979 to help coordinate research undertaken on climate topics by a number of federal agencies, working closely with the World Climate Research Program (WCRP) on many of the same problems, and serve as an

advisory body for governments. In 1991, funds from the federal Green Plan were used to increase basic research on climate; initiate integrated regional impact assessments of climate change on the Great Lakes region, the Mackenzie Basin and the Prairie Provinces; and address issues raised by negotiations for the UNFCCC (Environment Canada and Energy, Mines and Resources, 1993). Following the 1992 Rio Conference, the CCPB identified six directions for climate change studies in Canada which would contribute to the UNFCCC as well as contributing climate change information for sustainable development (e.g. Agenda 21) and the conservation of biodiversity (e.g. the UNCBD). These actions included those of the Canadian Global Change Program coordinated by The Royal Society of Canada, associated mainly with the International Geosphere-Biosphere Program (CCPB 1993).

In 1998, a Climate Change Action Fund (CCAF) was created by the federal government to provide about $50 million annually towards activities related to climate change set in the context of the Kyoto Protocol requiring Canada to reduce GHG emissions 6% below 1990 levels by 2008-2012. The original three-year program was subsequently extended through 2003-2004. Action Plan 2000 gave directions and priorities, as did a Climate Change Plan for Canada in 2002. The 2002 Plan reflected principles suggested by provincial and territorial governments regarding issues of equitable sharing of benefits and burdens, a “made-in-Canada” approach, and developing export-potential technologies for an energy-efficient and less emissions-intensive society. The Plan detailed “five key instruments” for achieving this: emissions reduction targets for large industrial emitters which will include a carbon trading scheme; strategic infrastructure investments; a partnership fund; a coordinated innovation strategy; and targeted measures that include incentives, regulations, tax measures, and other information (Government of Canada 2002).

Environment Canada and Natural Resources Canada (NRCan) continued as co-lead agencies for science, and for applications to industry sectors, respectively. At least 10 other federal agencies were involved for climate-related activities within their areas of jurisdiction (e.g. health or agriculture). A Climate Change Secretariat helped coordinate this through bodies such as a National Air Issues Coordinating Committee, the Canadian Councils of Ministers for the Environment and for Energy, the federal Interdepartmental Climate Change Management Committee, and various working groups. Several broad lines of work have been conducted.

Environment Canada, through a Canadian Climate Centre, continued climate research, first initiated in 1979, to the extent it has become an internationally recognized centre for climate system monitoring, analyses, and development of global general circulation models. These models have become progressively more sophisticated as linkages among atmospheric, oceanic and land-based processes were included in them, and refined through calibrations using data from the geological past along with more recent (past century) and current sources. Progress has also been made on “down-scaling” global models to large regions of the world to provide climate change scenarios which can then be assessed for possible impacts and adaptations needed to protect vulnerable water or food supplies or to protect human health. Useful experience has been gained from conducting integrated assessments (first proposed in 1991) as reported for the Mackenzie Basin (e.g. Cohen 1997).

NRCan has developed public-private partnerships for demonstrating Technology Early Action Measures (TEAM) in key sectors to reduce GHG emissions, and for some community-based initiatives to do the same. Sustainable Development Technology Canada was created to fund the development and commercialization of new technologies for dealing with climate change and air quality problems. Different approaches for achieving targets set by the Kyoto Protocol have been evaluated through modeling studies and analyses, and have been used to inform negotiations both domestically and internationally about implementing the agreement. Among the approaches examined was a “Domestic Emissions Trading” option.

A number of pilot projects explored alternative energy sources and conservation measures. Wind Power Production Incentives (WPPI) were made available in 2001, as were funding for “Green Municipal” initiatives to reduce emissions. The latter were administered by the Federation of Canadian Municipalities through its Centre for Sustainable Community Development. An “EnerGuide for Houses Retrofit Incentives” program was introduced in 2002 and is being delivered mainly through the Green Communities Association. A national GHG emission inventory system is being developed. Public education and outreach activities were organized around partnered projects for individual communities, business and industry sectors, schools (K-12) and for the general public.

Partnerships and networks have been organized across Canada to carry out different components of climate change work. Following an independent review of issues about adapting to climate change (Smit 1993), Environment Canada established an Adaptation and Impact

Research Group (AIRG) in 1994; the group subsequently distributed staff among headquarters and four universities (Toronto, York, Waterloo, and UBC) to help develop collaborative research, some of which has been used by the IPCC. NRCan helped organize a Canadian Climate Impacts and Adaptation Research Network (C-CIARN) around sectoral nodes for water, fisheries, coastal zones, forestry, agriculture, and health; and for 6 regions of Canada. The Ontario C-CIARN was formed following an exploratory workshop (Klassen and Auld 2001) and is based at Laurentian University. A Climate Change Scenarios Network has been created with the University of Regina as the national node, and the University of Toronto, Institute for Environmental Studies, the Ontario regional node. The Climate Change and Health Office of Health Canada coordinates six Health Issues Research Networks.

The federal Project Green Plan announced in 2005 builds on all this through to 2012. It includes a total of $2 billion for existing climate change programs, and additional funds (totalling almost as much) for renewable energy, purchase of emission reduction and removal credits, and special partnership projects. A Sustainable Energy Science and Technology Strategy will guide the implementation of the Plan. Priorities are to go to reducing GHG emissions from “large final emitter systems” in the oil and gas, mining and manufacturing, and thermal electricity sectors; voluntary reductions to target levels have been agreed to with the automotive industry. The purchase of carbon credits is to be coordinated by an “offsets body” in Environment Canada, and incorporated eventually into an anticipated international trading market for carbon under the terms of the Kyoto Protocol. Regional climate centres, cost-shared with provinces and territories, will deliver “Community Challenges” programs and incentives. Public education and participation activities (e.g. the One Tonne Challenge) continue as a major component (Government of Canada 2005). While generally welcomed, this Plan has been criticized by both supporters and sceptics for its lack of specificity, targets and timelines.

Munn (1995) argued the need to consider a number of atmospheric change issues rather than just climate change, and that they need to be considered in some integrated way rather than individually by independent programs for each major group of contaminants or causes of negative changes (as was the prevailing practice for climate change, ozone and ultra-violet B radiation, acid rain, smog, etc.) The Ontario Ministry of the Environment has adopted this broader approach, emphasizing “co-benefits” from emissions reductions generally, and especially for the reduction of smog. The strategy announced in 2001 included the drive clean and smog patrol for vehicles, mandatory tracking and reporting of 358 airborne pollutants from

major industrial sectors, an intent to phase out coal-powered thermal power plants (originally by 2007), up-dating building codes to provide for energy-efficiency, assistance for urban forestry and roof-top gardens (as solar energy absorbers and carbon sinks), and encouraging volunteer measures from industries and individuals. The success of this depends greatly on securing cooperation from neighbouring US States (OMOE 2001).

Research by the multi-sponsored Climate Change, Air Pollution, and Health Research Network should reinforce the importance of these policy measures. Two, among a number of current projects, are conducting an integrated analysis of weather-related mortality in the Toronto-Windsor corridor, and investigating synergistic impacts of winter and summer weather and air pollution due to global warming on human mortality in south-central Canada (Windsor, Toronto, Ottawa, Montreal).

NGOs and networked organizations have taken on significant roles for addressing climate change and air quality issues. An international climate action network was established in 1989 to follow, and participate where possible, in international discussions and negotiations for the UNFCCC and Kyoto Protocol; it has 13 national networks with over 340 NGOs and is based in Bonn, Germany. The Canadian Climate Action Network (a member) has more than 100 organizations involved in different ways in the climate change debates. This includes advocacy for best practices conducted by organizations such as the Pembina Institute, Pollution Probe, the David Suzuki Foundation, Greenpeace, and the Sierra Club (Canada). A Green Communities Association delivers the NRCan EnerGuide for the Home Retrofit Incentive Program and, working with the Montréal based NGO Equiterre, has been a major proponent of energy efficiency programs targeted to low-income residents to achieve equity as well as ecological benefits.

Along with the International Council of Local Environmental Initiatives (ICLEI), the Federation of Canadian Municipalities (FCM) also manages a Partners for Protection Program to assist municipalities in preparing and implementing plans to reduce GHC emissions in cost effective ways. Arguably, municipalities in Canada and elsewhere have often shown more initiative than their federal or provincial counterparts in climate change action. They have also been more consistent in seeing opportunities to include climate change mitigation in multi-objective undertakings. One example is the Toronto Atmosphere Fund, established in 1991 by

the Toronto City Council to support efforts to improve urban air quality as well as reduce greenhouse gas emissions.

Biodiversity Conservation

Environment Canada established a Biodiversity Convention Office in 1991, initially to coordinate Canadian participation in negotiations for the UNCBD. The Office continued this role for preparing Canada Country Reports, and coordinating a federal-provincial-territorial Canadian Biodiversity Strategy which was completed and approved in 1995 and released the following year. The Strategy has a vision statement, a set of guiding principles, five general goals, and some 190 statements about “strategic directions”, all said to represent a national perspective. The scope of the report covers issues related to the conservation and sustainable use of biodiversity, promotion of understanding about what this entails, and identifying programs, legislation, and incentives (with examples) that are available to do this. The expectation was that different agencies and NGOs would take guidance from this to prepare their own contributions to the purpose of the CBD as it would apply in Canada.

In 1992, the federal-provincial-territorial Ministers of Environment, Parks, Forestry and Wildlife issued a “Statement of Commitment to Complete Canada’s Networks of Protected Areas”. It was generally assumed that the various systems of parks and protected areas being developed independently by different federal and provincial-territorial agencies would be the major vehicles for biodiversity conservation. A Conservation Areas Data Base maintained for the Canadian Council on Ecological Areas (CCEA) has listed some 3,500 protected sites, categorized with reference to the international classification developed by the IUCN (World Conservation Union). The sites are administered by both government agencies and major NGOs (such as the Nature Conservancy of Canada, and Ducks Unlimited).

The Canadian Biodiversity Strategy also identifies intergovernmental programs for resource management that provide contexts for including elements of biodiversity conservation. Examples include the National Forest Strategy, the Whitehorse Mining Initiative, the Prairie Farm Rehabilitation Administration, the North American Waterfowl Management Plan, and the Fisheries Resource Conservation Council. Programs for ecosystem rehabilitation also provide opportunities; examples cited were the Fraser River Basin Action Plan, Great Lakes Water Quality Agreement, and St. Lawrence Action Plan.

In 2001, a federal-provincial-territorial biodiversity working group identified four priorities for collaboration to implement the Canadian Biodiversity Strategy over the period 2001-2006: address the threat of invasive alien species; build a foundation for biodiversity science and information management; monitor and report on the status of biodiversity using a common framework from the scale of species through ecosystems to the national and international levels; and engage the public and NGOs in biodiversity stewardship. “Business plans” to detail these priorities were to be produced.

In June 2005, Ontario issued a biodiversity strategy following the principles of the Canadian Biodiversity Strategy. It highlighted recent initiatives to create a Greenbelt around the Niagara-Greater Toronto region, on-going reviews of legislation for provincial parks and other protected areas, and work towards developing an invasive species strategy (Government of Ontario 2005).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was established in 1977 to obtain expert judgement about the conservation status of vertebrate animals and vascular plants, and its scope was expanded in 1994 to cover other taxa. After considerable delays and controversy, the federal government passed a Species at Risk Act (SARA) in 2003, with modified provisions for COSEWIC and a $45 million 5-year Habitat Stewardship Program (2000-2005) to fund organizations that carry out habitat conservation activities for particular species at risk. Some 345 species were listed as of 2005. The Recovery of Nationally Endangered Wildlife (RENEW) program was started in 1988 to draw up recovery plans for endangered or threatened species, and management plans for species of “special concern”. As of 2004, 25 recovery plans for individual species of animals and plants had been published and 146 others were being prepared; another eight ecosystem-level recovery plans were also underway. Some provinces maintain their own lists of species and have provincial endangered species legislation.

Beginning in 1989, Conservation Data Centres have been created in seven provinces or regions of Canada, modelled on the US Nature Conservancy’s state natural heritage programs, through collaboration between the NCC and provincial agencies. These provide a more extensive classification and assessment of conservation status. The CDC for Ontario is the Natural Heritage Information Centre in Peterborough (ONHIC); the Centre carries out selective

field surveys to enhance knowledge of species occurrences, including different major groups of invertebrates and non-vascular plants.

Two sets of legal changes have facilitated a rapid growth in NGO involvement in biodiversity conservation through land trusts. One was modifications of the federal tax code in the 1995, 1997, and 2000 budgets, especially with reference to exemptions from capital gains taxes on lands donated for conservation ("EcoGifts"). The other allowed for NGOs approved by Environment Canada (about 136 across Canada so far) to hold lands conveyed to them under the "EcoGift" provisions. A Nature Trust Alliance, formed in Ontario in 1997, became the Ontario Land Trust Alliance in 2001 and now has about 30 member organizations; a Canadian Land Trust Alliance was formed in 2003.

Other kinds of partnerships have been developed to enhance biodiversity conservation. The Biodiversity Convention Office maintains the Canadian Biodiversity Information Network (CBIN) as the Canadian node for the "Clearing-house Mechanism" established by the UNCBD. Environment Canada established an office in 1994 to help develop the Ecological Monitoring and Assessment Network (EMAN) to link organizations and people conducting community-based ecological monitoring in Canada. EMAN promotes information exchange, adoption of shared protocols for data gathering and information management, and closer ties with users of information obtained from monitoring. EMAN has the lead responsibility in Canada for monitoring climate change, ultra-violet B radiation, toxic contaminants, and biodiversity. Its annual science conference and regional training workshops on monitoring protocols fulfill an important support role for biodiversity conservation.

In Ontario, the Royal Ontario Museum created a Centre for Biodiversity and Conservation Ecology in 1995 to facilitate cross-curatorial collaboration for basic scientific work, including molecular systematics. The Canadian Botanical Conservation Network was established in 1998 by the Royal Botanical Gardens in Hamilton to bring together botanical gardens, arboreta and related organizations more directly in an "ex-situ" backup role for plant conservation. It currently has 18 member institutions and is guided by a strategy statement prepared for 2000-2005. Most universities offer instruction related to biodiversity, conservation, and restoration, and some, such as UBC, have research centres devoted to this.

Millennium Ecosystem Assessment – Sub-regional Application

The multi-scale design of MEA called for a number of sub-regional assessments at different scales using the conceptual framework applied to specific situations. Sixteen sub-global assessments were approved, including the “Coastal Information Team” (CIT) in northern coastal British Columbia (the only Canadian example). A number of “associated assessments” initiated by other organizations were also recognized, including the Northern Highland Lake District, Wisconsin, the only other example from North America.

The CIT was an independent, multi-disciplinary group recruited to work with stakeholders engaged in the Central Coast Land and Coastal Resource Planning process for the “Great Bear Rainforest” and the Haida Gwaii to help with the implementation of a Framework Agreement signed in 2001. The region covers a land area of 118k km^2 and a sea area of 107k km^2. From 2002 to 2004, CIT conducted regional and local analyses of ecological, social, and economic information to prepare an ecosystem-based management framework and handbook, a hydroriparian planning guide, and other technical support for pilot projects. CIT was required to use the best available scientific, technical, and traditional local knowledge of the aboriginal residents for these analyses.

The scope of the studies included detailed ecological analyses of the ecological integrity of each main biogeoclimatic zone within the eight major sub-regions of the study area; integrity was seen as the key to the sustained provision of ecological services. A human well-being assessment was made, based on studies of peoples’ access to both ecosystem services and economic activities, general social conditions, and policy and institutional support arrangements. A detailed set of indicators was developed to provide an ecological integrity index for ecosystems in each sub-region, and a human well-being index (as of 2001) for each sub-region. This index was based on nine objectives such as health, economic incomes and sustenance, education levels, participation in community cultural practices, and community peace and security.

Constraints or limitations were encountered by the lack of some information and data in the form desired. The tasks assigned to CIT required considerable ecological analyses to provide the ecosystem-management framework, so some desirable work on other aspects could not be completed with the budget and time available. The team recommended that the

stakeholders adopt a more integrated framework, one very similar to the conceptual framework used by the MEA, in order to link ecological integrity with human well-being (Allen 2005).

The ICSU Co-Sponsored Programs

The World Climate Research Programme (WCRP).

The WCRP was established in 1980 by ICSU, WMO, and the UNESCO Intergovernmental Oceanographic Commission. It promotes fundamental research into the physical climate system and climate processes, natural climate variability, and human-induced climate change. Much of this work directly informs assessments conducted by the IPCC. The WCRP is guided by a Joint Scientific Committee of 18 people, it has International Program Offices for each major project established at universities or research institutes in different countries, and a Joint Planning Staff based in the WMO.

The main core projects (most with sub-projects) include: Climate and the Cryosphere (CliC); Climate Variability and Predictability (CLIVAR); the Global Energy and Water Cycle Experiment (GEWEX); the Surface Ocean-Lower Atmosphere Study (SOLAS); Stratospheric Processes and their Role in Climate (SPARC); as well as various modeling studies. WCRP is a founding member of the Earth Systems Science Partnership (ESSP).

DIVERSITAS – An Integrative Approach to Biodiversity Science.

This program was established in 1991 by UNESCO, the International Union of Biological Sciences (IUBS), and ICSU/SCOPE to address scientific questions about changes and loss of global biodiversity. During its first phase, from 1991 to 1998, DIVERSITAS was organized around 12 major projects developed at different times over the years, with Secretariat services provided by UNESCO/MAB. The program was guided by a 12 member Scientific Committee, and an International Advisory Board. It was funded mainly by national funding agencies in ten countries (not including Canada) along with other grants and sponsorships. The project themes addressed questions in areas such as biosystematics; relationships between biodiversity and ecosystem functioning; monitoring, conservation, and restoration; improved understanding of

soil and microbial biodiversity; biodiversity in marine and freshwater ecosystems; invasive species; and “human dimensions of biodiversity”.

Sponsors of DIVERSITAS decided in 2001 to embark on a second phase of the program, with a new Secretariat based in ICSU. Consultations held with various scientists in 2002 identified three interrelated research themes that were further elaborated by “scoping meetings” in 2003. The themes have been named “bioDISCOVERY, ecoSERVICES, and bioSUSTAINABILITY”. Work is underway to refine them into sets of research projects, identify “cross-cutting networks”, establish International Project Offices to coordinate each theme, and encourage formation of national committees to further the work (~30 so far, but not Canada). Details are found in DIVERSITAS (2004) and in Bulte, Hecor and Larigauderie (2005). The proposed program follows up work of the MEA, and DIVERSITAS is a founding member of the ESSP.

International Geosphere-Biosphere Program (IGBP)

The IGBP was established in 1986 by ICSU to promote scientific research on “…the interactive physical, chemical and biological processes that regulate the total Earth system” and changes that are occurring, many through human activities. Following extensive consultation and organizational activities, a set of core projects had been initiated by 1990, guided by a set of research questions and grouped under theme areas such as terrestrial-atmospheric interactions; marine-atmospheric interactions; global models and processes; the Arctic region; remote sensing; proxy environmental data (paleo-environments); and baseline data and information management. This work was carried out with assistance from 78 IGBP or Global Change National Committees (including Canada). Results were shared through many scientific and technical meetings around individual projects and through three IGBP Congresses held in Germany (1996), Japan (1999), and Canada (2003). The last marked the conclusion of the first phase of the IGBP, following publication of a great many scientific papers and reports over the years as well as several major volumes that synthesized work accomplished under particular themes, and a program-wide synthesis (Steffen and others 2004).

The current phase of work under IGBP, just getting underway, is organized around “three interlocking and complementary structures”. Core projects will continue to study global biogeochemical cycles in the atmosphere, oceans, and land as well as the interfaces among the

three; a more formalized integrated study of the entire Earth system, both functionally and geographically, is being developed though an “Analysis, Integration and Modeling of the Earth System (AIMES) project; and cross-cutting projects on topics of major societal importance are being planned with other international programs.

The AIMES project acknowledges that the Earth must be seen as a coupled, interactive human-environment system as a whole, and that it is no longer appropriate to consider humans as disruptive external forces acting on natural systems. This approach requires the project to integrate social science components, building in part on earlier work of IHDP-IGBP on methodologies for integrating social and biophysical research, and on integrated scenarios of the evolution of the “Earth System in the Anthropocene” (Schellnhuber 1999). The cross-cutting themes are being addressed by joint projects with the WCRP and IHDP. The initial ones include global carbon studies, global environmental change and food systems, global water systems, and global change and human health.

This move from what had been a set of quite autonomous projects during the first phase of ICBP towards a more ambitious inter-linked or integrated set is reflected by the formal alliance among the four international global change programs (IGBP, WCRP, DIVERSITAS, and IHDC) into the Earth System Science Partnership (ESSP) in 2001.

International Human Dimensions Program (IHDP)

This was started as the human dimensions program in 1990 by The International Social Science Council. In 1996, ICSU became a co-sponsor, the name was changed to IHDP and a Secretariat was established in Bonn, Germany. It promotes policy-oriented research and also research that would be of wider interest to other social organizations. An ultimate goal “… is to fashion a human dimensions research agenda that is specific and relevant to current global realities and scenarios of future trends in global transformations. These realities include not only social and cultural globalization and the prevailing free-market economic frameworks, but also alternatives emerging from groups that contest globalization” (IHDP 2005).

IHDP has four core projects. The Industrial Transformation (IT) project is exploring driving forces for change and development trajectories based on production and consumption systems that are environmentally sustainable. An Institutional Dimensions of Global

Environmental Change (IDGEC) project is examining the role of social institutions in both causing, exacerbating, and solving large-scale environmental problems, using ocean governance, forest use, and carbon management as examples; A Global Environmental Change and Human Security (GECHS) project focuses on relationships between global environmental change and human security and related issues of perception, adaptation, vulnerability, interaction, response, and thresholds; and the Land-Use and Land-Cover Change (LUCC) project, carried out with IGBP, investigates the driving forces for land use change such as climate change, food production, urbanization, coastal zone development, transboundary migration, and water availability. IHDP is also involved with three other joint projects that form part of the ESSP. Each project has an International Project Office in a host country; GECHS is based in Carleton University, Ottawa. The program has people from 68 countries (including Canada) participating in its projects, and is guided by an international science committee (IHDP 2003).

Preparations for “Sustainability Science”

The perspectives adopted for the ESSP generally, and the AIMES project in particular, have raised considerable discussion about how science should be done to overcome limitations arising from exclusive reliance upon methods and techniques from natural sciences in projects that only seek input from social science (if at all) as an add-on. This led to declarations about the need to address phenomena posed by complex interdependent social and environmental systems that pose extensive uncertainties and indeterminancies; to learn effective participatory approaches whereby scientists work as partners with non-scientists who contribute to, benefit from, or use research results; and examine the necessary changes in scientific institutions and practices in order to enable this collective capacity to develop (e.g. Friiberg Statement 2000; McMichael, Butler, and Folke 2003; Palmer and others 2005). The main rationale of the ESSP is to enhance transitions to sustainability, hence the knowledge to be sought has been called “sustainability science”, and key questions for it to address have been posed by Kates and others (2001). A detailed overview of the current state of scientific knowledge and a realistic assessment of what an earth systems approach will entail is presented by Schellnhuber and others (2004).

One recurring theme for sustainability science is the need to analyze vulnerability in coupled human-environment systems (Kasperson and Kasperson 2001). This general concept

had been discussed in the context of the IGBP almost from its beginning (e.g. Meredith and others 1994). A conceptual framework developed by the Research and Assessment Systems for Sustainability Program at Harvard University (Turner and others 2003a) draws upon the concepts of “entitlement and endowment”, “coping through diversity”, and “resilience” (from ecology). Three case examples of its application (one from a biosphere reserve in Mexico) are given by Turner and others (2003b).

A quite similar, or complementary perspective has been developed around the concept of “syndromes of global change” (Schellnhuber and others 1997). It is based on about 80 symptoms of negative human impacts on environments. These combine in various ways in different regional through local areas around the world to become complex functional patterns of human-nature interactions that maintain or exacerbate environmental and social degradation with increasing non-sustainability. Models to describe these syndrome situations, partly in quantitative terms, can identify points where corrective actions might be taken. About 16 of these syndrome patterns have been identified and classified as primarily caused by resource exploitation, impacts from development activities, or discharge of pollution and toxic contamination (Ludeke, Petschel-Held, and Schellnhuber 2004).

Sustainability science will also encounter issues similar to those studied more extensively for some time under the rubric of “managing transitions for sustainable development”. This is a guided “participatory integrated assessment (PIA)” of technological changes and social innovations required in complex systems over a number of years within a country to make a transition from a dynamic equilibrium state that is no longer sustainable to a new one that would be more sustainable, at least for a generation or so. The procedures to apply this approach make extensive use of scenarios combined with models and techniques to present them, backcasting exercises that develop a vision of a sustainable future as the basis for thinking through strategies that would move towards it, and extensive exploration of stakeholder participatory processes for the PIA. There is an extensive literature on this, most based on exercises focused on some key economic sector, but recognizing implications from linkages with related sectors (e.g. Rotmans, Kemp, and van Asselt 2001; Quist and Vergagt 2003; van der Brugge 2004; Siebenhuner 2004; Geels 2005). Smart, Raskin, and Robinson (2004) describe the significance of this work for the goals of sustainability science.

Canadian Participation and Responses to the ICSU Programs

Canada, through the National Research Council, provides an annual subvention of about $1m to ICSU's annual budget of about $14m. The Canadian Climate Program works closely with the WCRP. The Royal Society of Canada (RSC) established the Canadian Global Change Program (CGCP) in 1985 as a network for communication and coordination among participants engaged in work related to the WCRP, IGBP, and the IHDP; it also served as the Canadian "focal point" for these programs. The goal of the CGCP was "…to ensure that global change research in Canada is cohesive, comprehensive, and responsive to national needs and international initiatives". The RSC support for CGCP ended in 1998 following budget cuts, and responsibilities for elements of the program were transferred to the University of Victoria. There appears to be no specific institutional support for DIVERSITAS.

Indirect support for the ICSU Global Change Programs comes from academic and government research funds for specific projects. ICSU seeks volunteer International Program Offices to help coordinate each major project, and some of these have been hosted by Canadian institutions (e.g. SPARC at the University of Toronto, and GECHS at Carleton University). A number of individuals participate in both the Rio Convention and ICSU-related activities, for example, in IPCC Working Group II and the IHDP. There undoubtedly are a number of informal interpersonal networks as well.

Implications for Biosphere Reserves

UNESCO/MAB has formal cooperative arrangements with the UNCBD, ICSU/SCOPE and DIVERSITAS among the programs noted above, and work done through the UNESCO International Oceanographic Commission (linked to WCRP) and International Hydrological Program contributes to that of other global change programs. The UNESCO Management of Social Transformation (MOST) Program shares similar issues with the IHDP and sustainability science initiatives. Under its Chairs and Networks in Social and Human Sciences, UNESCO has sponsored at least five in Canada, including one at Laval University established in 1992 to foster a sustainable development network, one at UQUAM established in 1992 for environment and sustainable development, and one at York University established in 1999 for re-orienting teacher education towards sustainability.

UNESCO/MAB relies on MAB national committees (and/or national commissions for UNESCO) to coordinate and link national (and provincial) programs within any given country to the appropriate international programs (especially those co-sponsored by UNESCO). Biosphere reserves are expected to be served this way; Canada/MAB lost its funding and became dormant in 1992 so any links have to come from individual initiatives. Biosphere reserves in Canada are pre-occupied with issues of capacity-building and program support, and depend largely, or in some cases exclusively, on volunteerism. This limits the number and range of initiatives they take on.

While it is generally recognized that issues addressed under the Rio Conventions and ICSU programs can have relevance for biosphere reserves, they need to be thought about and interpreted at geographic scales closer to the local levels in which biosphere reserve groups work. The climate change scenarios for the Great Lakes region help to do this for Ontario, as do studies by a C-CIARN coastal sector group on adaptation options for the coastal Great Lakes under climate change. Scenarios have suggested that with a doubling of CO_2 GHG concentrations in the atmosphere (expected by about 2030), the mean air temperatures could increase by up to $+5^0$C in summer and even more in winter over this century. Extreme weather events are expected to increase in frequency, the base flows in rivers and streams will likely drop, more runoff will occur in fall and winter, periods of winter ice will be shorter, and water levels in the Great Lakes may decrease by 1 to 2 metres. Forests and agriculture crops will be subjected to more stress and biodiversity will be affected. (e.g. Mortsch, Alden, and Scheraga 2003). Under these conditions, the Georgian Bay Littoral Biosphere Reserve (GBLBR) and Long Point Biosphere Reserve (LPBR) will be most affected by lake level changes, and the Oak Ridges Moraine (ORM), in particular, will be affected by reductions in the base flows of rivers and streams originating on the moraine. Atmospheric contamination (including smog) already affects all five areas in Ontario, especially the more southern portions of the Niagara Escarpment Biosphere Reserve (NEBR), LPBR and ORM.

There are some activities related to adaptation and mitigation in biosphere reserves. LPBR and NEBR, as part of a Canadian Biosphere Reserves Association (CBRA) project, have examined local trends in weather data as a first step towards informed discussions about the implications of this for the future. LPBR has been funded by Ontario Power Generation (OPG) to undertake reforestation using native species to enhance corridor connections among the

Carolinian forest tracts, and 66 ha have been planted since 1995. This is part of OPG's carbon sequestration and biodiversity program to meet its own GHG reduction targets and at the same time accumulate "off-sets" that could be converted into monetized credits should a carbon market develop. ORG has initiated similar arrangements with other organizations in southern Ontario, including groups in NEBR and ORM.

The "ecoPerth" joint program with the Ontario Healthy Communities Coalition has 14 community-based projects underway, including the NRCan EnerGuide for house retrofits, to make the town of Perth (in Lanark County) a "greenhouse gas reduction leader" by reducing its GHG emissions by 20% by 2010. Funding comes from Environment Canada and the Ontario Trillium Foundation, and in part this is to have "ecoPerth" help other communities do the same and create a network of support. The Windfall Ecology Centre in York Region provides these services in the ORM area. The Frontenac Arch Biosphere Reserve (FABR) has started several of these projects in Leeds and Grenville County (Leeds is almost co-terminous with the biosphere reserve), and Gananoque (within FABR) has joined the new network. A Lanark & Leeds Green Community project has also been started with Environment Canada funding to reduce air pollution from farm and homeowner practices of burning garbage outside in large drums.

Biosphere reserves have a larger, although mostly passive, role for the conservation of biodiversity. It arises from the UNESCO requirements to have core areas and buffer zones as part of their land use configurations. The NEBR provides for this in the Niagara Escarpment Plan (NEP), updated most recently in 2005, under the terms of the 1973 Niagara Escarpment Planning and Development Act. The "core area" requirements are met by lands designated as "Escarpment Natural Areas" under the NEP, and "buffer zones" are lands designated as "Escarpment Protection Areas" and "Escarpment Rural Areas". This conservation function is further enhanced by 123 provincial parks or other protected areas along the escarpment and inclusion of the two national parks along the Bruce Peninsula as part of the biosphere reserve. Similar arrangements exist for the ORM, if the Oak Ridges Moraine Conservation Plan (prepared under the Oak Ridges Moraine Conservation Act, 2001) is viewed in terms of a biosphere reserve. "Core areas" would be lands designated as "Natural Core Areas" and "Natural Linkage Areas", and buffer zones are the "Countryside Areas" referred to specifically as buffers in the Plan.

The other three areas in Ontario have some mix of protected areas that fulfill core and buffer zone requirements. The GBLBR has the most extensive arrangements comprising one national park, five provincial parks, and 14 conservation reserves which (along with large areas of unused or inaccessible lands) results in a largely continuous green corridor along the entire biosphere reserve.

Local land trusts also exist in each of the five areas. The FABR is working closely with other groups on GIS mapping at regional and local scales to identify connectivity corridors and key sites for ecological restoration in cooperation with willing land owners. Bird Studies Canada and Ontario Nature identify and help protect Important Bird Areas (IBAs) using criteria specified for worldwide application by BirdLife International; several IBAs are in Ontario biosphere reserves, and the Long Point complex itself is an IBA of global significance. Ecological restoration projects have been undertaken in each of the five areas, some initially stimulated by a CBRA project that received funding for this purpose.

All five areas help protect COSEWIC-listed species at risk: LPBR has 31; NEBR 24; GBLBR 24; FABR 23, and ORM 14. NGO groups in several biosphere reserves help monitor different groups of fauna, especially birds. In LPBR, Bird Studies Canada maintains the Long Point Bird Observatory, established in 1960, and now the longest continuously operated bird observatory in North America; a Bruce Peninsula Bird Observatory was established in NEBR in 1999. In GBLBR, a community volunteer group has a reptile awareness program that tracks occurrences of 11 species of snakes and turtles at risk.

National Parks have a statutory requirement to make protection of “ecological integrity” a priority in management decisions. The three national parks associated with Ontario biosphere reserves approached this by defining a “greater ecosystem” for viewing parks in their larger landscape surroundings. While the boundaries used for this differ from those defining the biosphere reserve (they were defined prior to the biosphere reserve in two cases), there is scope for collaboration in thinking about ecological integrity in a larger biosphere reserve context.

Land and water stewardship activities are conducted by several organizations in most of the five areas. Conservation Authorities (CAs), organized on a watershed basis, have a major role. LPBR and FABR have shared projects with the one CA in their respective areas, and

NEBR has several projects with some of the seven CAs having jurisdiction for watersheds that include portions of the escarpment. There is no CA in the GBLBR. Stewardship Councils are formed on a county-wide basis to work with private owners of rural lands on stewardship activities. LPBR and FABR have shared projects with their local Stewardship Council. For the ORM, a Moraine Stewardship Partner Alliance was formed in 2002 by the nine CAs and seven Stewardship Councils (and Wildlife Habitat Canada) to coordinate moraine-wide stewardship activities. For the farm sector, the Ontario Farm Environmental Coalition with the Ontario Soil and Crop Improvement Association administer a federal-provincial program for Environmental Farm Plans; there seem to be few, if any, direct links with the Ontario biosphere reserves.

Biosphere Reserves also have to develop capabilities though research and monitoring programs, and education and public information activities. Monitoring has become a major area of interest, in part because of the assistance received from EMAN. Biodiversity monitoring plots, based originally on the design developed by the Smithsonian Institution's "Monitoring and Assessment of Biodiversity" program (SIMAB) have been established in at least four of the areas in Ontario, especially in LPBR, GBLBR, and along the NEBR. Monitoring follows a set of protocols that have been adopted or developed by EMAN. With EMAN's help, LPBR installed a climate tower at one of the plots to gather data on air temperatures at different heights above ground (up to 30m), and at different depths below ground (to 100 cm) along with readings of relative humidity and photosynthetic active radiation. This is an important step towards integating site level climatic and biodiversity data gathering and exemplifies a general approach that has been urged for some time (e.g. Munn 1996; MacIver and Urquize 2000). Research by the Cliff Ecology Research Group (University of Guelph) to develop a 2,878 year dendrochronology sequence for old growth eastern white cedars in the NEBR is a palaeoenvironmental contribution to climate change studies.

LPBR works closely with the County of Norfolk to develop community-based monitoring in the context of a new (2005) Official Plan for the County, and based on a framework that includes EMAN protocols. LPBR had already inventoried some 55 recent or current monitoring activities conducted by different government agencies and NGOs. Ideally, this should be supplemented by an inventory of on-going research which would include for example, long-term studies in the LPBR area by McMaster University of the carbon flux over different aged conifer plantations using automated recording of data from research towers and remote sensing (that complements data gathered by LPBR). The NEBR has a monitoring framework keyed to the

objectives of the NEP and relies heavily on volunteers to gather relevant observations. The ORM is embarking on a similar endeavour. At some point, these initiatives might be compared with, and perhaps adapted to proposals from the Biosphere Reserve Integrated Monitoring Program (BRIM) for incorporating social data along with environmental data (Lass and Reusswig 2002). Looking ahead, cross-scale levels of monitoring might draw upon some of the global environmental research, such as linking the MEA with sub-national analyses of possible syndrome situations in areas of the biosphere reserves, along the lines sketched out by Petschel-Held (c2002).

Review of on-going research and monitoring in the five Ontario areas may reveal other possible links with global initiatives. There could be opportunities for direct collaboration. It may also be a matter of identifying the larger relevance of local initiatives when viewed in some global context, or how examples from elsewhere might be usefully explored for application in one or more of the five Ontario areas. The biennial Leading Edge conferences co-sponsored by the NEBR could provide an occasion to examine this more carefully.

Two general observations can be made from this general overview of international collaboration in the emerging field of earth systems science for sustainability. One is that when Canada through the federal government makes commitments under international agreements *and* follows up with programs to implement these obligations in Canada, biosphere reserves can and do participate where there is clear mutual interest between the local and the global. The other is that new initiatives underway, such as the MEA and ESSP, recognize the need to work across all scales. This requires “bottom-up” along with “top-down” approaches with much broader participatory and co-managed partnerships among scientists and other people with different kinds of relevant knowledge and skills. One could argue this was originally anticipated by the UNESCO/MAB program, but institutionally remained almost impossible to do in practice. The new realizations starting to come from a few scientists themselves, may open up possibilities for a more “pro-active” stance on the part of biosphere reserves, with help as may be necessary from government and NGO intermediaries. This is a question the “Biosphere Sustainability Project” might explore.

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