NASA Carbon Monitoring System Briefing:

Steps Towards Improved Measurements of Biomass

Friday, 9 September 2011
8:30 am to 1:15 pm
Resources for the Future (RFF)
7th Floor Conference Room
1616 P Street NW
Washington, DC 20036

Report by Molly E Brown, NASA GSFC and Vanessa Escobar, Sigma Space/GSFC

The fiscal year 2010 NASA Appropriation funded NASA to begin work on a Carbon Monitoring System (CMS). The NASA CMS will develop pilot studies to provide information across a range of spatial scales, on carbon storage in biomass and the atmospheric distribution of carbon dioxide, and to provide information about carbon storage in biomass. NASA has initiated this work by building on its global measurement capability for carbon*. Other agencies and organizations are undertaking related activities to support national policy objectives and resource management.[1]

This briefing will provide an overview of the status of the NASA CMS biomass pilot and data products under development and ascertain the data needs of other agencies and organizations engaged in biomass measurement in order to enable NASA to generate better overall products in support of these needs.

The outcome of this briefing will be help produce a report to the NASA CMS science teams documenting ways in which groups are currently measuring and using biomass measurements. Summarizing what additional biomass measurements groups find useful and highlighting how this information will be used for the future will help improve decision-making processes for NASA's CMS study.

Attendees:
Peter Griffith, NACP, carbon cycle and ecosystem office
Jeff Masek, NASA GSFC, CMS Biomass pilot
Lola Fatoyinbo, NASA GSFC, CMS Biomass pilot
Niara Pinto, University of Maryland College Park
Doug Morton, SilvaCarbon
Richard Birdsey, US Forest Service

[1] *More information about the CMS and other elements of the NASA plan for responding to the challenge of climate and environmental change can be found in NASA's "Plan for a Climate Centric Architecture for Earth Observations and Applications from Space" at http://science.nasa.gov/media/medialibrary/2010/07/01/Climate_Architecture_Final.pdf*

Carl Shapiro, USGS
Matthew Bennett, JPL
Ken Brewer, US Forest Service
Sally Claggett, US Forest Service
Dan Morris, RFF
Naikoa Aguilar-Amuchastegui, World Wildlife fund
Dan Rider, Maryland Department of Natural Resources
Woody Turner, NASA HQ
Diane Wickland, NASA HQ
Molly Brown, NASA CMS Applications
Molly Macauley, RFF CMS Applications
Allison Leidner, AAAS Fellow and CMS Applications
Joanne Howl, Sigma Space CMS Applications

Meeting Summary

The meeting began with Molly Macauley welcoming the group to Resources for the Future and introducing herself. Molly was to act as moderator for the meeting during the meeting.

Woody Turner, NASA Headquarters said a few words describing NASA and the Applied Sciences program. Woody discussed how NASA began to do Earth science because of its unique technology and vantage point. We are interested in using our capabilities to improve our understanding of what is happening with Carbon cycle to fill in gaps of our knowledge.

Peter Griffith of the North American Carbon Program (NACP) and carbon cycle and ecosystems (CCE) office then spoke. He noted that CMS is part of the CCE program. NACP is a core element of the US Global Change Research Program (USGCRP), and is Partnered with NASA, USGS, USFS, DOE and other agencies to work on carbon research. CMS thus is part of NACP, and NASA considers CMS to be a contribution to interagency effort for USGCRP's work. We recognize that many agencies work on carbon monitoring, and many agencies have congressionally mandated systems that have either carbon monitoring as the center or as a key element to their programs. Thus there is a need to coordinate these efforts, and NACP and CCE can play a role in that coordination.

Molly Brown then mentioned the importance of the coevolution of policy and decision making, and how only through communication between science, policy and decision-making could such a co-evolution occur. This meeting is the start of the communication between these groups.

We then went around the room and introduced ourselves.

- Sally Claggett– state and local partners in the US Forest Service, and works with the Chesapeake Bay program.

- Carl Shapiro – he is interested in examining trade-offs, ecosystems services, land use decision making. The USGS has land carbon project, which is statutorily required under energy and security act of 2010. The project has completed its methodology and is in the beginning of assessment. Carl is an observer of the land carbon project.
- Danny Morris – climate and electricity policy – forest carbon and policy recommendations for REDD and others. He is interested in what NASA is doing for monitoring capacity, and wants to know what it should be for REDD+.
- Allison Leidner – science-policy translation focus, conservation biologist by training, potential overlaps between carbon and conservation biology.
- Richard Birdsey – program manager for carbon and fire side – forest inventory and carbon cycle, as one of the investigators – local biomass part of the study. His role is error analysis and comparison of results and what would get from results of data.
- Ken Brewer – is standing in for Greg Reams, who could not make the meeting. Greg and Ken have a role in research branch – national, biomass carbon, biomass study to improve our equations and estimations from in-situ data
- Matt Bennett – systems engineer at JPL – CMS pilots – flux and biomass and how measurements going to make and need to make to understand carbon
- Doug Morton – SilvaCarbon – fire emissions, land use change, tropical deforestation, ecological modeling - building capacity in developing countries – US Commitment in Copenhagen – fast track financing – continuing to feed scientific expertise into SilvaCarbon
- Lola Fatoyinbo – measuring forest 3D structure – Radar, lidar – part of biomass pilot
- Niara Pinto – Lidar and Radar remote sensing – learn ways today to reconcile national with local measurements of biomass. Hope to compare local to national product
- Dan Rider – Maryland DNR forest – consumer of data that we provide – aggressively pursuing carbon markets, and looking for opportunities to utilize forest for attenuation devices

Late arrivals include Diane Wickland and Naikoa Aguilar-Amuchastegui.

Peter Griffith mentioned that there will be an open meeting for the pilot project on October 5 during the afternoon at the combined CCE meeting. All are invited.

Jeff Masek then gave a talk summarizing the CMS Biomass pilot. The powerpoint PPT is attached at the end of this summary in Appendix A.

Molly Macauley – A primary issue that we would like to address in this Briefing is how good is good enough? What errors are acceptable to your project or program? How do we operationalize these measurements at periodic time step?

We passed out a table (end, Appendix B) and are looking for inputs. Right now, what are the attributes of your data? How much better could they be if you could have anything?

Carl Shapiro - Are there different levels of uncertainty at different levels of biomass – are there target rates of uncertainty of decision-making, considering getting feedback from stakeholders? Do they vary for different types of decision makers, types of decisions? Any thinking or discussions you have to date on that issue would be of interest. In the USGS we face the same issues as you – how do you balance different aspects of data - trade-offs between error and resolution and time step.

Jeff Masek – we don't yet have the answers but we do talk about it. My understanding of the carbon credit requirements that came out of REDD+ is that they are very strict – 10-20% uncertainty at the project level to award money. We won't get better national numbers than FIA – but to improve the spatial information we need to use remote sensing information.

Richard Birdsey – users don't think about uncertainty in percent of total biomass or carbon, etc. +/-20% we will loose 20% of that fund. Closer to actual will improve funding of site. Knowing what uncertainty is critical for project – informs users. Wilderness society has a campaign to identify high carbon stock areas – Carbon Gems – small areas within national forests – trying to identify those sites that have lots of carbon. Maybe 100 ha – fairly small areas, but specifically in national forests. They want to influence public policy – have used Kellendorfer's map to identify these areas. Local land managers say that they are wrong – the areas that they have identified as 'Carbon Gems' are simply not high in carbon or even especially unusual. Thus the Kellendorfer map is not only wrong it is not useful and has misled that campaign.

Jeff Masek – it is an issue – we always say that errors are normally distributed. Often errors actually have big tails – 80% in middle but extremes are usually large and extreme. Hard to map those areas and hard to display these tails on a map.

Woody Turner – If certain parts of the product are in error, the perception often is that the product is all wrong – if going to Bartlett forest – scale is going to help you out. National map is harder to support and harder to get right.

Jeff Masek– Mapping data wall-to-wall is the solution, but is hard to do.

Ken Brewer – inherent in the map is a comparative design. We are working on developing plot-based estimates that can be compared to model-based estimates from the map for the same area – for whole range of data. Within the same area – good way if using a design-based sample to build a model –map product. Good way to evaluate the product.

Carl Shapiro – the most striking conclusion from the prediction of uncertainty is that they are not uniform. There are definite trends that exist – and are associated with uncertainty factors

Jeff Masek– Sassan's national products and error maps are evolving, as the pilot has a year left in its work.

Carl Shapiro – Are we going to produce products at high resolution that take decades or have a low-resolution map now? There are tradeoffs between national map and local map and difference in errors.

Doug Morton – different projects we are trying to work on these issues – local level often has a high precision. Errors of pan tropical forests – 20-40% of uncertainty – errors in forest area and carbon stock losses, degradation and fires to add up to carbon. How good is good enough is as good as we can get – if the original maps are 50% then the rest of the carbon will be discounted and the carbon sequestration product through REDD+ will be very hard to sell. Local scale information might only be provided in areas where we need it – margin of deforestation and much higher errors at center of forest with lower risk – risk-adjusted emphasis on error instead of a comprehensive, wall-to-wall local product.

Jeff Masek– Another question is how will errors be propagated – can we sample and start reduce some of the errors by not trying to get wall-to-wall product.

Doug Morton – high-resolution lidar may be the key– in some domains sampling is so low that it can only help.

Woody Turner– We should compare how space borne assets vs. airborne lidar affect both the data products and the errors in them.

Doug Morton – airborne assets are invaluable in efforts on how to understand uncertainty – Landsat data has identified uncertainty. Question of temporal decorrelation of information – how long beyond lidar datasets can be used – if observation was taken in 2003, can we really use in 2011? Limited lifetime for information of all kinds of real-time data, since the landscape changes over time.

Peter Griffith – particularly on frontiers in Brazil, where rapid change occurs

Doug Morton – disturbances can be up to 1% per year – local focus and great need for detailed information will be important. Lidar vs. radar – w don't have an Lband radar – assuming radar is a problem and no new replacements, airborne lidar measurements remain really important. Sampling lets you get to this point where you can identify change through time.

Jeff Masek – It is not a question of radar vs Lidar – P-band radar or inferometric – radar will always be part of the equation, as will Lidar data.

Molly Macauley – In May, we had our forest center advisory board meeting. As part of effort, 20 people from academic and corporate community came together. The buzz at that meeting was that Greg Asner is already doing biomass monitoring. How does Greg's effort fit into the picture here? He is already doing it and using Lidar – project-by-project basis – telling us that it is 'free' but is it really free?

Naikoa Aguilar-Amuchastegui – forest carbon scientist – WFF – he is familiar with what Greg is doing in Madagascar effort in Thailand, Arbonet in Nepal. Results are mixed – Lidar measurements are not a cure-all. Hard to transfer to local organizations and institutions. MaxENT model is the model that he uses – but no one produces error maps. Greg's example is not the mainstream effort – these countries are working under REDD standards, which are not precise. We don't know what is going to come out. These aren't as sophisticated as other measures. Voluntary measures are difficult to get to and there is a problem implementing expensive technologies. When work in Peru, Indonesia, Colombia, etc, we have to do it as good as we can – how well can we pay. Funding is always going to be restricted. $50B per year for whole world if extrapolated costs of carbon sequestration – where come from? Carbon emissions reductions based on how good your estimate and basis for the estimate – try not to cover everything with a wall-to-wall product.

Molly Macauley- How often will the REDD markets have to be updated?

Naikoa Aguilar-Amuchastegui - Every two years – we going to use an activity based-approach. Land cover monitoring – cannot do it every two years. National land cover basis – every five years. We shouldn't really ask everyone else to do more. This is not going to fill everyone's pockets. Implement REDD at tier 2 level, lowering the bar – and then if works, improve things later. Technology, knowledge and viability of knowledge, Lidar is cool but it is not really viable on a place-by-place basis. Airborne approach is expensive and difficult to deal with by the countries – we'd love to have NASA space-based product. Replicability across time is difficult because of change of technology, particularly in the Lidar technology. There is no ground plots on the ground – cannot go and measure height of trees in rainforest.

Doug Morton – agrees with Naikoa's points – difficult to know where we sit – lot of promises made but hard to tell if it will happen. There are applications and opportunities beyond REDD+. Resource management and science that should exist beyond REDD +. Number of realistic projects is smaller and smaller and the more precise measurements that are available the better.
Another issue is Deforestation vs. degradation – vary by order of magnitude – in may cases, Brazilians conflate the two issues. We have a set of interesting science questions around carbon stocks and fluxes. Carbon dynamics – net exchange of carbon and forests – error bars are very high still. We can be cautiously pessimistic on the implementation of REDD, but the science is strong.

Jeff Masek – Should we focus on REDD tier-two products?

Naikoa – Many countries are using a stratified hierarchical approach – have as many plots as you can, as many variables, extrapolate estimates you also extrapolate error estimates. We all know that we don't have as many plots as wanted. Should be used as a stepping-stone – could be very useful for errors – we are finding this out in Nepal. Can't use SRTM – geocorrections, etc. Stepping stone approach for frontier areas, etc. Lidar is expensive – mission in Peru is $1.5m – we extrapolated to 4.3 m hectares. We don't know how well that extrapolation is, but we haven't finished in our estimates. In Nepal, Winrock international just delivered a carbon map using traditional approaches – Arbonet is using lidar information. For the first time we can see the improvement and do the cost-benefit analysis between lidar and traditional approaches. What to use where, when is it good, when is it not, steep slopes, transferring knowledge to other countries.

Cost-benefit, resources, transferring, updating, etc. Those are the questions I face every day.

Allison Leidner – Thank you for this - you've summarized three issues –

- first, Lidar is expensive compared to other methods,
- second, is the technological issues, that they are not measuring biomass as well as you thought, and
- third, even if wasn't expensive, we can't use it as a tool – wasn't as much carbon as we thought. Isn't as much help as we thought.

Naikoa – A fourth point is - massive use of lidar technology will require a huge increase in plot measurements. DBH based – need height not biomass. We need to link satellite data with the ground information to make sure we get good results.

Coffee Break

Diane Wickland – program managers at NASA HQ – lead the carbon cycle and ecosystems focus area that this work maps into.

Molly Macauley – We will now ask the representative from the State of Maryland – what do you think we need and what could you use from this product.

Dan Rider – hearing key words and some that he is not hearing. Data needs and how MD will use the data. What might that look like? Would need accuracy level – applications that include being able to quantify changes in the forest to either claim success or being beaten up about our management protocols for carbon. Nitrogen and phosphorous uptake is a critical issue and a key role of forests in Maryland. Precision levels of the product are also important. How frequent should the product be updated? Hard to say, but we would need at a minimum once every 5, or 10 at the outside. We'd like to get it every two years. The policies coming down the pike would need updating every 10 years.

Scale of the product also important. Existing datasets – FIA – what is happening statewide. We measure trees – if going to do it remotely then the issue of scale is very important. Landscape of MD is patchy – interiors, western MD, mountains – unbroken forests, Eastern MD patch size can be big. Rest of state – patches are 150 acres – very small! The accuracy map – I wonder if that high probability of error was related to the small patch size.

Another thing to think about – exchangeability – great that your product fits – we should be able to use the data – data delivery and size of files need to be sufficiently small to access it using on normal computers. That will be an issue – because we are struggling about that on many issues. The cost of using data and information itself can be a big issue if the file sizes are too big or the formats obscure. If we can't afford it we won't use it – one of the driving forces in our interest in remote sensing is to reduce the expense of going out and sampling. We are sitting in the back seat – hoping this is an affordable product.

We are interested in carbon – the Agriculture side of state government is also keenly interested in biomass estimates. If you can get out of woods there is an equally interested argument on the agriculture side. Rate of growth, cover types, differentiate quantification by cover type, maple beech, Loblolly, etc. The most important factor for us is being able to demonstrate change over time. How much today? How much 5 yrs ago vs. today? Is management working and are we achieving our goals and metrics for carbon, etc.

Other areas we would use this information would be for habitat management. We work with NASA and US Fish and Wildlife service to use lidar to predict the species habitat distribution, etc. We'd like to extend this product. Fire – where are our threats for wild-land fire threats, particularly in the wildland-fire interface? We'd like to develop a fire detection plan to be able to rank the relative threats for each individual community based on the biomass predicted, and how it is spatially related to community itself. Oak, hickory, 40% slope, southern aspect, greater than 5 miles water, population density, - focus our resources in developing our fire management instead of another area. This information can make more efficient informed information.

Biomass energy – where is it? Do we have enough wood to fuel a power plant, for how long, at what cost, etc? Steer economic development, etc. What parts of state are at high risk – shouldn't harvest these areas.

The most important will be around water development – a lot of future forest management will be all about water. Not just quality, also water quantity. How biomass information can be used to inform all the various decision making surrounding water issue. How much, where and how fast water refiltration, etc. Frequency of biomass observations – accuracy vs. precision – can identify the change in forests. Ecosystem services that forests provide that support water delivery. 85% of Maryland's population relies on forest-derived water support.

Cheaper to grow a forest than it is to build and maintain a water treatment plants. When start looking at land development patterns – better predict and manage development patterns – focus decision making with a high credibility product developed by NASA or USGS or whomever makes a big difference.

Forest type, density, position in landscape, where should we have forests where we don't already? How healthy are our existing forests? Lidar data we can make predictions as to the health of the forests – sick forests don't make good water. So land use decision-making is going to be how we apply the information.

Molly Macauley – Do you have examples of public policies that are the drivers of work on forests?

Dan Rider – GHG reduction act of 2008. State of MD to reduce overall greenhouse gas emissions by 25% by the year 2020. To implement that the state leads by example – each state agency was given their diet. Here's how much you need to trim the carbon budget – how will you going to do this? State highways – fuel economy – net positive emissions, etc. All agencies emitters and DNR is going to grow more forests and do it better.

This type of information – it feeds directly into our policy. We will be reliant on your information based on satellites and airplanes will become the new standard. The degree of precision that is considered good enough will be ratcheted down. Second decimal place – will be fourth or fifth place in ten years. Million tons of carbon etc. On this acre, this is what we are going to do, this is how much extra carbon we are going to be able to sequester vs 'no management' or old style management. Stand level not tract level. Kind of like precision agriculture – we can be the sample.

Sally Claggett – She works on state and private partnerships – Chesapeake Bay program – as the liaison between National forest service and state and local partnership. How trees contribute to water quality – nitrogen, phosphorus and sediment – the Chesapeake Bay is on a mandatory reduction requirements on the 6 states to reduce these. This is the biggest Total Maximum Daily Load (TMDL) that has ever been tried to be enforced by EPA. Massive area and politically important regulatory action. 43 million acres are covered. All land managers – forest, farms, cities, etc. are covered.

Two things – my role that may be relevant to these are to spy on the biomass – how can we see from space. If we are growing forests, they are attenuating pollution. Bay program has a very complicated model – they contribute a certain amount of pollution coming off the forests. Air deposition – forest processes reduces that amount of those pollutants just by growing. The model is so precise at such a large area, and tries to assign these reductions by forest area. Getting the model right is really important - broad leaves and evergreens – currently the model is a blunt instrument.

Change over time is also very important. In Maryland alone, nitrogen coming off the forests – 14% of nitrogen loading in the state down to 10% in the state. It was that the model did sort of how it was assigning forest, urban areas, etc. Made a huge difference in this regulatory environment.

We also try to demonstrate how forest management can improve pollution reduction – we don't have good evidence, but we believe it. We are always looking for better evidence for this argument. Active management, reducing noxious weeds, grow forests faster, hold on to carbon and actively assimilating nutrients because of some of the actions are done on the forests. Thinning, weed reduction, etc.

Second point of intersect is that the Chesapeake bay pollution diet but is also an executive order strategy 2010 – multi-federal agency effort. There is a new strategy on this executive order. The document describes several major goal areas – responding to climate change, number of actions specific to this area. Better science, better information, and relevant to many efforts. Lead agency is USGS. Document goes out to 2025 – being able to introduce a group of agencies is valuable. NOAA and USGS are major agencies – 9-11 Federal agencies are collaboratoring. Science and technical advisory committees at Chesapeake Bay program would also like to hear more about the strategy.

Peter Griffith– this is a federal executive order? We don't know about it really.

Dan Rider – with our state forests being certified with state forestry standards – measure quantity of biomass – tons or board feet. Now we are getting to the point where we need to demonstrate the form that the biomass is in. How much carbon is going to be harvested and how much will stay in landscape as habitats? How will ongoing management opportunities, managing, burning, etc – how impact nutrient cycling? Scale of entire state and management. The Biomass product can help us with this.

Rich Birdsey – process modeling on how well forests do on taking up deposited nitrogen – biomass-monitoring project. How fast forests are going, not used information directly. Could be a direct input on improving those models. Old forests vs. young forests. Different purpose

Dan Rider – the type of information provided is an important consideration – structure of the forests would be useful. Basal area, height, mental picture of what to expect. Oak hickory type, knowing that there is a well developed mid-story is very important. Most people need to know board feet per acre; we need to know overall health and maintenance. Structure, stand density, total height, species composition, etc.

Molly Brown – Dan Morris, could you tell us about the product you've developed for RFF?

Dan Morris – the tool that could be used by investors to target REDD project. Land cover and carbon density maps from IIASA, and took them and combined agriculture and opportunity costs of land. Rob and others at WWF. We essentially developed profit potential for the entire globe –risk factors, governance measures, ease of doing business, accessibility to markets, rule of law, etc. To come up with unit less measure of forest carbon index – high carbon areas do really well (Brazil) than the Congo in areas – low opportunity cost of land and high carbon metrics. Life on the ground would affect the ability of investors to access the forest.

Now are trying to adjust to new REDD world – five, maybe ten years it will be until the program is implemented. Bilateral and multilateral agreements – developing country gives money to country to be part of REDD world. Wrapping that up right now – how can we take this tool to better fit the policy discussion, make more accessible for USAID and the State Department? First iteration is global – now will try to get to a smaller scale. Is developing a short paper on trying to estimate what the supply on forest carbon would be to California. Markets online in 2013 – have signed a memorandum of understanding of areas giving credits to them – what that would look like.

We need large-scale datasets that have some defensibility – uncertainty is difficult. Risk factors are really uncertain so better data on environment side is important.

Naikoa - historical rates of deforestation derived from Landsat is super important – clear estimates of deforestation rates from 1990 to 2010. SPOT images, etc. The basis of this all rely on landsat imagery. How you use it to strike a deal.

Not just a matter of quantifying how much loosing or adding, but where it is happening on the land surface. 90% prediction of where deforestation is happening using historical data. Linking data to scenarios

What is a forest – we need a definition. Matt Hansen definition is 70% other people's is 10%.

Dan Morris – MRV infrastructure is being built – what could be really valuable is to figure out a way to make sure that the data is widely distributed. Another part of the forest carbon briefs is to define what are the forest carbon standards. Whole discussion about MRV – whole of government approach to deforestation. MRV and silvacarbon and server and other things that are going on right now. Finding ways to make sure that there are data clearinghouse sources for the information is critical.

Molly Macauley – asking Diane, Woody, once the data products are validated, and verified, they would be made available for everyone, would be placed in the DAAC?

Diane Wickland– everything is available, but in what form and is it in a way that user communities can use it. We are exploring the feasibility on quantitative and

space technology – we'd be making datasets that are prototypes of an approach that could be more operational, as our nation's MRV approach. MRV is a difficult word that I also don't agree with.

Molly Macauley – in chart – people use whatever data are available, how good is good enough is defined by what is available. So if you do have thoughts on what should go into the table, please provide them. Are there other communities that we should be asking – where do they fit, people who are suing biomass measures? We can bring them into the dialog – many people do not really think that forests are important. We need to know how to measure them and measure them well. We need to help NASA management to why natural resources matter. We need to speak louder – more people bring to our table.

Peter Griffith – is a forest healthy? Forest biomass question – should be able to estimate from other areas of NASA CCE programs.

Dan Rider – we could use information as a screening tool to figure out why a stand, for example on height and biomass could find low-yielding or sick forests. Another question would be how aggressively should MD pursue carbon markets – faced with the decision on what we should do one day when the market does take off, if it does. We need much more data to determine what to invest.

Naikoa - Additionality – most of the carbon markets – paid for stock and not for flow. There must be also incentives to keep them low. Deforestation level at 0.3% instead of 0.6%, which is between 09-11. There needs to be a stabilization fund – low rates keep them low – otherwise we have to pay to keep forests.

Dan Rider – 85% of private owners own the forest – need policies to keep forests on the land. If you do not develop property, we will pay you. Periodically derive income from sale of products, habitat for wildlife, etc. Other incentive = the hammer instead of the carrot. Carbon markets, wildlife markets, broad spectrum of ecosystem services, baseline services. Repeatable measurements can set up a reward system manage ecosystem as measured by affordable, repeatable, consistent, measuring system, then markets can work.

DNR has 100,000 acres and it didn't dabble in the markets when they were high because they couldn't afford to. American tree farm system – certification system, we would like to piggy back on them to somehow bring ecosystem service markets down to individual land owners can access the markets. Can aggregate with 25,000 land owners who also have 25 acres – government can help this – can access the markets. Still need the data, cheaply – every five years.

Carl Shapiro – four topics to throw out for consideration – extending the focus from one of measurement to the use of the data for analysis.

- Topic 1 – risk – we've had no discussion of risk – as we evaluate carbon and biomass we need to consider risk – of fire, diseases, human

settlement, etc. The risk of change and working to focus on where these changes really matter.

- Topic 2 – whole issue of forecasts – what is the expectation of change. Is there an ability to forecast change? Looking at linking with decision-making we need to forecast future as well as measure past.
- Topic 3 – relationship with other ecosystem services. What other ecosystem services are associated with biomass – water, habitat
- Topic 4- ecosystem health, should be broadened to resilience. How able is the system to recover from a shock if there is disease, fire, etc. What is the ability of recovery is the system strong or are there issue associated
- Topic 5 – what are the drivers of change – what could be the impacts of certain change factors on biomass and ecosystem?

What is NASA CMS? Whole scoping study – using information to affect policy

Naikoa – what you do with the data is the focus of the question.

Carl Shapiro – department of interior – significant land management responsibility, DNR uses data, forest service uses the data. All factors are important

Jeff Masek– question for Dan Morris – when data are available we are focusing on US. We all have in the back of our heads on how to map uncertainty, could be applied globally particularly in Silvacarbon. How transferrable are the lessons if we stick to the US?

Dan Morris – applicability of lessons in US – not as applicable because the international system – MRV system on data gathering is extremely nascent. Other people out there who are interested in REDD, can't gather, absorb or even use data.

Should it be a goal of NASA to go international? Absolutely – should supply the data and how we should measure, more reliable measure over time, etc. Landsat data forms the basis of many deforestation measures and we can build on that history.

Naikoa – US has a specific situation, but just because there is access to data, but doesn't mean that it is being used. Brazil is using MODIS and Landsat – countries are catching up really fast on MRV. Colombia used $2million from the Moore foundation and is moving really fast and have the whole system set up and are ready to go. Decent initial stage – landsat, MODIS, more ground plots, MODIS early warning system – phenology measurements to be an early warning system. Hierarchical system that will really work.

Starts up funds are critical – once that money runs out – how are MRV systems going to maintain themselves? Japanese, Europeans, American, - developing countries have access. Cost-benefit things. Landsat is the reference because 40 years of data. If you talk degradation – landsat band 5 spectral mixture analysis, tassel cap, etc.

LDCM – five landsats, more modis – more data. Degradation is a process, hierarchical approach.

Grabbing data and massaging data into something decision makers are going to use, etc. Great opportunity that allow us to digest research – we publish among ourselves. Listen to what people are doing with data abroad. Weird stuff people use – rapid land cover mapping system – to the coolest system. One thing – all the 47 countries are doing MRV implementation now. Now they are doing stuff now – new data, Brazilians are everywhere.

Niara Pinto – Could we develop a priority map for Maryland, where are the places important for water, fire, susceptible for hurricane damage – where should we prioritize the high resolution data acquisition? How to gather more information from MD for example?

What are the intermediate products? What would you do with it? Each country using a different procedure – what agencies can tell what appropriate classes, standards, etc. Standards, will happen – comply with standards. How countries are implementing MRV system, we are all using the same datasets and analytical processes. A pan-tropical map is not very helpful for administration. One-hectare resolution carbon map – reporting unit. Functional scale – 100m to 250m.

Land cover product – allow you to stratify carbon sampling with accuracy that will focus on standard that need to deliver carbon markets. How good – research that moves the frontiers – paying attention to what standards are going to be.

Dan Morris – there is possible, and what can actually do and deliver for not too much money. An excellent place for this community to be in the discussion. Education on what is really possible and difference. Budget –

Doug Morton– cost benefit analysis, different sampling intensities, ability to constrain the carbon stocks, not 25 cents per hectare. Depends on how to extrapolate. Can we come up with ranges of costs, from highly sampled to out of the air information? No understanding of accuracy in many of the policies.

Naikoa – full waveform or one bounce – we should compare them to find out how good the estimates are, significantly different, or not, or what the costs differences are? We need answers. Lidar sampling questions – stratify with respect to plots on ground. Ground plotting and lidar area coverage. ‘

Jeff Masek– where geographically are the break points? Some differences make huge impact on errors.

Woody Turner – Assigning uncertainties to biomass is key. Worthy research effort and one Diane has been working to support. Behind that is the NASA Biodiversity Program that knows vegetation structure matters in terms of what lives there. Our

understanding of that is really important – species composition is at center of our work.

On the applied side – simpler may be better for now – Landsat data and MODIS – large stacks of data, time series of deforestation, etc. – use these to generate land cover change (deforestation) estimates. Those rates of deforestation are very useful for getting something going immediately as we work toward more complex estimates of biomass. We need to get Landsat data processed to some land cover that users can agree on. In 2011, the EROS Data Center is generating global 30m land cover products from Landsat (and other) data. This is a good start. We do not have that yet. We can focus on fancier data later.

Naikoa – when you look for TM 5 data – southwestern data in Colombia and Ecuador is missing!

Diane – One of my big take-home messages from this meeting is that users don't care about water and carbon and ecosystem divisions of NASA. We must work harder at crossing the different discipline areas in CCE.

Molly Macauley – enhancing the relevance of CMS. Those who sought to fund it may have had a more limited role. CMS is important but it has much greater relevance than we might have thought.

Naikoa - we preserve nature – REDD came up, we forgot everything. But now one of the jobs is to reeducate that MRV is an excuse to figure out what is going on. Carbon is just an excuse – the impact is going to be way larger than bigger than that.