UK Research and Innovation

Briefing: Net zero versus No Net Loss - why carbon markets aren't a good model for investing in nature recovery

Based on an AFN Network+ webinar, held 28.02.25

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About Alex Teytelboym & this briefing

About this briefing:

This briefing is based on a webinar discussion between Prof Alex Teytelboym and Emily Norton, given to the AFN Network+ community on the 28th February 2025. Alex's work on auctions was done in partnership with his University of Oxford colleagues Professor Paul Klemperer and Professor Elizabeth Baldwin. This briefing is collated and written by Nina Pullman, food systems writer for AFN Network+, who has also lightly edited the transcript to paraphrase in parts. The briefing is edited by Jez Fredenburgh, knowledge exchange fellow at AFN Network+. You can also watch the webinar.

About the webinar topic:

In this webinar, Oxford University economist Alex Teytelboym set out a new approach to scaling investment in nature recovery. At a time of urgent need for private finance to pick up the heavy lifting in nature recovery, Alex explained why existing market designs such as carbon and Biodiversity Net Gain are not sufficient to scale investment in nature. He presented an innovative case study to demonstrate how a different, auction based approach, could scale and enable investment. Alex was in conversation with Emily Norton, AFN Network+ policy champion, and natural capital markets expert.

About Alex Teytelboym:

Alex Teytelboym is a professor of economics at the Department of Economics, University of Oxford, fellow by special election at St. Catherine's College, and a professorial research fellow at the Institute for New Economic Thinking at the Oxford Martin School. He directs the Oxford University Business Economics Programme and the MSc in Financial Economics Programme.

His current research interests lie mainly in market and mechanism design. He is also interested in environmental economics and co-leads the finance theme at the Leverhulme Centre for Nature Recovery. He often advises companies, governments and NGOs on auction and market design. He's also co-founder of Refugees.AI, an organisation that is developing new technology for refugee resettlement (originally funded by Skoll Centre for Social Entrepreneurship).

About Emily Norton:

Emily Norton has 25 years' experience in the food and farming sector. She originally qualified as a lawyer before undertaking an MSc in sustainable agriculture. Her career has taken her from family business to global PLC, with time spent in Brussels and across the UK.

Emily is the founder of Farm Foresight Ltd, a strategic advisory service for the land management sector, working with farmers, investors, politicians and businesses on rural policy and emerging trends. She has expertise in natural capital influences on land, food and farming. Emily holds non-executive board positions at Soil Association Exchange, the Environmental Markets Board and for the Duchy of Cornwall. She is a member of the national policy committee of the Country Land and Business Association and is a trustee at the Royal

Norfolk Agricultural Association. She writes a regular opinion column in the Farmers Weekly and lives and farms in Norfolk.

Summary of key points

Key points from Alex Teytelboym

Markets can be made to work for nature, but require good design and regulation

- Economists at the Leverhulme Centre for Nature Recovery have ample evidence that markets can be made to work well in many contexts, but they require attention to detail of the market function, design and regulation.
- Companies create pollutants as a by-product of consumer products. Without a price on this by-product, there will be no incentive to reduce.
- There are two ways to set a financial incentive against carbon reduction, one is a tax and one is an emissions trading scheme.
- Globally, there are several emissions trading schemes, including the EU emission trading scheme, of which the UK is still essentially part.
- Trading schemes work by creating permits that allow carbon emissions. To emit more than the allocated number of permits, you have to buy from the market. This leads to trade, and a set price for trading carbon.
- The two mechanisms lead to the same outcome: paying to pollute. The success of permit trading schemes for carbon and other pollutants, like sulphur dioxide or water pollution, has led to transparent and effective regulation, as well as investment into cleaner forms of production.
- In the UK, there is now a price that developers have to pay in order to offset the damage that they cause to biodiversity when they build housing, known as Biodiversity Net Gain (BNG).

Credit trading works for carbon but not for biodiversity

- A tonne of carbon is equal regardless of location, in terms of how much damage it causes. As such, carbon markets have developed around the concept of one pollutant and one price.
- The concept of one price has been translated into biodiversity. Diversity units damaged by a housing developer are offset by the same number of biodiversity units elsewhere. The problem is that biodiversity is not homogenous, and it also requires interaction within an ecosystem. Replacing a unit of biodiversity is not possible without also replacing its interlocking parts.
- Government should continue with BNG, but consider reforming it away from something that commodifies nature into one unit.

Offering multiple prices could better reflect landscape complexity

- The ecological benefit of biodiversity restoration often comes from actions that are concentrated, interlocking and adjacent. Financial rewards for biodiversity restoration should work in the same way.
- For example, three adjacent landowners should be compensated together, even though it might seem expensive at a pure cost level, because the ecological value of several coordinated components at a landscape level is so valuable.

Auctions are a viable way to sell biodiversity credits and incentives

- Auction mechanisms could ensure that recipients of government subsidies or private finance are those who, as a combination, deliver the most ecological value per pound.
- In 2021, Alex and his Oxford colleagues Professor Elizabeth Baldwin and Professor Paul Klemperer designed and implemented the first-ever “combinatorial auction” for habitat restoration.

The RSPB and Defra trialled auction payments to protect turtle doves

- Endangered turtle doves need three things: scrub, for nesting habitat; water from ponds and accessible rivers; and food (seed mix). The key is that these need to be close

together so chicks can reach them without travelling far.
- Farmers and landowners submitted different actions into a combinatorial auction. For example, indicating the location of their scrub, or when they commit to covering fields with seed mix. They also stated how much they would need to be paid to do this.
- Farmers or landowners signed up for a two-year agreement with payments distributed by RSPB. Winning bids offered a combination of scrub, water access and adjacent food plots, and therefore delivered the most ecological value. In practice, farmers were able to bid together as clusters to offer these combinations.
- The system compares ecological value per pound by placing bids on the background of a complex ecological model that reflects the ecosystem that will be funded.
- This case study is believed to be the first time a combinatorial auction has been used for ecosystem restoration. The aim was to show how a coordinated set of bids is beneficial for ecology and value for money.

The US has restored wetlands by offsets in the same location

- The United States, which has had a huge decline in wetlands since the Second World War, implemented a novel offset system.
- Any housing development on marginal wetland had to offset that lost wetland in the same location.
- It has been one of the most successful biodiversity recovery policies ever implemented.

Auctions reveal true cost of ecological restoration, separate to the question of overall support for farming

- Farmers are the only ones who know how much it costs for them to restore nature on their land. Biodiversity markets do not have access to that information.
- In principle, there is nothing wrong with taxing corporate businesses and redistributing the money. But it leads to a question around who is responsible for taking the action to restore damage caused by those corporate activities.
- How society values food production and overall farming support are separate issues to how funding is made available to restore landscapes.

Key points from Emily Norton

Funds generated by Biodiversity Net Gain credits are not reaching nature

- Funds created through the market for biodiversity credits are not coming back down to nature adequately or at the speed required.
- There is often a mismatch in terms of pricing between what makes sense at the corporate level, compared to what makes sense for nature.
- The scale of investment that is needed to repay the ecological debt caused by economic activity is in total mismatch.

Carbon credits create single issue ecological outcomes

- The problem is the simplistic level of traded units, for example the carbon credit, leads to single issue outcomes.
- For example, poor woodland creation is a result of simply equating carbon to carbon without looking at ecological requirements.

Farmers face competition despite being at the centre of nature markets

- Farmers are prioritised within nature markets, but they have unfair competition in corporate entities that are used to working within financial market systems.
- Carbon and biodiversity trading schemes are geared towards a corporate paying as little as possible for a beneficial nature outcome, against a backdrop of farmers already being economically exploited by a market that doesn’t pay them enough.
- The auction doesn't fix supply chain inequality. Nature markets are fixing a problem that shouldn't exist in terms of financially rewarding farmers for what they already do.

Key points from audience Q&A

Voluntary markets can work but compulsory schemes can generate more money and scalability

- A voluntary carbon scheme can work, where people pay what they think carbon or biodiversity credits are worth. The key

factor in success is how well the market or scheme is organised.
- The more money a scheme generates, the better. That is the key difference between compliance and voluntary; a compulsory scheme will generate more funds and is easier to scale up to create more impact.

Reliance on well-meaning landowners won't deliver nature at scale without the right incentives

- Encouraging a land management approach that isn't extractive and provides space for nature can offer an alternative to financial mechanisms to leverage cash from polluters to a certain extent.
- Relying on the most well-meaning landowners to do the right thing without appropriate incentives is not going to deliver nature recovery at scale.
- Commercial landowners require incentives and opportunities, in order to choose nature restoration over other options, such as cattle farming.
- The evidence is that incentives work but they need to be carefully created.

Markets can be made to work for land equality or other objectives

- Nature markets can help tackle the underlying inequality of land ownership. For example, in Scotland, land is held by few people, and there is a risk of increasing inequality by providing a new source of income for landowners.
- Markets can be made to work with very complicated objectives, for example addressing degraded ecology and inequality of land ownership.
- For example, an auction could be designed to uplift bids from tenant farmers to allow them more chance of winning funds.

Communities and villages could bid to win funds for nature recovery

- Government departments including Defra and the Treasury could look at how innovative funding mechanisms for local communities could help restore nature without commodifying it, as better value for nature and for public funds.
- Community groups could lobby, write letters and raise awareness that nature recovery money is currently not being used efficiently. Communities could also get together as a village, for example, and bid to be paid together for restoring nature.
- The new environment fund announced by the government could be used in a more innovative way.

Webinar transcript

Speakers: Alex Teytelboym (AT), Emily Norton (EN), Jez Fredenburgh (JF).

Oxford University economist Alex Teytelboym sets out a new approach to scaling investment in nature recovery, in conversation with AFN nature capital expert Emily Norton.

Alex Teytelboym is Professor of Economics at the University of Oxford and leads the finance theme at the Leverhulme Centre for Nature Recovery

JF: Welcome and thanks very much for joining this AFN webinar on 'net zero v no net loss: why carbon markets aren't a good model for investing in nature recovery'. So I'm Jez Fredenburgh. I'm based at the School of Environmental Sciences at the University of East Anglia, where I'm the Knowledge Exchange fellow for the AFN network.

I'm delighted to welcome our speaker, Alex Teytelboym. Alex is Professor of Economics at the University of Oxford, a fellow at St Catherine's College and a professorial research fellow at the Institute for New Economic Thinking at the Oxford Martin School. He directs the university's Business Economics program and an MSc in financial economics as well. His current research interests lie mainly in market and mechanism design, and he's interested in environmental economics, and leads the finance theme at the Leverhulme Centre for Nature Recovery. He advises companies, governments and NGOs, on auction and market design. So needless to say, Alex knows a thing or two about markets.

We're running things a little bit differently today to our normal webinars. I've asked Emily Norton, who many of you will know, to be our chair. She's our policy champion on land, and she's also our natural capital market expert. So Emily, if I hand over to you, and off you go.

There are questions around the role of private finance in nature recovery

EN: Happy days. Thank you so much, Jez, and welcome everybody to this webinar. I know a huge amount of you are deep in the weeds of figuring out mechanisms for nature recovery, with all sorts of different organisations represented here. So I'm not going to spend a huge amount of time reminding us all why investment into nature recovery is absolutely critical. You will all, I'm sure, be at that stage, as I am in various different guises, of frustration that the projected wall of demand that we keep getting is not manifesting itself at project level. So whether it's landscape recovery or across different forms of carbon markets or nature markets, the theory of them seems pretty good. But the reality of them seems mired in all sorts of different levels of problem.

And so what Alex is thinking through is a reason why some of those things aren't working quite the way that they could be. And then Alex has got a really amazing case study of how finance can be unlocked. I have got some challenging questions to put to Alex. However, this is really about everybody to add this, and I think with Alex's permission, really also challenging the role of private finance in nature, and whether we're putting too much expectation on the private sector to be doing this. So I think there's some legitimate questions there that really need answering.

So in this context, as an experienced policy champion for the AFN network - and there are three policy champions this year, as well as lots of other champions, we're all looking at different aspects of the shifts that we need in order to transform the agri food system. But also I do a variety of other things, as some of you will know, including the environmental markets board, which is looking at the governance of nature markets. And so I'm going to be drawing on some of that experience today. So enough, Alex, please tell everybody who you are and what you do at the Leverhulme Centre for Nature Recovery.

AT: It's really wonderful to be chaired by somebody so knowledgeable. So I'm Alex. I am an economist, I'm an academic economist, but a lot of what I do, especially in the Leverhulme Centre, which is a new centre devoted to interdisciplinary research on nature recovery questions, is how to make markets work for nature. Economists have a lot of evidence that markets can be made to work well in many contexts, but what it requires is very careful design, very careful regulation, a lot of attention being paid to the detail of the market function. And when we get it right, they work miraculously to solve all sorts of problems, in particular environmental problems. So that's something I want to convey to the wonderful audience today.

Mechanisms like tax or trading can force corporates to pay money for polluting

EN: I love that concept. When we get it right, hopefully we'll come back to some examples later of where it has been got right, because it doesn't feel yet that we've got very many examples to draw on. But let's start from beginning anyway. The whole title of this 'net zero versus no net loss': explain that, the principles of carbon markets, which is the net zero bit, and then how that's been a model for the biodiversity net gain markets as well. And perhaps why those things haven't been working quite as well as they should.

AT: So let's start with net zero. And the idea of how to use markets to try to get us to net zero. The idea is quite old and very well developed. And the problem is the following: people and companies pollute. They produce things that we want to buy, but in the process of doing so, they produce carbon, and this carbon creates global warming, increases temperatures and harms everybody else. And what economists point out is if you have no incentive to reduce the pollutant, there will be too much of the pollutant. So what can one do? Basically, you have one option in a narrow economic way. You have to price it. You have to set a price on carbon that will reflect the cost to society of this carbon. So it's true for all sorts of forms of pollution. Carbon is a just one manifestation of this. And essentially, there's two ways in which you can do this. One is that you can set a tax on carbon, very straightforward. And if you set the tax that is going to reflect the cost of the carbon to society, that's going to appropriately shift the incentives of consumers and producers in a way that will take you from excess production of carbon to an appropriate amount of carbon production.

The other way to do it is to say, well, we're not sure exactly what the price should be, but we have a better idea of the quantity of the carbon we want to get to, and we should let people figure out what the price is. And this is the idea behind the EU emission trading scheme that the UK is still essentially part of, and various other emissions trading schemes around the world. And the way it works is very simple. You get some number of permits that allow you to to emit carbon. So if you want to emit more than the number of permits that you have, you have to go and buy permits from the market. You go to the market and you buy these permits. And these are called allowances, very often.

And if you pollute more, you have to buy more permits. And so people buy and sell permits. If you have more permits than you need, you can sell them into the market. If you need to buy more permits, you will go and buy these from the market. Note that the number of permits is set to be some quantity that is smaller than what people would have produced without this regulation. And so somebody is going to have to cut. And so the question is, who's going to cut? And so people trade, and the price that comes out in this market is what we would think of as the permit price or the carbon price in this context.

So it's a price that comes out of this trading mechanism. And essentially what happens to the polluters, is that they now pay, instead of paying the carbon tax, they pay this carbon price that emerges in this market. In fairness, it's a very complicated way of achieving something quite similar that you could have achieved by a carbon tax, and there are interesting reasons why you might use one versus the other, but by and large, the idea that eventual outcome is pretty similar. You end up paying for polluting.

Now these schemes for carbon and for other things, like sulphur dioxide or water pollution, they've been used all over the world to try to regulate pollution in ways that are transparent and effective and have flexibility to help direct investment into cleaner forms of production. And because they've been so incredibly successful, we've started thinking, where can we move them on to? And one of the things that people have turned their eyes to is biodiversity, and that's where the versus part comes in. So that's where I would talk about no net loss or net gain.

So the idea behind this in the biodiversity context, is to say, hey, look, no net loss. It really says that whenever you harm biodiversity, you harm the natural environment in some way. You should maybe offset it, or buy an offset to compensate for the loss that you've caused. And so that creates a market. It says every time you create a housing development and you destroy some nature, you're going to have to offset this damage somewhere else. There's going to be people who will help you do that. They will make sure that you know this gets done and it's appropriately accounted for.

And in the end, you will have a price that's going to emerge for this. And the quantity here now just says no net loss, right? So maybe 'or net gain', or some amount, and there's going to be a price that's going to come out. And so in the context of the biodiversity net gain market we have in the UK. That's essentially the system, with bells and whistles, but basically that's the system. There is now a price that developers have to pay in order to offset the damage that they cause to biodiversity, natural environment when they build housing, for example.

There is a gap between how much funding nature requires and how much it receives

EN: So in my mind, all this is focused on the economic activity, and then working out how you regulate or impose some kind of tax on that activity in order to generate a financial flow. And the financial flow is then somehow placed in nature in order to achieve the outcome. And we can maybe get to that bit in a minute. So this is very much around thinking about the economic activity that's creating the pollutant, and working out how you can manipulate that thing, right?

So we know that flow is not necessarily coming back down to nature adequately or at the speed that it should be, and that sometimes this pricing problem is mismatching between what makes sense at the corporate level or at the economic activity level, and then what makes sense at the nature level. And certainly the scale of investment that's needed in nature in order to repay the ecological debt caused by the economic activity is in total mismatch. And that's this big gap that we've been very aware of that needs to come back into nature. So what's this innovation that you have been thinking about, and how is it going to start to address this flow problem?

AT: So there's two. When it comes to carbon, this system is basically great. And the reason is very simple, because a tonne of carbon in Cambridgeshire is the same as the tonne of carbon in Bergen, in terms of how much damage it causes to the whole world, not just locally. And so to an economist, when there is one pollutant that is polluting, in that case, carbon, you need one price to be able to regulate it. And we've taken this idea of just having one price and we've transplanted it into biodiversity by saying, well, there is a buyer.

Diversity units that are being damaged by, say, this housing developer, and so we need to offset the number of biodiversity units somewhere else. And so that gives you one price for biodiversity. And I think it's obvious to everyone on this call that there's something suspicious about this idea from the start, that even though it makes a lot of sense for carbon, it just doesn't quite add up when you think about biodiversity, because somehow, in the process of transplanting this idea, you've just said, well, all biodiversity is the same as just measured in units.

It's quite clear that there's a lot of stuff going on in a landscape that is not just some mass of nature. These are amazing, interacting, very spatially coordinated components that somehow all need to work together to produce what we might call natural capital, or biodiversity. And so what you might worry about, and this is, I think, what you're referring to as the gap, Emily, is basically that when developers might destroy something, the cost they end up paying, in terms of the units, is not properly reflective in what they offset.

So it's very difficult to recreate the exact ecosystem, but you make it even harder for yourself when you turn it, the thing that you have harmed or damaged, into some sort of homogenous blob of credits that is supposed to get offset somewhere else. You lose the interlocking parts, the different landscapes that function together by making everything homogenous. And in particular, what it does is creates a very bad incentive. So having the single price creates a very bad incentive to try to offset, if you like, at the lowest ecological cost in terms of these units. So note, in both schemes, carbon or biodiversity net gain. The intention is a good one. The intention is to make markets work in order to protect nature. The goal is to limit damage to the environment at the lowest possible cost.

Using an auction rather than simplified Biodiversity Net Gain units could better reflect the complexity of landscapes and ecosystems

EN: The problem is when it's rendered to that simplistic level of these units, the carbon credit, you get these single issue outcomes. The example being bad woodland creation, because you're looking at carbon to carbon, right? And in the same way as the BNG type model looks at what's been destroyed and then tries to recreate it in the most reductive way, as opposed to a blended landscape. Landscape is complicated, but your landscape is really complicated at the micro level. You know, all of the fungi and bacteria and everything that's making that work when we're not reflecting or recreating that, when we're doing this very simplistic here's the credit and the money flow to here's the offset, right? So your idea is around this combinatorial approach. So perhaps you could explain a little bit about that, and then I think let's move into your case study, because I think it will really help people understand.

AT: So at a very high level, the idea that I'm suggesting is to try and use something that is a bit more sophisticated than having a single price. And what we want is for a landscape to function well. For ecological function, it needs the appropriate components. And so the idea is very simple. There is public funds in order to create new habitats and new ecosystems. We need to think carefully about not just a price, but exactly which landowner is paid how much at a landscape level. So it might very well be that three landowners who are next to each other who are taking a particularly good environmental action should be compensated together, even though they might seem expensive at a pure cost level, because the ecological value of several coordinated components at a landscape level is so ecologically valuable.

Remember, we want to achieve as much ecological benefit at the least cost, but we care about the ecological benefit. So the ecological benefit is often coming from the fact that things are concentrated and interlocking and adjacent and so on. We need to reward it in some way, right? And so we can't have a single price, because that does not say who should be paid what. And so the idea is to use auction-like mechanisms to direct, to make sure that the winners of these auctions for perhaps government subsidies, or it could be for private finance, but to make sure that the winners of these auctions are people who are delivering together as a combination. That's the word combinatorial. As a combination, they deliver the most ecological value per pound.

EN: So these auctions are quite common already. They're quite a well-known concept. So telecoms, other things which are bundled together. We've got a local auction house, and you get the tray that's full of old crockery, and there's all sorts of rubbish in there. But there also might be one really, really good thing that people really value above all of the others. But you buy the whole thing, and you bid on the whole thing, right?

Even though it's got lots of different things in there, just different people might value the items within that collection that lot differently. And so this is all about how you bundle together all of these different things of value, some of which are easily monetised or easily viewed, and other things which are incidental or there anyway, in order to get a good price discovery on that. So hopefully that all makes sense. Right, now let's give this case study.

AT: Just to come back to your example. You might go to an auction and you need a fork, a knife and a spoon, because otherwise you can't have dinner. But maybe Jez is selling the fork and I'm selling the knife and the spoon. You need to buy all of them to be able to go and have dinner. This is going to be the same idea here, except that you're going to be Defra and we are going to be landowners with very important ecosystems together. But that's exactly the idea. So you've got the analogy exactly right, so I hope people can see it.

Case study: The RSPB project to trial an auction system to restore turtle dove populations

AT: So this is a project we did with RSPB in Norfolk and Suffolk. And I saw there were some people in Norfolk and Suffolk here with my wonderful colleagues, Elizabeth Balden and Paul Klemperer, and our student, Chris Hyland , has been helping us with some of the analysis. So the objective here was to protect turtle doves. I don't think I need to tell this audience here why turtle doves are wonderful and why we should protect them. They're obviously endangered. They've been endangered for a long time, and we wanted to use auctions to create habitats and ecosystems to try and help them.

So here is what happened in this auction at a very high level. Turtle doves need three things: scrub, which is a nesting habitat and usually looks like hedgerows; water to drink and that can come from ponds and accessible rivers; and they need food, which is essentially seed mix. And the key thing is that these things need to be close to one another. So they all need to be within a certain distance. In particular, when turtle doves come and breed, the little chicks can't travel too far to the seed mix or to the water, or they might perish. And so all of these things need to be sufficiently close to one another to be useful to the little turtle doves that breed in England. And so the closer the better, basically.

But if things are a bit further apart, maybe they deliver a bit less ecological value. So now what we want, we want to procure these three things at once, but they might all be on different people's lands. And they might be different parts of different people's land. So how are we going to use an auction-like mechanism? So the idea is pretty straightforward. And I should say the ecology of this is very complicated. You want things to be clustered, but you want the clusters to be spread out. And we worked with RSPB to figure out what is the best possible configuration that you can get. And then when we can't get the best possible configuration, what is the next best thing, and so on, given the budget that we had.

So here's how a combinatorial auction works. I imagine most people have an idea of how an auction works. Remember, this is a procurement auction. In this case, the government. In this case, Defra used its funds to try and pay farmers to take certain actions that are going to help turtle doves with RSPBs help. So what we want is people to get as low cost as possible, the biggest bang for buck from the government's perspective. I'm sure if you're a landowner joining, you might think about it in the opposite way. But for sure, the government wants to get the most bang for its ecological buck.

So we have some features of the landscape, it might be a river which is already there. And people can even create their own ponds. So they can submit different actions into this combinatorial auction. And they might also indicate on a map, and they do this all on the website, where their scrub is, and they can indicate their own scrub and their neighbour's scrub and so on. And finally, what they commit to doing is to cover some of their fields with seed mix at an appropriate time in the year. And they would say how much they need to be paid to do this.

So they might say, I'm going to put the seed mix here, and I would like to be paid 100 pounds. Okay, the numbers are completely made up in this case. And so what do we do? What happens in a combinatorial auction? We get all these bids from different landowners, and we evaluate any possible combination of them together. Then we say, okay, well, maybe these two bids on the top left, what are they worth in terms of ecology, right? So we have to think about what is going to be the ecological outcome.

Now, if you look at this map I've created, the two cheapest bids are seven pounds and 48 pounds. And maybe these are the ones you might want to take if you didn't care about ecological value. But once you take all the features into account, the scrub and the river and the adjacency of the different food plots, you might actually conclude that the winning bids are completely different, because they will deliver the most ecological bang for buck. And here our objective, we created a unit, which we called turtle dove happiness, which we abbreviate to TDHA. And so we're trying to get as many TDHAs per pound as we possibly can. And in this particular example, what we want to do is actually take quite expensive bids, because they deliver so much ecological value per pound.

And so we had this very complicated ecological model in the background of this auction to try and figure out who should be a winner. And the thing I want to stress is that the winners of this auction are not necessarily people who put in the lowest bids. The people who won in this auction are the people who, in combination with their neighbours, perhaps, and with other bidders, delivered the most ecological value per pound. And this can be very common. In this case, the ecological model is very complicated. We ran two of these auctions a few years ago as a pilot to show how this works. We had a bunch of bids from each one. You can see the bids were actually quite large. And the landowners were paid quite substantial amounts of money, quite a bit above, actually, what you might get from alternative schemes.

But remember, we're not here just comparing cost to cost. We're trying to compare ecological value per pound to ecological value. And the hope was that by having coordinated bids, you could actually justify paying farmers much more because they would be delivering more ecological benefits. In this case, so people were actually being paid quite substantial sums for the actions that they were taking. But this can be justified by having greater ecological value that was delivered within the auction budget that we were given by Defra.

So you get all these bids, and you have to evaluate them all in any possible combination, and there's a lot of computation that needs to be done. And in the end, you say, ta, da, here are the winners, given the budget that we've got. And so we ran these auctions to show the government that this really can be done, and this idea can be scaled quite a bit to other places. I think this was the first time in human history somebody has used a combinatorial auction for ecosystem creation.

EN: So in this situation, it was government who was paying ecological value. So it was Defra who was underwriting that scheme?

AT: That's exactly right. So this was during the ELM test and trials phase when the government was suddenly very interested in innovative approaches to post Brexit payments to landowners, to try and create an alternative to the Common Agricultural Policy. And as part of that, they were trying to use innovative designs, and we were one of the ones that were selected.

Questions from the audience

EN: Could voluntary biodiversity markets provide a more competitive mechanism, rather than compliance markets, or a government-derived market? Can voluntary biodiversity markets be trusted to pay for full ecological value?

AT: It's a great question. So it doesn't really matter who the money comes from. So if the money came from some voluntary carbon scheme, great. The question is, how is the market organised? That's a key point. So we can discuss whether or not a voluntary carbon market, voluntary biodiversity market is a good idea relative to a compliance market, and I have some views on that. But what I'm trying to suggest is almost orthogonal to this, because who pays in this case is not the relevant thing. Obviously, the more money, the better, because then you can pay more farmers. And that's actually, I think, the key difference between compliance and voluntary. Ultimately, there just isn't enough funds from a voluntary market. The reason why we need a compliance market, I think, is because we can scale this, and we can make sure that we have enough coverage and enough funds. But it's not just about the amount of money.

What I'm trying to suggest is that the way we use the money that we have, because in the end, we have money from developers that's coming from the BNGG, so that's some pot of cash that is there because things get built. The problem is how we use it. And what I'm suggesting is that the way we use the money is perhaps not actually restoring the ecology in the way that we hope, which is one for one or plus 10% or something. Maybe we actually lose while we think we're gaining 10%, that's my concern.

EN: If the economic algorithm is complicated, the bidders are really in the dark in terms of calculating their bid. Might this undermine their ability to deliver?

AT: So it is complicated. So the way that we often think about, how do you design a good market is the one that makes it easy for the bidder to bid that cost, or something that is maybe a bit higher than their cost that they think is reasonable. So here, in a way, because it's so complicated, it makes it quite difficult to try and get too clever and too strategic. We want to avoid cases in which a landowner would try to strategise. And here it's very hard to strategise, in part because whether or not you win depends on what other farmers are bidding in a pretty complicated way.

So even though we gave farmers a lot of guidance to try and say if you locate your food bed next to the scrub, that's going to make you more likely to win. As I said, things being closer is always good. So that you can say with some certainty, but in the end, you can't really say, you're going to win, because it really does depend on who else is bidding next to you, on what they're bidding and what their landscape looks like.

So in some sense, it does put the landowners in the dark, and that might be frustrating, and the feedback we got was certainly frustration. But as an auction designer, somebody who designs markets, I think annoying your participants is actually often a good thing, because then you think, okay, well, they're not able to just take that money and do very little with it. They are actually bidding in an aggressive, competitive way, trying to deliver some value. And I know if you're a landowner, that would be frustrating, but if you think about it from a public funds point of view, you do want to get that sense of competition and value for money. But the question is exactly right, it is going to be tricky, but I think this is just the nature of more complex markets like that.

EN: Okay, so there's a lot of complexity in this stuff, and we're trying to manage complexity through simple mechanisms that address complexity while also being simple. So there's always this massive trade off. But I think there's a really interesting question here, which speaks to the human, economic, arguably capitalist, approach of trying to intervene in stuff, spending a lot of time worrying about price and less about the underlying systems that sustain biodiversity.

EN: Should we just be encouraging a land management approach that isn't extractive? Is providing space for nature (by its very definition creating space for biodiversity to exist), preferable to finding mechanisms to leverage cash from polluters?

AT: So I think we need to get the incentives right. And I think relying on the most well-meaning landowners to do the right thing without appropriate incentives is not going to deliver biodiversity recovery and nature recovery at scale. So as an economist, what I think about all the time is, what are the incentives? Now, typically they're going to be financial and monitoring incentives. I agree there are other incentives at play here. Actually, the approach that I'm suggesting is very community based. Note that if you're doing something good, and your neighbour is doing something good, that makes you both more likely to win. And so I'm usually for an auction. We're encouraging collaboration.

We're encouraging people to come together as communities, to do things together at the landscape level. So I think that the monetary incentive is going to be important. Ultimately, the landowners we often engage with, a lot of them are commercial. They're going to pay attention to what is the opportunity cost. What is the alternative to doing biodiversity? Is it growing things? Is it cattle, etc? We need to make sure that the choices they're making are going to reflect the benefits and the cost to society at large, right? And so, while I agree that we can wish that people were doing more things, the evidence is that incentives, monitoring incentives do work, but they do need to be carefully created.

The US has managed to restore wetlands by compulsory offsets in the same location

If I may give you one example outside of our country, in the United States, which had a horrific decline in wetlands since the Second World War, because of huge infrastructure creation and these precious, beautiful wetlands were being destroyed at extraordinary pace. And what they implemented was a system not that different to what we have as BNG. So the idea was if you're going to be creating housing development on marginal wetland, you have to offset that wetland in the same location. It has probably been the most successful biodiversity recovery policy ever implemented. This market is worth billions of dollars a year, and it stopped the loss of wetlands in the United States. Essentially, in the early Bush years, the amount of wetlands went up, which is just remarkable right now. There's all sorts of caveats about the quality of the wetlands that were restored, and I accept all of those. But if you compare the pace of loss to what is happening right now, it is night and day. So we have so much evidence that incentives can work, but I think they need to be carefully thought through.

EN: Is there a risk in looking at keystone species, like Turtle Dove? What is the ecological impact of prioritising one species over any other?

AT: So the turtle doves are supposed to be an example. It's supposed to get you to show up to the seminar, I think. And it was a way for us to say we all agree that turtle doves are wonderful. So let's just imagine we want to get as many turtle doves as possible. Okay? And it's really not about turtle doves, right? It's about the fact that many species function in ecosystems, and these ecosystems have interlocking components, and they need to be connected and need to be spatially coordinated. I think, if I may speak for RSPB, even though they have an entire project devoted to turtle doves called operations Turtle Dove, which is an amazing project in that part of the country, they themselves saw this as a broader way of trying to restore bird species in the country, because these things that we are doing for turtle doves are just as good for pretty much any other bird species.

Now we wanted to show that even if you created an extremely complex ecological model that was targeted at turtle doves, that it can still be made to work, right? So we made it as difficult for ourselves as possible. But of course, if you were to scale this, you've got to think much more broadly. How much do you want to devote to restoring bird habitats? How much do you want to devote to restoring wetlands or grasslands and so on. And that's a choice for the government. But I think what they shouldn't do, or maybe they should move away from,

I think they should continue doing BNG, but think about reforming it from something that just commodifies all nature into one unit. And I think that is a flawed way of thinking about it. It is much better to think about it as nature, as being heterogeneous. Now exactly what it is, I think, is up to landowners. It's up to local councils, it's up to the government and so on. This is a societal decision, but I don't think society would choose, if it could, to say one unit of nature here is like another unit of nature here. That seems to be too much commodification. In your words, that's maybe too capitalistic, right? But markets can deliver other types of outcomes, and this is an example.

EN: How successful was the scheme at delivering outcomes at farm level, what were the farmers signing up to? Has it been successful in delivering turtle dove outcomes?

AT: So as I said, we were never really trying to measure success by counting the number of turtle doves. The number of turtle doves in this country has plummeted by over 95%, maybe 99%, over the last 30 years. It has been a complete disaster. So there are very few of them. Those of you who have seen a turtle dove in this country, you should count yourself as lucky. I think more people have seen the late Queen than they have seen a turtle dove. So I think RSPB was thinking about it from a broader support for bird habitats while making this about turtle doves here in terms of measuring success.

I think what we wanted to show is that you might get bids that are going to be comparable, we expected them to be higher than for alternative schemes. Remember, farmers had an outside option. They could just get paid for doing similar things from other schemes. And so they were paid more. And so you might say, well, that's not very good value for money. But again, what we want to show is that the bids that we're going to get are going to have this sort of spatial, coordinated component that is going to be good for ecology.

And then some of the things we try to do is compare for ourselves in our analysis. What would have happened if we did not pay attention to the ecology? Would we have got good value for mileage just by picking the lowest bids? And the answer was basically no. It does make a difference that you actually take the full ecology into account. Remember, we still need to invent units like our TDHAs, right? And so it's difficult to express value in terms of TDHAs. But there is a way of quantifying these kinds of benefits. So to us as auction designers, this auction certainly was a success. There was some very interesting things that emerged. We want people who are adjacent neighbours to bid together, because they are more valuable as a group, essentially. And people figured that out.

Farmers are very smart, and we knew farmers were going to be very smart, and so we expected for this to happen. But it really did happen that farmers who were together submitted bids, which were in some cases really quite high, because they realised that they're going to deliver a lot of value in a nefarious way. You might call this collusion, right? But I don't think it was so nefarious. People go to the pub together. They say I'm going to be bidding in this auction. I say, yes, I am. Well, okay, good. And then you think, okay, maybe I'll submit a bid that's a little bit higher.

But we expected this to happen because we almost encouraged farmers to do it. And so you might say, how do you actually create enough competition value for money in this context where we're encouraging people, essentially, to coordinate their bids, right? Or to make bids that are nearby more valuable. And the idea was to actually run this auction in several parts, in both Norfolk and Suffolk at the same time, to make sure that we create competition across the clusters. So don't think each bidder is competing against all the other bidders. It's really a cluster of bidders competing against another cluster of bidders. It's back to village football. It's 10 farmers together versus another 10 farmers. That's where the competition's coming from.

EN: Was it a five-year agreement that they were signing up for?

AT: So it was a two-year agreement that you were signing up for, and the money was distributed by RSPB. It was a payer's bid auction. So if you won in this auction, you would be paid exactly your bid, over the course of the two years, if I remember correctly. And that was all made very clear. So you were committing to do this for two seasons. RSPB would come and check the compliance rates were fantastic. So thank you to the farming community for being so on top of it. Essentially nobody dropped out. And that was a metric of success for us, that people actually delivered what they promised to deliver. It was really superb compliance.

EN: How do you consider the underlying inequality of land ownership when implementing these markets? In Scotland, land is held by only a few people, so there is a risk that these markets make inequality worse as they provide a new source of income for land owners.

EN: Communities have so much influence over landscapes, not just farmers and landowners, so how do we think about broadening and using these tools that can manage that complexity of lots of different buyers and sellers together to include these ideas of inequality and fairness?

AT: What I hope to convey through the case study is that markets can be worked, can be made to work even, with very complicated objectives. So here our objective was ecology. And the question is really about other types of objectives that we care about, like inequality of land ownership and so on. The point is that something like an auction, if well designed, can capture these kinds of objectives. So for example, you can imagine an auction in which tenant farmers, for example, would get an uplift in their bids, right? So whatever they're going to decide to do, we will score their bid to be more valuable, and so therefore more likely to win, right? And so you can encode and incorporate these objectives in a pretty transparent way. To give you a very dull example, when the government does a radio spectrum as you mentioned, if you're a new entrant, you're often going to face less competition. There might be a spectrum set aside for you that only the new entrants would compete on, because the government might care about bringing new people into making your mobile phone work very well, not just the incumbents. And so you can do things like that.

Now, inequality is at the core of how you think about market design. Equity concerns come up all the time, and I think we don't pay enough attention to them, actually, in general. But in the same way as we can think about turtle doves, as it's a very complicated objective, we can think about very complex objectives related to equity. I dare not speak to the specific context of Scotland, which I don't actually know that well. I know the issue of land ownership. Exactly how it should be fixed, I probably should not speculate on this call, but just to say there are ways of doing it. Auctions are not just about getting people to pay as little as possible for the cheapest possible thing. It's about delivering value for money, and value can come from all sorts of objectives, including equity.

I think part of that is this policy confusion we've got at the moment, which is the government is leaning into nature markets for various different reasons. One of the reasons it's leaning into nature markets is because it's got a nature problem. Another one is because of the farmer income problem, which is part of the transition away from the Common Agricultural Policy. As we all famously know, food markets don't reward farmers for producing food, or the system is designed in order to ensure that farmers are economically optimising their output to provide food products to the market not necessarily in a way that covers the natural capital exploitation costs of doing so. So we're not paying enough into the system in order to restore it and ensure that the externalities are minimised and reduced.

EN: And so I suppose this is what concerns me when you said, what does fair to farmers even mean? Farmers as economic agents are being prioritised within this nature market space, but are doing so against what feels like unfair competition. And a lot of this is about saying, how can the corporate pay as little as possible for a nature outcome that's deemed to be beneficial, against this backdrop of farmers being economically exploited by a system which says, we will buy your produce, but we won't necessarily invest in you. So the auction doesn't really fix that inequality unless everybody is on an equal footing, in having enough of a demand side and enough of a supply side equality in order to use these mechanisms to create those outcomes, right? This strikes me as being the heart of the problem of nature markets: we think they're great, but they're fixing a problem that shouldn't exist,

AT: But it does so, and we need to fix it. So I think the idea, and I have heard this when I've tried to pitch this idea directly to farmers to say, look, it's just the same old, same old. You're trying to pay us as little as possible for doing this. Why shouldn't it be the other way around? And the reason why we design auctions is actually not just to pay farmers, and that's not the intent. The real intent is to reveal their actual cost. The only people who really know how much it costs for them to do certain actions on the land, how much they're going to benefit are the farmers themselves, and that information we do not have access to. In principle, there is nothing wrong with taxing corporates a lot and then redistributing some of this money in a way that is not tied to actions, right, and then making some of it dependent on the specific actions that people might be taking.

So again, I think exactly how much of the burden is falling on the polluter and how much of the burden is falling on the restorer, is an orthogonal question to exactly how you design a particular incentive scheme, like the one I was suggesting, right? And it comes back to a question of equities. On whom should the burden fall? I think that is a crucial question, which is absolutely important. But a combinatorial auction would have functioned just as well if we had gone to the farmers, given them all 100,000 pounds for the start and said, here's 100,000 pounds. Just have it, and then let's have an auction. I have absolutely no problem with that, but that's a separate issue about overall farming support and how much we prioritise food versus something that is something that's on the landscape.

EN: Who needs to take this seriously in order for it to be successful? What needs to happen next?

AT: Defra needs to pay attention. Government needs to pay attention, actually.Ultimately, the Treasury Department for local communities needs to pay attention. We have funds that we want to use to risk recover nature. We should not commoditise and commodify nature, because that's not going to be a good way of spending money. I would be very grateful for people in their own community groups, in whatever channels they have to lobby, to write and to say, we are not using this money very well at the moment. So I have some hope for the environment fund that the government has just announced that it could be used in this way. The way that the environment fund is pitched is to say we want to do things at scale by delivering good value for money. This is a way of doing it. So do get together as a village, for example, and say we want to be paid together for restoring nature.

EN: Thank you. That was brilliant. My mind has exploded. I'm really looking forward to watching this back and listening to everything that you've said in detail. It's been absolutely fascinating and so many issues in this space that we really need to unlock quite quickly.

Follow up questions sent by email

Market theory is great but doesn't it all depend on what the buyers want/have to buy? Do the products need to be stackable in order to be sold?

AT: Procurement auctions like the turtle dove project allow for very rich and flexible objectives for the buyer(s). Stackability is certainly possible, but simpler objectives are also fine.

Is there an assumption that the economic drivers would be sufficient to create the motivation and capabilities to establish sufficient bidder capacity? Or are other interventions/ incentives required in the system to service the model?

This sort of auction is complex and a lot of work went into helping bidder bid. No doubt other motivations than financial ones are important and here the combinatorial nature of the winner determination incentivised bidders to be prosocial rather than simply competitive.

Would the auction model work for retailers rewarding farmers for biodiversity at scale?

The auction could certainly allow for multiple buyers (rather than one as in our case) and to be scaled up.

This bidding style is predominantly focused on creating 'new habitats' for the benefit of nature. But how does *maintaining* landscapes play into this? Plenty of folk have land that hasn't been drained and cleared of scrub etc

Auctions can work for conservation contracts as well. Even in our case, part of the contract was in fact conservation: actually ensuring that the scrub mentioned in the bid would be there.

Is there a risk that offsetting biodiversity impacts by polluters will reduce incentive to not cause so much negative biodiversity impact in the first place? Does there need to be increased policy push for reduction of biodiversity impact alongside offsetting?

Mandatory offsetting relative to having no policy seems to be similar to a penalty for harming biodiversity in that it should reduce incentives to destroy biodiversity. Of course, a prohibition on any biodiversity destruction is a stronger incentive but this might be incompatible with house/infrastructure building etc. There is a very careful balance to be struck.

How are you going to ensure that the scheme of singling out auctions for individual species does not have a damaging effect for other species, or even that 'contradictory' protection auctions do not take place?

As I said, the turtle dove auction was really about bird habitats more generally. But you might still worry about spillovers on other species. We didn't see any reason to worry about it in our case, but you can imagine that if such auctions are scaled objective need to be carefully managed to avoid this

Couldn't this create a market to continue polluting in a way that impacts on biodiversity? What if farms producing pollution that is harming local ecosystems

(e.g. high nitrogen emissions from manure) need to move away from agriculture on that land, but instead, they are paid to continue?

I'm not sure what unintended consequences you have in mind, but the auction incentivised landowners to move away from agricultural activities and towards those that create bird habitats. There was a careful spec for exactly how the bids—seed mixes on fields—had to be executed.

How do you see the emerging Local Nature Recovery Strategies in helping to provide a framework of priorities for nature recovery in areas?

We certainly think that combinatorial auctions could play a very important part in Local Nature Recovery Strategies in helping achieve ecological objectives at scale at a reasonable cost.

What tools are available / should be available for landowners to consider which interventions would deliver the most ecological benefit and economic benefit and consider the trade offs?

Landowners didn't need to do any mapping of this kind. They simply needed to state how much they would be willing to accept to plant seed mix on their fields. All the ecological calculations of all the bids were done by our model carefully designed alongside RSPB, which has huge amounts of expertise and data on bird habitat effectiveness. So while these auctions can sometimes be complex to design, they are fairly straightforward for bidders.

What role does outcomes measurement play in environmental markets?

A big role. But given that there is often a lot of uncertainty about natural outcomes, it is not always possible to create appropriate incentives using outcomes. This is why a lot of contracts are based on actions rather than outcomes.

Since this is such a new approach, how can you already be sure it will work better than what exists? Are you still waiting for evidence e.g. on turtle doves, in those areas? How are outcomes monitored, and who pays for this?

There hasn't really been an approach that has tried to create bird habitats at a landscape level so it is hard to compare. The number of turtle doves is too small and uncertain to be able to measure effectiveness in this way. However, looking at outcomes such as compliance and the distribution of bids, it is clear that the auction worked reasonably well. There were many ways this auction could have been run and we are still analysing the counterfactuals.

About the AFN Network+

The AFN Network+ (UKRI Agri-food for Net Zero Network+) is a unique network of 2,000+ academics, researchers, third sector organisations, policy makers, and agri-food industry professionals from farmers to retailers.

Together, we are working to identify key research gaps that may be holding the UK food system back from transitioning towards a net zero UK by 2050, while also enhancing biodiversity and healthy ecosystems, nurturing livelihoods, supporting healthy consumer habits, and minimising the environmental impacts of overseas trade. Our findings will inform the next decade of research investments in this area by UKRI (our funder and the UK research councils umbrella organisation).

Alongside our core research, we run in-person and online events, produce topical resources, and give out hundreds of thousands of pounds of funding a year.

The AFN Network+ is coordinated by the University of East Anglia, University of the West of England, University of York, and University of Leeds, and is a £5m, 3-year project funded by four research councils; the Biotechnology and Biological Sciences Research Council, Economic and Social Research Council, Engineering and Physical Sciences Research Council, and the Natural Environment Research Council.

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