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The paradox of regulating negative emissions technologies under US environmental laws

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Research Article

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Non-technical summary

Most domestic environmental laws control the act of emitting pollutants into the environment. As a result, they do not apply squarely to negative emissions technologies (NETs) that remove ambient contaminants and do not emit pollutants themselves. As a result, current US environmental laws cannot readily govern a NET unless it has features that would typically allow regulation of a clean-up, such as ownership of the polluted resources, being at fault for polluting them or instituting projects to restore them. We should reinterpret such laws to focus on actual disruption or harm to the environment instead of using emission of pollutants as a proxy for ecological damage.

Technical summary

Negative emissions technologies (NETs) promise to remove greenhouse gases (particularly carbon dioxide) from the ambient atmosphere and current plans to attain the Paris Agreement's secondary goal relies heavily on them. Their governance, however, remains an open question, and most domestic environmental laws regulate pollutant emissions rather than their removal from the environment. Under US environmental laws, the clean-up of prior pollutant releases typically occurs when (i) the person releasing the pollutant bears fault or liability, (ii) the contaminated natural resource is owned by a party who must remediate it regardless of fault or (iii) a governmental authority removes it as a public work. The historical releases of greenhouse gases and anthropogenic climate change will not fall into these categories. This governance gap may spark concerns if the uncoordinated or overzealous deployment of NETs might cause unintended consequences, their full use unexpectedly transfers ownership of public resources to private parties or their deployment without transparency disenfranchises stakeholders. We should reinterpret domestic environmental laws to focus on direct harms to ecological systems rather than requiring a pollutant release. Federal and state legislatures and agencies should explicitly declare how (or if) current environmental laws will apply to NETs and provide guidance to the public and stakeholders.

Long-range strategies to respond to climate change now increasingly rely on the aggressive use of negative emissions technologies (NETs) [1]. While these technologies remain at an early stage of development, NETs might be able to remove sizable amounts of greenhouse gases (GHGs) from the ambient atmosphere for safe sequestration, reuse or disposal. For example, when the International Panel on Climate Change recently prepared a suite of integrated assessment models to identify pathways to achieve the Paris Agreement's temperature goals, an overwhelming majority of successful strategies relied heavily on NETs such as bioenergy with carbon capture and sequestration (BECCS) [2]. To be deployed at a useful scale, NETs such as direct air capture (DAC) of GHGs (particularly carbon dioxide (CO_2)) presumably would involve the construction of a massive industrial infrastructure to remove and safely store or reuse vast quantities of gases in a fashion that largely withdraws, rather than prevents the addition of, a pollutant from the ambient atmosphere in hopes of reducing the dangers of anthropogenic climate change.

Because they focus on the removal, rather than the emission, of a pollutant into the ambient atmosphere, the governance of NETs under domestic environmental laws remains an open question. For example, US environmental statutes do not explicitly govern this specific type of large-scale remedial removal of pollutants. Most domestic environmental statutes and regulations (with some important exceptions) instead focus on the paradigmatic scenario where a person discards a pollutant into the environment, but these laws have little to say when someone removes that pollutant from shared resources. This one-way function of environmental law naturally reflects the historical rarity of altruistic removal of pollution from publicly-held natural resources or elements in the public common. The large-scale removal of ambient GHGs may be performed by parties who do not bear responsibility for historical emissions and who can never own the ambient air resource itself. As a result, if a person builds a large industrial facility to directly remove sizable amounts of CO_2 from ambient air, most

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domestic laws probably would not require any environmental permit or authorization unless the capture operation itself caused collateral emissions or harms. This lack of direct governance of the removal process itself could spark future concerns about proper oversight, possible indirect damage to publicly-owned natural resources and disenfranchisement of interested parties.

This paper examines the ability of US domestic environmental laws to regulate NETs, especially DAC and other large interventions to remove environmental dangers to the atmosphere and other publicly-held resources[i]. It proposes that domestic US environmental laws effectively treat emissions of pollutants as a surrogate for a deeper value – the risk of damage to the ecological systems and resources exposed to those pollutants – and it suggests that the laws can be productively reinterpreted to focus on this more fundamental concern. It then concludes by offering regulatory and legal approaches in light of this reinterpretation to govern DAC and other NETs under US environmental statutes.

1. Negative emission technologies and US regulation

1.1. A thought experiment

To clarify the odd legal posture of NETs, a thought experiment can shed light on how current US environmental statutes govern large-scale projects that seek to alter the environment without themselves emitting pollutants or causing environmental side-effects that would trigger regulatory jurisdiction under federal or state laws.

GeoFix, a large corporate entity, has constructed a sizable industrial facility in an open field. The company has decided to emit regulable pollutants into the air as part of its normal production operations, and those pollutants will indisputably foul the air, damage the surrounding ecosystem's ability to sustain life, and interfere with the use of adjoining public and private lands. Under US federal and state environmental, property and tort laws, this common scenario calls up a familiar response: legal actions would force GeoFix to obtain a permit to authorize and limit its discharges, or to require GeoFix to pay damages to persons injured by its emissions or to the government entity that acts as a trustee for the public's natural resources. This fact pattern lies at the heart of our common notions of US environmental law.

Now consider the reverse. GeoFix's facility still sits in the same field, and the company has flipped the same switch, but this time GeoFix's facility withdraws large volumes of air, removes a gas or pollutant from it, and then discharges cleaner air back into the skies. This scenario may spark objections if it interferes with someone else's ownership rights or if the cleaning process damages other aspects of the environment. But absent these complications, most US environmental laws in this situation have little, or nothing, to say. The act of cleansing public or private natural resources, absent the specters of direct liability or property rights held by third parties, typically doesn't in itself trigger a duty to obtain a permit, pay damages or user fees or (absent other major federal action) assess its impact to the environment or natural resources [3].

This approach reflects common assumptions about natural systems and how they react to pollution or other discharges into ambient air or open waters. Absent a precipitating pollutant that could entrain itself into land, sediment or waters, the most important step to protecting environmental resources is to halt the act of pollution itself. Notably, this framework fails to adequately account for the long-term and sustaining damage wreaked by discharges of persistent pollutants onto physical land-based resources or ecosystems. As a result US tort, property and regulatory frameworks (in particular, the federal Resource Conservation & Recovery Act[ii] (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act[iii] (CERCLA)) have focused the legal significance of the act of physically persistent land pollution in different ways.

1.2. Other possible examples of regulatory strategies for negative emission technologies

This thought experiment, while fanciful at the moment, has already begun to surface in certain research projects and field demonstrations of NETs that fall squarely into this regulatory hollow in US environmental laws [4]. As a result, if NETs do not involve the emission of a regulated pollutant in a way that would require the issuance of a permit under the federal Clean Air Act, Clean Water Act, RCRA (if the facility does not generate hazardous wastes) or other environmental quality laws, we do not have any guidance or binding precedent on how US environmental laws would apply to them [5]. To look to other possible examples, we can examine how negative emission concepts have arisen in narrow and limited circumstances in the past under other US environmental programs.

As a threshold matter, federal environmental laws and regulations have long accepted uses of offsets, netting, bubbling and mitigation approaches that implicitly acknowledge reductions of emissions within a source, airshed or watershed as a basis to allow other continuing emissions or impairments of wetlands at a related source. For example, a refinery might offset new emissions of air pollutants from a modified production unit by reducing emissions of the same type of pollutant elsewhere within the refinery. These market-based and efficiency-based regulatory tools, however, rarely explicitly address control strategies that capture or withdraw existing ambient pollutants as a direct offset for emissions from a regulated point source or impairment of a protected wetland or resource.

More directly, some emerging air pollution control technologies focus on reducing ambient pollutants rather than capturing emissions of those pollutants from stationary or mobile sources. While air quality regulation under the federal Clean Air Act has typically focused on the attainment of ambient air quality standards through permits to control the emission of regulated air pollutants from stationary sources and national emission standards for mobile sources, the Act has also created a secondary impetus to remove ambient air pollution already present in the airshed. These environmental intervention mechanisms typically surface within larger State Implementation Plan (SIP) proposals that provide credit for reductions of regulated pollutants (typically ambient ozone or ozone precursors) accomplished through technologies that scavenge pollutants from the relevant airshed. In one example, the Texas Commission on Environmental Quality has approved proposed credits for reductions in ozone precursors in SIPs. Other technological entrepreneurs have proposed large-scale electrostatic precipitators that could reduce the amount of ambient ozone in an airshed through a system of towers that could create localized reductions in harmful concentrations of ozone. To date, however, these proposed tower systems have not been deployed at scale in the United States[iv].

In a similar fashion, US federal water pollution control regulations provide a limited niche that recognizes the removal of pollutants dispersed in ambient waters of the United States. Under these

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approaches, the federal Clean Water Act will typically focus on the attainment of surface water quality standards through the issuance of National Pollutant Discharge Elimination System (NPDES) permits to persons who discharge pollutants into waters of the United States through a point source. This approach, by definition, excludes attainment of surface water quality standards through removal of contaminated water, treating it and then discharging cleaner effluent back into waters of the United States. If this process removed all pollutants without introducing any other new pollutant, the discharge arguably would not contain a pollutant that would require the issuance of a NPDES permit[v].

In addition to NPDES permits for discharges of pollutants from point sources, the federal Clean Water Act also mandates that states designate plans to assure attainment of surface water quality standards through the Total Maximum Daily Load (TMDL) process. Notably, a key tool to reach attainment of surface water quality standards under TMDL rules is the development of waste load allocations for point sources that discharge into the water body as well as non-binding waste allocations for non-point sources. To the extent that a facility operator removes contaminants already present from that water body, the TMDL process does not include an explicit mechanism to account for negative discharges as part of a waste load allocation[vi].

Notably, while each of these scenarios deals with polluters who utilize NETs to reduce the amount of pollutant discharges attributable to them, a non-polluter may also take advantage of NETs to create economically beneficial removals of pollutants from the ambient environment. This strategy, however, is not easily and automatically endorsed under current federal environmental laws. For example, while the US Environmental Protection Agency (EPA) has endorsed the use of market-based trading of pollutant credits to attain water quality standards for impaired water bodies, its Water Quality Trading Policy focuses on reductions of pollutant discharges from other point and non-point sources to create tradable credits rather than direct reduction of ambient pollutants in the water body [6]. The Policy, however, explicitly notes that EPA "supports the creation of water quality trading credits in ways that achieve ancillary environmental benefits beyond the required reductions in specific pollutant loads, such as the creation and restoration of wetlands, floodplains and wildlife and/or waterfowl habitat" that might create tradable credits through reductions in ambient levels of pollutants in waterbodies[vii].

These examples don't capture all possible emerging negative emission strategies under other US environmental programs, but they begin to demonstrate the core concept. By requiring the act of discharging pollutants into the environment or a specific harm to environmental resources as a predicate for regulatory jurisdiction, federal environmental laws do not provide a coherent or sufficient legal basis to govern the development and deployment of technologies that either remove ambient pollutants already in the environment or reduce ongoing specific harms to injured resources. They instead will turn on fortuitous aspects of particular NETs that might create a handle for regulatory jurisdiction, such as the emission of collateral pollutants related to power generation or the impact to land created by dispersing minerals for accelerated weathering. While many NETs may have these environmental side-effects that trigger environmental obligations, this situation could subject some NETs to intense regulatory scrutiny while other NETs – even if they have larger atmospheric impacts or operational scale – could escape oversight entirely.

2. Distinguishing negative emissions interventions from conventional environmental regulatory actions

While US environmental laws have focused on the paradigmatic act of pollution as the gateway for regulation and control, they have nonetheless also required polluting parties to take actions to clean-up historical or prior contamination. The laws' dictates in this arena, however, typically rely on circumstances that allow exceptions from the requirement of an attributable discharge of a pollutant as a basis for the exercise of legal power. These exceptions provide an enormously important and powerful platform for US environmental regulation, but they do not offer a ready basis for governance or oversight of negative emission interventions that remove pollutants from publicly held natural resources and ecosystems.

2.1. Fault and liability

One of the most potent legal bases to require and regulate a person's removal of contaminants from the environment is, obviously, fault. If a person has incurred legal liability because their actions resulted in an attributable release of the contaminant into the environment, exacerbated its effects and consequences or for policy reasons unrelated to their culpability they bear direct liability for the effects of the pollution, then US environmental laws provide a ready basis to require and control the method and degree of the environmental remediation or decontamination.

For example, if a person engages in conduct that unreasonably interferes with another person's enjoyment of their property, the injured party can seek compensation or injunctive relief under relevant tort laws such as nuisance or trespass. These tort actions not only allow restoration of the injured party's status, but they also shift the negative (and positive) externalities and associated costs of the restoration activity away from the public and the adjoining affected persons back to the operator conducting the activity – and who would presumably also have the greatest capacity to modify behavior, limit any damages or imposition, and collect any necessary information or authorizations to take corrective actions.

The use of this strategy to shift costs or responsibilities for large-scale NETs – especially DAC – may be difficult because of the challenge of attribution. Given the relatively small impact of local DAC systems on larger regional or global climate systems, or the difficulty of imputing local weather consequences to broader NET approaches, aggrieved parties will face serious evidentiary and jurisdictional hurdles if they try to attribute their harms to any particular DAC or other NET project. As a result, while traditional tort and liability tools theoretically offer a mechanism for governance of DAC and other NET projects, the practical impediments posed by proving causation, establishing proper jurisdiction over the defendants and quantifying attributable harm will make them ill-suited and ineffective tools in most cases.

2.2. Ownership

Another basis to regulate the removal of contaminants from natural resources is when another party owns those resources. That ownership could reside in a private party, or – for certain natural resources – with the sovereign government on behalf of the public. In such circumstances, the ownership of the resource alone would allow legal action to protect against any actions that interfere with the owner's control and disposition of natural resources

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and property that she owns. To return to our prior example above, the removal of contaminants from public resources such as a lake or public water body would require approval of the person who may own that water body as a private property or has access to it – even if that removal would not otherwise create any other harm, arguably violate a fault-based standard of care or otherwise trigger liability to another party.

Private property rights may deeply shape how DAC and other NETs proceed if they collaterally affect real property or other property interests held by affected parties. For example, a broad-scale deployment of BECCS systems will require enormous swaths of arable land to grow crops for eventual production of fuels or other energy feedstocks [7]. If that strategy requires the acquisition or condemnation of those land holdings, private property rights may tightly constrain some BECCS options. To some extent, these private property constraints parallel the limits imposed by the creation of liability under tort standards for nuisance or trespass actions, but the invocation of ownership rights may bar the use of NETs even if other elements for a tort action cannot be satisfied (such as proof of causation of personal injury or of the interference with enjoyment of real property). Property rights approaches to govern NETs and DACs seem especially ill-suited because the traditional economic rationale for preserving property rights (i.e., to assure that the property owners receive compensation that reflects the harm created by the imposition on their property rights) makes little sense when NETs seek to affect global atmospheric challenges that will yield little, if any, immediate benefit on a local scale.

Apart from ownership of environmental resources, gases in the ambient air may also raise ownership issues. Notably, such gases do not have any affiliated property interests associated with them. It is a common practice for industrial gas producers to simply withdraw large volumes of gases from ambient gas without any need to acquire license, title or royalty arrangements with any other persons within a local airshed. Title to the gases only accrues once they have been captured and rendered into a usable product. As a result, large-scale DAC strategies may not face a significant property rights challenge based on the ownership of gases in the ambient air[viii].

2.3. Restoration and public works

Beyond liability precepts and property rights, governments often regulate contaminant removals from public resources through the framework of restorative public works projects. For example, broad contamination of environmental assets can be addressed through natural resource damage actions under the federal Clean Water Act, CERCLA and the Oil Pollution Act. In addition, CERCLA and RCRA provide a legal framework to redress historical and ongoing contamination of resources without a framework of fault or ownership. That remediation can occur either by statutorily designated responsible parties or through direct government action. Similar public-works oriented remediation can take place under the Water Resources Development Act with the US Army Corps of Engineers and other federal agencies.

Regulation and responsibility for this type of direct action is often clearer and simpler than private party fault allocations and private property rights disputes. For example, CERCLA and RCRA provide extensive regulatory frameworks to oversee the remediation of releases of hazardous substances or corrective action for releases from solid waste management units[ix]. Natural resource damage actions can proceed under extensive regulatory oversight as well for private parties that wish to qualify for an evidentiary presumption, but even outside that framework the federal and state government trustees play a key role in overseeing the restoration work. Restoration work by federal agencies must also meet statutory and regulatory standards that apply to all such actions under federal statutes.

The restoration approaches offer a ready platform for governing NETs if the federal government or other responsible parties wish to reduce ambient levels of atmospheric pollutants as a natural resource damages restoration project. This type of environmental remediation, however, has never previously been applied to air pollution or atmospheric contamination, and it may raise troubling issues about which governmental entities or affected parties can serve as trustees for the atmosphere as well as the type of acceptable mitigation for current and prior natural resource damages to the atmosphere.

3. The need for oversight

If US environmental laws do not squarely regulate NETs, should they? The problem with public goods typically is their underproduction, not uncoordinated or large-scale actions that generate unanticipated disruptions. If environmental interventions that alter ambient resources by removing contaminants and pollutants constitute such a public good, regulating such interventions may be unhelpful – or even damaging – to protecting and enhancing the environment. NETs would potentially fall squarely into this dynamic, and the need to regulate them should be balanced against the possible costs created by delaying their implementation.

While each NET and environmental action will pose its own unique set of risks and benefits that might merit oversight, we can broadly identify general classes of concerns that could arise with large-scale negative emission environmental interventions.

3.1. Failure to assess need or context of oversight

One possibility of leaving beneficial environmental interventions unregulated – even if they do not have regulated side-effects or impinge on property or liability rights – is that multiple parties may choose to undertake environmental interventions in an uncoordinated or fragmented fashion. If so, some environmental interventions, while beneficial in themselves, may collectively lead to unanticipated feedback effects, inefficient allocation of resources, or overproduction of environmental benefits. In addition, an environmental intervention which does not cause unanticipated effects when viewed from a large-scale system perspective may cause undesired local effects if the collective rate of removal or restoration exceeds certain thresholds.

Notably, most of these concerns arising from uncoordinated or unmanaged environmental interventions focus again on the collateral effects of removal (rather than the intervention itself). As a result, it largely restates the premise that environmental interventions may trigger regulation if they cause collateral environmental harms or create their own environmental externalities (such as production of wastes or pollutants from the intervention process itself). If an environmental intervention truly generates a desirable benefit to the public resource, the risk of overproduction of that desired benefit without any collateral side-effect that could incur regulation seems small (especially in the case of NETs for GHGs).

The other concern is that environmental interventions may accrue a benefit to the public at large that nonetheless injures

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the interests of other parties or individuals. For example, active interventions to reduce the effects or causes of climate change may undermine the interests of parties and individuals who actually benefit from climate change effects[x]. In addition, some ecosystems may have adapted to existing levels of pollution or disruption that would cause them to suffer significant harm from the removal of those pollutants (or from the temporary disruption caused by the removal process itself).

3.2. Conflicts and inefficiency from overlapping legal status of public natural resources

One potential problem from large-scale environmental interventions that affect ambient resources is that they may translate resources from unowned public goods into privately owned property. For example, gases in ambient air do not have any affiliated property interest held by surface property estate owners where the gases may pass. Once a person captures those gases, however, that person owns the captured gas as private property. This conversion of public ambient environmental resource into private property may create sizable transfers of ownership over natural ambient gases, recaptured water pollutants or restored natural resources. For example, the operator of a DAC facility will presumably own the captured CO_2 as private property and can sell or manage that captured gas as wished [5]. Similarly, recaptured chemicals or metals from contaminated sites or water bodies would also belong wholly to the person who captured those contaminants from the ambient environment.

If the translation of ambient environmental resources or pollutants into private property is meant to serve the primary purpose of environmental benefit, the policy bases for acquisition of private property interests in these circumstances may need to be re-examined.

3.3. Disenfranchisement of interested parties

While these speculative harms and unexpected system effects may provide the rationale for regulation under certain special cases, the most likely and potent basis for legal objection to private or public interventions into ambient resources is the objection of other groups, parties and persons who also share or rely on those resources. For example, a local community may object to an environmental intervention into a shared waterbody or ambient airshed – even if the intervention arguably benefits them – if they do not have the opportunity to participate in the selection and implementation of the intervention, or if they lack the opportunity to consent to its deployment. The need for a voice in governance of a shared resource – especially one as vitally important, widely distributed and universally available as the atmosphere – will likely play an especially important role in the testing and deployment of large-scale NETs and DAC. The vast size of the universe of potentially affected parties, for example, may make it difficult to craft an effective framework to receive, process and respond to comments and objections.

4. Possible paths for governance

4.1. Traditional environmental regulatory approaches

US environmental laws have historically relied on a small set of models to guide regulatory approaches to manage risks and concerns. The economic paradigm, which strongly influences most current US environmental laws, holds that environmental challenges arise from externalities and market inefficiencies that cause overproduction of pollution, overconsumption of public commons and underproduction of non-rivalrous, non-excludable public goods. When applied to NETs, an economic theoretical framework would likely classify such actions as classic positive public goods: the removal and safe disposal of ambient pollutants from public air, water or land, or the restoration of impaired or lost ecosystems and species, would not accrue any excludable and direct benefit to a private party under current US laws, and multiple parties could seek to remove such ambient pollutants in most cases simultaneously with an unlimited number of other actors.

From this perspective, a typical economic prescription to maximize the needed production of a public good would be assigning economic value to the resource, typically through market mechanisms – in this case, perhaps by assigning economic value to recaptured pollutants from the ambient resources (e.g., carbon credits, effluent trading credits, wetland mitigation credits or ownership in genetic stock of restored extinct species). Alternatively, public goods production can be restricted to state-sanctioned actors if they operate as a natural monopoly. Given the possibly competitive costs of decentralized DAC and other NETs (when compared with costs of aggressive mitigation), however, these technologies do not seem to pose the high costs or limited capacity that would constitute barriers to entry which would create a natural monopoly.

By contrast, a rights-based environmental regulatory approach would rely on legal actions to protect the interests of affected parties. This approach, of course, suffers from well-known disadvantages. As a threshold consideration, some of the persons whose rights arguably might be most affected (e.g., future generations living in areas vulnerable to the effects of climate change or the broad deployment of NETs) could lack any legal cognizance to bring a claim under existing US environmental laws. In addition, the types of legal action typically used in this approach (e.g., torts, property and contract actions) can be slow, expensive and difficult to pursue if the alleged environmental injury involves a small amount of individual damage to a large number of persons. It is also unclear whether an individual can identify a distinct and concrete injury sufficient to support standing in federal and state court if the environmental intervention produces results that are difficult to attribute or quantify.

A rights-based regulatory approach, however, may address the root objection that will likely arise against broad environmental interventions that do not produce regulable side-effects or externalities. As discussed below, the nature of the right may differ from traditional property-based or individual-injury based tort legal actions, and it may instead require some form of right to informational disclosure and – in certain contexts – consent.

4.2. Deeper options

Leaving aside their host of complications and potential side-effects, restorative interventions such as NETs raise a core question: should environmental laws seek to control or regulate actions that deeply alter the environment even if they do not emit any pollutants or directly inflict any environmental damage in their own right? And what if these interventions produce a positive externality?

This fundamental question offers two possible answers. First, we can view US environmental laws' historical focus on the

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central role of pollution as a surrogate for a deeper concern. Namely, the release of environmental pollutants arguably served as an indicator for actual harm to the environment. This initial focus on pollutant releases was an eminently reasonable first step given the difficulty of detecting and assessing the scope of harms to an ambient environmental system. The release of a pollutant is easily detected, measured and tracked; to the extent that knowledge about that pollutant's toxicity or side-effects allows an inference about the harm that its release would inflict on the environment, the two concepts are functionally equivalent.

But if an action results in potential harm to the environment without releasing a pollutant or causing a regulated side effect – or that action even causes disruption solely by removing an ambient pollutant – the central intermediary role of pollutant releases falls aside. The only way to justify the legal oversight and control of such a technology is to show it can cause environmental harm or disruption without the presence of a pollutant. If so, environmental statutes and regulations should be revisited and interpreted with an eye to crafting a role for direct environmental harm without the release – or even a removal – of a regulated pollutant.

Alternatively, to the extent that removal of ambient environmental pollutants (without regulated side effects) is an unalloyed public good, or if the intervention does not cause any direct measurable or detectable harm to the environment, the more pressing concern is finding ways to encourage broader deployment and use of that intervention technology. For example, even if NETs do not require environmental permits because they do not emit or manage any pollutants or hazardous wastes, those technologies may face threats of litigation or opposition that might chill research or deployment activities. To the extent that federal or state environmental agencies can clarify that these operations do not trigger environmental permitting or management requirements through either a guidance, memorandum of understanding or clarification in other regulations under federal environmental statutes, it could provide legal certainty needed to organize and finance these interventions[xi]. Taken to its logical endpoint, some of these same environmental permitting and management obligations might even require the use of NETs as part of a selected suite of control technologies that emitters could use to comply with restrictions on emissions of GHGs[xii].

This legal pathway, however, does not answer the foundational concern that individuals may strongly believe that they have a right to participate or consent to actions that affect an environmental resource shared by the public[xiii], even if the technology removes a pollutant or otherwise benefits the resource without creating a regulated side-effect. This rights-based perspective may require a more aggressive development of environmental disclosure frameworks to assure that the public has an opportunity to submit comments or identify potential effects, and that the public can ultimately see and comment on final environmental assessments that weigh those risks. To the extent that the federal agencies undertake, authorize or fund environmental interventions such as DAC, the National Environmental Policy Act may provide that framework by requiring the preparation of an environmental impact statement or other assessment. The scale of some NETs make it likely that some degree of federal involvement would trigger the National Environmental Policy Act's obligations for an environmental assessment or a full environmental impact statement, especially if the NET could affect a protected species or require some use of federal lands or resources. It remains unclear, however, whether an environmental intervention that removes ambient pollutants (and therefore has a net positive effect) would have a significant impact which would merit an environmental impact statement or other review.

5. Conclusion

Current domestic environmental laws – particularly US air and water pollution control laws – focus on controlling or halting the addition of pollutants to the environment. With the discharges halted, these laws then relied on the curative powers of environmental degradation and dispersion (combined with any remedial actions) to naturally replenish ecological systems. The accumulation of persistent ambient pollutants at national or global scales, in particular CO_2, will challenge this paradigm, and as a result these laws cannot readily regulate the likely development of technologies such as NETs to remove these persistent ambient pollutants.

Regulatory uncertainty may discourage the research and development of these important technologies, and oversight gaps may create concerns about disruptions or side effects created by disjointed implementation of NETs and the silencing of interested parties who wish to know about its deployment or governance. We may decide, ultimately, that these technologies should not be regulated under current or new environmental laws. But US federal and state legislatures and agencies need to make that choice consciously and explicitly, and they should develop and promulgate laws and policies to clearly communicate that decision now to the public, industry and scientific communities.

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Notes

i This article focuses on US domestic environmental law as a useful example of national environmental governance structures that might regulate negative emissions from a local perspective. Public international environmental law and multinational climate commitments obviously can affect this analysis, and other nations may have environmental statutes and requirements that share similar attributes.

ii 42 U.S.C. § 6901 *et seq*. RCRA provides the federal legal framework to regulate the generation, transportation, treatment, storage and disposal of solid and hazardous wastes in the US.

iii 42 U.S.C. § 9601 *et seq*. CERCLA sets out a comprehensive statutory scheme to govern responses to releases of hazardous substances into the environment, including from abandoned or orphaned waste sites. It holds certain categories of persons to be strictly liable for costs arising from the containment and clean-up.

iv While State Implementation Plan (SIP) credit for these approaches reflects some initial acknowledgement of intervention technologies to control ambient

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air pollution already present in the airshed, this recognition is limited, temporary and derivative. In effect, these reductions only matter to the extent that they offset emissions that would otherwise be regulated under permits issued to stationary sources within the non-attainment area. If a state proposed to reach attainment through a SIP that focused solely on removal and scavenging technologies without controlling stationary sources, the US Environmental Protection Agency would almost certainly reject that proposal as failing to demonstrate attainment using mandated permit limits on stationary sources that implement either Best Available Control Technologies or Lowest Achievable Emissions Rate standards.

v *Los Angeles County Flood Control District v. Natural Resources Defense Council, Inc.,* 133 S.Ct. 710 (2013); *South Florida Water District v. Miccosukee Tribe of Indians,* 541 U.S. 95 (2004); 40 C.F.R. § 122.3(i) (water transfer rule); *Catskills Mountains Chapter of Trout Unlimited v. EPA,* 846 F.2d 492 (2017).

vi 33 U.S.C. § 1313(d); 40 C.F.R. § 130.7 (2017).

vii *Id.* at B-3.

viii Industrial-scale direct air capture (DAC) facilities may also require the commitment of sizable amounts of land to host the facilities, but it appears unlikely at this point that the siting problems posed by DAC systems will fall outside the norms of industrial land-use siting requirements.

ix 40 C.F.R. Part 300; 42 U.S.C. §§ 6924(u), (v).

x To some extent, the concept of 'contaminant' reflects a value or policy judgment by the party classifying the material as an unwanted side product. Other parties may view that same material as a desirable environmental material. *See* **Ruhl, J.B.** 2012 The Political Economy of Climate Change Winners. *Minnesota Law Review* 97, 206.

xi US federal environmental laws have long used general permits, permits-by-rule, de minimis exemptions and case-specific waivers to provide legal authorization for broad categories of activities when full individual permit reviews aren't justified by the risks posed by the facility or release, or the administrative burdens of conducting such site-specific individualized permit reviews would unduly strain governmental resources. See, e.g., *Natural Resources Defense Council v. Costle,* 568 F.2d 1369 (D.C. Cir. 1977) (statutory authority under federal Clean Water Act to issue general permits).

xii The US Environmental Protection Agency or delegated state agency, for example, might identify a negative emissions technology as an approved Best Available Control Technology, Best System of Emission Reduction or Lowest Achievable Emission Rate technology that a major source must use to comply with its federal Clean Air Act permit obligations.

xiii For example, persons who may lack a cognizable injury to support standing for a legal claim nonetheless enjoy the legal ability to comment on major federal agency actions and receive responses to substantive comments under both the Administrative Procedure Act and some federal environmental laws. See 5 U.S.C. § 553(c) (notice-and-comment rulemaking under the federal Administrative Procedure Act); 42 U.S.C. § 7607(d) (rulemaking under the federal Clean Air Act).

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