FROZEN FUTURES

The 'Doomsday vault' buried in the Arctic ice will provide a backup for the world's seeds. But more needs to be done to safeguard food diversity, says **Michael Hopkin**.

Fittingly, the end-of-the-world vault lies at the end of the world. The plane to Svalbard gets you to within about 1,000 kilometres of the North Pole — further north than any other commercial flight. Today, the beautiful if desolate island of Spitsbergen in the Svalbard archipelago is home to a tight-knit population of just 2,000 miners, hoteliers and Arctic researchers. In a few years time, it will also be home to seeds from some 1.5 million varieties of crop.

On 26 February, a small group of officials, politicians, scientists and journalists carried the first deliveries of seeds down an icy tunnel dug deep into the frozen flank of an Arctic mountain and into the Svalbard Global Seed Vault. When the collection is completed over the next four or five years, the vault will have amassed seeds from virtually all the recognized varieties of 150 crop species routinely grown and eaten by humans — including the 100,000 varieties of rice, the world's top staple and the crop that accounts for more than 20% of all calories eaten worldwide.

Conserving crop biodiversity is an urgent undertaking. The Intergovernmental Panel on Climate Change (IPCC) predicts that 25–30% of plant species will be extinct or endangered in the next century. "We're losing crop diversity every day, going out with a whimper, not a bang," says Cary Fowler, executive director of the Global Crop Diversity Trust, which will curate the vault's collection. "In a real sense,

Doomsday is every day."

Built by the Norwegian government at a cost of 45 million kroner (US\$8.8 million), the vault was built in Svalbard partly because its storage rooms, deep under the permafrost and chilled to the optimum seed-storing temperature of -18°C , will remain insulated even in the unpredictable centuries to come.

The seeds it will store are copies of those already held by the roughly 1,400 existing national and regional seed banks worldwide. It's nicknamed the Doomsday vault because of its intended role in bailing out these banks in the event of mishaps — anything from power cuts, to flooding, to war. "If we had built this vault ten years ago, we would have used it at

least ten times already, for the loss of the gene [seed] banks in Iraq and Afghanistan, for example," Fowler says. It's an extra insurance policy.

But no matter how well intentioned and executed, Svalbard cannot single-handedly save the world's threatened bio-

logical resources, edible or otherwise. A seed vault won't help to conserve the threatened livestock breeds that billions of people depend on for both dietary and financial sustenance, or indeed the complex ecosystems that exist alongside both crops and livestock and in many cases allow them to thrive. Conserving these, and hence securing humanity's food supply, will require schemes even more impressive than an Arctic dugout. Nevertheless, the global approach behind the Doomsday vault may

offer inspiration to those aiming to conserve these other resources.

The Svalbard effort already shares its ethos with another scheme, called the Millennium Seed Bank Project, run by Britain's Kew Gardens. Based in the temperate garden of an English stately home, this bank is somewhat less theatrical than a frozen mountain bunker. But Britain's freezer is the only other to be storing seeds from all over the world, and aims to safeguard more than 24,000 wild plant species, including some crops. Together with Svalbard, the banks will still preserve only a fraction of the world's plant species.

Cold comfort

Keeping spares of the animal kingdom poses even more of a challenge. "It's a lot easier to put 1,000 radish seeds in cold storage than frozen animal material," says Don Bixby, a cryopreservation technician and former executive director of the American Livestock Breeds Conservancy (ALBC), a North Carolina-based non-profit organization. Yet the problem of dwindling diversity is just as great, if not greater, in the world's livestock as it is in its crops. Last year, a survey by the United Nations Food and Agriculture Organization revealed that 16% of the world's 7,600 recorded indigenous breeds of cattle, pigs, sheep and poultry are at risk of disappearing — 11% have already gone extinct.

This has mostly resulted from the rise of high-yield breeds such as the familiar black-and-white Holstein-Friesian dairy cow, now found in 120 countries. International breeding companies have promoted these breeds, and

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Rice crop from Bali, Indonesia (above) will be among 1.5 million varieties sent to Svalbard.

farmers, keen to increase their output, have willingly adopted them. All of the estimated one billion Holstein-Friesians in the world were ultimately sired by the same few dozen bulls, who have been bred for daughters with high milk yields and whose sperm is collected, frozen and sold worldwide. “We’re dealing with an effective population of 30–35 animals globally,” says Bixby. This is a “very worrying number”, because the homogeneous animals are not adapted to local drought conditions or to resist disease.

Can endangered livestock breeds be given their own version of the Svalbard seed vault? It’s a tricky proposition. Unlike seeds, which are generally capable of germinating after being frozen, delicate sperm, eggs and embryos are far more susceptible to damage by freezing — and methods for doing so have to be refined for every species’ unique physiology. Cattle sperm is one success story. “Fifty-year-old semen still produces calves,” Bixby says, but, “for many species we’re not able to put away material that can be reconstructed into live animals.”

If there is hope of developing an animal counterpart to Svalbard, it may lie in the network of regional tissue banks being developed by the US Department of Agriculture. It has given itself a mandate to collect reproductive material from every livestock breed found in the country, with an emphasis on conserving genes that will be useful for maintaining future food production. This could go a long

way towards saving the world’s resources, because the United States’ history of importing and breeding animals with valuable traits — which these days would be decried as biopiracy — means that many foreign breeds are represented there. But the US tissue banks are not designed to be a global repository for animal diversity, and there is no talk of starting such a store elsewhere.

Cryobanks cannot, however, be the whole story, and parallels can be drawn with wildlife conservation, where breeding from cryopreserved material is still seen as a last resort. The argument here, in essence, is that there is little point in resurrecting frozen seeds or embryos if their natural environment has vanished too. “Wildlife conservation realized 15 or 20 years ago that it’s not good enough to just save a seal, or a quail — we have to save the ecosystems where they live, and in many cases that’s also true for livestock and food plants,” Bixby says.

But agricultural systems are often excluded from conservation efforts because they are, by their nature, artificial. Some credit the organic farming movement with helping to preserve indigenous crops and livestock and their surrounding ecosystem.

The Svalbard seed vault is generating almost universal good will, but even its supporters acknowledge that it’s not enough to bank

existing biodiversity for use after Doomsday. They also advocate efforts to withstand impending disaster — by creating breeds that can resist whatever endangers them.

Gordon Conway, chief scientific adviser to the UK government’s Department for International Development (DFID), argues that biotechnology techniques will prove instrumental in preserving biological diversity. They allow, he says, genes that confer drought resistance or other valued traits to be moved from one variety to another more quickly than conventional selective breeding. Conway cites the example of a new, devastating variant of wheat rust fungus, called Ug99, which is spreading through East Africa towards the Indian subcontinent. Earlier this month, the UN reported that it has already been detected in Iran.

Efforts are underway to cross disease-susceptible strains with natural varieties carrying a gene resistant to Ug99. “We have to get that gene into Asian variants, and we have to do it quickly,” Conway says. In this sense, he argues, environmentalists need to embrace techniques such as genetic modification that are sometimes viewed with suspicion.

The Svalbard vault’s creators have not so far suggested using its seeds as a gene bank that can be mined in the future. But the bunker is “not the only element in the master plan”, says Fowler. Besides overseeing the vault, the Global Crop Diversity Trust has amassed a war chest of more than \$260 million, much of which will be spent on projects to breed hardier crops, and strengthen national and regional seed banks. Donors include the Bill & Melinda Gates Foundation, DFID, agribiotech giants such as DuPont and, most recently, the Norwegian government. The trust’s work will add

to the existing efforts of international philanthropists such as the Rockefeller Foundation to boost the effectiveness of plant breeding, not to mention the profit-driven activities of multinational crop firms.

Farms thus represent the real battleground where the fight

to save food diversity will be won: it is there that the many varieties of food species grow today — and it is there, ideally, that they will be preserved intact. For those at the Svalbard vault’s bitterly cold opening ceremony, it’s hard to imagine its icy caches ever being thawed. And that, really, would be the best case scenario — after all, no one wants to have to cash in their insurance policy.

Michael Hopkin is a senior reporter for *Nature* in London.

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— Don Bixby**