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Biological Carbon Sinks: Transaction Costs and Governance

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Biological Carbon Sinks: Transaction Costs and Governance

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Abstract

Activities that remove CO_2 from the atmosphere and store it in forest and agricultural ecosystems can generate CO_2-offset credits that can thus substitute for CO_2 emissions reduction. Are biological CO_2-uptake activities competitive with CO_2 offsets from reduced fossil fuel use? In this paper, it is argued that transaction costs impose a formidable obstacle to direct substitution of carbon uptake offsets for emissions reduction in trading schemes, and that separate caps should be set for emissions reduction and sink-related activities. While a tax/subsidy scheme is preferred to emissions trading for incorporating biologically-generated CO_2 offsets, contracts that focus on the activity and not the amount of carbon sequestered are most likely to lead to the lowest transaction costs.

Keywords: carbon sequestration; transaction costs; climate change

JEL Categories: Q54, Q23, Q42, H23, D23

Biological Carbon Sinks: Transaction Costs and Governance

By removing CO_2 from the atmosphere, activities to sequester carbon and create biological carbon sinks have long been considered an important aspect of any attempts to address anthropogenic climate change. However, implementing policy to bring biological sinks into an international agreement to reduce greenhouse gases, specifically the Kyoto Accord, has turned out to be both difficult and controversial. There have been a number of reasons for this, including questions regarding ‘additionality’ (whether a sink activity would have been undertaken without concerns about global warming), leakages (tree planting in one region is offset by greater harvests in other regions as the additional plantings lead to lower timber prices), measurement and monitoring (to ensure that stated amounts of carbon are actually sequestered), permanence of sinks and responsibility for maintaining them after a commitment period, and equivalency of CO_2 credits from sink activities and emissions reduction. In a companion paper (van Kooten 2008), I examine questions concerning additionality, leakages and the value of temporary versus permanent CO_2-offset credits. In the current paper, I focus on two often neglected issues related to the creation of biological sinks – transaction costs and governance – and thereby on the role of sinks in a true cap-and-trade system. Although high transaction costs and the inability to govern carbon sinks (especially in developing countries) make them a generally unattractive option in the arsenal to combat climate change, they are too important to neglect entirely. As a result, I conclude by providing an alternative means of addressing biological sinks that lowers the transaction costs and might be acceptable in a domestic or international CO_2-offset trading system.

Background

The main focus of efforts to mitigate climate change is on the avoidance of CO_2 emissions associated with the burning of fossil fuels, although in lieu of this the Kyoto Protocol permits certain activities, such as tree planting and changes in agricultural land use, that remove CO_2 from the atmosphere and store it in biological sinks. Emissions reduction and carbon sequestration are not equivalent activities, however, nor can a CO_2-offset generated by avoiding emissions be considered the same as one obtained by sequestering carbon in a biological sink. Therefore, it is not directly relevant to compare land use, land-use change and forestry (LULUCF) activities as defined under Kyoto with emissions reductions as an alternative means of creating CO_2-offset credits, primarily because of the temporary and uncertain nature of carbon sinks versus emissions reduction. Sequestered carbon can be released from a forest sink, for example, as a result of early harvest (if economic incentives warrant doing so) or as a result of wildfire, disease and/or pests (viz., mountain pine beetle infestation).Various attempts have been made to relate sink-generated offsets and emissions reduction in a way that facilities trades between them, but none can be considered entirely satisfactory. Therefore, it is probably best to separate the two types of activities, as argued below.

There is no doubt that tree planting and silvicultural investments that enhance tree growth remove CO_2 from the atmosphere and store the carbon in biomass. But are such activities competitive with emissions reduction? Are they financially attractive? To answer these questions requires information about the financial costs and carbon-uptake benefits of forest-sector activities in various regions. If there are many studies that provide this information, they can be analyzed using meta-regression analysis (see van

Kooten et al. 2004).

A recent meta-regression analysis of the costs of sequestering carbon in forest sinks by van Kooten et al. (2007) indicates that, if one assumes sink activities are to compete with emissions reduction – that CO_2 offsets will trade in markets – at \$50 per tonne CO_2 (t CO_2), tree planting and other forest management activities are economically attractive. The meta-regression analysis is based on 68 studies with a total of 1047 observations, with a summary of results provided in Table 1. If the opportunity cost of land is appropriately taken into account, forest management and forest conservation cannot be seen as economically attractive activities. Assuming emissions reduction credits can be purchased for \$50 per t CO_2 or less, tree planting appears to be attractive only in the tropics, although there are clearly projects in other regions of the world where they are attractive if harvested trees are used for fuel in lieu of fossil fuels (reducing CO_2 emissions). Europe might be an exception because the opportunity costs of land are simply too high, although even in that region there might exist some marginal lands where tree planting for bio-energy might be feasible.

Van Kooten et al. (2004, 2007) considered many more studies than the 68 included in their final meta-regression analyses, but these failed to provide sufficient information to calculate the costs and benefits of carbon uptake. As an example of the inconsistency with which cost and carbon uptake data are reported, see the review of forestry projects conducted by the UN Food and Agriculture Organisation (FAO 2004). Even for studies included in the meta-regression analysis, many left out details concerning the time profile of carbon uptake, which van Kooten (2008) shows to be highly relevant. Importantly, studies also failed to take into account transaction costs.

Overall, one cannot be confident that the values provided in Table 1 are not a gross underestimate of the actual costs of generating sink-based CO_2 offsets.

Table 1: Marginal Costs of Creating CO_2-Offset Credits through Forestry, Meta-regression Analysis Results (\$/tCO_2)

Region and Scenario	Study Averages (n=68)	All observations (n=1047)
Global	$28.85	$25.10
Planting	$0.26	-$4.93
Planting & opportunity cost of land	$29.80	$21.91
Planting, opportunity cost of land & fuel substitution	-$40.14	$19.88
Forest management	$88.47	$35.31
Forest management & opportunity cost of land	$118.01	$62.15
Forest management, opportunity cost of land & fuel substitution	$48.07	$60.12
Forest conservation	$158.28	$20.16
Forest conservation & opportunity cost of land	$187.82	$47.00
Europe	$173.26	$183.64
Planting & opportunity cost of land	$185.44	$180.14
Planting, opportunity cost of land & fuel substitution	$115.50	$178.11
Forest management & opportunity cost of land	$273.65	$220.38
Forest management, opportunity cost of land & fuel substitution	$203.71	$218.35
Tropics (CDM Projects)	-$26.20	$4.04
Planting & opportunity cost of land	-$25.26	$0.85
Planting, opportunity cost of land & fuel substitution	-$95.20	-$1.18
Forest management & opportunity cost of land	$62.95	$41.09
Forest management, opportunity cost of land & fuel substitution	-$6.99	$39.06
Conservation	$103.22	-$0.90
Conservation & opportunity cost of land	$132.76	$25.94
Boreal Region	$58.01	$8.77
Planting & opportunity cost of land	$70.19	$5.26
Planting, opportunity cost of land & fuel substitution	$0.25	$3.23
Forest management & opportunity cost of land	$158.40	$45.50
Forest management, opportunity cost of land & fuel substitution	$88.46	$43.47

Source: van Kooten et al. (2007).

In addition to forest ecosystem sinks, agricultural activities that lead to enhanced soil organic carbon and/or more carbon stored in biomass can be used to claim offset credits. Compared to forestry activities, those in agriculture provide only very temporary

CO_2 offsets. Although agricultural activities such as conservation and zero tillage practices, and conversion of cropland to pasture, received quite a bit of attention in the early 2000s as another source of revenue for farmers, subsequent policies favouring biofuels essentially removed many incentives that CO_2-offset trading might provide farmers. The benefits to landowners of growing bio-energy crops generally exceeded those of practicing conservation tillage.

Transaction Costs

Transaction costs refer to the costs of measuring, monitoring, enforcing and negotiating trades, while governance structures are the means by which trades are made. Both are affected by the institutional framework that exists in a country or, in the case of international trading, by the nature of agreements between independent jurisdictions. Included in the institutional framework are such things as social capital, rule of law (independence of the judiciary) and freedom to engage in trade, while international agreements rely primarily on trust and the ability of one or more parties to an agreement to make credible threats should other parties not comply. The ability to impose credible threats on Kyoto-ratifying countries that fail to meet their obligations is pretty well non-existent – the offending state is required to reduce emissions even further than it would otherwise in a future, unspecified commitment period. It is at the individual country level, or at the level of a bloc such as the European Union, that one is most likely to encounter credible offset trading schemes that involve biological sinks. For example, the EU's emission trading system (ETS) permits the use of offset credits from LULUCF projects, including projects in developing countries as permitted under Kyoto's Clean Development Mechanism (CDM).

The effect of transaction costs can be illustrated with the aid of Figure 1. For simplicity, assume we are only interested in the sales of temporary or biological sink CO_2-offset credits so that S refers to the supply and D to the demand for sink offset credits. In the absence of transaction costs, market equilibrium occurs where Q^* offsets are sold. As shown by Bovenberg (2002), transaction costs occur on both sides of the market, with respect to purchasers of offset credits and suppliers. For the current purposes, we consider only the supply side. In Figure 1, transaction costs cause the supply curve to shift upwards to S′ with equilibrium sales now equal to Q^{**}. Importantly, the price of biological sink credits has risen, implying that large industrial firms that need to offset emissions will shift purchases toward emission reduction offsets rather than sink offset credits. The total transaction costs amount to area $a+b+c+d$, but there is also a cost equal to area $e+g$ that constitutes the loss to society because some transactions are crowded out – emitters wishing to purchase offset credits must seek a more expensive means to meet emission reduction targets.

Are transaction costs a significant obstacle to the use of CO_2-offsets generated by biological sinks? Relevant research reported by Slangen et al. (2008, pp.204-205) indicates that these amount to one-quarter or more of the costs of providing nature services. Since transaction costs were ignored in the meta-regression results reported in Table 1, it is clear that transaction costs make biological sinks a lot less attractive, with forestry projects in the tropics (essentially via the CDM) and perhaps some fuel substitution projects in the boreal region left as the only options capable of competing with emissions reduction.

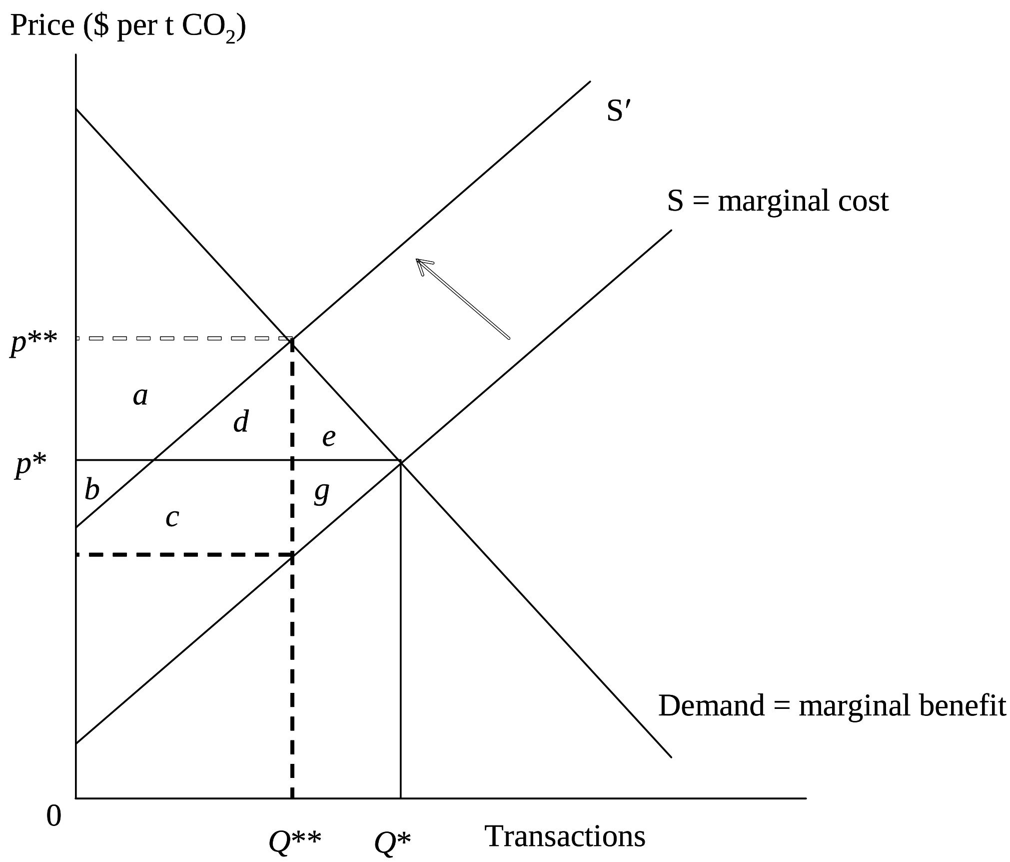

Figure 1: The effect of transaction costs on trade in CO_2 offsets generated by biological activities

Governance: Carbon Sinks with Cap and Trade in Emissions

Biological CO_2 offsets pose a problem for emission trading schemes as it is difficult to compare and smoothly trade off temporary sink offsets against emissions reduction. The problem that the authority faces can be illustrated using Figures 2 and 3. In the figures we treat emissions abatement as the difference between actual (current) CO_2 emissions and targeted emissions, with a cap on economy-wide emissions showing up as a required target.

In Figure 2, we assume that, after correcting for the ‘exchange rate’ between temporary and permanent CO_2 offsets, the marginal costs of carbon uptake (thin solid line) lie below those of emissions reduction (dashed line) over some range, but that there is an overall limit to annual (and total) sequestration in biological sinks. The total marginal cost of abatement curve (thick solid line) is simply the horizontal sum of the separate marginal cost curves. It is kinked at the point where MC_{Sink} equals the lowest point on (vertical axis intercept of) the $MC_{Emission}$ curve (denoted *N*) and again at the point *L* where the MC_{Sink} becomes vertical (beyond which only the $MC_{Emission}$ is relevant so that MC_{Total} runs parallel to it). Between *N* and *L* a mix of terrestrial carbon uptake and emissions reduction is used to achieve the lowest cost of removing CO_2 from the atmosphere.

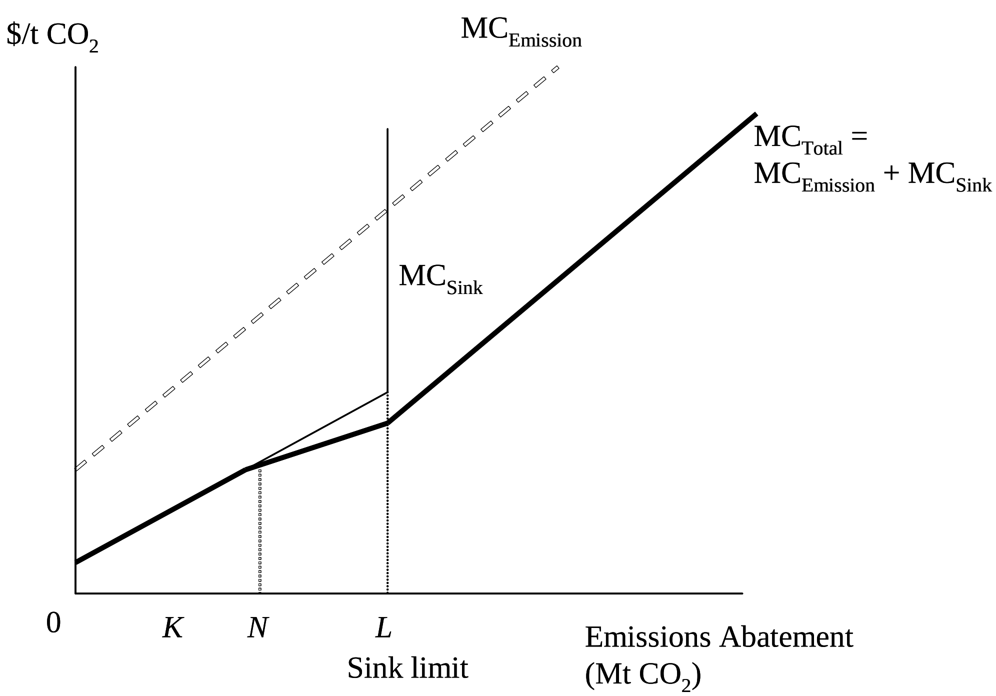

Figure 2: Marginal costs of carbon uptake and of emissions reduction

In Figure 3, the total amount by which CO_2 emissions must be abated (C*) might represent a country's Kyoto target. Given the MC of abatement function for emissions reduction as indicated, the price of permits would equal *p* if only emission allowances were considered. Now, the availability of biological sink activities could lead a country to exceed its Kyoto emissions reduction target by permitting sink offsets to substitute for emissions reduction. In the limit, if there are sufficient domestic and offshore sink offsets available, a country could potentially maintain or exceed current levels of emissions and comply with emissions reduction targets. This is even more the case for a single large emitter. Therefore, it may be necessary to place a cap or target on the use of biological-sink generated CO_2 offsets (set at *K* in the figures), as well as a target on emissions reduction that equals the difference between the overall (Kyoto) targeted emissions reduction and the CO_2 offsets permitted through biological activities (=C^*-K in Fig 3).

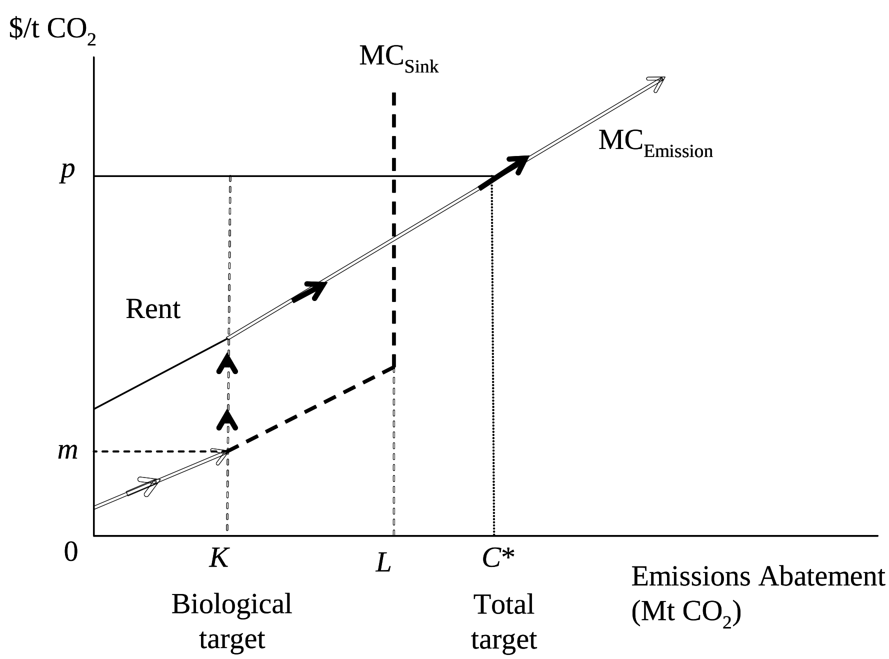

Figure 3: Caps on terrestrial and total carbon: the arbitrage gap

Suppose that the emissions reduction target is set at *C**–*K*, with *K*<N (see Fig 2). Then, given the marginal cost of abatement function $MC_{Emission}$ for emissions (which is the same as in Fig 2), and with biological sequestration less costly than emissions reduction, the terrestrial option is always chosen over emissions reduction as long as the sink target is not reached. Arrows in Figure 3 are used to indicate the direction along which costs should increase as a country mitigates its CO_2 emissions – this denotes the overall marginal cost of abatement function and differs from that in Figure 2.

If, on the other hand, the sequestration option is more costly everywhere than emissions reduction, as suggested by the results in Table 1 (and particularly if transaction costs are included), then the biological sink option will not be chosen unless there are political reasons for doing so. In that case, setting a target for emissions reduction that is less than *C** will result in the country (firm) not achieving the desired or targeted amount by which it hope to reduce atmospheric CO_2.

Setting a target for biological carbon sequestration could also lead to potential political maneuvering. The existence of a gap at point *K* (the vertical section in the abatement function) implies that, unless there is competitive bidding to supply sink-generated offset credits, a scarcity rent is created and there is room for higher cost sequestration projects to push out lower cost ones as a result of rent seeking behaviour.

Finally, a domestic carbon-trading scheme will also need to specify limits on the use of other Kyoto instruments over and above domestic biological sink offsets. Indeed, using the same reasoning as above, limits will also be needed on the credits available through Joint Implementation and the CDM. If carbon trading is international in scope, caps on various mechanisms for creating credits will be required, at both the country level and supra-national levels. Further, given the difficulty of comparing tree planting and forest conservation programs (see van Kooten 2008; van Kooten and Sohngen 2007), it is also wise to set global and domestic caps on the amount of CO_2-offset credits that can be earned by preventing deforestation. Otherwise, every woodlot owner will want to receive offset credits whenever harvests are postponed for whatever reason.

Discussion

One alternative to emissions trading is to employ a tax on CO_2 emissions, and expand it to include biological sink activities. When marginal abatement costs and/or marginal benefits (supply and demand) are uncertain, choosing quantity (the amount by which emissions must be reduced) can result in a mistake about the forecasted price that firms will have to pay for CO_2-offset permits, while a CO_2 tax can lead to the 'wrong' level of emissions reduction – to emissions reduction below the desired level (Weitzman 1974). Such errors have social costs. If the demand function for emissions reduction is relatively steep but damages accumulate only slowly (as is likely the case with climate change), the social costs of relying on tradable emission permits are much higher than relying on CO_2 taxes (Pizer 1997).

By expanding a CO_2 tax scheme to include subsidies for carbon uptake, biological activities can be included. Activities that release CO_2 into the atmosphere are taxed according to the amount of CO_2 emitted at the time of release, whether as a result of fossil fuel burning, cultivating grasslands or felling trees, while activities that remove CO_2 from the atmosphere (e.g., planting trees or converting land from cultivation to pasture) are subsidized in like manner (van Kooten et al. 1995). Since tax revenues will almost certainly exceed subsidies for CO_2 uptake, the tax/subsidy scheme is self financing. The only problem with this scheme, which is true of emissions trading as well, is that there are transaction costs of monitoring to ensure that offset credits are not overstated and CO_2 release is not underreported.

Despite the benefits of carbon taxes, politicians have opted for emissions trading. The EU's emissions trading system requires large emitters to purchase offsets if they fail to meet the targets they negotiated. Offsets can be purchased from firms whose emissions fall below their target, or from outside the EU through such Kyoto mechanisms as Joint Implementation and CDM. In western North America, seven U.S. states and four Canadian provinces participate in the Western Climate Initiative, which intends to employ a cap-and-trade scheme (Olewiler 2008). Although details remain to be worked out, experience with ETS and political expediency suggest that participants will eventually opt for something other than true cap-and-trade. True caps on emissions are generally not set because a variety of means (tree planting, agricultural activities, CDM, etc.) can be used to generate offset credits that allow emitters to exceed their emissions cap, in which case we have credit trading and not cap-and-trade. As argued in this paper, true cap-and-trade requires, in addition to limits on emissions of CO_2 from fossil fuels, limits on the CO_2-offset credits that can be earned from tree planting, silvicultural investments, reduced deforestation, and other LULUCF activities.

This is not to suggest that biological sinks are unimportant. Rather, subject to caveats concerning their integration into an emissions trading scheme if a carbon tax is not used, it is necessary to incorporate sink offsets into the CO_2-mitigation arsenal in the least costly manner. Perhaps the easiest way of doing this is to find governance structures that minimize transaction costs. One possibility is to ignore the actual amounts of CO_2

that are removed from the atmosphere and stored in the biological sink, and focus only on the activity. As long as a particular activity (say planting trees and letting them grow) is undertaken, credits are issued in each period over the length of the contract according to a pre-determined schedule. The schedule is laid out in a contract that also provides for penalties should trees be harvested or destroyed by wildfire or pests. Similarly, farmers can negotiate a contract that compensates them for practicing no-till agriculture, but then penalizes them for reverting back to conventional tillage. In this way, it is unnecessary to measure CO_2 flux; only land-use activities need to be monitored. Yet, even in these circumstances, there will remain unavoidable transaction costs related to negotiation, possible re-contracting in the event of unforeseen contingencies, and so on (see Slangen et al. 2008, p.204).

Clearly, uptake and storage of CO_2 in biological sinks has scientific merit and countries should pursue activities that increase terrestrial CO_2. Landowners could benefit from higher revenues and higher land prices if they are compensated for sequestering carbon. Yet, despite these benefits, effectively integrating carbon sequestration activities into a broader policy arsenal for mitigating climate change is likely to continue to prove challenging.

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