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Population projections of the Arctic by levels of education

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Approved by: Wolfgang Lutz, Program Director World Population Program
November 2017

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Working Paper **WP-17-022**

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Contents

Abstract

The Arctic is a rapidly changing geographical area surrounding the North Pole. A relatively small total number of around 10 million people (in 2015) reside in the territorial vastness of dozens of sub-national entities north of eight Arctic countries. Local people are subject and driver of the widely discussed transformation. In this study we examine recent population developments and model future demographic trends forward to 2050. By combining available data from national statistics and data demographically reconstructed on health, mortality, and mobility we provide an overview of the factors influencing the number of children born to Arctic women, mortality levels and patterns, causes and implications of changes in the sex and ethnic composition, aspects of population ageing, as well as the spatial distribution and patterns of migration across the North.

To account for regional characteristics we incorporate assumptions on the processes of population change explicitly Arctic in nature in addition to global ones. We explore the age and sex parameters of interest, and the level of higher education based on the fertility and mortality of people with a different level of attained education. We present three alternative future scenarios: “Medium development”, “Arctic Boost”, and “Arctic Dip”. The sub-national and country-wide population projections suggest how education as a factor of human capital may drive demographic shifts in various parts of the Arctic.

Acknowledgments

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About the Authors

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Population projections of the Arctic by levels of education

Anastasia Emelyanova

1 Introduction

The Arctic region covers more than 10% of the planet's total land area but is one of the most desolate and least populated areas due to peripherality and unfriendly climate conditions. A rapid transformation of the Arctic in different extremes and directions started to take place in recent decades. Environmental and socioeconomic drivers interact in a complex way and amplify those changes, making the future difficult to predict. Both global and local mining, oil and gas industries, fisheries, transportation, technology development, and boosting tourism are among those factors most affecting Arctic ecosystems and biodiversity. They come together with climate change that leads to the loss of sea ice, erosion and contamination of coastal lands due to e.g. thawing permafrost and global transport of chemicals. As a governmental response, Arctic development strategies have been recently re-evaluated and released by all Arctic states.

In this study we address several other, equally important factors that impact the region's future: Human populations, migration of people, and education as a proxy of human capital. Likewise global population growth, northern and Indigenous communities experienced a marked population growth since World War II. For instance, in 1945 the population of Alaska in the US was 100 000 and has grown sevenfold by 2015. In Greenland, the increase has been more than fivefold, and a fourfold increase occurred in Iceland during the same period (Larsen & Fondahl, 2015)

At present, only Alaska, Iceland, and the Canadian Arctic have continued to experience population growth due to still positive net migration and natural population increases (more births than deaths) (Larsen & Fondahl, 2015). However, populations living in the northern parts of Sweden, Finland and Arctic Russia have declined by 5 to 10% in the last 15 years because of accelerated out-migration and natural population decline. In particular, starting in the 1990s, the dramatic growth seen in Greenland and the Faroe Islands has reversed to a trend of "thinning out societies" (Gløersen et al., 2006).

A major concern is the imbalance between sexes. On the one hand, the character of labor in the North traditionally favors male dominated occupations leading to a higher regional male-female ratio. In the Russian Arctic, however, there has been a predominance of older women living alone due to excessive death rates of Russian men. Another trend that affects the sex balance negatively is the out-migration of young women from the North Atlantic corner of the Arctic who leave their native lands to study and work elsewhere (Hansen et al., 2012).

These demographic trends as well as trends in education are discussed in more detail in Section 2. First, we define the study area and data sources. Next, we look at the population dynamics with regard to fertility, mortality, migration and ethnicity, while considering the available data for the Arctic. Section 2.4 introduces patterns of educational development as a third source of observable human heterogeneity in addition to the traditional components of population projections – age and sex. In Section 3 we examine the chosen methodological approaches, assumptions and umbrella scenarios to forecast regional mortality, fertility and migration that shape the population composition in the Arctic. Some of the computations and findings about the future population size and structure in various Arctic regions by age, sex, and educational level in the period 2015 to 2050 are discussed and visualized in Section 4.

2 Population and education in the Arctic

Section 2 defines the geographical scope of the analysis and the selected borders of the Arctic. It uncovers main data sources which were scrutinized in order to understand and model population and education trends. An overview of the characteristics in regional fertility, mortality, migration, as principal determinants of population change in the Arctic, is given next. It also reveals the aspects of the ethnic composition that makes an important impact on overall demography. We finalize Section 2 by describing what kind of education trends and gaps there are in the Arctic.

2.1 Geographical scope of analysis

It is important to note that several borders define "the Arctic" by various criteria, making it not very straightforward to define the region exactly. For the purpose of this study the region is defined according to the Circumpolar Health Observatory on basis of health and population data. Accordingly, we consider the Arctic to encompass the regions located to the north of 60º N latitude (Figure 1), consisting of 25 sub-national entities and one country – Iceland. There are four larger regions: North American Arctic, North Atlantic Arctic, Fennoscandian Arctic, and The Russian Arctic.

The North American Arctic covers Alaska in the US and the three northern territories of Canada: The westernmost Yukon, the most populous Northwest Territories (NWT), and Nunavut, which forms the largest, least populated, and youngest territory of Canada. The closely standing sub-provincial Nunavik in northern Québec and Nunatsiavut in Labrador have been excluded due to a lack of data on age and sex specific mortality as well as health related data constraints. The data is available only for the entire provinces of which they are part ("Circumpolar Health Observatory," 2017).

The North Atlantic Arctic region consists of Iceland and two autonomous territories of Denmark: The Faroe Islands and Greenland.

In Fennoscandian Arctic, Norrbotten and Vesterboten of Sweden are included as well as three regions of Norway – Nordland, Troms, and Finnmark – and three regions of Finland – Lapland, Kainuu, and North Ostrobothnia. "Region" here refers to fylke in Norway, län in Sweden, and lääni in Finland.

The Russian Arctic includes eleven federal subjects ("subyetkty") across the Russian Federation based on location and in part availability of the recent time series of population data. Russia is constituted of different types of administrative divisions called subjects, including republic, kray, oblast, and autonomous okrug, with varying degrees of autonomy. The ones included in the Arctic analysis can be also divided into two parts: (1) the Barents part of the Russian Arctic which includes five regions: the republics of Karelia, Komi, Arkhangelsk and Murmansk oblasts, and the Nenets autonomous okrug; and (2) the Siberian part of the Russian Arctic, which is the republic of Sakha Yakutia, Magadan and Murmansk oblasts, Kamchatka kray, and the autonomous okrugs of Yamalo-Nenets, Khanty-Mansi, and Chukotka. Siberian autonomous areas of Taymyr and Evenki have been excluded because they are only minor part within their larger subjects since 2007, and thereafter have no distinct population data available.

Figure 1. Coverage of the Arctic area ("Circumpolar Health Observatory," 2017)

2.2 Sources of data on population and education

2.2.1 Raw data on population

A number of publications provides the context to understand human development in the Arctic, including demographic and health transitions as well as societal drivers of change (Andrew, 2014; Einarsson et al., 2004; Hansen et al., 2012; Larsen & Fondahl, 2015; Larsen et al., 2010; *Megatrends*, 2011; Young et al., 2012). In addition, demographic and socio-economic publications released by national and territorial statistical bureaus of Arctic countries have been considered in this study. Tables with various national and regional population data have been widely retrieved from the national statistical databanks.

The Federal State Statistics Service and the Unified Interdepartmental Statistical Information System are the main data supplier of population accounts and components of population change in Russia (Fedstat, 2017; Rosstat, 2017). For the Nordic countries, national and sub-national statistical agencies publish time series on various population events (Statistics Denmark, 2017; Statistics Faroe Islands, 2017; Statistics Finland, 2017; Statistics Greenland, 2017; Statistics Iceland, 2017; Statistics Norway, 2017; Statistics Sweden, 2017).

Canada's national statistical agency and the Canadian Human Mortality Database (CHMD) are the other main sources of regional and national population data (Department of Demography, Université de Montréal, 2017; Statistics Canada, 2017). However, they use different methodologies and their demographic estimates may differ from those used in the other Arctic countries. The Canadian Socioeconomic Information Management database of Statistics Canada publishes tables in population and demography. In view that the CHMD life tables are available for longer time series (1950 to 2010–2011) and given by sex, it was chosen as main source for mortality data. One shortage is that life tables are not available for all three Canadian Arctic provinces separately: CHMD publishes data for NWT and Nunavut combined. When projecting the US and Alaska's populations, baseline data is assumed on the basis of population estimates and further data from local statistics as well as census data of the US (Alaska Department of Labor and Workforce Development, 2017; US Census Bureau, 2017).

2.2.2 Raw data on education

The population of the Arctic is projected by several levels of educational attainment according to the national education classification (*International Standard Classification of Education ISCED 2011*, 2012) in the eight Arctic countries, encoded in Table 1. The full list of educational levels, codes and data suppliers according to the national systems of education can be found in Appendices 1 and 2. The levels of education largely vary as they are (dis)aggregated over different combinations of educational groups, for example primary and secondary education combined in one region and separated in statistics of the other, or the holders of Master and Doctoral degrees are reported together in one country and separately in others. Also, the content of levels may vary, for example in Norway upper secondary education includes intermediate level courses based on already completed upper secondary level, but they are not accredited as tertiary education, which is in contrast to other countries, where this was reported as short-cycle post-secondary level of education.

It is important to note that the starting point of projections – Arctic data on population by education – is collected for various years in the period 2010 to 2015 depending on census or survey waves (Appendix 1 and 2). Only Denmark, Greenland, Norway, Sweden and the US provide data for the year 2015. For reasons of simplicity the education distribution of other territories with data from earlier years 2011 or above was assumed as of the baseline year 2015 and should be regarded with such warning. The accompanying demographic components – life expectancy, fertility and migration rates – have been forecasted until 2015 where actual data for 2015 has not yet been released by national statistical databases. One more exception to bear in mind is Sweden, Norway and its Arctic territories, where data for the usual age group 15–19 is published for the age group 16 to 19. In projections, this age group is regarded as 15–19.

Table 1. Educational categories applied in the projections

EDUCATIONAL CATEGORY	DESCRIPTION
E1	No schooling completed
E2	Nursery school, preschool, kindergarten
E3	Primary general
E4	Lower secondary
E5	Upper secondary
E6	Post-secondary non-tertiary education
E7	BA degree / Professional degree beyond a bachelor's degree
E8	Master's degree
E9	Doctorate degree
E10	No information about level of education attainment

Note: For many areas, educational categories are reported in various combination.

Educational data might be incomplete for a small number of persons in the Arctic. For instance, this concerns people with degrees from abroad or private degrees, people with internal company-education, or people with degrees from old systems of education classification (as in Sweden). Statistics Norway provides an estimate of educational level for missing values for immigrants. Other territories could have similar data issues, not explicitly mentioned by the national statistical bureaus. In the known cases the missing values are relatively negligible.

2.3 Evolving population dynamics

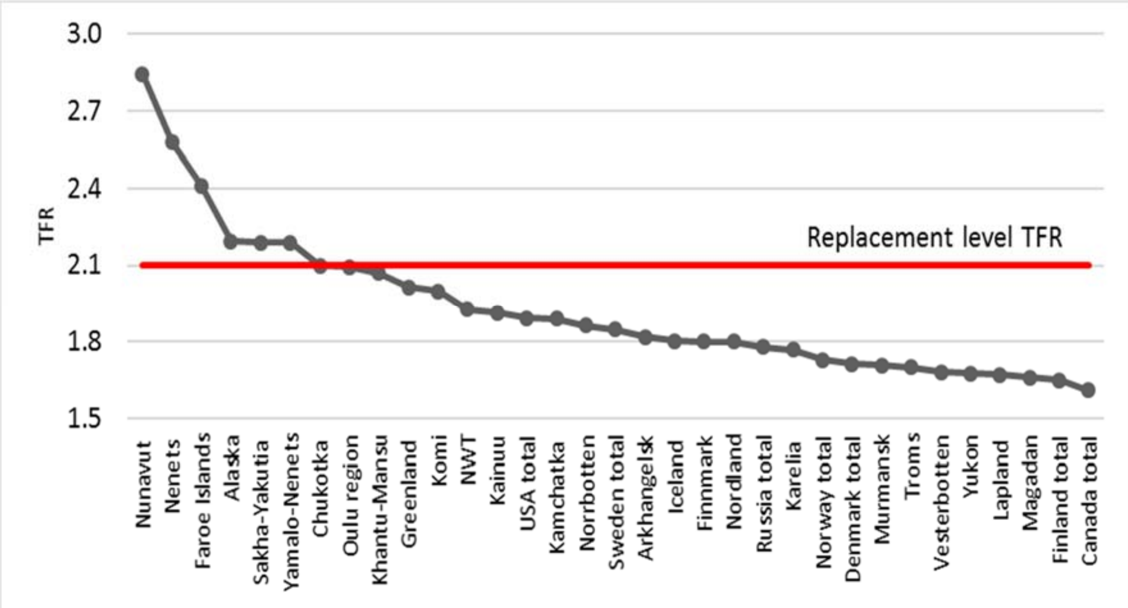
2.3.1 Fertility

Fertility is known as a strong determinant of future population growth. At the turn of the century, Arctic fertility rates have undergone a decline, however, dynamics will not likely cause a major population loss as fertility changes occur relatively slowly. Still, fertility has been above or catching up the national average with some Arctic territories showing one of the highest fertility rates in Europe. In 2015, the Total Fertility Rate (TFR) above the replacement level[1] was encountered in one quarter of regions and countries under study (8 areas out of 33). The highest TFRs have been found in Canadian Nunavut (2.8),

[1] About 2.1 children per woman (United Nations 2015).

Nenets area of Russia (2.6), and the Faroe Islands (2.4). Alaska, Sakha Yakutia, Yamalo-Nenets, Chukotka, and Northern Ostrobothnia (Oulu) of Finland have fertility levels around replacement (2.0–2.2). The remaining areas have fertility levels below replacement, marking as low as 1.7 in the Russian region of Magadan, Canadian Yukon, and northernmost areas in Scandinavia. On average, Northern Fennoscandia and Russian Arctic's fertility have been lower than in the North American and North Atlantic parts of the Arctic (Figure 2).

Figure 2. Total Fertility Rate (TFR) in the Arctic constituting regions and countries, 2015



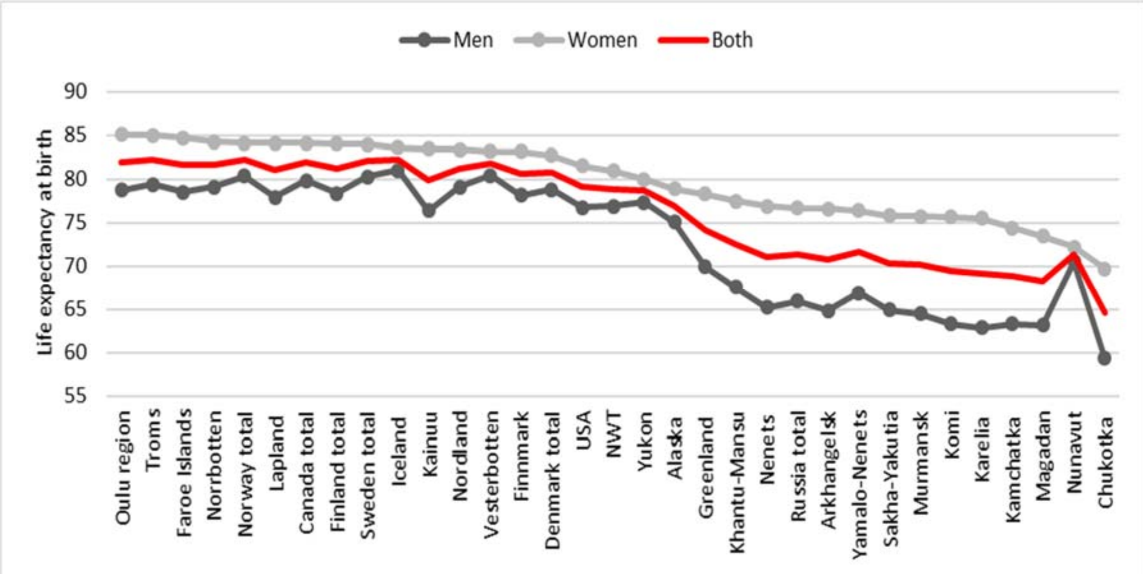
2.3.2 Mortality

The indicator of life expectancy at birth (LE0) depicts mortality patterns well and was forecasted for the populations under analysis. In the Arctic, there is a significantly varying pattern of longevity due to large differences in mortality. There is an enormous gap of 22 years in male LE0 between the area with the lowest level Russian Chukotka and the leading areas such as Finnish Oulu. The Arctic regions of Russia have the lowest indication of life expectancy (LE) particularly in the Siberian part of the Arctic (Chukotka, Magadan, Kamchatka). Nunavut of Canada has a relatively low LE0, in part due to history of local population in the colonial times (Larsen & Fondahl, 2015).

The populations of the Faroe Islands and Iceland enjoyed two to five years more life expectancy than the Danish population and the same being true for women in northern Finland (higher LE0 than national average for women in Finland) and men of Troms (higher male LE0 than nation-wide). There are also populations where life expectancies do not differ dramatically from the average values of their nation states, namely Alaska, Yukon, and the majority of the Scandinavian and European regions of the Russian Arctic.

Several northern territories have a life expectancy substantially below the national average, such as Canadian Arctic (except Yukon), Greenland and Chukotka in Russia. Chukotka is the lowest in the Arctic, that is, 59 years for men and 69 years for women, and almost 7 years less than Russia's all-population rate, though improved over the last few years. Men of the Russian Arctic have still the largest inequality in LE0 in comparison to women, and the largest difference up to 12 years in favor of women in the Barents part of the Russian Arctic. In fact, many regions with low LE0 are settled predominantly by the Arctic Indigenous people and they are characterized by relatively poorer health and impoverished economic status (see Section 2.4 Evolving education dynamics for further discussion).

Figure 3. Expectations of life at birth in the Arctic constituting regions and countries, by sex, 2015

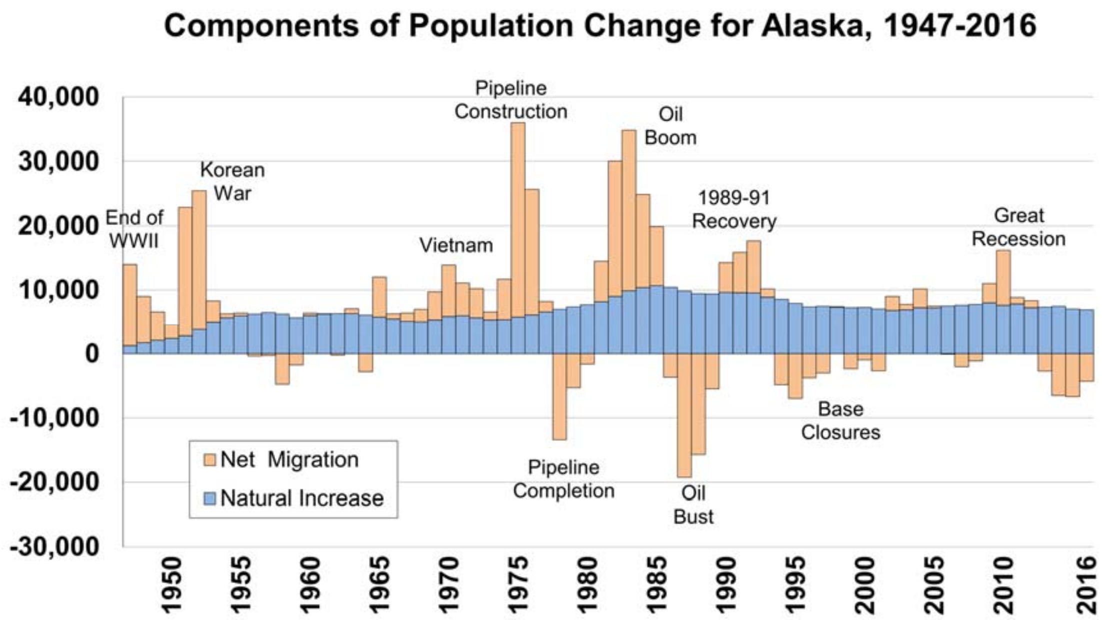


2.3.3 Migration

The majority of the Arctic regions have always had higher rates of migration turnover than the rest of their countries, with more people moving to, from, and within the North. Hence, to capture these changes is a challenge and of substantial importance for reliable predictions. The flow of people from outside the Arctic to work in resource extraction projects have increased in recent decades. Movement of Arctic natives to outside the Arctic has also become common resulting in a large Arctic diaspora population (Heleniak, 2014). Because of the small populations located across vast areas, these processes count for substantial changes in population size, distribution, composition, and human capital of the Arctic population.

The character of regional migration oftentimes reminds of a cycle of booms and busts that have been historically associated with large-scale industrial projects, such as pipeline constructions, oil exploration and mining, and military activities. At times many Arctic settlements have experienced migration inflows substantially larger than the natural rate of increase (births/deaths) (Hamilton & Mitiguy, 2009). An example of population changes in the northernmost state of the US – Alaska – illustrates the waves of migration responding to wars and economic projects in the natural resources industry (Figure 4).

Figure 4. Alaska's population changes from 1947 to 2016 (Alaska Department of Labor and Workforce Development, 2017)

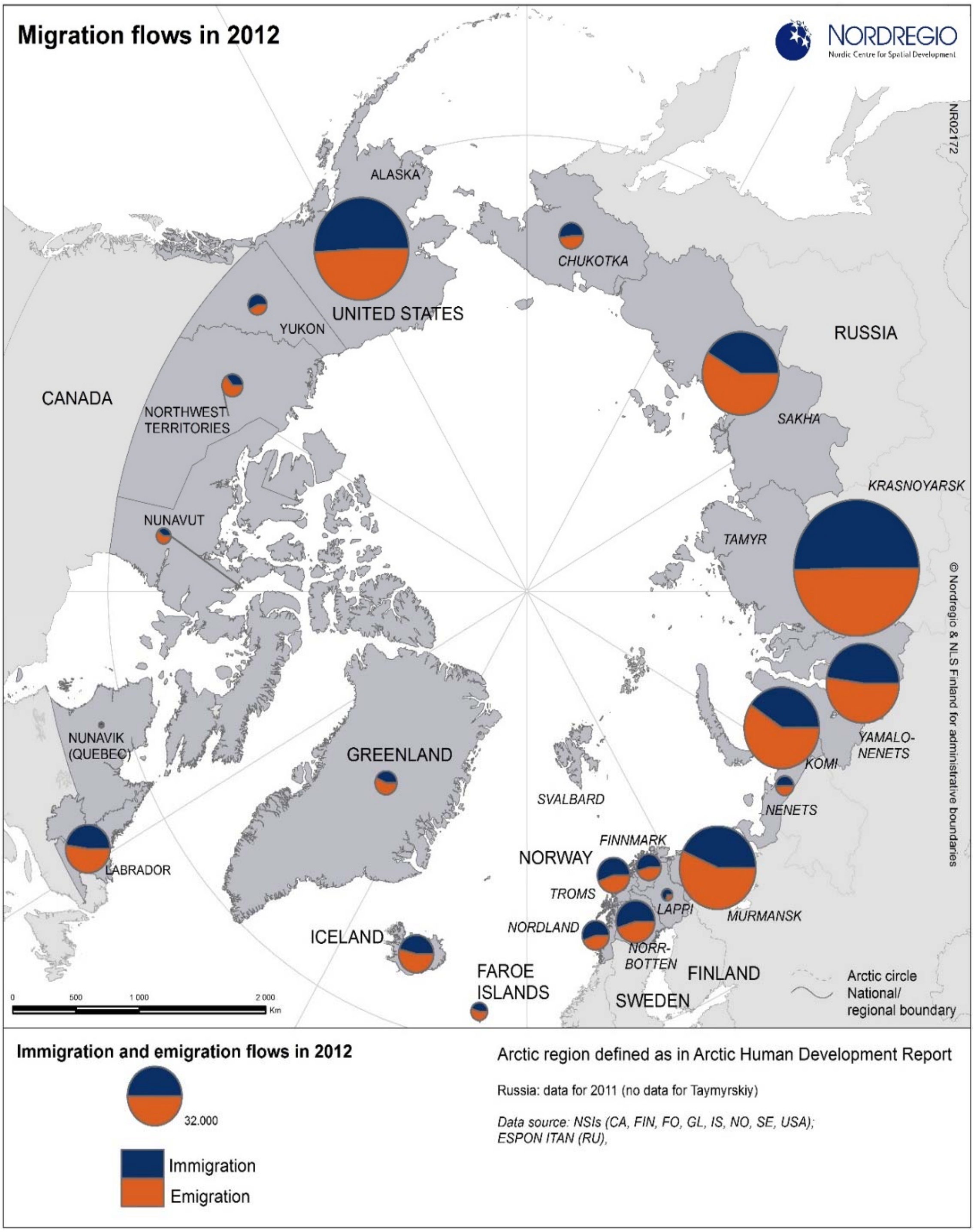


The Canadian Arctic areas, similarly to Alaska, have seen their population spikes and dips associated with natural resource splashes and subsequent retreats. Greenland has numerously faced an age and sex specific migration spike, with youth leaving for higher education after finishing local schools and many not returning, and Greenlandic women marrying Danish men who tended not to stay in Greenland permanently (Hamilton & Rasmussen, 2010). Iceland's 2000s banking boom and bust saw a spike in immigration during the boom, that is, a net immigration of 15,921 persons prior to the 2008 banking crisis, and a spike in emigration following the crisis (net emigration of 8,692).

The Russian Arctic has experienced massive immigration with a variety of government support in the 20th and 21st centuries, turning to striking out-migration following the harsh economic decline after the dissolution of the Soviet Union. In this way, most compounding regions of the Arctic have population compositions largely made of migrant populations e.g. in the Russian North up to 70% of residents were born outside ("Federal State Statistics Services of the Russian Federation," 2017), in Alaska it was 60%, etc. Hence, the Arctic can most likely face either booms or busts in the shares of "outsiders" which is explicitly assumed in our scenarios of the future. Figure 5 highlights immigration and emigration flows in the Arctic, the largest to be found in Alaska and Russian Arctic.

Both international and internal migrants have been making the overall migration turnover in the Arctic. International migration is defined as flows to and from the Arctic into other countries. Internal migration flows are those within Arctic countries and regions and include movements up the urban hierarchy from smaller to larger settlements which is the predominate trend. In the Artic, international migrants have been only a minor part hence the majority of incomers to the North have been from the middle-land and southern regions of the respective Arctic countries (Heleniak, 2014).

Figure 5. Migration flows in the Arctic, 2012 (“Nordregio,” 2017)



2.3.4 Ethnicity

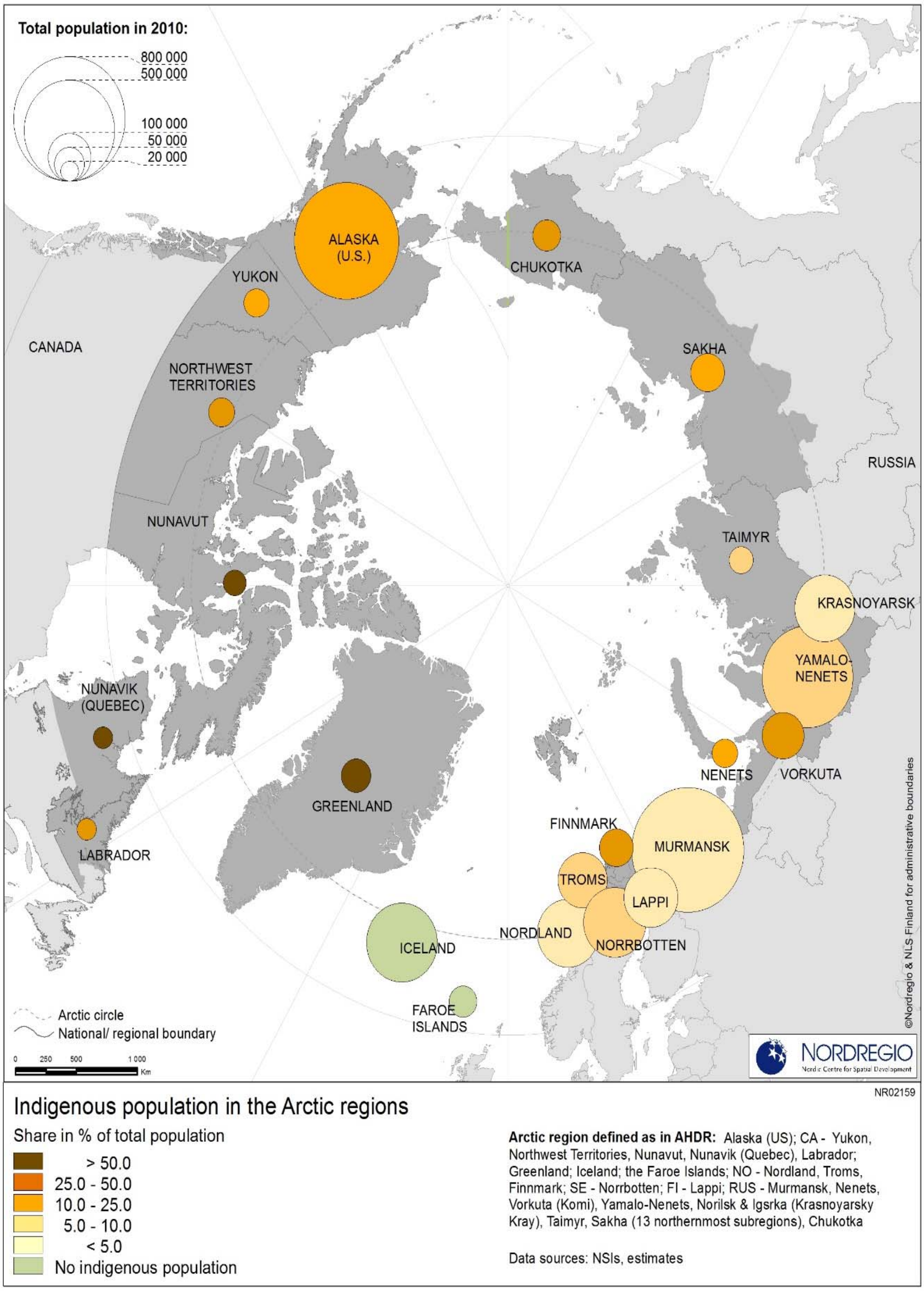
Mortality and fertility in the northern provinces have been noticeably different from the nationwide numbers of Arctic countries since the times of the first registration. One explanation is that population living in the Arctic is ethnically nuanced and rich in Indigenous people. The North American Arctic is home to several major aboriginal groups, the Inuit people, First Nations (North American Indian), the Métis in Canada, and several peoples in the north of the US collectively called Alaska Natives. In Greenland there are Native Greenlanders or Inuit. The Nordic countries are homes to the Sami people. In Russia, numerically small Native peoples live in the North, the largest of which are the Karelians, Yakuts and Komi (the latter not recognized as Native by Russia being below the by law required total number of 50,000 individuals) (Emelyanova, 2015).

The ethnic composition greatly affects demographic indicators of birth, death, median ages, mobility, urban-rural residence, and household structure. Previous studies document poorer outcomes for Indigenous people compared with benchmark populations (Anderson et al., 2016) also claiming the earlier stages of demographic and epidemiological transitions of Indigenous populations. In particular, the health of people living in rural, remote Indigenous communities in the North is poorer than that of their urban and non-Indigenous counterparts. The Indigenous population also has a much younger age structure, higher fertility and mortality, and a distinct male-female gender ratio.

Bogoyavlenskiy and Siggner estimated a total of between 350,000 and 400,000 of people with Indigenous identity in the early 2000s in the Arctic (Einarsson et al., 2004). According to Nordregio, Indigenous populations in the Arctic have been growing by about 1.5% annually (*Megatrends*, 2011). At the moment, the Indigenous share is thought to be at around 10% of the total population in the Arctic (Larsen & Fondahl, 2015), though it is difficult to estimate precisely because of scarce and incomplete data on different ethnic groups residing in the Arctic. From what is known, the percentage of the Indigenous populations within the total area's population ranges widely across the Arctic, and can be as large as 86% of Native Greenlanders in Greenland and Indigenous people in Canadian Nunavut, 50% in NWT, 20% in Alaska and Yukon, 15% in Arctic Norway, and as little as 3–6% in the Russian Arctic (except for 30% in Chukotka).

While acknowledging aforementioned differences in health status and demographics between Indigenous and non-Indigenous populations in the Arctic, this study is undertaken with only a partial reference to ethnic distinction because of weak data. The computation of projections is restricted to only the total populations living in the studied sub-national entities.

Figure 6. Indigenous population in the Arctic, 2013 (“Nordregio,” 2017)



2.4 Evolving education dynamics

Education is highly diverse across the Arctic region, with considerable progress made in some areas, but resistant long-term challenges in others. The number of people with upper and post-secondary educational attainment is increasing. New technologies are providing more opportunities for distant learning for many remote and rural residents, a trend that is incorporated into our education scenarios. From a quality perspective, there is a growing recognition of the importance of Indigenous and local knowledge at all levels. It is considered as a cornerstone of Arctic prosperity in the future. Curricula are changing from a purely needs perspective of the Arctic industries towards preparing students to address all future challenges – adaptation to climate change, health threats, development needs of mixed economies – both globally and with a greater focus on content that speaks to local needs and conditions.

Alongside the recent progress, there are still various forms of inequalities and gaps in the Arctic education (all elaborated in Larsen & Fondahl, 2015). The main challenges can be summarized as following:

- The uneven distribution and access to education and its quality. The introduction of compulsory formal education has been challenged by the vast, sparsely populated spaces of the Arctic which have been often managed by residential schooling. Moreover, fiscal constraints and out-migration result in limited resources and slow improvements of infrastructure and curricula. The costs of transportation, food, student housing, and weather conditions all contribute to lower attendance and graduation. In addition, there is ongoing process of closure of small rural schools in many areas of Arctic countries, in Finland and Russia in particular (Autti & Hyry-Beihammer, 2014; Vorontsov & Glotov, 2016). Canada does not yet have a northern university (Exner-Pirot, 2015; Graham, 2015) which leads to a low access to post-secondary education in northern Canada. Greenland has just one university for quite a gigantic territorial coverage.
- Various types of gaps in educational attainment and outcomes persist within and beyond the Arctic. It remains a major concern that the rates in many regions, particularly the rural Arctic, are below the national levels, southern regions, and urban/industrial Arctic territories.
- There is still a largely observed gender gap. Since the late 1990s an increasing number of females pursued higher education which is partly reflected in the so-called 'feminization' of human capital in the Arctic. Alongside, many women prefer to move away from their home communities seeking education and a career. Male residents tend to stay in their community as they are often intertwined with traditional means of family subsistence, resulting in a lower utilization of education options. Within those enrolled in education, girls outperform boys on standardized measures of achievement and graduate from high school at higher rates.
- Another gap is by ethnicity. There are lower attainment and higher dropout rates among Indigenous students from remote communities. These are major concerns both in secondary school and institutions of higher education. Indigenous knowledge and languages are another sensitive issue for Arctic education. There is a major incompatibility or a lack of a vision of Indigenous knowledge within local curricula versus the dominant global economy knowledge. Indigenous languages in education are the aspect that needs new approaches since many

Arctic regions deliver education via mainstream in the national language, contributing to a loss of cultural diversity. In particular, ethnic languages are threatened across northern Russia and Siberia and in much of Alaska.

- The high mobility of human capital in the Arctic is a considerable challenge. Intensive in- and out-migration of human capital cause brain drain, brain turnover and brain waves altogether and are associated with the traditional boom-and-bust economic cycles in the Arctic.

Figure 7 shows the potential of human capital in the Arctic in the share of population having the highest level of attained education – tertiary. It is indicated by the intensity of color scale (dark colors indicate higher shares and light colors indicate lower shares). High shares are found in Yukon, Alaska, Troms (Norway), Russian North and Iceland in contrast with Nunavik and Nunavut (Canada) and Greenland where shares are relatively low. There are several main reasons, first, a lack of universities (one in Greenland, none in the Canadian Arctic), second, a lack of affordable housing, third, a lack of choice in the degree programs, and fourth, the high out-migration of youth.

3 Future scenarios

Section 3 specifies assumptions for components of population change. The way they are combined are further discussed in a narrative for the three umbrella scenarios: Medium, Arctic Boost, and Arctic Dip. Methodological solutions and quantitative differentials applied to model fertility, mortality, migration, and education are also identified for each computational step.

3.1 Assumptions behind scenarios

The assumptions to predict regional mortality, fertility and migration that shape the outcome population composition in the Arctic are developed based on three levels. We looked at the global dynamics in population changes, the overall nation-wide demographics of Arctic countries, and identified Arctic specific forerunners for the considered demographic processes, to drive our assumptions into the future.

The population distribution is projected in 5-year periods starting from 2015 until 2050. Oftentimes, Arctic provinces are inhabited by relatively small populations and projections for longer time periods would be subject to larger uncertainty. For our assumptions we consider the latest data available (2000−2015) to take into account the recent shifts in demographic patterns. This also helps smoothing abrupt outliers and at the same time provides a continuation of earlier trends. All assumptions were applied to the multi-state cohort component model to project the population at the national (8 countries) and sub-national (25 administrative subjects) levels. Excel Microsoft Office Professional Plus 2016 software is used for the computations.

This study explores three alternative future scenarios based on four projection components (Table 2). At their core, these population projections are based on fertility and mortality forecasts, which are dependent on population data by age and sex. In the case of the highly mobile Arctic, migration is the third component. Assumptions on the future education development is the fourth element within the scenarios.

Figure 7. Tertiary education in the Arctic regions in the recent past ("Nordregio," 2017)

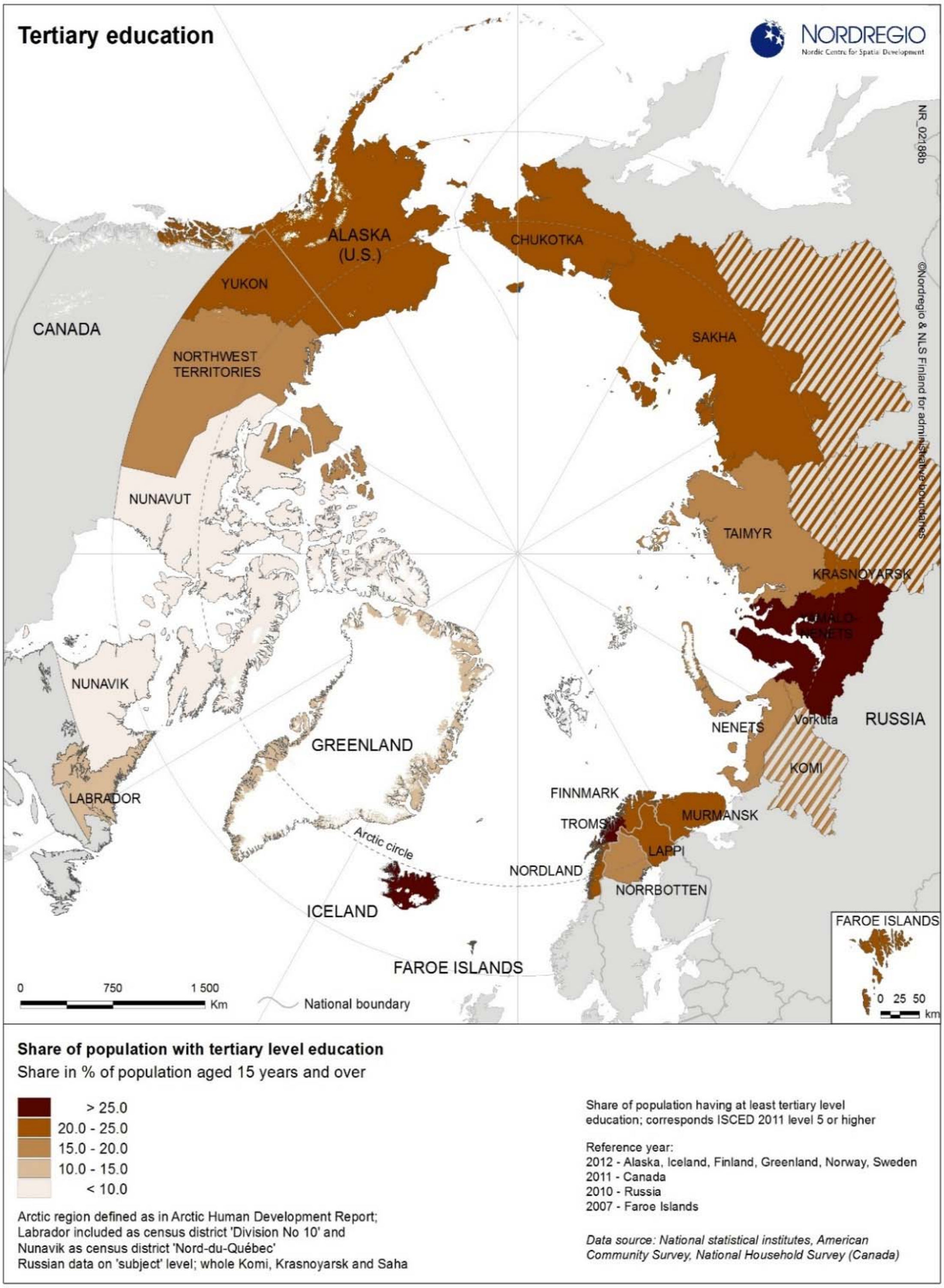


Table 2. Scenarios as a basis for projections

	UMBRELLA SCENARIOS		
	"MEDIUM" **Scenario 1**	**"ARCTIC BOOST"** **Scenario 2**	**"ARCTIC DIP"** **Scenario 3**
1. **FERTILITY**	**Scenario 1.1. and 2.1. Arctic fertility setting** – forecasted with a continuing downward trend, where the TFR will go down 0.2 points by 2030 as the average of Arctic areas where decline happened throughout 2000–2015. Further decline is slowing down -0.1 by 2050		**Scenario 3.1. UN fertility** setting on 2030 and 2050 "medium" forecasts in TFRs of the UN World Population Prospects: The 2015 Revision (United Nations, 2015)
2. **MORTALITY**	**Scenario 1.2. Arctic & Fast improvement** setting on the Arctic forerunner Faroe Islands (84.5 years female life expectancy (LE) in 2014–2015) with a 1.24% growth in LE per each 5-year period (based on Faroe Islands empirical data in 1990–2014)	**Scenario 2.2. Global Convergence** assumption Setting Arctic countries on the global forerunner Japan, assumed to experience a constant increase of 2 years in LE per decade. Sub-national areas to follow the dynamics of the respective country	**Scenario 3.2. UN mortality** setting on 2030/2050 "medium" forecasts in LE of the 2015 Revision of World Population Prospects. Arctic sub-national areas follow the dynamics of the respective country
3. **MIGRATION**	**Scenario 1.3. Levelled-off Convergence** baseline migration towards equilibrium in 2050 so that each region's immigration and emigration probabilities converge to their average, net migration reaches zero by 2050	**Scenario 2.3. In-Migration Ups** 100% probabilities of in-migration move up at a 10% probability pace by 5-year period until 2030, after that the growth in number of incomers is set at 5% reaching 150% of that in baseline year by 2050	**Scenario 3.3. Prevailing Out-Migration** 100% probabilities of out-migration move up at a 10% pace in each 5-year period until 2030, with 5% from 2035 to 2050, overall reaching 150% of the baseline number of outcomers by 2050.
4. **EDUCATION**	**Scenario 1.4.** 20% EAPRs up each level with 10% for E8– E9	**Scenario 2.4.** EAPRs grow 40% up by 2070 from the distribution found via logit model in 2020 for each education level except 20% for E8 (Master) and E9 (PhD)	**Scenario 3.4.** 5% EAPRs up each level with 0% growth for E8–E9

1. The "**Medium"** scenario projects a continuation of Arctic trends in the recent past (business as usual). Scenarios two and three consider migration as a larger cause of demographic change.

2. The **"Arctic Boost"** scenario implies a multi-faceted boom in the Arctic region. It is based on a growth in the number of newcomers from elsewhere, changes in climatic conditions and technological developments, which together make the region more tangible for new industries, resources exploration, and infrastructure development. It also implicates faster education progression between educational levels and an increase in the number of people with the highest qualifications who contribute to the boost.

3. The **"Arctic Dip"** scenario entails accelerating out-migration as a driver of future population decline combined with a number of larger constraints to development in the Arctic (discussion on constraints e.g. in Andrew, 2014). Progression of population groups to higher levels of education is slower and rather behaves stalled for the highest educational levels as many qualified students/professionals may want to opt to go elsewhere to pursue further education and careers.

In order to find education specific survival ratios, life tables by educational level have been constructed applying the Relational Brass logit mortality model by year, region, age, and sex. The optimization procedure was done similarly to the Wittgenstein Centre approach (more in KC et al., 2013; Lutz et al., 2014) with a few alterations and the next steps:

1. LE at age 15 are extracted from life tables we constructed at the earlier stage of the analysis for the three mortality scenarios 1.2, 2.2. and 3.2. It is subjected to the difference in LE by sex between the lowest and highest educational levels – 6 years for males and 4 years for females. The difference between specific levels varies depending on the country/region and its classification of educational system to which data was available (more in Section 2.4 Evolving education dynamics). The applied differentials in education-specific LE at age 15 can be found in Table 3.
2. The multiple field matrices are used to optimize the choice of LE at age 15 (e15) for each educational category, keeping the chosen differentials constant. We calculate the inverse of a square matrix for both sexes, followed by finding the matrix product of two arrays or so-called representing matrices. This generates a final set of e15 of educational levels which averages (mean) are equal to e15 of a total population.
3. Having life expectancies at age 15 defined for each educational level, territory, sex, and scenario, again the Brass logit model is applied on the basis of mortality schedules of earlier forecasted life tables of a total population, and produce a new set of life tables and respectively survivorship contrasted by educational categories.
4. The weights of population in each educational category help to proportionate the remaining residuals of deaths to complete the number of people after survival, aggregated over attainment levels to be equal to the total number of people in the projection, forecasted in the first round which was done without education distinction.

Table 3. Applied differentials in education-specific life expectancy at age 15 (e15), years

EDUCATION LEVEL	MALES	FEMALES	EDUCATION LEVEL (GROUPED)	MALES	FEMALES
E1	0.00	0.00	E1–E3	1.13	0.75
E2	0.50	0.33	E1–E4	1.50	1.00
E3	1.50	1.00	E2–E3	1.00	0.67
E4	2.50	1.67	E2–E4	1.50	1.00
E5	3.50	2.33	E6–E7	4.75	3.17
E6	4.50	3.00	E7–E8	5.25	3.50
E7	5.00	3.33	E8–E9	6.00	4.00
E8	5.50	3.67			
E9	6.00	4.00			
E10	0.00	0.00			

Note: Differentials grow upward with each educational level, except for e10 which is assigned to zero difference from the overall life expectancy and refer to people with reported "Unknown", "Not stated" or "Not applicable" education. Educational levels by country and region can be traced in Appendix 1.

Differentials in education-specific fertility levels, computed in scenarios 1.1.-.2.1. and 3.1. of Table 2, started with those empirically observed in individual countries and then were assumed to converge to a global pattern over the coming decades with computation solutions explained in detail in KC et al. (2013). In the absence of good data on the education composition of migration, it is assumed that the educational composition of migration is equal to that of the origin country. Migration scenario 1.3., 2.3. or 3.3 is applied respectively to the population after survival and implementing education attainment scenarios 1.2, 2.4. and 3.4., weighted for various educational groups.

This set of migration assumptions is again used to forecast changes in the migration probabilities of (1) in-migrants and (2) out-migrants. On this basis the final number of net migrants by age and sex for the projection can be restored. The scenario differences between men and women, age specific distributions and the shares of migrants within the total population correspond with the latest observed 2014–15 data. To note, both international and internal migrants have been summed up to give a baseline number of persons leaving or in-coming to the sub-national entity.

Education scenarios were defined as the transition from lower to higher educational levels similar to the approach applied in a similar study of provinces in Turkey (Yüceşahin & KC, 2015). At first, computation of the Education Attainment Progression Ratio (EAPR) is undertaken by calculating from an initial population distributed by education categories, finding out the proportion of the population who progressed from a lower level to the next higher level. For instance, if 15% of a population in a certain age group have completed at least Bachelor degree level and 87% have completed upper secondary, it means 17% of upper secondary graduates transited to tertiary education Bachelor level. As a second step, finding logits of EAPR for each age group allows us to find intercept and slope to predict EAPRs for the next period 2020. From 2020 to 2070, EAPRs for each education level follows the scenario stated in the 'Education' row of Table 2. In this study, we define various number of educational attainment levels and hence need EAPRs minus one, for example, in case of 6 educational groups 5 EAPRs are computed.

Finally, the resulted population distributions were smoothed for several regions that showed education related distortions in the middle age groups. The smoothing was done separately for each sex and education level, the small residuals to total population being proportionally adjusted. The Arriaga's strong and light smoothing formulas were applied to solve this issue, using data for ages 20-25 through 65-69. The Arriaga technics were preferred over some other tested formulas (the United Nations, the Karup-King-Newton and the Carrier-Farrag) due to better performed indices measuring the accuracy of the different smoothing procedures.

3.2 Scenario 1 "Medium"

The Medium scenario basically implies a continuation of trends in the recent past of the Arctic and moderate changes in education progression.

The TFR is forecasted assuming the recent patterns of Arctic fertility. Age Specific Fertility Rates (ASFR) follow the same scenario as the TFR. In detail, the 1.1. and 1.2. **"Arctic fertility setting"** (see subheadings of scenarios in Table 2) is mostly assuming a downward trend, where the TFR will go down 0.2 points by 2030. The amount of -0.2 is the average of Arctic territories where fertility decline occurred based on 2000–2015 data. Further decline is defined to slow down at -0.1 by 2050. The Arctic regions do not depend on the national path, and thus assumptions are Arctic-specific. This scenario allows further demographic transition towards lower births, later marriages, and increased birth control within the Arctic populations, as happens globally.

The **"Arctic & Fast"** set of assumptions (scenario 1.2. of Table 2) on mortality follows the dynamics of the regional Arctic forerunner chosen among the latest available observed data that is the Faroe Islands as of 84.5 years female LE in 2014–2015 with a 1.24% growth rate in LE per a 5-year period (average based on 1990–2014 empirical evidence). The abridged life tables have been constructed by year, region, age, and sex**.** Survival rates naturally follow the expectations of the forecasted LE at birth. The method used to construct life tables is the Relational Brass logit mortality model. It incorporates the natural pattern of regional mortality with the latest age-specific mortality schedules in the studied regions (2014 or 2015) according to the assumed life expectancy forecasts.

The **"Levelled-off Convergence"** (1.3. of Table 2) of baseline migration towards equilibrium in 2050 – the end point of projections – is applied for Medium scenario. Each country/territory immigration and emigration probabilities converge to their average, so that each area's net migration reaches zero within 35 years towards the last projected period 2045–2050. According to similar approach discussed in the methodological exercises of the UN population projections (United Nations, 1992), such an approach reduces errors caused by assuming that some unusual changes during the base period will continue indefinitely . The new values of the scaled migration are predicted applying linear regression.

In education, EAPRs (1.4. of Table 2) for the levels below Bachelor are set on 20% growth to reach by 2070 from the 2020 year distribution, calculated using a logit model, and 10% increase for the MA and PhD graduates share.

3.3 Scenario 2 "Arctic Boost"

The Arctic Boost scenario accounts for the vision on future growth in the Arctic that, according to experts, will come from immigration (Larsen & Fondahl, 2015). It implies an influx of immigrants due to burgeoning realizations of economic megaprojects associated with mining and oil exploration, increased accessibility for shipping and trade via traditional sea routes (for example the Northern Sea Route), attractive commodity prices, intensified investments and improved infrastructure in all Arctic states, and more capital investors coming from the outside. Moreover, increasing tourism is likely for the coming decades (Andrew, 2014) and with it a general interest of people to explore living, working and studying in the Arctic. The growth in the number of educational institutions, international exchange programs of educational and industrial mobility, and opportunities for trade and small-size services in the private sector are other encouraging factors behind this scenario.

The attractive prospects of the Arctic development suggest the number of in-migrants to the region may change upwards; however, the context is complex and variations can be large across the constituting regions. Here, we accept net-migration to be positive (more people coming into a region than leaving), however the growing number of total in-migrants is not accounted to be very large in absolute terms. In the comprehensive analysis of migration in the Arctic, several experts suggest that a 'huge' influx of people to the Arctic in the foreseeable future is not very likely (Andrew, 2014; Heleniak, 2014). Similarly to this, our assumptions on migration here lead to a moderate pattern of increase.

The **"Arctic fertility setting"** as in the Scenario 1 Medium (2.1. of Table 2) is applied.

The **"Global Convergence"** approach (2.2. of Table 2) assumes mortality on the basis of a global conditional convergence model developed at the Wittgenstein Centre (Lutz et al., 2014). It assumes that life expectancies in the countries follow the dynamics of change of the global forerunner Japan and suggests a constant increase in life expectancy of two years per decade. This goes in line with a large influx of new people into the region that combines local and international patterns of mortality, reflecting a globalized pattern.

The **"In-Migration Ups"** scenario (2.3. of Table 2) predefines the influx of immigrants as linearly growing from 2014/15 baseline numbers throughout 2050. The relative linearity is chosen to avoid extreme heterogeneity of in-migration practices across the Arctic. The probabilities of in-migration are moved up at a 10% probability pace by each 5-year period until 2030, after that the growth is set at a 5% growth. The point of departure is the base-year (2015) which estimates as 100%, hence, 2020 equals 110% of the 2015 number of immigrants, 2025 equal 120%, 2030 equals 130%, 2035 equals 135% etc., until 150% is assigned for the last interval 2045−2050. This change is assumed equal for both sexes and across all age groups. The probabilities of out-migration are kept stable within the projection period.

In education, the assumptions of the 2.4. scenario on EAPRs are set as such: for the levels below Bachelor are set on 40% growth to reach by 2070 from the 2020 year distribution, calculated using a logit model, and 20% increase for the MA and PhD graduates share.

It should be noted, that the Arctic has never performed a consistent trend of prevailing in-migration experienced by all constituting territories. On the opposite, a lion's share of the Arctic regions experience a large exodus of peoples, in particular, some areas in the Russian Arctic and Greenland. Hypothetically assuming that all Arctic territories will have positive net migration is only serving the research question of what would happen to the overall population if the development boost and associated boom in newcomers all over the Arctic becomes reality.

3.4 Scenario 3 "Arctic Dip"

The Arctic Dip scenario is helpful as, even though the stakes are high, should there be continuing economic downturns and aggravated global recessions, the "boom" of Arctic projects may never come. Possible policy mechanisms sanctioning against resource-dominated development of the region coupled with financial crisis and reinforced environmental protection actions against large-scale industrial plans imply that a growing number of current residents may retain ties to places outside the Arctic to where they could move. Furthermore, increasing risks of "climigration" – climate change driven migration – will make either planned or unplanned movements unavoidable in the near future for many coastal Arctic residents under impact, possibly away to the South (Hamilton et al., 2016). The climatic change outcomes most affecting the Arctic include sporadic extreme weather events, long-term deterioration of the residing area, reduced access to sea ice as a source of drinking water, further environmental contamination, and broader the issues of retaining local traditional food supply and methods of food conservation possibly not secured anymore in the Arctic (Beaumier & Ford, 2010; Bronen & Chapin, 2013; Ford et al., 2006; Gerlach et al., 2011). This all can decrease the attractiveness of the Arctic to be home for future cohorts of newcomers.

We apply the **"UN fertility setting"** (3.1. of Table 2) targeted to the UN 2030/2050 "medium" forecasts of the World Population Prospects 2015 Revision (United Nations, 2015). In most cases, this assumption produces stability or a slightly upward trend, where Arctic sub-regions follow their nationwide dynamics of change. It may reflect the case when general stagnation of the region slows down modernization, urbanization and eventually demographic transition.

Similar to fertility, the **"UN mortality setting"** (3.2. of Table 2) on the basis of UN 2030/2050 "medium" forecasts in life expectancy according to the World Population Prospects 2015 Revision (United Nations, 2015), shows an upward trend, and the Arctic regions follow the same speed of change as their national speed. Life expectancy at birth is calculated using the latest empirical data but not considering the UN difference between male and female LE0 in the "medium" scenario. This assumption appeared to be close to LE forecasts released by Statistics Greenland, Iceland and Sweden.

The **"Prevailing Out-Migration"** (3.3. of Table 2) assumption echoes the pace of change as in the Arctic Boost scenario on migration ("Migration Ups"). This time out-migration is the demographic process under modification. The probabilities of out-migration will move up at a 10%-probability pace in each 5-year period until 2030 and with a 5% growth per 5-year period until 2050. This change is assumed equally for all ages and both sexes.

In education, 3.4. assumptions on EAPRs for the levels below Bachelor are set only on 5% growth to reach by 2070 from the 2020 year distribution, calculated using a logit model, and constant from 2020 (no increase) for the MA and PhD attainment levels. With regard to education and diversification of career opportunities, if the trend of young persons in their twenties and thirties leaving in large numbers (i.e. the Danish North case) intensifies in the rest of the Arctic, net out-migration is likely to happen.

4 Results and discussion

Section 4 reports on some of the results found applying our scenarios and methods to deliver population projections. It discusses visions on the future trends in the Arctic population structure with regard to sex, age, educational level, and region-wise. We start with a wider pan-Arctic focus which picks a few main features on the overall Arctic level. We proceed with identifying more findings inside larger Arctic compounding areas such as the North American Arctic, North Atlantic Arctic, Fennoscandian Arctic, and the Russian Arctic. We do comparisons and find differences within and across those areas. Lastly, we outline some of our thoughts comparing the results between sub-national (Arctic) and national (country) levels, which may be insightful when it comes to demographic policy planning for specific territories within each Arctic country.

4.1 Pan-Arctic patterns

Bearing in mind that the Arctic hides a profound inner diversity, it is still informative to observe the results at the pan-Arctic level. According to our results, following many decades of growth, the projected population of the Arctic between 2015 and 2050 will not significantly change. In many publications 4 million people is given as the total number of inhabitants in the Arctic. However, we claim the population size of at least 10 million people by the geographical border (Figure 1) which is commonly defined in the majority of publications. Hence, in 2015 (circa), 10.08 million people is considered as a baseline number.

The Medium scenario predicts 5% growth reaching 10.59 million people in 2050. Despite this growth, there will be a continuing population decline in some of the Arctic compounding areas in the Russian and Lappish North, but that is forecasted to be offset by growth in other areas. There is a difference of approximately 1 million people between the side scenarios and the Medium scenario. It shows a variation up to 15% population increase from 2015 to 2050 in case of the Arctic vigorous development (Arctic Boost), and 5% decline in compliance with the Arctic Dip scenario. We can conclude based on all scenario variations that the population in the Arctic will remain in a relative status-quo and are no big changes foreseen.

Figures 8 and 9 and Table 4 provide data on the population distribution according to four major education categories, and by sex and scenario[2]. The majority of the 'Arctic total' data reflects patterns of the Russian population which is the largest share of the Arctic (two thirds). With regard to the idea that post-secondary education can lead to the

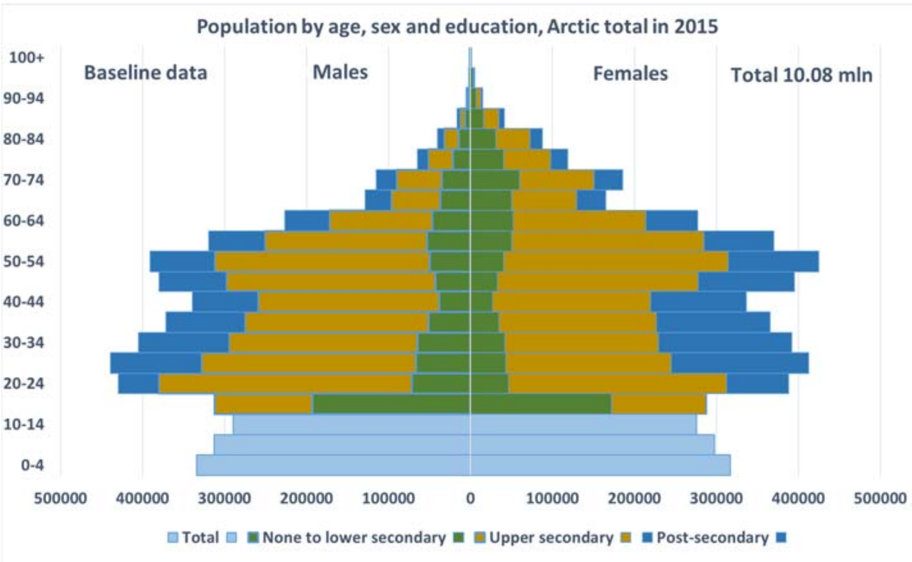
[2]In the series of graphs in Section 4 the variety of levels are combined into four larger education groups (E1–E4, E5, E6–E9, Total) due to variations in the education classifications by various Arctic countries and regions (Section 2.2.2). For individual Arctic countries and territories, details by educational categories within the larger four is available upon request from the author.

most advanced, innovative and creative economies and societal benefits[3], it is satisfactory to know that in many Arctic regions, post-secondary education attainment has been on increase (Larsen & Fondahl, 2015).

Will post-secondary education be growing equally for males and females under given scenarios, or will perhaps more males or females be earning college and university diplomas? The answer is illustrated in Figures 8 and 9 and Table 4. There is a gender gap which has been growing towards feminization of human capital. In 2015, the percentage of Arctic females, who acquired post-secondary education qualification was consistently higher than that of males: 29.8% of females holding a post-secondary degree in total female population aged 15+ and 23.7% of such highly educated males in male population aged 15+. Both sexes combined, a post-secondary educational level alone has got a sex distribution as of 58% females and 42% males in 2015. This difference is going to reach 62% females and 38% males in 2050 in the Medium scenario, signifying a growing gap between sexes. This observation is in line with the historical trend. Already in the early 1990s women had become the dominant group in relation to formal post-secondary education attainment in several countries, and by the late 1990s virtually all regions in the Arctic had moved into this direction (Larsen & Fondahl, 2015).

Thus, female population is projected to continue dominating the realm of post-secondary education in the decades to come. This can be also seen comparing the right and left sides of the pyramids in deep blue color (Figures 8 and 9). Generally, the gender gap is likely to increase: In 2050, almost 40% of the total female population aged 15+ will attain post-secondary education, varying between 36.5% (Arctic Dip) to 42.1% (Arctic Boost). In comparison, only 24.2% to 30.4% of the total male population aged 15+ will attain post-secondary education,

Figure 8. Age, sex, and education pyramid for total Arctic, 2015



[3] More reference that higher education in broad segments of the population is likely to give a strong boost to economic growth can be found in Lutz et al. (2008).

Figure 9. Age, sex, and education pyramids for total Arctic, 2050, three scenarios

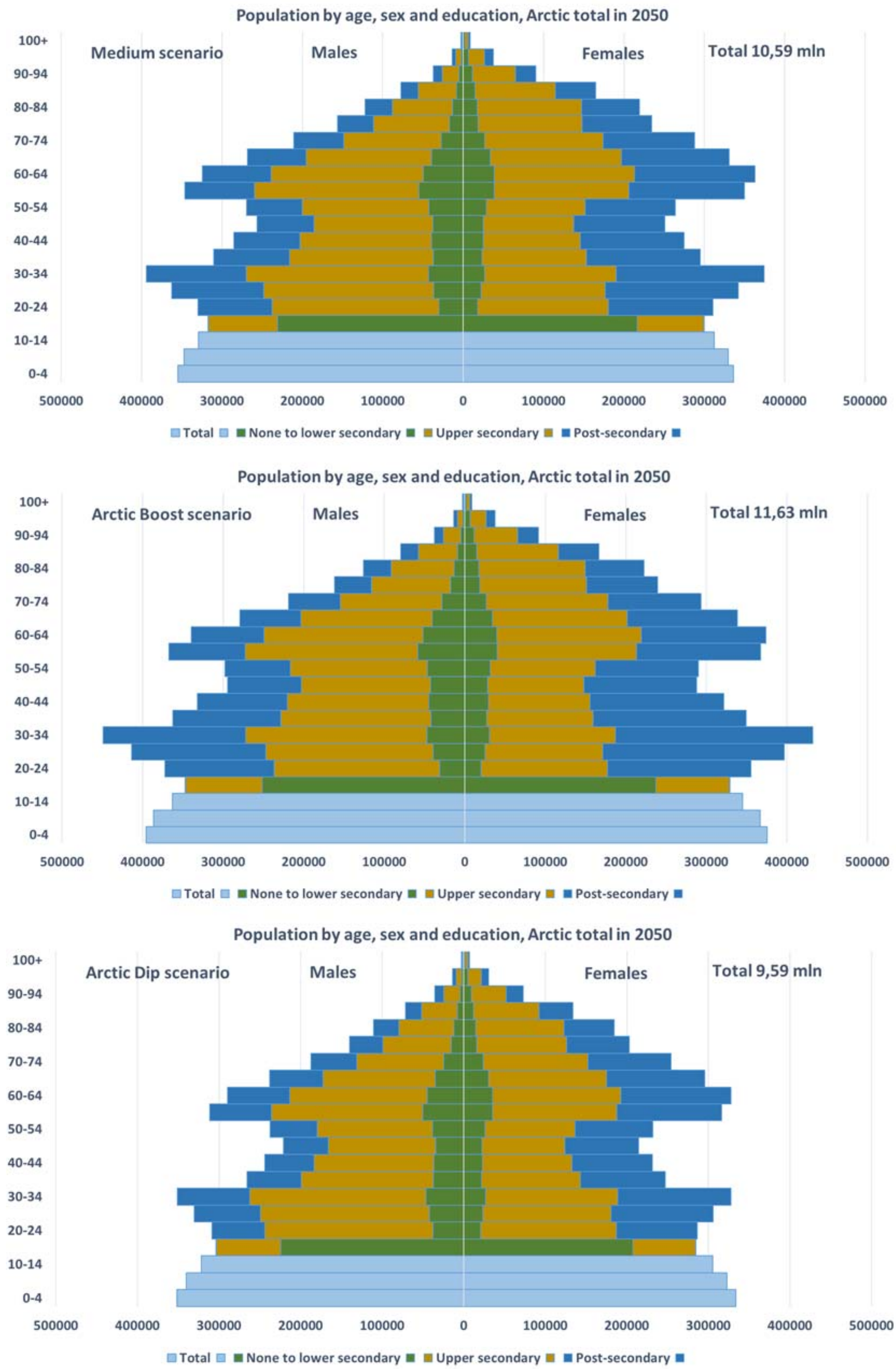


Table 4. Total Arctic population by sex, major education categories and scenarios, 2015–2050, % in total male or female population aged 15+

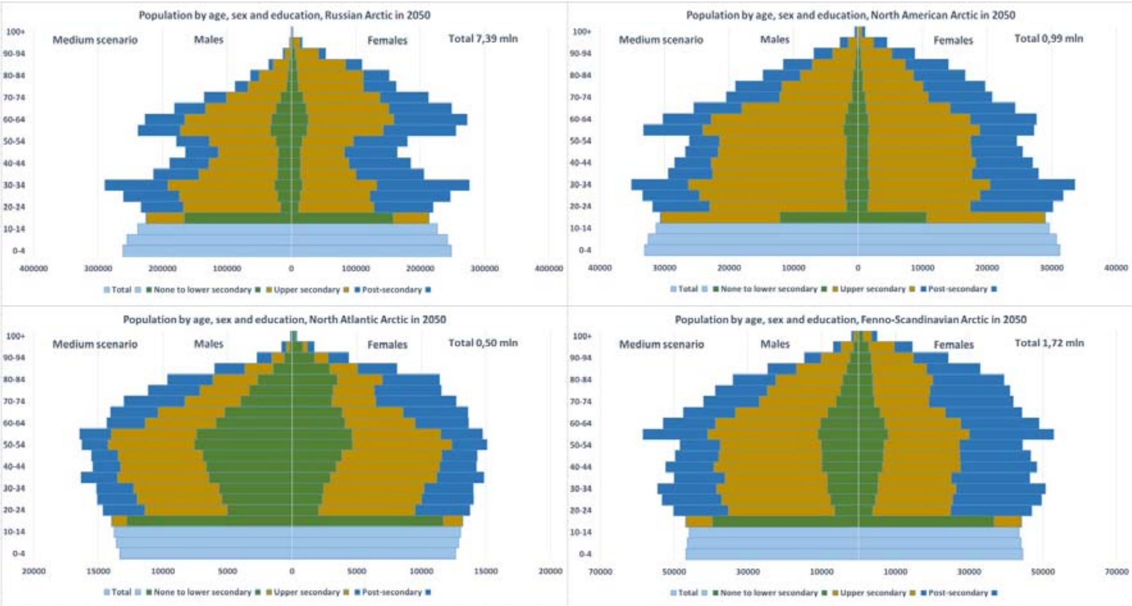
	MALES				FEMALES			
	Male population 15+, mln	Primary to Lower secondary, % in P15+	Upper secondary, % in P15+	Post-secondary, % in P15+	Female population 15+, mln	Primary to Lower secondary, % in P15+	Upper secondary, % in P15+	Post-secondary, % in P15+
MEDIUM SCENARIO								
2015	3.99	26.4	49.9	23.7	4.26	24.4	45.8	29.8
2020	3.99	25.8	50.1	24.1	4.30	23.2	45.6	31.2
2025	4.00	25.7	50.2	24.2	4.34	22.4	45.4	32.1
2030	4.02	25.3	50.3	24.4	4.38	21.5	45.3	33.2
2035	4.10	25.5	49.7	24.8	4.49	21.4	44.6	34.1
2040	4.13	24.9	50.1	25.0	4.53	20.2	44.3	35.6
2045	4.11	24.1	49.9	26.0	4.53	19.1	43.5	37.5
2050	4.08	23.4	49.5	27.0	4.50	18.2	42.5	39.2
ARCTIC BOOST SCENARIO								
2015	3.99	26.4	49.9	23.7	4.26	24.4	45.8	29.8
2020	3.99	25.8	50.0	24.1	4.30	23.2	45.5	31.2
2025	4.02	25.6	50.0	24.3	4.36	22.4	45.3	32.3
2030	4.08	25.2	50.0	24.9	4.44	21.4	44.9	33.7
2035	4.23	25.4	49.2	25.3	4.61	21.2	43.9	34.9
2040	4.33	24.5	49.0	26.6	4.73	19.9	43.1	36.9
2045	4.41	23.5	47.7	28.9	4.82	18.8	41.7	39.6
2050	4.50	22.7	47.0	30.4	4.90	17.9	40.0	42.1
ARCTIC DIP SCENARIO								
2015	3.99	26.4	49.9	23.7	4.26	24.4	45.8	29.8
2020	3.99	25.8	50.1	24.1	4.30	23.2	45.6	31.2
2025	3.98	25.7	50.2	24.1	4.31	22.5	45.5	32.1
2030	3.94	25.5	50.4	24.1	4.29	21.6	45.4	32.9
2035	3.94	26.3	50.0	23.7	4.29	21.7	44.9	33.4
2040	3.89	25.9	50.3	23.7	4.23	20.9	44.8	34.3
2045	3.78	25.6	50.4	24.0	4.11	20.1	44.4	35.5
2050	3.66	25.5	50.4	24.2	3.95	19.7	43.8	36.5

Note: P15+ is all population by respective sex, aged 15 years and above.

4.2 Inside the Arctic

Disaggregating the Arctic into its four larger regions – the North American Arctic, North Atlantic Arctic, Fennoscandian Arctic, and the Russian Arctic – allows to examine the enormous Arctic heterogeneity (Figure 10, Tables 5 and 6). Only 10% share constitutes population of Canadian Arctic and Alaska. The North Atlantic areas count for the remaining 5% of total Arctic population. This distribution remains mostly in effect throughout the projection horizon. Around 15% of Arctic residents live in the northern lands of Sweden, Finland, and Norway. Finally, the Russian Arctic does and will keep the position of a lion's share of the total number of people in the region, varying between 6.6 to 8.1 million people in 2050, which is approximately 70% of Arctic residents.

Figure 10. Total population of the Arctic by its four major constituting regions, 2050, Medium scenario



Note: Russian Arctic (left top panel), North American Arctic (right top panel), North Atlantic Arctic (left down panel), Fennoscandian Arctic (right down panel).

With rather little population growth compared to the total Arctic, the North Atlantic and North American parts will likely undergo the most dynamic population growth (Table 5). These are the regions with, in comparison to other aggregate regions, higher shares of Indigenous people, higher fertility, and, in certain areas (for example Yukon and Iceland), higher levels of immigration. Along the optimistic Arctic Boost storyline, the population of the North Atlantic Arctic will grow 24% from its baseline size. The population of North American Arctic will increase by one third from its baseline size. The Russian Arctic and Fennoscandian Arctic will grow negligibly. According to the Medium scenario it will go 3–4% up, but will experience a population downsize in the case of the Arctic Dip scenario (for example -8% in the Russian Arctic).

Table 5. Population change in aggregate regions of the Arctic, % to the baseline 2015 population size of the respective aggregate region

SCENARIO	NORTH AMERICAN ARCTIC	NORTH ATLANTIC ARCTIC	FENNOSCANDIAN ARCTIC	RUSSIAN ARCTIC
MEDIUM	17	18	4	3
ARCTIC BOOST	30	24	14	14
ARCTIC DIP	7	15	-2	-8

Note: Negative % signifies a population decline, positive % is of population growth.

In the Fennoscandian North, the Finnish region of Oulu (North Ostrobothnia) and Norwegian Troms are the two adding the most number of inhabitants. Traditionally, these are dynamically developing regions around the Barents Sea with attractive large universities and diverse industries that prevent larger out-migration in the neighboring Lapland and the lands inhabited by the Sami people. In the Russian Arctic, population growth is witnessed in the most prosperous and attractive for immigration (natural resources) regions Khanty-Mansi, Nenets autonomous areas, and Sakha Yakutia which also have Indigenous people and higher fertility (TFR 2.3).

It is not surprising that there is increased education to be expected in all scenarios within the projection horizon, since that is an explicit assumption made to the scenarios. What was however a target for us to explore is the effect of educational assumptions made to the population distribution. Table 6 shows shares of population aged 15+ for major levels of education for the aggregate regions of the Arctic possible, in addition, to compare to the Arctic total as well as country-wide data with the results of eight Arctic countries are put averaged.

Table 6. Education distribution under three scenarios for country level, total Arctic, and major four Arctic regions, as a % of total male or female population aged 15+, 2015, 2030 and 2050

SCENARIO		MALES				FEMALES			
1 – MEDIUM 2 – BOOST 3 – DIP		Total population aged 15+, mln	E10 to E4 None to lower secondary	E5 Upper secondary	E6 to E9 Post-secondary	Total population aged 15+, mln	E10 to E4 None to lower secondary	E5 Upper secondary	E6 to E9 Post-secondary
COUNTRY LEVEL (EIGHT ARCTIC COUNTRIES AVERAGED)									
1	2015	80.74	25.9%	43.6%	30.6%	92.67	24.9%	39.7%	35.4%
	2030	79.60	24.2%	44.1%	31.7%	91.75	20.9%	39.4%	39.8%
	2050	78.79	21.2%	44.0%	34.8%	90.55	16.4%	37.5%	46.1%
2	2030	80.50	24.1%	43.8%	32.1%	92.92	20.9%	39.1%	40.0%
	2050	84.17	20.8%	41.7%	37.5%	96.48	16.4%	35.4%	48.2%
3	2030	78.60	24.4%	44.1%	31.4%	90.46	21.0%	39.5%	39.5%
	2050	73.83	23.3%	44.7%	32.0%	83.71	17.8%	38.7%	43.5%
ARCTIC TOTAL (25 SUB-NATIONAL AREAS PLUS ICELAND AVERAGED)									
1	2015	3.99	26.4%	49.9%	23.7%	4.26	24.4%	45.8%	29.8%
	2030	4.02	25.3%	50.3%	24.4%	4.38	21.5%	45.3%	33.2%
	2050	4.08	23.4%	49.5%	27.0%	4.50	18.2%	42.5%	39.2%
2	2030	4.08	25.2%	50.0%	24.9%	4.44	21.4%	44.9%	33.7%

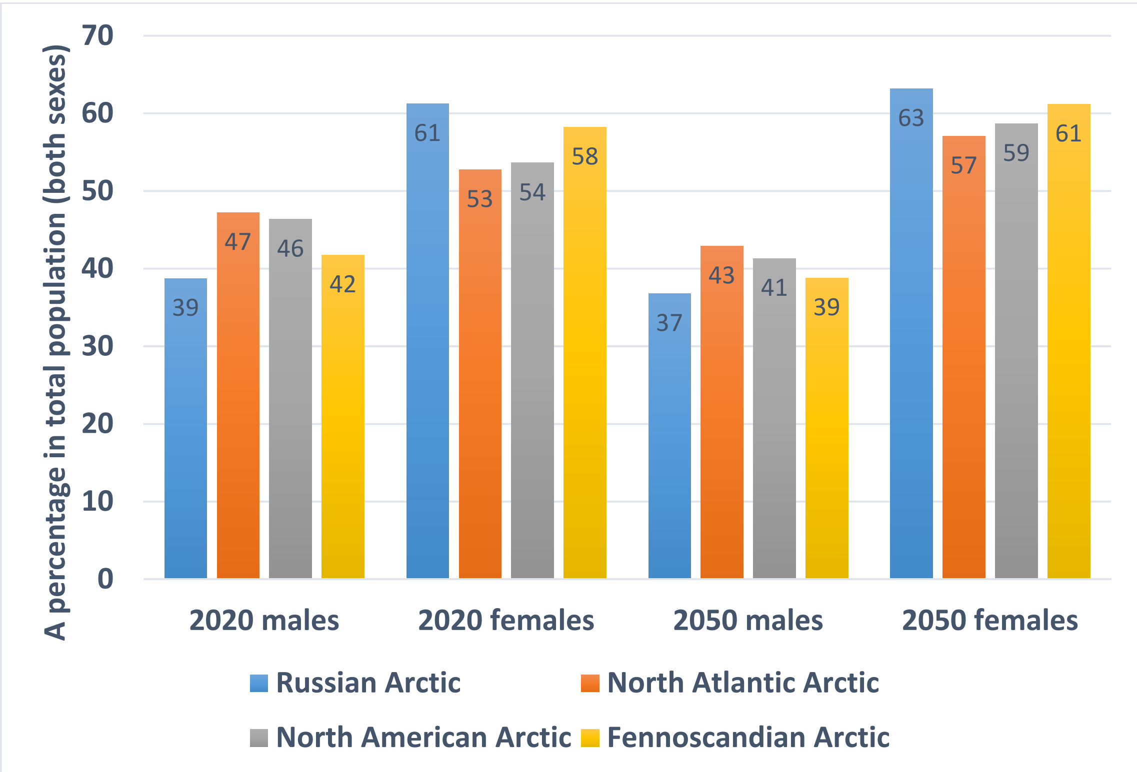
	2050	4.50	22.7%	47.0%	30.4%	4.90	17.9%	40.0%	42.1%
3	2030	3.94	25.5%	50.4%	24.1%	4.29	21.6%	45.4%	32.9%
	2050	3.66	25.5%	50.4%	24.2%	3.95	19.7%	43.8%	36.5%
NORTH AMERICAN ARCTIC									
1	2015	0.35	27.8%	30.8%	41.4%	0.32	27.0%	30.0%	43.1%
	2030	0.38	26.8%	34.6%	38.6%	0.36	24.8%	32.4%	42.7%
	2050	0.41	24.9%	38.1%	37.0%	0.39	21.8%	33.7%	44.5%
2	2030	0.39	26.6%	34.3%	39.0%	0.36	24.7%	32.2%	43.1%
	2050	0.45	23.7%	36.1%	40.2%	0.44	20.8%	31.9%	47.3%
3	2030	0.37	27.1%	34.7%	38.2%	0.35	25.1%	32.6%	42.3%
	2050	0.37	27.0%	39.2%	33.8%	0.35	23.6%	35.2%	41.2%
NORTH ATLANTIC ARCTIC									
1	2015	0.17	45.0%	32.8%	22.2%	0.16	49.2%	28.4%	22.4%
	2030	0.19	44.1%	36.4%	19.6%	0.19	40.9%	36.9%	22.2%
	2050	0.21	42.7%	39.6%	17.8%	0.21	32.5%	43.9%	23.6%
2	2030	0.19	43.7%	36.4%	19.9%	0.19	40.5%	36.9%	22.6%
	2050	0.22	40.0%	39.4%	20.6%	0.21	31.1%	42.7%	26.2%
3	2030	0.19	44.4%	36.2%	19.4%	0.18	41.0%	37.0%	22.0%
	2050	0.20	45.5%	38.9%	15.6%	0.19	34.7%	44.2%	21.1%
FENNOSCANDIAN ARCTIC									
1	2015	0.69	28.4%	48.3%	23.4%	0.68	25.3%	41.7%	33.0%
	2030	0.71	25.7%	50.1%	24.2%	0.70	21.5%	41.4%	37.1%
	2050	0.73	23.0%	50.9%	26.1%	0.72	17.5%	39.6%	42.9%
2	2030	0.72	25.6%	49.9%	24.6%	0.71	21.5%	41.2%	37.3%
	2050	0.79	22.3%	48.7%	29.0%	0.78	17.4%	37.6%	44.9%
3	2030	0.70	25.9%	50.2%	23.9%	0.69	21.6%	41.6%	36.8%
	2050	0.68	25.0%	51.2%	23.8%	0.66	19.2%	40.7%	40.2%
RUSSIAN ARCTIC									
1	2015	2.78	19.3%	62.7%	18.0%	3.10	16.0%	59.2%	24.7%
	2030	2.73	19.3%	60.0%	20.7%	3.14	15.0%	55.0%	30.0%
	2050	2.74	18.0%	55.4%	26.6%	3.18	13.6%	47.5%	38.9%
2	2030	2.78	19.3%	59.4%	21.3%	3.18	15.0%	54.5%	30.5%
	2050	3.03	17.9%	51.7%	30.5%	3.47	13.6%	43.9%	42.5%
3	2030	2.67	19.5%	60.1%	20.3%	3.06	15.1%	55.2%	29.7%
	2050	2.41	19.8%	56.9%	23.3%	2.75	14.5%	49.2%	36.3%

Note: As an example of using this table's data, see the share of Russian males' attained upper secondary education in 2030 (60.0%). The population of Russian males over the age 15 in 2030 is 2.73 million by Medium scenario. 60% of 2.73 million males gives 1.64 million males with such education qualification in this region at this given year.

The North Atlantic Arctic has the largest share of least educated adults aged 15 and above (none to lower secondary education), which is expected to significantly improve for females over the projected time horizon, but will stay as low (more than 40%) for males in 2050 as was registered in 2015. The least educated group of population is equally divided between men and women (50% women and 50% men in the level E1 to E4), but the sex gap is growing to 59% men and 41% women in the level E1–E4 in 2050 (Medium). Hence, more women will be educated in the future in the North Atlantic region of the Arctic as is the case at the overall Arctic. Similarly, this trend is traced in other regions of the Arctic: The share of less (least) educated males within the total population of both sexes will grow while female shares will decrease as females are on a faster transition to the next education levels.

With regard to post-secondary education, the North American Arctic is by far ahead of other regions. 43% among all females and 41% of all males obtained post-secondary education qualifications in 2015. This is twice as high as in the Russian Arctic and North Atlantic Arctic (Table 6). To also note, the Russian areas of the Arctic have the largest gender gap. Figure 11 shows 39% males and 61% of females in the Russian Arctic with post-secondary qualification in 2020 (blue columns), which is changing to 37% and 63% in 2050 (Medium scenario) – a trend of an increasing sex gap being in accord with earlier stated findings.

Figure 11. The share of males and females in the Arctic major regions acquired post-secondary level of education, 2020 and 2050, Medium scenario



4.3 Country- vs. Arctic-wide

Among the total population of a country, the share of people living in the parts extending into the Arctic is invariably small. The lowest shares include those living primarily in Russian (Siberian), Alaska and Canadian northernmost regions (<0.1% of respective country's total population). The negligible number of people contrasts sharply with the colossal part of the country's land mass they occupy. This characterizes the Arctic as in many cases a place of pristine wilderness without a human trace. The existing settlements are divided into highly urbanized centers and cities and, on the other hand, highly dispersed little communities and villages situated across the region. Of the more populated areas are the ones in the Fennoscandian Arctic, with North Ostrobothnia (Oulu) region being most populated among northern areas of Finland (7.5% of population in Finland in 2015).

Table 7 displays the changes in population size according to the three scenarios for the years 2030 and 2050, as a percentage of change to the baseline values. The color shading is set to visualize the gradient with which each region or the aggregate set of northern regions (e.g. all 11 Russian regions together as the Russian North) has a share in total population of their respective country. The red color signifies the minimal share while green is of larger percent in total population of the country.

It is important to note that the more Indigenous people in the population structure of the particular area, the less similar the patterns look compared to the overall respective country. As an example, the large share of Inuit people living in Nunavut (86%) makes its population structure overwhelmingly different from Canada (Figure 12). According to the theories of demographic and epidemiological transitions, Indigenous people are at an earlier stage of development. As discussed earlier in 2.4., these populations tend to grow due to high fertility. In fact, Nunavut is the youngest region with the highest fertility of both Canada and the Arctic overall. In contrast, Arctic areas with a minimal share of Indigenous people look just like the national population pyramid. Komi Republic is an example of similarities between the shape of population pyramid of Russia and the Russian area in the Barents Euro-Arctic region (Figure 13).

In assessing the education composition of the adult population, Figures 12–15 demonstrate that high school completion rates in the Arctic territories are (and will be) to a various degree lower than that of their respective countries. The gap in education outcomes is remarkably larger for the areas dominated by Indigenous people such as Nunavut, NWT, Chukotka, Greenland and a few others. Correspondingly, the results appear closer to the national pattern in the areas with a negligible share of recognized Indigenous people as in the illustrated example of Komi Republic, North Ostrobothnia, and Norrbotten.

Table 7. Arctic population by provinces, % in respective country's total population, 2015, 2030 and 2050

Scenario	BASELINE	MEDIUM		ARCTIC BOOST		ARCTIC DIP	
Year	2015	2030	2050	2030	2050	2030	2050
DANISH ARCTIC	1.84	1.96	2.13	1.96	2.18	1.93	1.98
Greenland	0.85	0.94	1.09	0.94	1.11	0.94	1.06
Faroe Islands	0.99	1.02	1.04	1.02	1.07	0.99	0.92
FINNISH ARCTIC	12.14	12.45	13.26	12.43	13.11	12.38	12.90
Kainuu	1.37	1.28	1.20	1.28	1.17	1.28	1.16
Lapland	3.30	3.15	3.00	3.15	2.97	3.13	2.88
Oulu region	7.47	8.01	9.06	8.00	8.97	7.98	8.87
NORWEGIAN ARCTIC	9.26	8.96	8.67	8.97	8.60	9.03	8.76
Finnmark	1.46	1.43	1.35	1.43	1.36	1.42	1.33
Nordland	4.65	4.41	4.27	4.40	4.19	4.42	4.33
Troms	3.15	3.13	3.05	3.14	3.05	3.19	3.11
SWEDISH ARCTIC	5.21	5.08	4.98	5.11	5.18	5.00	4.54
Norrbotten	2.54	2.46	2.41	2.47	2.49	2.42	2.20
Vesterbotten	2.67	2.62	2.58	2.63	2.69	2.58	2.34
ALASKA (US)	0.23	0.24	0.24	0.24	0.27	0.23	0.21
CANADIAN ARCTIC	0.33	0.37	0.44	0.37	0.47	0.37	0.42
Nunavut	0.10	0.13	0.19	0.13	0.20	0.13	0.19
NWT	0.12	0.13	0.14	0.13	0.15	0.13	0.13
Yukon	0.10	0.11	0.11	0.11	0.12	0.11	0.10
RUSSIAN ARCTIC	5.01	5.22	5.40	5.24	5.55	5.19	5.24
Arkhangelsk	0.86	0.84	0.81	0.84	0.82	0.84	0.80
Chukotka	0.04	0.04	0.04	0.04	0.04	0.04	0.03
Kamchatka	0.23	0.23	0.23	0.23	0.24	0.23	0.22
Karelia	0.45	0.43	0.42	0.43	0.42	0.43	0.41
Khanty-Mansi	1.07	1.20	1.34	1.21	1.39	1.20	1.30
Komi	0.63	0.63	0.63	0.64	0.64	0.63	0.61
Magadan	0.11	0.10	0.09	0.10	0.10	0.10	0.09
Murmansk	0.56	0.56	0.54	0.56	0.56	0.56	0.53
Nenets	0.03	0.03	0.04	0.03	0.04	0.04	0.05
Sakha Yakutia	0.67	0.75	0.85	0.75	0.86	0.74	0.82
Yamalo-Nenets	0.37	0.39	0.41	0.40	0.44	0.39	0.37

Figure 12. Age, sex, and education pyramid for Canada total and Nunavut territory, 2015 and 2050, Medium scenario

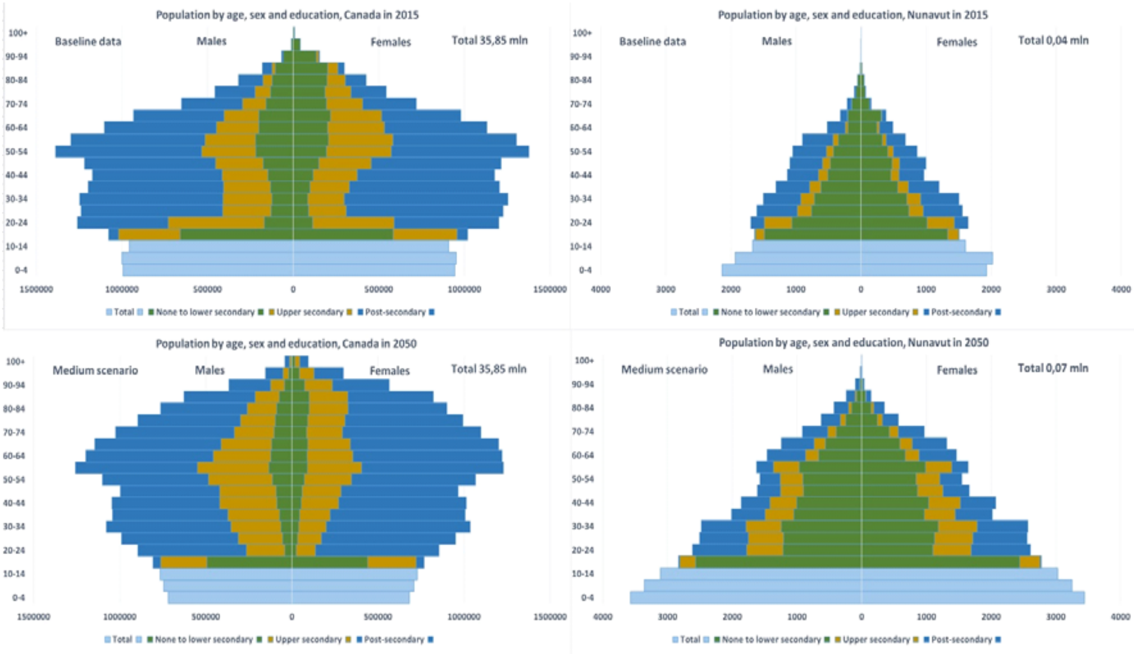


Figure 13. Age, sex, and education pyramid for Russia total and Komi Republic in 2015 and 2050, Medium scenario

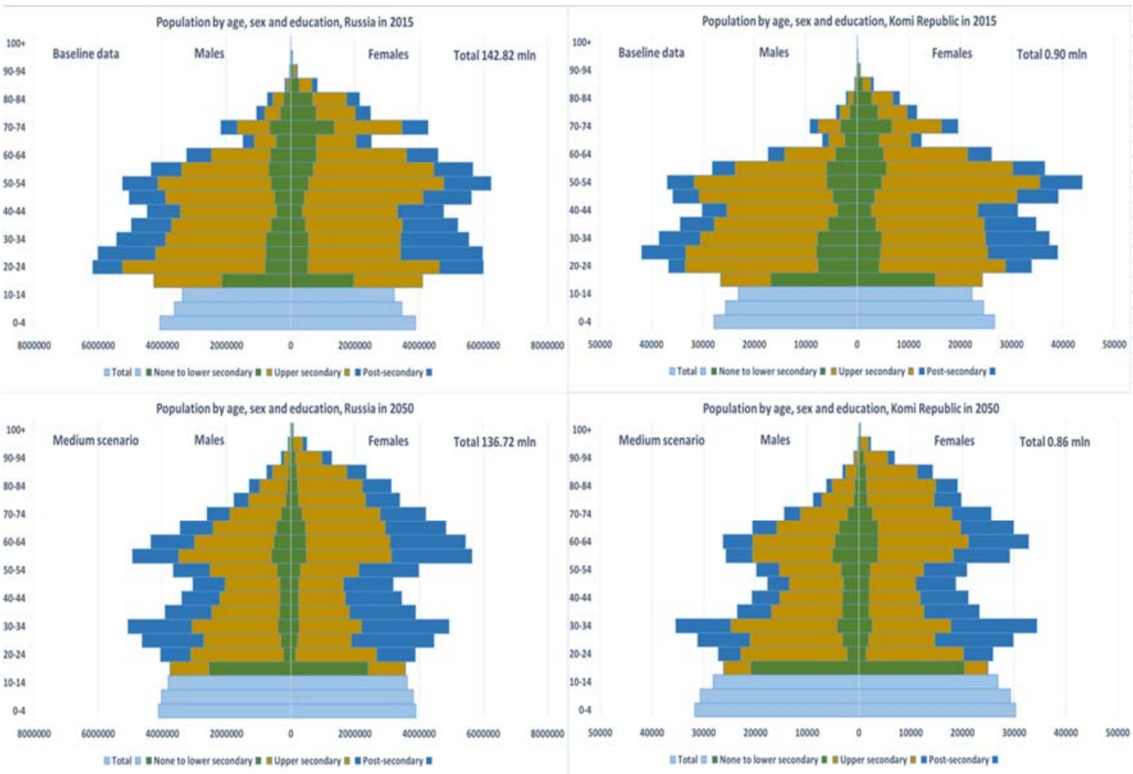
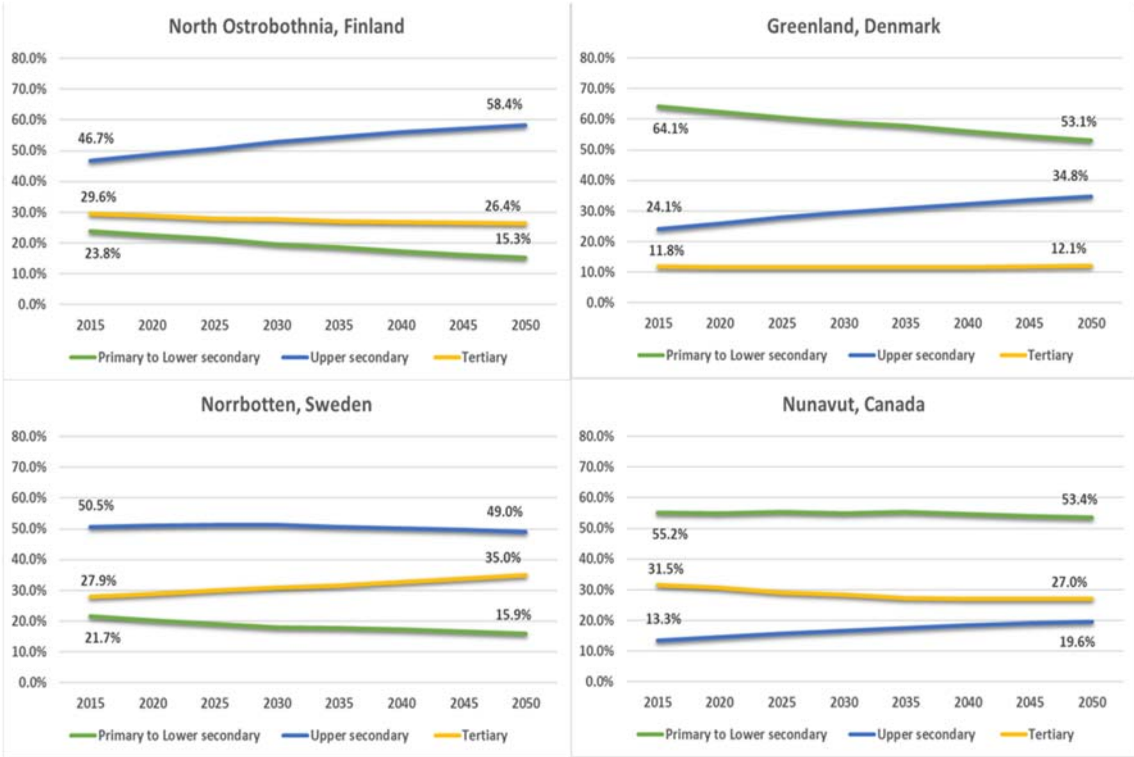


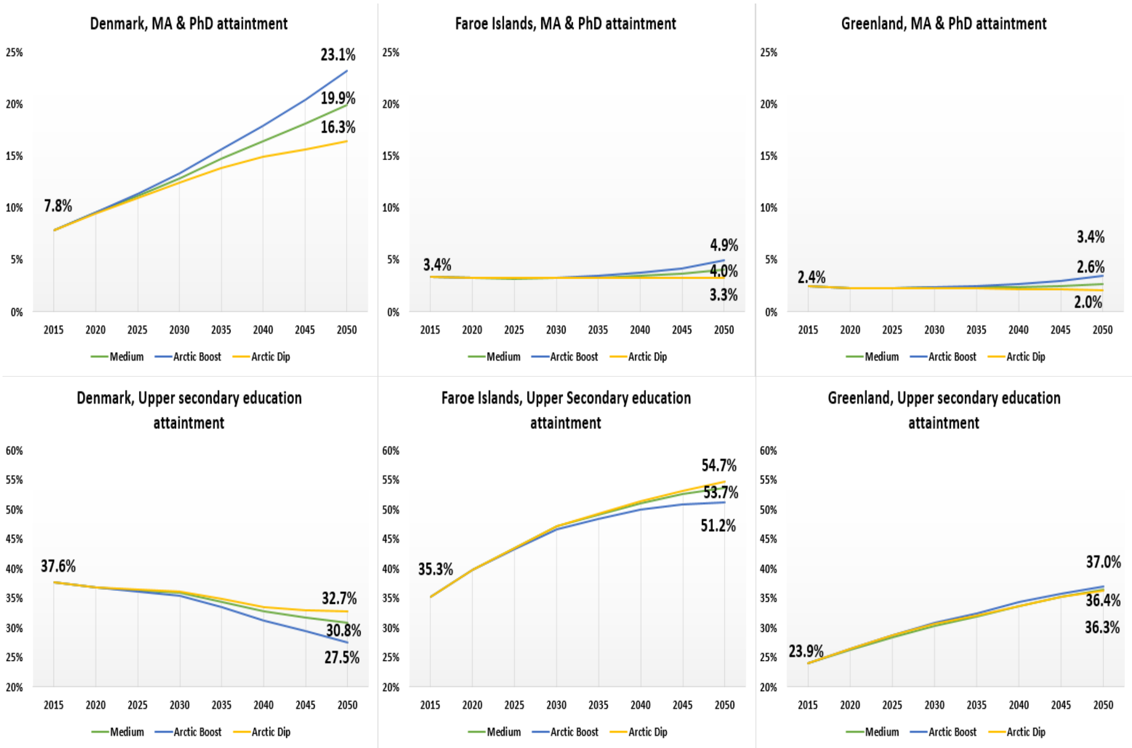
Figure 14. Education development in areas of the Arctic less (left panel) or more (right panel) dominated by Indigenous people, 2015–2050, Medium scenario



It is highlighted on the right panel of Figure 14, that Greenland and Canadian Nunavut have the high shares of people with the lowest education attainment (green lines) and in fact get the largest share of least educated people in total population. The projections suggest that we can think of the redistribution towards improvement such as less educated share of people will decrease while groups with upper and post-secondary education will increase. However, still policy effort is needed to support tackling the current disparities in education in many Arctic areas. As we discussed in Section 2.4, there are large disparities between Indigenous and non-Indigenous people in education, not only in the educational attainment, level of education, but also high dropout rates among Indigenous students, as well as a very limited access to the educational institutions which can be just few or none.

One more finding is that in the social transition of people along education groups, many Arctic populations will likely experience the change less slowly than nationwide in the highest levels of education attainment. For instance, female Master and PhD graduates from the Danish northern autonomies will still not exceed 5% of total population in 2050, while in Denmark overall, already every fifth female will feasibly hold at least an MA degree. In other words, the transition from lower to upper educational levels will happen gradually. The least educated societies will grow first in the upper secondary segment, for example in Faroe Islands and Greenland, while the regions with most advanced in terms of human capital (i.e. the largest share of university graduates in the society), will decrease their share of upper secondary redistributing towards more people in the top education segment, as in mainland Denmark. Alongside Danish situation, this is also the case in Arctic Canada and the majority of the Russian Arctic versus their countries' totals.

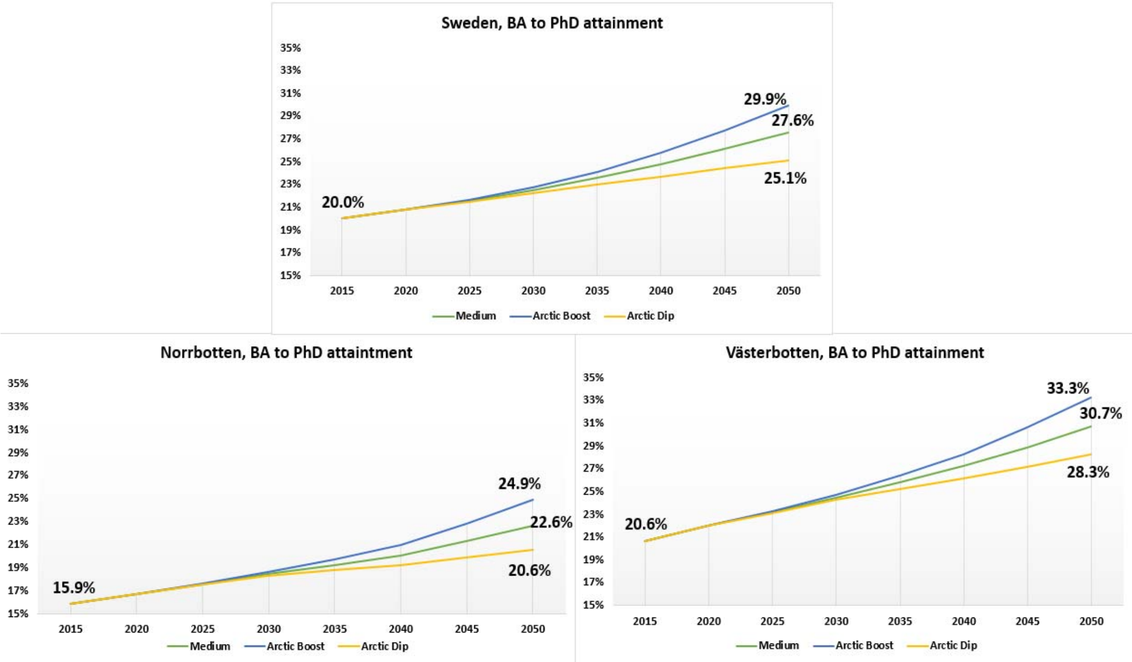
Figure 15. MA and PhD (top panel) and Upper secondary (down panel) attainment of female education in Denmark and its northernmost autonomous areas, 2015–2050, three scenarios



Rather rarely met in this context are the few territories where northern residents with post-secondary education attainment as a share in total population are close or catching up to a country-wide share (cases of Oulu to Finland-wide, Troms to Norway, Yukon to Canada) or even already better-off in the highest university education as Västerbotten region in northern Sweden (Figure 16, right down panel). By Medium scenario, the tertiary education will reach 27.6% in Sweden by 2050 while 30.7% in Västerbotten. As of 2015, 10.4% of the population in the municipality of Umeå were foreign-born, first of all attracted to the Umeå University of more than 50,000 students and staff.

Surprisingly enough, Kamchatka, Khanty-Mansi and Yamalo-Nenets are three regions in Russia where a share of people with the highest education attainment (E7 to E9) is also equal or prevailing a national average pattern, as in the case of Västerbotten. These federal subjects are one of the few places in Russia where the ethnic Russian population is growing due to perhaps the area's oil and natural gas wealth, support of traditional economies such as reindeer herding, well developed transportation and shipping etc. Respectively, both regional and national allocation of resources and quotas for education are relatively good, and there is a large number of new settlers to these regions already with post-graduate degrees, which are necessary to work in the local intellectually demanding economic sectors.

Figure 16. Swedish case in post-secondary education projection, 2015–2050, three scenarios



5 Conclusion

In this work, for the first time, population projections have been generated for all the territories in the peripheral part of the world next to the North Pole – the Arctic. As the further gradient of novelty, education is introduced into the cohort-component model of population projections. Calibrating the input data, we included differentials in local fertility and mortality, along with specific education scenarios for the future. Applying a number of demographic technics to reconstructing missing sub-national data, smoothing at times abrupt patterns in demographic processes in typically small populations in the Arctic, we prepared a baseline dataset and further delivered projections by 5-year age groups, sex, and education (5 to 9 categories) at the sub-national (25) and country-wide (8) level for the medium term 2015–2050 and by three what-if scenarios: Medium, Arctic Boost, and Arctic Dip.

By the results received in the course of this exercise, heterogeneity is apparent at all levels of demographics and education in the Arctic region. We conclude that the Arctic is likely to keep a status quo in the future number of inhabitants, varying between 9.6 (Arctic Dip) and 11.6 (Arctic Boost) million people in 2050, yet representing only a tiny share in their countries' totals. Inside the region, the population of the North Atlantic and North American Arctic will grow faster than in the territories of the Russian and Fennoscandian Arctic. Population growth is forecasted explicitly by all three scenarios but to a various extent in the North American Arctic and North Atlantic Arctic regions; also in Oulu, Troms, Norrbotten and Västerbotten of the Fennoscandian region; and Khanty-Mansi, Sakha Yakutia and Nenets areas in Russia, with the rest of the Arctic provinces expected to shrink or, in case of the optimistic Arctic Boost scenario, to increase very slightly.

In education, gender gap has been found to be already substantial and will increase further towards feminization of human capital, meaning less females than males in the primary educational segment and more females than males in the post-secondary educational segment in the trajectory 2015 to 2050. 'Indigenousness' has a strong presumable effect on the future population structure, with both younger, less educated populations showing slower dynamics of human capital development than in the areas with only a minor share of Indigenous people. The main policy message here is to revise current programs and plan the future ones to meet the need for diverse educational opportunities at all levels within and between Arctic territories, in particular for rural, remote, and Indigenous areas.

6 References

Alaska Department of Labor and Workforce Development (2017) Alaska Population Estimates. Available at: http://live.laborstats.alaska.gov/pop/

Anderson I, Robson B, Connolly M, Al-Yaman F, Bjertness E, King A et al (2016) Indigenous and tribal peoples' health (The Lancet–Lowitja Institute Global Collaboration): a population study. *The Lancet* 388 (10040): pp. 131–157. DOI: 10.1016/S0140-6736(16)00345-7

Andrew R (2014) *Socio-Economic Drivers of Change in the Arctic*. Oslo. Arctic Monitoring and Assessment Programme (AMAP). Available at: https://www.amap.no/documents/doc/socio-economic-drivers-of-change-in-the-arctic/1115

Autti O, & Hyry-Beihammer EK (2014) School closures in rural Finnish communities 29 (1): pp. 1–17.

Beaumier M, & Ford JD (2010) Food Insecurity among Inuit Women Exacerbated by Socio-Economic Stresses and Climate Change. *Can J Public Health* 101 (3): pp. 196–201. DOI: 10.17269/cjph.101.1864

Bronen R, & Chapin FS (2013) Adaptive governance and institutional strategies for climate-induced community relocations in Alaska. *Proceedings of the National Academy of Sciences* 110 (23): pp. 9320–9325. DOI: 10.1073/pnas.1210508110

Circumpolar Health Observatory(2017) . Available at: http://projects.amap.no/project/circumpolar-health-observatory-circhob-circhob/

Department of Demography, Université de Montréal (2017) Canadian Human Mortality Database. Available at: http://www.bdlc.umontreal.ca/chmd/

Einarsson N, Nymand Larsen J, Nilsson A, & Young OR (2004) *Arctic Human Development Report*. Akureyri. Stefansson Arctic Institute, under the auspices of the Icelandic Chairmanship of the Arctic Council 2002-2004. ISBN 978-9979-834-45-8

Emelyanova A (2015) Cross-regional analysis of population aging in the Arctic.

Exner-Pirot H (2015) Blog: Northern Canada doesn't have a university … Does it need one? – Eye on the Arctic.

Federal State Statistics Services of the Russian Federation(2017) . Available at: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/

Fedstat (2017) Unified Interdepartmental Statistical Information System of the Russian Federation. Available at: https://fedstat.ru/

Ford JD, Smit B, & Wandel J (2006) Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16 (2): pp. 145–160. DOI: 10.1016/j.gloenvcha.2005.11.007

Gerlach SC, Loring PA, Turner AM, & Atkinson DE (2011) Food systems, climate change, and community needs. In: *North by 2020*. pp. 111–134. Fairbanks, AK. University of Alaska Press. ISBN 978-1-60223-142-9

Gløersen E, Dubois A, Copus A, & Schürmann C (2006) *Northern Peripheral, Sparsely Populated Regions in the European Union and in Norway*. ISBN 91-89332-60-1

Graham A (2015) The University Project in the Canadian North, 1964 to 2014. *Historical Studies in Education / Revue d'histoire de l'éducation* 27 (1): p. Available at: http://historicalstudiesineducation.ca/index.php/edu_hse-rhe/article/view/4426

Hamilton LC, & Mitiguy AM (2009) Visualizing Population Dynamics of Alaska's Arctic Communities. *ARCTIC* 62 (4): pp. 393–398. DOI: 10.14430/arctic170

Hamilton LC, & Rasmussen RO (2010) Population, Sex Ratios and Development in Greenland. *ARCTIC* 63 (1): pp. 43–52. DOI: 10.14430/arctic645

Hamilton LC, Saito K, Loring PA, Lammers RB, & Huntington HP (2016) Climigration? Population and climate change in Arctic Alaska. *Population and Environment* 38 (2): pp. 115–133. DOI: 10.1007/s11111-016-0259-6

Hansen CG, Rasmussen RO, Olsen LS, Roto J, & Fredricsson C (2012) *Megatrends in the Arctic - New inspiration into current policy strategies. Report from Nordic Council of Ministers' seminar at Nordregio 29th May 2012*. Available at: http://www.nordregio.se/en/Publications/Publications-2012/Megatrends-in-the-Arctic/

Heleniak T (2014) Migration in the Arctic. In: *in Heininen L., Exner-Pirot H., and Plouffe J. eds. Arctic Yearbook 2014 "Human Capital in the North"*. pp. 82–104. Akureyri, Iceland. Northern Research Forum. Available at: https://www.arcticyearbook.com/articles2014/92-migration-in-the-arctic

KC S, Potančoková M, Bauer R, Goujon A, & Striessnig E (2013) Summary of Data, Assumptions and Methods for New Wittgenstein Centre for Demography and Global Human Capital (WIC) Population Projections by Age, Sex and Level of Education for 195 Countries to 2100. Laxenburg, Austria. IIASA: IR-13-018. Available at: http://pure.iiasa.ac.at/10742/

Larsen JN, & Fondahl G (2015) *Arctic Human Development Report: Regional Processes and Global Linkages*. . Nordic Council of Ministers. Available at: http://norden.diva-portal.org/smash/record.jsf?pid=diva2:788965

Larsen JN, Schweitzer P, & Fondahl G (2010) *Arctic Social Indicators - a follow-up to the Arctic Human Development Report*. Available at: https://oaarchive.arctic-council.org/handle/11374/39

Lutz W, Butz WP, & KC S eds, (2014) *World Population and Human Capital in the Twenty-First Century*. Oxford, New York. Oxford University Press. ISBN 978-0-19-870316-7

Lutz W, Cuaresma JC, & Sanderson W (2008) The Demography of Educational Attainment and Economic Growth. *Science* 319 (5866): pp. 1047–1048. DOI: 10.1126/science.1151753

Megatrends(2011) . Copenhagen. Nordregio; Nordic Council of Ministers. ISBN ISSN 0908-6692

Nordregio(2017) . Available at: http://www.nordregio.se/

Rosstat (2017) Federal State Statistics Services of the Russian Federation. Available at: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/
Statistics Canada (2017) Statistics Canada. Available at: https://www.statcan.gc.ca/eng/start
Statistics Denmark (2017) Statistics Denmark. Available at: http://www.dst.dk/en/Statistik
Statistics Faroe Islands (2017) Statistics Faroe Islands. Available at: http://www.hagstova.fo/en
Statistics Finland (2017) Statistics Finland. Available at: http://www.stat.fi/index_en.html
Statistics Greenland (2017) Statistics Greenland. Available at: http://www.stat.gl/?lang=en
Statistics Iceland (2017) Statistics Iceland. *Hagstofa*. Available at: http://statice.is/
Statistics Norway (2017) Statistics Norway. *ssb.no*. Available at: http://www.ssb.no/en
Statistics Sweden (2017) Statistics Sweden. *Statistiska Centralbyrån*. Available at: http://www.scb.se/en/
United Nations (1992) *Preparing migration data for subnational population projections*. New York. United Nations Population Division | Department of Economic and Social Affairs. Available at: http://www.un.org/en/development/desa/population/publications/manual/migration/subnational-migration.shtml
United Nations (2015) *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables*. New York. United Nations Population Division | Department of Economic and Social Affairs. Available at: https://www.popline.org/node/639412
US Census Bureau (2017) US Census Bureau. Available at: https://www.census.gov/en.html
Vorontsov AV, & Glotov MB (2016) Demographic Situation in Russia and Problems of Education. *Управленческое консультирование* (7 (91)): pp. 87–91.
Young K, Rawat R, Dallmann W, Chatwood S, & Bjerregaard P (2012) *Circumpolar Health Atlas*. Toronto. University of Toronto Press. ISBN 978-1-4426-6090-8
Yüceşahin MM, & KC S (2015) Demographic and human capital heterogeneity in selected provinces of Turkey: A scenario analysis using multi-dimensional population projection model. *Economics & Sociology* 8 (3): pp. 215–244. DOI: 10.14254/2071-789X.2015/8-3/16

Appendices

Appendix 1. Educational levels according to the national systems of education in the Arctic

REGION AND YEAR	CODES ISCED 2011	DESCRIPTION OF THE LEVEL ACCORDING TO THE OFFICIAL DATA SOURCE (SEE NOTE)
CANADA	e1-e4	No completed education (No certificate, diploma or degree)
2011	e5	High school diploma or equivalent
	e6	Post-secondary education / various programs (Apprenticeship or trades certificate or diploma; College, CEGEP or other non-university certificate or diploma; University certificate or diploma below bachelor level)
	e7	Bachelor's degree
	e8	Master's degree / University certificate or diploma above bachelor level / Degree in medicine, dentistry, veterinary medicine or optometry
	e9	Earned doctorate
DENMARK	e1	None
2015	e2-e4	Primary education
	e5	Upper secondary education /vocational and qualifying
	e6	Short-cycle higher education
	e7	Bachelor and equivalent level, academic / vocational
	e8	Masters programmes
	e9	PhD programmes
	e10	Not stated
FAROE ISLANDS	e1	No education
2011	e3	Primary school
	e4	Lower secondary school / Less than 1 year after elementary school
	e5	Upper secondary school / Upper secondary vocational
	e6	Post-secondary diploma (1-2 years)
	e7	Tertiary (bachelor)
	e8	Tertiary (master)
	e9	Second stage tertiary (PhD, research)
GREENLAND	e1	No education / Early childhood education /
2015	e2	Pre-primary education
	e3	Primary education
	e4	Lower secondary education, general
	e5	Upper secondary education, general / vocational

	e6	Post-secondary non-tertiary education, general and vocational / Short-cycle tertiary education, general and vocational
	e7	Bachelor and equivalent level, academic / professional
	e8	Master or equivalent level, academic / professional
	e9	Doctoral or equivalent level
FINLAND	e1-e4	Basic education
2015	e5	Upper secondary
	e6	Lowest level tertiary
	e7	Lower level tertiary
	e8	Higher level tertiary
	e9	Doctorate level
ICELAND	e1	No formal education
2011	e2-e3	Primary education
	e4	Lower secondary education
	e5	Upper secondary education
	e6	Post-secondary non-tertiary education
	e7	First stage of tertiary education
	e8-e9	Second stage of tertiary education
	e10	Not applicable
NORWAY	e1	Unknown or no completed education
2015	e2-e4	Basic school level
	e5	Upper secondary education
	e6-e7	Tertiary education short
	e8-e9	Tertiary education long
RUSSIA	e1	Without primary/illiterate
2010	e2	Without primary/literate
	e3	Primary general 1-4 grades
	e4	Basic general 5-9 grades
	e5	Secondary general 10-11 grades / Basic vocational / Secondary vocational / Incomplete higher
	e7	Bachelor
	e8	Specialist / Master
	e9	Postgraduate
	e10	Education not stated
SWEDEN	e3	Primary and secondary education less than 9 years
2015	e4	Primary and secondary education9-10 years
	e5	Upper secondary education, 3 years or less
	e6	Post-secondary education, less than 3 years

	e7-e8	Post-secondary education 3 years or more
	e9	Post-graduate education
	e10	No information about level of education attainment
UNITED STATES	e1-e3	No education to primary
2015	e4	Lower secondary
	e5	Upper secondary
	e6-e9	Post-secondary
ALASKA	e1	No schooling completed
2010–2014	e2	Nursery school, preschool, kindergarten
	e3	Grades 1-6
	e4	Grades 7-9
	e5	Grades 10-12 / Regular high school diploma / GED / college, certificates
	e6	Associate's degree / academic and vocational
	e7	BA degree / Professional degree beyond a bachelor's degree
	e8	Master's degree
	e9	Doctorate degree

Note: Sources: Statistics Sweden, Statistics Finland, Statistics Norway, Statistics Denmark, Statistics Faroe Islands, Statistics Greenland, Statistics Iceland, Russian Federation State Statistics Services, U.S. Census Bureau, Statistics Canada. In Finland, Norway and Sweden the data and labels of education are based on the Registers of Completed Education and Degrees kept by national statistical bureaus. There, Upper secondary education includes intermediate level courses based on completed upper secondary level, but which are not accredited as tertiary education. Tertiary education short comprises higher education up to 4 years in duration. Tertiary education long comprises higher education more than 4 years in duration.

Appendix 2. The suppliers of population data distributed by education for the Arctic areas

REGION	SOURCE	TITLE OF DATA TABLE
CANADA	Statistics Canada	2011 National Household Survey, Education and Labour section. Highest Certificate, Diploma or Degree, Age Groups, Major Field of Study - Classification of Instructional Programs (CIP) 2011, Labour Force Status, Location of Study Compared with Province or Territory of Residence, Attendance at School and Sex for the Population Aged 15 Years and Over, in Private Households of Canada, Provinces, Territories and Census Divisions
DENMARK	Statistics Denmark	Educational attainment (15-69 years) by sex, age, ancestry, region, highest education completed and time
FAROE ISLANDS	Statistics Faroe Islands	Census 2011, Population by educational attainment (title and country/place of education/training), current activity status, age and sex
GREENLAND	Statistics Greenland	Educational profile by municipality, gender and time
FINLAND	Statistics Finland	Population aged 15 or over by level of education, municipality, gender and age, by years 1970-2015 and area
ICELAND	Statistics Iceland	Census 2011, Population by household status, educational attainment, sex and age
NORWAY	Statistics Norway	Persons 16 years and above, by region, sex, age, level of education, time and contents
RUSSIA	The Russian Federation State Statistics Services	Census 2010, Population by age, sex, education attainment and by region of the Russian Federation
SWEDEN	Statistics Sweden	Population 16-95+ years of age by region, level of education, age and sex. Year 2008 – 2015
UNITED STATES	U.S. Census Bureau	Current Population Survey, 2015. Annual Social and Economic Supplement. Educational Attainment of the Population 18 Years and Over, by Age, Sex, Race, and Hispanic Origin: 2015
ALASKA	U.S. Census Bureau	American Community Survey 5-year Estimates 2010-2014 for Alaska. Highest level of educational attainment by age and sex -- Alaska population 15 years and older. Data is sent by e-mail based on the 2014 ACS Public Use Microdata Sample (PUMS) by Liz Brooks, Research Analyst, Alaska Department of Labor and Workforce Development, Population and Census Unit.