Supplementary material 2 Data matrix with a summary of locally perceived environmental changes and scientific knowledge on the same phenomena				
Phenomenon	**Perceived changes**		**Scientific observations of changes**	
	Savukoski	**Jokkmokk**	**Savukoski**	**Jokkmokk**
Changes in seasonal weather and snow and ice conditions				
Weather variability	Increased variability and unpredictability of daily and annual weather, esp. in winter	Increased variability and unpredictability of daily and annual weather, esp. in winter and spring	Interannual variability in climate indices in Northern Finland Changes in weather variability or daily weather persistence have been studied very little. (Rasmus et al., 2020b)	Interannual variability in mean seasonal temperatures is high, esp. between winters and somewhat between springs in northern Sweden (SMHI, 2015).
Windiness	Increased windiness, esp. during cold winter days	Increased windiness, esp. during cold winter days	Mean and maximum windspeeds have decreased 1979-2008 in northern Finland (Laapas and Venäläinen, 2017). No significant change in wind conditions detected between 1981-2020 in northern Finland (Gregow et al., 2021).	Increasing annual and seasonal mean windspeed trends in the region of Jokkmokk 1979-2008. In period 1956-2013 significant increase found esp. In spring, summer and autumn seasons. (Minola et al., 2016)
Autumn temperatures	Warmer autumns with later lake and river ice formation	Warmer autumns	No statistically significant change in autumn temperatures have been recorded in weather station near Savukoski. Number of frost days has decreased by 8 days in the past century. (Kivinen et al., 2017)	The average autumn season temperature has risen by a degree during 1991-2013 (SMHI, 2015).
Winter season lenght	Winter season has become shorter	Winter season has become shorter	Snow season has become shorter in Savukoski area (Luomaranta et al., 2019; Rasmus et al., 2014; Turunen et al., 2016).	Decreasing trend in the number of days with snow cover in northern Sweden (SMHI, 2015).
Winter temperatures	Milder winters with shorter periods of subzero temperatures	Milder winters with shorter periods of subzero temperatures	Winter air temperatures have increased during the past 30–50 years in northern Finland (Kivinen and Rasmus, 2015; Lépy and Pasanen, 2017; Rasmus et al., 2020b, 2014). Extremely cold weather events have declined in all seasons during the past 100 years (Kivinen et al., 2017).	Winter air temperatures have increased slightly since ca. 1990 in Northern Sweden (SMHI, 2015). Slightly more thaw-freeze cycles were experienced in Sweden during 1991-2020 compared to 1961-1990 (SMHI, 2023).
Precipitation	More commonly rain during winter months	Increased precipitation	Increased number of rainy days during winter in Savukoski between 1981-2010 (Rasmus et al., 2014). Increase in mean annual precipitation in northern Finland during 1947-2011 (Merkouriadi et al., 2017).	Precipitation has increased slightly since ca. 1990 (SMHI, 2015).

Lake & river ice conditions	Lakes and rivers do not freeze properly and ice remains weak longer into the winter	Lakes and rivers do not freeze properly and ice remains weak longer into the winter	There is a slight trend of later freeze-up of lakes in a hundred-year period in northern Finland (Korhonen, 2006). In Lake Inari north of Savukoski, statistically significant decreasing trend in average ice thickness was measured in both early winter and early spring during 2010-2017 in a study period of 1960-2017 (Puro-Tahvanainen et al., 2019).	Ice formation is generally expected to occur later and ice breakup earlier in lakes of northern Sweden due to rising air temperatures (Länsstyrelsen Norrbotten, 2012).
First snow cover formation & icing events	More commonly basal ice and mold formation underneath snow cover; formation of ice layers in snow pack has increased	Icing events have become more common	Number of winters with basal ice formation has slightly decreased between the periods 1948–1982 and 1983–2016 in Savukoski (Rasmus et al., 2018). No statistically significant change in ice days or rain on snow days, which may indicate basal ice formation, during 1981-2010 (Rasmus et al., 2020b).	Increased thaw-freeze cycles in Sweden during 1991-2020 compared to 1961-1990 (Päiviö, 2006; SMHI, 2023), which may indicate increased frequency icing events.
Freezing of peatlands	Peatlands do not freeze completely as in the past	NA	Peatland ice conditions in northern Finland have not been comprehensively studied. In north-western Finland significant degradation of permafrost has been reported during a 1959-2021 study period. (Verdonen et al., 2023)	NA
Snow cover height	The depth of snow cover varies a lot between years; contradicting perceptions of increasing and decreasing trend exist	The depth of snow cover varies a lot between years; contradicting perceptions of increasing and decreasing trend exist	Snow depth varies annually (Rasmus et al., 2016, 2014). Snow cover depth depends also on environment: open landscape, forest of average density, and dense forest (Rasmus et al., 2016). In Nov-April 2019-2020 snow heights were exceptionally high compared to 2010-2019 (Kumpula et al., 2020).	NA
Winter storms	Snow blizzards have become rarer	Winter storms have become more common	Long term records of winter storms are scarce. Climate models predict increased storm frequency in the subarctic region, however, the reduction of Arctic sea ice extent can affect wind regimes and reliability of predictions. (Gregow and Vihma, 2012)	
Spring temperatures	Spring and snow melt start earlier	NA	Snow melt date has become earlier 1981-2010 (Rasmus et al., 2020b) and the number of frost days in spring decreased 1914-2013 (Kivinen et al., 2017).	NA

	Spring starts later (i.e. temperature stays cold and snow cover stay longer)	Spring starts later (i.e. temperature stays cold and snow cover stay longer)	Exceptionally high snow cover evidenced in March-April 2019-2020 compared to 2010-19 (Kumpula et al., 2020). Similar perceptions of later spring by herders (Rasmus et al., 2020b).	The average temperature in spring has increased to some degree since mid-1990s in northern Sweden (SMHI, 2015).
Lake & river ice melting	Lake and river ice melts gradually and is not as thick as before causing no jamming of ice in the rivers	NA	Negligible change towards earlier and significant variation ice break-ups in Torne river (Norrgård and Helama, 2022). In Lake Inari ice break-up has become earlier and ice thickness reduced during 1960-2017 (Puro-Tahvanainen et al., 2019). Slightly earlier ice break-up in lakes in Northern Finland 1885-2002 (Korhonen, 2006).	NA
Summer temperatures and precipitation	Higher summer temperatures and more commonly dry spells	Higher summer temperatures and more commonly dry spells	Number of days with extremely high daily maximum temperatures have increased in spring and autumn but not summer during the past 20 years compared to 1914-2013 in northern Finland (Kivinen et al., 2017). No statistically significant change in annual number of hot days during 1981-2010 (Rasmus et al., 2020b).	The number of consecutive summer days warmer than 20 degrees has increased by a few days since the 1961-1990 reference period in northern Sweden. The greatest increase in the average summer temperature occurs in the mountains. (SMHI, 2015)
	Increased variability in summer weather	Increased precipitation during summers	No statistically significant change in monthly summer precipitation has been recorded in Northern Finland during 1914-2013 (Kivinen et al., 2017).	Mean daily precipitation during summer months show slight increase between 1961-1990 and 1991-2013 periods in northern Sweden (SMHI, 2015).
Changes in vegetation, landscape features and animal populations				
Annual yield of berries	Berry yields have decreased and variability in yields exists	NA	There are no systematic berry inventories but a recent indicative study shows high interannual variability in berry yeilds in Finland (Turtiainen et al., 2015). Effects of changing climate conditions differ between berry species and mainly cause shifts in species dominance (Markkula et al., 2019).	NA

Shrubification & Arctic greening	Shrubification of fjelds is adavancing and hay is growing in landscape where it did not grow before	Tree line is climbing upwards on mountains and shrubification is advancing	Changes in species rations in the transition zone between fjelds and boreal forest have been evidenced in Northern Finland (Pöyry and Aapala, 2020). In Savukoski biomass of shrubs (bilberry, lingonberry, crowberry, heather) increased in sample plots by 2/5 between 2005-18 (Kumpula et al., 2019).	The tree line has risen altitudinally (approx. 200 m) since the early twentieth century in some parts of northern Sweden (Kullman, 2010), but remained stable in others (Van Bogaert et al., 2011).
			Estimation of the magnitude of Arctic greening is complex in relation to climate, reindeer herding and topoclimatic constraints (Kullman, 2010; Markkula et al., 2019; Myers-Smith et al., 2020; Stark et al., 2021; Van Bogaert et al., 2011).	
Forest logging & biodiversity loss	Increased extent of forest havesting, reduction in the extent of old forests and decreased forest biodiversity	Increased extent of forest harvesting and effects on habitats	Forest harvesting has affected 2/3 of the Reindeer herding district area in Finland and in Kemin-Sampio 17.3 % of mature and old growth forests outside nature reserves have been deforested between 1995-2018. There are no reliable data on the deforestation of old natural forests. (Korhonen et al., 2021; Kröger, 2018; Kumpula et al., 2019)	Clearcutting of old forests has increased in extent since 2003 in unprotected areas in northern Sweden (Ahlström et al., 2022).
			Managed forests in northern Finland and Sweden have generally poor biodiversity and ecological integrity due to clearcutting and heavy soil preparation practices in forestry (Ahlström et al., 2022; Kumpula et al., 2019; Mönkkönen et al., 2022).	
Forest drainage and soil preparation	Peatland drainage and heavy soil preparation in forestry have altered vegetation types and waterbodies	NA	Twenty-tree percent of forest peatland has been drained since 1950s in northern Finland due to forestry (Turunen and Valpola, 2020). Peatland drainage, ditch maintenance and soil scarification affect waterbodies long into the future (Kumpula et al., 2019; Räinä et al., 2022). Many different peatland types prevalent in Savukoski have been declared endangered, vulnerable or near threatened in Finland (Kaakinen et al., 2018).	NA

Eutrofication & siltation of waterbodies	Eutrofication and siltation of waterbodies has increased	NA	Larger waterbodies in Savukoski are estimated to be in excellent or good condition, except the outlet river of Lokka which is in satisfactory condition (Finnish Environmental Institute, 2019). Phosphorus and nitrogen loads are 30-99% higher than natural levels in the southern part of the water catchment in Savukoski mainly due to forestry practices and these practices cause also siltation (Räinä et al., 2022).	NA
Lichen prevalence	Diminishied or dissappeared epiphytic and terricolous lichen, esp. epiphytic lichen	NA	Biomass of reindeer lichen Cladonia spp. decreased statistically significantly by one third between 2005-2018 in Kemin-Sompio herding district (Kumpula et al., 2019). Current forestry practices reduce epiphytic lichen abundance and terricolous lichen abundance show intricate dynamism with winter and summer grazing by reindeer and climate change (Jaakkola, 2014; Stark et al., 2021).	NA
Reindeer behavior	Reindeer move more commonly scattered in the landscape	NA	The effects of changes in pasture conditions and extent has been shown to affect reindeer behavior such as scattered herds due to poor browsing conditions (Jaakkola, 2014; Rasmus et al., 2020b; Turunen et al., 2016).	NA
Fish species prevalence	Diminished or currently non-existent stocks of, esp. European grayling (Thymallus thymallus), common whitefish (Coregonus lavaretus) and migratory fish such as brown or river trout (Salmo trutta m. fario) and Atlantic salmon (Salmo salar). Stocks	Increased stocks of esp. Brown trout (Salmo trutta), Pike (Esox Lucius) and Common perch (Perca fluviatilis) and dimished stocks of Arctic char (Salvelinus alpinus) which is taken over by other species.	In inland waterbodies of Finland, the catch of common whitefish and river trout has decreased, while catches of pike, common perch and salmon has increased during 1980-2021. No conclusive data on arctic char or brook trout and grayling catch reduced during 2000-2021. (Natural resource institute of Finland, 2023a)	The mountainous areas in Sweden have been modelled to provide refugia for Arctic char (Salvelinus alpinus) under warming temperatures and species interactions (Hein et al., 2012). Brown trout (Salmo trutta) abundance is evidenced to depend on the reservoir storage volume in waterbodies (Donadi et al., 2021).

	of northern pike (Esox Lucius), common perch (Perca fluviatilis) and carps (Cyprinidae) have increased and brook trout (Salvelinus fontinalis) is considered a proliferated invasive species		Increased water temperature, extreme seasonal temperatures and browing and precipitation changes have been shown to affect fish survival in northern Fennoscandia (Karvonen et al., 2010; Saura and Kallasvuo, 2023; van Dorst et al., 2019).	
Bird species prevalence	Diminishing of willow ptarmigan (Lagopus lagopus) and other grouses (Tetraonidae), geese (Anserinae), as well as common starling (Sturnus vulgaris), terns (Sterninae) and other cavity nesters.	Decrease of forest bird species	Willow ptarmigan and western capercaillie (Tetrao urogallus) have reduced in numbers and black grouse (Lyrurus tetrix) slightly increased in Värriö area in Savukoski (personal communication, Mikko Sipilä, professor, Head of Värriö subarctic research station, University of Helsinki, 07.04.2022). Willow ptarmigan population has decreased likely due to climate warming and atropogenic pressure (Markkula et al., 2019; Valkama et al., 2011). Common starling and Arctic tern (Sterna paradisaea) have become rare in northern Finland (Valkama et al., 2011).	Increasing numbers of wintering forest birds in northern Sweden during 1986–2017 and show stronger correlations with forest development than with local weather (Ferry et al., 2020).
	Several new species observed, e.g. pigeons and doves (Columbidae), Blue tit (Parus caeruleus) and seagulls (Laridae).	Several new species observed	Blue tit and some pigeon and dove species have extended to northern Finland (Valkama et al., 2011). Many southern bird species breeding range has moved northward shown in latest Finnish bird monitoring (Brommer et al., 2012).	Many southern bird species' breeding range has moved northward in Sweden (Elmhagen et al., 2015).
Prevalence of large terrestrial predators	Large terrestrial predators have increased	NA	Large predator populations have recovered in northern Fennoscandia in the past 50 years due to protection policies; wolf (Canis lupus), Eurasian lynx (Lynx lynx), wolverine (Gulo gulo), brown bear (Ursus arctos) and golden eagle (Aquila chrysaetos) are found in northern Finland and northern Sweden (Åhman et	NA

			al., 2022; Metsähallitus, 2023; Rasmus et al., 2020a).	
	Large terrestrial predators have decreased	Large terrestrial predators have decreased	There are spatial and annual variation in the extent of wolves (Åhman et al., 2022; Rasmus et al., 2020a).	Wolverines have mostly retreated to tundra areas, but have extended their range back into the forest zone in recent years (Elmhagen et al., 2015).
Prevalence of other terrestrial species	Decrease of moose (Alces alces) and increase of roe deer (Capreolus capreolus)	Increase of new terrestrial species, especially the roe deer (Capreolus capreolus)	Moose population density in Savukoski was highest early 2000 and has reduced slightly since, the past two years has been the lowest 2000-2021 (Natural resource institute of Finland, 2023b). Roe deer population has increased in northern Finland in the past 30 years, however the intense areal track counts show large interannual variation mainly due to snow conditions (Natural resource institute of Finland, 2023c).	Roe deer has extended its range northward in Sweden in the 1900s and its current official distribution limit lies southeast of Jokkmokk (Elmhagen et al., 2015).
Prevalence of Nematocera	Nematocera (mosquitos, blackflies) season may start earlier in the summer but their numbers have decreased	Nematocera have decreased	There are no long-term records of insect populations available in Northern Finland and the prevalence of insect populations likely varies annually (personal communication, Jukka Salmela, conservation biologist, University of Lapland, 24.02.2023)	NA
Human disturbance on animals	Hunting by non-locals has increased	Increased disturbance from human activities on animal populations, esp. predators due to increased scooter and snowmobile traffic	Number of hunting license buyers to northern Finland has increased and licenses run out in recent years 2021-2022 (Metsähallitus, 2022).	Increasing trend in tourist numbers in northern Sweden (Sveriges officiella statistik, 2022).

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