was created to follow up on the climate change impact on the main economic activities in the country. However, information for the forest sector was too scarce to allow any objective assessment of its exposure, sensitivity, and adaptive capacity to climate change. The objective of this work was to present empirical evidence as the basis of an analysis of climate change impacts in *Eucalyptus* and *Pinus* spp. plantations. The relationship between disturbance of forest tree phenology and growth, pest outbreaks, and extreme frost, drought, rainfall, and storm events from 1998 to 2012, and temperature and precipitation variations as the main climatic factors was investigated. The aim was creation of the first long-term data series in the country on climate change impacts on forest plantations. The need to consolidate this data series for use in modeling and prediction of climate change impacts on forest plantations at the local level and as a tool for practitioners is discussed.

**'Carbon debt' – lost in the forest?** Bentsen, N., Graudal, L., Madsen, P., Felbu, C. (*University of Copenhagen, Denmark; nb@ign.ku.dk*; *lgr@life.ku.dk; pam@ign.ku.dk; cf@gmail.com*).

The concept of 'carbon debt' and carbon payback time with reference to bioenergy and biofuels was probably launched by an article in Science in 2008. The concept is increasingly seen as an indicator of the sustainability of bioenergy supply chains. Particularly for forest bioenergy supply chains the time lapse between harvest and regrowth may be a significant factor for the modeled carbon debt. A meta-analysis of more than 250 model scenarios was conducted to evaluate the factors and assumptions determining carbon debts and payback time of forest bioenergy supply chains. Factors such as spatial and temporal scale, biome, origin of the wood resource, which fossil fuels are displaced, forest history, baseline scenario, accounting principle, and data background were included in the analysis. This paper discusses the evolution of the carbon debt concept, how different factors and assumptions influence the outcome of carbon debt studies, the reproducibility of carbon debt analyses, and the applicability of the concept as a measure of sustainability of forest bioenergy supply chains.

**Assessing forest change across Canada using successive kNN-based maps of imputed forest inventory data.** Bernier, P., Beaudoin, A., Guindon, L., Villemaire, P., Stinson, G. (*Canadian Forest Service, Canada; pbernier@rncan.gc.ca; abeaudoin@nrcan.gc.ca*, *lguindon@rncan.gc.ca; philipe.villemaire@rncan.gc.ca; graham.stinson@nrcan.gc.ca*).

The authors recently produced a suite of national maps of forest attributes for Canada at a resolution of 250 m for the 2001 base year. The non-parametric kNN approach was applied on a set of Canada-wide layers of predictive variables, most notably multi-spectral information from the MODIS sensor, as well as climate variables, topography, and land cover to impute National Forest Inventory baseline measurement data. Yearly maps at 250-m resolution were also produced showing severe forest disturbances, i.e., yearly areas affected by either harvesting or fire from 2001 to 2011. This paper presents updated maps of forest properties for 2011 and evaluates the extent to which changes between these maps and those for 2001 are able to capture the patterns of changes expected based on the yearly disturbance maps. Limitations of the approach as well as avenues for improvements of the kNN products are discussed.

**Estimating stand heights and crown structure of subtropical broad-leaved forest using LiDAR data in Okinawa island, Japan.** Binti Ahmad Zawawi, A. (*Kagoshima University, Japan; azitazawawi@gmail.com*), Shiba, M. (*Faculty of Agriculture, University of the Ryukyus, Japan; mshiba@agr.u-ryukyu.ac.jp*), Jemali, N. (*Kagoshima University, Japan; idiana0303@yahoo.com*).

The application of LiDAR to extract data at the single-tree level has long been recognized in providing valuable information about forest stands. Most studies involving crown detection and tree height estimation have focused on analysis of plantations, boreal forests, and temperate forests, and less study has been done in subtropical or tropical forests. This study presents an approach for estimating tree heights, stand density, and crown structure using LiDAR in the complex subtropical forest of Okinawa island in Japan. A digital canopy height model (DCHM) was derived from the LiDAR data for tree height estimation, and the watershed segmentation method was applied for individual crown delineation. Dominant tree canopy layers were estimated using multi-scale filtering and local maxima detection. Information on crown structure characteristics such as crown diameter and fractal dimension was also produced. The computed result was compared to field data and validated using IKONOS imagery over the forest area. The results of this study suggested that LiDAR data have huge capability to estimate tree height in subtropical forests, but were not sufficiently capable in the detection of small understory trees and in single-tree delineation. We found that LiDAR computation results underestimated the frequency of trees and overestimated the crown size.

**Comparing alternatives for increasing sampling intensity in forest inventories.** Blackard, J., Patterson, P. (*U.S. Forest Service, USA; jblackard@fs.fed.us; plpatterson@fs.fed.us*).

Each of the U.S. Forest Service's Forest Inventory and Analysis (FIA) regions has an occasional need to intensify the national sampling grid. A variety of methodologies exist within the various FIA regions and National Forest Systems regions for constructing plot intensifications, and there is no consensus on a national procedure The primary objectives of this paper were to identify various intensification methods being implemented by FIA or used by other groups, examine their advantages and disadvantages for establishing intensified plots within the existing FIA framework, and recommend a potential national FIA plot intensification procedure that might adequately address the needs for all FIA regions.

**Paired catchment experimental methodology: a critique.** Bren, L. (*University of Melbourne, Australia; lbren@ncable.net.au*), Nettles, J. (*Weyerhaeuser Company, USA; jami.nettles@weyerhaeuser.com*).

Paired catchment experiments have been around for almost a century. This paper examines how the technique has been used since the first project at Wagon Wheel Gap in Colorado, USA. Recent Australian work on the units and length of the calibration period showed that there is a rapid buildup of information in the first year of calibration and there may be little gain in long calibration periods. For this paper this hypothesis was tested in other countries using international data sets. Errors of measurement with this method were compared to alternative approaches such as plots or modeling. Although the presence of a "control" catchment is a great asset, the assumption of this control as a constant is examined given the long duration of some projects, and supplementary