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## Meeting Report:

## Rescuing valuable Arctic vegetation data for biodiversity models: IAVD–CBIO-NET Workshop, Roskilde, Denmark, 29-31 May 2012

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# The Roskilde meeting

A recent workshop held in Roskilde, Denmark, 29-32 May brought together key Arctic vegetation scientists with biodiversity modelers to discuss the potential rich source of species-distribution information contained in Arctic vegetation-plot (relevé) data for plant-biodiversity-modeling studies. Georeferenced plot-based vegetation data are necessary to the vegetation-science community to understand factors that shape Arctic plant communities, to map distributions of species and plant communities, and to assess vegetation changes through the use of spatially explicit predictive models. This is particularly important at this moment in history because the Arctic is responding particularly fast to the effects of climate change ([Callaghan et al. 2005](#_ENREF_1)).

The goals of the meeting were to 1) develop a strategy for harmonizing the relevé data and database approaches available in the various Arctic countries for developing an International Arctic Vegetation Database (IAVD, Walker and Raynolds 2011), 2) lay the foundation for prototypes vegetation databases for Greenland and northern Alaska, and 3) highlight promising methods for modelling and predicting biodiversity trends from patterns in the plant distribution data. The Nordic Network on Climate and Biodiversity (CBIO-NET) project and the Conservation of Arctic Flora and Fauna (CAFF), the biodiversity monitoring arm of the Arctic Council, sponsored the workshop.

# Data needs for Arctic plant species distribution models

Documenting and understanding distributions of Arctic plant species is an important step toward predicting changes at all trophic levels in Arctic terrestrial ecosystems. CBIO-NET’s major objective is to increase the understanding of the effects of climate change on ecosystems and biodiversity. Knowledge-based ecosystem models and predictive models make up an important part of the CBIO-NET activities (need CBIO-NET reference or website). A wide variety of species distribution modeling tools are already available and can be applied to predict historical, present and future vegetation and plant distributions to help refine predictions of ecosystem change and e.g. gas exchange between tundra vegetation and the biosphere. New advances in these methods offer the possibility to incorporate information on biotic interactions (Wisz et al 2012 in press), dispersal capacity (Engler et al 2011) as well as phylogeographic history (Pellissier et al 2012 in press) to fill gaps in distributional information in space and time.

Addressing biodiversity questions in the Arctic is, however, a challenging task because there are large gaps in the information on vegetation patterns, which are essential to quantify species-environmental relationships and make ecosystem-level predictions. Data from a large body of vegetation plot data that have been collected across the Arctic during the past century would provide a key missing link required to derive predictive models of future distributions under different climate-change scenarios.

# The International Arctic Vegetation Database initiative

The goal of the International Arctic Vegetation Database (IAVD, Walker and Raynolds 2011) is to unite and harmonize the vegetation data from the Arctic Tundra Biome (Fig. 1) for use in developing a panarctic vegetation classification and for use in research on climate and biodiversity. This open access database would be the first to represent an entire global biome. A parallel effort is being considered for the boreal forest biome south of the Arctic treeline (Talbot et al. 2008).



***Figure 1.*** *Extent of the Arctic Tundra Biome (CAVM Team 2003). Map units are defined by the dominant physiognomic vegetation types within regional complexes where the boundaries are drawn primarily on the basis of large physiographic features such as mountains, hills, plains and large wetlands. (Walker et al. 2005).*

Arctic vegetation data are especially valuable because of the large time, cost, and even risk associated with their collection in remote areas of the Arctic. These data, however, are scattered across many institutions in a variety of formats. Some of these data are maintained in electronic databases managed by various research groups working in the Arctic, while other data are still in field books in danger of becoming lost because they have not yet been electronically catalogued – several of the botanists who collected the data are retired or deceased. There is thus an urgent need to catalogue these data before they are lost. An internationally coordinated effort has therefore recently emerged to accelerate the preservation of these data and harmonize them for use in comparative studies ([Walker and Raynolds 2011](#_ENREF_16)).

The concept of an International Arctic Vegetation Database and classification was first proposed at the International Arctic Vegetation Classification Workshop in 1992 at Boulder, CO, USA ([Walker et al. 1994](#_ENREF_18)). This meeting strongly stimulated international interest in Arctic plant-community research. The idea was revived at the Second International Workshop on Circumpolar Vegetation Classification and Mapping, Tromsø, Norway 2004 ([Daniëls et al. 2005](#_ENREF_4)) and received an endorsement from the CAFF Flora Group at the 4th International CAFF Workshop in Tórshavn, Faroe Islands ([Talbot et al. 2008](#_ENREF_15)).

The Circumpolar Arctic Vegetation Map ([CAVM Team 2003](#_ENREF_2)) was the first major step toward fulfilling the ideas from the Boulder Workshop ([Walker et al. 2005](#_ENREF_17)) (Figure 1). Plot-level plant-community information gathered for local and national vegetation classifications and maps were reviewed during the process of making the CAVM. Recent developments in database methods now make it feasible to assemble an Arctic wide vegetation database from these data ([Schaminée et al. 2009](#_ENREF_13)). About 20,000 relevés are available for inclusion in the database (Walker and Raynolds 2011, updated).

## Harmonizing data and database approaches

Harmonizing plant species names and North American and European data-gathering, database, and classification approaches are significant challenges to address before the IAVD can be developed. One of the first challenges is a list of accepted plant-species names. Prof. Robert Peet (University of North Carolina) presented an overview of the species-name challenges in developing a vegetation database and how this has been addressed in VegBank, the plot database used in the United States for the U.S. National Vegetation Classification ([Faber-Langendoen et al. 2009](#_ENREF_9)). Taxonomists working in conjunction with CAFF have developed lists of currently accepted species names for the vascular plants (Elven et al. 2011), lichens (Kristinsson 2010), and mosses (Belland 2012 draft). These will be combined with the Russian liverwort checklist (Konstantinova et al. 1992) to develop a single list of taxa names with synonyms for the Arctic. Amy Breen (University of Alaska Fairbanks), Helga Bültmann (University of Münster), Martha Raynolds (University of Alaska Fairbanks), and Stephan Hennekens (Alterra, Wageningen, The Netherlands) are developing the list, which is expected to be available by the end of 2012 and later published. Members of the species-list team will update the list regularly. Finn Brochsenius (Aarhus University) discussed how the Arctic species database could be linked the Global Biodiversity Information Facility (GBIF). Simple synonym lists do not allow full integration of plot data collected across many places and many years, so once the initial list of accepted names is developed, it would be highly desirable to map other lists onto it using taxon concept relationships as is done in the VegBank species lists (Peet et al. \_\_\_).

In addition to taxonomic challenges, methods for quantifying and inventorying vegetation coverage have also varied over the years and in different places. For example, Braun-Blanquet cover-abundance scores and other subjective means of estimating species cover are most commonly used in vegetation plot data and can be used for vegetation classification and to derive complete species lists for small plots, but they are not appropriate to monitor quantitative changes in species cover. A variety of point-intercept methods are widely used for this purpose ([Mueller-Dombois and Ellenberg 1974](#_ENREF_12)), but these methods are not appropriate for classification purposes nor for developing lists of rare species. During the meeting Prof. Chr. Damgaard (Aarhus University) presented a novel method in a Bayesian framework for harmonizing data derived from point-intercept and Braun-Blanquet relevés (Damgaard 2012). Such methods show great promise for bolstering the data available for comparative, long-term studies across the Arctic where diverse methods for collecting information have been practiced.

One of the principal products that would eventually be derived from the IAVD would be a panarctic vegetation classification. In Arctic regions, two approaches to vegetation classification are prevalent: the European approach (Braun-Blanquet 1928, Westhoff & van der Maarel 1978) and the American approach (Faber-Langendoen et al. 2009). The European approach has been used extensively in both the Eurasian and the American Arctic, but the method has not gained wide acceptance elsewhere in North America. The American and European approaches are similar at the lowest level (plant-association level) of the hierarchies, but the details of the hierarchic approaches make it difficult to make the systems totally compatible. Plant associations described according to the European approach can be included in the U.S. and Canadian vegetation classification systems; whereas, the reverse is not easily accomplished without considerable additional attention to the naming and publication of the plant communities according to international protocols (Weber et al. 2000). There is need, especially in the Arctic, for harmonizing the European and American approaches because so much of the world is heavily invested in one or the other method ([De Cáceres and Wiser 2012](#_ENREF_5)). The Arctic vegetation database would be constructed so that the data could be incorporated into either approach.

A large body of international experience for developing national databases will help to make the IAVD a reality. The participants agreed that the Turboveg database management system ([Hennekens and Schaminée 2001](#_ENREF_10)) is the best option for initial data entry and management because this system is widely used in Europe and worldwide for several national classifications and is compatible with SynBioSys Europe ([Schaminée et al. 2007](#_ENREF_14)) and the European Vegetation Archive (EVA) ([Chytrý et al. 2012](#_ENREF_3)), the database initiative of the European Vegetation Survey. The data will be permanently archived in the EVA, and VegBank. A protocol for importing information from Turboveg to VegBank will need to be developed using the Veg-X exchange standard ([Wiser et al. 2011](#_ENREF_19)). The metadata for the IAVD will be entered into the Global Index of Vegetation Plot Databases (GIVD) ([Dengler et al. 2011](#_ENREF_6)). Members of CAFF Flora Group will manage the database, and data will be disseminating through the CAFF ArcticData Portal (<http://www.arcticdata.is/>). The portal will link to the IAVD, which will be maintained in VegBank and will also be available through European Vegetation Archive (EVA). Vegetation records, community types and plant taxa may be submitted to VegBank and may be subsequently searched, viewed, annotated, revised, interpreted, downloaded, and cited. Archives such as VegBank and EVA will allow a flexible system for archiving and retrieving the data.

The focus of the IAVD is on vegetation plot data (relevé data). Other valuable types of vegetation data, such as point-intercept data, other types of community and species specific data, are in highly variable formats. It was decided at the meeting that these other types of data should be recovered and described in a metadatabase and archived in the GIVD and in a central Arctic data facility, such as that being developed for northern Alaska.

## Greenland and Alaskan prototypes

One of the first steps in the IAVD effort will be to develop prototype databases for Greenland and Alaska, where a wealth of vegetation plot data collected using the European approach already exists in digital format. Greenland is the arctic country with the longest coast running north to south, resulting in a complete Arctic climactic gradient from the subarctic to the extreme High Arctic along both the east and west coasts, and from the maritime coast to the continental inland ice margins along the extensive fjord systems. These gradients make Greenland particularly well suited for informing climate-change research and studying changes as plant species shift their ranges. Professor Emeritus Fred Daniëls (University of Münster) described data collected during his 15 expeditions to Greenland since the 1960s. Christian Bay presented an overview of other Greenland data sets. During the meeting Daniëls, Bay (Aarhus University) and Bültmann agreed to contribute as many as 2000 Greenland vegetation plots (relevés) to the database. At least 1500 of these will be available in the next year. In North America, Amy Breen and Martha Raynolds will assemble about 1000 relevés from northern Alaska into an Alaskan prototype. These data are currently maintained at the Alaska Geobotany Center (<http://www.geobotany.uaf.edu/iavd/posters.php>).

## Predictive models

The IAVD will be a part of the Circumpolar Biodiversity Monitoring (CBMP) Program. Tom Christiansen (CAFF) and Niels Martin Schmidt (Aarhus University) described the CBMP’s Terrestrial Expert Monitoring Group and the plan for monitoring biodiversity in the Arctic. During the meeting, methods were presented for integrating spatially explicit vegetation, remote sensing data with new spatial modeling tools such as stacked spatial distribution models (SDMs) and structural equation models. A diverse set of papers described some recent applications of SDMs and other approaches to issues related to Arctic biodiversity, including biological responses controlled by geodiversity, geomorphic processes, herbivory, and climate effects on biodiversity and treeline (Miska Luoto, University of Helsinki, e.g. Luoto and Heikkinen 2008, Virtanenen et al. 2010), Arctic plant distribution changes related to history of glaciation, species origins, plant functional types, and velocities of change (Loic Pellisier, Aarhus University), and applications of DNA metabarcoding in soils to questions of biodiversity (Nigel Yoccoz, University of Tromsø, e.g. Yoccoz et al. 2012).

Quantifying and predicting changes in Arctic ecosystems requires a sound understanding of the processes that sustain its biodiversity and ecosystem function over time, and vegetation plots replicated in time and space are crucial to shape this understanding. Consolidation of the existing information about vegetation plots into the International Arctic Vegetation Database is an essential first step in this process. It will take many years to harvest all the existing data, but large amounts of data are relatively accessible and realistic progress is expected in the next 5 years.

## Next steps

The participants scheduled a follow-up CBIO-NET—IAVD meeting in December 2012, to focus on the Greenland and Alaska prototypes and discuss the application of the data to modeling needs of the CBIO-NET project. It is also important now to involve the full Arctic vegetation-science community to begin the much larger task of assembling data from the whole Arctic. Other vegetation databases are being developed in Canada and Russia and these need to be integrated into the Arctic-wide effort. Proposals will need to be developed to insure that there are funds and personnel for full participation from the widest group of Arctic scientists possible. A general Arctic-wide IAVD meeting is tentatively planned for 2013 either in Krakow Poland at the Arctic Science Summit Week, or in Wageningen. Vegetation scientists from all the circumpolar nations will gather to review the status of Arctic vegetation data in their respective countries, become updated on the latest vegetation database technology, and formalize the plans for the IAVD. A web page for the IAVD (<http://www.geobotany.uaf.edu/iavd/>) includes most of the talks from the workshop.

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