INTEGRATED ENERGY POLICY REPORT WORKSHOP

BEFORE THE

CALIFORNIA ENERGY COMMISSION

In the Matter of:	)	
	)	
Preparation of the 2009 Integrated Energy Policy Report (2009 IEPR)	)	Docket No. 09-IEP-1P
	)	
The Potential of Terrestrial Carbon Sequestration Methods As Options for Climate Change Mitigation	)	

CALIFORNIA ENERGY COMMISSION

HEARING ROOM A

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Johan Six, U.C. Davis

Katie Goslee, Program Associate, Winrock International

Kimberly Taylor, USGS

Andrew Fynn, C Restored LLC

Greg San Martin, PG&E

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PROCEEDINGS

MAY 26, 2009 9:00 A.M.

MS. PITTIGLIO: Thank you all for coming today. There are some housekeeping to take care of. First of all, if you are not familiar with the building, the restrooms are just outside the doors and to the left. We also have a snack bar upstairs if you need a beverage. And in case of an emergency, we will convene at Roosevelt Park which is sort of kitty-corner across the street from here. Also, we have had some updates to some of the presentations this morning, but we will have all of those presentations available online after the workshop for you to download.

This meeting is being recorded and it is also being broadcast over the Internet via WebEx, and in order for the people online to hear you, it is important to speak into a microphone, and we have a podium over here. So later in the discussion, if you would like to speak, please go up to the podium. Also, everyone who speaks should state their name and affiliation for the record because the meeting is being recorded, as well.

I am Sarah Pittiglio from the Energy Commission -- I guess I should follow the rules, too. And I would just like to start off by talking about PIER's Efforts in Terrestrial Carbon Sequestration. PIER stands for Public Interest Energy Research. The PIER Program was started in the late

'90s. The program is meant to research the environmental effects of energy technology, energy production, delivery, and use in California. In 2005, Governor Schwarzenegger signed an Executive Order that mandated biennial scientific assessments of the effects of the climate change on California, and the Energy Commission has been leading that effort. The first assessment came out in 2006 and the latest assessment, the draft, came out April 1st. It is available online.

The Climate Change Research Center is sort of a virtual center. We have roughly $6 million available per year. We divide our research into four main topics, the first being Regional climate monitoring, analysis, and modeling, primarily led by the Scripps Institute; also GHG Inventory Methods, Options to Reduce GHG Emissions, and Impacts and Adaptation Studies.

So as far as reducing GHG emissions, we have two primary objectives, the first is controlling GHG emissions, so we have funded studies on increasing energy efficiency, and also reducing fossil fuel consumption, and also looking at carbon sequestration, the PIER Program runs programs on geologic carbon sequestration and we actually had an IEPR Workshop last week on that topic. I hope you were able to attend, it was very informative. And then, of course, in this IEPR workshop, we will be talking about soil carbon storage and above-ground biomass carbon storage.

Obviously, at first glance, carbon sequestration can seem like a win-win situation, especially soil carbon sequestration in improving soil fertility, water holding capacity has a lot of positive benefits, but as we have seen in the EU, it is sometimes difficult to sell the regulators in the European Union and the forestry carbon sequestration has represented 33 percent of the voluntary carbon market, whereas it only represents 2 percent of the regulated carbon market. So we will be discussing those pros and cons today

We funded a couple of the terrestrial carbon sequestration studies; I am not going to go into depth about any of them because they will all be covered in talks today, but we funded a study with U.C. Davis, looking at how different agricultural practices can sequester carbon. We also funded the study with Winrock, looking at how a forestation could address carbon sequestration in Shasta County. And we are also contributing to a study that the USGS is doing looking at carbon sequestration on Delta islands. But, again, they will all be covered today.

We also have future funding set aside to possibly look at the potential of biochar. Biochar has gotten a lot of publicity recently; it has a lot of potential. There are soils in Brazil that have shown that biochar amendments could be a staple for centuries, and so it has a lot of potential, but it is unclear how that will work in California soils, and it is also unclear how it will affect GHG emissions. So it is important to get a handle on N2O and methane emissions from the soils amended with biochar in California, to get a real full potential of carbon sequestration for that method.

Then we are also looking at carbon sequestration through the management of cattle also, it has shown a lot of potential. But, again, these topics will be covered today.

Then I would just finally like to do a little plug for our annual climate change conference that is coming up in September. It is at the Sacramento Convention Center again. And if you have any further questions, please feel free to contact us, and we also have a website online. Thank you.

Our first speaker will be Tim Robards from the California Department of Forestry and Fire Protection.

MR. ROBARDS: Good morning. Is everybody awake after a three-day weekend? Ah, I thought so. So I am going to kick off the talk here, let's see, as soon as I get oriented. Can you hear me okay? I was not sure if I was speaking into the microphone. So this is what I am going to talk about. I thought, since I was kicking off the day, I would give a little bit of background information, cover some of the basics on what is forest carbon sequestration, how do forests affect climate change, where are the California forests and the different forest types in California, talk a bit on the forest management methods that affect the sequestration, a little bit on the up and down side of the potential for either carbon sequestration or emissions, and then talk about some of the policy options and some of the implications around the policy.

So carbon sequestration is a conversion of atmospheric carbon into the more complex molecules in trees and it is one of the few ways that you can actually accomplish that. Forest carbon pools is a common way of referring to the different components within the forest ecosystem of where the carbon is stored. You will hear the term "bole" or "stem", that is just the trunk of the tree, and that is the live part, or considered the live part, above ground. The crown, both the branches and the leaves, and the leaves, and leaves can be broadly for needles as above ground. Litter and duff, litter is that stuff where you can see what the twigs are when you are looking at the forest floor, and you can identify the individual components. The duff is when it has kind of gotten into this almost peat-like material that is underneath the litter. And so the below ground can be divided into the roots, the tree roots, and the soils so that the part of the organic material that is attached to the mineral components of the soil is considered the soil carbon separate from the roots. But both of those are the below ground. The above ground also includes the dead wood, both the standing dead, which is commonly referred to as snags, and the down deadwood. And then there is the off-site is one way we refer to dead wood, and that would be in the wood products, for what ends up in landfills. And there is also, of course, what will be talked about today, the energy productive aspect of it, the biomass.

So what I was just talking about is the carbon cycle over here, and there are other considerations -- and you will see it in the literature -- if we start over here, we look at hydrology, so if you are thinking about adaptation to climate change, the interaction of trees with snow accumulation and melt, so there are implications under adaptation planning for water supply or hydrology. And then there is energy flux issues, or considerations if you have a very bright soil and you put dark trees on it, you can change the amount of heat that is absorbed, and so you could either counteract or more than undo the effect of the carbon sequestration, depending on what you are starting with and what you are ending with; if you are going from a shrub lands forest, you are not going to change things as much. So these are different considerations that are outside the carbon sequestration realm, but affect the bottom line of the global warming issue.

Then, of course, to point out here the issue of conversion, and so if you are going from agricultural land to forests, like a reclamation, or you are going the other way, there are implications if you are trying to do GHG accounting for biofuels and those sorts of things.

So real briefly, Forests Globally, this is from the IPCC Report, and they thought forests were important enough to put it in this sentence about the 35 percent increase in carbon dioxide in the industrial era, and primarily the combustion of the fossil fuels and removal of forest. Most of those forest removals, the 17.3 percent that they are estimating here, is from the tropical regions. But, of course, there are still implications to both the terrestrial and the bole real forests, as well, especially under climate change.

So talking specifically about California forests, 12.5 million hectares, it is nearly a third of California by acreage, lots of services from these forest ecosystems, water, wood products, recreation, lots of ecosystem services. The urban forests are about 5 million acres, or 5 percent of the land base. About 8.5 billion tons of CO2e are stored in the California forests. So the forested ecosystems of California -- this is going to be a map when it comes up, and it is probably because it is a very large

PDF, so it is killing the computer -- but what this map will show is, simply, California and the fact that you have forested ecosystems in California at the top of some of the mountains down in Southern California, and then kind of a fish hook shape around the Central Valley, with much of the forest in the Sierra Nevadas, the Southern Cascades, and around the top of the valley in the Klamath region, and over on the coast in the coast range. The interesting thing about California is some of the oldest trees are in California, in the world. The tallest tree is the Coast Redwood down in California. The largest trees are the giant Sequoia down in California. And if you look on a per-acre basis and you look at the amount of carbon stored on a given acre, it is the post Redwood ecosystem that does that. It just refused to put the map up, so it is in the handout.

Carbon stored in California, this is where we get the 8.5 down at the bottom here, 8.5 million tons, metric tons. And if you look at this briefly, you can see that it is broken out by the carbon pools, but if you also look at public and private timberlands, you can see that, if you are really going to look at sequestration, you have to consider it in the state, both public and private lands, since it is roughly broken out 50-50 between the private and public in forestlands in California.

Briefly, forest management methods, and some of these will be talked about later today. But avoided Deforestation, or conversion, is one; Afforestation and Reforestation, which Katie will be talking about later. And some considerations under Forest Management, whenever you are talking about them, it is usually important to distinguish whether you are talking about Natural Stands or Plantations, Resiliency to disturbance, and so the risks if you are looking at carbon sequestration, it is not just the amount, but the risk of that carbon staying on the landscape over time, adaptation to climate change, another consideration tied to resiliency. Site occupancy is a consideration, so if you have a forest stand, you might have a forest cover, but it might not be fully stocked with trees, you might have intervening brush, etc. And so one methodology other than a strict reforestation might be to go in and interplant clear brush between trees, which would be looking at the site occupancy of the trees on the area. Another would be species composition. An example would be historically tanoak, a broad leaf tree, has taken over a lot of acreage on the coast because of past harvesting practices, and so if one were to go in and reclaim those soils from tanoak to conifer, you can store a lot more carbon because the conifers are much taller and have a lot more biomass.

Wood products, of course, is another consideration.

And any time you are looking at accounting for carbon or GHG impacts, the farther you can go into the lifecycle, the more accurate implications that you can derive to the atmosphere.

So I want to take a moment here and consider some history, forest history. Forestry is a relatively new discipline. It came in around the turn of the century in 1900, and these are a couple of excerpts from 1911, where there is a statement being made that, unless fires can be kept out of the forests, it is impossible to practice forestry on them, and it is actually the first duty of the forester to prevent against fire. In this other article, there is a discussion about how the early settlers used to use fire in a management context, and used to do a lot of proscribed burning. And there was a debate back then about should we be maximizing biomass on the landscape, or should we be using these ecosystem tools such as a fire to maintain the ecosystems as they were closer to pre-settlement, and keep them more robust. And all I am really trying to say here is point out an example that we need to be humble when we are considering on a statewide basis the management of carbon. Any time we have gone out and tried to manage one thing without considering a more holistic view of all the implications, what I liken it to is trying to manage a national economy, and so you can try to do things, you can try to have incentives, you can measure, but if you try to micromanage, you know how that work, it does not generally work too well. So I guess I am just putting a word of caution in here when we consider a policy and look at past information.

So potential sequestration. There is the concept of no net loss if you look at the AB 32 Scoping Plan, and there are Resources Board people here, and I suspect they are going to correct me if I say anything wrong, but the concept of no net loss and the 5 million ton target per year that is in the AB 32 now is on growth, and it is for maintaining growth for the 2020 target. So you can look at the concept of no net loss either for growth or sequestration, or just for the stocks, which would be zero growth, and balancing your growth and emissions over time; or you could take a defensive posture and you could say, "Let's protect the existing stocks." And so one thing I wanted to point out here is that the target reductions of AB 32 is 174 a year, and if you look at California, just the above ground forest stocks, you have almost 6,000. So if you had a 10 percent hit by some disease, or insect, or something, here you could wipe out several years of total reductions under the AB 32 Scoping Plan. So I just want to get a sense of scale here and not just sequestration, but also a more holistic view of this. And this really also ties into adaptation planning under climate change.

A more offensive posture, say, would be to maximize sequestration, and I already alluded to that, it may not be the most optimal in the long-run.

A combination of that would be to protect and enhance the asset out there.

And so under the AB 32 Scoping Plan, there are five strategies: Conservation, Forest Management, Reforestation, Afforestation under Urban Forestry, and Fuels Management. I also pointed out it requires state and federal coordination -- and I am not talking about climate policy at this point, I am just talking about land ownership and land management -- and Measuring the progress of inventory and monitoring has been discussed quite a bit recently.

This brings us to the Interagency Forestry Working Group, which was started under the auspices of the California Board of Forestry & Fire Protection and the California Natural Resources Agency, of which the Energy Commission is a member. The purpose is to provide recommendations and technical information to assist the Board that is the Board of Forestry in achieving the A.B. 32 targets and for adaptation strategies.

Some of the IFWG -- we call it IFWG for short -- principles are protection and conservation, resilience, restoration, utilization, and both mitigation and adaptation. You can track the progress of that on the website that is listed there with the Board of Forestry.

There is a lot more to come on the policy arena, the Cap and Trade Program, setting targets and setting up how offsets will operate under that is something that will be worked on a lot over the next year; the Western Climate Initiative, it is kind of a hierarchical structure in the sense of how California is implementing the Cap and Trade Program through WCI, but there are also offsets and an offsets group under that. Revised Climate Action Reserve -- they changed their name from the California Climate Action Registry, but the protocols will be coming out in June, revised protocols for forestry, and those will be considered by the CAR Board, as well as ARB in June. The revised Forest Sector Inventory is one of the first things that the IFWG group has set staff to working on, and of course, all the national and international considerations that you all are tracking, and there is news every day, so I will not even try to touch on those. And can we take questions now? Okay. Good, they are asleep.

UNIDENTIFIED SPEAKER: Maybe you covered this earlier, I did not catch it, but where is the line between forest and non-forest in terms of habitat types? I did not get that -- you know, Oak Savannah, Oak Woodlands, what -- it is on that map that we did not see.

MR. ROBARDS: Yeah, that is a great question.

THE REPORTER: Could we get a name for the record?

MR. RAYBURN: My name is Rick Rayburn. I am the Natural Resource Division Chief at State Parks.

MR. ROBARDS: That is a great question because one of the things in looking at a carbon inventory is you want to make sure when you are going down the mountain, out of the forested areas, that you are getting to the point where agriculture takes over and you are not leaving gaps, so you are not double-counting things. And what we are considering right now is forestlands -- there is usually a distinction between timberlands and forestlands, timberlands being up more in the conifer commercial species, and then forestlands also going down into the Oak Savannahs and into the rangeland areas. And 10 percent canopy cover is often a cut-off that is used, but if you are starting to talk about afforestation or reforestation, say, in areas that did have oaks and they had been removed by past practices on rangelands, then you might consider that there is going to be a fuzzy area in there where you might be considering different practices, and maybe even restoration of forestlands.

MR. RAYBURN: Would that include Riparian Zones?

MR. ROBARDS: The question was, does that include Riparian Zones down into the valley and those sorts of things, and it certainly could, yes.

MR. SCHARF: Hi, I am Jerry Scharf, Green Pyro. I have read about methane release in standing wood decomposition and have not found much clear science behind that, at least. What is the state of that? And how does one understand that as part of this?

MR. ROBARDS: That is a good question. There is not a whole lot out there, so I do not really have a lot to contribute to that, other than it has been brought up as an issue, and if for full accounting it needs to be incorporated, especially when you are looking at different alternatives. I am not aware of a vast amount of literature on it.

MR. SCHARF: I was hoping you could tell me.

MR. ROBARDS: Sorry.

MR. McLAUGHLIN: Bruce McLaughlin with Braun, Blaze (phonetic) and McLaughlin. Do you have a personal view on suppression of fire -- wildfires, and then the CO2 emissions from wildfires? I have seen just calculations 1 through 175 million metric tons, and another one 9 million metric tons, and I guess it all depends on which scientists you ask, but if you could maybe give me your view, I would appreciate it.

MR. ROBARDS: That is absolutely true. You do get a lot -- well, you see it out in the media and, in fact, that is a question we will get after large fires, is what were the emissions. And from our department's standpoint, we tend to go with what the Air Resources Board is using for their estimations with models that were developed at U.C. Berkeley. A lot of it goes back to assumptions and how much basic data you also have, so when a fire burns, it never consumes everything, and then the assumptions of how intense the fire was, how much was consumed, how much will continue to live, how much of that duff and litter layer were burned, how much is maybe salvage logged, and put into long-term forest products storage. All those are factors, and when you make those estimates, you have to make assumptions, so it is not just a modeling issue, per se, it is also driven by the assumptions that you have and how good your underlying data is. So was that kind of a political answer?

MS. PITTIGLIO: Thanks, Tim. I also would just like to take a second to thank Commissioner Byron for attending our workshop. Commissioner Byron is leading the IEPR Committee and we appreciate his attendance.

Our next speaker is John Moussouris.

MR. MOUSSOURIS: Okay, I am here representing VenEarth Group. I am going to talk about the potential of biochars to sequestration carbon. Some of the most famous people in the climate change area have made strong statements in the last several months, emphasizing biochar as a unique solution for reversing climate, for enhancing soil fertility, and for improving the environment. And I basically want to assess -- I want to give the basic data and assess the possibility that this might be true.

The expression of this interest in biochar has been enhanced a lot in the last several years as a consensus has emerged that soil type called Terra Preta in Brazil -- Terra Preta is Portuguese for "dark soil," that is found very very broadly in all the anthropological sites of pre-Columbian Indians, that lie along the rivers and tributaries, the occupied areas, and under the rain forest. That soil which is there in gigantic quantities is of human origin. There is so much of it, it was originally thought it might be geologic, it might be sedimentary or volcanic, but anthropologists noted that wherever there was Terra Preta, there were lots of pottery chards, and dating showed that it was placed there over the last several thousand years, up to 500 years ago, and it has got 10-20 percent carbon by weight, compared to less than 3 percent in the untouched soils, the sandy soil of a typical tropical rain forest, and it has been there for thousands of years, it is this gigantic amount of carbon, it is extremely fertile, and it is a very bio diverse and ecologically wholesome area. So that has created a great deal of excitement.

Now, VenEarth Group has been trying to focus on answering the question, supposed we determined that we needed to restore climate, restore the atmospheric CO2 back to pre-industrial levels, 280 ppm, would it be physically possible to do that, and would be it economically possible? It is clear that the Amazonian Indians did put a gigantic amount of carbon per hectare in the land that they cultivated without motivations to get carbon, to get climate change -- they did not have a climate change problem, or to get carbon credits. They did it for the purpose of growing more crops with less work. And so, in other words, it was economically self-sustaining for them to do it. And we asked the question, what would it take for it to be self-sustaining for us? And one interesting thing that I have noticed, that tends to be under-appreciated, is that if you take the entire excess CO_2, a little over 100 ppm now, 240 billion tons of carbon, and you bring it down to the Earth, just vertically in place from the atmosphere, bring it down to the Earth and re-condense it as something of familiar density like oil, if you re-condense it as oil, covering the entire planet, land and sea, uniformly, the depth of the layer you would get would only be about ½ mm, one-fiftieth of an inch, spread uniformly over the planet. So over the one-third of the planet that is land, it would be 1.5 mm, over the one-tenth that is agricultural, including grazing land, it would be 5 mm, and over the 3 percent of the planet that is cropland, ploughed up, industrial cropland, it would only be 15 mm, a little bit over a half of an inch. So just to get a scale there, how fast could soil carbon sequester all this excess carbon? 15 mm at the density of water is 150 tons per hectare, or 10,000 square meters in a hectare. So we would have to be depositing carbon in soil at the rate of 3 tons per hectare for 50 years to sequester all that excess carbon by 2060. Now, of course, we have to stop emitting carbon and we also have to take into account the feedback effects that have already kicked in. But just for the sake of scale, that 4.5 -- it would be over the 1.5 Gha of cropland, it would be three times 1.5, or 4.5 Gt per year, which is about exactly equal to the rate at which we now emit minus the ocean absorption. So depositing 3 tons per hectare, about a third of the millimeter at the density of oil, over just the cropland, would negate all the fossil emissions. So 10 percent would have to be 3 mm or about an eighth of an inch of 10 percent enriched top soil is all it would take to counteract. And it appears that the Terra Preta cultivation exceeded this rate. Terra Preta is found to depths of six or seven feet, deposited over a 500-year period, that is about the longest occupancy, so that works out to about six inches over 50 years, or an eighth of an inch each year of this 10 percent or more enriched soil.

Now, what is going on globally is that about 120 gigatons per year is photosynthesized by plants on the planet. Sixty of those gagatons go right back up because the plants also breathe, especially at night, but even during the day they breath. The other 60 is the biomass in the plants, almost all of which normally goes back up within a single growing season because it gets eaten by bugs, little ones and big ones, and by animals. It gets respired and goes back up into the atmosphere. Now, what we would have to do in order to get the 4.5 gigatons into the soil as biochar is we would have to divert about 9 gigatons out of that 60 and cook it to make a charcoal rich soil amendment. Normally in the course of that cooking, if you do the cooking carefully, you lose about half of the carbon as CO_2, as shown on the right of this slide here. It goes up, it is emitted as gas -- emitted as consumer gas, or rather producer gas, a combination of hydrogen and carbon monoxide and carbon dioxide, and you can go ahead and burn that and get some energy from the burning of that, usually just low grade energy. It takes a lot more energy to make electricity out of it. You know, that part is lost. So the part that actually becomes the soil amendment is only half.

Now, how much biomass do we actually get yearly? First of all, we have to notice that biomass is only -- bone dry biomass is only about one-third carbon. And as we said, biochar only captures about half of that carbon. So to get three tons per hectare, this ideal rate that would sequester what we are putting up -- what we have put up in 50 years --

what we are putting up now, each year -- we would have to get 18 tons per hectare of raw biomass. And the rough data, in tropical forests actually get about 20 tons per hectare of biomass in regenerating forests such as are used in areas where you do shifting cultivation, they create about 20 tons per hectare. But temperate forests, only about 12 tons per hectare, and typical temperate cropland, only 6 tons per hectare, unless you use very specialized crops like miscanthus is advertised at 30 tons per hectare, but it is obviously very undesirable to reallocate cropland to specialized crops. So that is, I do not think, a practical alternative. So basically what we see is that the tropical cropland can be self-sufficient with its own generated biomass, but in temperate areas, we have to find biomass waste streams from other places in order to reach this 3 ton per hectare ideal goal without using purpose grown crops.

Now, here is the assessment I am borrowing from the California Energy Commission document that lays out in great detail biomass resources in California, mainly for the purposes of assessing bioenergy, biofuel and bioenergy, and so on. But there is a tremendous amount of data here, and the gross amount of biomass separated between agriculture, forestry, municipal waste, and dedicated crops, a small fraction of it assumed here, in 2010, next year, it is estimated to be 89 million tons of raw bone dry biomass, and it is expected to grow between now and 2020 to 98 -- so from about 90 to 100 million tons. However, in this analysis, the portion of that biomass that is regarded as -- it is called a technical resource, technically sustainable, is a little bit less than half, 36 going to 40 million tons.

Now, if you look at the agricultural land in California, there is about 25 million hectares, but only 8.46 is cropland. And that is about 3.5 million hectares, so if you divide that into the 89 million of gross biomass we have next year, that works out to 25 tons per hectare. But the sustainable portion is only 10 tons per hectare. So we have quite a bit less than the 18 tons we need if we lost half of the carbon in the course of cooking the biomass to make it into biochar. Now, these assumptions were based -- this reduction from 25 tons down to 10, from the gross to the sustainable, are based on an energy scenario where you have to throw away biomass that would not go into a power plant or a refinery very well, and the making of biochar is more robust, and it can also be placed closer -- it can be done at smaller scale than power generation, so it can be put closer to the source and destination. So there is some potential to improve these numbers, but it is hard, it is very challenging.

There are some other major positive factors, though. One is that, in studying Terra Preta, there is a company that we have helped to found in Australia, founded by Stephen Joseph, the former CEO of Best Energies that is focusing -- a professor at the University of New South Wales, who has been studying Terra Preta under electron microscopes, and in particular studying the role of clay. There is an enormous amount of clay, much more clay in Terra Preta than the sandy tropical soils. And he is building a set of equipment that will allow biomass, shown on the left here, to be mixed with clay and minerals and rock dust, and then cooked at relatively low temperature, torified, rather than pyrolyzed, and the result is that the presence of the clay that had very high surface area, and that complex would be raw carbon in the biomass is that you get a much higher potential carbon capture, you could capture 75 percent of the carbon, ideally, instead of just 50 percent. An extreme example of this, in this next slide, is that you can actually make char mineral complexes in a brick kiln. This is a biochar mineral brick that started out with about a 50 percent mixture of clay with waste biomass, which in turn was a mixture of animal manure and sawdust. And it was fired at relatively low temperatures in a brick kiln, and what you see on the surface of this brick, very little carbon, you see that the carbon has burned out through the porosity of the brick, but in the interior, the brick is split here, you see extremely rich -- you see a very high carbon -- the carbon is sealed in by the outer layer of clay, and this brick is very crumbly, you can see on the bottom of the table that just laying it on the table, it has started to crumble. If you lay this on soil, it very quickly weathers and becomes top soil. But it takes energy to make this brick. It does not produce energy, you are not burning off carbon, it takes energy. So this is an energy-requiring process, not an energy-generating one. So in order to make that process really of interest to the California Energy Commission, you know, it is solving the AB 32 kinds of problems, you need to find a source of energy that is clean, and the obvious way to do that is to capture thermal energy from solar, from a solar source, and use that to assist in the reaction of the clay and minerals with the biochar.

And one of the companies we are working with, it is helping us to design solar biochar greenhouses that actually have concentrating solar thermal energy, store some of that heat, and use it to drive biochar reactions in the direction of more carbon capture, take what gas does outgas and use it, as is normally the case, to enhance the CO_2 to improve the growth of horticulture inside the greenhouse portion, and also use the char from agricultural waste within the greenhouse and from surrounding land to increase the fertility of what is the greenhouse. Now, it turns out that if you map out the biomass in California, the regions that have highest biomass also have high direct sunlight, so they are actually the best sites for solar greenhouses. And it would only take a few percent, 3-4 percent, of the agricultural land in California to have some kind of solar collecting canopy of the sort that was shown schematically on the previous page, to produce enough energy to actually off load all the fossil inputs. If you do the arithmetic, that is how much sunlight we have in California. So if the average 30 hectare farm had 1 hectare of greenhouse put on it, it could be -- and also did char, it could actually be accomplishing the goal shown in the beginning of sequestering, within its own domain, a sufficient amount of carbon to reverse within 50 years our existing climate situation, and still provide enough energy to replace fossil fuels.

There are other upside factors. Biochar can be applied to a lot of other lands besides croplands. It increases water retention. There is some very interesting data about improving animal feeds, putting a small amount of charcoal in animal feeds makes animals healthier, especially chickens -- especially young chickens, it turns out. They tend to get very sick, and there are some wonderful results that were just reported in Australia, the International Biochar Initiative meetings in Australia from Japan, the curing of diseases using char in chicken feed, and what the char does is it actually absorbs the ammonia and the NOx that normally appears in the digestive track of a chicken. It also enhances soil biodiversity and when you have a depleted soil, it can restore the microbial mechanisms from the carbon capture, and there are some anecdotal reports showing more than a ton per hectare per year of carbon being captured microbially from less than a tenth of a ton per hectare of char, char acting as just a medium to help protect an enhanced biological diversity. The storage times vary enormously, but they are of the order of hundreds of years. Here is highly aged biochar at low temperature with mean residence time of 4,000. Here is one at high temperature with mean residence time of over 700 years. There is a lot of data. In essence, what is going on is, if you use ordinary plant residues, manures, compost, you saturate, according to Johan, who is going to speak in a little while on his paper in 2002, but if you use appropriately made biochar, you can continue to increase soil carbon for along time. We only need six inches on our cropland, and the Amor (phonetic) Indians did six feet, more than six feet. So there is a lot of head room.

Here is another summary of the amount and the storage time from Lackner, a *Science* article. It is relatively easy to keep track of it. As of just last week, the Copenhagen Draft Negotiating Text now contains a paragraph in the Agriculture section, which acknowledges the roles of soils and carbon sequestration, including for the use of biochar, which is a major step in the direction of having the UN actually acknowledge credits for biochar.

And this is some background slides here. I have used up my time, so I will just go through really quickly, that there is a lot of data showing that, by adding biochar, you get more productivity here, in this case more grain yield than Zambia, both in low rainfall and high rainfall, you get about a factor of 2, but notice how much variance there is in the data, the data is very scattered. You see that much more than 3 tons per hectare can be added, all the way up to 130 tons in this plot, results from 24 experiments on 10 different crops, and you are still getting yield increases.

This slide did not display for some reason. What is going on is not just carbon, not just carbon and minerals, but also structure that acts as a home for microbes, especially the microregional fungi. And here we are showing the effects on calcium and magnesium on the top, potassium and nitrates on the bottom, of adding char in both improving -- if you look at the potassium on the lower left, we are seeing almost twice as much potassium uptake into a plant when char has been added, but half as much leaching from water flow, or from flooding flow, so it is very stable. It keeps the nutrients in the plants and out of the water, also out of the air. Here are examples of reduction in nitrous oxide emission from both pasture grass and maze soil, by the addition of 20 tons per hectare, total biochar. This is Rhonda's data. And then, here, you can do small stoves that are suitable to reduce smoke-induced illnesses, so they have multiple benefits, you can do big stoves that are being done in China and Japan and South Africa, and lots of other places around the world.

At the end of the day, the reason why I think this works is that it is restoring -- charcoal occurs naturally. The way we have managed lands, both in agriculture, agri-forestry, has tended to push out the charcoal because, as we have shown earlier, we tend to either stop burning, or have burning be so extreme that it burns all the way down to ash, leaving very little charcoal. The natural circumstance is to have small frequent fires that die out, leaving a lot of charcoal. So I think what the Brazilians reinvented here is a way of coexisting, cultivating the soil to restore the natural charcoal content in a way that actually enhances the biodiversity of the soil and the environment, in an ecologically wholesome way.

So I think it is a very promising mitigation strategy. It is a challenge about knowing how to do it properly, we need protocols that figure out that measure and -- we are a company helping to form, and we have helped to form in England, is actually proposing a specific protocol to the UN for measuring where is the biomass coming from, where is it going to, and what is being done, the lifecycle in between, to verify that we are doing biochar in a healthy, stable way. Thank you. I will take questions during the break.

MS. PITIGLIO: Yeah, I think in order to stay on schedule, we are just going to hold the questions until the end. Our next speaker is Johan Six from U.C. Davis.

MR. SIX: Okay, so after biochar, I will be talking about some potentials within agriculture that are on a much smaller scale, and that are just helping -- going through what farmers actually can do fairly easily on their lands.

First of all, I want to point out, when we look at sources of greenhouse gases in California, what the California Energy Commission came up with is, agriculture and forestry have only about 8 percent of all the emissions. So obviously if you have only about 8 percent of the emissions, reducing some of it is not going to have huge impacts, except if you can effectively bring in more materials into agriculture to effectively mitigate. So a pure reduction is not going to be all that big, but I still think that there is definitely reasons for trying to reduce that 8 percent, too.

When you look at that, within agriculture, first of all, we do not only talk about CO_2, we are talking about CO_2, methane, and Nitrous Oxide all at the same time, and then you see also that N_2O is really the major source for greenhouse gases in agriculture, so it accounts for about 50 percent of the emissions. And so, when you look at the sources for methane, obviously, we are talking about livestock and manure, and then the anaerobic soil rise; when we are talking about CO_2, then the sources are fossil fuels, biomass burning, soil degradation, and for N_2O, we are talking mostly about fertilizer, but also crop residues and manures. When we talk about the sinks, the sinks for methane are not in the anaerobic soils, the anaerobic soils are clearly a source, but we do have it in anaerobic soils, and then it is especially forest and grasslands. We do not necessarily have that much in agricultural land. For CO_2, the buildup of soil organic matter is obviously the major sink, and then the biggest problem we are having is that, for N_2O, there is really no sink, there is nowhere that N_2O is being taken up. So the only way you can effectively do soil mitigation is just by reducing that source. Once it is out in the atmosphere, you do not have a way of capturing it again. So the only thing you can do is effectively reduce it.

So what we have been looking at is basically looking at different practices for greenhouse gas mitigation that have been tossed around quite a bit, such as reduced or zero tillage, your set-asides, so you do a conversion to perennial grasses, winter cover crops, which seem to have quite a bit of potential, you have more hay if you put more hay in your crop rotations, you know, farmers here do a lot of crop rotations and are going to bring in the alfalfa and that is definitely one that can help out. Higher residues, so whatever amount of residue you can increase, so true for example for high-yielding crops, that can help out. Manure applications is clearly one that will sequester some carbon. And then the one that we can look at when it comes to reducing N_2O emissions is reducing the fertilizer application rate.

So we have these practices that have been tossed out there as potentials, and so what we wanted to do was actually look very much at a regional scale, in California, what kinds of potentials would we have. And we started with Yolo County, and then went over to about 17 counties in the Central Valley. And so all the numbers that I will show you is basically looking at, if you have -- what are your emissions under alternative practices compared to the emissions under conventional practices. And so we subtract the conventional practices, and so if you get a negative number, it means that we effectively are mitigating the greenhouse gasses, and therefore global warming.

So the way we have approached it and that we feel like is one of the better approaches to do it, is that we obviously rely on measurements for calibration and validation of the model, so there are lots of measurements that have been done, and so we use those, then, to really basically gain confidence in our modeling of these systems, and so that we then can use that modeling for regional extrapolation and prediction in a cost-effective way because going out there and measuring it all the time is definitely not going to be cost-effective. But then, obviously, it is not because you have one model and it works out once, that you do not have to measure anymore, we obviously have to keep monitoring and further validating the model. I mean, the models, we are having some confidence in it, but they are obviously not perfect and there is always room for improvement.

So one of the ways that we have looked into actually integrating also the modeling with remote sensing so that we can actually get a bit more of temporal and spatial variability in crop growth and production. But I will not talk in detail about that, it is just an option that is there, actually, to improve the monitoring and, therefore, the modeling.

So the main approach that we have taken is, in essence, you know, there is lots of data out there on crop and land use at a regional scale. We have the soils data from SSURGO (Soil Survey Geographic Database) is the main database that we are using, you know, where you have properties for the soils are catalogued, mostly soil organic matter, texture, what kinds of water status and whatever, and so that we bring, then, together with the weather data at a regional scale, and put that into our Regional model. In essence, what we have done is used the DAYCENT, there are several models out there like DNDC, well, I would say DNDC and DAYCENT are probably the most widely used ones. We went with the DAYCENT for no particular reason, actually, and so that is the model, then, that we use to predict the yield and the greenhouse gasses associated with that production.

So as I said, first of all, what we have to do is clearly test our model vs. the data, the measurements that are out there, and so here in California we have basically four different sites, longer-term sites that we could use, and see how well we can predict our yields, is the first thing. So, as you can see, there is obviously some scatter, but we do get the general trends, and if you do it in more statistical ways, we basically could explain about 90 percent of the variation in the yield across these four different sites, and the most important thing, though, is that we see actually that the non-unity of the slope is where we have -- so our error associated with non-unity is very low and that is what you want. It is not enough to just correlate, but it really has to have that 1:1 line. And so we are doing very well over there. The lack of correlation is exactly what explains most of our error, so that is what you see here. So you see the 1:1 line, we basically have it, but then you do see some variation around that 1:1 line, so the 10 percent that we do not explain is mostly just some variation around that 1:1 line. When you look at the prediction of the soil organic carbon, we are doing not as well as for the yield, but we are still sitting at about 70 to 80 percent, except for that one field, and that is in essence because there was actually very little variation in soil carbon, and that little bit of variation, that is something that the model can indeed not pick up. I mean, we can do general trends. As you can see, in these other fields we do these bigger differences, we can pick up, but for very small differences, that is something that the model cannot pick up on. So, clearly, there are some caveats in the model, but in general we are doing not too bad. Ignore the black because actually you did not have to see. So for LTRAS, then, so one of the sites, and we started comparing the standard tillage vs. standard tillage and cover cropping, the standard tillage and organic, and then we go over and bring actually in conservation tillage, and then again combine it with cover cropping and combine it with organic management. And so what you see, then, if we go immediately over to the GWP, Global Warming Potential, where we have integrated the differences in soil organic carbon and nitrous oxide, and the methane, and we put it all in CO_2 equivalence, if you do your standard tillage and cover cropping, I mean, you do actually have about a ton less of CO_2 coming out, but it is especially when you have your organic coming in, then you effectively actually make your system from being a source of GWP to a sink, so we are mitigating on that. And then, when you do the conservation tillage, only the conservation tillage, you see the difference between standard tillage and conservation tillage is minimal; if you bring together the conservation tillage and cover cropping, you actually do see a little bit of an interaction there. So we start making it a mitigating -- so a sink -- for global warming, and then if you do the conservation tillage and the organic, then you get at about the same level as the standard tillage, and from a practical farming standpoint, the standard tillage and organic is much easier than doing the conservation tillage and organic. That is a practice that is far from easy to be done.

Now what you are seeing also is that we obviously have some errors around that, but what we also see, though, is that the variation that we see across these numbers is actually mostly due to seasonal difference. I mean, we have some drier years, we have some wetter years, hotter, or colder, and so some of that variation is actually purely climate. So some years we are going to have better sequestration and that has nothing to do with the practice, it purely has to do with what kind of climate we have that year, which we obviously do not have under control.

When we look at the other slides, then we basically kind of see the same, is when you bring in cover cropping, when you do the conservation tillage and the cover cropping, that is when you start sequestering and your just purely conservation tillage, you do not have too much of a difference in amount of GWP on the land. The thing that we are not bringing in here is that, when you go over to conservation tillage, you do use less CO_2, you know, you are using less fuel, and so therefore you do have actually less CO_2 emissions. And that comes out at about -- if you do it on a GWP, you know, about 200 kilograms per year. And so that is definitely something that is helping out, is just the reduction in fuel use.

So just to reiterate, in essence, what you see for conservation tillage, not too much of a difference; when you do the cover cropping, but especially when you add in the manure, so within the organic systems, that is when you start sequestering. When we look at the GWP, though, and how much is related to the N_2O, as I said, N_2O is the main one, the main greenhouse gas that we are emitting in agriculture, and with these practices we are actually not changing it all that much because, as you can see, the contribution of the differences in N_2O to the differences in GWP is only about, well, 2 to about 28 percent. So you are not talking about a huge amount of reductions in N_2O, but given that we have N_2O being such a big source for greenhouse gasses, obviously, what we have to start looking at is, well, what can we do to reduce N_2O emissions, because that will play a big role, then, if we can find ways of doing that.

So that was all at the site level. Obviously, what we want to do, then, was at the regional level, so we did again the validation of the model, well, the calibration of the model for Yolo County, and so we got some pretty good predictions for the yields. When we then go over to all 17 counties and did not recalibrate, which was due to validation, what you see here is, again, around we have that 1:1 line is pretty well, we do clearly have some variation around that, that we do not pick up with the model all the time.

And then when we look at the kinds of numbers that we get for, again, focused on the GWP, and you look at it, here we actually brought in -- if we now can reduce end fertilizer and therefore reduce N_2O, we see that we actually are getting at about almost a ton that we can deduce, but with a big error, you know, you see plus, minus about the same, and that is what is typical for N_2O at the moment. We just have not that much confidence in -- well, we have basically a lot of uncertainty in the numbers that we get due to mostly a lack of numbers, actually, measurements to really validate the model. Then, if you look from the moment you bring in your cover crop, you start sequestering and then it is especially once you bring in those, the cover cropping and the manure, that you see a reduction. Well, you do see at the same time, also, though, is that the Sacramento Valley we have a little bit better potentials than compared to the San Joaquin Valley. The San Joaquin Valley, just because it is quite warmer, we do have not as much of a sequestration and so, in the Sacramento Valley, we actually can do better with some of these alternative practices compared to the San Joaquin Valley.

Now, the domain, the three concerns that we always have, obviously, around carbon sequestration is the permanence because, when you get your carbon sequestered in the soil and you change your practice again, well, you might lose again that carbon, so permanence is an issue. That is where, though, however, the N_2O again can come in because if you, for example, do not add your fertilizer to the land, then there is a reduction in N_2O and that is a reduction that will never going to all of a sudden come back out; whatever you did not add is not going to come out. And so that is really a permanent solution, actually, is with the N_2O. But as you can see with the N_2O, we still have that uncertainty. So we do take care of the permanence, but we have some other issues. Additionality is a big issue and that is with every sequestration is, is it really additional, or is it something that will happen anyway. And then another thing is the Leakage, you know, if some farmer all of a sudden makes one of his fields conservation tillage, is he ploughing up some other land to compensate? And so there is that leakage issue there, too.

So I would say for future needs, then, clearly we need to get a handle on that nitrous oxide and we will have to keep monitoring and then what we want to do is get into a decision support tool for stakeholders. And so that is where I come in with COMET-VR, we have done some work on that, and I will explain in a minute. So a need for N_2O, I think one thing we have to start looking at is how much can we do by, for example, reducing fertilizer amounts. At this point, here, you can see for example, if you reduce your fertilizer amounts, or you go from about 100 percent, what is normal conventional practice, and you bring it down to 50 percent, in some of the modeling that we have done, you actually do not necessarily have a yield decrease, but you do have a huge decrease in your N_2O emissions because whatever fertilizer you are adding, if it is not taken up by the plant, then it is available to the microbes, and so then you will have N_2O emissions. So if we can make it more optimal, then we will have, indeed, less N_2O emissions. Obviously, with farmers, that is not necessarily the most popular practice, but at the same time, I mean, once you start explaining to them that, if you reduce your fertilizer -- in essence, why they are doing now a bit of over-fertilizing is because of risks. If that risk can then be taken care of through the carbon training, then they are more than willing to, indeed, reduce some of the fertilizer application rates that they have currently. So that is something that we will have to see on how much that is, indeed, an option across different soils and different crops.

Then I [inaudible] at the monitoring. I mean, we will have to keep monitoring, it is not like I feel like all of a sudden we are just going to have the models spit out all of our numbers, we do need to keep some monitoring going on, and there are ways that we can, indeed, keep going over time back to the same place and keep monitoring, and so then basically keep on revalidating the model and recalibrating the model. And then you need, currently there is need to C COMET-VR that is being used for carbon management and what is being done at the moment now is actually also bringing N_2O emissions, so it is planned actually some time in August, probably, that a new version is going to come out, and then we will have N_2O. One of the problems that we still have, though, especially when we are talking about California, I mean, we know all our perennial systems are pretty big systems here, and they are not really dealt with, well, not in a very good way, in COMET-VR, due to the inherent complexity, in essence, to model some of these perennial systems. And with that, I will take any questions, but before that I want to just point out there is a need -- we have a few articles in California that explain a lot of this, not very scientific wording, it is more lay terms, and you can find it for free on the Web page there of the Cal Ag page. So if you want to get a bit more of an idea of what it is all about, you can just look at those two articles, and especially the last article, the second article, I have not talked about here, but then we bring in some of the economics and actually how much of a price would you have to have for CO_2 in order to make it feasible for the farmers. I will take any questions, or -- okay.

MR. FYNN: Andrew Fynn, C Restored. When you were looking at the fertilizer application, were you looking only at the quantity applied with exactly the same methods? Or did you also have to scope to look at more precision means of split application?

MR. FIX: No, so what we did -- so it was already a split application, so the most -- well, the conventional way is now already a split application, and so what we did was just do a reduction of the amounts over the different splits. So we did not play around with different ways, then, of applying it. In the model, actually, we do not really necessarily have that capability to really account for the differences of application methods, so that is something that definitely could be looked at, but not through the modeling. We would actually have to have first -- well, there is already quite some data, but we would have to modify the model quite a bit in order to account for those differences. So it was not just a pure reduction.

MS. PITTIGLIO: Thanks, Johan. Our next talk is going to be from Katie Goslee from Winrock.

MS. GOSLEE: Good morning. My name is Katie Goslee from Winrock International, as Sarah said. And I am going to talk a little bit about Forest Carbon Projects, in general. I think Tim went over this pretty well. And then I will talk a little bit more specifically about afforestation, and reforestation projects, and the potential for those.

Winrock works on, among other things, agriculture forestry and other land uses projects for carbon sequestration. And one of the things that we are doing, we are the terrestrial leader for the West Coast for West Carb, which I always get a little twisted up on, the West Coast Regional Sequestration Partnership. I would get less twisted on it if I looked at the bottom of my slide.

So just some Terrestrial Sequestration Options that exist for project types identified here and, like I said, I am going to focus on the forest projects, but you can see in the agenda from this meeting that there are numerous potential project types, all of which have multiple pros and cons to each of them. Forest projects, in particular, have a pretty decent rate of sequestration and also high co-benefits usually, so other benefits in addition to the carbon sequestration, which sort of gets at Tim's point about drawbacks of managing for just one thing; forest projects offer an opportunity to focus on multiple benefits and management.

Changing forest management, which was again a big thing that Tim addressed, but this is -- well, I was going to say one forest project type, but that is not quite accurate, it encompasses a number of project types, some of which are listed here, increasing the rotation length, extending riparian zones, and also planting in riparian zones, changing the volume that is logged, and looking at wood products, as well. Just to give you one example of one other project that we worked on, it was outside of West Carb, looking at a change in forest management in Redwoods, actually, it was a property that had an approved timber harvest plan on it, that was purchased and the new owner decided not to harvest that timber, so it is kind of interesting to consider it a forest management project, but it is appropriately considered that. And the additionality of that was 27 tons of carbon dioxide over 100 years on about 200 acres, sequestered, the change from if the timber had been harvested to the decision not to harvest timber. And that was second-growth Redwood, so already pretty old forest at that point.

This untitled slide, which could be anything, I suppose, actually is the potential amount of carbon that could be sequestered on forest lands by lengthening the rotation time by five years for timber harvest, and this is obviously broken down by county. And this is the tons of carbon harvested under a couple discount scenarios and also when it is un-discounted, you will see it goes from blue -- I am not sure how well you can read that -- but blue is the smallest amount that is actually above zero, going up to green, yellow, and then the reds are the higher amounts of carbon sequestered. And I apologize for these being on two separate slides that you cannot see simultaneously, but these are the corresponding costs, dollars per ton of carbon harvested by lengthening the rotation for a time of five years, which increase in length. And you will see that the least expensive counties did not necessarily, and in most cases do not under an increase in rotation length, produce the highest amount of carbon. So there are some cost trade-offs that have to be addressed, or at least thought of in looking at forest carbon projects.

Another option that was in addition to increasing rotation length is extending riparian buffers, and I just wanted to mention that because, in that case, what we found is that the least expensive counties sometimes do sequester more carbon, although there is a much lower level of carbon sequestered in that project type than in extending the rotation overall, just based primarily on acreage available for the project types.

Another type of project is forest conservation, stopping conversion of forest and non-forest uses, and you have up here some potential for the amount sequestered in such projects. It is sort of difficult in this project type to accurately establish a baseline, and one of the other projects that Winrock is working on is through PIER, also, and partly helping identify a baseline for forest conversion projects, but also looking at development and how that affects carbon, so looking at both avoided conversion projects and the possibility for what you might conservation development and the carbon trade-offs in those types of projects. And then, finally getting to afforestation and reforestation projects, and I just wanted to say a word about verbiage, I guess, and the terms afforestation and reforestation, which are used differently, depending on who is using them, unfortunately. I know under CEQA, and I believe under AB 32, and correct me if I have gotten this wrong, afforestation is basically planting trees on non-forest lands, whereas reforestation is planting trees on lands at some point in the past were in forest cover. Some other systems, I guess you could say, look at more of sort of a time difference, so, let me start with reforestation, it is considered planting trees on lands that were in forest cover within the last 50 years, whereas afforestation is planting trees on lands that were in forest cover more than 50 years ago, so the reason that I say this, I hope that was not all overly and unnecessarily confusing, but since Winrock works a lot in the international arena, we often use the word "afforestation" in a way that I think, in California, would be the word -- the word "reforestation" would be used because we are looking at forest soils and planting trees on forest soils.

So this project type has a really high potential for return in terms of carbon sequestered, and I will get back to this point a little bit later, but there is a big delay, as you can probably imagine, it is sort of common sensical.

One other project that we worked on was actually a reforestation project, but specifically on riparian areas that were actually hardwoods and this is a very wide range, but we found a range of 178 to 481 tons of carbon sequestered per acre, I believe that is -- sorry, that was CO_2 per acre, depending basically on the species composition, and then some other specifics about potential project tapes and rates of sequestration are shown on this slide, as well.

So in terms of -- and this is based on not specific on-the-ground field work, but a modeling study that Winrock did under West Carb that is available in our publications, as well. Just the various forest types and the amount of carbon that could be sequestered in the area that is available, this is within California. I guess I did not put that on this slide anywhere, but it is specifically in California. So under forest management, you have a lengthening rotation -- or, excuse me, a lengthening -- the period of rotation increasing the riparian buffer width, and then afforestation -- also could be called reforestation -- of grazing lands. And that last possibility shows in terms of total quantity of carbon sequestered in California shows the greatest potential, and just sort of a map to let you know where the areas are available. This does have the tons of carbon per hectares sequestered next to the dollars per ton and, here again, you can also see it is not necessarily in the least expensive areas where you are able to sequester the highest amount of carbon.

And just going back to one point that was shown in the previous slide -- oh, and I guess I forgot to -- sorry, let me just go back to this and explain the price points. This is basically the cost of -- at $13.6 per ton, in terms of the management required for lengthening the rotation, you would be able to sequester in 20 years 3.4 million metric tons of carbon dioxide. And the afforestation projects, you see multiple price points, that is because, for the rotation, lengthening the rotation period, at price points lower than $13.6. There is no potential for sequestered carbon, those are the more expensive projects across the board.

This slide is the total carbon sequestered by afforestation of rangelands and the weighted average cost per metric ton of carbon after 20 years, 40 years, and 80 years. Again, as I referred to earlier, there are low returns because you are planting trees anew, so in the early years they are not sequestering a lot of carbon, so there are low returns and high costs in the early years. And then, as time passes, the number of offsets increases and the price per ton decreases over time, but you do have that initial payment up front with these types of projects.

This is just, in looking at all of the maps and the data that I have been showing, we sort of looked at the forest suitability for planting. This gets back a little bit to the afforestation-reforestation language question, but this shows the forest suitability score which is based on things like soil, temperature, precipitation, slope, and elevation, as well as currently forested areas. And the rangeland and sort of where the forest and rangelands overlap in terms of the suitability score and the acreage available. And we found that there are approximately 23.6 million acres of current rangelands available with the suitability score above 20, and you will see that 20 is where you start to see higher area of forest, a suitability score of 20, you start to see higher areas of forest.

Moving on to -- and Sarah mentioned these, the pilot projects in Shasta County that we have been doing with afforestation/reforestation on private lands. Most of these have been on small properties and we, total, have planted 470 acres and we are looking at the existing baseline, which I will get to in a little bit more detail in a minute. The types of species that can be planted and then the projected sequestration from these trees -- or, excuse me, from these projects. And obviously there is a lot that goes into developing these projects. We ended up with about 12 pilot projects, like I said, on small acreage, and all of those land owners had to be educated or contacted, many more than that were obviously contacted and educated about forest management, carbon sequestration, the benefits and the sort of responsibilities of having these projects. And I do not think I have time to go into that in much more detail, but that is a pretty interesting component of sequestration of forest carbon projects because there is a lot of private land that is available for these types of projects, but there are a lot of, I guess you could say, social aspects to the needs required to implement such projects in terms of meeting with landowners and having the necessary discussions. And then there are also a number of other maybe more ecological or forest management type issues which include site preparation and then modeling the growth and, well, establishing a baseline and modeling the growth. So these are just a little bit of eye candy, maybe, some pictures of -- this is just showing the different -- these are all within Shasta County, the different sort of types of rangeland that exists in terms of the existing cover that is out there. And these represent, of course, different baselines for these projects, as well. Just a picture of some seedlings after a fire in Shasta County, which is basically eventually in the early years how we hope the projects will look. And by that, I mean the seedlings, not necessarily the burnt snags.

Then just, this is showing -- as Winrock was out there taking the baseline measurements, doing the field work, some of the baseline conditions of these pilot projects in Shasta County, this is a whole lot of Whitethorn that we had to measure, and then some Whiteleaf Manzanita here, old growth in some cases, and then Greenleaf Manzanita, as well, on some of the projects. And these are the baselines, the tons of CO_2 per acre prior to site preparation, and one interesting question about these baselines is what happens to these shrubs in comparison to what happens with trees. And they are not as long-lived, they probably are much more likely to burn, and burn to the ground in a fire. And so how exactly do you consider the baseline for these projects? Is it the total amount of carbon or does that cycle -- well, I should say it does cycle around, is emitted, then sequestered and emitted, and sequestered without really any human intervention. So there are some differences of opinion and it is a pretty big question to figure out how exactly to identify the baseline on these projects. And there is also a great variation, as you can see, even sometimes within the same species. And, I should say, great time investment to measure these baselines.

So these are the plantings that we did on some of the projects. This is not a complete list of all of the projects, but you will see in some cases we just planted Ponderosa Pine, and in some cases we planted both Pine and Doug Fir. We had one Oak Woodland site and I think we had two, I only have one listed, but I think we had two Oak Pine afforestation sites. I think I already said it was a total of 470 acres, but all pretty much small projects, which is another question that leads into policy issues in terms of allowing aggregation of these projects, so that small landowners are still able to participate in carbon markets, even if there are high costs for the project, or in some cases higher costs for measuring the baseline. And depending on the existing vegetation, they are quite varied costs for site preparation for the project. Some of the projects that we looked at had been recently burned, and so there was almost no cost for site preparation because it was easy to just go out there and plant. Others, in the case of some of the old growth Manzanita, there was a pretty high required investment for clearing that.

This is just showing you some differences in terms of the level of carbon sequestered based on species, but obviously it is pretty important to match the appropriate species to the site, rather than just choosing a species that sequesters the highest amount of carbon.

Just some general maps, not based on the specific work we have done, but based, I believe, on look-up tables and site conditions for the available carbon that could be sequestered within Shasta County. And then these are projections that are still rough at this point. Based on our planting, the density was typically 300 trees per acre of either Pine or Doug Fir and this modeling was done -- it is a little bit back of the envelope, I will admit, but it was done in FVS, the Forest Vegetation Simulator, for those of you that are familiar with the models. And you see a slight difference, and this is also based -- I said it is rough -- one of the ways it is rough is that it is pretty much based on high survivorship. And eventually with these pilot projects, we will be looking in, I believe, Year 2 and 3, depending on the project after planting, of the survivorship and we will be able to model the growth based on a more accurate survivorship, which has been pretty good, I should say, despite -- this is interesting -- despite some pretty dry years, the survivorship of these plantings has been pretty good.

So just a little bit about costs and what is involved in costs for carbon management projects, and this is basically true for not just afforestation/reforestation, but any types of forest carbon projects. They are the establishment costs for, as I was discussing, site preparation and acquiring seedlings, any type of easement or land use permits that might be necessary. Maintenance costs, to make sure that the trees continue to live, and then measurement costs for establishing both the baseline and the growth over time. There are also the lost opportunity costs from whenever uses the land was under prior to the carbon project and carbon alone, as I think has been at least inferred, or intimated in other talks, rarely covers all the costs of these projects. But I guess, going back just a minute, one thing that is important to note is that the biggest costs, generally speaking, is the opportunity costs, the lost opportunity costs, which present both an economic challenge and sort of a maybe even an emotional challenge, in a way, or a little bit of a mind shift for landowners, especially because they are losing that income up front, and seeing the economic gains to the carbon down the road, as I have said a number of times.

And just to give an example of some work we did in the Southeast, in terms of looking at the percentage of costs of carbon projects, on average in Southeastern states for forest carbon projects, the opportunity costs represented 79 percent of the total costs of the project. The conversion and maintenance costs to implement the project represented 22 percent, and the measurement and monitoring costs only actually represented one percent of the project, so on average. That will, of course, change, and change depending on a number of factors, including the size of the acreage of the individual projects.

And so just some policy thoughts, really, I guess. Just looking at how offsets themselves are structured, and the option of regulating offsets, it seems unlikely within any scenario, any time in the near future, that the forestry sector and perhaps land use sectors, in general, will be regulated. And so it is important to have sound regulations on the offsets themselves, and to make sure that the offsets produced are real and additional. At the same time -- and that is based partly on an appropriate setting and an appropriate baseline. At the same time, there are a number of co-benefits, as has been mentioned, to forest carbon projects, and it is important to encourage, I believe, forest carbon projects for that reason, as well. And so incentives could potentially play a role in encouraging forest carbon projects based partly on just the truth that carbon offsets often do not cover the entire cost of projects. And that is all I have to say. Thank you very much. And Winrock's website is www.winrock.org. And some of the publications that we have put out that have a lot of the information in this presentation are available on our website.

MR. HARRISON: Jerry Harrison from the VenEarth

Group. I was recently in Australia and meeting with farmers who were -- there was the Oil Mallee Association and it was sort of a different scenario in that they were being given information that there were companies that would buy the carbon rights from them, and it ended up being that they would make money, but they had to make sure that the trees would still be there for 100 years, and they were being warned that it potentially would mean that they were going to sell their land, that their land was going to be worth more because they had already pre-sold this. But it meant, instead of the scenario that you are suggesting, where it is very hard for someone to say that they are losing income now for future income, they were actually -- companies were coming in and giving them the money now, and is something similar happening to that happening in the United States?

MS. GOSLEE: Is something similar to that happening in the United States? Is that your question?

MR. HARRISON: Yes.

MS. GOSLEE: I think that is more true for forest management projects. It may be true in some cases with afforestation projects if companies are willing to take that risk. Is that what you were seeing, afforestation projects or tree planting?

MR. HARRISON: Yes, it was on -- there is a problem over there with the water table has come up because the deforestation has caused the -- there is nothing of the roots going to lower it. So there is great encouragement to plant these trees, to bring the water table down, and to reduce salinity

MS. GOSLEE: You know, off hand, I do not know if anyone else does, but I do not know of any specific examples of sort of payments up front for offsets that are sequestered tons that are really going to be realized for 10, 20 years or so.

MR. HARRISON: Yeah, this was over sometimes 100 to 150 year period, but there were a number of groups competing to offer these -- and, in fact, there were farmers who were saying, "I was going to sell my land, but maybe I don't have to sell my land, I can retire on basically the carbon offsets of the coming years."

MS. GOSLEE: Right. And permanence is another issue and most forest carbon projects do have some time requirement in terms of verifying that the trees will still be in the ground for -- often it is 100 years. But, again, those credits or those tons are not really sequestered in afforestation projects for some period of time, and so often buyers, in our experience, want sequestered tons rather than "to be" sequestered tons, I guess. But I can see it happening. I mean, it is sort of a futures trading scenario, basically, on the part of the companies.

MR. HARRISON: Yeah.

MS. PITTIGLIO: Thank you. All right, we are going to take a really quick break, just five minutes. So that clock says 10:42, so be back in five. Also, if you are giving a talk some time after the break, can you please come up to the podium, please?

[Break.]

[Back from Break.]

MS. PITTIGLIO: Public comments are being taken for this workshop and they should be submitted by 5:00 p.m. on June 2nd. If everyone could take a seat, we are going to get started. Our next speaker is Kimberly Taylor from the USGS.

MS. TAYLOR: I am not sure I know who "Kimberly" is, I am Kim. I just want to talk a little bit about a carbon capture farming project that the USGS has going on in the Delta and we have been at research related to land subsidence, what are the processes that are causing it on the peat soils in the Sacramento-San Joaquin Delta now for about 20 years, and this project is an extension of that and takes what we have learned further into the realm of carbon sequestration and whether or not these systems will be effective and appropriate for carbon credits on the market. I want to start off with the punch line. As you all know, wetlands are exceptionally productive systems, and they grow a lot of stuff really fast in comparison to other systems like forests, and here in the Sacramento-San Joaquin Delta, you can see that we have been able to accrete a lot of root matter. This stuff is really hard, it is like rattan or wicker, it is not soft gushy stuff, you can stand on it. We call it -- some people call it proto-peats, so it is what would turn into peat over thousands of years, or biochar. And one of the other key things in the Delta is this subsidence, the land is continuing to subside as we speak, and so the net benefits -- potential net benefits of carbon sequestration wetlands would be the difference between the secretion and the avoided subsidence.

I want to give you a sense of the environment in which we are working and why this potential managed wetland project would work here, and also where else it would work. The Delta is reverse delta, it formed and there were these repeat islands. You see the dark brown, we have a lot of very deep peat forming over time, and then when you see the light brown or white, there is much more mineral soil. And the subsidence corresponds to the amount of peat. So the darker areas have subsided up to 25 feet below sea level, the lighter areas, especially around the very fringes of the delta, hardly at all. So it is a very variable environment, and some of the issues that water suppliers and folks who are interested in wetland restoration in the Delta for fish and other species' benefits focus on are the risks that these subsided lands pose to the water supply and for the potential frustrations on some of these islands. Our early research focused on the question of why were these islands subsiding. They are farmed. It could be because of soil compaction or other reasons, and we pretty much pinned it down to the microbial oxidation of soils. And the soils continue to degrade during the year if they are not covered in water, so basically you need to stop the microbial oxidation process if you are going to stop the oxidation of peat in the Delta. And the way to do that is to keep it continuously flooded with water. Seasonal flooding, partial flooding, you know, changing soil tillage practices on these peat lands does not seem to work. You keep on getting a lot of soil loss over the year.

And here is a pretty picture of the beginning of a test site, I just emphasize that point. Once we found out that stopping the microbial oxidation process was really key to stopping land subsidence, we asked the question, well, can we reverse land subsidence and raise these islands back up towards sea level, reducing the risk of levee failure, problems with the water supply, etc., and what we found out is, what we tried to do is we wanted to use existing water management in the Delta lands themselves, so what do the farmers do naturally. This is -- I am not sure which river it is, but it is main river channel out here. Because the islands are below sea level, the water comes in by siphon and also because the islands are typically below sea level, you have this drainage network system throughout the islands, and in order to keep the islands dry, they have to pump the water off of the islands, back into the channel. So using this natural sort of water management system that is there already, and the goal of keeping the water on the island, on the test flats at certain depths, we established two pilot sites, a west pond and east pond out at Twitchell Island, which is out in the Western Delta. And the basic treatment here was to different water level depths, the question was what was the optimal water depth for re-growing tules and wetland plants such that we could raise the land service back up again.

I will just show you some of the construction out at the Twitchell site. The areas were leveled like they are out in the rice fields, and then they were flooded and planted with tules and cattails. We did a number of site studies out there, we did chamber experiments where we measured the gas fluxes over a small piece of area in the wetlands. We did biomass secretion studies. We looked at decomposition rates over time with litter bags. We did water budgets. We were looking at the quality of the dissolved organic carbon that comes through the soil and out into the drain. We have done ET measurements. And what we found is that, over time, these two wetland sites evolved differently. From the time that they were flooded, these west pond, which you remember is a shallower pond, is pretty homogenous. It colonized with the plants fairly quickly after the first year, and this is -- you can see it is fairly uniform in its planting. The water runs through at a fairly uniform rate, you cannot see very well defined channels. The east pond here is a little bit deeper and it is very heterogeneous, we have got all kinds of different things going on in here. You have got some very very dense stands in some area which are denser than they are in the shallower ponds. We have open water areas that did not colonize, and some still are not colonized. I think we are -- what -- 10 years into the project, Roger, something like that? And you also have different flow rates and paths for the system. And one of the things that we found that was very exciting, and why this is a potential for carbon capture, was a very high accretion rate in some of these areas with the dense stands that were removed from high flow rates. So if you take the most optimistic carbon capture amount that we got from this test plot, and you compare it to Delta corn crops, we have on the order of 30 tons of carbon per acre that can be sequestered.

Another thing to pay attention to is time. You know, often people want immediate results, especially in the policy world. And it took about between 1997 and 2003, we had a really slow, but steady accretion rate in the ponds, then all of a sudden in 2003, the rate took off.

And this is just a basic comparison, if you took our range of carbon sequestration and you compared it to different ecosystems, marshes, quarries, and forests, you see that, at least at the high end, it is really really high; of course, at the low end, it is comparable to the high end of the other systems. The thing to notice down here is the corn, and the corn is the target baseline. We need to establish a baseline for this project, and we are using the corn as sort of the first target. There is a lot of different land uses in the Delta, a lot of different crops being grown there, but one of the biggest crops in the Western Delta is corn.

Let me tell you a little bit about why I think that we are getting some of these results. We think that over time the plants are growing tall enough that they are shading the water, reducing the temperature, which reduces algal activity and reduces the amount of dissolved oxygen in the water. We see maximum accretion where the flow rates are fairly low, and that sort of leads us to believe that the wetland is kind of treating itself, it is taking the nutrients out that could speed decomposition and, by the time the water with the nutrients gets into the middle of the wetland, those levels are low. So you are minimizing decomposition and you are maximizing plant growth and it gets you to a very sweet spot where you have minimal methane emissions and maximizing your carbon sequestration. So that is sort of the tipping point that we are trying to figure out where it is, why it happens, and whether those conditions could be controlled over large bodies, large bases, many numbers of acres.

I want to re-emphasize that our gas flux measurements that we have done so far indicate that, in these wetlands, in these tule stands, the methane emissions are negligible. If you look in the open water areas, we do have methane coming out, it is kind of not the optimal situation. We have water that has been standing there for a long time, you have anaerobic conditions down at the bottom, more nutrients, more organic matter churning methane out. And so, like I said, one of our targets is to figure out in the research what is the difference between these open water areas and these areas where we see very high sequestration rates.

I want to talk a little bit about the baseline plan, which is the portion that PIER is funding. You need baseline conditions, obviously, to figure out what the carbon credit potential would be for these managed wetlands.

And in the Delta, we know that the greenhouse gasses are highly variable. Preliminary data -- and I apologize for stealing this from Wendy Silver and Dennis Baldocchi -- pretty much show that some of the greenhouse gas emissions could be off the scale with respect to literature values, especially in the context of pastureland that is seasonally flooded. And our research project is really aimed at trying to account for the net GHG emissions in some of these areas in the Delta that are seasonally flooded, where we expect high nitrous oxide levels to be coming off in the pastures, with flood-up and draw-down, and to take a closer look especially at the corn fields, and look at what happens in the corn fields as the water sits on them for longer periods of time, and find out how much methane comes off them. So the corn fields are our baseline and hopefully will be out there this summer to take a much better accounting of what is going on in there.

So the project overall includes some other components in it. We will be asking questions about flow rates of water going through these systems, what kind of different plant communities have what kind of effects, whether sediment amendments are having any kind of effects. We are looking at using the DNDC model as a method for looking to the future for measuring and testing the validity of the amount of carbon that is captured in these systems.

There is a lot of work that has to go into adapting the DNDC model to take into account some of these measurements accurately and assess what is going on in these things, because they are very heterogeneous and it would take a lot of money to go out there and do the measurements bit by bit. There is also a concern about mercury methylation. We are in a high mercury environment and wetland conditions are prime factories for methylation mercury, and we are going to look at what happens to mercury in these systems, whether the mercury that actually does get methylated can get de-methylated before the water goes back out in the channel and the organisms that come to the wetland export it. We will also be looking at the dissolved organic carbon, which is an issue for drinking water supplies, and what kinds of carbon comes off the system.

And I would just like to point out that this work -- we are aiming for having these managed wetland systems be viable in the carbon credit market, that is our goal for producing the information. And as you all have heard today, I know you are all familiar with this, but it takes a lot of different pieces to put that puzzle together. We are also aiming for different scales of economy, at least to make sense of the foreign scale, but it also needs to make sense at the regional Delta scale. There are a lot of subsidies, public subsidies, that go into keeping the levees whole for the protection of water supply and other beneficial uses in the Delta. And also, for costs associated with hazard planning and risk reduction and recovery after hazards in the area. And it is a collaboration between USGS and the Energy Commission and the Department of Water Resources. Hopefully the Department of Water Resources will be able to stay on line, assuming the bond funding comes back at some point in time. But with that, does anybody have any questions? If you do, yeah, I have some other folks in the audience, it depends on how technical they are. They can team in.

MR. MOUSSOURIS: Hi, I am John Moussouris from VenEarth Group. Your baseline Delta corn shows minus five or 10 tons per acre, and I am just wondering why is it so -- you are saying that you are emitting carbon dioxide --

MS. TAYLOR: Yes.

MR. MOUSSOURIS: What is the mechanism for that?

MS. TAYLOR: Well, the first mechanism is that you are oxidizing the peat soil that you are growing the corn on. And then, on top of that, you probably have -- which is not included in this estimate -- you probably have high nitrous oxide emissions, as well, as it seasonally floods and drains out.

MR. MOUSSOURIS: So it is mainly that you have had to dry up the soil to plant corn in it, and drying up the soil causes the microbes to oxidize the peat?

MS. TAYLOR: Correct, which is a predominant land use in the Delta. Most of the agriculture -- virtually all of the agriculture drains the soil at some point in time, and that draining process keeps it oxidizing.

MR. MOUSSOURIS: I see. Are there crops in -- you should probably come and use the microphone so the people on the broadcast can hear you. That accounts for most of the subsidence. What about crops like rice that allow the peak to be kept wet? Did you mention that?

MS. TAYLOR: The crops like rice only allow peat to be kept wet for a certain number of months, and then they drain it out and you have the microbial oxidation process again. So you get less subsidence, probably, with rice, and they are doing tests on that right now to find out how much less.

MR. MOUSSOURIS: Is there any form of cash crop that would be economic for farmers that does keep the -- that could actually be carbon positive in wetlands?

MS. TAYLOR: Besides carbon credits?

MR. MOUSSOURIS: I mean, is there any crop that would grow in wet -- you say rice is partially wet -- are there any cash crops --

MS. TAYLOR: Is there anything that is continuously wet that does not require -- I do not know. Roger wants to say something.

MR. FUJU: I just want to reiterate about the rice. There is actually a rice trial going on right now. There is rice grown in the Delta on other islands and it is economically feasible. The test that is going on right now is really specifically designed to look at carbon sequestration, to look at subsidence reversals, and to look at mercury methylation potential. And they have already planted the rice, and so we will get a lot more information about that. Oh, Roger Fuju with the USGS.

MR. MOUSSOURIS: Could I also ask, those 40 tons per hectare numbers, are they one time, or are they -- can you do that per year? Could you harvest this vegetation, stabilize it, and then continue to get 40 tons? Or how does that work?

MR. FUJU: You mean the graph that she was showing? Yeah, that was from the measurements that were made in 2005, I believe, and you do not harvest anything, it is cumulative -- well, it is what was done in one year during that period of time. So, for example, there was another measurement that was made in 2007 and it came up with similar numbers. It is on an annual basis.

MR. MOUSSOURIS: You cannot do the raised level and continue to sequester more carbon?

MR. FUJU: Well, that was the graph that Kim showed, where she showed the accretion rates and how, starting in 2003, that line increased tremendously, there was the change in slope. So there was a big change in the rate of accretion that took place, and that is one of the things that we are trying to figure out is what causes that. And what we did find in 2007 is that rate increase continued, so that is one of the main things that we are trying to investigate with the research is, what are the biogeochemical conditions that allowed that to happen, and how can we recreate those.

MS. PITTIGLIO: All right, thank you, Kim. Our next speaker is Andrew Fynn from C Restored.

MR. FYNN: Good morning. So we have not heard much about rangeland so far this morning. As has already come up, you have to be very discerning in looking at what is forestland and what is rangeland, and where the two meet, and that obviously defines pretty exclusively on your definition criteria. There is also an overlap with pastureland. Considerable work, as you know, has been done for many years on carbon sequestration in woody biomass. So we will be looking a little bit at biomass sequestration on rangelands today because, ultimately, where we need to go with this is protocol development, and it only makes sense to have a protocol that will cover woody biomass, as well as soil carbon on rangelands.

So what exactly are rangelands? It is uncultivated land, native vegetation is predominantly grasses and grass-like species. It covers only 63 million acres in California, so there is considerable potential, if technical potential, which is what sounds nice, can be converted into what can actually be done with considerable adoption rates. So one of the things that I am going to be looking at today is some of the methodology issues around protocol development because, I think if anyone looks out there for how much research has been done into rangeland carbon sequestration, you will see that it is a long way behind forestry.

Pastureland, as well, if you mention the ven diagram, there is going to be some overlap because anyone grazing cattle will also be considering that as an option. And the definition criterion there is that periodic cultivation occurs, and certain inputs may also be in place.

So what is considered primary rangeland in California, excluding upland forestland, is over 57 million acres, of which around 41 million acres are available for grazing. Grazing, obviously, is not the only project action, or project action category that affects soil carbon sequestration, but it is the chief one. And current estimates of grazeland of any type is 84.1 million acres.

So the composition of these rangelands, just to give you an idea, the Chaparral is a pretty high figure there. The Deserts, well, that is a very high number, but what can you actually do there? Perhaps there is more potential there with some avoided carbon emissions if you consider the fragility of those ecosystems. I am not going to stay long on this slide, but for those of you who are very punctilious, if you add up these totals, they will not add to the total I gave you in the previous slide, which speaks a little bit of the quantification definitions and issues around what exactly is defined as one type, and what is defined as another.

So rangeland carbon, obviously you have your soil carbon and your biomass carbon. The components, as I intimated for biomass carbon, that have been developed already and within the forestry protocols can be accessed, for those aspects of any new rangeland carbon protocol. Soil carbon comprises soil organic carbon and soil inorganic carbon, the latter which forms a small portion of total soil carbon. And soil organic carbon really needs to be understood as part of the carbon cycle, a very dynamic cycle, a cycle of life, and within that it forms 48-58 percent of soil organic matter. So when you consider the difference between a severely eroded hard pan that nothing grows in, and a very luxurious peaky loam, then what you are looking at in the latter case is, as we saw in the Terra

Preta slides, a high soil organic matter content. So that, in essence, I think, is common to a lot of the presentations this morning, is the tantalizing prospect of the win-win scenarios that we are all looking to convert to actual benefit, if possible. Biochar is interesting because it is organic material, but due to its recalcitrance and the way that it bonds with certain minerals, it behaves a lot like soil and inorganic carbon.

And so management can affect soil/carbon balance, either directly through imports and exports, or by affecting the processes that influence soil carbon accumulation, and in reality many management practices will be affecting both. And as I mentioned, there is not yet information or research being done to quantify exactly what mitigation potential there is from avoided erosion and weathering from calcic soils; however, that is also something to be considered when you consider rangelands, and not limited to grazing lands.

There is a number of known project actions for soil organic carbon (SOC) sequestration, sustainable stocking rates is sometimes less, sometimes more; improved nutrient management, sometimes less, sometimes more; management intensive grazing, which I will touch on briefly in a couple of slides; introduction of grasses and legumes; restoration of overgrazed lands, etc., etc. I will just highlight something interesting there, pasture cropping, which is doubling up your land use, and a lot of work has been done on this in Australia, whereby you will grow a cereal crop in the fallow season and you will have a grazing crop and bring the grazes in to harvest that, and therefore reduce the amount of bare soil on the land. And then, at the bottom, a few project actions associated with woody biomass sequestration.

So when it comes to current research, as I said, there is not a whole lot out there and I think the need is pretty urgent. So, like Kim, I am going to steal from Dennis Baldocchi and Wendy Silver's research. Dennis has found that Oak Woodlands are carbon sinks and annual grasslands in California are carbon neutral. Now, we need to consider that additionality is not determined by what is happening now, but what can be done with these ecosystems, so it is the difference between business as usual scenario and the effective project actions. Rains are triggering the release of soil carbon dioxide from these ecosystems and the grasslands are more variable than Oak woodlands.

So Wendy Silver's work replicated in Marin and Sonoma on the one hand, and SFREC and Marysville. This slide has moved around a little bit. Compost application, its early stages for both of the two land management techniques being looked at, but five months after application at 10 mg of carbon per hectare over 90 percent of carbon was retained in the soil. No significant increase in methane or nitrous oxide. More biomass in the composted sites, and the line that is kind of missing says they were also preferentially grazed by cattle. And then this image on the right is the subsoiler from Australia called the keyline plow, which is designed partially to remediate the effect of compacted soils and allow plant roots to penetrate and, as you can imagine from this image, for water infiltration to be increased and bulk density to be decreased. CO_2 emissions were lowest from subsoil sites and there was definitely a negative effect on plant growth on these sites, as well. And I think we are all aware, it is going to take some time before we really know what the long-term effects of these and other project actions are. And so a couple of upcoming monitoring activities going on with this work over the summer.

I am going to focus more than the other presenters on what the research needs are and some of the soft and fuzzy ideas around what that needs to look like in terms of involving landowners and land managers from the outset. So one example is a management intensive grazing, which is some would say a very high reputation among rangeland managers throughout the country, and yet, as far as I can tell, there is practically no soil carbon research into it. And given that rangeland managers will only do things that improve the bottom line and secondarily improve the ecosystem, if it is improving productivity, then there is a good argument for looking at its effect on soil carbon sequestration. And there is a vital need for coordinating research. If we are going to come together in this arena and find solutions that are going to have real potential and can lead to very significant mitigation benefits. So the last two points, I will get into them a little bit later.

A pretty controversial topic, but in the soil, carbon and nitrogen ratios are pretty closely fixed and 10:1, so the nitrogen that is being sequestered with the soil carbon is not being fixed for nitrates, that is not the issue; however, if you look at the nitrogen cycle, if you are thinking of a credit that has a lifetime of 100 years, and that nitrogen is being taken out of the cycle as a whole for that period, then there is a portion of it that would have de-nitrified to nitrates in the atmosphere. And lifecycle analysis needs to be conducted to find out what the net sequestration value in terms of GWP is for one ton of soil carbon, beyond the carbon and carbon dioxide values.

So one of the issues we are looking at today is how will rangeland carbon credits and other forms of terrestrial carbon credits be regulated under a cap and trade system. These are the well-known criteria for any kind of offset credit, real, permanent, quantifiable, verifiable, enforceable and additional. So ARB recognizes that these will be met through the protocol development for each offset category. So I am just going to use that as a segway into talking a little bit about what kind of methodology we need.

There is a spectrum of methodologies from the simple to the complex, and the most simple, which is that of the Chicago Plan Exchange, or CCX, does not require project specific measurements. It is a matter of whether or not your project exists within a county that they have considered is within their whole level project boundaries and they are assigned an associated sequestration value. The CCX experiment shows that simple methodologies like that will not drive adoption because of conservative compensation rates due to costs of data and low buy interest. And on the other hand, very complex suggested methodologies will be too complex and expensive to implement within an emissions trading system. So we are going to have to find something in the middle ground to drive adoption. So only a balanced protocol will work and, on this slide there are a number of models that you have heard today, a state transition model, which is being developed with the Southwest partnership that uses a system of visual indicators, and will be tied to COMET-VR. And I think that some of these solutions are getting close to what we need, and I think that this kind of balanced protocol will attract interest from both ends of the spectrum, and I think it is the only thing that will actually take this out of the realm of the theoretical into the achieved. And, as such, it should be taken very seriously. So the key is compromise, when it comes to the methodology. It is not going to be pleasing to everyone, but it is going to be somewhere in the middle. And it is important, also, that as we move forward that it is not hardwired to any particular methodological element or technology, but can be updated over time and common to both research and the methodology, would have to work very closely with landowners to avoid a waste of time and resources.

So the key is collaboration and what I would suggest is a means for California rangeland carbon sequestration to be truly understood is a baseline soil carbon mapping throughout the state, and an assessment of Best Management Practices. It sounds like Winrock are going to be working for PIER on some of the grazing management strategies, and we certainly need to see the kind of data that we saw this morning for forestry and price opportunities, and so on. And, again, at the risk of seeming boring, landowner participation is crucial because we need to access the knowledge and the skills that are out there without remaining in our ivory towers.

And so I suggest three phases of this procedure which would be very helpful for protocol development and, again, collaboration being driven by different agencies, would identify both potential and areas for necessary targeted research. And to manage a collaboration, one solution would be a panel that looks after protocol development and have a shared vision of maximizing mitigation potential. Obviously protocol development for ARB and CAR, although they are now on a national scope.

Because of the differences in baseline, and the different effects of project action, and the lack of data, it is difficult to quantify the potential at this stage, but what is likely to occur is a mosaic pattern. So the most attractive projects will see their implementation more than one project action, and include other forms of GHP emissions reductions, and the methodology should be developed comprehensive to encourage these. In time, we are likely to see system-wide GHG emissions reductions programs, including carbon sequestration and these will help ensure permanence, and systems are harder to reverse in single project actions. Full accounting for GHG budgets needs to occur on either a project or a regional level, and there needs to be more research into management by environmental factors.

So 50,000 feet -- attempt to look at the potential, and this is the technical potential from rangelands based on the area of primary grazing rangelands in California, so it is not considering secondary rangelands, biomass carbon, pastureland, avoiding carbon losses, or use of biochar. A 1 percent absolute increase, that is 1 percent not against current levels, but in total soil organic matter content, to a 50 cm depth in rangelands would remove 750 million metric tons of carbon from the atmosphere. So the question, then, with a figure like that is, well, how long does that take to achieve? If it took 100 years, then your annual mitigation would be $27.5 million metric tons of carbon dioxide equivalent. And the next slide shows a calculation for that. So, again, this is a technical potential vs. an achieved potential, and the methodology would be crucial to converting as much of this as possible into reality, but at that rate, it would provide 14 percent of the emissions reductions target under AB 32 by 2020. And just one thing to bear in mind is the rate of soil carbon loss when virgin soils, prairie soils, for example, converted to agriculture can be 25 percent of the total within 10 years. So I will leave you to quarrel with this after the presentation, but you are basically multiplying the area by the volume by the average bulk density, and using the figure of 50 percent soil organic carbon, or soil organic matter for the 1 percent increase, and dividing that mitigation by 100, and timesing it by 3.67 tons of carbon dioxide for 1 ton of carbon.

So how can rangeland credits be secured over 100 years? Forestry credits, forestry protocols can be accessed for this kind of solution and obviously there is going to be some debate about exactly how this is done, but that would suggest assessing the risk of accidental reversal, factoring it in to calculations creating a buffer pool, and creating pretty prohibitive penalties for intention reversal so that, for example, if a landowner did want to sell a land for development, that there would be a very high premium that comes with replacing those credits that he has already sold. And it is worth pointing out that, for anything that is secured over 100 years, and there is confidence around that, that other factors must also be assessed over 100 years, including any permanent increase in the labile carbon pools, whether it is counted or not, and needs to be considered. And as I mentioned, the fate of nitrogen sequestered with the soil carbon and associated global warming potential.

So, again, back to the win-win scenario, given the vital functioning of soil carbon within soil ecosystems, and the fact that it is why we are here today, and the great win-win opportunity for climate change and restoring degraded lands, I think it really behooves us to find solutions to challenges around this and other forms of terrestrial carbon sequestration. Thank you.

MS. PITTIGLIO: Our next speaker is Greg San Martin from PG&E. And I believe the copies of the presentation are available at the front desk.

MR. SAN MARTIN: Hi. I am Greg San Martin. I am the Climate Protection Program Manager with PG&E in San Francisco. Thanks for this opportunity to speak, Sarah. The companies regulated under cap and trade typically face three main compliance options: we can reduce our emissions, we can purchase allowances that are issued or sold by government, or we can buy offset credits. The topic of today's workshop is the role of sequestration credits in cap and trade, and so I am here to talk about that, not so much from a technical perspective, but really from a perspective of a company that is engaged in some procurement, some project work, and so I will be more focused at a policy level on the role of sequestration credits in the cap and trade market.

First and foremost, we view offsets as a significant potential cost containment mechanism that should be a part of any cap and trade program. PG&E as a company has long supported cap and trade at the state and regional and national levels. The five most likely offset categories to qualify under cap and trade are -- we have heard a lot of them today -- Ag, waste, forestry, fugitive emissions from coal mines and other sources, landfill gas, and soil sequestration. Most common forest-based offset protocols, we have covered this, so I will pass by this.

I have a few slides today from Point Carbon. We are a subscriber to their research services. They look at carbon markets domestically and internationally. This chart shows the offset pipeline primarily from the voluntary market and the highlighted -- the circled typologies that are designated as most likely account. You can see that, in 2012, it looks like from the voluntary market there is only about 12 million tons throughout the entire U.S. As the states, the regions and the federal government moved to actually adopt cap and trade, and put some of the meat on the bones with regard to which offsets are going to count, and how much they are going to count, these numbers could increase substantially.

There are quite a maze of domestic offset standards and you can see a partial list here: U.S. EPA, Climate Action Reserve, the Regional Initiatives on the East Coast and the West Coast and the Mid-West, even states and local air districts in California are developing their own protocols, and then there are a variety of voluntary standards. This is another slide from Point Carbon. It shows the results of a survey they did earlier this year and the opinions of U.S. respondents to the likelihood that particular standards would be eligible for U.S. cap and trade program, or near the top of the list as the Climate

Action Reserve in California.

So next question -- will domestic offsets satisfy the demand? It is unclear, but it may be unlikely is what some people are saying. The demand for domestic offsets will, under the federal proposed legislation depend on how they compare to other compliance options that may be available at the time the cap and trade market goes into effect. Regi allowances currently are trading at $3.50 per ton, which makes the demand for offsets relatively low in regi. How the cap and trade is designed remains to be seen. Current prices for voluntary credits are pretty much all below $10.00 per ton. The Climate Action Reserve, CAR futures trade at roughly $7.00 on the Chicago futures exchange. International offset prices will depend on a lot of factors, including the extent to which the Europeans have access to those same credits that we may be looking for domestically. And then field switching can phase in over a variety of different prices and so there is a lot of uncertainty with regard to where sequestration will fit in, in a market. This slides shows -- it is just conceptual -- it kind of shows where we would see domestic offsets, including sequestration credits, basically near the beginning of the program is when we would likely see U.S. offsets and according to this, they would be fairly low on price. And as the demand rises over time, the allowances increase. There are additional options that become viable and cost-effective. And so, over a longer period of time, I believe, some sequestration typologies that we are just beginning to consider today, that may be promising in the future, could actually become viable and cost-effective under future cap and trade programs.

So we have a program at PG&E called Climate Smart, and this program is part of our portfolio solution, the way we look at how energy and climate can be managed. We have a loading order and some of it is on here, the energy efficiency demand response is where we begin, and then we buy as much renewables as we can. And then, for the residual amount of greenhouse gas emissions that remain, we have a voluntary program for customers who want to sign up to use -- to procure offsets, essentially, to offset and fully mitigate the emissions associated with their energy use. The cost is based on emissions associated with usage, which we have had verified with the California Climate Action Registry, Climate Action Reserve, and the intent is to road test existing and new Climate Action Reserve protocols. The livestock methane, forced sequestration landfill gas are examples, but there are more protocols being added to the list every year. We also provided funding to help pay for some of the costs to develop the protocols. I think wetlands is an example of a protocol that did not go forward because there was not enough technical basis to move forward, there were gaps in the research. And that is certainly, I guess, a point I would like to make before I get to the conclusions pages, is that there is an opportunity, I think, to identify gaps in the research literature that can help move the protocols from an area of research into an area where the protocols actually are getting adopted by the Climate Action Reserve. The importance of the Climate Action Reserve is that they, then, are in a good position to influence which protocols are adopted at the national level, and potentially at the international level, as well.

Funding -- there is an option for participants to -- Climate Smart is an option for customers to demonstrate environmental leadership. We have an external advisory group which consists of regulators and other stakeholders. And the investments in the projects are, at the end of the day, to produce reductions equivalent to, or more that the emissions associated with the customers' energy use. All of those verified reductions are independently verified and registered with Climate Action Reserve, and then permanently retired on behalf of the customers who paid for them. We do not use the credits for any requirement under state or federal law. The program was approved and is overseen by the Public Utilities Commission. Our commitment is to contract for 1.5 million tons of GHG emission reductions. And so, really, what the program is doing is it is helping to demonstrate the new protocols that have been developed by the Climate Action Reserve. There is an important research element to getting the protocols developed and, then, what we do is we help demonstrate them in the marketplace. We are using a competitive bidding process currently to select the best projects that are available. We only invest in projects that are in California. As I have said, we have an external advisory group, they help provide input from a wide variety of different stakeholders.

So this is just a graphic showing essentially what is happening, the household has the emissions from its gas and electricity use. They sign up for Climate Smart, we contract for a project, in this case it looks like a forestry project, and when the emissions reductions from that project are equal to the emissions from the enrolled customers, balance has been achieved and there is no net effect on the atmosphere. We have a few pages on the website that help customers identify what their footprints are from home and household. The program is also available to business customers. And in addition, we are not just looking at the effects of the projects, sequestration projects offsets, but we are also looking at the impacts of different appliance uses, different things that are used in the home that cause emissions.

So an important element of the program is the education, awareness, because there is a challenge. Generally, to legitimize offsets, people need to understand them first, and so we are seeking to educate customers about their emissions and the program helps us do that. These are some of the projects that we are investing in. The first projects that we have invested in are the Garcia River Forest, Wilmapco Headwaters Forest.

And some conclusions now. I guess, first of all, offsets -- the availability of offsets will be a key price driver, initially, and potentially until 2030 under the federal program, and that will depend in part on how many free allowances are allocated and how the cap and trade is actually designed. I think that it would be helpful to identify which offset protocols are most cost effective in California. I think embracing uniformity and avoiding patchworks, recognizing that a federal program is coming, and is very likely to be in effect in the next five years is something that we need to plan for today. We have an opportunity today to influence, as a state, we have an opportunity to influence what U.S. EPA does, what protocols they select for use in a national cap and trade market. I think, you know, I am going to wrap it up there in the sake of time -- I see it is a few minutes to noon. I think that a lot of what I have heard this morning is right. I think there is a lot of potential sequestration tons in wetlands, in the Delta, in protocols that could be developed, but have not been developed yet, and I think that is an area. Like forests and like dairies where California has taken some initiative to develop protocols and to demonstrate them, I think the opportunity now is to take the research that has been done and the research that is being done, and potentially will be done, and use that to support what the Climate Action Reserve is trying to do. What they are trying to do is develop protocols that can be used in the market, that can transition from voluntary protocols, once we have the information from acting using them in practice, and transition to a compliance basis. In the future, again, the compliance offsets, to the extent that they draw from sequestration credits, will help fund sequestration projects in California. And I think the idea of having folks from outside California pay for sequestration within California is very appealing to PG&E. Thank you very much. Questions?

MR. VAYSSIERES: My name is Mark Vayssieres with the Air Resources Board. I am trying to understand in your presentation, you are talking about two different type of offsets, there are the offsets that I could buy through the Climate Smart Program, and then you are also thinking about offsets that would come under either California or a federal cap and trade. I am not sure I understand the difference. Would the Climate Smart disappear if there is a cap and trade? Or would they count for it? Could you clarify that?

MR. SAN MARTIN: Sure. Yes to your first question, I was talking about voluntary offset credits which make up almost all of the credits that we have seen today, the reductions. But then I was also talking about, in the future, when states, regions and the national government move forward with their cap and trade programs, there will be a compliance market that will likely allow offsets. And so your next question, I think, was what happens to Climate Smart. We continue to support cap and trade. We want to help facilitate it, demonstrating the protocols at the Climate Action Reserve, I think, has helped in that effort. Just because a federal cap and trade or even a state cap and trade goes into place does not mean that all of the voluntary protocols that are out there are going to disappear. We may still have access to cost effective voluntary reductions that could be used as a basis for the Climate Smart Program. But I guess the larger issue is the sequestration, the opportunity to make some of these, or many of these sequestration opportunities in California the basis for compliance offsets currency and, in the national market, I think has substantial potential value to Californians and to the California environment. So I want to distinguish between what we will be doing in the voluntary program and, more importantly, what is happening at a national level with cap and trade.

MR. VAYSSIERES: Thank you.

MR. SAN MARTIN: Thank you. Any other questions?

MS. PITTIGLIO: So I would like to open up the discussion and people can address any of the speakers. But remember, if you come up to the podium, please state your name and affiliation, and if you are a speaker, you can come up to the podium to speak.

MR. MOUNT: Thank you. My name is John Mount. I am a Forest Resources Manager for the Southern California Edison Company, located at Shaver Lake where Edison owns 20,000 acres of forestland. Those lands were cut over completely by 1914 and it is a very young, fast-growing forest. I want to comment on the forest sector of carbon sequestration. Tim did a great job of outlining what can really go on in the forest. I am going to also keep my remarks based on the section of the handout that we had the sector overview emission reduction strategies on the forest section. The assumptions, all of the numbers given in this handout were, I think, a little bit low. We have a tremendous opportunity in managing our forests. But that is the key to my statement there is the forests have to be managed if we are going to gain all the great offsets and carbon sequestration. And under the recommended action in that handout, harvesting and renewal of our forest resources is keystone for the long-term sequestration of carbon. For example, building with wood rather than steel so that we can take those trees that were thinning the forest, put them into dimension lumber that sequesters that carbon for additional years than the growth years. Less rules, I believe, in the forest practice rules are going to help, not more rules. And the use of market forces, and I do not mean just pure market forces, but the correct regulations that allow a landowner to receive dollars on either a cap and trade or a voluntary program. The differences, really, between voluntary and cap and trade are the landowners, themselves. There are some landowners like Edison Company that would be better influenced by cap and trade; but I know -- I was a consulting forester for years, and I know of a large number of small landowners, 400 or 500 acres, even 40 acres, that would do a voluntary market and not cap and trade because they do not want to meet some of the rules that may be established in the cap and trade. The real opportunity we have for very short-term increasing of carbon sequestration is the removal of the billions of tons of small trees in what we call the biomass operation, all up and down the Sierra, all on the Coast range, Southern California ranges, we just have billions of tons of what I would call excess fuels that are sitting out there and need to be removed because of many things. First of all, it would allow a greater increase in growth of trees, which means increased carbon sequestration. And it would also reduce the fire hazard, which, as was brought up, the tons that are emitted by these catastrophic fires are not being overstated, they are being understated. There is a tremendous loss for long-term and short-term sequestration. In the forest management, increasing rotation is fine, except on my forest, we do not go by rotation because it is a selection system, so what you want to do is talk about increased diameter size. And it was real key when he talked about ecosystem management because there are values out there that are greater, even, than carbon sequestration, and that is our wildlife component of our forests. And proscribed fire while it emits CO_2 is extremely necessary, and you can still have a net sequestration of carbon, even with a proscribed fire program. The next opportunity for carbon sequestration would be your afforestation and I loved that definition of afforestation of anything that has not, even though it is forestlands, it has not been forested for 50 years because there are just tens of thousands of acres in California. And long-term is the key in that one and, yes, you will get companies that are willing to pay for the investment to plant those acres and get the carbon offsets for the next hundred plus years. Thank you.

MR. DOHERTY: Hi, I am Abe Doherty with the California Coastal Conservancy which is a state agency. And we are very interested in supporting research to look at the possibility for tidal wetland as carbon offset protocol, particularly because, with the pressure of sea level rise, our tidal wetlands are going to be under a lot of pressure in terms of habitat conversion, and it is going to be costly to support the management actions to preserve those habitats in terms of sediment management to accrete the wetlands. So we are interested in partnering with others to really explore how do we look at carbon sequestration benefits for tidal wetlands so that we can look at this issue, and it is also something we need to do for our projects anyways, to look at the net carbon budgets of our projects for CEQA purposes, to think about what the actions that result in restoration of wetlands in terms of transporting soil, breaching levees, these results emissions, and how do our restoration projects sequester carbon in terms of looking at that carbon budget.

MS. KRAUS (phonetic): My name is Mara Kraus. I with the U.S. Geological Survey. I have kind of an open question which is, a lot of the work so far has been looking at carbon stocks, largely above-ground carbon, and how do people see the whole greenhouse gas emission balance and bringing the nitrous oxides, as well as methane into the picture, and how quickly can the methods sort of catch up with the policy? And maybe Johan Six can start off by talking about the methods that he has looked at to actually get good numbers for nitrous oxide and methane.

MR. SIX: Johan Six at U.C. Davis. I mean, I think the question is very relevant in the sense that, when it comes to the methods for doing nitrous oxide and methane, they are quite labor intensive, and so, I mean, we do have some methods out there, but measuring a salt carbon is done quite a bit quicker than doing nitrous oxide or methane emissions. At the same time, I mean, that is where I think we are going to need that -- if we do some combination of having some chamber measurements, we can do some at equal variance measurements so we can look at different scales, because obviously the chamber is only going to measure it in one little spot where that chamber is, and we know that the spatial and temporal variability of these emissions are quite big, so that is where the at equal variance can come in, you know, then you have a bigger spatial coverage with your measurements. But there, the costs are quite high. And so therefore, I strongly believe that we will have to always try to combine these measurements with some modeling and really integrate the two because we doing continuous measurements are going to be prohibitive for doing any actions because it is just too much. So at one point, I mean, you have to start relying on the models. And, as I said, I mean, you still need to do some measurements so that you can keep calibrating and validating the models, it is not like the end by just having once your model established. So it is very much that integration of measurements, you are doing your calibration, your validation of the modeling, and then keep on monitoring. That, I think, will help out with this issue.

MR. VAYSSIERES: Mark Vayssieres again from ARB. I am really interested in the prospect to sequester carbon with biochar. It seems like the permanence of it is the great argument. What I think needs a lot of thinking is how do you make it happen because it seems to me, I thought your presentation was interested in taking the global view, you know, and then we cover the entire land with carbon and all that, but then, you know, part of me was thinking, yeah, but then you have to convince farmers that they want to do it. And your example, I think, the guy who has 30 acres and has to cover one of those acres with a greenhouse, it is going to cost a lot of money to do that, so to me it seems like it is prohibitive, at least to start. So the amount of energy you get out of it is there, but it is probably not enough to make it happen. The ergonometric advantages are, you know, talked about, but I am not sure they have been actually measured very much, at least in California, on an ergonometric scale. And it seems to me that there is going to be a need for both of those things, both the ergonometric plus and maybe the energy coming as a way to pay for, you know, burning the stuff, I mean "cooking" the stuff, and all that. And it seems to me also that it is going to have to be decentralized because, if you have to move the biomass, you know, long distance, then I do not think it would be visible. Anybody wants to comment on this?

MR. MOUSSOURIS: This is John Moussouris, VenEarth Group. I agree that it needs to be self-financing and, you know, I did not have time to discuss this in the talk, but I think it actually can be self-financing, particularly in California where there is very high sunlight and high agronomic value. Let me clarify that the greenhouse example that I stated was in the context of figuring out how to make more biocarbon per biomass input by supplying the energy less aggressive biochar manufacturers, energy positive, for example, one of the early commercial uses of biochar in the U.S. is poultry farmer who takes poultry litter and makes char out of it to replace propane heating, the chicken coops, and so that is the energy component, and then sells the chars as fertilizer. And it is true, even in California, they are very hypersensitive -- the farms are fertilizer dependent. Fertilizer prices have gone down a little bit with the reduction of fossil fuels, but they are still extremely high compared to the practical price of making similar char. It is challenging because you have to add minerals, you know, just as you do with ordinary fertilizer, you have to suit the fertilizer to the soil and the crop and the winter conditions, so it is not one site -- you cannot just make charcoal and throw it in the soil and expect to get an ideal result. So, in that sense, it is complicated. It is about as complicated as making wine or beer. You know, it takes some skill. But I do think the numbers actually do work out, where the farmers -- two farmers, one of which did intelligent char on their farm in the growing season, and the other one did not, at the end of that season, I believe the farmer that did the char would actually be cash positive relative to his neighbor. And that is the essential requirement for the doubling that is needed, you know, for the neighbor to adopt, and the neighbor's neighbor to adopt. And you know, we did not have time, I really did not go into the economics, but I think the numbers can actually surprisingly work out. They definitely worked out in Brazil. You know, the people did not do what they did there to get carbon credits from some certification board, or to worry about somebody else's climate, they did it to be more affluent. And they did not have metal, they had very simple -- their main technology was just pottery, but they still managed to do it. And I think we can actually do as well. We may not be able to do significantly better, but I think we can do as well.

MS. PITTIGLIO: Mark, also to address your question, I know the Energy Commission has given out some small grants to farmers to produce biochar on their land and, if whatever crop they grow produces a waste that can become char, I think it is more viable to have it as sort of a small closed unit on one farm. And I have heard other people talk about how also another viable option would be to have a co-op of farmers together, you know, investing in one biochar machine, and those machines could even produce energy, as well.

MR. MOUSSOURIS: I also wanted to mention that one of the things about char that is advantageous is that it can be scaled to be local. You know, one of the difficulties of bioenergy is that you need a fairly large piece of equipment to be economic, you know, you have to have a certain megawatts. If you have something that is going to use a steam turbine, then you have to have many megawatts, and whereas making char is quite a bit simpler, it is more like cooking, and it can be done fairly small. But while I am up here, I also want to ask -- I have a question because I think I missed something and I must be off by a factor of 10, but I have a question from Andrew Fynn's discussion of nitrogen in his rangelands talk. He said that the -- oh, you are still here, good -- that there is a sort of fixed ratio of carbon to nitrogen of 10:1 in the soil; now, carbon multiplies up to CO_2 equivalent to over a factor of 3, nitrogen by a little bit over a factor of 300, so that would imply that the effect of having nitrogen locked up in addition to -- along with the carbon through soil enhancement would be 10:1 more significant than greenhouse gas equivalent for the nitrogen effect relative to the CO_2 effect. Now, am I missing something there? Is most of the nitrogen not NO_2 -- you know, is there a factor, Fynn, that is lost? We had an earlier sort of chart saying that methane was 37.5 percent, nitrous oxide was 50 percent, and CO_2 was, I think, 12 percent or something like that. So somewhere the numbers are off by at least a factor of 3? Will you explain that?

MR. FYNN: Andrew Fynn, C Restored. So the ratio is simply for carbon to nitrogen in the soil, it is nothing to do with what any kind of mitigation effect of sequestered CN is and, in terms of getting those numbers, I know Johan has something to say about this, again, I just emphasize that [inaudible] is not being removed from nitrous oxide form, but it is going to affect, in very complex ways, the net amount of nitrogen in the cycle, and some of that will have a GWP effect. So in terms of what that quantification is, and the kind of final number you are talking about, it is just not know right now, as far as I am aware.

MS. PITTIGLIO: Are there any other comments from the audience? Well, you can also submit written comments to the Energy Commission. In the Notice that is going to be posted online, it shows the instructions for formerly submitting comments regarding the workshop. So we definitely welcome your comments. And if you do not have the link for the notice, feel free to e-mail me.

I would like to thank all of our speakers for coming. It was a really entertaining workshop. And thank you all for coming.

[Adjourned at 12:20 P.M.]

REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, an electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF,

I have hereunto set my hand this 8th day of June, 2009.

Barbara Little
Electronic Reporter