Biospheric Carbon Centre

Canadian Action Plan

Prepared by TEC Edmonton

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Executive Summary

The United Nations Framework Convention on Climate Change (UNFCCC) has expressed concern over the role of human activities in contributing to climate change and has acknowledged that the adverse affects of climate change are of international concern[1]. Recognizing the role that increasing levels of carbon dioxide play in climate change, a variety of market mechanisms, including voluntary and regulated carbon markets, have emerged to encourage reductions in emissions and to spur sequestration efforts.

Despite representing the largest global fluxes of carbon (several times larger than anthropogenic emissions[2]), exchanges between the biosphere and atmosphere are not adequately represented in carbon markets. Carbon markets tend to take a static approach to measuring biological carbon stocks and have yet to take full advantage of available monitoring capabilities and technologies that might allow for the integration of biospheric carbon data and more completely inform markets. The lack of a suitable operational methodology for developing a comprehensive and universal measure of biospheric carbon is a primary challenge addressed here.

This action plan is a companion to the white paper, "*The Case for a Biospheric Carbon Network*" (the "White Paper"), and provides a framework for the creation of a research centre, the Biospheric Carbon Centre (the "Centre"), and an affiliated not-for-profit organization (*to be named*) to promote research and development in the emerging field of biospheric carbon monitoring.

The primary focus of the Centre will be to promote collaborative research focused on developing methodologies and tools for integrating various measurements of biospheric carbon fluxes and stocks into a unified, transparent and validated measurement of carbon sequestration (the "Biospheric Carbon Index"). The Centre will focus on core research and cyberinfrastructure needed to "translate" disparate data sources into a unified set of carbon metrics, and will foster scientific exchanges, curricular efforts, and commercial activity around the theme of biospheric carbon.

The not-for-profit will advance broad-range application of the cyberinfrastructure to meet the needs of carbon cycle science and carbon markets. The provision of a Biospheric Carbon Index is expected to provide an essential tool for validating carbon sequestration initiatives, certifying emerging carbon markets and encouraging the development of various support industries related to carbon monitoring (e.g. remote sensing).

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[1] United Nations Framework Convention on Climate Change, United Nations, 1992 http://unfccc.int/resource/docs/convkp/conveng.pdf

[2] Prentice, I. *et al*. 2001. IPCC Third Assessment Report - Climate Change 2001: Working Group I: The Scientific Basis. Chapter 3: The Carbon Cycle and Atmospheric Carbon Dioxide. IPCC. Geneva, Switzerland.

The Biospheric Carbon Centre

Current research on biospheric carbon (i.e. carbon absorbed and stored by biological systems) at the University of Alberta (the "University") focuses on developing and applying technologies for monitoring carbon exchange between ecosystems and the atmosphere (the "breathing of the planet"). These include direct measurements of this exchange, and indirect monitoring from optical sensors and remote sensing. Investigations range from basic research into environmental and biological factors controlling carbon exchange to applied research into the economic consequences of carbon exchange for agriculture or insurance industries. Recently, the approach developed by University researchers is receiving attention around the world, with recent meetings held in Finland and California, and through expanding interactions with industry in California and Alberta.

The Biospheric Carbon Centre will be a leading centre for biospheric carbon research, with a particular focus on developing the cyberinfrastructure needed to integrate disparate data sources into a comprehensible metric of biospheric carbon sequestration (also called *biosequestration*). A key goal will be to foster interdisciplinary collaborations, to develop national and international networks of scientific data needed for a global approach to biospheric carbon, and to engage the business community in opportunities for the delivery and usage of these data. The Centre is expected to leverage existing University of Alberta strengths in environmental research, information and communication technologies and natural resource research.

Vision

The Centre will be a global leader in the application of novel carbon monitoring technologies and in addressing the need to integrate carbon data from these different technologies into a unified, comprehensible metric of biospheric carbon exchange and storage. This will be done by supporting research and development of next generation methodologies and technologies for measuring, monitoring and reporting of biospheric carbon. A particular focus will be on developing the core informatics and cyberinfrastructure needed to generate useful information from carbon monitoring data.

Mission

To foster world-class research, academic, government, and industry partnerships focused on developing cost-effective, reliable and transparent methodologies and technologies for measuring, monitoring and reporting biospheric carbon fluxes and stocks.

The Global Carbon Challenge

Recognizing the need to reduce global carbon dioxide emissions, a plethora of policies and management programs are in place or being developed in an effort to manage carbon and to mitigate the negative impacts of climate change. For example, the VCS program (the "Voluntary Carbon Standard") provides an assurance system used to account for greenhouse gas emission

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reductions and credits for over-the-counter (OTC) or voluntary transactions. An example of a regulated allowance program is the EU-ETS ("European Trading System"). The EU-ETS is based on cap and trade principles and is the largest international scheme for the trading of greenhouse gas emissions.

The Global Warming Solutions Act of 2006 was signed into law in California in September, 2006 and establishes a comprehensive program of regulatory and market mechanisms to achieve quantifiable and cost-effective reductions of greenhouse gases. The Act requires regulations for reporting and verification of statewide greenhouse gas emissions and monitoring and enforcement compliance. The roadmap to achieving these goals is the Climate Change Scoping Plan. Key strategies described in the Climate Change Scoping Plan related to biological activity include a broad-based cap-and-trade program, forest sequestration and voluntary reduction from forestry projects. As the California carbon marketplace becomes a reality, public confidence will depend mostly on perceptions of offset quality, the transparency of accounting, and the distribution of costs and benefits of climate policy[3].

The Western Climate Initiative, a partnership between seven U.S. states and four Canadian provinces[4], has reached a consensus on a regional strategy to reduce greenhouse gas emissions and build towards a green economy. The regional plan includes a carbon offset credits systems and a market-based cap-and-trade system to provide incentives for companies to develop new technologies that increase energy efficiency and promote the use of renewable energy.

In Alberta, large emitters, who are required by legislation to reduce the intensity of their greenhouse gas emissions, have three options for meeting the reduction, including the purchasing of carbon credits from Alberta's carbon offset system. An accepted approach adopted by many management programs is the use of carbon offsets. Carbon offsets can be effective in providing real environmental benefit by sequestering atmospheric CO_2. An example of a developing, nationally geared offsets system is the Climate Action Reserve ("CAR") in the United States. CAR aims to reduce atmospheric greenhouse gas (GHG) concentrations by implementing "regulatory-quality" standards for GHG emissions reduction projects.

A key challenge for carbon offset projects is demonstrating that an actual reduction in atmospheric CO_2 has occurred and that this reduction was the result of a specific management activity. To help address this challenge, rules and standards for carbon offset projects have been developed. The rules and standards guiding offset project development and implementation (i.e. protocols) are, in effect, assurance mechanisms that provide confidence to investors, regulators and the public that a carbon transfer actually occurred. Offset protocols typically provide direction regarding the development of measuring and monitoring procedures for carbon offset projects.

Regardless of the market, players involved in the carbon offset market demand reliable offset information. In order to provide information to inform transactions, there is need for accurate and

[3] Niemeier, D. & Rowan, D. "From kiosks to megastores: The evolving carbon market" *California Agriculture* 63 (2) April-June 2009: 96-103.
[4] Washington, Oregon, California, Arizona, Montana, Utah, New Mexico, British Columbia, Manitoba, Ontario and Quebec.

cost-effective measuring and monitoring. The approach to offset measuring and monitoring varies by standard. Multiple methods have been suggested and are in various stages of development. Many of these methods do not yet take full advantage of the capabilities and monitoring technologies currently used by the carbon cycle science community, highlighting an unmet opportunity that is at the core of this centre plan.

Development of a Biospheric Carbon Network to accurately analyze and predict future carbon sequestration and a related Biospheric Carbon Index to illustrate actual costs will be an essential step towards viable carbon markets and the success of the emission reduction goals. As discussed in the White Paper, the Biospheric Carbon Network could begin with test projects at the regional level (e.g. Alberta and California) and could expand progressively to larger regions (e.g. North America), with the ultimate goal of covering a global system.

Why Biospheric Carbon?

Biological carbon sequestration is a widely recognized means of mitigating climate change. Carbon cycle scientists have developed many methods for monitoring biological carbon exchange with the atmosphere, and many of these are mature enough to provide reliable metrics of biospheric carbon sequestration and loss. Recent agreements[5] are now providing a framework[6] for tackling tropical deforestation through provision of information on carbon stocks. Declining carbon stocks through deforestation and degradation is one of the chief sources of biospheric carbon release to the atmosphere[7]. However, these agreements are limited to tropical forests and fail to cover biospheric carbon storage in the rest of the world's biomes.

There is a growing expectation that land based systems such as agricultural lands, forests and wetlands, due to their significant carbon sequestration potential, will have an increasingly important role to play in climate change mitigation. This is an important opportunity for nations and regions with arable lands suitable for agriculture and vast forestry land bases. Alberta, for instance, could be considered as having significant potential for developing biologically based offsets. A report found on the Alberta based Climate Change and Emissions Management Corporation's ("CCEMC") website describes the technical potential for Alberta's biologically based industries to capture and manage carbon stocks in the 23.9 to 33.0 Mt CO_2e per year range[8]. The report also suggests that biological capture and fuel replacement strategies are the most efficient mitigation options readily available to Alberta. Further supporting evidence for biological based offsets is found in the IPCC 4th Assessment Report that indicates that over 50%

[5] United Nations Climate Change Conference, Cancun, Mexico. November 29th to December 10th, 2010.

[6] Reducing Emissions from Deforestation and Forest Degradation (REDD) and REDD+ are an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development (http://www.un-redd.org/AboutREDD/tabid/582/Default.aspx).

[7] Asner GP, Powell GVN, Mascaroa J, Knapp DE, Clark JK, Jacobson J, Kennedy-Bowdoin T, Balaji A, Paez-Acosta G, Victoria E, Secada L, Valqui M, and Hughes RF (2010) High-resolution forest carbon stocks and emissions in the Amazon PNAS 107(38): 16738–16742.

[8] Biological Opportunities for Alberta. Report developed for CCEMC by Haugen-Kozyra, Karen and Milo Mihajlovich, March 2010.

of fossil fuel emissions could be removed from the atmosphere on an annual basis through carbon sequestration in soils, forests and other biological systems[9].

Forests in particular have generated significant interest among carbon offset purchasers, in part because of the large amount of carbon stored in forests. This interest is evidenced by the many offset protocols involving forest carbon. For instance large corporate buyers such as Capital Power Corporation and TransCanada Corporation are actively pursuing forest-based carbon offsets. Corporations are interested in offset projects that meet minimum standard criteria in terms of being real, additional, permanent, etc., but also that can be understood by their shareholders. However, carbon sequestration opportunities abound in other ecosystem types as well, including shrubland, grassland, and farmland. Consequently, the centre will focus on generic approaches to monitoring biospheric carbon that can be applied across all ecosystem or vegetation types.

Another driver in the increasing interest of forest carbon offsets are the co-benefits that typically accompany forest carbon offset projects. Watershed protection, provision of habitat for biodiversity values and sustenance of non-timber product flows are just a few of the co-benefits that could be affiliated with biosequestration projects. Consequently, opportunities exist for coordination with other resource-based programs (e.g. Alberta's Land-use Framework (http://landuse.alberta.ca/) and the Alberta Biodiversity Monitoring Institute (http://www.abmi.ca/abmi/home/home.jsp)) as part of an integrated land management plan–

In pursuing the development of a forest related or biologically based offset, a key consideration is ensuring that the carbon stocks and fluxes are adequately measured. Currently, there are several approaches and methods used for measuring and monitoring biospheric carbon. Methods range from traditional field inventory sampling to direct carbon flux measurements to automated optical sampling and remote sensing (see White Paper for further details).

For policies and management programs to be effective a universal carbon accounting framework is required. In particular, accurate, reliable and readily accessible information on carbon stocks, and fluxes (the short term changes in stocks), is seen as a critical part of the accounting framework. The Centre will facilitate the integration of this information via a transparent and accessible informatics framework to provide a continuous metric of carbon uptake and loss.

Research & Commercialization Program

The Biospheric Carbon Centre will serve as a focal point for global research, attracting world-class researchers, international funding agencies and a broad-cross section of industry, from multinationals to SME and start-up technology companies. The establishment of a Centre would seek to significantly advance development and application of novel carbon monitoring technologies along with the cyberinfrastructure needed to deliver a unified carbon metric (i.e. BCI).

[9] Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) IPCC, Geneva, Switzerland. Jan. 2010.

Biospheric Carbon Index (BCI)

A key product of the Centre will be the "Biospheric Carbon Index (BCI) – a unified metric of biospheric carbon fluxes (or stocks) that can help inform scientific understanding and carbon markets. The underlying BCI data will include data from satellites, aircraft, field sensors, and sensor networks, as well modeled data products. A range of indexes and other database tools will enable organization, access and search capabilities.

The cyberinfrastructure and collaborative relationships fostered by the Centre, and supporting the generation of the BCI, will be collectively called the Biospheric Carbon Network (BCN). The role of the network will be to engage a much larger community in the development of the cyberinfrastructure and generation of a scaleable, global product that meets broad needs. The goal of BCN is to develop the informatics and cyberinfrastructure tools to integrate data from a wide range of sampling methods and to provide quantitative, validated and transparent information on biospheric carbon stocks and fluxes. On-line, web-based, and map-based user interfaces to BCN data products at multiple spatial and temporal scales will enable users to make tailored requests. Data mining and analytics mechanisms will be key enablers in the development of these interfaces. By providing a standardized, scalable carbon metric derived from multiple data sources, the BCI would provide a universal foundation for valuing biospheric carbon sequestration and could help ensure carbon markets are functioning as intended.

The BCN data management infrastructure will provide the core of a collaborative data system, with large-scale storage to enable the archiving, processing and visualization of data. Issues such as scaleability, storage, and archiving will most likely be addressed through a distributed, cloud computing approach. A not-for-profit organization will be created to facilitate an open source community approach and achieve the goals of broad engagement with existing networks (i.e. FLUXNET, SpecNet) and other collaborators.

The following diagram provides a conceptual overview of the BCN. For a more complete description of the data inputs, outputs and functionality of BCN see the White Paper.

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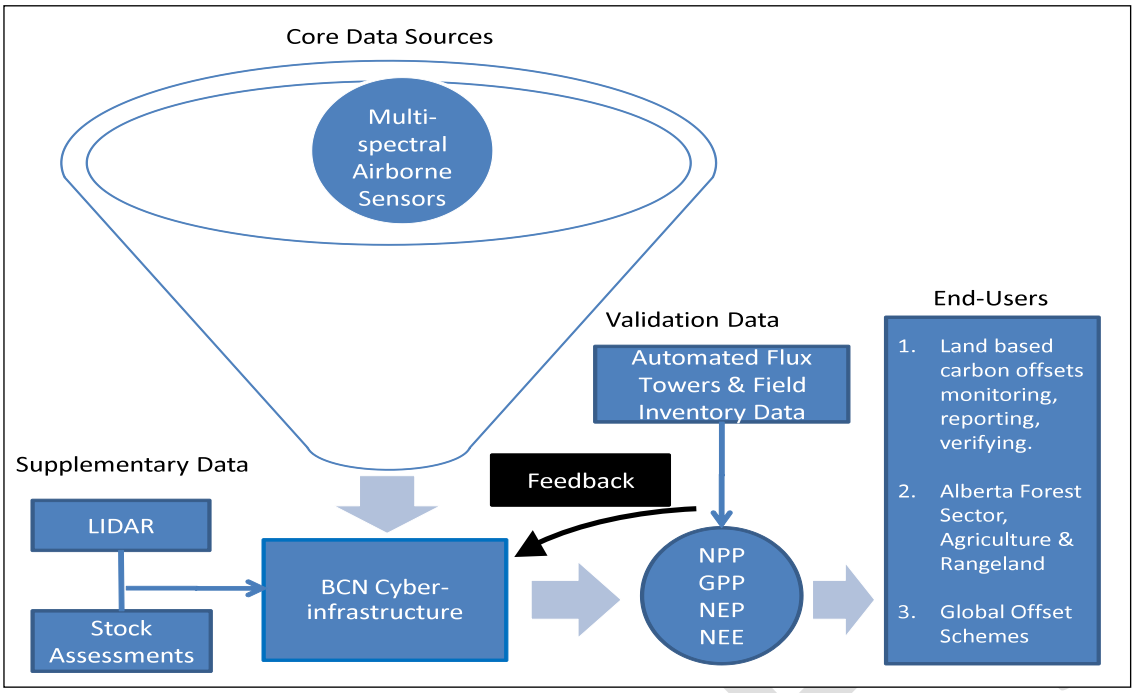

Figure 1: BCN Schematic showing inputs, outputs and potential end-users. Validating BCN products against independent data provides a path for improving the cyberinfrastructure ("Feedback" arrow).

Commercial Applications

Workshops and interviews were conducted to assist with the refinement of the BCN concept and to identify potential applications for the core informatics and cyberinfrastructure. As a result of those interviews[10] and additional investigation, several potential applications for BCN were identified:

- Policy and protocol development: for example, informing natural resource policy development; assurance as part of carbon mitigation programs and markets (e.g. REDD and REDD+)
- OTC carbon market measuring, monitoring and verifying ("MRV'); regulated carbon market "MRV"; monitoring, verifying and reporting of carbon offset projects
- Forestry sector applications: for example forest pest outbreak monitoring; forest inventory applications.
- Agriculture sector applications: for example informing optimal fertilizer application rates; food supply chain environmental impact/life cycle analysis; crop and grazing insurance – identifying economic losses due to weather or climate change.

Some of the same technologies identified here can also be applied to monitoring industrial carbon sequestration (e.g. geological carbon capture and sequestration). However, based on the mandate of the Centre, a core area of focus will be on measuring carbon in *biological* systems. More specifically, initial efforts will be directed toward developing the metrics needed to measure, monitor, and verify biological carbon offsets.

[10] See Appendix 1 for list of interviewees and synopsis of interviews conducted.

Policy & Protocol Development

As discussed in the White Paper, the recent progress made in adopting the current REDD framework as a tool for reducing tropical deforestation is limited on a number of fronts – it is far from a global solution since most of the world's biosphere is excluded from this framework. It is also based largely on intensive forest inventory sampling. These methods can be extremely subjective, and are often susceptible to fraud. In contrast to these field methods, satellites provide globally consistent metrics of biospheric carbon stocks and fluxes. However, many offset projects are local in scope, and the coarse scale of these satellite measurements makes them difficult for carbon markets to use. Consequently satellite data have had only limited application in current REDD protocols, and remote sensing solutions represent a range of technologies with considerable unrealized potential for carbon markets, particularly when combined with inventory and other methods.

Carbon Markets & Carbon Offset Projects

Although the voluntary carbon market remains smaller than the compliance market, it is growing rapidly in financial terms (US$91 million in 2006[11]) and is taking a leadership role in terms of quality assurance. This voluntary market is a major driving force behind the development of a functional, effective offset standard, because establishing and maintaining such a standard enhances the market's credibility and has a direct impact on the capacity to trade. To date, however, no reliable standards for quality assurance in the carbon market have been established, and this market remains poorly linked to metrics of biospheric carbon. Consequently, a purchaser of voluntary offsets has little chance of confirming that measurable carbon sequestration has actually occurred. However, with the right information on biospheric carbon, carbon markets could dramatically and quickly improve their effectiveness. BCN will be capable of providing such information using existing monitoring technologies to address the certification problem. It is anticipated that this could help evaluate the success or failure of emerging carbon offset schemes.

As discussed in the White Paper, various policy and market mechanisms contemplated to reduce carbon emissions and enhance carbon sequestration have fueled growth of the carbon offset industry. However, with no agreement on which of these market or regulatory methods should be adopted, and a shortage of certification methods to validate their effectiveness, there is considerable uncertainty and risk in the current carbon markets.

To be useful for carbon markets, the Biospheric Carbon Index must be expressed as a single metric (or set of related metrics) with readily comprehensible units that are independent of sampling method used, yet traceable to source. One of the problems facing the existing carbon offset markets is that they cannot easily demonstrate effective carbon sequestration due to lack of clear validation and certification. The lack of a global policy has added further uncertainty. Consequently, prices for forest carbon credits have ranged from $0.65/t$CO_2$ to more than

[11] Hamilton K, Bayon R, Turner G, Higgins D (2007) *State of the Voluntary Carbon Market 2007: Picking up Steam*. New Carbon Finance and Ecosystem Marketplace (http://ecosystemmarketplace.com/documents/acrobat/StateoftheVoluntaryCarbonMarket18July_Final.pdf).

$50/t$CO_2$[12]. By providing a metric of actual carbon sequestration, BCI can help in market certification.

BCN has the potential to be an offset standard measuring, reporting and verifying service provider. Based on an initial assessment of the standards where BCN has a good opportunity of being adopted, one consideration is the Voluntary Carbon Standard (VCS). The VCS' Agriculture, Forestry and Other Land Use (AFOLU) program includes afforestation, reforestation and revegetation (ARR), agricultural land management (ALM), improved forest management (IFM) and reducing emissions from deforestation and degradation (REDD). To pursue this opportunity, a methodology for BCN would need to be developed to provide measurement, monitoring and verification (MRV) for AFOLU and then submitted to the methodology approval process[13].

Alberta Opportunities

Alberta is unique in that it has a functioning regulated carbon market that has been operational for three years and allows carbon offsets to be used as a compliance mechanism. The province currently has 31 approved carbon offset protocols[14]. Although only one protocol is land-based, it is expected several land-based or bio-based offset protocols are to be developed. Such protocols will require carbon stock and flux information initially and over time to assess the effectiveness of management action in sequestering atmospheric CO_2 into biospheric carbon pools. Examples of protocols being contemplated include:

- A wetlands related protocol
- Afforestation
- Bio-char
- Grazing
- Forest management
- Perennial forage
- Inform regional planning (e.g. Alberta Land Stewardship Act Regional Plans[15])

There exists a clear opportunity for a university-based Centre to develop an Alberta test of the BCI concept as a foundation for a more global program. Similar opportunities exist in California and in western states and provinces, however the details might vary due to contrasting market and policy approaches.

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[12] Hamilton K, Chokkalingam U, Bendana M (2010) *State of the Forest Carbon Markets 2009: Taking Root & Branching Out.* Ecosystem Marketplace. http://moderncms.ecosystemmarketplace.com/repository/moderncms_documents/SFCM_2009_smaller.pdf
[13] Swickard, Naomi. VCS, AFOLU Coordinator. Personal communication. October 22, 2010.
[14] Carbon Offset Solutions – Offest Protocols http://carbonoffsetsolutions.climatechangecentral.com/offset-protocols/approved-alberta-protocols
[15] Alberta Land Stewardship Act. http://www.qp.alberta.ca/574.cfm?page=A26P8.cfm&leg_type=Acts&isbncln=9780779742271

Ancillary Industries

As currently envisioned, BCN offers the potential for several possible commercial spinoffs. Particularly promising technologies with opportunities for further commercial development include aircraft monitoring systems, optical sensors and sensor networks. Additionally, the development of an operational cyberinfrastructure could have several commercial spinoffs, much in the way that investment in bioinformatics surrounding the human genome product led to novel commercial developments. Provision of a biospheric carbon index could not only provide a clear signal that could help the development of certifiable carbon markets, but it could also encourage the monitoring industries that provide the monitoring tools that would be the basis for this index.

Organizational Structure

Scientific Director

The Biospheric Carbon Centre will be led by the Scientific Director who will be responsible for overall leadership, developing the Centre's strategic direction, coordinating research activities at the University and forging strong industry collaborations. This position will report directly to the Board of Directors and will be accountable for all strategic, operational, research and partnership decisions.

Scientific Advisory Board

The Scientific Advisory Board, comprised of senior researchers from several faculties at the University and researchers from other leading institutions, will provide advice to the Scientific Director on the Centre's strategic, research and operating plans. The Board will also act to promote the work of the Centre internationally and assist in the recruitment of world-renowned researchers. Board composition will reflect a diverse perspective on science and policy.

Scientific Advisory Board members (and areas of expertise) currently under consideration include:

- Dr. Susan L. Ustin, Professor, Center for Spatial Technologies and Remote Sensing, University of California, Davis (*Remote Sensing and Modeling*)
- Dr. Steven Running, Regents Professor/Director, Numerical Terradynamic Simulation Group, College of Forestry & Conservation, University of Montana (*Remote Sensing, GIS & Computer Simulation*)
- Dr. Dennis Baldocchi, Professor, Dept. of Environmental Science, Policy and Management, University of California, Berkeley (*FLUXNET*)
- Dr. Rob Simmonds, Adjunct Assistant Professor, Computer Science, University of Calgary; WESTGRID (*High-Performance Computing Cyberinfrastructure*)
- Woody Turner, Program Scientist for Biological Diversity and Program Manager for Ecological Forecasting, NASA (*Satellite-derived Information*)

Subsequent to the development of Terms of Reference, these individuals will be contacted to confirm their interest and availability.

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Business Advisory Board

The Business Advisory Board will include balanced membership from industry, government and academia. The functions of the Business Advisory Board will include advising the Centre on strategic, research and operating plans. The Board will also assist in the recruitment of industrial partners and play a key role in moving technologies developed at the Centre into the market.

Business Advisory Board members currently under consideration include:

- Stephanie Race, CEO, Earth Analytics Group (*Environmental Analytics*)
- Tom Mikes, Director, Headwall Photonics (*Sensors & Instrumentation*)
- Claude Labine, Campbell Scientific (Canada) (*Sensors & Instrumentation*)
- Jack Sample, President, Onset Computer Corporation (*Sensors and Dataloggers*)
- Dr. Chris Field, Director of Global Ecology, Carnegie Institution of Washington (*Policy*; *IPCC*)
- Dr. Werner Kurz, Senior Research Scientist, Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada (*Policy; National Forest Carbon Accounting System)*

The Business Advisory Board will also seek to draw expertise from industry executives in information technology, oil and gas, forestry, agriculture & grazing, and insurance/reinsurance industries.

Subsequent to the development of Terms of Reference, these individuals will be contacted to confirm their interest and availability.

Centre Manager

The Centre Manager will work closely with the Scientific Director to identify and source project funding, provide support to visiting scientists, graduate students, post-doctoral fellows and support exchange programs. The Centre Manager will be responsible for day to day operations, project delivery, building and maintaining relationships with collaborators and managing the overall operating budget. In addition, two interns or graduate student positions will assist with operational delivery of projects.

The diagram below provides a proposed organization structure for the Centre.

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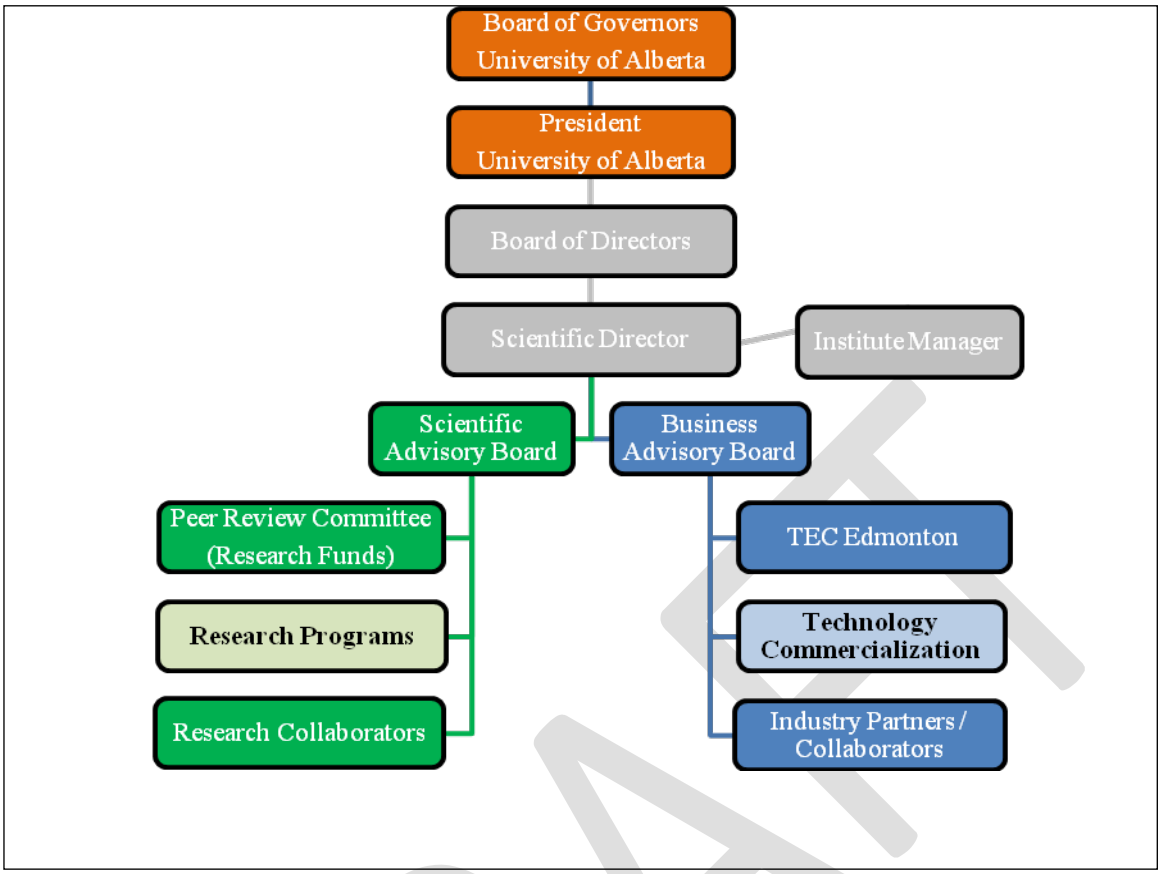

Figure 2: Biospheric Carbon Centre Organizational Structure

Collaborators and Partners

Fundamental to the success of the Centre will be the formation of key research, government and industrial partnerships. Potential clients and collaborators will include members of the carbon science community, developers of carbon offset protocols and participants in the existing and developing carbon markets, as well as key informatics and cyberinfrastructure developers, sensor manufacturers, airborne service companies and geomatics providers.

Although no formal arrangements are in place, discussions have taken place with a number of organizations that are potentially interested in collaborating with the Centre. Based on those discussions to date, the organizations demonstrating interest in collaborating or forming partnerships with the Centre include:

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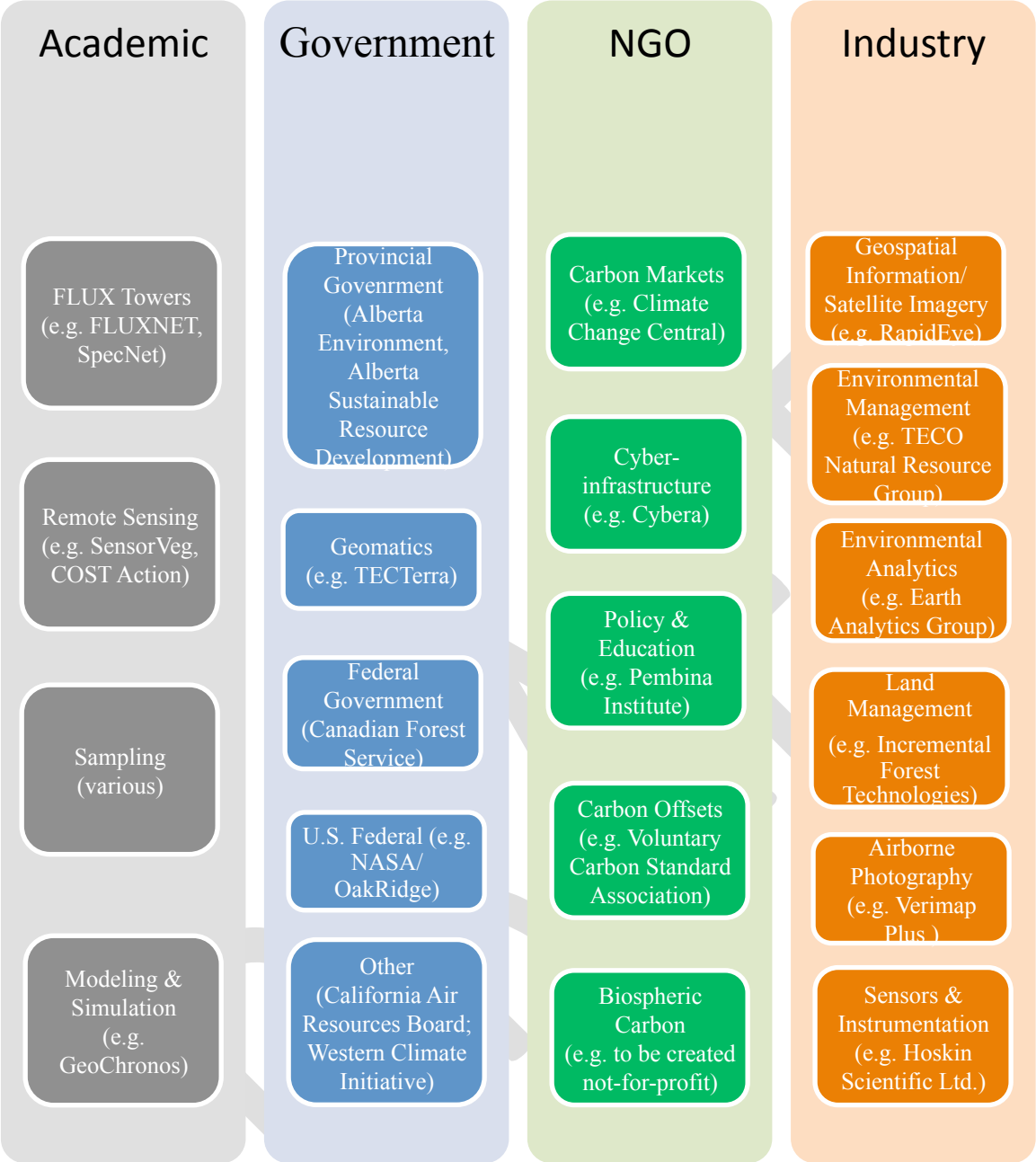

Figure 3: Biospheric Carbon Centre Collaboration Opportunities

Industry Collaborators

Informatics & Infrastructure Collaborators

The Centre will seek to collaborate with existing research networks and commercial projects on data calibration, aggregation, integration and visualization tools. Several nascent cyberinfrastructure efforts related to biospheric carbon have been developed, including FLUXNET, SpecNet, and GeoChronos. To the extent possible, BCN will attempt to take advantage of collaborative opportunities with these existing cyberinfrastructure efforts. A key

role of BCN will be to address issues of how to link these several efforts, many of them involving technical issues of calibration and data aggregation.

A number of significant cyberinfrastructure efforts (e.g. web-based data access and visualization methods) are underway in the computing, remote sensing and research communities. Projects involving cloud computing include Microsoft's AZURE program, Cisco's ALERTS (Automated Land change Evaluation, Reporting and Tracking System), Google Earth Engine, and Canada's WestGrid, all of which could provide computational support to BCN. See the White Paper for a more detailed discussion of similar and complementary cyberinfrastructure efforts

Remote Sensing Collaborators

The use of remote sensing in climate change applications is not new. For instance, at a broad level, 60% of Annex-I countries under the Kyoto Protocol used remote sensing for the preparation of national GHG inventories. The advent of several new satellite sensors at much finer ground resolution is presenting new opportunities for collaborations with the satellite remote sensing industry, which will be pursued by the Centre. Airborne remote sensing programs provide flexible ways to obtain regional high resolution coverage and links to airborne service companies will be expanded. Additionally, the rapid growth of new field sensors used for validating satellite data is providing additional collaborative opportunities with industry. While inexpensive optical sensors are now in limited use as research tools, expanded application of these sensors, development of wireless sensor networks, and competition among several manufacturers is likely to reduce the costs. Consequently, low-cost optical sensors represent a major un-tapped opportunity for biospheric carbon monitoring.

By improving access, standardizing products and reducing costs, BCN could foster the expansion of the remote sensing industry and provide business opportunities for airborne service companies and sensor manufacturers. Potential collaborators include Hoskin Scientific, Campbell Scientific, LI-COR, Onset Computing, Verimap Plus, Headwell Photonics and Decagon.

Centre Development Plan

Key Activity 1 – Initiation

The first step in the formation of the Centre will be to engage with Department Chairs, Faculty Deans and Provost. Preliminary discussions have taken place at the Department and Faculty Level and will continue over the near term. The formation of Centres at the University of Alberta is a highly structured process and the advice and guidance of the Faculty Development Office is being sought. Discussions will be initiated with existing centres and institutes on campus to gain a clearer understanding of research scope for the Biospheric Carbon Centre.

Key Activity 2 – Implementation

Begin identifying key personnel and developing initial key relationships with industry and academic partners. This stage will involve an active search for a Scientific Director (the Centre champion) and Centre Manager. The Scientific Director will be a world-renowned researcher with strong name recognition and the ability to attract collaborators and sponsors.

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In conjunction with the department Chairs and faculty Deans, the Scientific Director will begin building out the Scientific & Business Advisory Boards and formalizing relationships with various scientific networks.

The Scientific Director will be responsible for securing major funding support for research efforts. Appendix 2 contains a high level list of possible provincial, federal and international funding opportunities. A key task here is to conduct a scan of possible funders and develop a targeted list. The Scientific Director will be responsible for indentifying lead donors or sponsors willing to commit to multi-year funding. Subsequent tasks will focus on securing a stream of funding sources (corporate, foundation, association, individuals)

Develop 5-year strategic plan. Following preliminary discussions with academic collaborators, both at home and abroad, industry partners, and funders, the plan will outline specific research activities and further define the shared goals and activities of participants in the Biospheric Carbon Centre.

Key Activity 3 – Pilot Project
Set up Cyberinfrastructure Pilot Project. An initial step for developing an effective biospheric carbon monitoring system for the carbon market would be to develop a pilot project at a regional scale that might include the western states and provinces of North America. If successful in meeting the market needs, this approach could be expanded to other regions, and eventually the whole globe, particularly as global policies and markets develop. A key step in being able to expand beyond the pilot stage will be the demonstration of a successful cyberinfrastructure.

Similarly, a globally scaleable cyberinfrastructure can be started by focusing on the core algorithms needed to integrate different satellite, aircraft and field optical sensors into uniform metrics compatible with the light-use efficiency (LUE) model (part of the proposed modeling framework for BCN). Procedures for managing data, metadata, and for keeping track of provenance can provide the necessary transparency needed for carbon markets. To scale up to a more global effort, a logical starting point would be to work through existing efforts (e.g. SpecNet and FLUXNET communities) to build a scaleable cyberinfrastructure that around the LUE model framework, and around existing protocols for flux data.

Operating Budget

As a non-profit, the Centre will operate on a revenue neutral basis whereby operating costs are covered by grant funding, industry sponsorship and revenues generated from commercialization activities. In the short term (operating year one through five) the Centre will rely on grants, industry sponsored projects, donations and other externally driven sources of funding. The focus will be on completing BCN and building a community of contributors, collaborators, prospective users and other stakeholders. The completion of BCN is expected to generate revenue through users who purchase a subscription for site access. Subscribers will register with the Centre and may obtain access to data and integrated outputs through a contractual agreement. A multi-tiered fee structure is envisioned as one model that may help to support the Centre over the long term.

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Centre Operating Budget*

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue					
Grant Funding	325,000	345,000	390,000	440,000	480,000
Industry Funding	200,000	225,000	245,000	265,000	310,000
Faculty of Science	75,000	75,000	75,000	0	0
Donations	30,000	30,000	30,000	30,000	30,000
BCI-Net Royalties	0	0	15,000	20,000	40,000
Total Revenues	**630,000**	**675,000**	**755,000**	**755,000**	**860,000**
Expenses					
Scientific Director	120,000	120,000	125,000	125,000	130,000
Centre Manager	70,000	70,000	75,000	75,000	80,000
Interns[a]	25,000	50,000	50,000	50,000	75,000
Post-Doctoral Fellows[b]	0	60,000	60,000	60,000	120,000
PhD Students[c]	60,000	60,000	120,000	120,000	120,000
Programming Coordinator	80,000	80,000	85,000	85,000	90,000
Programmers	120,000	120,000	125,000	125,000	130,000
Equipment	50,000	10,000	10,000	10,000	10,000
Supplies & Services	10,000	10,000	10,000	10,000	10,000
Travel & Conferences	20,000	20,000	20,000	20,000	20,000
International Exchanges	60,000	60,000	60,000	60,000	60,000
General Operations	10,000	10,000	10,000	10,000	10,000
Communications	5,000	5,000	5,000	5,000	5,000
Total Expenses	**630,000**	**675,000**	**755,000**	**755,000**	**860,000**

[a] @ $25,000 [b] @ $60,000 [c] @ 40,000

* **Note:** This budget complements peer-reviewed research funding and industry sponsorship secured by members of the Centre.

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Appendix 1.0 Interviews Conducted

Interviews conducted during business plan development (chronologically presented).

1. Mike Kennedy, Senior Resource Economist, Pembina Institute
2. Andrew Leach, Assistant Professor, School of Business, University of Alberta
3. Karen Haugen-Kozyra, Principal, KHK Consulting
4. Stephen Kull, Research Scientist, Canadian Forest Service, Natural Resources Canada
5. Stephanie Race, CEO, Earth Analytics Group
6. Naomi Swickard, AFOLU Program Coordinator Voluntary Carbon Standard Association
7. Tanya Maynes, Manager Carbon Offset Solutions, Climate Change Central
8. Lane Gelhorn, Senior Biometrician, TECO Natural Resource Group Ltd.
9. David Stonehouse, CEO, Verimap Plus, Inc.
10. Doug Calvert, Regional Manager, Hoskin Scientific Ltd.
11. Milo Mihajlovich, Co-Principal, Incremental Forest Technologies Ltd
12. Bob Savage, Section Head, Climate Change Regulation, Alberta Environment

Synopsis of Interviews

What is your understanding of the BCI/BCN product concept?
The interviewees all understood the BCN to be a "tool" to measure biospheric carbon flux or change. Also common to all participants was their understanding that the tool could be applied across multiple vegetation types and spatial scales. There was also consensus in the understanding that BCN is very conceptual at this stage.

Two of the interviewees assumed that existing data would be used as the main input. Another viewed the tool as being potentially able to function independently (i.e. stand alone or incorporate data sets with algorithms).

One respondent viewed the BCN concepts as a quantification tool that could be instrumental in establishing a new accounting framework for biospheric carbon.

Are you aware of any analogous models i.e. data integration frameworks for natural resource management that should be reviewed?
Two of the respondents were not currently aware of any analogous models.

However, one of the respondents did refer to the NASA-CASA Biosphere Model[16]. In addition, this respondent also referred to the importance of estimating soil carbon and to the work completed by Tristam West from the Oak Ridge National Laboratory on estimating regional changes in soil carbon with high spatial resolution.

[16] The NASA-CASA (Carnegie-Ames-Stanford Approach) Biosphere Model simulates net primary production and soil heterotrophic respiration at regional to global scales.

Do see applicability in the current carbon markets? Future markets? How do you think BCI/BCN could be applied?
A general response to this question was a potential application in "land use change and carbon offsets".

More specifically, the common thread in the responses to this question was the potential opportunity with REDD.[17] The common thinking is that policy developers will be looking for an increased understanding of certainty in establishing and measuring against baselines. A question raised in the responses was how are deforestation estimates currently determined?

Further to REDD, it was acknowledged that the IPCC is responsible for setting country accounting at the appropriate level and as such should be consulted. A key point is that due to the IPCC, there is currently strong standardization in methodologies and systems that needs to be understood. Due to the strong standardization, there may be limited applicability in the VCS (Voluntary Carbon Standard). However, under the IPCC there are various levels of validation and the thinking is that BCN could be applied for validation purposes at the regional and country scale. Validation of existing models is a great possibility, but not necessarily applicable for verification. There is however, likely to be a good opportunity for BCN with regard to measuring and monitoring applications.

Another key point raised during responses to this question was the opportunity with respect to the development of a monitoring/measuring framework for new and emerging initiatives. It was speculated that several developing countries are at this stage. A source suggested for further investigation included the BioCarbon[18] fund under the World Bank.

Finally it should also be noted that one of the respondents raised the concern that nitrogen should also be considered for monitoring under BCN because of the close link between nitrogen and carbon.

If a carbon index was to flow from the framework, would that be something markets, industry players and policy makers might be interested in?
All respondents agreed in general to the value of an index. However, each made the point that an index would only be useful if it were to be developed with a clear understanding of how the end user would be using the index.

Based on your understanding of the BCI/BCN concept, describe any other potential applications in both the private and public sectors?
One respondent suggested that speculators and potential investors in carbon markets may be interested in obtaining such information. However, another interviewee did not see any likely applicability in the private sector as they again raised the opportunity in relation to REDD.

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[17] It should be noted that all respondents had qualified their responses stating that answers were based on their perceived understanding of the forthcoming BCN concept.
[18] The World Bank has mobilized a fund to demonstrate projects that sequester or conserve carbon in forest and agro-ecosystems. The Fund, a public/private initiative administered by the World Bank, aims to deliver cost-effective emission reductions, while promoting biodiversity conservation and poverty alleviation.

An interesting application proposed by one respondent was in the agri-food sector. Large companies such as Unilever, Wal-Mart, Nestle and Costco are increasingly looking for monitoring and verifying tools for various points along supply chains. They are increasingly interested in understanding life-cycle analysis (LCA) and the obtaining the best tools for assessment. Further investigation is warranted in this area a suggested resource includes the Global Agriculture Climate Assessment Project[19].

In terms of the public sector, another respondent was suggesting that an application could be for governments and parliamentary budget offices to monitor and audit various land use and environmental programs (i.e. policy audits). For instance, if several million dollars were invested in a region with the aim of a 40Mt reduction in GHG, but only 20Mt occurred during the expected period, perhaps the BCN could be used as an investigative or validation tool.

Other potential applications discussed:

- Tree disease/pest management
- Agriculture / fertilizer application management
- Water use assessments
- Oilsands monitoring
- Mining applications

Based on your responses above, what significant barriers do you anticipate regarding the application and continued development of this concept?

Four categories of barriers can be used to summarize the responses. The first is in relation to the project. The question was raised: are the right people and adequate resources included as part of the BCN project.

The second category can be described as institutional barriers. This potential barrier refers to gaining access to the necessary people and processes in relation to the decision making that is important to potential applications of BCN i.e. policy institutions and governments. For instance, if a prototype was developed and a "pitch" was to be made, could the right audience from the WCI, VCS or IPCC be accessed? Also, related to existing systems and methodologies is the standardization barrier.

The third category can be described as market concerns. For instance, there may be the perception or the concern that BCN will increase transaction costs. In short, the concept needs to be cost effective.

The fourth barrier category is related to the sourcing and sharing of data and information. The levels of collaboration and open source sharing of information and data is expected to be highly variable. Some sources will be easily accessed while others will be extremely difficult to obtain.

[19] http://sustainablefoodlab.org/index.php?option=com_content&view=article&id=117:gaca-home&catid=18&Itemid=53

As this concept is in its early stages of design and market assessment, are you aware of funding sources that would be accessible in the near term to further this project?

The following potential sources of funding were identified[20]:

- *Sustainable Prosperity*. Sustainable Prosperity is a national research and policy network, based at the University of Ottawa. SP focuses on market-based approaches to build a stronger, greener economy. It brings together business, policy and academic leaders to help innovative ideas inform policy development. http://www.sustainableprosperity.ca
- *WCI (Western Climate Initiative).* The WCI is a collaboration of independent jurisdictions working together to identify, evaluate, and implement policies to tackle climate change at a regional level. This is a comprehensive effort to reduce greenhouse gas pollution, spur investment in clean-energy technologies that create green jobs and reduce dependence on imported oil. http://www.westernclimateinitiative.org
- *CAR (Climate Action Reserve).* The Climate Action Reserve is a national offsets program working to ensure integrity, transparency and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of greenhouse gas (GHG) emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. http://www.climateactionreserve.org
- *Government of Alberta – Ministry of Environment*. The province is regulating and reducing emissions from large industrial emitters. They have put a price on carbon dioxide and have a regulated carbon offset market. http://environment.alberta.ca/0918.html
- *UNFCC (United Nations Framework Convention on Climate Change*). The international treaty. http://unfccc.int/2860.php
- *UNEP (United Nations Environment Programme)*. The United Nations environment programme is the voice for the environment in the United Nations system. http://www.unep.org
- *CCEMC (Climate Change Emissions Management Corp)*[21]. CCEMC is a not-for-profit, independent organization with a mandate to expand climate change knowledge, develop new 'clean' technologies and explore practical ways of implementing them. http://ccemc.ca
- *Global Research Alliance.* The Global Research Alliance was formally launched in New Delhi in January 2003 following a preparatory meeting in South Africa in 2002. The Alliance is a network of some 50 000 scientists and engineers, with expertise in a wide range of disciplines, who are committed to the promotion of science, technology and innovation in development. http://www.research-alliance.net

Can you suggest any other subject matter experts or market specialists that should also be interviewed?

Individuals identified by the participants that could be verified during the post-interviews review and summary compilations are summarized below alphabetically. Organizations without specific contacts identified are also listed below.

[20] Surprisingly none of the respondents mentioned foundations.

[21] BCN would not fit with funding criteria under current programs, but one interviewee is of the understanding that a new area related to biological opportunities is likely for the future.

People:

- *Vic Adamowicz*. Distinguished Professor, Department of Rural Economy, University of Alberta
- *Ricardo Bayon*. Partner, EKO[22] Asset Management
- *Len Eddy*. Climate Change Consultant based out of Edmonton, Alberta
- *Stuart Elgie.* Steering Committee, Sustainable Prosperity
- *Jerry Hatfield*, Plant Physiologist, National Laboratory for Agriculture and the Environment, USDA
- *Tim Lesiuk*. Executive Director Business Development, BC Ministry of Environment
- *Ken Knewcombe.* CEO, C-Quest Capital[23]
- *Chuck Rice*. Distinguished Professor, Department of Agronomy, Kansas State University
- *Paul Vickers*. Natsource[24]
- *Skip Willis*. Principal, Willis Climate Group

Organizations:

- CDM - Afforestation and Reforestation Working Group, UNFCCC
- Pacific Climate Trust
- Saskatchewan Government – Ministry of Environment

As the product concept evolves and a better understanding of potential markets increases, what recommendations would you provide to the development team?

Two strong recommendations were given by respondents. The first was to clearly define and identify the concept. The importance of having a well-defined concept was linked with the recommendation of developing a prototype or pilot in advance of making a pitch to potential buyers. They strongly believed that the concept would need to be effectively marketed. The second was to remove the auction bidding concept.[25] They were concerned that the concept was not a realistic approach to addressing landuse issues and would likely be an impediment to giving legitimacy to the overall BCN concept.

Other recommendations included ensuring that the right development team is in place, that a good understanding of existing and emerging regulatory frameworks was established, and that the team would need to be prepared to market the concept.

For interviews #5 onwards, interviewees were asked if they see any opportunities for collaboration between their organizations and BCN. (Exceptions: Tanya Maynes, Naomi Swickard and Bob Savage)

[22] EKO is a specialized investment firm focused on discovering and monetizing unrealized or unrecognized environmental assets.
[23] C-Quest Capital (CQC) is a carbon finance business dedicated to originating and developing high-quality emission reduction projects around the world.
[24] Natsource LLC, with headquarters in New York and offices worldwide, is a leading provider of asset management, origination, and advisory and research services in global emissions and renewable energy markets. Natsource Advisory and Research staff have participated in the development of policies that have created markets for greenhouse gases and conventional air pollutants.
[25] Recommendations from the interviewees who were participants at the Edmonton Kick-Off meeting.

Stephanie Race, CEO, Earth Analytics Group (EAG)

- Does see an opportunity for collaboration
- Believes the effort needs to take a sector or industry approach

Lane Gelhorn, Senior Biometrician, TECO Natural Resource Group Ltd.

- Sees a longer term opportunity for the forestry sector
- BCN capabilities could pay an important complementary role to current forest inventory approaches
- A pilot would be a logical starting point as forest industry resistant to change due to investments in current approaches

David Stonehouse, CEO, Verimap Plus, Inc.

- Very interested in collaborating on a pilot
- The collaborative overlap would be a databank and a distribution engine
- Believes that $250,000 would be needed to develop pilot
- Company interest is to further demonstrate the effectiveness of Verimap's aerial sensor system and that it can greatly outperform current million dollar digital systems
- Believe that a multi-sector approach is needed

Doug Calvert, Regional Manager, Hoskin Scientific Ltd.

- Open to collaboration with the recognition that "the bottom line is key"
- Sees an opportunity for to collaborate on innovative sampling and data integration
- Could possibility assist with provision of equipment depending on pilot or collaboration proposed

Milo Mihajlovich, Co-Principal, Incremental Forest Technologies Ltd

- Milo is chair of a committee working to establish forest offset protocols for the Province of Alberta
- He believes there could be an opportunity for BCN to provided measuring and monitoring tools.

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Appendix 2.0 Potential funding sources

Funding for the Centre is being sought from a variety of government, non-profit and industry stakeholders. A shortlist of potential government and industry funding sources has been developed and formal opportunities will be explored over the next 12 months.

TecTerra - Geomatics Commercialization Kick-Off (GECKO) program

TECTerra is an Alberta-based organization that supports the development and commercialization of geomatics technology. TECTerra provides a variety of funding opportunities (e.g. guided strategic research projects; "Idea to Implementation" projects; industry-sponsored projects) to support the commercialization of technology solutions in various resource and information management applications

The Geomatics Commercialization Kick-Off (GECKO) program will provide early-stage funding to geomatics entrepreneurs and researchers for the development of comprehensive business plans for the purpose of commercializing new geomatics technologies. Grants of up to $25,000 per business plan project are available to qualified applicants.

Climate Change Emissions Management Corp.

CCEMC is a not-for-profit, independent organization with a mandate to expand climate change knowledge, develop new 'clean' technologies and explore practical ways of implementing them. Although there is not currently a funding opportunity[26], based on discussions with the program manager, Kirk Andries[27], it is expected that CCEMC will be a biological-related call for proposal round as a follow-up to the Energy Efficiency and Renewable Energy rounds. Information on the timing and other details are forthcoming. A follow-up with Kirk is to be conducted in February 2011.

Government of Alberta – Ministry of Environment

The province is regulating and reducing emissions from large industrial emitters. They have put a price on carbon dioxide and have a regulated carbon offset market.

Natural Science and Engineering Research Council of Canada (NSERC)

NSERC's Idea to Innovation (I2I) program is designed to accelerate the pre-competitive development of promising technology and promote its transfer to a new or established Canadian company. The program provides funding to college and university faculty members to support research and development projects with recognized technology transfer potential.

Sustainable Prosperity

Sustainable Prosperity is a national research and policy network, based at the University of Ottawa. SP focuses on market-based approaches to build a stronger, greener economy. It brings together business, policy and academic leaders to help innovative ideas inform policy development.

[26] BCN would not fit with funding criteria under current programs, but one interviewee is of the understanding that a new area related to biological opportunities is likely for the future.

[27] Personal communication. October 21, 2010.

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WCI (Western Climate Initiative)
The WCI is a collaboration of independent jurisdictions working together to identify, evaluate, and implement policies to tackle climate change at a regional level. This is a comprehensive effort to reduce greenhouse gas pollution, spur investment in clean-energy technologies that create green jobs and reduce dependence on imported oil.

The Deutsche Bundesstiftung Umwelt DBU
The Foundation concentrates on environmental technology and research, nature conservation, environmental communication and cultural assets.

The Ford Foundation
The Environment and Development program helps people and groups acquire, protect, improve and manage land, water, forests, wildlife and other natural assets in ways that help reduce poverty and injustice.

The Gatsby Charitable Foundation
The Developing Countries Program aims to promote environmentally sustainable development and poverty alleviation through selected programmes aimed at supporting basic agriculture and other enterprise in selected African countries.

The David and Lucile Packard Foundation
The Conservation and Science Program is focused on the challenge of sustainability, finding paths for human progress that protect and restore the ecological systems upon which all life depends.

The Andrew W. Mellon Foundation
The Foundation's program in Conservation and the Environment (C&E) has evolved over time.

The John D. and Catherine T. MacArthur Foundation
The Conservation and Sustainable Development grantmaking area is dedicated to conserving biodiversity.

The Gordon and Betty Moore Foundation
The Environmental Conservation program aims to change the ways in which important terrestrial and coastal marine ecosystems are used to conserve critical ecological systems and functions, such as the climate function of the Andes-Amazon rainforest, for future generations, while allowing current uses to be sustained.

Charles Stewart Mott Foundation
The Mott's Foundation's environment grant making includes support to nongovernmental organizations (NGOs) working to make national and global financial institutions more responsive to environmental and social concerns through its International Finance for Sustainability focus.

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CAR (Climate Action Reserve)

The Climate Action Reserve is a national offsets program working to ensure integrity, transparency and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of greenhouse gas (GHG) emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system.

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