

average, and ranged from 178.41 to 369.70 metric tons C/ha. The carbon sequestered during the 2 years of the study based on biomass accumulation in the four natural mangrove stands studied was 3.83 t C/ha/yr, on average, and ranged from 1.90 to 5 t C/ha/year. For mangrove plantations, all of the plantations studied were *Rhizophora* plantations, mostly mixed *Rhizophora apiculata* and *Rhizophora mucronata* stands with trees 12–27 yr old or 18.5 yr on average. The combined carbon held by the biomass and upper 30 cm of sediment in the mangrove plantations was on average 190.59 metric tons C/ha and ranged from 117.56 to 262.45 metric tons C/ha. The yearly rate of carbon accumulation in the biomass of the four mangrove plantations based on carbon stock and plantation age was 4.01 t C/ha on the average and ranged from 2.75 to 5.15 t C/ha/year. The study demonstrated the potential of mangrove forests in the Philippines, both in natural stands and in plantations, as an option for climate change mitigation.

National assessment of non-timber forest products: prospects for improving the reporting of volumes and values of these products. Chamberlain, J., Patel-Weynand, T., Haan, T. (U.S. Forest Service, USA; jchamberlain@fs.fed.us; tpatelweynand@fs.fed.us; tjhaan@fs.fed.us).

Non-timber forest products (NTFPs) have been significant contributors to the forest products industry in the United States (Chamberlain *et al.*, 1998) since this country was established. The United States has been a major supplier of herbal forest products used for their medicinal value, though the economic contribution has not been fully accounted for in valuing the forest products industry. For more than 60 years, the U.S. Forest Service has been tracking wood production through the timber products output (TPO) assessments and can estimate production by product and county of origin. In addition, the Forest Service's Forest Inventory and Analysis (FIA) group can estimate growing stock, tree removals, and forest condition and age, as well as land ownership patterns. These estimates provide a comprehensive assessment of the trees and timber products that make up the forests and related industries. But that assessment capability is lacking for the non-tree resources or the non-timber products that are harvested from the forests. Through a series of interviews, conversations, a workshop, and reviews of policies, regulations, and literature, the Forest Service has undertaken a national assessment to examine the potential and pitfalls of improving the reporting of NTFPs. This presentation examined the status of non-timber forest products and identified gaps in the knowledge and ways to improve conservation, management, and reporting of these valuable products.

Assessment of aboveground biomass and soil carbon storage of the fallow forests after swidden cultivation in the Bago Mountains, Myanmar. Chan, N. (Kyoto University, Japan; nchan08@gmail.com), Takeda, S. (Kyoto University, Japan; takeda@asafas.kyoto-u.ac.jp), Suzuki, R. (Kyoto Gakuen University, Japan; suzuki@kyotogakuen.ac.jp), Yamamoto, S. (Kagoshima University, Japan; sotayama@cp.kagoshima-u.ac.jp).

This study was conducted to assess the aboveground biomass (AGB) accumulation and soil carbon (SC) storage in the swidden cultivated fallows of the Bago Mountains, Myanmar, by using a chronosequential approach. The 34 sample plots were randomly set up in 1-, 5-, 10-, 15-, 20-, 25-, and 30-year-old fallows, as well as in nearby old forests. The AGB in the fallows was estimated by the allometries established through destructive sampling. Similarly, the 213 soil samples were taken at 0–10 cm, 10–20 cm and 20–30 cm layers from the fallows to analyze soil carbon storage by using an NC analyzer. The average total AGB (including trees, bamboo, understorey vegetation, and vines) in 1-, 5-, 10-, 15-, 20-, 25-, 30-year-old fallows and in the nearby old forests were 13.91, 31.31, 52.96, 66.52, 103.12, 88.45, 92.42 and 112.48 Mg/ha, respectively. The average total SC was 23.31, 18.31, and 15.01 Mg ha⁻¹ in the 0–10 cm, 10–20 cm and 20–30 cm layer, respectively. The results show that the AGB increased with fallow age, with the largest contribution by bamboo biomass in the fallows. However, the average SC accumulation in the fallows was about 58.14 Mg/ha with the fluctuation trend along the fallow age.

The contribution of historical vegetational database recovery to the study of forest biodiversity in Trentino (Italy). Ciolli, M. (University of Trento, Italy; Marco.Ciolli@unitn.it), La Porta, N., Zottele, F. (Edmund Mach Foundation, Italy; nicola.laporta@fmach.it; fabio.zottele@fmach.it), Geri, F. (University of Trento, Italy; geri.francesco@gmail.com).

Multi-temporal biodiversity data for a forest ecosystem can provide useful information about the evolution of biodiversity in that area. The Edmund Mach Foundation owns an archive used to determine the main Schmid's vegetational belts in the Trento province of Italy. The archive contains data collected over 20 years, from the 1970s until the 1990s. The database was developed with tools and technologies that are now obsolete, making it unusable. As part of the FORCING project, a comprehensive process of database recovery was carried out: an analysis of the data structure was performed to reverse-engineer the database structure, and missing data were digitized from historical maps and other preserved documents. All the maps of the 16 forest districts and the related 8,000 detected transects have been georeferenced to geographically enable the whole database and to evaluate the possibility of performing comparative samplings on up-to-date data sets. Raw data for vegetation (about 200,000 specific identifications including frequency indices) remain an important and irreplaceable source of information not only for their historical value, but also for many other applications. Provided here are examples of how this kind of data can be used in different multitemporal comparisons. The potential and the limits of the specific data set and of the historical data base in general are highlighted.

An historically consistent and broadly applicable MRV system based on LiDAR sampling and Landsat time-series. Cohen, W., Andersen, H., Healey, S., Moisen, G., Schroeder, T., Woodall, C., Domke, G. (U.S. Forest Service, USA; wcohen@fs.fed.us; handersen@fs.fed.us; seanhealey@fs.fed.us; gmoisen@fs.fed.us; tschroeder@fs.fed.us; cwoodall@fs.fed.us; gmdomke@fs.fed.us), Yang, Z. (Oregon State University, USA; zhigang.yang@oregonstate.edu), Stehman, S. (State University of New York, USA; svstehma@syr.edu), Kennedy, R., Woodcock, C., Zhu, Z. (Boston University, USA; kennedyr@bu.edu; curtis@bu.edu; zhuzhe@bu.edu), Vogelmann, J., Steinwand, D. (U.S. Geological Survey, USA; vogel@usgs.gov; steinwand@usgs.gov), Huang, C. (University of Maryland, USA; cqhuang@umd.edu).

The authors are developing a REDD+ MRV system that tests different biomass estimation frameworks and components. Design-based inference from a costly field plot network was compared to sampling with LiDAR strips and a smaller set of plots in combination with Landsat for disturbance monitoring. Biomass estimation uncertainties associated with these different data sets

in a design-based inference framework was examined. The authors are also testing estimators that rely primarily on Landsat within a model-based inference framework. Contributions from Landsat are current (e.g., 2013) spectral response and metrics describing disturbance history derived from a time-series leading up to the current date. An advantage of the model-based framework is its extension back in time (e.g., to 1990) using a consistent approach based on disturbance history as an indicator of biomass density. This requires use of the older, MSS archive to be fully effective in estimating biomass for the 1990 baseline. The United States, though not a REDD country, is party to the UNFCCC and has a need for similar NGHGI baseline information. The various components of the authors' MRV system will be tested in the United States, where sufficient data are available for parsing the uncertainty contributions of the several system components being tested.

Longitudinal and radial variation of the wood density in an unmanaged stand of *Araucaria angustifolia*. Curto, R. (*Federal University of Paraná, Brazil; rafaellacurto@yahoo.com.br*), Mattos, P., Muñoz-Braz, E. (*EMBRAPA, Brazil; patricia.mattos@embrapa.br; evaldo.braz@embrapa.br*), Pellico Netto, S. (*Federal University of Paraná, Brazil; sylvio pelliconetto@gmail.com*), Zachow, R. (*Brazilian Forest Service, Brazil; randolfzachow@hotmail.com*).

The objective was to evaluate the wood density variation of *Araucaria angustifolia* in a 66-year-old stand. Thinning was carried out only between 1970 and 1980, without records after this period. Nine trees in three diameter classes (suppressed, intermediate, and dominant) were selected randomly. Wood density was determined at six different heights (0, 20, 40, 60, 80, and 100% of commercial stem) and in the radial direction in five samples, for each height. The average wood density along the stem presented no statistical difference among the three diameter classes, when comparing similar height percentages. Average wood density differed significantly, decreasing in the longitudinal direction. However, it was observed that the average wood density at 60% was greater than at 40%, suggesting that this is an effect related to the thinning carried out in the past. Management of *Araucaria angustifolia* stands, aiming at balanced tree competition with periodic thinning, will enable the production of wood with lower density variability, and will reduce problems in mechanical processing.

Forest carbon storage and tree biomass dynamics under the Natural Forest Protection Project in the northeastern forest region of China. Dai, L. (*Chinese Academy of Sciences, China; lmdai@iae.ac.cn*).

The role of forest ecosystem carbon storage and biomass dynamics under the Natural Forest Protection Project (NFPP) in China's forests remains unknown. This study collected forest inventory data and used plot databases in northeastern China to calculate forest ecosystem carbon storage in the region. Results showed that under the NFPP trees in the northeastern region functioned as a carbon sink from 1998 to 2008, with a carbon storage accumulation of 6.3 Tg C/yr. Most of the C storage was in natural forests (5.1 Tg C/yr), but simultaneously, planted forests also acted as a carbon sink, with accumulation of 1.2 Tg C/yr. In addition, the existing total ecosystem carbon storage in the region was 4 603.8 Tg C, of which 4 393.3 Tg C was stored in natural forests and 210.5 Tg C in planted forests. Tree carbon density of natural forests was also higher than in planted forests. Soil contained the largest carbon storage and contributed 69.5–77.8% of total carbon storage. Tree and forest floor carbon pools accounted for 16.3–23.0% and 5.0–6.5%, respectively. Understory pools, which ranged from 1.9 to 42.9 Tg C, accounted for only 0.9% of total carbon storage under the NFPP in northeastern China.

Using inventory-based tree-ring data as a proxy for historical climate: investigating the Pacific decadal oscillation and teleconnections. DeRose, R. (*U.S. Forest Service, USA; rjderose@gmail.com*), Wang, S. (*Utah State University, USA; simon.wang@usu.edu*), Shaw, J. (*U.S. Forest Service, USA; jdshaw@fs.fed.us*).

In 2009, the Interior West Forest Inventory and Analysis (FIA) program of the U.S. Forest Service started to archive approximately 11 000 increment cores collected in the Interior West states during the periodic inventories of the 1980s and 1990s. The two primary goals for use of the data were to provide a plot-linked database of radial growth to be used for growth model development and other biometric analyses, and to develop a gridded dendroecological database that could be used to analyze regional patterns of climate, disturbance, and other ecosystem-scale processes. Early analysis related to the latter goal showed that the finely gridded data could be used to map past climatic patterns with more detail than is possible using traditional chronologies. FIA-based Douglas-fir and pinyon pine chronologies showed high temporal coherence with previously published tree-ring chronologies, and the spatial and temporal coherence between the FIA data and water year precipitation was strong. FIA data also captured the El Niño-Southern Oscillation (ENSO) dipole and revealed considerable latitudinal fluctuation over the past three centuries. Finally, the FIA data confirmed the coupling between wet/dry cycles and Pacific decadal variability known to exist for the Intermountain West. These results highlight the further potential for high-spatial-resolution climate proxy data sets for the western United States.

Adaptability of ecosystem-based management to climate-induced increase in fire frequency and growth anomalies in an eastern Canadian boreal forest. Dhital, N., Raulier, F. (*Laval University, Canada; narayan-prasad.dhital.1@ulaval.ca; Frederic.Raulier@sf.ulaval.ca*), Bernier, P. (*Natural Resources Canada; pbernier@nrcan-mcan.gc.ca*), Lapointe-Garant, M. (*Université du Québec à Montréal, Canada; lapointe-garant.marie-pierre@courrier.uqam.ca*), Bergeron, Y. (*Université du Québec en Abitibi-Témiscamingue, Canada; yves.bergeron@uqat.ca*), Rodriguez, G. (*Laval University, Canada; gereroba@gmail.com*).

Adaptability of ecosystem-based management (EBM) to the potential impact of climate change was evaluated with attention to the role of climate on forest growth and fire regime in a boreal forest of eastern Canada. A climate-sensitive growth index model was calibrated for three commercial species (black spruce (*Picea mariana* (Mill) B.S.P.), jack pine (*Pinus banksiana* Lamb.), and trembling aspen (*Populus tremuloides* Michx.). The model was used to project the evolution of merchantable volume over time under conventional sustained yield timber production and EBM under two climate scenarios. Current burn rate and burn rates under future climate scenarios were also considered. Under the projected climate scenarios, the periodic timber supply responded with long-term reduction by up to 79%. An interaction between the response of growth and fire to the projected climate scenarios was also revealed. EBM emerged a better management strategy in the context of projected climate. It maintained a higher mean standing inventory age, a lower proportion of area under younger age, and a higher level of periodic timber supply. However, further adaptation strategies are needed to deal with the projected climate scenarios and their potential impact on growth and disturbance dynamics.