Ecological Capital, Climate Change, and the Economy of the Future

By Jim Blackburn

This paper is an edited transcript of an oral presentation made February 8, 2022, at the Houston Museum of Natural Science. The transcription was provided by Jeffrey Mills from Documentary Alliance and the revised text was edited by Melanie Martin.

I. Introduction

Tonight, I am speaking about climate, ecology, and the economy of the future. I know there is a lot of concern and angst about Houston and the energy companies and our being the energy capital of the world. We could be considered ground zero for carbon emissions in the world and we'll talk about that tonight. But there is good news. Change is underway. I'm talking about one of the most dramatic changes I've ever seen in my career.

To be able to participate in that change and in that process of change at one of the last moments of my professional career is really one of the nicest capstones that I could ask for. And that's what I want to share with you – where I think we're heading in the future. We'll talk about a lot of the thinking that I've become exposed to and what I think is really a very optimistic future relative to climate which is sometimes hard to find.

I want to start with corporate net zero thinking and go through the transition that I have seen over the last three years, but probably more so since January of 2020. Amazingly enough, during the time that all of us have been confined in the pandemic, this change has rocketed through virtually every manufacturing industry in the world, including the oil and gas community. I'll next discuss nature-based carbon capture and removal systems which I think will be a major part of the portfolio for the future. Then, we'll talk about the BCarbon system that I had a hand in creating and of which I'm fortunate to be the chief executive officer and chairman of the

board. It's a non-profit here in town. Then I want to finish with just a few images of what the future might look like.

II. The Corporate Net-Zero Rapid Evolution

The rapid evolution of corporate net-zero thinking takes place after the signing of the Paris Accords in 2016. President Obama signed the Paris Accords on behalf of the United States, and President Trump was elected shortly thereafter and pulled the United States out of the Paris Accords. President Biden got elected in 2020, and in 2021, one of his first steps was to put us back into the Paris Accords. But whether the Paris Accords were in effect or not in the United States, this change that I'm talking about took place outside of and around government, despite government if you will.

Let’s start with climate change itself. My favorite climate scientist is Katharine Hayhoe. She teaches at Texas Tech, and she's an evangelical Christian. She spoke here in Houston some time back and started off by saying, "I don't believe in climate change." Everybody in the audience was kind of shocked, thinking "Oh my, what have we come to hear?" She goes on to clarify, saying "I believe in my faith. My religion is a belief. Climate change is science, and it is fact. It is not belief." So, what are those facts? Simply that the climate is changing and we're causing it. It's as simple as that. Period.

The intergovernmental panel on climate change had said that these two facts are irrefutable. It's not debatable. Climate has changed one degree centigrade from 1900 to 2000. It is continuing to change. Humans are causing it. Period.

Now, Pope Francis took notice of this. He wrote probably the most revolutionary piece of environmental literature that I have read, a papal encyclical called "Laudato si’" which translates as "Praise be to You," with the you referring to God. It's about climate change. It's about the obligation to address climate change for everybody in the world. For a billion Catholics in the world, what the Pope thinks is important. It is also important for many who are not Catholic. He is a very highly regarded moral, ethical statesman, if you will.

Pope Francis put out "Laudato si’" right before the Paris Accords. The image below is from June, 2019 when the Pope convened a meeting in the Vatican and invited the leaders of most of the oil and gas companies of the world and most of the financial institutions of the world. Talk about a meeting where I would've liked to have been inside the room. At least according to the reports that are from the outside, the Pope pretty much called everyone to task in that room and effectively said, "You've got to start doing something."

Figure 1. Pope Francis coming to address assembled oil and gas and financial executives. Picture courtesy of Vatican Media – Reuters, June 14, 2019.

I had been working on carbon-related issues for some time. Elizabeth Winston Jones and I were on the board at Houston Wilderness and developed some concepts of payments for carbon storage on the Texas coast during the 2005-2007 time period. At SSPEED Center, Elizabeth and I continued working on these issues in 2011. I'll talk more about that in a minute. I've been hearing about and talking about this issue for a long time. During these early days I was told, one, I was crazy to pursue a voluntary carbon market, and, two, watch Black Rock Financial. If Black Rock were to

do something, it would be important. I was told that back in 2015 or so and those words were very predictive of subsequent events.

On January 14, 2020, Larry Fink, President of Black Rock made a statement. Black Rock is a trillion-dollar-plus financial investment institution. According to Mr. Fink, Black Rock will exit investments in coal, introduce funds that are climate and environmentally sensitive (so-called ESG funds), and vote their shares against corporate management that is not making progress on fighting climate change. Now, that change of policy sent shockwaves throughout the financial community, throughout the manufacturing community, and throughout the oil and gas community. Black Rock sent ripples out that began to change the world relative to climate change responses.

I don't know how many of you have tried to have social conversations about climate change in Houston, but sometimes you don't get invited back to parties in Houston if you talk about climate change. It's not the most popular topic in our community. We've never heard business talk about climate change in Houston openly, publicly. It was just not wanted, not welcome. Bobby Tudor changed that.

In January of 2020, at about the same time that Larry Fink acted with Black Rock, Bobby Tudor, then President of the Houston Partnership, said that Houston must lead the energy transition of the future. We must commit to lower carbon emissions. We've got to develop new technologies that address the dual challenge of meeting global energy demand while lowering the world's carbon footprint. We must leverage Houston's strength in natural gas. We must lead development of carbon capture, use, and storage, and we must be leaders in the energy efficiency, conservation, and sustainability in smart city technology. In so many ways, this is really a blueprint for the future survival of Houston as an economic center, and certainly the future of Houston will lie at the center of this transition that has to take place and is now taking place. Figure 2 summarizes the context of much of the climate conversation in Houston.

Figure 2. A slide that captures the attention of the business community relative to climate change.

Ultimately, what we're talking about is money. The pursuit of money in the future means you must talk about climate change. Without a climate change plan, there's not a financial future for almost every corporation, and everybody is beginning to figure this out, but no one knows exactly what to do. It's one of the most interesting situations I've ever run across in my career where giants of industry that have been in control of most of their surroundings for the last several decades are suddenly very uncertain, very insecure, very unsure.

Now, consider the Paris Accords. As shown in figure 3, by 2050, the world needs to be carbon neutral. Right now, there's about 38 to 40 billion tons of carbon dioxide emitted globally. That needs to come down to zero. We've got until about 2050 to make that happen under the Paris Agreement. And many are now discussing a 50% down payment by 2030. So, two big deadlines. First, net zero by 2050. And second, a 50% down payment by 2030. These are becoming the goals and objectives of almost every company in the world. And it has happened very fast.

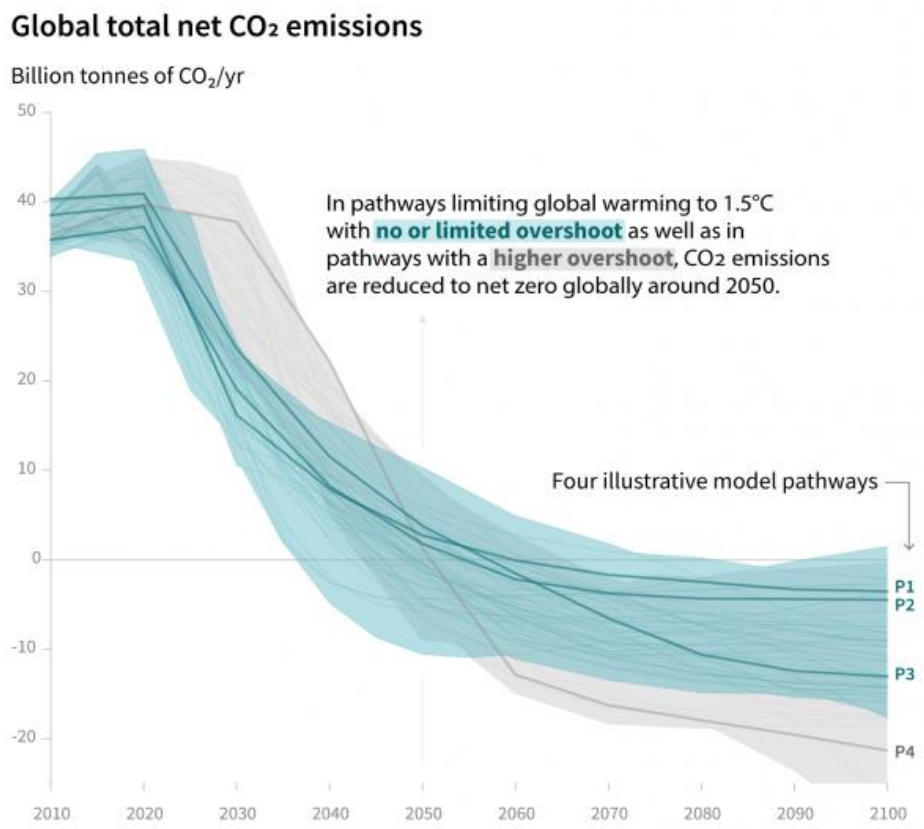

Figure 3. Paris Accords pathways to goal of net zero by 2050.
https://www.ipcc.ch/sr15/chapter/spm/

All big corporations are not at the same place on this transition to the future. There's a wide array, which I'll talk about in a minute, but the concept is really important. This is not fiction. This isn't me just wishing this to be true. This is a conversation that is taking place in every industry, every retail company, Walmart, Microsoft, Exxon Mobil. They're all having these conversations. Prior to January 2020, these conversations were not occurring. Keep that in mind.

Again, amazingly enough, all of this has occurred during the pandemic, during the time of COVID. I've been informed that the audience tonight may be one of the largest so far at the Museum of Natural Science since the beginning of the pandemic. Think about it; we don't go out much anymore. We don't interact like we used to. And yet all this change in corporate

climate thinking has taken place with limited personal social contact. That fact – that circumstance – makes this transition more amazing to my mind.

So now, I want you to think about the pressure on the oil and gas industry for a minute. First of all, there's moral opposition to climate and carbon emissions. The Pope and various religious statesmen are beginning to speak out about this. A lot of pressure. Maybe not enough to change anything, but pressure.

Second, lawsuits abound. I'm an environmental lawyer. Both the number and creative aspects of the lawsuits about climate change are incredible. We're talking about impacts that will cause the sea level to rise. There are parts of the Texas coast that will become uninhabitable. There are certainly parts of New York, Boston, Baltimore, San Francisco, Los Angeles, San Diego that will become uninhabitable because of the water-level rise. And don't forget a place like Bangladesh which is incredibly low-lying. Is there liability for that? The courts have not gone there yet. The courts have basically said, "This is legislative territory. We're going to stay out of it." At least the federal courts have. State courts, well, that is yet to unfold. So far, no major losses for the oil and gas industry, but a lot of lawsuits.

Third, there is public opposition. Consumers have the potential to be a major force if they were to organize as "buyers" but they have not gotten unified like they will in the future. However, you are beginning to see stockholders, a type of consumer, becoming organized. Engine No. 1 put three board members on Exxon Mobil's board. Now that was wild. Conversations are occurring within Exxon Mobil today that did not occur before this election. These are changes that are happening – have happened. And these changes are adding to the pressure to change.

And fourth, there is the big one to date – the financial side. One aspect is the concept of voting shares for corporate policies that are pro-climate. The idea here is that the financial world has a major stake in what happens, and they're beginning to use their clout. And then there is ESG. I don't know how many of you have heard of it, but it stands for Environmental, Social, and Governance. This is a big issue. I teach sustainable development

at Rice and one of the focus areas is corporate websites and what they are reporting about sustainability, the environment, and climate particularly. A lot of corporations have sustainability reports. Some of those are called Corporate Social Responsibility Reports. Some of those are called Environmental, Social, and Governance Reports. In one way or another, these are reports that lay out the company's climate plan. If you go to the website of most any major corporation, you'll find pages on climate and on their climate policies. Major and minor corporations are suddenly becoming very interested.

However, during all of this new focus on carbon and transition, three letters – ESG - have probably captured the greatest amount of attention. I can't tell you how many phone calls I've had saying, "Blackburn - What is this ESG stuff? And what can I do about it?" These are people that have large amounts of oil and gas reserves, coal reserves, and various types of oil and gas production. Suddenly, they're finding out that in order to access money to drill, to undertake their business activity, they must have an ESG plan. This is all new since January of 2020. If you ask somebody here in Houston in oil and gas, "Do you have an ESG plan," they'll probably smile at you and say, "We're getting one." Or they have one, with most being developed since January 2020.

Next, consider figure 4, developed by my friend Dr. Henk Mooiweer. It is a wonderful image of where business is heading. Business as usual just about doesn't exist anymore. The old business as usual of 2015, 2016, 2017 is gone, left behind, obsolete. Everyone has some plan for a lower carbon footprint. Less harm. No question about it.

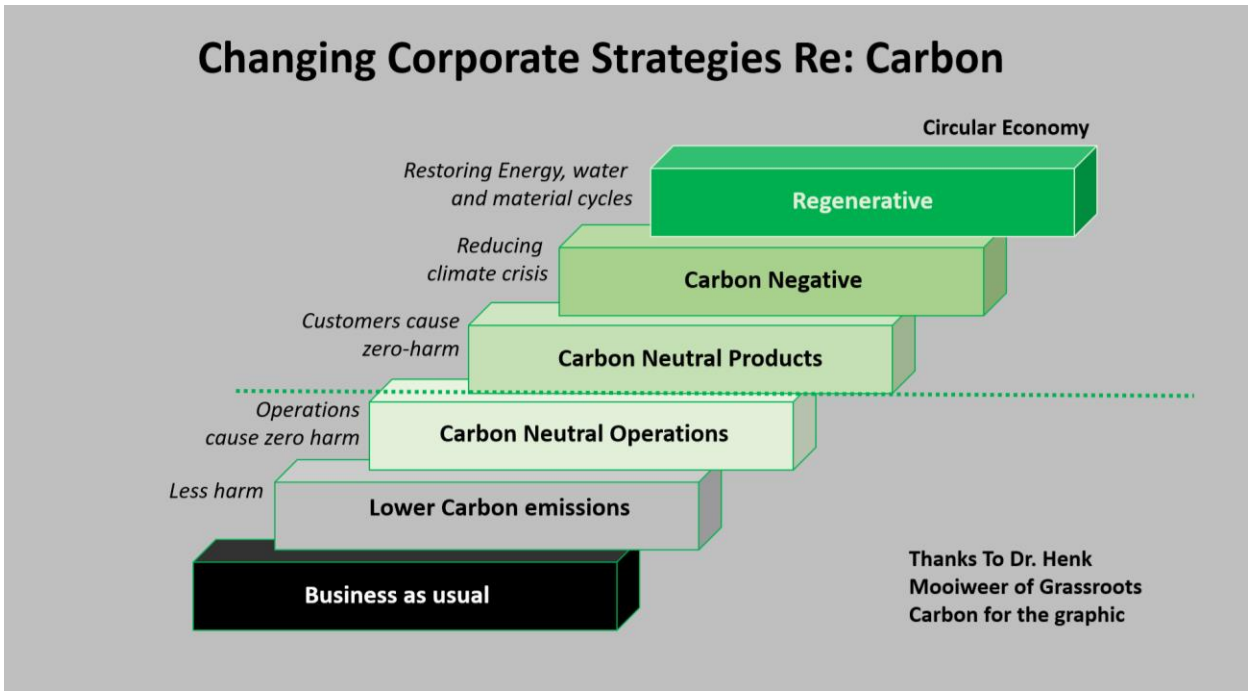

Figure 4. The stairstep of corporate climate strategies. Graphic courtesy of Dr. Henk Mooiweer, Grassroots Carbon.

Now consider carbon neutral operations. Scope one emissions are direct emissions. If you're a refinery, it's what comes out of your smokestacks. It's what comes out of your co-gen facilities where you make your own electricity. Scope two emissions are those from the electricity you buy. Scope one and scope two are a company's direct carbon footprint. If you made those carbon neutral, you would have carbon neutral operations.

Scope three are the carbon emissions from the use of your products and the impact that comes from your supply chain, both what you buy and what you sell. To move to carbon neutral products involves addressing scope three emissions and requires seriously addressing the carbon neutral commitment. But then beyond carbon neutral is carbon negative. There are companies today that have plans to take more carbon dioxide out of the atmosphere than they're putting into it. Now, that's pretty amazing. That's pretty cool. That is something that you don't see a lot, but it's out there, and you'll hear much more about it going forward.

The regenerative corporation is the top of the staircase - the penultimate - and that is where we're headed. To my mind, that is a new economic system often referred to as the circular economy, a concept popularized by the Ellen MacArthur Foundation. It has now been adopted by the plastics industry, and I think you'll see it being adopted by most industries. Here the goal is to reuse and recycle as much as you possibly can and eliminate waste. Plastics are catching it for the pollution that they're generating on land, in our creeks, bayous, rivers, and in the oceans of the world. We've all seen the images. The point here is that this top stairstep is the future of every corporation. All will be moving toward carbon neutral products by 2050, if not carbon negative. I think there will be competition among companies to get to carbon negative and regenerative.

Remarkably, we have in Texas today a new entity called the Carbon Neutral Coalition (CNC) on which I am proud to co-chair the offset subcommittee. CNC was started by Corby Robertson - a man whom I have known for a long time going all the way back to undergraduate school – a man heavily invested in hydrocarbons. CNC has four groups established to bring to the Texas legislature and to the citizens of Texas these changing industry needs relative to climate. CNC is addressing carbon capture and storage and methane reduction. It's talking about nature-based offsets and other types of offsets. It's openly discussing a carbon neutral future. These conversations are today being brought to the legislature and to the Governor's office by people that have never said these things before. It's a major change here in Texas, and it's difficult to convey how different the conversation on these topics is today than from five years ago.

In figure 5, the global carbon dioxide atmospheric concentrations are set out. We've gone from about 320 parts per thousand in 1969 to about 420 in 2020. In about 50-60 years, we will have increased by a third the amount of carbon dioxide in the atmosphere. That is an incredible impact on the atmosphere of the planet, and we have achieved this in an incredibly short period of time.

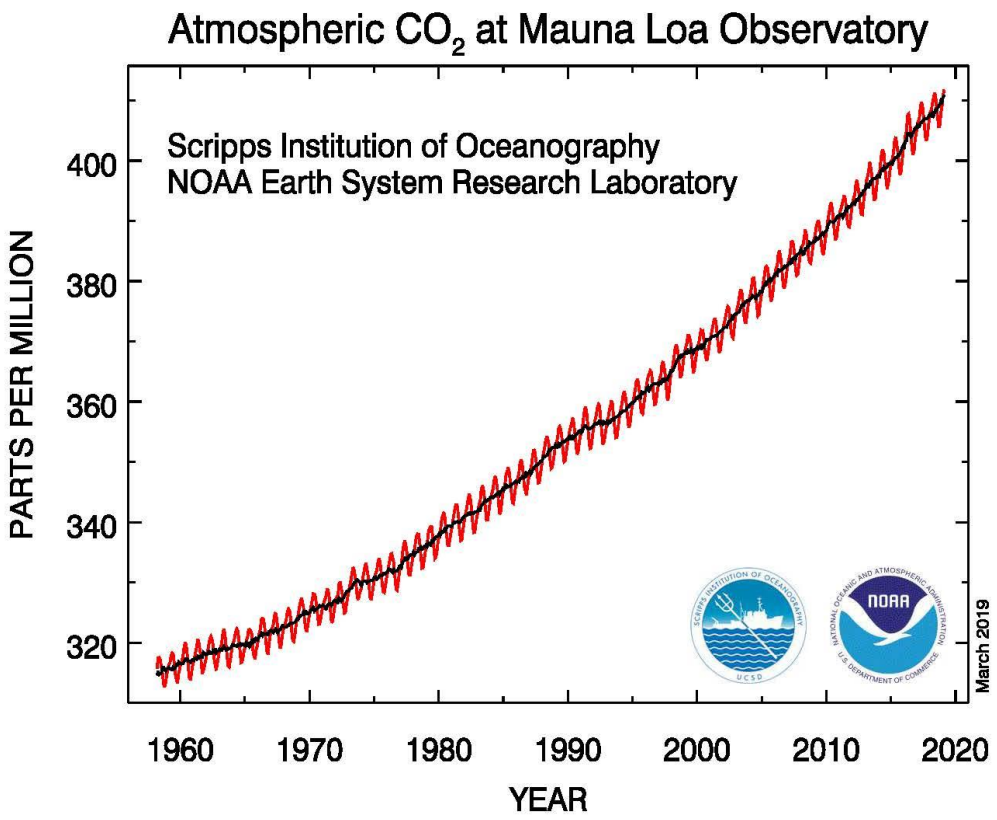

Figure 5. Global atmospheric concentration of carbon dioxide in parts per million from 1960 to 2020. Source: Scripps Institution of Oceanography and the National Oceans and Atmospheric Administration (NOAA).

To address increasing carbon dioxide concentrations in the atmosphere, three choices exist – avoidance, minimization, and mitigation, and they are set out beautifully in figure 6. This illustration is adapted from an article called "The Wedges", probably one of the most brilliant pieces I've ever read on climate adaptation. It was written by Pacala and Socolow, two professors from Princeton at the time this article was written. According to Pacala and Socolow, carbon emissions can be avoided by switching to renewables such as solar and wind or by going to nuclear; you can minimize carbon emissions by becoming more efficient and by substituting natural gas for coal; you can mitigate your emissions either by nature-based capture and storage or by technological carbon capture and storage. These are the strategies being pursued, in one manner or another, by every company in the world.

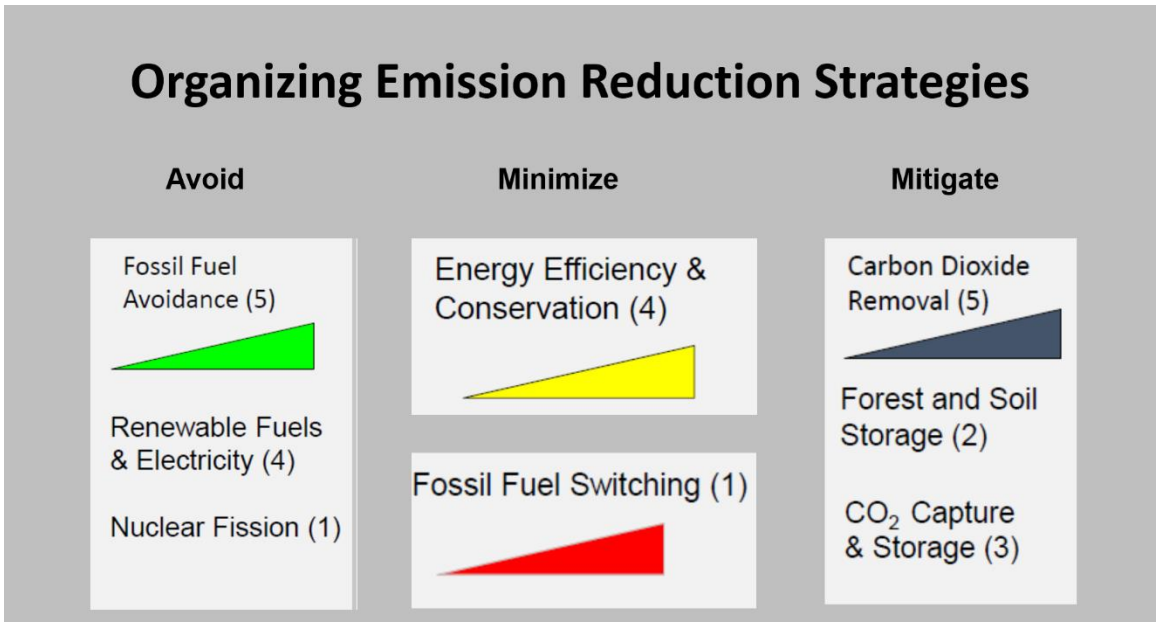

Figure 6. The wedges of Pacala and Socolow organized by avoidance, minimization and mitigation categories. The numbers in parentheses represent billions of tons of carbon emission reduced which must be multiplied by 3.6 to obtain tons of carbon dioxide removed. From Pacala and Socolow.

This leads to figure 7 which is an important introduction to the rest of this presentation. I think this figure sets out a reasonable mix for the company of the future where we look at renewables being about 29 percent of the portfolio. I just talked to a plastics company that's going to build a solar farm right next to their plastics plant and shut down their co-generation facilities within the plant. They're also going to have a wind farm. Another excellent alternative is efficiency – making better use of energy, 29 percent can be achieved here. Switching from natural gas to coal can generate about 7 percent, primarily in the power plant community. Nature-based solutions are shown to be about 14 percent, and carbon capture and storage technology about 21 percent.

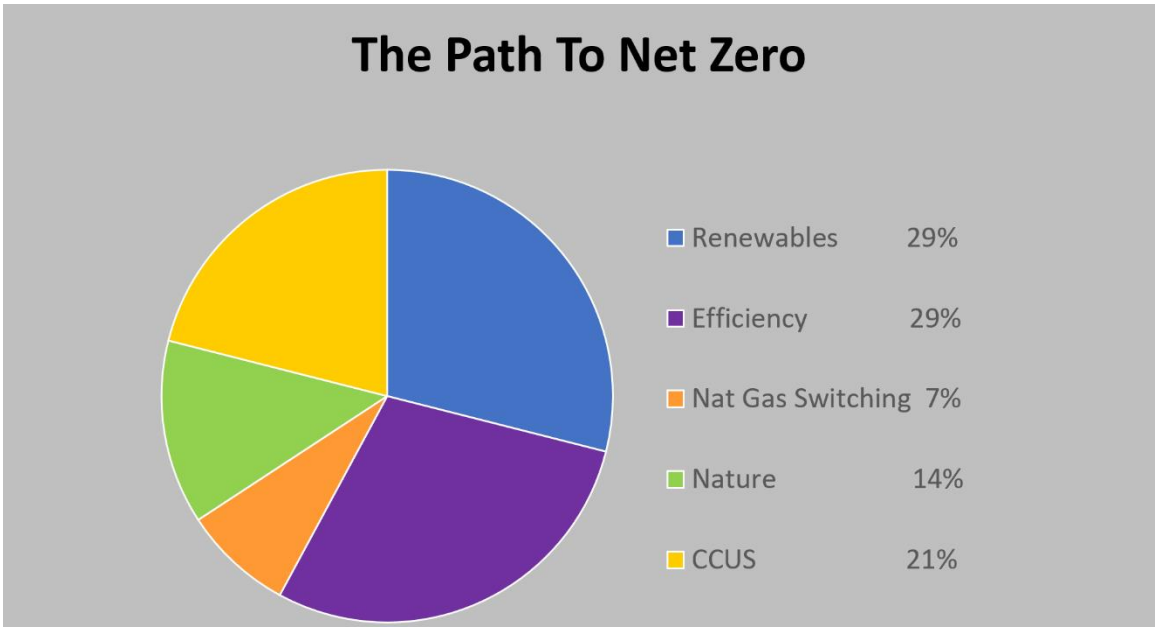

Figure 7. Globally, there are 37.5 billion tons of carbon emissions. A reasonable estimate of an industrial strategic portfolio for addressing carbon emissions in shown above. Note that nuclear has been omitted as most industrial operations will not have a nuclear option. Adapted from the Wedges, Pacala and Socolow.

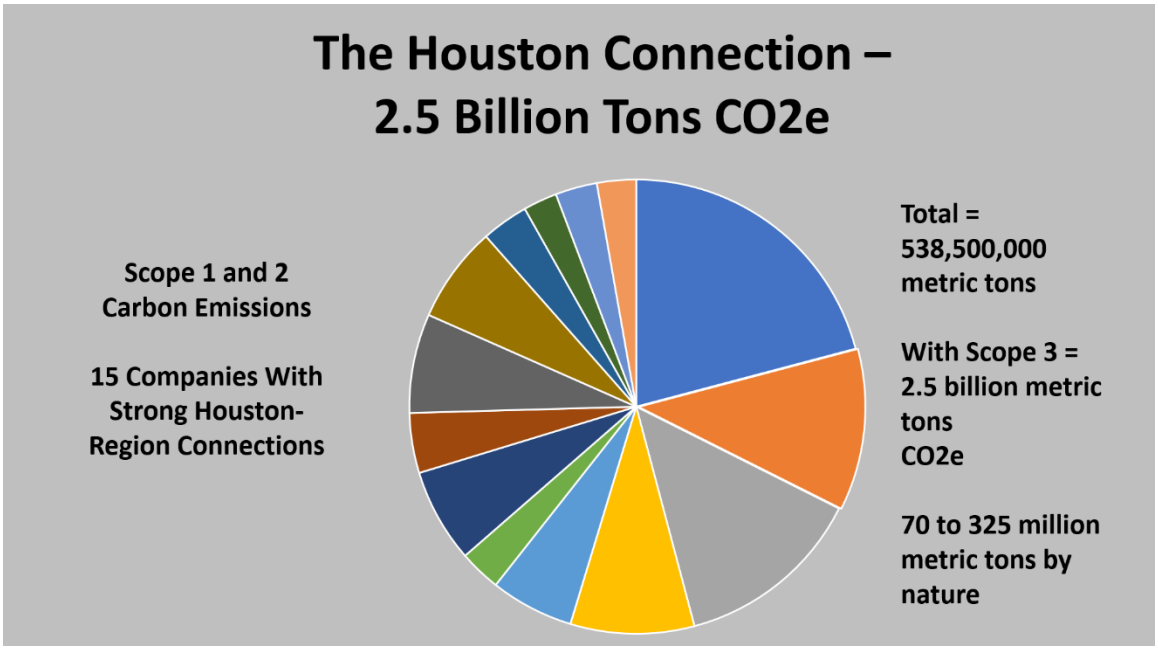

Figure 8. 15 companies with a strong presence in Houston represent 538,500,000 tons of Scope 1 and 2 emissions and about 2.5 billion tons of

emissions including Scope 3. Data from public sources and assembled by the author.

Now if you think of that as a reasonable portfolio, then now focus upon Figure 8. This is the carbon footprint of 15 companies with a major presence in Houston. Direct emissions - scopes one and two – amount to 538 million metric tons of carbon dioxide. If we add scope three, they're all the way up to 2.5 billion tons of carbon dioxide emissions. If nature is going to take care of 14 percent of that, that means we're looking at 75 million tons and up to 350 million metric tons with Scope 3 included, all being absorbed by nature beyond what is currently absorbed. Now, at $20.00 a ton, that's a fair amount of money. It's $1.5 billion for Scopes 1 and 2 and over $7 billion with all three scopes covered. At $50.00 a ton, $70.00 a ton, it just gets better.

Now, consider scopes one, two, and three. It is relatively straightforward, if expensive, to capture scope 1 or scope 2 carbon dioxide emissions out of the stack. Once captured and concentrated, it can be placed in a pipeline and stored underground in several different ways. This type of carbon capture and storage is going to happen all along the Texas Gulf Coast. Exxon Mobil has a huge plan to bring a lot of other companies with it. Down the coast, one of the companies I've been working with is looking at putting one of these systems in, and this company is being asked if they would allow others to come in and put their carbon dioxide into this underground storage system that is being considered. These conversations are happening. Deals are being made. It's going to take a while, but the plans are beginning to be developed.

Now, that's the stuff coming out of a stack. What about if I'm emitting into the atmosphere from dispersed sources, like cars burning gasoline? How do I get it out of the atmosphere? Well, direct air capture technology is under development, and this is a giant vacuum cleaner for the air. People are really serious about this. Cost-wise, we're talking about $250.00 to $900 per ton. It's expensive. It's hard to get to scale. Now, think –we are considering hundreds of millions and billions of tons of carbon dioxide at the U.S. and global levels. That is a huge scale. How many of these giant

vacuum cleaners would you have to build and at what cost, with what type of materials?

Or – we can use photosynthesis. Now, this is where I lose a lot of industry people because it does not compute that photosynthesis is a solution to their carbon problem. If I had patented photosynthesis, it would have been a lot easier. Everybody understands a patent, but when you talk to a lot of people in the oil and gas business, they want to talk to you about pumps. They want to talk about compressors, pipelines. I had someone ask me, "How big of a pipeline do I need to get my carbon dioxide to your field, to your tree?" I said, "No, no, no, no, no. That's not what we're talking about. We're talking about nature taking carbon dioxide out of the atmosphere." "Oh, that's weird," is often the response. Yet this weird solution may be the key to the future of oil and gas and every other emitter out there.

You can reduce scopes one and two without nature, but it's almost impossible to address scope three emissions or to achieve a carbon negative solution without using nature. It is either nature or a giant vacuum cleaner for the sky. So, I suggest to you that nature is going to be a key aspect of our future carbon solution, and the remainder of this paper will be devoted to how nature will play a major role in this future.

III. Nature-Based Solutions

Now let's turn to nature and consider grasslands. Look at those roots in Figure 9. Those are carbon pumps. Photosynthesis comes into the leaves and moves the sugars or moves the carbon as sugars down into the root system. You either grow the roots – that's carbon – or the sugars go out through the roots to the microbes, and you grow microbes in the subsurface. Plowing is the enemy of soil carbon because it introduces oxygen into the subsurface and releases stored carbon as carbon dioxide. If you don't plow, the carbon will build up over time with no till agriculture or by re-establishing grasslands. It's as simple as restoring the prairies of the United States to have a huge impact on carbon dioxide levels in the

atmosphere. It's as simple as planting trees. It's as simple as expanding marshlands, and as simple as building new oyster reefs.

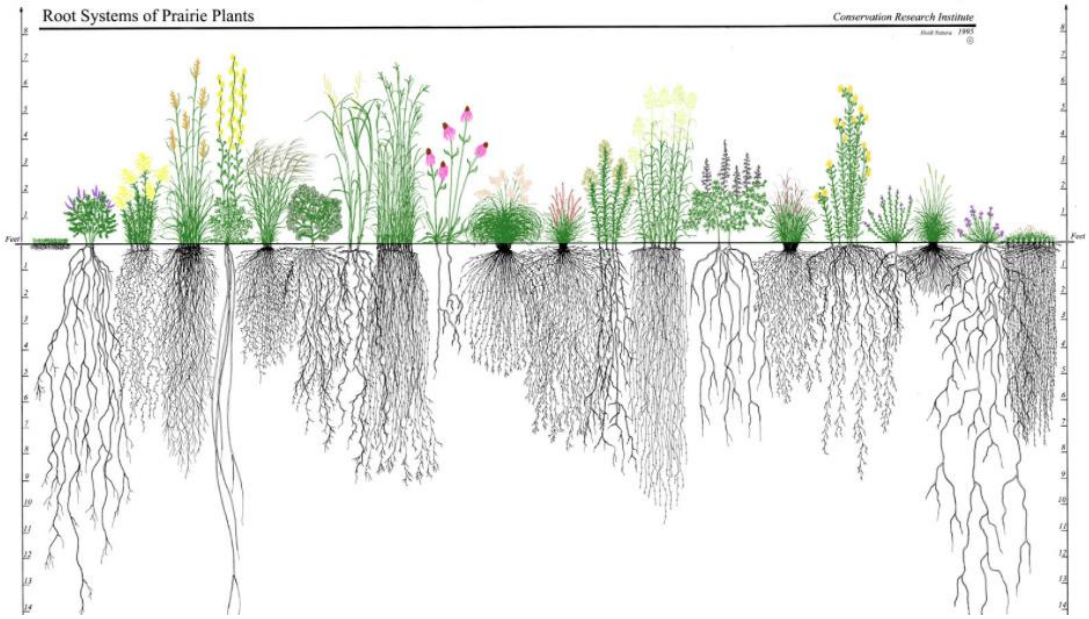

Figure 9. Various prairie grasses and their root systems. Source: https://driftlessprairies.org/confluence-our-water-ways-in-art/prairie-roots/.

For years, nature has been identified as a potential solution to the climate crisis. The Chicago Carbon Exchange was set up in the early 2000s, soon after the Kyoto Protocol of 1997. They were ambitious about buying and selling carbon dioxide removal credits, but unfortunately it failed. At that time, the buyers weren't ready for a carbon market. Today we're in a different time period with different pressures at work. As far back as that time, they divided the country between the dry west and wetter east and put out a map showing that most of the wetter areas would sequester one ton of carbon dioxide per acre per year and the drier west would only remove and store about 0.4 tons per acre per year.

Today, we have some data that offers a refinement on those general findings, but data is unfortunately limited. However, there are certain innovative ways of managing cattle, and there are publications that have studied regenerative, adaptive, multi paddock grazing. Some of these have reported levels of carbon sequestration per acre that are quite high. One report is as high as 11 tons per acre per year. I have trouble believing that

one, frankly, but these are reported numbers. A more likely range is from 2 to 4 tons. Any time you're talking over two tons of carbon dioxide per acre per year, you're talking about a pretty strong amount of carbon dioxide being removed and put in the ground. Yet there is published, peer reviewed literature to support higher numbers, but again, these data are sparse. At best, soil carbon sequestration is poorly studied.

The current price for high quality, reliable soil carbon credits in the United States is about $20 to $25 a ton. In Europe, these credits just went from €25 a ton to €60 a ton within a 6-month period. Now you start talking about $60 a ton, $50 a ton, and 3 tons an acre, that begins to be some interesting cashflow. I was talking to a rancher the other day who said that he netted about $50 an acre from his current cattle operation. If he and other ranchers could add another $50 per acre on top of his current income, he thinks that overgrazing could be substantially reduced throughout the United States. Overgrazing is a very common practice that drains carbon out of the soil. You could reverse, if you will, the dynamics of carbon, to bring more carbon into the soil by providing the cashflow to the ranchers to make it less necessary to overgraze. That is how we can begin to let nature solve our climate problem by making cash flow consistent with good carbon practices.

Restoring native prairies generates amazing results. The Wildlife Habitat Federation is a great organization, and they are about restoring prairies because, among other reasons, a lot of quail come with prairies and a lot of quail hunters want to have a restored prairie. Nobody was really thinking about carbon when they began restoring prairies. But the root systems for prairies are ten feet in depth or more, as seen in Figures 9 and 10. The photo that is figure 10 was taken one year after planting seeds. That's the type of root growth that puts a lot of carbon into the soil.

Figure 10. Photograph of the root system of three common Texas native prairie grasses hanging on the side of a barn. Photo courtesy of the Wildlife Habitat Federation.

How about various types of Texas forests? Pine forests generate about four and a half tons per acre. Bottomland hardwoods generate about three and a half. But look down further on Figure 11. Mesquite, the tree that South Texans love to hate, generates 2.8 tons per acre. Then look at Juniper in the Texas Hill Country - 3.1 tons per acre. Many landowners have been clearing cedar and mesquite on a continuing basis. That may not be best management for the future. Perhaps we should be encouraging those forests to grow, at least in some key areas.

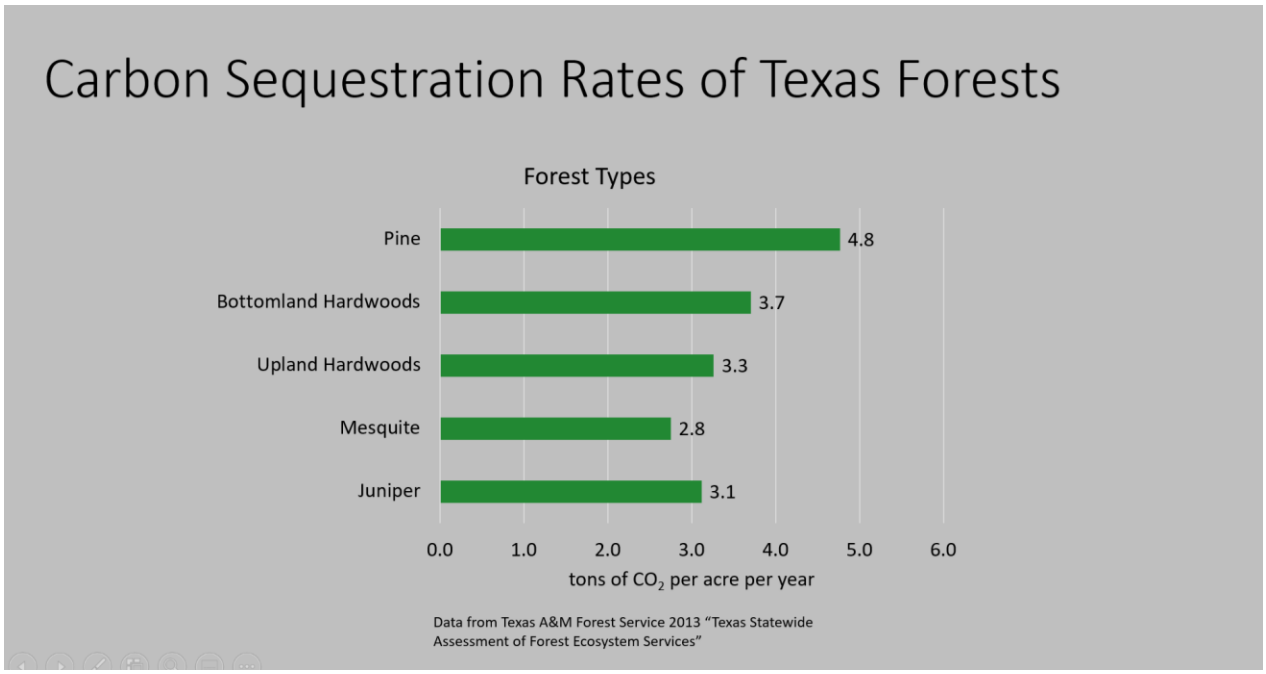

Figure 11. Carbon sequestration rates of key Texas forest types. Graphic by BCarbon based on data from Texas A&M's "Texas Statewide Assessment of Forest Ecosystem Services".

Now, at our non-profit BCarbon, we are attempting to verify these numbers. A lot of people have raised their eyebrows, particularly with the mesquite and juniper. There are density issues that must be normalized. But these data do suggest that we rethink how we have been looking at nature and some of our vegetation. It offers a different perspective. And the reception has been uniformly positive. I am talking to farmers and ranchers who are not interested in a conversation about climate change. But if I'm talking about paying them for maybe changing their agricultural ranching practices a bit, we have a basis for discussion. That conversation doesn't have to ever mention the word climate. We're just talking about payment for various types of performance, and it is one of the most interesting phenomena I've ever experienced.

Figure 12 is about the carbon yield from the lifetime of one tree of three different species. If you plant an individual tree, over the life of that tree, there is an expectance of carbon storage. Live oaks are among the best. In 30 years there are about 5 tons for that one live oak tree. I've just entered into a project with the City of Houston Parks Department to plant trees in a

number of parks paid for by a company that would like to get carbon credits. So, we're going to be basically restoring or bringing a lot more trees into parks in parts of town that are very poorly served, mostly minority areas because a company might be able to get some carbon credits for them. We're experimenting with that. We're trying to see how that would work. It's an interesting proposition.

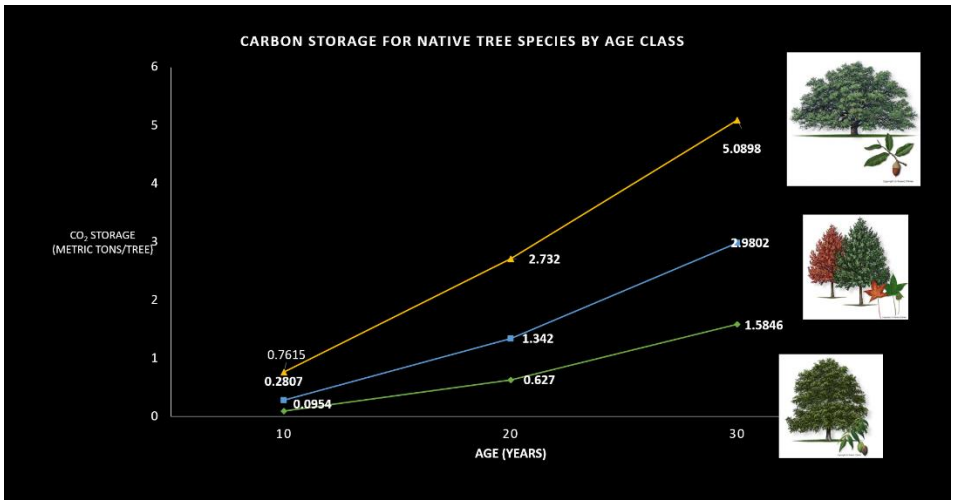

Figure 12. Lifetime carbon storage for three tree species – live oak, sweet gum and pecan. Graphic prepared by Erik Hawkins and courtesy of Texas Coastal Exchange.

Every company is now beginning to ask the following set of questions.

Do these solutions offer real atmospheric carbon dioxide reduction?
Can these solutions offer measured, credible, and accepted credits?
Is the carbon going into the tree, into the ground, permanent?
How long will it stay? Is it permanently in place?
Is this approach scalable?

And these questions are being asked about all types of alternatives, not just nature, but natural solutions offer a positive answer to each question.

In addition to carbon, nature also generates other benefits referred to as co-benefits. Prairie nesting birds are among the most heavily impacted in the United States because we have destroyed most of our native prairie. If we restore native prairie, it would be very beneficial for the birds. Soil that is rich in carbon holds more water, reducing peak runoff and flooding and

making the land more resilient to drought. The ecological diversity will return with the native grasslands that bring pollinators of all types as well as a healthy, diverse soil ecology. Great soil means a better ecological system.

Cost is a key question with all alternatives. Is it affordable? Depending upon type, technological carbon capture and removal solutions range from $150 to $900 per ton. Soil carbon approaches that emphasize testing are trading at $20 to $23 per ton in early 2022. Comparatively, nature's looking pretty good right now. But every buyer that I speak with is nervous about nature because purchasing nature-based carbon credits is something that they've never done. Nature has never been a solution for major manufacturers. It has not been taught in business school as a solution so far, but that will change. Nature-based credits are about change and change is always a fascinating subject.

A new solution offers buyers many problems. These nature-based solutions have never been traded to the extent that they soon will be. Consultants trying to hustle business will abound, selling several different types of nature-based credits. There is and will be confusion. To date, there is no guidebook or rule book. And while many see opportunities, many others see risks and hazards.

Landowners have issues, too. How much money goes to the landowner versus perhaps some agent that's putting this whole deal together? What are the terms and conditions of landowner and project developer agreements? What are the landowner commitments? For how long? What are the management requirements - what is the landowner required to do? And public information. Is the public going to find out about my property, my land? How much information? What type of information?

There are at least three ways to create nature-based carbon credits. One type is called avoided conversion. A conversation about this type of credit might be like this: "Pay me and I won't cut this forest down. There's a lot of carbon stored in these trees. I won't cut it down. I will not convert it to something else." Some entities create a carbon credit on avoided conversion; it’s a form of credit that's out there. Generally, you must prove

that there's some risk of conversion that is being avoided. The risk issue does create interpretative issues. If the land was north of Houston, right at the edge of suburban development, there's probably a true risk of conversion. If your land is located in Groesbeck, Texas or out in somewhere in the remote Texas Hill Country, there probably is not a lot of risk. As you might imagine, some pretty fantastic stories have been made up regarding risk of conversion. Every now and then, there's some horror story that shows up in the *Wall Street Journal* about some group that had just made some questionable claim of a risk and got called out on it. But it is a form of credit.

A second type of credit is an agricultural emissions reduction credit. Nitrogen fertilizer releases nitrous oxide, N2O. N2O is an incredibly potent greenhouse gas. One ton of N2O is equivalent to about 300 tons of carbon dioxide. Very potent. Ag reduction credits pay a farmer to reduce N2O emissions by changing practices, such as becoming more efficient in the use of nitrogen fertilizer, and there are those who are turning these changed practices into an agricultural emission reduction credit.

Now, I have questions about this practice. If a carbon dioxide credit can be created over reduced emissions in agriculture, why couldn't oil and gas say, "Pay me, and I will reduce my carbon dioxide emission"? I am sure that concept raises some eyebrows, if not hackles. Everybody in the world believes that oil and gas should be reducing their carbon emissions without any subsidies. However, the agricultural community is treated and thought of a little differently.

At BCarbon, we've been asked to consider the agricultural emissions reduction type of credit. I'm going to be slow to move to it because I like credits that actually remove carbon dioxide from the atmosphere. Here I am describing the type of credits that we have been discussing and that are referred to as nature-based capture and storage. Those are not an offset. They actually capture and store carbon dioxide; they actually remove carbon dioxide from the atmosphere. That is an incredibly important differentiating concept.

Now let me introduce BCarbon. BCarbon is a registry that has created a nature-based credit system that we developed at the Baker Institute with the help of a stakeholder group. BCarbon is a Houston-based non-profit that is offering carbon credits for nature-based capture and storage. The concept for an entity such as BCarbon started over at the Severe Storm Center at Rice University. We were concerned about these low-lying lands along the Texas coast. In Figure 13, everything in orange is 20 feet lower in elevation on the upper coast and everything in pink is 15 feet lower in elevation on the lower coast. We used 20 feet because there's a higher surge potential in the upper coast, whereas on the lower coast we believed 15 feet to be more reasonable. That's dangerous real estate. That real estate is going to be flooded by a major hurricane.

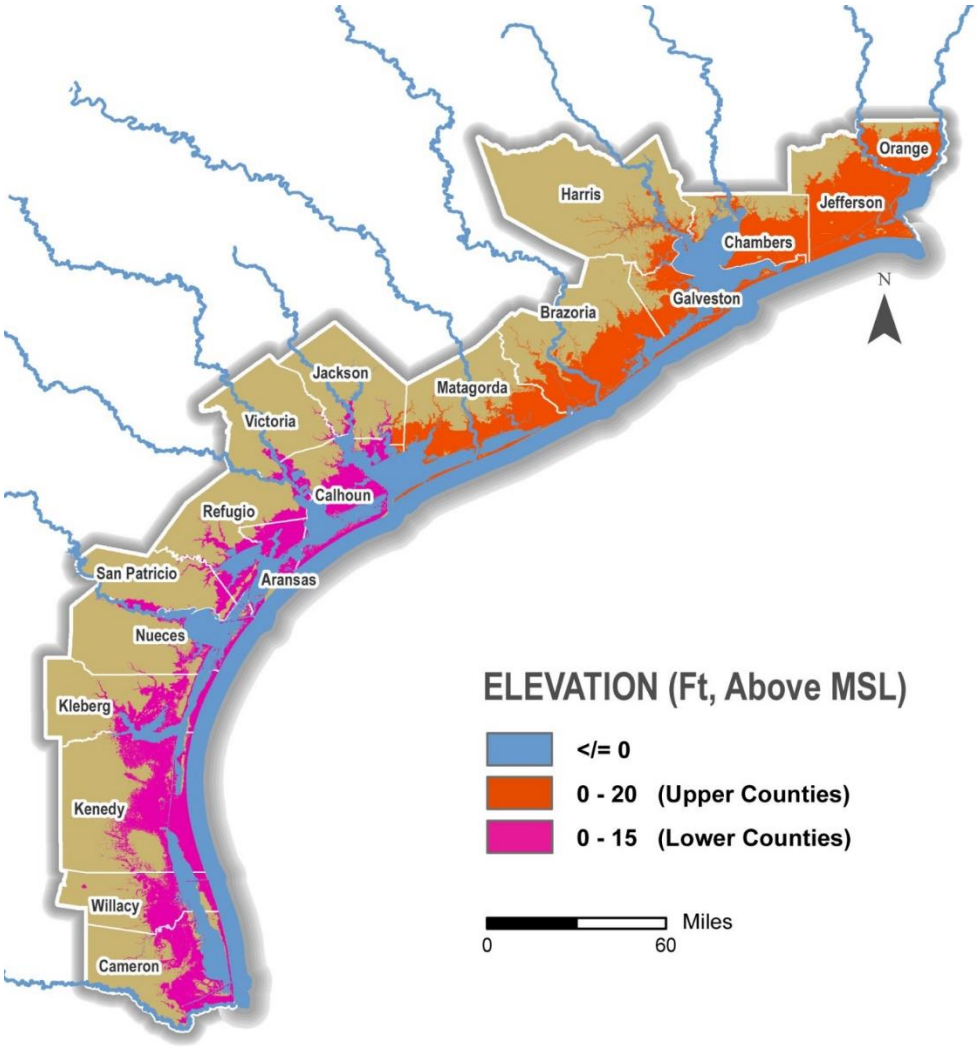

Figure 13. Low-lying land on the Texas coast that is subject to storm surge inundation. Image from A Texan Plan for the Texas Coast by Jim Blackburn. Image by Christina Walsh.

In Texas, you're not going to regulate to prevent development from occurring. But you could pay the landowner not to develop. We started evaluating concepts for paying the landowner, and we came up for paying them for the carbon that is being put into the ground by the plants on their land. We started researching that issue back in 2011, 2012. In our work, we discovered the international system of credits for nature-based carbon capture and storage. It is called the Clean Development Mechanism of the Kyoto Protocol, an international agreement negotiated back in 1997. It failed miserably as a carbon dioxide control method, but the Clean Development Mechanism (CDM) was created under this treaty amendment and was established as a trading mechanism between countries. One country would pay another country not to cut down, for example, the Amazon Forest. But the system that they set up made no sense to us, and we and Texas landowners felt it was not workable, dysfunctional, and poorly designed.

Figure 14 is a flowchart of the process a landowner must go through in order to qualify as “additional” under the CDM. All of these boxes are elimination tests. Way up at the top, if it was required by law, for example, if you had to put a wetland in, you couldn't get credit for that wetland. We agree with that. But then, if the land is otherwise making money right now, you wouldn't qualify under this system. You needed to be financially unattractive without carbon payments. Then there is the question about whether or not other barriers exist to the project. If there's no other barriers to prevent your grassland grazing project, for example, then it would not qualify. Probably the hardest test to understand is the box which asks "Is the type of management you are proposing common (the common practices test)?" If it is, you don't get credits. Your project doesn't qualify. It is not additional.

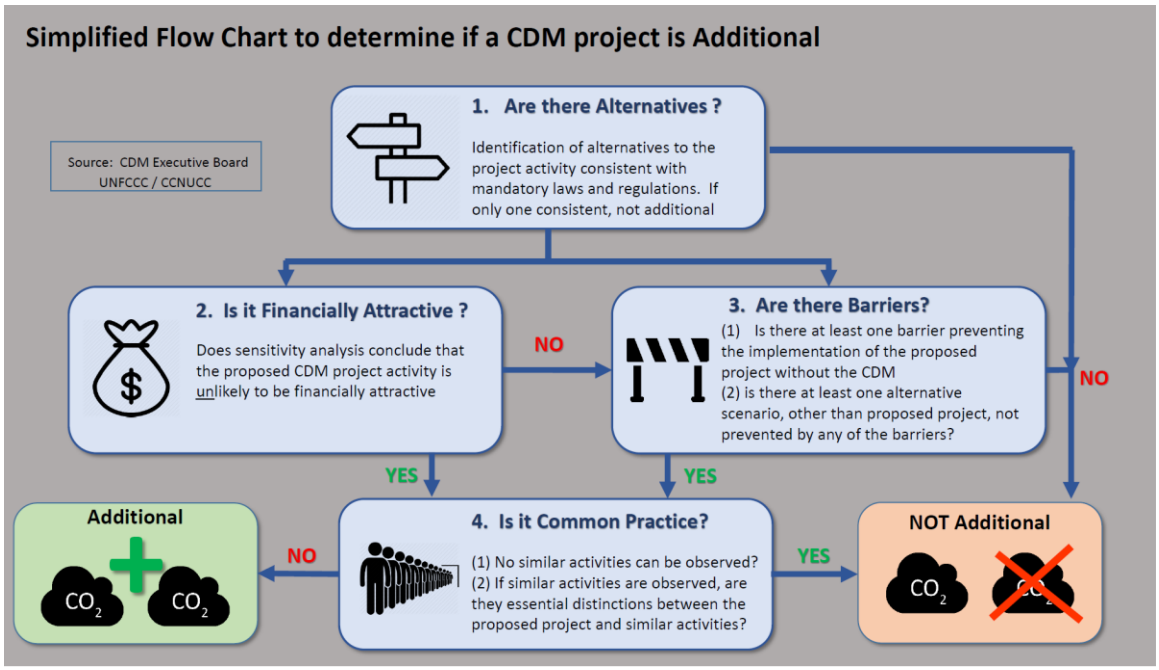

Figure 14. Simplified flowchart of the Clean Development Mechanism (CDM) process. Source: CDM Executive Board, UNFCC/CCNUCC.

We took these sets of conditions to several landowners and discussed them. Not a single landowner either would agree to participate or could qualify. In response, we at the SSPEED Center at Rice University decided to establish a system that was not based on the international standards but instead was based on our own standards that we created. Ultimately, we met with Ken Medlock at the Center for Energy Studies at the Baker Institute at Rice University and started talking. Eventually, we concluded that we should form a stakeholder group under the auspices of the Baker Institute. We started off with 40 stakeholders - some landowners, some emitters, some former clients of mine, some companies that I had sued in the past – and formed the core stakeholder group. This stakeholder group today has over 330 participants. This is the breakdown of participation by percent.

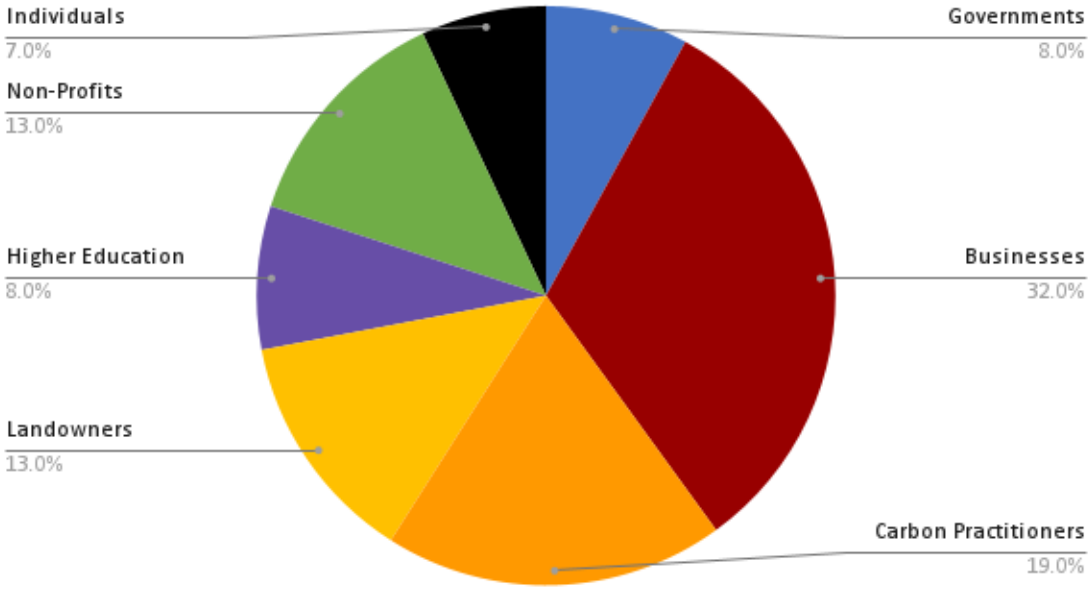

Figure 15. Percentage breakdown of the 330 stakeholders currently participating in the Baker Institute BCarbon stakeholder group. Slide prepared by stakeholder group facilitator Robin Rather of Collective Strength, Austin, Texas.

The large number of stakeholders is reflective of the interest among landowners, emitters, academics, and governmental representatives. There is a real need for a carbon market that works for both landowners and buyers. Importantly, we do not charge pay-to-play which is a common practice with many standard development processes. Under that approach, if you want to participate in helping develop the standard, you pay perhaps $10,000 or perhaps $50,000 to participate – serious money by anyone's criteria. By contrast, the Baker-BCarbon stakeholder group allows anyone who wants to participate to participate for free. As a result, we have an incredible and varied group of stakeholders. Everything that we have adopted has been approved by the stakeholders.

The world of carbon credits is set out in Figure 16. You have the landowners that are selling carbon storage. Additionally, there likely will be a project developer or an entity we call an assembler. They will be putting the deals together by working with the landowners to secure storage and by working with the buyers to generate cash flow. They are the dealmakers. And then there is an entity like BCarbon that adopts a standard and issues

credits. Under this construct, a project comes in as an applicant for BCarbon credits. At that point, the staff at BCarbon evaluates the application according to the standards that BCarbon developed in association with the stakeholder group. Ultimately, a determination is made whether the application meets the standards or not and, if so, to what extent. We then will issue the credits for tons of carbon dioxide removed from the atmosphere and stored in the soil by this project.

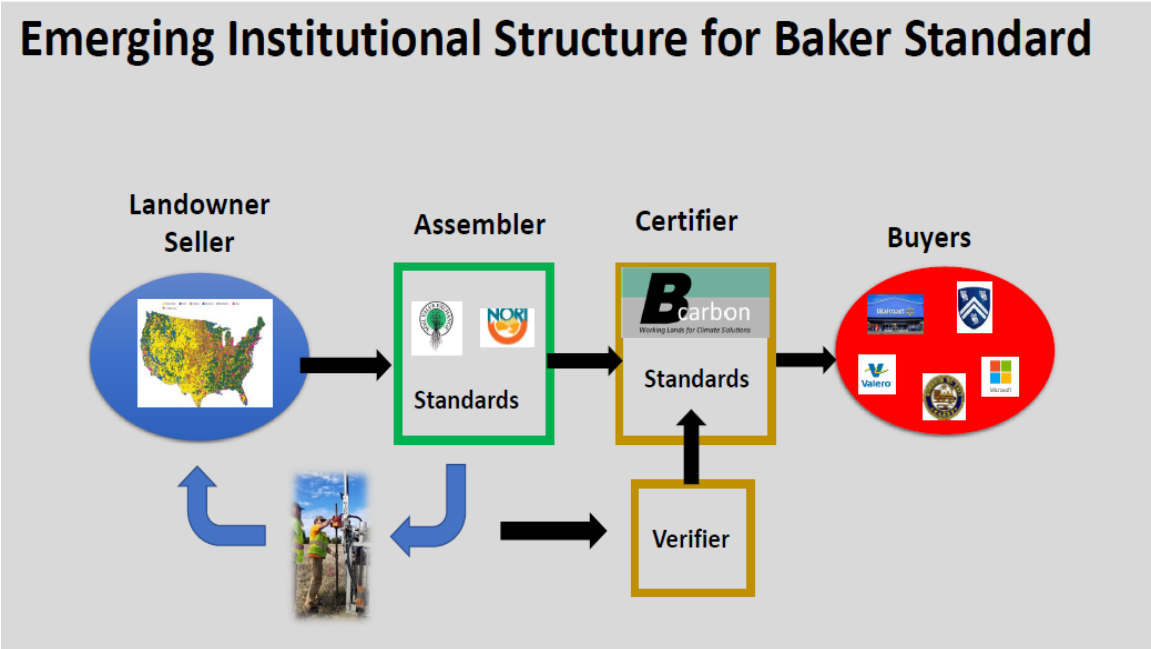

Figure 16. The institutional structure within which the standard created by the Baker-BCarbon stakeholder group leads to fiscal transactions. Image from BCarbon.

To create the standard, our process polled the buyers within the stakeholder group, asking "What do we need to do to make you feel comfortable?" The response was uniform. "We really want to know if we're buying something real. You're telling us this soil storage works, but does it?" So, we said, "Well, what if we test it?" They said, "Whoa, we like testing." So, okay, the buyer wants testing. Tests are expensive. Our costs are going to rise but our buyer comfort level is also going to rise.

Then we went to the landowner and said, "What do you want?" and their first response was almost uniform: they did not want anyone telling them what to do. Additionally, the landowners were concerned about how

long their land was being obligated to this project. They asked for the least amount of temporal restriction as possible. So, we said, "Well, internationally, they're talking 100 years." Response: “Not a chance." “How about fifty years?" Response: "No." "Twenty years?” Response: "Ugh." "Well, how about ten? Can you handle ten?" What we found is most landowners, at least to their own comfort, could foresee ten years out. So, what we said is, "Every year that you sell, you agree to not plow for ten years; you agree to no significant subsurface disturbance. If you sell credits again in year two, then you renew a ten-year commitment." In this way, a rolling ten-year commitment became a key aspect of our standard. We've found broad acceptance among landowners and buyers for those two principles. We believe that a strong market will lead to decades of credit sales on a yearly basis, with each year extending the commitment for another ten years.

In any nature-based system, the landowner's the key. If landowners don't participate, we don't have the ability to generate these credits. Now that fact makes the oil companies and other potential buyers a tad nervous. This isn't like technology you just put somewhere. It is not like pumping some product you have captured with technology down into a cavern. Basically, you've got to work thousands and perhaps hundreds of thousands of landowners. We are discussing amassing hundreds of millions of tons of carbon dioxide removal and storage in grasslands. At a ton an acre, that's a minimum of 500,000,000 acres to produce 500,000,000 million tons of carbon dioxide storage. Assuming an average tract size of 1000 acres, that represents 500,000 landowners. Have you heard of herding cats?

I had one person say, "Well, do we need to buy all that land?" I said, "No, no. That's more land than you're going to buy. But you can work with the landowners. You can basically lease storage." I said, "So, just think of it like a storage locker, just like these storage units you've got all over town." Someone is emitting carbon that's, by the way, their property. Okay? You don't lose that carbon dioxide molecule. That carbon dioxide molecule is being captured by a plant and locked in the soil or the tree or the oyster reef. That's carbon capture and storage. It's all based on the concept of property rights. The landowner has the right to capture, store, and sell the

stored carbon. The emitter owns the carbon and wants a secure final resting place.

What you see in that yellow rectangle of figure 17 is stored carbon. It's just like growing potatoes. Imagine that this is how we're going to solve our climate problem - just like growing potatoes. We're going to have a lot of carbon farmers, and it's going to transform the United States and global agricultural thinking and production. This may be the biggest single concept to hit agriculture in the United States since the green revolution of the 1950s and 1960s. Globally, this movement toward new economic thinking about carbon and the circular economy is certainly the biggest thing to hit industry since the Industrial Revolution.

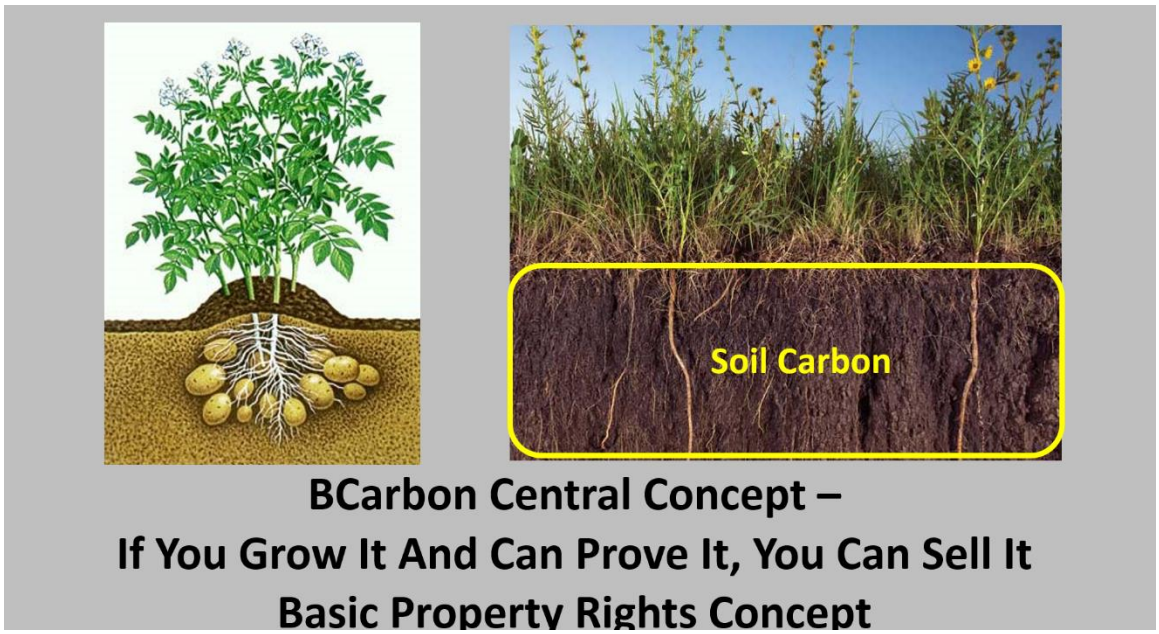

Figure 17. Soil storage of removed and captured carbon dioxide is just like growing potatoes. Under the BCarbon concept, the ability to capture and store atmospheric carbon dioxide is a property right of the landowner to capture and store the property of the emitter. Image from Dr. Henk Mooiweer, Grassroots Carbon.

Testing is absolutely required. We have begun to see these results. Figure 18 shows one of our technicians taking a soil core. Literally, we take a core, take it out of the ground and send it to the laboratory and get test results. What we're finding is that the U.S. Department of Agriculture never tested carbon very much. They have tested everything else. You won't

believe how much testing they have, and there's almost no data about carbon. The laboratories aren't equipped to test for carbon. So, we're having companies buy labs and convert them to carbon testing because this is going to be really one of the important tickets for the future.

Figure 18. Photo of Giddings mounted probe in the field. Shadow is that of the author. Photo by Jim Blackburn

Our goal is to quantify, to certify, to have our credits be defensible, and to try to reduce the risk to everybody involved in this process. We do it with transparency. We obtain our ethical strength from our stakeholders. A key aspect of everything that we have done is that it has been approved – it has been vetted - by our stakeholder group and by working subcommittees of stakeholders.

Under our process, we do allow for interim credits. That process is illustrated in Figure 19. After defining the project scope, we require an initial round of testing (step 2). Under step 3, we conservatively forecast the carbon yield of the property. Soil carbon potential varies depending on whether the soil is sandier or loamier (loamier is better) and on the amount of rainfall (more is better than less). We have some data and are gaining information monthly on yields by different types of terrain. After this initial

estimation process outlined in red on Figure 19, we come back and we do a second round of testing and then undertake a true-up process. Hopefully, we have issued fewer credits than have accrued in the soil and we then will issue additional credits. However, if we issued too many credits, then we will work with the landowner to get the account balanced, often by the landowner not being paid for a subsequent year or two.

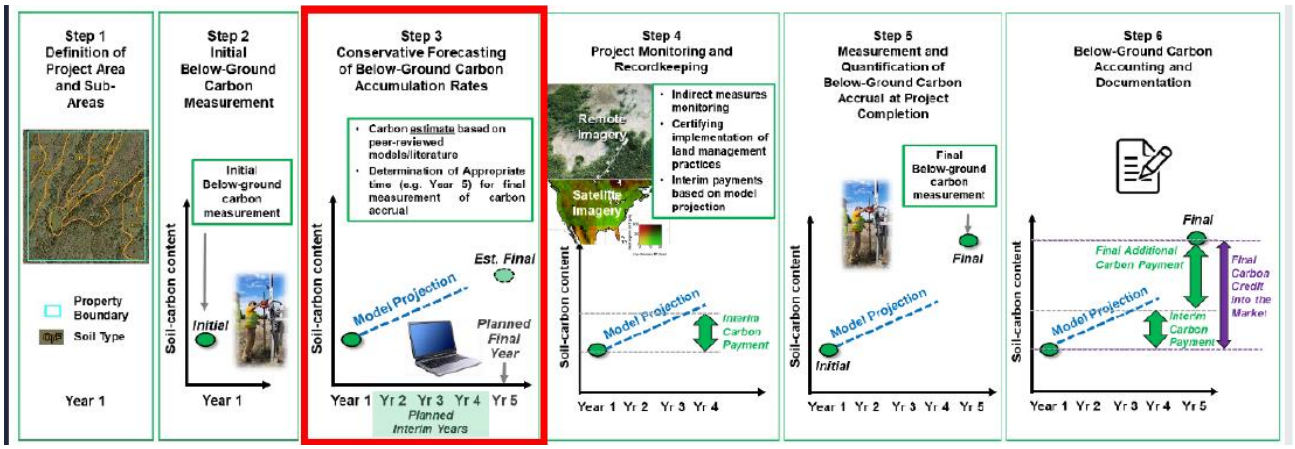

Figure 19. Schematic diagram of the BCarbon testing protocol. The step for awarding interim credits is shown in the red outlined box. Diagram by Dr. Henk Mooiweer of Grassroots Carbon.

This is similar to the way they accomplish the billing for the natural gas you use in your home or how they do your electric meter. They estimate it for a period of time, and then they come in and check it. You either have paid too much or too little. We're hopeful that we don't allow too many credits to be issued beyond what's going into the soil because we'd have to go to the landowner and, somehow or another, get compensation for that shortfall. We don't want that. We're going to make conservative estimates of yield to keep projects reasonable and to, hopefully, be well within the range of what would be measured. But ultimately, everything will be measured.

Now, what are we going to change through the introduction of BCarbon? How are we going to increase the carbon removed from the atmosphere? Consider an overgrazed pasture versus a restored pasture as shown in Figure 20. On the left side is a pasture that is overgrazed. There is likely no carbon dioxide removal and storage here, and the possibility exists that carbon is being drained from this soil. It sheds water rather than

absorbing it and the ecology is in very poor condition. On the right is a restored native pasture that is adding carbon to the soil every year. This restored prairie has openings along the root system that bring water into the ground. It has ecological diversity. It’s a positive for wildlife. With a vibrant market, the impetus for overgrazing can be replaced by the market that will reward good stewardship.

Figure 20. These two slides from Wildlife Habitat Federation show the same tract as overgrazed when first purchased and restored a few years later. The carbon performance of this tract has changed dramatically along with the hydrologic and ecological characteristics. This is the change that BCarbon seeks to cause. Slides from Wildlife Habitat Federation.

In addition to reducing overgrazing, a BCarbon market can bring about changed management practices such as regenerative grazing. Adaptive multi paddock grazing has generated some very high carbon sequestration results. This is a grazing technique that has tremendous potential. There are also a lot of landowners practicing regenerative grazing that believe that it has tremendous potential. It's fun to talk with people that have such excitement about what they're doing. But this is a different form of grazing.

Figure 21. Regenerative grazing has been identified as one management process that will increase soil carbon yields. Note the electric, mobile fencing crossing the lower 1/3 of this image.

It certainly requires different infrastructure. That little white line against that black cow, the largest of the black cow, is electric fencing. AMP ranchers are moving their cattle and moving electric fencing and moving cattle from paddock to paddock to paddock in a very concentrated feeding process. It requires watering facilities as well. Much of this thinking was pioneered by Allan Savory, and the Savory Institute teaches these techniques as do other practitioners. And regenerative grazing can help restore prairies. It’s such great synchrony when good cattle grazing practices and good ecological results go hand in hand.

So, with nature and BCarbon implementing this economy of the future, we think that we would see the market lead to significant transformation. We foresee marginal farmland, particularly on the western side of the Ogallala Aquifer really from North Texas all the way up through the Great Plains on the western side, being converted to grassland carbon farms. They're running out of water. They're not going to be irrigated ten years from now. They'll convert to grazing. This will be the restoration of the American Prairie almost parcel by parcel over time. It'll be one of the greatest land use transformations I think we'll ever see.

Or consider western irrigated land. My wife and some friends and I went out to Lake Powell recently. Lake Powell is just incredibly low, dropping with the drought and filling up with silt from the bottom up. There is a very real chance that the water supplied to California and Arizona from the Colorado River system will need to be curtailed. Irrigated farmland is going to cut be off from this water supply before Los Angeles gets cut off from water or Tucson or Phoenix. Much of that land will probably be converted back to grazing and carbon farming.

BCarbon is also committed to diversity, equity, and inclusion, or DEI. This comes from some of the stark realities of farming and ranching in the United States. One buyer approached me about U.S. landowners, asking "Aren't most of the landowners in the United States white?" We researched that issue and discovered that 97% of the private property in the U.S. is held by Anglos. Once we understood that fact, we became committed to having a diversity, equity, and inclusion principle added to our ten operating principles. As a result, BCarbon will make an incredible effort to be inclusive of all communities.

DEI will require substantial creative thinking. From the beginning, we have tried to be creative in our thinking about carbon credits. From a DEI perspective, we are committed to identifying BIPOC farmers and ranchers. We are committed to working with indigenous tribes on carbon credits generated within their tribal lands. One interesting issue is whether we could create a credit for the fewer transportation miles travelled and fewer carbon dioxide emissions associated with local farmers' markets as compared to bringing the produce in from California or from Chile? We think we can do the math on that. We think we can create a credit that would basically be payable to urban farmers, which would include a lot of urban gardens, and we think that's a wonderful direction to go.

BCarbon is new and does not have a long track record, but we have been evaluated by CarbonPlan in work funded by Microsoft. At the time of the evaluation, we had just published our soil carbon methodology. We barely made the submission deadline because we were finalizing our requirements and writing them up, but we made the deadline. And as

fortune would have it, we ended up among the best 2 out of 14 that were evaluated. That was because of our testing requirements, an excellent affirmation that our approach was technically solid.

As of February, 2022, BCarbon has approved issuance of our first 34,600 credits to Grassroots Carbon. At this time, an application for 84,000 tons is pending by a group known as Native, which used to be Native Energy. A group called Future Food Solutions out of Great Britain has come to us and asked to apply. They are barley growers utilizing no-till agriculture and no plowing. They use cover crops to put carbon into the soil. And we have received notification that as many as 300,000 more tons of carbon credit applications will be filed in the first and second quarter of 2022.

So, it's actually beginning to happen. These are our projected applications. We've got applications coming in from about ten states or so. We've also got interest from around the world in addition to United Kingdom. We've had interest from Western Australia and South and Central America. We have several Zoom conversations each week about whether somebody at the international level can participate with BCarbon, which they are more than welcome to do.

We are in the process of creating a blockchain system to track our credits. BCarbon and outside parties will be able to identify every credit we issue on our blockchain, and these credits can be followed from sale to sale and back to the originator of that credit. Portions of this information will be accessible to different parties, depending upon whether you are a member of the general public, the buyer, or the landowner. Blockchain allows these credits to be tracked from transaction through transaction to retirement. A credit is retired when the buyer wishes to apply that credit to reduce or “zero-out” their emissions inventory.

Buyers are out there. Right now, they're slow, but they're there. We're just starting. For us, 200,000 tons of credits is our goal for the first year, and we’ll exceed that level. We'll probably be well over a million credits in year 2, and probably upwards of 5 million credits or more by the end of year 3 or the first of year 4. This market is beginning to happen, and it is exciting.

BCarbon also has several research projects. One has just been funded by Exxon Mobil Research and Engineering (EMRE). In this work, we are going to be studying the rates of carbon accumulation on different ranches in different ecological systems. The ranches and states that are participating in this EMRE project are shown in Figure 21. The circles you see are the different ranches. King Ranch, H.C. Clark's place up in Groesbeck, Dixon Water Foundation out in Martha, XL Ranch up in Amarillo. Additionally, the State of New Mexico and the State of North Dakota are participating in this as well as an NGO from Montana.

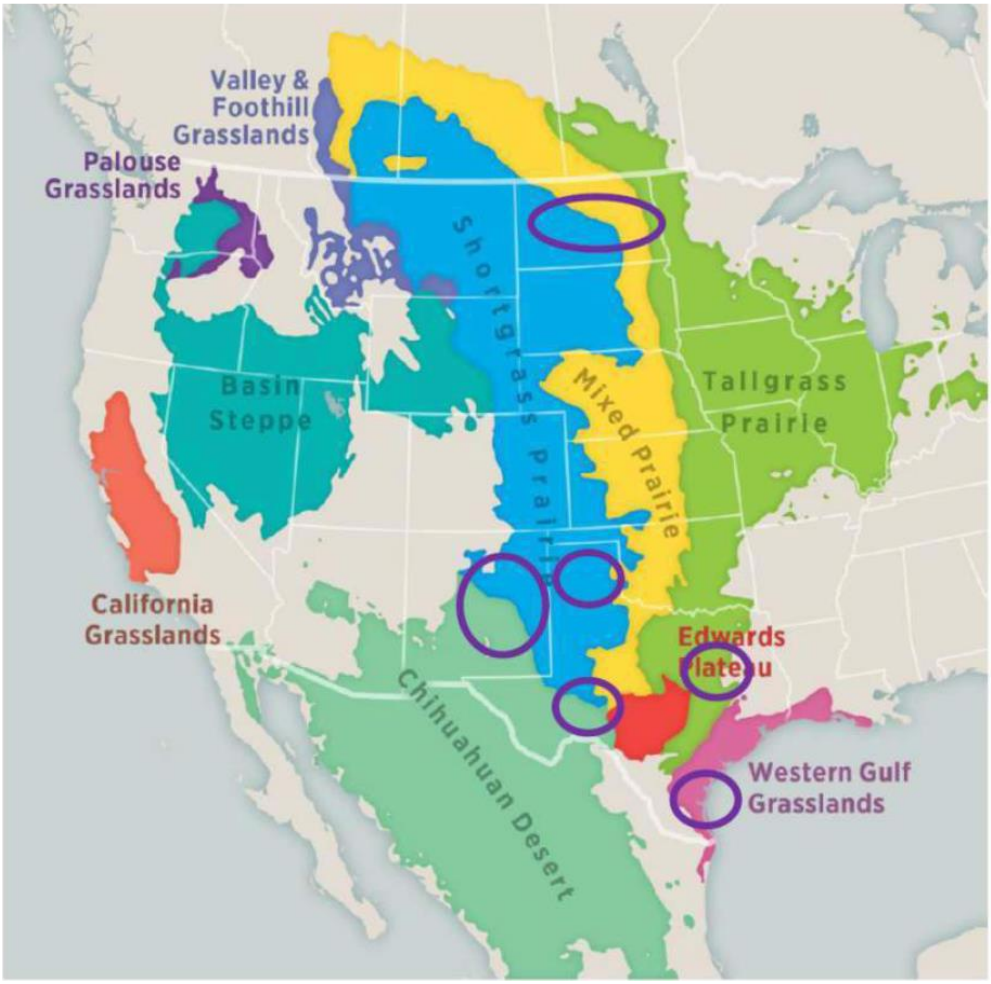

Figure 21. The circles show the ranches or states participating in the EMRE-BCarbon research project involving the different ecological systems shown on this map. Source: National Audubon Society.

One area of great interest is the concept of multiple benefits. Can we sell water benefits as well as carbon benefits? Can we sell biodiversity

benefits? I had one of the worst receptions I've ever had when making a presentation to a group of organic farmers who became a bit angry because carbon removal and storage was the only ecological service product that anybody was buying. They raised the point that their agricultural practices were excellent stewardship practices leading to all different types of benefits for which no market currently existed. I found myself apologizing. A carbon credit was not enough for them. So BCarbon continues to investigate how to implement a biodiversity credit that will find traction in the marketplace. Biodiversity credit is kind of the gold standard. And there's interest.

BCarbon is, right now, involved only in issuing soil carbon credits. We have a forest credit subcommittee that is developing a forest credit methodology. We will likely be expanding into forest credits in the third quarter of 2022. We are considering issuing credits for carbon capture and storage by oyster reefs and the wetlands protected by those reefs. One acre of oyster reef is about eight-and-a-half tons of carbon dioxide per year. Oyster reefs are expensive, but there are carbon benefits there, but we're also very interested in the oyster reef as a wave break. It also, of course, is a wonderful fish habitat and has water quality benefits. But we are very worried about marshes being lost to sea level rise. If we can put an oyster reef in front of every marsh on the Texas coast, as seen in figure 23, we can keep those marshes in operation longer and we can generate dollar credits for those marshes.

Figure 23. Oyster reef adjacent to wetlands serves as a "wave break" to help protect the wetland from erosion. Source: https://volunteer.handsonneworleans.org/need/detail/?need_id=320584

A local NGO, the Texas Coastal Exchange, has started a 1,000-mile shoreline project – a plan for 1,000 miles of oyster reefs along the wetland shorelines of the Texas coast. In Figure 24, you can see the oyster reefs in purple in Matagorda Bay, in Lavaca Bay up at the top, and in Espiritu Santo Bay down at the bottom left. In green are the marshlands. We believe that we can come in and put a string of oyster reefs all along that shoreline and keep those marshes from sloughing, from being destroyed and releasing the carbon that's stored there, and we can also keep them viable for decades into the future capturing and storing carbon.

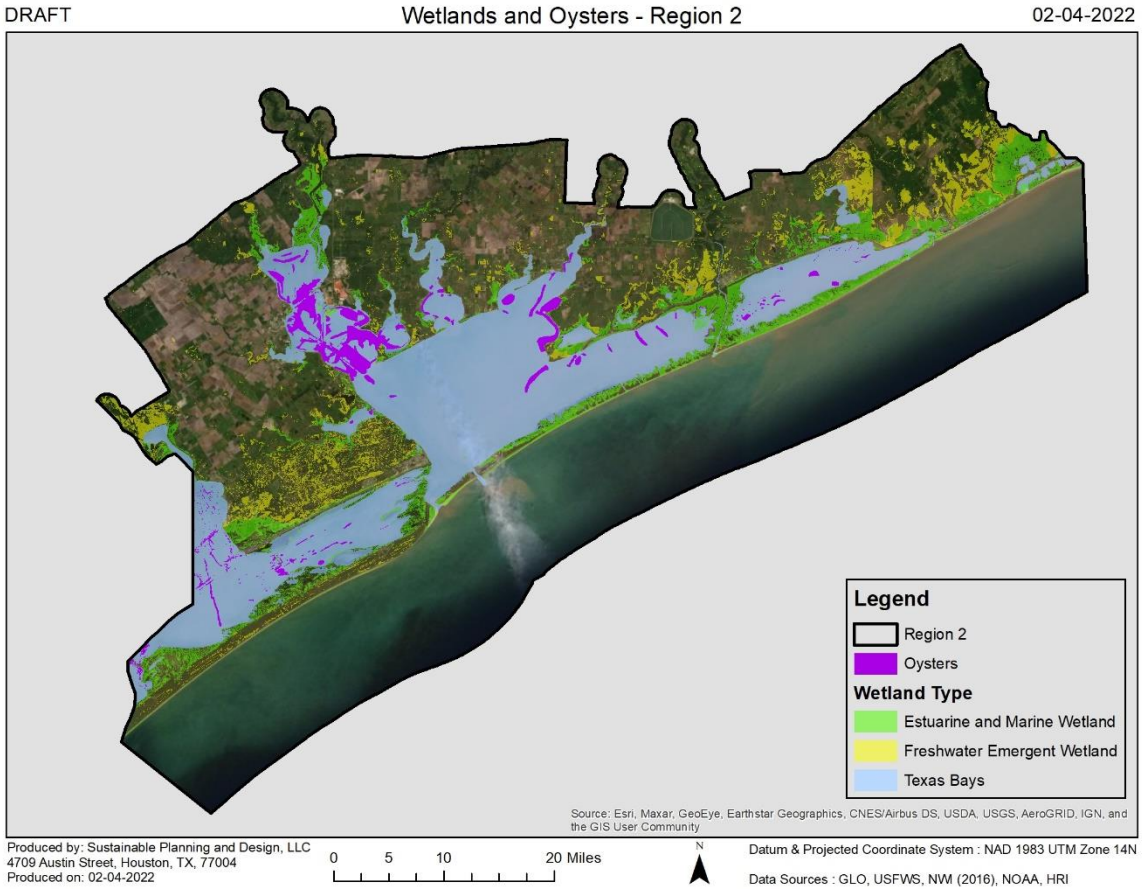

Figure 24. The ecological resources of Region 2 of the Texas coast. Oysters are in purple, estuarine wetlands are in green, freshwater wetlands are shown in yellow, and the bays are shown in the blue. Graphic by Emily Fucile and Jace Hodder of Sustainable Planning and Design.

Further, as sea level rises, we want these marshes to move inland. Right now, there's no incentive for a landowner to let the marsh come in because nobody makes any money off a marsh. But if you can get the carbon sales, you can.

IV. Conclusion

So, let’s talk about the future. We're talking about a billion acres of grazing lands contributing a billion tons of carbon dioxide removal from the atmosphere. Two-hundred million acres of cropland is currently used for animal feed. If we change that back to grassland, that would represent 200 million acres of grassland, and we'd have animals on it. At $50.00 a ton, we're talking about a $10 billion a year income stream if these animal feed

farms were converted back to grasslands. Now, that ought to get the agricultural community's attention. That's just for grasslands.

In Figure 25, the former Great Plains of the United States are highlighted, much of which is currently under the plow, much of which could be converted back to grasslands. In yellow in figure 24, you see the current grazing lands of the United States. In brown, the farmland. The primo area is circled. We're studying New Mexico. We're studying Montana, North Dakota. But we know that the Heartland is going to be excellent, and we're looking forward to the transformation of much of that land area back to prairies.

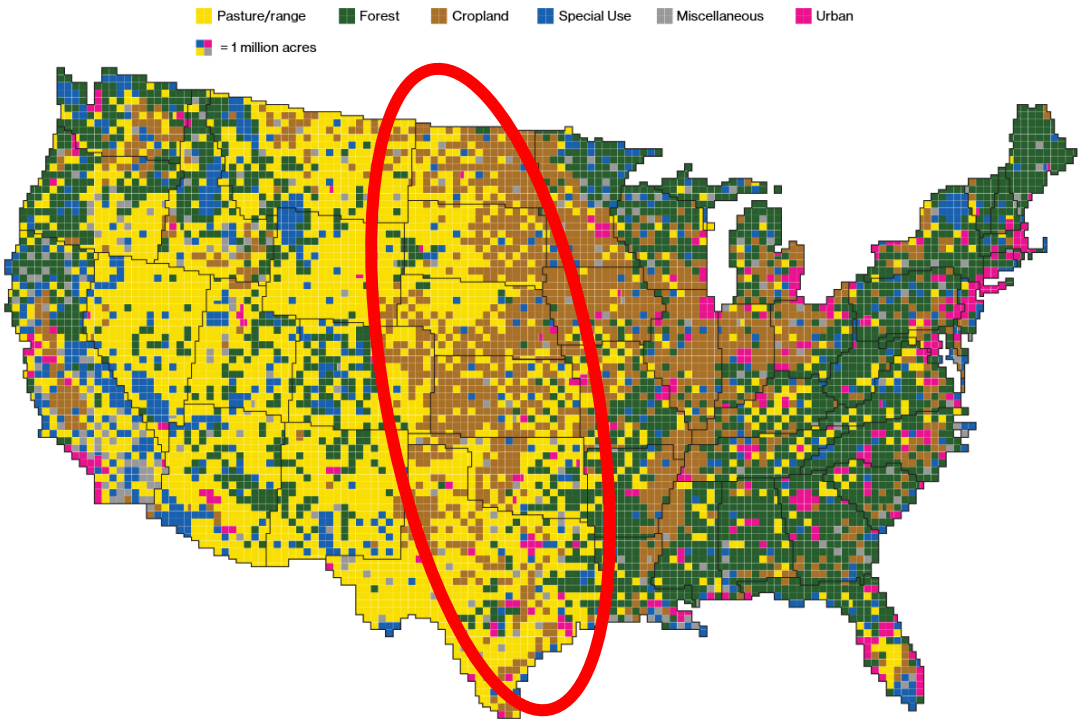

Figure 25. Map showing the land use of the United States with yellow being grazing lands and brown being cropland and the former great plains ecoregion roughly outlined in red. Map Source: Bloomberg

So, we think that nature-based carbon capture will open up the economy of the future for Texas, the United States, and the world. We need a market. It's hard to regulate your way to a market. You have to open up a market. This is going to be market driven. The farmers and ranchers will come because there's money to be made in the market. But creating a

market is tricky. Ultimately, whether we can do this will be whether we can succeed in creating a market.

We are talking about valuing nature. Every economist out there has talked about it, but no one has ever done it. This is getting value for natural, ecological services. It's consistent with the carbon cycle and it's part of the circular economy of the future. I think we'll have a resilient and green Texas coast in the future. The yellow lines are some of the shoreline protections the Corps of Engineers has proposed along with some of the structural projects proposed to protect the Galveston Bay region. But in dark green, you see the lands that I think will be preserved for flooding because we're going to pay for the carbon as opposed to see them developed.

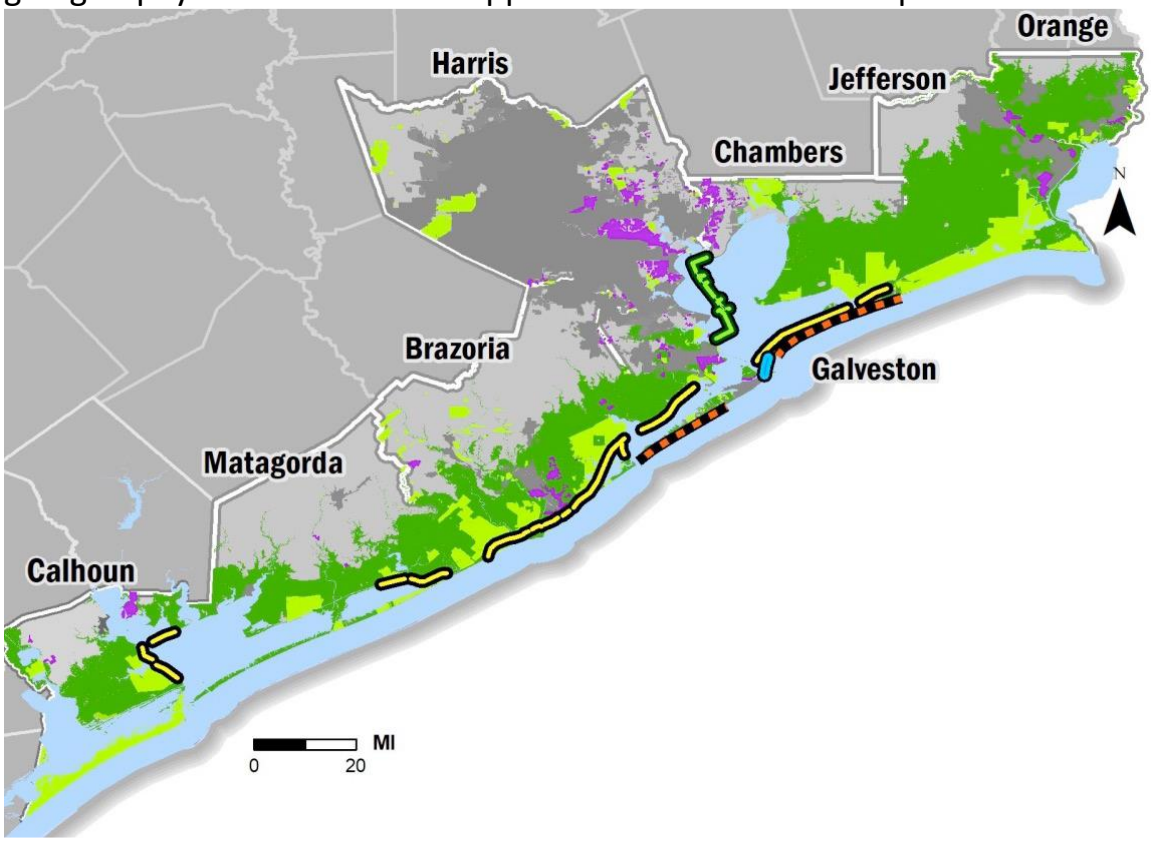

Figure 26. The Green Coast of Texas from A Texan Plan for the Texas Coast by Jim Blackburn.