



List of created scientific publications, other important publications, and data and tools produced by CHARTER

Deliverable 7.16

Grant Agreement Number: 869471

Project Acronym: CHARTER

Project title: Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity

Starting Date: 01/08/2020

Project Duration: 54 months

Project Officer: Alberto Zocchi

Project Coordinator: Bruce Forbes / LAY

Author(s): CHARTER coordination team

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Status	
Draft	x
Final	

Type		
R	Document, report	x
DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings, videos, etc.	
OTHER		

Dissemination level		
PU	Public	x
CO	Confidential, only for members of the consortium (incl. the Commission services)	

Revision history

Date(s)	Lead author(s)	Comments
23.1.25	Coordination team	1 st draft version
28.1.25	Coordination team	2 nd draft version
30.1.25	Coordination team	Final version, submitted

Introduction

The aim of the CHARTER project has been to advance state-of-the-art knowledge on Arctic biodiversity change and social-ecological systems (SES) on four critical fronts: i) Feedbacks: To understand transitions in vegetation cover, energy balance and cryospheric change at centennial, decadal, and present-day time scales; ii) SES and biodiversity: To understand the effects of biodiversity changes on Indigenous/local communities and traditional livelihoods, e.g. reindeer herding; iii) Modelling: To integrate biochemical/permafrost soil carbon exchange, sea ice and albedo into an Earth System Model (ESM), and incorporate these into the latest Arctic Regional Climate modeling efforts; and iv) Policy: To develop strategies supporting Arctic communities with co-benefits and synergies between adaptation, mitigation and policy implications. To accomplish these, CHARTER has combined expertise from Earth System sciences, biodiversity indices and SES research. CHARTER has been an ambitious effort to advance the modelling of 21st century Arctic change with major socio-economic implications and feedbacks for the cryosphere. CHARTER has brought strongly participatory approaches that incorporate Indigenous/local communities' ways of knowing regional changes with state-of-the-art research on circumpolar climate dynamics and long-term palaeoecological studies. CHARTER has collated and processed truly transdisciplinary quantitative and qualitative empirical datasets for a holistic view that can be modeled. Arctic residents and stakeholders have worked alongside scientists to identify risks and viable adaptation strategies in relation to projected changes and future resilience in Arctic SESs. CHARTER combined natural sciences with ESM and participatory approaches to leverage the untapped potential for wild ungulate and livestock management to regulate global climate feedbacks through 'biogeoeengineering'. CHARTER has produced new tools and data, and has supported and established public ARCTIC related dialogue. These, together with CHARTER's scientific results will support implementing sustainable Arctic strategies for decades to come.

CHARTER project tasks were distributed across multiple cross cutting work packages which ranged across academic disciplines and temporal timescales. A focus of several tasks was placed on synthesis which has resulted in the creation of the ground breaking Arctic Holocene Database, as well as significant steps towards the difficult task of comparing vegetation structures across Finland, Sweden and Norway. New tools including remote sensing, AI and drone campaigns were used extensively. A catalogue of rain-on-snow events derived from a reanalysis of remote sensing data was created. While workshops are not new in this field, CHARTER took steps to initiate new dialogue inducing techniques that included games and other hands-on activities to build trust and engagement. This included a citizen science component. As part of mainstream outreach, the project collaborated with the Arktikum Science Centre in Rovaniemi, Finland, to create two exhibit stations that focused on rain-on-snow and the study of snow.

In this report we list the scientific publications produced in CHARTER and published in peer-reviewed journals between August 2020 and January 2025. We also list other important publications, as well as data and tools produced by CHARTER.

List of scientific publications

Akperov, M., Wenxin Zhang, Paul A Miller, Igor I Mokhov, Vladimir A Semenov, Heidrun Matthes, Benjamin Smith and Annette Rinke. 2021. Responses of Arctic cyclones to biogeophysical feedbacks under future warming scenarios in a regional Earth system model. *Environmental Research Letters*, Volume 16, Number 6

Anderson, M., Myers-Smith, I.H., Zaja, E., Thomas, H.J.D., García Criado, M. et al. Earlier and increased growth of tundra willows in a warmer common garden environment. In review at *Journal of Ecology*. Preprint available at <https://doi.org/10.32942/X2132Q>

von Baeckmann, C., Bartsch, A., Bergstedt, H., Efimova, A., Widhalm, B., Ehrich, D., Kumpula, T., Sokolov, A., and Abdulmanova, S.: Land cover succession for recently drained lakes in permafrost on the Yamal Peninsula, Western Siberia, *The Cryosphere*, 18, 4703–4722, <https://doi.org/10.5194/tc-18-4703-2024>, 2024.

Barbero-Palacios, Laura, Isabel C Barrio, Mariana García Criado, Ilona Kater, Matteo Petit Bon, Tiina HM Kolari, Ragnhild Bjørkås, Jonas Trepel, Erick Lundgren, Katrín Björnsdóttir, Bernice C Hwang, Laura Bartra-Cabré, Mathilde Defourneaux, Jennifer Ramsay, Thomas K Lameris, A Joshua Leffler, Janine G Lock, Mari S Kuoppamaa, Jeppe A Kristensen, Anne D Bjorkman, Isla Myers-Smith, Nicolas Lecomte, Jan C Axmacher, Olivier Gilg, Michael Den Herder, Emmanuel P Pagneux, Anna Skarin, Natalia Sokolova, Torben Windirsch, Helen C Wheeler, Emmanuel Serrano, Tarmo Virtanen, David S Hik, Elina Kaarlejärvi, James DM Speed, Eeva M Soinen. 2024. The effects of herbivore diversity on tundra ecosystems: a systematic review. *Environmental Evidence* 13(6). <https://doi.org/10.1186/s13750-024-00330-9>

Barrio, I.C., Barbero-Palacios, L., Kaarlejarvi, E. et al. What are the effects of herbivore diversity on tundra ecosystems? A systematic review protocol. *Environ Evid* 11, 1 (2022). <https://doi.org/10.1186/s13750-022-00257-z>

Bartsch, A., G. Pointner, I. Nitze, A. Efimova, D. Jakober, S. Ley, E. Hogstrom, G. Grosse, P. Schweitzer (2021): Expanding infrastructure and growing anthropogenic impacts along Arctic coasts. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/ac3176>

Bartsch, A., Bergstedt, H., Pointner, G., Muri, X., Rautiainen, K., Leppanen, L., Joly, K., Sokolov, A., Orekhov, P., Ehrich, D., and Soinen, E. M. (2023): Towards long-term records of rain-on-snow events across the Arctic from satellite data, *The Cryosphere*, 17, 889–915, <https://doi.org/10.5194/tc-17-889-2023>.

Bartsch, A., Strozzi, T., and Nitze, I.: Permafrost Monitoring from Space, *Surveys in Geophysics*, 2023. <https://link.springer.com/article/10.1007/s10712-023-09770-3>

Bartsch, A., Efimova, A., Widhalm, B., Muri, X., von Baeckmann, C., Bergstedt, H., Ermokhina, K., Hugelius, G., Heim, B., and Leibman, M. 2024. Circumarctic land cover diversity considering wetness gradients, *Hydrol. Earth Syst. Sci.*, 28, 2421–2481, <https://doi.org/10.5194/hess-28-2421-2024>.

Berner, L.T., Assmann, J.J., Normand, S. and Goetz, S.J. (2023), 'LandsatTS': an R package to facilitate retrieval, cleaning, cross-calibration, and phenological modeling of Landsat time series data. *Ecography*, 2023: e06768. <https://doi.org/10.1111/ecog.06768>

Bjerke, J.W., Magnussen, K., Bright, R.M., Navrud, S., Erlandsson, R., Finne, E.A. & Tømmervik, H. 2024. Synergies and trade-offs between provisioning and climate-regulating ecosystem services in reindeer herding ecosystems. *Science of the Total Environment* 927, 10.1016/j.scitotenv.2024.171914.

Bårdsen, B.J., Tømmervik, H., Bjerke, J.W., Næss, M.V. 2025. Misreading or living in denial? Reindeer overstocking and long-term effects on vegetation: an experimental approach. *Ecoscape* (in print).

Castano C, Hallin S, Egelkraut D, Lindahl B, Olofsson J, Clemmensen KE. 2023. Contrasting plant-soilmicrobial feedbacks stabilize vegetation types and uncouple topsoil C and N stocks across a subarctic landscape. *New Phytologist* 238:2621-2633

Chen, Y., Moore, J. C., & Ji, D. 2024. Simulated responses and feedbacks of permafrost carbon under future emissions pathways and idealized solar geoengineering scenarios. *Environmental research letters*, 19(2), 024050.

Deilmann, T., Christiansen, D.M., García Criado, M. et al. 2024. Early Career Researchers advocate for raising the profile of bryophyte ecological research. *Basic and Applied Ecology* 81, 106-111. <https://doi.org/10.1016/j.baae.2024.11.001>

Doering, N., Dudeck, S., Elverum, S., Fisher, C., Henriksen, J.E., Herrmann, T., Kramvig, B., Laptander, R., Milton, J., Omma, E.M., Saxinger, G., Scheepstra, A.J.M. & Wilson, K. 2022. Improving the relationships between Indigenous rights holders and researchers in the Arctic: An invitation for change in funding and collaboration. *Environmental Research Letters*, 17 (6): 065014. DOI 10.1088/1748-9326/ac72b5

Druckenmiller, M.L., Thoman, R.L., and Moon T.A....Forbes, B.C....Tømmervik, H....., 2024: The Arctic [in "State of the Climate in 2023"]. *Bull. Amer. Meteor. Soc.*, 105 (8), S277–S330, <https://doi.org/10.1175/BAMS-D-24-0101.1>.

Eilola, S., Horstkotte, T., Forbes, B.C., Habeck, J.O. Komu, T., Rasmus, S., Fagerholm, N. 2024. Perceptions and impacts of environmental changes under multiple stressors: a case study from two boreal forest communities in northern Scandinavia/subarctic Scandinavia. *Regional Environmental Change* 24:89. <https://doi.org/10.1007/s10113-024-02241-4>

Erlandsson, R., Bjerke, J.W., Finne, E.A., Myneni R.B., Piao, S., Wang, X., Virtanen, T., Rasanen, A., Kumpula, T., Kolari, T.H.M., Tahvanainen, T., Tommervik, H. 2022. An artificial intelligence approach to remotely assess pale lichen biomass. *Remote Sensing of Environment* 280 (2022) 113201. <https://doi.org/10.1016/j.rse.2022.113201>

Forbes, B. C., Kumpula, T., Meschtyb, N., Laptander, R., Macias-Fauria, M., Zetterberg, P., Verdonen, M., Skarin, A., Kim, K.-Y., Boisvert, Linette N., Stroeve, J. C., Bartsch, A. 2022. Coping with a Warming Winter Climate in Arctic Russia: Patterns of Extreme Weather Affecting Nenets Reindeer Nomadism. In: *Resilience Through Knowledge Co-Production*, eds. Marie Roue, Douglas Nakashima, Igor Krupnik (pp.217-232). Cambridge: Cambridge University Press. DOI:10.1017/9781108974349.017

Frost, G. & Macander, M., Bhatt, U., Epstein, H., Logan, B., Bjerke, J.W., & Forbes, B., Goetz, S., Lara, M., Phoenix, G., Reynolds, M., Tommervik, H., Walker, D. (2021). Tundra greenness in: Blunden J. & Boyer T. (red.): *State of the Climate in 2020*. *Bulletin of the American Meteorological Society* 102 (8): S297–S299. doi:10.1175/2021BAMSStateoftheClimate. *Bulletin of the American Meteorological Society*. 102. S297-S299. 10.1175/2021BAMSStateoftheClimate.1. <https://doi.org/10.1175/BAMS-D-21-0082.1>.

Frost, G.V., Macander, M.J., Bhatt, U.S., Berner, L.T., Bjerke, J.W., Epstein, H.E., Forbes, B.C., Goetz, S.J., Heijmans, M.J., Lara, M.J., Magnusson, R.I., Park, T., Phoenix, G.K., Pinzon, J.E., Serbin, S.P., Tommervik, H., Tucker, C.J., Walker, D.A., & Yang D. 2022. State of the Climate in 2021: 5. The Arctic. *Bulletin of The American Meteorological Society - (BAMS)*, 103 (8), S290-S293. <https://doi.org/10.1175/BAMS-D-22-0082.1>.

Frost, G.V., Macander, M.J., Bhatt, U.S., Berner, L.T., Bjerke, J.W., Epstein, H.E., Forbes, B.C., Goetz, S.J., Lara, M. J., Magnusson, R. I., Phoenix, G.K., Serbin, S.P., Tommervik, H., Tutubalina, O., Walker, D.A. and Yang, D. 2023. Tundra greenness [in “State of the Climate in 2022”]. *Bull. Amer. Meteor. Soc.*, 104 (9), S305–S308, <https://doi.org/10.1175/10.1175/BAMS-D-23-0079.1>.

García Criado, Mariana, Isla H. Myers-Smith, Anne D. Björkman, Sarah C. Elmendorf, Signe Normand, Peter Aastrup, Rien Aerts, Juha M. Alatalo, Lander Baeten, Robert G. Björk, Mats P. Björkman, Noémie Boulanger-Lapointe, Ethan E. Butler, Elisabeth J. Cooper, J. Hans C. Cornelissen, Gergana N. Daskalova, Greg H.R. Henry, Robert D Hollister, Toke Thomas Høye, Belen Fadrique, Bruce C. Forbes, Ida Bomholt Dyrholm Jacobsen, Annika K. Jägerbrand, Ingibjörg S. Jónsdóttir, Elina Kaarlejärvi, Olga Khitun, Kari Klanderud, Tiina H. M. Kolari, Simone I. Lang, Nicolas Lecomte, Jonathan Lenoir, Petr Macek, Julie Messier, Anders Michelsen, Ulf Molau, Robert Muscarella, Marie-Louise Nielsen, Matteo Petit Bon, Eric Post, Katrine Raundrup, Riikka Rinnan, Christian Rixen, Ingvild Ryde, Josep M Serra-Diaz, Gabriela Schaepman-Strub, Niels M. Schmidt, Franziska Schrod, Sofie Sjögersten, Manuel J Steinbauer, Lærke Stewart, Beate Strandberg, Anne Tolvanen, Craig E. Tweedie and Mark Vellend. (2023). *Plant diversity*

dynamics over space and time in a warming Arctic. Pre-print at EcoEvoRxiv, paper currently under review at Nature. <https://ecoevorxiv.org/repository/view/5557/>

Habeck, J.O. (2024/2025, in press). Arrivals and Departures: The shifting "forefield" of anthropological research in Russia from a personal perspective. In: A Fractured North: [subtitle of volume 3 of the book series: #], edited by Erich Kasten, Igor Krupnik, & Gail Fondahl, pp. #-#. Fürstenberg/Havel: Kulturstiftung Sibirien.

Hannon, G.E., Molinari, C., Bradshaw, R.H.W. 2022. Factors influencing late-Holocene vegetation dynamics and biodiversity on Hallands Väderö, SW Sweden: A statistical evaluation. *The Holocene* 32, 1317-1326.

Horstkotte, T., Kumpula, J. Sandstrom, P. Tommervik, H., Kivinen, S. Skarin, A. Moen, J. & Sandstrom, S. 2022. Pastures under pressure. Effects of other land users and the environment. I: Reindeer Husbandry and Global Environmental Change. Routledge 2022 ISBN 9781003118565. 76-59

Istomin, K. V. & M. J. Dwyer (2021). Reindeer herder's thinking: A comparative research of relations between economy, cognition and way of life. Furstenberg/Havel: Kulturstiftung Sibirien; SEC Publications.

Istomin, K.V. 2020. Roads versus Rivers: two systems of spatial structuring in Northern Russia and their effects on local inhabitants. *Sibirica: Interdisciplinary Journal of Siberian Studies*, 19(2): 1-26. doi: 10.3167/sib.2020.190202

Istomin, K.V. 2022. Why (not) Marry a Reindeer Herder? Gender displacement and gender replacement among Izhma-Komi reindeer herders of Bol'shezemel'skaia Tundra. *Region: Regional Studies of Russia, Eastern Europe, and Central Asia*, 11 (3): 47-68.

Istomin, K.V., Habeck, J.O. & Laptander, R. 2022. Reindeer Herding Statistics in Russia: issues of reliability, interpretation, and political effect. *Pastoralism: Research, Policy and Practice*, 12(1): 19. <https://doi.org/10.1186/s13570-022-00233-9>

Istomin, K. V. (2023). Cultured reindeer, domesticated land, and (self)-cultivated herders: Histories and structures of reindeer herding landscapes in the European part of Russia. *Pastoralism: Research, Policy and Practice*, 2023, 13(1): 11 . <https://doi.org/10.1186/s13570-023-00273-9>

Истомин К. В. (2023) Между свободой и необходимостью движения: типы оленеводческих миграций в крупностадном оленеводстве севера европейской части России и Западной Сибири. *Этнография*, №1, сс. 139–163.

Istomin, K. 2024. Snowmobile revolution and sedentarization of reindeer-herding nomads in the Kola Peninsula and Bolshezemelskaya tundra, North of European Russia. In Allan Degen (ed.), *Lifestyle and Livelihood Changes among Formerly Nomadic Peoples: Entrepreneurship, diversity and urbanisation*. Springer, 2024

Istomin, K.V., Laptander, R., Habeck, J.O. 2025. From a Cut to a Tag: Formalization of Reindeer Marking Practice by the State and its Consequences in the North of European Russia and Western Siberia. *Sibirica: Interdisciplinary Journal of Siberian Studies*, 23 (3). in print.

Kaaronen, R.O., Manninen, M.A., Eronen, J.T. 2023. Rules of thumb, from Holocene to Anthropocene. *The Anthropocene Review*
<https://doi.org/10.1177/20530196221149105>

Kaaronen, R.O. Manninen, M.A. Eronen, J.T. 2023. Body-based units of measure in cultural evolution. *Science* 380, 948-954.

Kaasik M, Meinander O, Leppanen L, Anttila K, Dagsson-Waldhauserova P, Ginnerup A, Hampinen T, Liu Y, Gunnarsson A, Langley K, et al. Accuracy of Manual Snow Sampling, Depending on the Sampler's Cross-Section—A Comparative Study. *Geosciences*. 2023; 13(7):205. <https://doi.org/10.3390/geosciences13070205>

Karlsen, S.R.; Stendardi, L.; Tommervik, H.; Nilsen, L.; Arntzen, I.; Cooper, E.J. 2021. Time-Series of Cloud-Free Sentinel-2 NDVI Data Used in Mapping the Onset of Growth of Central Spitsbergen, Svalbard. *Remote Sens.* 13, 3031.
<https://doi.org/10.3390/rs13153031>

Karlsen, S.R., Elvebakk, A., Tømmervik, H., Belda, S. & Stendardi, L. 2022. Changes in Onset of Vegetation Growth on Svalbard, 2000–2020. *Remote Sensing* 2022, 14, 6346. <https://doi.org/10.3390/rs14246346>.

Komu, Teresa (forthcoming) Engaging with the Anthropology of the Good (Life) in the Arctic: Musings on Success and Reindeer Husbandry. In *Arctic Anthropology Handbook*. Stammler, F, Komu, T, Mazzullo, N & Vitebsky, P (eds). Routledge (mid-October 2024: forthcoming).

Kuosmanen, N., Valiranta, M., Piilo, S., Tuittila, E-S., Oksanen, P. and Wallenius T. (2023). Repeated fires in forested peatlands in sporadic permafrost zone in Western Canada. *Environmental Research Letters* 18, 094051, Doi: 10.1088/1748-9326/acf05b

Laptander, R. The weight of words and the power of silence in the Nenets life story narratives. *Scientific Journal of the Yamal Nenets Autonomous Okrug*, 111: 60-78 (in Russian). doi: 10.26110/ARCTIC.2021.111.2.004

Laptander, R. The Yamal Nenets' traditional and contemporary environmental knowledge of snow, ice, and permafrost. *Ecology and Society*, 2023, Volume28, Issue 3. <https://doi.org/10.5751/ES-14353-280306>

Laptander, R., Horstkotte, T., Habeck, J.O., Rasmus, S., Komu, T., Matthes, H., Forbes, B.C., Istomin, K., Eronen, J.T. 2023. Critical Seasonal Conditions in the Reindeer-Herding Year:

A Synopsis of Factors and Events in Fennoscandia and Northwestern Russia. *Polar Science* 101016. <https://doi.org/10.1016/j.polar.2023.101016>

Laptander, R., Stammler, F., Forbes, B.C., Stark, S. 2024. Ways of identifying lichen and plant species by the Nenets reindeer herders in Yamal. *Arctic Science* 10: 713-730. [dx.doi.org/10.1139/as-2023-0046](https://doi.org/10.1139/as-2023-0046)

Laptander, R., Forbes, B.C. & Kumpula, T. (2024). From Gorbachev's Murmansk Speech to the Present: 37 Years of International Collaboration in Northern Russia. In: *A Fractured North: Journeys on Hold*, edited by Erich Kasten, Igor Krupnik, & Gail Fondahl, pp. 15-34. Fürstenberg/Havel: Kulturstiftung Sibirien. <https://bolt-dev.dh-north.org/files/dhn-pdf/fn2laptander-et-al.pdf>

Leppänen, L. 2024. Uncertainty analysis of IceCube instrument to enhance accuracy of specific surface area measurements. *Cold Regions Science and Technology*, 219, 104105.

Martin, A.C., Assmann, J.J., Bradshaw, R.H.W., Kuoppamaa, M., Kuosmanen, N.I., Normand, S., Speed, J.D.M., Macias-Fauria, M. 2022 What evidence exists for temporal variability in Arctic terrestrial and freshwater biodiversity throughout the Holocene? A systematic map protocol, (*Environmental Evidence*, Volume 11, 13) <https://doi.org/10.1186/s13750-022-00267-x>

Martin, A.C., Macias-Fauria, M., Bonsall, M.B., Forbes, B.C., Zetterberg, P. and Jeffers, E.S. 2021. Common mechanisms explain nitrogen-dependent growth of Arctic shrubs over three decades despite heterogeneous trends and declines in soil nitrogen availability. *New Phytol.* <https://doi.org/10.1111/nph.17529>

McCrystall, M.R., J. Stroeve, M. Serreze, J. Screen and B. Forbes. 2021, New climate models reveal faster and larger increases in Arctic precipitation than previously projected, *Nat Comm.*, 12, 6765, <https://doi.org/10.1038/s41467-021-27031-y>.

Markkula, I., Turunen, M., Rasmus, S., Rikkinen, T., Koski, V., Welker, J.M. 2025. On winter cultures: changing snow and its meanings for indigenous Sámi people. *Arctic* (in print)

Menard, C., Rasmus, S., Merkouriadi, I., Balsamo, G., Bartsch, A., Derksen, C., Domine, F., Dumont, M., Ehrich, D., Essery, R., Forbes, B.C., Krinner, G., Lawrence, D., Liston, G., Matthes, H., Rutter, N., Sandells, M., Schneebeli, M. & Stark, S. 2024. Exploring the decision-making process in model development: focus on the Arctic snowpack. *Cryosphere* 18 (10): 4671–4686. <https://doi.org/10.5194/tc-18-4671-2024>

Moon, T.A, Thoman, R.L., Druckenmiller, M.I., Forbes, B.C., ...Tømmervik, Zolkos, S. 2023. State of the Climate in 2022: The Arctic. *Bulletin of The American Meteorological Society* - (BAMS) 104.(9) S271-S321.

Oehri, J., Schaepman-Strub, G., Kim, J.S. et al. 2022. Vegetation type is an important predictor of the arctic summer land surface energy budget. *Nat Commun* 13, 6379. <https://doi.org/10.1038/s41467-022-34049-3>

Pedersen, A.O., E.M. Soininen, B.B. Hansen, M. Le Moullec, L.E. Loe, I.M.G. Paulsen, Eischeid, S.R. Karlsen, E. Ropstad, A. Stien, A. Tarroux, H. Tommervik and V. Ravolainen. 2023. High seasonal overlap in habitat suitability in a non-migratory High Arctic ungulate, *Global Ecology and Conservation*, doi:<https://doi.org/10.1016/j.gecco.2023.e02528>

Piilo, S.R., M. M. Valiranta, M. J. Amesbury, M. A. Aquino-Lopez, D. J. Charman, A. Gallego-Sala, M. Garneau, N. Koroleva, M. Karppa, A. M. Laine, A. B. K. Sannel, E.-S. Tuittila, H. Zhang. 2022. Consistent centennial-scale change in European sub-Arctic peatland vegetation towards Sphagnum dominance – implications for carbon sink capacity. *Global change biology*. <https://doi.org/10.1111/gcb.16554>

Pointner, G., Bartsch, A., Dvornikov, Y. A., and Kouraev, A. V. 2021. Mapping potential signs of gas emissions in ice of Lake Neyto, Yamal, Russia, using synthetic aperture radar and multispectral remote sensing data. *The Cryosphere*, 15, 1907–1929, <https://doi.org/10.5194/tc-15-1907-2021>

Pointner, G.; Bartsch, A. 2021. Mapping Arctic Lake Ice Backscatter Anomalies Using Sentinel-1 Time Series on Google Earth Engine. *Remote Sensing*, 13, 1626. <https://doi.org/10.3390/rs13091626>

Povoroznyuk, O., Vincent, W.F., Schweitzer, P., Laptander, R., Bennett, M., Calmels, F., Sergeev, D., Arp, C., Forbes, B., Roy-Leveillee, P., Walker, D. 2022. Arctic Roads and Railways: Social and environmental consequences of transport infrastructure in the circumpolar North. *Arctic Science*, 11 August 2022, <https://doi.org/10.1139/as-2021-0033>

Rasmus, S., Yletyinen, J., Sarkki, S., Landauer, M., Tuomi, M., Arneberg, M.K., Bjerke, J.W., Ehrich, D., Habeck, J.O., Horstkotte, T., Kivinen, S., Komu, T., Kumpula, T., Leppänen, L., Matthes, H., Rixen, C., Stark, S., Sun, N., Tømmervik, H., Forbes, B.C., Eronen, J.T. 2024. Policy documents considering climate, biodiversity and land use changes in the European Arctic reveal visible, hidden and imagined nexus approaches. *One Earth*. 7(2): 265-279. <https://doi.org/10.1016/j.oneear.2023.12.010>

Rasmusson, E., Bjerke, J., Finne, E., Myneni, R., Piao, S., Wang, X., Virtanen, T., Rasanen, A., Kumpula, T. Kolari, T., Tahvanainen T., & H. Tommervik. 2022. Tree species classification from airborne hyperspectral and LiDAR data using 3D convolutional neural networks *Remote Sensing of Environment*. 280, 113201 [10.1016/j.rse.2022.113201](https://doi.org/10.1016/j.rse.2022.113201)

Ravolainen, V., Paulsen, I.M.G., Eischeid, I., Forbey, J.S., Fuglei, E., Hájek, T.; Hansen, B.B., Loe, L.E., Macek, P., Madsen, J., Soininen, E.M., Speed, J.D.M., Stien, A., Tømmervik, H., Pedersen, Å.O. 2024. Low spatial habitat overlap of herbivores in the High Arctic tundra,

Global Ecology and Conservation 49, e02797,
<https://doi.org/10.1016/j.gecco.2024.e02797>

Rixen, C., Høye, T. T., Macek, P., Aerts, R., Alatalo, J., Andeson, J. T., ... Zong, S. 2022. Winters are changing: snow effects on Arctic and alpine tundra ecosystems. *Arctic Science*, 8(3), 572-608. <https://doi.org/10.1139/AS-2020-0058>

Sarkki, S., Pihlajamäki, M., Rasmus, S., Eronen, J.T. 2023. "Rights for Life" scenario to reach biodiversity targets and social equity for indigenous peoples and local communities. *Biological Conservation* 280, 109958.
<https://doi.org/10.1016/j.biocon.2023.109958>

Serreze, M.C., Gustavson, J., Barrett, A.P., Druckenmiller, M.L., Fox, S., Voveris, J., Stroeve, J., Sheffield, B., Forbes, B.C., Rasmus, S., Laptander, R., Brook, M., Brubaker, M., McCrystall, M.R., Bartsch, A. 2021. Arctic Rain on Snow Events: Bridging observations to understand environmental and livelihood impacts. *Environmental Research Letters*, 16, 105009. <https://doi.org/10.1088/1748-9326/ac269b>

Skarin, A., Verdonen, M., Kumpula, T., Macias-Fauria, M., Alam, M., Kerby, J. & B.C. Forbes. 2020. Reindeer use of tundra in a nomadic herding system: shrub growth, greening and climate feedbacks in low Arctic tundra. *Environmental research letters*.
<https://iopscience.iop.org/article/10.1088/1748-9326/abbf15>

Speed J.D.M., Sobocinski A., Kolstad, A.L. Linnell J.D.C., Solberg, E.J., Mattisson, J. & Austrheim, G. 2025. The trophic distribution of biomass in ecosystems with co-occurring wildlife and livestock. *Scientific Reports*. 10.1038/s41598-025-85469-2

Spiegel, M. P., Volkovitskiy, A., Terekhina, A., Forbes, B. C., Park, T., & Macias-Fauria, M. 2023. Top-Down Regulation by a Reindeer Herding System Limits Climate-Driven Arctic Vegetation Change at a Regional Scale. *Earth's Future*, 11(7), e2022EF003407.
doi:10.1029/2022EF003407

Stroeve, J., V. Nandan, R. Willatt, R. Dadić, P. Rotosky, ..., M. Scheebeli. 2022. Rain-on-snow (ROS) understudied in sea ice remote sensing: A multi-sensor analysis of ROS during MOSAiC, *Cryosphere*, 16(10), <https://doi.org/10.5194/tc-16-4223-2022>.

Stark, S., Horstkotte, T., Kumpula, J. Olofsson; J. Tommervik, H., and Turunen, M. 2023. The ecosystem effects of reindeer (*Rangifer tarandus*) in northern Fennoscandia: Past, present and future. *Perspectives in Plant Ecology, Evolution and Systematics* 58, 2023, 125716, DOI.ORG/10.1016/J.PPEES.2022.125716.

Stendardi, L. Karlsen, S.R., Malnes, E., Nilsen, L., Tommervik, H., Cooper, E.J. and Notarnicola, C. 2022. Multi-Sensor Analysis of Snow Seasonality and a Preliminary Assessment of SAR Backscatter Sensitivity to Arctic Vegetation: Limits and Capabilities. *Remote Sensing* 14(8), 1866; <https://doi.org/10.3390/rs14081866>

Thoman, R., M. L. Druckenmiller, and T. Moon, Eds., 2022: "State of the Climate in 2021". Bull. Amer. Meteor. Soc., 103 (8), S257–S306, <https://doi.org/10.1175/BAMS-D-22-0082.1>.

Turunen, M., Rasmus, S. Montonen, M., Salonen, E., Lehtonen, I. 2025. Coping Strategies of Commercial Fishers in a Changing Climate and Society: Combining practitioners' insights and long-term monitoring data. Regional Environmental Change 25:17. <https://doi.org/10.1007/s10113-024-02357-7>

Turunen, M., Rasmus, S. Montonen, M., Salonen, E., Lehtonen, I. 2024. Kaupallinen kalastus Inarijärvellä - kestävää sopeutumista muuttuvaan toimintaympäristöön? Terra 136 (1): 3–23. <https://doi.org/10.30677/terra.141159>

Tømmervik, H., Julitta, T., Nilsen, L., Park, T., Burkart, A., Ostopowicz, K., Karlsen, S.R., Parmentier, F.-J.W., Pirk, N. & Bjerke, J.W. 2023. The Northernmost Hyperspectral FLoX sensor Dataset for Monitoring of High-Arctic Tundra Vegetation Phenology and Sun-Induced Fluorescence (SIF). Data in Brief 50, 109591. <https://doi.org/10.1016/j.dib.2023.109581>.

Verdonen, M., Berner, L.T., Forbes, B.C. & T. Kumpula. 2020. Periglacial vegetation dynamics in Arctic Russia: decadal analysis of tundra regeneration on landslides with time series satellite imagery Environmental research letters <https://doi.org/10.1088/1748-9326/abb500>

Verdonen, M., Stormer, A., Lotsari, E., Korpelainen, P., Burkhard, B., Colpaert, A. & Kumpula, T. 2023. Permafrost degradation at two monitored peat mires in north-west Finland. The Cryosphere 17: 1803–1819.

Villoslada, M., Ylanne, H., Juutinen, S., Kolari, T.H.M., Korpelainen, P., Tahvanainen, T., Wolff, F. and Kumpula, T. 2023. Reindeer control over shrubification in subarctic wetlands: spatial analysis based on unoccupied aerial vehicle imagery. Remote Sens Ecol Conserv. <https://doi.org/10.1002/rse2.337>

Wang, W., He, C., Moore, J., Wang, G., & Niu, G.-Y. 2022. Physics-based narrowband optical parameters for snow albedo simulation in climate models. Journal of Advances in Modeling Earth Systems, 14, e2020MS002431. <https://doi.org/10.1029/2020MS002431>

Ward Jones, M., Habeck, J. O., Ulrich, M., Crate, S., Gannon, G., Schwoerer, T., Jones, B., Kanevskiy, M., Baral, P., Maharjan, A., Steiner, J., Spring, A., Price, M.J., Bysouth, D., Forbes, B.C., Verdonen, M., Kumpula, T., Strauss, S., Windirsch, T., Poeplau, C., Shur, Y., Gaglioti, B., Parlato, N., Tao, F., Turetsky, M., Grand, S. Unc, A., & Borchard, N. (2024). Socioecological dynamics of diverse global permafrost-agroecosystems under environmental change. Arctic, Antarctic, and Alpine Research, 56(1), 2356067. <https://doi.org/10.1080/15230430.2024.2356067>

Windirsch, T., Guido Grosse, Mathias Ulrich, Bruce C Forbes, Mathias Gockede, Juliane Wolter, Marc Macias-Fauria, Johan Olofsson, Nikita Zimov, Jens Strauss. 2022. Large Herbivores on Permafrost – a Pilot Study of Grazing Impacts on Permafrost Soil Carbon Storage in Northeastern Siberia, published in *Frontiers in Environmental Science*, section Atmosphere and Climate. *Front. Environ. Sci.*
<https://doi.org/10.3389/fenvs.2022.893478>

Zhang, J., Huang, X., Wang, J., Bradshaw, R.H.W., Wang, T., Xiang, L. Luo, D., Wang, Z., Chen, F. 2022. An inverse relationship between moisture and grazing intensity in an arid mountain-basin system. *Progress in Physical Geography* 46, 310-322.

In addition, several submitted works.

Other important publications, data and tools produced by CHARTER

Outreach and publications for general public and livelihood practitioners:

A Birds Eye View. Drones: A New Lens for Science, A New Tool for Herding

By Philip Burgess, Jeff Kerby, Miguel Villoslada :

<https://storymaps.arcgis.com/stories/3f270d210de44fdf9280ded4fd89095d>

The Vanishing Palsa Mire. Often Seen, Little Understood, Under Threat

By Philip Burgess.

<https://storymaps.arcgis.com/stories/c09e93eb17da45ac9cc8257018b0995f>

For centuries, herders followed their reindeer...Now, their animals follow them.

By Irina Wang & Philip Burgess

<https://storymaps.arcgis.com/stories/26d9be8cad5b431a85bdea38a344047c>

In 2050, what will my corner of the world look like? Mention the phrase 'climate change' and reactions differ: Indifference. Misunderstanding. Anxiety. Anxiety fatigue. By Philip Burgess, Heidrun Matthes, Sirpa Rasmus

<https://storymaps.arcgis.com/stories/95207a47d7bf4d5bb674a66da6a3db79>

When Rains Fell in Winter. A decade ago, heavy winter rains washed over the Yamal Peninsula in Northwest Russia, killing 60,000 reindeer and ruining livelihoods.

By Philip Burgess & Irina Wang

<https://storymaps.arcgis.com/stories/b63ced1af26a435bbfd4a910c8fac488>

Kun talvella satoi

Kymmenen vuotta sitten Jamalin niemimaalla satoi talvella rankasti, minkä seurauksena 60 000 poroa kuoli ja ihmiset menettivät elinkeinonsa.

Philip Burgess & Irina Wang

<https://storymaps.arcgis.com/stories/4edca133e64b4ca9a1d907bdf7a27643>

CHARTER Poster Exhibit:

13 large format museum quality posters

Available for download on Zenodo: <https://zenodo.org/records/14272869>

CHARTER webpage: <https://www.charter-arctic.org>

CHARTER on X (discontinued): <https://x.com/CharterArctic/>

CHARTER on Instagram: @arctic_charter

Policy briefs:

CHARTER-project. 2024. TENSIONAL DREAMS: Policy Options for a Sustainable Arctic.

CHARTER-project. 2025. JÄNNITTEISIÄ UNELMIA: Arktisen kestävä tulevaisuuspolut.

CHARTER-project. 2025. Spenninger og drømmer: Politiske alternativer for et bærekraftig Arktis

CHARTER-project. 2025. Förhoppningar och spänningar: Policyalternativ för ett hållbart Arktis

Policy briefs available here: <https://www.charter-arctic.org/policy-briefs/>

Visual Fact Sheets and Policy Recommendations created with sister FACE IT and ECOTIP Horizon 2020 projects: <https://www.charter-arctic.org/charter-fact-sheets/>

Working papers:

Eronen J., Rasmus S., Landauer M., Forbes, B. 2020. Knowledge and Arctic Perspectives to Support Climate and Environmental Legislation development. CHARTER Working Paper 1 (English version). [https://www.charter-arctic.org/wp-content/uploads/2020/12/CHARTER Working Papers 01 EN.pdf](https://www.charter-arctic.org/wp-content/uploads/2020/12/CHARTER_Working_Papers_01_EN.pdf)

Eronen J., Rasmus S., Landauer M., Forbes, B. 2020. Tietoa ja arktisia näkemyksiä ilmasto- ja ympäristölainsäädännön tueksi. CHARTER Working paper 1 (suomenkielinen versio). https://www.charter-arctic.org/wp-content/uploads/2020/11/CHARTER-Working-Paper-1_2020.pdf

Rasmus, S., Sarkki, S., Pekkarinen, A.-J., Jokinen, M., Mettiäinen, I., Post, L., Rikkonen, T., Sorvali, J. and Väärälä, T. 2023. Porotalouden tulevaisuus: unelmia ja yllätyksiä. CHARTER Working Paper 2. [https://www.charter-arctic.org/wp-content/uploads/2023/02/Porotalouden tulevaisuus tyopaja - Inari raportti 221222 valmis.pdf](https://www.charter-arctic.org/wp-content/uploads/2023/02/Porotalouden_tulevaisuus_tyopaja_-_Inari_raportti_221222_valmis.pdf)

Rasmus, S., Sarkki, S., Pekkarinen, A.-J., Jokinen, M., Mettiäinen, I., Post, L., Rikkonen, T., Sorvali, J. and Väärälä, T. 2023. The Future of Reindeer Husbandry: Surprises and Dreams. A Workshop Summary Report, 2023. CHARTER Working Paper 3. <https://www.charter-arctic.org/wp-content/uploads/2023/02/Reindeer-husbandry-dreams-and-surprises-report.pdf>

Eronen, J., Rasmus, S., Sarkki, S. 2024. Tensional dreams – Policy option for a sustainable Arctic – Background for the policy brief. CHARTER working paper 4. [https://www.charter-arctic.org/wp-content/uploads/2025/01/CHARTER working paper 4 tensional dreams.pdf](https://www.charter-arctic.org/wp-content/uploads/2025/01/CHARTER_working_paper_4_tensional_dreams.pdf)

CHARTER data and metadata; tools developed:

CHARTER data on the ZENODO platform

<https://zenodo.org/communities/charter/records?q=&l=list&p=1&s=10&sort=newest>

CHARTER has aimed at utilizing existing material as much as possible. Nevertheless, new data has been gathered and tools have been developed. Some examples:

CHARTER Citizen science snow measurements and snow protocol:

<https://zenodo.org/records/14259269>

CHARTER project 'Secrets of Snow' protocols:

<https://www.charter-arctic.org/secrets-of-snow/>

CHARTER-HANKKEEN KANSALAISHAVAINTOJA LUMESTA: <https://www.charter-arctic.org/secrets-of-snow/lumen-salaisuuksia-ratkomassa/>

Playing With Dreams - Workshop Playing Cards:

Openly accessible design process; workshop material and a guide for facilitating future-oriented workshop. Developed by Irina Wang, with Sirpa Rasmus, Simo Sarkki, Otto Habeck, Philip Burgess, Antti-Juhani Pekkarinen and Jussi Eronen.

<https://zenodo.org/records/10038003>

Arctic Holocene Biodiversity Database. Available at <https://acm.im/holocene-arctic-biodiversity-map/ahbdb/>

Metadata: see the appendix. WP3 metadata also available in Zenodo and in D3.6, and WP6 metadata in D6.5

CHARTER deliverables

Below we list CHARTER deliverables per WP. Years refer to the time of the original submission (not to the time of revision, if revisions were asked in project reviews). Authors are given as listed in the reports. Some reports are confidential, only for members of the consortium (including the Commission Services). Public reports are found here: <https://www.charter-arctic.org/charter-deliverables/> and here: <https://cordis.europa.eu/project/id/869471/results>. More information from leading authors of the reports, and from CHARTER coordination team.

WP1 - Transitions in land cover, biodiversity and cryosphere at decadal time scales

Bartsch, A. and CHARTER WP1 team. 2022. Improved characterization of observables of drivers and impacts on panarctic scale. CHARTER deliverable D1.1 (Confidential).

Kumpula, T. Bartsch, A. and CHARTER WP1 team. 2023. Improved characterization of impacts on local to regional scale. CHARTER deliverable D1.2. (Confidential).

Bartsch, A., Leppänen, L., Schaepman-Strub G., Oehri, J., Macias-Fauria, M., Spiegel, M., Bergstedt, H., Tanguy, R., von Baeckmann, C., Efimova, A., Khairullin, R., Muri, X., Widhalm, B., Rixen, R., Stroeve, J. and McCrystall, M. 2024. Combination of satellite and in situ records for regional characterization (original title: Report on pan-Arctic biodiversity change on decadal scale). CHARTER deliverable D1.3 (Confidential).

WP2 - Changing grazing regimes and Arctic biodiversity at local and regional scales

Stark, S., Horstkotte, T., Kumpula, J., Olofsson, J., Tømmervik, H. and Turunen, M. 2022. Synthesis on the effect of grazing and trampling on plant biodiversity. A case study of northernmost Fennoscandia (original title: Synthesis on the effect of grazing and trampling on plant biodiversity at a circumpolar level). CHARTER deliverable D2.1. <https://www.charter-arctic.org/charter-deliverables/>

Stark, S., Wallén, H., Kuoppamaa, M., Kumpula, J., Kurkilahti, M., Pekkarinen, A.-J., Horstkotte, T., Olofsson, J., Tømmervik, H., Bårdsen, B.J. and Bjerke, J.W. 2024. Expected habitat-specific vegetation trajectories under differing grazing management practices, land-use histories and environmental conditions. CHARTER deliverable D2.2. <https://www.charter-arctic.org/charter-deliverables/>

Ehrich, D., Ramirez, J.I., Barbero-Palacios, L. and Speed, J. 2025. Comparative assessment of Arctic food webs in contrasting reindeer management and climatic regimes. (original title: Estimates of relative presence of predators feeding on reindeer carcasses). CHARTER deliverable D2.3. <https://www.charter-arctic.org/charter-deliverables/>

WP3 - Socio-economic impacts of Arctic environmental changes on indigenous populations and local communities

Habeck, J.O., Rasmus, S., Horstkotte, T., Istomin, K., Marin, A. and Tømmervik, H. 2021. Compiling reindeer statistics (original title: Report: statistics on animal husbandry). CHARTER deliverable D3.1. <https://www.charter-arctic.org/charter-deliverables/>

Marin, A. and the WP3 team. 2022. History of animal husbandry in CHARTER study area (original title: Report: history of animal husbandry in key regions). CHARTER deliverable D3.2. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Rasmus, S., Turunen, M., Horstkotte, T., Tømmervik, H., Komu, T. and Eilola, S. 2022. CHARTER first-round stakeholder workshops (original title: Report: translated minutes of 1st-round stakeholder workshops). CHARTER deliverable D3.3. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Matthes, H., Forbes, B.C., Istomin, K., Komu, T., Laptander, R., Rasmus, S. and Tømmervik, H. 2022. Overview of socioeconomic parameters for modelling. CHARTER deliverable D3.4 (Confidential).

Istomin, K., Habeck, J.O., Laptander, R., Tømmervik, H., Horstkotte, T. and Rasmus, S. 2023. Socio-economic processes in selected communities: The interplay of formal and informal institutions and practices in reindeer herding (Russia and Fennoscandia) (original title: Report: socio-economic processes in selected communities). CHARTER deliverable D3.5. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Eilola, S., Horstkotte, T., Istomin, K., Komu, T., Laptander, R., Marin, A., Rasmus, S. and Tømmervik, H., 2024. Summary of CHARTER WP3 field research: data collection, metadata, key findings from selected communities (original title: Summary: interviews conducted in selected communities). CHARTER deliverable D3.6. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Horstkotte, T., Rasmus, S. and Tømmervik, H. 2024. CHARTER 2nd-round stakeholder workshops (original title: Report: translated minutes of 2nd-round stakeholder workshops). CHARTER deliverable D3.7. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Eilola, S., Fagerholm, N., Forbes, B.C., Horstkotte, T., Istomin, K., Komu, T., Laptander, R., Marin, A., Rasmus, S., Stammler, F. and Stark, S. 2024. Land users' observations on environmental change. CHARTER deliverable D3.9. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Horstkotte, T., Istomin, K., Melamies, I., Rasmus, S., Sandström, P. and Sandström, S. 2024. Leverage and Leeway: Comparing the Scope of Reindeer Herd Management and Decision-Making in Four Communities of the Eurasian North (original

title: Land-use and pasture management changes). CHARTER deliverable D3.10. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Istomin, K., Laptander, R., Horstkotte, T., Rasmus, S., Tømmervik, H. and Marin, A. 2024. Futures of Reindeer Herding (original title: Land users' expectations and prospects of reindeer husbandry). CHARTER deliverable D3.11. <https://www.charter-arctic.org/charter-deliverables/>

Habeck, J.O., Bartsch, A., Ehrich, D., Eronen, J.T., Istomin, K., Laptander, R., Macias-Fauria, M., Marin, A., Matthes, H., Rasmus, S., Stark, S., Forbes, B.C. 2025. Synthesis of Findings [WP3 and others] (original title: WP3 synthesis). CHARTER deliverable D3.8. <https://www.charter-arctic.org/charter-deliverables/>

WP4 - Arctic terrestrial biodiversity changes at centennial time scales

Macias-Fauria, M., Martin, A. and the WP4 team. 2023. Systematic Map (original title: Systematic review & map, identifying sources of biodiversity proxy data for the Arctic through the Holocene). CHARTER deliverable D4.1. <https://www.charter-arctic.org/charter-deliverables/>

Macias-Fauria, M., Martin, A. and the WP4 team. 2023. Holocene Arctic Biodiversity Database (original title: Holocene climate and cryosphere database). CHARTER deliverable D4.2. <https://www.charter-arctic.org/charter-deliverables/>

Macias-Fauria, M. and the WP4 team. 2023. Holocene Climate and Cryosphere Database (original title: Pan-Arctic paleoecological database). CHARTER deliverable D4.3. <https://www.charter-arctic.org/charter-deliverables/>

Martin, A., Macias-Fauria M. and the WP4 team. 2024. Key essential biodiversity / ecosystem variables (original title: Key biodiversity variables computed from the data in D4.2. and MS4.2). CHARTER deliverable D4.4. <https://www.charter-arctic.org/charter-deliverables/>

Martin, A. and the WP4 team. 2025. Scaffolding key indicators of Holocene Arctic biodiversity change (original title: Research paper reporting trends of key biodiversity variables in the Arctic during the Holocene, and on how they compare with contemporary, recent observations). CHARTER deliverable D4.5. <https://www.charter-arctic.org/charter-deliverables/>

Martin, A., Macias-Fauria M., Bradshaw, R. and the WP4 team. 2025. Sensitivity of key indicators of Holocene Arctic biodiversity to climate/environment (original title: Research paper). CHARTER deliverable D4.6. <https://www.charter-arctic.org/charter-deliverables/>

Piilo, S., Kuoppamaa, M., Tahvanainen, T., Kumpula, T., Kuosmanen, N., Macias-Fauria, M. and Välranta, M. 2025. Research paper reporting on the relationships between key

biodiversity variables and the environment in CHARTER sites during the Holocene, with a special focus on i) the role of large herbivore density and ii) the last 2ka and the effects of the emergence of Arctic husbandry on these relationships (original title: Research paper). CHARTER deliverable D4.7. <https://www.charter-arctic.org/charter-deliverables/>

Martin, A., Macias-Fauria M. and the WP4 team. 2025. Comparison of biodiversity trends in the Holocene vs. the observational period and modelling outputs, part I (original title: Research paper). CHARTER deliverable D4.8. <https://www.charter-arctic.org/charter-deliverables/>

Martin, A., Macias-Fauria M. and the WP4 team. 2025. Comparison of biodiversity trends in the Holocene vs. the observational period and modelling outputs, part II (original title: Research paper). CHARTER deliverable D4.9. <https://www.charter-arctic.org/charter-deliverables/>

WP5 – Designing futures based on system-wide natural and human drivers

Matthes, H., Moore, J., Eronen, J.T., Schaepman-Strub, G. and the WP5 team. 2022. Definition of ‘biogeoenineering’ scenario experiments (original title: Production of future ‘biogeoenineering’ scenarios). CHARTER deliverable D5.2. <https://www.charter-arctic.org/charter-deliverables/>

Matthes, H., Ménard, C., Chen, Y., Essery, R., Moore, J., Stroeve, J., Veyssiere, G. and McCrystall, M. 2023. Analysis of existing climate model simulations (original title: Analysis of existing climate model data from AR6, G4 and CMIP6 including GeoMIP6). CHARTER deliverable D5.1. <https://www.charter-arctic.org/charter-deliverables/>

Matthes, H., Ménard, C., Chen, Y., Essery, R. and Moore, J. 2023. Implementation of ‘biogeoenineering’ scenarios and the Factorial Snow Model. CHARTER deliverable D5.3 (Confidential).

Matthes, H., Ménard, C., Chen, Y., Essery, R. and Moore, J. 2024. Analysis of model simulations under the ‘biogeoenineering’ scenarios. CHARTER deliverable D5.4 (Confidential).

Matthes, H., Forbes, B.C. and Rasmus, S. 2024. Synthesis of cryosphere and biodiversity changes in present, past, future (original title: Synthesis of scenario-driven biodiversity changes). CHARTER deliverable D5.5. <https://www.charter-arctic.org/charter-deliverables/>

WP6 - Narratives and policy options for biodiversity and land use to increase resilience of Arctic social-ecological systems

Eronen, J.T., Rasmus, S. and the WP6 team. 2022. Biodiversity and land use narrative synthesis (original title: Biodiversity and land use narrative synthesis based on an

extensive literature review). CHARTER deliverable D6.1. <https://www.charter-arctic.org/charter-deliverables/>

Eronen, J.T., Rasmus, S., Yletyinen, J. and the WP6 team. 2023. Mapping of stakeholder network required for the co-design of pathway narratives by means of a social network analysis. CHARTER deliverable D6.2 (Confidential).

Tømmervik, H., Bjerke, J.W., Eronen, J.T., Rasmus, S., Habeck, J.O., Istomin, K. and Horstkotte, T. 2024. Examination of Arctic land use and biodiversity management practices: Links between local livelihoods, albedo, and climate (original title: Examination of Arctic land use and biodiversity management practices including local livelihoods). CHARTER deliverable D6.3. <https://www.charter-arctic.org/charter-deliverables/>

Eronen, J.T., Rasmus, S., Sarkki, S., Forbes, B.C., Tømmervik, H., Habeck, J.O., Horstkotte, T. and Matthes, H. 2024. Co-design of policy options to inform climate adaptation and mitigation policies and practices and enhance the viability and resilience of Arctic local livelihoods. CHARTER deliverable D6.4. <https://www.charter-arctic.org/charter-deliverables/>

Eronen, J.T., Rasmus, S., Sarkki, S., Forbes, B.C., Tømmervik, H., Habeck, J.O., Horstkotte, T. and Matthes, H. 2025. Cross-cutting work with all CHARTER WPs to develop Arctic strategy and provide policy recommendations. CHARTER deliverable D6.5. <https://www.charter-arctic.org/charter-deliverables/>

WP7 - Management and dissemination

Rasmus, S., Forbes, B.C. and CHARTER Coordination team. 2020. CHARTER management processes – Management handbook (original title: Management processes established and functional). CHARTER deliverable D7.1. <https://www.charter-arctic.org/charter-deliverables/>

Burgess, P., Heikkilä, M. and CHARTER coordination team. 2020. CHARTER Website and Communication Tools. CHARTER deliverable D7.2. <https://www.charter-arctic.org/charter-deliverables/>

Rasmus, S., Habeck, J.O. and CHARTER coordination team. 2021. CHARTER Gender inclusion action plan. CHARTER deliverable D7.3. <https://www.charter-arctic.org/charter-deliverables/>

Heikkilä, M. and CHARTER coordination team. 2021. Communication plan. CHARTER deliverable D7.4. <https://www.charter-arctic.org/charter-deliverables/>

Leppänen, L., Komu, T., Rasmus, S., Barrio, I., Matthes, H., Kontu, A., Habeck, J.O., Marin, A., Stammler, F., Laptander, R., Istomin, K. and CHARTER coordination team. 2021.

CHARTER Data Management Plan. CHARTER deliverable D7.5. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER coordination team. 2021. Risk Management Plan. CHARTER deliverable D7.6. <https://www.charter-arctic.org/charter-deliverables/>

Rasmus, S., Bradshaw R., Marin, A., Eronen, J.T. and CHARTER coordination team. 2021. CHARTER Plan for the Exploitation and Dissemination of Results (original title: PEDR Plan). CHARTER deliverable D7.7. <https://www.charter-arctic.org/charter-deliverables/>

Landauer, M., Rasmus, S., Habeck, O.J., Horstkotte, T. and CHARTER coordination team. 2021. Stakeholder Analysis Template (original title: Stakeholder Analysis Template designed and used). CHARTER deliverable D7.8 (Confidential).

Burgess, P. and CHARTER coordination team. 2021. CHARTER infographic and other outreach tools (original title: CHARTER infographic). CHARTER deliverable D7.9. <https://www.charter-arctic.org/charter-deliverables/>

Rasmus, S., Heikkinen, M. and CHARTER coordination team. 2021. CHARTER Expert Advisory Group. CHARTER deliverable D7.10. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER coordination team. 2021. First Annual meetings of the Steering Committee and the Expert Advisory Group. CHARTER deliverable D7.11 (Confidential).

CHARTER coordination team. 2022. Second Annual meetings of the Steering Committee and the Expert Advisory Group. CHARTER deliverable D7.12 (Confidential).

CHARTER coordination team. 2023. Third Annual meetings of the Steering Committee and the Expert Advisory Group. CHARTER deliverable D7.13 (Confidential).

Leppänen, L., Komu, T., Habeck, J.O., Marin, A., Eilola, S. and CHARTER coordination team. 2023. Update of the data management plan. CHARTER deliverable D7.18. <https://www.charter-arctic.org/charter-deliverables/>

Heikkilä, M. Rasmus, S., Burgess, P. and CHARTER coordination team. 2023. CHARTER communication plan (updated) (original title: Update of the communication plan). CHARTER deliverable D7.19. <https://www.charter-arctic.org/charter-deliverables/>

Honkasaari, H., Rasmus, S., Bradshaw, R. and CHARTER coordination team. 2023. Update of the Plan for the Exploitation and Dissemination of Results (original title: Update of the PEDR plan). CHARTER deliverable D7.20. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER coordination team. 2023. CHARTER Gender Inclusion Action Plan (original title: Update of the gender inclusion plan). CHARTER deliverable D7.21. <https://www.charter-arctic.org/charter-deliverables/>

Burgess, P. and CHARTER coordination team. 2024. Interactive interface. CHARTER deliverable D7.14. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER coordination team. 2024. Fourth Annual meetings of the Steering Committee and the Expert Advisory Group. CHARTER deliverable D7.17 (Confidential).

Rasmus, S. Landauer, M. and CHARTER coordination team. 2025. Evaluating the impacts of CHARTER science-policy dialogue. CHARTER deliverable D7.15. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER coordination team. 2025. List of created scientific publications, other important publications, and data and tools produced by CHARTER (original title: List of created scientific publications). CHARTER deliverable D7.16. <https://www.charter-arctic.org/charter-deliverables/>

CHARTER milestones

MS1: CHARTER kick-off meeting, Consortium, SC and EAG up and running
MS2: Governance structure and documents established and approved by the SC and distributed amongst the consortium for implementation. Documentation in D7.1

MS3: Early-phase consultation with local land users on additional drivers of biodiversity change - Meeting minutes / summaries in: UHAM and the CHARTER coordination team. 2021. Early-phase consultation with local land users on drivers of biodiversity change. Milestone report (Confidential, only for members of the consortium; including the Commission Services).

MS4: Literature review done, papers written and submitted - Literature review documents in D6.1, paper submission/publication: Rasmus et al. 2024. One Earth. 7(2): 265-279. <https://doi.org/10.1016/j.oneear.2023.12.010>

MS5: Stakeholder mapping done, workshops for period I in Finland and Sweden organized – Stakeholder mapping material shared with consortium (Confidential); Report, workshop minutes / summaries published in D3.3.

MS6: Documentation/database of existing relevant records done - Database with documentation available. Reported in D1.1.

MS7: Implementation of biogeoengineering scenarios “Reindeer management” - Implementation in place. Reported in 5.3.

MS8: Documentation/ database of high resolution satellite observations done - Database with documentation available. Reported in D1.2

MS9: New environmental proxy material sampled from CHARTER key sites: Field case study report. Reported in D4.3.

MS10: Research papers on stakeholder network analysis and co-design process submitted. Work based on analyses and utilizing the co-design process submitted: Sarkki et al. to Globalizations; Journal of Land Use Science; Land Use Policy.

MS11 Half-way assessment of project impacts: Assessment report published CHARTER coordination team. 2022. Half-way assessment of project impacts. <https://www.charter-arctic.org/wp-content/uploads/2022/12/CHARTER-Half-way-impact-report.pdf>

MS12: Workshop I in Norway organized: Workshop minutes: Tømmervik, H. 2023. Report from the seminar/workshop in Plassjesne-Rossen tjälte – Røros, Norway August 15th -16th 2023. Milestone report (Confidential, only for members of the consortium; including the Commission Services); workshop minutes / summaries in D3.7.

MS13: Documentation of feedback and dependencies analyses done: Reported in D1.3.

MS14: New environmental proxy material analyzed from CHARTER key sites: Field case study report. Reported as part of CHARTER 36-month reporting.

MS15: Workshop for period II organized in Finland, Sweden, Norway and additional consultation (with possibly a workshop) held in other parts of the arctic - Workshop minutes/summaries published in D3.7.

MS16 Townhall events and world cafes organized - Meeting minutes/summaries published in D6.5.

MS17 Long-term data storing and sharing tools and services in place. ZENODO platform: <https://zenodo.org/communities/charter/records?q=&l=list&p=1&s=10&sort=newest>

MS18: Interactive interface in Arktikum Science Centre Exhibition (Rovaniemi, Finland). Interface in place; more about the renewed exhibition: <https://arktikum.fi/en/exhibitions/arctic-opposites/>

MS19: Briefing note of the final report. Note will be published when the final reporting will be finalized (Feb-March 2025).

APPENDIX – Metadata

WP3 metadata also available in Zenodo and in D3.6, and WP6 metadata in D6.5.

Title /Dataset	Creator	Creator's affiliation	Contributors	Time-span start	Time-span end	Location	Type of data	Description	Method	Keywords	Open data? Link to the repository (or contact)	File format	License
Circumpolar mid-winter thaw and refreeze based on fusion of Metop ASCAT and SMOS, 2011/2012 - 2021/2022	Bartsch	b.geos	Bergstedt, Pointner, Muri, Rautiainen	2011	2022	Arctic north of 65°	daily values for grid centres	Rain on snow events	Active and passive microwave data have been combined to identify Rain on snow events	remote sensing, Arctic, rain on snow	Yes ZENODO https://zenodo.org/records/7575927	csv	Creative commons 4
Circumarctic Landcover Units (v2.0)	Bartsch	b.geos	Khairullin, R., Efimova, A., Widhalm, B., Muri, X., von Baeckmann, C., Bergstedt, H., Ermokhina, K., Hugelius, G., Heim, B., Leibman, M., & Gruber, C.	2016	2024	Arctic north of treeline plus Scandinavia	raster, static	Landcover units at 10m resolution	Sentinel-1 and Sentinel-2 fusion	remote sensing, landcover	Yes ZENODO https://doi.org/10.5281/zenodo.14235736	geotiff	Creative commons 4
Drained lake basin in situ landcover data, Yamal Peninsula /Erkuta River	Ehrich	UiT	Abdulmanova, Sokolov	26.7.2016		Erkuta, Yamal	vegetation survey	Drained lake basin in situ vegetation data	vegetation survey	in situ , vegetation	Yes The Cryosphere https://doi.org/10.5194/tc-18-4703-2024	Table (A1) in pdf	Creative commons 4
Trends and correlations with sea ice	Bartsch	b.geos	tbd	2000	2019	Arctic north of 60°N	raster, one period	tbd	Time series analyses	remote sensing, time series	Yes ZENODO in preparation	geotiff	Creative commons 4
Citizen science observations of snow	Leena Leppänen	LAY	Anonymous citizens	1.4.2021	11.3.2023	Finland, Sweden, Alaska	Snow observations	Citizen science observations on snow depth, SWE and layers. Aalso background info on ground and surroundings.	Manual snow measurements	citizen science, snow	Yes Zenodo https://zenodo.org/records/14259269	xlsx	cc-by 4.0
Weather station measurements		FMI				Saariselkä, Finland					Yes Litdb In preparation		cc-by 4.0 nc
Arctic terrestrial surface energy budget components and drivers dataset	Jacqueline Oehri	UZH	Gabriela Schaeppman-Strub, data contributors listed in acknowledgment	1994	2021	Pan-arctic, >60°N, 64 vegetated and glaciated sites	point data with daily aggregated surface energy fluxes and driver variables	surface energy fluxes and tested drivers relating to vegetation and climate	aggregated fluxes from existing in situ eddy covariance flux tower data	surface energy flux, in situ, arctic vegetation	Yes Pangaea https://doi.pangaea.de/10.1594/PANGAEA.949792	tab delimited text	CC-BY-4.0
Arctic bryophyte and lichen diversity across microclimatic and competition gradients	Mariana García Criado	UEDIN	Konsta Happonen, Inka Kuusisto, Claudia Colesie	2021	2023	Sweden, Svalbard, Greenland	Vegetation surveys	Data collected as part of the project 'Arctic bryophyte and lichen diversity across microclimatic and competition gradients'.	Plant data with standardised protocol across latitudinal gradient: Latnjajaure, Sweden 2021, Longyearbyen, Svalbard 2022, Disko, Greenland 2023. Point-framing method 0.5x0.5 m plots, 30 hits/plot 110 plots.	in situ, vegetation	Yes, but under embargo until 2027 to ensure that the manuscript is published Zenodo https://doi.org/10.5281/zenodo.14259495	csv	cc-by 4.0

Supplement to the manuscript: Pointner et al. (Remote Sensing)	Pointner	b.geos	Pointner, Bartsch	2015	2020	Yamal, Lena delta, North Slope	raster, annual	Like ice anomalies from Sentinel-1	Sentinel-1 change detection	lake ice, satellite data	Yes ZENODO https://zenodo.org/records/4694533	geotiff	Creative commons 4
Global NOAA GIMMS and MODIS data	Hans Tømmervik	NINA	Hans Tømmervik	1982	2019	Global	raster, annual, 8 days/15 days data		NOAA AVHRR, MODIS		Yes ZENODO		
Vegetation survey in Northern Finland / Norway along border fence	Tim Horstkotte	UmU	Johan Olofsson	July 2022	August 2022	Kilpisjärvi Northern Finland	Vegetation surveys along an elevation gradient in two different grazing regimes	Comparing the composition of the ground and field layer in an area grazed year-round by reindeer vs. grazed only during autumn	Point frequency analysis	Reindeer grazing, vegetation change, tundra			
Systematic review on the effects of herbivore diversity on Arctic tundra ecosystems	Laura Barbero-Palacios	LBHI	Isabel C. Barrio et al. *	1982	2021	circum-polar	List of published studies and data extracted from them	Database of published studies addressing effects of herbivore diversity on tundra ecosystems obtained using a published protocol for a systematic review	Systematic review	herbivore diversity, tundra, systematic review	Yes Environmental Evidence https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-024-00330-9	Excel file	
Lichen vegetation survey data in Finnmarksvidda	Hans Tømmervik	NINA	Hans Tømmervik	1998	2018	Finnmark	Vegetation survey data		Photographic, plot/frame	Reindeer grazing, vegetation change, tundra, forest			
Savukoski online mapping survey on perceived environmental changes	Salla Eilola	UTU	Nora Fagerholm, Teresa Komu, Tim Horstkotte, Otto Habeck, Sirpa Rasmus	3.2. 2022	11.5. 2022	Savukoski, Finland	Survey answers	Survey answers to structured and open-ended questions; map markings with a corresponding x- and y-coordinates that can be utilized and analysed in a GIS software. Survey topics include perceived environmental changes, their impacts on lives and livelihoods, possible adaptation strategies to the changes and wishes for the future of the community.	Online participatory mapping survey (Maptionnaire)	Adaptation, Arctic, Climate change, Knowledge integration, Local knowledge, Participatory mapping, Savukoski, Jokkmokk, Environmental change perception	Yes Fairdata.fi https://doi.org/10.23729/a36fe438-f2e3-4649-b916-1e44bd12b953	csv	CC BY 4.0

Jokkmokk online mapping survey on perceived environmental changes	Salla Eilola	UTU	Tim Horstkotte, Nora Fagerholm, Teresa Komu, Otto Habeck, Sirpa Rasmus	9.5.2022	30.8.2022	Jokkmokk, Sweden	Survey answers	Survey answers to structured and open-ended questions; map markings with a corresponding x- and y-coordinates that can be utilized and analysed in a GIS software. Survey topics include perceived environmental changes, their impacts on lives and livelihoods, possible adaptation strategies to the changes and wishes for the future of the community.	Online participatory mapping survey (Maptionnaire)	Adaptation, Arctic, Climate change, Knowledge integration, Local knowledge, Participatory mapping, Savukoski, Jokkmokk, Environmental change perception	Yes Fairdata.fi https://doi.org/10.23729/a36fe438-f2e3-4649-b916-1e44bd12b953	csv	CC BY 4.1
Arctic Holocene Biodiversity Map (metadata)	Andrew C Martin	UOXF / UCAM	Several (authors of original protocol)	12500 cal yr BP	1950 AD	Pan-Arctic	Metadata		Output of the systematic map as described in Martin et al 2022		GitHub.com/AndrewCMartin/holocene-arctic-biodiversity-database	json custom graph structure	Open Database License
Arctic Holocene Biodiversity Database	Andrew C Martin	UOXF / UCAM	Tom Pavey, Jo Bartram, Katie Blake, Daniel Villar, Olivia Rider, Louie Bell, Matthew Speight	12500 cal yr BP	1950 AD	Pan-Arctic	Raw datasets and age depth models	Metadata; includes raw datasets from many contributors (much of which has been digitised by us from figures). Contains recalibrated age-depth models (i.e. reanalysis) by us.			GitHub.com/AndrewCMartin/holocene-arctic-biodiversity-database	json custom graph structure	
Biodiversity Coder app (source code)	Andrew C Martin	UOXF / UCAM		NA	NA						GitHub.com/AndrewCMartin/biodiversity-graph-db	source code (F#)	
Arctic Essential Biodiversity Variables	Andrew C Martin	UOXF / UCAM	Marc Macias Fauria										
Workshop notes	Sirpa Rasmus, Minna Turunen, Salla Eilola, Hans Tommervik, Tim Horstkotte	LAY, UTU, NINA, UmU,	LAY, UH, UTU, UHAM, NINA, UmU, AWI	2021	2024	Finland, Sweden, Norway	Notes, photos	Detailed notes of discussions from participatory workshops, meetings, researcher workshops, world cafe discussions and group discussion		participatory work	Not open data; confidential information. Data creator can be contacted about the content. Content summarized in D3.3, D3.7, and D6.5		

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