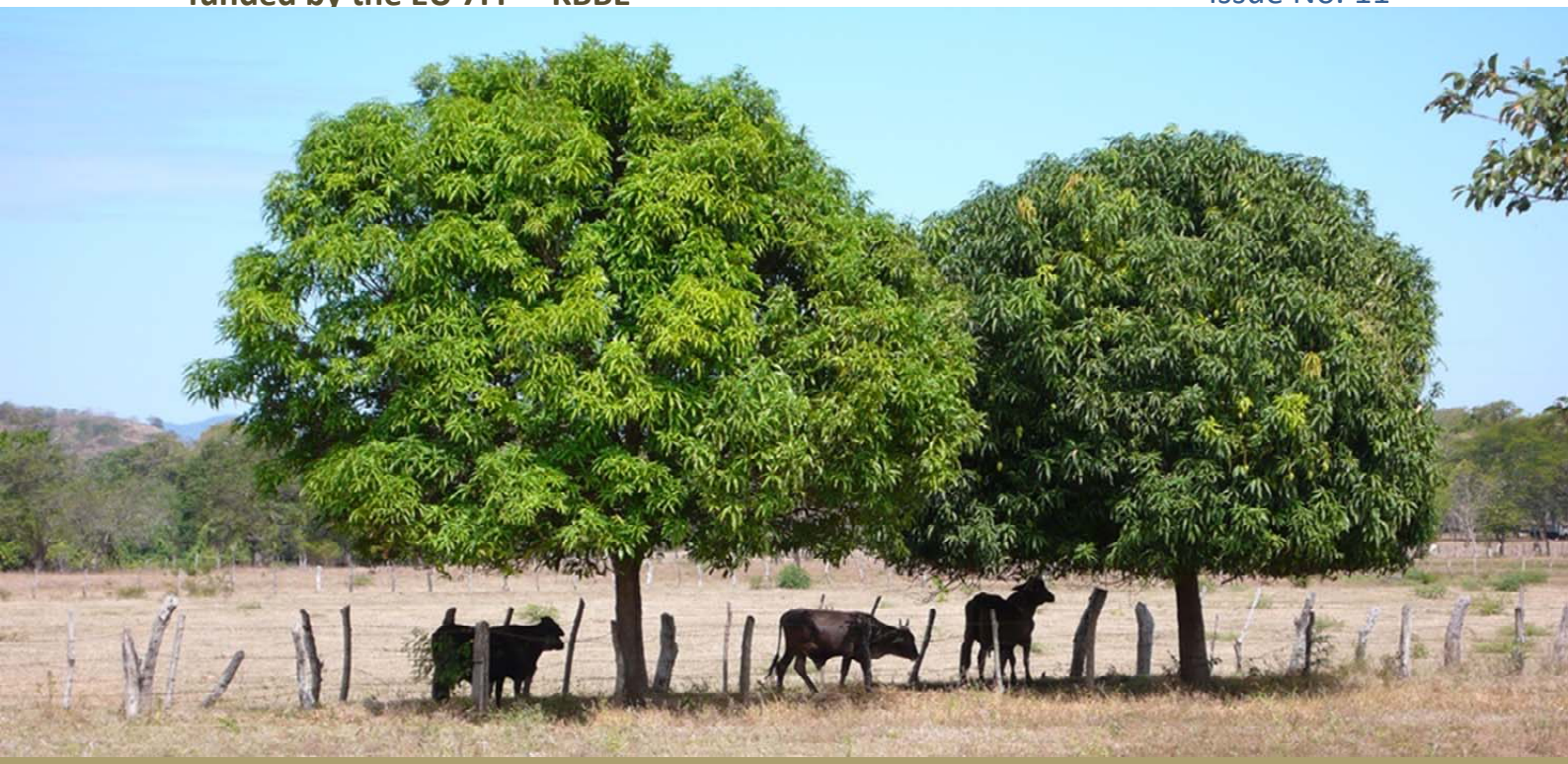


FUNCiTREE

REPORT

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The role of functional diversity for ecosystem services in multi-functional agroforestry

Book of abstracts

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BOOK OF ABSTRACTS

FUNCiTREE FINAL CONFERENCE

The role of functional diversity for ecosystem services in multi-functional agroforestry

Trondheim 23-25 May 2013

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Oral presentation
Session I

Biological pest control - an ecosystem service provided by biodiversity at multiple spatial scales

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Abstract

Biological pest control provided by predators and parasitoids is an ecosystem service of immense economic value. It is an example of a service provided by mobile organisms where local delivery, e.g. to a crop field, not only depends on local management but also on the composition and structure of the surrounding landscape. The diversity and abundance of predators and parasitoids have often been found to be lower in landscapes dominated by intensive agriculture and in fields with intensive management. However, the effects on pest populations have been less clear, in part because the relationship between natural enemy diversity and biological control is not straightforward.

In this talk I will discuss how local management and landscape structure influence biological control, and how processes at different spatial scales may interact. I will also discuss during what conditions increasing natural enemy diversity is likely to lead to improved biological control and how we can attempt to enhance the 'right' kind of biodiversity that is most effective at delivering biological control. I will exemplify with my own research from temperate and tropical agroecosystems.

Oral presentation
Session I

Unraveling plant water and nutrient use strategies in dry tropical agroecosystems using stable isotopic signal

Cristina Armas* (EEZA-CSIC), F. Casanoves (CATIE), J. S. Diémé (EEZA-CSIC), M. Diouf (ISRA), D. Fall (ISRA), I. Prieto (EEZA-CSIC), L. Rocha (NINA), D. Sánchez (CATIE), J. I. Querejeta (CEBAS-CSIC), F. DeClerck (CATIE), F. I. Pugnaire (EEZA-CSIC) and G. M. Rusch (NINA)

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Abstract

Unraveling belowground processes, especially root-soil interactions whereby plants acquire water and nutrients, remains one of the greatest challenges in plant ecology. Stable isotopic composition of xylem water and leaf tissues coupled with soil and different water sources provide valuable insights on fundamental plant processes such as plant water sources or water and nutrient use efficiency to name a few.

In two dry tropical agroforestry systems (AFs), one in Central America (Rivas, Nicaragua) and the other in Africa (Potou, Senegal), we collected stems and leaves of 21 tree species, soils where trees grow at two depths, surface and 1 m deep, and water of different wells distributed along the field sites during both the rainy and dry seasons. The analysis of $\delta^{2}H$ and $\delta^{18}O$ composition of xylem sap, soil and well water, and the composition in $\delta^{13}C$, $\delta^{15}N$ and $\delta^{18}O$ of dry leaves revealed high plant functional diversity in both AF systems. Water relations of species were variable, with some species almost exclusively relying on groundwater (e.g., *Maytenus senegalensis* in Senegal), others on water stored in the first meter depth of the soil profile (e.g., *Cassia grandis* and both *Spondias* species in Nicaragua, and *Sclerocarya birrea* in Senegal) and others changing their sources of water uptake between seasons (e.g., *Cordia dentata* in Nicaragua or *Neocarya macrophylla* in Senegal). Water use efficiency was usually related to the source used of water by trees. We related these results with other functional traits and physiological behavior of trees.

Overall, our results show that multiple-isotopic analyses of AFs trees and water provide a unique way to explore the relationships between water and carbon fluxes in the plant-soil-atmosphere continuum, and provide evidence on the diversity of water-use and drought coping strategies in AFS in seasonally dry areas.

Oral presentation
Session I

Response to drought of nine sahelian trees in the northwest semiarid area of Senegal

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Abstract

Plant attributes and functional traits are related to the environmental conditions they have to withstand and thus can be used to assess species tolerance to stress. We analyzed the physiological responses to drought along abiotic gradients of nine woody species dominant in a tropical semiarid savannah agroforestry system in Sahel, where scattered trees grow in a matrix of seasonal grasslands and crops. The study was conducted in the steppe of Leona, northwest Senegal, where agriculture during the rainy season and free-range livestock are the main activities. Our study area has two contrasting zones, the Niayes (in the maritime fringe) and the Diéri, continental. We selected nine dominant tree species, *Acacia tortilis*, *Adansonia digitata*, *Balanites aegyptiaca*, *Combretum glutinosum*, *Celtis integrifolia*, *Faidherbia albida*, *Neocarya macrophyla*, *Sclerocarya birrea*, and *Tamarindus indica*. On five contrasting seasons differing in water availability–dry or rainy season–and mean temperatures–relatively cold or hot seasons–we measured predawn relative water content (RWC), predawn leaf water potential, specific leaf area (SLA) and leaf area index (LAI) on 6 mature trees per species. Our data show contrasting physiological responses and tolerance to drought in these species, which allow us to classify them into different functional groups. Results of this study can be used as input to models predicting the effect of dominant woody species on ecosystem functioning and its evolution in a context of climatic change.

Oral presentation
Session I

Responses of agro-forestry species to water availability in seasonally dry climates and their effect on understory vegetation

Francisco I. Pugnaire* *(EEZA*-CSIC), C. Armas (EEZA-CSIC), M. Diouf (ISRA), J. S. Diémé (EEZA-CSIC), F. Casanoves (CATIE), D. Fall (ISRA) and G.M. Rusch (NINA)

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Abstract

The adoption of tree species to improve the performance of agro-forestry systems in dry and marginal areas requires characterizing the main physiological factors influencing productivity and tree-grass interactions. Tree responses to drought conditions involve not only plant adaptations to water limitation but interactions with soil and soil biological communities, in addition to livestock and understory vegetation. Such characterization is needed to identify tree species suitable for agro-forestry systems in dry and marginal areas. Tree species traits monitored along several seasons in target areas of Latin America and Africa evidence contrasting responses to water shortage. Here we present data from Potou (Senegal), where the more consistent sampling was carried out, to explore relationships between tree functional traits and understory productivity.

Several physiological traits are associated with tree size. Larger tress have higher Ψ_{pd} in both wet and dry seasons, influencing SLA, RWC, WUE, and related measurements. Tree size is also correlated to $\delta^{15}N$, D_2O, and ^{18}O, suggesting that the larger the tree the more access to deep water reserves. However, trees with dense foliage (high LAI) and therefore more evaporative surface area show lower Ψ_{pd}. In general, the more water is available the less efficient are plants in the use of that water. Water and nutrient use processes appear to be correlated, such as N concentration in leaves which was positively correlated with water availability.

Tree attributes have an impact on understory vegetation. Trunk diameter and height negatively influenced understory biomass and cover, and taller trees were associated with fewer species in the understory. Trees with dense foliage show less grass productivity and cover in the understory.

There were significant differences among sites regarding several measured variables such as understory species richness and grass productivity, nutrient availability, pH, soil salinity, and the presence of mycorrhizal fungi. pH has strong effects on species richness, and the higher the pH the more species are present. Soil salinity also influences productivity and the less salinity the more species. Grass richness and fungi also depend on water availability (indirectly measured through tree RWC) and more species and more fungal spores were present with greater availability of water.

In conclusion, and although there are site-specific effects, different tree species have different access to resources and affect understory productivity in different ways, providing tools for improvement of agro-forestry systems.

Oral presentation
Session I

The importance of environmental gradients and tree functional attributes on tree-understory interactions in seasonally dry tropical agroforestry systems

Graciela M. Rusch*(NINA), C. Armas (EEZA-CSIC), M. Diouf (ISRA), P. Zapata (CATIE), D. Fall (ISRA), F. Casanoves (CATIE), J. S. Diémé (EEZA-CATIE), M. Ibrahim (CATIE), F. DeClerck (CATIE) and F.I. Pugnaire (EZZA-CISC)

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Abstract

Understanding how trees affect understory vegetation is critical for planning agroforestry systems. Trees may suppress grass growth through direct competition for water, light, and nutrients but trees may facilitate grass growth by directly or indirectly improving environmental conditions for understory growth. Current knowledge about tree-understory interactions indicate that the relative importance of facilitative and competitive processes is a function of environmental harshness, with higher facilitation towards more extreme environments while competition predominates under higher resource availability. We assessed the effects of trees in seasonally dry tropical agro-pastoral systems on understory herbaceous vegetation along a gradient of environmental productivity in West African savannahs and in seasonally–dry, tropical forests in Central America encompassing a range of environmental productivity including soil properties and rainfall.

The productivity of the open area was used as an integrative index of site productivity. Site productivity explained 42 % of the variance of the effect of trees on understory ANPP. The effect of trees growing in more productive sites was predominantly negative, resulting in a decrease of ANPP compared to open patches, while the facilitative effects of trees increased with decreasing productivity. The relationship between the effect of trees and site productivity was monotonic, indicating the absence of thresholds and showing a steady increase in facilitation with productivity. The effect of trees on understory ANPP was negatively associated with tree size, which explained 14% of the variance. Site productivity did not explain the net effect of trees in terms of understory species diversity and cover. The effects seem to be linked to direct interactions between the canopy and the understory, since the net effect of trees on ANPP was unrelated to net changes in soil C, N and pH. Trees in tropical agro-pastoral systems fulfill many important functions and both trees and grasses are vital for system productivity. However, these functions may be in conflict with each other at times, particularly in the most productive sites, where competition prevails. However, facilitation effects were more frequent in less productive sites.

Oral presentation

Session I

Comparative effect of forest species on soil fertility, herbaceous diversity and biomass production in Leona (Louga, Senegal)

Dioumacor Fall* (ISRA), M. Diouf (ISRA), S. Diatta (UCAD), C. Armas (EEZA), G. M. Rusch (NINA), L. Furubardsen (NINA) and A. Gaye (ISRA)

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Abstract

In Senegal, soil fertility decline limits agricultural productivity with as consequences food insecurity and rural poverty. Thus, in order to restore soil fertility and increase agricultural productivity, farmers practice more and more agroforestry. However, the success of an agroforestry system depends largely on forest species. Thus, our study aims to assess the influence of 14 forest species, 11 trees (*Acacia senegal, A. tortilis var. raddiana, Faidherbia albida, Celtis integrifolia, Combretum glutinosum, Adansonia digitata, Balanites aegyptiaca, Neocarya macrophylla, Tamarindus indica, Zizyphus mauritiana* and *Sclerocarya birrea*) and 3 shrubs (*Annona senegalensis, Boscia senegalensis* and *Maytenus senegalensis*) (***i***) on some soil fertility indicators, (***ii***) herbaceous diversity and biomass production in four villages of Leona Rural Community (Region of Louga, Senegal). Soil fertility (pH, electrical conductivity, total carbon, total nitrogen, available phosphorus and density of mycorrhizal fungal spores), species richness and herbaceous biomass production were evaluated under cover (R/2 or half-crown) and out cover (3R) of trees canopy. The results showed that all species increased electrical conductivity and slightly acidify the soil except *C. integrifolia* and *A. senegal*. *C. glutinosum, S. birrea, T. indica, B. senegalensis, N. macrophylla* and *B. aegyptiaca* increased soil electrical conductivity more than 200%. *T. indica A. raddiana, F. albida, A. senegal* and *N. macrophylla* increased total carbon more than 150%. However, only nitrogen-fixing trees (*A. raddiana, F. albida* and *A. senegal*) increased total nitrogen over 150% and only *F. albida* increased over 100% the available phosphorus and herbaceous biomass production. The spore density was lower under cover than out cover except for *C. integrifolia, S. birrea* and *M. senegalensis*. Herbaceous total cover was higher under cover than out cover except for *C. integrifolia, Z. mauritiana* and the three shrubs. No significant effect of forest species were observed on herbaceous specific richness. Based on species effects on assessed variables, *F. albida, N. macrophylla, A. raddiana, T. indica* and *A. senegal* were the species that have the most important positive effect on soil fertility and herbaceous biomass production while *C. integrifolia* seemed to have a depressive effect.

Oral presentation
Session I

Soil carbon storage is promoted more by Jícaro than by Guácimo trees in silvopastoral systems in Nicaragua

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Abstract

The role of solitary trees in providing ecosystems services to silvopastoral systems gained attention in recent years. Next to providing fodder (fruits), fuel and timber wood, trees are also likely to affect soil characteristics and the cycling of C and nutrients in their vicinity. These tree – soil effects are hypothesized to affect soil respiration (CO_2 efflux) and C stabilisation.

The soils in the Rivas area were formed in marine clay and sand deposits of young Tertiary age. For this study, 6 *Guazuma ulmifolia* (Guácimo) and 6 *Crescentia alata* (Jicaro) trees were selected in relatively flat parts of the landscape. Soils were classified as Vertic Haplustolls (Mollisols on gently sloping alluvial fans) and Haplusters (Vertisols in the central parts of depressions). Soil samples and soil respiration measurements were collected from *three locations near each tree*: *1* pasture – no tree effect (10 m up-wind from the tree); *2* tree canopies – above and belowground tree litter input; *3* pasture and aboveground leaf litter input (down-wind zone where most leaf litter is deposited). Soil samples were taken to represent the 0 – 20 and 20 – 50 cm depth increments.
Soil bulk density was affected by soil type (P=0.011), tree species (P<0.001) and location (P<0.001), with respectively higher bulk density values in Vertisols, under Jicaro and in the canopy and leaf litter zones. Soil C content (g C m^{-2}) was higher in Vertisols (P<0.001), was not affected by tree species and lower in pasture (P<0.001) and lower in the sub-soil (P<0.001). There was, however, a significant tree species × location effect (P=0.008) with high C contents under the canopy and leaf litter zone of Jicaro (Table 1). Soil C present in the "free labile" and "occluded" fractions was only lower in the sub-soil (P<0.001), but otherwise not affected. The mineral associated C fraction was affected in a similar way as total soil C content.

Soil N content was, just as C, higher in Vertisols (P=0.001), lower in pasture (P=0.001) and lower in the sub-soil (P<0.001), but higher under the canopy and leaf litter fall of Jicaro (P=0.012). Nitrogen in soil fractions followed similar trends as for C. Soil P content was marginally higher in the Mollisols (P=0.053) but was not affected by tree species or relative

location to the trees. Soil C: N, C:P and N:P were higher in Vertisols ($P<0.001$), but these ratios were not affected by location, and only C:P was higher under Jicaro ($P=0.023$).
Soil respiration, measured as CO_2 efflux at the soil surface, was highest in the leaf litter zone, intermediate in the pasture and lowest under the canopy ($P<0.001$), while average respiration was higher under Guácimo ($P=0.013$).

We infer that high soil C storage is promoted by Vertisols, due to higher clay % ($P<0.001$) and impeded drainage, and by the canopy and leaf litter zones of Jicaro trees. The latter corresponds well with the observed higher respiration rates under Guácimo. The observed species effect on C:P, but not on C:N, may indicate increased uptake of P under Jicaro and a possible growth limiting role of P. By looking at the free labile and occluded fractions, the early stages of soil C stabilisation processes seem not to be affected by tree species or location, or may be obscured by the rapid turn-over of organic matter and its high spatial variability. However, the most stable mineral associated fraction, which makes up ~ 89% of total soil C, is about one-and-a-half times larger under Jicaro than under Guácimo or pasture. Carbon sequestration as an ecosystem service may therefore be promoted by the use of Jicaro in silvopastoral systems.

Oral presentation
Session I

Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) – a brief introduction and upcoming activities

Nina Vik* (DN-Norway)
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Abstract

No Abstract

Oral presentation

Session I

Forage intake of tree species on rangelands : a relative value as a combination of resource availability, species traits and ruminant feeding behavior

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Abstract

In sub-saharan Africa animal feeding depends mainly on free grazing on rangelands and pastoralists have to deal with fodder shortages during the dry season. During the lean season, trees and shrubs represent the only source of green fodder still available on rangelands. The main objective of this study was to identify fodder species and their functional characteristics as animal feed on the specific conditions of Sahelian rangelands of the Louga area in Senegal. This context is characterized by high anthropogenic pressure and low biodiversity of tree layer. The methodology used consisted in analyzing the behavior and the feed preferences of cattle for available woody species on rangelands. Regular monitoring of cattle herds have been done during the dry season. Food preferences were characterized by direct observation method of the woody plants intakes. Results were compared with biological aspects of consumed species. *Guiera senegalensis* and *Boscia senegalensis* appeared to be the most important trees consumed as they represent 60% to 100% of the feeding time to woody plants. Differences in behaviors were partially explained by differences in morphological characteristics and phenology stages among the fodder species. Chemical analysis of the consumed trees and scrubs provided in next studies would allow searching for other characteristics impacting the food choices of woody plants. The results obtained in this study on the main species contributing to cattle diets during the late dry season in Louga context are primarily of methodological interest. To strengthen the diagnostic of traits related to the fodder function of these forage species, they must be compared to the results obtained in other diversified sahelo-sudanian agro-pastoral rangelands.

Oral presentation
Session I

Sustainable use of browse from woody plants as cattle feed
Christina Skarpe* (NINA & HiHM)
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Abstract

With globally increasing level of atmospheric carbon dioxide, woody plants are increasing and invading grazing land particularly in semi-arid and sub-humid tropics. This one of many incentives to make a better use of woody plant resources as livestock feed. Woody plants constitute a much more variable and dynamic forage resource than grasses. Foraging by browsers on woody plants can be seen as a feeding lope, where animals first respond to inherent traits of the plant, and then the plant can respond to the browsing, where after the animal can respond to the response traits by the plant by increasing or decreasing subsequent browsing. I will use examples from Nicaragua and from southern Africa to discuss significance of plant traits and of mode of browsing or cutting for sustainable use of woody plant forage.

Oral presentation

Session I

Fodder function of trees and shrubs for domestic ruminants in arid areas : characterization with multi-dimensional functional traits

Hubert Guerin* (CIRAD) and A. Ickowicz (CIRAD)

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Abstract

Farmers in arid regions traditionally know trees and shrub species with fodder and medicinal interest. This knowledge has been capitalized by naturalists. Then ecologists, agro-forestry and livestock scientists have applied their analytical specialized methods. Droughts have prompted investigations to characterize, quantitatively and qualitatively, forage provision by trees and preferences of animals. Exotic species were also tested. Many descriptive and analytical data have been collected but had little effect on the management of forestry and tree species in agro pastoral rangelands. New research stimulated by climatic and demographic changes must integrate socio-economic processes of management of forest stands and the multi-functionality of trees. Within this overall framework, the functional traits related to forage function must express:

- productivity of foliage and reproductive organs
- availability of forage for livestock following simultaneity between phenological cycles and major nutritive needs of animals
- palatibility of species
- nutritional value expressed by concentration of digestible nutrients (nitrogen, minerals, fiber)
- capability of re-sprouting after grazing or pruning.

Traits are related to demography, phenology, morphology, anatomy, chemical composition, animal browsing behavior and intake. Many data exist. It must be organized so that they are accessible, located in their agro-climatic and socio-economical environments and taking into account the multi-functionality of species. These criteria are not absolute and depend on biodiversity of forest stands. The use of such data for engineering in land management based on needs and constraints of the users must take into account this diversity between species and intra-species according conditions. Examples of situation and species present this diversity and explore ways for useful integration of information in databases.

Oral presentation

Session I

Is sensitivity to xylem cavitation a relevant physiological trait for fodder production in dry season?

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Abstract

In the Sahel parklands, trees can provide fodder during the dry season if they keep functional foliage. In such conditions, the xylem vessels sustain high tension which can induce cavitation, decrease the conduction of sap and lead to branch mortality. Therefore, xylem resistance to cavitation is a good index of tree tolerance to water stress. However, information about this parameter remains scarce in Sahel tree species. Moreover, its measurement is difficult and requires equipment limiting its feasibility in field conditions.
To measure the vulnerability to xylem cavitation in 10 tree species with fodder potential in North Senegal and to assess if this ecophysiological trait can be correlated to morphological traits that are easier to measures: wood density, xylem anatomy, and vessel length.
Branch samples were collected in parklands in Louga region, Northern Senegal. Wood density and xylem anatomy were determined. Branch sections were wrapped to keep wet and sent to France within 1 week. The Cavitron spinning technique was used to construct cavitation vulnerability curves and to compute the P50 (water potential inducing 50 % loss of conductivity). Vessel length was assessed by flushing air at low pressure through gradually shortened branch sections.

The Cavitron spinning technique was not relevant on nine out of ten species. Most vulnerability curves had a sharp increase in loss of conductivity, starting at low water stress. The resulting P50 which were not consistent with water potential measured in the field. All this species but *Tamarindus indica* had xylem elements longer than the device rotor. They were severed during measurement, inducing artificial loss of conductivity. Only *Boscia senegalensis* showed correct curves, and revealed very resistant to cavitation (P50 = -7.9 Mpa). Wood densities ranged between 0.41 – *Adansonia digitata* – to 0.71 – *Acacia tortilis*. P50 estimated from these densities were between – 2 and – 6 MPa.

Vulnerability to xylem cavitation could not be assessed by the spinning technique 'Cavitron', due to long xylem vessels elements in most the species. The probable low vulnerabilities estimated from high wood densities could be corroborated by xylem anatomy.

Oral presentation
Session I

Mixed model approach to analyze unbalanced paired data

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Abstract

There is increasing interest in quantifying the ecosystem services provided by tree species in agroforestry systems. A common analytical approach to assess them is to analyze the effects of different tree species growing under different environmental conditions, treatment factors and seasons on a variable of interest (e.g., plant productivity, C storage, soil nutrient content and so on). Each of these variables is usually recorded as the effect of the tree compared to that of a nearby open area. Thus, each variable is analyzed as paired data using the difference between the values recorded beneath the tree canopy and its paired open area. This technique has the disadvantage that if any of the paired values –either under the tree or nearby open area- is lost the information of the whole pair is lost. The use of maximum likelihood estimators under the framework of the general linear mixed models (GLMM) can circumvent this problem without any loss of information. Furthermore, GLMM can model within the same analysis repeated measurements, heterogeneous variances and random effects such as the identity of each tree. The overall benefits of this approach are illustrated with an example.

Oral presentation
Session II

Identifying and prioritizing agroforestry options in agricultural landscapes to optimize biodiversity and multiple ecosystem services

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Abstract

Agroforestry can play an important role in maintaining biodiversity and multiple ecosystem services in agricultural landscapes. Agroforestry encompasses a wide variety of agricultural management strategies that incorporate perennial vegetation in and around either cropland or pasture all with various potential biodiversity and ecosystem service outcomes. The quality and quantity of these outcomes is largely dependent on adoption rates, and matching management objectives with landscape site conditions. While adoption of these various strategies are contingent on a number of factors, we see providing land managers, planners and policy makers with a better understanding of their options and potential outcomes as critical. This understanding can be a component for developing effective incentive strategies for adoption. Here we present a framework for assessing baseline characteristics of an agricultural landscape using field sampling, remote sensing technology and geostatistics to identify potential agroforestry options and outcomes. Land cover, vegetation and soil results will be presented from a baseline assessment of a 100 km^2 site in a mountainous region in El Salvador. The options for incorporating various types of agroforestry and a decision matrix will be shared. While the results of this analysis are specific to this agricultural landscape, the framework presented here has broad application for management decisions and adoption of agroforestry.

Oral presentation

Session II

Trees and shrubs, key elements to improve sustainability of livestock agro-ecosystems in Colombia

Antonio Solarte* (CIPAV, Colombia) and E. Murgueitio R (CIPAV, Colombia)

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Abstract

Colombia is a rich country in terms of biodiversity, but also a country that has suffered reduction in its natural ecosystems, especially tropical forests due to extensive cattle ranching activities. These changes in land use alter the complex interactions of ecosystems and the services they provide, such as climate regulation, biodiversity maintenance, services of water quality and soil fertility. The population of cattle is 23.5 million of heads which occupy nearly 40 million hectares of pasture. The traditional livestock production parameters are very low and there is a growing degradation in the grazing areas soils.

In order to reversing trends of deterioration in this traditional production system, it is necessary to do an environmental and productive planning of this activities towards a livestock agro-ecosystems based on principles such as: increasing biomass and plant diversity, conservation and restoration of soil quality, protection and rational use of water sources, and increasing animal productivity per area. In this sense, agroforestry and silvopastoral systems (SS) are an important part of the conversion strategy of this livestock agro-ecosystem.

The purpose of the presentation is to share some experiences developed in Colombia in the use of trees and shrubs to improve the sustainability of livestock agro-ecosystems. Traditional SS are more related with live fences and scattered trees in pastures. In the other side are systematically planted systems, which have been called intensives- due to the high density of trees and shrubs planted per area- such is the case of mixed fodder banks for cut and carry, and also intensive silvopastoral systems use for grazing and browsing directly by the cattle.

Oral presentation
Session II

Bayesian networks for the analyses of tree functions trade-offs in tropical agro-silvopastoral systems

Carlos Pérez Carmona* (NINA-UAM), G M. Rusch (NINA), D N. Barton (NINA), M. Diouf (ISRA), C. Armas (EEZA), D. Fall (ISRA) and H. Guerin (CIRAD)

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Abstract

Natural system produces several resources and processes, known as ecosystem services (ES), which contribute to human wellbeing. Frequently, different ES are interlinked together, which translates into positive or negative covariation between ES. However, despite its capital importance, very little is known about which are the functions that regulate the different ES, about the effect that different management practices can have on the capacity of natural systems to produce ES or about the trade-offs between different ES.

Groups of species with similar attributes can be linked to specific effects on other organisms, which consequently affect ecosystem functioning and the provision of ES. In this study, we explored the use of Bayesian Networks (BN) to represent the probabilistic relationships between effect traits of trees in a seasonally dry agro-silvopastoral system and three service provision functions (grassland productivity and soil properties under the trees and fodder quality of trees). Based on physiological and phenological traits (for grassland and soil) and chemical components (for fodder quality), we classified trees in functional groups (PFG), estimated the linkages between these groups and the studied functions and evaluated the influence of environmental characteristics on these linkages. The BN approach allowed us to assess the trade-offs between different ecosystem functions.

We found that different PFG can have very different effects on different functions, and that these effects can be strongly modulated by environmental features. For example, there were marked differences in the productivity of the understorey vegetation between different PFG both within and across environments, which indicates that the attributes of trees play an important role determining the effect of trees on understorey vegetation. These results contrasted with those observed for the effect of trees on soil properties, which was generally positive and independent of the effect on understorey productivity, suggesting the absence of trade-offs between these functions.

Oral presentation
Session II

Defining functional groups of tree species according to rural stakeholder perceptions in Central-Mali

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Abstract

In the Tiby area (Segou region, Mali), the intensive exploitation of timber resources and the lack of tree regeneration lead to a degradation of agroforestry parklands for years. In 2010, a study was conducted concerning local knowledge and uses of tree species in a same territory, depending on different kind of stakeholders. Qualitative surveys have been carried out to identify farmer's perceptions of tree functions and corresponding functional traits. The results show that most of woody species have a significant multifunctionality. Only few species are unifunctional. The most multifunctional species cover all types of production and service functions but not all the uses, particularly for medicinal uses. Some specific uses are fulfilled by only one species. Correspondence analysis with tree functions data show the possibility of grouping species in relevant functional groups. Socio-economic analyses emphasize the fact that a same species does not fulfill the same functions depending on user groups (cultivators, livestock farmers, women, etc.) and depending on agri-environmental and socio-economical contexts (activities, knowledge, means and practices). The surveys reveal common perceptions between farmers of certain functional traits linked to strategic functions, and specific knowledge depending on farmer activities. But data on functional traits were tricky to analyze because of their sparse character and a number of interviews too low. Nevertheless, comparisons between traits quoted by farmers and some functional traits known in scientific literature will be helpful in the aim of trying to build functional groups of tree species. Finally, it seems that each user group seeks for satisfying a given need (maintain of soil fertility in cropped fields, fodder, fruits, fences, timber, firewood, medicines, etc.) by targeting a group of species among available woody species, on the base of functional traits as they discern them, and by mobilizing their knowledge and their means. It means that scientific databases composed of lists of functions and traits for a given species have low generic value and must be valued depending on the context. The notion of functional group gathering substitutable species for a same function takes thus all sense. These results aimed to emphasize the functions and specific uses of tree species that must be taken into account in perspective of improving the management of agroforestry systems.

Oral presentation
Session III

Payments for environmental services (PES) - from theory to practice
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Abstract

The aim of the presentation is to give an overview of the standard theory behind payments for environmental services (PES) and how practice fits with these assumptions. PES is dominantly seen as a market for environmental services (ES). It is argued that using the market will enhance efficiency because the values involved are measured more accurately. Moreover, budget fights within governments are avoided, and payments are expected to be better targeted. It will be argued that while these arguments have some merit, they are built on an inconsistent theory of human action and underestimate the importance of transaction costs. Concerning the former, standard economic (efficiency) theory assumes rational action in the sense of utility or profit maximization. To the extent that ES are public goods, paying for these implies some kind of altruism on behalf of producers and/or consumers. Concerning the latter, the complexities of ES – the high cost of commodifying them – and the large number of producers and/or consumers make it very costly to establish and run markets – i.e., transaction costs are high.

The practice of PES lends substantial support to this critique of standard PES theory. Buyers are dominantly public bodies. About 90 % of the global finances for PES are estimated to be public. Moreover, about 90 % of the private funding are for private ES – e.g., fishing and hunting. The assumption that public payments are less targeted than private ones will be discussed. To the extent that this postulation is right, the question whether it is an indication of inefficiency will also be evaluated. Finally, the issue of the assumed property rights in PES programs will be discussed.

Oral presentation
Session III

Colombian experiences in PES and other incentives to mainstream biodiversity in sustainable cattle ranching

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Abstract

In Colombia silvopastoral systems (SS) have been identified as a means to achieve a conversion of traditional cattle ranching towards systems that generate less environmental impact and to conserve and restore ecosystems and ecosystem services. Despite of the many advantages offered by the SS, there are still different barriers for a massive adoption by farmers. Among these barriers have been identified socioeconomic aspects related to the needs of capital, time of establishment of the tree component, low return and initial cash flow, need for labor and skilled technical assistance, or technical aspects of operation, level of training required by the farmer to handle a more complex production system, cultural aspects such as resistance to change and misperceptions.

The use of economic instruments to promote policies and changes in production systems in the livestock sector is a new issue in the country, as the main instruments used have been the establishment of standards and command and control mechanisms. In the last decade some experiences have been developed to promote the adoption of SS.
The purpose of the presentation is to share some experiences on the use of instruments in a policy mix as payment for environmental services, technical assistance, training and credit.

Oral presentation

Session III

Learning from payments for environmental services: private sector, development cooperation and PES in campesino lands in Nicaragua

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Abstract

Across a wide range of Latin American countries and institutions exists a widespread acceptance that the best way to protect the environment is by allocating prices to nature services and trading these services in markets. Attempts are being made to include agroforestry systems in Payment for Environmental Services (PES) schemes.
In this essay I explore how the objectives, knowledge, technologies, and practices of actors with asymmetrical power relations are negotiated in a PES project in Nicaragua and produce a particular form of environmental governance.

The essay is based on standard qualitative research methods including interviews with all relevant actors involved in the project, farm visits, and secondary sources.
My analysis suggests that the PES project is restructuring of rules and authority over access to and use of natural resources. The project represents an experiment by way of which different neo-liberal based ideas (CSR, PPP, PES) meet in order to secure the expansion of the activities of corporate actors and favoring their perspectives, while at the same time claiming to promote the conservation of natural resources. It has not been possible to calculate a price for the service to be traded or to establish a market for environmental services. Payments, prices and markets are only rhetorical devices in the project and they do not offer real alternatives among which peasants could choose.

My study also reveals how spaces for participation are shaped by the agenda of the most powerful actors drawing the borders of what is possible to discuss and negotiate in such spaces. These so-called "participatory processes" in practice legitimate the exclusion of critical concerns about to the activities of corporate actors and the exclusion of socio-natures that are seen as subordinated to corporate interests. The project is in effect changing some of the peasants' practices, eliminating some natures that are part of their livelihoods and re-casting peasants as "environmental service providers" while corporate practices and activities remain solely accountable to companies own designed principles and standards.

Oral presentation
Session III

Boosting traditional management of Sahelian Faidherbia parks

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Abstract

Traits and functions of Apple-ring acacia (*Faidherbia albida* (Del.) Chev.), iconic species of sahelian agroforesters, are well known of agro-pastoralists farmers and scientists. Traits include its deep taproot system reaching the water table on alluvial soils, its inverted phenology, and the leaves being present in the dry season and absent during the rainy season, and its ability to vegetative propagation (root suckers, coppices of stumps and branches). For functions, its general positive impact on associated crop, production of forage (leaves and fruit) and firewood are also widely recognized.

However, the area extension of *Faidherbia* agroforestry systems (parklands) is still far below what it could be, despite the isolated actions of many extension services and NGOs. The example of northern Cameroon shows that research on crop productivity under *Faidherbia* helped changing the perception of this tree by services and operators of agricultural development, in the 1990s. Then it was possible to "boost" the restoration of these parklands on a large scale, mobilizing public funding, associations and farmer organizations and subsidizing (even at a low level) Assisted Natural Regeneration.

The results of socio-economic surveys and pruning trials, conducted in 2012, confirm, at least, the interest of farmers for pruning the trees and fire-wood sustainable productivity of this method. Demand of farmers, on the right of pruning trees and freely use the wood harvested has been taken into account in the draft amendment to the Law on the forest regime, introduced in 2012, to the Cameroon parliament.

These studies on *Faidherbia albida* have helped Cameroonian farmers to keep more than one million young trees, but also have helped to change the law in the sense of increasing the rights of peasants on the tree. This concern planted trees, often exotic, but also natural species kept and maintained by farmers, such as shea-butter tree (*Vitellaria paradoxa*) and many other multipurpose species.

Oral presentation
Session IV

Local knowledge about how ecosystem services and biodiversity conservation are related to trees in silvo pastoral system

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Abstract

The FUNCITREE project gathered and analysed the local knowledge regarding ecosystem services provided by the tree cover in pasture lands of Nicaragua, Mali and Senegal, and compared this knowledge across a range of farming conditions. The extent to which pastures provide ecosystem services depends on local context and management practices. There is a paucity of information about how and why farmers manage their farms in the way that they do and the local knowledge that underpins this. Only the local knowledge from Nicaraguan farmers is presented here; however, despite the cultural and ecological differences, similar results were found with the same methodology in Mali. Knowledge was acquired from 30 farmers in a stratified purposive sample, using established knowledge based systems methods: AKT –Agroecological Knowledge Toolkit–. Farmers had detailed knowledge about how trees affected ecosystem services such as soil formation, erosion control, provision of wildlife habitat and water conservation. Links between trees and biodiversity, and micro-climate regulation were understood and species were classified according to their role in both provisioning and regulating services. The relation of functional traits (e.g. leaf texture and size, foliage density, crown shape, roots) was expressed by the farmers. The importance of the trees in livelihoods, as timber, firewood, and human-eatable fruits was also ranked; being *E. cyclocarpum* and *A. saman* preferred because of its multifunctionality in services and goods provided.

Farmers' knowledge related to trees was similar among the whole population; however the producers that have had direct contact with extension services detained more knowledge regarding feed banks, cattle nutrition, and milk production. The results obtained could be useful to improve the adoption likelihood of agroforestry practices in livestock farms of dry tropical lands.

Oral presentation
Session IV

Agroforestry systems in the Sahel: Determinants of production priorities and management in the rural communities of Dioro and Farakou-Massa in Segou, Mali (Presentation in French with slides in English)

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Abstract

Agroforestry systems and natural forests play many important functions in the Sahel. They provide a variety of wood and non-wood products, with significant impact on people's lives. The improvement and sustainability of the operating space, subject to the constraints of various kinds, require not only a better knowledge of constraints and priorities of rural communities' agrarian practices, but also a deep understanding of their functioning.

This study conducted in the rural Sahelien communities of Dioro and Farakou Massa, located in the region of Ségou in Mali, is especially dedicated to deepening its understanding. Of the 39 villages that comprise two municipalities, a sample of 302 households was selected for this exercise. Households were divided into homogenous subgroups, or Focus Groups of farmers, pastoralists and women. The surveys were conducted at household level within the three focus groups. The matrix pair classification was used for grading and scoring functions played by trees and shrubs.

The study gives a fair idea of the constraints and development priorities of rural communities in Dioro and Farakou-Massa. It highlights the full knowledge that people have on the various species that inhabit their villages, as well as key functions (of products and services) that meets their day to day lives. It appears from the analysis results, that taking into account the functions of trees and shrubs in agroforestry parks is essential in the process of up scaling and adopting agroforestry technologies. The analysis has also highlighted the specific players in the outcome of this complex process, and has showed the extent of the scope attributed to agroforestry species and priority functions.
It was concluded that future research should focus on mechanisms that link the functions as well as identifying constraints and developmental priorities of the study area, in order to better promote the adoption of agroforestry technologies.

Oral presentation

Session IV

Factors determining the adoption of agro-forestry technologies in the Sudano-Sahel area in Mali: The case of the communities of Dioro and Farakou Massa

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Abstract

The factors that affect the adoption of agroforestry technologies by producers are little well known. This study has as principle objective to determine the factors underlying adoption and rejection of agroforestry technologies and practices in the Sudano-Sahelien zone. This study was conducted in the intervention zone of the Millennium Villages project, which covers rural communities of Dioro and Farakou Massa as part of the FUNCiTREE project "Functional diversity: An Ecological concept for adopted and sustainable agroforestry systems in arid and semi-arid zones."

Enquiries were made at household level in order to discuss issues related to agroforestry practices and technologies and the factors determining these decisions. The transferred agroforestry technologies in the intervention area of the Millennium Villages project used for this analysis were: food storage, hedgerows protection (defensive hedges against animals), village groves, household groves and hedges bordering properties. The latter is a local practice used by the local communities with the purpose of materializing property rights over parcels of land. The variables taken into consideration in this model were the age of the head of the household, labor (availability of abled workers), affiliation to a village association, contact with village leaders, access to plots, livestock size, level of soil erosion of the land, and access to villages during the rainy season. A logistical regression model was used to determine factors of adoption and implementation of agroforestry technologies.
The application of the logistical regression model revealed that the adoption of agroforestry practices and technologies depends on several factors which vary from one technology to another according to the socio-economic characteristics of households and villages In other word, the economic status of households, their affiliation to village association, their frequent contact with village leaders, the state of soil degradation and access to the village in all seasons are favorable factors which lead to the adoption and use of new agroforestry technologies. Large numbers of livestock (cattle) favors the adoption of village groves, which are easy to supervise and protect against animal divagation. Contrary to our expectations, the variable "age" is not a determinant factor in the adoption or rejection of agroforestry technologies. This study makes a contribution the assessment of conditions that would enable up-scaling of these technologies and practices.

Oral presentation
Session IV

Establishment of demonstration plots on multifunctional silvopastoral systems to promote their adoption in the dry tropics of Nicaragua

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Abstract

The demonstration plots are a tool to show agricultural innovations in participatory training processes in order to encourage the adoption of technologies in farms. Within of the FUNCITREE project the aim was to establish functional silvopastoral systems (SPS) plots through the retention and the introduction of new species in pastures selected participatory with the owning family. In Belen, Rivas, Nicaragua were selected two typical farms, open to collaboration, accessible and willing to share with neighbors and other stakeholders. In the first farm was established 0.7 hectares with SPS cut and carry fodder bank with *Gliricidia sepium* and *Cratylia argentea* species; which constitutes an alternative to supply throughout the year, mainly in the dry season. The richness of the plot is 12 species, scattered trees density of 37 individuals/ha and 23 trees/100 meters. In the second farm was established 3.1 hectares with SPS- *Panicum maximum* associated with *Leucaena lecucocephala*, to use under grazing and browsing of woody. The richness of the plot is 33 species, dispersal trees density of 109 individuals/ha and 9 trees/100 meters. In both farms predominate scattered trees with light to moderate canopy and will require pruning to reduce shadow effect. Also, live fences were reinforced by increasing richness and looking at least 25 individuals/100 meters, almost uniformly distributed. The woody component fulfills several functions as timber products, fruit for human consumption, feed resources, shade for livestock, soil conservation, carbon sequestration, biodiversity conservation and others. The richness and abundance reflect the multifunctionality of pasture to improve the productivity and ecological performance and adaptation to climate variability, which is consistent with the focus of the FUNCITREE project.

Oral presentation

Session IV

Traditional nomadic tending of trees in the Red Sea Hills

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Abstract

Background: *Acacia tortilis* (Forssk) Hayne is a dominant species across the arid to hyper-arid Red Sea Hills (RSH) of Egypt and Sudan. Pastoral nomads have relied on fodder resources from this drought-resistant, multipurpose tree for millennia, in particular during long dry periods when ephemeral grazing is scarce. Presently, political, social and economic factors impose changes in the traditional livelihoods and landuse of the indigenous tribes. Documenting traditional tending practices and underlying ecological knowledge can be of vital importance for safeguarding these essential resources for future generations.

Research objectives: We focus on the use and tending of *A. tortilis* and its subspecies among the five main tribes in the area, the Hadandawa, Amar Ar, Bishaari (all Beja tribes), Ababda and Ma^{c}aza. Our aim is to record tending practices and their underlying traditional ecological knowledge while there are still informants who can tell us in their own terms how they understand and carry out their activities.

Methodology: The information was collected through structured and open-ended interviews among 74 informants across tribes, gender and generation, and was complemented by our observations from more than 25 years of studies in this area.

Results: *A. tortilis* is utilized (for fodder, fuel, cordage, etc.), shaped (circumcised and pruned) and tended (shaken, cleaned, renewed, protected and cared for) during all its growth stages. These old practices are subject to a set of rules regulated under traditional laws that gradually are losing influence where signs of abandonment and sedentarisation are pronounced. Alleged destructive pruning are subject to a set of rules that are in line with good pruning practices.

Main messages: The “gardening” of trees that is still traditionally practiced in the RSH, in particular among the Beja, has several effects that undoubtedly protects, strengthens and renews these trees.

Oral presentation

Session IV

Use of the community capitals framework to understand adaptation of silvopastoral systems: bridging the gap between research and development

Isabel Gutiérrez-Montes*(CATIE), N. Sibelet (CATIE-CIRAD), C. Villanueva (CATIE), D. Sánchez (CATIE), D. Mosquera (CATIE) and C. Marie (CIRAD)

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Abstract

Research on sociology of adoption and diffusion seems to highlight the separation between agricultural and natural resources research efforts, and its relevance and application (so called adoption) by local producers. Trying to address these issues and in order to bridge the gap, we propose the use of the community capitals framework (CCF) within agro ecological research efforts as a twofold to: by the one hand include, analyze, and process socioeconomic data (within the context of an agro ecological research); and by the other hand to open spaces where producers (key stakeholders) can be part of a participatory research process and based on evidence and a deep and systematic contextual analysis, start the *adaptation* of SPS.

Results from Rivas- Nicaragua, highlight the fact that producers have local knowledge (cultural capital) to identify functions and ecosystem services from trees within the pastures: i. e., timber and wood production; feed resources and shade for livestock; soil, water and biodiversity conservation, carbon sequestration and others. This local knowledge (cultural capital) combined with relationships with neighbors', family and friends (social capital) are a starting point to promote the development of multi-functional silvopastoral systems (SPS) toward the improvement of productivity of livestock farms.

FUNCITREE participatory research experiences along with our experience in the Mesoamerican Agroenvironmental Program (MAP) with farmer field schools (FFS), have shown a key role of these efforts of capacity building (human capital) toward the generation of a learning environment in which participants can learn, share and apply more and better knowledge and skills to improve their farms. Knowledge sharing or *wisdom dialogue* (cultural capital) within FFS, allow participants to build and strengthen relationships (social capital) and conserve the ecosystem services (natural capital) through the use of innovative sustainable land use practices, such as SPS. Additionally, the process seeks to empower participants to increasingly take part in local and national decision making structures (political capital). Finally, there is also an enhancement of the productive infrastructure (physical capital) and an increase of income and/or savings (financial capital) coming from the improvement of the productivity.

Oral presentation

Session IV

Bayesian network modeling of adoption of agrosilvopastoral practices in Tiby, Mali

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Abstract

A Bayesian belief network (BBN) is used to model household level data on adoption of agrosilvopastoral practices in Tiby, Mali. Statistical modeling of agricultural adoption practices has tended to use categorical (logit/probit) regression models focusing on a single technology or practice, explained by a number of household and farm characteristics. We discuss the advantages of BBNs in modeling more complex data structures, including (i) multiple practices implemented jointly on farms (ii) correlation between probabilities of implementation of those practices, and (iii) correlation between household and farm characteristics. The paper demonstrates the use of BBNs for 'deductive' reasoning regarding adoption practices, answering questions regarding the probability of implementation of combinations of practices, conditional on household characteristics. As such, BBNs can be used as a complement to logistic regression analysis, also exploring causal structures in the data before deciding on a reduced form regression model. More uniquely, we show how BBNs can be used 'inductively' to answer questions regarding the likelihood of certain household characteristics conditional on certain practices being adopted. The article discusses the potential of BBNs to complement the toolkit of agricultural extension.

Poster No 1

Trees of SSP in the efficient use of water and tolerance to drought

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Abstract

Silvopastoral systems are composed of surface and underground elements, which influence ecosystem and productivity processes according to their ability to withstand drought events. The purpose of this study was to evaluate root traits as a step to identify the strategies adopted by tree species to tolerate or avoid climatic variations in cycles of drought and rain. Soil and root samples of six tree species: *Albizia saman*, *Guazuma ulmifolia*, *Coccoloba caracasana*, *Tabebuia rosea*, *Crescentia alata* and *Enterolobium cyclocarpum* were extracted underneath the tree crown and two different soil depths in cattle farms in the Rivas province of Nicaragua (Fig. 1). The study explores fine root density (g m^{-3}), specific root length, and length volume (cm^3) using the program WinRhizo.

The tree species differed significantly in root traits and their distribution in depth, and root traits were correlated with aerial traits such as crown density, leaf water content, both absolute and relative, and specific leaf area (SLA). Species could be clustered (Ward, Euclidian distance) based on root traits in the dry and in the wet season, into three and four functional plants types (FPT), respectively. For instance, in the rain season, FPT 1 was characterised by high SRL and low RBD, whereas trees in FPT 2 had the longest roots. FPT 3 had the lowest SRL and root length. The species with greater root length and density was *C. caracasana*, which appears to have a strategy of using conserved resources during the dry season based on the patterns of root distribution in the dry season. *E. cyclocarpum* and *A. saman* are associated with greater root diameter and lower crown density.

Poster No 2

Functional traits and properties of trees and their effects on rainfall and nutrient throughfall

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Abstract

The study aimed to evaluate the effects of whole plant and leaf properties of the tree species: *Albizia saman*, *Coccoloba caracasana*, *Coccoloba floribunda*, *Crescentia alata*, *Enterolobium cyclocarpum*, *Guazuma ulmifolia* and *Tabebuia rosea* on the proportion of rainfall throughfall that reaches the ground, and on its content of NO_2^-, NO_3, total P total, K^+, Mg^{2+} y Ca^{2+}. We evaluated 27 isolated trees located in paddocks in 9 livestock raising farms in the department of Rivas, Nicaragua. Rainfall samples were collected in 324 rain gauges, 12 for each tree (8 under the tree, 4 in the open grassland). The data were collected after 20 rainfall events during the rainy season, from May to September 2011. Thirty-nine samples (28 composite samples under the tree, and 11 in the open grassland) were analysed chemically. There were significant inter-specific differences in the proportion of throughfall, which was in turn associated with leaf size. *Enterolobium cyclocarpum* was the species with highest proportion of throughfall (84%). Leaf tensile strength, peciole length and leaf size were traits associated with the amount of nutrients captured in the throughfall. *Coccoloba* spp. was the species group with highest nutrient contents (mg/l) in the throughfall.

Poster No 3

Evaluation of biomass production and regrowth capacity of woody forage in pastures in the dry tropics of Nicaragua

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Abstract

The forage woody species are an alternative for cattle feeding in the dry season. The objective of this study was to determine the biomass productivity and regrowth capacity of forage woody on pastureland. Also identify the function traits related to biomass productivity. Six species common in pastures were selected with six replicates for each for a total of 36. The trees were distributed in active pastures, isolated and without management of recent pruning. These were pruned in April 2011 at a height of 2 m; each month was recorded regrowth, specific leaf area (SLA), leaf area (LA), and leaf intensity, and end of the trial (4 months) biomass production. The results showed variability in the edible biomass production and shoots among woody forage. *Cordia dentata* and *Pithecellobium dulce* had the highest of edible biomass 5,95 $\pm$ 1,43 and 3,20 $\pm$ 1,12 Kg DM / tree respectively; while *Albizia niopoides* showed the lowest yield 0,53 $\pm$ 0,14 Kg DM / tree. In descending order the average production of sprouts per tree was *Pithecellobium dulce* (260,5), *Cordia dentata* (147,83), *Guazuma ulmifolia* (69,0), *Albizia saman* (54,0), *Gliricidia sepium* (24,33), and *Albizia niopoides* (17,33). In terms of functional traits was determined that a lower LA is probably related to a higher reservoir meristems and axial buds which improve the productivity, for instance *Pithecellobium dulce* (4171,9 mm^2) and *Cordia dentata* (4212,1 mm^2). Both species have potential for cattle feeding in the dry season, either under the cut and carry system or by cutting and offering on the floor near the tree. However, we must know the effect of prolonged pruning on the response of *Cordia dentata* and *Pithecellobium dulce* and some studies on how to manage dispersal trees in pasture to produce fodder, mainly for the dry season.

Poster No 4

The more things change, the more they stay the same: A historical ecology of cattle ranching and associated land use in western Nicaragua

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Abstract

This presentation was developed within the framework of the research project "Bioengineering multifunctional silvopastoral landscapes: a case study in Nicaragua." To date, this project has had a focus on biophysical and economic issues, but a more complete understanding of farm-level decision-making requires looking at the social dimension of livelihood choices. Biophysical, economic, or ecological studies alone cannot answer questions related to how people make decisions regarding land management or how their decisions today are constrained by decisions made in the past. An historical ecology approach has particular salience when applied to land management history since collective decisions to shift traditional practices and livelihoods are generally made on the basis of culturally transmitted information. This has implications for policy-making, particularly because escalating deforestation in Nicaragua is in part an historic product of collective decision-making.

The historical hegemony of the elite class in Nicaragua has effected developments within the national economy and on its principle products, many of which are derived from cattle ranching. These developments have ranged from market trends to technological shifts, but not until 1979 did they include fundamental changes in the worker/employer relationship within the agricultural sector. Up until this point, the agricultural practices of the Nicaraguan peasantry had been largely based on local knowledge. Since the reforms of the Sandinista Revolution diffused many of the technologies that had previously been monopolized by large-scale landowners, local practices were in many instances combined with the technologies of the 'Green Revolution.' In the past few decades, local practices like silvopastoral systems have been incentivized and reinvigorated by international organizations by means of a diverse range of initiatives. This paper provides a long-term perspective on the political, economic, and cultural factors involved in land management by investigating the thresholds of environmental change associated with the practices of cattle ranching from an historical ecology perspective.

Poster No 5

Tree functional traits approach to assess ecosystem services in silvopastoral systems of Rivas, Nicaragua

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Abstract

From March to August 2010 six species of isolated trees were characterized in silvopastoral systems of Rivas, Nicaragua, according to their ability to withstand drought events. A functional ecology approach was used to evaluate how trees strategies vary, and the synergies and trade-offs between traits. A total of 20 traits were assessed and measured to characterize six isolated tree species (*Albizia saman*, *Guazuma ulmifolia*, *Coccoloba caracasana, Tabebuia rosea*, *Crescentia alata*, *Enterolobium cyclocarpum*). We aimed to find axes that indicated different drought tolerance strategies. Principal components analysis showed a clear separation of species based on the traditional classifications of avoidance-tolerance vs. conservative-acquisitive axes of specialization. We found the first PCS axis to be an indicator of drought tolerance and avoidance strategies (canopy traits) and a second PCA axis reflecting the individual resource capture and identified as a conservative and acquisitive strategies (leaf size and toughness). Our finding suggest not only that there are specific traits associated with responses to climatic stress, but also that this traits manifested in species provide different effects to drought mitigation by preventing understory water loss. We measured actual evaporation under the different canopies trees in relation to differentiate the ability of the species to conserve humidity during the end of the drought period. Pasture cover estimations were also made to relate the drought tolerance service provisioning with the effect of the tree actual pasture production at the end of the dry period and after the first rains. We recommend the species *G. ulmifolia* and *C. alata* to improve provisioning of ecosystem services of drought resistance and pasture production as they prove to have well defined different drought responses, prevent a significant amount of evapotranspiration under their canopies during the dry season, and allow enough light transmission to reach the understory to guarantee pasture production.

Poster No 6

Preference of dairy cows in the consumption of woody forage in Rivas Nicaragua

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Abstract

In dry areas of Central America woody plants are an alternative forage for cattle feed. It was conducted a study in a dry zone of Nicaragua its objective was to evaluate the preference in foliage consumption of ten common woody species in pastures and traits that favor greater acceptance by livestock. The preference was determined by cafeteria testing in pairs of woody using five cows. The combination of ten species in pairs originated a total of 45 events for each cow, each lasted three minutes. The descending order of consumption was *Samanea saman*, *Leucaena leucocephala*, *Albizia niopoides*, *Cordia dentata*, *Moringa oleífera*, *Guazuma ulmifolia*, *Gliricidia sepium*, *Brosimum alicastrum*, *Mimosa pigra* y *Acacia farnesiana*. The first three species are legumes that have higher nitrogen content, leaves large and soft; although the latter two are legumes of low preference is due to the presence of thorns and high concentration of condensed tannins. Many forages species present condensed tannins that can poison livestock by high consumption. This usually occurs when cattle have this food only diet and it is difficult to happen in pasture where there is a variety of forages. Preference studies give us guidance on the preferred livestock species, although silvopastoral system designs must consider other attributes such as ease of propagation woody, resprouting capacity, forage yield, tolerant frequent pruning, and are multipurpose. Therefore species like *Leucaena leucocephala*, *Cordia dentata*, *Gliricidia sepium*, and *Guazuma ulmifolia* have important advantages as on-farm feed resources.

Poster No 7

Effects of tree cover and its functional traits on the movement patterns and behavior of dairy cows in Rivas Nicaragua.

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Abstract

Using geographic information systems, the effects of tree cover on the movement patterns and behavior of dairy cows was studied in 13 pastures in Rivas Nicaragua. Cow preferences for functional traits and for functional groups of trees were also identified. A continuous period of time from February to September between 7:00 and 18:00 was evaluated. The study showed that during the day, higher variations occur than seasonal changes for all the variables studied. Cows mainly use trees at noon for protection and preferred functional groups of trees that best reduced the effects of radiation and temperature. It was observed that cows used trees more during the rainy season than in the dry season. Depending on the activities that cows do and the time of day, they visit different functional groups. Cows use trees with less coverage to graze and those with denser canopy coverage for protection. When deciduous trees regain their leaves in the rainy season they are visited by cows while during the dry season these trees are not visited. A design of silvopastoral systems with the presence of both deciduous and evergreen trees is recommended, because the different functional groups are utilized by the cows during different seasons. In the rainy season the effect of both evergreen and deciduous groups is the same, however cows prefer deciduous trees. In the dry season the evergreen trees offer greater protection than the deciduous trees which lose their leaves, and cows switch their preference to evergreen trees. We recommend pruning the evergreen trees in the rainy season when both groups of trees offer similar protection, because too much canopy coverage will affect the grass growth and cows prefer deciduous trees during this time.

Poster No 8

Tree cover effect of paddocks and lactancy on diurnal behavior double proposal cattle managed under grazing on sub-humid tropic

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Abstract

Extreme temperatures, relative humidity, solar radiation and wind speed can cause caloric stress in cattle (Gaughan *et al.* 2008). However, trees in pastures help to dissipate the sun's energy and lower temperatures (Pezo & Ibrahim 1999). This study evaluated the effect of different levels of tree cover (<8%, 10-17%, >23%) in pastures, the lactancy stage (<3 and >5 months), and season (dry and rainy) on the time spent by dual purpose cows to five activities, as well as on physiological indicators of heat stress such as rectal temperature (TR) and respiration rate (FR). Grazing/browsing was the main activity during the day, with 55 and 61% of the time spent by cows in the paddocks, for the dry and rainy season, respectively. The time dedicated to grazing was significantly affected by the interactions season × tree cover (p= 0,0089) and season × period within the day (p= 0,0159). During the dry season, cows spent less time grazing in those paddocks with the lowest tree canopy cover (< 8%); whereas during the rainy season the tree cover did not affect such parameter. THI was the climatic parameter that influenced the most the time spent grazing in both season. Fifty percent of the cows were grazing when the THI was 92,5. The temperature reducing effect of trees was measured and differences were found in ambient temperature under trees (α=0.05). Pastures with high tree coverage had an average temperature of 30.83^{o}C (0.16)a, with medium tree coverage 31.12^{o}C (0.13)ab and low coverage 31.28^{o}C (0.10)c.

Poster No 9

Isolated trees effect over soil characteristics in silvopastoral systems in Rivas, Nicaragua

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Abstract

Research concerning isolated trees effect of *Crescentia alata Kunth* (Jícaro) and Guazuma *ulmifolia* Lam. (Guácimo) over soil characteristics under silvopastoral systems was carried out in the Southeast of Nicaragua. 36 Jícaros and 20 Guácimos trees were selected in paddocks with minimum variability in use, topography and soils. Soil compound samples were taken under each tree top and in the open paddock adjacent to each tree, at a 0-10 and 10-20 depth. Total carbon and nitrogen, pH in water, available phosphorus, potassium, calcium and removable magnesium were verified in each sample. Herbaceous coverage was evaluated in both sample positions, at the end of the dry season and at the beginning of the rainy season. Results indicated that there are differences in various soil characteristics under tree tops and in open pastures. Carbon quantity and total nitrogen in the soil is higher under tree tops of Guácimo than in the open pastures, but there are not differences in the case of Jícaro. The pH value increases in the first 10 cm of soil under tree tops of both species, without differences in the next 10 cm of depth. For both species and depths higher contents of potasium and available phosphorus were found under the trees. Differences refer to the quality and quantity of aerial leaf litter, which jointly with a lower temperature under the trees results in differences in the leaf litter decomposition processes finding higher quantity of wider leaves in both seasons. Therefore, it is needed to study trees contribution with other tree species in silvopastoral systems, but the actual study states that trees environmentally benefit the soil, improving its fertility through the contribution of nutrients to increase farm productivity.

Poster No 10

FUNCiTREE: A tree trait base of seasonally dry agro-silvopastoral ecosystems

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Abstract

Plant traits are widely used as indicators of eco-physiological and other functions that support plant establishment and persistence, often referred to as *response traits*. Similarly, plant traits can be used to define the effects of plant on the environment and on other organisms, *effect traits*. Traits can then be used to predict general ecological functions and those that underpin the provision of ecosystem services.

The FUNCITREE trait base gathers tree traits that are related to four functions important in agro-silvo-pastoral systems in seasonally dry climates in the tropics: 1) tree strategies of water and resource use, 2) tree-understory vegetation interactions, 3) soil formation and 4) fodder production. The data base has a modular structure and is formed by 3 major groups of data. The *location* and habitat information entries consist of data such as the tree geographical position, landscape form, and land-use and soil type. The *trait* entries are structured in a nested manner, with identifiers at the level of organ, individual and species. The date and/or sampling period and the source of the data are documented for each entry. A third group of data consists of *effect functions* and includes data linked to the tree individuals or species such as productivity and diversity of understory vegetation, soil chemistry and animal forage preference.

Poster No 11

Riparian forests role and their ecosystem services in livestock landscapes; conservation and restoration strategy in the medium watershed of Gil González River, Belén, Rivas, Nicaragua

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Abstract

28.3% of Nicaragua's territory is covered by livestock landscapes that keep small forests patches in riparian forests. These forests play a key role in the provision of multiple ecosystem services -shelter, food and connectivity, among suitable habitat areas for irrigation and recreation. Some species provide fruits for human consumption and serve as windbreaks for animals and crops. The objective of this synthesis is to highlight the importance of ecosystem services in the riparian forests of the Gil Gonzalez watershed and contribute to improve conservation and restoration strategies using the results and experiences of the "FUNCITREE" and "Multi-functional Landscapes" projects, carried out in Belén, Rivas. Here two types of riparian forests were found as of high value habitats for conservation and provision of ecosystem services (water quality for human consumption and infiltration capacity to retain water during the dry season); and three types of degraded riparian forests also were found that have considerably decrease their capacity to provide ecosystem services. Producers, owners of these forests have the great responsibility to conserve or restore these forests to assure common benefits as the provision of clean water, impact reduction for climatic change and contribution to biodiversity conservation. In the same manner, favored people with these ecosystem services have the responsibility to acknowledge and support the conservation.

Poster No 12

Differences in tree effects on pasture primary production in silvopastoral systems in Central America

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Abstract

In savannas, wooded meadows and other ecosystems with trees in a matrix of herbaceous vegetation, trees and herbaceous plants interact in various ways. Through the effects of trees on the water balance in the soil and in the vegetation, on soil fertility (Velasco et al. 1999) and on light availability, trees have a large impact on the conditions for understorey growth. We studied the effects of three tree species with different attributes in terms of their crown architecture and phenology, *Cassia grandis*, *Tabebuia rosea* and *Guazuma ulmifolia*, on the above-ground net primary production and composition of silvopastoral pastures in Central Nicaragua.

In the study grassland net primary production (ANPP) differed significantly between months ($F_{(3,84)}$ = 52.04; P < 0.0001), being highest in June and lowest in April. There were also significant temporal changes in the percentage of grassland cover ($F_{(3,72)}$ = 37.05; P < 0.0001). The results show a marked decline of ANPP in the middle of the rainy season (July) and provide evidence of this phenomenon and raise the question about a switch of the factors that limit productivity along the growth season in these systems.
ANPP was higher ($f_{(1,84)}$=3.97; *P* = 0.0495) in the open grassland (2.21 g $m^{-2}day^{-1}$) than under the trees (1.86 g m^{-2} day^{-1}), which corresponds to an average of 15.8% reduction of ANPP by the tree. Although there was no significant (P>0.05) interaction term tree species x location (under the tree vs. open), the difference in ANPP between under the tree and in the open was larger in the case of *C. grandis* than in *G. ulmifolia* and *T. rosea*.
In this study rainfall increased relatively steadily from April to July and also soil moisture increased consistently during this period. Finally, ANPP is limited by rainfall in the dry season, and a sharp increase is triggered at the onset of the rains. The pattern observed also agrees with earlier evidence of a decline of ANPP at high levels of accumulated rainfall.

Poster No 13

Challenges and limitations of Mixed Research on the Adoption of Agroforestry Practices in Mali

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Abstract

For my master thesis, I conducted field research at the Funcitree project site in Tiby, Mali to find out more about farmer preferences, attitudes and socioeconomic parameters that influence their decisions to adopt and practice agroforestry.
A structured representative household survey, with a sample size of about a 100 households was conducted. In addition, qualitative data from a few in-depth follow-up interviews and field observation was meant to be used for later data analysis. This mixed method approach was meant to corroborate data to make analyses with Bayesian Belief Networks to find out about decision-making processes.

The main results of the research are drawn from the impediments that came up during the planning period, the actual field research, (lacking) collaboration with partner projects and the resulting data analysis with an incomplete data set. From those difficulties and challenges, conclusions about possible improvements of future research strategies are drawn.

The main messages are an appeal for a more simplified (and shorter) survey design, better planned communication with partner projects, and more qualitative research, e.g. focus groups to pretest and discuss a questionnaire and qualitative interviews to follow-up and close knowledge gaps.

Poster No 14

A review of the extent to which tenure arrangements are considered in estimating opportunity costs of REDD+

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Abstract

Reducing emission from deforestation and forest degradation (REDD+) is a mechanism which compensates the associated economic losses that the developing countries would face for their contribution to climate change mitigation, by reason of keeping their forest intact. The losses represent the foregone revenues and foregone benefits from alternative land uses – the opportunity cost in economic domain. There are numbers of literature about the interpretation of opportunity cost, with varying degree of estimated values for similar cases. However, the accurate estimation of opportunity cost is strategic to determine fair compensation. Clear and secure tenure arrangements are critical calculating the costs of REDD+. This review focuses on to what extent has economists considered the tenure arrangements in their calculation of the opportunity cost. Since secure tenure rights determine who is eligible for incentives and responsible to meet the objectives of the program, tenure matters the economic assessments. It's a bitter truth that in the tropics there exist mosaics of complex tenure arrangements. In most of the literatures it is recommended that secure tenure arrangements is essential indicator for true economic assessment, however there is very limited study to figure out the consequences of insecure tenure arrangements. It was found that the economists have in most cases made subjective evaluation taking into account the GIS database on land cover and land use change, the land use trajectories, the market accessibility and the biophysical conditions influencing returns from the alternative land use etc. but not the differences in land tenure, to estimate the opportunity cost. Although such assumptions provides the macro scale of the cost of the program, the real cost is undermined. A clear recommendation is that tenure reform and its enforcement are a part that needs to be solved before making an economic assessment of such mechanism or say before the implementation of any program. It is because the assessments without clear tenure arrangement do not provide the real opportunity cost and eventually will dispossess the poor people with insecure rights over the resources.

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