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February's Museletter kicks off with "I hear voices", a thought piece that takes the form of a self-therapy session on responses to the existential crises facing the world. The second essay, "Is World Population Peaking Now?", is an interview with scientist and population modeller Chris Bystroff.

I hear voices

I'm not complaining of a psychological disorder or claiming supernatural powers, but I do hear voices in my head. These voices continually verbalize differing philosophical and psychological responses to the existential crises threatening our world. Two of these voices are particularly persistent. One of them contends that there is no hope for the survival of civilization, regardless what we do; while the other thinks that humanity can get through this century of crises more or less intact, if it pulls together and behaves itself.

Writing this article has turned out to be a self-therapy session. I hope that letting these two internal voices have their say will help readers sort out what they themselves think.

Voice 1: There's a simple reason we're seeing [so many crises](#) converging in today's world—including climate change, widespread toxic pollution, resource depletion, skyrocketing inequality, and the disappearance of wild nature. During the past 10,000 years, humanity developed agriculture, a slew of technologies, and, eventually, capitalism. Then, in the last two centuries, we wholeheartedly embraced fossil fuels. These additions to our natural biological [powers](#) have put us on a trajectory to overshoot global environmental limits. They also make it possible for a few people to exploit the many in truly diabolical ways. The whole modern techno-social system is unsustainable and it's bound to crash. We're seeing plenty of warning signs that the crash is imminent—from worsening trends in [planetary boundaries](#) and [ecological footprint](#) analyses, to the evaporation of democracy worldwide. At this point, there's not much we can do, other than acknowledge reality, prepare ourselves psychologically, and adapt as best we can.

Voice 2: Sure, the problems are severe. But there's actually lots we can do. Name a problem, and there's an answer. We know what needs to be done to tackle climate change: replace fossil fuels with renewable energy. Yes, that's a big job, but we can start by overcoming the political and economic clout of the fossil fuel industries. Getting toxics out of the environment requires that

we demand stronger regulation of the chemicals and plastics industries. We can reduce economic inequality within and between countries with policies as simple and familiar as progressive taxation (including wealth taxes) and redistributive programs, and ones as edgy and controversial as [degrowth](#). We can make space for nature to recover by setting aside as much as half of Earth's surface for that purpose. Government leaders have already agreed in principle to making [a third of the planet](#) off-limits to development. Indeed, strides are being made in each of our problem areas. We just need to do more.

Voice 1: But some of these solutions have been around for a long time. A few people get behind them, but seldom enough to make a real difference. The trends just keep worsening. Yes, we're installing record numbers of solar panels and wind turbines, but global carbon emissions keep increasing anyway. There's a reason why the problems keep piling up: the processes that create these problems (principally, economic expansion and population growth) are systematically supported by governments, religions, and corporate advertising. Growth produces jobs, profits, and returns on investment. Everybody benefits—except nonhumans, people in the global South, poor people in the global North, and future generations. Just try explaining to your government representatives that economic growth and population growth are destroying our children's future by depleting resources and polluting the environment, and see how far you get. Nobody wants to hear it.

Further, a lot of “solutions” don't really solve anything—or they just create more problems. For example, the energy transition that's supposed to solve climate change will need enormous amounts of [minerals](#), requiring an expansion of mining on land and under the seas. It will deplete natural resources, rob other species of habitat, and pollute some of the most vulnerable human communities with mining waste.

Why can't we just be honest with ourselves? There are too many of us humans, using too many resources too fast. This is a [dilemma](#) familiar to human societies in the past, when it led to societal collapse of one degree or another—though on a much smaller overall scale than the global collapse we are triggering. Some ancient societies eventually wised up and became Indigenous to a particular area, living within nature's limits. Hopefully we'll do that, too—but likely not until after the crash.

Voice 2: In instances where environmental and social trends are headed in the wrong direction, we need to help people understand what's at stake, and motivate more of them to get involved. If we're going to avert the worst, an enormous number of folks will need to change their thinking and behavior. How do we motivate those changes? We have to use [psychology](#). People will make sacrifices and work hard if they feel that their efforts are making a difference. So, it's important that we highlight solutions and victories wherever we can find them. Even if we gloss over some difficulties and trade-offs, that's better than giving in to paralyzing visions of doom, which cause people to disengage from environmental and social action. When they disengage, we get the worst outcomes.

Also, in many cases it's possible to have the benefits of technology, science, and economic development without severe costs to environment. We can substitute less-polluting chemicals for the really toxic ones. We can make

plastics from plant fiber. We can recycle more. The list is long. Some of the solutions are social, such as finding ways to reduce energy demand through behavior change—like persuading more people to use public transit. At some point, a critical mass of people will adopt these kinds of solutions. By giving in to despair, we make that much less likely.

Voice 1: [Solutionism](#) demands always looking at the bright side, focusing on accomplishments and successes. Yes, that may motivate some people (though typically not enough) to get involved in campaigns. But convincing ourselves that we're solving global problems, when in fact those problems are worsening, is an exercise in futility.

There's something refreshing about ditching this compulsion to look at everything in the world as a problem that we must solve. It makes space for curiosity. We might well ask: just how and why did we humans get onto this anti-nature, self-destructive tangent? Maybe it was the search for solutions that led modern humans astray. After all, every toxic chemical started as somebody's good idea. Humans are products of evolution. But evolution, particularly social evolution, has driven us into a *cul de sac* through a series of [maladaptations](#). Instead of forging ahead, we need to back our way out of this dead end, where we answer every problem with more technology and growth, thereby creating worse problems later. Realistically, that fundamental about-face will probably not happen until the whole system crashes, when it becomes obvious to just about everyone that we've gone wrong.

Voice 2: Yes, it's interesting to speculate about human evolution. But meanwhile, real people have to deal with real crises. Heroic people pursuing solutions are making a difference, and we'd all be much worse off if they weren't doing so. Over a century ago, conservationists started campaigns that led to the creation of national parks—at first in the US, now in many other countries. Nature benefits from these protected wildlands, and so do people. Back in the 1980s, chlorofluorocarbons were destroying the atmospheric ozone layer. Countries convened to adopt a ban on those chemicals, and the ozone layer has recovered. Right now, there are battles taking place around the world to stop new oil and gas infrastructure, preserve forests and other habitat, and protect poor and Indigenous people from the onslaught of industrial development. These campaigns need money and volunteers—not navel-gazing critiques of how human evolution went wrong.

Voice 1: I visit national parks, and it's certainly good that we protected the ozone layer. Still, I can't help seeing self-deception at work. A few years ago, somebody coined the word "hopium" to highlight the fact that, while hope sometimes makes us feel better, it is addictive and can make us delusional. It blinds us to what's really coming. It promotes the sense that everything will be fine, even though nearly everything we're doing ensures that it won't.

One of the big drawbacks of solutionism is that it fails to distinguish between simple problems, which have solutions, and [wicked problems](#) or dilemmas, which don't. Even if some of our problems can be solved, at least in principle, the sheer scale of our overshoot of environmental limits ensures that the rest of this century will be a time of crisis upon crisis, conflict upon conflict—a time unlike any we've seen historically. Whether it's global warming [already in the pipeline](#), or the horribly degraded condition of the world's oceans, or the extreme and worsening economic inequality in the

world today, we have created conditions that will lead to decades in which social and natural systems will unravel. We could minimize the suffering that's coming by building resilience at the household and community levels now. But that's not going to happen unless people realize that many of our worst problems aren't going to be solved, because they've grown so huge that there's no way to really address them without behavioral and institutional change so dramatic that many people would perceive the immediate result as worse than the problems we're grappling with now.

Voice 2: Yes, I see your point. It's important to wake people up, and help them realize the severity of what's happening. But if we leave them at that—if we leave ourselves at that—then we've done little but spread hopelessness and despair. Your distinction between wicked and simple problems is intriguing, but at a certain level it's just nitpicking. What people want and need is awareness of actions they can take that will lead to better outcomes—even if the goal is not utopia, but just the avoidance of immediate harm.

Voice 1: What about just loving this amazing world that evolution has given us? Live with integrity and create beauty. Maybe civilization is in hospice care, and we just need to honor its dying process. Recall the [Kübler-Ross five stages of grief](#). We see people around us at every stage—from denial to anger, bargaining, depression, and acceptance. Solutionism could typify the bargaining stage. Maybe some so-called "[doomers](#)" have arrived at the acceptance phase sooner than others.

Voice 2: That's a nice-sounding sentiment, but it's also a lazy, fatalistic cop-out. Saving lives and ecosystems requires action and courage. Standing in the way of a bulldozer may not stop all the things going wrong in the world, but under the right circumstances it can be a strategic action that leads to broader public awareness or new legislation. Or, we can build alternatives—cooperatives businesses, ecovillages, and farmers markets. Protect a bit of nature. Stop a pipeline. Contribute to social and political theory. Persuade just one person to change their behavior. Any of those actions is better than just sitting on the sidelines philosophizing.

Voice 1: But just doing something can be a cop-out, too, if we're using adrenaline to distract ourselves from grappling psychologically and spiritually with what it means to be living at this unique moment. Maybe it's only by really getting to the core of what's gone wrong—in ourselves as much as in the world—that we can see what actually needs to happen in order for humans to live sustainably on this planet. Maybe the change needed is so radical that it can only occur after profound personal transformation, or a collapse of the system.

Voice 2: I agree that we need radical change. That's the solution. Would you agree, then, that at some point there can be a solution? If so, then why wait until after the collapse to get to work?

Voice 1: Okay, I guess you have a point there. We're starting to get repetitive and I'm growing tired. Truce?

Voice 2: Truce.

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How do I reconcile these two voices? Well, to a certain degree, I simply don't. Psychological and neurological research suggests that, for all of us, the unified sense of self is at least partly [a useful fiction](#). There are indeed some things I'm sure about; for example, any voice in my head speaking up for armaments manufacturers and fossil fuel companies was drowned out long ago. But between the voices articulated in this article, an internal debate rages on.

It's true that we all need to grapple with the root causes of our predicament, and it's also true that the grappling needs to include urgent on-the-ground action. To a certain extent, these responses are not mutually exclusive. Maybe the overlap on their shared Venn diagram is the place I'll choose to call my intellectual and spiritual home—at least for now.

Is World Population Peaking Now?

An Interview with Chris Bystroff

A couple of years ago I read a [paper](#) titled “Footprints to Singularity: A Global Population Model Explains Late 20th Century Slow-Down and Predicts Peak Within Ten Years.” The banner finding of the paper—that world population is very close to peaking—seemed intriguing, but the population statistics then available seemed to show continued growth, at about 80 million net additions per year. I was unfamiliar with the author, Chris Bystroff, but made a mental note to keep track of how his modeling squared with developing demographic trends. Since then, significant population declines have been reported in [China](#), [South Korea](#), [Japan](#), and many other countries. Official world population growth forecasts are being [revised downward](#) rapidly. I recently revisited Bystroff's paper and was impressed by its methodology as much as its conclusions. I contacted him and invited him to engage in an interview by email; he graciously agreed.

Chris Bystroff is a San Francisco Bay Area native who studied biochemistry at the University of California San Diego and earned a doctorate studying the three-dimensional structures of protein molecules. He completed postdoctoral stints at the University of California San Francisco and the University of Washington, and in the 1990s was a visiting professor at the National University of Engineering (UNI) in Nicaragua. In 1999 he took a faculty position at Rensselaer Polytechnic Institute (RPI) in upstate New York, where he still works. At RPI he rose to full professor and maintains a research laboratory funded by the National Science Foundation, the National Institutes of Health, and the Grantham Foundation. His lab is currently working on a contraceptive vaccine and a contraceptive transgene for temporary, non-hormonal birth control in men and women. Bystroff teaches courses in protein structure, protein computational modeling, and, since 2016, a course in modeling human population. He has 75 peer-reviewed published papers to his credit, along with one [book](#) and three patents.

RH: Thank you, Chris, for taking time to answer a few questions. Let's start with some basic information. How are population statistics typically compiled? And how do demographers make forecasts about population growth? Do you have a critique of these methods?

CB: I have had the pleasure of being interviewed for a podcast along with demographer Wolfgang Lutz, who is the lead author on the publications that the UN uses for their published population projections. Lutz makes forecasts using trends in birth and death rates, their first and second derivatives, and using a stochastic model for immigration. I have critiqued this method saying that it ignores global limits. When I said this during our interview, Lutz countered that (to paraphrase his response) there are no physical limits to population growth. His view was that climate change and other environmental effects have had a negligible effect on the birth/death rates. He thinks the decline in the birth rates is due to Demographic Transition Theory (DTT), which states that economic advancement leads to decreased family size. DTT is encoded into the population projections through an assumption that Total Fertility Rate will converge on replacement value (TFR=2.1); this despite recent TFR values well below 2 and going down in many countries. I tried to convert him to an alternative view, in which the Earth has a voice, because in his model there is no Earth, no limits, and no carrying capacity (Lutz dismissed the notion that there is a carrying capacity for humans). To convince him, I pointed to the projected effect of climate change on agriculture. I pointed to declining freshwater aquifers. But changing an ingrained model takes more than just data and arguments.

Population statistics can be census data or vital statistics. Both have shortcomings. Census is regarded as more accurate, but census numbers can be politicized. China essentially admitted to overstating their population. India projects pride in having overtaken China in the count. In the US, states are motivated to overstate population since this could give them additional seats in Congress. Census numbers are not all direct counts. Projections, vital statistics, and demographic statistics are used to estimate the non-response rate. Then the estimated non-responses are added to the responses to get the reported count. I have not looked into the non-response rate, but I think it must be rather large, perhaps 10%. If so, then the reported census numbers may be contaminated with expectations. This was the case with China as reported by China-watcher Yi Fuxian. China overstated 2020 population, along with crop production. A paper from 2010 showed that China has done this in the past, significantly underestimating mortality. People ask why my predictions were off and I think, well, the predictions are only as good as the data going in.

RH: Your analysis leads you to a conclusion that few demographers would likely accept. How is your methodology different from theirs? How would you defend it against likely critiques?

CB: In discussions with the few demographers I have met (I am not a demographer, as you may know, I'm a biochemist), I have put them on the defensive and have not heard good defenses. The typical defense is to say, "This is what everybody is saying." This is a fallacy. Just because people are saying it doesn't mean it is true. I had an interaction with John Sterman (MIT) at the System Dynamic Society meeting in Albuquerque in 2020. Sterman is the lead author on [En-Roads](#), a comprehensive model for climate change. I'm sure you know of it and have probably played with it. The population model in En-Roads is taken from the UN population model. I complained that there is no feedback from climate change to population, as we know there should be. A truer population model should allow for a crash (using the dramatic term). He stopped talking to me at that point.

I also put Wolfgang Lutz on the defensive. When the interviewer asked us at the end of the interview what we could take away from each other's critiques, Lutz said he would consider putting global limits into his model. I in turn said I would start to consider economics more.

My model is different in that I focus on the carrying capacity (which is a non-starter for demographers like Lutz). I subscribe to the theory that a K-selected species is limited by carrying capacity and that we are a K-selected species. It's Ecology 101. Also, my model uses the power of system dynamics, inspired as I was by [The Limits to Growth](#). A systems approach allows me to set constraints in a way that demographics analysis does not. For instance, I put total world biocapacity into a two-stock sub-system with global hectare units. The sub-system can't grow, just like the Earth can't grow. We can only change the allocation of hectares (humansphere versus ecosphere), we can't add hectares. This view is inspired by Bill Rees and Mathis Wackernagel. Also, my model is different in that it explicitly factors in technology and treats technology like a living thing, growing exponentially. Others have published about technology, but I am not aware of it being included in a formal model before. It is always discussed informally (i.e., non-numerically). Finally, I can't neglect to mention the machine-learning aspect. My model was fit to population data using a simple machine-learning algorithm (called hyperfit in my paper). The program allowed me to optimize the parameters of the model even though they are interdependent. For instance, the total biocapacity of the Earth is an unknown that I can find by machine learning, but it correlates with another parameter, the sensitivity of the carrying capacity to ecosystem loss. Using hyperfit I could explore how parameters were related, and that was useful for the story-telling part of the paper.

RH: What evidence do you see that world population is in fact peaking right about now?

CB: The TFR of more than half of the world's population is now below replacement value. That alone should tell us the population is sinking. Some think TFR tells you about future birth rates, but that's not how it is calculated. There's such a thing as "demographic inertia" if the age demographics are skewed (lots of young people), but they're not very skewed, so TFR relates to birth rates now, and expresses that number in terms of average family size later. So, we can look at TFR as an indicator of the slope of the population. I haven't done it yet, but if I took the TFR times the size of the country and summed it over all countries (and then divided by the sum of the populations), I would probably get a number below 2.1. That would be a decline. If you look at the TFR data publicized by the UN in 2022 and compare those to the TFR published by the OECD in 2021, the difference is night and day. In the latter, the vast majority of countries have TFR less than 2.1. In fact, the eyeball average is about 1.5. This includes China (TFR=1.16) and India (TFR=2.03). What does the OECD know that the UN doesn't? So, I would say the world population is peaking right now or has already peaked. The uncertainty comes from the degree of demographic inertia and uncertainty in the statistics.

RH: How much of this has to do with declining birth rates, versus increasing death rates?

CB: It's all about declining birth rates. But as climate change heats up, population decline will be about increasing death rates. If the IPCC "hot models" are correct, then we can expect a 5-6 degree change by 2100. Long before that, equatorial countries will be losing population due to heat, and/or migration to the poles.

RH: Do you think falling birth rates might be influenced somewhat by environmental hormone-mimicking toxins? What other factors?

CB: Fertility is falling everywhere. So, the explanation must be global. Environmental toxins may have a local effect, but are they everywhere? I think a simpler explanation is that decreased fertility is intentional. What is everywhere is social media. Everyone knows about climate change and the associated sea level rise, raging storms, heat waves, and droughts. The outlook for the future is gloomy, and if you are a woman of childbearing age, you might think twice about bringing a child into this world with this future. Also, everywhere the prices of things are going up—childcare and rent among them. When asked why they chose to have zero or one child, women invariably cite the cost of raising a child. So that's what I blame, climate change and cost of childcare, not toxins.

RH: Pro-growth economists are fretting over falling birth rates, portraying them as a catastrophe. How do you see population decline?

CB: I think population decline will be a relief, like an escape valve in a pressure cooker. As we shrink in numbers we will grow in other areas, like resources per capita and free time. I don't buy the argument that an aging population is a big problem. Climate change is a big problem. An aging population is a small problem, not worth mentioning by comparison. Pro-growth economists are motivated by what economic theory says about economic stability, namely, that you need growth for stability. I don't think that is a law of nature. I believe that when the economy shrinks, we will invent an economy that is stable with a shrinking populace. Japan is already shrinking and it is not going through a depression. Doesn't that mean the doomsaying economists are wrong about needing growth?

So, I believe we will [*Decline and Prosper*](#) (book by Vegard Skirbekk). But part of me says [*The Heat Will Kill You First*](#) (book by Jeff Goodell), so what happens to you may depend on where you live. In any case, the population [*Countdown*](#) (book by Alan Weisman) is happening now or soon, certainly not in 2100.