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## **#397: Embracing the finite: Making our way in an era of dwindling natural resources**

VOICEOVER

This is Up Close, the research talk show from the University of Melbourne, Australia.

ANDI HORVATH

I'm Dr Andi Horvath, thanks for joining us. Over its 4.5 billion years of life, our planet has been a dynamic and evolving place, with asteroid impacts, volcanoes, shifts in climate like ice ages. We know that life first began on Earth some 3.8 billion years ago, but our species, *Homo sapiens*, has only been here perhaps 300,000 years. While humans began to make their mark on the planet with hunting and early farming, it wasn't until quite recent times with the spread of large-scale agriculture, industrialisation and global trade that human impact on the world's environment has become a key driver of planetary health.

We live in what is referred to as the Anthropocene, a geological epoch where our species shapes the Earth's systems, instead of the other way around. We've altered or polluted our air, water and soils. Our climate is changing. We've altered the biodiversity of plants and animals in the sea and on land, leading to extinctions, invasions and imbalances. The Anthropocene has brought disrupted ecosystems and is endangering our own resources and the health and livelihood of future generations. There are many challenges ahead.

But this isn't the first time human societies have had to act more sustainably with limited resources or nutrients needed for survival. Islands in the Pacific are microcosms of limited resources, and the way some human groups have survived or thrived there may provide a clue to how to get by in an ecologically uncertain future.

Our guest today is biologist Peter Vitousek. He has for many years researched and been inspired by the generational cultural practices of agriculture found in the varied islands of Polynesia, and armed with knowledge from history and science, he's seen what's worked and what hasn't. Peter Vitousek is Clifford G. Morrison Professor in Population & Resource Studies at Stanford University and Senior Fellow at the Stanford Woods Institute for the Environment. Peter's authored over 300 papers in a

long career in ecology and has been named by Time Magazine and CNN as one of America's top scientists. Peter, welcome.

PETER VITOUSEK

Thank you.

ANDI HORVATH

Peter, tell us about the term Anthropocene.

PETER VITOUSEK

Anthropocene is really a way of expressing the fact that humans are a large influence on the planet. We've named other geological epochs after what controlled them, and humans are clearly a geological force on the planet now, and so it makes reasonable sense to speak of the Anthropocene.

ANDI HORVATH

When did we first start making that impact?

PETER VITOUSEK

That's a really good question. We've had an impact for a long time. When did the impact become pervasive enough to really label it as something different? Probably the Industrial Revolution in the 19th century, maybe more recently than that, but it's an extremely recent phenomenon.

ANDI HORVATH

Now, some of the impact of humans has been irreversible, like extinctions like bird species. Tell us about that.

PETER VITOUSEK

Many of the changes we make are pervasive and global, but not irreversible. The changes we've made in the atmosphere are the sorts of things that are really important, but if our species were to go away, which is unfortunately not impossible, those changes would reverse themselves in only a few hundred years, long by the scale of a human life but not long in terms of the life of the planet. However, there are things like the extinction of a unique species that are completely irreversible. There is nothing that will bring back a species once it is extinct, and it may take a long time for the functions it played to come back in new forms.

ANDI HORVATH

Give us a perspective of how different the Anthropocene is to, say, Jurassic times.

PETER VITOUSEK

Well, the biggest change in the Anthropocene is the influence of a single species. The influence of us is pervasive over the Earth, and no single species played a role like that at any time in the past. It's a very short time so far. We don't know if it is going to expand and the human influence is going to become clearer, if we're going to get smart and minimise our influence, or if we're going to go away and our

influence will also gradually then disappear. But it's strong now.

ANDI HORVATH

Peter, take us through some of the key drivers of human activity on Earth's systems. Where shall we start?

PETER VITOUSEK

Well, if we wanted to really start at the beginning, the most important ultimate driver is our population, the fact that our population has expanded enormously, especially since about 1800. Even in the time since then, it's really remarkable. When I first became aware that there was a global human population, I was an elementary school system, there were perhaps 2 billion people on the world as a whole. There are now almost 7.5 billion.

That of course is a fundamental change, because we all want to live well. We all want our fellows to live well, but that means we consume resources to make that happen, and the fact that we consume those resources, the fact that we're such a large influence, means that even our waste products loom large on a global scale. We aren't mostly deliberately changing the world. We're accidentally changing the world as a by-product of our activities.

ANDI HORVATH

But we've become more cognizant of things like land clearing and intensive agriculture. Are we starting to make inroads there that are not going to permanently damage soils?

PETER VITOUSEK

We're certainly making inroads. There's no question that in many of the things that we pay attention to, things were worse in the past, and through our focused effort to make them better, often through technology but not always through technology, we've managed to greatly reduce the impact per person or the impact per unit of economic activity in many aspects of how the world works. Is that enough? Well, it would have been enough when we had 2 billion people.

ANDI HORVATH

Tell us more about the driver of what you call biotic additions and losses, the changes in balances between plants and animals in various land spaces, say, like, introducing cane toads from Hawaii to Australia. Hunting, peak fishing, those sorts of things, is there a tipping point that we've reached?

PETER VITOUSEK

Well, we'd always like to know where tipping points are. They tend to reveal themselves in retrospect better than they do in prospect, as we know, and it's hard to know even when they're going on, but we are making massive changes in the biological diversity of Earth. And it is something that is irreversible. Once you lose species, or once you move a new species to a new place, that's a very difficult thing to reverse, as I know you've seen in Australia many times, as we've seen in Hawaii

also. And the losses are really substantial.

Of course, extinction of species is a natural process. It's always been going on, but the rate at which species are becoming extinct has gone up many-fold, and lots of estimates converge on about 100-fold in the past century through intensive human activity, mostly through land clearing. But it'll be increasingly through climate change and other sorts of influences people have, through introduction of species to new environments, even though hunting and through overfishing, as we're really effective predators. We're really effective fishers, and so we tend to knock out the things that we focus on over time.

ANDI HORVATH

Tell me about the invisible parts of our planet, things like nitrogen, carbon and also synthetic molecules that we're putting into our system. There's a lot of pollution going on as well. Now, these are invisible to us as humans on a daily basis, but these are having a huge impact.

PETER VITOUSEK

They are, but we think in terms of the elements like carbon and nitrogen as of the great biogeochemical cycles of Earth that underlie all of life. And the most pervasive of our influences globally are changes in those cycles. We're increasing the amount of carbon dioxide in the atmosphere substantially. We can't taste or smell that. We can't see that, but it is changing the climate. It is changing the growth and chemistry of plants, and that influence is globally pervasive.

Also, the oceans, their acidity is controlled by the amount of carbon dioxide dissolved in them. As carbon dioxide in the atmosphere increases, carbon dioxide in the surface ocean also increases, and it becomes more acidic, and that has an influence on corals and any other organism that builds its structure out of molecules that ultimately derive from carbon dioxide.

Nitrogen, too, is something that we use in fertiliser. We use it because adding nitrogen to agricultural fields is essential to their sustainable production. We have to do it if we're going to maintain highly productive agriculture, but it transforms the global cycle of nitrogen. Unequivocally increases various estimates of the amount of increase in the amount of active nitrogen in the biosphere are that it's increased between twofold and fivefold, and that's an extraordinarily pervasive change that changes the way the world works.

When I think of the Anthropocene in these terms, I don't focus so much on the fact that it's all bad. What I focus on is the fact that it's all changed, and it's unequivocally all changed, and we can see that and show that very clearly, especially in alterations in the biogeochemical cycles, ultimately in changes in climate as well. From our human perspective, those changes bring winners and losers. From biological perspectives, they bring winners and losers, too. If you're a cockroach, humans are the best thing that ever happened to you, right? There's no question about that. It's not a matter of everything being bad for everyone. It's a matter of everything's

changed, and that's what the Anthropocene is.

ANDI HORVATH

So if we don't take stock of sustainability, this is going to be good for cockroaches but bad for humans.

PETER VITOUSEK

I think that's true, yeah. With the power to change the world comes responsibility for doing that right. If we don't pay very serious attention to trying to mitigate the consequences of what we do, if we don't take that responsibility, then I think it will be very bad for us.

ANDI HORVATH

So then do we maintain the function of the ecosystems and sustain life as they are now? Is now an ideal condition, although it's changed?

PETER VITOUSEK

I think that there's no real chance of maintaining things in an unchanged state. I think that the important thing is to design, to do the best we can under what will undoubtedly be changing circumstances, recognising that there are some things of importance and beauty that will be lost in the process, but that through our actions we can keep much that's important and beautiful in the world. And if we do that, we'll have done the best we can. We can't ask for more.

ANDI HORVATH

I'm Andi Horvath, and we're talking about the Anthropocene with ecologist/professor Peter Vitousek here on Up Close. Peter, what can we learn from the history of some of the Pacific Islands, which I know you've been looking at. They're microcosms of limited resources.

PETER VITOUSEK

They're microcosms of worlds is how I look at it, really. When people reach some of the more isolated Pacific islands, they were on their own and their island was their world, and so they really faced a global system in a way that we're only now beginning to. They had the advantage, which we have now too, but most humans have not had, but they had the advantage of their world was finite. They could see what was going on. They could see that they were changing things. They could see that what was left was all there was. There wasn't a horizon. They couldn't just go somewhere else and take care of things or take something from someone else, somewhere else. They had their island, and they could see for themselves that things were not as good as they'd once been in some ways. They faced the challenge of making a transition to living sustainably, much as we do now. And I think the important thing is that the fact that they were worlds, that they faced what we think of as global change on a much smaller scale, much earlier than we did.

ANDI HORVATH

Now, you have studied some of these islands. Tell us about Hawaiian agricultural

practices pre-European contact. What did they eat and how did they farm?

PETER VITOUSEK

Yeah. Well, the Hawaiians - Polynesians generally, but the Hawaiians especially, even among Polynesians, were superb farmers. They intensified agriculture by multiple pathways. By intensified, I mean used the same ground over and over, put a lot of inputs of irrigation and other kinds of management in and got very high yields, very high population densities, very highly structured societies as a result.

Of course, the very highly structured societies and the organised agricultural systems are a sort of a chicken and egg situation. You need to be organised to do intensive agriculture. You need intensive agriculture to be organised, and so the two evolved together in Hawaiian history. But they were great. They were highly productive. My analysis of Hawaiian agriculture won't mean a lot to people who haven't had experience in Hawaii, but except for the city of Honolulu, the island where the city of Honolulu is located, there were probably more people when Hawaii was on its own, before the world came crashing in, than there are now, on all of the islands except for Oahu, where Honolulu is located. So completely from local resources, using only local resources, they'd maintained a greater population than is there now and had done so in a sustained way for a couple of centuries, at least, before the world came crashing in. So they'd figured some interesting things out.

ANDI HORVATH

What did they figure out, did they?

PETER VITOUSEK

Well, that's the interesting research challenge, is to understand how they did it, because so much of the world didn't do that, and even our systems now are more productive. Our intensive agriculture is beautifully done, but we don't know if it's going to last 200 years, and theirs did. So I don't know that theirs was sustainable in the sense that it could have gone on forever. I don't know that ours is, but I do know that theirs was sustained for a long time.

ANDI HORVATH

So what are the lessons learned in observing how they did agriculture? Obviously, they didn't have scientists, but we now know that they had a good system of nitrogen cycling. Tell us about that.

PETER VITOUSEK

Well, they weren't scientists. That social role didn't exist. They practiced science. They experimented. They did observations. They saw what worked, and they followed up on it, and they spent time on crop breeding and developed new varieties of their main crops and developed new production systems for those crops.

ANDI HORVATH

So they explored by planting, say, taro in areas where there was nice volcanic runoff or something of nutrients.

PETER VITOUSEK

They would have done that. They would have also, as many people in the tropics did, practiced shifting cultivation, slash-and-burn agriculture, where they would clear an area of land, burn it, plant their crops, probably sweet potato in the uplands, then after two, three or four crops, let it go back to forest, and then come back maybe 20 years later and repeat the process. That's a sustainable system as long as you let the forest stay there long enough between clearing, but it's never going to be a very efficient system, because you're only using a small fraction of the land for crops in any year. I'm sure that they practiced that system and experimented with it and found they could extend the cropping period in some places and were eventually able to farm most of the land that they farmed most of the time.

ANDI HORVATH

So this went on for many generations.

PETER VITOUSEK

Had to have.

ANDI HORVATH

What happened? Europeans arrived.

PETER VITOUSEK

Europeans arrived, brought the world's diseases in. Probably 90 percent of Hawaiians died from those diseases, and the agricultural system, which depended on a highly structured society and substantial population to work the land, collapsed, as 90 percent of the people died.

ANDI HORVATH

Do we see examples of this type of clever strategy in New Zealand? And there are a couple other case studies you've studied, too.

PETER VITOUSEK

We see Polynesians were very good agriculturalists, but of course, what they could do was constrained by the land that they found. And so if you look at the islands of Polynesia, some of them are small and don't have much in the way of terrestrial resources. Some are big and relatively rich. Aotearoa-New Zealand is interesting because it's temperate, and on South Island, most of the crops the Polynesians carried in their canoes wouldn't grow on the southern half of the South Island, so they had to evolve ways of living that didn't involve agriculture. And so they evolved from agricultural people into non-agricultural people. In Hawaii, they evolved from agricultural people who had an idea of how to do irrigated taro into people who did some upland things with sweet potato in particular that were globally unique.

ANDI HORVATH

So would it be fair to say there are common factors that the land influenced development of culture on the islands?

PETER VITOUSEK

Yes, absolutely. Vice versa too, of course. The Anthropocene came early there. Those people were shaping their lands, but the lands were also shaping the societies.

ANDI HORVATH

I'm Andi Horvath. We're talking about the social and natural history of some of the Pacific islands and what they may teach us about living sustainably with limited resources, with biologist Peter Vitousek, here on Up Close. Now, Peter, not all of these island stories are success stories. Tell us about Rapanui or Easter Island.

PETER VITOUSEK

Well, that's what makes it interesting in a lot of ways, in that these societies did face the challenge of intensifying agricultural production and supporting a complex society, and most of them did. They then faced the challenge that when you practice intensive agriculture, you degrade the resource base which your intensive agriculture is based on, so they faced the challenge of making a transition to living more sustainably.

Some of them did a beautiful job, but not all of them. Now, there are stories about societies collapsing before European contact. Looking at Rapanui or Easter Island in particular, what my colleagues and I see is a really constrained society, one that didn't have the potential for intensifying agriculture that a place like Hawaii did, that did make the transition to an intensive production system but wasn't able to keep it going, and so the term I like to use is regressed from their peak of production, social organisation and probably population before Europeans arrived.

Then Europeans arrived, and the society collapsed with disease and Rapanui people being taken as slaves to South America to work in mines. That was the true collapse on Rapanui, but I think things probably got worse in much of Rapanui than they had been at one time before Europeans arrived, but they certainly did not - maybe were not able to, but for whatever reason did not, make a transition to living more sustainably on that land.

ANDI HORVATH

So, Peter, some of these islanders might have moved around quite a bit. There would have been some migration or drift over time. Did this pose challenges or perhaps even advantages?

PETER VITOUSEK

I'm sure there were opportunities that came from it. If you have people coming from another island where they've figured something out, they would bring that information and say there's a way. We can do this. Some of the Pacific islands - Tikopia is the one that is best recognised for this - clearly made an active choice to live more sustainably, redesigned its agricultural production system completely, regulated its population explicitly and persisted that way without changing much for about 1,000 years. Now, that sort of static sustainability is a very unusual thing in human history, but one cannot doubt that it was an interesting thing for a society to have chosen,

and not common at all.

ANDI HORVATH

When you talk about the regulation of societies for these islands for sustainability, what exactly do you mean?

PETER VITOUSEK

Well, what we know in the case of Tikopia was that they changed the agricultural system to be more sustainable. They also developed an ethic of population regulation to the point that that is carried in the controlling chant of the island. Each of the cultural groups has a chant that expresses the nature of this land and society, and the one there includes the idea that every man and woman should have a son and daughter and no more. It also includes the notion that the chiefs should gather the people - it's a small island - every year and decide how many young should be born in the coming year. So there's very explicit population regulation.

Of course, with the contraceptive technology they had, it's not something our society would recognise necessarily as a very humane system, but in a lot of ways, sustainability isn't always pretty. It does involve loss. It does involve forgoing things, and they made an explicit choice to keep their population at a level, which they've actually sustained into the present. There was no doubt infanticide, and I understand also if the population got too high for resources, if you had hurricanes or bad years, there would be forced voyaging. People would be forced to get in canoes and leave the island, which probably most of them didn't survive.

ANDI HORVATH

I wonder how they got voted off the island.

PETER VITOUSEK

Well, the chief I'm sure decided. Sustainability has a price. There's no question about that, but the price of a society losing its social organisation is also a horrendous price.

ANDI HORVATH

So, Peter, how do we know what went on in those Pacific islands, like Hawaii? What's the evidence? How did you find information about them?

PETER VITOUSEK

Well, there are lots of lines of evidence. First and foremost, the culture is alive, and it's carried its stories. Those are accessible and understandable. Second, these were intensive agriculturalists, so they changed the face of the land, just as we have, and where they haven't been overwritten by later human modifications, the evidence of those modifications is still clear in the land. That's what archaeology does. So the combination of archaeology and cultural understanding that has carried through from Hawaiian cultures to the present is really a pretty rich and powerful body of information that tells us about practice in the past.

ANDI HORVATH

Let's widen this out. Can we use this information to understand pathways to sustainability in a more global sense now?

PETER VITOUSEK

That's the interesting challenge. That's in a lot of ways why we do the work, trying to see if there's some information there that will help globally. For myself, I think that we're not likely to learn much about practices that will help us. They had a very constrained toolkit of technology and crops, and we have a broader one. As a global society now, we have more options in front of us. But there had to have been some extremely important ways of thinking that went into the transition, ways of social organisation that either fostered or stood in the way of making an active choice for living sustainably, and those are the things that I think we need to understand. Unfortunately, you won't see them by studying the remains of agricultural systems. You have to learn what you can of the society.

There's one thing that's interesting when you think about us as compared to those Pacific island societies. What was unique about them is that they were worlds, and as societies occupying isolated worlds, they were able to see the whole world, and they were able to see what was changing. And they were able to see that what's left was all there was. We've never been in that position before, but we are now. We have satellites that allow us to see the world repeatedly and with a pretty high resolution. We have sensors that tell us how the atmosphere is changing globally, and so we can unequivocally see how we are changing our world, and we also have pictures back from the moon that make it absolutely clear that Earth is an island. So we're in the same place they were, and they didn't all succeed, but we have that choice now.

ANDI HORVATH

It seems to me that we all have to cooperate globally on this one, which worries me.

PETER VITOUSEK

Yeah.

ANDI HORVATH

What happens if some nations won't work or play with us?

PETER VITOUSEK

Well, I think we have the advantage that in the long run, it's in people's interest to collaborate. And so some very bad things can happen in the short run, but should we manage our way to navigate through without things like nuclear war or pandemic disease, then I think the fact that it's in our long-run interest will bring us together, undoubtedly with blips because we're humans and we do stupid things politically and socially, and much will be lost because we didn't take a straight-line path, but I am confident that we will. Because it's in our interest to do so, we will collaborate in the long run.

ANDI HORVATH

Let's collaborate, and thanks for collaborating with us, Peter.

PETER VITOUSEK

Thank you.

ANDI HORVATH

We've been speaking about sustainability and what we can learn from the social and natural history of Pacific islands with biologist Peter Vitousek, who is Clifford G. Morrison Professor in Population & Resource Studies at Stanford University and a Senior Fellow at the Stanford Woods Institute for the Environment. You'll find a full transcript and more info on this and all our episodes on the Up Close website.

By the way, if you like Up Close, you may want to check out another one of our podcasts, Eavesdrop on Experts, which features stories of inspiration and insight in conversation with researchers and experts.

Up Close is a production of the University of Melbourne, Australia. This episode was recorded on the 8th May 2017. Producer was Eric van Bommel, audio engineering by Gavin Nebauer. I'm Andi Horvath. Cheers.

VOICEOVER

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