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Conservation of Arctic Flora and Fauna

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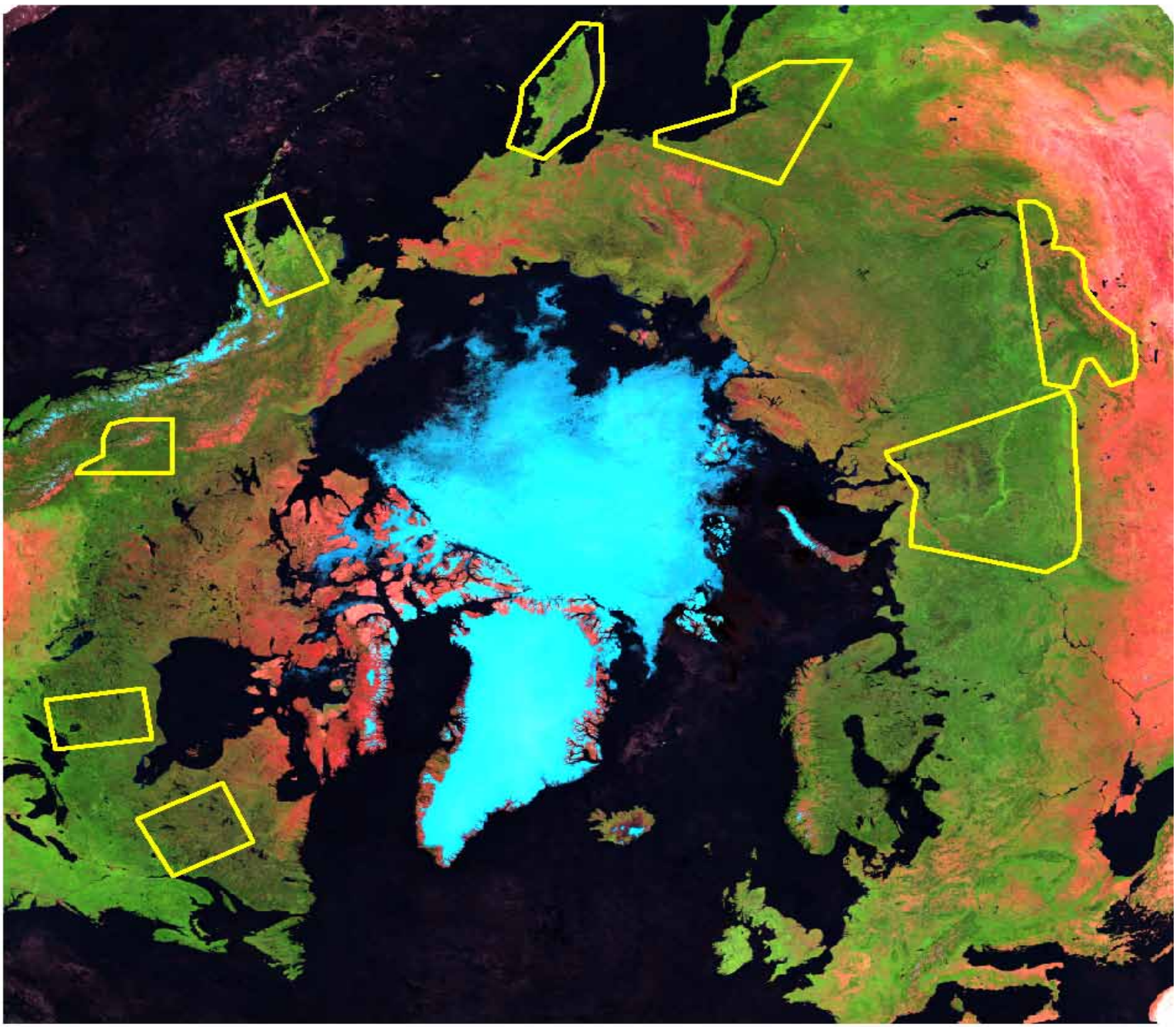
Circumboreal Vegetation Map (CBVM)

Mapping the Green Halo

CONCEPT PAPER



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CAFF Designated Agencies:

- Directorate for Nature Management, Trondheim, Norway
- Environment Canada, Ottawa, Canada
- Faroese Museum of Natural History, Tórshavn, Faroe Islands (Kingdom of Denmark)
- Finnish Ministry of the Environment, Helsinki, Finland
- Icelandic Institute of Natural History, Reykjavik, Iceland
- The Ministry of Domestic Affairs, Nature and Environment, Greenland
- Russian Federation Ministry of Natural Resources, Moscow, Russia
- Swedish Environmental Protection Agency, Stockholm, Sweden
- United States Department of the Interior, Fish and Wildlife Service, Anchorage, Alaska

CAFF Permanent Participant Organizations:

- Aleut International Association (AIA)
- Arctic Athabaskan Council (AAC)
- Gwich'in Council International (GCI)
- Inuit Circumpolar Conference (ICC) – Greenland, Alaska and Canada
- Russian Indigenous Peoples of the North (RAIPON)
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Cover Map: Modis map of the boreal biome and neighboring areas, Modis map produced by David Selkowitz (U.S. Geological Service, Alaska Science Center, Anchorage) in cooperation with Alex Trishchenko (Canada Centre for Remote Sensing, Ottawa) indicating the location of the prototype test areas; these study sites are delimited as yellow polygons.

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CAFF Designated Area

Circumboreal Vegetation Map (CBVM)

Mapping the Green Halo

Concept Paper

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Contents

Introduction

The mandate of the Conservation of Arctic Flora and Fauna (CAFF) working group of the Arctic Council is to address the conservation of Arctic and boreal biodiversity, and communicate findings to the governments and residents of the North, helping to promote practices which ensure the sustainability of northern resources. The mandate also includes working towards regulations and practices for flora and vegetation, fauna, habitat management, utilization, and conservation. To help fulfil this role, CAFF produces a range of strategies that present plans for directly conserving species and plant communities and also provides a framework that facilitates, more effective conservation measures. These strategies provide scientific and conservation recommendations on how to implement and insure the most effective management response. They are developed via intensive international cooperation between countries and scientists across the Arctic region. Many environmental problems are no longer national or regional in character and must be addressed in a global context. Because vegetation acts as an integrator of many of the physical and biological attributes of an area, a vegetation map can be used as a surrogate for ecosystems in conservation evaluations (Specht 1975, Austin 1991). Political boundaries seldom coincide with biogeographic boundaries. Thus, management strategies for long-term maintenance of biodiversity may be better focused on the characteristic biota of a region (Noss 1983). Aggregating information on ecological resources by zones and vegetation units organizes information according to the natural characteristics of the vegetation, rather than along national boundaries, which frequently cut across natural ecosystems (Simons 2005). A vegetation map, therefore, provides the foundation for assessing of ecological regions and their distribution.

Traditionally, conservation and research activities for arctic plants have not been well coordinated in terms of common direction, concerns, reporting, and information exchange. An exception was the production of an international Circumpolar Arctic Vegetation Map (CAVM), which was supported in part by the CAFF working group of the Arctic Council. Although many governmental and non-governmental conservation and research activities are organized singly or bilaterally, few plant-oriented organizations have a fully circumpolar, trans-boundary perspective. Toward an international perspective, the CAFF Flora Group (CFG) was created in 2004 within CAFF to ensure that scientists, conservationists, and managers interested in arctic and boreal flora and vegetation would have a forum to promote, facilitate, and coordinate conservation, management, and research activities of mutual concern.

The objectives of the CAFF Flora Group are to:

- Seek international opportunities to support the conservation needs of the biodiversity of arctic flora and vegetation;
- Create conservation partnerships within the Arctic and neighboring areas;
- Support research and education for conservation partnerships;
- Exchange published information and unpublished data concerning arctic flora and vegetation; and
- Develop cooperative botanical activities for the CAFF annual work plan.

What is the CBVM?

The Circumboreal Vegetation Mapping group, or CBVM, is a subgroup of vegetation scientists within the CAFF Flora Group and the International Association for Vegetation Science (IAVS) devoted to mapping the vegetation of the boreal region. Currently, vegetation maps of the circumboreal region exist at a wide variety of scales using many legend approaches. These maps have been developed by numerous authors for a wide variety of disparate applications but are not integrated into a unified system. To fully address the consequences of these conservation and management issues, a circumboreal vegetation map is needed with a unified legend approach.

The development of the CBVM is an attempt to understand the boreal in a new way that looks beyond the confines of administrative regions and regional approaches. In this respect it will form an important information, assessment and planning basis for solving nature and environmental protection problems at a global level.

Why focus on the vegetation?

Vegetation can serve to describe many facets of ecological patterns across the landscape and is an essential component of energy flow in ecosystems and provides habitat for many organisms (De Cáceres 2011). Vegetation generally integrates the ecological processes acting on a site or landscape more measurably than any other factor or set of factors and is often chosen as the basis for the classification of terrestrial ecosystems. Because vegetation provides the primary production and structure of the food web, it controls the distribution of other biota such as fish, birds, and mammals. Patterns of co-occurring plant species have received more attention than those other components, such as fauna, because they are relatively easy to measure and map. An additional benefit is that vegetation is often used to infer soil and climate patterns.

Why is there a need for a CBVM?

For an astronaut 300 kilometers above the Earth, a stunning view emerges of an immense coniferous forest that encircles the earth, the world's largest forest ecosystem. Gawthrop (1999) termed this vast coniferous biome, which can be seen in a Modis image on the cover of this publication, "the green halo." Its northern limit meets the treeless lands of the arctic tundra, while the southern limit is less easily defined because the vegetation grades into broadleaf deciduous forest, parkland, and grassland. This circumpolar ecosystem stretches across the northern latitudes of North America, Iceland, Southern Greenland, Russia, and Fennoscandia. The boreal forest and its associated oceanic heaths, thickets, and peat bogs play an essential role in helping to protect us from climate change by absorbing carbon dioxide and purifying the air we breathe. However, during the next few decades the boreal forest will be strongly affected by many forces from within and outside the region, including global climate change, cumulative impacts of resource development, human populations, and tourism. The relatively simple and fragile ecosystems could be dramatically altered through changes to the vegetation, demands for lumber and pulp, wetland destruction, and thawing of ice-rich permafrost (Shiklomanov et al. 2011, Wells et al. 2010). This could have important consequences to the wildlife resources and people living within the boreal forest. Therefore, it is important to create the Circumboreal Vegetation Map, which will contribute to global-scale boreal research programs and modelling efforts, facilitate educational materials, and contribute to conservation efforts and encourage sustainable use. The maintenance of a healthy biosphere ultimately depends on the preservation of plant diversity through conservation programs based on the biological requirements of component species and ecosystems. Through reporting by ecological units, valuable insight is obtained regarding characteristics of vegetation resources, which may serve to identify and resolve issues of importance to many countries, entire regions, or even the circumboreal realm as a whole. To achieve understanding, the map units in a boreal ecological framework must identify and accurately group broad, yet relatively homogeneous, natural vegetation types (Simon 2005).

Photo by: Peter Prokosch http://www.grida.no/photolib

Uses of the CBVM


Photo by: Antoine Leboeuf

A new vegetation map would provide a common legend and language for ecosystems of the boreal region. It would be a key component of a GIS database of circumboreal ecosystem characteristics. Such a map is needed for a wide variety of purposes related to resource development, land-use planning, studies of boreal biota and biodiversity, education, and anticipated global changes, and human interactions. Some of the key conservation/management issues in the boreal forest region include effects of fire disturbance, timber harvesting, and exotic species management (Potapov et al. 2011). A key objective of the map will be to identify and map regions of diversity/rareness/value and their vulnerability to global and local climate change and anthropogenic impacts, i.e. "boreal hotspots,". Climate and vegetation-change models, estimation of northern soil carbon stocks, analysis of animal migrations, roads and industrial developments, and boreal-human interactions all require maps that include the boreal region. A global approach to conservation of the boreal biome requires an international vegetation map because many plant and animal species occur across national borders, conversely, other communities endemic to specific regions and their global significance can only be appreciated in an international context . A circumboreal vegetation map will have numerous application uses for boreal scientists and managers, including impact studies on wildlife and feedback mechanisms in models Illustrating climate change(Groisman et al. 2009, Hayes et al. 2011). Documenting the current distribution of the boreal forest is a first step toward monitoring these long-term changes. A circumboreal map will also improve global understanding and communication about potential risks to humanity and our environment.

Goals and Objectives

The map is directed at a wide spectrum of users, including but not limited to, policy and decision makers, land-use managers, climate change scientists, global modelers, educators, ornithologists, and vegetation scientists. The aim of the CBVM project is to produce a vegetation map at a scale of 1:7.5 million with geobotanical database and derived products of the entire boreal biome using a unified, international method for classifying and mapping boreal vegetation. The map will provide a common legend and language for the various ecosystems that make up the boreal region with a consistent treatment for the vegetation through legend descriptions, photographs, lists of major vegetation types, and supplementary maps. Although there are a number of useful remote-sensing products displaying vast areas of the north, we intend to develop a true vegetation map such as the Map of the Natural Vegetation of Europe (Bohn et al. 2003). The basic map units will be physiognomic and/or a combination of physiognomic-floristic units. The internationally recognized Braun-Blanquet plant-community nomenclatural system, or the closest equivalent that can be provided, is a logical choice as the preferred approach for cataloging plant communities. Boreal forests are particularly appropriate for unified classification because of their high level of floristic, physiognomic, and syntaxonomic similarity across the entire biome. Our primary rationale is that global-scale boreal research programs, modelling efforts, educational materials, and conservation efforts require a common language for describing boreal ecosystems.

The CBVM builds on the CAVM. Linking these two global-scale maps is necessary because very few issues relevant to the Arctic or the boreal regions stop at tree line. For example, most rivers flowing into the Arctic Ocean have their origin far to the south of the tree line. Accordingly, a major goal is to make the CBVM compatible with the CAVM

How will the CBVM be created?

The CBVM Leadership Team will develop the map; an organization table details the group structure (Fig. 1). This team will produce;

- A vegetation map legend, including principles, mapping methodology, and glossary;
- Remote sensing and geographical support;
- Bioclimatic framework; and
- Map database, design and printing.

Funding development is in cooperation with the CAFF Secretariat. Within the leadership team, two major groups organized by geographic region will provide guidance for the actual mapping:

- North America with two subgroups
  - Alaska
  - Canada
- Eurasia with three subgroups
  - North Atlantic
  - Europe
  - Russia.

Science-Driven Approach


Photo by: Peter Prokosch

The CBVM will portray Potential Natural Vegetation (PNV) rather than the "actual" or "existing" vegetation that is commonly generated by classification of satellite imagery. PNV, generally represents the vegetation that would exist in the absence of human land conversion, such as agricultural cultivation, forestry, harvesting and settlement. It also does not represent the short-term seral stages that arise from natural disturbances by wind, fire, and flooding. The PNV concept can become highly hypothetical when terms such as "climax vegetation" are invoked, and there are practical limitations of forecasting the outcome of succession when human disturbances are relaxed (Mueller-Dombois & Ellenberg 1974). Tüxen (1956) used the following definition for "potential natural vegetation of today" to reconcile these issues; "the vegetation structure that would become established if all successional sequences were completed without interference by man under present climatic and edaphic conditions." Using this definition, PNV is mapped based on present day vegetation-environmental relationships in relatively undisturbed landscapes, and these relationships are extrapolated to disturbed areas using climatic zones and enduring geological landscape features.

Although still under development, the CBVM Vegetation Legend has been strongly influenced by the principles used in the development of the Natural Vegetation of Europe Map (Bohn et al. 2003; Ermakov & Bond 2011). The proposed legend will be a hierarchy that at the highest levels should reflect the most essential regularities common for the boreal zone of both continents (Eurasia and North America). Moving down the hierarchy, the legend will reflect more detailed divergence in regional vegetation structure and composition. The following levels for the boreal biome are recognized in the most recent revisions from the CBVM meeting February 2011 in Akureyri, Iceland.

Hierarchical level of CBVM	
Level	Main Criteria
1 Formation Type	Broad physiognomy and structure (forest, woodlands, …)
2 Formation Group	Structure and physiognomy, reflecting main climatic conditions (zonal vegetation) or site, edaphic, or topographic conditions (extrazonal, azonal)
3 Formation	Dominant growth forms (evergreen, deciduous, …)
4 Bioclimatic Subdivision	Based on climatic parameters and bioclimatic indices as reflected by vegetation, usually North–South broad zonation
5 Geographic variants	Based on species or ecosystem distribution, usually West–East broad zonation (most detailed level at the scale of 1:7 million)
6 Plant community	Species composition (site specific)

The boundaries of the boreal biome in North America basically follow the recent review by Brandt (2009), while those in Eurasia basically follow the Map of the Natural Vegetation of Europe (Bohn et al. 2003) and the Geobotanical Map of USSR (scale 1:5 million)(Lavrenko & Sochava, eds. 1954; scale 1:5 million).

A bioclimatic framework for the CBVM was proposed by Sánchez-Mata & Rivas-Martínez (2011) following the published bioclimatic proposals by Rivas-Martínez, Sánchez-Mata & Costa (1999), and Rivas-Martínez (2005); the data were compiled in a special website (Rivas-Martínez & Rivas-Sáenz 2011). This framework provides an empirical definition of the boreal macrobioclimate based on mean annual temperature, positive annual temperature, and positive summer temperature. Walker (1999, 2010) has proposed a six-step mapping methodology for integrating remote sensing, geology, and soils data to create landscape polygons that are sensitive to variation in edaphic conditions.

Following the development of a draft CBVM Legend (Ermakov & Bohn 2011), prototype mapping projects were initiated in several major regions of the boreal biome; these regions are indicated on the front cover. Regional vegetation scientists are presently testing the legend and are experimenting with mapping approaches and methods:

- Iceland - Guðmundur Guðjónsson, Eyþór Einarsson, and Rannveig Thoroddsen
- Greenland – Fred J.A. Daniels
- Faroe Islands – Anna Maria Fosaa
- Alaska – Torre Jorgenson
- Western Canada – Will MacKenzie and Del Meidinger
- Québec Canada – André Robitaille, Jean-Pierre Saucier, Antonine Leboeuf and Élisabeth Dufour
- West Siberian Plain– Nikolai Ermakov
- Kamchatka – Valentina Neshataeva
- Southern part of the Russian Far East – Pavel Krestov

The results of the mapping were presented at the CBVM Workshop in Akuryeri, Iceland, 28 January - February 3, 2011 <http://caff.arcticportal.org/workshops/akureyri-2011>. The prototype maps helped considerably in the revision of the CBVM Vegetation Legend presented above. The prototypes also identified a need for a subsequent workshop to develop more consistent methods that balance the requirement for international consistency with the reality of the great disparity in knowledge and information across the vast boreal biome. Work is also needed on unified conceptual models such as those proposed by Nicolai Ermakov for Eurasia (Fig 2).

Partnership Framework

The CBVM works within the CFG under the Arctic Council, which is a high-level intergovernmental forum to provide a means for promoting cooperation, coordination, and interaction among the Arctic States. This work is done with the involvement of the Arctic Indigenous communities and other Arctic inhabitants on common Arctic issues, in particular ,issues of sustainable development and environmental protection. Member States of the Arctic Council are Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States of America.

Participating scientists actively working on the CBVM come from a wide spectrum of university, government, and industry organizations. Examples include: Canada (Natural Resources Canada, Canadian Forest Service; Ontario Ministry Of Natural Resources; Ministère des Ressources naturelles et de la Faune, Québec; British Columbia Ministry of Forests and Range); Iceland (Icelandic Institute of Natural History, Reykjavik, Iceland); Faroe Islands (Faroese Museum of Natural History, Tórshavn); Finland (Botanical Museum, University of Helsinki); Germany (Ecology Center, University of Kiel, Kiel; University of Münster, Münster; Institute of Geobotany, Leibnitz University, Hannover). Russian Federation (Laboratory of Ecology and Geobotany, Central Siberian Botanical Garden, Novosibirsk; Botanical Garden-Institute, Vladivostok; Komarov Botanical Institute, St. Petersburg); Spain (Department of Plant Biology II, Complutense University, Madrid; Phytosociological Research Center, Los Negrales, Madrid); United States of America (Alaska EcoScience, Fairbanks; Alaska Geobotany Center, Institute of Arctic Biology, University of Alaska Fairbanks; Division of Realty and Natural Resources, U.S. Fish and Wildlife Service, Anchorage).

Photo by: Peter Prokosch http://www.grida.no/photolib

Organizational/Partnership Structure

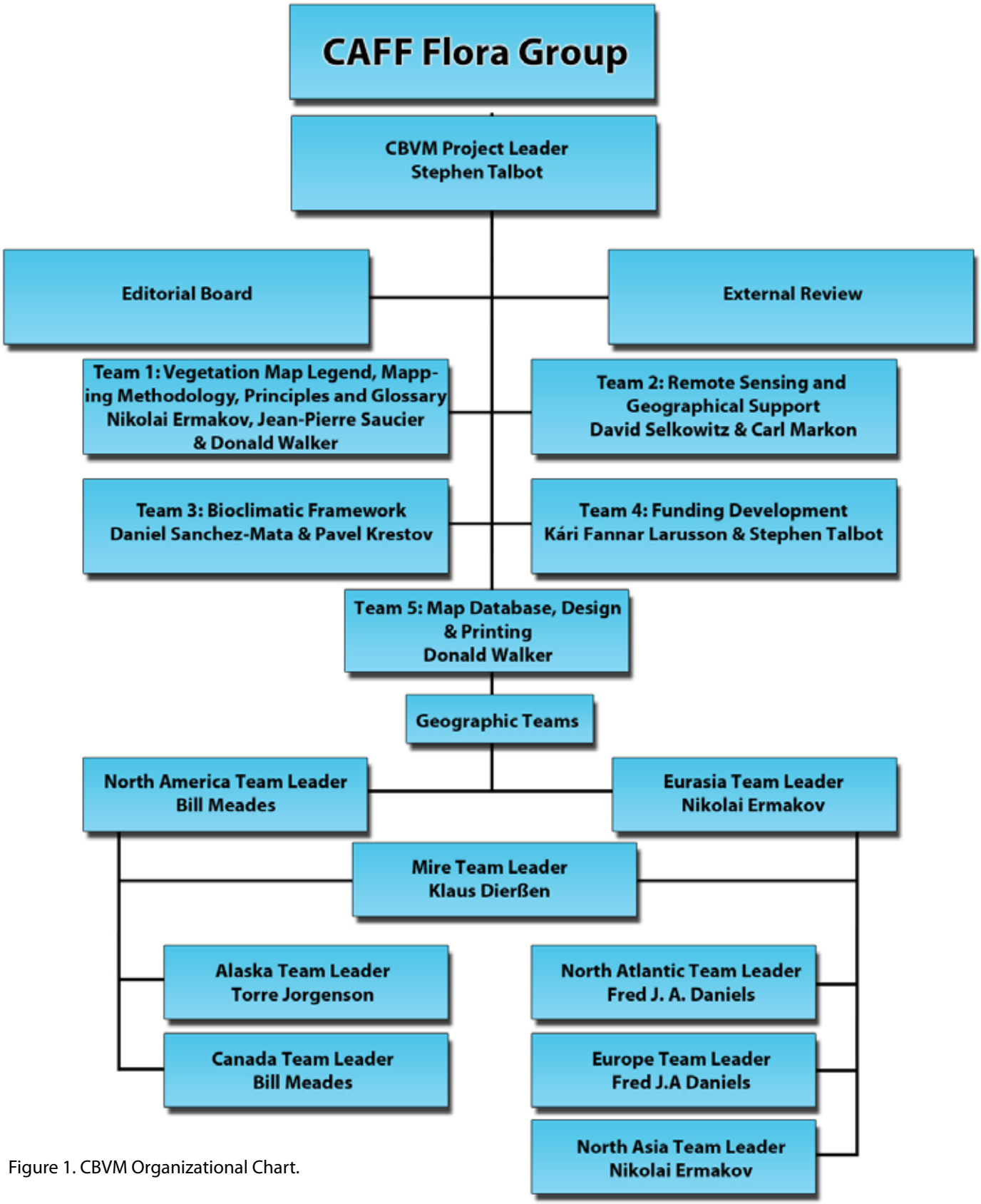

Figure 1. CBVM Organizational Chart.

Information Resources

Data will be structured so that it is possible to provide national geographic information in a harmonized form as background for analyzing and presenting of other Arctic and boreal spatial data. Internationally adopted standards for data and metadata will be adhered to by all data providers and system developers.

Technology

The CBVM project will use base map imagery from the Moderate Resolution Imaging Spectro Radiometer (MODIS) in a manner similar to the way base map imagery from the older Advanced Very High Resolution Radiometer (AVHRR) was used for the Circumpolar Arctic Vegetation Map (Walker et al. 2005b). Standard gridded, composited MODIS products available from NASA exhibit significant geometric distortion at high latitudes and away from the Prime Meridian, altering the appearance of landscape features. The circumpolar mosaic of late summer cloud-free composited MODIS imagery developed by the Canada Centre for Remote Sensing (Trishchenko et al. 2009) and used for the CBVM base map minimizes this geometric distortion and is also available at 250 m spatial resolution for all seven spectral bands.

Climatic parameters are a key element in the CBVM classification, and the classification process will also incorporate modelled precipitation and temperature surfaces to assist with the classification. The completed CBVM product will be available both as a printed map and as a digital product with attribute information associated with each mapped polygon. in a database.

Milestones

The need for such a Circumboreal Vegetation Map was discussed at the 2nd International Workshop on Circumpolar Vegetation Classification and Mapping held in Tromsø (Sommarøy), Norway, in June 2004. The new map expanded the area covered by the Circumpolar Arctic Vegetation Map (CAVM) far to the south (CAVM Team 2003, Walker et al. 2005b). At Tromsø the participants resolved to develop a unified international method for classifying and mapping boreal vegetation (Walker et al. 2005a). Following this workshop a CBVM funding initiative action item was developed in 2005 at the 3rd CFG Workshop held in Helsinki, Finland. This was followed by an organizational meeting at Fairbanks, Alaska, where an initial funding proposal was developed.

At the CAFF XI Biennial Meeting in Yllas, Finland, in March 2006, the CAFF National Representatives endorsed the CBVM. This approval was followed by an endorsement by the Senior Arctic Officials representing the eight Arctic States, CAFF Flora Group received support from Environment Canada, Faroe Islands Homeland Government, and U.S. Department of State to fund the Fourth International CAFF Flora Group Workshop, 15-18 May 2007, Tórshavn, Faroe Islands (Talbot 2008). This workshop helped pave the way for further progress and an updated proposal was submitted by Finland to the Nordic Council of Ministers for a major CBVM workshop in Helsinki, Finland (Talbot et al. 2010); this proposal was successful and workshop funding for the CBVM was obtained in 2008 from the Nordic Council of Ministers by Finland. Following the Helsinki workshop we held workshops in Uppsala, Sweden, Sault Ste. Marie, Ontario, Helsinki to develop a circumboreal map legend (Talbot 2011).

Endorsements and Recognitions

The CBVM was endorsed by the International Arctic Science Committee (IASC) in January 2011. The CBVM is also an official working group of the International Association for Vegetation Scientists (IAVS). The IAVS is a worldwide union of scientists and others interested in theoretical and practical studies of vegetation: and its composition and structure, history, classification, distribution, ecology, dynamics, management, and uses in the landscape. The project is supported internationally through the Conservation of Arctic Flora and Fauna (CAFF) Working group of the Arctic Council with an international Secretariat located in Akureyri, Iceland (<http://www.caff.is/>).

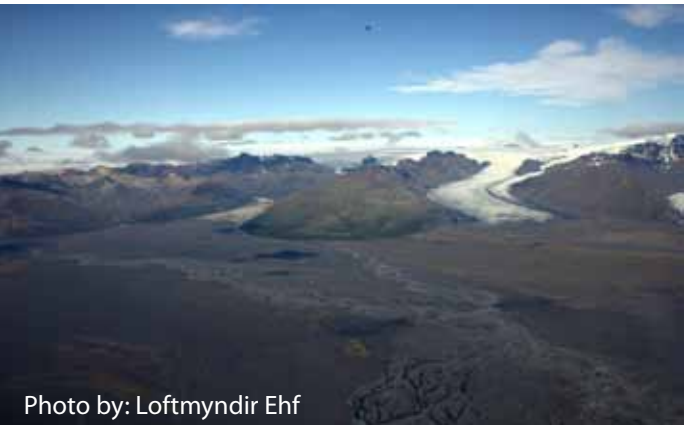
Photo by: Loftmyndir Ehf

The Circumboreal Vegetation Mapping (CBVM) project received the endorsement of the "New Roots for the 21st Century" US-Russia Botanical Conference (September 20-23, 2005, Wilson College, Chambersburg, PA), the Conservation Arctic Flora and Fauna (CAFF), and the Senior Arctic Officials representing the eight Arctic States, have all endorsed the development of a circumpolar boreal vegetation map by Ministerial Declaration at the 4th meeting of the Arctic Council, November 24, 2004.

CBVM workshops would not have been possible without the generous contribution of the following agencies for staff time, travel and operating funds: CAFF, Nordic Council of Ministers; Faroe Islands Homeland Government; Natural Resources Canada, Canadian Forest Service; United States Geological Survey, Alaska Science Center; United States Fish and Wildlife Service; University of Alaska, Fairbanks; Environment Canada, Parks Canada Agency; Ministère des Ressources naturelles et de la Faune, Québec; Ontario Ministry of Natural Resources; British Columbia Ministry of Forests and Range; ArtDatabanken, SLU, Swedish Species Information Centre; and United States Department of State.

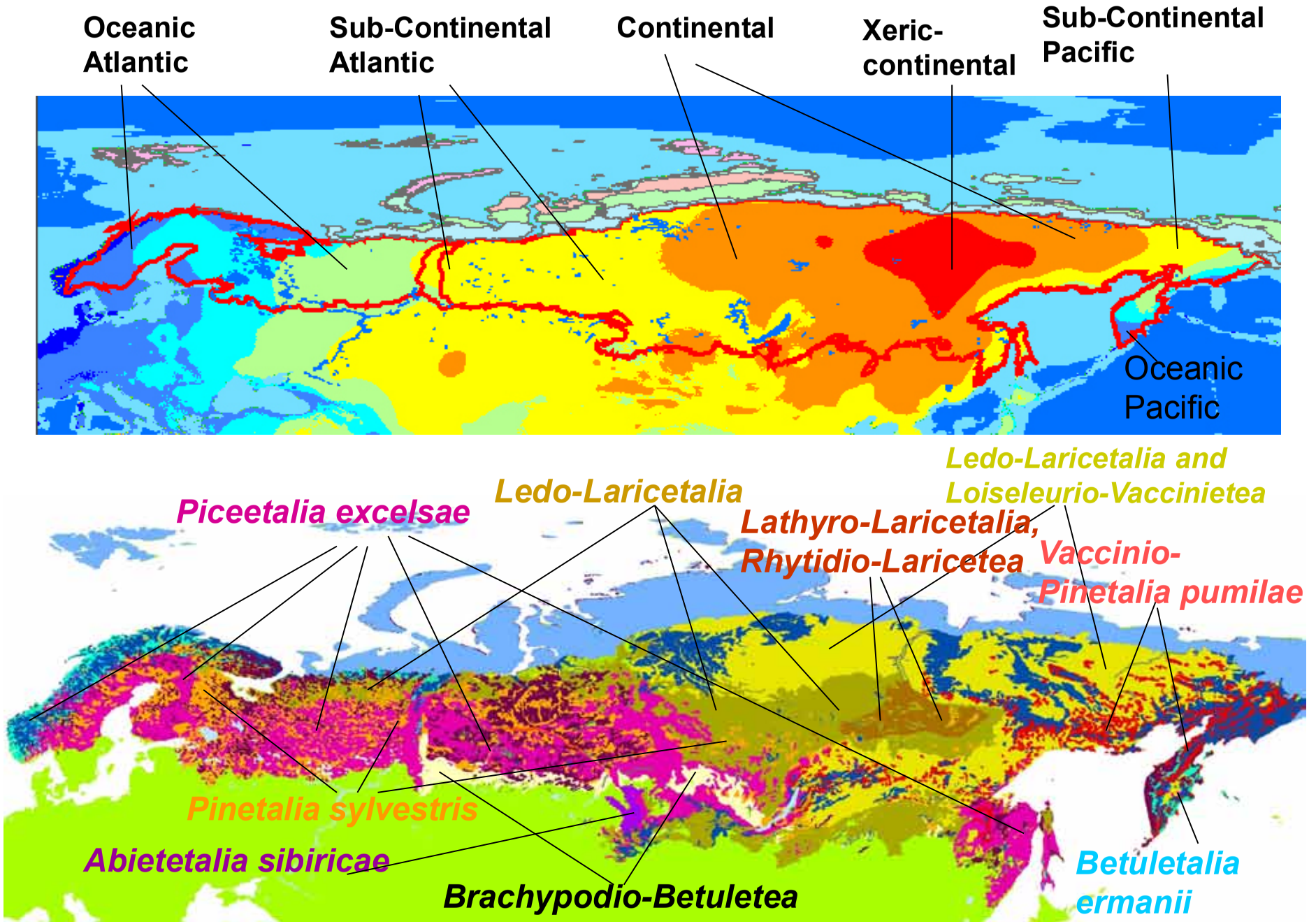

Figure 2. The higher vegetation units (classes and orders) of forests and bioclimates in the boreal biome of Eurasia proposed by Nikolai Ermakov, Laboratory of Ecology and Geobotany, Central Siberian Botanical Garden, Novosibirsk.

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