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CORRIDOR

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Deliverable 5. Protocols for collecting and interpreting data on tree cover in coffee plantations

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PU	Public	PU
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Protocols for collecting and interpreting data on tree cover in coffee plantations

Coffee farms are amongst the most complex agroecosystems, where site conditions, such as percent cloud cover, humidity and temperature play important roles and vary with elevation and latitude. In addition, farmers are increasingly encouraged to manage shade on their farms to increase conservation values by incorporating trees within their production systems. Relationships between tree cover and productivity are governed by a combination of environmental and management variables with some farms being well-suited to increased shade, and others not. Likewise with tree cover and biodiversity, it has become clear that tree cover is not necessarily synonymous with high conservation values. Rather, there are several variables at the farm, and landscape scale that are critical in determining the effect of tree cover on conservation in these systems. Diversity (number and eveness of tree species) and complexity (number of strata and presence of epiphytes) together with proximity to forest and management intensity, all affect habitat quality for different species with some taxa and functional groups being more sensitive than others to these variables. Critical data to collect when studying coffee agroecosystems vary with the scale of the study but it is helpful for all reported data to be accompanied by sufficient contextual information for it to be appropriately interpreted.

Key priorities for all studies are an adequate characterisation of tree cover and management intensity – this needs to consider the vertical stratification of vegetation and the seasonal leaf area duration as affected by farm management (regular pruning) as well as quantification of management inputs (weeding, fertilisation, use of agrochemicals). Without this, the response of either coffee productivity or biodiversity (and preferably both) to tree cover cannot be adequately understood and studies will not be comparable across sites. It is recommended that both productivity data and biodiversity data are collected simultaneously, specifically coffee productivity should be assessed as a matter of course in biodiversity assessments.

In addition to collecting more substantial data as set out in each section below, each coffee farm studied should be located and described overall in terms of a standard typology applicable for the whole Mesoamerica (**Table 1**).

Table 1. *Typology of coffee shade for Mesoamerica according to tree species richness, and the number of strata. For each type of system the level of management intensification (low, medium or high - in terms of specified management inputs) and which trees are planted or naturally regenerated should be stated.*

Tree Species Richness	Tree Strata (#)	Type of System	Example
0	0	Sun coffee	No tree cover
1	1	Monostrata	*Erythrina*, *Inga* or *Musa* spp
2	2	Two strata	*Inga* with Bananas or *Erythrina* with *Cordia*
3-9	>2	Polystrata	Diversified shade in certified farms
>10	>3	Forest-like	Mature diversfied stata and tree species

1. Landscape context

There are an increasing number of studies that have demonstrated that the landscape level context is critical to understanding mechanisms of ecosystem functioning including conservation and productivity in coffee agroecosystems. Though the focus has often been on the on-farm tree cover, ecologists and agronomists recognize that off-farm tree cover can have an impact on farm level, and landscape level functions. Landscape level features are most easily measured using remote sensing technologies including the percent forest cover and other landuses surrounding the farm (either total area, percent or both), the distance to the nearest forest fragment, the number and size of adjacent fragments, and the area of individual as well as total forest patches within a predetermined distance (typically less than 1 km). Additional landscape level variables which should be identified include a characterization of the natural vegetation of the region. In MesoAmerica, the most frequently used classification is the Holdridge life zone designations. In terms of biodiversity, any regional, national or local conservation priorities should be described including reference to internationally recognised endangered species on CITES. Location of sites in relation to protected areas and position with respect to biological corridor initiatives should be noted. Critically, GPS co-ordinates should be given for all sites, so that other contextual information can be derived. Priorities for location of studies are given in the regional strategy in CORRIDOR Deliverable 6.

2. Overall tree cover and community data

Collections of individual species make communities, that in turn, have distinct quantifiable properties. Recommended tree community data to collect include:

- tree density per ha,
- the number of strata, or vertical layers present
    - (herbaceous layers, shrub layer, sapling layer, sub-dominant tree layer, dominant tree layer, and emergent tree layer with species assemblage and measurements of canopy depth for each stratum where possible – preferably from an individual tree inventory as set out below, otherwise a general description will suffice);
    - strata can be extracted from diameter or height class distributions if the dbh and height of individuals are collected as is recommended in the individual tree protocol;
    - the highest canopy height, and the lowest canopy height should be measured and used to calculate canopy depth.
    - presence of epiphytes should be noted, preferably an inventory, but at least a generalised description of what is present (species and their abundance)
- rank abundance should be the standard form of presentation of tree diversity data in the most disaggregated form possible (which is usually per plot) in addition the tree and/or shrub species richness of the plot should be calculated along with either the Shannon, or Simpson indices of diversity or both, where mean values across plots are quoted a measure of variability (usually the standard error) should accompany them;
- where possible data on the spatial distribution of tree cover in the plot should be collected, noting whether trees are regularly spaced, randomly distributed or in clusters (see Sinclair, 1999 for minimum descriptions required for agroforestry configurations).

Canopy cover should be noted as a percent that can easily be measured using a canopy densiometer (Ganey and Block, 1994). The densiometer is a cheap instrument (less than 50$) and thus measuring tree cover with such an apparatus should become the minimum standard methodology. In addition:

- a relationship between tree cover and light intercepted by shade trees (from direct measurement of photosynthetically active photon flux density outside and below the canopy using a quantum sensor) must be performed over the range of tree cover encountered in the field so that light availability for coffee underneath can be assessed;
- when shade management and/or tree phenology result in large variation in tree cover throughout the year, measurements need to be repeated during key periods of the production cycle, at least the leaf duration of predominant tree species and the timing and extent of any tree pruning should be noted (from asking farmers if repeated measurement is not possible)

Ground cover should also be described (sampling to reflect variability). Where there is a well developed understorey then botanical inventory is preferable using standard quadrats methods (Bonham, 1989) but where this is not possible a generalised description should be included.

Presenting clear information on the sampling scheme used: plot type, size, number and location is critical for comparing data across sites. Coffee plants are members of the agroforest “community”, therefore data on the density, type, and height of coffee plants should be noted in addition to shade trees and other flora.

3. Individual tree data

Where it is possible to do so, a complete tree inventory or a sample, is recommended - samples should follow transect methods adjusted for the variability of the system. Measurements for individual trees include the species complete botanical name including family, and regional common name. The diameter at breast height of 1.3 m (to a precision of 0.1 cm), and the total tree height (to a precision of 0.5 m). Since height and diameter are frequently correlated, simple, diameter/height models can easily be created from a subset of trees to save time. Note however that such models are species specific and may not remain valid if the trees are pruned.

Additional information on individual trees or species should include socioeconomic data, including utility, economic value, cultural roles and the farmers' rationale for having each species in their farm. Record should be made of whether each tree is a forest remnant, or whether it originates from natural regeneration or was planted. If possible, the canopy width, depth, and leaf area index should be measured as they provide important autecological information.

Though rarely collected, data on tree phenology, including periods of fruiting and flowering should be collected where possible, as they are important for understanding the wildlife value of tree species included in coffee agroforests as well as shade at key times for coffee flowering and fruiting (see tree cover section above). Complementary data from national floras can be used to determine the fruit and flower typology of trees but tend to be generalised over large geographical areas. Local knowledge of tree phenology is often a reliable and more cost effective source of this information. Where local knowledge acquisition is done we recommend the use of systematic sampling and recording as set out in the AKT knowledge-based systems methodology, the software for which is freely available (Sinclair and Walker, 1998; http://akt.bangor.ac.uk/). We recommend maintaining a master database of tree species and the above-mentioned characteristics and making this information generally available to other researchers, as is general practice for published gene sequences.

4. Farm and coffee productivity data

Coffee production data should be collected as a matter of course in all studies (Vaast et al., in press). The minimum requirement is the yield per unit area (stratified in relation to any key variation and noting the position within the biennial yield cycle of coffee where high and low yielding years tend to alternate) preferably over multiple annual cycles. More detailed breakdown of yield components (yield per tree, berry size, flowering etc) are desirable, particularly where they can be related to detailed data on tree cover at key points in the production cycle, to increase understanding of effects of tree cover on productivity. Where information is available on quality this should be collected (Vaast et al., 2006), since economic performance is increasingly a function of both quantity and quality (the importance of quality varies in relation to how farmers are paid for their coffee and the level of aggregation at which quality is determined).

Quantification of pest, weed and disease incidence (Wintgens, 2004) is of critical importance, since this may affect both yield and quality of coffee and shade effects on coffee production may be largely mediated by effects on incidence of key pests and diseases.

In addition to the coffee system typology above, we recommend collecting and reporting basic farm level data. Minimum requirements are the location of the farm (country, region, district), and at the very least a single GPS point of the farm (co-ordinates for any plots or other measurements are recommended – see above). Other environmental data of importance include elevation, slope, topographic position, and the level of management intensification. Management data can strongly influence tree cover and should be noted, including the use of chemical fertilizers and pesticides, the removal of epiphytes, or pruning of trees found in the system. Additionally the size of the farm should be measured or noted, as well as the proportion of the farm that is dedicated to coffee production. Where possible farm income from coffee and other enterprises (including where relevant any payment for environmental services) is of value in understanding potential trade-offs between diversity and livelihood. Farm level tree species richness should be noted (including trees in non-coffee farm areas). Where possible: the original vegetation (prior to agricultural use), the mean annual temperature and precipitation, and soil types should be included. When available, the year that the forest was cleared for the farm, the main economic activity of the area, the % landscape under pasture, annual crops, coffee, or forest is also valuable (see landscape section above).

5. Animal diversity

Tree and ground flora diversity are covered in the preceding sections of the protocol, and animal diversity is seen here primarily as a response to vegetation. The most pressing priority is for biodiversity studies to include sufficiently detailed information about tree cover and management intensity (see above) for such responses to be understood. The next priority is for multiple animal taxa to be studied at the same sites, since we anticipate that there will be variable responses to tree cover amongst taxa. The third priority is to collect biodiversity data from the central section of the MBC (Guatemala to Nicaragua), initially for birds and ants, since these are well characterised at either end; other taxa require study along the entire corridor. Clearly, the taxa studied and, where appropriate, the species focus needs to be locally determined (see above) in relation to conservation priorities. While quantification of canopy species can be expected to relate directly to tree vegetation structure as set out above, conservation of understorey species is more challenging in coffee and the priority must be to focus on the effectiveness of interventions to maintain understorey connectivity, such as undisturbed strips organised at landscape scales.

Standard protocols should be used for assessing diversity of all taxa that are assessed. For example, birds (Bibby, 1992), ants (Agosti et al 2000), amphibians (Heyer et al., 1994), and mammals (Wilson et al., 1996). The precise details of methods used should be reported including sampling schemes and measurement methods. For all taxa rank abundance data should be presented in its most disaggregated form as the principal data format, as set out for trees above. This is in addition to whatever data summaries in terms of means of abundance, species richness and or various diversity indices (Shannon and/or Simpsons) are calculated. Key information on diversity for animal taxa as summarised for pasture in CORRIDOR Deliverable 3 Table 2 are equally valid for studies in coffee systems and should be followed.

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