New Policy-based Population Projections for the European Union, with a Consideration of their Environmental Implications

Working paper

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Abstract

This working paper presents new population projections out to 2100 for the countries of the European Union and for the EU as a whole under a wide range of fertility and migration scenarios. As policy-based projections, they aspire not to maximize predictive success regarding what will happen, but to accurately show the impact on overall numbers of different migration and socio-economic policy choices, with the aim of clarifying those choices for European policymakers and citizens. Among key results, we find that demographic policies have the potential to significantly increase or decrease future populations across the EU. Migration policy offers greater scope for influencing future population numbers than policies aimed at influencing national fertility rates. However, in countries with particularly low fertility rates or high emigration levels, egalitarian economic and family support policies have the potential to limit future population decreases to some extent. In most cases, EU nations are well placed to stabilize or slowly reduce their populations–thus achieving one of the necessary conditions for creating ecologically sustainable societies. Potential environmental benefits of smaller populations include a reduction in greenhouse gas emissions and increased opportunities for biodiversity conservation.

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Introduction: motivation and goals

In this working paper, the researchers at The Overpopulation Project present new population projections for the countries of the European Union and for the EU as a whole, under a variety of fertility and migration scenarios. These projections build on the work of Eurostat and the various European national statistical bureaus as well as numerous individual demographers. They differ from previous national and region-wide projections primarily in projecting a wider range of scenarios farther out into the future than has typically been done.

Our national population projections are designed to illuminate the policy choices facing the countries of the EU today, with a special emphasis on the long-range demographic and environmental implications of those choices. As policy-based projections, they aspire not to maximize predictive success regarding what will happen, but to accurately show what would happen given different policy choices. The goal is to clarify those choices for those who have to make them: Europe's leaders and citizens.

Because the primary goal of national statistical bureaus is to project the most likely national demographic outcomes, they are leery of projecting more than a few decades into the future. Furthermore, their limited alternative scenarios are usually narrowly centered around what is considered most likely to happen (the "base" or "principal" variant).[1] For example, the most recent national population projections from the Federal Statistical Office of Germany present only two different fertility scenarios (1.4 TFR and 1.6 TFR) and two different migration scenarios (annual net migration of 100,000 and 200,000) (Federal Statistical Office of Germany 2015).[2] Such a small variation in the total fertility rate arguably does not capture the fertility

[1] The following critiques of projections from Destatis and Istat are not designed to show the superiority of our projections, but rather to explain our goals in making them.
[2] They also model zero net migration and 300,000 annual net migration, but the results are not presented to readers.

changes possible through changes to family support programs or economic policies more generally. Similarly, the two immigration scenarios hardly account for the range of policy choices facing a country where annual net immigration has averaged 259,000 over the past twenty years and varied widely (from – 56,000 in 2008 to 1.2 million in 2015) and where there is widespread support both for greatly increasing immigration (Greens, Social Democrats) and greatly decreasing it (AfD, Christian Democratic Union). The report makes no attempt to explicitly link these fertility rates and immigration numbers to particular policies. Furthermore, the projections only go out to 2060, obscuring the longer-term demographic impacts of higher or lower fertility rates or immigration numbers.

Consider the main chart from Germany's Population by 2060 presenting the study's immigration projections:

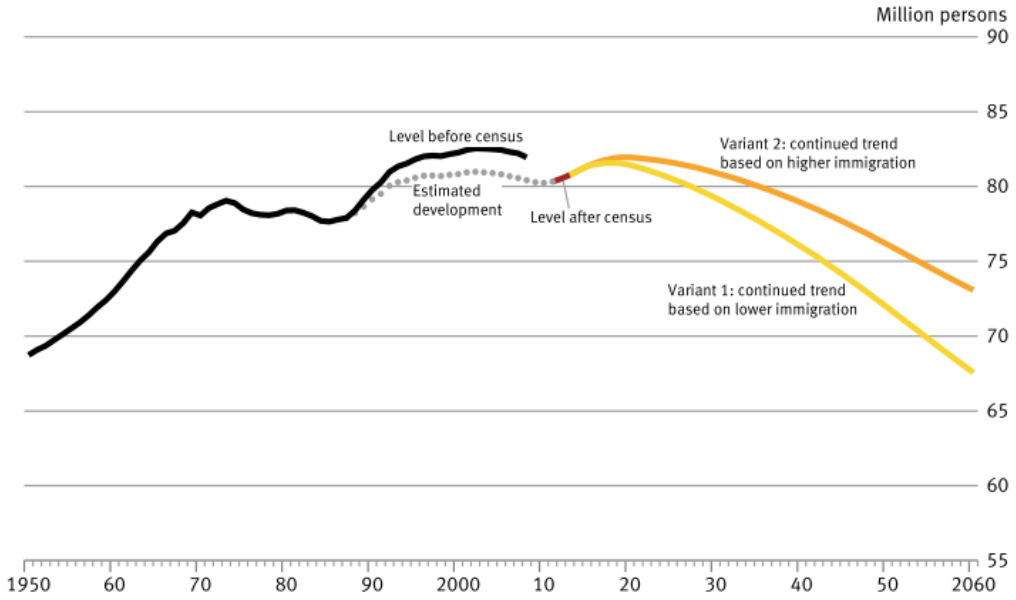

Figure 1. Population of Germany from 1950 to 2060 (Federal Statistical Office of Germany 2015)

It implies that Germany's population is likely to decline regardless of where immigration levels are set: the trend lines slope downward under both "lower" and "higher" immigration levels. In

fact, our projections suggest that a continuation of status quo migration levels would result in a relatively stable population—80 million in 2100 compared to 82 million today—while increasing or decreasing immigration numbers could raise or lower Germany's future population by tens of millions of people.

Compare our chart presenting a fuller range of Germany's immigration possibilities, ranging from zero net migration to 4X the average annual net migration for the past twenty years (approximately the rate at the height of the refugee crisis of 2015):

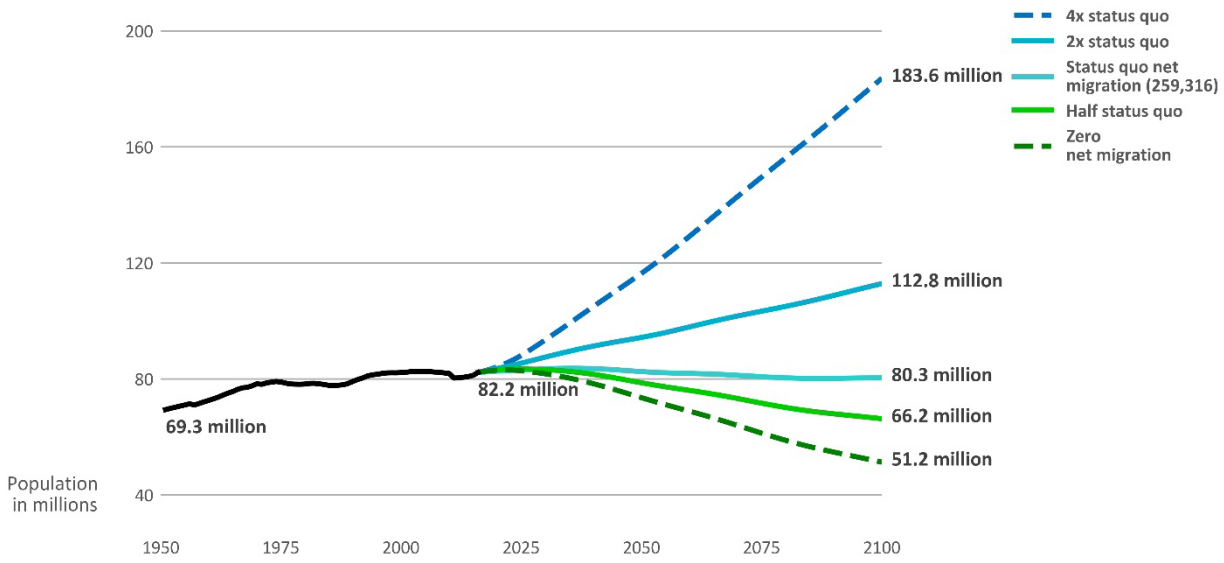

Figure 2. Germany Population Projections under five migration scenarios. Status quo migration is the continuation of the past 20 years average annual net migration level (259,316). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Our claim is that our projections capture a more accurate range of Germany's possible immigration policy futures. Inclusion of a zero net migration scenario makes immigration's contribution to future population numbers at other immigration levels more explicit. Because demographic changes are cumulative and build on themselves, projecting out to 2100 helps readers better understand the demographic implications of choosing certain immigration policies rather than others.

It is easy to lose sight of the goal of policy clarification while pursuing predictive rigor. Consider the most recent national population forecasts from the Italian national statistical bureau. Il Futuro Demografico del Paese takes a probabilistic approach, using stochastic models to estimate future fertility, mortality and immigration trends, which they present with 90% confidence intervals (Istat 2018):

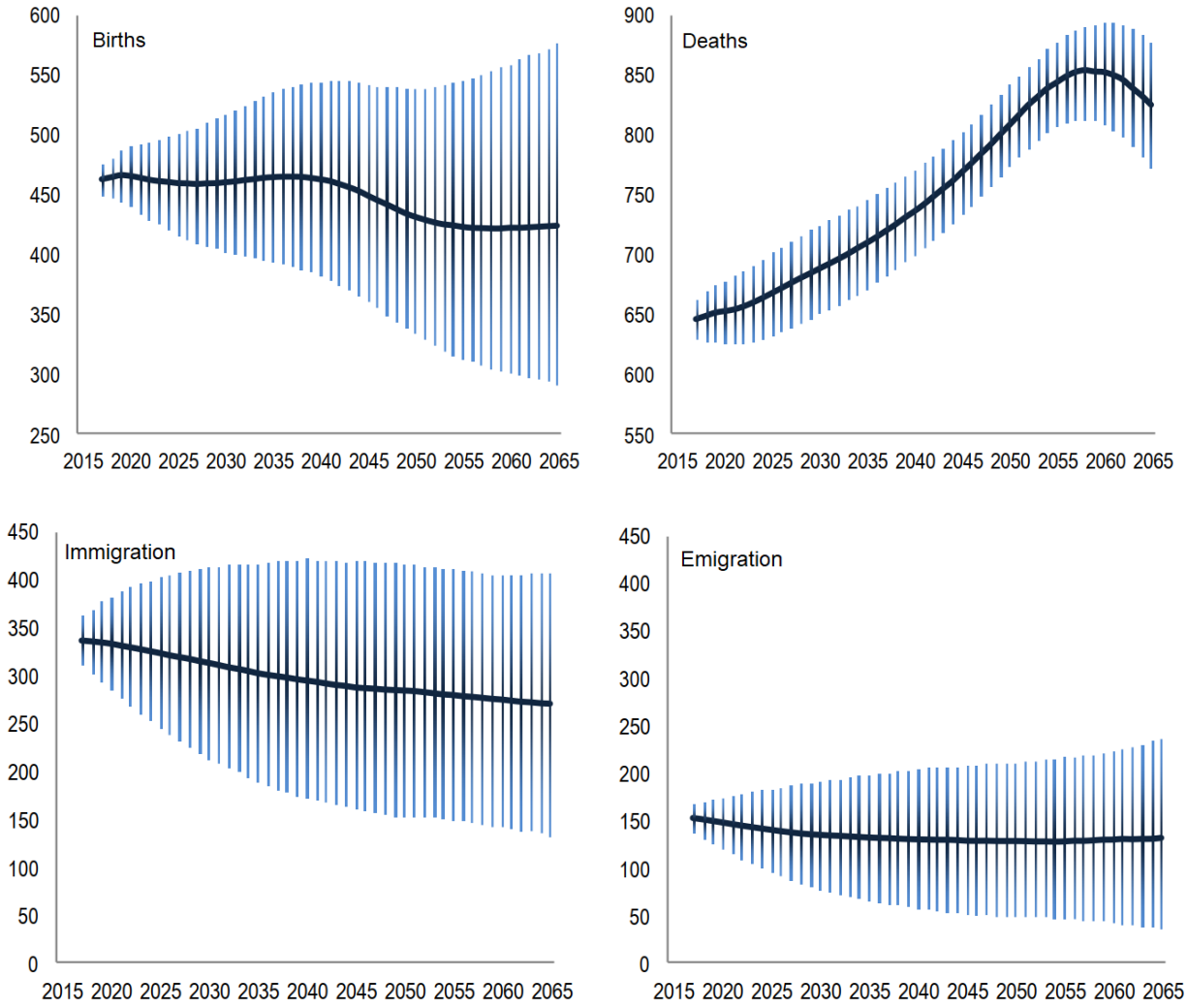

Figure 3. Births and deaths, international immigration and emigration in Italy under the median scenario with 90% confidence intervals, 2017-2065. Numbers are in millions

Probabilistic approaches seem to be supplanting traditional cohort-component population projection methods, including in the most recent (2017) United Nations Bayesian population projections (methodology described in Raftery et al. 2014). The claim is that they are more

accurate, in part because they generate predictions that include statistically rigorous confidence intervals, in part because the factors influencing demographic change are so numerous and complicated that random statistical agglomeration provides a better basis for prediction than the expert knowledge of demographers (Azose et al. 2016). Whether or not probabilistic approaches turn out to be more accurate in predicting the future, an unremarked consequence of this approach is that median scenarios with confidence intervals tend to displace the presentation of a variety of alternative scenarios—thus breaking any explicit connection between future numbers and current policy choices.

We can see this when we turn to the chart presenting Istat's median projection of Italy's future population out to 2065. Again, readers are provided with a single projection and confidence intervals rather than alternative scenarios. While the projection is based on projected fertility, mortality and migration trends, there is no explanation of precisely how these factors might influence future numbers, or their relative importance:

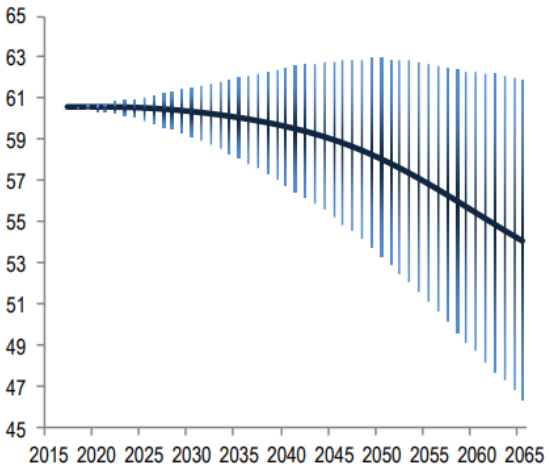

Figure 4. Resident population in Italy, median scenario with 90 % confidence intervals, 2017-2065, in millions

In contrast, our Italy projections disaggregate fertility and migration, presenting separate projections with multiple policy scenarios for each:

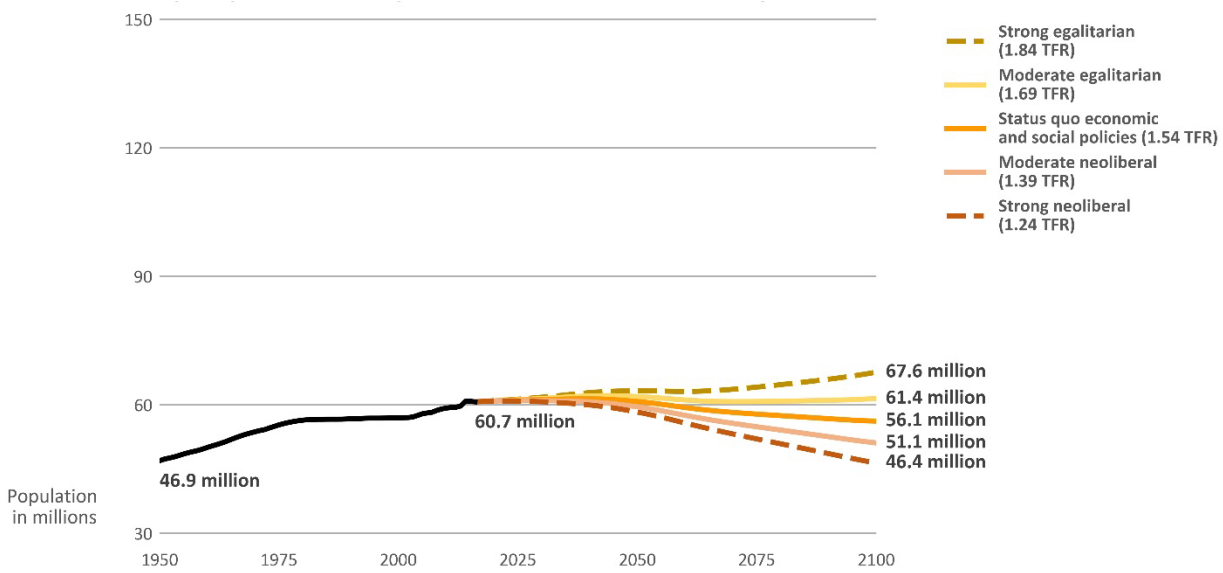

Figure 5. Italy population projections under five fertility scenarios. All scenarios assume the continuation of the past 20 years average annual net migration level (229,093). Source: own calculations

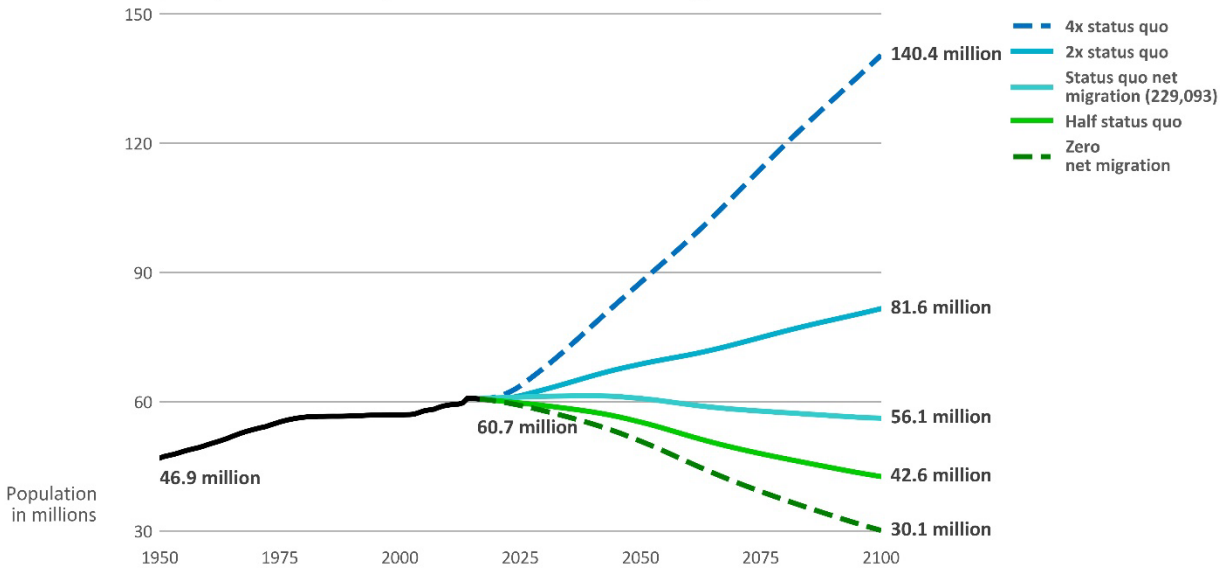

Figure 6. Italy population projections under five migration scenarios. Status quo migration is the continuation of the past 20 years average annual net migration level (229,093). Migration scenarios use total fertility rates varying between 1.49 and 1.74, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Here as elsewhere, we set the parameters for fertility rates and annual immigration numbers with reference to recent rates and numbers, in our status quo scenarios. Then we build

additional scenarios by phasing in plausible changes to these rates and numbers, which may be brought about by different policy choices. Future Italian fertility rates may be raised or lowered, depending on how much support Italian governments provide for couples who want to have children and for women who want to combine family and a career (we discuss this below under "Fertility scenarios"). Future immigration numbers may be raised or lowered, depending on how many new arrivals future Italian governments choose to allow in. Fertility rates and immigration numbers, in turn, will influence future population numbers and hence Italy's future greenhouse gas emissions and the amount of land available for biodiversity conservation. Our new projections seek to clarify these matters for the nations of the EU and for the EU as a whole.

Perhaps the simplest way to explain how our approach in these projections differs from previous ones is to note that most demographers are searching primarily for accurate forecasts. If they could replace their projections with a crystal ball, providing exact information about the future, they would do so. The closer their projections approximate crystal ball-like results, the greater their perceived achievement. We begin from different premises: that future population numbers are open; that they will be, in part, a matter of policy choices; that those choices can be more or less well-informed; and that it is better to make well-informed rather than poorly-informed decisions. Our goal for these projections is not the most accurate forecasts possible, but informed citizens and intelligent choices.[3]

[3] This explains, in part, our relatively long time horizon. We recognize that projecting out to the end of the century increases the uncertainty surrounding any projections. But we also believe it is irresponsible to make demographic policy without thinking at least this far into the future. The economic benefits of narrowing one's time horizon lead to unacceptable ethical and environmental costs.

Recent demographic trends & future uncertainties

When we look at the major demographic trends of the past century in Europe, three stand out. First, fertility rates have declined to below replacement rate and have remained there. All European countries have completed the "demographic transition" to small families with long-lived members (Frejka 2008). While there is considerable variation (from a current TFR of 1.34 in Italy and Spain to 1.92 in France), no European country is at or above replacement fertility. Second, as a function of this, after growing relatively slowly for much of the century, Europe's population has leveled off and is now poised to naturally decline. However, this region-wide trend masks important differences among countries. According to the latest Eurostat population projections (baseline scenarios), if current fertility and migration trends continued Sweden would increase its population by almost 45% while Romania's population would decrease by 25% by 2080.

Although a few analysts see incipient population decline as a positive development and part of the natural evolution of successful societies (Götmark et al. 2018), most policy-makers see it as a problem to be fought (European Commission 2014). This has played a role in the third major trend: over the past century, Europe has gone from a major immigrant sender region to a major immigrant receiver region. According to the Migration Policy Institute, Italy "accounted for the largest voluntary emigration in recorded history, with 13 million leaving between 1880 and 1915"; further millions emigrated from the country in search of work after World War II (Scotto 2017). Today, Italy is a leading immigrant destination with net migration topping a quarter million in recent years. Spain's immigrant population increased from 0.52% of the total population in 1981 to 9.8% in 2017 (Instituto Nacional de Estadística 2018). While most EU nations historically have not seen themselves as "immigrant nations" like the United States,

today many western European countries allow in more immigrants annually as a percentage of their populations than the U.S. (Spain and the U.K.), have higher percentages of foreign-born residents than the U.S. (Germany and Ireland), or both (Austria and Sweden).

These three trends seem likely to continue, broadly speaking, and modeling them is an important part of our projection efforts. But while population projections always rely more or less on extrapolating from previous trends, it is important to realize the degree to which Europe is entering demographic terra incognita as it moves further into the 21st century. EU nations are on the cutting edge of what some demographers are calling the "second demographic transition": where fertility rates remain permanently well below replacement rate, as citizens of advanced industrialized nations become comfortable with having few or no children (Lesthaeghe 2015). We do not know how such societies may evolve demographically in the future; this has never happened before in human history.

Meanwhile, many EU migrant sender countries in Africa and the Middle East are entering a different sort of unknown territory: continuing rapid population increase in a world where climate change, ocean acidification, and other global ecological stressors could lead to crumbling ecosystem services and declining food production (Guengant and May 2011). These worrisome trends have the potential to send huge numbers of their citizens seeking refuge and better lives in the EU (Docquier 2018). The most recent UN population projections show many sub-Saharan nations tripling or quadrupling their populations by 2100 (figure 7). Whether such increases will actually materialize, and if they do, how Europeans will respond to the resulting demographic pressures, are simply unknown.

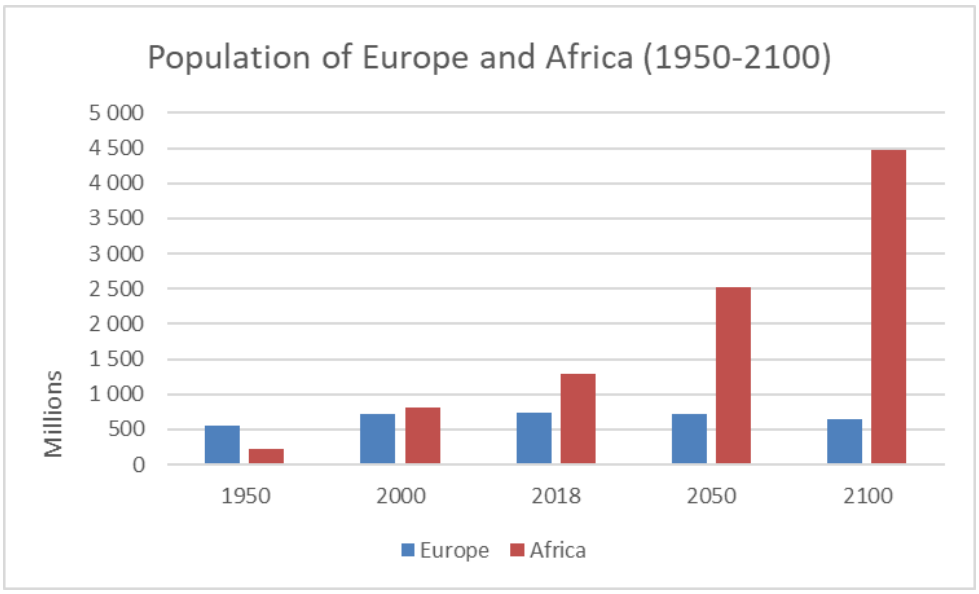

Figure 7. While Europe had double Africa's population in 1950, Africa is on track to have more than 3X Europe's population by 2100. Source: UN World Population Prospects, medium variant (United Nations Population Division 2017)

Another layer of uncertainty involves who will make migration policy in the years to come: individual countries, the EU's most powerful countries, or the EU as a whole. In recent years, national governments have ceded significant control over migration policy to the European Commission, through region-wide asylum policy and border controls—only to wrench it back in some instances (Lavenex 2006; Collett 2015). We have seen Germany and Sweden assert a de facto claim to make migration policy for the whole EU in 2015, by combining expansive national asylum policies with moral demands that the rest of the EU should follow suit. And we have seen Hungary and the United Kingdom emphatically reject such claims: Hungary by refusing to take in any asylum seekers, the U.K. by voting to leave the EU altogether, in large part over immigration policy. At this point, it seems fair to say that we do not know who will be making immigration policy for Hungary and Sweden in the future: Hungary and Sweden, their more powerful neighbors, the European Parliament, or some combination of all three.

Similar uncertainty holds regarding economic and social policies that affect fertility rates. There appears to be broad consensus among EU policy-makers and their constituents on the need to keep national fertility rates high enough to avoid steep population declines (European Commission 2014). Nevertheless, there are wide differences within EU countries in their levels of support for family-friendly child-care and employment policies, a robust economic safety net, and other policies that significantly influence fertility rates (Thévenon 2011). And here, too, we cannot be sure who will be setting policies for whom. By forcing severe economic austerity policies on Greece, Germany (acting through the EU and global financial bodies) helped drive Greek fertility levels to historic lows. In effect Germany, not Greece, has been setting Greek fertility policy for the past decade (Mavridis 2018).[4]

In such a world, policy-making obviously will take place under relatively strong uncertainty. Yet this does not preclude the need to link possible policy choices to their likely demographic consequences. Quite the contrary. Because those demographic consequences will influence Europe's future in important ways, they should be taken into account by EU citizens and policy-makers.

Scenarios selected for projection

In our various projection scenarios, we seek to capture a proper range of policy options, neither exaggerating nor downplaying what is politically and demographically possible. The scenarios are informed by reference to recent policy choices made or advocated in the political sphere, and by analyses of the effectiveness (or ineffectiveness!) of these policies in the recent

[4] Note that such interference in weaker governments' fertility policies also can work in the other direction. Germany or France, working through the EC, might force poorer eastern and southern European countries to enact laws and policies furthering gender equality, making it easier for women in those societies to combine careers with babies. In theory, they could push them to improve their economic safety nets, bolstering the security of working-class families during difficult economic times. Either change would likely lead to higher fertility rates.

demographic literature. Given considerable uncertainty regarding future demographic trends and the wide range of policy proposals under discussion today, we have opted to consider a wider rather than a narrower range of population projections.[5]

Regarding mortality rates, we assume continued improvements in medicine and health science and consequent increases in longevity over the course of the 21st century. Although such increases are not guaranteed, we think they are likely, particularly given universal, affordable health care region-wide. While medical breakthroughs or different health care spending scenarios might impact longevity, their impacts are so speculative and uncertain that we see no reason to run alternative policy scenarios around possible mortality rates. Instead, we have followed the demographic consensus represented by the "baseline" scenario for future life expectancies in the latest Eurostat projections, incorporating them (by sex) into our projections until 2080, and then holding them constant until the end of the century. For the EU, we averaged the member states' values for both sexes and weighted them based on population numbers. This has average EU lifespans increasing from 81.0 years today to 89.2 years in 2080.

In contrast, both national fertility rates and net migration numbers will be affected by explicit policy choices in the coming years in ways that can be understood and modelled. In some cases, these effects may be indirect, as when cuts to social services in the name of budgetary austerity lead to economic stress and declining birth rates, or changes in asylum processing policies lead to an increase in overall immigration numbers. In other cases, policy changes may seek to affect those rates and numbers directly, as when countries pay families a bonus for having more children, or immigration rates are raised or lowered. In either case, policy

[5] Here we have followed John Bongaarts (2018, personal communication) advice: "Using a wide range of scenarios, even if seemingly unrealistic, is generally desirable because it gives researchers and policy makers a feeling for the sensitivity of outcomes to policy actions. A second point is that extreme scenarios usually do not materialize because there is a response [to extreme trends or policy proposals]—either at the individual or public level."

impacts may be substantial. Hence our projections specify a range of policy-based fertility and migration scenarios, as described below.

Fertility scenarios

The EU countries (and Japan) have led the world in entering into the "second demographic transition": a period of sustained (multi-generational) below-replacement level fertility. Although some EU countries have seen a rebound in the past two decades from historically low fertility rates, the old hypothesis that fertility rates would eventually stabilize right around replacement rate (2.1-2.2 TFR) seems decisively refuted by recent evidence. Much uncertainty exists regarding how low fertility rates may remain over time, how much they might rebound, and how much rates may fluctuate in the future. Most demographers predict a small rebound in the coming decades for EU nations with lower fertility rates (Goldstein et al. 2009; Myrskylä et al. 2009, 2013); this is reflected in the most recent Eurostat and United Nations projections, and in many national statistical bureau projections. We follow this near-consensus in our own projections.

Historically low fertility rates have induced EU countries to make a variety of attempts to raise them. Key efforts include bonuses and tax breaks for having more children, and more generous provision of child care services which make having children easier. By now, policy-makers have a good sense of what works for permanently raising fertility levels in developed nations (Björklund 2006; Luci-Greulich and Thévenon 2013; Reibstein 2017): comprehensive Nordic-style policies that make work-life balance easier for women and couples, combined with strong economic safety nets generally and more egalitarian societies (Thévenon and Gauthier

2011; Balbo et al. 2013; Pollmann-Schult 2018).[6] We have also learned which policies only provide a short-term boost to fertility rates (by influencing only the timing of child-bearing, not the completed fertility), or that do not work at all. Among these are isolated payments to encourage larger families within unchanged contexts of economic or career uncertainty (Kalwij 2010; Kim 2014).

When societies expect and train women to have careers, they must find (and fund!) ways for them to combine this with having children—or accept significantly lower fertility rates and significantly higher frustration among young couples looking to start families (DeRose et al. 2008). While generous funding for child-related benefits is a part of this package, other components are also important, including a society-wide commitment to gender equality (Oláh and Bernhardt 2008). As one researcher notes: "in general, national fertility is possibly best seen as a systemic outcome that depends more on broader attributes, such as the degree of family-friendliness of a society, and less on the presence and detailed construction of monetary benefits" (Hoem 2008).

In addition, there is good evidence from the EU and elsewhere that hard economic times and economic uncertainty drive down fertility rates (Sobotka et al. 2011; Frejka and Gietel-Basten 2016, Matysiak et al. 2018). Countries that fail to cushion their citizens from economic hardship, or that fail to provide viable pathways to economic and career success for many of their younger citizens, tend to have lower fertility rates than countries that support their citizens' economic security and flourishing. These countries, such as Hungary, have found it difficult to

[6] "There is evidence that a consistent system of population and family policies can effectively sustain or modify fertility levels in contemporary societies. Total fertility rates have been maintained relatively close to the replacement level in countries where principles of gender equity in the household and in society have been systematically nurtured for extended periods of time, and have been supplemented by wide-ranging societal support for childbearing. Material and structural measures alone, such as paid parental leaves and child bonuses, even when generous, seem to have a limited influence on fertility when they are implemented in a "traditional" male-dominated societal environment" (Frejka 2008).

raise fertility rates even when they have spent considerable sums directly for that purpose. In contrast, countries like France and the Scandinavian nations, that combine generous economic safety nets and a comprehensive commitment to equality between the sexes with subsidies and benefits for raising children, have the highest fertility rates in the EU (Thévenon 2011).

Given this general understanding, we develop and project the following five fertility policy scenarios:

Table 1. Projection assumptions made under different fertility scenarios

Scenario	Policy changes	Impact on fertility rates
(1) status quo economic and family support policies	Continue existing level of family support, existing economic safety net, existing levels of economic equality and equality between the sexes	Lower fertility countries: +0.2 TFR Medium fertility countries: +0.1 TFR Higher fertility countries: no change
(2) moderate egalitarian policy shift	Increase economic safety net, decrease economic inequality within society, increase policies that support family formation, commit to equality between the sexes	All three categories: status quo fertility +0.15 TFR
(3) strong egalitarian policy shift	Greatly increase economic safety net, greatly decrease economic inequality within society, greatly increase policies that support family formation, strongly commit to equality between the sexes	All three categories: status quo fertility +0.3 TFR
(4) moderate neo-liberal policy shift	Reduce economic safety net, allow growing economic inequality within society, decrease support for children and family formation, ignore inequality between the sexes	All three categories: status quo fertility -0.15 TFR
(5) strong neo-liberal policy shift	Greatly reduce economic safety net, allow greatly increased economic inequality within society, greatly decrease support for children and family formation, ignore inequality between the sexes	All three categories: status quo fertility -0.3 TFR

For purposes of predicting future "status quo" fertility trends among EU countries, lower fertility countries are defined as countries with < 1.5 TFR in 2016, medium fertility countries had a TFR between 1.5 and 1.7, and higher fertility countries had > 1.7 TFR. These break down as follows:

Table 2. EU countries plus Norway divided into three fertility groups

Lower fertility countries TFR < 1.5 TFR		**Medium fertility countries 1.5 < TFR < 1.7**		**Higher fertility countries TFR > 1.7**	
Italy	1.34	Austria	1.53	Norway	1.71
Spain	1.34	Hungary	1.53	Latvia	1.74
Portugal	1.36	Bulgaria	1.54	Denmark	1.79
Cyprus	1.37	Finland	1.57	United Kingdom	1.79
Malta	1.37	Slovenia	1.58	Ireland	1.81
Greece	1.38	Estonia	1.60	Sweden	1.85
Poland	1.39	Germany	1.60	France	1.92
Luxembourg.	1.41	European Union	1.60		
Croatia	1.42	Czech Republic	1.63		
Slovakia	1.48	Romania	1.64		
		The Netherlands	1.66		
		Belgium	1.68		
		Lithuania	1.69		

In the status quo policy scenario, we imagine economic and family policies remaining approximately what they are today. Under this scenario, we hold TFR steady for higher fertility countries and phase in a small increase in TFR for the lower fertility (+0.2) and medium fertility (+0.1) countries. There is good evidence of such a rebound from low fertility for many EU countries, and clear evidence of the end of extra-low fertility in Eastern Europe (Goldstein et al. 2009; Myrskylä et al. 2013). We thus follow the majority of demographers who expect a slight upsurge in lower fertility EU countries and a partial "convergence" among EU countries' fertility rates (Lanzigi 2010; Rees et al. 2012). Such a convergence finds expression, for example, in Eurostat and in many (but not all) EU national statistical bureaus.

In the two egalitarian policy scenarios, moderate and strong, we visualize countries enacting family-friendly policies that make it easier for couples to form and sustain families. Such policies can include financial payments or tax incentives for childbearing. More important are family leave policies that provide substantial time off to raise children, with full or close to full reimbursement for lost wages, and a guarantee that one can return to one's job; opportunities for part-time jobs for parents who want to spend more time with young children; and available, affordable, high-quality childcare for young children.

These scenarios also involve countries creating or sustaining generous social safety nets and willingly re-distributing wealth so as to sustain a relatively egalitarian economic structure. Such economic policies increase fertility rates within advanced nations, because most citizens have the economic security needed to raise children in confidence.[7] This appears to be key in avoiding sharp downturns in fertility levels during periods of economic stagnation or recession.

Under these egalitarian scenarios, which could look very different in their policy details from one country to another, we predict TFRs will rise by either +0.15 (for a relatively strong effort) or +0.3 (for an even stronger, more comprehensive and more expensive effort) compared to the status quo scenario among all countries (lower, medium and higher fertility). There is much disagreement among demographers about the effectiveness of policy in influencing fertility (Gauthier et al. 2013; Luci-Greulich and Thévenon 2013; Potts 2013). We believe these scenarios represent a conservative yet reasonable estimate of the potential impact of family-friendly, economically-egalitarian policies on national fertility rates, at least for lower and medium fertility countries. We are aware that they may overestimate the impact further policy improvements could have in higher fertility countries, such as France, that have already gone a

[7] Note that in developing nations, improvements in the economic safety net may help reduce fertility rates, since people no longer depend on having a large number of children for support in their old age.

considerable way in enacting such policies. However, there remain relatively large gaps between desired and achieved fertility rates among women in the EU, typically in the range of 0.5-1.0 children even in higher fertility countries (Testa 2007). For this reason among others, we assume continued room to increase fertility rates, even in relatively high fertility countries.[8]

In contrast, in the two neo-liberal policy scenarios, moderate and strong, we imagine countries retreating from their current levels of family support or cutting their economic safety nets, or both. There is strong direct and indirect evidence that such cuts undermine individuals' sense of economic security and can substantially depress fertility (Kiester 2010). An obvious example is the huge fertility decrease in Eastern Europe in the decade after the fall of communism (Frejka and Gietel-Basten 2016). There is recurring pressure in the EU today to make such cuts, often in the name of austerity, budget-balancing and "economic competitiveness." In fact, some successful family-friendly policies designed to boost fertility rates in EU nations were ended or drastically cut back in the wake of the 2008 recession (Matysiak et al. 2018).

Lack of demographic understanding might play a role in enabling these scenarios. Political leaders may believe that they can cut social services yet still boost fertility through direct payments for childbearing. For ideological reasons, they may find it hard to accept that creating more gender-egalitarian societies is a key to keeping fertility levels up as young women pursue careers. Given recent trends of stagnating wages and high unemployment among younger workers, it is easy to imagine economic life becoming harder for young people in the EU, both

[8] Although Gauthier et al. (2013) argue that "the gap" is overestimated and should not be used as evidence for the possible impact of family-friendly policies, it has been cited as evidence for such possible impacts (European Commission, 2005).

upwardly-mobile career strivers and couples who just want to make a decent living and have a few children, so that fertility rates decline.

Under the two neo-liberal scenarios, we project TFRs declining by either -0.15 or -0.3 across all countries (compared to the status quo scenario, not the actual 2016 TFR). Again, it is possible that some lower fertility countries, which already have relatively weak economic safety nets and poor commitments to gender equality, do not have as far to fall and thus are particularly unlikely to reach the very low fertility levels projected for them under the strong neo-liberal scenario. Then again, the degree to which political leaders who are both pro-natalist and pro-laissez-faire economics will sacrifice one goal for the other is yet another question to which we do not know the answer.

We believe these five fertility policy scenarios well capture the policy choices facing EU countries as they consider ways to boost fertility rates—an explicit goal of most countries and of the EU as a whole. The strong neo-liberal scenario is less likely to be implemented in most countries than a more moderate scenario, given relatively strong commitments to a decent economic safety net and to the equal value of all citizens. Similarly, the strong egalitarian scenario is less likely to be achieved in many countries than a more moderate scenario, given its difficulty and expense, and the fact that economic egalitarianism conflicts with the interests of the wealthy and politically powerful. For these reasons, we believe our three middle fertility policy scenarios capture the range of most likely outcomes and graph them with solid lines, compared to the dashed lines for our two "outlying" scenarios. But the pressures for austerity and laissez-faire economics, on the one side, and for equality and human dignity on the other, are substantial. Hence we believe our outlying scenarios remain politically possible and worthy of analysis.

Migration scenarios

Regarding migration, we develop a similarly wide range of policy-dependent scenarios, recognizing the greater uncertainty around future migration numbers compared to future fertility levels (Azose et al. 2016). Migration numbers vary widely across the EU, as illustrated by this table giving individual countries' average annual net migration over the past twenty years:

Table 3. Average annual net migration (1998-2017) of EU countries plus Norway

Countries with positive average annual net migration				**Countries with negative average annual net migration**	
European Union	1,188,235	Ireland	21,645	Slovakia	-305
Spain	270,112	Czech Republic	18,747	Estonia	-942
Germany	259,316	Denmark	16,778	Croatia	-4259
United Kingdom	230,107	Hungary	13,652	Poland	-12,552
Italy	229,093	Portugal	12,262	Latvia	-14,362
France	100,525	Finland	11,104	Bulgaria	-21,052
Sweden	50,024	Greece	8390	Lithuania	-27,212
Belgium	42,575	Luxembourg	6967	Romania	-103,807
Austria	40,547	Cyprus	5855		
Norway	27,350	Slovenia	4128		
Netherlands	26,427	Malta	3642		

In recent decades, many EU countries and the EU as a whole have evolved from having low immigration numbers to accommodating relatively high numbers. More recently, high and seemingly out-of-control immigration levels have produced a strong populist reaction, but whether this leads to permanently reduced immigration numbers in the future or is merely the prelude to even higher numbers (as in the U.S., Australia and Canada over the past half century) remains to be seen.

On the one hand, many EU citizens would like to see immigration reduced for social, cultural, economic, or political reasons (Connor and Krogstad 2018). They perceive current immigration levels offering few benefits and considerable dangers. On the other hand, some

residents feel a humanitarian obligation to help their poorer neighbors to the south and east by allowing more immigration. Many business leaders and politicians see increased immigration as the solution to the potential problem of shrinking numbers of workers and consumers (Legrain 2014; d'Albis et al. 2018). As one European Commission green paper put this conventional policy wisdom: "Europe is facing today unprecedented demographic change … In many countries, immigration has become vital to ensure population growth" (European Commission 2005). The sheer range of policies advocated by European political parties is impressive and we seek to capture this range in our projections.

We project five migration scenarios for those countries (21 out of 29) that have averaged net positive migration over the past twenty years:

Table 4. Projection assumptions under different migration scenarios for countries with net positive migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) status quo net migration	Continuation of the country's average annual net migration level for the past 20 years for rest of the century	TFR the same as under status quo fertility scenarios
(2) 2X status quo net migration	2X average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR +0.05 by 2036
(3) 4X status quo net migration	4X average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR +0.2 by 2036
(4) half status quo net migration	½ average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR -0.025 by 2036
(5) zero net migration	0 net migration by 2026, held stable for the rest of the century	Status quo TFR -0.05 by 2036

For those EU countries with positive net migration, we build a status quo net migration scenario by taking the average net migration into that country for the past twenty years and projecting it out to 2100 (note that our status quo net migration scenario is identical to our status

quo fertility policy scenario). Such a lookback period provides a relatively current number, mirroring contemporary policies and conditions, while smoothing out yearly fluctuations (which can be substantial, as witnessed by the refugee surge in 2015 and 2016). We then build four further scenarios around the status quo scenario.[9]

The 1/2X status quo net migration scenario and 2X status quo net migration scenario capture what we take to be the most likely range of policy choices, representing significant increases or decreases in net migration levels. We phase in these changes over ten years, as migration levels can be raised or lowered relatively quickly. For our purposes, we do not distinguish between economic migrants and refugees or asylum seekers, as this is largely irrelevant to our chief purpose: projecting future population numbers. Policy changes to net migration levels could be justified in very different ways. For example, humanitarian demands or economic self-interest, or a combination of both, could argue for increasing immigration. Preserving social solidarity or job opportunities for current citizens, or some combination of both, could argue for decreasing it. Again, such justifications are irrelevant to what we focus on here: the impact of different migration policies on overall numbers.

One of our most difficult questions was deciding the degree to which increasing or decreasing net migration is likely to impact national fertility rates in the future.[10] A number of national statistical bureaus have stated that increased migration boosted their national fertility rates slightly in recent decades, on the order of a 0.1 increase to national TFRs (Kulu and González-Ferrer 2014; Pailhé 2017; Kulu et al. 2017).[11] But that does not mean that a doubling

[9] Calling this the "status quo" net migration policy scenario may be misleading. This scenario averages the past 20 years net migration numbers. But annual numbers may be highly variable, more recent trends may be quite different from the past 20 years average, and national migration policies may have changed greatly during this time.
[10] Many thanks to Tomáš Sobotka of the Vienna Institute of Demography, for sharing slides from a talk he gave on this topic in June, 2018, titled "Migrant Fertility in Europe: Accelerated Decline During the Recession Period?"
[11] "In recent years, immigrants' childbearing raised the TFR in Northern, Southern and Western Europe by three to seven percent, exceptionally by 10 percent." (Frejka 2008), See also (Sobotka 2008)

of immigration numbers would lead to twice as big an impact. Among other things, the impact of immigration on fertility levels strongly depends on where migrants are coming from: Somali migrants into the EU have approximately 3X as many children as Iranian migrants. Such uncertainties have led many demographers to leave out altogether migration's effects on fertility when doing projections, but this seems misleading. In our own projections, we have opted to modestly raise or lower fertility rates to account for changes in the percentage of immigrants among women in their child-bearing years under different scenarios (see tables 4-5).

In addition to ½ and 2X status quo migration scenarios, we project a zero net migration scenario and a 4X status quo net migration scenario. The former represents a strong "shutting the door" to extra-EU migration and a substantial decrease in inter-EU migration; the latter can stand as a proxy for an "open borders" policy of unlimited immigration, which is difficult to model. Neither of these two scenarios seem as likely as our three main migration policy scenarios; hence we graph them with dashed lines in our projection charts. However, both have substantial numbers of advocates and both have been put into practice in recent years, at least for a time. In 2015 and 2016, Germany and Sweden tried to accommodate all the asylum seekers who reached their borders, without questioning whether some were merely economic migrants, while Hungary and Poland slammed the door on extra-EU migration in response to the resulting influx, without asking whether some were legitimate political refugees. In both intent and effect, these actions seem to approach our more "extreme" migration scenarios. For these reasons and because these scenarios appear possible, we believe they deserve to be modelled.[12]

[12] Note further that while the 4X status quo scenario seems very high to many analysts, a net annual migration level based on the past five years average rate for Germany would be even higher than that for many of the countries we are looking at (9 out of 29), while it would be roughly comparable to the 4X status quo net migration scenarios for Finland, Slovenia, the Czech Republic, Portugal and Hungary.

We treat the eight net negative migration EU countries, where emigration has exceeded immigration in the last two decades, somewhat differently. For these countries, which are all in eastern Europe, we have built a status quo net migration scenario around continued negative net migration, again taking the average annual net migration for the past twenty years and projecting that out to 2100.[13] We then projected a zero net migration scenario and three positive net migration scenarios built around applying a multiple of the average annual net migration rate for the EU as a whole during the past twenty years to the countries in question. These three positive net migration scenarios are EU status quo net migration rate scenario, 2X EU status quo net migration rate scenario and 4X EU status quo net migration rate scenario. We summarize the five migration scenarios for net negative migration countries below:

[13] For several countries, such as Romania and Lithuania, this leads to absurd long-term population declines which could not occur because the source for such large emigration numbers, the total population, would be too small to support it by the second half of the century.

Table 5. Projection assumptions under different migration scenarios for countries with net negative migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) status quo net migration	Continuation of the country's average annual net migration for the past 20 years for rest of the century	Status quo TFR
(2) zero net migration	0 net migration by 2026, held stable for the rest of the century	Status quo TFR
(3) EU status quo net migration rate	Net migration level equal to the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR +0.05 by 2036
(4) 2X EU status quo net migration rate	Net migration level equal to 2X the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR +0.1 by 2036
(5) 4X EU status quo net migration rate	Net migration level equal to 4X the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR +0.2 by 2036

The goal behind these five scenarios is to capture the full range of possible migration futures for these net negative migration countries: from a continuation of substantial out-migration and population decline; through an end to their recent hemorrhaging of younger workers (in the zero net migration scenario, to which most of these countries aspire); to a more or less greater convergence with richer EU nations and their more favorable economic outlooks and more welcoming attitude toward migrants. Many of the demographers we have consulted are skeptical that these more expansive alternatives are possible for these countries. But the examples of Italy and Spain, which not that long ago flipped from large net negative to large net positive migration countries, in just a few decades, suggest that such change is possible—particularly in the face of demographic decline or great pressure from overpopulated, unstable source countries, or both.

As with our fertility scenarios, we believe our migration scenarios well capture the range of policy choices facing EU countries today. These two sets of five alternatives present the full gamut of policy choices on immigration: from drastically curtailing it to drastically expanding it; from fed up with or afraid of immigration to fully embracing it; from the Sweden Democrats to Sweden's Green Party. Again, any of these levels could be chosen for a variety of reasons. The fact that a country could allow in approximately the same number of immigrants it has allowed in for the past twenty years (status quo net migration scenario) and yet have somewhat different demographic impacts depending on where the migrants came from, or their ages, or their sex ratios, are just some of the factors lending uncertainty to the projections that follow. Still, focusing on annual net migration numbers clarifies the likely demographic impact of different immigration policy choices and thus can help EU citizens and policy-makers think more clearly about the potential demographic paths before them.

Combination scenarios

It is helpful to consider a range of fertility scenarios while holding net migration steady, in order to properly gauge the potential demographic impacts of changes in family support policies. Similarly, it is good to show a range of migration scenarios while assuming unchanged fertility policies, in order to assess the potential demographic impacts of changes in net migration levels. But of course, both kinds of policies can change, in ways that can multiply or cancel out their demographic effects. This led us to graph several combination scenarios in an attempt to better understand the range of potential demographic futures facing EU countries and the full range of impacts that population policies might have on them. Since the rationale for considering particular ranges of fertility and migration possibilities has already been explained, it remains to say why we have chosen to graph the particular combination scenarios we have chosen.

Obviously, strengthening family support policies and increasing net immigration levels, together, will ratchet up future national population numbers, while weakening support for family formation and decreasing net immigration levels, together, will depress future numbers more strongly than just reducing one factor or the other. To get a sense of how impactful such combined changes might be, in our combination scenarios for positive net migration countries, we graph a "2X status quo net migration & strong egalitarian family support policies scenario" and a "½ status quo net migration & strong neoliberal family support policies scenario." Increasing or decreasing immigration even more is possible, with potential impacts that can be roughly estimated by consulting our more extreme immigration scenarios (zero and 4X status quo net migration). Similarly, increasing or decreasing family support policies more modestly is possible, with results that would fall within the range laid out by these high and low combination scenarios. We thus take ourselves, with these two scenarios, to be setting the range of likely policy choices and likely demographic outcomes facing the positive net migration countries.

For most of these countries, the potential demographic outcomes encompass some (often relatively modest) amount of population increase or decrease over the coming century. Such demographic impacts could be the focus of political debate and decision-making in these countries (although typically they are not). In addition, policy-makers have a choice regarding whether to sustain future populations more with immigration or with native-born citizens. To illustrate this aspect of current EU demographic options, our combination scenarios also graph a "½ status quo net migration & strong egalitarian family support policy scenario," which would simultaneously decrease immigration and increase support for current residents having more children, alongside a previously-graphed "status quo net migration & status quo family support policies scenario." To summarize, for net positive migration countries, we graph the four

combination scenarios listed in table 6. Note that fertility rate assumptions combine the impacts from changes to family support policies with the impacts from changes in the number of immigrants (whose fertility rates vary from natives) in the general population:

Table 6. Combination scenarios for countries with net positive migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) 2X status quo net migration & strong egalitarian family support policies	2X average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR + 0.35 by 2036
(2) ½ status quo net migration & strong egalitarian family support policy	½ average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR + 0.275 by 2036
(3) status quo net migration & status quo family support policies	Continuation of the country's average annual net migration level for the past 20 years for rest of the century	TFR the same as under status quo fertility scenarios
(4) ½ status quo net migration & strong neoliberal family support policies	½ average annual net migration level by 2026, held stable for the rest of the century	Status quo TFR - 0.325 by 2036

We treat our eight negative net migration countries, all in central or eastern Europe, somewhat differently. As already noted, these countries have low fertility rates, little immigration and often significant numbers of younger workers emigrating. Their policy-makers are primarily concerned to avert excessive, or excessively rapid, population decline. Thus, rather than try to model the most likely combination scenarios for these countries, we have modelled those combination scenarios that show the full range of options for mitigating some or all of the population decline these countries face under a continuation of status quo population policies. These five combinations are summarized in table 7 below:

Table 7. Combination scenarios for countries with net negative migration

Scenario	Annual net migration level	Fertility rate assumptions
(1) 2X EU status quo net migration & strong egalitarian family support policies	Net migration level equal to 2X the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR + 0.4 by 2036
(2) EU status quo net migration & strong egalitarian family support policy	Net migration level equal to the recent average EU net migration rate by 2026, held constant for the rest of the century	Status quo TFR + 0.35 by 2036
(3) EU status quo net migration & status quo family support policies	Net migration level equal to the recent average EU net migration rate by 2026, held constant for the rest of the century	TFR the same as under status quo fertility scenarios
(4) Zero net migration & strong egalitarian family support policies	0 net migration by 2026, held stable for the rest of the century	Status quo TFR + 0.3 by 2036
(5) Zero net migration & status quo family support policies	0 net migration by 2026, held stable for the rest of the century	TFR the same as under status quo fertility scenarios

Again, increasing net migration even more is possible, as is continuing negative net migration. The demographic results of following these paths, in combination with changes to family support policies, can be roughly estimated by consulting our more extreme immigration scenarios (4X EU status quo and continued net negative migration). And similarly, increasing family support policies more modestly is possible, with results that would fall within the range laid out within these combination scenarios. Together, the combination scenarios projected for positive and negative net migration countries provide a fuller sense of the demographic futures on offer and the policy options available to the countries of the European Union.

Projection methods

Our population projections use the deterministic cohort-component method. Initial population numbers by age and sex are projected forward in annual increments based on three primary factors: fertility rates, mortality rates, and net migration levels. The base year for all projections is 2016. Our source for baseline 2016 data on population numbers by sex and age, national TFRs, life expectancy at birth and net migration figures is the European Statistical Office (Eurostat). We use 2016 as our base year because at the time we made the projections that was the most recent year for which actual TFR figures were available. For changes to life expectancy, we use the sex specific assumptions of the baseline scenario of the Eurostat 2015 population projections until 2080, then hold these constant until the end of the century. In order to work with age-specific mortality rates, we use the UN's country specific model life tables. To calculate our "status quo net migration" values, we average the annual figures of net migration from Eurostat for the twenty-year period from 1998 to 2017, assume equal proportions between the sexes, and use the UN's country specific migration age distributions.

We have calculated our projections using the Spectrum policy development and planning tool, version 5.71, using its DemProj software model developed by Avenir Health (Stover et al. 2010). All changes to TFR assume a linear change phased in between 2016 and 2036, while all changes to net migration rates are phased in between 2016 and 2026. Appendix I gives population projections for all EU member states, including the United Kingdom (which may or may not be a member of the EU by the time this study is published), plus Norway. Appendix II provides tables showing fertility rates and net migration numbers for all scenarios across all countries in the study.

Projection results

For an introduction to the results, consider our projections for a relatively representative country in Western Europe. The Netherlands had a population in 1950 of 10.0 million and its current (2016) population is 17.0 million. Its current total fertility rate is 1.66, very close to the EU average. Holland's most recent (2016) net migration level was 78,864 and average annual net migration over the past 20 years (1998-2017) averaged 26,427. Here are the country's projections under our nine fertility and net migration scenarios:

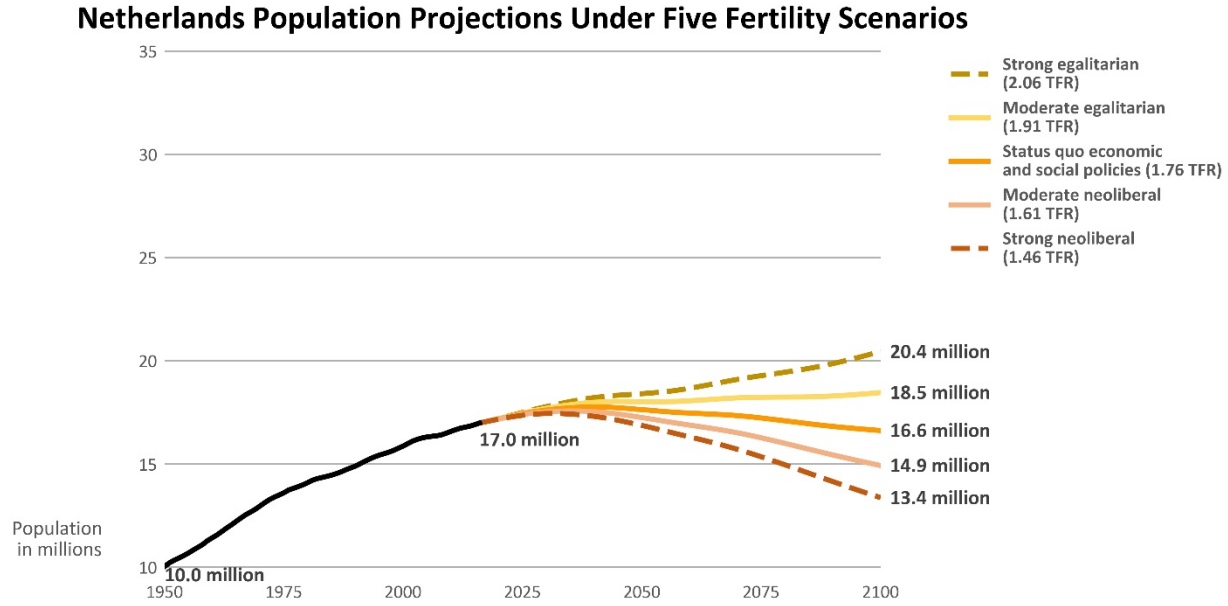

Figure 8. All scenarios assume the continuation of the past 20 years average annual net migration level (26,427). Source: own calculations

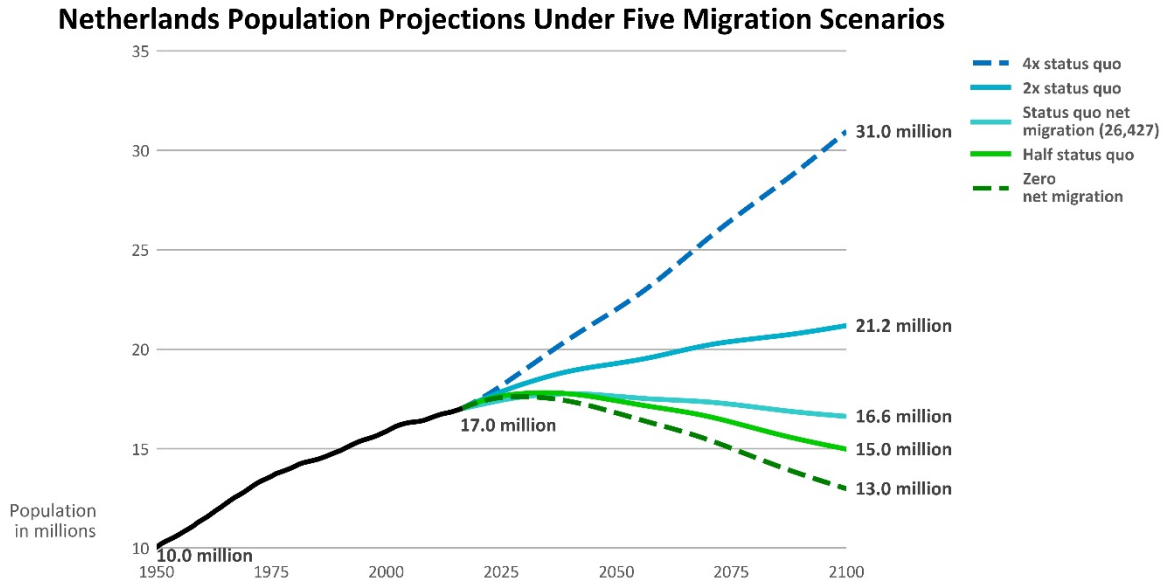

Figure 9. Status quo migration is the continuation of the past 20 years average annual net migration level (26,427). Migration scenarios use total fertility rates varying between 1.71 and 1.96, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Looking at these charts (and the tables that accompany them in appendix I), readers can begin to see how current policy choices could influence future population numbers. For example, given a continuation of current immigration numbers and current family support and economic policies, the Dutch population is set to decline from 17.0 to 16.6 million by 2100, a modest 2% decrease. Moderate improvements or cuts to the economic safety net could add or subtract between 1.7 and 1.9 million to/from that total by influencing national fertility rates. Doubling net migration, meanwhile, could add 4.6 million to Holland's population, while cutting net migration in half instead could decrease the population by 1.6 million. This represents the difference between a 25% increase and a 12% decrease in total population between now and 2100.

Holland contains about 3.3% of the total EU population. Zooming out for an overview, consider our projections for the European Union as a whole. The current 28 countries in the EU had a combined population in 1950 of 379.8 million and their current (2016) combined

population is 510.3 million.[14] The region's current total fertility rate is 1.60, its most recent (2016) net migration level was 1,222,979 and its average annual net migration level over the past 20 years (1998-2017) was 1,188,235. Here are the population projections for the region under our five fertility policy scenarios:

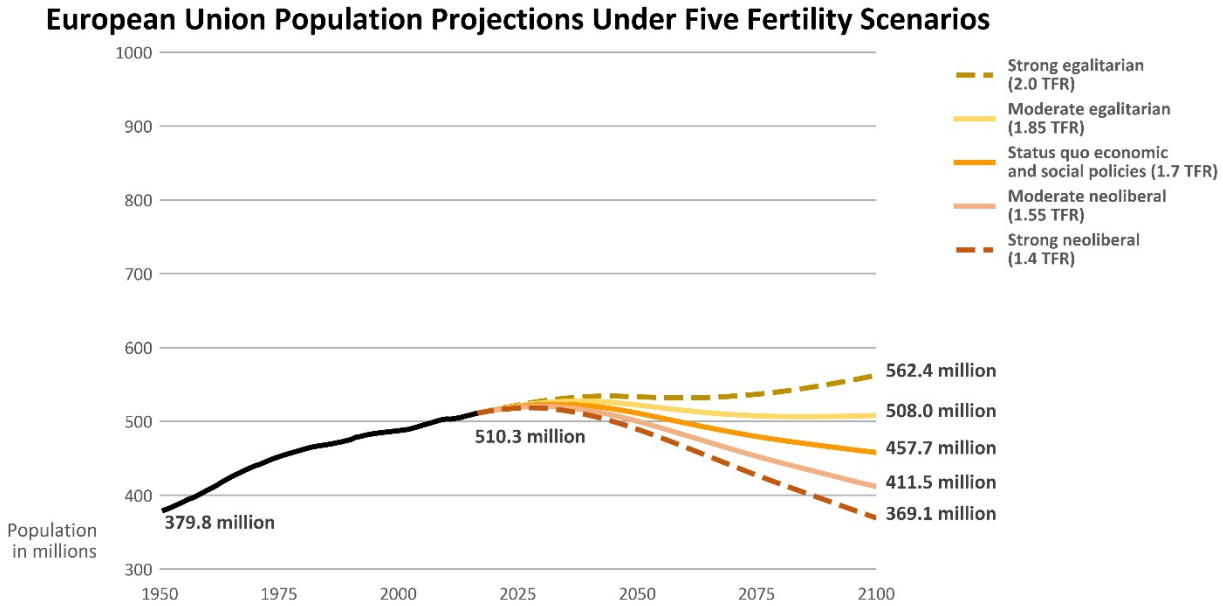

Figure 10. All scenarios assume the continuation of the past 20 years average annual net migration level (1,188,235). Source: own calculations

Under a continuation of status quo family support and economic policies (and an extension of current immigration levels), we would expect a 10% decrease in the EU population: from 510.3 million to 457.7 million.[15] This would be significant but not overwhelming, spread out over eight decades. A relatively modest turn toward less generous support for family formation, under the moderate neoliberal scenario, would accelerate population decrease, leading instead to a 19% population decline (again, leaving migration policy as is). On the other hand,

[14] Note that past, present and future numbers for "the EU" are all for the EU's current members, including UK.
[15] It is important to remember that these policies mostly are set at the national rather than the EU level. An approximate continuation of the status quo might involve decreasing family support (and fertility) in some countries while increasing family support (and fertility) in others, so as not to change the average TFR. Similarly, a combination of higher and lower national net migration numbers could preserve "status quo" net migration across the EU.

more generous support for workers and their families, under the moderate egalitarian scenario, would increase fertility rates sufficiently to avoid any population decline, leading to a population in 2100 virtually the same size as today's. Given wide disparities among EU countries in economic support systems, commitments to egalitarian relations between the sexes, and financial support for having children, there seems sufficient scope for enacting such policies and thus avoiding a decline if that is desired. The full range of fertility-related policy scenarios (dashed lines), from strong neoliberal to strong egalitarian policies, leads to populations ranging in 2100 from 369.1 million (a 28% decline) to 562.4 million (a 10% increase): almost a 200 million spread.

Here are our population projections for the EU as a whole under our net migration policy scenarios:

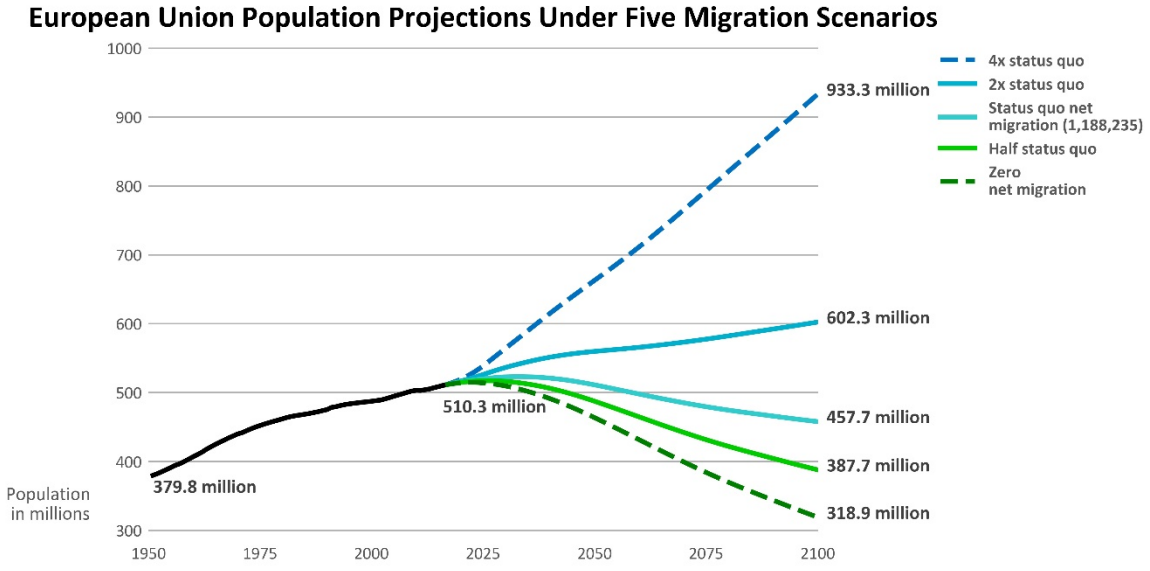

Figure 11. Status quo migration is the continuation of the past 20 years average annual net migration level (1,188,235). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Over the past twenty years, net migration across the EU has averaged about 1.2 million yearly. Again, continuing this status quo (along with status quo family support policies and

economic safety net policies) would lead to a 10% population decrease, or 52.6 million fewer people in 2100. However, altering immigration levels provides much greater scope for increasing or decreasing the total EU population, compared to changing fertility-related policies. Cutting net average migration in half would reduce the EU population by an additional 70 million people, or an extra 14% compared to the population loss under the status quo scenario, for a total drop of 122.6 million people by 2100 (24%) compared to the current (2016) population. Doubling net migration, conversely, would switch the EU's population from declining by 52.6 million (10%) under the status quo to growing by 92.0 million (18%). That's a swing of 214.6 million people across our most likely range of immigration policy changes. The spread across the full range of policy choices is much greater: over 600 million people, from swelling to 933.3 million in 2100 (an 83% increase) in the case of quadrupling status quo net migration numbers, to contracting to only 318.9 million in 2100 (a 38% decline) by reducing net migration to zero.

Here are our population projections for the EU under our combination scenarios:

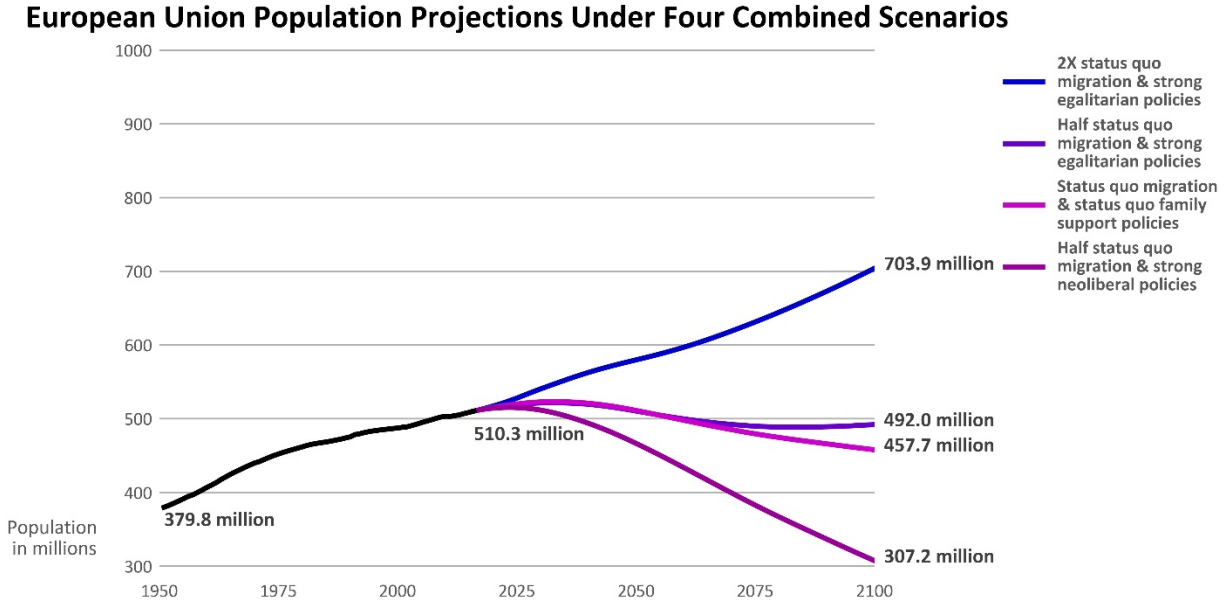

Figure 12. Status quo migration is the continuation of the past 20 years average annual net migration level (1,188,235). Combination scenarios use total fertility rates varying between 1.37 and 2.05, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

Doubling recent average net migration levels and at the same time improving family support through egalitarian social and economic policies lead to an increase of 193.6 million people, or 38% by the end of the century. In contrast, cutting immigration in half and cutting back on social and economic support for family formation leads to a population decline of over two hundred million people (203.1 million less, a 40% decline). Interestingly, combining decreased migration levels (halving the recent average level) with significant improvements in family support under a strong egalitarian policy shift leads to a relatively stable population: 18.3 million fewer people by the end of the century, a decrease of only 3.6%. Of course, it is important to remember that this overview masks large differences between individual countries and regions. Under regionwide EU scenarios where overall population numbers increase, some countries' populations would still decrease, and vice versa in the case of EU scenarios resulting in overall population decreases. For a more fine-grained picture, turn to appendix I for our projections for individual countries.

Regional differences

Despite their shared experience of dealing with the second demographic transition, EU nations all face somewhat different population futures and policy choices. In particular, it is worth highlighting the substantial differences among four different regions of the EU.

Central and Eastern Europe. Under status quo policies, many low fertility / net emigration countries are on track for steep population declines this century. An example is Romania:

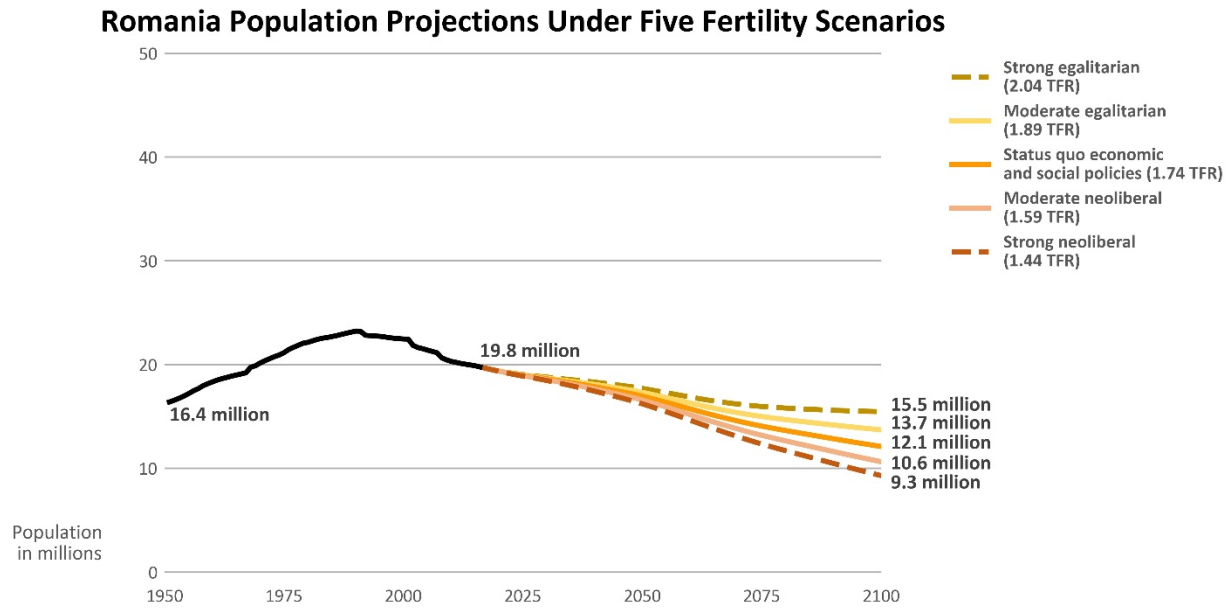

Figure 13. All scenarios assume zero net migration level. Source: own calculations

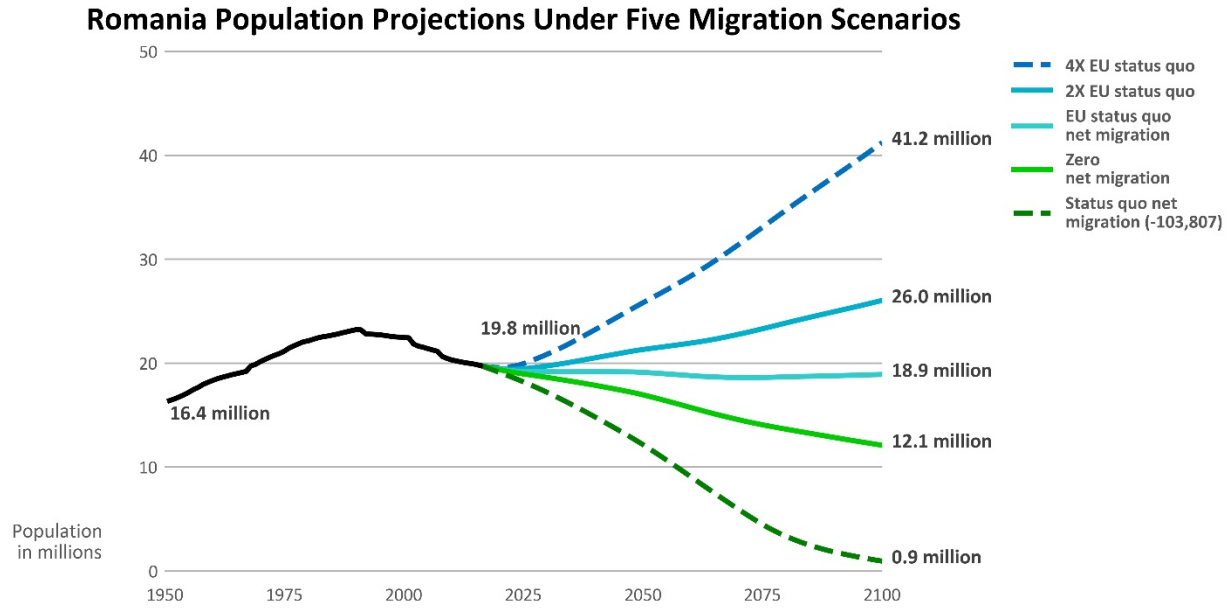

Figure 14. Status quo migration is the continuation of the past 20 years average annual net migration level (-103,807). Migration scenarios use total fertility rates varying between 1.74 and 1.94, with higher immigration levels projected to drive higher TFRs. Source: own calculations

The status quo net migration scenario, driven by heavy out-migration, obviously could never proceed to such a dramatic conclusion, because the flow of potential emigrants would dry

up well before 2100 as the total population decreased. But assuming zero net migration and status quo family-support and economic policies, under the status quo fertility policy scenario, Romania still is on track to lose 7.7 million people: a 39% decrease. Even under the strong egalitarian policy shift scenario, with zero net migration, great improvements to the economic safety net and greatly increased funds for family support policies, the county will decline by 4.3 million people by 2100, or 22%.[16]

Egalitarian economic and social policies could mitigate population declines in Central and Eastern Europe, to some degree, by increasing fertility rates and (potentially) decreasing emigration numbers. Working in tandem with increased immigration, these factors could be powerful, as shown by the combination scenarios below:

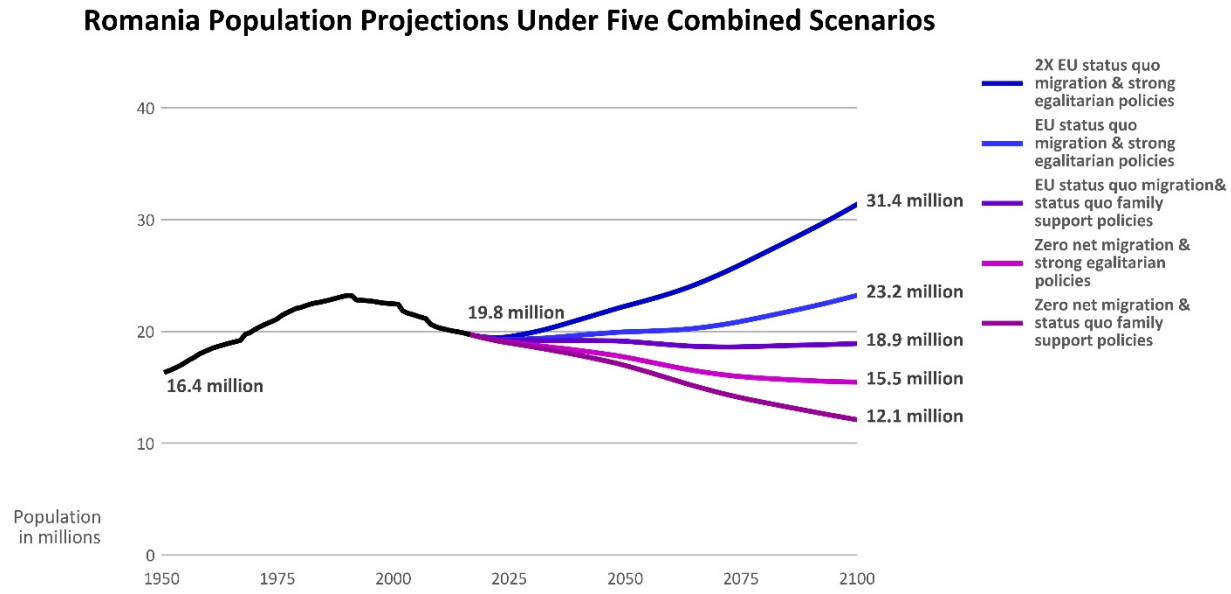

Figure 15. Projecting the EU status quo net migration rate onto Romania leads to an average annual net migration of 47,146. Combination scenarios use total fertility rates varying between 1.74 and 2.14, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

[16] Sobotka (2003) argues that the countries of Central Europe and Eastern Europe are following somewhat different paths, the former moving toward western European norms of later child-rearing and the latter shifting toward larger proportions of one-child families.

Beyond mitigating population decrease, this wide range of combination scenarios even shows the possibility of substantial population increase. The 11.6 million increase (58.5%) by 2100 in the top scenario would require a fairly extreme change in migration levels, with net migration corresponding to 2X EU migration rate. Perhaps a more achievable shift to zero net migration (representing moderate immigration increases combined with solving Romania's severe emigration problem) fused with strong egalitarian family support policies has good potential to mitigate depopulation. Under this scenario, Romania's population would decrease by only 4.3 million, or 22%. Decreased emigration and significant increases in immigration, sufficient to achieve the current EU average net migration rate or greater, could lead to stable or only slightly decreasing population numbers for countries in this region facing these demographic challenges, which include Bulgaria, Croatia, Slovakia, Poland and the Baltic states.

Southern Europe. Low fertility / high net migration countries such as Italy and Spain are propping up population numbers through high immigration levels under status quo policies.[17] These nations cannot cut back significantly on immigration without either embracing egalitarian economic and family support policies that increase fertility rates, or accepting significant population declines this century. This is illustrated by Spain:

[17] Greece and Portugal, averaging relatively modest positive net migration over the past twenty years, instead face steep population declines in coming decades under status quo scenarios. Their overall choices going forward are somewhat similar to Italy's and Spain's, however: accept higher net migration numbers, and boost support for family-formation and create stronger economic safety nets for common citizens, or accept rapid population decline.

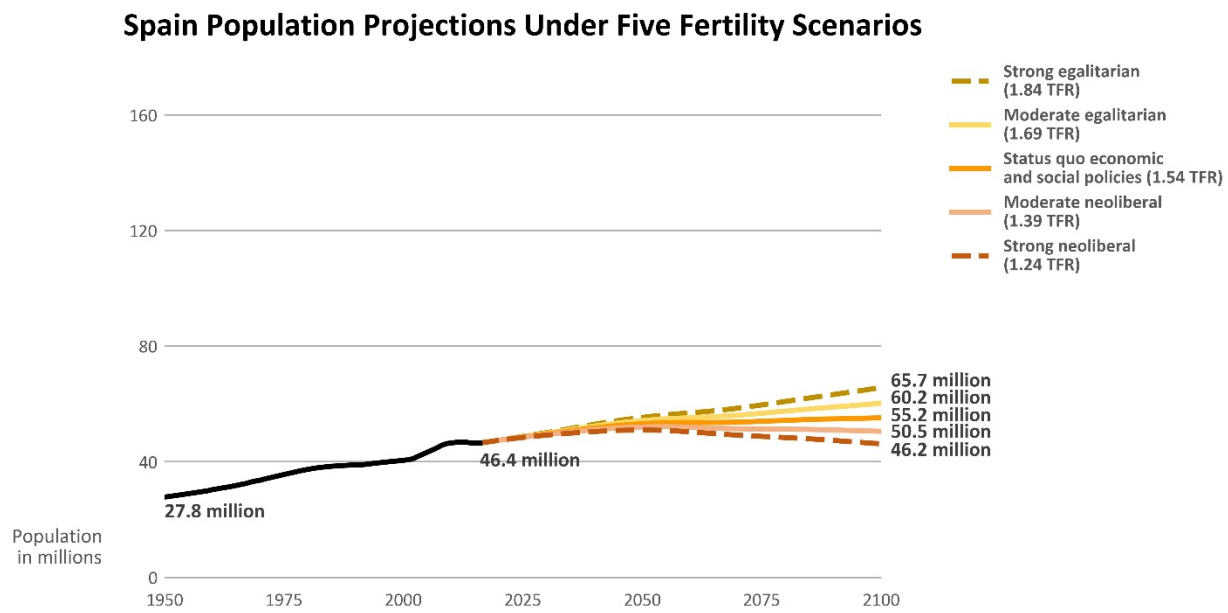

Figure 16. All scenarios assume the continuation of the past 20 years average annual net migration level (270,112). Source: own calculations

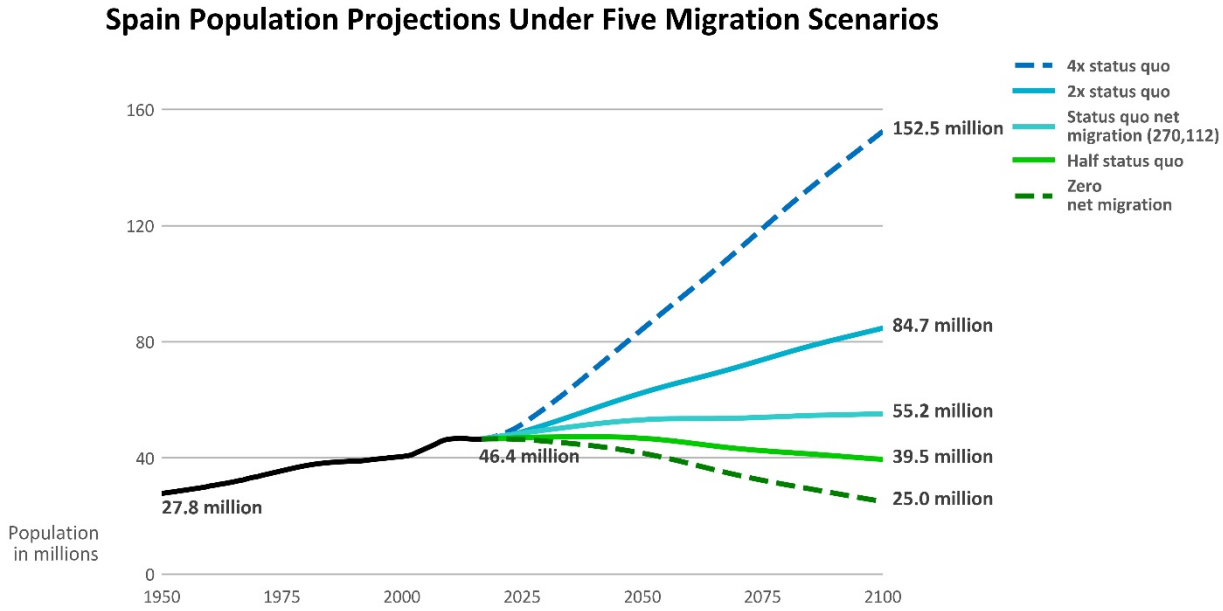

Figure 17. Status quo migration is the continuation of the past 20 years average annual net migration level (270,112). Migration scenarios use total fertility rates varying between 1.49 and 1.74, with higher immigration levels projected to drive higher TFRs. Source: own calculations

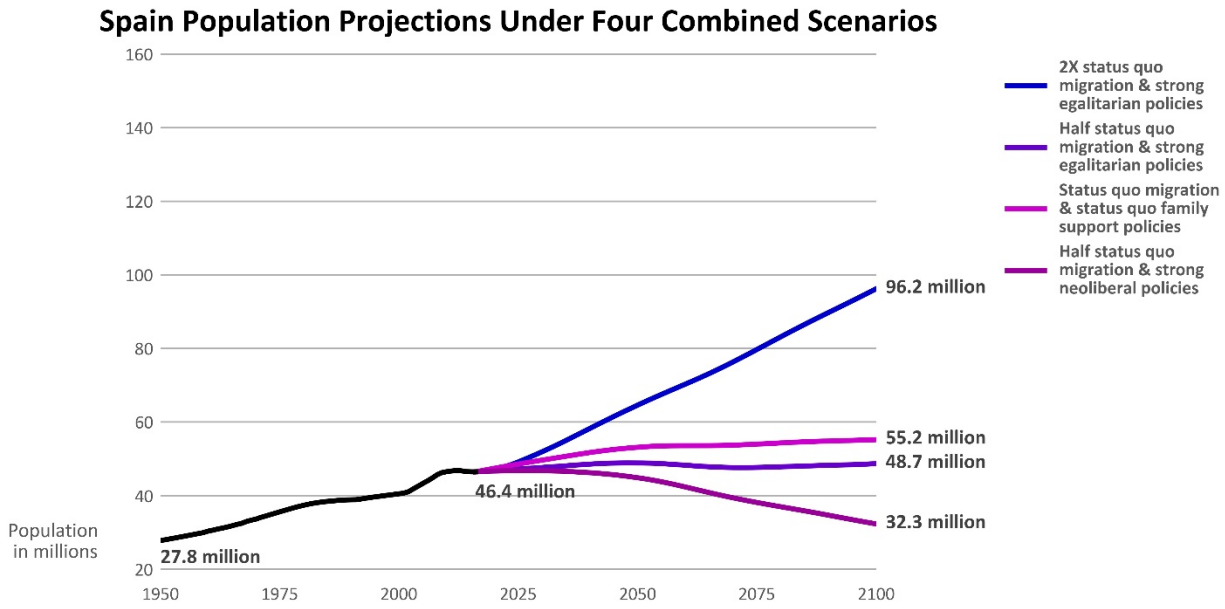

Figure 18. Status quo migration is the continuation of the past 20 years average annual net migration level (270,112). Combination scenarios use total fertility rates varying between 1.21 and 1.89, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

Over the past twenty years, Spain has had one of the highest net migration rates in the EU as a percentage of total population, and the highest overall annual net migration numbers. Without heavy immigration its population probably would already be declining, since its TFR has been below replacement rate since 1981 and stood at 1.34 in 2016. While Spain's near neighbor Italy seems to have little appetite for either continuing high levels of immigration or accepting rapid population decreases, Spaniards so far have remained relatively tolerant of high immigration levels, although this may be changing (Arango 2013).

What population policies these countries pursue in the future remain to be seen. Status quo migration and family support policies have Spain on track for a relatively small 16% (8.8 million) population increase during this century. As with Italy, comparing this status quo scenario with a scenario combining half status quo migration and a strong egalitarian shift in family support policies leads to relatively similar results, coalescing around a fairly stable population. Spain would experience a small population increase in both scenarios, Italy a small

population decrease. A clearer understanding of likely population declines under decreased net migration scenarios might lead to greater support for historically high levels of immigration. Perhaps a combination of increased support for family formation and economic security, decreased immigration, and acceptance of a relatively stable or slightly declining overall population might be most appealing to southern Europe's residents

Northern European countries with high fertility / high immigration will see significant population growth this century under status quo policies, and some growth under almost all plausible policy scenarios. An example is Sweden, which is on track to increase its population 52% by 2100 under status quo fertility and immigration policies:

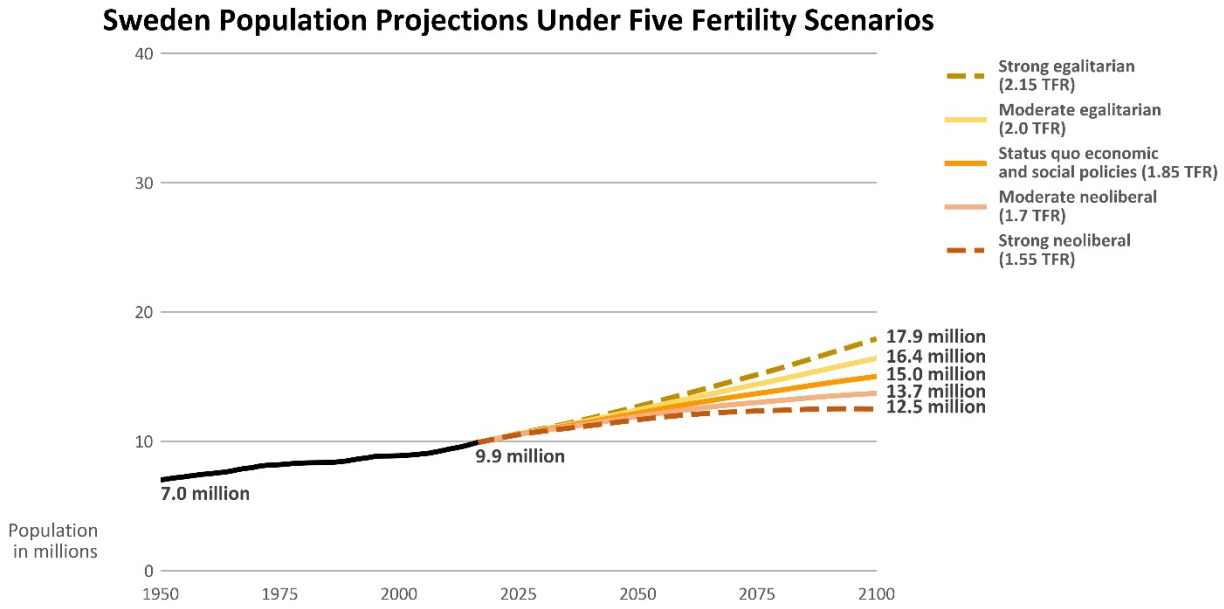

Figure 19. All scenarios assume the continuation of the past 20 years average annual net migration level (50,024). Source: own calculations

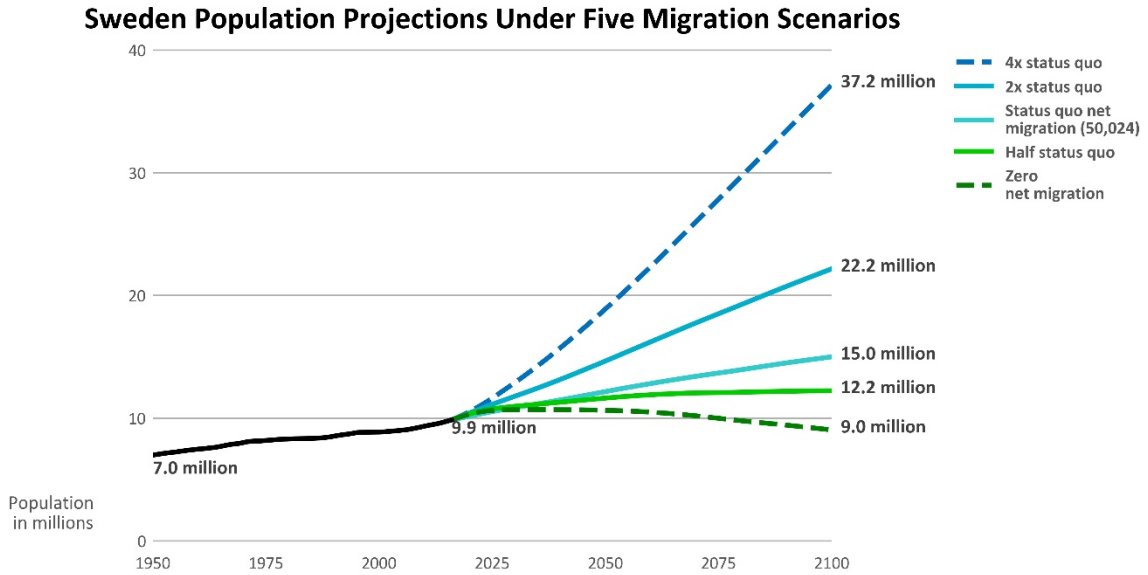

Figure 20. Status quo migration is the continuation of the past 20 years average annual net migration level (50,024). Migration scenarios use total fertility rates varying between 1.80 and 2.05, with higher immigration levels projected to drive higher TFRs. Source: own calculations

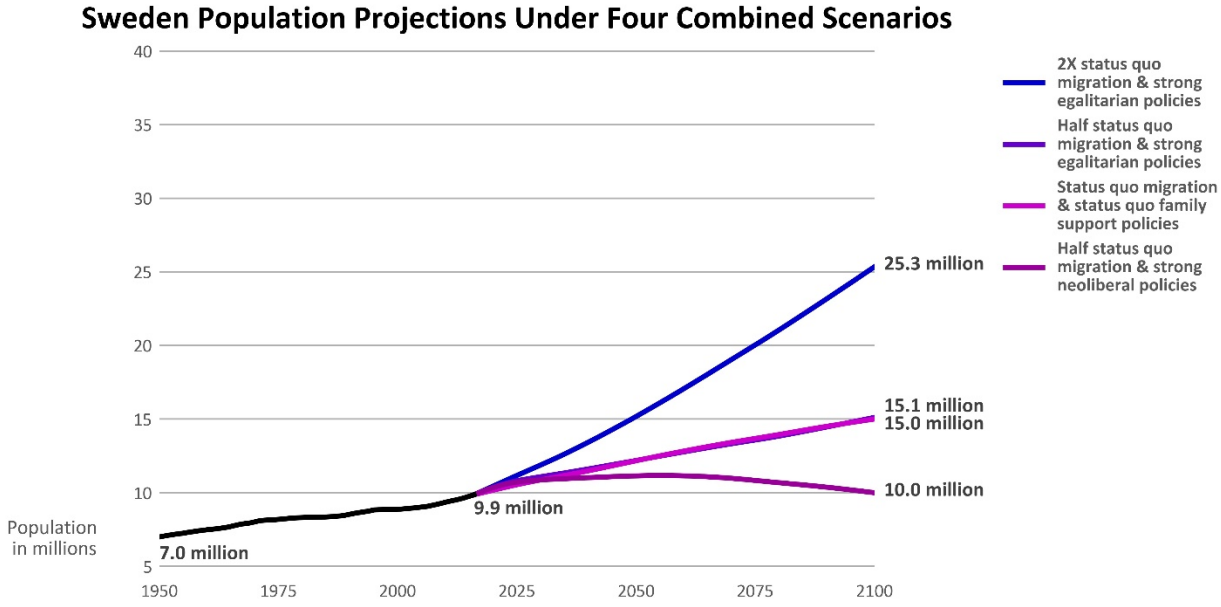

Figure 21. Status quo migration is the continuation of the past 20 years average annual net migration level (50,024). Combination scenarios use total fertility rates varying between 1.53 and 2.20, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

Increases in immigration levels could lead to much larger populations throughout Scandinavia: 100% to 200% increases, or even higher. Doubling net migration, which would

equal the net migration level the country experienced in 2016 and 2017, would increase Sweden's population by 124%, while increasing it 4X would increase the population by 276%. Doubling net migration while strengthening family support policies, as shown under the highest combination scenario, would lead to population increases of 156%. With wealthy societies, low population densities by European standards, and a post-war tradition in some countries of taking in large numbers of refugees, significant increases in immigration levels are a real possibility—although there is also considerable opposition to such increases, as demonstrated in recent elections across the region.

Like citizens in southern Europe, those in the North debate these policies with little understanding of their potential demographic consequences.[18] Sweden has a lively, ongoing debate about immigration policy (Götmark 2018). Yet whether they are for more or less immigration, few of its highly educated citizens have any idea of how annual immigration levels may affect future population numbers, or how those numbers may in turn affect their societies.

Western European countries with medium to high fertility / high immigration levels are on track for relatively stable to slightly increasing populations under status quo policy scenarios. Examples include Belgium, the Netherlands, Germany, the UK, and France (shown below):

[18] To the extent Europeans consider immigration's demographic changes, the focus is on the changing ethnic or religious composition of society, rather than changes in total population numbers. See for example (Stonawski et al. 2015; Pew Research Center 2017; Tarvainen 2018)

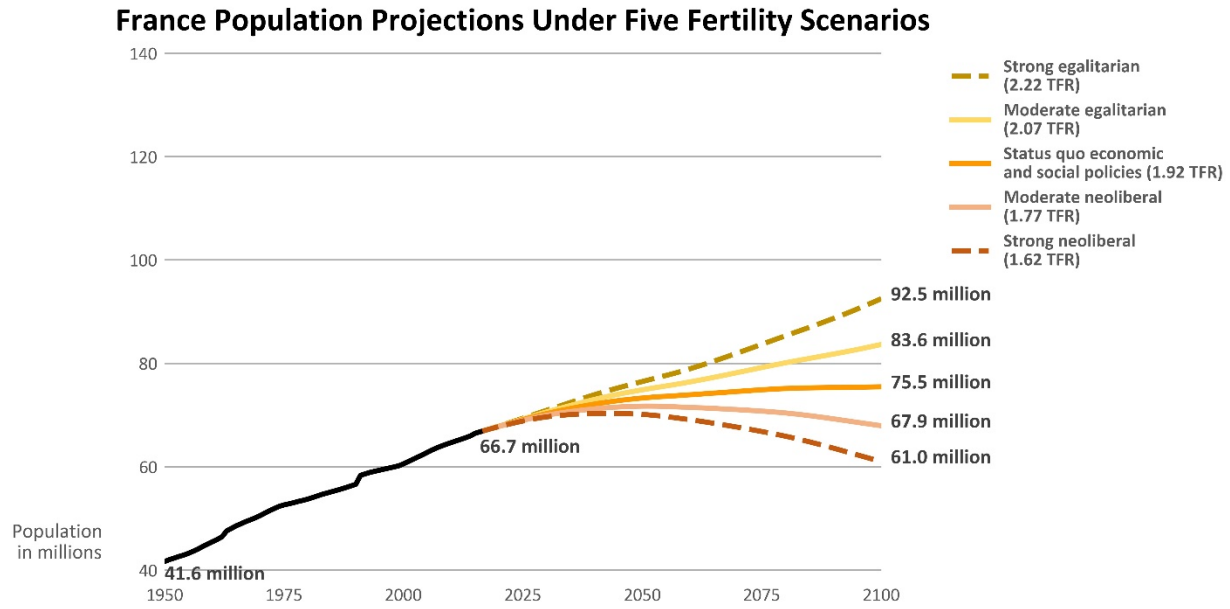

Figure 22. All scenarios assume the continuation of the past 20 years average annual net migration level (100,525). Source: own calculations

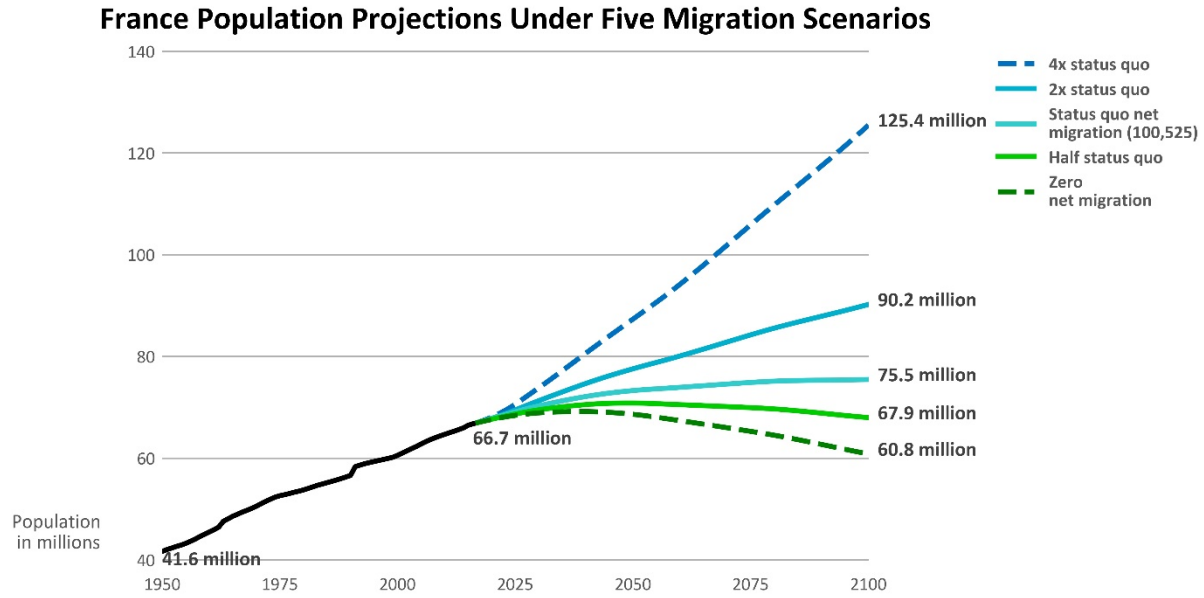

Figure 23. Status quo migration is the continuation of the past 20 years average annual net migration level (100,525). Migration scenarios use total fertility rates varying between 1.87 and 2.12, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Under a continuation of status quo fertility and immigration policies, France is on track to increase its population by 8.8 million people by 2100, or 13%. The more likely fertility policy scenarios (moderate egalitarian and moderate neoliberal policy shifts) open up a slight policy

space for essentially stabilizing (+2%) or more substantially increasing (+25%) France's population. The more likely migration policy scenarios (2X and half status quo migration) open up a somewhat larger space (+2% to +35%). But only the 4X status quo net migration scenario contemplates truly drastic changes to Frances 2100 population: a 57.7 million increase, or +88%. There is little desire for such a large increase in immigration, however, just as there is little interest in drastically cutting back on France's generous family support policies in ways that might lead to future population decreases.

While increases in immigration levels could lead to much larger populations, decreases could lead to smaller ones. These countries, like the Scandinavian nations, arguably face a range of appealing demographic futures from which to choose. Because the more likely policy choices do not lead to future population numbers that are radically higher or lower than current ones, citizens in these countries, like those in the rest of Europe, typically discuss such policy matters in a demographic vacuum.[19] This seems to us a mistake. Whether considering matters from an economic, environmental, social or political angle, the impacts of different population policies can be quite substantial (we look at some potential environmental impacts below, in the sections on greenhouse gas emissions and biodiversity conservation).

In addition to these broad regional differences, countries within every region face more or less unique demographic challenges and opportunities. At the same time, shared membership in the EU ties them all together in EU-wide policy-making endeavors and, to some degree, in a common demographic destiny.

[19] But not all of them. The Club van Tien Miljoen in the Netherlands argues for voluntary decreases in childbearing and immigration reductions in order to bring the Dutch population down from its current 17 million to an ecologically sustainable 10 million. The UK-based group Population Matters argues for ending population growth both nationally and globally; it is the largest and most influential such organization in the EU. Both the Netherlands and the UK have very high population densities, relative to other countries in Europe and around the globe.

Policy implications

What further conclusions can we draw from these projections, particularly regarding potential guidance for EU policy-makers? We would direct attention to four key results.

(1) Migration policy offers greater scope for influencing future population numbers than changes to family support policies, or changes to other fertility-related economic policies in the EU.

Changing fertility does influence population size, and economic and social policy can influence fertility rates. But in the context of relatively low-fertility regimes where policy changes' impacts on fertility are often fairly small, resulting in fertility rates that are still sub-replacement, changes to national immigration levels could have a much greater impact going forward. Compare Germany's fertility policy and migration policy projections:

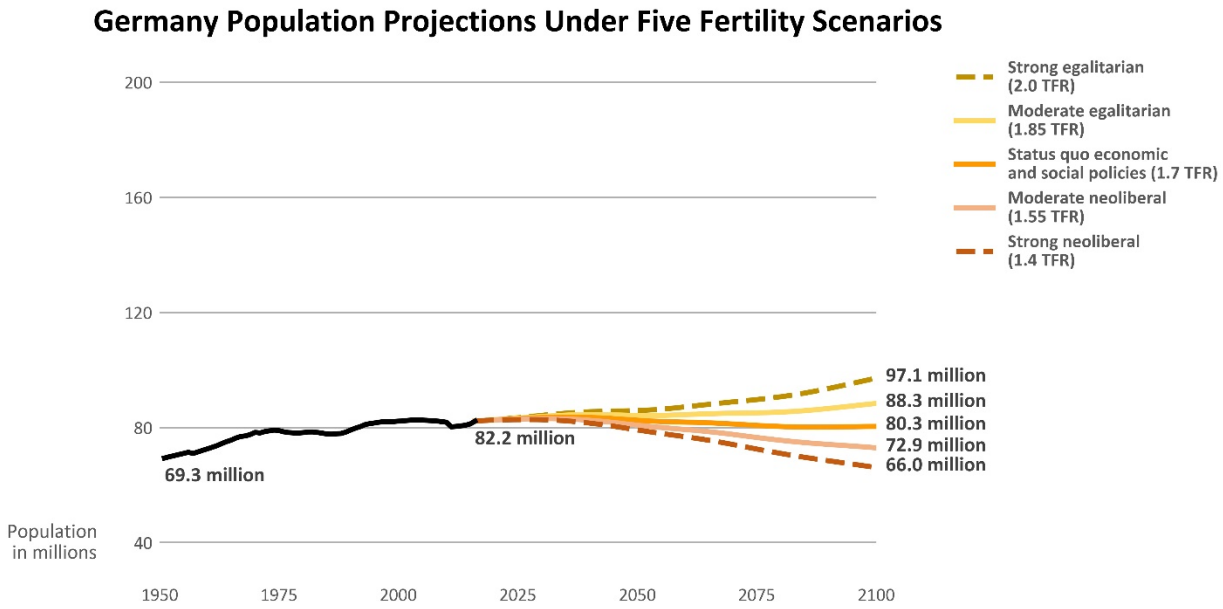

Figure 24. All scenarios assume the continuation of the past 20 years average annual net migration level (259,316). Source: own calculations

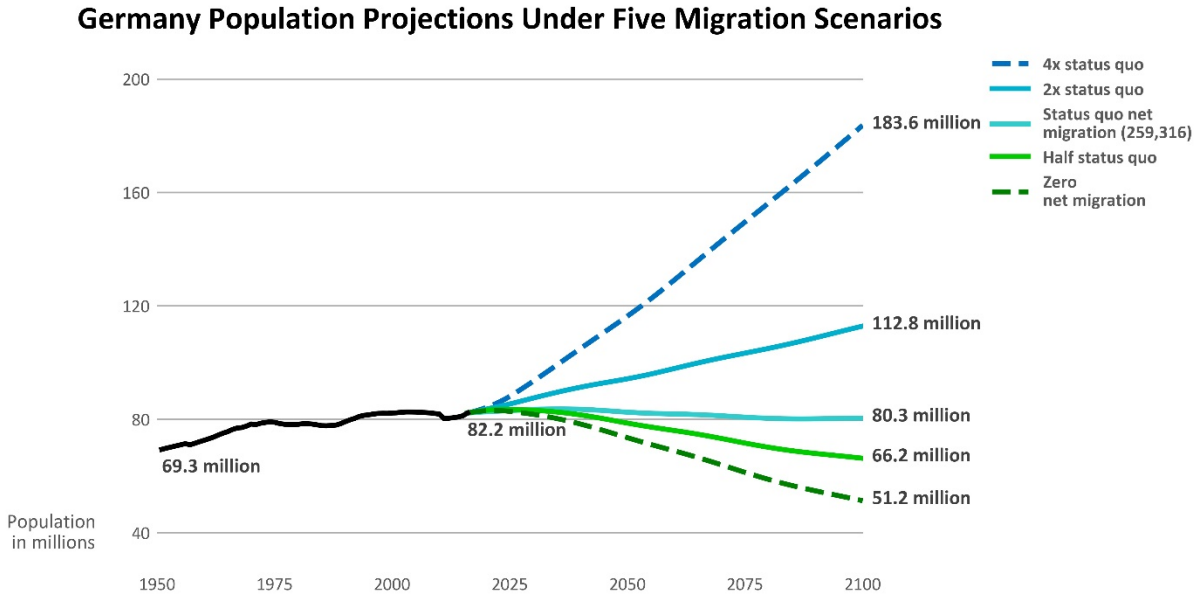

Figure 25. Status quo migration is the continuation of the past 20 years average annual net migration level (259,316). Migration scenarios use total fertility rates varying between 1.65 and 1.90, with higher immigration levels projected to drive higher TFRs. Source: own calculations

The most likely scenarios for fertility variation range between 1.55 TFR and 1.85 TFR, leading to a potential difference of 15.4 million people in 2100 (72.9 million versus 88.3 million). In contrast, the three most likely net migration scenarios generate a 3X greater

population range in 2100: 46.6 million people. Considering the full range of fertility change scenarios, including less likely but still possible low and high scenarios of 1.4 TFR to 2.0 TFR, doubles the potential range for the 2100 population to 31.1 million. But considering the full range of net migration scenarios increases the 2100 population variability to 132.4 million—over 100 million more. While the full range of fertility scenarios all lead to populations in 2100 that are broadly commensurate with Germany's present population of 82.2 million (80% to 118% of current numbers), the extreme migration scenarios would lead to much more drastic changes: from 62% of the current population (51.2 million) under the lowest scenario to 223% of the current population (183.6 million) under the highest. Similar results, with much higher ranges across migration scenarios than fertility scenarios, obtain for most EU countries.

(2) In most cases, EU nations are well placed to stabilize or slowly reduce their populations–thus achieving one of the necessary conditions for creating ecologically sustainable societies.

We can see this in many of the status quo scenarios, which tend to stay relatively flat throughout the 21st century: often within 10% of current population figures (Holland, Italy, Germany) and if not, then within 20% of current numbers (France, Spain, Denmark, Czech Republic). In replenishing their populations, these countries have room to shift the balance somewhat between immigration and births to citizens, either in one direction or the other, while still keeping their populations stable or declining. This is shown, for example, in the comparison of the status quo scenario and ½ immigration & increased fertility combination scenario for the Czech Republic in figure 26 below:

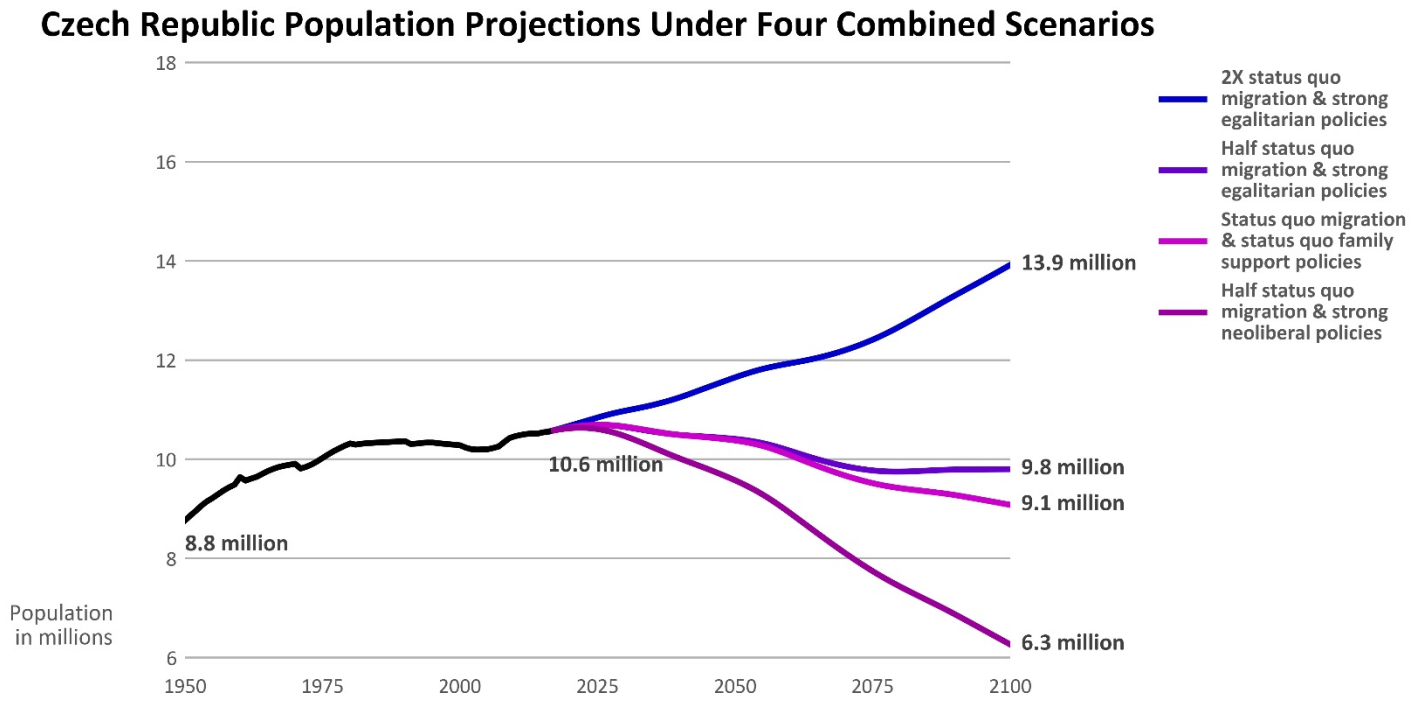

Figure 26. Status quo migration is the continuation of the past 20 years average annual net migration level (18,747). Combination scenarios use total fertility rates varying between 1.40 and 2.08, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

For the EU as a whole, the status quo policy scenario leads to a 10.5 % reduction by 2100, from 511.5 million today to 457.7 million in 2100. Taking the economic challenges into account, this seems like a manageable decrease, spread out over more than 80 years.

A few countries, like Sweden and the United Kingdom, are set for higher population increases this century (52% and 24% respectively) under the status quo fertility and migration scenarios. Such increases could be mitigated or avoided altogether by decreasing net migration, as can be seen by considering the migration scenario projections for the UK:

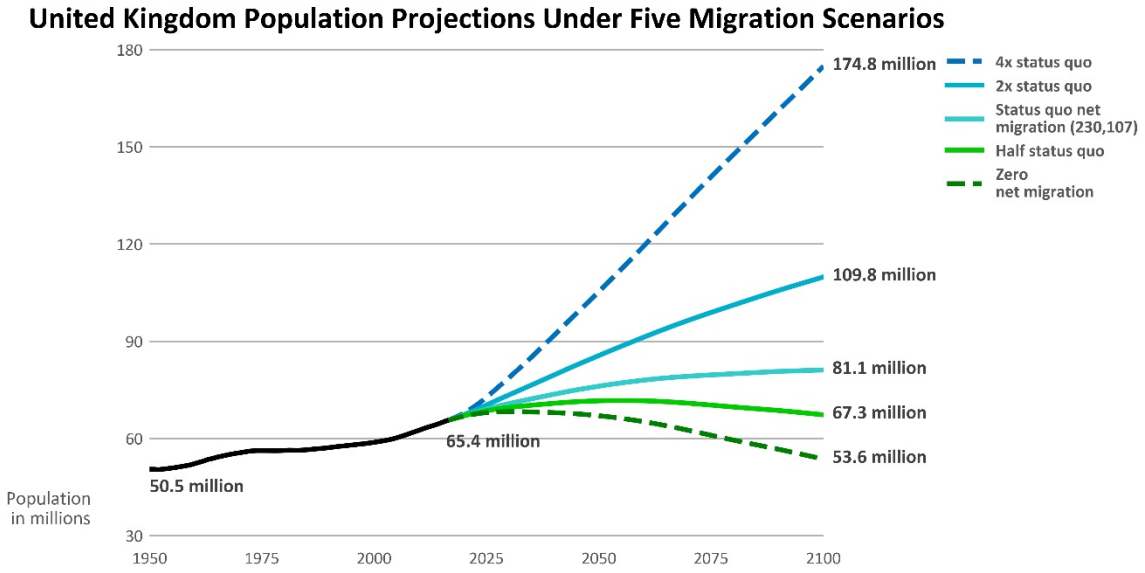

Figure 27. Status quo migration is the continuation of the past 20 years average annual net migration level (230,107). Migration scenarios use total fertility rates varying between 1.74 and 1.99, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Cutting projected net migration to half the last 20 years average decreases the UK's projected population growth between 2016 and 2100 from 24% to 3%—essentially stable. Cutting migration further could lead to a moderately decreasing population. Judging by the recent Brexit vote, there exists considerable support within the UK for some decrease in immigration. In contrast, decreasing fertility rates through neo-liberal policy shifts likely would be less popular with the general public and would result in much smaller decreases in UK population growth, as seen by looking at our projections of plausible UK fertility policy scenarios:

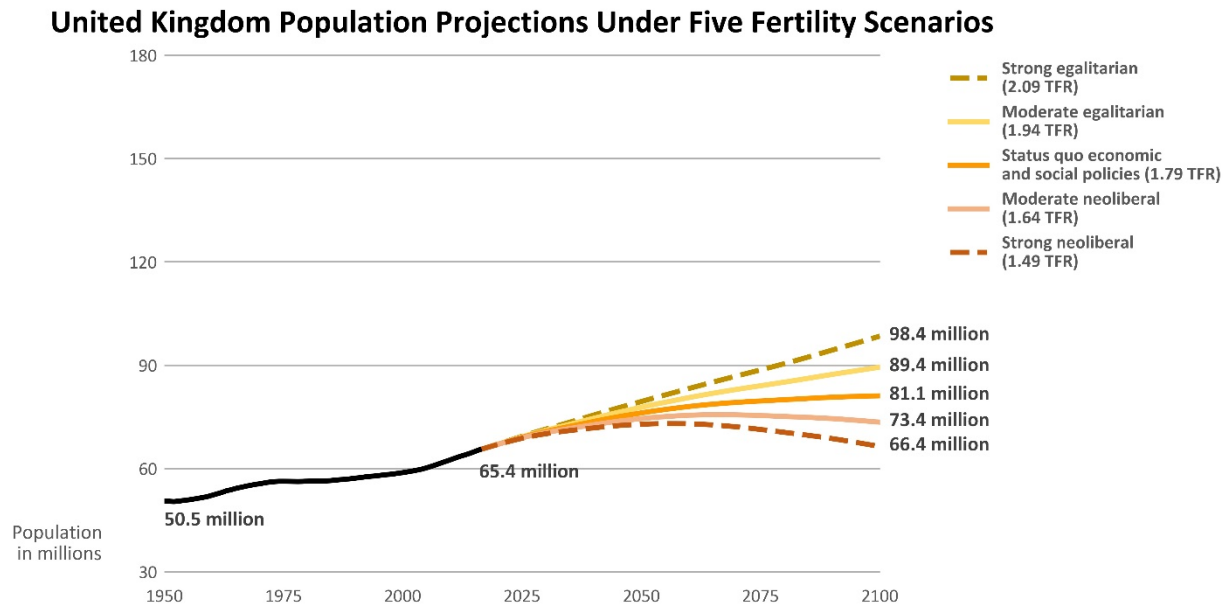

Figure 28. All scenarios assume the continuation of the past 20 years average annual net migration level (230,107). Source: own calculations

(3) Egalitarian economic and family support policies and increased net migration have significant potential to mitigate excessive population decreases in the EU's lower fertility countries.

Several eastern European countries with low fertility levels and high emigration rates are on track for rapid population decreases this century. While the dangers of small population decreases are often overblown, too large or too quick decreases could cause social problems in these societies (Rees et al. 2012; Jakovljevic and Laaser 2015). So it is good to know that part of this potential decrease could be avoided by adopting the economic and family support policies that have proven so successful at boosting fertility rates in northern Europe.[20] Consider our fertility scenarios for Poland:

[20] For good policy suggestions, see (Oláh 2015).

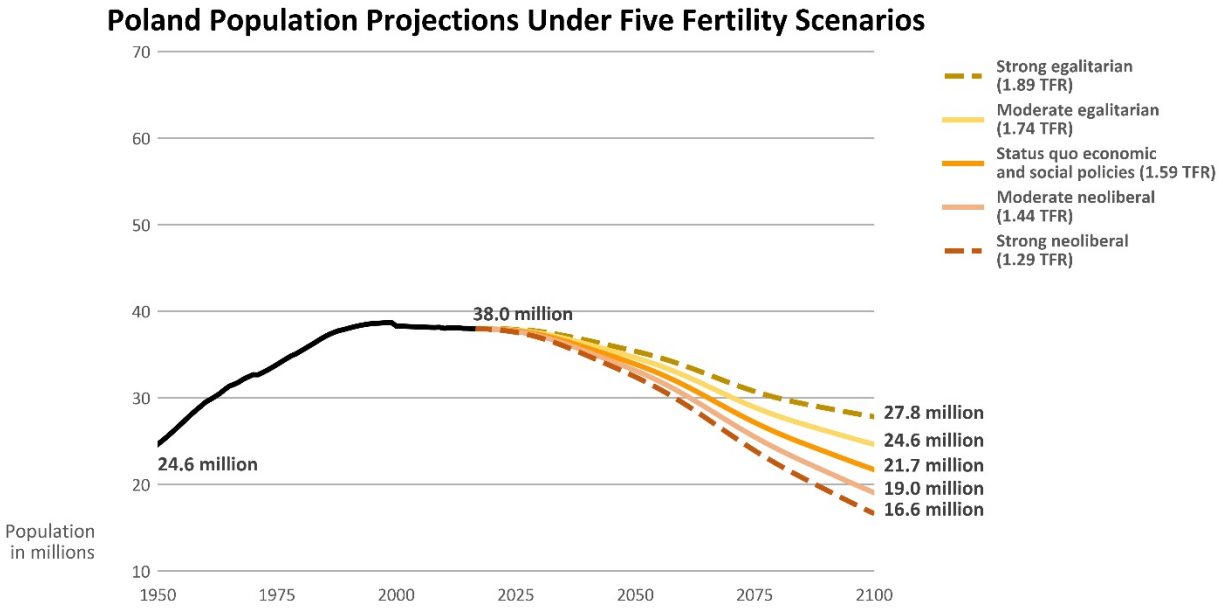

Figure 29. All scenarios assume zero net migration level. Source: own calculations

Under status quo policies that provide little support for women who want to combine careers with creating a family, Poland's population is set to decline by 43% by 2100, from 38 million to 21.7 million. A shift to strongly egalitarian policies could increase Polish fertility rates from 1.59 TFR to 1.89 TFR, leaving the country with a 27% decrease instead.[21] That is still a substantial decrease, but more manageable. Perhaps some part of this decrease is acceptable to Poles; the rest might be avoided by addressing migration issues, as can be seen by looking at our Polish migration scenarios:

[21] Reading (Mishtal 2009) suggests that the right policies could raise fertility rates even higher.

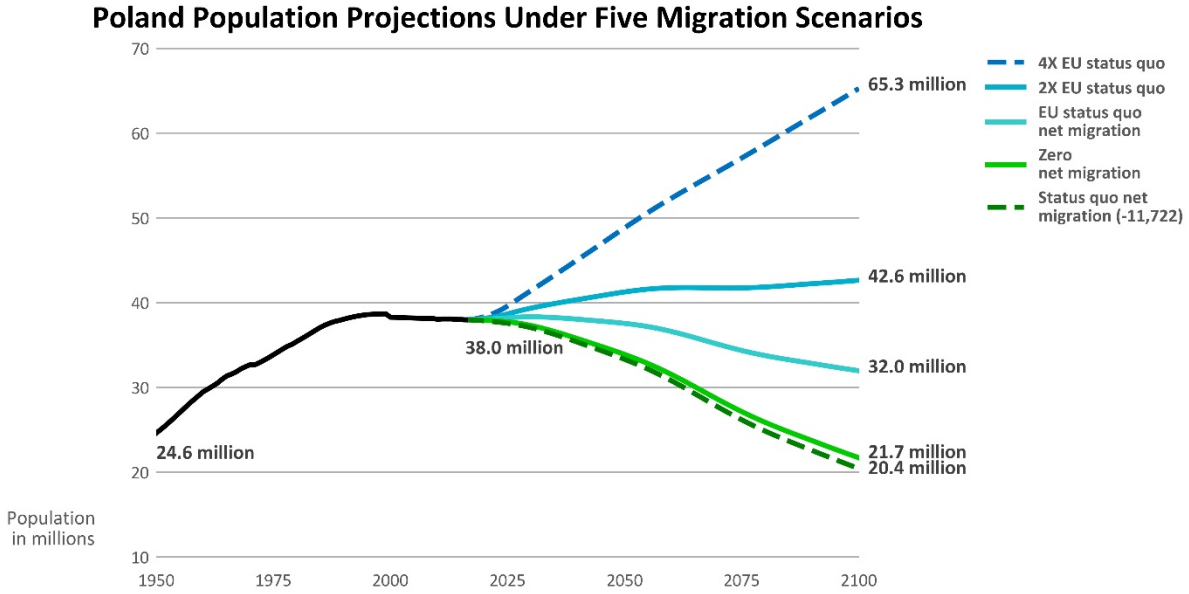

Figure 30. Status quo migration is the continuation of the past 20 years average annual net migration level (-11,722). Migration scenarios use total fertility rates varying between 1.59 and 1.79, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Poland is a net negative migration country, with emigration exceeding immigration by more than 11,000 annually over the past twenty years. Improving job opportunities within the country and expanding the economic safety net could help decrease emigration. Allowing more immigration into the country (current numbers are quite low) would also push up net migration. According to our projections, moving from Poland's current net negative migration status quo to the EU's current status quo net migration rate would increase the country's population in 2100 by 11.6 million people, avoiding most future population decrease. Combining more egalitarian family support and economic policies with increased net migration could potentially avoid all predicted population decrease for Poland during this century, as can be seen in the combination scenarios below:

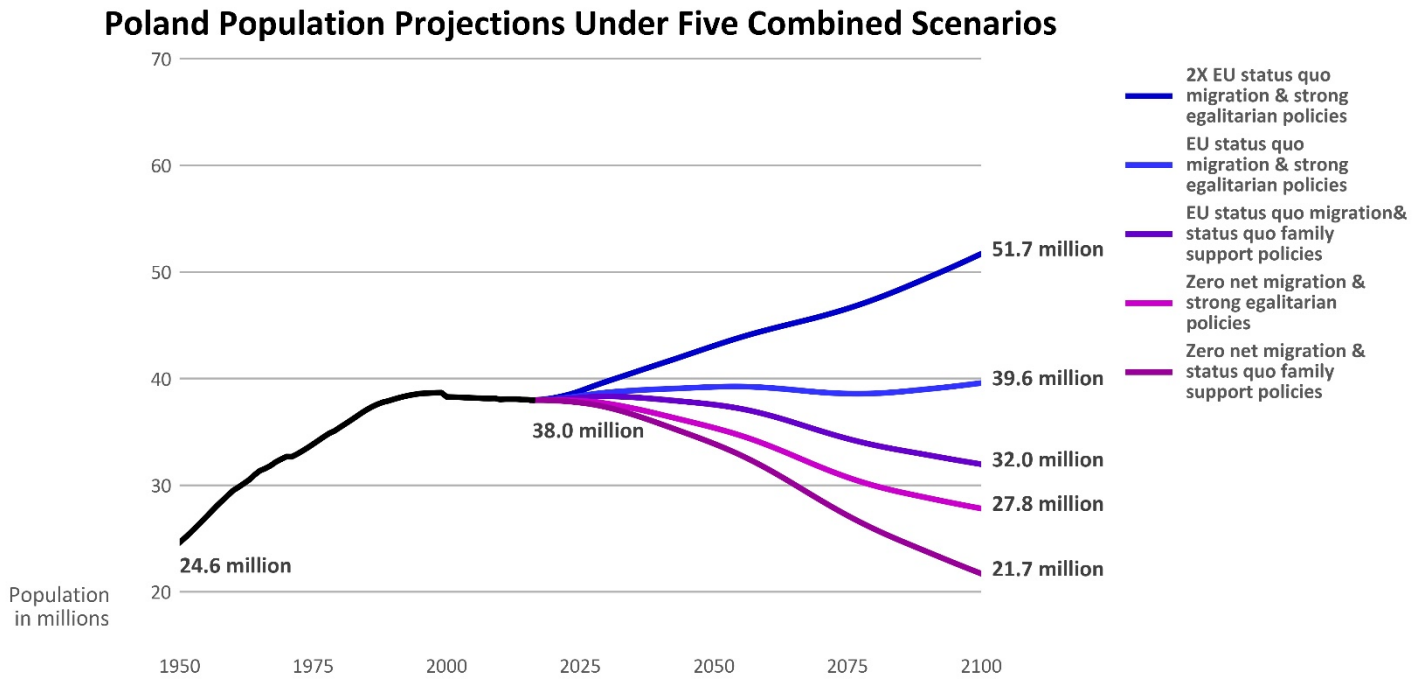

Figure 31. Projecting the EU status quo net migration rate onto Poland leads to an average annual net migration of 91,135. Combination scenarios use total fertility rates varying between 1.59 and 1.99, with higher immigration levels and increased support for family formation projected to drive higher TFRs. Source: own calculations

Combining increased net migration up to the current EU status quo net migration rate with a strong increase in support for family formation would slightly increase Poland's total population: 1.6 million more in 2100, or a 4% increase. Higher immigration levels could lead to even more robust population growth. Similar reflections apply to Romania, Bulgaria, Italy, Portugal, Greece and other countries in eastern and southern Europe that could see significant population losses over the next 80 years. It is particularly noteworthy that some of the same economic policies that could raise national fertility rates might also increase economic security, thus decreasing emigration by younger workers, convincing some emigrants to return, and attracting more immigrants. While these policies, such as improved child-care programs and paid family leave for workers, are expensive, they hold out hope for a slow, manageable population decrease rather than a precipitous decline in these countries (Frejka and Gietel-Basten 2016).

(4) Demographic policies have the potential to significantly raise or lower future populations, and hence to make it harder or easier for EU nations to create ecologically sustainable societies.

In a world where the population growth rate is slowing down and most future population growth is projected for the developing world, it is easy to overlook the importance of demographic policies to developed countries' futures. But this is misguided.

In the first place, many developed nations are still pursuing policies that will significantly increase their populations in the coming years and hence increase their environmental footprints.[22] As already noted, Sweden and the UK, with robust native fertility rates, have current immigration levels that will increase their populations significantly in the coming years, with pressure to raise immigration levels even more for humanitarian reasons. Many western European countries have similar potential trajectories, including France, Ireland, Norway, Denmark, and Belgium:

[22] Or keep their footprints from decreasing as fast as they otherwise would. The key point is that ceteris paribus, more people means a higher ecological footprint. There is abundant evidence that humanity's current biophysical demands are far in excess of what is ecologically sustainable (Ripple et al. 2017). We must lower our footprint as quickly as possible, and fewer feet is an essential part of this effort.

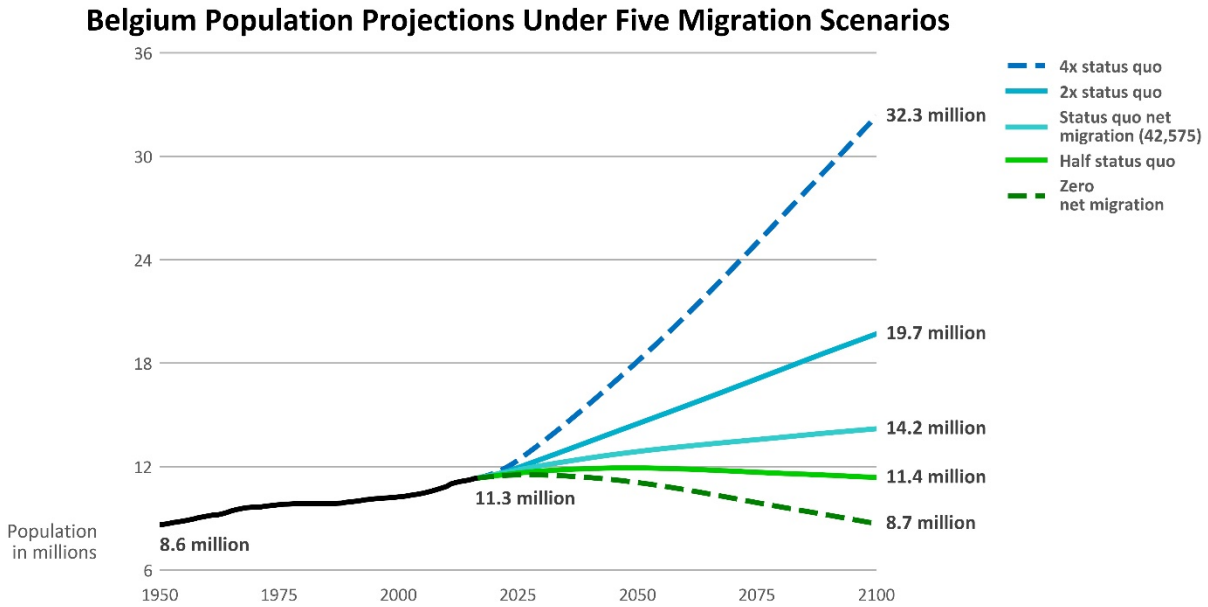

Figure 32. Status quo migration is the continuation of the past 20 years average annual net migration level (42,575). Migration scenarios use total fertility rates varying between 1.73 and 1.98, with higher immigration levels projected to drive higher TFRs. Source: own calculations

While current net migration numbers[23] are set to help increase the Belgian population by 26% by 2100, doubling those numbers would increase its population by 74%, while raising them 4X would increase its population by 186%. Such increases are not out of the realm of possibility.

Second, EU countries whose fertility levels could lead to shrinking populations and hence help shrink their environmental footprints, are instead bolstering their populations through high immigration levels. Germany, Italy and Spain are important examples. Spain, with a current TFR of 1.34, is on track to increase its population by 8.5 million by 2100 due to net migration of 270,000 people annually. Italy, with the same low current TFR, is on track to decrease its population by only 3.5 million people this century due to annual net migration numbers of 229,000. With zero net immigration, Italy's population would instead drop in half by 2100, from 60 million to 30 million:

[23] Belgium's average annual net migration numbers, as a percentage of its total population, are slightly higher than the United States' average during the past twenty years.

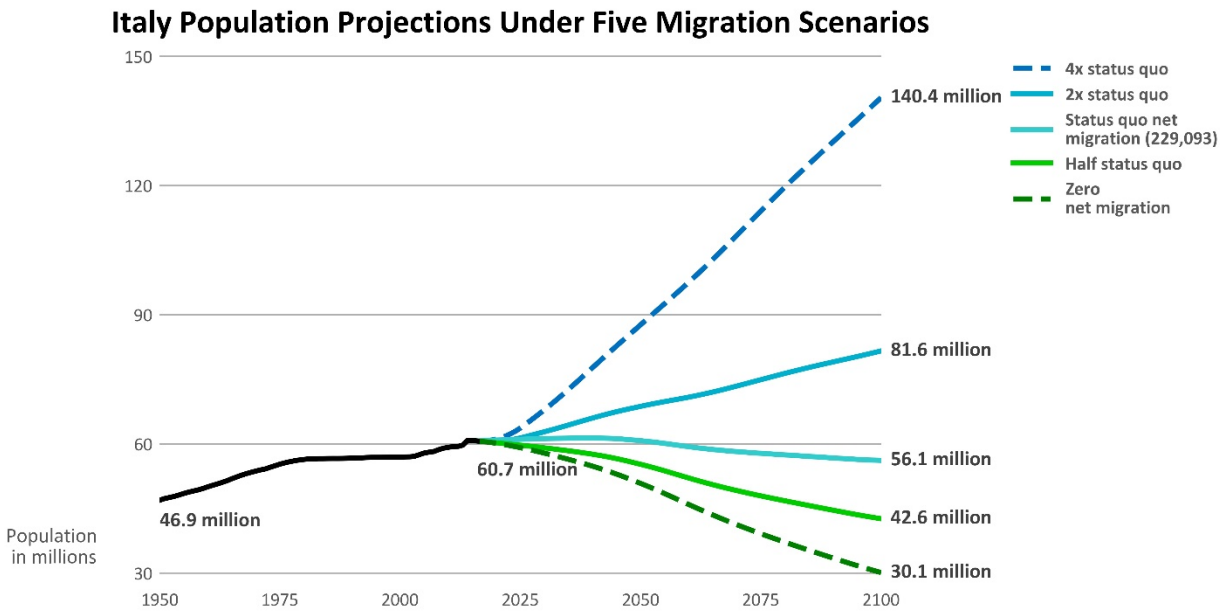

Figure 33. Status quo migration is the continuation of the past 20 years average annual net migration level (229,093). Migration scenarios use total fertility rates varying between 1.49 and 1.74, with higher immigration levels projected to drive higher TFRs. Source: own calculations

Accepting such a large population decrease in such a short time is probably not to be expected, nor would such steep immigration cuts necessarily be advisable. But accepting some population decrease in wealthy, crowded societies may be reasonable, given the benefits of smaller populations and the contentions caused by high immigration levels. Italy's recent national election shows strong support for some cuts in immigration numbers.

Third, we argue that it is a mistake to ignore demographic policies and their potential contribution to ecological sustainability, because there are big differences in future population numbers under these different scenarios which would lead to big differences in future environmental footprints. Consider again our fertility and migration projections for the EU as a whole. The fertility projections range across a difference of 193.3 million people living in the EU in 2100. The migration projections range further, across a difference of 614.4 million people—greater than the entire current population of the EU. Even limiting our view to the three most likely net migration scenarios, considering policies that could cut net migration in half or double

it—well within the realm of political possibility—encompasses a difference of 214.6 million people more or less in 2100. We should also consider the possibility that family support policies and migration policies might reinforce one another, potentially leading to unexpectedly wide population swings upward or downward. Comparing our highest and lowest combination scenarios (the 2X status quo migration & strong egalitarian policies scenario versus the 1/2 status quo migration & strong neoliberal policies scenario) encompasses a difference of 703.9 million versus 307.2 million people in 2100 (see figure 12). That is a potential swing of 396.7 million people, equal to 78% of the current population of the EU.

The fact that these potential changes would not be as large, either as a percentage change or in absolute numbers, as those that occurred in India and China during the past century, or those being predicted for Africa during this one, should not mislead us. Increasing Europe's population by even 100 million more people would be a very big "ask" on nature. Whether the EU's population of relatively wealthy, high-consuming citizens is two or three hundred million higher or lower will be highly important from both a regional and a global environmental perspective. As a matter of de facto environmental policy, demographic decisions will be at least as important as any other policy decisions made by EU nations (energy, transportation, acceptable pollution levels), as we show in the next two sections.

Of course, the relationships between population numbers and environmental impacts are complicated. Yet ceteris paribus, more people lead to greater environmental impacts. Our working hypotheses therefore are that the smaller the EU population going forward, the more effectively it will be able to meet all its environmental challenges; and the smaller their populations, the more individual EU member nations will be able to create ecologically sustainable societies. Consider the evidence for these hypotheses in two key environmental

areas: reducing the EU's greenhouse gas emissions, so as to help limit global climate change; and restoring Europe's long-settled landscapes, in order to help preserve global biodiversity.

Future population numbers & EU greenhouse gas emissions

To their credit, the EU and its member states have set some of the most ambitious climate goals in the world. The EU enacted legislation to reduce greenhouse gas emissions 20% by 2020 compared to 1990 levels, a goal it has already achieved. There is a 40% reduction target for 2030 in the union's "nationally determined contribution" under the Paris Agreement, and the EU's low-carbon economy roadmap (European Commission 2017) aims for 80% to 95% reductions by 2050 (figure 34 below). How might EU demographic policies impact the chances of meeting these future goals?

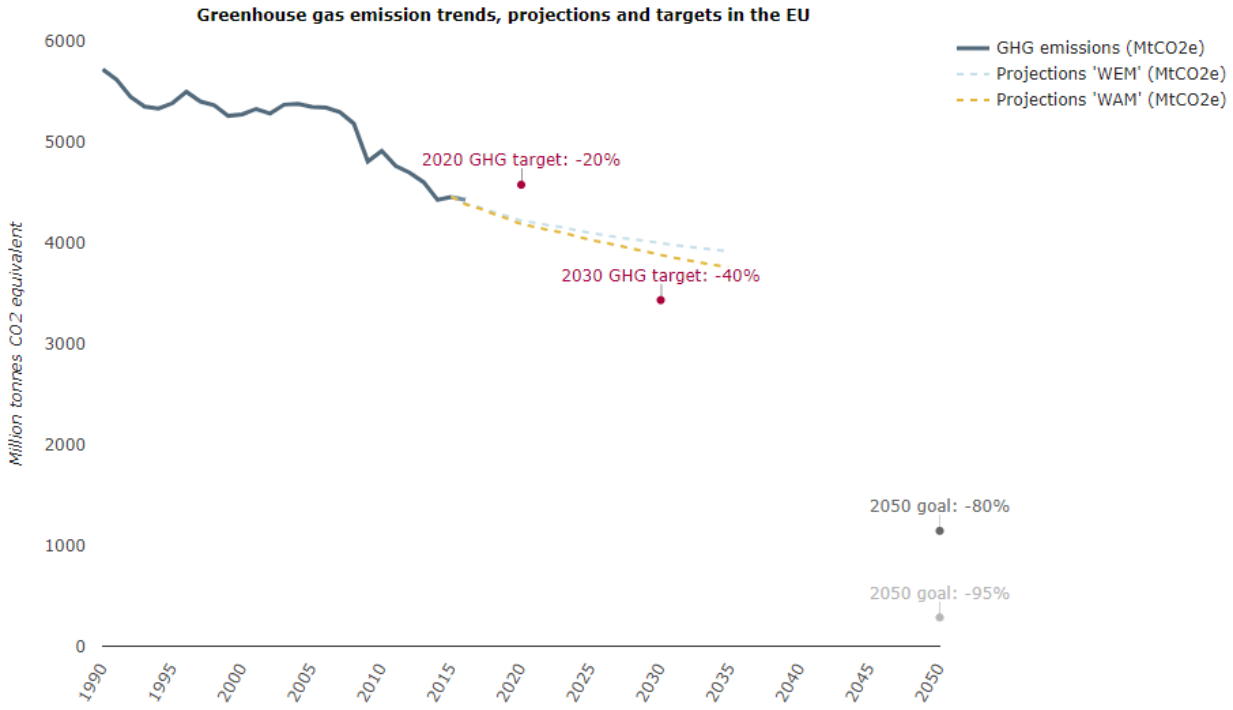

Figure 34. Greenhouse gas emission trends, projections and targets in the EU. "WEM" are projections with existing mitigation measures and "WAM" are projections with additional mitigation measures (European Environment Agency 2017)

Population growth generally leads to increased CO_2 emissions (O'Neill et al. 2012). Despite considerable differences in per capita consumption, since all people emit some CO_2, more people emit more CO_2. A recent study found that regional population growth has contributed considerably to recent CO_2 emissions in Western Europe (Weber and Sciubba 2018). Some analysts speculate that future changes in technology or income may compensate for the near scale effects of larger populations. Nevertheless, we expect that policy scenarios leading to continued population growth will make it harder for the European Union to achieve its ambitious climate goals, even with considerable per capita emissions reductions. On the other hand, scenarios that yield smaller future populations have great potential to keep more greenhouse gases from being emitted into the atmosphere, especially in combination with per capita emission reductions.

The following basic calculations demonstrate the potential impact of total EU population size on greenhouse gas emissions throughout the century. We juxtapose three per capita emissions reduction scenarios with our nine population change scenarios for the EU as a whole. Then we compare the resulting total emissions by 2050 to the 2016 EU reference scenario, and to the minimum and maximum emission goals of the EU's low-carbon economy roadmap (see figure 34).

In the EU reference scenario, annual GHG emissions are projected to fall 48% by 2050 relative to 1990, and per capita emissions are set to decline to an average of 5.66 tonnes of CO_2e (CO_2 equivalent) (Capros et al. 2016). In context, this means that by 2050, an average EU citizen will emit approximately the same amount of GHGs as an average Swede in 2016. This emissions projection is based on the optimistic assumption that the policies agreed to by the EU and its member states will be implemented. Combining this per capita emissions decrease with all

possible 2050 population sizes from our population projections, we see that the reference scenario emissions level is exceeded in the three highest population scenarios (red line on figure 35).

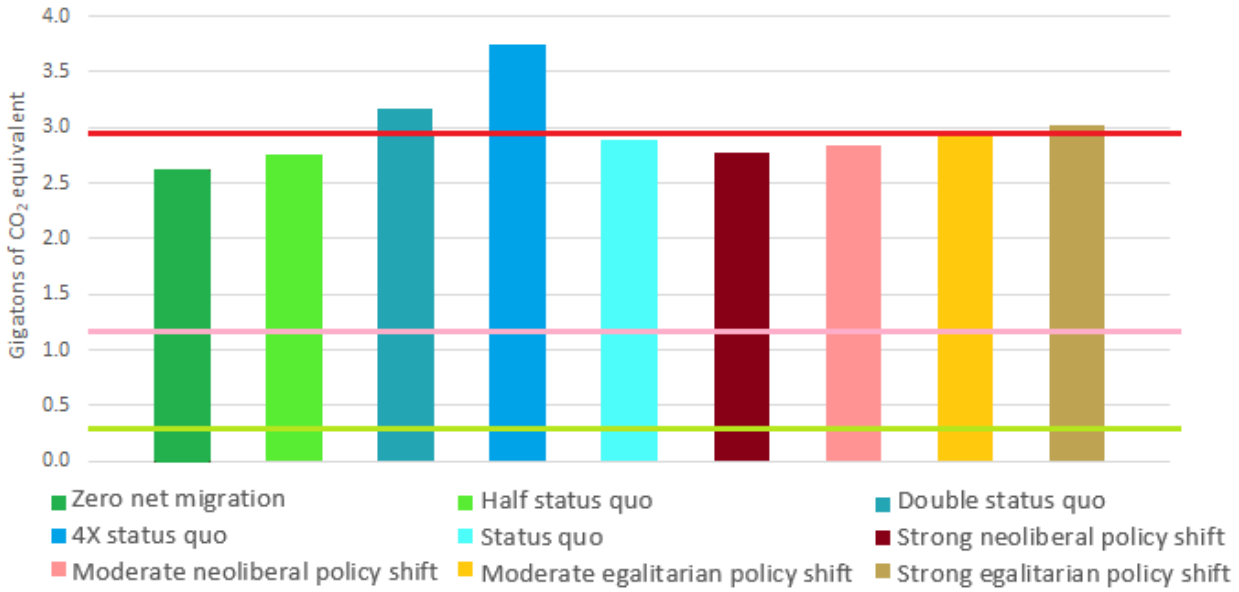

Figure 35. The EU's total greenhouse gas emissions in 2050 under 9 fertility and migration scenarios, assuming a decrease in per capita emissions to recent Swedish levels. The red line represents the projected total GHG emission level in 2050 under the EU reference scenario (2016); the pink and green lines represent the minimum and maximum 2050 targets for the low carbon economy roadmap (85% and 95% reductions compared to 1990). Source: own calculations

Furthermore, under only a 1.5 times reduction in per capita emissions (from the current 8.7 to 5.6 tonnes of CO_2e) no scenarios can meet the 2050 goals of the low-carbon economy roadmap, represented here by the pink and green lines. A 3.5 times per capita reduction would be needed to meet the "minimum" 2050 goal under the lowest population (zero net migration) scenario; in contrast, a 5 times per capita reduction would be needed under the highest population scenario (4X status quo migration). The same relationship holds for meeting the "maximum" 2050 goal: this would demand a 14 times per capita reduction under the lowest population scenario versus a 20 times per capita reduction under the highest.

Let us look farther into the future and assume that per capita GHG emissions will halve by the end of this century, to 4.35 tonnes of CO_2e in 2100, declining linearly. In this case, we see that the steep population growth under the highest population projection (4X status quo migration scenario) would completely offset the effect of the per capita consumption reductions over the period as a whole. Annual GHG emissions would increase until 2050—despite declining per capita emissions—and they would be only slightly lower than current annual emissions by 2100 (figure 36). In contrast, the fastest declining scenario (zero net migration) leads to sharply reduced annual GHG emissions, down to 1.38 $GtCO_2e$ (gigatonnes CO_2e) by 2100 compared to 4.44 $GtCO_2e$ in 2016, and thus to substantially reduced total GHG emissions over the entire period.[24]

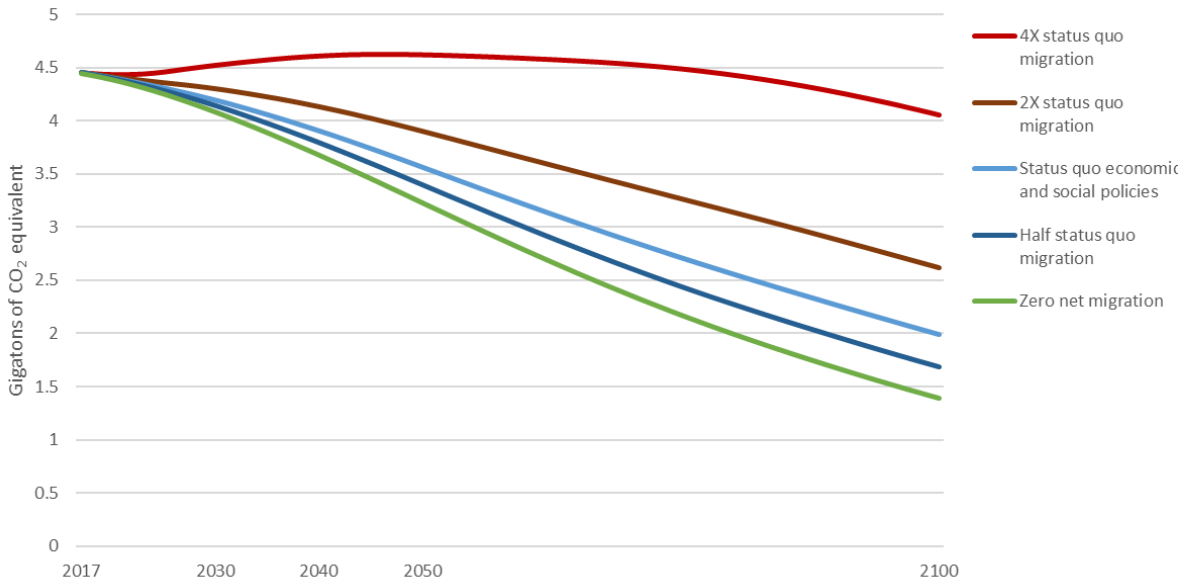

Figure 36. Total annual greenhouse gases emitted under five migration scenarios, assuming a linear decrease in per capita GHG emissions reaching 50% of today's per capita emissions by 2100. Source: own calculations

Calculating cumulative GHG emissions under all population projection scenarios, we see that the difference between the fastest growing and the fastest declining scenarios would reduce

[24] Note that all the fertility scenario projections would lie between the double status quo net migration and the zero net migration scenario projections, and none of the population projections are consistent with the low carbon roadmap's emissions reduction targets.

emissions by 132.8 $GtCO_2e$ by the end of the century (figure 31). This is equivalent to all global GHG emissions for 2002, 2003 and 2004 added together. Even if we reject the two extreme migration scenarios as unlikely and compare the doubled and halved net migration scenarios, the difference between them would still be 47.5 $GtCO_2e$ of emissions potentially avoided by 2100 by choosing the lower scenario.

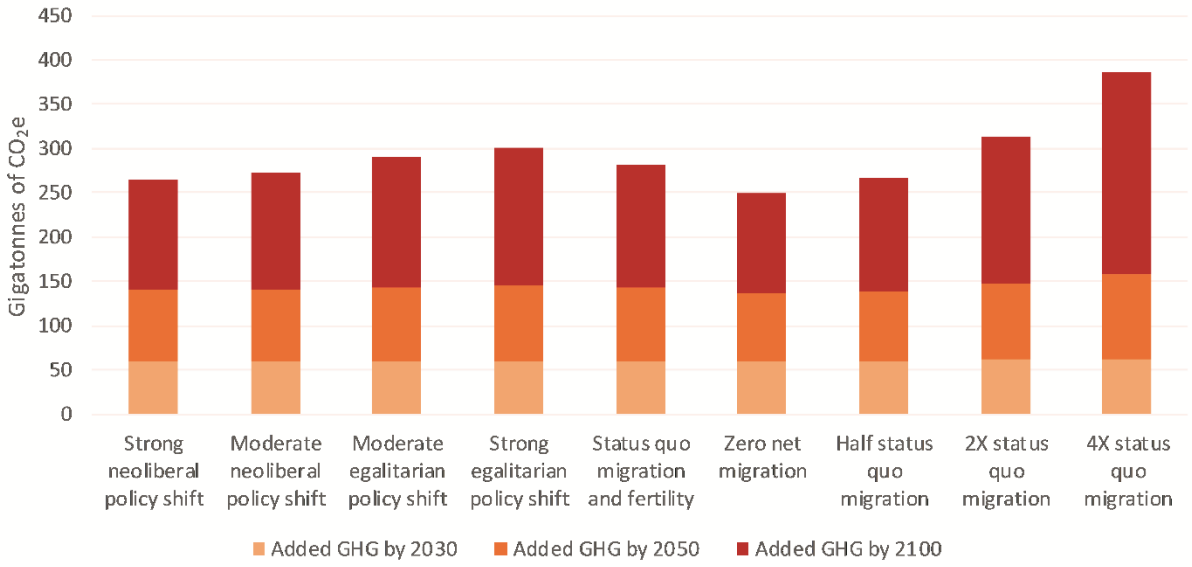

Figure 37. EU GHG emissions under 9 fertility and migration scenarios, assuming that the average per capita emissions decline 50% by 2100. Source: own calculations

Let us examine a more optimistic scenario and assume that per capita greenhouse gas emissions in the EU will fall even further in the future, declining linearly from the current 8.7 tonnes of CO_2e to 2.2 tonnes CO_2e by 2100. This low per capita emissions level, equivalent to average annual per capita emissions in the United Kingdom in 1800, could be due to widespread use of renewable energy, greatly improved efficiency, or various technological breakthroughs. Even under such an optimistic assumption, four of the migration and fertility scenarios leading to higher population numbers would be unable to meet the low carbon 80% emissions reduction goal by 2050. The five scenarios that result in stable or declining EU populations, in contrast, are consistent with meeting this goal (figure 38).

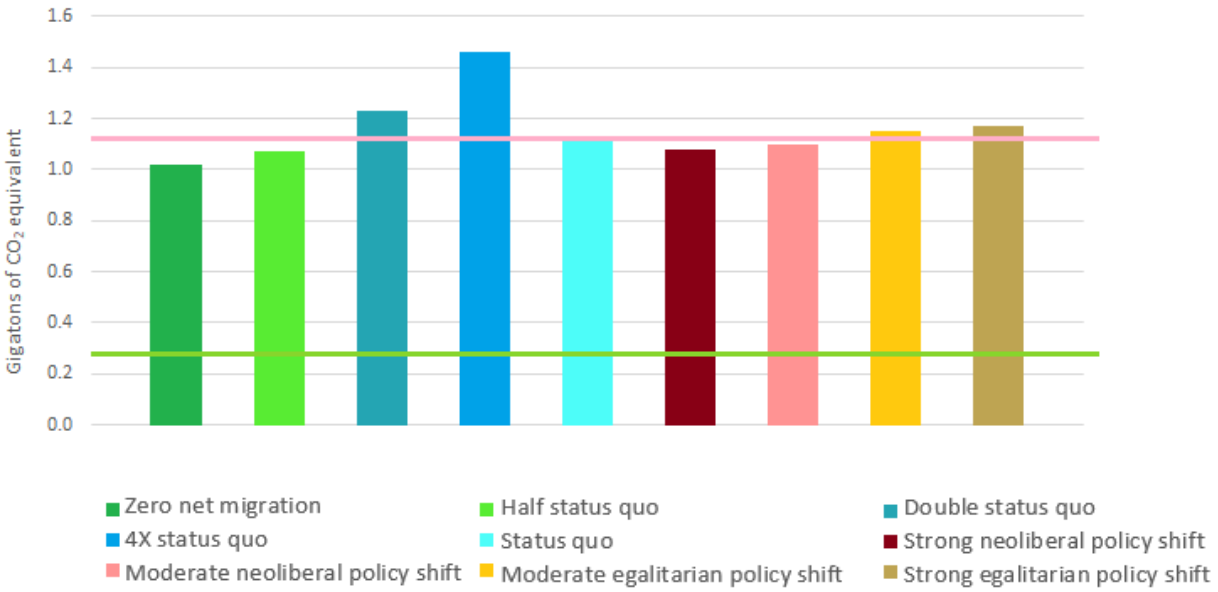

Figure 38. The EU's total greenhouse gas emissions in 2050 under 9 fertility and migration scenarios, assuming a linear decrease in per capita emissions to 2.2 tonnes CO2e. The pink and green lines represent the minimum and maximum 2050 targets for the low carbon economy roadmap (85% and 965% reductions compared to 1990). Source: own calculations

Examining cumulative GHG emissions throughout the century, the scenario with the lowest projected population would result in 207.1 $GtCO_2e$ total emissions by 2100 (figure 33). Compared to the 304 GtCO2 emitted under the highest population scenario, following a humbler demographic path would reduce cumulative emissions by 97 $GtCO_2e$ by the end of the century. If we compare the more likely scenarios, with double and half status quo net migration numbers, the difference still would be quite substantial: 34.7 $GtCO_2e$, which is approximately equal to all global CO_2 emissions in 2011.

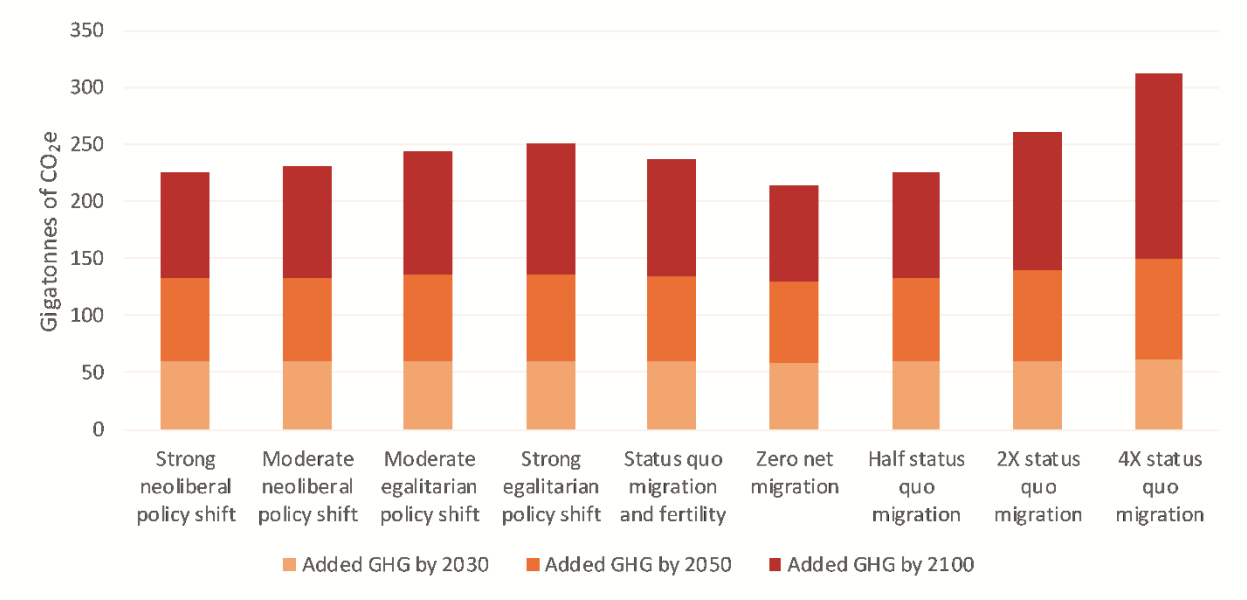

Figure 39. Cumulative EU GHG emissions under 9 fertility and migration scenarios, assuming per capita emissions decline linearly to 2.2 tonnes of CO2e by 2100. Source: own calculations

Overall, the evidence suggests that population growth would make it harder to meet EU climate goals, while stable or declining populations would help cut greenhouse gas emissions within the EU. In making climate policy, policymakers arguably should consider the multiplier effect of population growth, and the potential climate benefits of lower populations (Wynes and Nicholas 2017; Bongaarts and O'Neill 2018). Policies that aim to increase national fertility, or that increase immigration numbers, would appear to work at cross-purposes with ambitious climate mitigation goals. The most effective way to cut EU greenhouse gas emissions would seem to be to reduce per capita emissions in combination with allowing a natural decline in the number of "capitas."

Future population numbers & preserving EU biodiversity

While climate change is often seen as today's premiere global environmental challenge, massive biodiversity loss poses an equally serious threat. Populations of wild animals are

declining sharply around the world (Secretariat of the Convention on Biological Diversity 2014; WWF 2018) and biologists estimate that half of all wild species may go extinct in the next century or two, if current trends continue (Ceballos et al. 2017). The European Union has committed to addressing this problem under the UN's Convention on Biological Diversity, in part by increasing the amount of land dedicated to conserving regional biodiversity (European Commission 2011). Such efforts include protecting existing natural areas, preserving traditional farms and pastures with high natural values, and restoring or "rewilding" areas formerly devoted to agriculture.[25] All three types of efforts can benefit from smaller human populations, especially rewilding. Because it is long-settled and densely populated, Europe's biodiversity protection efforts often focus on restoring what has been lost.[26]

Since 1960, Europe's rural population has declined by 20% (World Bank Group 2014), contributing to extensive farmland "abandonment." Within the past two decades, up to 7.6 million hectares of agricultural land have gone out of production in Eastern Europe, southern Scandinavia and Europe's mountainous regions, as have 10-20% of the agricultural lands in the Baltic states (Leal Filho et al. 2017).[27] This trend has been both good and bad news for European wildlife (Benayas 2007). In the absence of proper conservation management and wild herbivores, land abandonment led to ecological homogenization and local decline of biodiversity in many places, particularly among species strongly dependent upon open habitats (Queiroz et al. 2014).

[25] Rewilding means assisting the natural regeneration of large areas of forests, grasslands, wetlands and other natural habitats, through passive management approaches, with the goal of restoring the natural ecosystem processes that existed before agricultural activity. The aim is to reduce human control of landscapes and create self-sustaining areas with thriving wildlife populations. Although rewilding emphasizes less intensive management of nature, some interventions, such as the reintroduction of extirpated species, typically are required in the early restoration stages. (Navarro and Pereira 2015).

[26] Because land use and land-use change have the greatest effects on broad habitat distributions, they are key to the future of biodiversity in the EU (Lehsten et al. 2015). Despite this, future land-use changes are typically neglected in forward-looking biodiversity projections (Titeux et al. 2016).

[27] Although some of this farmland became tree plantations, 15.8 % of total EU land area was considered abandoned farmlands as of 2015 (Eurostat 2017).

On a larger scale, however, several large herbivore and carnivore species have substantially increased their populations since the 1960s. Elk and red deer, wolves and bears have rebounded thanks to increased habitat availability, decreased human pressures, and remnant wild areas serving as sources of natural recolonization (Deinet et al. 2013; Boitani and Linnell 2015). Though legal protections and active conservation measures were crucial to these comebacks, rural depopulation also furthered them by reducing human pressures, both direct (e.g. less hunting) and indirect (e.g. more land available for habitat restoration).

Rural population decreases have been particularly important in furthering ecological restoration efforts. A good example comes from the Côa Valley of Portugal, a region with one of the highest farmland abandonment levels in Europe. Releasing land from agriculture opened up an opportunity to reintroduce wild horses and tauros, whose grazing reduced the frequent, severe fires associated with the shrubby vegetation that spontaneously follows farmland abandonment in the region. Restored herbivory led to a biodiverse mosaic landscape that boosted populations of rabbits, red-legged partridge, Iberian lynx, and Bonelli's eagle, and led to the return of griffon vultures (DeSilvey and Bartolini 2018).

Figure 40. Landscape in the Faia Brava Nature Reserve, part of the Côa Valley Special Protection Area located in the Western Iberia rewilding area in Portugal. Source: Staffan Widstrand / Rewilding Europe

The most prominent European organization working along these lines is Rewilding Europe, a group that aims to create or expand large wild landscapes across the continent. They explicitly acknowledge the positive role population decrease plays in rewilding: in fact, most of their projects include ecological restoration of abandoned agricultural lands. Activities have included removing small dams on streams to help restore fish populations in the Oder river system (Germany and Poland), expanding ancient beech forests and helping small farming communities capitalize on nature tourism opportunities in the Central Apennines (Italy), and reflooding former polders and reconnecting isolated lakes and wetlands in the Danube river delta to benefit waterfowl (Romania and Ukraine) (figure 41).

Figure 41. A rewilding vision for the Danube Delta, the largest river delta wetland in Europe. According to Rewilding Europe, the Danube Delta "has become one of the finest, wildest, best-protected and most famous wildlife areas of the whole continent. The area provides new sources of income and pride for the people who live here and in the surrounding Romanian and Ukrainian regions." Source: Rewilding Europe website

Continued population reductions and release of land from agriculture could contribute even more to such successes in the future, allowing European nations to meet and hopefully exceed the targets for increased protected areas set under the UN biodiversity convention. The population of predominantly rural regions is projected to fall another 7.9 million people by 2050 (ESPON Policy Brief 2017). According to the Institute for European Environmental Policy, an additional 3–4% of total EU land will go out of production by 2030, with 126,000–168,000 km2 potentially available for nature restoration. Other estimates range from 5 to 15% of agricultural areas (arable land and pasture), or 10 to 29 million hectares of land released between 2000 and 2030 (Verburg and Overmars 2009). These areas will be concentrated primarily in the Alps,

Apennines and Iberian mountains, and in the semiarid plains of southern and Central Europe (Navarro, L. M. and Pereira 2015) (figure 36). Many factors influence land abandonment. But we can assume that if population declines continue as projected under many of our status quo fertility and migration scenarios, or accelerate, as in our decreased fertility and migration scenarios, even more agricultural land may be released from human use and made available for wildlife over the course of this century.[28]

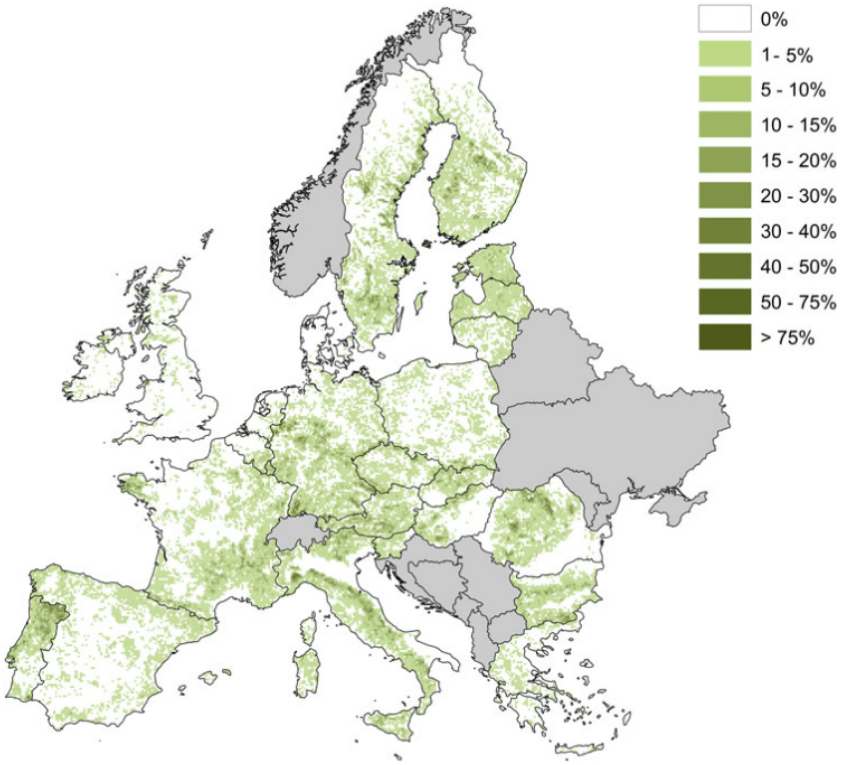

Figure 42. Localization of the hotspots of farm abandonment and rewilding in Europe. Hotspots are areas categorized as ‘‘agriculture’’ in 2000 that are projected to become abandoned, rewilded or afforested by 2030. Hotspots are expressed as a percentage of each 10 km2 grid cell. Source: (Navarro and Pereira 2015)

[28] Of course, agricultural demands cross political boundaries. Increased populations in the EU increase agricultural demands both within and beyond Europe, while increased populations in the Middle East and Africa increase demand for EU agricultural products. The same dynamic applies to population decreases. This points up the environmental importance of ending population growth globally. But it does not obviate the need for individual countries to work on reducing their own populations, if they hope to create sustainable societies.

Fewer people also means less pressure to intensify and expand agricultural practices: a major threat to biodiversity on the European landscape, since modern agriculture tends to create "biological deserts" that sacrifice all other species to one or two favored crops. Smaller populations make fewer demands on agricultural land for both food and biofuels, so that traditional farming practices and organic farming—which tend to be less productive, but which use fewer herbicides and pesticides, leave more land fallow and support more biodiversity—may remain acceptable. Preserving traditional pastures is particularly important for numerous bird, wildflower and insect species that thrive in open habitats, which may be scarce in densely populated European countries and may be lost when former agricultural lands revert to scrub or are reforested in the absence of wild herbivores (Lasanta et al. 2015). It is true that rural depopulation may make it harder to maintain traditional, less intensive farms, as labor becomes scarce and expensive. Subsidies directed specifically toward traditional farms may mitigate this, however. Alternatively, with the right management (such as reintroduction of large herbivores), open and diverse habitats can be maintained after land abandonment.

Whether preserving existing biodiversity-rich landscapes or trying to creating new ones, smaller populations generate more opportunities for nature protection. Ceteris paribus, fewer people means less pollution, less hunting pressure, less need to build or maintain roads that fragment the landscape. And arguably a less crowded, wilder European landscape would benefit people, too (Navarro 2014). On the world's most densely populated continent, preserving beautiful natural areas and attractive and varied traditional farms and pastures should be aesthetic imperatives (Rolston 2008). In addition to restoring biodiversity, rewilding often enhances a variety of ecosystem services, including increased freshwater supply, reduced soil erosion, flood prevention, and the removal of air pollutants (Schnitzler 2014). Where restoration increases

woody plant cover, as is typically the case in Europe, carbon sequestration also increases. Moreover, if large areas are rewilded, the combination of connectivity and species diversity may enhance ecosystem resilience to the impacts of climate change (Corlett 2016).

Of course, realizing the benefits of population decreases, for people and wildlife, depends on putting in place the right policies and management—just as in the case of greenhouse gas emissions. Unfortunately, the potential benefits of smaller populations have largely been ignored by European policy makers. Rural depopulation and farmland abandonment is viewed exclusively as a problem by governments, not an opportunity (Queiroz et al. 2014). Under the European Common Agriculture Policy "less favored areas" (i.e., areas where agricultural use is difficult or less profitable) have been designated mainly to maintain agricultural activity, regardless of its appropriateness. This sometimes includes environmentally destructive monocultures which fail to preserve biodiversity (Pe'er et al. 2014). Better policies would keep extensive acreages in traditional farmlands, as in existing EU agro-environmental schemes, while recognizing that some former agricultural lands can be given back to nature and shared more generously with other species. A comprehensive, forward looking land-use policy would support both kinds of efforts, deploying the right amount and kinds of management, as appropriate.[29]

With the many successful examples of rewilding across Europe, more conservationists are coming to recognize the opportunities inherent in population decreases (Keenleyside and Tucker 2010; Navarro and Pereira 2015). Embracing such opportunities shows the growth of new attitudes fostering co-existence rather than the conquest of nature (Washington et al. 2018;

[29] The largest amounts of funding for biodiversity conservation are available through agro-environmental schemes aimed at preserving traditional farming systems and reversing abandonment trends. It is true that traditional farming methods can often co-exist with substantial biodiversity preservation, and for this reason among others are worth preserving. But sometimes rewilding is the better management option, both because of cost savings and because bringing back wildness restores something precious that is rare on many parts of the European landscape (Cerqueira et al. 2015; Navarro and Pereira 2015).

Crist 2018). So does preserving traditional farming methods and landscapes, despite economic pressures to industrialize agriculture to increase productivity. The key point is that the 10% EU population decline predicted under our status quo fertility/migration scenario would likely open up space to sustain and perhaps increase the amount of land devoted to traditional agriculture and biodiversity preservation, while we would expect the 18% or 83% population increases under our 2X and 4X migration scenarios to ratchet up pressure to intensify agricultural practices and expropriate wildlife habitat for human purposes. Whether the aim is preserving biodiversity or reducing greenhouse gas emissions, decreasing populations will help the EU achieve its stated environmental goals, while increasing populations will undermine them (Weber and Sciubba 2018). If Europeans want to create ecologically sustainable societies, their future population numbers matter.

Conclusion

In setting population policies, we believe that EU policy-makers should keep in mind a robust, comprehensive conception of societal well-being. The goal should be the creation of just, prosperous, ecologically sustainable and economically egalitarian societies whose members maintain strong social solidarity. Such a conception of the good society is justified, ultimately, because it is most likely to further the happiness and well-being of all its members (Nussbaum 2007). This ideal can guide demographic policy (and other public policy) and keep it from deviating into unprofitable tangents that lead to poor policy decisions (Coole 2018).

One such tangent is an economistic view in which demographic policy is made in terms of "what the economy needs." This invariably turns out to be more workers and more consumers. Such an approach, seeking to maximize the sheer size of the economy ("maximizing economic growth"), sacrifices the interests of labor to capital, and sacrifices long-term, widely-shared

prosperity to short-term, concentrated profits (Daly 2014). It is only by rejecting such an approach and disciplining "economic rationality" with reference to norms of community wellbeing and environmental protection that EU nations have created the kinds of societies that so many people want to join today.

Another tangent is a moralistic view which attempts to justify overly generous refugee policies by appealing to humane concern for the world's poor. Such an approach, while well intentioned, threatens to undermine the social solidarity, commitment to democracy[30] and respect for the rule of law that have allowed European citizens to create good societies in the first place. It forgets that the benefits provided by successful societies are not unlimited and that social systems can break down when too many demands are made upon them (Hardin 1993). It fails to distinguish short-term solutions for the indigent few, from long-term solutions to global poverty for the many, based on sustainable development and the creation of a peaceful and prosperous world order.[31]

Europeans have been focused on the problems of the European Union in recent years, including responding to challenges to its very existence. But it is worth taking a longer view and appreciating recent achievements. From the rubble of World War II, in the shadow of the Cold War, the countries of Europe created some of the most successful nations in history. According to the UN Human Development Index, western European nations are among the world leaders in terms of health and longevity; in wealth and (more importantly) sharing that wealth equitably; in securing honest governments that serve the interests of their citizens and uphold the rule of law;

[30] A recent study finds that "domestic public opinion does not play a central role in the policy positions adopted by Member States" in setting immigration policy (Arregui and Creighton 2018). Whether one finds this democracy deficit a matter of concern or congratulation says something about their commitment to democracy.

[31] These moralistic views also typically fail to distinguish between intelligent self-interest and civic concern, the backbone of successful democracies, and selfishness, which is their bane. But this is a large issue in ethics and political philosophy that cannot be dealt with here. See (Schmidtz 1997) for a good introduction.

and in promoting tolerance and ensuring human rights (United Nations Development Programme 2018). In the EU, they have created a framework for international cooperation which has greatly diminished the specter of war on the continent.

EU nations have created flourishing societies, with the possibility—we believe it is the necessity—of embedding them in flourishing ecosystems. European democracies need to show the world the way forward to (even more) just and (genuinely) sustainable societies, living in peace with their neighbors. Arguably, achieving this is more important than serving as a refuge for as many desperate foreigners as possible. That is a hard thing to say, but it needs saying, because these two goals are not compatible. A world caught up in an economic system built around the uncritical pursuit of growth needs to see that the socio-economic challenges of aging and shrinking societies are manageable (Götmark et al. 2018). As we bump up against global ecological limits (O'Neill et al. 2018), we need to create societies that not only acknowledge but embrace limits to growth (Kallis 2018). We thus should aim for stable or smaller populations.

The European Union's demographic challenges are complex, and which population policies best further both justice and sustainability remains to be determined.[32] We hope these population projections and our discussion of their environmental implications can help clarify these questions for EU citizens and policy-makers. We look forward to collaborating in the future with other researchers who share these goals.

[32] In our view, justice and sustainability are the twin ideals which should guide all government policies. They are equally important, equally indispensable, and therefore one cannot be sacrificed to the other (Staples and Cafaro 2012). The failure to appreciate this has led to many failures in demographic policy-making over the years, from Indira Gandhi to Angela Merkel.

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