Conservation of Arctic Flora and Fauna

ARCTIC COUNCIL

IASC

CAFF Proceeding Series Report
September 2019

Arctic Vegetation Archive and Arctic Vegetation Classification:

Proceedings and abstracts from two workshops

30-31 March 2017
Czech Academy of Science Building
Prague Czech Republic

21 May 2019
NArFU Main Building,
Arkhangelsk, Russia

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- Norwegian Environment Agency, Trondheim, Norway
- Environment and Climate Change Canada, Ottawa, Canada
- Faroese Museum of Natural History, Tórshavn, Faroe Islands (Kingdom of Denmark)
- Ministry of the Environment, Helsinki, Finland
- Icelandic Institute of Natural History, Reykjavik, Iceland
- Ministry of Nature and Environment, Government of Greenland
- Ministry of Natural Resources and Environment of the Russian Federation, 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 Council (ICC)
- Russian Indigenous Peoples of the North (RAIPON)
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— CAFF Designated Area

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Summary

An Arctic Vegetation Archive (AVA) and an Arctic Vegetation Classification (AVC) are needed to support several of the biodiversity activities of the Conservation of Arctic Flora and Fauna (CAFF) and circumpolar activities of the International Arctic Science Committee's Terrestrial Working Group (IASC TWG). Activities include recording and monitoring arctic plant-community diversity and distributions, wildlife habitat studies, and modelling the changes in the structure and function of the vegetation as the arctic climate changes.

One of the primary purposes of the AVA is to gather a legacy of plot data that are in danger of being lost. Approximately 31 000 historical vegetation plots have been identified and are being gathered using a standardized format for vegetation classification and analysis. The AVA initiative is encouraging each arctic country to assemble its own archive with common protocols that will later allow the databases to be united into a single circumpolar AVA where the data can be used to create a panarctic vegetation classification and many other applications. Towards these ends, two workshops were organized in conjunction with the Arctic Science Summit Weeks in 2017 and 2019. This document includes the full proceeding outcomes, abstracts, and list of participants for both workshops.

Prague Workshop, 30-31 April 2017: The first workshop was held prior to the Arctic Science Summit Week 2017 (31 March to 3 April) at the Czech Academy of Science Building. Twenty-nine individuals from most of the Arctic countries participated in the two-day workshop. Nine oral talks and nine posters were presented — a total of 18 abstracts are included in this proceedings volume. We reviewed the datasets and plots that are available for each of the floristic provinces in each circumpolar country and made a map of the known plot datasets. Discussions focused on the different database approaches in each country, reflections on the realization of a pan-Arctic vegetation classification, steps still needed to achieve the AVC, and the relevance of the AVA and AVC in the IASC 5-year Science Plan. At the end of the meeting, the assembled members presented the Prague Arctic Vegetation Synthesis Resolution.

Arkhangelsk Workshop, 21-22 May 2019: The second workshop was held prior to the Arctic Science Summit Week 2019 (22–30 May) in Arkhangelsk, Russia. A total of 32 persons attended the workshop and 25 related abstracts are included in this proceedings volume. This meeting continued the focus on strategies to complete the Arctic Vegetation Archive (AVA) and Arctic Vegetation Classification (AVC) with an emphasis on inclusion of the large amount of Russian Arctic vegetation data and further development of the Russian Arctic vegetation classification. Another emphasis was the use of the AVA and AVC products to address key questions on biodiversity and vegetation distribution at regional and pan-arctic scales. A Turboveg training session was held on the afternoon of 22 May, and a half-day wrap-up and synthesis meeting occurred on 23 May.

Major outcomes of the workshops:

- An integrated vision for circumpolar vegetation science that includes mapping, surveying, archiving, classification and analysis of Arctic vegetation as expressed in the Prague Resolution.
- A new raster version of the Circumpolar Arctic Vegetation Map.
- A major review of the progress and status of circumpolar arctic vegetation classification.
- Revitalized interest, funding and progress toward the AVA and AVC as a result of both workshops.

Part I

Proceedings of the Second International Arctic Vegetation Archive and Classification Workshop, Prague, CZ

Czech Academy of Science Building, Národní 1009/3, Praha 1, Room 206, Prague, Czech Republic, 30-31 March 2017

Introduction

An Arctic Vegetation Archive (AVA) is needed to develop an effective Arctic terrestrial monitoring program and provide a standardized vegetation framework and data for an Arctic Vegetation Classification (AVC), land-cover mapping, ecological experiments, modelling, and biodiversity studies. Insufficient and non-standardized Arctic vegetation plot data are available to accomplish this task. The recently launched AVA and AVC aim to fill this knowledge gap.

The AVA and AVC would cover the entire Arctic tundra biome — the first for any of the world's major biomes. This is achievable because the Arctic is the only biome that has its entire list of known vascular plants, mosses and lichens documented in flora checklists developed by taxonomists within the CAFF Flora Group. Also, the amount of vegetation plot data from the Arctic is still relatively modest compared to other biomes (approximately 31,000 plots). A large body of international experience and collaboration with database experts in other regions will also help to make the Arctic task feasible.

The primary goals of the Prague workshop were: (1) Progress toward the development of an international vegetation database useful for addressing a wide variety of pressing science questions that involve vegetation information, including making a panarctic vegetation classification; (2) locating and preserving legacy vegetation data sets from all the circumpolar countries that are in danger of being lost; (3) creation of an international framework for future studies of vegetation change; and (4) harmonization of the North American and European approaches for archiving and classifying Arctic vegetation.

Twenty-nine participants from most of the Arctic countries attended the two-day workshop at the Czech Academy of Science Building in Prague, Czech Republic, 30-31 April 2017. Eighteen abstracts are included in this volume.

During the first day, Marilyn Walker, who initiated the Arctic vegetation classification initiative (Walker et al. 1994), provided an historical overview and rationale for making an Arctic vegetation classification. The AVA and AVC are being modeled after the approach used in Europe. Milan Chytrý (Czech Republic) provided an update on the European vegetation archive and classification; Stephan Hennekens (the Netherlands) — an update on the Turboveg database management software; Lubomir Tichý (Czech Republic) — an update on the JUICE vegetation analysis software. Bob Peet (US) described the VegBank database and EcoVeg classification approach used in the United States (Peet et al. 2012). William MacKenzie (Canada) described the Biogeoclimate Ecosystem Classification (BEC: Pojar et al. 2011) approach used in British Columbia. Will MacKenzie (Canada), Fred Daniëls (Greenland), Nadya Matveeva (Russia), and Amy Breen (Alaska) provided overviews of recent AVA progress. Jozef Šibík (Slovak Republic) presented the approach and early results of the database analysis of the Alaska Arctic Vegetation Archive. Olga Khitun (Russia) presented the Russian method of developing local floras.

During the second day, panel discussions were devoted to: (1) Reflections on the realization of an international panarctic vegetation classification; and (2) Looking ahead to application of the AVA to arctic vegetation classification. Discussion periods focused on: (1) Relevance of the AVA and AVC in the IASC Science Plan; (2) Publications; and (3) Future proposals. During the two days, participants provided data to develop a map of the known plot datasets with in the Arctic (Fig. 1).

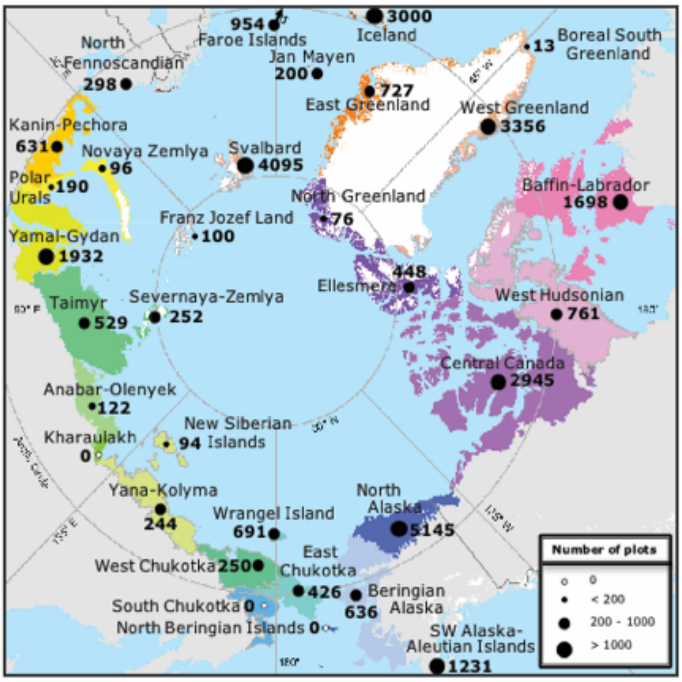

Figure 1. *Inventory of available plots within each of the 21 phytogeographic provinces of the Arctic Tundra Zone (Walker et al. 2019)*

Major points emerging from the panel and group discussions

1. An Arctic Vegetation Archive is an essential first step for developing an Arctic Vegetation Classification, monitoring change in terrestrial ecosystems, and developing a circumpolar framework for studying and modeling changes to the Arctic.
2. Major progress on the AVA was achieved since the first AVA workshop in Krakow (Walker et al. 2013), including completion of the Alaska Arctic Vegetation Archive (AVA-AK; Walker et al. 2016), and recent efforts toward using this in developing an Arctic Vegetation Classification (Walker et al. 2016b, 2017 in review, Šibík et al. 2017 in prep.).
3. Many of the legacy data in the AVA were collected using non-standardized protocols. Going forward, new datasets should incorporate standardized methodologies for surveys, archiving, and analysis of Arctic plot data; workshops to develop these protocols should probably be proposed as part of the Arctic Observing Network activities.
4. The European Vegetation Archive (EVA: Chytry et al. 2012) and European Vegetation Classification (EVC: Mucina et al. 2016) are models for creating the AVA and AVC. The tools used in creating the EVA and EVC (Turboveg: Hennekens & Schaminée 2002; and JUICE: Tichy et al. 2017) are also being used for the AVA and AVC. Considerable help from the European community of vegetation scientists is gratefully acknowledged.
5. The AVA and AVC have been endorsed by IASC and the CAFF and remain high-priority international projects that are in need international funding to complete. Important issues include: (1) Standardized methods are needed for making local-floras and plot surveys for vegetation classification and monitoring, and should be part of the Arctic Observing Networks efforts for monitoring terrestrial ecosystems. (2) Special attention is also needed for collecting standardized, soil, and spectral data, biomass, and other forms of ancillary data from the same plots for other applications including mapping, modeling, biodiversity, and remote sensing studies. (3) Bringing the datasets from each Arctic country into a common database is a non-trivial task. Tools for exchanging information between different database approaches are under development (e.g., Veg-X, Wiser et al. 2011) but need to be applied to the Arctic situation.

6. The countries with the most plots nearly ready for inclusion in a panarctic AVA are Alaska, Canada, and Greenland. The next step should be to combine these in a North America Arctic Vegetation Archive and Classification.
7. The leaders of the AVA and AVC are aging and leadership needs to be passed to a new generation of Arctic vegetation scientists. Therefore, there is a critical need to identify new leaders, and to train a new generation of Arctic vegetation scientists in the techniques of Arctic field botany and the new analytical tools of vegetation science. (1) A workshop is needed to train AVA participants in use of key software, including Turboveg v2 and v3 (Hennekens and Schaminée 2002) and JUICE v7, and for developing applications of the AVA. (2) Field and classroom courses in Arctic vegetation science need to be developed and promoted through IASC, CAFF, the University of the Arctic, and the Association of Polar Early Career Scientists (APECS), and other national Arctic education forums. (3) Exchange programs with European universities that have strong vegetation science programs would be most helpful.
8. Other high-priority Arctic vegetation activities that are endorsed by both IASC and CAFF include:
    a. Periodically updating and maintaining the Pan-Arctic species lists (Raynolds 2014) is a critical need for both the AVA and AVC as new species are discovered and the names of species change to reflect new knowledge. Several individual checklists and lists of synonyms need to be maintained or revised including those for the vascular plants (Elven 2011), lichens (Kristinsson 2013), mosses (Belland 2012, pers. comm), and liverworts (e.g. Konstantinova 2009). Although the existing checklists were major efforts of the CAFF Flora Group, all of its founders have either passed away or retired, and creating and maintaining the checklists is no longer a priority of the existing Flora Group, so another pathway to achieve current panarctic checklists is needed.
    b. Finishing the Circum-Boreal Vegetation Map (CBVM: Talbot and Meades 2011), and harmonizing it with the CAVM.
    c. Updating the Circumpolar Arctic Vegetation Map to a raster format, including new information on tree-line boundaries, and otherwise improving the map from its original publication (CAVM Team 2003, Walker et al. 2005).
    d. Vegetation classification, mapping and monitoring need to be highlighted as part of the IASC Terrestrial Working Group's input to the IASC 5-year science plan, and for the CAFF Flora Group's input into the Circumpolar Biodiversity Monitoring Program.

Prague Arctic Vegetation Synthesis Resolution

A common Arctic vegetation language and data framework are needed to achieve several key aspects of the International Arctic Science Committee's (IASC's) five-year Science Plan, including:

- Assessing the diverse impacts of climate change and human activities on Arctic biodiversity and its consequences for ecosystem services and societal impacts.
- Linking studies across all spheres: biosphere, social sphere and the physical spheres of the Arctic;
- Supporting international efforts to make Arctic data and metadata easily accessible, such as the Sustainable Arctic Observing Network (SAON) and the Arctic Data Committee (ADC).
- Developing an international agreement for standards and maintenance of key observing systems.

Furthermore, such a vegetation framework is necessary to accomplish goals of the IASC Terrestrial Working Group (TWG), the Arctic Council's Conservation of Arctic Flora and Fauna's Flora Working Group (CFG), and the Circumpolar Biodiversity Monitoring Program (CBMP). These include such specific products as the Arctic Vegetation Archive (AVA), Arctic Vegetation Classification (AVC), Circumpolar Arctic Vegetation Map (CAVM), Circumboreal Vegetation Map (CBVM) and a hierarchical series of maps and data products that are needed for Arctic terrestrial land-surface characterization, climate- and land-cover change models, government land-use policy makers, and educators.

Therefore, the members of the community of Arctic Vegetation Scientists assembled at the ASSW 2017, resolve to accomplish the following within 5 years:

1. Promote the updating, and maintenance of the Panarctic Flora (PAF) and the Arctic lichen, moss, and hepatic checklists as a panarctic standard for plant nomenclature;
2. Secure funds for completing the Arctic Vegetation Archive (AVA) and developing an Arctic Vegetation Classification (AVC);
3. Develop and use standardized plot-data collection and archiving methods modeled after the European Vegetation Archive and the Alaska Arctic Vegetation Archive;
4. Develop a checklist of existing described Arctic vegetation habitat and vegetation types according the European Vegetation Classification approach (an Arctic prodromus);
5. Modify the existing vector-based Circumpolar Arctic Vegetation Map to a raster-based format with 12.5-km resolution, and incorporate modifications based on new knowledge;
6. Develop a funding strategy to complete the Circumboreal Vegetation Map and link it to the Arctic map with a revised treeline, and a raster format;
7. Work with the Arctic Data Center (ADC) to develop data sharing methods and rules for Arctic vegetation data;
8. Facilitate and promote the application of AVA, AVC, CAVM, and CBVM to the Arctic research community, land managers, and policy makers;
9. Contribute to training a new generation of young professional Arctic botanists and vegetation scientists through international field courses at the University of the Arctic, and the Association of Polar Early Career Scientists (APECS);
10. And finally, we resolve to meet again at Arctic Science Summit Week 2019 in Arkhangelsk, Russia.

Signed by participants of the AVA and AVC workshop at ASSW, March 31 2017, Prague, CZ

References

Belland, R. (Personal communication, 2012). Arctic moss database. Spreadsheets sent to Amy Breen, May and August 2012.

CAVM Team. (2003). Circumpolar Arctic Vegetation Map. *Conservation of Arctic Flora and Fauna Map (CAFF) Map No. 1*. Anchorage, AK: U.S. Fish and Wildlife Service.

Chytrý, M., Hennekens, S. M., Jíménez-Alfaro, B., Knollová, I., Dengler, J., Jansen, F., et al. (2015). European Vegetation Archive (EVA): an integrated database of European vegetation plots. *Applied Vegetation Science*, *19*, 173–180. http://doi.org/10.1111/avsc.12191

Elven, R., Murray, D. F., Razzhivin, V. Y., & Yurtsev, B. A. (2011). Annotated checklist of the panarctic flora (PAF): vascular plants. *National Centre of Biosystematics, Natural History Museum, University of Oslo*.

Hennekens, S. M., & Schaminée, J. H. J. (2001). TURBOVEG, a comprehensive data base management system for vegetation data. *Journal of Vegetation Science*, *12*, 589–591.

Konstantinova, N. A., & Bakalin, V. A. (2009). Checklist of liverworts (Marchantiophyta) of Russia. *Arctoa*, *18*, 1–64.

Kristinsson, H., Hansen, E. S., & Zhurbenko, M. P. (2010). *Panarctic Lichen Checklist* (Vol. 20, pp. 1–120). Akureyri, Iceland: Conservation of Arctic Flora and Fauna, CAFF Technical Report nr. 20.

Mucina, L., Bültmann, H., Dierßen, K., Theurillat, J.-P., Raus, T., Čarni, A., et al. (2016). Vegetation of Europe: Hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science*, *19 (Suppl. 1)*, 3–264. http://doi.org/Doi: 10.1111/avsc.12257

Peet, R., Lee, M., Jennings, M., & Faber-Langendoen, D. (2012). VegBank – a permanent, open-access archive for vegetation-plot data. *Biodiversity and Ecology*, *4*, 233–241. http://doi.org/10.7809/b-e.00080

Pojar, J., Klinka, K., & Meidinger, D. V. (1987). Biogeoclimatic ecosystem classification in British Columbia. *Forest Ecology and Management*, *22*(1–2), 119–154.

Raynolds, M. K., Breen, A. L., Walker, D. A., Elven, R., Belland, R., Konstantinova, N., et al. (2013). The Pan-Arctic Species List (PASL). *Arctic Vegetation Archive Workshop, Krakow, Poland, 14-16 April 2013, CAFF Proceedings Series Report Nr. 10*, 92–95.

Talbot, S. S., & Meades, W. J. (2011). Circumboreal Vegetation Map (CBVM). *CAFF Strategy Report No. 3, CAFF Flora Group, CAFF International Secretariat*.

Tichý, L. (2002). JUICE, software for vegetation classification. *Journal of Vegetation Science*, *13*(3), 451–453. http://doi.org/10.1111/j.1654-1103.2002.tb02069.x

Walker, D. A., Raynolds, M. K., Daniëls, F. J. A., Einarsson, E., Elvebakk, A., Gould, W. A., et al. (2005). The Circumpolar Arctic Vegetation Map. *Journal of Vegetation Science*, *16*(3), 282. http://doi.org/10.1658/1100-9233(2005)016[0267:TCAVM]2.0.CO;2

Walker, D. A., Breen, A. L., Druckenmiller, L. A., Wirth, L. W., Fisher, W., Raynolds, M. K., et al. (2016a). The Alaska Arctic Vegetation Archive (AVA-AK). *Phytocoenologia*, *46*, 221–229.

Walker, D. A., Daniëls, F. J. A., Alsos, I., Bhatt, U. S., Breen, A. L., Buchhorn, M., et al. (2016b). Circumpolar Arctic vegetation: a hierarchic review and roadmap toward an internationally consistent approach to survey, archive and classify tundra plot data. *Environmental Research Letters*, *11*(5), 055005. http://doi.org/10.1088/1748-9326/11/5/055005

Walker, D. A., Daniëls, F. J. A., Matveeva, N. V., Šibík, J., Walker, M. D., Breen A. L., et al. (2017 in review). Circumpolar arctic vegetation classification. *Phytocoenologia.*

Walker, M. D., Daniëls, F. J. A., & Van der Maarel, E. (1994). Circumpolar arctic vegetation: Introduction and perspectives. *Special Features in Journal of Vegetation Science*, *5*(6), 757–920. http://doi.org/10.1111/j.1654-1103.1994.tb00395.x

Wiser, S. K., Spenser, N., De Cáseres, M., Kleikamp, M., Boyle, G., & Peet, R. K. (2011). Veg-X — an exchange standard for plot-based vegetation data. *Journal of Vegetation Science*, *22*, 598–609

Yurtsev, B.A. 1994. Floristic division of the Arctic. *Journal of Vegetation Science*, 5:765-776.

Prague Workshop Agenda

Thursday 30 March: Overview

Morning: Welcome, goals for the workshop, keynote talks, progress in Alaska Facilitator: Skip Walker

08:00 Welcome, introduction of participants: *Skip Walker*

08:10 Logistics: *Jana Peirce*

08:20 Why an Arctic vegetation classification? *Marilyn Walker*

08:40 Review of history and progress on the AVA and AVC, goals for workshop: *Skip Walker*

09:00 The European Vegetation Archive (EVA), EuroVeg Checklist, and possibilities for contributing AVA data to the EVA: *Milan Chytrý*

09:30 Turboveg and recent advances: *Stephan Hennekens*

09:50 JUICE v.7: A complex expert system language for vegetation classification: *Lubomir Tichý Milan Chytrý, Flavia Landucci*

10:10 Coffee Break

10:30 Discussion of EVA, TurboVeg, JUICE

10:50 The Alaska AVA (AVA-AK): *Amy Breen, Lisa Druckenmiller, Stephan Hennekens, Skip Walker et al.*

11:10 The Canadian Geobioclimate Ecosystem Classification (BEC) approach: *William MacKenzie*

11:30 Lunch

Afternoon: Progress in Canada, Greenland, Russia and maritime boreal tundra, discussion. Facilitator: Amy Breen

12:30 Overview of the AVA in Canada: Will MacKenzie, Esther Levesque, Greg Henry, Dietbert Thannheiser, Fred Daniëls

12:50 Overview of the AVA in Greenland: *Fred Daniëls & Helga Bültmann*

13:10 Overview of the AVA in Russia: *Nadya Matveeva, Natalia Koroleva, Olga Lavrinenko & Igor Lavrinenko, Ksenia Ermokhina, Olga Khitun, Sergei Kholod & Volodya Razzhivin, Elena Troeva, Gabriella*

13:40 Maritime boreal tundra Overview: *Starri Heiðmarsson, Inga Svala Jónsdóttir, Lennart Nilsen, Dietbert Thannheiser, Stephan Talbot*

14:00 Breakout groups to prepare map of databases in each floristic subprovince

15:00 VegBank and the US National Vegetation Classification: *Bob Peet*

15:30 Discussion (Potential questions)

1. How to exchange data between the Canadian (VPro), USNVC (VegBank)
2. EVA (TurboVeg v.3) and the AVA-AK (TurboVeg v.2)?
3. Should we plan a TurboVeg and JUICE AVA training workshop? How to fund?
4. How to standardize all the databases and bring them into the AVA?
5. How to keep the PAF and species lists updated? (Also on agenda for 31 Mar)

16:00 Adjourn

Friday 31 March: Reflections and the future

Morning: "Reflections and looking ahead," classification, local floras, biodiversity studies — Facilitator: Jozef Šibík

09:00 Welcome back and logistics, travel reimbursements: *Jana Peirce*

09:10 Panel Discussion 1: Reflections on the realization of an international pan-Arctic vegetation classification: *Marilyn Walker, Fred Daniëls, & Nadya Matveyeva*

09:50 Panel Discussion 2: Looking ahead to application of the AVA to the Arctic Vegetation Classification: *Marilyn Walker, Fred Daniëls, Nadya Matveyeva, Jozef Šibík, & Will MacKenzie*

10:30 Coffee Break

10:45 Panel Discussion 2: Looking ahead (cont.): Questions to address

Progress on an Alaska Arctic vegetation classification using the AVA-AK: *Jozef Šibík*

Plan toward a circumpolar AVA: *Amy Breen, Lisa Druckenmiller, Nadya Mateveyeva, Will MacKenzie, Ksenia Ermokhina, Skip Walker & Jozef Šibík*

What are the big problems with bringing other datasets into the AVA? Where should we start? Can we proceed without dedicated funding? *Skip Walker*

The concept of Arctic local floras and can we apply it more widely? *Olga Khitun*

12:00 Lunch & view posters and further discussion of classifications

Afternoon: Advancing the AVA and AVC in the IASC Science Plan, Publications, Proposals – Facilitator: Skip Walker

14:00: Discussion of how to elevate the AVA and AVC in the IASC Science Plan: *Skip Walker, Kristine Westergaard, Inga Svala Jónsdóttir, Inger Alsos, other CAFF FG participants*

1. Closer coordination and some shared research items between the CAFF FG floristics and vegetation folks.
2. Coordination between CAFF FG and IASC TWG.
3. Advance the priority FG research items in the IASC Science Plan.
4. Advance IASC Science plan in national Arctic research plans.

14:30: Publications

CAFF Workshop Proceedings volume: *Jana Peirce*

AVC-AK: Jozef Šibík

AVC paper for Vegetation of Russia: *Skip Walker & Nadya Matveyeva*

Others Arctic classification papers in press or in preparation?

14:50: Ideas and proposals for developing the national Arctic Vegetation Archives:

USA: *Skip Walker & Amy Breen*

Canada: *Will MacKenzie, et al.*

Greenland: *Fred Daniëls & Helga Bültmann*

Russia: *Nadya Matveyeva et al.*

Boreal maritime tundra: *Anna Marie Fosaa et al.*

15:20: Summary of action items, review Krakow resolution, and wrap up: *Jana Peirce*

15:50: Travel reimbursement logistics: *Jana Peirce*

16:00: Adjourn

Prague Workshop Abstracts

1. The Alaska AVA (AVA-AK)

Amy Breen

University of Alaska Fairbanks, Fairbanks, AK, USA

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 (Fig. 1), and we anticipate adding another 1,000 plots over the next year. 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 present the contents of the archive, assess its strengths and weaknesses, and provide a brief overview of the database data dictionary and individual datasets.

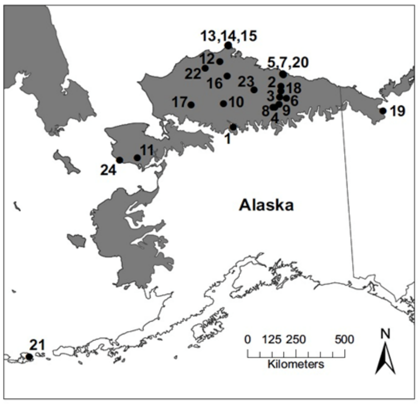

Figure 1. *Locations of the first 24 datasets in the Turboveg AVA-AK database. The shaded area is the region of Arctic Tundra in Alaska. (Walker et al. 2019)*

2. Toward a circumpolar AVA

Amy Breen[1], J. Šibík, H. Bultmann, M.K. Raynolds, L. Druckenmiller, K. Ermokhina, D.A. Walker

[1] *University of Alaska Fairbanks, Fairbanks, AK, USA*

The goal of a circumpolar AVA is to unite and harmonize vegetation data from the Arctic tundra biome for use in developing a pan-Arctic vegetation classification and to facilitate research on vegetation and biodiversity change. The Arctic Vegetation Archive (AVA) working group of the Conservation of Arctic Flora and Fauna (CAFF) has begun gathering a baseline record of vegetation plot-data in archive modeled after the European Vegetation Archive and the Alaska Arctic Vegetation Archive. The AVA working group launched three prototype databases for Greenland (AVA-GL), Arctic Alaska (AVA-AK) and Yamal (AVA-YL) since the Krakow AVA Workshop at Arctic Science Summit Week in April 2013. These databases utilize the TURBOVEG database program and follow protocols developed for the European Vegetation Archive (EVA) and the Global Index of Vegetation Databases (GIVD). Within TURBOVEG, a common header data format was prepared that includes minimal required environmental data and a suite of recommended data to collect in the field. A suggested common AVA field protocol was published and datasheets for use in the field will be made available. Vegetation-plot data from the AVA-AK are also being deposited in the US vegetation archive, VegBank, and data from AVA-GL is included in the EVA. A Pan-Arctic Species List (PASL, v2.0) provides a standard list of accepted vascular plant, bryophyte, and lichen species names for the Arctic biome for the three databases. The Pan-Arctic Species List (PASL v 2.0) was created from lists of accepted taxa for different groups in the Arctic: vascular plants, mosses, liverworts, lichens and lichenicolous fungi, compiled by members of the Conservation of Flora and Fauna (CAFF) Flora Working Group. We present an overview of steps undertaken to construct the prototypes, lessons learned, and make suggestions of issues to consider as other regions step up their efforts to construct their database contributions to the AVA.

3. The European Vegetation Archive (EVA), EuroVegChecklist, and possibilities

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The European Vegetation Archive (EVA, euroveg.org/eva-database) is a centralized data repository of vegetation-plot observations (phytosociological relevés) from Europe and adjacent areas, which is maintained by the IAVS Working Group European Vegetation Survey. Its aim is to facilitate the use of these data for non-commercial purposes, mainly academic research and applications in nature conservation and ecological restoration. Currently it includes more than 1.2 million plot observations from 70 databases. Since its establishment in 2014, EVA provided data for 51 projects of basic and applied research, some of which have already resulted in published papers. However, the data from the Arctic and Boreal zones are strongly under-represented in EVA and it would be highly desirable to include more databases covering these zones. Therefore, a close cooperation between EVA and AVA is most welcome.

Another initiative of the IAVS Working Group European Vegetation Survey is so-called EuroVegChecklist (EVC), a compilation of a critically revised hierarchical classification system of European vegetation at the level of phytosociological classes, orders and alliances. After almost 15 years of work of a team of 32 experts from 16 countries, this system was published at the end of last year (Mucina et al. 2016, Applied Vegetation Science). It is divided into a classification system for communities dominated by vascular plants (EVC1), which includes 109 classes, 300 orders and 1108 alliances, a system for communities dominated by bryophytes and lichens (EVC2; 27 classes, 53 orders and 137 alliances) and a system for communities dominated by algae (EVC3; 13 classes, 24 orders and 53 alliances). In total 13 448 taxa were assigned as indicator species of individual classes and a computer expert system was developed to identify the classes based on these taxa. The names of all syntaxa were checked following the International Code of Phytosociological Nomenclature and extensive lists of synonyms were provided. Each syntaxon was characterized by a brief description.

4. Overview of the AVA in Greenland

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The status of the Greenland vegetation sample plot-datasets stored in Münster, Germany, is almost the same as three years ago. The digital data are still in different formats such as Turboveg-database, Excel files and Word files. We will concentrate to harmonize those digitized data, which stem from several Master and PhD theses of the former Utrecht (Netherlands) and Münster (Germany) working groups. Material published earlier and non- digitized, is considered safe and is not considered for inclusion the AVA for now. The first step will be to harmonize the header data, the species lists and cover values with the Alaska-AVA and Turboveg. Parts of datasets are published, but rarely as a full dataset. We will try to identify and tag the published relevés within the datasets. Additionally, relevés, which bear Br.-Bl. nomenclature types, should be marked. We present screenshots of the datasets for discussion and propose that the finalized Turboveg datasets should be kept safe within the Alaska-AVA in Fairbanks.

5. Yamal and Gydan peninsulas

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The Tundra Zone of the West Siberia has been visited by many geobotanists since early 1930s. The Gydan Peninsula is still rather poorly known. The purpose of studies during the first part of the century was mainly with regard to reindeer range quality (B. Gorodkov, V. Andreev). The second part of the previous century was dedicated to many aspects of vegetation study. The key geobotanists that worked there are N. Andreyashkina (mainly vascular plants; research on phytomass), M. Boch (wetlands; mainly vascular plants and bryophytes), S. Gribova (mainly vascular plants and bryophytes) and L. Meltser (mainly vascular plants). The last 20 years this work including the study of lichen cover dynamics has been carried out by Yekaterinburg group (M. Magomedova, S. Ektova, M. Morozova, S. Abdulmanova). All scientists mentioned above worked using Russian dominant classification system and didn't make relevés with full list of species. Only three datasets of relevés made in this region not long ago meet the requirements of AVA format of data storing and are either already imported or are in process of being imported into the archive. Also, it is known that there is a relevant dataset of O. Sumina (Biological department of Saint Petersburg University) that is mainly focused on vegetation of anthropogenic environments (670 relevés).

6. Turboveg v.3 – A gateway to vegetation databases

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Although Turboveg v.2 is acceptable for many users, the need for a better database model has been growing to overcome the current version's shortcomings. The Dutch National Vegetation Database requires information regarding the distribution and range of Natura 2000 habitats every 6 years for a report to the EU, and 'quality status A' is required. Therefore, a proper database model had to be set up. Because v.2 normally deals with multiple databases, and potentially different databases structures and different taxonomies, it was the challenge to deal with all these differences in a single SQL-based database (SQLite for locally stored databases).

A new Turboveg v.3 is now underway. The prototype not only is able to import Turboveg v.2 databases but also already contains functions to select data and to export selected plot observations to various formats for further processing with other programs. For example, plots observations can already be exported for use in JUICE, GIS and Excel. Moreover, editing of plot data is already build in, including sophisticated localization by means of an integrated Google Maps. Storage of metadata is also included for almost every level in the database. Information on data providers (custodians), and the accessibility of data can be stored on the level of plot observation. A clear distinction between plots and plot observations is also supported in the database model and the software.

The European Vegetation Archive (EVA) currently comprises almost 1.5 million plot observations and much different taxonomy. By integrating a crosswalk between the many different taxonomies (already more than 40), an analysis of such large heterogeneous data sets has now become feasible. For the dissemination of the data the EVA Data Property and Governance Rules will be followed (euroveg.org/download/eva-rules.pdf).

7. Update on the AVA in Iceland

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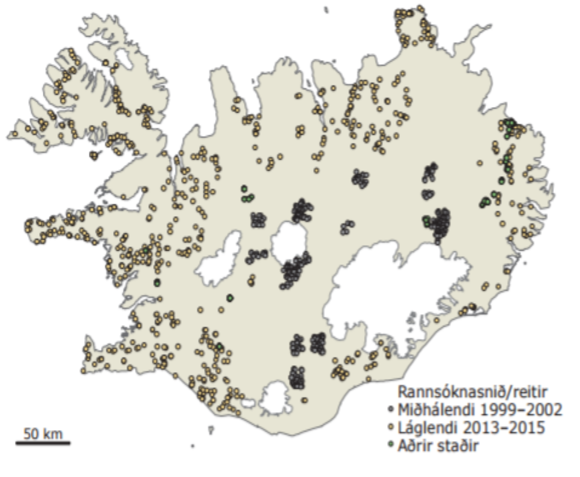

Distribution of plot dataset in Iceland.

As presented at the AVA workshop in Krakow in 2013 there are substantial plot-based vegetation data available in Iceland (Fosaa et al. 2013). Since then there has not been much progress in synchronizing the data nor accumulate it. The amount of suitable data has, on the other hand, increased significantly in Iceland mainly thanks to the mapping of habitat types in Iceland (Ottósson et al. 2016), a project which has been ongoing since 1999 when the work started at the central highlands of Iceland (Magnússon et al. 2009).

Since 2013 several hundred transects have been studied on the lowland part of Iceland more than doubling the number of plots included in the analysis. Furthermore, all data have been added to a common database. All transects included in the habitat-type mapping can be seen on a map from Magnusson et al. 2016.

Analyses of available data resulted in the delimitation of 64 different terrestrial habitat types which follow the EUNIS classification system as possible (www.eea.europa.eu/themes/biodiversity/eunis/eunis-habitat-classification). A map showing the habitat types of Iceland can be assessed at vistgerdakort.ni.is.

References

Ottósson, J.G., Sveinsdóttir, A. & Harðardóttir, M. (eds) 2016. Vistgerðir á Íslandi [Habitat types in Iceland]. Fjölrit Náttúrufræðistofnunar nr. 54. 299 pp.

Magnússon, S.H., Magnússon, B., Elmarsdóttir, Á., Metúsalemsson, S. & Hansen, H.H. 2016 Vistgerðir á landi [Terrestrial habitat types] in Ottósson, J.G., Sveinsdóttir, A. & Harðardóttir, M. (eds) 2016. Vistgerðir á Íslandi [Habitat types in Iceland]. Fjölrit Náttúrufræðistofnunar nr. 54. 17-169.

Fosaa, A.M., Daniëls, F.J.A., Heiðmarsson, S., Jónsdóttir, I.S. & Talbot, S.S. 2013. Vegetation data from boreal tundra of the North Atlantic and North Pacific regions. in Walker, D.A. Breen, A.L., Raynolds, M.K. & Walker, M.D. (Ed). Arctic Vegetation Archive (AVA) Workshop, Krakow, Poland, April 14-16, 2013. CAFF Proceedings Report #10. 45-49.

8. The concept of Arctic local floras and can we apply it more widely?

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The local flora method is widely used by Russian botanists. The method strives to achieve the complete floral list for the studied area, which is normally about 100 km^2 in lowlands and 300 km^2 in mountainous regions. Detailed information about the method is given in *Khitun* et al. 2016. The authors have created a database on Russian Arctic local floras, which by now includes 287 localities. Initially database included only local floras from the Asian Arctic, but it has been expanded to the European part of the Arctic due to recently published surveys (Sergienko 2013, Matveeva & Zanokha, 2015; Lavrinenko et al., 2016).

Although a great number of relevés were made during the local flora studies in the past, absolute majority of them is not suitable for AVA (poor records on cryptogam component, lack of coordinates and/or permanent marking, many authors died and even if diaries and cryptogam collections exist, it is not realistic to organize these data). Less than ca 1/3 of relevés made by O.V. Khitun and O.V. Rebristaya during the local flora studies in Gydan and Yamal meet the requirements for AVA. They are not processed yet but can be used for AVA in future.

The local flora method provides very detailed information about the species distributions within the area. The method demands thorough search in all habitat types and includes records of many rare species which can be missed otherwise. Information gathered by this method contributed to PAF and CAFF initiatives. Old local flora data can be used for studying the gradients of various taxonomical parameters, zonal and provincial changes in geographical and biomorphological structure of flora, for clarifying the boundaries of phytogeographic regions and sets of differential species. A numerical approach to the floristic subdivision of the Russian Arctic was tested. The units obtained in cluster analysis of species composition similarity partly resembled subprovinces suggested by Yurtsev (1994), but there was a difference also. Our (Khitun et al. 2016), showed the same tendencies as found in other research (Callaghan et al. 2013) but lack of accurate documentation from the initial surveys did not allow definitive conclusions.

Considering the difficulties in reaching remote locations throughout the Arctic and also shortage of qualified personnel to do thorough botanical surveys, incorporating the local floras approach to existing network of Arctic observatories seems advantageous. Complementary studies of local floras in the vicinity of existing stations can provide additional material for monitoring and modeling.

We want to stress the necessity of accurate documentation. It should include such information as coordinates of the base camp, GPS tracking of daily routes, coordinates (with permanent marking of survey sites) of all relevé plots and their photographs, GPS coordinates of all rare species found in the area. And this information should be published! Even today there are publications of local floras where sites are shown on the map (of very small scale) and no coordinates are given. A roadmap towards uniform approaches of vegetation sampling is given in Walker et al. 2016. Evaluation of general species occurrence within the local flora remains rather subjective, its combination with data from permanent plots can provide more reliable data.

References

Callaghan, T.V., Jonasson, C., Thierfelder, T. et al. 2013 Ecosystem change and stability over multiple decades in Swedish subarctic: complex processes and multiply drivers. Philos. Trans. Roy. Soc. B. 368

Khitun, O., Koroleva, T., Chinenko, S., Petrovsky V., Pospelova E., Pospelov I., Zverev A. 2016. Applications of local floras for floristic subdivision and monitoring vascular plant diversity in the Russian Arctic. Arctic Science 2(3): 103-106

Lavrinenko, O., Petrovsky V., Lavrinenko, I. 2016. Local floras of the islands and SE coast of the Barents Sea. Botan. Zhurn.,82(3):107-118

Matveeva, N.V. & Zanokha, L.L. 2016. Vascular plants. In.: Matveeva (ed) Plants and fungi of polar deserts of the northern hemisphere. SP., Maraphon. Pp.35-74. Sergienko, V.G. Concrete floras of the Kanin-Mezenski region KMK Scientific Press Ltd, SPb-Moscow

Walker, D.A. Daniëls, F.J.A., Bhatt U.S. et al. 2016. Circumpolar Arctic vegetation: a hierarchic review and roadmap toward an internationally consistent approach to survey, archive and classify tundra plot data. Env. Res. Lett 11 (2016) 055005

Yurtsev, B.A. 1994. Floristic division of the Arctic. J. Veg. Sci. 5(6):765-776

9. Large-scale geobotanical mapping of the East European tundra

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Since 1996, we have been doing large-scale geobotanical mapping of the East European tundra using ArcGIS and remote sensing, based on ground surveys, including observations from more than 1500 relevés. The following works were performed:

1) Vegetation map projects (scale 25 000 – 100 000) for the 10 regional nature reserves and protected areas.

2) The "The Red Book of the Nenets Autonomous Okrug", which is a GIS project that contains 1300 locations of 102 rare plant species and layers with the key areas for the conservation of rare and endemic species.

3) 132 geobotanical districts with homogeneous composition and distribution of vegetation cover have been defined for the East European tundra territory. Distribution of the maximum NDVI correspond to this scheme geobotanical zoning. Maps of geobotanical districts conservation values have been prepared on the basis of analysis of the diversity and density of rare vascular plant species, as well as the most well-known species.

4) Maps of long-term dynamics of the vegetation cover for the key areas on the Vaigach and Kolguev Islands were prepared using remote sensing techniques and field relevés. The maximum NDVI values increased over the last 25 years by 30% and 15% on Vaigach and Koguev islands respectively. There is a high correlation between increases in phytomass and increases of the average summer temperatures, lengthening the growing season (at the beginning and end) and the amount of accumulated heat over this period.

5) Satellite images show that between 1973 and 2010 the area of marshes along the Kolokolkovoy Bay (Barents Sea coast) was not constant and varied from 357 to 636 ha. After a severe storm surge July 24—25, 2010, the area was reduced to 43—50 ha. A comparative analysis of species composition and vegetation structure in the relevés made in 2002 and again in 2011, allowed evaluation of syntaxa changes in the marshes.

6) Draft of the typological scheme of vegetation territorial units, based on the Braun-Blanquet classification was prepared for Kolguev Island as model. Four ranks of typological units were offered: department, class, type and subtype, which correspond to the basic levels of the hierarchical organization of vegetation. This typology is consistent with the EUNIS habitat classification.

10. Vegetation of the East European tundra: classification and database

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More than 40 sites on the East European tundra plains were visited during 1996–2016, and 1500 relevés using the Braun-Blanquet approach were made along the latitudinal gradient from typical tundra to forest-tundra. A Prodromus of this works contains 17 classes, 20 orders, 27 alliances and 53 associations (20 new ones). Vegetation of *Juncetea maritimi* marshes, *Oxycocco–Sphagnetea* and *Scheuchzerio–Caricetea nigrae* bogs and mires, *Carici rupestris–Kobresietea bellardii* on calcareous rocky grounds and *Thlaspietea rotundifolii* on unstable fell-fields was studied rather well. The new *Rubo chamaemori–Dicranion elongati* alliance within *Oxycocco–Sphagnetea* is proposed for dwarf-shrub–moss (*Dicranum elongatum, Polytrichum strictum*)–lichen communities of oligotrophic palsa bogs and peatlands of the Subarctic — in contrast to the boreal *Oxycocco–Empetrion hermaphroditi* with dwarf-shrub–*Sphagnum* communities in ombrotrophic raised bogs. There is need for a new class for zonal tundra vegetation on placor (interfluve habitats with loamy soils), which unites the diverse sedge–dwarf-shrub–moss communities. Their structure and composition are characterized by: continuous or discontinuous plant cover with regular frost boils with bare ground; high (more than 200) species richness; well-developed (up to 8 cm) moss layer dominated by common tundra bryophytes (*Aulacomnium turgidum, Hylocomium alaskanum, Ptilidium ciliare, Tomentypnum nitens*); dominance by *Carex arctisibirica* / *C. lugens* in grass layer; high dwarf-shrub willows (*Salix reticulata, S. polaris*) abundance; non constants presence of *Dryas octopetala* / *D. punctata* and shrub willows (*Salix glauca, S. lanata*). We reserve the name *Carici arctisibiricae–Hylocomietea alaskani* for coming new class. The current practice to putting zonal tundra communities into *Carici rupestris-Kobresietea bellardii*, *Loiseleurio-Vaccinietea* or *Juncetea trifidi* blurs their ecological affinity and brings disbalance in Arctic syntaxonomy. There are plans to continue classification with long-term perspectives to use results in making vegetation maps as well as in zonation with updating the between/inside boundaries and geobotanical subdivision schemes.

11. Overview of the AVA in Canada

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International Polar Year funds were used to compile an initial arctic vegetation archive for the Canadian Arctic and sub-Arctic in 2010-2011. Approximately 4800 Arctic reléves were acquired from 82 published and unpublished theses, papers and other reports as part of this effort. Since 2013, additional datasets from previously published and unpublished sources as well as contemporary collections have added 3500 reléves to the Canadian Arctic Vegetation Archive (CAVA). 900 Alaska reléves originally included in the CAVA are now omitted. Major additions to the archive include an extensive unpublished data set of ~1900 reléves collected by Thannheiser between 1971 to 1998, ~750 plots from Parks Canada collections in Aulavik, Ivvavvik, Torngat Mountains, and Ukkusiksalik national parks and ~500 plots from the Yukon territorial government archives. Contemporary field collections in the eastern Yukon (~190 reléves in 2015) and in the Canadian High Arctic Research Station study area (~150 reléves in 2014) has been incorporated. Additional datasets have been identified for possible inclusion in the CAVA: including a large body of work from the eastern arctic in Quebec (currently 425 reléves), an unknown and unreviewed dataset from the Northwest Territories government, and several known historical datasets from published papers and reports (~500 reléves). The 7450 reléves in the 2017 CAVA are housed in VPRO, a programmed ACCESS database designed for management of vegetation and environmental reléves and classification hierarchies. Initial trials to convert CAVA data from VPRO to TurboVeg format indicate that the most common issue will be alignment of taxonomic standards and coding between datasets.

12. The Canadian Biogeoclimate Ecosystem Classification (BEC) approach

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BEC is best described as an ecological framework that uses Braun-Blanquet associations of mature vegetation as phytometers to identify and delineate ecologically equivalent regional climatic regions and local stand-level environmental conditions. Developed by phytosociologist Vladamir Krajina to describe forest ecosystems and their distribution within a climatically and topographically complex region of Canada, the BEC approach could also provide an ecological framework for aligning existing Arctic Braun-Blanquet associations. Central concepts in BEC are the Russian concept of the biogeocoenose, the identification of the zonal association to delineate areas of biologically uniform climate, the linkage between associations and site condition through the concept of ecological equivalence, and a structured process of correlation to align and harmonize regional classification concepts. Developed to be an applied tool for resource management, the terminology of the system uses common language to facilitate its application with non-academic users. The central role of vegetation classification in delimiting consistent climatic regions and site conditions facilitates application of ecosystem-based management, modelling the spatial distribution of ecosystems and to assess and predict the impacts of changing climate and environmental condition on terrestrial ecosystems. A consistent ecosystem classification is an important tool for experimental design, ensuring representation in monitoring networks, and the appropriate extrapolation of research findings.

13. Overview of progress on the AVA in Russia

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The study of plant cover within the Russian Arctic started in the 1930s and was intensified gradually reaching its peak in the 1970s and 1980s. Initially, very few phytocoenologists sampled vegetation using a relevé approach. Even less who published these with enough repetition. However, the famous tundra ecologists B. N. Gorodkov, V. N. Andreev, A. A. Dedov and V. D. Aleksandrova were among those who did. The formal methods of the Braun-Blanquet approach were used by some Russian phytosociologists who worked in southerner biomes in the late 1970s, but only at the beginning of 1990s did the approach begin to be applied in the Russian Arctic.

Presently the pool of data published validly according to the Codex of Phytosociological nomenclature (Weber et al. 2000) in total contains close to 5000 relevés that belong to about 130 associations within the 35 alliances of 21 orders and 19 classes while about 40 new associations have not been placed into higher units. The main information is from the most important classes: three zonal — *Loiseleurio-Vaccinietea, Carici arctisibiricae–Hylocomietea alaskani* (prov.), *Drabo corymbosae-Papaveretea dahliani,* and four intazonal **—** *Scheuchzerio-Caricetea nigrae, Oxycocco-Sphagnetea, Carici rupestris–Kobresietea, Salicetea herbaceae*.

The unpublished data still exceed that of published. And a lot of data are still in field notebooks and boxes with incompletely identified cryptogam specimens. There are also phytosociologists who have data but so far did have not classified or published these. The perspectives for such very valuable data are vague.

The published relevés are not only the best but also the only one source that is ready to be incorporated into the AVA, at least at the initial stage. Most of these are stored in Excel tables by their owners in botanical institutions in six cities (Saint-Petersburg, Syktyvkar, Kirovsk, Novosibirsk, Yakutsk, Magadan).

The AVA project is the basis for a more ambitious task of creating a classification of circumpolar Arctic vegetation.

14. The US National Vegetation Classification and the VegBank plot archive

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Rapid progress is being made in the development of the US National Vegetation Classification. Use of the system is mandated by the federal government to assure a common language for the effective inventory, management, and conservation of plant communities in the U.S. The classification includes of an 8-level hierarchy with the potential for implementation globally at the upper levels. The lowest levels, Alliance and Association, contain units similar to the alliances and associations of the Braun-Blanquet system, with around 9000 associations currently recognized within the US. Proposals for changes are peer-reviewed as coordinated by the Vegetation Panel of the Ecological Society of America in collaboration with Federal agencies and NatureServe. A critical component of the peer review is to assure that accepted types are based on data from across the range of the type and are clearly differentiated from other accepted types. All proposals are expected to be based on plot data that is publicly available, typically through deposit in VegBank. VegBank is a stand-alone, Internet-accessible, vegetation plot archive designed to allow users to easily submit, search, view, annotate, cite, and download diverse types of vegetation data. The archive also contains embedded databases that contain classifications of vegetation and individual organisms, designed and implemented to track the many-to-many relationship between names and plant or community concepts, as well as alternative party perspectives on accepted taxa. The VegBank data model is also implemented in VegBranch, a desktop tool for data management and for uploading to and downloading from VegBank.

15. Progress on an Alaska Arctic vegetation classification using the AVA-AK

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Vegetation classification has recently become the most important tool of vegetation scientists, ecologists and nature conservationists all over the world. Following the Braun-Blanquet approach, botanists in Europe created a sophisticated hierarchical system of units representing plant communities based on their floristic, ecological and structural criteria. The advantages of language of this classification system is mainly that behind each name, which follows certain prescripts, there is whole treasure trove of taxonomic and ecological information that can be compared hierarchically with other similar or vicariant units in other regions. Up to now, the arctic parts of North America were missing this kind of overview of vegetation units that can be comparable with rest of the world. Contemporary activities led by Alaska Geobotany Centre of University of Alaska Fairbanks and other institutions resulted into establishment of Arctic Vegetation Archive that has had ambitions to put together all relevant vegetation data with available ancillary data from whole arctic biome.

The data stored in Alaska Arctic Vegetation Archive – 3026 relevés, were analyzed based on floristic criteria and their abundance using cluster analyzes. Using the methods of crispness of classification, the best interpretable number of clusters were identified that lead to exploring the structure of stored data. On the highest level of dissimilarity, the four main divisions represent i) initial, aquatic and azonal communities; ii) moist to dry acidic dwarf shrubs; iii) zonal alpine communities and iv) graminoid tundra and dwarf-shrub heath vegetation, respectively.

The next goal should be the creation of a useful classification system of arctic vegetation based on formal language which will be understandable and easy to use. Based on our preliminary results obtained by above mentioned methods together with finding the main gradients and drivers of vegetation variability in our dataset, we will be able to create logical expert system comparable and combinable with recently used units developed for the US National Vegetation Classification.

16. JUICE v. 7: A complex expert system language for vegetation classification

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Major steps have been made recently towards the development of a common vegetation classification system for Europe. The existence of new, huge resources of ecological information, coupled with the lack of comprehensive classification system applicable on the continental scale calls for the development of expert system language for the formal description of vegetation classification. We have introduced a complex, but visually understandable structure and syntax for an expert system for vegetation classification based on logical formulas for automatic identification of vegetation types. With this approach, we can simplify and clearly describe general definitions of vegetation units, which are able to match the units of the traditional expert-based classification, or to define new vegetation types. The expert system is now so flexible that it can be used for definitions of all hierarchical levels of vegetation classification system. We have a scientific tool, which is highly efficient, fast and flexible and can be also automatically improved. The whole tool is included in the Expert System function of the JUICE program (www.sci.muni.cz/botany/juice.htm).

17. Introduction to the Circumpolar Arctic Vegetation Archive and Classification Workshop

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A uniform Arctic Vegetation Classification (AVC) is needed as a framework for a wide variety of international Arctic initiatives that involve vegetation information. An Arctic Vegetation Archive

(AVA) is needed to gather the information in a standardized format for analysis. Arctic Science Summit Week is an appropriate venue for this international AVA meeting. The AVA is a supported initiative of the International Arctic Science Committee (IASC), the primary organizers of the conference. The AVA is also a priority initiative of the Conservation of Arctic Flora and Fauna (CAFF), the biodiversity working group of the Arctic Council.

The idea for an Arctic vegetation classification began in 1992 at the first Arctic vegetation classification workshop in Boulder, Colorado, USA, where a resolution was presented to make a circumpolar vegetation classification and map. The Circumpolar Arctic Vegetation Map, published in 2003, was the first concrete product arising from the Boulder resolution. A consistent plot-level Arctic vegetation classification was much slower to develop because of the lack of a common taxonomy and nomenclature for the Arctic and difficulties in standardizing and archiving the large amount of plot data from all the Arctic countries. The Pan-Arctic Species List now provides a unified checklist of accepted names and synonyms for Arctic vascular plants, bryophytes and lichens, and a standardized set of header data for a Turboveg database provide the basic framework. Two workshops in 2013 at Krakow and Boulder revitalized the effort, and a prototype AVA was recently published for Arctic Alaska. Furthermore, recent rapid advancements in international vegetation databases and the European Vegetation Classification now provide models for creation of the Arctic AVA and AVC. The Braun-Blanquet (Br.-Bl.) classification approach, with zonal and habitat-type based grouping of syntaxa, is proposed as a model for the first AVC, similar to the approach used for the European Vegetation Classification.

The next step is to begin the task building a truly international AVA. This meeting in Prague will focus on progress in Canada, Greenland and Russia. We will review the datasets and plots that are available for each of the floristic provinces in these countries. The primary goal is to develop a strategy for each country to assemble its own archive with common protocols that will later allow the databases to be united into a single AVA using TurboVeg v3. We will then move toward developing the Br.-Bl. classification. Long-term plans are to also use the data in the AVA to develop comparative classifications using North American classifications approaches.

18. Why an Arctic Vegetation Classification?

Marilyn Walker

HOMER Energy, Boulder, CO, USA

Why should we take the considerable time and expense to develop a unified classification of arctic vegetation? Is it not sufficient to have a repository for vegetation data? It is worth our while to take a moment to answer these questions, which underpin the work that has been ongoing, in some form, for 25 years, but is not yet complete.

I convened a workshop in Boulder, Colorado, in March 1992, with a goal of beginning international cooperation toward a common circumpolar arctic vegetation classification. This was the first time this particular group of vegetation scientists came together, and the workshop, which has come to be a watershed event for arctic science, was inspired by two very different people, both Russian. The first was Boris Yurtsev of the Komarov Botanical Garden in (at that time) Leningrad. Yurtsev had developed a map illustrating his visions of the arctic flora as a single region, divided into provinces and subprovinces that reflected the geologic history of the region as well as current climate. Yurtsev's map and theory were published in the special edition of the *Journal of Vegetation Science* that prepared as a key outcome of the workshop (Yurtsev 1994). Yurtsev's work had strongly influenced my thinking and analysis of the vegetation and floristics of pingos (Walker 1990), as I analyzed how the flora of a particular microsite reflected the species' larger distribution. This finding is not particularly surprising, but it made me think about the plants I was studying as a part of larger flora that spread around the entire globe. The second Russian who influenced the meeting was, ironically, Mikhail Gorbachev. Although current popular of opinion of him is low in Russia, he was instrumental in opening Russia and the Soviet Union. Because of Gorbachev's policies, I was able to bring the right Soviets to the Boulder meeting, launching a multi-decadal international cooperative effort toward understanding the integrated ecology of this important region.

I presented the Indian story of "The Blind Men and the Elephant" as an allegory for how the world's vegetation scientists viewed the Arctic in the 1980's. In this folktale, a group of blind men all approach an elephant, and then describe what an elephant is "like." Since the animal is so much larger than them, each describes it according to the piece upon which they happened to land – a spear for the tusk, a snake for the trunk, a tree for the leg, etc. There were publications available on the vegetation of various arctic regions available in the 1980's, many with a synthetic approach to a broad region – such as Canada, Russia, Europe, etc. But each of them seemed to me to be strongly influenced by the unique climate or geology of the geographic area, and therefore not truly extrapolatable to the entire region. This was before we had a globally connected information system that made communication and information sharing trivial, and at a time when travel into the USSR was difficult, and out of the USSR was nearly impossible. So, my goal was to get everyone together and move from the allegory of the blind men into a unified view of a region.

One of the clear goals that came out of the 1992 meeting was a desire to create a database of arctic vegetation plots that could be the basis for a classification (Walker et al. 1994), but the most important goal was to create the classification. There should be no need to justify why a classification is required. Classifications are languages. Just as biologists have agreed upon a way of defining and describing a species, which represents a degree of evolutionary isolation, vegetation units describe the synthesis of the local flora with climate and geology. They are the most fundamental and profound description of the ecological functioning of a region. If two different areas have the same fundamental plant community on them, then you can know a great deal about the commonality of their climate, soils, and geology. Without this classification system, there is nothing but a volume of data concerning the presence and abundance of the species. Classifications allow regions to be mapped, and allow those maps to be used as a basis for management, modeling, and other activities (CAVM Team 2003).

One of the important goals for a classification is to serve as a baseline for ecosystems and landscapes in the process of change. Although we spoke of climate change in 1992, we had no idea what the earth would look here in the "future" of 2017. We already recognized the Arctic as a sensitive and important region for climate, for two primary reasons: (1) changes of only a few degrees represent very large effective changes in systems where the growing season temperatures are only just above zero C, and (2) the stores of carbon in arctic soils and permafrost are vulnerable and have the potential to magnify climate change through adding more carbon to the atmosphere. Climate change is now recognized as an international emergency threatening all species, and changes to arctic regions are even more rapid than anticipated (SEI 2016).

Beyond all the compelling scientific and political reasons for an arctic vegetation classification, however, is what I believe is the primary driver for those of us who do the work. We love nature, and we adore the delicate and beautiful arctic plants and their landscapes. More than anything, this is a labor of love.

The development of an arctic (or any) vegetation classification proceeds in a series of steps, beginning with collection of data in the field. Every species, including the smallest bryophytes, and its relative abundance are accounted for. There is often a very long secondary step of verifying that the identifications are correct, which can sometimes take months or even years in some cases, if samples must be sent to experts for taxonomic verification. Then the data are digitized. They may be submitted to various databases or stored locally. For regional or very large classifications, such as the European Vegetation Classification (Mucina et al. 2016), data are pulled from a common database and manipulated with specialized software for classification. Although the addition of data to a secure, agreed upon database is an important step, the synthetic step of the classification gets the highest value out of the data, and makes it useful to the greatest number of people and applications. Classification moves data into information. It protects a valuable legacy.

I share a slide of Vera Komárková, a remarkable vegetation scientist, particularly poignant as she was Czech. Vera completed a detailed and complete classification of the Front Range Colorado alpine vegetation (Komárková 1979), but her very detailed work in the Atqasuk region of Alaska was lost after her death from breast cancer in 2005, at age 62. The data that Vera collected is lost forever, and a legacy is gone.

It is somewhat ironic that a political leader was part of my inspiration for beginning this work in early 1990's, given that we are now seeing active moves on the part of United States Executive Branch to destroy science data and information. Gorbachev, for all his current disrepute in Russia, seemed to understand the peril facing the world in the late 1980's. His intention, I believe, was to save the human race and the planet from annihilation, and he continues to speak of these challenges in our current political environment (Gorbachev 2017). Regardless of our own political views or our opinions of any particular leader, as scientists and ecologists, we all agree that our planet and all the life within it are precious.

As a young woman who spent many years bent over plots, collecting, measuring, and analyzing vegetation data, I used to daydream that one day someone would come up with a mechanism to scan a piece of ground and instantly identify all the species present there through their DNA. And perhaps that day will come. It seems even very likely to me, still, even though I am also waiting for flying cars. But until that day, there is a great deal of work and love involved in measuring and classifying arctic vegetation data. I hope that the valuable legacy represented by that data, and those decades of work, can one day soon become a part of synthetic, integrated classification of the circumarctic region, while we still have time.

References

CAVM Team. 2003. Circumpolar Arctic Vegetation Map. (1:7,500,000 scale), Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Gorbachev, M.K. 2016. It all looks as if the World is preparing for war. *Time* Jan 26, 2017.

Komárková, V. 1979. Alpine vegetation of the Indian Peaks area, Front Range, Colorado Rocky Mountains. *Flora et Vegetatio Mundi, VII, Tüxen, R., J. Cramer, Vaduz.*

Mucina, L., and others. 2016. Vegetation of Europe: hierarchical floristic classification systems of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19 (suppl. 1): 3-264.

SEI Stockholm Environment Institute. 2016. Arctic Resilience Report 2016. 240 pages.

Walker, M.D. 1990. Vegetation and floristics of pingos, central Arctic Coastal Plain, Alaska. Dissertationes Botanicae Band 149, J Cramer, Stuttgart, Germany, 283 pp.

Walker, M.D., F.J.A. Daniëls, and E. van der Maarel. 1994. Circumpolar arctic vegetation: Introduction and perspectives. *Journal of Vegetation Science* 5: 758-764.

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Arctic Vegetation Archive and Classification Workshop
Czech Academy of Science, 30-31 March 2017

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Part II

Proceedings of the Third International Arctic Vegetation Archive and Classification Workshop, Arkhangelsk, Russia

NArFU Main Building, Naberezhnaya Severnoy Dviny, 17, Room 1323
Arkhangelsk, Russia, 21-23 May 2019

Background

Ground-based observations of plant-species, soils, and environmental factors are needed to develop effective Arctic terrestrial monitoring and mapping programs and to inform modelling and prediction of biodiversity, ecosystem functioning, and climate under future conditions. The Arctic Vegetation Archive (AVA) and Arctic Vegetation Classification (AVC) aim to identify, gather, archive, classify, and analyze species and environmental data from vegetation plots from all circumpolar Arctic countries. A large legacy of vegetation plot data has been collected from most areas of the Arctic during the past century.

The AVA/ AVC workshop in Arkhangelsk was part of an activity of the Terrestrial Working Group, International Arctic Science Committee (IASC) https://iasc.info/working-groups/terrestrial/activities, initiated by Gabriela Schaepman-Strub, Skip Walker, Amy Breen, Ksenia Ermokhina, Nadezhda Matveyeva and Jozef Šibík. The workshop builds upon the success of previous AVA workshops: in Boulder, US — two in 1992 and 2013 (M.D. Walker et al. 1994; Walker, D.A. 2014); Roskilde, Denmark — two in 2012 (Walker 2014); Krakow, Poland — 2013 (Walker et al. 2013); and Prague, Czech Republic 2017 (abstracts published in this proceedings volume as Part I).

Participants were invited to discuss new data contributions, data archiving, vegetation classification, and key questions in biodiversity and ecosystem functioning to be answered by the use of the Arctic Vegetation Archive.

The principle objectives of workshop were: (1) develop strategies to complete the Arctic Vegetation Archive (AVA) and Arctic Vegetation Classification (AVC), with emphasis on Russian data sets; (2) develop strategies to begin work on the available portions of the AVA and AVC for regional vegetation classifications: (3) use of available species and environmental data to develop key questions on biodiversity and vegetation distribution at regional and pan-arctic scales, and (4) develop a strategy for international coordination of Arctic vegetation activities between CAFF and the IASC Terrestrial Working Group.

The organizing committee for the workshop consisted of Gabriela Schaepman-Strub and Elena Plekhanova (Switzerland); Amy Breen, Jana Peirce and Skip Walker (USA); Ksenia Ermokhina and Nadezhda Matveyeva (Russia); and Jozef Šibík (Slovak Republic).

Achievements and other outcomes

Thirty-two attendees participated and 25 abstracts of talks and posters are included in the proceedings. Strong progress was made toward achieving the AVA. The choice of Arkhangelsk as the venue for the workshop greatly promoted participation by the leading Russian botanical institutes and encouraged a surge of interest by young Russian investigators, several of which presented talks and posters at the workshop. A Turboveg vegetation database training session was held on 23 May.

Achievements since the Prague workshop included:

1. Publication of a review paper in *Phytocoenologia* regarding the progress and status of circumpolar arctic vegetation classification (Walker et al. 2018).
2. Publication in Remote *Sensing of Environment* of a new raster version of the CAVM (Raynolds et al. 2019). The publication improves the resolution of the map to 1-km pixels, draws on local knowledge across the Arctic, and will promote the application of the map to numerous analysis and modeling applications that require raster-format data.
3. Major progress has been achieved in Russia since the Prague workshop. Nadya Matveyeva and colleagues at the Komarov Botanical Institute in St. Petersburg have inventoried the vegetation syntaxa and their distribution within the Russian floristic provinces based on a new geodatabase and GIS in a new “Russian Arctic Vegetation Archive”. New vegetation datasets are being added to the Russian archive, under the leadership of Ksenia Ermokhina, and are hosted at the A.N. Severtsov Institute of Ecology and Evolution, RAS (Moscow). The initial focus of the archive is on vegetation from European Russia, the Yamal and Gydan Peninsulas, and published datasets from elsewhere in arctic Russia. The Russian arctic vegetation classification is proceeding under the leadership of Nadezhda Matveyeva.
4. The Komarov Botanical Institute has formed a new “Laboratory of the Dynamics of Arctic Vegetation Cover” under the leadership of Igor Lavrinenko, with funding from the Russian Academy of Science. The laboratory has developed a cohort of new arctic vegetation scientists that is focusing on vegetation of European Arctic Russia and achievement of a Russian arctic vegetation classification.
5. Canadian participants are working on circumpolar biogeoclimate map that would be a powerful tool to help in the analysis and modelling of Arctic vegetation data.

Areas needing continued progress included:

1. Strong coordination is needed between IASC and CAFF with regard to circumpolar vegetation datasets and analysis. The formation of an international Circumpolar Vegetation Group was suggested to focus on development of the key circumpolar vegetation maps, plot archives, classification, and application of these to the core biodiversity- and ecosystem-change questions being addressed in the CAFF and IASC science plans.
2. A continued push is needed to update the panarctic species list or develop an acceptable approach for making a panarctic list that can be updated as new species are found and the existing Latin names of organisms change to reflect new knowledge. One pathway may be a workshop between key members of the CAFF Arctic Flora Inventory (AFI), and the Circumpolar Vegetation Group to arrive at a workable list.
3. More steps are needed to standardize data in the national AVAs, including use of unique Turboveg relevé numbers (e.g., Alaska (10000-19999), Russia (20000-29999), Canada (30000-39999), etc.); development of country archive coordinators; development of species synonym lists for each country linked to the current Pan-Arctic Species List (PASL).

New ideas discussed at the workshop included:

1. An international Arctic Vegetation Network is needed to improve communication, share publications, data, and coordination regarding arctic vegetation data. Several suggestions were made with regard to the structure of the network, varying from an informal network to a formal “association” with membership and dues similar to the International Permafrost Association (IPA) or the International Association of Vegetation Scientists (IAVS). A major question is how to fund the administration of the proposed network.
2. Participants agreed that a central website will be developed as a step toward an AVG network. A suggested model was the database of the Czech flora and vegetation (pladias.cz). Other

possibilities included expansion or coordination with existing and planned websites (e.g. www.synbiosys.alterra.nl/evc (European Vegetation Survey); Arcticatlas.geobotany.org (Alaska); Ava.sevin.ru (Russia); Binran.ru (Russia); http://cnvc-cnvc.ca (Canada); http://usnvc.org (US); http://www.natureserve.org (US-Canada NatureServe), https://www.biodiversity.ru/eng/ (England). Several unresolved questions include: a) Who would act as overall coordinator? b) What content would the site contain (e.g., user-group emails, general info, literature, the core vegetation plot archive and classification as it is developed, dataset- and plot-location maps, links to other relevant web sites, opportunities for early career scientists, guidelines for dataset protocols and best practices)? c) Do we need a committee that oversees the quality of added datasets? d) How to edit content?

3. The participants agreed to printing/publishing the workshop outcomes and abstracts as a CAFF Proceedings Report.
4. The next international AVA/AVC workshop will be at ASSW 2021 in Lisbon. Progress reports in the interim will be made at ASSW 2020, March 27 March – April 2, in Akureyri, Iceland, and at EGU 2020, May 3 – 8, in Vienna followed by a data workshop in nearby Bratislava.

References

Walker, D. A. (Ed.). (2014). Proceeding of the Alaska Arctic Vegetation Archive Workshop, Boulder, Colorado, USA October 14-16, 2013. CAFF Proceedings Series Report #11. Retrieved from http://www.caff.is/publications/view_document/252-arctic-vegetation-archive-ava-workshop-krakow-poland-april-14-16-2013

Walker, D. A. (2014). Toward a pan-Arctic vegetation archive and classification: Two recent workshops. *IAVS Bulletin*, *2014/1*, 12–16.

Walker, D. A., Breen, A. L., & Raynolds, M. K. (Eds.). (2013). Arctic Vegetation Archive (AVA) Workshop, Krakow, Poland, April 14-16, 2013 (pp. 1–111). Akureyri, Iceland: CAFF Proceedings Series Report No. 10.

Walker, M. D., Daniëls, F. J. A., & Van der Maarel, E. (1994). Circumpolar arctic vegetation: Introduction and perspectives. *Special Features in Journal of Vegetation Science*, *5*(6), 757–920. http://doi.org/10.1111/j.1654-1103.1994.tb00395.x

Arkhangelsk Workshop Agenda

Tuesday 21 May 2019

Arctic Vegetation Archive: Going around the Arctic — Chair, Elena Plekhanova

09:00 Welcome and introductions — *Gabriela Schaepman-Strub & Skip Walker*

09:10 Introduction to the Arctic Vegetation Archive — *Skip Walker*

09:25 The Alaska Arctic Vegetation Archive (AVA-AK): Achievements, status and lessons learned — *Amy Breen*

09:45 Status of the Canadian Vegetation Archive — *Will MacKenzie*

10:05 Results of the inventory of vegetation syntaxa and their distribution in floristic provinces based on the geodatabase and GIS “Russian Arctic Vegetation Archive” — *Nadezhda Matveyeva*

10:25 There and back again: the critical importance of a truly international database of Arctic vegetation — *Marilyn Walker*

10:40 Coffee break

Recent advances in regional Russian vegetation efforts — Chair, Daria Karsanova

11:00 Status and perspective of the Russian Arctic Vegetation Archive — *Ksenia Ermokhina*

11:15 Zonal and intrazonal communities on the latitudinal gradient of the East European tundra — *Olga Lavrinenko*

11:30 Vegetation of a small Arctic island at the limit of the tundra zone (Sosnovets Island in the White Sea as a case study) — *Ekatarina Kopeina*

11:45 About vegetation data in high mountain zone (‘goltzy’ deserts and sub-nival zone) in Kola Peninsula and Svalbard — *Alena Danilova*

12:00 Approach to the typology of vegetation units for CAVM based on phytosociological data — *Igor Lavrinenko*

12:15 Lunch and posters

Applications of AVA — Chair, Vitalii Zemlianski

13:45 Utilization of vegetation databases in environmental and ecological research — *Jozef Šibík*

14:05 Identifying botanical research gaps across Arctic terrestrial gradients — *Anna Virkkala*

14:20 Hearing the grass grow: vegetation records at automatic climate stations — *Christian Rixen*

14:35 Future international coordination, IASC and CAFF — *Discussion led by Skip Walker*

15:00 Breakout groups/ Science café

Topics include 1. practical issues of AVA data integration, 2. status of Russian data for AVA, 3. international coordination of vegetation activities & PAF future

17:00 Summary and end of workshop

18:00 Adjourn

Wednesday 22 May 2019

Turboveg training workshop

14:00-18:00 Facilitators: *Amy Breen, Ksenia Ermokhina, Jozef Šibík*

Arkhangelsk Workshop Abstracts

1. The Alaska Arctic Vegetation Archive (AVA-AK): Achievements, status and lessons learned

Amy L. Breen[1], L. A. Druckenmiller, J. Šibík, S. Hennekens, J. Pierce, M.K. Raynolds, L.W. Wirth, D.A. Walker

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The Arctic Vegetation Archive (AVA) is a vegetation-plot database for the Arctic tundra biome. The geographic scope of the AVA includes seven countries within the circumpolar arctic region and maritime boreal tundra. An estimated approximately 30,000 historical plots have been identified for inclusion (see Part I, Fig. 1). A Pan-Arctic Species List (PASL) provides a standard list of accepted vascular plant, bryophyte, and lichen species names. Work on the AVA is being accomplished within individual Arctic countries. Herein we provide an overview of the status of the Alaska prototype for the AVA (AVA-AK).

The AVA-AK contains vegetation plots from homogeneous plant communities with tables of cover or cover abundance scores for species, and accompanying environmental site data. Data are collected using Braun-Blanquet and U. S. National Vegetation Classification protocols, or comparable methods. The archive is accessible to scientists and the public via the Arctic Alaska Geoecological Atlas, an on-line resource being developed by the Alaska Geobotany Center and the Geographic Information Network of Alaska with funding from the U. S. National Aeronautics and Space Administration (NASA) initiative called the Arctic-Boreal Vulnerability Experiment (ABoVE).

The AVA-AK utilizes the Turboveg for Windows database program. Species cover and ancillary data, including environmental, soils and spectral data, photos, maps, and publications, are linked to each plot's geographic location via the Arctic Alaska Geoecological Atlas. These data are also archived in the ORNL-DAAC, NASA's Distributed Active Archive Center, and VegBank (the U. S. Vegetation Archive); and referenced through the Global Index of Vegetation Databases (GIVD-ID: NA-US-014). The archive currently contains 31 datasets with 3,509 non-overlapping plots — 25 from Alaska, 5 from Canada, and 1 from Russia. Of these, approximately two-thirds have geo-location data with 25-m or better precision. We present the contents of the archive, assess its strengths and weaknesses, and provide a brief overview of the database data dictionary and individual datasets. Details of the Alaska vegetation data archive have been presented at previous AVA workshops (Breen et al. 2013, 2014).

References

Breen, A. L., Raynolds, M. K., Hennekens, S., Walker, M., & Walker, D. A. (2013). Toward an Alaska prototype for the Arctic Vegetation Archive. In D. A. Walker, A. L. Breen, M. K. Raynolds, M. D. Walker, & M. Walker (Eds.), (pp. 17–28). Proceedings of the Arctic Vegetation Archive Workshop, 14-16 April 2013, Krakow, Poland. CAFF Proceedings Series Report Nr. 10. Conservation of Arctic Flora and Fauna, Akureyri, Iceland.

Breen, A. L., Druckenmiller, L., Hennekens, S. M., Raynolds, M. K., Walker, M. D., & Walker, D. A. (2014). Progress toward an Alaska prototype for the Arctic Vegetation Archive: Workflow and data dictionary. (pp. 7–21)/ Proceedings of the Alaska Arctic Vegetation Archive Workshop Boulder, Colorado, USA October 14-16, 2013. CAFF Proceedings Series Report Nr. 11. Conservation of Arctic Flora and Fauna, Akureyri, Iceland.

2. Tundra plant communities of southeastern Taymyr (south tundra subzone)

Svetlana Chinenko

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During the expedition of Taymyr Nature Reserve in 2012 (Pospelova, Pospelov, 2014) about 120 vegetation relevés were made in the lower reaches of Zakharova Rassokha and Novaya rivers. The region refers to south tundra, or bioclimate subzone E (CAVM 2003); and Taymyr floristic province (Yurtsev 1994) or Khatanga-Olenyok geobotanical subprovince (Aleksandrova 1980). Data on tundra, mire, shrub (willow, dwarf birch, alder), meadow and snow-bed vegetation were collected. The most common tundra communities (about 40 relevés) are the following:

Dryas-sedge lichen-moss spotty tundras on very gentle slopes with moderately moist loamy soils. The horizontal pattern usually consists of frost-boil spots (5—30 % cover, 0.2—0.7 m width), hummocks or rims (15 cm height, 40 cm width, 40 % cover) and troughs (30—50 cm width, 25—40 % cover). Shrub layer: cover 15—20 %, height is 10—20 cm; field layer: cover 70—80 %, from 2 up to 10—20 cm; ground layer: cover 70—90 %, 2—3 cm. Dominant species are usually: *Dryas punctata, Carex arctisibirica, Tomentypnum nitens*, *Hylocomium splendens* var. *obtusifolium*; abundant species: *Betula exilis*, *Salix pulchra, Cassiope tetragona, Vaccinium microphyllum, Ditrichum flexicaule, Distichium capillaceum, Aulacomnium turgidum, Polytrichum juniperinum*, *Flavocetraria cucullata, Thamnolia vermicularis, Cladonia arbuscula*; common species: *Salix glauca, S. reptans*, *Salix arctica, Eriophorum vaginatum, Bistorta vivipara, B. plumosa, Minuartia arctica, Tofieldia coccinea, Poa arctica, Parrya nudicaulis, Pedicularis capitata, P. oederi, Luzula nivalis, Arctagrostis latifolia, Carex melanocarpa, C. fuscidula, C. misandra, C. quasivaginata, Astragalus umbellatus, Alopecurus alpinus, Saxifraga nelsoniana, Oxytropis mertensiana,* *Hedysarum hedysaroides, Lagotis minor, Juncus biglumis*, *Rhytidium rugosum, Sanionia uncinata, Orthothecium chryseon*, *Ptilidium ciliare, Cetraria islandica, Flavocetraria nivalis, Dactylina arctica, Cladonia rangiferina, C. gracilis, C. amaurocraea, Stereocaulon* sp., *Asachinea chrysantha, Ochrolechia* spp., *Pertusaria* spp. These communities refer to the ass. ***Carici arctisibiricae-Hylocomietum alaskani* Matveyeva 1994** that includes zonal tundras of Taymyr (Matveyeva 1994, 1998) and Yakutia (Telyatnikov et al. 2015).

Willow-dwarf birch cotton grass-Dryas-sedge moss tundras in moist habitats on gentle slopes. Frost-boil spots cover about 5 %. Shrub layer: 20—30 % cover, 10—15 cm height; field layer: 50—75 %, from 2 up to 20 cm; ground layer: 80—95 %, 2—5 cm. Dominant: *Betula exilis*, *Salix pulchra, Dryas punctata, Carex arctisibirica, Eriophorum vaginatum, Tomentypnum nitens, Aulacomnium turgidum, Dicranum* spp.; abundant: *Equisetum arvense, Arctagrostis latifolia, Eriophorum polystachion, E. brachyantherum*, *Sanionia uncinata, Ditrichum flexicaule, Distichium capillaceum, D. inclinatum, Bryum* spp., *Ptilidium ciliare, Orthothecium chryseon*, *Polytrichum juniperinum, P. strictum*, *Sphenolobus minutus*, *Flavocetraria cucullata, Cetraria islandica, Cladonia arbuscula*; common: *Salix glauca, S. reptans, Cassiope tetragona, Vaccinium uliginosum, Bistorta vivipara, Tofieldia coccinea, Pedicularis capitata, P. oederi, Luzula nivalis, Carex fuscidula, C. quasivaginata, Lagotis minor, Saxifraga hirculus, Pyrola grandiflora, Juncus biglumis*, *Rhytidium rugosum, Thamnolia vermicularis, Alectoria ochroleuca, Dactylina arctica, Cladonia rangiferina, C. uncialis, C. gracilis, C. amaurocraea, Peltigera* spp., *Pertusaria* sp. Syntaxonomical position is intermediate between ass. ***Carici arctisibiricae-Hylocomietum alaskani* Matveyeva 1994** and ***Sphagno-Eriophoretum vaginati typicum* Walker et al. 1994**, that is common for bioclimate subzone E in Taymyr; probably close to ass. ***Dryado octopetyalae-Eriophoretum vaginati* Telyatnikov 2010** described in southwestern Taymyr (Telyatnikov 2010).

Dryas-Cassiope lichen-moss tundras are widely spread on watershed very gentle slopes and river terraces, in dry, usually sandy-loamy or sandy plots. Horizontal pattern is often distinctly polygonal, with ground spots (5—30 % cover) and vegetation covered troughs (15—30 % cover, 20—30 cm widths). Shrub layer: 10—15 % cover, 10—15 cm height; field layer: 60—80 %, 5—15 cm; ground layer: 60—80 %, up to 3 cm. Dominant: *Betula exilis* (less often *B. nana*), *Dryas punctata, Cassiope tetragona, Hylocomium splendens* var. *obtusifolium, Aulacomnium turgidum, Tomentypnum nitens*; abundant: *Vaccinium uliginosum* ssp. *microphyllum*, *Empetrum subholarcticum, Salix nummularia, Equisetum arvense*, *Rhytidium rugosum, Abietinella abietina, Ditrichum flexicaule, Distichium capillaceum*, *Dicranum* spp., *Ptilidium ciliare, Flavocetraria nivalis, F. cucullata, Cetraria islandica, Thamnolia vermicularis, Bryocaulon divergens, Cladonia arbuscula*; common: *Salix glauca, Arctous alpina, Ledum decumbens, Tofieldia coccinea, Carex melanocarpa, Astragalus subpolaris, A. umbellatus, Pedicularis amoena, P. capitata, Oxytropis nigrescens, Artemisia borealis, Luzula confusa, L. nivalis, Bistorta vivipara, B. plumosa, Minuartia arctica, M. macrocarpa, Poa arctica, Hedysarum hedysaroides, Lagotis minor, Armeria scabra, Hieracium alpinum, Pinguicula algida, Saussurea tilesii, Alectoria ochroleuca, Bryoria nitidula, Peltigera* spp., *Dactylina arctica, Cladina rangiferina, Cladonia gracilis, Sphaerophorus globosus, Asachinea chrysantha*, *Hypogymnia* sp., *Stereocaulon* sp., *Ochrolechia* spp., *Pertusaria* sp. Syntaxonomical position is uncertain, the communities are alike both ***Bryocaulo divergentis – Vaccinietum uliginosi* Telyatnikov 2010** from southwestern Taymyr (Telyatnikov 2010) and ***Alectorieto nigricantis – Diapensietum obovatae* Telyatnikov et al. 2013** from northwestern Yakutia (Telyatnikov et al. 2013).

Small plots of **Dryas tundras** often occur in dry wind-swept habitats above slopes, on sand-loamy soils. Field layer: 30—70 %, from 2—5 up to 10—15 cm; ground layer: 20—30 %, up to 1 cm. Dominant: *Dryas punctata*; abundant: *Salix nummularia, Polytrichastrum alpinum, Polytrichum juniperinum*, *Ditrichum flexicaule, Distichium capillaceum*, *Niphotrichum panschii*; common:

Cassiope tetragona, Pedicularis amoena, Oxytropis nigrescens, Artemisia borealis, Luzula confusa, Lychnis samojedorum, Minuartia arctica, M. rubella, Poa glauca, P. arctica, Bistorta vivipara, Tofieldia coccinea, Parrya nudicaulis, Abietinella abietina, Pohlia cruda, *Flavocetraria cucullata, F. nivalis, Cetraria islandica, Bryocaulon divergens, Alectoria nigricans, A. ochroleuca, Bryoria nitidula, Stereocaulon* sp., *Hypogymnia* sp., *Ochrolechia* spp., *Pertusaria* spp. These communities refer to the ass. ***Rhytidio rugosi-Dryadetum punctatae*** **Matveyeva 1998**, that is common for Taymyr (Matveyeva 1998) and Yakutia (Telyatnikov et al. 2013, 2015).

Dwarf birch sedge-dwarf shrubs moss tundras occur in river or stream valleys, on moist sandy or loamy soils. Shrub layer: 20—30 %, 15—20 cm; field layer: 50—60 %, 20—30 cm; ground layer: 80—95 %, 2—3 cm. Dominant: *Betula exilis*, *Salix pulchra, Cassiope tetragona, Vaccinium uliginosum* ssp. *microphyllum, Carex concolor, Aulacomnium turgidum, Tomentypnum nitens*, *Hylocomium splendens* var. *obtusifolium*; abundant: *Dryas punctata, Eriophorum polystachion*, *Ditrichum flexicaule, Distichium capillaceum*, *Dicranum* spp., *Sphagnum* spp., *Ptilidium ciliare*; common: *Salix glauca, S. reptans, Ledum decumbens, Andromeda polifolia, Carex rariflora, Bistorta vivipara, Pedicularis capitata, P. albolabiata, Sanionia uncinata, Polytrichum juniperinum, Cetraria islandica, Dactylina arctica*. Syntaxonomical position is uncertain, probably in the alliance ***Carici concoloris-Aulacomnion turgidi*** **Telyatnikov et al. 2013** described for mire tundras in northwestern Yakutia (Telyatnikov et al. 2013).

References

Aleksandrova V.D. 1980. The Arctic and Antarctic: their division into geobotanical areas (Komarov lecture 29). Cambridge Univ. Press, Cambridge. 247 p.

CAVM Team. 2003. Circumpolar Arctic Vegetation Map (1:7,500,000 scale). U.S. Fish and Wildlife Service, Anchorage, Alaska.

Matveyeva N. V. 1994. Floristic classification and ecology of tundra vegetation of the Taymyr Peninsula, northern Siberia // J. Veg. Sci. Vol. 5, N 6. P. 813—838.

Matveyeva N. V. 1998. Zonation in plant cover of the Arctic. RAS, Proceedings of Komarov botanical institute, 21. St.-Petersburg. 220 p. (In Russian)

Pospelova E. B., Pospelov I. N. 2014. Floristic investigations in south tundra subzone of east Taimyr // Turczaninowia 17 (2). P. 61–73. (In Russian)

Telyatnikov M. Yu. 2010. Characteristic of syntaxa of the class Loiseleurio-Vaccinietea of the north-eastern part of the vicinities of lake Pyasino (south-west of the North Siberian Plain) // Plant Life of Asian Russia. N 1(5). P. 33—41. (In Russian)

Telyatnikov M. Yu., Troeva E. I., Gogoleva P. A., Cherosov M. M., Pestryakova L. A., Pristyazhnyuk S. A. 2013. Syntaxonomy of tundra and meadow vegetation in the area of middle and lower reaches of the Anabar river (part of the Arctic Yakutia) // Plant Life of Asian Russia. N 1(11). P. 65—85. (In Russian)

Telyatnikov M. Yu., Troeva E. I., Pristyazhnyuk S. A., Gogoleva P. A., Cherosov M. M., Pestryakova L. A. 2015. Vegetation in the lower reaches of Indigirka river (zonal and mountain tundras) // Turczaninowia 18(4). P. 128—168. (In Russian)

Yurtsev B. A. 1994. Floristic division of the Arctic // J. Veg. Sci. Vol. 5, N 6. P. 765—776.3.

3. About vegetation data in high mountain zone (‘goltzy’ deserts and sub-nival zone) in Kola Peninsula and Svalbard

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Introduction. The vegetation of mountains beyond the polar circle, as well as in arctic tundra are well studied (Cooper, 1986; Sieg et al., 2006; Sieg et al., 2009 et al.), but we still don’t have enough data about the plant cover on highest position on mountain in the Arctic, namely in «goltzy» and sub-nival zones. Some relevés were presented in M. S. thesis about the Brooks Range

(Kasanke, 2019). Few amounts of actual data are connected with inaccessibility of mountainous arctic areas and in general with a poor knowledge on the "arctic mountain landscape" concept.

The purpose of our study was description and comparison of the vegetation in the highest areas in mountain (Khibiny and Lovozersky mountains) in Murmansk Region (Russia) and in mountains of Svalbard.

Materials and Methods. The Khibiny and Lovozersky Mountains are located in the center of the Kola Peninsula, with relative elevation 900–1000 m. The highest peak of Khibiny is the Yudychvumchorr (1201 m, or 3940 ft), and of Lovozersky Mountains – the Angvundaschorr (1120 m, or 3673 ft). The features of mountain landscape are the plateau-like summits with steep slopes, small firn fields in high canyons. Both Khibiny and Lovozersky Mountains are located in boreal forest zone (taiga). The vegetation zones include northern taiga (forest) zone, (100–450 m a.s.l.; mountain birch forest zone (450–600 m a.s.l.); mountain tundra zone (600–900 m a.s.l.); 'goltzy'or 'goltzovy' desert zone (900–1200 m a.s.l.).

Svalbard is an arctic archipelago with numerous islands; the biggest are Spitsbergen, Nordaustlandet and Edgeøya. The territory is mainly mountainous and covered by glaciers (to 60% of area). The tallest peak is Newtontoppen (1717 m or 5633 ft). Svalbard lies in arctic tundra and polar deserts.

Relevés were collected in southwestern part of Svalbard, in Mountain Sverdruphamaren, Pyramiden mountain and on the peak Olav in Grønfjördfjellet ridge, in 2018, and in Khibiny and Lovozersky Mountains, in 2014–2018.

73 relevés in total were made in 'goltzy' and sub-nival zone. 28 relevés – in mountains of Svalbard, from 250 to 750 m a.s.l., and 65 – in Khibiny and Lovozersky Mountains, at from 800 to1200 m a.s.l. Plot size was 10 x 10 m, samples of plants and lichens which could not be determined in the field were taken for identification in the laboratory. We used Braun-Blanquet methodology for vegetation description. All relevés were collected with geo-positioning and description of habitat conditions (namely, altitude above sea level, slope exposure, slope angle, substrate characteristic). Nomenclature of plants follows the Cherepanov (1995) for mosses – Ignatov et al. (1992), for liverworts – Konstantinova et al. (1992), lichens – Santesson (2004). All relevés have been entered in Excel database.

Results. Vegetation in 'goltzy' desert in Khibiny and Lovozersky Mountains looks like scattered mosses-and-lichens cushions or sedge tufts, size of a few squire decimeters, with small portion of dwarf shrubs and grasses. Most common among grasses are *Juncus trifidus* and *Carex bigelowii*, among dwarf shrubs – *Vaccinium vitis-idaea, Empetrum hermaphroditum, Dryas octopetala, Silene acaulis, Harrimanella hypnoides*, *Luzula arcuata* and *Saxifraga oppositifolia*. *Racomitrium lanuginosum, R. canescens*, *Andreaea rupestris* are among commonest and dominant mosses, *Gymnomitrion concinnatum* and *G. corallioides* – among liverworts. Lichens *Flavocetraria nivalis, F. cucullata, Alectoria nigricans, A. ochroleuca* and *Ochrolechia frigida* are among dominants. For now, there were identified 112 species at all, 35 vascular plants, 14 mosses, 24 liverworts, and 39 lichens.

In mountains of Svalbard, vegetation of 'goltzy' and sub-nival deserts looks like small moss-and-crustose lichens with small portion of vascular plants. Among vascular plants the most common among forbs – *Saxifraga cernua, S. hyperborea, S. oppositifolia* and *Cerastium arcticum*., among mosses – *Racomitrium lanuginosum, R. canescens*, *Andreaea rupestris, Leptobryum pyriforme, Polytrichastrum alpinum* and *Dicranoweisia crispula*, among lichens – *Cetrariella delisei, Stereocaulon alpinum, Ochrolechia frigida* and crustose soil-covering lichen (*Psoroma hypnorum, Baeomyces placophyllus, Caloplaca* spp. etc.). *Nostoc commune* algae often cover the substrata.

For now, there were identified 170 species in total, 32 species of vascular plants, 34 mosses, 19 liverworts, and 85 lichens.

Conclusion. For the first time there were collected data on vegetation of the hard-accessible areas of highest position in mountains in Murmansk Region and Svalbard, and the diversity and species number there proved to be rather high. The species composition of 'goltzy' deserts in Murmansk Region differs essentially from this in sub-nival zone of Svalbard: Jaccard coefficient for lists of vascular plants is 0,08; that is due to different zonal and geographical position of areas. Difference in structure of plant cover, namely lower portion of fruticose lichens in sub-nival vegetation in Svalbard, is mainly due to effect of reindeer pasture.

References

Cherepanov, S. K. 1995. Vascular plants of Russia and neighboring countries (in boundaries of former USSR). S.-Pb, 992 p. [Сосудистые растения России и сопредельных государств (в пределах бывшего СССР). С.-Пб. 992 с.].

Ignatov, M. S. & O. M. Afonina. 1992. Check-list of mosses of the territory of former USSR. Arctoa: 1(1–2):1–187. [Игнатов М.С., О. М. Афонина. 1992. Список мхов территории бывшего СССР // Arctoa. 1992. Т. 1, № 1-2. С. 1–85].

Konstantinova, N.A., A. D. Potyomkin & R. N. Schljakov. 1992. Check-list of liverworts and hornworts of territory of former USSR. Arctoa 1(1–2):87–127. [Константинова Н. А., Потемкин А. Д., Шляков Р. Н. 1992. Список печеночников и антоцеротовых территории бывшего СССР // Arctoa. 1992. Т. 1, № 1–2. С. 87–27].

Santesson, R., R. Moberg, A. Nordin, T. Tonsberg, O. Vitikainen. 2004. Lichen–forming and lichenicolous fungi of Fennoscandia. Uppsala. 359 p.

Sieg, B., Drees, B., & Daniëls, F. J. A. (2006). Vegetation and altitudinal zonation in continental West Greenland. *Meddelelser Om Grønland, Bioscience*, *57*, 1–93.

Sieg, B., Drees, B., & Hasse, T. (2009). High-altitude vegetation of continental West Greenland. *Phytocoenologia*, *39*(1), 27–50. doi:10.1127/0340-269X/2009/0039-0027

4. Status and perspective of the Russian Arctic Vegetation Archive

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Russian Arctic vegetation datasets owned by several RAS institutes were previously reviewed as a part of the AVA project (Matveeva et al., 2017; Ermokhina, 2018). Datasets of relevés meeting requirements for classification of vegetation using Braun-Blanquet approach were selected for the Archive. At the moment the work is mainly focused on datasets of Komorov Botanical Institute, datasets deal with West Siberian tundra vegetation and historical data collected by A. Dedov.

The RFBR grant (№ 18-04-01010) for classification of vegetation and spectral analysis of remote sensing imagery for geobotanical division of West Siberian Arctic was developed by a group of geobotanists (K. Ermokhina, N. Koroleva, M. Telyatnikov and E. Troeva) in 2018. The assigned activities include import of regional relevés into the AVA. The group provides technical support for the authors including transformation of Excel tables with relevés and environmental data into AVA format and taxonomic ids unification according to the Panarctic Species List. Datasets with geobotanical information from other arctic regions of Russia are also involved in the process.

***Table 1**. List of datasets in the Russian Arctic Vegetation Archive*

Year	**Location**[П1]	**Authors**[П2]	**Number of relevés**	**Bioclimatic subzone***
1928-1939	Malozemelskaya Tundra, Timanskaya Tundra	Dedov A.	up to 476	Subzone E
2018	67°00'13.04"N 66°35'00.19"E (Polar Urals)	Khitun O.	137	Subzone E
2018	67°28'33,42"N 66°57'05,16"E (Polar Urals)	Khitun O.	100	Subzone E
2018	67°59'23,32"N 67°37'42,23"E (Polar Urals)	Plusnin S.	85	Subzone E
2018	68°51'47,21"N 66°42'47,61"E (Baidara Bay)	Zemlianskii V.	80	Subzone D
2018	66°54'11,92"N 65°20'37,25"E (Polar Urals)	Telyatnikov M.	75	Subzone E
2018	67°05'25,43"N 65°56'00,71"E (Polar Urals)	Kudr E.	41	Subzone E
2018	67°05'25,43"N 65°56'00,71"E (Polar Urals)	Telyatnikov M.	67	Subzone E
2018	68°04'02,22"N 65°50'26,90"E (Polar Urals)	Kudr E.	34	Subzone E
2018	68°04'02,22"N 65°50'26,90"E (Polar Urals)	Telyatnikov M.	46	Subzone E
2018	68°27'22,64"N 66°19'20,72"E (Polar Urals)	Kudr E.	29	Subzone E
2018	68°27'22,64"N 66°19'20,72"E (Polar Urals)	Telyatnikov M.	33	Subzone E
2017	68°12'57,28"N 75°13'52,93"E (Tazovsky Peninsula)	Khitun O.	66	Subzone E
2017	72°28'33,40"N 70°9'0,36"E (Northern Yamal)	Ermokhina K., Telyatnikov M., Troeva E.	105	Subzone C
2017	70°13'47,23"N 70°50'3,27"E (Neyto lake, Yamal)	Koroleva N.	73	Subzone D
2017	70°13'47,23"N 70°50'3,27"E (Neyto lake, Yamal)	Zemlianskii V.	81	Subzone D
2017	68°26'7,45"N 70°4'22,77"E (Southern Yamal)	Koroleva N.	98	Subzone E
2017	68°26'7,45"N 70°4'22,77"E (Southern Yamal)	Zemlianskii V.	55	Subzone E
2017	67°20'44,14"N 72°7'15,35"E (Nakhodka bay, Southern Yamal)	Koroleva N.	119	Subzone E
2017	67°20'44,14"N 72°7'15,35"E (Nakhodka bay, Southern Yamal)	Zemlianskii V.	32	Subzone E
2017	71°13'4,79"N 79°16'25,48"E (Northern Gydan)	Ermokhina K., Telyatnikov M., Troeva E.	150	Subzone C
2017	71°54'49,77"N 78°40'34,23"E (Khalmyer Bay)	Ermokhina K., Telyatnikov M., Troeva E.	162	Subzone C
2017	69°57'30,45"N 78°47'26,06"E (Tanama river, Gydan)	Khitun O.	108	Subzone D

Year	Location[П1]	Authors[П2]	Number of relevés	Bioclimatic subzone*
2017	70°5'29,63"N 75°37'23,58"E (Parisento lake, Gydan)	Khitun O.	120	Subzone D
2012	68°18'55,70"N 71°21'38,00"E (Myam, Southern Yamal)	Ermokhina K.	4	Subzone E
2005	70°23'9,80"N 68°27'15,60"E (Bovanenkovo, Yamal)	Ermokhina K.	95	Subzone D
2005	70°7'15,20"N 68°19'12,30"E (Khalevto lake, Yamal)	Ermokhina K.	241	Subzone D
2011	70°17'4,10"N 68°55'0,90"E (The research station *"Vaskiny Dachi"*, Yamal)	Ermokhina K.	128	Subzone D
2012	71°14'12,40"N 72°7'8,40"E (South Tambey gas field, Northern Yamal)	Ermokhina K.	21	Subzone D
2012	69°56'48,80"N 74°6'54,90"E (″Geophysics″ gas field, Gydan)	Ermokhina K.	7	Subzone D
2012	70°53'16,70"N 74°35'34,80"E (″Salma″ gas field, Gydan)	Ermokhina K.	14	Subzone C
2012	72°39'41,40"N 72°56'24,50"E (Obskaya Bay, Nothern Yamal)	Ermokhina K.	6	Subzone C
2012	72°8'0,30"N 72°33'15,00"E (Tasiyskoe gas field, Northern Yamal)	Ermokhina K.	8	Subzone C
2011	66°49'47.7"N 65°56'43.3"E (Kharp, Polar Urals)	Ermokhina K.	73	Subzone E
2015-2016	68°31'46.8"N57°18'57.0"E (Bolshezemelskaya Tundra)	Lavrinenko O.&I.	136	Subzone D
2001-2007	68°49'15.0''N 54°15' 23.0''E (Malozemelskaya Tundra)	Lavrinenko O.&I.	99	Subzone E
1998 - 2016	68°28’20”N 57°13’49”E (Malozemelskaya Tundra, Bolshezemelskaya Tundra)	Lavrinenko O.&I.	129	Subzone E
2001 – 2014	68°51’45”N49°13’38”E (Malozemelskaya Tundra, Bolshezemelskaya Tundra)	Lavrinenko O.&I.	71	Subzone E

**CAVM Team, 2003*

References

Matveyeva N., Koroleva N., Lavrinenko O., Lavrinenko I., Kuljugina E., Ermokhina K., Telyatnikov M., Zanokha L., Cherosov M., Troeva E., Kholod S., Razzhivin V. Overview Progress on the AVA in Russia // AVA workshop / ASSW 2017, Prague , April 2017

Ermokhina K. The next steps for bringing Russian Arctic vegetation datasets into the AVA // The Arctic Biodiversity Congress, Rovaniemi, October 2018

CAVM Team. 2003. Circumpolar Arctic Vegetation Map. (1:7,500,000 scale), Conservation of Arctic Flora and Fauna (CAFF). U.S. Fish and Wildlife Service, Anchorage, Alaska

5. Carbon assimilation, respiration and allocation in Arctic tundra vegetation: species-specific differences

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To obtain more accurate future climate predictions, the contribution of terrestrial ecosystems should be considered because of their substantial impact on carbon (C) sequestration and emissions and, as a consequence, on climate warming trends. The uncertainty comes from multiple, inter-linked positive and negative feedbacks activated by the interaction of the abiotic climate drivers with metabolic processes at plant and soil level. This is particularly true for Arctic regions due to amplified warming and enormous amount of C stored in permafrost soils. Climate change and, in particular, global warming impacts the balance between C assimilation and respiration at the ecosystem level in several ways. Firstly, increasing air and soil temperatures thaw the permafrost soil increasing the soil active layer depth, and consequently the amount of organic C available for microbial decomposition. Secondly, increasing temperatures and atmospheric CO_2 concentrations may have multiple interacting effects on photosynthetic activity, by modulating future behavior of tundra higher plant species. Moreover, the variation in photosynthetic C assimilation at plant level can affect C allocation belowground and in turn influence the rate of soil respiration through priming decomposition of the soil organic matter. The ultimate aim of our research in Arctic tundra was to disentangle the contributions of tundra ecosystem gas exchange components to the C balance and to evaluate how these components will be affected by future climate change. We assessed the response of plant and soil CO_2 efflux and CO_2 assimilation to climatic and biotic drivers in the most abundant vegetation types of Ny-Ålesund arctic tundra (Svalbard Islands, Norway). The experiment was conducted in 2013 and 2018 growing seasons. In 2013 physiological characterization of the most representative higher plant species was conducted, while allocation patterns of recently assimilated C and its residence time in vegetation-soil-atmosphere continuum in target communities was assessed with stable isotope pulse labelling/chasing approach in 2018.

Leaf net CO_2 assimilation of *Salix Polaris*, *Dryas octopetala*, *Saxifraga oppositifolia* and *Carex rupestris* was assessed at different atmospheric CO_2 concentrations, light intensities and air temperatures. While all species responded, as expected, positively to CO_2 fertilization reaching assimilation rates comparable to temperate vegetation, response to warming was negative and species-specific. Diurnal periodicity in assimilation was tested on some species and not confirmed but all species responded promptly to the variation of the light intensity. *D. octopetala* and *S. Polaris* were identified as the most productive species in terms of assimilated C. At the same time soil and plant CO_2 efflux in the dark were also among the highest for these two species. The growing season of *D. octopetala* appeared to be considerably shorter in comparison to other species, which should be considered while accounting for individual input of the species to the seasonal C balance.

Allocation of recently assimilated C in four vegetation communities dominated by *Salix Polaris*, *Dryas octopetala*, *Carex rupestris* and moss, respectively, was assessed by pulse labelling the vegetation in $^{13}CO_2$ enriched atmosphere. Dynamic of ^{13}C was traced for 21 days in green and woody tissues and in respiration flux of microbial, leaf and root origin, where applicable. Compound-specific analyses on plant tissues were done in order to discriminate between allocation of ^{13}C to fast and slow cycling pools. Preliminary results suggest that labelled ^{13}C remains preferably in aboveground tissues, with roots being just slightly enriched in ^{13}C. Labelled

^{13}C was completely absent in soil of plots with moss. Mean residence time of C in pools and fluxes appears to be species-specific. Analyses on the label allocation to soil and microbial community ongoing and will give valuable information on the potential of different arctic species to impact the soil organic matter decomposition processes through priming mechanisms.

Summarizing, different tundra plant species contributed differently to the local C balance. Efficiency of arctic plants CO_2 assimilation is expected to rise with increase of atmospheric CO_2 concentrations. Ability to acclimate to higher temperatures will determine the final sequestration potential of the species, which was not confirmed in case of the short-term exposure.

6. Legacies of boreal forests in Siberia under constraining fires and climate change

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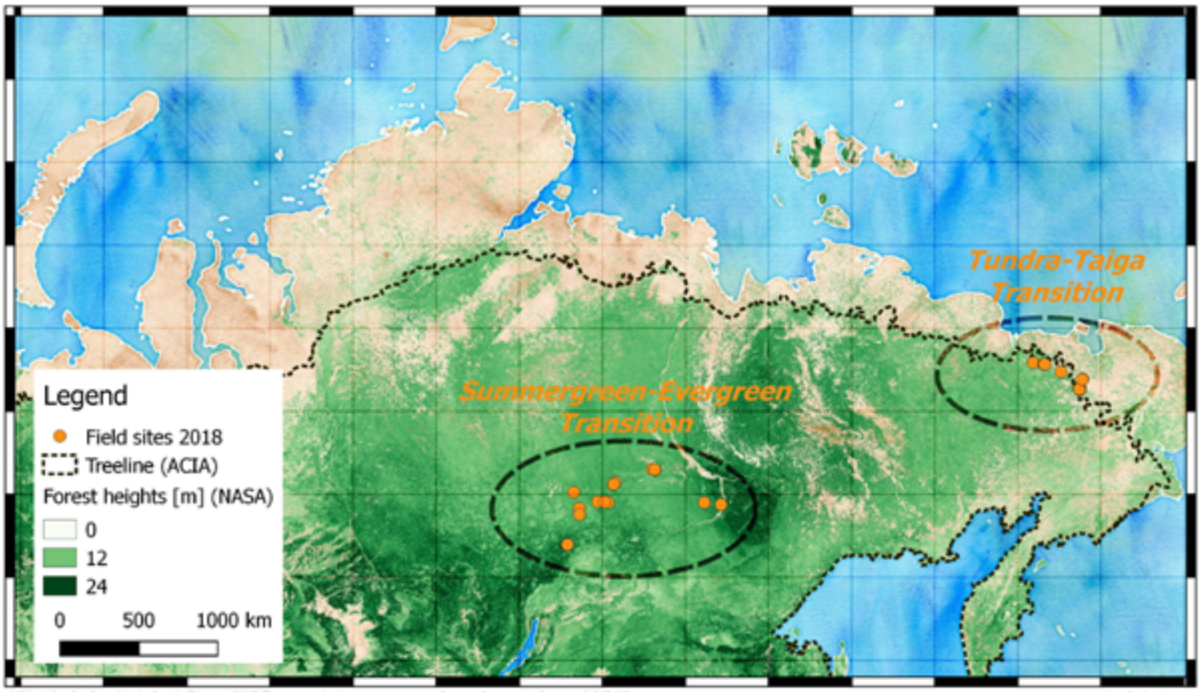
Background. Ecosystem services of boreal forests are of critical importance for humanity and differ markedly between evergreen and summer-green needle-leaf forests. Within the framework of the European Research Council (ERC) consolidator grant *GlacialLegacy* we will address the timely questions “Why is northern Asia dominated by summer-green boreal forests?" and “How will these larch forests change in the future?” with a coherent empirical and modelling approach integrating pollen data synthesis, sedimentary ancient DNA analyses, vegetation & biophysical survey and vegetation modelling.

In mixed forest stands, light-demanding *Larix* trees are outcompeted by evergreen taxa. It is an open question as to how *Larix* forests, once established, hinder their replacement by evergreen forests and thus maintain vegetation–climate disequilibrium. This self-stabilization most likely results from the unique interactions between vegetation, fire, permafrost, and climate. However, a small amount of modelling evidence suggests that feedbacks only provide weak protection for larch forests against evergreen taxa invasion. The inference of feedbacks is strongly dependent on the processes that are incorporated and their parameterization, requiring a broader empirical base than is currently available for northern Asia. Therefore, we aim to quantify the feedbacks in the coupled forest-fire–permafrost–climate system along broad environmental gradients

Study sites. Our fieldwork in the summer of 2018 (Fig. 1) focused on the tundra taiga transition zone in North-Eastern Siberia (Chukotka) for tundra associations that are successively replaced by summer-green larches along a bioclimatic gradient. We extended this gradient in Yakutia to capture the southwestwardly replacement of summer-green larch-dominated forests by evergreen taxa (*Picea*, *Pinus*, *Abies*), and sites having different disturbance histories (fire, wind throw, land-use). At each of the 64 sites visited, we conducted surveys of three 2 x 2-m vegetation plots for each dominant vegetation type (>30% cover) within a circular area with a radius of 15 m and if trees were present we recorded full forest inventories (sampling adapted from Kruse et al. 2016). Plant material was collected from tree individuals and 2 x 2-m surface vegetation plots for biomass analyses and modern genetic analyses. For three-dimensional reconstructions of vegetation structure images (RGB, RG-NIR) were taken with an unmanned aerial vehicle (UAV). We characterized the soil by measuring different layers and transition zones from top of the plant canopy to the permafrost table, recorded temperature and humidity profiles and took soil samples. All samples were brought to Potsdam for further processing in our laboratories.

Weather station set up. To understand how larch stands modify the local hydrological and thermal conditions and whether this protects permafrost from further degradation further understanding of the heat and water exchange between the atmosphere, larch forests and the permafrost is needed. The installation of two microclimate stations and soil temperature sensors, as well as the sampling and describing of the forest and soil types across a transect in North-Eastern Siberia will provide data to study and understand the heat and water transfer processes in larch dominated boreal forest areas. Temperature sensors were buried in the ground in order to monitor the thermal state of the active layer and permafrost. The measurement set-up allows the calculation of a full energy and water balance. Additionally, two climate stations were set up in Chukotka and Southern Yakutia (Fig. 2) to collect meteorological field data such as temperature, humidity, radiation and wind data for at least the duration of one year.



ACIA: Walker DA, Raynolds MK, Daniëls FJA et al. (2005) The circumpolar Arctic vegetation map. Journal of Vegetation Science, 16, 267-282.
NASA: Simard, M., N. Pinto, J. B. Fisher, and A. Baccini (2011), Mapping forest canopy height globally with spaceborne lidar, J. Geophys. Res., 116, G04021, doi:10.1029/2011JG001708.
Background data by OpenStreetMap, under CC BY SA https://creativecommons.org/licenses/by-sa/3.0/

map created by Stefan Kruse

Figure 1. *Overview map showing the field sites visited during the campaign in 2018.*

Preliminary results. The 64 analyzed plots were situated at altitudes between 94 to 887 m a.s.l. with a mean slope of 1 to 4.7° and covering all slope aspects. The analyzed tundra plots (N=17) near Lake Ilirney (67.40° N, 168.35° E) were of a variety of tundra assemblages: mountain tundra grows in harsh environments on stony and rubbly screes with a poor vegetation cover by *Dryas* sp., *Vaccinium uliginosum*, *V. vitis-idaea* or *Empetrum nigrum*, and in more favorable, wetter areas denser, tussocky *Eriophorum* communities prevail, and steep slopes were dominated by *Pinus pumila* with 60-80% coverage. Near the lake and westwards in the direction of the Kolyma River, larch-forest stands (*Larix cajanderi*) (N=24) reached up to 55% coverage. The moss and moss-lichen-rich forest floor was dominated with typical tundra dwarf-shrub species (*Betula exilis*, *Vaccinium uliginosum*, *V. vitis-idaea* or *Ledum palustre*) and larger shrubs <20% *Salix spec.* and <5% *Pinus pumila* occur. In contrast, up to 70% was covered in southeastern, mixed-coniferous forests (N=23) visited on the transect between Yakutsk (62.08° N, 129.62° E) to Lake Khamra (59.97° N, 112.96° E). Here, forests were dominated by *Larix gmelinii* <60%, mixed with other tree species: tree-forming *Salix* spp. (<30%), *Picea obovata* (<30%), *Betula pendula* (30%) and *Pinus sylvestris* (<20%) that grows together with *P. sibirica* at the southernmost areas near Lake Khamra at which also *Abies sibirica* was observed on one plot with a cover of 8%. Further, stands were dominated by *Picea obovata* with 30-50% cover but also mixed with *Larix* <10%, or by *Pinus* *sylvestris and P. sibirica* with 15-30%. At some stands, we found clear signs of recent or recurrent fires events, either fire scars, burnt bark and/or cohort-like recruits.

The first results from 3D reconstructions using the UAV imagery show that our field sampling approach (forest plots of radius of 15 m) are representatively capturing the tree stands, or the field plot information could be upscaled using these 3D-forest reconstructions (e.g. Fig. 2). Furthermore, from the recovered point clouds, single-tree information and forest metrics can be derived.

The soils were in general more deeply developed in southeastern forests than in the tundra-taiga transition zone at which we observed active layer depths of ~18-84 cm in the former compared to ~48-226 cm in the latter. The weather stations recorded data between July and November 2018 and will most probably provide a comprehensive view of the permafrost-vegetation interactions after the full year data is available.

References

Kruse, S. and Stoof-Leichsenring, K. R.: Keperveem - Past and present vegetation dynamics at the most eastern extension of the Siberian boreal treeline, in Russian-German Cooperation: Expeditions to Siberia in 2016, edited by P. P. Overduin, F. Blender, D. Y. Bolshiyanov, M. N. Grigoriev, A. Morgenstern, and H. Meyer, pp. 130–137, Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung , Bremerhaven, Germany, Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung , Bremerhaven, Germany., 2016.

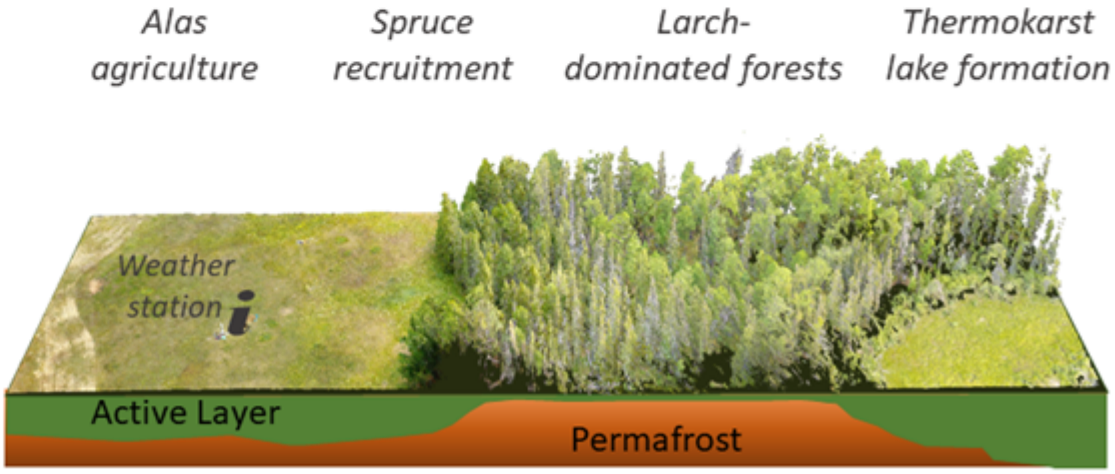


Figure 2. *Weather station at site EN18070 that is a line transect starting at the weather station and ending in the center of the forest patch.*

7. Syntaxa and spatial structure of the typical tundra vegetation cover, Vangurei Upland, European arctic, Russia

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In July, 2017, 33 complete and 50 reconnaissance relevés are executed in the territory of the key site in the typical tundra subzone (Bolshezemelskaya Tundra, height Vangureymusyur). The study area (16.5 km^2) differs in a larger variety of phytocoenosis of different syntaxon and their combinations. Relevés were obtained from on plots (5 x 5 or 10 x 10 m) according to Braun-Blanquet approach. The full specific structure of communities, including mosses and lichens were considered. Syntaxa have been named according to Braun-Blanquet approach. Nano -, micro and mesorelief, the sizes, a form and a ratio of elements also were described at the description. Soil pits were dug to 30-70 cm were obtained to characterize the soil.

Table 1. *Terrestrial Units of Vegetation (TUV), Vangurei Upland, European arctic, Russia.*

№	Class TUV	Syntaxa
1	***Luzulo confusae–Saliciohorietea nummulariae***	Cl. ***Luzulo confusae*–*Salicetum nummulariae*** Smirnova 1938 ***Empetrum hermaphroditum* – *Hylocomium splendens* –** ***Flavocetraria nivalis*** com. type ***Vaccinium myrtillus*** com. type ***Vaccinium uliginosum*** subsp. ***microphyllum*** com. type
2	***Dryado octopetalae–Hylocomiohorietea alaskani***	Ass. ***Dryado octopetalae*–*Hylocomietum splendentis*** Andreyev 1932
3	***Sphagno–Eriophoriohorietea vaginati***	Ass. ***Sphagno–Eriophoretum vaginati*** Walker et al. 1994 ***Betula nana–Hylocomium splendens*** com. type ***Betula nana–Pleurozium schreberi*** com. type ***Carex aquatilis subsp. stans–Salix phylicifolia*** com. type ***Geranium albiflorum–Salix glauca*** com. type ***Hylocomium splendens–Salix glauca*** com. type
4	***Rubo chamaemori–Dicraniohorietea elongati***	Ass. ***Carici rariflorae–Sphagnetum lindbergii*** (Andreyev 1932) Lavrinenko et al. 2016 Ass. ***Rubo chamaemori–Dicranetum elongati*** (Dedov 1940) Lavrinrnko et Lavrinenko 2016 Ass. ***Sphagno–Eriophoretum vaginati*** Walker et al. 1994 ***Carex juncella–Sanionia uncinata*** com. type
5	***Cariciohorietea aquatilis***	Ass. ***Caricetum aquatilis*** ***Carici stantis–Warnstorfietum exannulatae*** subacc. ***typicum*** (Bogdanovskaya-Gienef 1938) Lavrinenko et al. 2016 ***Carici stantis–Warnstorfietum exannulatae*** subacc. ***comaretosum palustris*** (Bogdanovskaya-Gienef 1938) Lavrinenko et al. 2016
6	***Equiseto arvensis–Saliciohorietea glaucae***	***Carex aquatilis*** subsp. ***stans*–*Salix phylicifolia*** com. type ***Geranium albiflorum*–*Salix glauca*** com. type ***Hylocomium splendens*–*Salix glauca*** com. type

Large-scale geobotanical maps of the study area were prepared in scales from 1: 2500 to 1: 25000. Given the complex spatial structure of vegetation, the main mapped units depending on the scale were the territorial units of vegetation (TUV): homogeneous phytocoenosis and heterogeneous (complexes and ecological series). Heterogeneous TER, according to the typology of I. Lavrinenko (2015), are combined into types, classes or divisions.

Below are the classes of territorial units of the watersheds that prevail by area in the study area. ***Dryado octopetalae – Hylocomiohorietea alaskani*** and ***Sphagno – Eriophoriohorietea vaginati*** classes prevail by area (35% each).

There were 6 classes of TUV in division of watershed (Lavrinenko, in press):

On the map of circumpolar vegetation in the Arctic (CAVM Team, 2003), the study area belongs to G3. *Non-tussock sedge, dwarf-shrub, moss tundra*. Vegetation is represented by ass. ***Carici arctisibiricae-Hylocomietum alaskani*** Matv. 1994 and cl. ***Scheuchzerio-Caricetea nigrae*** (Nordh. 1936) Tx 1937. These syntaxa correspond to 2 classes of TUV: ***Dryado octopetalae - Hylocomiohorietea alaskani*** and ***Rubo chamaemori - Dicraniohorietea elongati***, which occupy 49% (35% and 14% respectively) of the map. The first class occupies watershed surfaces and is a zonal type of community. The second class of includes peat-bog complexes.

References

CAVM Team. 2003. Circumpolar Arctic Vegetation Map. Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, AK.

Lavrinenko I. A. Typology of the territorial structure of vegetation for the purposes of large-scale mapping (on the example of Kolguev Island) // Geobotanical mapping. - 2015. - pp. 95-119. (Лавриненко И. А. Типология территориальных единиц растительности для целей крупномасштабного картографирования (на примере острова Колгуев) // Геоботаническое картографирование. – 2015. – С. 95-119.)

8. Ecological content classification of vegetation and its value for the protection of the habitats of the Arctic

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The increasing influence of anthropogenic factors on the vegetation cover of the Arctic leads to the reduction and destruction of natural habitats and reduces floristic diversity and stability of communities. In this regard, the inventory, classification and mapping of Arctic habitats can be confidently called the most important direction for the organization of the environmental system of the Arctic region.

The Arctic Vegetation Archive (AVA) and ecological-floristic classification of Arctic vegetation are the basis for the development of habitat typology. Each community of the rank of Association and below diagnoses a certain set of environmental conditions, which historically formed within the habitat. Diagnostic features of a syntaxon is determined by its species composition and ecology of the species.

The diversity of natural and climatic conditions of the Arctic, the distinct severity of zoning phenomena, leads to the fact that the ecological preferences of species often change during the transition, for example, from the southern tundra to the typical or Arctic (Secretareva 2004). This suggests that for accurate diagnosis of habitats is necessary to develop regional ecological scales, reflecting the ecological amplitude of species in relation to individual factors, in particular zonal positions (arctic, typical, southern tundras). In this regard, currently, in parallel with the development of ecological and floristic classification of Arctic vegetation, work is being carried out to analyze the existing ecological scales for Arctic species (Ramensky et al., 1956; Ellenberg, 1974, 1979; Secretareva, 2004, etc.) and estimation of distribution of each species in relation to ecological factors for different regions of the Arctic on the basis of materials from relevés.

This study will present the first versions of ecological scales for certain types of Eastern European tundra and provide a preliminary integrated assessment of ecological features of individual habitats on the basis of phyto-sociological diagnostics.

In the future, as a result of the research, it is planned to determine the ecological uniqueness of habitats of landscapes of the Russian Arctic and to develop models of their dynamics under the influence of anthropogenic influence and climate change, to prepare prognostic maps for different categories of habitats and landscapes. The most important result of the work will be the formation of the Red List of Russian Arctic Habitats on the basis of phyto-sociological indication for habitats under threat of existence for which the development of environmental measures is necessary.

References

Secretaryeva, A. N.. Vascular Plants of the Arctic and adjacent territories, 2004, p. 117-123

Ellenberg, H. Zieger werte der FSES as pflanzen Mitteleuropas / / geobotanica script. Gottingen, 1974, p. 1-122
Ellenberg, H. Zeigerwerte der Gefasspflanzen Mitteleuropas / / Scripta geobotanica. 1979. p. 1 -
Ramenskii, L. G., Tsatsenkin I. A., Chizhikov.N., Antipin, N. Ecological assessment of the grassland vegetation cover. M., 1956 p. 472

9. Taxonomic diversity gradients in Russian Arctic local floras

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Latitudinal and longitudinal changes in taxonomic characters were analyzed in 319 local floras (LFs) in the Russian Arctic. Studied variables and the expression of their latitudinal and longitudinal variation within the Russian Arctic on a whole and in the separate subprovinces are summarized (Table 1). Within the studied segment of latitudinal gradient most of changes can be described by linear regression with negative coefficients for the number of species, genera and families, but positive coefficients for the proportions of the leading families and genera. According to the regression analysis, on average, with 1˚ latitude northwards, the LFs diversity decreases by 16.7 species, by 7.9 genera and 2.6 families. Mean number of species in a family or genus practically does not change with increasing latitude but slightly increases eastwards. Parameters of biodiversity in various subprovinces exhibit similar tendencies in correlation with latitude although coefficients vary. The proportion of monocots does not correlate with latitude but slightly decreases eastwards. Proportions of various families change asynchronously. Although correlation with longitude was less pronounced, mean species richness was specific for many subprovinces, even within a certain subzone. These differences reflected both the diversity of landscapes and the history of flora formation.

The work was done within the research topic of Komarov Botanical Institute RAS “Variation of the plant cover in the Far North in space and time”.

***Table 1.** Coefficients of correlation between the floristic variables and geographical position of the local floras in the Russian Arctic on a whole and in various subprovinces.*

Variable	**Subprovinces**								
	all	**KK+KP+ SF**	**KP**	**UZ**	**YaG**	**T**	**AO+ Kh**	**YaK**	**CC+CW +CS+CB**
Number of LF	319	63	47	14	27	59	38	20	98
	Coefficients of correlation with latitude								
Number of species	**–0.62**	**–0.76**	**–0.90**	**–0.89**	**–0.66**	**–0.79**	–0.05	**–0.47**	**–0.45**
Number of genera	**-0.71**	**–0.82**	**–0.91**	**–0.92**	**–0.84**	**–0.86**	**–0.35**	**–0.63**	**–0.68**
Number of families	**–0.76**	**–0.92**	**–0.88**	**–0.94**	**–0.93**	**–0.87**	**–0.42**	**–0.70**	**–0.70**
The proportion of the 10 leading genera	**0.78**	**0.98**	**0.80**	**0.98**	**0.76**	**0.80**	**0.40**	**0.67**	**0.67**
The proportion of the 10 leading families	**0.80**	**0.98**	**0.80**	**0.99**	**0.91**	**0.89**	**0.64**	**0.71**	**0.72**
The proportion of Monocots	0.05	0.08	**0.54**	**0.70**	0.37	0.05	**-0.42**	–0.15	–0.12
	Coefficients of correlation with longitude								
Number of species	**0.28**	**–0.37**	**–0.36**	0.23	**0.49**	0.21	0.25	**–0.54**	**0.23**

Variable	Subprovinces								
Number of genera	0.03	**–0.35**	**–0.41**	0.42	0.25	0.12	0.31	**–0.61**	0.01
Number of families	-0.01	**–0.29**	**–0.49**	0.34	0.08	0.11	0.20	**–0.47**	–0.12
The proportion of the 10 leading genera	–0.02	0.14	**0.40**	-0.30	0.10	-0.03	-0.18	**0.46**	0.13
The proportion of the 10 leading families	-0.01	0.18	**0.52**	-0.39	-0.03	-0.05	-0.17	0.18	0.09
The proportion of Monocots	**-0.30**	-0.05	**0.39**	-0.14	-0.37	**0.28**	**-0.82**	0.09	**-0.26**
Number of species in the family:	**Coefficients of correlation with latitude**								
Poaceae	**-0.41**	**-0.70**	**-0.59**	-0.26	-0.32	**-0.61**	0.26	-0.42	0.05
Cyperaceae	**-0.62**	**-0.74**	**-0.85**	**-0.88**	**-0.52**	**-0.78**	**-0.49**	-0.37	**-0.56**
Asteraceae	**-0.65**	**-0.78**	**-0.86**	**-0.94**	**-0.65**	**-0.80**	-0.01	-0.39	-0.16
Caryophyllaceae	**-0.41**	**-0.64**	**-0.70**	**-0.75**	0.11	**-0.73**	0.29	-0.22	**-0.28**
Brassicaceae	0.05	-0.21	**-0.63**	0.09	**0.66**	**-0.26**	**0.49**	-0.14	**-0.22**
Ranunculaceae	**-0.48**	**-0.82**	**-0.78**	**-0.65**	-0.14	**-0.74**	0.07	0.0	**-0.29**
Rosaceae	**-0.64**	**-0.69**	**-0.87**	**-0.77**	**-0.60**	**-0.73**	-0.25	**-0.54**	**-0.40**
Salicaceae	**-0.67**	**-0.84**	**-0.51**	**-0.88**	**-0.84**	**-0.81**	-0.13	**-0.56**	**-0.48**
Saxifragaceae	0.06	**0.60**	**0.49**	-0.51	**0.71**	-0.05	**0.75**	0.35	-0.11
Scrophulariaceae	**-0.49**	**-0.78**	**-0.81**	**-0.83**	**-0.73**	**-0.71**	-0.05	-0.29	**-0.23**
Juncaceae	**-0.63**	**-0.62**	-0.10	**-0.62**	**-0.75**	**-0.73**	0.06	-0.07	**-0.67**
Fabaceae	**-0.40**	**-0.64**	**-0.87**	**-0.83**	-0.27	**-0.62**	0.05	**-0.54**	-0.11
Ericaceae	**-0.76**	**-0.87**	**-0.68**	**-0.89**	**-0.93**	**-0.83**	-0.29	-0.39	**-0.81**

Note: Subprovinces: KK, Kola; SF, Svalbard and Franz Josef Land; KP, Kanin-Pechora; UZ, Ural-Novaya Zemlya; YaG, Yamal-Gydan; T, Taimyr; AO, Anabar-Olenek; Kh, Kharaulakh; YaK, Yana-Kolyma; CC, Continental Chukotka; CW, Wrangel Chukotka; CS, Southern Chukotka; CB, Beringian Chukotka. Statistically significant (p<0,05) values are indicated in bold.

10. Flora and vegetation of the Matyuisale Cape in the arctic tundra subzone of the Gydansky Peninsula (West Siberian Arctic)

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The studied area is a part of the Gydansky Nature Reserve, however there were no botanical investigations in the area except for ours, which took place in July-August of 1989, long before the establishment of the reserve. The territory around the Matyuisale Cape and the Salem Lekabtambda River mouth (71° 56′ N, 76° 32′ E), on the Mamont Peninsula (in the NW part of the Gydansky Peninsula) was studied in detail according to local floras methodology (Khitun et al. 2016).

According to botanical-geographical approach (Yurtsev 1994) this territory belongs to the southern arctic tundra subzone or bioclimatic subzone C (CAVM team 2003). Our research (Khitun et al. 2007) and recent field work by Ksenia Ermokhina showed that this subzone occupies much less territory in the north of Gydansky Peninsula than it was shown in above mentioned schemes. Therefore, it is especially important that this flora exhibiting all characteristic features of the arctic tundra is studied in detail and belongs to the protected area.

The territory is a gently rolling plain dissected by numerous lakes and creeks, with various cryogenic relief forms (ice-wedge polygons, nonsorted circles, baidzharkhi-mounds). Mean July and August temperatures are 6.1°C and 7.1°C respectively.

Local flora “Matyuisale” contains 149 species of vascular plants from 66 genera and 27 families (taxonomy follows “The Arctic Flora of the USSR”). There is an increased proportion of the 10 leading families with particularly large role of *Brassicaceae* and *Saxifragaceae* (due to appearance of such species as *Draba micropetala, D. pauciflora, D.pseudopilosa, D. subcapitata, Saxifraga ursina, S. oppositifolia, S. spinulosa, S. hirculus)* are typical for the southern arctic tundra. The latitudinal structure of flora reflects its subzonal position. Arctic species (including proper arctic, meta-arctic and arctic-alpine species) contribute 69% of total flora. Many arctic species which are widespread and common in Taymyr, in West Siberian Arctic were found only in the very north of the Gydansky Peninsula (*Stellaria edwardsii, S. humifusa, Cerastium alpinum, Gastrolychnis affinis, G. apetala, Ranunculus affinis, R. sulphureus*). *Pedicularis amoena* and *Saxifraga spinulosa* are rare in this region’s flora. Only one boreal species was found (*Ranunculus monophyllus*) and here is its northernmost locality in West Siberia. Arctic-boreal species form 10% of the flora. Interestingly, their composition is practically the same along the zonal gradient in this region (*Sparganium hyperboreum, Stellaria crassifolia, Cardamine pratensis, Chrysosplenium sibiricum*, *Nardosmia frigida*). The proportion of hypoarctic species is low in this region (20%), but some species are still rather wide spread (*Ranunculus lapponicus, Pyrola grandiflora*, *Vacciunium vitis-idaea* subsp. *minus* and even *Salix lanata*).

The main feature of the vegetation cover in the arctic tundra is absence of dwarf-birch in zonal communities, it is replaced by the polar willow. Also, ericoid dwarf-shrubs are absent, except for *Vaccinium vitis-idea* which grows on southern slopes. Instead, *Dryas punctata* and arctic-alpine willows predominate in tundras. An important feature of the arctic tundra is increased participation of herbs in zonal communities.

Better drained flat hills are occupied by polygonal herbaceous (Dryas punctata-Salix polaris-Carex arctisibiricae) – moss tundra with abundance of arctic-alpine herbs (Lloydia serotina, Draba alpina, D. glacialis, D. fladnizensis, Cardamine bellidifolia, Luzula tundricola, L. nivalis, Parrya nudicaulis, Eutrema edwardsii, Saxifraga nelsoniana, S. cernua, S. hieracifolia, S. hirculus, Eritrichium villosum, Pedicularis oederi, Senecio atropurpureus). On less drained flat hills, peat horizon is thicker, ice-wedge polygons are more expressed and cotton-grass (Eriophorum polystachion) is predominated in herbaceous-Salix polaris- Eriophorum polystachion-moss tundra. Dominant moss species in both types are Tomentypnum nitens, Ptilidium ciliare, Aulacomnium turgidum, Hylocomium splendens.

Convex marginal parts of the flat hills are characterized by nonsorted circles pattern with high cover of bare clay (60%) and herbaceous–*Dryas-Salix nummularia*-moss tundras in surrounding cracks. Such herbs as *Papaver lapponicum* subsp. *jugoricum, Minuartia arctica, M. macrocarpa, Gastrolychnis apetala, Parrya nudicaulis, Pedicularis amoena* are common.

Only in this locality (from totally 11 studied by us) species richness of zonal communities was the same as that of the most favorable habitats – steep warm slopes (67-69 species). That was due to diversity of herbs. In grass-forb-*Salix polaris* communities on slopes such herbaceous species as *Poa alpigena* subsp. *alpigena, Festuca brachyphylla, Bistorta elliptica, Ranunculus borealis*, *Papaver lapponicum* subsp. *jugoricum, Hedysarum arcticum, Myosotis asiatica, Lagotis minor, Saussurea tilesii* are abundant. Salt marshes (laidy) are relatively rare habitats in Gydansky

Peninsula with specific communities dominated by the halophytes *Puccinellia phryganodes, Carex subspathacea, Carex glareosa,* and *Stellaria humifusa*.

Although species richness of this flora is somewhat less than of those of Taimyr floras in the same subzone, it is richer than Yamal floras and reflects all characteristic for arctic tundras peculiarities.

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References

Khitun O.V., Koroleva, T.M., Chinenko S. V., Petrovsky V. V., Pospelova E. B., Pospelov I. N. and Zverev A. A. 2016. Application of local floras for floristic subdivision and monitoring vascular plant diversity in the Russian Arctic. *Arctic Science*, 2: 103-126. doi: 10.1139/as-2015-0010.

Khitun O.V.; Zverev A.A., Rebristaya O.V. 2007. Changes of latitudinal geographical elements structure in local and partial floras in West Siberian Arctic// Botan. Zhurn.:92 (12),p. 1857—1873.

CAVM *Team*.2003. Circumpolar Arctic Vegetation Map. Scale 1:7500000. Conservation of Arctic Flora and Fauna (CAFF). Map No.1. U.S. / CAVM Team, Project Director D. A. Walker – Anchorage, Alaska, Fish and wildlife Service.

Yurtsev B.A. 1994. Floristic division of the Arctic// J. of Veg. Sci.: 5(6), p.: 765—776.

11. Vegetation of a small arctic Island at the limit of the Tundra Zone, Sosnovets Island in the White Sea

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Biodiversity of arctic islands is highly vulnerable under anthropogenic pressure and climate change. Many arctic islands, being almost inaccessible, are hitherto poorly investigated, so that we even don’t know the scale of presumed changes and possible losses in biodiversity. Our study and analysis of the vegetation of Sosnovets Island is to contribute to the knowledge about arctic island ecosystems.

Sosnovets Island (66°29' N, 40°41' E) is located 8 km southward the Arctic Circle, near the southeast part of the Tersky Coast, in the funnel-shaped opening of the White Sea to the Barents Sea. The area of the Island is 40.6 ha, and the shore height is 10–15 m above sea level. There is Sosnovets Lighthouse (in action since 1862) situated in the central part of the Island and a meteorological station in the southern part.

Sosnovets Island lies at the southern limit of tundra, and its placement to the tundra or the forest-tundra has been debated in various regional and circumpolar botanical and geographical schemes. In our work we consider the Sosnovets Island to belong to the southern tundra on the basis of its flora and vegetation.

We used the Braun-Blanquet approach for vegetation description and classification. 76 relevés were collected in August 2016, with geo-positioning and habitat descriptions. All of them were included in the TURBOVEG database. Herbarium specimens were deposited in Lomonosov Moscow State University (MW), University of Helsinki (H), Petrozavodsk State University (PTZ), Kandalakshsky Reserve (KAND), and Polar-Alpine Botanical Garden-Institute (KPABG).

Dwarf-shrub (*Empetrum hermaphroditum*) and lichen (*Cladonia arbuscula*, *Flavocetraria nivalis*) communities of class ***Loiseleurio procumbentis–Vaccinietea*** Eggler ex Schubert 1960 are formed on sandy deposits and occupy only a limited area – 0.4 ha (1 % of the Island’s area). Vegetation of the permafrost peatland prevail on the major part of the Island. Cloudberry-crowberry-lichen and cloudberry-crowberry communities prevail on drained elevated sites of the peatland. They are similar to those described from vast peatlands of East European tundra in the alliance ***Rubo chamaemori–Dicranion elongati*** Lavrinenko et Lavrinenko 2015, class ***Oxycocco-Sphagnetea*** Br.-Bl. et Tx. ex Westhoff et al. 1946. Nevertheless, the absence of characteristic species of the class ***Oxycocco-Sphagnetea,*** namely *Andromeda polifolia*, *Ledum palustre*, *Eriophorum vaginatum* and *Sphagnum* spp., is a characteristic feature of Sosnovets Island. This feature distinguishes the peatland of Sosnovets Island from peatlands on the mainland of Malozemelskaya and Bolshezemelskaya Tundras and brings it together with those on islands of the Barents Sea (Vaygach, Kolguev, and Dolgiy) where these species are absent or rare as well (Lavrinenko, Lavrinenko 2015).

The majority of cottongrass- and sedge-and-Sphagnum communities of the Island belong to the class ***Scheuchzerio palustris–Caricetea fuscae*** Tx. 1937. They occur in flarks and coastal extensions of dells draining the peatland. They are attributed to the suballiance ***Caricenion rariflorae*** Lavrinenko et al. 2016 of the alliance ***Sphagnion baltici*** Kustova in Lapshina 2010, due to the presence of characteristic species of these syntaxa: *Sphagnum lindbergii*, *S. balticum*, *Polytrichum jensenii*, *Eriophorum scheuchzeri* (Lavrinenko et al. 2016). Several sedge-Sphagnum dominated communities of the peatland flarks lack the abovementioned species but include *Straminergon stramineum*, *Warnstorfia exannulata*, *Epilobium palustre*. They are analogous to communities of the alliance ***Drepanocladion exannulati*** Krajina 1933. The communities of the suballiance ***Caricion rariflorae*** are widespread in the peatland flarks of the East European tundra, the communities of the north and high-altitude alliance ***Drepanocladion exannulati*** occur, although rarely, in flarks with flowing water (Lavrinenko et al. 2016).

Coastal vegetation of the Island belongs to intra-zonal classes ***Juncetea maritimi*** Br.-Bl. in Br.-Bl. et al. 1952 (alliances ***Puccinellion phryganodis*** Hadač 1946, ***Caricion glareosae*** Nordh. 1954, ***Armerion maritimae*** Br.-Bl. et De Leeuw 1936) and ***Ammophiletea*** Br.-Bl. et Tx. ex Westhoff et al. 1946 (alliance ***Agropyro–Honckenyion peploidis*** Tx. in Br.-Bl. et Tx. 1952). The grass species *Calamagrostis deschampsioides* is a characteristic feature of these communities. It has more eastern distribution in Fennoscandia, and is very rare on the Kola Peninsula.

The anthropogenic vegetation of Sosnovets Island is a result of the anthropogenic impact for more than 150 years and is quite diverse and extensive (5.0 ha, 12.3%). It takes the 2nd place on the Island, regarding its area, whereas the 1st place is taken by the vegetation of peatland. It is predominantly composed of alien meadow species (*Deschampsia cespitosa*, *Lathyrus pratensis*, *Trifolium repens*, *Alchemilla subcrenata*, *Vicia cracca*, *Ranunculus acris*). The invasive *Deschampsia cespitosa* occurs in the wet degraded flarks of the peatland and other species were found in moderately moist places.

Thus, the vegetation of Sosnovets Island is typical of the tundra zone and Sea shore. At the same time, due to the combination of the natural conditions and the long-term anthropogenic impact, the vegetation of Sosnovets Island has a high specificity among the small-size Arctic islands.

Keywords: vegetation; island vegetation; Braun-Blanquet classification; Murmansk Region.

References

Chernov, Y.I. & Matveeva N.V. 1979: (Regularities of zonal distribution of communities on Taimyr.) — In: Alexandrova, V.D. & Matveeva, N.V. (eds.), (Arctic tundra and high arctic tundras (polar deserts) of Taimyr): 166–200. Science Publishers, Leningrad. (In Russian.)

Lavrinenko, O.V. & Lavrinenko, I.A. 2015: (Communities of the class Oxycocco-Sphagnetea Br.-Bl. et R. Tx. 1943 in the East European tundras.) — Rastitelnost Rossii 26: 55–84. (In Russian with English summary.)

Lavrinenko, O.V., Matveeva, N.V. & Lavrinenko, I.A. 2016: (Communities of the class Scheuchzerio-Caricetea nigrae (Nordh. 1936) Tx. 1937 in the East European tundras.) — Rastitelnost Rossii 28: 55–88. (In Russian with English summary.)

12. Vegetation of the White Sea islands within the boreal zone: Porya Guba Archipelago, White Sea, Russia

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Insular ecosystems have a certain level of peculiarity because of their restricted size and isolation, which makes them suitable for biodiversity studying but also leads to their vulnerability under climatic changes and anthropogenic pressure. This research includes vegetation description and mapping.

The aim of the study is the vegetation diversity of the Porya Guba Archipelago (66°41'—66°51' N, 33°32'—33°56' E) in the White Sea, which has not been studied properly yet.. The study area is located within the Kandalaksha Strict Nature Reserve. It is located within the Baltic shield and affected by post-glacial rebound, which allows the study of succession. The territory is within the northern taiga (boreal) zone, nevertheless tundra-like communities are formed on some islands.

Major part of archipelago is covered by pine (*Pinus sylvestris*) and spruce (*Picea × fennica*) boreal forests and crowberry (*Empetrum nigrum* ssp. *hermaphroditum*) tundra-like communities. Vegetation is also represented by mires, coastal vegetation, rock communities and secondary anthropogenic communities covered a smaller territory.

The field work was carried out in 2008-2013, 2015 by Mikhail Kozhin and in 2017, 2018 by Ekaterina Kudr. Phytosociological data were collected according to the relevé method of sampling vegetation at sites within areas of homogeneous microtopography and moisture. Plots of 400 sq. m. were used for the large-scale communities, mostly forests, and small-scale communities, tundra-like communities, mires and meadows. Phytosociological studies focused on the main types of the islands' vegetation. In total, 226 relevés were obtained. All of them were included in the TURBOVEG database. Relevés were classified by means of Braun-Blanquet approach. Vegetation map of the Archipelago was compiled according to a set of relevé and field observations. High resolution orthophoto map was used to determine borders of plant communities. The map legend was designed according to plant community classification based on the Russian ecologic-phytocoenotic approach. The main mapping units for homogenous vegetation correspond to associations or groups of associations, for heterogenous complexes, and ecological series. Vegetation mapping was done with ArcGIS software. Collected specimens of vascular plants, mosses, liverworts, and lichens were deposited in the herbaria of Lomonosov Moscow State University (MW), University of Helsinki (H), Kandalaksha State Nature Reserve, and Polar-Alpine Botanical Garden-Institute (KPABG).

Forest communities belong mainly to the class *Vaccinio-Piceetea*. Oligotrophic pine forests were attributed to the alliance *Cladinio stellaris – Pinion sylvestris*; mesic spruce, pine and secondary birch forests – to the alliance *Empetro – Piceion obovatae*; palludified spruce forests with horsetail – to the alliance *Piceion excelsae*; wooded oligotrophic mires – to the alliance *Vaccinio uliginosi – Pinion sylvestris* alliance; birch krummholz — to the alliance *Empetro hremaphroditi – Betulion pumilae* alliance; eutrophic spruce forests with rich herb layer — to the class *Mulgedio aconitetea* (alliance *Mulgedion alpini*).

Tundra-like communities with dwarf-shrubs and lichens belong to the class *Loiseleurio procumbentis – Vaccinietea* (alliance *Phyllodoco – Vaccinion myrtilli*). However, the peatland communities are closely related in terms of species composition to class *Oxycocco-Sphagnetea.*

Mire communities are represented by three classes: Oxycocco – Sphagnetea, Scheuchzerio palustris – Caricetea fuscae, and Betulo carpaticae – Alnetea viridis. Oligotrophic Sphagnum bogs were attributed to the class Oxycocco – Sphagnetea (alliance Oxycocco microcarpi – Empetrion hermaphroditi). Within the class Scheuchzerio palustris – Caricetea fuscae minerotrophic brown moss fens were attributed to the alliance Stygio – Caricion limosae and sedge-moss rich fens – to the alliance Sphagno warnstorfii – Tomentypnion nitentis. Swamp willow thickets belong to the class Betulo carpaticae – Alnetea viridis (alliance Salicion phylicifoliae).

Coastal vegetation was attributed to the classes *Juncetea maritima* (alliance *Caricion glareosae*) and *Ammophiletea* (alliance *Agropyro-Honckenyion peptiloidis*) and various associations. Plant communities of open rocks close to *Juncetea trifidi* (*Carici – Juncion trifidi*).

Anthropogenic vegetation of the archipelago is represented by meadow (class *Molinio – Arrhenatheretea,* alliance *Arrhenatherion elatioris*).

Thus, according to results of our preliminary study plant communities of the Archipelago were attributed to 15 alliances, 14 orders, and 10 classes. Vegetation is distinguished by great diversity and complex horizontal vegetation structure. In order to perform spatial analysis of vegetation and to estimate impact of different factors on its formation we created vegetation map of the territory. The map represents 209 islands, total area of the mapped islands equals 521 ha. Map legend includes 51 units, that correspond to associations or groups of associations according to the Russian ecologic-phytocoenotic approach. The highest diversity of plant communities is observed within forests, mires and tundra-like communities. Forests cover significant area on islands in the inner part of the Archipelago, while tundra-like communities prevail on islands in the outer islands. Mires cover insignificant area, nevertheless they show a great variability. On some big islands with calcareous groundwater seepage complex mire systems are formed.

According to island equilibrium model (MacArthur and Wilson (citation?)) size of the island affects species diversity of this island and number of species increases on bigger islands. We assume that the same model may describe patterns of vegetation diversity. The Arrhenius equation formula was used to describe dependence of vegetation diversity and size of an island as well as the coefficients' values were calculated: $y=3.3*x^{0.25}$. On average communities of 3 different classes were observed on island of 1 ha.

So then, a great diversity of plant communities is represented on the Porya Guba Archipelago. The vegetation map demonstrates distribution patterns of plant communities due to impact of geographical factors.

13. The syntaxonomic composition of vegetation as a basis for reindeer pastures monitoring

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We present comparative data regarding dry phytomass of lichens and green parts of plants of all life forms (including mosses) from syntaxa of two vegetation classes located in the Ural-Novaya Zemlya province (the eastern macroslope of the Polar Urals and the Vaigach island) and the Kanin-Pechora province (the continental regions of the East European tundras in the Pechora river delta). The Polar Urals site and the Pechora delta are located in the southern tundras (subzone E, CAVM Team, 2003), Kolguev island – in typical tundras (subzone D, CAVM Team, 2003), on Vaygach Island in typical tundras (subzone C, CAVM Team 2003).

The analysis included 62 relevés made by O. V. Khitun in the Polar Urals during geobotanical survey conducted by the A.N. Severtsov Institute in 2018, and 192 samples by S. A. Uvarov in

2011–2014. Phytomass samples were selected with threefold frequency from 23 and 28 communities, respectively.
According to the Braun-Blanquet approach for plant classification, the vegetation is preliminarily assigned to associations of the 2 classes – ***Carici arctisibiricae–Hylocomietea alaskani*** Matveyeva et Lavrinenko 2016 cl. nov. prov. (Lavrinenko et al., 2016) and ***Loiseleurio procumbentis–Vaccinietea*** Eggler ex Schubert 1960.

Carici arctisibiricae–Hylocomietea alaskani

In the East European tundra, shrub-sedge-moss communities on the plakor (zonal class ***C.a.–H.a***.) are attributed to syntaxa: ass. ***Dryado octopetalae–Hylocomieteum splendentis*** subass. *caricetosum redowskianae* (northern part of typical tundra, Vaigach Island), ass. ***Carici arctisibiricae–Hylocomietum splendentis*** (southern part of typical tundras, Kolguev Island), ass. ***Calamagrostio lapponicae–Hylocomietum splendentis*** (southern tundra, Pechora river delta) (Lavrinenko et Lavrinenko, 2018).

In the Polar Urals, zonal communities of the southern tundra are attributed to the ass. ***Calamagrostio lapponicae–Hylocomietum splendentis*** Lavrinenko et Lavrinenko 2018 (southern tundra).

Preliminary prodromus of zonal vegetation of the sites.

Class ***Carici arctisibiricae–Hylocomietea alaskani*** Matveyeva et Lavrinenko 2016 cl. nov. prov.

- Order ***?***
  - Alliance ***?***
    - Ass. ***Dryado octopetalae–Hylocomieteum splendentis*** Andreyev 1932 субасс. ***caricetosum redowskianae*** Lavrinenko et Lavrinenko 2018
    - Ass. ***Carici arctisibiricae–Hylocomietum splendentis*** Andreyev 1932 em. Lavrinenko et Lavrinenko 2018
    - Ass. ***Calamagrostio lapponicae–Hylocomietum splendentis*** Lavrinenko et Lavrinenko 2018

Loiseleurio procumbentis–Vaccinietea
The shrub-lichen communities on sandy soils (class ***L.p.–V***.) in the East European tundra are attributed to syntaxa: ass. ***Arctoo alpinae–Salietum nummulariae*** ass. prov. (southern part of typical tundra, Kolguev island); and ass. ***Loiseleurio–Diapensietum***, ass. ***Empetro–Betuletum nanae*** and ***Stereocaulon rivulorum*** com. type (southern tundra, continental part). There were no sandy habitats found on Vaigach island. In the Polar Urals, this class contains ass. ***Ledo decumbentis–Betuletum nanae*** var. *typica* and var. *Alnus fruticosa*, and ***Hierochloë alpina-Betula nana*** com. type (southern tundra).

Class Loiseleurio procumbentis–Vaccinietea Eggler ex Schubert 1960

- Order ***Rhododendro–Vaccinietalia*** Br.-Bl. ex Daniëls 1994
  - Alliance ***Loiseleurio-Arctostaphylion*** Kalliola ex Nordh. 1943
    - Ass. ***Loiseleurio-Diapensietum*** (Fries 1913)
    - Ass. ***Arctoo alpinae–Salietum nummulariae*** ass. prov.
    - ***Stereocaulon rivulorum*** com. type
    - Ass. ***Empetro–Betuletum nanae*** Nordhagen 1943
    - Ass. ***Ledo decumbentis–Betuletum nanae*** Bocher 1954 ex Dierssen et Dierssen
      - Var. ***typica***
      - Var. ***Alnus fruticosa***
    - ***Hierochloë alpina-Betula nana*** com. type

The tables (Table 1, 2) show the limits of above-ground phytomass values and a standard error (M±m). In Eastern European tundras (Canin-Pechora Province and Vaigach island) the phytomass of green parts of plants was higher in the ***L.p.–V. a.*** class. Its maximum values in communities of the class ***L.p.–V.*** are 662.73 g/m^2 (in the southern tundra) and 668.06 g/m^2 (in typical tundra) (Table 2), while in the communities of the class ***C.a.–H.a.*** it makes up 87.7 g/m^2 and 242.6 g/m^2, respectively (Table 1). Data on lichen phytomass in communities of the class ***L.p.–V.*** are missing.

In communities of the class ***C.a.–H.a.*** (in both Kanin-Pechora and Uralo-Novaya Zemlya provinces) the lichen and green parts of the plant's phytomass are higher on the islands (Kolguev and Vaigach) than in continental areas (Table 1).
No significant differences in green phytomass in communities of the class ***L.p.–V.*** in typical and southern tundra of the Kanin-Pechora province was determined. The data for Vaigach island (Ural-Novaya Zemlya Province) are not available.

For the syntaxa communities of both vegetation classes, the stocks of lichen phytomass and green plant parts were minimal in the Polar Urals (Tables 1 and 2). Total phytomass in the class ***C.a.-H.a.*** communities in the East European tundra varies from 133.6 to 950.3 g/m^2, in the Polar Urals - from 42.8 to 480.7 g/m^2. In the communities of the class ***L.p. –V.*** phytomass varies from 144.1 to 1123.5 g/m^2 in the European tundras and from 38.5 to 121.5 g/m^2 in the Polar Urals respectively. The much lower biomass in the Polar Urals can be explained by the active grazing of domestic deer in this area.

Table 1. *The limits of variation of dry phytomass (g/m^2) in syntaxon communities of the* ***Carici arctisibiricae–Hylocomietea alaskani*** *class.*

Provinces	Subzone			
	Southern tundra		Typical tundra	
Kanin–Pechora	Pechora tundra		Kolguev Island	
	Lichen	Green	Lichen	Green
	63.9–362.8 177.3 ± 47.2	53.9–518.8 41.7 ± 27.7	281.6–711.9 473.1 ± 141.8	59.9–242.6 118.5 ± 40.2
Polar Ural – N. Zemlya	Polar Urals		Vaigach Island	
	Lichen	Green	Lichen	Green
	12.5	15.2	136.1–557.5 351.1 ± 105.7	92.3–284.3 170.4 ± 46.3

Table 2. *The limits of variation of dry phytomass (g/m^2) in syntaxon communities of the* ***Loiseleurio procumbentis–Vaccinietea*** *class*

Provinces	**Subzone**			
	Southern tundra		**Typical tundra**	
Kanin–Pechora	Pechora tundra		Kolguev Island	
	Lichen	Green	Lichen	Green
	101.4–218.5 154.1 ± 21.7	119.1–662.7 494.5 ± 98.1	42.3–455.4 185.8 ± 59.4	33.3–668.1 355.7 ± 95.8
Polar Ural – N. Zemlya	Polar Urals		Vaigach Island	
	Lichen	Green	No data	
	1.4–7.3 4.1 ± 0.97	18.6–240.4 83.8 ± 24.8		

References

CAVM Team. 2003. Circumpolar Arctic Vegetation Map. (1:7,500,00 scale), Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska. ISBN: 0-9767525-0-6, ISBN-13: 978-0-9767525-0-9

Lavrinenko O. V., Matveyeva N. V., Lavrinenko I. A. 2016. Preliminary results of classification of the East European tundra vegetation and a new class for zonal habitats // Diversity and classification of vegetation. (Works of the State Nikita Botanical Gardens. Vol. 143). Yalta. P. 95–105. (In Russian).

Lavrinenko O. V., Lavrinenko I. A. 2018. Zonal vegetation of the plain East European tundras // Vegetation of Russia. St. Petersburg, 2018. N 32. P. 35–108. (In Russian)

14. Approach to the typology of vegetation units for CAVM based on phytosociological data

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The CAVM reflects the large territorial units (CAVM, 2003), each of which is often represented by many syntaxes and diagnostic species of different ecology that may be common to different units. Here I will examine the phytosociological composition of the different CAVM map units.

The raster version of CAVM is the best variant of the circumpolar arctic vegetation map and reflects well the features of zonal and provincial division of vegetation, as well as the peculiarities of the selected units. However, I believe that this is only the first stage of work on the creation of Arctic Vegetation Map and it is necessary to continue to create maps at larger scale on a phytosociological basis (1,000,000-2,500,000), at least for the most studied regions.

One of the problems – the approaches of allocation of the territorial units of vegetation on the map and work with the legend. It is clear that on maps of such scales it is impossible to display absolutely all syntaxa for most units. To find a solution of this problem in Western Europe widely used approaches based on the works of R. Tüxen (1973, 1978), J.-M. Géhu (1977, 1978 and other), S. Rivas-Martínez (1976, 1982 and other) within the framework of symphytology and geosymphytology. Currently, this field is actively developing by a number of European scientific schools (C. Blasi et al., 2014, 2017 et al.; Delbosc et al., 2015, 2016, 2017 et al.; Casavecchia et al., 2007, 2014 et al.).

However, I believe that this approach is largely of a formal nature for the following reasons: 1. The hierarchical organization of the vegetation cover of any territory is actually reduced to only two levels - sigmets and geosigmets; 2. Sigmets and geosigmets of any degree of complexity are represented simply by a list of syntaxa or sigmets; 3. The sigmet system, "if you fully realize the construction of Tüxen ... it will be so complicated that even the author himself cannot navigate it" (Mirkin, Naumova, 1998); 4. Separately for sigmets and geosigmets it is necessary to develop an independent classification schemes, represented by ranks from sigma-association to sigma-class, which excessively complicates the already overloaded typology.

In this regard, an approach to the classification of units for vegetation maps of different scales is proposed, which will allow to reflect the geomorphological and landscape-ecological features of map units along with the preservation of information on the composition of syntaxa.

The spatial structure of the vegetation cover of any natural area is represented by a hierarchically organized system of territorial units of vegetation, reflecting the geomorphological and ecological features of habitats. The number of hierarchical levels may be different even for neighboring territorial units, however, general categories can be distinguished, corresponding to the main levels of the hierarchy.

For the East-European tundra, three main ranks are allocated, which are common to any territory, regardless of its zonal affiliation. The highest unit of the typological scheme is the Department, which combines the territorial units confined to such geomorphological structures as: 1) watersheds; 2) valleys with floodplain regime; 3) low sea terraces, flooded tides. Departments are well distinguished on the Remote Sensing (RS) data and most significantly differ in content and combinations of syntaxa.

Within the departments, there are **Classes** that combine the territorial units of vegetation, which reflect the ecological originality of genetically homogeneous simple relief forms (hill, ridge, complex peat mound bog, salt marsh, near-lake depression, floodplain, etc.) by the composition of syntaxa. For the class, the ecological and physiognomic features of vegetation, which form the appearance of territorial units, are of great importance. It allows to clearly distinguish most of the classes on the materials of the RS data. In most cases, the class of territorial units includes communities of two or more syntaxonomic classes, whose communities together form a pronounced topographic unit.

The elementary units of the typological scheme, displayed mainly on large-scale maps, are **types**. The basis of their selection is the spatial structure (phytocenosis, combinations - ecological series, complex) and syntaxonomic content of the territorial unit. Types and other auxiliary categories are not covered in this research.

For typological units, it is proposed to use the names of the diagnostic syntaxa of the association rank and below, since they most reflect the local and regional originality of the mapped territory.

Despite the wide use of the term "sigmetum" and its derivatives (minorsigmetum, permasigmetum, geosigmetum, etc.) in the symphytosociologists works, taking into account the fundamental differences of the proposed approach to typology, when naming typological units it is proposed to use the term "*horietum*". It reflects the chorological aspect of the territorial unit. When naming a class, the name of 1-2 diagnostic syntaxa with ending in the genera of second syntaxa – horietea (***Luzulo confusae – Salicetohorietea nummulariae***) is used, for the type – horietum (***Callitricho – Ranunculetum trichophylli — Carici rariflorae – Saliciohorietum glaucae***).

The main category that can be legally used in the preparation of maps on a phytosociological basis can be classes of territorial units. Below is a preliminary list of classes of the watershed, which will be supplemented in the process.

a. ***Luzulo confusae – Saliciohorietea nummulariae***. Grass, dwarf-shrub and dwarf-shrub-lichen communities on elevated well-drained parts of watersheds, hills and ridges with sandy soils, including groups of grasses on deflation outcrops.
b. ***Dryado octopetalae – Hylocomiohorietea alaskani***. Rare-willow, small yernik sedge-dwarf-shrub-moss communities on upland habitats, often with loamy spots.
c. ***Potentillo crantzii – Pachypleuriohorietea alpini***. Grass and grass-dwarf-shrub communities on the hillsides and terraces of different exposures; soil from well-drained mineral to sod-gley.
d. ***Sphagno – Eriophoriohorietea vaginati***. Tussock cotton-grass-moss communities, willow grass-moss on horizontal and slightly sloping parts of lowered weakly drained watershed terraces on peaty-gley soils.
e. ***Rubo chamaemori – Dicraniohorietea elongati***. The complex of dwarf-shrub-lichen-moss communities on frozen peat polygons and mounds and sedge-moss communities in cracks and swamps; low swamp areas of watersheds with bog peat and peat-gley soils.
f. ***Hippuriohorietea lanceolatae***. Serial grass and grass-moss communities on the bottoms of dehydrated lakes - from recently dried up areas with muddy silt or sandy bottom to overgrown, on slightly peaty loam or sandy loam.
g. ***Cariciohorietea aquatilis***. Grass and grass-moss communities of near-lake depressions, forming ecological series along the gradient of moisture; soils are sod-gley or cryogenic-gley and silty.
h. ***Equiseto arvensis – Saliciohorietea glaucae***. Grass-moss and grass-willow communities of runoff hollows, tide-downs and logs on sod-like and peaty-gley soils.

The proposed typology is in good agreement with the general approach to the identification and classification of habitats adopted in Europe (CORINE, Palearctic Habitats, EUNIS). In this regard, we consider the classes of territorial units, as the main categories for the typology of complex and mosaic habitats for the Arctic on a phytosociological basis.

According to the proposed typology, vegetation maps were prepared for some of the geobotanical regions of East-European tundra.

References

Blasi C., Capotorti G., Copiz R., Guida D., Mollo B., Smiraglia D., Zavattero L. 2014. Classification and mapping of the ecoregions of Italy // Plant Biosystems. Vol. 148. № 6. P. 1255–1345.

Blasi C., Capotortia G., Alós Ortía M-M-A., Anzellottia I., Attorrea F., Azzellaa M-M., Carlia E., Copiza R., Garfib V., Manesa F., Marandoa F., Marchettib M., Molloa B., Zavatteroa L. 2017. Ecosystem mapping for the implementation of the European Biodiversity Strategy at the national level: The case of Italy // Environmental Science & Policy. V. 78. P. 173–184.

Casavecchia S., Biondi E., Catorci A., Pesaresi S., Cesaretti S., Vitanzi A. 2007. vol Biogeographical regionalisation as condition for a better evaluation of habitats: The marche region study case [La regionalizzazione biogeografica quale elemento per una migliore comprensions del valore degli habital:It caso della regione marche] // Fitosociologia. V.44. № 2. P. 103–1113.

Casavecchia S., Paradisi L., Pesaresi S., Biondi E. 2014. Phytosociological study of the eastern slopes of Alpe della Luna (northern Apennines, Italy) // Plant Sociology. Vol. 51. № 1. P. 89-136.

CAVM Team. 2003. Circumpolar Arctic Vegetation Map, scale 1:7 500 000. Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Delbosc P., Bacchetta G., Gonçalves J.-C., Bioret F., Panaïotis Ch., Lalanne A., Pedrotti F., Boullet V., Sawtschuk J. 2015. Phytosociologie dynamico-catenale des vegetations de la Corse: methodologies typologique et cartographique. Geographie. Universite de Bretagne occidentale. Brest. 748 p.

Delbosc P., Bioret F., Panaïotis Ch. 2016. Subhalophilous and halophilous geopermaseries and minoriseries of sandy and sandy gravel systems of Corsica: typology, bionomy and sequential analysis vegetation // International Journal of Geobotanical Research. Vol. 6. P. 9-26

Delbosc P., Bioret F., Panaïotis Ch. 2017. Dynamic-catenal phytosociological mapping of Corsica: inductive methodological approach // Contribuţii Botanice. V. 52. P. 29–54.

Mirkin, B.M., Naumova, L.G., Nauka o rastitel'nosti (History and Modern Status of Basic concepts). 1998. Ufa: Gilem. 413 p. (in Rus).

Tüxen, R. Vorschlag zur Aufnahme von Gesellschaftskomplexen in potentiell naturlichen Vegetationsgebieten / R. Tüxen // Acta Botanica Academiae Scientiarum Hungaricae. – 1973. – T. 19. – № 1–4. – P. 379–384.

Tüxen R. Bemerkungen zur historischen, bergifflichen und methodischen Grundlagen der Synsoziologie-Assoziationskomplexe (Sigmeten) und ihre praktische Anwendung R. Tüxen // Berichte der lntemationalen symposien der lntemationalen Vereinigungen fur Vegetationskunde Herausgegeben von R. Tüxen (Riental n4-7.4.1977). Vaduz, 1978. P. 3-16.

Géhu, J.-M. 1977. Le concept de sigmassociation et son application à l'étudé du paysage végétal des falaises atlantiques francaises / J.-M. Géhu // Vegetatio. V. 34. №2. P. 117–125.

Géhu, J.-M. 1978. Les phytocoenoses endémiques des côtes françaises occidentals // Bulletin de la Société Botanique de France. V. 125. №3-4. P. 199-208.

Rivas-Martínez S. 1976. Sinfitosociologia, una nueva metodologia para el studio del paisaje vegetal // Anal. inst. Bot. AJ. Cavanilles. Madrid, Vol. 33: P. 179-188.

Rivas-Martínez S. 1982. Les étages bioclimatiques, secteurs chorologiques et series de végétation de l'Espagne mediterranéenne. Ecol. Medit. Vol.8. № 1-2. P. 275–288.

15. Zonal and intrazonal communities on the latitudinal gradient of the East European tundra

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The successional change of syntaxa (associations, subassociations) communities of 5 main vegetation classes in automorphic and hygromorphic habitats in watersheds has been studied on a conceptual transect from forest-tundra to arctic tundra in Eastern European tundras (Kanin-Pechora and Ural-Novaya Zemlya provinces; subzones E, D, C). For the analysis, 709 relevés were used, most of which were published and transferred to EVA and partly to AVA.

Changes in the species composition and structure of communities are shown for:

- sedge–dwarf-shrub–moss communities (with regular frost boils with bare ground) of the ***Carici arctisibiricae–Hylocomietea alaskani*** Matveyeva et Lavrinenko 2016 cl. nov. prov. (***C. a.–H. a.***) on zonal habitats (placors — interfluve surfaces with loamy soils) (Lavrinenko et Lavrinenko, 2018);
- sedge–dwarf-shrub communities ***Carici rupestris–Kobresietea bellardii*** Ohba 1974 (***C. r.–C. b.***) (all: ***Kobresio-Dryadion*** Nordh. 1943) on drained snowless habitats with rocky carbonate substrates (Lavrinenko et al., 2014);
- dwarf-shrub–lichen communities ***Loiseleurio procumbentis–Vaccinietea*** Eggler ex Schubert 1960 (***L. p.–V.***) (all: ***Loiseleurio-Arctostaphylion*** Kalliola ex Nordh. 1943) on poor acidic substrates (sands);
- dwarf-shrub–moss–lichen communities ***Oxycocco-Sphagnetea*** Br.-Bl. et Tx. ex Westhoff et al. 1946 (***O.-Sph.***) (alls: ***Rubo chamaemori–Dicranion elongati*** Lavrinenko et Lavrinenko 2015) on oligotrophic palsa bogs and peatlands of the Subarctic (Lavrinenko et Lavrinenko, 2015);
- sedge–cotton grass–moss communities ***Scheuchzerio palustris–Caricetea fuscae*** Tx. 1937 (***Sch. p.–C. f.***) **(**alls: ***Caricion stantis*** Matveyeva 1994 (***C. s.***), ***Drepanocladion exannulati*** Krajina 1933 (***D. e.***); ***Sphagnion baltici*** Kustova 1987 ex Lapshina 2010 (***Sph. b.***)**)** on Arctic

mineral sedge mires, sedge-hypnum mires and sedge-sphagnum hollows of flat palsa-bogs (Lavrinenko et al., 2016a);

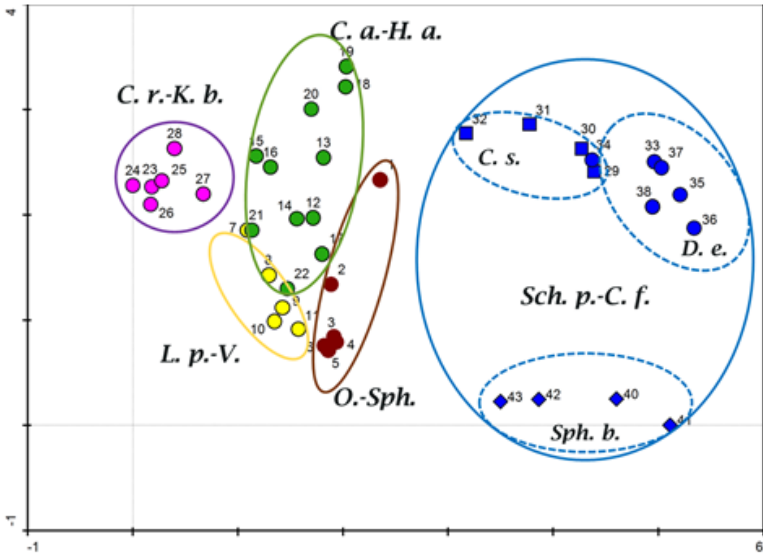

Figure 1. Ordination Eastern European Tundra Syntaxa grouped by five Br.-Bl. classes (solid colored ellipses) and alliances (dashed lines) using Detrended Correspondence Analysis (DCA).

The differentiation of 43 syntaxa (described in different subzones and longitudinal sectors of Eastern European tundra) from 5 classes was demonstrated by DCA-ordination method (Fig. 1).

The spectrum of plant ecological groups (in relation to moisture) well reflects the environmental conditions in which communities of syntaxa of different classes exist. In all tundra subzones in syntaxa of ***C. a.–H. a.*** the share of hygromeso- and mesophytes is the highest — more than 40%, mesohygro- and hygrophytes — 25–30 %, eurytopic plants occurring from moderately dry to moderately wet habitats a little less — about 20 % and xeromeso- and mesoxerophytes — less than 10–15 %.

In syntaxa of ***C. r.–C. b.*** and ***L. p.–V.***, communities are confined to well-drained habitats, share of xeromeso- and mesoxerophytes — 20–25 %, hygromeso- and mesophytes — about 30–40 %, eurytopic — about 20 % and meso hygrophytes and hygrophytes least of all — 15–20 %.

In syntaxa of ***Sch. p.–C. f.*** and ***O.-Sph.*** mesohygro- and hygrophytes predominate, in the first — significantly (55–80 %), and in the second, quite a lot (30–40 %) of hygromeso- and mesophytes too.

Thus, placor habitats are moderate in such important environmental characters as moisture and nutrition of soil and snow depth, so zonal syntaxa are the richest in species number, many of them are represented by mesophytes, compared with all the others.

Characteristic species (exclusive, selective and preferential) for higher syntaxa unites of East European tundra were determined by analyzing the synoptic tables. It's for classes:

L. p.–V.: dwarf-shrubs *Arctous alpina, Diapensia lapponica, Loiseleuria procumbens;* grass *Hierochloë alpina,* moss *Polytrichum piliferum;* lichens *Alectoria ochroleuca, Cetraria aculeata, Cladonia verticillata*.

C. r.–C. b.: dwarf-shrubs *Dryas octopetala, Cassiope tetragona,* herbs *Androsace chamaejasme* subsp. *arctisibirica, Carex rupestris, C. misandra, Lloydia serotina, Pedicularis oederi, Saxifraga oppositifolia, Silene acaulis;* mosses *Hypnum bambergeri, Syntrichia ruralis*.

O.-Sph.: dwarf-shrubs *Andromeda polifolia* subsp. *pumila, Ledum palustre* subsp. *decumbens,* moss *Polytrichum strictum*, lichens *Cladonia squamosa, C. sulphurina, C. pleurota, Ochrolechia inaequatula.*

Sch. p.–C. f. sedges and cotton grass *Carex aquatilis* subsp. *stans, C. rariflora, Eriophorum angustifolium*. In its unions ***Caricion stantis*** Matveyeva 1994, ***Drepanocladion exannulati*** Krajina 1933, ***Sphagnion baltici*** Kustova 1987 ex Lapshina 2010: sedge *Carex rotundata*, cotton grasses

Eriophorum russeolum, E. scheuchzeri, mosses *Polytrichum jensenii, Sphagnum balticum, S. lindbergii, Warnstorfia exannulata, W. sarmentosa*.

Zonal communities in placor habitats differ from others by their high constancy of shrub *Salix glauca,* dwarf-shrub *S. polaris,* monocot and dicot herbs *Carex bigelowii subsp. arctisibirica, Deschampsia borealis, D. glauca, Eriophorum brachyantherum, Juncus biglumis, Luzula arcuata, Pedicularis lapponica, Petasites frigidus, Poa arctica, Bistorta major, Saxifraga hieracifolia, S. hirculus, Stellaria peduncularis, Valeriana capitata;* mosses *Aulacomnium turgidum, Hylocomium splendens, Ptilidium ciliare, Racomitrium lanuginosum, Tomentypnum nitens;* lichens *Lobaria linita, Nephroma expallidum, Protopannaria pezizoides*, *Psoroma hypnorum.* Some of them appear to be characteristic of a ***C. a.–H. a.*** class that has yet to be described (Lavrinenko et al., 2016b; Matveyeva, 2016; Lavrinenko et Lavrinenko, 2018).

Eurytopic hypoarctic shrubs and dwarf-shrubs *Betula nana*, *Empetrum hermaphroditum*, *Vaccinium uliginosum* subsp. *microphyllum* and *V. vitis-idaea* subsp. *minus* have high constancy and the same abundance in almost all syntaxa of ***C. a.–H. a.***, ***L. p.–V.*** and ***O.-Sph.*** classes, except in High Arctic. In most syntaxa, common tundra lichens are constant and often abundant — *Cladonia amaurocraea, C. arbuscula* s. l.*, C. coccifera, C. rangiferina, C. uncialis* and *Sphaerophorus globosus*, and in the same classes and in ***C. r.–C. b.*** — *Alectoria nigricans, Bryocaulon divergens, Cetraria islandica* subsp. *crispiformis, Cetrariella delisei, Cladonia gracilis* subsp. *elongata, Flavocetraria cucullata, F. nivalis, Ochrolechia androgyna, O. frigida* and *Thamnolia vermicularis*. All these common species, especially lichens, mask the differences between communities of different classes. At the same time, not being characteristic of classes, they can be part of differential combination of syntaxa of different levels.

Flora markers of subzonal belonging of zonal communities (***C. a.–H. a.*** class) in the East European tundra were identified. In the southern tundra are active *Betula nana* and hypoarctic dwarf-shrubs *Arctous alpina, Empetrum hermaphroditum, Vaccinium uliginosum* subsp. *microphyllum* and *V. vitis-idaea* subsp. *minus*, there are *Ledum decumbens* and *Salix phylicifolia*. In typical and arctic tundra there are *Salix polaris* (its activity to the north increases) and *Dryas octopetala* (in some syntaxes). In the southern part of the typical tundra subzone (on the mainland and on Kolguev Island) there are *Salix glauca*, *Betula nana* (elfin) and all the hypoarctic shrubs, and they are already absent in the northern part of Vaigach Island, with the exception of the genus *Vaccinium* (with low constancy). In the arctic tundra all shrubs and hypoarctic dwarf-shrubs are absent on placor habitats, *Salix polaris* is abundant.

References

Lavrinenko O. V., Lavrinenko I. A. 2015. Communities of the class Oxycocco-Sphagnetea Br.-Bl. et R. T x. 1943 in the East European tundras // Vegetation of Russia. N 26. P. 55–84. (In Russian).

Lavrinenko O. V., Lavrinenko I. A. 2018. Zonal vegetation of the plain East European tundras // Vegetation of Russia. N 32. P. 35–108. (In Russian).

Lavrinenko O. V., Matveyeva N. V., Lavrinenko I. A. 2014. Dryad fell-fields in the East of the European part of the Russian Arctic // Vegetation of Russia. N 24. P. 38–62. (In Russian).

Lavrinenko O. V., Matveyeva N. V., Lavrinenko I. A. 2016a. Communities of the class Scheuchzerio–Caricetea nigrae (Nordh. 1936) Tx. 1937 in the East European tundras // Vegetation of Russia. N 28. P. 55–88. (In Russian).

Lavrinenko O. V., Matveyeva N. V., Lavrinenko I. A. 2016b. Preliminary results of classification of the East European tundra vegetation and a new class for zonal habitats // Diversity and classification of vegetation. (Works of the State Nikita Botanical Gardens. Vol. 143). Yalta. P. 95–105. (In Russian).

Matveyeva N. V. 2016. Results, problems and perspectives of the classification of the Russian Arctic vegetation // Diversity and classification of vegetation. (Works of the State Nikita Botanical Gardens. Vol. 143). Yalta. P. 106–117. (In Russian).

16. Advances in the Canadian Arctic Vegetation Archive and Development of the CASBEC Classification

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The Canadian Arctic-Subarctic Biogeoclimatic Ecosystem Classification System (CASBEC) is a framework for coordinating and standardizing the identification, interpretation, classification and mapping of terrestrial ecological communities across Subarctic and Arctic landscapes of northern Canada. The CASBEC uses a bottom up approach to develop the three main components of the system – vegetation classification, site classification and biogeoclimatic classification. The CASBEC is built on the principles pioneered by the British Columbia Biogeoclimatic Ecosystem Classification (BCBEC; Pojar et al. 1987) and adapted for the classification of Arctic and Subarctic landscapes, e.g., a more detailed assessment of shrub heights. The lowest vegetation units – plant associations – are based on the analysis of the ground-collected plot data (reléves) that are assembled up into classification hierarchies following principles of Braun-Blanquet and the Canadian National Vegetation Classification (CNVC). Plant associations are linked to repeating site factors to develop an ecological site classification that defines a range of ecosites (biogeocoenose) within biogeoclimatic subzones, also defined by plant associations using the zonal concept (McLennan et al. 2018). Baseline plant association data to develop CASBEC are stored and disseminated through the Canadian Arctic Vegetation Archive that is linked to the international Arctic Vegetation Archive (Walker et al.2011).

The Canadian Arctic Vegetation Archive currently contains 7,450 reléves housed and managed in VPRO, a programmed ACCESS database, designed for the management of ecosystem data (vegetation, environment, and soils) and classification hierarchies collected for Biogeoclimatic Ecosystem Classification. Initial trials to convert CAVA data from VPRO to TurboVeg format indicate that the most common issue is alignment of taxonomic standards and coding between datasets. Some progress has been made to construct conversion methods in the R environment which converts data into TurboVeg format, but also to manage species lists and coding among different data systems.

The last major additions to the CAVA were in 2015-2016. Plots collected or compiled in the last four years are slated to be entered into the archive in 2019-2020.

Ecosystem classifications using data from the CAVA have been completed for the Yukon and drafted for mapping in the CHARS study area (Ponomarenko et al.2019) and many of Canada's National Parks (Ponomarenko et al.2014). A correlation of these regional classifications and inclusion of preliminary national classification will stitch together a coherent second approximation of a Canadian national arctic classification and guide the development of biogeoclimatic maps of the Arctic.

References

McLennan, D.S., MacKenzie, W.H., and Meidinger, D., Wagner, J., Arko, C. 2018. A standardized ecosystem classification for the coordination and design of long-term monitoring in the Arctic-Subarctic Biomes. Arctic. Vol 71, SUPPL 1, pp. 1-15.

Pojar, J., Klinka, K., and Meidinger, D. 1987. Terrestrial ecosystem classification in British Columbia. Forest Ecology and Management 22: 119-154.

Ponomarenko, S., McLennan, D.S., Pouliot D. and Wagner, J. 2019. High Resolution Mapping of Tundra Ecosystems on Victoria Island, Nunavut – Application of a Standardized Terrestrial Ecosystem Classification. Canadian Journal of Remote Sensing (in press).

Ponomarenko, S., Quirouette, J., Sharma, R., and McLennan, D.S. 2014. Ecotype Mapping Report for Wapusk National Park. Monitoring and Ecological Information. Natural Resource Conservation. Parks Canada. Gatineau, QC.

Walker, D.A., and Raynolds, M.K. 2011. An International Arctic Vegetation Database: A foundation for pan-Arctic biodiversity studies. CAFF Strategy Series Rep

17. Results of the inventory of vegetation syntaxa and their distribution in floristic provinces based on the geodatabase and GIS “Russian Arctic Vegetation Archive”

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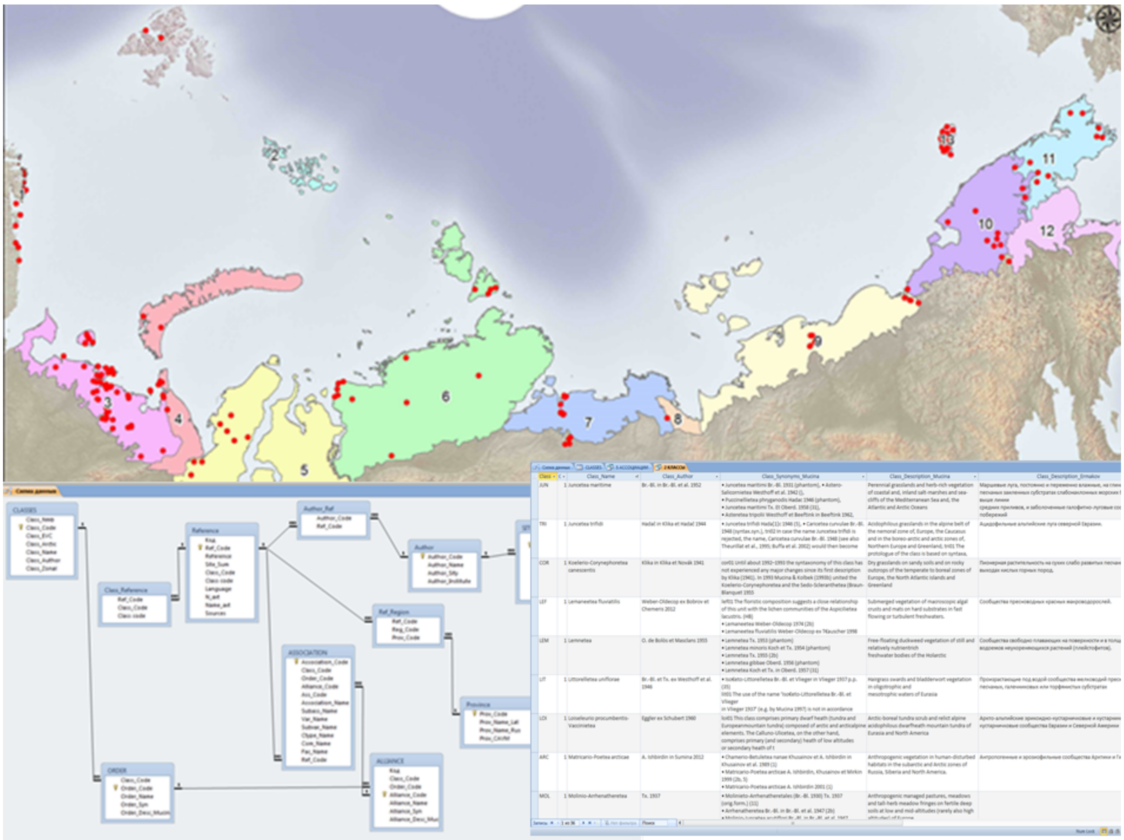

Figure 1. *Some modules of the GBD-GIS “Russian Arctic Vegetation Archive”*

An earlier recent analysis of the diversity of plant communities in the Russian Arctic was presented at the previous Working Group in Prague in 2017. It was made based on viewing literature where the syntaxa from various arctic regions were published according to the Braun-Blanquet approach. The process of data extraction was continued and both geodatabase (GDB) and GIS containing information on all syntaxon names, area of their distribution with source-linked data have been done (Fig 1).

An inventory of syntaxa identified (including known and newly described ones) by numerous authors on the territory of the Russian Arctic, and primary sources that justify their selection, including tables of relevés and syntaxon characteristics is being carried out. At this stage, only data obtained from published peer-reviewed sources that have undergone professional review are entered into the GDB of the National Archive of Vegetation of the Arctic. These include papers in the journals "Vegetation of Russia", "Botanical Journal", "Phytodiversity of Eastern Europe", “Journal of Vegetation Science”, "The Flora of Asian Russia", "Turczaninowia", "Proceedings of the Karelian Research Center of the Russian Academy of Sciences" and some others.

Currently, more than 60 sources have been processed, in which information on 600 syntaxa are given, ranging from association to facies and the community type, including subassociations, variants and subvariants. The total number of relevés is about 5 000. The GBD contains 168 associations (with more than 120 subassociations) from over 60 alliances of 45 orders and 21 classes (Table 1). Some lower-level syntaxa (alliance, association) were identified without assigning them to any orders and sometimes classes that is suggested to be done later. In the process of data entering, their geographical reference to provinces and study areas (sites) were considered. Currently, more than 130 sites are registered for 13 floristic provinces.

There is a more or less detailed information for 7 the most important (landscape forming, widely spread) classes: three zonal — *Drabo corymbosae-Papaveretea dahliani* in polar desert zone and *Carici arctisibiricae–Hylocomietea alaskani* (prov.) in tundra zone, *Loiseleurio-Vaccinietea* (edaphic variant of zonal vegetation on sandy and light loam substrates) in tundra zone; four intrazonal — *Scheuchzerio-Caricetea nigrae* and *Oxycocco-Sphagnetea* (mires), *Carici rupestris–Kobresietea* (little snow or snowless fellfields), *Salicetea herbaceae* (snow beds). Relatively detailed information is available for salt marsh vegetation (class *Juncetea maritimi*) for European part of Russian Arctic. Clearly little information is on aquatic (freshwater bodies, springs) vegetation as well as on wet grasslands which are common in all landscape types, as well as on herb scrubs in spring and small river valleys in the southern tundra subzone.

Considering that not all data are still included into GBD, the most studied provinces at this stage are Kanin-Pechora, Yamal-Gydan, Taimyr, West Chukotka and Wrangel Island, the number of relevés in each of these is more 600. The least studied are the Kharaulakh and South Chukotka provinces, for which no one relevé was found in the above listed sources.

These results so far do not reflect a real diversity of plant communities and their syntaxa within any region due to various reasons: not all data still have been treated and published and the number of unpublished relevés still exceeds that of published; a lot of new syntaxa of all levels are still on the waiting list to be described (including new zonal tundra class *Carici arctisibiricae–Hylocomietea alaskani* (prov.) which also needs its valid presentation in literature); too little data has been obtained for such a huge area with no real prospects to improve this situation in the nearest future. Nevertheless, now is the time to summarize what has been done and outline the prospects for the near and distant future.

Table 1. *Class distribution in provinces*

Class \ Province	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Placors with loamy substrates													
Drabo corymbosae-Papaveretea dahliani						+							+
Carici arctisibiricae–Hylocomietea alaskani			+	+		+	+						
Sandy substrates, gravel fellfields													
Loiseleurio procumbentis-Vaccinietea	+		+	+	+	+	+		+	+			+

Class \ Province	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Carici rupestris-Kobresietea bellardii	+	+	+	+		+	+		+	+			+
Mires													
Scheuchzerio palustris-Caricetea fuscae	+	+	+	+		+			+	+			+
Oxycocco-Sphagnetea			+	+					+	+			+
Snow beds													
Salicetea herbaceae	+	+				+	+		+	+			+
Coastal dunes, marshes													
Ammophiletea	+	+	+										
Juncetea maritime	+	+	+			+				+			+
Wet grasslands													
Juncetea trifidi													+
Mulgedio-Aconitetea					+								
Freshwater bodies, springs													
Phragmito-Magnocaricetea			+							+			+
Potamogetonetea			+							+			
Montio-Cardaminetea						+							+
Sandy substrates													
Koelerio-Corynephoretea canescentis	+		+			+							
Herb scrubs in spring/small river valleys													
Betulo carpaticae-Alnetea viridis													
Small rush vegetation on temporarily moist soil													
Isoëto-Nanojuncetea	+									+			
Zoo, anthropogenic, scree, rock habitats													
Saxifrago cernuae-Cochlearietea groenlandicae		+				+					+		
Matricario-Poetea arcticae					+					+			
Thlaspietea rotundifolii	+	+		+	+	+			+				+
Rhizocarpetea geographici													+
Total: classes	**9**	**7**	**10**	**6**	**4**	**11**	**4**	**0**	**6**	**10**	**1**	**0**	**12**
Total associations	**15**	**16**	**29**	**6**	**6**	**23**	**11**		**9**	**47**	**7**		**11**

Class \ Province	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of relevés	425	97	914	122	766	1013	401		373	675	311		760

Provinces: 1 — Fennoscandia, 2 — Svalbard - Franz-Josef (incl. Kola Peninsula), 3 — Kanin - Pechora, 4 — Polar Ural - N. Zemlya, 5 — Yamal - Gydan, 6 — Taimyr, 7 — Anabar - Olenyek, 8 — Kharaulakh, 9 —Yana - Kolyma, 10 —West Chukotka, 11 —East Chukotka, 12 —East Chukotka, 13 —Wrangel Island.

18. The Rybachy and Sredny Peninsulas vegetation dataset

Ksenia B. Popova

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The study site is in the northern part of Pechengsky District of the Murmansk region, representing the northernmost part of continental European Russia (69°33’-69°56’ N, 31°44’-32°07’ E; Fig. 1). The study site is divided into two parts: the smaller southern part, Sredny Peninsula, and the larger northern part, Rybachy Peninsula. The western parts of both peninsulas belonged to Finland in 1920-1940. It was the reason of Finnish scientists' interest for this territory. In that time, there were several villages and small settlements in this area. Aarno Kalela collected the biggest dataset on the herb vegetation in 1927 - 1930 there (Kalela, 1939). Reino Kaliola also worked there and published some relevés (Kaliola, 1939).

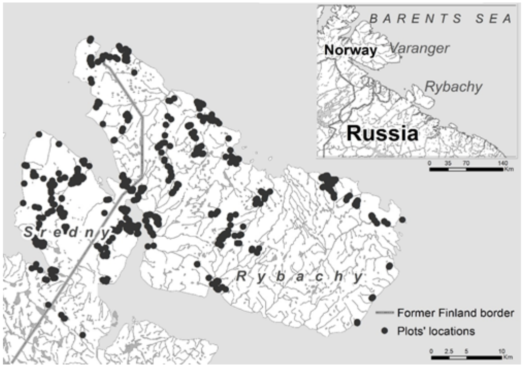

Figure 1. *Study area and locations of plots*

Study area. The bedrock consists of upper Proterozoic solid (rocks), such as sandstones, shales and conglomerates, unlike the granite dominated mainland coast of the Murmansk region (Siedlecka, Siedlecki 1967). The main soil type is podzol rich in aluminum (Al) and iron (Fe). Fine-grained earth material occupies the empty spaces between the split pieces of shales (Koroleva, Pereversev 2007). The highest plains are up to 300 m a.s.l. in the inland. The climate is oceanic. Being influenced by the south extension of the North Cape current, the climate is relatively mild compared to other areas at similar latitudes. For the last century, the climate had changed significantly. Mean annual temperature has increased from +1.2 °C in the period from 1901 until 1939 to +2.7 °C in the period from 2006 until 2018. Total annual precipitation has increased from 350 mm (1886-1935) to 772 mm (2006-2018). The average temperature of July (the warmest month) had changed from +10.2 (1881-1980) to + 11.4 (2008-2018).

Aims. Climate and land-use changes are the main rationale for new data collection to compare with the earlier Finnish studies. The old data are useful for comparison and studying of vegetation changes. Furthermore, in 2014 a nature protected area was established on the peninsulas. The Rybachy and Sredny Peninsulas are located within an earlier CAFF phytogeographic Arctic boundary (CAFF, 1996), but was excluded in the latest survey for Arctic vegetation (Walker et al., 2017). For these reasons, we started the studying of the peninsulas' vegetation. The aim of the study is to determine the plant-community diversity and investigate ecological and floristic features of the vegetation types.

Dataset. The data provides information for all vegetation types of the study area (Table 1). The dataset contains 1063 relevés collected from the area in 2008-2015. The high rank classification was conducted using Braun-Blanquet approach. The plot size was chosen according to the plant community type. Tree, shrub, herb, and lichen and moss (in total) layers cover were marked for each plot. Geographic localization was marked also for each plot using GPS coordinates (WGS 84).

Database format: Turboveg
Plot size: 1-400 m^2
Number of Taxa: 585
Performance measure: cover: 100%.
Cover abundance scale: percentage: 100%

Environmental data
Slope aspect: 64%, **Slope degree**: 64%
Shrub height: 93%, **Herb height**: 60%
Data contributors: K.B. Popova (Lomonosov Moscow State University, Moscow), A.V. Rasumovskaja (Institute of North Industrial Ecology Problems, Kola Science Centre RAS, Apatity)

Table 1. *The structure of database on Rybachy and Sredny Peninsulas' vegetation across different vegetation classes.*

	Vegetation class	**num. of relevés**	**Percentage of complete relevés (with identified mosses)**
LOI	***Loiseleurio procumbentis-Vaccinietea***	137	26%
KOB	***Carici rupestris-Kobresietea bellardii***	40	27%
PIC	***Vaccinio-Piceetea***	101	18%
HER	***Salicetea herbaceae***	24	8.3%
TRI	***Juncetea trifidi***	47	4%
MUL	***Mulgedio-Aconitetea***	67	11%
MOL	***Molinio-Arrhenatheretea***	79	37%
SCH	***Scheuchzerio palustris-Caricetea fuscae***	139	20%
OXY	***Oxycocco-Sphagnetea***	54	7%
VIR	***Betulo carpaticae-Alnetea viridis***	51	50%
AMM	***Ammophiletea***	47	100%
CAK	***Cakiletea maritimae***	9	100%
JUN	***Juncetea maritimi***	57	100%
LIT	***Littorelletea uniflorae***	22	100%
MON	***Montio-Cardaminetea***	49	14%
PHR	***Phragmito-Magnocaricetea***	11	45%
ASP	***Asplenietea trichomanis***	79	13%
RAC	***Racomitrietea heterostichi***	2	0%
POL	***Polygono-Poetea annuae***	8	25%
EPI	***Epilobietea angustifolii***	40	50%

	Total:	1063	32%

Results. The classification of coastal vegetation is complete. It was based on 99 original relevés using TWINSPAN algorithm and following analytical revision, was carried out with Braun-Blanquet approach. The plant communities were classified as five associations and one community type. These syntaxa belong to 4 alliances, 4 orders, and 3 classes (***Cakiletea maritimae*** R. Tüxen et Preising in R. Tüxen 1950, ***Honckenyo peploidis–Leymetea arenarii*** R. Tüxen 1966, ***Juncetea maritimi*** Br.-Bl. in Br.-Bl., Roussine et Negre 1952). The results are already published (Popova et al., 2017). Now the most urgent aim is identification of the last part of moss collection and continuing classification of the rest of relevés.

References

CAFF. 1996. Habitat Conservation Report No. 2. Proposed Protected Areas in the Circumpolar Arctic 1996. 196p.

Kalela A. 1939. Über Wiesen und wiesenartige Pflanzenge-sellschaften auf der Fischerhalbinsel in Petsamo Lapp-land. Acta Forestalia Fennica. Bd. 48. N 2. 523 P.

Kalliola, R. 1939. Pflanzensoziologische Untersuchungen in der alpinen Stufe Finnisch Lapplands. Ann. Bot. Soc. Zool.-Bot. 'Vanamo'.. Bd. 14. 321 P.

Koroleva, N. E., Pereversev, V. N. 2007. Zonal types of vegetation and soils at Murmansk tundra [Zonal'nye typy rastitel'nosti i pochv v tundrah Murmanskoi oblasti]. Bulleten MOIP. Biology. Vol. 112. P. 23-30. (in Russian).

Popova, K. B., Cherednichenko, O. V., Razumovskaya, A. V. 2017. Classification of coastal vegetation of the Rybachiy and Sredniy peninsulas (Barents Sea coast). Vegetation of Russia. St. Petersburg, 2017. № 31. P. 77–92 (in Russian).

Siedlecka, A., Siedlecki, S. 1968. Some new aspects of the geology of Varanger peninsula (Northern Norway). Geological Survey of Norway. Vol. 247. P. 288-306

Walker, D.A., Daniëls, F.J.A., Matveyeva, N.V., Šibík, J., Walker, M.D., Breen, A.L. (...) & Wirth, L.M. 2018. Circumpolar Arctic Vegetation Classification. Phytocoenologia Vol. 48. 2018. Iss. 2. P. 181–201

19. The Russia portion of the new Raster Circumpolar Arctic Vegetation Map

Martha K. Raynolds[1], D.A. Walker, and Raster CAVM Team (see caption below)

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Introduction. The Raster Circumpolar Arctic Vegetation Map shows the dominant physiognomy of the vegetation of the Arctic, with 16 vegetation types. It was created to improve on the original vector (polygon) CAVM. The raster format matches satellite data, and is commonly used by modelers and other researchers. The Raster CAVM has 1-km pixels, compared to the minimum mapping unit of 14 km for the original CAVM. This poster presents the Russian portion of the Raster CAVM.

Methods. An unsupervised classification of 18 regions of the Arctic used seven data layers: AVHRR Band 1, Band 2 and NDVI (Markon 1995), MODIS Band 1, Band 2 and NDVI (Trishchenko et al. 2009), and elevation (ESRI 1993). The resulting units were then modelled to the CAVM types using a variety of ancillary layers: climate data, substrate maps, regional vegetation maps, and ground studies. Map extent and projection are the same as the original CAVM. The same legend was used as the original CAVM. The spatial resolution of the raster CAVM is 1 km. The map was reviewed by experts in the Raster CAVM Team (see list in citation below) with experience mapping the vegetation of their particular regions, including many of the original authors of the CAVM. This expert input was used to revise and improve the map.

Results

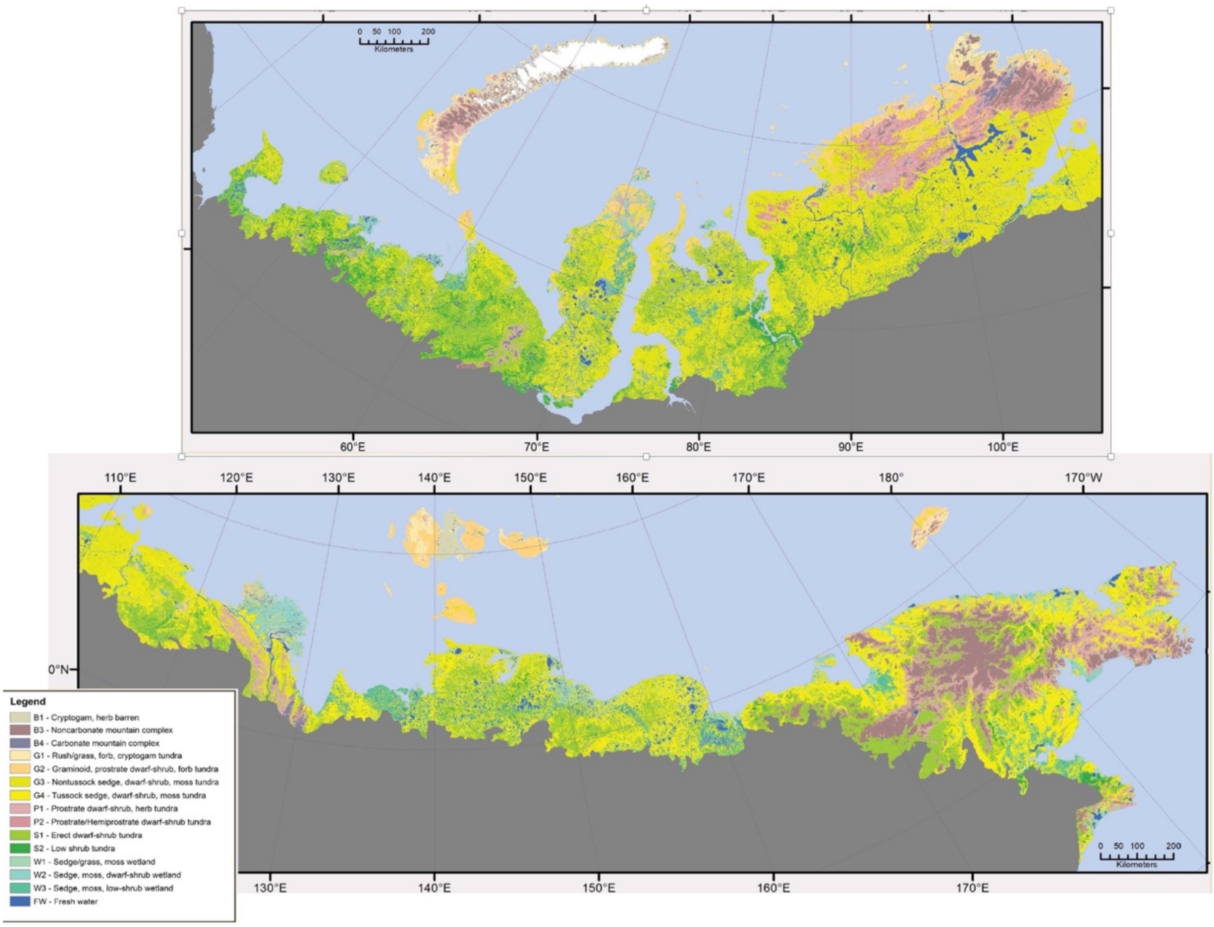

Figure 1*. Most of the Russian portion of the Raster CAVM. Some high arctic polar desert islands (e.g., Severnaya Zemlya and Franz Josef Land) are not shown.*

Full citation for raster CAVM: Raynolds, M.K., Walker, D.A., Balser, A., Bay, C., Campbell, M.W., Cherosov, M.M., Daniëls, F.J.A., Eidesen, P.B., Ermokhina, K.A., Frost, G.V., Jedrzejek, B., Jorgenson, M.T., Kennedy, B.E., Kholod, S.S., Lavrinenko, I.A., Lavrinenko, O., Magnússon, B., Metúsalemsson, S., Olthof, I., Pospelov, I.N., Pospelova, E.B., Pouliot, D., Razzhivin, V.Y., Schaepman-Strub, G., Šibík, J., Telyatnikov, M.Y., & Troeva, E. 2019. A raster version of the Circumpolar Arctic Vegetation Map (CAVM). Remote Sensing of Environment, 232: 111297.

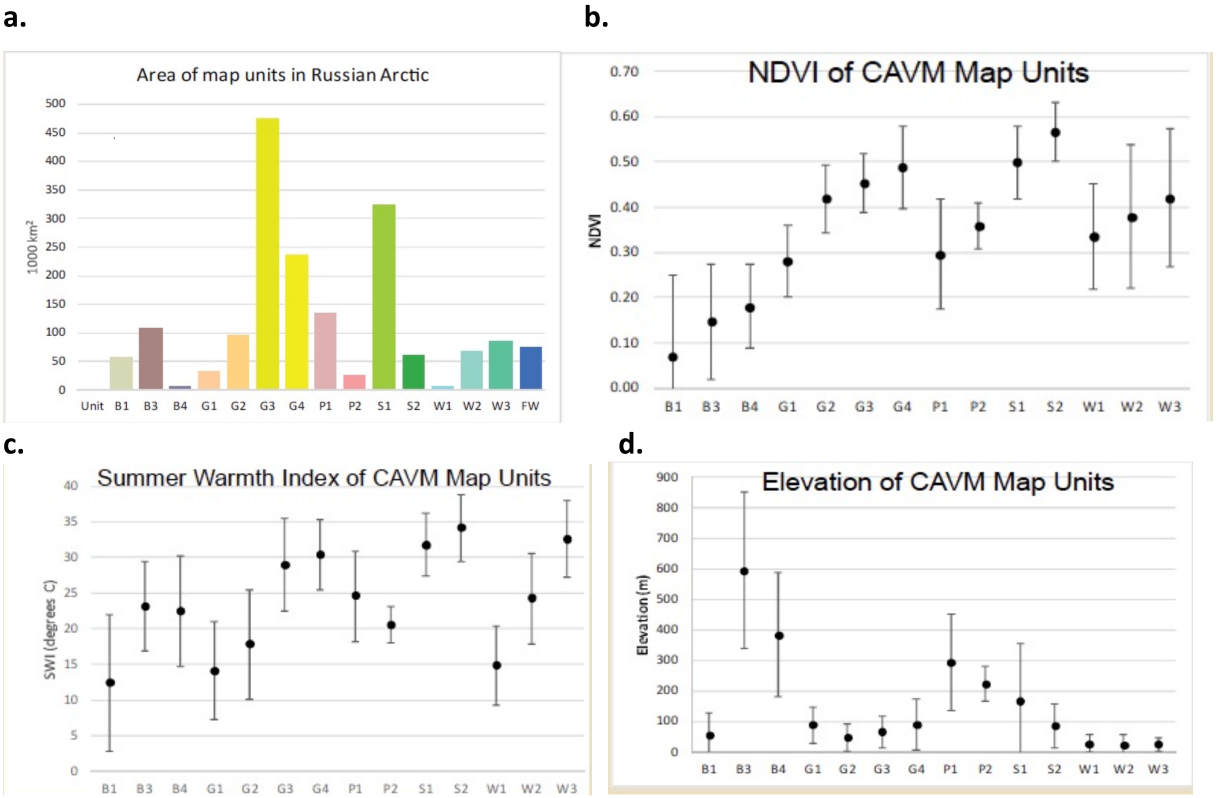

***Figure 2**. Analysis of the map units of the Russia portion of the raster CAVM. **a.** Areas of the map units in the Russian Arctic. **b.** Mean and standard deviation of MODIS NDVI for each of the CAVM map units. Values are averaged across the whole Russian Arctic. The MODIS data are from a circumpolar maximum NDVI composite produced by the Canadian Centre for Remote Sensing, from a mid-summer compositing window for the years 2000–2009 (Trishchenko et al. 2009)**. c.** Mean and standard deviation of Summer Warmth Index (SWI) for each of the CAVM map units. Values are averaged across the whole Russian Arctic. The SWI data are calculated as the sum of annual monthly means above 0 °C, based on AVHRR surface temperature 1982-2003 (Raynolds et al 2008). **d.** Mean and standard deviation of elevation for each of the CAVM map units. Values are averaged across the whole Russian arctic. Elevation data are from the Digital Chart of the World (ESRI 1993).*

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References

ESRI (1993). Digital Chart of the World. In. Redlands, CA: Environmental Systems Research Institute, Inc.

Markon, C.J., Fleming, M.D., & Binnian, E.F. (1995). Characteristics of vegetation phenology over the Alaskan landscape using AVHRR time-series data. Polar Record, 31, 179-190

Raynolds, M.K., Comiso, J.C., Walker, D.A., & Verbyla, D. (2008). Relationship between satellite-derived land surface temperatures, arctic vegetation types, and NDVI. Remote Sensing of Environment, 112, 1884-1894.

Trishchenko, A.P., Luo, Y., Khlopenkov, K.V., Park, W.M., & Wang, S. (2009). Arctic circumpolar mosaic at 250m spatial resolution for IPY by fusion of MODIS/TERRA land bands B1–B7. International Journal of Remote Sensing, 30, 1635-1641.

20. Hearing the grass grow: vegetation records at automatic climate stations

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Many ecological studies lack detailed information about the local climate and the climate history. This problem can be solved if vegetation studies are carried out in the immediate vicinity of (long-term) climate stations that measure e.g. air temperatures, precipitation and timing of snowmelt.

We studied climate, vegetation and phenology at 100+ climate stations in Switzerland, at elevations ranging from 1139 to 2950 m asl, some of which have been running for 45 years. We are currently in the process of extending this study to climate stations in cold regions world-wide, which can be relevant for the AVA workshop.

For Switzerland we saw

(i.) that snow cover duration has significantly shortened in Switzerland on average by 8.9 days per decade over the 1970-2016 period,
(ii.) that snow cover is an excellent predictor for spring plant phenology,
(iii.) that despite climate warming the frost risk for alpine plants during the early growing season has not decreased, and
(iv.) how snowmelt timing modulates effects of temperature on alpine vegetation.

References

Klein, G., M. Rebetez, C. Rixen, and Y. Vitasse. 2018. Unchanged risk of frost exposure for subalpine and alpine plants after snowmelt in Switzerland despite climate warming. International Journal of Biometeorology **62**:1755-1762.

Klein, G., Y. Vitasse, C. Rixen, C. Marty, and M. Rebetez. 2016. Shorter snow cover duration since 1970 in the Swiss Alps due to earlier snowmelt more than to later snow onset. Climatic Change **139**:637-649.

Vitasse, Y., M. Rebetez, G. Filippa, E. Cremonese, G. Klein, and C. Rixen. 2017. 'Hearing' alpine plants growing after snowmelt: ultrasonic snow sensors provide long-term series of alpine plant phenology. International Journal of Biometeorology **61**:349-361.

Vitasse, Y., L. Schneider, C. Rixen, D. Christen, and M. Rebetez. 2018. Increase in the risk of exposure of forest and fruit trees to spring frosts at higher elevations in Switzerland over the last four decades. Agricultural and Forest Meteorology **248**:60-69

21. Utilization of vegetation databases in environmental and ecological research

Jozef Šibík[1], A.L. Breen, L.A. Druckenmiller, S. Hennekens, J. Peirce, M.K. Raynolds, L.M. Wirth, D.A. Walker

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Vegetation databases (archived plot data) have become a standard tool for ecologists and vegetation scientists in recent decades. Species data together with environmental characteristics of sites and other ancillary data, such as soils, NDVI, etc., serve as a unique source of ground-based information. The Arctic Vegetation Archive (AVA) represents a complementary platform to the European Vegetation Archive (EVA) and other plant community databases in global repositories such as sPlot or GIVD. Based on the Turboveg database management system for input, storage and further processing of phytosociological relevés or similar interconnected software solutions, we are able to share data and easily link them with other tools.

Possible utilization of vegetation databases found in various domains:

1. Phytosociologists usually benefit from vegetation overviews, supra-regional synthesis, and the naming of spatial and temporal changes of vegetation.
2. Ecologists profit from analyses of various environmental variables in relation to individual species or from the determination of species response on a target gradient. They can use huge databases for macro-ecological analyses.
3. Geographers prefer using data for calibration of their models.
4. Taxonomists focus on chorological studies, and identification of co-occurrences of selected species.
5. Conservationists utilize archive data for habitat mapping and the detection of specific taxa potentially serving as bioindicators. Plot data can also be used for the compilation of red lists on several hierarchical levels (species, habitats, regions, countries) and help to prepare for the assessment of ongoing processes in environment.

Choosing appropriate indicators, we could potentially detect particular impacts of climate changes on biota and subsequently evaluate the degree of actual and potential threat and specifically address future problems for each of these groups of users.

This talk provides an overview and inspiration for potential applications of plot data for vegetation classifications, mapping, habitat monitoring, species diversity hypotheses testing, evaluating spatio-temporal changes and other relevant topics.

21. New information on the vegetation of the northern part of the Gydan Peninsula (subzone of typical tundra)

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[1] *The Central Siberian Botanical Garden, Siberian Branch of the Russian Academy of Science, Novosibirsk, Russia*

The vegetation of Gydan Peninsula is still poorly studied. The local data on plant communities of Gydan are mentioned in the works by A. I. Tolmachev (1926) and B. N. Gorodkov (1928, 1932). Brief data on Gydan vegetation are given in the legend of the map of Western Siberian Plain vegetation (Ilina et al., 1985).

The study aimed to reveal the vegetation diversity in the region, to classify it, as well as the characteristics of the selected syntaxons.

The studies were conducted in two regions of the northern part of Gydan Peninsula: Yambuto Lake vicinities (N 71°13', E 79°16') and lower reaches of the Laptanyakha River (N 71°54', E 78°40'). In total, 319 complete geobotanical relevés were made. The plot size ranged from 30 to 100 m^2.

The relevés were arranged as a database in TURBOVEG package environment. Mathematical analysis was made by means of MegaTab and TWINSPAN software. The nomenclature of derived syntaxa is in accordance with the International Code of Phytosociological Nomenclature (Weber, Moravec, Theurillat, 2000).

For the first time, syntaxonomic vegetation diversity of the northern part of Gydan Peninsula was defined. A total of 9 associations of 6 subassociations, 1 variant and 1 community were identified for this territory. Of them, 4 associations (***Peltigero caninae–Hylocomietum alaskani*** Telyatnicov et al. (in press.), ***Hierochloo alpinae–Hylocomietum alaskani*** Telyatnikov et al. (in press.), ***Hylocomieto alaskani–Salicetum glaucae*** Telyatnikov et al. (in press.), ***Chrysosplenio sibirici–***

Polemonietum acutiflori Telyatnikov et al. (in press.), 5 subassociations (***Carici concoloris–Hylocomietum splendentis aulacomnietosum palustris*** Telyatnikov et al. (in press.), ***Chrysosplenio sibirici–Polemonietum acutiflori typicum*** Telyatnikov et al. (in press.), ***Chrysosplenio sibirici–Polemonietum acutiflori salicetosum reticulatae*** Telyatnikov et al. (in press.), ***Pediculari verticillatae–Astragaletum arctici trisetosum litoralis*** Telyatnikov et al. (in press.), ***Poo arcticae–Dupontietum fischeri salicetosumglaucae*** Telyatnikov et al. (in press.) were described for the first time.

Some similarities in the vegetation of the Taimyr and Gydansky peninsulas are revealed. Part of the discussed syntaxa of subassociation level and the variants refer to the associations described for Taimyr peninsula.

This work was supported by the Russian Foundation for Basic Research (project № 18-04-01010 A).

References

Gorodkov B. N. 1928. Raboty Gydanskoj e'kspedicii Akademii nauk po puti k istokam r. Gydy [The works of the Gydan expedition of the Academy of Sciences on the way to the upper reaches of the Gyda River] Dokl. AN SSSR. Ser. A. [Report of the USSR Academy of Sciences. Serie A]. № 7. P. 113–117. (In Russian).

Gorodkov B. N. 1932. Pochvy Gydanskoj tundry [Soils of Gydan tundra] // Tr. Polyarnoj komissii AN SSSR [Proceedings of the Polar Commission of the Academy of Sciences of the USSR]. № 7. P. 1–78. (In Russian).

Ilina I.S., Lapshina E.I., Lavrenko N.N., Melcer L.I., Romanova E.A., Bogoyavlenskij B.A., Maxno V. D. 1985. Rastitel`ny`j pokrov Zapadno-Sibirskoj ravniny` [The vegetation cover of the West Siberian Plain]. Novosibirsk. 251 p. (In Russian).

Telyatnikov M.Yu. Telyatnikov, E.I. Troeva, K.A. Ermokhina, S.A. Prystyazhnyuk. (in press). Tundra vegetation of two regions at the northern part of Gydan Peninsula (the subzone of typical tundra).

Tolmachev A. I. 1926. Predvaritel'nyj otchet o poezdke v nizov'ya Eniseya i v pribrezhnuyu chast' Gydanskoj tundry letom 1926 g. [Preliminary report on the trip to the lower reaches of the Yenisey and to the coastal part of Gydan tundra in the summer of 1926] Izv. AN SSSR. [Proceedings of the USSR Academy of Sciences]. Vol. 6. №18. P. 1655–1680. (In Russian).

Weber H. E., Moravec J., Theurillat J.-P. 2000. International code of phytosociological nomenclature. 3rd ed. // J. Veg. Sci. Uppsala. Vol. 11. P. 739–768.

22. Identifying botanical research gaps across Arctic terrestrial gradients

Anna Maria Virkkala[1], A.M. Abdi, M. Luoto, D.B. Metcalfe

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Global warming is driving environmental change in the Arctic. However, our current understanding of this change varies strongly among different environmental disciplines and is limited by the number and distribution of field sampling locations. Here, we use a quantitative framework based on multivariate statistical modeling to present the current state of Arctic sampling across environmental disciplines, with an emphasis on botanical research. We utilize an existing database of georeferenced Arctic field studies (Metcalfe et al. 2018) to investigate how sampling locations and citations of disciplines are distributed across Arctic topographical, soil and vegetation conditions, and highlight critical regions for potential new research areas. Continuous permafrost landscapes, and the northernmost Arctic bioclimatic zones are studied and cited the least in relation to their extent. Sampling locations for botanical studies cover the environmental gradients the best compared to other environmental disciplines. We conclude that more research is needed particularly in Canadian Arctic Archipelago, northern Greenland, central and eastern Siberia, and also in Canadian mainland, western Siberia and northern Taimyr region. We provide detailed maps of potential new sampling locations that consider multiple variables simultaneously. These results will help prioritize future research efforts, thus increasing our knowledge about the Arctic environmental change.

References

Metcalfe DB, Hermans TDG, Ahlstrand J, et al. (2018) Patchy field sampling biases understanding of climate change impacts across the Arctic. Nature Ecology and Evolution: 1–6.

23. Circumpolar arctic vegetation mapping, classification, and transects: A framework for Arctic change analysis

D.A. (Skip) Walker, M.K. Raynolds, A.L. Breen, L.A. Druckenmiller, J. Šibík, H.E. Epstein, U.S. Bhatt, G. Schaepman-Strub, Circumpolar Vegetation Group*

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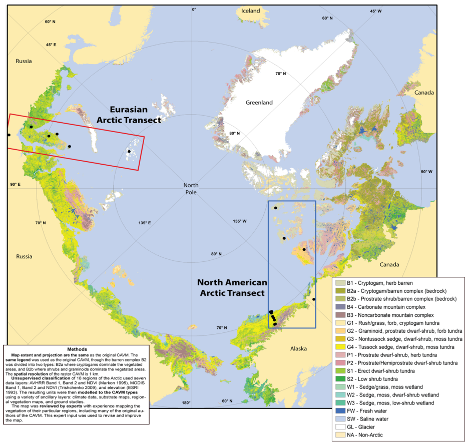
**The Circumpolar Vegetation Group includes participants in Circumpolar Arctic Vegetation Map (CAVM), Arctic Vegetation Archive (AVA), Arctic Vegetation Classification (AVC), Circumboreal Vegetation Map (CBVM), the IPY Greening of the Arctic analysis of circumpolar NDVI patterns (including the North America and Eurasia Arctic transects), and others involved with the circumpolar analyses of these data.*



Methods

Map extent and projection are the same as the original CAVM. The **same legend** was used as the original CAVM, though the barren complex B2 was divided into two types: B2a where cryptogams dominate the vegetated areas, and B2b where shrubs and graminoids dominate the vegetated areas. The **spatial resolution** of the raster CAVM is 1 km.

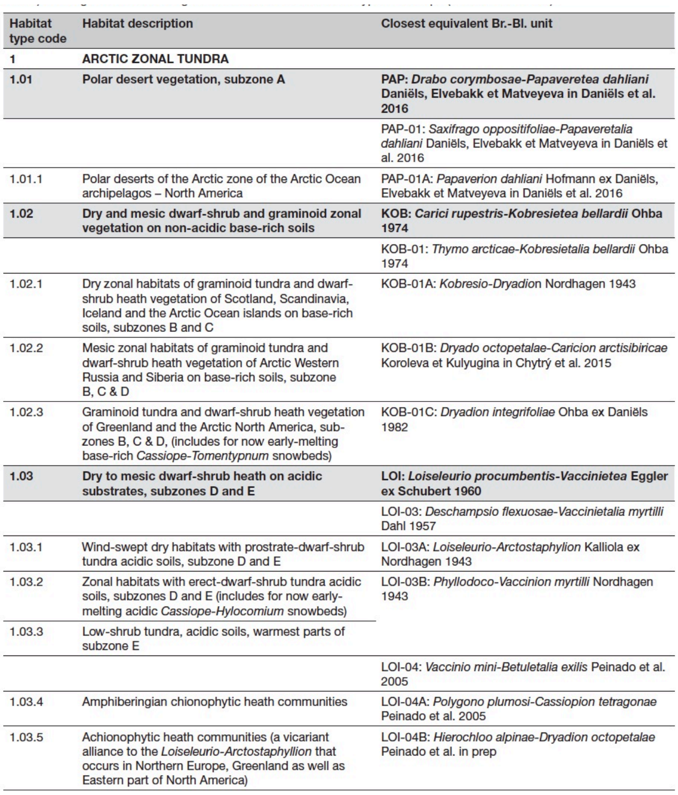
Unsupervised classification of 18 regions of the Arctic used seven data layers: AVHRR Band 1, Band 2 and NDVI (Markon 1995), MODIS Band 1, Band 2 and NDVI (Trishchenko 2009), and elevation (ESRI 1993). The resulting units were then **modelled to the CAVM types** using a variety of ancillary layers: climate data, substrate maps, regional vegetation maps, and ground studies.

The map was **reviewed by experts** with experience mapping the vegetation of their particular regions, including many of the original authors of the CAVM. This expert input was used to revise and improve the map.

***Figure 1**. The raster CAVM (Raynolds et al. 2019), with the locations of the two arctic transects.*

A hierarchical circumpolar framework of arctic tundra vegetation is needed for a wide variety of purposes including studying and modeling past and future changes to arctic terrestrial ecosystems Walker et al. 2016a). Several products of the Conservation of Arctic Flora and Fauna are key to our current understanding including the PanArctic Flora (Elven et al. 2011), the Circumpolar Arctic Vegetation Map (CAVM Team 2003), the Arctic Biodiversity Assessment (Daniëls et al. 2013), the Arctic Vegetation Archive (AVA) (Walker et al. 2016b) and Arctic Vegetation Classification (Walker et al. 2018) as they relate to efforts to describe and map the vegetation, plant biomass, and biodiversity of the Arctic at circumpolar, regional, landscape and plot scales. Cornerstones for all these tools are ground-based plant-species and plant-community surveys. Most of these build on the Russian geobotanical traditions (Yurtsev 1994) and a key international workshop in 1992 that initiated international collaboration in

***Table 1**. Partial table of arctic habitat types with the closest equivalent Br.-Bl. unit based on information from Greenland (Bültmann & Daniëls 2013), Europe (Mucina et al. 2016), Western North America (Peinado et al. 2005) and Alaska (Walker et al. 2016) with the organization following Mucina et al. (2016).*



Habitat type code	Habitat description	Closest equivalent Br.-Bl. unit
1	**ARCTIC ZONAL TUNDRA**	
1.01	**Polar desert vegetation, subzone A**	**PAP:** ***Drabo corymbosae-Papaveretea dahliani*** **Daniëls, Elvebakk et Matveyeva in Daniëls et al. 2016**
		PAP-01: *Saxifrago oppositifoliae-Papaveretalia dahliani* Daniëls, Elvebakk et Matveyeva in Daniëls et al. 2016
1.01.1	Polar deserts of the Arctic zone of the Arctic Ocean archipelagos – North America	PAP-01A: *Papaverion dahliani* Hofmann ex Daniëls, Elvebakk et Matveyeva in Daniëls et al. 2016
1.02	**Dry and mesic dwarf-shrub and graminoid zonal vegetation on non-acidic base-rich soils**	**KOB:** ***Carici rupestris-Kobresietea bellardii*** **Ohba 1974**
		KOB-01: *Thymo arcticae-Kobresietalia bellardii* Ohba 1974
1.02.1	Dry zonal habitats of graminoid tundra and dwarf-shrub heath vegetation of Scotland, Scandinavia, Iceland and the Arctic Ocean islands on base-rich soils, subzones B and C	KOB-01A: *Kobresio-Dryadion* Nordhagen 1943
1.02.2	Mesic zonal habitats of graminoid tundra and dwarf-shrub heath vegetation of Arctic Western Russia and Siberia on base-rich soils, subzone B, C & D	KOB-01B: *Dryado octopetalae-Caricion arctisibiricae* Koroleva et Kulyugina in Chytrý et al. 2015
1.02.3	Graminoid tundra and dwarf-shrub heath vegetation of Greenland and the Arctic North America, sub-zones B, C & D, (includes for now early-melting base-rich *Cassiope-Tomentypnum* snowbeds)	KOB-01C: *Dryadion integrifoliae* Ohba ex Daniëls 1982
1.03	**Dry to mesic dwarf-shrub heath on acidic substrates, subzones D and E**	**LOI:** ***Loiseleurio procumbentis-Vaccinietea*** **Eggler ex Schubert 1960**
		LOI-03: *Deschampsio flexuosae-Vaccinietalia myrtilli* Dahl 1957
1.03.1	Wind-swept dry habitats with prostrate-dwarf-shrub tundra acidic soils, subzone D and E	LOI-03A: *Loiseleurio-Arctostaphylion* Kalliola ex Nordhagen 1943
1.03.2	Zonal habitats with erect-dwarf-shrub tundra acidic soils, subzones D and E (includes for now early-melting acidic *Cassiope-Hylocomium* snowbeds)	LOI-03B: *Phyllodoco-Vaccinion myrtilli* Nordhagen 1943
1.03.3	Low-shrub tundra, acidic soils, warmest parts of subzone E	
		LOI-04: *Vaccinio mini-Betuletalia exilis* Peinado et al. 2005
1.03.4	Amphiberingian chionophytic heath communities	LOI-04A: *Polygono plumosi-Cassiopion tetragonae* Peinado et al. 2005
1.03.5	Achionophytic heath communities (a vicariant alliance to the *Loiseleurio-Arctostaphyllion* that occurs in Northern Europe, Greenland as well as Eastern part of North America)	LOI-04B: *Hierochloo alpinae-Dryadion octopetalae* Peinado et al. in prep

arctic vegetation Science (M.D. Walker et al. 1994).

Here we present an update on a new version of the Circumpolar Arctic Vegetation Map, the classification, and two arctic transects that traverse the full bioclimate gradient in North America and Eurasia (Fig. 1). The new raster version of the map provides a much higher resolution version of the CAVM that will increase its application for modeling (Raynolds et al. 2019). The map is part of a hierarchy of maps centered on the Arctic LTER site (Walker et al. 2010).

The Arctic Vegetation-plot Archive (AVA) (Walker et al. 2016, Breen et al. 2013, 2014) and an Arctic Vegetation Classification (AVC) are modeled after the European Vegetation Archive (Chytry et al. 2015) and Classification (Mucina et al. 2016). Approximately 30,000 vegetation plots from across the Arctic have been identified for inclusion in the AVA (Walker et al. 2019). The units of the classification are organized according to their associated habitat types, similar to the approach used in the European Vegetation Archive) (Table 1).

A prototype AVA was produced for Alaska (the AVA-AK) (Walker et al. 2016b) and is publicly accessible via a web-based portal, the Alaska Arctic Geobotanical Atlas (http://alaskaaga.gina.alaska.edu). The next step will be to assemble similar archives for other regions of the Arctic. New data are currently being added from Canada and Russia. The archive, classification and hierarchy of maps provide a framework to examine change across the Arctic bioclimate gradient.

Two transects in North America (Walker et al. 2011)and Eurasia Walker et al. 2019) have been established (Fig. 1). Analyses from plots along the Eurasia transect demonstrates the types of key information that are available regarding vegetation structure and species composition along the arctic climate gradient in different soil conditions (Fig. 2).

Similar studies are needed along the Arctic climate gradient in other parts of the Arctic, and across other gradients, such as toposequences, snow and glacial sequences, and a variety of substrates within each subzone.

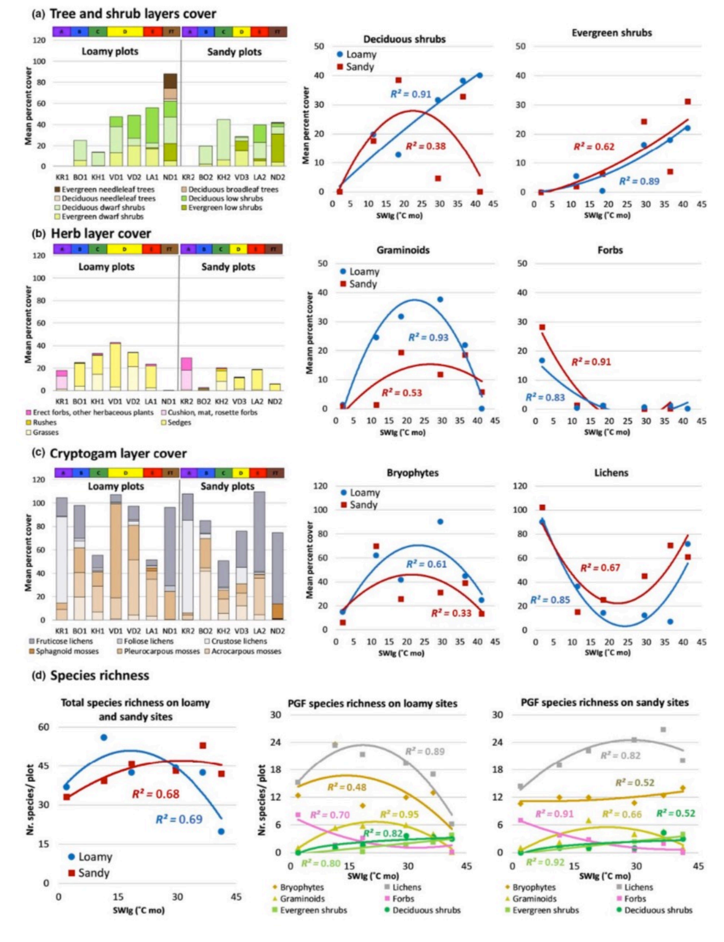


Figure 2. *Analysis of the trends of plant growth form biomass and species diversity along the summer warmth gradient of the Eurasia Arctic Transect (Walker et al. 2019).*

As sea ice retreats in the Arctic, it will be especially important to consider the consequences to the land-surface temperatures and vegetation. The current vegetation patterns will likely change in unpredictable ways, possibly eliminating the most northernmost subzone if summer sea ice totally vanishes. Difficult logistics limit the number of sampling locations and the quantity of data that can be collected, so it is important that standardized methods of data collection are developed and followed wherever possible. A longer-term goal is to use the AVA to develop a classification according to both the European Braun-Blanquet approach and the EcoVeg approach of the U.S. National Vegetation Classification (Faber-Langendoen et al. 2018), and the Canadian vegetation classification approach (MacKenzie et al. 2018) with a crosswalks between the approaches.

References

Breen, A. L., Raynolds, M. K., Hennekens, S., Walker, M., & Walker, D. A. (2013). Toward an Alaska prototype for the Arctic Vegetation Archive. In D. A. Walker, A. L. Breen, M. K. Raynolds, M. D. Walker, & M. Walker (Eds.), (pp. 17–28). *Proceedings of the Arctic Vegetation Archive Workshop, 14-16 April 2013, Krakow, Poland.* CAFF Proceedings Series Report Nr. 10. Conservation of Arctic Flora and Fauna, Akureyri, Iceland.

Breen, A. L., Druckenmiller, L., Hennekens, S. M., Raynolds, M. K., Walker, M. D., & Walker, D. A. (2014). Progress toward an Alaska prototype for the Arctic Vegetation Archive: Workflow and data dictionary. (pp. 7–21)/ *Proceedings of the Alaska Arctic Vegetation Archive Workshop Boulder, Colorado, USA October 14-16, 2013.* CAFF Proceedings Series Report Nr. 11. Conservation of Arctic Flora and Fauna, Akureyri, Iceland.

Bültmann, H. & Daniëls, F.J.A. 2013. Greenland data stored in the Arctic Vegetation Archive (AVA) in Münster. *Arctic Vegetation Archive (AVA) Workshop, Krakow, Poland, April 14-16, 2013,* CAFF Proceedings Series Report nr. 10. Akureyri, IS: Conservation of Arctic Flora and Fauna, 29– 32.

CAVM Team, et al. (2003). Circumpolar Arctic Vegetation Map. *Conservation of Arctic Flora and Fauna Map (CAFF) Map No. 1*. Anchorage, AK: U.S. Fish and Wildlife Service.

Chytrý, M., Hennekens, S. M., Jíménez-Alfaro, B., Knollová, I., Dengler, J., Jansen, F., et al. (2015). European Vegetation Archive (EVA): an integrated database of European vegetation plots. *Applied Vegetation Science*, *19*, 173–180. http://doi.org/10.1111/avsc.12191.

Daniëls, F. J. A., Gillespie, L. J., Poulin, M., et al. (2013). Plants. In *Arctic Biodiversity Assessment* (pp. 310–345). Akureyri, Iceland: Conservation of Arctic Flora and Fauna.

Elven, R., Murray, D. F., Razzhivin, V. Y., & Yurtsev, B. A. (2011). Annotated checklist of the panarctic flora (PAF): vascular plants. *National Centre of Biosystematics, Natural History Museum, University of Oslo*.

Faber-Langendoen, D., Baldwin, K., Peet et al. (2018). The EcoVeg approach in the Americas: U.S., Canadian and international vegetation classifications. *Phytocoenologia*, *48*(2), 215–237.

Hennekens, S. M., & Schaminée, J. H. J. (2001). TURBOVEG, a comprehensive data base management system for vegetation data. *Journal of Vegetation Science*, *12*, 589–591.

MacKenzie, W. H., & Meidinger, D. V. (2018). The Biogeoclimatic Ecosystem Classification approach: an ecological framework for vegetation classification. *Phytocoenologia*, *48*(2), 203–213.

Mucina, L., Bültmann, H., Dierssen, K., et al. (2016). Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities . *Applied Vegetation Science*, *19 (Suppl. 1)*, 3–264.

Peinado, M., Aguirre, J.L., Delgadillo, J., González, J. & Martínez-Parras, J.M. 2005. A phytosociological survey of the chinophilous communities of western North America. Part II: Boreal Associations. *Plant Ecology* 180: 243–256.

Raynolds, M. K., Walker, D. A., Balser, A., Bay, C., Campbell, M., Cherosov, M. M., et al. (2019). A raster version of the Circumpolar Arctic Vegetation Map (CAVM). *Remote Sensing of Environment*, *232*, 111297.

Walker, D. A., Daniëls, F. J. A., Alsos, I., Bhatt, U. S., Breen, A. L., Buchhorn, M., et al. (2016). Circumpolar arctic vegetation: a hierarchic review and roadmap toward an internationally consistent approach to survey, archive and classify tundra plot data. *Environmental Research Letters*, *11*(5), 055005. http://doi.org/10.1088/1748-9326/11/5/055005.

Walker, D. A., Raynolds, M. K., Maier, H. A., et al. (2010). Circumpolar geobotanical mapping: A web-based plant-to-planet approach for vegetation-change analysis in the Arctic. *Viten Fra Skog Og Landscap*, 125–128.

Walker, D. A., Kuss, P., Epstein, H. E., et al. (2011). Vegetation of zonal patterned-ground ecosystems along the North America Arctic bioclimate gradient. *Applied Vegetation Science*, *14*(4), 440–463.

Walker, D. A., Breen, A. L., Druckenmiller, L. A., et al. (2016). The Alaska Arctic Vegetation Archive (AVA-AK). *Phytocoenologia*, *46*, 221–229.

Walker, D. A., Daniëls, F. J. A., Matveyeva, et al. (2018). Circumpolar Arctic Vegetation Classification. *Phytocoenologia*, *48*(2), 181–201.

Walker, D. A., Epstein, H. E., Šibík, J., et al. (2019). Vegetation on mesic loamy and sandy soils along a 1700-km maritime Eurasia Arctic Transect. *Applied Vegetation Science*, *22*(1), 150–167.

Walker, M. D., Daniëls, F. J. A., & Van der Maarel, E. (1994). Circumpolar arctic vegetation: Introduction and perspectives. *Special Features in Journal of Vegetation Science*, *5*(6), 757–920.

Yurtsev, B. A. (1994). The floristic division of the Arctic. *Journal of Vegetation Science*, *5*(6), 765–776.

24. There and back again: the critical importance of a truly international database of arctic vegetation

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The question as to which book I should bring along, should I be stranded alone on an island for some length of time, has always been easy for me. I would bring J.R.R. Tolkien's *The Hobbit, or There and Back Again*, and I should spend my days memorizing it. Although this may seem a strange introduction to a scientific talk, it is important to remember that the title of the first chapter is "An Unexpected Party." From that party and all those strange guests who showed up came one of the great adventures of all time.

As a young scientist, I never dreamed my naïve ideas that the global community of arctic vegetation scientists should come together and form a unified approach to describing and mapping vegetation would lead to lifelong friendships, travel to remote lands, and an unexpected party. The first meeting, in Boulder, Colorado in the Spring of 1992, was a few years in the making - first to gather the modest budget for it, and then to communicate, via the postal service, with the key players. We came from different languages, different scientific approaches, and different landscapes, each convinced that the part of the proverbial elephant right in front of us was the correct one. There was no internet, no instant communication. The principle finding of the meeting was that we should develop an international database of arctic vegetation, so that we would have a common understanding for all other science that depended upon this basis.

As the convener of that meeting, I never imagined myself here in the future, looking at global temperature anomaly maps that have moved from the surprising and into the alarming, with the greatest anomalies concentrated in the high latitudes. The anomalies are so great that we need a new scale for these maps. So, I am very pleased to be once again here in Russia, where I first traveled in 1990, with a handful of my colleagues from that original Boulder meeting as well as these brilliant early and mid-career scientists who have done much of the work. The moment is now. You have succeeded in many things, and made great strides toward this international cooperation. There now *is* a database, but it needs completion. The meeting is here in Arkhangelsk so that you can make the final push to include the decades of Russian research and analysis that are critical toward protecting and managing the fragile biodiversity of the planet's Arctic. We are so much more together.

25. Plant species composition of tundra vegetation in subzone D and E, West Siberia: the approach to comparative analysis

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The territory of Gydan, Tazovsky and Yamal peninsulas is characterized by simple landscape structure and low species richness (Khitun, Rebristaya, 2014).The absence of significant natural barriers, the prevalence of similar parent materials, soils and biotopes contribute to considerable flora similarity across the vast area. Due to this reason, climate factors play a leading role in floral differentiation of the territory. This provides favorable conditions for study of zonal trends and patterns (Rebristaya, 2013). The aim of the research was to perform a comparative analysis of taxonomic, geographical and ecological groups of vascular plants in West Siberian tundra based on new field data.

We used the subzonal division of the Arctic suggested by CAVM team (CAVM, 2003). Nomenclature of plants follows the Pan Arctic species list (Raynolds et al. 2013). As to groups of plants for geographical and ecological analysis we follow N. A. Sekretaryeva (1999). To access similarity of flora we used Jaccard index.

Vegetation of 6 key territories was studied by the scientific team during the field season, 2017. 459 relevés were collected in subzone D and 370 – in subzone E: Nakhodka bay, Central part of Southern Yamal and West part of Tazovsky Peninsula (subzone E), Neyto lake region, Parisento lake region and left bank of Tanama river (subzone D). We also use the data collected by Ksenia Ermokhina in 2003 (Bovanenkovo region and Khalevto lake (Yamal), subzone D), 2011 (The research station "Vaskiny Dachi", subzone D) and in 2012 (South Tambey (Yamal), “Geophysics” and “Salma” gas fields (Gydan) (subzone D)), Myam region (Yamal, subzone E)). Total number of relevés was 496.

Flora of tundra in subzones D and E have a high degree of similarity (Jaccard index 0,5) and similar composition of prevailing families: namely *Cyperaceae*, *Poaceae*, *Asteraceae*, *Salicaceae, Rosaceae*, *Scrophulariaceae*, *Ranunculaceae*. Nevertheless, some differences were identified. *Polygonaceae* and *Ericaceae* are better represented in subzone E and *Caryophyllaceae и Brassicaceae* – in subzone D. Most important families also differ: *Poaceae* has leading position in subzone D while *Cyperaceae* – in subzone E. Species of *Juniperaceae* and *Isotoeaceae* were found in subzone E but not in subzone D. Vascular plants species richness in subzone D (233 species, 106 genera and 44 families) is higher than in subzone E (168 species, 100 genera and 46 families). This difference probably is due to tundra subzone E overgrazing (Golovatin, Morozova, Ektova, 2012).

As to geographical groups of species, vegetation of subzone D is characterized by a high portion of arctic and meta-arctic (31%) and circumpolar (36%) species. In contrast, boreal species in flora reach only 8% in subzone D and 13% in subzone E. The role of hypoarctic species is also higher in subzone E (table 1).

Table1.*Proportions of geographical elements in floras of West Siberian tundra (subzones D and E) (after 2017 field season data)*

Latitudinal geographical fractions	D, %	E, %	Δ, %	**Longitudinal geographical fractions**	D, %	E, %	Δ, %
Arctic	23	13	-10	Circumpolar	36	29	-7
Meta-arctic	9	6	-3	Circumboreal	14	18	+4
Arctic-alpine	18	17	-1	Amphi-ocean	4	6	+2
Hypoarctic	22	28	+6	North-American	4	5	+1
Arctic-boreal	19	20	+1	Eurasian	20	23	+3
Boreal	8	13	+5	European	6	8	+2
Plurizonal	1	3	+1	Siberian	16	8	-6

The ratio of ecological groups does not differ significantly between subzones D and E (table 2). Hygrophytes and hydrophytes have a slightly greater weight in subzone E than in subzone D. It can be explained by a contrast between swamplands of Tazovsky Peninsula and Southern Yamal and more well-drained low hills of the central part of Yamal and Gydan.

Table 2. *Proportions of ecological groups in floral composition of communities of West Siberian tundra (subzones D and E)*

Ecological groups	**Subzone D**,%	**Subzone E**, %	Δ,%
Mesoxerophytes	4	2	-2
Xeromesophytes	13	11	-2
Mesophytes	32	26	-6
Hydromesophytes	7	11	+4
Mesohygrophytes	16	20	+4
Hygrophytes	13	12	-1
Hygrophytes-Hydrophytes	3	5	+2
Hydrophytes	1	2	+1
Hydatophytes	0	1	+1
Eurytopic plants	11	10	-1

Polycarpic grasses prevail in both subzones (86% of identified subzone D species and 76% of identified subzone E species). The most visible difference is the higher role of long-rhizome herbs species and greater presence of shrubs in subzone E than in subzone D. A noticeable common feature of both subzones is the low number of monocarpic grasses, insectivorous and aquatic plants (Table 3).

Table 3. *Plant life forms composition in the West Siberian tundra (subzones D and E)*

Plant life-forms	**Subzone D, number of species (%)**	**Subzone E, number of species (%)**	**Δ,%**
Shrubs	11 (4,7)	14(8,3)	+3,6
Dwarf-shrubs	14 (6,0)	14 (8,3)	+2,3
Hemi shrubs	7 (3,0)	6 (3,6)	-0,6
Main-root herbs	34 (14,6)	11 (6,5)	-8,1
Long-rhizome herbs	52 (22,3)	43 (25,6)	+3,3
Root-shoot herbs	4 (1,7)	2 (1,2)	-0,5
Creeping herbs	10 (4,3)	6 (4,2)	-0,1
Stoloniferous herbs	3 (1,3)	5 (3,0)	+1,7
Short rhizome herbs	39 (16,7)	27 (16,1)	-0,6
Coronal root herbs	9 (3,9)	7 (4,2)	+0,3
Loose tussock herbs	20 (8,6)	12 (7,1)	-1,5
Dense tussock herbs	19 (8,2)	10 (6,0)	-2,2
Tuberous and bulbous herbs	2 (0,9)	2 (1,2)	+0,3
Insectivorous plants	1 (0,4)	1 (0,6)	+0,2
Mono- and oligocarpic herbs	7 (3,0)	2 (1,2)	-2,8
Aquatic herbs	1 (0,4)	3 (1,8)	+1,4

The obtained results confirm the floristic unity of both subzones as parts of tundra biome. The most significant difference between subzonal floras is the decrease of arctic and increase of hypoarctic and boreal fractions from subzone D to subzone E, but the role of arctic-alpine and arctic-boreal species is still stable. Another distinction is the fall of the role of Siberian and circumpolar species and the increase of circumboreal species role. There are noticeable also the decline of polycarpic grass portion and the increase of the shrubs portion from the north to the south.

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References

Golovatin, M. G., Morozova, L. M., & Ektova, S. N. (2012). Effect of reindeer overgrazing on vegetation and animals of tundra ecosystems of the Yamal peninsula. *Czech Polar Reports*, *2*(2), (pp. 80-91).

Sekretareva, N.A. (1999). The vascular plants of the Russian Arctic and adjacent territories. No. 1. Pensoft Pub, (pp. 1-160.)

Khitun, O.V., Rebristaya, O.V.(1998). Study of plant species diversity in the West Siberian Arctic. In *Personal, societal, and ecological values of wilderness: sixth World Wilderness Congress: proceedings on research, management, and allocation*. Vol. 1. US Dept. of Agriculture, Forest Service, Rocky Mountain Research Station (pp. 42-48).

Raynolds, M. K., Breen, A. L., Walker, D. A., Elven, R., Belland, R., Konstantinova, N., ...&Hennekens, S. (2013, September). The Pan-Arctic Species List (PASL). In *Arctic Vegetation Archive (AVA) Workshop* (p. 92).

Rebristaya, O.V. (2013). Flora of the Yamal Peninsula. Current state and formation history. SPb. SPbGETU «LETI» Publ (p.188). (In Russian)

CAVM Team (2003). Circumpolar Arctic Vegetation Map. (1:7,500,000 scale), Conservation of Arctic Flora and Fauna (CAFF). U.S.N Fish and Wildlife Service, Anchorage, Alaska

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