Plants and land use

Biodiversity and underutilised species

Building a Global System for *ex situ* Conservation of Crop Diversity

ELENA POPOVA, CHARLOTTE E. LUSTY, LUIGI GUARINO

Global Crop Diversity Trust, Germany

The Global Crop Diversity Trust (the Crop Trust) is an independent international organisation established in 2004 by the Food and Agriculture Organisation (FAO) and the international agricultural research centres (IARCs) of the CGIAR (formerly the Consultative Group on International Agricultural Research) as a worldwide response to the problems of food insecurity, poverty and environmental degradation. Specifically, the Crop Trust is raising an endowment to provide long-term funding for the conservation of priority collections of crop diversity around the world. At a time when environmental and human demands are placing an unprecedented strain on agriculture the world over, it is critical to conserve plant genetic resources for food and agriculture to guarantee that farmers and plant breeders continue to have access to the raw materials they need to improve and adapt their crops – to provide food and income for us all in the future, while preserving the environment. The Crop Trust endowment provides that guarantee. The Crop Trust and the endowment it manages constitute an integral part of the financial strategy of the International Treaty on Plant Genetic Resources for Food and Agriculture. The strategic *ex situ* conservation activities supported by the Crop Trust from its endowment (and from additional project funding) on the basis of its Fund Disbursement Strategy on the one hand, and the priority *in situ* activities supported by the Treaty's Benefit Sharing Fund on the other, are equally important, complementary efforts to conserve and sustainably use plant genetic resources for food and agriculture. The urgency of such efforts is increasing, not least because of pressure on food production systems from climate change.

Keywords: Agrobiodiversity, conservation, genebank

Contact Address: Luigi Guarino, Global Crop Diversity Trust, Platz der Vereinten Nationen, 53113 Bonn, Germany, e-mail: luigi.guarino@gmail.com

Bee Pollinator Communities and Human Disturbance in West African Savannahs – Implications for Crop Yield?

Katharina Stein[1], Kathrin Stenchly[2], Drissa Coulibaly[3], Alain Pauly[4], Ingolf Steffan-Dewenter[1], Souleymane Konaté[3], Dethardt Goetze[5], Stefan Porembski[5], Karl-Eduard Linsenmair[1]

[1] *University of Wuerzburg, Theodor-Boveri-Institute of Bioscience, Dept. of Animal Ecology and Tropical Biology, Germany*

[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics (OPATS), Germany*

[3] *University Nangui Abrogoua, Dept. of Res. in Ecology and Biodiversity, Ivory Coast*

[4] *Royal Belgian Institute of Natural Sciences, Department of Entomology, Belgium*

[5] *University of Rostock, Inst. of Biological Sciences, Dept. of Botany and Botanical Garden, Germany*

In many parts of the world pollinators and pollination services are threatened by land use changes involving degradation of semi-natural habitats or the conversion into agricultural land. Such disturbances are often leading to lowered pollinator abundances or diversity thereby increasing risks to humans by e.g. lower crop yield. Our study is the first of its kind in West Africa to monitor bee community changes across gradients of human disturbance and the functional consequences thereof. Bee species richness, abundance and diversity was monitored by pan traps during 22 months covering two rainy and two dry seasons in 2014 until 2015. Traps were installed in savannah plots of varying disturbance intensities (low, moderate, high) and in nearby cotton and sesame fields. Species richness was stable at all sites. Whereas bee abundance increased with intensified land use, bee diversity decreased significantly. Bee communities in the moderate and high disturbed sites comprise only subsets of the communities in the least disturbed site. Crop yield in cotton was positively associated with bee abundance regardless of disturbance intensity. No correlation was found in sesame. Particularly wild bees were relevant for crop productivity even when honey bees were abundant. Hence, the presence of specific species in a pollinator community drives the positive pollinator abundance – pollination service relationship, in particular for fruit set. Retention of diverse bee communities is important because species are likely to vary in sensitivity to different disturbances, making service provision more stable. A clear spillover of bees from savannah into cotton fields was observed during the rainy season when crops are mass flowering indicating that agricultural areas serve as important food resources for bee species in times when resources in the savannah are scarce. Even though our study did not reveal negative effects of disturbance on crop yield, the results nevertheless emphasise the importance of the conservation and restoration of diverse pollinator communities to maintain their pollination service and hence human benefits.

Keywords: Abundance, bees, Burkina Faso, diversity, floral resources, pollination, seasonal variation, spillover, sub-Saharan Africa

Contact Address: Katharina Stein, University of Wuerzburg, Theodor-Boveri-Institute of Bioscience, Dept. of Animal Ecology and Tropical Biology, Josef-Martin-Weg 52, 97074 Wuerzburg, Germany, e-mail: katharina.stein@uni-wuerzburg.de

Diversity of East African Wetland Vegetation: A Classification Based on Current and Historic Surveys

KAI BEHN[1], SAMUEL MUTEBI[2], MIGUEL ALVAREZ[1]

[1]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany*
[2]*Makerere University, Department of Botany, Uganda*

Wetlands in East Africa are important ecosystems for biodiversity conservation and ecosystem service provisioning. Due to their suitability for crop production, the use of wetlands is getting increasingly intensified as food demand rises. In consequence, wetlands are at high risk of degradation, especially when land use changes include the establishment of drainage infrastructure. In order to project sustainable management strategies and conservation plans, it is crucial to understand structures and dynamics of wetlands. Plant communities reflect ecological conditions and degrees of disturbances and may hence be used as bio-indicators. While many published works have been focused on classification of East African wetland vegetation, consistent classification schemes for the region are still missing. We hence conducted detailed studies of vegetation in two different wetland ecosystems in East Africa. The first site is the lowland floodplain of the Kilombero river in Tanzania, which is characterised by Tropical Savannah climate and two distinct rainy and dry seasons. The second site is located in Central Uganda and consists of small inland valleys with a climate at the transition between Tropical Monsoon and Tropical Rainforest. While at both study sites patches of natural vegetation and long-term fallows can be found, cultivation of rice is the dominating form of land use. We sampled vegetation in nearly 400 plots, each 4 m^2 size. They were chosen along gradients of land use intensity and flooding duration. A classification of the plots was conducted based on species composition using the Cocktail-Classification method. Formal definitions of plant communities were developed and compiled to an expert system and then applied in the classification of data stored in the vegetation-plot database "SWEA-Dataveg" (http://www.givd.info/ID/AF-00-006). In the study area, 18 plant communities were identified, of which most belong to the phytosociological classes of Phragmito-Magno-Caricetea (marshes and reeds) and *Oryzetea sativae* (weed and pioneer vegetation). While the two study sites did not share any communities, 9 were recognised in the database with the developed definitions. Integration of these results and literature resulted in an overview of East African wetland vegetation with reference to ecological conditions, degree of disturbance and geographic distribution for each unit.

Keywords: Classification, East Africa, land use changes, plant communities, vegetation ecology, wetland

Contact Address: Kai Behn, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Nussallee 1, 53115 Bonn, Germany, e-mail: kaibehn@uni-bonn.de

Plant Communities Changes in Relation to Land Uses and Soil Properties in Malinda Wetland, Tanzania

NEEMA MOGHA[1], COLLINS HANDA[2], MIGUEL ALVAREZ[3], BODO MÖSELER[3], HELLEN KAMIRI[4]

[1] *University of Dar es Salaam, College of Education, Tanzania*

[2] *Technical University of Kenya (TUK), School of Biological and life sciences, Kenya*

[3] *University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany*

[4] *Karatina University, Crop Science, Kenya*

In East Africa, demographic growth, inter-generational inheritance of land, increasing land scarcity in the highland areas, degradation of upland soils and inter-annual rain variability is increasing cropping pressure on seasonal and nearly permanent wetlands. This study was carried out between 2008 and 2016 in order to find the changes of plant communities in Malinda wetland due to intensity of land use which results into changes of soil properties which impacts the functions of wetland ecosystems and on potential productivity of the soils. A first survey and plant communities characteristics in the area was firstly done in 2008 and a rapid appraisal with key informants was carried out to determine the characteristic land uses and to collect information on land use history of the area. Four land use types were determine which include unused part with domination of wetland vegetation, fairly used area with minimal grazing during dry period of the year, high intensity used area dominated by horticulture and fallow land which has been left after use or is used for yearly grazing. According to preferential sampling, 40 plots of size 10 m^2 representing the main types of land uses were selected. In those plots all species and their estimated abundance as percentage cover were recorded. In each plot soil samples of the layer 0–15 cm were taken for soil chemical analysis. The same sampling techniques and procedure were repeated in the year 2016. The vegetation was classified by using hierarchical clustering technique and the relationships between species composition (land uses and plant communities) and soil properties of the wetland. The canonical correspondence analysis (CCA) was applied and the vegetation was classified into ten plant communities (clusters), five of them were weed communities of croplands while the remaining plant communities were from fallow, grazing land and unused part of wetland. There was no great difference in vegetation composition and plant communities obtained between the period of eight years. Both showed almost the same species composition and the plant communities were determined by soil exchangeable K, electric conductivity and pH according to ordination analysis.

Keywords: East Africa, land degradation, soil properties, use intensity, wetland

Contact Address: Neema Mogha, University of Dar es Salaam, College of Education, P.O. Box 2329, Dar es Salaam, Tanzania, e-mail: moghang@yahoo.com

Agroforestry-Based Restoration and Enhanced Resilience of Agricultural Production through Adaptation of Smallholder Farming Systems, Nicaragua

Mirjam Pulleman[1], Pablo Siles[2], Edwin Garcia[3], Carsten Marohn[4], Melanie Mason[5,2], Orlando Tellez[2], Elbis Chavarria[2], Emily Webster[6]

[1]*Wageningen University and Research, The Netherlands*

[2]*International Center for Tropical Agriculture (CIAT), Nicaragua*

[3]*International Center for Tropical Agriculture (CIAT), Honduras*

[4]*University of Hohenheim, Inst. of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), Germany*

[5]*University of Copenhagen, Agricultural Development, Denmark*

[6]*University of California, Dept. of Plant and Environmental Sciences, United States of America*

Rural communities in the Dry Corridor of Central America are highly vulnerable to the consequences of soil and land degradation, and climate change. Smallholder farmers traditionally produce grain crops on steep hillsides through slash-and-burn agriculture, increasingly combined with small-scale cattle farming. Only 3% of the original forest cover remains. The ARA (Agroforestry for Restoration of Agroecosystems) project aims to restore degraded land, enhance agroecosystem productivity, profitability and resilience, and generate ecosystem services through agroforestry systems. Between 2008 and 2013 a platform of 25 on-farm experiments, representing three different communities in the Dry Corridor of Nicaragua, was established. The platform has served different objectives: (i) participatory adaptation of agroforestry systems; (ii) research to understand and quantify the impacts of agroforestry-based interventions on ecosystem services, including crop production, and farmer revenues (iii) training of farmers and technicians and knowledge sharing to facilitate out scaling. Agroforestry systems included Quesungual, a maize-bean system intercropped with trees and established through selective clearing and pruning of regenerated trees. Five land use systems were established/selected on the participating farms: Traditional slash-and-burn maize-bean system (TCS), Quesungual Agroforestry (AFS), Secondary forest (SF), Naturalized pastures (NP) and Improved silvopastoral systems (SPS). Crop and forage production, soil fertility, soil erosion, C sequestration and biodiversity was monitored from 2013 to 2016. Results confirm that AFS and SPS can improve tree diversity conservation and carbon storage, while maintaining (maize) or increasing (bean) production. Collection of detailed soil, plant, microclimate and meteorological data allowed for the modelling of tree-crop interactions and land use scenarios to further evaluate impacts of Quesungual on ecosystem services.

Contact Address: Mirjam Pulleman, Wageningen University and Research, KM 17, Recta Cali-Palmira, CP 763537 Palmira, The Netherlands, e-mail: Mirjam.Pulleman@wur.nl

A detailed study on adoption rates and factors at the community level showed steadily increasing levels of adoption (up to 39 % of households in 2016). Strong support through capacity building was identified as a key factor to further enhance adoption. Despite increasing adoption rates and beneficial impacts of AFS and SPS on ecosystem services and production, further improvements in production systems are needed. A synthesis of key lessons from the project and reflections on future directions and research priorities will be presented.

Keywords: Adoption, agricultural productivity, agroforestry, Central America, ecosystem services, land restoration, Nicaragua, resilience, soil fertility

Vegetation-Based Indicators for Assessing Ecosystem Services of Cacao Agroforestry Systems, Buffer Zone of Abiseo River National Park, Peru

PEDRO DANIEL PARDO VILLEGAS[1], PATRICIA LANDAVERDE GONZALEZ[2], SVEN WAGNER[3]

[1] *Universidad de San Carlos de Guatemala, Biology School/ Dept. of Ecology, Guatemala*

[2] *Martin-Luther-Universität Halle-Wittenberg, Division of Zoology, Germany*

[3] *Technische Universität Dresden, Institute of Silviculture and Forest Protection, Germany*

This research aimed to identify vegetation structural attributes capable of performing as indicators for the assessment of support and provision services of the cacao agroforestry systems. This was done by setting up a comparison between the cacao agroforestry systems, the cacao plantation, and the natural forest in the buffer zone of the National Park 'Rio Abiseo', in the Peruvian amazon. The comparison was carried out under the assumption that structural attributes of the vegetation, such as the tree diversity (richness and evenness) and composition, forest structure (DBH, height, vertical layers, shrub and herbaceous cover, and diversity and composition of saplings) and coarse woody debris (snags, logs, and litter depth) can be indicative of supporting and provisioning services. The supporting services were focused on the provision of suitable habitat for the jaguar (*Panthera onca*) and the San Martin's titi monkey (*Callicebus oenanthe*) while the provisioning services focused on the average monthly income (USD per ha) from cacao production. The structural attributes were measured and compared in modified Whittaker plots (0,1 ha) set in the cacao agroforestry systems (19 plots), cacao plantations (21), and natural forests (20). A principal component analysis and a constrained correspondence analysis (with a permutation test) were used to compare different systems. These analyses allowed the identification of the presence of a shrub cover, the layer of trees between 16 and 20m tall, the presence of snags, the average tree height, and the layer of trees between 5 and 15m tall, as significant vegetation structural attributes for the assessment of the ecosystem services in the different systems. These attributes can guide the decision-making process in the buffer zone of the National Park to assure habitat provision, particularly for the endemic species of titi monkey of San Martin. At the same time, it can assure the sustainable production of cacao and the livelihoods of human communities that depend on the ecosystem services of the buffer zone of the National Park Rio Abiseo.

Keywords: Cacao agroforestry systems, ecosystem services, indicators, National Park Rio Abiseo, Peruvian amazon

Contact Address: Pedro Daniel Pardo Villegas, Universidad de San Carlos de Guatemala, Biology School/ Dept. of Ecology, 2a. Avenida 38-54 zona 8, 01008 Guatemala, Guatemala, e-mail: pepardavil@gmail.com

Farmers Have Too Low Knowledge to Protect and Benefit from Native Pollinators – Insight from Morocco

STEFANIE CHRISTMANN[1], ATHANASIOS TSIVELIKAS[1], ABDELLAH BENBYA[2]
[1] *International Center for Agricultural Research in the Dry Areas (ICARDA), Morocco*
[2] *University Mohammed-V, Dept. of Biology, Laboratory of Plant Physiology and Biotechnology, Morocco*

In 2016 The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) showed that agricultural production is now twice as dependent on pollinators than five decades ago, but pollinator decline accelerates globally, in particular in agricultural lands. Farmers cannot protect, what they do not see or recognise or value. Knowledgeable farmers are crucial for pollinator protection. In 2016 the knowledge of 110 male and female smallholder farmers (0.4 – 2.5 ha) in the Rabat-Salé-Kenitra region (Morocco) has been assessed by a standardised questionnaire. On average, farmers know only 1.4 pollinator species except honeybees. 23 out of 110 farmers had collaborated with beekeepers, but not for improved pollination of their crops. They had invited the beekeepers to bring hives, because according to local arrangements a farmer providing flowers gets a share of the honey as in kind payment. Despite availability in their agricultural lands no farmer is able to recognise nests of pollinators or predators. Though all farmers produced at least one pollinator dependent crop, only 19 % were aware that they need pollinators in their fields. They did not know for which crops pollination is essential, for which crop pollination has great, modest or little impact, they were e.g. much more concerned about pollination of tomato than of apple. As apple flowers in early spring, pollination by honeybees is often hampered by rain or cold days without sun. Farmers lacking knowledge might take wrong decisions in case of crop failure. All farmers enlarged fields reducing valuable pollinator habitats in field edges since the year 2000. Also the farmers increased the use of insecticides and fungicides on average by 54 % since 2000. There is very little literature on farmers' knowledge on pollinators, but according to the samples the knowledge in Morocco is comparatively low. There was nearly no difference between literate and illiterate farmers. Therefore, obligatory lessons on pollinators is recommended for primary and secondary schools. Involvement of mass media would be useful.

Keywords: Formal education, habitat, honeybees, IPBES, wild pollinators

Contact Address: Stefanie Christmann, International Center for Agricultural Research in the Dry Areas (ICARDA), c/o ICARDA BP 6299 Rabat Institutes, 10112 Rabat, Morocco, e-mail: s.christmann@cgiar.org

Farming with Alternative Pollinators Creates High Incentives for Farmers for Pollinator Friendly Agriculture

Stefanie Christmann[1], Moulay Shrif Smaili[2], Abdellah Benbya[3], Toshpulot Rajabov[4], Athanasios Tsivelikas[1]

[1]*International Center for Agricultural Research in the Dry Areas (ICARDA), Morocco*

[2]*Institut National de la Recherche Agronomique (INRA), Laboratoire d'Entomologie, Morocco*

[3]*University Mohammed-V, Dept. of Biology, Laboratory of Plant Physiology and Biotechnology, Morocco*

[4]*Samarkand State University, Uzbekistan*

Currently, environmental research on pollinator decline does not trigger broad protection of pollinators in particular in agricultural landscapes. Prevailing environmental recommendations, e.g. seeding wildflower strips in and between fields, don't take farmers' interests into account. Farmers prefer income from the entire area and they regard wildflowers as weeds potentially spreading their seeds all over the field. Whereas the new agricultural Farming with Alternative Pollinators (FAP) approach uses marketable plants for habitat enhancement and avoids spread of weeds. FAP triggers farmers' motivation to enhance habitats in fields based on evidence of increased income. FAP measures the impact of enhanced habitats (25 % of the field) on the diversity of pollinators and predators and on the total net income in comparison to control fields having the main crop on 100 % of the field. Pilot projects in Uzbekistan with cucumber and sour cherry as main crops and in Morocco with cucumber as main crop proved high increase of yields of the main crop and higher income per surface based on higher diversity and abundance of pollinators and predators in FAP-fields. In total income from FAP fields was more than double in comparison to control. The incentive of large income gain makes FAP scalable. FAP obviates the need to reward farmers for pollinator-friendly practices. As insect species highly differ in Central Asia and North Africa the approach proved replicability. Trials on more crops are recommended. In case they demonstrate substantial income increases as well, FAP might have high potential to protect pollinators and simultaneously enhance food security. Currently, the increase of horticulture production is mainly based on increase of area, whereas FAP increases the productivity per ha. Thus FAP might reduce the loss of forests and rangelands for establishment of additional fields and orchards. FAP is applicable also in low income countries, which cannot afford subsidies as e.g. the European Union pays.

Keywords: Habitat zone, intrinsic motivation, marketable plants, self-sustaining

Contact Address: Stefanie Christmann, International Center for Agricultural Research in the Dry Areas (ICARDA), c/o ICARDA BP 6299 Rabat Institutes, 10112 Rabat, Morocco, e-mail: s.christmann@cgiar.org

Flora Grown and Traded in Panama City, in the 16th Century and Nowadays

ISABEL MADALENO

The University of Lisbon, National Museum of Natural History and Science, Portugal

Panama City is located in the Pacific coast of the isthmus that united North and South America somewhere between 15 and 3 million years ago. The capital city of Panama is a tropical modern urban centre that registers about 1,750 mm of rain per year, which favours the growth of food, medicinal herbs, fruit trees and ornamental species in gardens and pots. In early 2017, the University of Lisbon conducted a scientific mission to Panama to survey the local flora, in order to compare this flora with the plant species mentioned in the 16th century manuscript of Gonzalo Fernández de Oviedo (1526), following a long time project initiated in Brazil in 1997 by the Portuguese Tropical Research Institute. The main objective of the research was to assess the availability of local food, spice and medicines in the early years of European colonisation and to evaluate the contribution of the Portuguese and the Spanish peoples to the evolution of flora consumption and therapeutic application. The current survey included two categories of informants: i) three (3) gardeners devoted to food and medicines cultivation inside the urban area; ii) forty-seven (47) formal and informal traders found in markets, supermarkets, or pharmacies. The results showed that 171 different plant species are offered to the public today against 55 mentioned by the chronicles in early colonisation days. More than half of the species have medicinal uses in our days and about one third are consumed as food. The final research aim is to build a database that permits to study the evolution of Latin American flora and their uses throughout times.

Keywords: Flora, food, Latin America, medicines, Panama, spices

Contact Address: Isabel Madaleno, The University of Lisbon, National Museum of Natural History and Science, Rua Andrade, 8-2ºE, 1170-015 Lisbon, Portugal, e-mail: isabel-madaleno@museus.ulisboa.pt

Enhancing Biodiversity – Identification of Conservation Corridors in a Plantation Dominated Landscape in the Mekong Region

LINDA HILGERS, PHILIP BECKSCHÄFER, CHRISTOPH KLEINN
University of Goettingen, Chair of Forest Inventory and Remote Sensing, Germany

The rapid expansion of rubber tree plantations (*Hevea brasiliensis*) and cash crops across southern subtropical China puts high pressure on natural forests and their biodiversity. Xishuangbanna Prefecture in the South of Yunnan Province is particularly affected as here rubber monoculture plantations currently cover about 440,000 ha and have replaced large shares of traditional land use systems and natural rainforests over the past 40 years. Today, contiguous blocks of mature natural forest are confined to the prefecture's nature reserves which are, however, isolated. Further, the ongoing transformation of the lands surrounding the reserves and the encroachment of plantations into them, continues to increase the separation of reserve dwelling plant and animal populations, impeding movements and interactions between them. In order to reconnect isolated populations, it is necessary to establish wildlife corridors that prepare the grounds for the dispersion of organisms. We identified potential wildlife corridors for three functional groups of species: (a) large mammals, (b) primates and (c) birds. Group specific resistance values that quantify the species' likelihood to migrate through certain land cover were derived from a literature review and an up-to-date land cover map was employed for corridor mapping using least-cost models. The identified least cost paths clearly displayed the high degree of isolation of all reserves since none of the routes connected two reserves on the shortest way. Instead, the model primarily proposed detours integrating fragmented forest remnants into the corridors. Conservation corridors for large mammals corresponded mostly with those for primates, solely the corridors for birds differed. The corridors for primates had most similarities with both other groups and were therefore suggested to be appropriate for the greatest variety of species. Our results illustrate the high degree of isolation of nature reserves in Xishuangbanna and confirm the urgent need of reconnecting them through corridors in order to protect, preserve and enhance the remaining biodiversity and counteract the ecological threats from the expansion of rubber plantations.

Keywords: Cost-based corridor, land transformation, landscape connectivity, landscape resistance values, least-cost path, Linkage Mapper, rubber plantation, Xishuangbanna

Contact Address: Linda Hilgers, University of Goettingen, Chair of Forest Inventory and Remote Sensing, Büsgenweg 5, 37077 Göttingen, Germany, e-mail: linda.hilgers@stud.uni-goettingen.de