

## Achieving multifunctional forest management through three-level structured silvicultural regimes: a review of case studies and pilot demonstration progress in China

Yuanchang Lu<sup>1</sup>, Xianzhao Liu<sup>1</sup>, Yangsheng Xie<sup>1</sup>, Xiangdong Lei<sup>1</sup>

<sup>1</sup>Chinese Academy of Forestry, Beijing, China (ylu@ifrit.ac.cn; xieys@ifrit.ac.cn; xieys@ifrit.ac.cn; xieys@ifrit.ac.cn)

Multifunctional forest management (MFFM) has been the new trend in forestry development in China and the world in the 21<sup>st</sup> century. It is an innovative model which actively strengthens and develops the many forest services and provides social, economic, environmental and ecological benefits for sustainable human development. The fundamental objective of forest management is to establish and maintain the stability and resilience of the forest ecosystem to maximize its viability, productivity and service functions. In this review the concept, scientific principles, technical processes and methodology for experimental verification of the silvicultural regimes (SRs) of MFFM are described. In addition, the paper addresses a three-level structured silvicultural technical system (STS) and Chinese MFFM development system which, based on the principle of using natural and artificial forces synergistically, integrates function/condition constrains, full growth/management cycle and standardized description of measures and elements of the final target. By monitoring, comparing and analyzing data from operational and reference plots of applying this STS as a national basis for forest management were compared. These results show that the objectives of MFFM models are being achieved and the new STS with three-level SR has a positive impact on the development of multifunctional forestry in China.

## Risk and governance dilemmas associated with assisted migration in the forest sector of British Columbia, Canada

Ricardo Pelai<sup>1</sup>, Shannon Hagerman<sup>1</sup>, Robert Kozak<sup>1</sup>

<sup>1</sup>University of British Columbia, Vancouver, Canada (ricardo.pelai@alumni.ubc.ca; shannon.hagerman@ubc.ca; rob.kozak@ubc.ca)

The assisted migration (AM) of trees is increasingly being proposed as a means of adapting forest management to climate change impacts. While there is a proliferation of natural science research to inform the implementation of AM, social science research in this domain remains relatively sparse. We use the case of the Canadian province of British Columbia (where AM policy is currently in development) to examine the human behavioral (e.g. perceived risks), and governance (e.g. participation in decision-making and the use of different forms of knowledge) dimensions of this emerging policy option. Based on 30 in-depth, semi-structured interviews with key government officials and forest industry professionals involved with AM, we find an overall optimistic view of AM. However, we identify three emergent dilemmas: i) narrow conceptions of the types of evidence that is required in decision-making (mostly biophysical), ii) uneven input from different stakeholder and rights holders, and iii) prevailing views that knowledge flows in a linear fashion at the science-policy interface. These findings demonstrate the contributions that social sciences (produced at multiple scales and from different worldviews) can make to decision-making for the implementation of assisted migration.

## Bid: RESILIENCE OF MANAGED TROPICAL FORESTS: IT IS TIME FOR SILVICULTURE

### Disturbance intensity determines recovery of multiple functions after a first logging cycle in the Brazilian Amazon

Angela Luciana de Avila<sup>1</sup>, Ademir Roberto Ruschel<sup>2</sup>, José Natalino Macedo Silva<sup>3</sup>, Lucas Mazzei<sup>2</sup>, João Olegário Pereira de Carvalho<sup>3</sup>, Jürgen Bauhus<sup>4</sup>

<sup>1</sup>Forest Research Institute Baden-Württemberg, Freiburg im Breisgau, Germany; <sup>2</sup>Embrapa Amazônia Oriental, Belém, Brasil; <sup>3</sup>Universidade Federal Rural da Amazônia, Belém, Brasil; <sup>4</sup>Chair of Silviculture, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg im Breisgau, Germany (angela.avila@forst.bwl.de; ademir.ruschel@embrapa.br; silvanatalino734@gmail.com; lucas.mazzei@embrapa.br; olegario.carvalho@gmail.com; juergen.bauhus@waldbau.uni-freiburg.de)

Sustainable forest management is based on the assumption that forest ecosystems are resilient to silvicultural interventions so that their ecosystem functions can recover between felling cycles and thus be maintained in the long term. However, our understanding of responses to silvicultural interventions and factors driving tropical forest resilience is rather limited. Here, we investigated how management intensity and post-logging (remaining) biological legacies (basal area and species diversity) affect the resilience of important forest attributes and functions related to biodiversity conservation, carbon sequestration and timber provision within 30 years following initial logging. We analysed data from a unique long-term experiment located in the Tapajós National Forest, Pará, Brazil, where trees  $\geq 5$  cm DBH were measured on 8 occasions in 41 permanent sample plots including unlogged forest. Management intensities comprised logging (1982) with associated damage and follow-up thinning (1993-1994). An important finding was that the recovery of tree species composition, above-ground biomass and timber stocks was impaired when basal area was reduced by more than 20% relative to pre-logging stocks. In contrast to our expectations, remaining basal area and diversity had no effect, but management intensity determined the recovery of multiple functions over the first logging cycle. Thus, when managing for ecosystem resilience within current felling cycles, our findings indicate that management intensity will directly affect the recovery capacity and subsequent ability of continuous provision of goods and services in these managed tropical forests of the Eastern Amazon.

### The main challenges of sustainable forest management in the Amazon: why sustainable forest management in the Amazon should be reinforced?



Plinio Sist<sup>1</sup>, Lucas Mazzei<sup>2</sup>, Camille Piponiot<sup>1</sup>, Bruno Hérault<sup>1</sup>, Geraldine Derroire<sup>3</sup>, Euridice Honorio<sup>4</sup>, Milton Kanashiro<sup>2</sup>, Marcus d'Oliveira<sup>5</sup>, Marielos Peña-Claros<sup>6</sup>, Ken Rodney<sup>7</sup>, Virginia Wortel<sup>8</sup>, Alexander Shenkin<sup>9</sup>

<sup>1</sup>Cirad-Forests & Societies, Montpellier, France; <sup>2</sup>Embrapa Amazônia Oriental, Belém, Brasil; <sup>3</sup>Cirad-Ecofog, Kourou, French-Guiana; <sup>4</sup>IIAP, Iquitos, Peru; <sup>5</sup>Embrapa Acre, Rio Branco, Brasil; <sup>6</sup>Wageningen University, Wageningen, Netherlands; <sup>7</sup>Iwokrama, Iwokra, Guyana; <sup>8</sup>CELOS, Paramaribo, Suriname; <sup>9</sup>Oxford, London, United Kingdom (sist@cirad.fr; lucas.mazzei@embrapa.br; camille.piponiot@gmail.com; bruno.herault@cirad.fr; geraldine.derroire@cirad.fr; eurihc@yahoo.com; milton.kanashiro@embrapa.br; marcus.oliveira@cirad.fr; marielos.penaclaros@wur.nl; krodneyn@iwokrama.org; rubia\_w@yahoo.com; ashenkin@ufl.edu)

Since the last 50 years, tropical natural forests have been intensively logged in the tropics to supply the increasing demand of tropical timber. Unplanned logging operations caused forest degradation leading to their conversion due to the loss of their commercial value. Today, natural forests remain a major source of timber and tropical production forests worldwide are estimated to cover around 400 million ha. Studies carried out on the long term impact of logging on timber yield showed that at best about only 50% of the timber volume extracted during the first harvest will be available for the subsequent cycles. We estimated the potential of natural production of the Amazonian forest to supply the future wood demand using more than 200 permanent plots for monitoring the long term response after logging of the TmFO network. Our results clearly show that natural forests alone will not be able to supply the increasing demand of tropical timber in the region and that significant efforts in forest restoration through plantations as well as intensive silvicultural practices such as enrichment planting in gaps and liberation, must

be initiated immediately. Although natural forests will not be able to supply alone the timber market demand, they will play a major role in environmental services (including biodiversity protection and conservation, climate change mitigation rather than solely for timber provision while they will continue to provide necessary income to forest communities that depend on the forests for their livelihoods).

### Population management of *Juniperus procera* tree from Ethiopia

Mindaye Teshome Legese<sup>1,2</sup> ; Tesfaye Bekele<sup>1</sup>, Patricia Póvoa de Mattos<sup>3</sup> ; Aline Canetti<sup>4</sup> ; Evaldo Muñoz Braz<sup>3</sup> ; Carlos Moreira Miquelino Eleto Torres<sup>2</sup>  
<sup>1</sup>Ethiopian Environment and Forestry Research Institute, P. O. Box 30708 code 1000, Addis Ababa, Ethiopia; <sup>2</sup>Universidade Federal de Viçosa, Departamento de Engenharia Florestal, Viçosa, Brasil; <sup>3</sup>Embrapa Florestas, Colombo, Brasil; <sup>4</sup>Universidade Federal do Paraná, Departamento de Engenharia Florestal, Curitiba, Brasil (mindayet@gmail.com; tebean77@yahoo.com; patricia.mattos@embrapa.br; alinecanetti@gmail.com; evaldo.braz@embrapa.br; carlos.eleto@ufv.br)

In this study we evaluated the sustainability of *Juniperus procera* timber management from two important dry afro-montane forests (Chilimo and Wofwasha) in Central Ethiopia. A total of 141 major sample plots were established. We used dendrochronological techniques and stand class projection model. The cutting cycle simulated was 30-year. Due to the higher population disturbance in Chilimo forest three scenarios were simulated: disturbance ceased; remain at the same intensity and increased by 25%. For Wofwasha forest we only considered the current situation. For both forests the diameter limit was simulated varying between 50 and 60 cm, seeking the optimal harvestable diameter and ensure a more sustainable structure. In Chilimo forest it would be possible to produce 0.76 m<sup>3</sup> ha<sup>-1</sup> year<sup>-1</sup>, stabilizing after 5 cutting cycles. The continuity of undue exploitation in the forest following the same pattern will lead to a reduction in 37% of timber volume production. And increasing the exploitation by 25% will lead to a 76% reduction, potentially destroying the capacity of the forest to recover, and it was considered unsustainable. In Wofwasha forest simulations resulted in 0.63 m<sup>3</sup> ha<sup>-1</sup> year<sup>-1</sup> of timber production. The simulations also showed that population structures of both forests become similar after the sixth cycle, suggesting that these forests have the same forest formation. The differences today appear to be due to the disturbance level or interventions by local communities and history of logging in each forest.

### Implications of silvicultural interventions for sustainable forest management: case study of Bobiri Forest in Ghana

Ernest Foli<sup>1</sup>  
<sup>1</sup>Forestry Research Institute of Ghana, Kumasi, Ghana (efoli@hotmail.com)

Silvicultural interventions are necessary for regulating tropical forest growth and productivity. This paper describes experiments carried out in Bobiri forest in Ghana through the tropical shelterwood system (TSS), post-exploitation system (PES) and the girth limit selection system (GLS) to simplify the forest structure and species composition to enhance productivity. Stand basal area was reduced from about 30 m<sup>2</sup> ha<sup>-1</sup> to 12 – 15 m<sup>2</sup> ha<sup>-1</sup>. After 40 years data on height, diameter and species were collected for all trees with DBH > 10 cm from six one-hectare plots in each treatment. The results showed that the forest was capable of recovery in terms of structure, species diversity, and productivity to the pre-intervention state. There was no significant difference between treated and unlogged forest ( $\chi^2 = 26.3$ ;  $df = 21$ ;  $P = 0.196$ ). However, stand density was higher in the silviculturally-treated stands relative to unlogged forest ( $F = 7.62$ ;  $df = 3$ ;  $P = 0.002$ ). A total of 176 tree species were recorded in 38 families; the 10 most common species between treatments accounted for > 50% of the species, but < 46% in unlogged forest, with no significant shifts in species composition. The treated stands attained structural and compositional attributes similar to unlogged forest after 40 years, but commercial basal area was higher in the treated forest. In conclusion, silvicultural interventions (including harvesting) can improve both commercial productivity and species composition, depending on intensity and frequency of interventions.

### Population dynamics of *Mezilaurus duckei* van der Werff (Lauraceae) in a managed forest in the Eastern Amazon region / Dinâmica da população de *Mezilaurus duckei* van der Werff (Lauraceae) em uma floresta manejada na Amazônia Oriental

Jaqueline Macedo Gomes<sup>1</sup>, João Olegário Pereira de Carvalho<sup>2</sup>, Ademir Roberto Ruschel<sup>3</sup>, Nisângela Severino Lopes Costa<sup>1</sup>  
<sup>1</sup>Universidade Estadual da Região Tocantina do Maranhão, Imperatriz, Brasil; <sup>2</sup>Universidade Federal Rural da Amazônia, Capitão Poço, Brasil; <sup>3</sup>Embrapa Amazônia Oriental, Belém, Brasil (jaquelinemacedogomes@hotmail.com; olegario.carvalho@gmail.com; ademir.ruschel@embrapa.br; nisangela.lopes@hotmail.com)

Estudos ecológicos são primordiais para avaliar a sustentabilidade do manejo florestal, pois indicam o estado de conservação das espécies exploradas. Com a finalidade de inferir sobre a conservação da população de *Mezilaurus duckei*, avaliou-se a sua dinâmica no período de 33 anos após a exploração. A pesquisa foi realizada na Área Experimental km 67, na Floresta Nacional do Tapajós (02° 53' 03,09" S; 54° 55' 30,10" W). Os dados são provenientes de inventário contínuo realizado em 36 parcelas permanentes (50 x 50 m) instaladas em 1981 em 64 ha que foram explorados em 1979. Foram medidas as árvores com DAP ≥ 5 cm em 9 ocasiões no período 1981-2012. Analisou-se a abundância, dominância, distribuição diamétrica, taxas de ingresso e mortalidade. A abundância (1,1 indivíduo ha<sup>-1</sup> em 1981) aumentou 10% em 31 anos e a dominância (0,051 m<sup>2</sup> ha<sup>-1</sup>) aumentou 39%. Não houve mortalidade no período, mas houve ingresso de 10%. Por isso, em relação à distribuição diamétrica houve acúmulo de indivíduos no período avaliado, sendo 54,5% na classe DAP < 25 cm, 36,4% na classe DAP 25-45 cm e 9,1% na classe DAP ≥ 45 cm. Comparando as distribuições diamétricas de 1981 e 2012, observa-se claramente a passagem de indivíduos das classes inferiores para as superiores. *M. duckei* aumentou gradativamente seu estoque na área explorada, demonstrando que pode se recuperar e garantir futuras colheitas de madeira. Recomenda-se a aplicação de tratamentos silviculturais na área para estimular o recrutamento, crescimento e evitar a sua extinção local. (Embrapa, CNPq, UEMASUL).

### The influence of initial stand structure on plant community composition and diversity in eucalypt forest

Anu Singh<sup>1</sup>, Craig Nitschke<sup>1</sup>, Patrick Baker<sup>1</sup>, Sabine Kasel<sup>1</sup>  
<sup>1</sup>University of Melbourne, Melbourne, Australia (anu6@student.unimelb.edu.au; craign@unimelb.edu.au; patrick.baker@unimelb.edu.au; skasel@unimelb.edu.au)

Effective forest management and conservation require knowledge of the structure and composition of forest stands and how they change over time. Disturbances are important drivers of these forest stand dynamics, providing opportunities for recruitment, shifts in relative dominance of species, and changes in the trajectory of stand development especially in Southeastern Australia. The type of disturbance, its intensity, and any interactions with previous disturbances all influence how individual species respond and will shape the post-disturbance development patterns. Forest structure has a substantial influence on plant community composition. The structure of vegetation plays a vital role in shaping biodiversity. The recruitment of target species in managed forests following harvesting is a crucial objective of sustainable