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Before the US House of Representatives Select Committee on the Climate Crisis
October 22, 2019

Chair Castor, Ranking Member Graves, and members of the Committee, thank you for inviting me to testify on natural solutions to cutting pollution and building resilience. I am Joseph Fargione, Science Director for the North America Region of The Nature Conservancy (TNC). Founded in 1951, TNC is a global environmental nonprofit working to create a world where people and nature can thrive. Thanks to more than a million members and the dedicated efforts of our diverse staff and more than 400 scientists, we work in all 50 U.S. states and impact conservation in 72 countries across six continents.

Climate change is no longer a distant threat. We are currently living with its impacts, as Americans are seeing chronic drought, rising seas, record high temperatures, more frequent extreme storms and fires, and significant economic losses (USGCRP 2017). The climate crisis is endangering people, livelihoods, and decades of work on the conservation of America's wildlife and environment.

Addressing climate change is necessary to create a world where both people and nature thrive, where we provide food and goods for our growing population, design healthy and livable cities, and conserve and protect lands, freshwaters, and oceans. To create this world, American innovation and leadership is both capable and necessary.

The Nature Conservancy is committed to tackling climate change and to helping vulnerable people and places deal with the impacts of a changing climate, including increasingly extreme weather conditions. We are doing this by mobilizing action for a clean energy future, accelerating the deployment of natural solutions, and building resilience through natural defenses.

Today, I'd like to talk to you about the critical role nature can play in fighting climate change, what I refer to as Natural Climate Solutions. If you remember one thing from my testimony, remember that we can help fight climate change by planting trees, promoting soil health, and protecting our wetlands and coastal ecosystems. Landowners and producers can be incentivized and rewarded for voluntarily engaging in practices that remove carbon while helping to provide clean water, clean air, and wildlife habitat. If fully realized, Natural Climate Solutions could have a climate benefit up to one fifth of our current net emissions.

You may wonder 'what does nature have to do with fighting climate change?' As you may recall from your biology class, or from watching Star Trek, life on Earth is carbon-based. Plants, for example, are about 50% carbon. The plants on Earth contain almost as much carbon as the atmosphere. And the soil contains nearly 4 times as much carbon as the atmosphere. This means that we can help fight climate change by storing more carbon on the landscape in our trees and soils and by reducing the emission of carbon dioxide and other greenhouse gases from our natural and working lands.

Last year, I led a study, with 37 other experts from 22 institutions that assessed the potential for Natural Climate Solutions to reduce emissions in the United States (Fargione et al. 2018). Our study shows that Natural Climate Solutions can play a significant role in fighting climate change, with the potential benefit equivalent to one fifth of our nation's current net emissions – that's the same as eliminating emissions from all cars and light duty trucks in America. In other words, nature provides much greater potential than most people realize. Significantly increasing our investments in Natural

Climate Solutions, *in addition to* increased energy efficiency and a rapid transition to zero-carbon energy sources, is our best hope for dealing with the climate crisis.

Natural Climate Solutions are not a silver bullet – it may be better to think of them as a collection of silver BBs. The largest opportunities include planting trees, improving forest management, avoiding conversion of forests and grasslands, and building soil health in our agricultural lands. Collectively, these efforts can be deployed across hundreds of millions of acres, in every state in our nation. All regions of the country have a role to play in implementing Natural Climate Solutions. Before I describe each Natural Climate Solution in detail, there are several important characteristics of Natural Climate Solutions worth pointing out.

NCS Provide Multiple Benefits

Natural Climate Solutions have strong co-benefits. They not only fight climate, they also help provide clean air and water, they improve quality of life, and they help store floodwaters and protect our coasts from storm surges. Further, they build soil health, increasing the productivity and resilience of our working lands. For example, investments in cover crops and other conservation practices on farm fields help improve soil health and water quality, in addition to storing more carbon in the soil. Improved nutrient management can reduce the cost of fertilizer and save farmers money. Urban reforestation increases quality of life and property values and reduces air pollution and mortality from heat waves. Restoring fire-prone forests will reduce the risk of catastrophic wildfires that threaten homes and air quality. And protecting and restoring coastal wetlands can help reduce storm surges, flooding and coastal erosion. Often, it is these other benefits that inspire people to invest in Natural Climate Solutions, and that is a big part of why I think this approach is so promising – because there are so many good reasons to invest.

NCS are Affordable

Natural Climate Solutions are also cost-effective. Specifically, there are hundreds of millions of tonnes of carbon dioxide per year that can be kept out the atmosphere for an investment of just $10 per tonne of carbon dioxide. And that is the price just for the carbon – all of the other benefits of clear air and water, flood protection, and wildlife are thrown in for free. For comparison, the cost of Natural Climate Solutions is well under the price of other technologies that can remove carbon dioxide from the atmosphere (e.g. Keith et al. 2018). While we support continued investments to help drive the commercial deployment of technologies to capture carbon, we know that Natural Climate Solutions are cost-effective today and can be implemented immediately. Therefore, they present an important near-term opportunity to reduce carbon emissions while efforts continue to bring new technologies online.

NCS Provide New Revenue to Farmers, Ranchers and Foresters

While we talk about the 'cost' of reducing carbon through Natural Climate Solutions, for landowners and producers this would be revenue – they would be getting paid for reducing pollution and helping provide a stable climate that benefits everyone. There are many ways to pay for Natural Climate Solutions: funds could come from voluntary payments by companies that want to meet emissions goals; by providing federal support provided directly to landowners and producers, such as through existing Farm Bill programs; or from new policies, like a price on carbon, that create an incentive for payments.

NCS Pathways

Below I describe the specific opportunities that my colleagues and I have identified for the United States (see Figure 1 and Table 1).

Figure 1: Climate mitigation potential of 21 Natural Climate Solutions in the United States. Black lines indicate the 95% confidence interval or reported range. Ecosystem service benefits linked with each Natural Climate Solution are indicated by colored bars for air (filtration), biodiversity (habitat protection or restoration), soil (enrichment), and water (filtration and flood control).

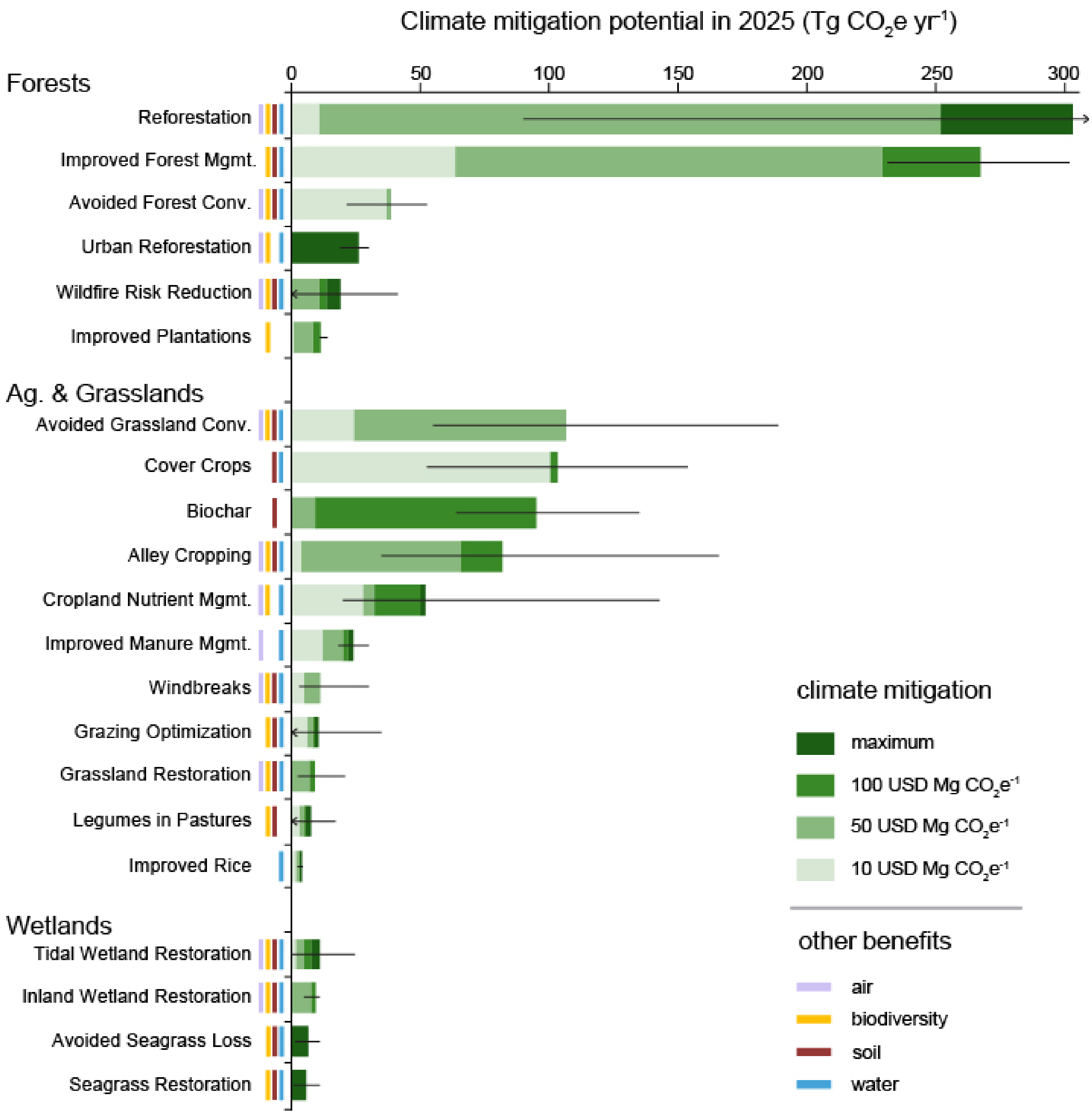

Table 1. Natural Climate Solutions available in the United States. CO_2e refers to the carbon dioxide equivalent, because methane and nitrous oxide are converted to their CO_2 equivalent, in terms of their global warming potential.

NCS Name	Area (Million acres)	Flux (Metric tons CO_2e acre^{-1})	Duration (yr)	Max (Million metric tons CO_2e yr^{-1})	Marginal abatement cost per metric tons of CO_2e (Million metric tons CO_2e yr^{-1}) $100	$50	$10
Reforestation	156	1.97 yr^{-1}	>90	307 (90-777)	252	252	11
Improved Forest Mgmt.	304	0.88 yr^{-1}	25	267 (232-302)	267	229	64
Avoided Forest Conversion	0.94 yr^{-1}	40	>100	38 (22-53)	38	38	37
Urban Reforestation	8	2.82 yr^{-1}	>40	23 (19-30)	0	0	0
Wildfire Risk Reduction	42	0.43 yr^{-1}	>100	18 (-5-42)	13	10	0
Improved Plantation Mgmt.	77	0.16 yr^{-1}	50	12 (11-14)	12	8	1
Avoided Grassland Conversion	1.7 yr^{-1}	62	>100	107 (55-188)	107	107	24
Cover Crops	217	0.47 yr^{-1}	>50	103 (53-154)	103	100	100
Biochar			>100	95 (64-135)	95	9	0
Alley Cropping	37	2.15 yr^{-1}	>50	82 (35-166)	82	66	4
Cropland Nutrient Mgmt.			>100	52 (17-121)	50	32	28
Improved Manure Mgmt.			>100	24 (18-30)	22	20	12
Windbreaks	2	5.28 yr^{-1}	>50	11 (3-30)	11	11	5
Grazing Optimization	131	0.07 yr^{-1}	>100	11 (-13-35)	9	8	6
Grassland Restoration	5.2	1.77 yr^{-1}	>50	9 (3-21)	9	7	0
Legumes in Pastures	14	0.52 yr^{-1}	>100	7 (-3-17)	6	5	3
Improved Rice Mgmt.	3	1.37 yr^{-1}	>100	3.7 (3.2-4.2)	3	3	2
Tidal Wetland Restoration	1	9.94 yr^{-1}	>100	12 (0-24)	7	5	2
Wetland Restoration	7	1.19 yr^{-1}	>100	9 (5-11)	9	7	0
Avoided Seagrass Loss	0.05 yr^{-1}	132	67	7 (2-11)	0	0	0
Seagrass Restoration	4.5	1.32 yr^{-1}	>100	6 (1-11)	0	0	0
Total				1,204 (855-1,644)	1,097	918	299

Specific Natural Climate Solutions

Reforestation – We identified 156 million acres in the United States that are potentially reforestable. If reforested, these lands would sequester, on average, nearly two tonnes of CO_2 per acre per year, or over 300 million tonnes of CO_2 per year. We first identified all the areas in the United States that used to be forest but have now been converted to some other land use (Hansen et al. 2013). Next, we excluded areas with intensive human development, including all major roads (Open Street Map 2016), impervious surfaces (Xian et al. 2011), and urban areas (U.S. Census Bureau 2015). To eliminate double counting with the wetland restoration pathway, we removed Histosol soils (Soil Survey Staff 2017). To safeguard food production, we removed most cropland and pasture. To estimate the carbon sequestration rate, we used the US Forest Service's estimates for forest growth for each forest type in each region, averaging growth rates over the first twenty years of reforestation (Smith et al. 2006). We discounted the carbon sequestration mitigation benefit in conifer-dominated forests to account for albedo effects. (Conifer-dominated forests are dark and absorb solar radiation, which offsets some of the cooling effect that they provide by sequestering carbon.) The Nature Conservancy and partners are currently analyzing reforestation potential to identify the most feasible opportunities for implementation, such as in floodplains, riparian buffers, burned areas, marginal agricultural lands, and critical wildlife migration corridors.

Natural Forest Management – The maximum mitigation potential of 267 million tonnes of CO_2 per year is based on a "harvest-hiatus" scenario starting in 2025, in which natural forests are shifted to longer harvest rotations. This could be accomplished with less than a 10% reduction in average timber supply (i.e. within the range of historic variation in supply volume) with new timber supplied from thinning treatments for fuel risk reduction until new timber from reforestation is available in 2030. Alternatively, selective harvest practices that remove competing vegetation, reduce "collateral damage" from felling, and stimulate the growth of remaining trees can achieve approximately 60% of the maximum carbon benefits that we identified, with minimal reductions in short term harvest volume (Ellis et al. 2019). The Nature Conservancy and partners are currently piloting these practices in the Central Appalachian region through the Family Forest Carbon Program (https://www.forestfoundation.org/carbon).

Avoided Forest Conversion – We estimate that almost one million acres – 940,000 acres – are converted from forest to other land uses in the United States every year, based on the North America Forest Database (Goward et al. 2015). This emits at least 38 million tonnes of CO_2 per year, which could be avoided with better land use planning and incentives to maintain this valuable carbon storage and other ecosystem services that forests provide. Most forest clearing is followed by forest regeneration, rather than conversion to another land use. While remote sensing is good at detecting forest clearing, is not able to predict whether this clearing will be followed by conversion to a new land use or whether it will be allowed to regenerate to forest. To estimate the proportion of cleared that that returns to forest, we examined land cleared before 2000 and quantified the proportion that had returned to forest by 2010, in each forest type and region of the United States. We then used these proportions to discount observed rates of forest clearing between 2000 and 2010. We used estimates of avoided carbon emissions from above and below ground biomass that are specific to each region and forest type. We did not count forest loss due to fire to avoid double counting with wildfire risk reduction. We did not count forest loss due to pests because it is unclear whether this loss can be avoided. We reduced the benefit of avoided conversion in conifer-dominated forests to account for their albedo effects. Our results are conservative because they do not count the loss of ongoing sequestration that protected forests would continue to provide. Although rates of carbon sequestration slow over time, available evidence suggests that forests continue to sequester carbon for at least 200 years (Luyssaert et al. 2008).

Urban Reforestation – We found that, across the 3,535 cities in the conterminous United States, roughly 8 million acres of trees could be added (Fargione et al. 2018, Kroeger et al. 2018). We considered the potential for additional street trees and, for those cities not in deserts, we also considered the potential for park and yard tree plantings. The potential percent increase in tree cover was estimated based on high-resolution analysis of 27 cities, which excluded sports fields, golf courses, and lawns (Kroeger et al. 2018). These trees would sequester carbon at a rate of roughly 2.8 tonnes per acre per year (Nowak et al. 2013), or around 23 million tonnes of CO_2 per year. This estimate is conservative in that it only considers the carbon stored in the tree and does not consider any additional benefits of trees. Trees in urban areas have additional co-benefits that are important to consider. For instance, urban trees in the United States already save around 1,200 lives a year during heat waves (McDonald et al. 2019), and many more lives could be saved with additional urban forest canopy. Additional forest canopy would also help clean the air by reducing particulate matter concentrations, reduce electricity consumption during the summer (Akbari et al. 2001, Akbari 2002), and help cities mitigate stormwater and floodwater.

Wildfire Risk Reduction – Prescribed fire and fuel reduction treatments can reduce the risk of high-intensity wildfire, such that that the initial increase in emissions associated with treatment is more than made up for over time by the avoided impacts of wildfires. We considered the effect of prescribed fire treatments on 42 million acres of fire-prone forests in the western United States. Over 20 years, these treatments would avoid emissions of 240 million tonnes of CO_2, an average of 12 million tonnes per year. These treatments also have substantial benefits to society, such as improving water quality and quantity, reducing loss of wildlife habitat, and protecting communities and forest dependent businesses like tourism, recreation and forest products. The impact of wildfires includes both direct emissions from combustion and the suppression of forest growth following wildfires (Collatz et al. 2014, Williams et al. 2016). Investing in targeted controlled burning and selective thinning can achieve long term carbon sequestration while helping to restore forest ecology and reducing the risk of severe wildfires.

Improved Plantations – We quantified the benefits of extending rotation lengths in even-aged, intensively managed wood production forests. Specifically, rotation lengths were extended from current economically optimal rotation length to a biological optimal rotation length in which harvest occurs when stands reach their maximum annual growth. To understand the carbon benefits of extending rotations, imagine if all plantations are harvested when they are twenty years old – the average age of plantations would be ten years. If rotation lengths were extended to forty years, the average age would be twenty years, roughly doubling the amount of carbon on the landscape. These longer rotations grow just as fast and produce just as much, if not more, timber product. However, because the percent increase in capital value slows slightly in later years, there would be some economic cost to plantation owners, which could be compensated for via carbon payments.

Avoided Conversion of Grassland – Conversion of grassland to cropland emits about 62 tonnes of CO_2 per acre. Most of this is from soil carbon, which we estimate is reduced by 28% down to 1 meter after conversion to cropland (Sanderman et al. 2017). Additionally, there is a loss of root biomass when grasslands are converted to cropland: annual crops don't store carbon long-term in roots, whereas grasslands have about 4 times as much root biomass as they do aboveground biomass (Mokany et al. 2006). About 81% of emissions are from the soil, and 19% from root biomass. The conversion of grassland to cropland is an ongoing issue in the United States. While the total amount of cropland in the United States fluctuates slightly with commodity prices, it is not going up in the long term. However, loss of farmland to development and urban sprawl (Sorensen et al. 2018) spurs the expansion of cropland into areas that are more marginal for crop production such as native rangeland (World Wildlife Fund 2018). Between 2008 and 2012, about 1.7 million acres of grassland and shrubland were converted to cropland each year (Lark et al. 2015). With hundreds of ranchers on federal waiting lists to receive easements to protect their grasslands from conversion in the Prairie Pothole region alone (U.S. Fish & Wildlife Service 2012), additional investments in easements would protect these important carbon stores, in addition to the ecosystem services that they provide for water quality (Johnson et al. 2016), pollinator habitat (Hopwood 2008), and waterfowl nesting (Reynolds et al. 2006), among others.

Cover Crops – Cover crops are grown in the fallow season between main crops; they can roughly double the number of days each year that a living cover is pulling carbon from the atmosphere and sequestering it in the landscape. Cover crops add about half a tonne of CO_2 per acre per year to the soils (Poeplau and Don 2015). We estimate that cover crops can be added to the 217 million acres of cropland used for the five primary crops (corn, soy, wheat, rice, and cotton) that are not already using cover crops (Conservation Technology Information Center et al. 2017). It is possible to use cover crops on cropland planted to crops other than these five primary crops, but agronomic research demonstrating the successful use of cover crops is limited outside of these primary crops, so we conservatively limited the maximum area of cover crop use to these five crops. The benefit that cover crops provide varies from place to place. The amount of sequestration depends on interactions between the climate, soils, the cropping rotation of cash crops, and which cover crops are used. However, on average, researchers consistently find soil carbon sequestration of 0.3-0.6 tonnes of CO_2 per acre under cover crops (Tellatin and Myers 2018).

Biochar – Biochar is made by heating biomass while restricting the amount of available oxygen, which creates charcoal. This charcoal can be incorporated into agricultural soils, where it increases soil carbon, increases water holding capacity, and can boost crop yields (Aller et al. 2018). Unlike biomass that has not been turned into biochar, the majority of carbon in biochar does not decompose after being incorporated into the soil. We estimated the carbon sequestration benefit from turning 144 million tonnes of biomass into biochar, the amount of additional biomass from agricultural residue that could be sustainably harvested in 2025 (U.S. DOE 2016). We assumed that 79.6% of biochar carbon persists on a timescale of >100 years (Liang et al. 2008, Dharmakeerthi et al. 2015) and that there are no effects of biochar on emissions of nitrous oxide or methane (Song et al. 2016, Wang et al. 2016). While biochar is not yet in widespread use, the science is clear that it could effectively store carbon. Improved cost-effective biochar production equipment and techniques and additional in-field agronomic research quantifying the benefits of biochar application are needed in order to provide both the means and the motivation for farmers to start building soil carbon using biochar.

Alley Cropping – Alley cropping is one way to incorporate more trees in agriculture. Alley cropping is planting widely spaced rows of trees with an annual crop grown in the alleyways between the rows. Trees considered for alley cropping include black walnut, hazelnut, chestnut, and pecan, which can provide timber and/or nuts, or pine trees that can provide pine straw for landscaping (Garrett et al. 1991, 2015, Revord et al. 2019). These added revenues mean that alley cropping offers increased profitability in many cases (Garrett et al. 2015, Wolz and DeLucia 2019). We estimated a maximum potential of alley cropping on 10% of U.S. cropland, or 37 million acres (Udawatta, Ranjith P., Jose 2011). Alley cropping sequesters about 2.2 tonnes of CO_2 per acre per year (Fargione et al. 2018).

Cropland Nutrient Management – Nitrous oxide is a potent greenhouse gas that is about 300 times as powerful as CO_2. Of the nitrogen fertilizer added to farm fields, about 2.5% ends up being emitted to the atmosphere as nitrous oxide, either directly from the farm field or indirectly after nitrogen leaks from farm fields to streams and wetlands (Davidson 2009). We estimated the benefit of the implementation of best practices that can maintain yields, increase profitability, and decrease nitrous oxide emissions. We considered four improved management practices: 1) reduced whole-field application rate, 2) switching from anhydrous ammonia to urea, 3) improved timing of fertilizer application, and 4) variable application rate within field. Because these practices improve efficiency, they decrease the total amount of fertilizer production that is necessary, reducing the fossil fuel emissions necessary for its manufacture, which we also account for (Snyder et al. 2014). Based on these four practices, we found a maximum potential of 22% reduction in nitrogen use, which leads to a 29% emission reduction, including emissions from fertilizer production.

Improved Manure Management – Manure lagoons from dairy cows and hogs release methane, a potent greenhouse gas about 34 time more powerful than CO_2. For large farms, it can be economical to capture this methane to use for on-farm heating or for electricity generation, although cost sharing for initial capital costs may be necessary (Klavon et al. 2013, Lauer et al. 2018). We estimated that there are 24 million tonnes of CO_2 per year of potential for emissions reductions from improved manure management on dairy farms with over 300 cows and hog farms with over 825 hogs. Our calculations are based on improved management practices described in Pape *et al.* (2016).

Windbreaks – Windbreaks help reduce soil loss from wind erosion and can increase crop yields by sheltering crops from damaging winds and creating favorable microclimates that increase yields (Brandle et al. 2004). We estimated that windbreaks could be planted on about 2 million acres, calculated assuming that 43 million acres of cropland that would benefit windbreaks and that windbreaks would be planted on ~5% of that cropland (Pape et al. 2016). We estimated that windbreaks provide 5.28 tonnes of CO_2 per acre per year of sequestration in tree biomass and soils (Kort and Turnock n.d., Sauer et al. 2007, Schoeneberger 2008, Wang et al. 2013, Chendev et al. 2014).

Grazing Optimization – Well-managed grazing lands store more carbon in their soils than grasslands that are either over-grazed or not grazed at all (Mcsherry and Ritchie 2013, Hewins et al. 2018). In general, more productive systems store more carbon, suggesting that practices that avoid degradation and promote plant growth will maximize grassland productivity, rancher profit, and carbon storage. A global study (Henderson et al. 2015) estimated that "grazing optimization" could be applied to 131 million acres in the United States with a modest soil carbon sequestration benefit of $1/14^{th}$ of a tonne of CO_2 per year. Grazing optimization prescribes a decrease in stocking rates in areas that are over-grazed and an increase in stocking rates in areas that are under-grazed, but with the net result of increased forage offtake and livestock production. While there is increasing interest and enthusiasm around various rotational grazing practices that may achieve more significant soil carbon storage per acre in some instances (Teague et al. 2015), additional research is needed to be able to predict which practices will have a strong carbon storage benefit in particular climates and soil types (Briske et al. 2008, 2011, Hawkins 2017).

Grassland Restoration – Since 2007, over 13 million acres have been lost from the federal government's Conservation Reserve Program. Much of this former conservation set-aside land has been put back into row crops (Morefield et al. 2016). Restoring marginal cropland to grassland, e.g. through increasing the acres enrolled in the Conservation Reserve Program, sequesters about 1.8 tonnes of CO_2 per acre per year in soils and root biomass. Grassland restoration also helps support conservation goals for water quality (Johnson et al. 2016), pollinator habitat (Hopwood 2008), waterfowl nesting (Reynolds et al. 2006), and wildlife habitat.

Legumes in Pastures – Legumes help increase soil fertility by converting nitrogen in the atmosphere into a form that is available to plants; this increased availability of nitrogen helps both fertilize the soil and further store soil carbon. Seeding legumes in pastures increases both the amount and quality of forage, increasing productivity for beef and dairy cattle. A global study (Henderson et al. 2015) estimated that legume planting could be applied to 14 million acres of pastures in the United States with a soil carbon sequestration benefit equivalent to half a tonne of CO_2 per year (after accounting for the potential for legumes to increase nitrous oxide emissions). We do not recommend seeding legumes into native prairie rangeland, as this could negatively impact the diversity of native prairie plants. Rather, this practice should be implemented in planted pastures, which are already comprised primarily of introduced species.

Improved Rice Management – Flooded rice paddies emit methane, a potent greenhouse gas that is about 34 times more powerful than CO_2. There are roughly 3 million acres of rice in the United States. Practices including mid-season drainage, alternate wetting and drying, and residue removal can reduce these emissions by roughly 40%, with an average avoided emissions benefit equivalent to 1.4 tonnes of CO_2 per acre per year (Yan et al. 2009, Pittelkow et al. 2014, Sander et al. 2015, Peyron et al. 2016). We used an EPA analysis that projects the potential for improvement across U.S. rice fields, in comparison with current agricultural practices (US EPA et al. 2013).

Tidal Wetland Restoration – In the U.S., 27%, or roughly one million acres, of tidal wetlands (salt marshes) have limited tidal connection with the sea, causing their salinity to decline to the point where methane emissions increase (Kroeger et al. 2017). We estimated the potential for reconnecting these tidal wetlands to the ocean to increase salinity and reduce methane emissions. This opportunity avoids emissions of the equivalent of almost ten tonnes of CO_2 per acre per year. Reconnecting these wetlands can be accomplished by widening culverts or installing tide gates (http://www.edc.uri.edu/restoration/html/tech_sci/restsalt.htm). Restored salt marshes act as fish nurseries, provide bird habitat (Barbier et al. 2011, Correll et al. 2017) and reduce flood risk and shoreline erosion. We note that our estimate omits drained tidal marshes due to lack of information about the extent to which they could be restored. Many drained tidal marshes are developed and thus are unlikely to be restored. However, drained tidal marshes that were cropped have the potential to recover large amounts of soil carbon (Anderson et al. 2016, Holmquist et al. 2018). Inclusion of these additional restoration opportunities would reveal even greater potential for tidal marsh restoration than quantified here.

Wetland Restoration – Wetlands store large amounts of carbon, because wet soils inhibit decomposition. When wetlands are drained, these large stores of carbon begin to decompose. Protecting existing wetlands and restoring drained wetlands helps store carbon and protects what carbon remains in these systems. Wetlands also emit methane, a potent greenhouse. After accounting for these methane emissions, there is still a net greenhouse gas benefit to wetland restoration, which we estimate at the equivalent of roughly 1.2 tonnes of CO_2 per acre per year. Our estimate of mitigation potential accounted for changes in soil carbon, biomass, and methane emissions, considering regional differences, the type of land use of the converted wetland, and whether or not the wetland was originally forested. We estimated that there are about 7 million acres of restorable wetlands, based on the difference between historic wetland extent [as determined by the extent of Histosols in soil maps (Soil Survey Staff 2016)] and current wetland extent.

Avoided Seagrass Loss – Seagrass traps and stores sediment in shallow ocean waters. Seagrass stores, on average, 211 tonnes of CO_2 per acre, and of this, an estimated 132 tonnes of CO_2 per acre are released to the atmosphere when seagrasses are lost (Pendleton et al. 2012). Seagrass habitat is being lost due to nutrient pollution and other human impacts (Orth et al. 2006). An estimated 1.5% of seagrass extent is lost every year (Waycott et al. 2009). Applying this to the estimated 3.6 million acres of remaining seagrass in the United States (CEC 2013, 2016), we estimate about 50,000 acres of seagrass loss per year. Such losses could be avoided by efforts to reduce nutrient pollution in seagrass habitat, as has successfully been achieved in Tampa Bay through waste water treatment plant upgrades, stormwater treatment, phosphate industry best management practices and fossil fuel power plant upgrades for nitrogen control (Morrison and Greening 2011, Cooper 2012, Sherwood 2017).

Seagrass Restoration – We estimate that there are 4.5 million acres of lost seagrass habitat that could be restored (Waycott et al. 2009). Restoration techniques include natural recolonization, seeding, and transplanting in locations where pollution has been sufficiently reduced to enable restoration (van Katwijk et al. 2016). Restored seagrass sequesters an estimated 1.3 tonnes of CO_2 per acre per year (Thorhaug et al. 2017).

Conclusion

I'm optimistic that we can implement Natural Climate Solutions through targeted investments and policies at a scale that will meaningfully contribute to fighting climate change. These approaches are gaining traction because there are so many good reasons to implement Natural Climate Solutions, even beyond climate. From reducing costs for farmers to improving air quality for people to protecting coastal communities from flooding, the benefits are numerous. Natural Climate Solutions are low cost and are available now. For all these reasons, the time is right to invest significantly in Natural Climate Solutions.

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