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CORRIDOR

Working group on evaluation and synthesis of information on tree cover to balance productivity and biodiversity in agricultural landscapes along the Mesoamerican Biological Corridor

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Deliverable 6. Regional research and development strategy to define thresholds for tree cover in the agricultural matrix along the MBC

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PU	Public	PU
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Regional research and development strategy to define thresholds for tree cover in the agricultural matrix along the Mesoamerican Biological Corridor (MBC)

The reviews of data available on the impact of tree cover on productivity and biodiversity in coffee and pasture along the Mesoamerican Biological Corridor (CORRIDOR deliverables 2 and 4) have revealed key research requirements. Priorities differ in relation to pastures and coffee farms and with respect to productivity and biodiversity, but the use of standard protocols set out in CORRIDOR deliverables 3 (pastures) and 5 (coffee) are vital for all studies if they are to contribute comparable data that can be used to understand what is happening along the MBC. Adherence to these protocols would fulfil an urgent need for tree cover to be well characterised in studies of both productivity and biodiversity so that both can be modelled as functions of tree cover. Simultaneous measurement of tree cover, biodiversity and productivity at the same sites, is the overriding priority for future studies, followed closely by, on the one hand, studies of multiple taxa at the same sites and, on the other, population dynamics of key taxa across sites along the MBC and especially in the middle section of the MBC from Guatemala to Nicaragua.

It is clear that tree cover is a complex issue for both productivity and biodiversity. While canopy cover (or more precisely leaf, branch and stem area projection), presented as a percentage of ground area, is the most basic data, a single measure of this is not adequate to characterise tree cover for either productivity or biodiversity purposes. For productivity, it is vital to know the relation between canopy cover and light interception throughout the production cycle, taking account of the seasonal pattern of leaf area duration that is often a combination of natural leaf shedding and deliberate tree pruning. For biodiversity, the tree species diversity, phenology and vertical stratification of vegetation, including ground flora and epiphytes is required. Responses of both productivity and biodiversity to tree cover are also directly affected by the intensity of management. Knowledge of pruning, weeding and the use of fertiliser, pesticides and herbicides for reported studies is essential so that effects of tree cover can be isolated from effects of management practices.

1. Location of research

While the location of coffee growing is inherently well placed in relation to key forest corridor development along the MBC, studies in pastures have tended to be located in major cattle production zones, rather than strategically in relation to corridor initiatives (**Figure 1**). A key priority is for future biodiversity studies in pasture to be located strategically with respect to corridor development so that the contribution of trees in pastures to the connectivity of forest habitat can be fully assessed.

Co-location of studies in forest, coffee and pasture is vital to understand how each of these land use components contributes to biodiversity conservation (priorities are elaborated in the next section).

Pasture productivity has very rarely been adequately measured in relation to tree cover anywhere along the MBC. The key priority is for research comparing primary pasture productivity across gradients of tree cover. Other aspects of the nutritive quality of pasture and browse and tree shade reducing animal stress are also important as set out below.

With respect to coffee, the overriding priority for biodiversity studies is to ‘fill in’ the middle section of the MBC for birds and ants, for which taxa there is the most comprehensive understanding at the northern and southern ends of the corridor (**Figure 2**). Better knowledge of other taxa is also desirable (see below) and for understorey species, the focus of research needs to be on the effectiveness of interventions that maintain networks of undisturbed understorey across connectivity gradients (see CORRIDOR deliverables 4 and 5). There is also a critical need to co-locate biodiversity and productivity measurements at the same sites so that trade-offs can be directly explored in addition to the use of modelling to extend predictions to a broader range of conditions. Modelling of coffee productivity in relation to environmental conditions, management inputs and pest and disease incidence makes it possible to predict productive potential of sites where biodiversity is studied, providing an adequate characterisation of tree cover and management inputs is available.

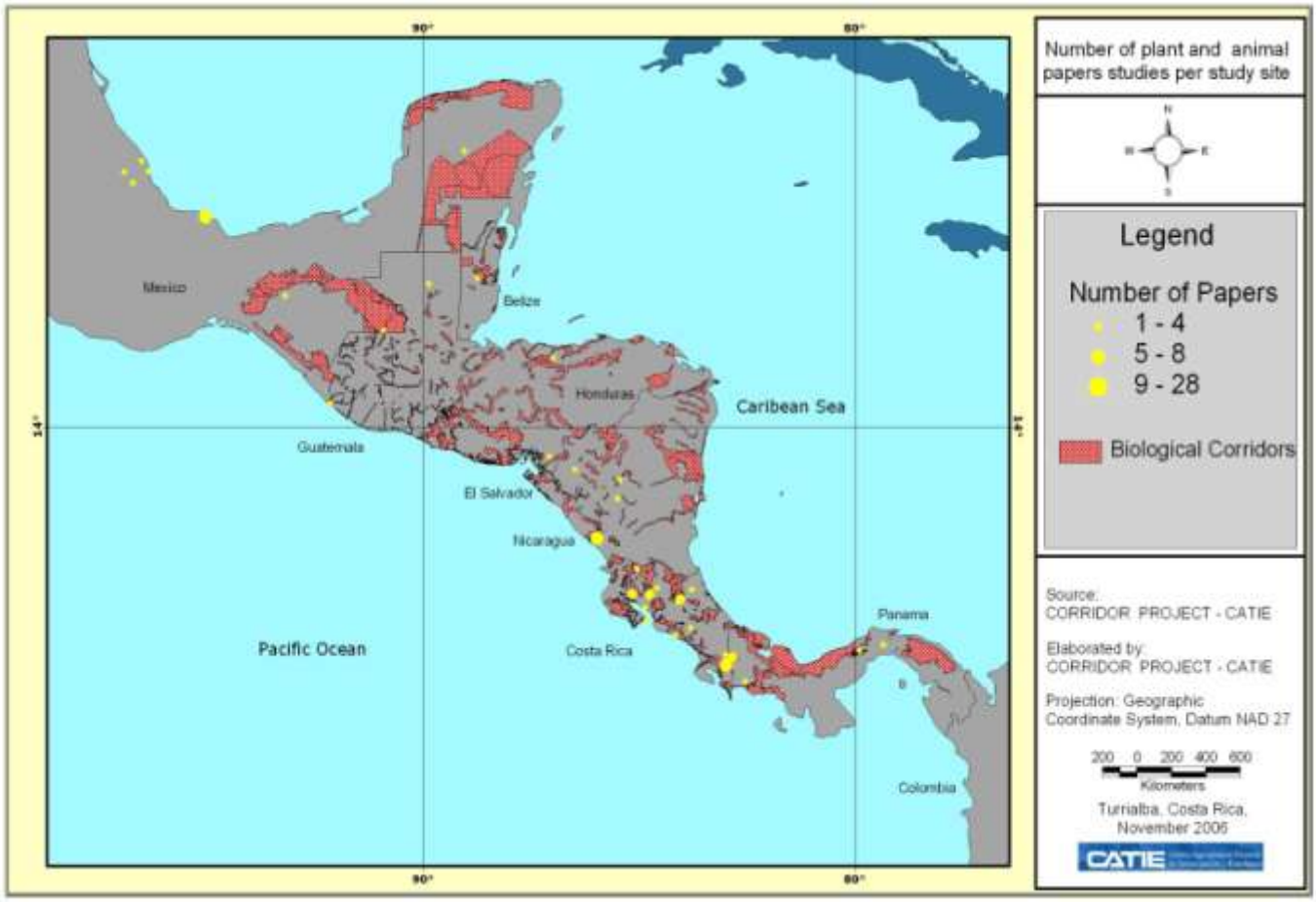

Figure 1. *Location of studies of biodiversity in pastures (numbers of articles proportional to size of yellow circles) in relation to biological corridor initiatives (red areas). See CORRIDOR deliverable 2 for details of the review process.*

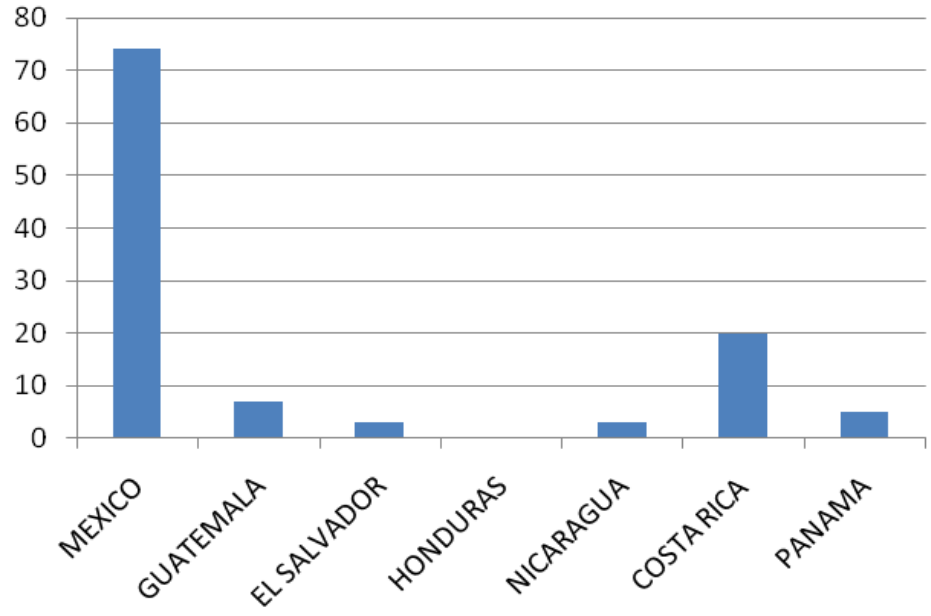

Figure 2. *Numbers of articles on biodiversity (for all animal and plant taxa) in coffee farms for countries along the MBC. Of these, in Mexico there were 17 articles on birds and 12 on ants while in Costa Rica and Panama there were 7 on birds and 4 on ants. See CORRIDOR deliverable 4 for details of articles included.*

2. Key research needs for co-located studies in landscapes comprising pasture, coffee and forest

Assuming that research can be focussed on the key agricultural landscapes that lie between and adjacent to protected areas and corridor initiatives within which coffee and pasture dominate as land uses, there are key research priorities to enhance our understanding of the extent to which tree cover on farms can mitigate forest conversion in terms of habitat connectivity. These priorities presuppose that data on productivity of the agricultural component and any productive element from the tree cover are also fully documented so that trade-offs between biodiversity conservation and livelihoods can be explored. The key biodiversity priorities are as follows.

- Understanding how different animal taxa respond to the same landscape and what the conservation implications of these differences are.
    - On the one hand, there is a need for more studies of individual taxa (using standardized and comparable methods) across different landscapes, to determine if individual taxa always exhibit the same responses to different types of tree cover and land use, regardless of landscape context, or whether these patterns are highly landscape-specific.
    - On the other hand, there is also an urgent need for more multi-taxa studies within the same landscape to determine to what extent different taxa respond in similar (or distinct) ways to different types of tree cover occurring within the same landscape.

- Understanding how individual animals and populations use landscapes and specifically the on-farm tree cover, and identifying which tree types (and species) are key to maintaining a rich animal diversity within the agricultural landscape

- Conducting long-term studies of the dynamics of animal populations and communities changes, to understand the viability of individual populations and the stability (or dynamism) of animal communities within these landscapes

- Exploring the relationships between the structure and composition of the agricultural landscape and patterns of animal diversity

- Determining if there are thresholds in forest or tree cover, or thresholds in the connectivity of tree cover, below which animal populations are not viable and/or communities crash.

- Understanding how both historical and current land management influences patterns of animal abundance, diversity and distribution

3. Implementation of a Mesoamerican research and development strategy

It is clear from the CORRIDOR review work that most research on tree cover in coffee and pastures in relation to productivity and biodiversity has been generated from the interest of individual researchers and research groups or institutions. There are local, national and regional initiatives to develop forest corridors along the MBC but most published research has not emanated from them. This represents a key constraint in that research ends up being clustered in areas close to active research groups rather than in relation to needs to understand patterns of variation across the MBC. Also some countries are clearly easier to work in than others, not only because of the location of key research institutions but also because of infrastructure, political stability and national resources available to support research and security. This has led to a predominance of research at the northern and southern extremes of the MBC and a dearth of information from the central section from Guatemala to Nicaragua.

While top down approaches are required to develop transnational corridor initiatives, appropriate research is most likely fostered bottom up, by making information on priorities and protocols available to the research community and research funders. This requires spatially explicit information on what research has been conducted to be maintained, standardized protocols for how to go about research to be readily available, and priorities for future research to be continuously updated as more data enter the public arena. Internet presence is essential here so that when new research or new research funding is planned, people can access information on the state of the art, key priorities and standard methods. CATIE is a regional institution well placed to handle such collation with satellite involvement of key national and local research institutions, but would require funding to do so.

3.1. Specifics of research needs for landscapes dominated by pasture

Pasture is by far the dominant agricultural land use along the MBC but has received much less scientific and certification attention with respect to how tree cover impacts productivity and biodiversity than other land uses. Consumers in North America and Europe may be familiar with eco-labelled coffee, but are unlikely to differentiate beef emanating from silvopasture as opposed to complete forest clearance. So, here we pinpoint key limitations in our knowledge of how trees in pasture influence productivity and biodiversity and the key requirements (not already set out above) required.

3.2 Limitations of the information available on tree cover and animal diversity in pastoral landscapes

Tree cover

Although there are many studies that have examined different aspects of tree cover in pastoral landscapes, it is difficult to directly compare results across landscapes and regions, due to differences in sampling methodologies, sampling intensity, sampling duration, data collected, and the way in which this information is analyzed and presented. While some studies provide detailed information on plot size, selection and sampling intensity, others provide only vague details, making it difficult to calculate densities Similarly, some studies provide detailed lists of all species encountered (including information on their abundance) while others simply provide information on total species richness without providing compositional information. Without detailed information on the abundance of individual species, it is impossible to generate species area curves comparing sites or land uses from different studies. And without detailed information on the sampling methodology and area sampled, it is not possible to compare tree densities across sites. Lists of the species present are also important inputs for comparing the composition of tree cover across landscapes, but this information is not always readily available.

Comparisons of tree cover at the landscape-level are even more problematic than plot-level comparisons, for a variety of reasons. First, individual studies define 'landscapes' in different ways, with important implications for subsequent descriptions of landscape tree cover. In addition, landscape characterizations usually differ in the types and numbers of land use(and tree cover types) recognized and the definition of these land uses. Individual studies differ in the way they define different land uses- particularly the different stages of secondary forest (alternatively named 'charrals', 'tacotales' or 'acahuales', and each having their own distinct definition in each individual study), and pastures with trees (with the minimum tree density and/or crown cover required to be classified as pastures with trees varying across studies). Live fences are also problematic in that some studies consider them as separate linear elements, while others consider them as part of the surrounding pasture and include them in pasture-level estimates of crown cover or tree density. Landscape-level characterizations also vary in the minimum mapping unit considered, with some studies being done at fine scales while others being done at larger, coarser scales. Many landscape characterizations are done at too broad a scale to include individual trees or live fences, thus sorely underestimating the on-farm tree cover. Last, but not least, most of the landscape-level studies pay little attention to the spatial arrangement of trees and tree cover within the landscape, despite the fact that this spatial information is of great importance to conservation groups seeking to take advantage of on-farm tree cover to promote landscape connectivity.

The adoption of standardized methodologies for tree characterization at both the landscape and plot level would greatly enhance the quality of scientific information available and facilitate the synthesis and analysis of tree cover information across landscapes in the region. Key information that these studies should systematically collect is stipulated in the data protocol for tree cover on pastures (Deliverable 3).

Animal diversity

The critical need is to have animal diversity studies on sites where tree cover is well described so that they can be related. There is also a need for more studies on population dynamics, animal behaviour and movement to understand how tree cover affects animals so that we can plan tree cover to meet animal needs.

Although there is a rapidly-growing number of studies of animal diversity within pasture-dominated landscapes, there is still insufficient information to clearly link patterns of animal diversity and species composition to different land uses and different levels (or spatial arrangements) of tree cover, making it difficult to assess how much tree cover of what types are most compatible with biodiversity conservation and how this tree cover should be arranged within the landscape.

There are four key obstacles to understanding the relationships between on-farm tree cover and animal biodiversity in pasture-dominated landscapes. First, there are simply not enough studies of animal diversity across different types of tree cover, different spatial arrangements of tree cover, or landscapes with varying patterns of tree cover. Although the number of studies has risen dramatically in the last five years, the information on different taxa is sporadic and incomplete- with most studies being single, one-time characterizations of a given taxa in a particular

landscape. For most taxa, there are less than five studies available and even for birds (the best-characterized taxa) the information is far from complete (with little information on survival rates, movement, and habitat use, for example). Not only are there few studies, but these studies have tended to focus on only a handful of sites (particularly Las Tuxtlas, the four FRAGMENT sites in Costa Rica and Nicaragua and Las Cruces) and many countries have had little, if any, studies on animal diversity outside of protected areas. Additional information is needed for a much larger number of animal taxa across a much broader array of landscapes. In particular, information is woefully missing for below-ground taxa and many insect groups (excluding dung beetles which have been reasonably well sampled). From a country-level perspective, information is particularly scarce in Belize, Panama, El Salvador and Guatemala.

Second, there are no common methodologies across studies, making it difficult to compare and interpret results from different areas. Individual studies vary in the methods used to sample organisms, and even within studies of the same taxa, there are no standardized methods used. Individual studies vary in the methods used to sample different taxa and even in the application of these methods. For example, although most bird surveys are conducted with point counts, the location of point counts within the landscape, the spacing between point counts and the length of observation vary across studies. Studies also vary in the sampling intensity, plot size, number of plots, plot selection, timing and duration of the study, among other factors. They also differ in the types of information collected, with some studies providing only the bare minimum data on species abundance and species richness, while other studies provide more detailed information on behavior, demography and movement. In addition, studies vary in the land uses sampled, as well as in the way in which they define these land uses- making it difficult to know whether the 'secondary forests' mentioned in one site are equivalent to 'areas of young growth' or 'abandoned fields' in another. A list of the types of information that should be routinely collected within studies of animal diversity in pasture-dominate landscapes are specified in CORRIDOR deliverable 3.

Another key limitation is the lack of information on animal behavior and movement within agricultural landscapes, as well as the dynamics of animal populations. To date, the vast majority of studies of animal diversity in agricultural landscapes focus solely on describing the animal community within specific land uses or a specific landscape, at a given point in time- with basic information provided on the species present and their relative abundances. These studies, in and of themselves, indicate which species are present within the landscape, but do not provide any insight into the degree to which these species use (or depend on the landscape), which resources within the agricultural landscapes they are taking advantage of, and whether individual populations are self-sustaining over the long-term or whether these are population sinks. Without long-term studies of how animals use and move within agricultural landscapes, it will be difficult to identify what features of landscapes are important for their continued survival. Similarly, without demographic studies, the long-term viability of populations and the stability of communities is unclear.

A fourth and final problem with the data is that few studies directly link patterns of animal diversity directly to the type, abundance or spatial arrangement of on-farm tree cover. Although it is well established in the ecological literature that animal diversity is often highly correlated to tree and plant diversity, few studies provide information on floristic and structural diversity of the land uses surveyed or attempt to relate vegetative characteristics to animal species richness, diversity or composition. In addition, there is remarkably little information on which tree species within different land uses in the agricultural landscapes provide key resources for different species and can help support wildlife populations. Similarly, although it is clear that the spatial arrangement of land uses and tree cover within the agricultural landscapes will impact the animal species present, very few studies provide detailed information on the structure and composition of the landscapes in which the studies were conducted, and even fewer explore the impact of landscape structure and composition on animal diversity. In particular, there are no studies that have directly considered the impact of landscape connectivity on animal populations, even though connectivity is likely to be a key factor structuring animal communities. Last, but not least, there are no studies that have identified thresholds of either the amount or degree of connectivity of forest and tree cover for different animal groups. This is, in part, due to logistical constraints because this type of research would require sampling over multiple landscapes with differing degrees of tree cover and/or connectivity, which would be very costly and time-consuming.

Although the numbers of studies on animal diversity in pasture-dominated landscapes has increased significantly in the last 5 years with 51 of the 60 publications reviewed having been produced in this time period, our understanding of the patterns and dynamics of animal populations and communities within pasture-dominated landscapes is still far from complete. Not only are there clear gaps in which taxa have been studied (with almost no information on below-ground biodiversity), but many basic questions about the long-term viability of animal populations within pasture dominated landscapes and the conservation value of these landscapes remain only partially understood. Priorities are set out in the section on co-located studies above.

3.3 Key research gaps

Despite the rapidly growing number of studies and the information presented here, there are still many gaps in our understanding of the patterns of tree cover in pastoral landscapes of Mesoamerica which limit our ability to integrate this tree cover into both conservation and production activities.

From a conservation perspective, three key aspects that require additional research are set out below.

1. Understanding the dynamics of tree cover within pasture-dominated landscapes (particularly understanding how tree density, composition and diversity will change over time, as farmers harvest trees and natural regeneration is impacted by grazing).
2. Characterizing the spatial patterns of trees within pasture-dominated landscapes and their ability to contribute to landscape connectivity for different animal species, and identifying the most appropriate composition and spatial arrangement of on-farm tree cover for biodiversity conservation.
3. Examining how natural regeneration can be enhanced within active pastures, such that a diverse tree community can be maintained over the long-term

From a production-oriented view, the key issues that demand additional attention are as follows.

1. Identifying which tree densities and spatial arrangements are most compatible with different production activities and are most beneficial to farmers
2. Acquiring additional information on the spatial patterns of trees and tree crown cover within pastures and linking this information to pasture and cattle productivity.
3. Identifying ways of facilitating natural regeneration within pastures without requiring the abandonment of the pasture.
4. Understanding how the dispersed tree component in pastures can be managed to provide a sustainable source of timber, firewood, fodder and other products to the farmer.

4. Conclusion

We recommend a bottom-up approach to encouraging scientists to make their research meet strategic priorities along the MBC by locating it in relation to key forest corridor developments and in relation to where new information on various plant and animal taxa are most needed to increment our understanding of how tree cover influences biodiversity conservation and key trade-offs with farm livelihoods. Maintaining an up-to-date picture of what research has been done along the MBC together with information on apparent priorities and standard protocols is the critical requirement to facilitate this.