PROTOCOLS FOR FIELD SAMPLING OF FOREST CARBON POOLS FOR MONITORING, REPORTING AND VERIFICATION OF REDD

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1. ABSTRACT

Monitoring, reporting and verification (MRV) of forest carbon (C) stocks, changes in these stocks (ΔC) and the resulting greenhouse gas emissions (GHGe) are critical technical challenges of climate change mitigation initiatives aiming to reduce emissions from deforestation and forest degradation in developing countries (REDD) [1,2]. MRV systems for annual reporting for REDD will require the careful integration of remotely sensed (RS) data and ground measurements for the retrieval of C, ΔC and GHGe with sufficient precision and accuracy to be marketable and tradable [3].

We will present protocols that can guide the design of field measurement campaigns for estimating C, ΔC and GHGe for national MRV systems in developing tropical countries. Field sampling will be an expensive component of MRV systems and efficiency and cost effectiveness are paramount. The design of any field measurement campaign must be explicitly integrated with the RS data source to be used for biomass retrieval; RS data will assist in the design of an efficient field sampling campaign by defining stratum and identifying areas of spatial variability; field sampling of C pools within stratum (with intensity selected to achieve desired error bounds on averages) can be used to calibrate remote biomass retrieval; further field sampling can be used to validate wall to wall biomass estimates. The calibration and validation of RS data for accurate and precise wall to wall biomass retrieval will be integral to MRVs [4].

Forest C pools that need to be measured in tropical forests include above- and below-ground living and non-living biomass. The largest and most important C pool in tropical forests is above ground live biomass in woody plant material. Measurement of this pool will be the foundation of C, ΔC and GHGe estimates [5]. Other C pools include fine litter (FL), coarse woody debris (CWD), below ground live biomass in root material, and soil

organic C. Fine scale measurements of C allocation and cycling for estimating decay rates, C fluxes, and respiration require detailed field studies [6] but may also be necessary for estimating GHGe. In particular, decay rates in FL and CWD need to be estimated as they are the major source of emitted CO_2 in forest ecosystems and vary significantly with mean temperature and elevation [7].

Techniques for measuring forest C stocks such as temporary or permanent sample plots, and repeat census for estimating ΔC and GHGe will be discussed. Uncertainties in field based estimates of C and ΔC propagate in calculations inflating errors associated with wall to wall biomass retrieval and estimates of GHGe [8]. Indeed, incomplete field data will result in highly uncertainty estimates of GHGe that may compromise REDD as an emerging climate change mitigation initiative [9]. Therefore, field sampling efforts should target those C pools that exert the greatest influence on, and reduce uncertainty in, final estimates of ΔC and GHGe. Sampling should also focus on C pools most affected by changed land-use practices under a REDD mechanism such as forestry and agriculture. Following this, MRV field sampling should focus on above ground live biomass in woody plant material in areas susceptible to forestry and agricultural activities. We will demonstrate these field sampling protocols and integration with RS data using examples from Papua New Guinea.

3. REFERENCES

[1] H. K. Gibbs, S. Brown, J. O. Niles, and J.A. Foley,. "Monitoring and estimating tropical forest carbon stocks: making REDD a reality". *Environmental Research Letters* 2. 2007

[2] J.B. Kauffman, R.F.Hughes, and C. Heider. "Carbon pool and biomass dynamics associated with deforestation, land use, and agricultural abandonment in the neotropics". *Ecological Applications* 19:1211-1222. 2009.

[3] GOFC-GOLD, *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation*. GOCF-GOLD Report version COP15-1, GOFC-GOLD Project Office, Natural Resources Canada, Alberta, Canada. 2009.

[4] S.Wertz-Kanounnikoff, L.V.Verchot, M. Kanninen, and D. Murdiyarso. How can we monitor, report and verify carbon emissions from forests? P. 87-98 In; Angelsen, A. (ed.) *Moving ahead with REDD: Issues, options and implications*. CIFOR, Bogor, Indonesia. 2008.

[5] J.C. Fox, C.K. Yosi, P. Nimiago, F. Oavika, J.N. Pokana, K. Lavong, and R.J. Keenan. "Assessment of aboveground carbon in primary and selectively-harvested tropical forest in Papua New Guinea". *Biotropica* In press. 2009.

[6] D. Metcalfe, O. Phillips, T. Baker, R. Brienen, K. Chao and J. Silva. *Measuring Tropical Forest Carbon Allocation and Cycling. RAINFOR field manual.* Oxford University. 2009.

[7] J.C. Fox, C.K. Yosi, and R.J. Keenan. *Estimating CO2 emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea*. Report submitted to the Department of Environment and Conservation, Papua New Guinea. 2009.

[8] J. R. Chave, S. Condit, A. Aguilar, S. Hernandez, K. Lao and R. Perez. "Error propagation and scaling for tropical forest biomass estimates*"*. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 359: 409-420. 2004.

[9] G. Grassi, S. Monni, S. Federici, F. Achard, D. Mollicone. "Applying the conservativeness principal to REDD to deal with the uncertainties of the estimates". *Environmental Research Letters*, 3,035005. 2008.