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Ecoinformatics
Long Database Report

The Alaska Arctic Vegetation Archive (AVA-AK)

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Abstract: The Alaska Arctic Vegetation Archive (AVA-AK, GIVD-ID: NA-US-014) is a free, publically available database archive of vegetation-plot data from the Arctic tundra region of northern Alaska. The archive currently contains 24 datasets with 3,026 non-overlapping plots. Of these, 74% have geolocation data with 25-m or better precision. Species cover data and header data are stored in a Turboveg database. A standardized Pan Arctic Species List provides a consistent nomenclature for vascular plants, bryophytes, and lichens in the archive. A web-based online Alaska Arctic Geoecological Atlas (AGA-AK) allows viewing and downloading the species data in a variety of formats, and provides access to a wide variety of ancillary data. We conducted a preliminary cluster analysis of the first 16 datasets (1,613 plots) to examine how the spectrum of derived clusters is related to the suite of datasets, habitat types, and environmental gradients. We present the contents of the archive, assess its strengths and weaknesses, and provide three supplementary files that include the data dictionary, a list of habitat types, an overview of the datasets, and details of the cluster analysis.

Keywords: Circumpolar, cluster analysis, database, tundra, Turboveg, vegetation classification

Nomenclature: Elven (2011) for vascular plants; Kristinsson et al. (2010) for lichens; Belland (2012, unpublished Arctic moss database for the Conservation of Arctic Flora and Fauna) for mosses; and Konstantinova & Bakalin (2009) for liverworts.

Abbreviations: AVA = Arctic Vegetation Archive; AVA-AK = Alaska Arctic Vegetation Archive; GIVD = Global Index of Vegetation-Plot Databases.

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GIVD Fact Sheet

GIVD Database ID: NA-US-014			**Last update:** 2016-05-05
Alaska Arctic Vegetation Archive		**Web address:** http://geobotanical.portal.gina.alaska.edu/plot-archive	
Database manager(s): Amy Breen (albreen@alaska.edu); Lisa Druckenmiller (lddruckenmiller@alaska.edu); Jozef Sibik (jozef.sibik@savba.sk)			
Owner: Donald A. Walker, Amy L. Breen, Jozef Sibik, Lisa Druckenmiller and Martha K. Raynolds			
Scope: The Alaska Arctic Vegetation Archive (AVA-AK) is a regional database that is part of the larger Arctic Vegetation Archive. The database contains vegetation plots from homogeneous plant communities with tables of cover or cover-abundance scores for all species, and accompanying environmental site data. Data are collected using Braun-Blanquet, US National Vegetation Classification protocols, or comparable methods.			
Availability: free online		**Online upload:** yes	**Online search:** no
Database format(s): TURBOVEG		**Export format(s):** TURBOVEG, Excel, CSV file	
Plot type(s): normal plots; time series		**Plot-size range:** 0.16-800 m²	
Non-overlapping plots: 3,026	**Estimate of existing plots:** 4,000	**Completeness:** 76%	**Status:** emerging
Total no. of plot observations: 3,156	**Number of sources (biblioreferences, data collectors):** 24		**Valid taxa:** 1,569
Countries: CA: 5.0%; US: 95.0%			
Formations: Forest: 5% = Terrestrial: 5% // Non Forest: Aquatic: 3% (Fresh water: 3%) , Semi Aquatic: 12% (Fresh water: 12%) , Terrestrial: 80% (Arctic alpine: 80%)			
Guilds: all vascular plants: 100%; bryophytes (terricolous or aquatic): 98%; lichens (terricolous or aquatic): 96%			
Environmental data: altitude: 68%; slope aspect: 84%; slope inclination: 84%; microrelief: 15%; soil depth: 48%; surface cover other than plants (open soil, litter, bare rock etc.): 40%; soil pH: 64%; other soil attributes: 73%			
Performance measure(s): cover: 100%; measurements like diameter or height of trees: 1%; biomass: 13%			
Geographic localisation: GPS coordinates (precision 25 m or less): 74%; point coordinates less precise than GPS, up to 1 km: 7%; political units or only on a coarser scale (> 10 km): 19%			
Sampling periods: 1950–1959: 4.0%; 1960–1969: 5.0%; 1970–1979: 5.0%; 1980–1989: 30.0%; 1990–1999: 30.0%; 2000–2009: 41.0%; 2010–2019: 6.0%			
Information as of 2016-17-05; further details and future updates available from http://www.givd.info/ID/NA-US-014			

Introduction

The goal of the Arctic Vegetation Archive (AVA) project is to gather all the available Arctic vegetation plot data into a publically accessible database and apply it to northern issues, including a circumpolar Arctic vegetation classification (Walker et al. 2013a, 2013b, Walker 2014a). The conceptual basis for the AVA originated in the Flora Group of the Conservation of Arctic Flora and Fauna (CAFF) (Walker & Raynolds 2011). CAFF is the biodiversity working group of the Arctic Council, which is an intergovernmental forum that promotes international cooperation, coordination and interaction among the eight Arctic Nations. The plan for the AVA calls for each Arctic nation to build their piece of the panarctic archive. Here we describe the Alaska AVA (AVA-AK, GIVD-ID: NA-US-014), the first prototype for the AVA. A workshop to organize the Alaska piece was held in Boulder, CO, October, 2013, where most of the key datasets were presented in a series of papers (Walker 2014b). This Long Database Record describes the methods for constructing the AVA-AK, its current content, and the results of a preliminary numerical analysis.

Background

The geographic scope of the AVA-AK is mainly the Arctic portion of Alaska, although the archive also contains a few boreal plots and a dataset from Canoe and Trout lakes in far northwestern Canada (Fig. 1). Early vegetation reconnaissance surveys in Arctic Alaska were conducted during the exploration of Naval Petroleum Reserve No. 4 and early surveys of reindeer ranges in the 1950s. More focused vegetation surveys began with the International Biological Program (IBP) Tundra Biome research starting in the late 1960s. These and later surveys were aimed at an ecological understanding of the controls of tundra vegetation spatial and temporal patterns. Numerous vegetation surveys in the 1980s up to the present were done in conjunction with a wide variety of regional landcover mapping and process-level studies. A brief overview of the history and current contents of the AVA-AK are in Supplement S1 with key references. A list of the current datasets in the AVA-AK is in Table S1-1, along with a summary of the available ancillary data and the current status of each record.

The AVA-AK Turboveg database

The AVA-AK uses a Turboveg v2 database management system to store, select, and export the plot data (Hennekens & Schaminée 2001). The archive includes standardized species-cover and header data. The workflow for the database includes data gathering, digitization of data, georeferencing of plots, assembly of bibliographic materials, import into Turboveg, and creation of metadata (Breen et al. 2014). Data are standardized for import into Turboveg according to a data dictionary (Supplement S2: Table S2-1). The header data include those required for all Turboveg datasets (plot coordinates, elevation, basic environmental data, and canopy structure information) and some recommended environmental data specific to the AVA-AK including habitat type (Supplement S2: Table S2-2).

The Pan-Arctic Species List (PASL, beta 1.1) (Raynolds et al. 2013) provides a uniform taxonomic framework for plant species names. The PASL is composed of the Pan Arctic Flora checklist for vascular plants (Elven 2011) and lists of accepted species names and synonyms for the Arctic lichens (Kristinsson et al. 2010), Arctic mosses (Belland unpubl., provided in 2012), and a Russian list of Arctic liverworts (Konstantinova & Bakalin 2009).

Forty-seven datasets containing approximately 5,300 plots were initially identified for possible inclusion in the database (Breen et al. 2014). This initial list was based largely on our personal knowledge of the literature and other known vegetation datasets in northern Alaska, several of which are unpublished. Several other potential datasets were identified later. After closer evaluation, some of the datasets were excluded from the Turboveg database for various reasons, including: (1) poor quality of the taxonomic information; (2) use of sampling methods that did not result in complete species lists from homogenous areas of tundra; (3) species cover values were available only in summary form for vegetation types and did not include data from individual plots; and (4) the original data were unavailable because they were considered proprietary information. In some cases, datasets were included in the AVA-AK but with notes regarding the quality of the data that could limit future applications. For example, some datasets were of historic value but had no photographs of the plots or specific location

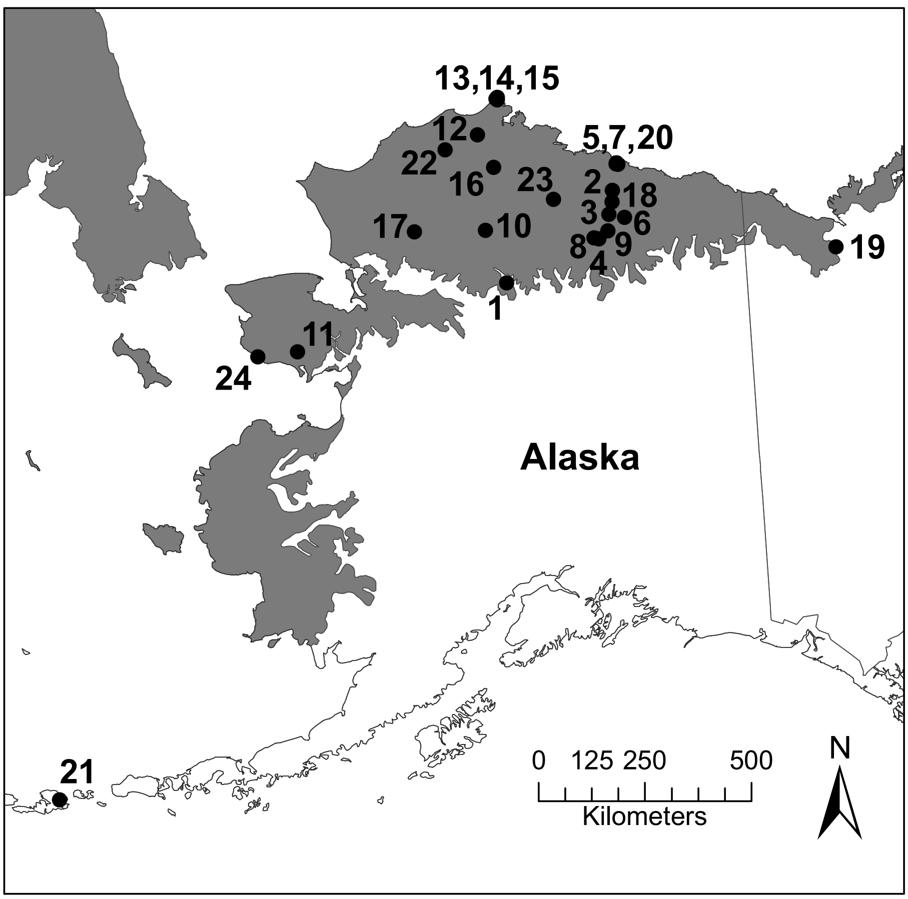

Fig. 1. Locations of the 24 datasets currently in the Turboveg AVA-AK database. The shaded area is the region of Arctic tundra. Names and authors of the datasets are in Supplement S1: Table S1-1.

information. Some datasets had good information for vascular plants, but weak or no information for cryptogams. Datasets that were not included in the AVA-AK Turboveg database were still referenced and described in a "Catalog" record of the Alaska Arctic Geoecological Atlas (see below).

The AVA-AK Turboveg database currently contains 24 datasets (3,026 plots) (Fig. 1 and Supplement S2). Another 13 datasets, containing approximately 1,000 plots are in the process of review and data entry. The data are also being entered into the VegBank database (http://vegbank.org), which is the main vegetation-plot archive for the U.S. (Peet et al. 2012). Vegetation metadata standards follow those of the Global Index of Vegetation-Plot Databases (GIVD) (Dengler et al. 2011) and standards developed for the Oak Ridge National Laboratory Distributed Active Archive Center, which is the archive of the National Aeronautics and Space Administration's Arctic Boreal Vulnerability Experiment (http://above.nasa.gov), which funded the AVA-AK. The 3,024 AVA-AK plots are also included in sPlot, a global vegetation-plot database with standardised plant nomenclature and header data (Dengler & the sPlot Core Team 2014).

A web-based approach for viewing and accessing the plot data

The Turboveg database is a free and publically-accessible through a web-based portal, the Alaska Arctic Geoecological Atlas (AGA-AK, http://alaskaaga.gina.alaska.edu) housed at the Geographic Information Network of Alaska (GINA), University of Alaska Fairbanks. Each dataset has a "Catalog" record, where a detailed description of the dataset can be found along with links to a variety of available data and information, including: (1) The main Turboveg file containing all the species data for all the datasets; (2) a link to the Turboveg software; (3) raw source data, which are stored in their original form as .csv files; and (4) available ancillary data. Ancillary data can include any of the following: original species and environmental data before they were standardized for the Turboveg database, key publications and data reports, maps of plot locations, plot photographs, vegetation structure information, soil and environmental site factors, aboveground phytomass, and ground-based spectral information (e.g. hand-held spectroscopy, Normalized Difference Vegetation Index (NDVI), and leaf-area-index (LAI) measurements).

Preliminary cluster analysis

We performed a preliminary cluster analysis to characterize the contents of the AVA-AK up until June 2015. The purpose of the analysis was to determine if a numerical anlaysis would result in meaningful clusters that would prove useful for characterization of the contents of the archive and for vegetation classification and analysis. These datasets included 1,603 plots within 16 broad habitat types (Supplement S2: Table S2-1, Accession numbers 1 to 16), representing 16 high quality datasets from most habitat types along two long north-south bioclimate transects from the Beaufort Sea to the Brooks Range on the eastern transect and from Barrow to the Seward Peninsula on the western transect. See Supplement S3 for details of the cluster analysis.

The peak separability of clusters in the diagram, using the crispness of classification method (Botta-Dukát et al. 2005) within the JUICE program (Tichý et al. 2011), was achieved with four clusters as shown by the top color bar in Fig. 2. At this level, the clusters are heterogeneous, but show sensible ecological organization. Cluster A is the largest and most heterogeneous cluster with 684 relevés, containing many azonal communities, including most wetlands, riparian shrublands, deep late-melting snowbeds, and pioneering communities along streams, rock crevices, and talus slopes. Cluster B contains 233 relevés, mostly moist to dry acidic ericaceous heath communities, including tussock tundra dominated by *Eriophorum vaginatum*. Cluster C contains 269 relevés, the bulk of which are from the communities in the one large alpine dataset from the Arrigetch Peaks region in the Brooks Range with many dry-graminoid- and forb-dominated communities, and drier dwarf-shrub snowbeds dominated by *Cassiope tetragona* and lichens. Cluster D contains 382 relevés, most of which are from dry non-acidic tundra and tundra steppe communities on south-facing slopes of pingos and which contain high numbers of Beringian species. Pingos are large ice-cored dome-shaped mounds, sometimes with heights exceeding 20 meters, which are important landscape components of the thaw-lake plains of northern Alaska (Walker 1990). There is a clear break at the highest level in the dendrogram between communities on mainly wet to moist acidic substrates of clusters A and B and the mainly moist to dry nonacidic substrates of clusters C and D.

The next highest level of separation power was achieved with 17 subclusters that reflect geographical or ecological affiliation of groups of plant communities (Fig. 2, labels on the branches of the dendrogram). Table S3-1 in Supplement S3 contains lists of the diagnostic, constant and dominant taxa within each of the 17 subclusters that were used to further characterize the four main clusters. Several subclusters are nearly entirely composed of plots from one of two large datasets. Subclusters 11, 12, and 13 are almost entirely from the Arrigetch Peaks dataset (Cooper 1986), and subclusters 14, 15, and 16 are nearly totally from the Pingos dataset (Walker 1990).

The preliminary cluster analysis revealed that the higher hierarchical levels of the dendrogram generally correspond to higher rank units such as phytosociologi-

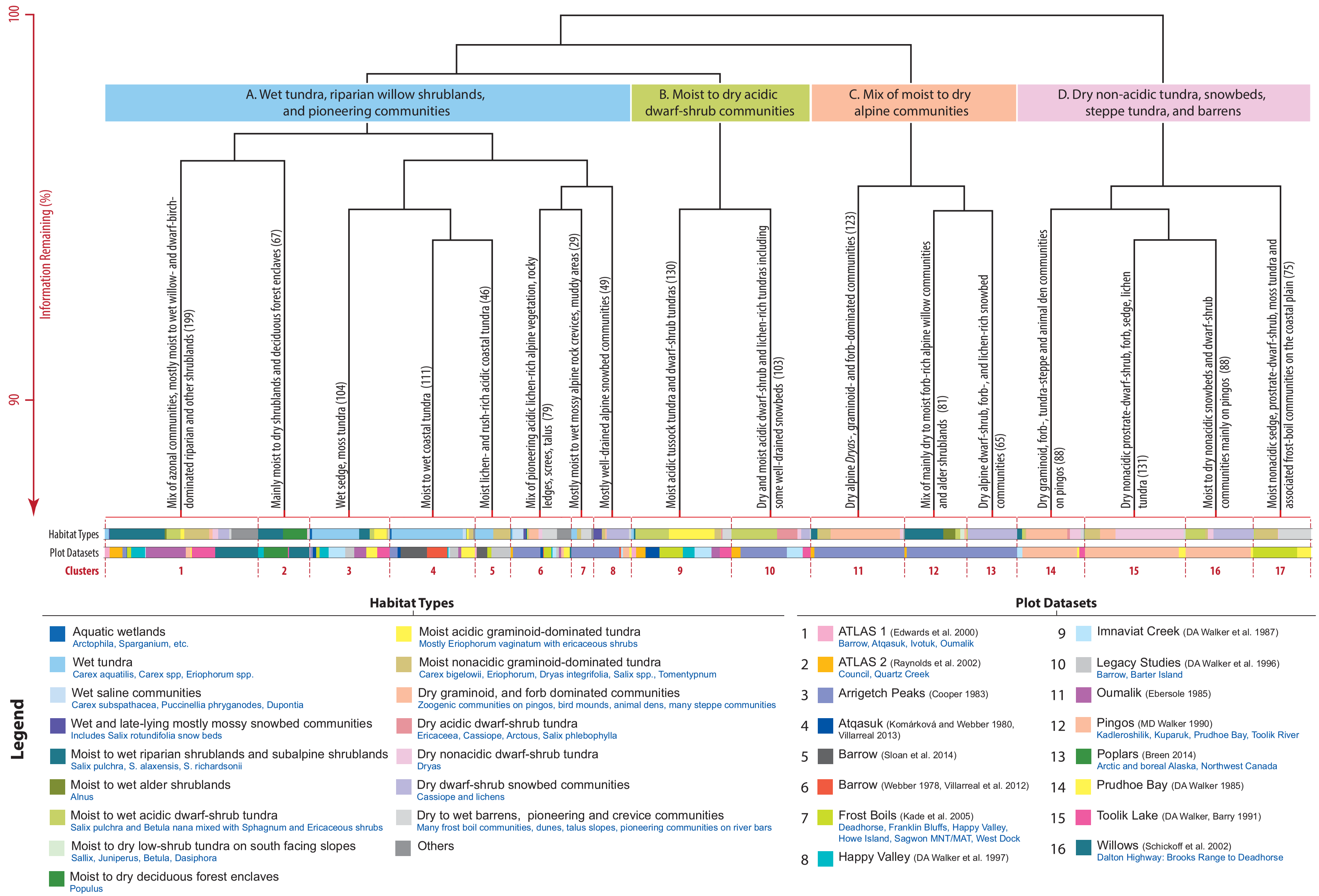

Fig. 2. Cluster analysis of the first 16 dataset (1,568 plots) entered into the AVA-AK (accession numbers 1 to 16 in Fig. 1 and Table 1). The color bars across the top summarize the broad groups of habitat types included in the four clusters that had highest separability in the analysis. The color bars at the bottom show the distribution of habitat types and datasets within each of the 17 subclusters that showed the next highest level of separability. See Supplement S3 for details of the cluster analysis and brief description of the included datasets.

cal classes or alliances, as well as geographical or ecological affiliation of individual plant communities (Cluster A. – azonal as well as pioneer communities affected by specific environmental condition such as water gradient or disturbance regime; B. – Boreal heathland communities; C. – Alpine communities, D. – Graminoid tundra and dwarf-shrub vegetation including various vegetation types from pingos. There are some artifacts/errors of spatial autocorrelation in our analysis where some plots from small regions representing different communities seem to be more similar than the same units from remote areas. The dominance of plots from the large Arrigetch Peaks (439 plots) and Pingos (293 plots) datasets in six of 17 subclusters of the preliminary cluster analysis indicates that these two datasets sampled much of the total habitat diversity at the drier end of the ecological gradients. These relatively large datasets also resulted in some spatial autocorrelation that resulted in the close clustering of most of these plots in a few large clusters at the highest level of the dendrogram.

Evaluation

The Alaska Arctic Vegetation Archive (AVA-AK) constitutes a major step toward consolidating existing plot data from Arctic Alaska into a single database with consistent species names that can be used for future classification and analysis of Arctic vegetation. A major strength of the AVA-AK is its web-portal, which makes the information easily accessible to users. The "Catalog" function of the portal links the species information in the Turboveg files to a wide variety of ancillary information for analyses. Several of the datasets are linked to field-based geoecological maps and remote-sensing land-cover maps in the Alaska Arctic Map Archive (AMA-AK).

Data gaps

Despite the importance of vegetation for studies of Arctic ecosystem change, the vegetation of large areas of Arctic Alaska remains unsurveyed. Only a few areas have been intensively sampled and mapped, mainly in the vicinity of permanent Arctic observatories, such as Barrow and the Toolik Research Station. Major data gaps occur in the sand region west of the Colville River, nearly all of the Arctic Foothills, the central and eastern Brooks Range, the west coast of Arctic Alaska, including Beringian, and species-rich habitats of the Seward Peninsula and the Yukon-Kuskokwim River delta. More data are needed from under-sampled habitat types, such as coastal salt marshes, sand dunes, aquatic communities, and the large variety of bedrock types and alpine habitats in the Brooks Range and Arctic Foothills.

Need for a more consistent approach to tundra vegetation surveys

The assembly and review of the AVA-AK revealed the need for a more consistent approach to survey Arctic vegetation so as to better support description and classification of Arctic vegetation. Although considerable amounts of vegetation data have been collected for various projects, much of the available information was project specific and was based on sampling protocols that are difficult to compare across sites. The older historical datasets were collected prior to the advent of the network of Global Positioning System (GPS) satellites and do not have accurate location information or permanently marked plots, thereby making it impossible to accurately resample these sites or link them to satellite-based observations. Some had questionable taxonomic determinations that were not supported by voucher collections, particularly for the cryptogam species, which limits the extrapolation potential of spatial distribution models that use these data. These and other inconsistencies across datasets point to the need for international standards for Arctic vegetation data collection (Walker et al. 2016). This problem is also recognized globally (De Cáceres et al. 2015).

Urgency of archiving legacy data sets

Assembly of the information for the archive pointed to the urgency to continue this work. Nearly every dataset required close communication with the author(s) to insure the accuracy of the information and that everything retrievable is archived, including field photos, maps, and information that may not have been in published reports. The retirement or death of the author(s) often meant loss of the original data and/or critical metadata information. For example, Vera Komárková collected a potentially major data set containing over 700 plots using Braun-Blanquet protocols in the sand region of northern Alaska (Komárková & McKendrick 1988), but the dataset could not be recovered because of her premature death in 2005 before the data could be processed and published.

Conclusions

Our preliminary analysis of first 16 datasets provides the first overview of the variability and hierarchical relationships of a broad spectrum of the plant communities in the Arctic region of Alaska. It has also identified gaps. We are continuing to add key datasets to the AVA-AK as they become available and anticipate many applications for examining biodiversity, vegetation classification, species distribution modeling, vegetation change modeling, land-use planning, resource development, and education. Our next step will be a full analysis of all the available datasets from Arctic Alaska. We expect this will be an iterative process as we link to Arctic vegetation archives from other parts of the Arctic.

The protocols developed for the AVA-AK could be applied elsewhere in the Arctic toward the goal of a panarctic vegetation database. Efforts are currently underway to apply the approach in Canada (MacKenzie 2014), Greenland (Bültmann & Daniëls 2013) and to the Yamal Peninsula region of northwestern Russia (Ermokhina 2013). Application to the entire circumpolar region will require consensus approval of the approach with appropriate modification by the international community of Arctic vegetation scientists. The vision for an eventual panarctic AVA is that we will move to Turboveg v3 (Hennekens 2014), and model the AVA after the European Vegetation Archive (EVA) (Chytrý et al. 2016). This would allow several independent national databases to be stored in the archive.

Author contributions

M.D.W. & D.A.W. conceived the database. D.A.W., A.L.B., L.A.D.& J.S. created the database and wrote the manuscript. J.P. prepared the figures and edited the report. S.H. provided advice and help with the Turboveg database. J.S. conducted the cluster analysis. H.E.E. and M.B. provided remote-sensing and biomass ancillary datasets and organized these data. M.K.R., A.L.B, S.H. and several other coauthros developed the Pan Arctic Species List. L.W.W., W.F., M.B. & J.P. were principally responsible for the web portal and system support; R.K.P. & M.T.L. provided guidance for transferal of data to VegBank and overall database guidance. F.J.A.D. & H.B. provided help with Braun-Blanquet classification and conceptual framework for the study. D.A.W., A.L.B., M.K.R., M.B., M.D.W., K.B., T.B., D.J.C., S.J.D., J.J.E., H.E.E., S.C.E. W.A.G., R.D.H., C.M.I., M.T.J., A.K., W.H.M., U.S., V.L.S., S.S.T., S.V., P.J.W., and D.Z. provided datasets.

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