Final Report Summary - PALMS (Palm harvest impacts in tropical forests)

Executive Summary:

4.1.1 Executive summary
Tropical forests harbour thousands of useful plants that are harvested and used in subsistence economies or traded in local, regional or international markets. The effect on the ecosystem is little known, and the forests resilience is badly understood. Palms are the most useful group of plants in tropical American forests and in this project we study the effect of extraction and trade of palms on forest in the western Amazon, the Andes and the Pacific lowlands. The PALMS project has determined the size of the resource by making palm community studies in the different forest formations and determine the number of species and individuals of all palm species. The genetic structure of useful palm species was studied to determine how much harvesting of the species contributes to genetic erosion of its populations, and whether extraction can be made without harm. We have determined how much palms are used for subsistence purposes by carrying out quantitative, ethnobotanical research in different forest types and we also studied trade patterns for palm products from local markets to markets that involve export to other countries and continents. Palm populations are managed in various ways from sustainable ones to destructive harvesting; we have studied different ways in which palms are managed and we propose sustainable methods to local farmers, local governments, NGOs and other interested parties. Finally we studied national level mechanism that governs extraction, trade and commercialization of palm products, to identify positive and negative policies in relation to resilience of ecosystems and we have used this to propose sustainable policies to the governments. The results have been disseminated in a variety of ways, depending on need and stake holders, from popular leaflets and videos for farmers, reports for policy makers to scientific publication for the research community. The team behind the PALMS project represents 10 universities and research institutions in Europe and northwestern South America.

Project Context and Objectives:

4.1.2 A summary description of project content and objectives
All over the world and particularly in developing countries human populations depend on a daily basis on natural resources provided by native plants and animals, for food, energy, handicrafts, construction, medicine, and these resources also provide a safety net during emergencies and food stress. Many forest products are sold locally and regionally and increasingly also on national or international markets. The sale of these products may have potential to provide incomes and reduce poverty in poor countries.

The use of and trade in natural resources impact the composition and services provided by ecosystems. The PALMS project has evaluated impacts of resource extraction regarding: 1) The biodiversity of ecosystems, 2) The resilience and limits of natural ecosystem functioning, 3) Local people’s use of and impact on ecosystem goods and services, 4) Goods and services at regional, national or international levels, 5) Sustainable levels and systems of resource use, and 6) Political-administrative measures that may further (or aggravate) sustainable practices.

PALMS’ focussed on forests of northwestern South America in Colombia, Ecuador, Peru and Bolivia. There, humid forest covers parts of the Amazon basin, the Andean slopes and highlands, and the Pacific lowlands of Colombia and northern Ecuador. These forests are among the most diverse ecosystems in the world, both in numbers of co-existing species and in total species numbers and the mountain forests and the Pacific coast are endangered bio-diversity hot-spots, while the western Amazon lowland constitute one of the major remaining tropical wilderness areas that have been populated, used and managed by Amerindian cultures for thousands of years (Roosevelt 1999). The impacts of indigenous traditional resource management are not very obvious, but it is increasingly clear that the composition of even seemingly virgin forests has been influenced by previous human activities (Willis et al. 2004). Modern occupation is far more conspicuous and has resulted in large-scale conversion of forests to farmland and pastures, and illicit cultivation of coca aggravates problems. Less conspicuous is the gradual degradation by over-exploitation of forests ecosystems. These forests have the potential to provide timber, game, construction materials, edible fruits, etc.,
sustainably, but excessive extraction devastates their productive potential. The objective of PALMS was to understand the impact of use and trade of extracted products in these forests; it focused on palms that are prime providers of subsistence and trade products and make up a representative subset of the useful species.

Palms are one of the economically most important plant groups in the world. Due to their unique architecture and high productivity palms play a key role in providing a sustainable income to smallholders in some of the poorest parts of the world. Palms include nearly >330 species in northwestern South America, where they are represented by numerous life forms. Palm communities are diverse in local species richness which often reaches 30–40 species per hectare and in number of stems (Vormisto et al. 2004); and palms are conspicuous and dominant in most Neotropical ecosystems where they often are key functional components forming complex assemblages, comprising co-existing life forms and they occupy all layers of the forest. Turn-over in species composition is high at all scales, from the microhabitat to the regional level, making them suitable for testing the impact of human use through space and time. Extensive areas are dominated by large palms that grow under extremely limiting conditions, and produce huge amounts of fruits and other valuable products. Fruits from a few abundant and widely distributed palms are the main food source for the regions large game-species such as peccaries, tapirs, brocket deer, etc. (Bodmer et al. 1999), and fish-populations feed on them during annual inundations of extensive palm-dominated areas (Goulding 1980). Local people apply palm products in numerous ways and most species are used locally for subsistence (Camara-Leret et al. 2014). Some species have major importance for food, fibres, construction, thatch, and medicine. Large amounts of these products are sold at regional markets and increasingly marketed on national and international markets

The paradigm behind PALMS is the reciprocal relationship between ecosystems and human use. Ecosystems provide human beings with ecosystem services, ranging from products harvested from plants for food, construction materials, medicine, etc. and game and fish themselves that depend on the plants, to indirect economic values, and aesthetic and ethical values. Human use has since pre-historic times impacted populations of the species they exploit and the ecosystems these species occur in, often but not always reducing or damaging ecosystem services (Burney et al. 2005).

Ecosystem services are the benefits that people obtain from nature. There has lately been much focus on the conditions of the earth ecosystems and the provisioning (food, water, fuel, etc.), cultural (spiritual, recreational, etc.), regulating (climate, water, disease, etc.) and supporting (photosynthesis, soil formation, etc.) services ecosystems provide to human livelihood and society (Millennium Ecosystem Assessment MA 2003). Over the next century the need for ecosystem services will rise dramatically, particularly in the developing world, at the same time exposing the earth ecosystems to enormous stress.

Society and economics depend on the capacity of the environment to maintain conditions for human and societal development, and are as such embedded in economic-ecological (or socio-ecological) systems. Human activities are responsible for a variation of direct and indirect drivers of ecosystem changes (Nelson et al. 2006), and the challenge is to manage the economic-ecological systems within the limits of their resilience.

In the humid forests of northwestern South America the principal direct drivers of ecosystem change have been deforestation and over-extraction of forest resources; particularly lumber but also non-timber forest products, and the impacts of fertilizers and pesticides, contamination and apparently climatic change are increasing (Walther et al. 2007). Forests degrade beyond recovery (regime shift) particularly after deforestation for pastures, and forest fragmentation may increase this trend by facilitating repeated wildfires. In the Brazilian Amazon an increasing fire-incidence limits forest recovery (Laurance et al. 2002).

From the early 1980s there has been a strong notion among conservationists and development practitioners that poverty reduction and environmental protection should and could go hand in hand (Kusters et al. 2006).

Major recommendations and observations are:

- Pay equal attention to ecological and economic components of economic-ecological systems (Frost et al. 2006)
- Build resilience into economic-ecological systems through attention to their regulatory services (Carpenter et al. 2006)
- Manage land at the landscape level; preserve and manage a matrix of vegetation in economic zones surrounded more high-diversity areas (Frost et al. 2006)
- Apply a holistic, interdisciplinary approach, and build on local customs respecting people’s priorities, values and knowledge (World Bank Group 2005)
- Combine bottom-up (community-based) and top-down (policy-level) procedures (Sayer et al. 2004)
- Emphasize monitoring of interventions (du Toit et al. 2004)

The design of PALMS was based on these recommendations. Basic studies focused on ecological and economic components, and applied studies on the management of Ecological-Economic Systems, and results have been communicated and applied. The objectives regarding the respective components/systems are to elaborate/define/attain:

The importance of palms in the humid forests of northwestern South America is evident both in villages and towns (Camara-Leret et al. 2014). Palms are used everywhere and by everybody: round trunks serve as posts for houses and split trunks are used as planks for floors and walls, numerous houses are thatched with leaves; people eat fruits on a daily basis either crude or boiled, or fermented as nutritious drinks, and seeds and palm hearts are eaten; palm materials and particularly fibres serve for hammocks, bags, mats, kitchen utensils, fishing gear, etc., and some have medicinal uses. Sale of materials from palms provides cash too many low-income households, e.g. most handicrafts sold for tourists include palm materials.

Palms have been intensively used by local cultures since people first arrived to the region (Morcote-Ríos and Bernal 2001). The distribution and abundance of palm communities including useful species found in seemingly virgin forests have for very long been subject to human impact and manipulation (Clement 1999). Currently deforestation and habitat fragmentation reduce populations and ranges of many palms, but also facilitate the expansion of disturbance-resistant palms in secondary vegetation and cleared land. Palms therefore lend themselves well to modelling diversity under changing conditions created by human impacts. Furthermore the need for palm products may increase in the future, and changes in diversity and abundance patterns of palms will affect availability of these resources for millions of people. Diversity and abundance of palms therefore has important socio-economic implications, and should be taken in account when planning land-use and conservation.

The general objectives of PALMS were to:

- Establish criteria and indicators for sustainability,
- Define better resource management taking ecological, social and economic criteria for sustainability in account
- Make it feasible to define monitoring systems to determine if management is sustainable, and if not to suggest more appropriate measures
- Compare the potential production of palm products with the demand for these products currently, and estimate trends for the next decades
- Extrapolate productive potentials vs. demand data across the region

Project Results:
Palms are an outstanding element in north-western South America’s tropical forests, both for their diversity and for their abundance in all habitats, but especially in very humid rain forests. The South American continent covers 18 million km² and has a total palm flora of 457 species. Our study region comprises Colombia, Ecuador, Peru and Bolivia. Together they cover 4.7 million km² and they house 336 species of palms. The largest genera are Geonoma with 52 species, Bactris with 41, Attalea with 28, Aiphanes with 28, Astrocaryum with 25, Wettinia with 20 and Syagrus with 8 species. Each biogeographic region has its own species richness and diversity patterns and each of the four countries have their peculiar palm characteristics.

4.1.3.1.1 Caribbean lowlands — The Caribbean lowlands along the north coast of South America are characterized by dry vegetation including semi-deciduous forests and is the region with fewest palm species in our study area, with only 53 species recorded so far. Tropical palms in this region are the widespread Copernicia tectorum, Arcoecia aculeata and Sabal mauritianformis. The wine palm Attalea butyracea, native to the dry Magdalena valley, extends to the Caribbean lowlands where it may be very abundant and dominating.

4.1.3.1.2 Chocó — The Chocó region covers 71,000 km² along the Pacific coast from Panama to northern Ecuador, and is characterized by extremely high rainfall reaching 10,000 mm per year in the wettest parts. The vegetation is humid evergreen tropical rainforest with extreme species richness, high biomass, etc. Due to its isolated placement the Chocó also has very high endemism. The northern part of Chocó has a palm flora with affinities to the Caribian lowlands, including such species as Attalea butyracea and Bactris pila. In the wetter parts connected to Panamá the palm flora is more related to the Central American palm flora and includes species such as Reinhardia koschnya, Reinhardia simplex, Reinhardia gracilis, Calyptranx costatifrons and others which have their southern limit here. The Chocó region includes about 119 palm species in total and a little less than half of them are endemic. The majority of palm species on the coastal plain of Ecuador grow both in humid and in semi deciduous forests, but then they have marked differences in abundances in the different vegetation types (Borchsenius 1997). Welfia regia, Iriartea deltoidea, Wettinia quinaria for example, are more common in humid habitats. The transition from Chocó to the Peruvian coastal desert occupies the largest part of Ecuador’s coastal plain towards the Pacific Ocean and it grades into the Tumbesian region that in turn reaches into the Peruvian coastal plain. Attalea colenda, Astrocaryum standleyanum and Phyttelepas aequatorialis are common in these dry habitats. In the remnants of semi deciduous forests there are populations of Oenocarpus bataua and Astrocaryum standleyanum as well as Bactris setulosa, Bactris gasipaes var. chiahuagü – the wild relative of the peach palm – and some species of Wettinia. Aiphanes eggersii is the only palm species that grows naturally in the dry forests with over six dry months every year. It is found where the total annual precipitation is c. 600 mm and the dry season lasts for eight months (Borchsenius et al. 1998, Skov & Borchsenius 1997).

4.1.3.1.3 Andes — The Andes stretch throughout our study region from northern Colombia to southern Bolivia. Palms occur abundantly and with great species richness in the Andean forests on both flanks. The Andes houses 131 species of which 85 occur above 1000 m elevation (Moraes et al. 1995).

In Colombia the Andes above 500 m elevation has 82 palm species. The most important genera are Wettinia, Aiphanes and Ceroxylon which together make up more than one third of the species. The evolution of these three genera is closely related to the upheaval of the Andes over the past 10 mio years. All species of Ceroxylon are Andean, but both Aiphanes and Wettinia have given rise to species that have invaded the lowlands on both slopes. On the other hand the Cordillera is also inhabited by some species that originated in the lowlands, but which have extended their distribution into the slopes up to elevations of 1300 m above sea level for instance Acrocomia aculeata, Oenocarpus bataua, Syagrus sancona and some species of Bactris. Of the 82 Andean palms in Colombia 20 are not found outside of Colombia, and therefore require special attention for their conservation and sustainable management.

In Ecuador the Andean forests have the greatest diversity of palms harbouring 76 (51%) of the 148 palm species in the country. However, only 22 (14%) of these are exclusive to the Andean lowlands, whereas the remaining 54 species are lowland species that reach up into the Andean forests. The great majority of the species grow at elevation of 1000–2000 meters (Pintoa et al. 2008). Above 2500 m the diversity of palms drop dramatically and only 12 palm species cross that elevation limit. In terms of very local diversity it is common to find only 2–4 species in plots of one hectare but they may be quite abundant, for instance Geonoma undata may have as many as 800 individuals in one hectare (Valencia 1995). Other species that are often seen in dense populations in the Ecuadorian Andes include Ceroxylon echinulatum on the eastern slopes at 1200–1800 meters, Dictyocaryum lamarckianum at 1500–1700 meters, Chamaedorea pinnatifrons at 1500–2000 meters, and Prestoea acuminata which grows at 1200–2200 meters above sea level. In Peru there are only few humid forests on the west Andean slopes, whereas the east Andean slopes have wet and very wet Andean forests. Of Peru’s 136 palm species 58 (43%) are Andean. Of these 40 species are limited to the Andes and 18 species are lowland species that reach up along the slopes to the Andean forests. The upper Andean forests in Peru are characterized by several species of Ceroxylon, Dictyocaryum lamarckianum, and about 10 species of Geonoma. The lower Andean forests house some species of Astrocaryum, a single Bactris, Chamaedorea fragrans and Ch. linearis, seven species of Geonoma, Welfia alfredi and three species of Wettinia (Kahn & Moussa 1994).

In Bolivia there are humid Andean forests, well suited for palms, along the east Andean slopes from the Peruvian border to Argentina. Of Bolivia’s 88 palm species 24 occur in the Andean forests above 1000 m elevation. As in the other countries the Andean palms are made up of purely Andean species, e.g. Ceroxylon (3 sp), Geonoma (8 sp) and Prestoea (1 sp). The genus Parajubaea is particularly interesting. It has two species in the Bolivian Andes, P. torallyi and P. sunkha, and the third species in the genus is only found in cultivation in the northern Andes. We studied the Andean forest in detail around the village of Apolo (Borchsenius et al. 1998, Skov & Borchsenius 1997). Welfia regia, Iriartea deltoidea, Wettinia quinaria for example, are more common in humid habitats.

4.1.3.1.4 Amazon — The Amazon lowlands cover 55% of the four countries’ land area and still maintain a large forest cover and the palms growing there are less threatened than those in the other regions. In the southern extreme in Bolivia there is a mosaic of savannah and rainforest. Within the Amazon there is a mosaic of floodplains along the rivers and terra firme away from the rivers where the land is never inundated. Another element in the Amazon mosaic is large swamps with permanent standing water that have formed in low-lying areas. These swamps are dominated by Mauritia flexuosa. The number of palm species in the western Amazon lowlands is high, with 162 species, which is almost proportional to the large area covered by this biogeographic region. Many of the palm species in the Amazon lowlands are widespread and few are restricted to smaller areas. The Colombian Amazon region encompasses 0.48 million km² which is 42% of the country’s territory. There are 92 palm species registered in the Colombian
Amazon, which is more, but not substantially more, than the two much smaller regions of the Colombian Andes and the Chocó forests (Galeano & Bernal 2010). The most species rich palm genera are the understory genus Geonoma and the spiny genera Bactris and Astrocarum. Along the rivers Guaviare, Caquetá and Amazonas in 71 transects, covering a total of 17.25 hectares, we found 74 species in 21 genera. The dominant species found in this study coincide with dominant species in other Amazonian palm communities. The three most abundant species in terra firme forests were Oenocarpus bataua, Iriartella setigera and Oenocarpus bacaba, whereas Euterpe precatoria, Attalea butyracea, and Socratea exorrhiza dominated the flood plain forests (Balslev et al. unpublished data). The Ecuadorian Amazon has terra firme forests as the dominant habitat; in the Yasuní National Park 80% of the area is covered by terra firme forest dominated by Iriartella deltoidea and Oenocarpus bataua. The flood plains are mostly inundated with white water that originates in the Andes, but there are some rivers that are born in the lowlands and therefore carry black waters. The white water flood plains are dominated by Phytelephas tenuicaulis, Astrocarum urostachys, and Attalea butyracea, whereas the black water flood plains are dominated by Astrocarum jauari and Bactris riparia. Mauritia flexuosa dominates the back-swamps and it is conspicuous because of its enormous size. The back-swamps also have other palms, but they are less abundant, for instance Mauritiella armata and Attalea butyracea. The Ecuadorian Amazon houses 73 palm species of which 34 are found neither in the Andes nor in the coastal plain of Ecuador. Four of the species (Ceroxylon amazonicum, Geonoma ecuadoriensis, G. pulcherrima and Wettinia aequatorialis) are endemic to the region. The terra firme forests are richest in palm species, for instance, in 25 hectares of forest in Yasuní 22 palm species grow together. They share this habitat by having species that are specialized to the understory, the mid story and the canopy, respectively (Vormisto et al. 2004, Montufar & Pintaud 2006).

The Peruvian Amazon covers 61% of Peru’s territory which correspond to about 0.8 million km2. Of Peru’s 148 species of palms, 100 occur in the Amazon part of the country, which is by far the highest number. Peru’s Amazon region is ecologically diverse. The terra firme are by far the richest in palms, with a total of 70 species of palms. Forests that are periodically flooded with white water have 16 palm species. Seasonal swamp forests have 22 palm species (Kahn & Moussa 1994). We made 35 transects along the Ucayali river covering 8.75 hectares and we found a total of 55 species with an average number of 3512 palm individuals per hectare. Hilly terra firme forest had 18 species and 4200 palm individuals per hectare, terra firme on terraces had 44 species and 6756 palm individuals per hectare, flood plain forest had 18 species and 1460 palm individuals per hectare, and terra firme on premontane hills had 36 species and 1622 palm individuals per hectare (Balslev et al. 2010). In 11 similar transects (2.75 hectare) in the Pebas region we found 54 species in terra firme forests, the most common ones being Lepidocaryum tenue, Astrocarum macrocarpus, Socratea exorrhiza and Geonoma macrostachys (Vormisto et al. 2004).

The Bolivian Amazon lies along the southern fringe of the basin. It experiences seasonality and is influenced by climatic conditions on the southern cone of South America such as irregular cold spells. It is a mosaic of tropical rain forest and open savannahs, some of which are periodically flooded. The palms of the Bolivian Amazon are either species that occur throughout the neotropics or species that are restricted to the Amazon basin.

4.1.3.1.2 Palm diversity per country

Colombia is the largest of the four countries in our study region, covering 2.1 million km2 corresponding to 12% of the South American continent. There are 246 native palm species in 44 genera (Galeano & Bernal 2010) corresponding 43% of the species of South American palms. Bactris with 31 species, Geonoma with 30, Alphanes with 22 and Wettinia with 17 species are the largest palm genera in Colombia. Of the 246 native species known in Colombia, 33 species (14 %) occur only in Colombia. Twenty of them, mainly in the genera Alphanes, Wettinia and Geonoma, grow in the Andes, six in the Pacific lowlands, three in the Andes, and four in the Inter-Andean valleys.

Ecuador has the highest concentration of palm species in South America. In its 0.28 million km2 corresponding to 1.6% of the South American continent there are 141 native palm species in 32 genera (Pintaud et al. 2008) corresponding to 25% of the species of palms in South America. Geonoma with 33 species, Bactris with 17, Wettinia with 13 and Alphanes with 12 species are the largest genera and together they include over half of Ecuador’s palms. Of the 141 palm species registered in Ecuador, 15 are endemic. Most of Ecuador's endemic palm species occur in the Andes.

Peru has a territory of 1.2 million km2 corresponding to 7% of the South American continent. Peru has 148 species of palms corresponding to 25% of the species of South American palms. Bactris with 20 species, Geonoma with 20, and Attalea with 15, and Astrocarum with 14 species are the largest genera of palms in Peru and together they make up over half of Peru's palm species. Twenty four species are endemic to Peru, belonging to 11 genera. Most endemic species are Amazonian, either in the lowlands or in the eastern Andean basement and inter-Andean valleys, especially in Attalea, Astrocarum and Desmoncus. Eight species are Andean endemics, among which the genus Geonoma is the most represented.

Bolivia has a territory of 1.1 million km2 corresponding to 6% of the South American continent. Bolivia has 88 species of palms corresponding to 16% of the species of South American palms. Bactris with 20 species, Geonoma with 18, and Attalea with 5 species are the largest genera and together they include over half of Bolivia’s palms. Of the 141 palm species registered in Bolivia, 33 species (23%) are endemic. Most of Bolivia's endemic palm species occur in the Andes.

4.1.3.3.2 Palm uses

Palm trees are widely used in the neotropics for many purposes and some categories of uses vary according to the region and between different species (Borchsenius et al. 1998, Balslev et al. 2008, 2012, Valencia et al. 2013, Moraes 2013). Palms are also of key importance in the cultural identity of some indigenous groups. Local communities rely on products harvested from palm populations, from subsistence to commerce and export. Both ethnic groups and peasants have developed their cultures and have been intensively dependent on the multiple services provided by products derived from native palms.

Of the total palm richness in northwestern South America, which is estimated to be 336 species, 63% are have been registered as useful to people and they are used for 2395 different purposes (Macía et al. 2011). Most species are used for human food and beverages and oils. The second group of uses in order of importance is tools, followed by uses for hunting and fishing gear, and palms used for cultivation. Palm trees also have an essential role in the construction of houses, mainly for thatch.
cerebral. Food for humans (44–67%) and construction materials (48–65%) are most predominant categories among useful palms in north-western South America. Of course the ceremonial significance of many species (11–47%) is remarkable when so many communities of Amerindians are represented here. The most important source of palm raw materials are harvested from stems, leaves and fruits, but virtually all parts including roots, seeds, fibres have some use. Trunks are mainly used to build the structure of houses, floors, fences, furniture, and domestic tools; leaves for thatch, baskets, fans, and many utensils; leaf bud for palm heart and fruits and seeds for food; roots and oil extracted from fruits as medicines. Jewellery such as rings, necklaces, ear rings and bracelets is elaborated from seeds or carved endocarps.

4.1.3.2.2 Food for humans — Most Amazonian people consume palms as an important part of their diet. In big cities in the Andes palm products such as canned or fresh palm heart (Bactris gasipaes, Euterpe precatoria) and certain fresh fruits (Bactris gasipaes) are found. Amazonian communities harvest fruits, which in some cases are produced in short seasons and in other cases for long periods throughout the year. Among these edible fruits are those of various species of Alphanea, Astrocaryum, Attalea, Bactris, Chelyocarpus. Mauritia flexuosa providing a natural source of vitamin A (Pacheco 2005), and Oenocarpus bataua has a protein content comparable to animal protein and is better than most of the grains and of legumes (Balick and Gershoff 1990). Phytelephas and Synechanthus warscewiczianus both have edible fruits. Some species are a source of edible seeds, for instance Attalea eichleri and Parajubaea toralyi.

Palm hearts, especially from Bactris gasipaes, Euterpe oleracea, E. precatoria, and Prestoea acuminata, produce cash incomes in the region; the latter species was formerly important in our study region but it has been replaced by Bactris gasipaes (Borchesianus & Moraes 2006). Most canned palm hearts come from plantations of Bactris gasipaes, while the other species are wild but also sometimes produced at industrial scales such as species of Euterpe. Some human communities harvest palm heart from other species such as Attalea phalerata, Dictyocaryum lamarkianum, Welfia regia. Alphanea horrida is a widespread Andean palm which has a high use potential because of its high content of vitamin A (Balick and Gershoff 1990). According to Pacheco-Palencia et al. (2009) and Kang et al. (2012), fruits of both Euterpe precatoria and E. oleracea are extremely promising not only due to their nutritional properties with important antioxidants and iron content but also for their benefits to health.

For the preparation of soft drinks, ice-cream and refreshments of mashed fruits of Bactris guineensis, B. major, Mauritia flexuosa are used. These are also served as cold drinks made of boiled fruits of Euterpe precatoria, Oenocarpus bataua and Oenocarpus mapora, the two last ones with a milky chocolate flavour. An indirect food use of palms is the palm of the palm weevil Rhynchophorus palmarum, which is rich in oil and is very much appreciated among Amazonian indigenous communities in the region as a protein compliment to their diet. The beetle deposits its eggs in old or rotten logs of various species of palm trees.

4.1.3.2.3 Construction materials — The stems of some palms are used for construction of shelters and houses (Astrocaryum, Bactris gasipaes, Ceroxylon, Dictyocaryum lamarkianum, Iriartea deltoidea, Iriartella setigera, Oenocarpus bataua, Socratea exorrhiza, S. rostrata, Welfia regia, Wettinia). Others are used for floors, walls, furniture and gutters (Copernicia alba, Iriartea deltoidea, Socratea exorrhiza). Leaves are used for thatch with different qualities and duration depending on the species and Amazonian inhabitants select those that prevent the rain and allow aeration on sunny days. Some species are long lasting such as Sabal mauritiiformis which is used for roofs that may last for 50 years, Geonoma deversa which may last for 25 years, and Attalea phalerata that only lasts for 4–5 years; a long list of palms used for thatch in the region include Attalea butyreae, Copernicia tectorum, Hysopesthes elegans, Iriartea deltoidea, Lepidocaryum tenue, Manicaria saccifera, Mauritia flexuosa, M. carana, Pholidostachys dactyloides, Phytelephas tenuicaulis, and Welfia regia. Palmate leaves of Chelyocarpus tenue serve to patch damaged roofs in Bolivia.

4.1.3.2.4 Medicinal — Both in the Amazon basin and on the Chocó forest medicinal uses of palms are quite important. For cosmetic and medicinal uses the following palm species are important in north-western South America: Acrocomia aculeata, Attalea butyreae, A. phalerata, Bactris gasipaes, Elaeis oleifera, Euterpe oleracea, E. precatoria, Mauritia flexuosa, Oenocarpus bataua, O. mapora, O. minor, Socratea exorrhiza, among others. Tsáchila healers in Ecuador know at least nine palm species that they use to treat more than 20 health conditions, such as asthma, muscle aches and bone piles and heart problems (Palacios 2009).

4.1.3.2.5 Handicrafts — Handicraft production is often related to touristic activities and it generate cash incomes to rural communities at the same time as it represents strong cultural expressions of ethnic identity. Palms are increasingly used for weaving hats, fans, mats, baskets, and other items. Examples from north-western South America include Astrocaryum aculeatum, Attalea spp., Copernicia alba, Ceroxylon schotii, Trithrinax schizophylla. Many local communities have taken up the carving of vegetable ivory nuts for numerous purposes such as jewellery, ornaments, key-chains, and other souvenirs of the ivory palms Phytelephas. Also necklaces, rings and ornaments with seeds of many palms species, such as Astrocaryum, Euterpe, Socratea exorrhiza, Syagrus, Wettinia quinaria. Fibres are gathered from different species for weaving handicrafts, purses, bags, hammers, and ropes, Astrocaryum cambria, A. malybo, A. standleyanum, Leopoldinia piassaba, Manicaria saccifera, Mauritia flexuosa, and Parajubaea sunkha. Musical instruments such as marimba from the Colombian Chocó forest (Iriartea deltoidea) and Caribbean guacharaca (Bactris brongniartii, B. guineensis).

4.1.3.2.6 Ornamentals — A long list of exotic palms from other continents are frequently used as ornamentals in cities and gardens. Less frequent are planted native palms for ornamentation, but it is an unexplored issue in our study region and according to ethnobotanical sources and our findings there are 3–27 palm species cultivated in the four countries of our regions for this purpose among others Allagoptera leucocalyx, Ceroxylon quinduense, Copernicia alba, Parajubaea, Syagrus sancona, Trithrinax schizophylla. For example more than 100 palms native to Colombia have qualities that would make them suitable for this purpose in the market as ornamental plants and contribute to the national landscape (Manrique et al. 2013).

4.1.3.2.7 Utensils and domestic tools — Brooms are made from the petioles of several palms such as Allagoptera leucocalyx, Copernicia alba, Parajubaea, Syagrus sancona, Trithrinax schizophylla. For example more than 100 palms native to Colombia have qualities that would make them suitable for this purpose in the market as ornamental plants and contribute to the national landscape (Manrique et al. 2013).

4.1.3.2.8 Food for animals — Three groups of palm species are used as food sources for wild animals: those that have fruits rich in oil, fruits without oil and old rotten stems of several palm species for larvae of a weevil species Rhynchophorus palmarum used as fishing bait by Amazonian communities. The first group is represented by Acrocomia aculeata, Attalea, Astrocaryum, Bactris gasipaes, Euterpe, Oenocarpus bataua and Sabal mauritiiformis; various animal species live from these palms such as parrots, rodents, monkeys, arthropods and birds. Cerocyon, Copernicia alba, Iriartea deltoidea, Socratea exorrhiza, and Wettinia belong to the second group and provide food and shelter for birds and insects. There are also species of palms that are used for livestock forage purposes.
4.1.3.2.9 Oils — Oil is extracted from the palm mesocarp and seed and mostly used for food but also as fuel. Palms used for oil production are Acrocomia aculeata, Bactris gasipaeas, Attalea, Astrocaryum and Euterpe, Elaeis oleifera, Mauritia flexuosa, Oenocarpus. All of these oils represent potentials for good quality food, for use in the pharmaceutical and cosmetic industry and for biofuel production. The best quality oil is produced in Bolivia and Colombia from Oenocarpus bataua and is rich in alpha-linolenic acid (Montúfar et al. 2010). For the high proportion of both oleic and lauric oils recommended it as vegetable oil for human consumption.

4.1.3.2.10 Ceremonials — Seeds of Iriartea deltoidea give good luck in certain rituals for purposes that are offered in markets in cities and are part of Andean traditions in Bolivia. Leaves of species of Ceroxylon in the Andean region are used for Palm Sunday, a catholic celebration. The palm heart of Prestoea acuminata is part of the celebrations of Easter by indigenous groups in Nariño, Colombia.

4.1.3.2.11 Other uses — Tapping sap to produce wine from Attalea butyreae is a great potential for the production of sugar from bleeding of inflorescences in Colombia. Similar sap extraction is done from Acrocomia aculeata in Bolivia but it is not used any longer (Vásquez & Coimbra 2002). A dye for textile fabrics using macerated leaves of Synychanthes warscewiczianus is used by the ethnic group Tsachila and also stems of Geonoma undata in Ecuador (Borchsenius et al. 1998). Floral arrangements with leaves of Geonoma orbignyana in Colombia; stems of large-sized species as Iriartea deltoidea Socratea rostrata and Wettinia quinaria are used as light poles and support of plants that produce flowers and bananas for export (de la Torre et al. 2013). Solid, straight trunks of Copernicia alba serve as light poles, both in rural and urban areas of Bolivia (Moraes 2004a).

4.1.3.2.12 Multiple uses and remarkable species — As a common pattern Bactris gasipaeas, Euterpe precatoria, Iriartea deltoidea, Mauritia flexuosa and Oenocarpus bataua offer a wide range of uses in our study region. For example, in Ecuador Oenocarpus bataua, Bactris gasipaeas, Mauritia flexuosa, and Iriartea deltoidea have over 30 different uses (de la Torre et al. 2013). More than 24 publications were produced on uses of Mauritia flexuosa in Peru (Alban et al. 2008). In Bolivia Attalea phalerata has 100 different uses, Oenocarpus bataua has 96 and Euterpe precatoria has 89. Acrocomia aculeata was formerly a multiple used palm in Bolivia (Vásquez & Coimbra 2002).

Some species of palms are valued as cultural heritage to advocate their conservation and by the value of identity and historic importance. One example is Bactris gasipaeas whose fruiting season is celebrated by Amazonian communities in Ecuador. Others are Phytelephas aequatorialis and Ceroxylon which are both part of the commercial history of western Ecuador (de la Torre et al. 2013). Useful palms are a key to the survival of human populations in the Amazon, the Chocó forest and the Andes where they provide food and medicine and raw material for building homes and all kinds of tools. The importance of all the uses, properties and derivatives from native palms in north-western South America supports a huge heritage which is full of opportunities for the establishment of productive models in which the development does not conflict with conservation. The utility of palms is more pronounced in tropical lowland forests such as the Amazon and the Chocó forests. Compared to the Amazon, palms in the Andes are less used for food, construction and medicines. Indigenous communities usually have greater knowledge about the uses of plants than other human groups as peasants and mestizos.

4.1.3.3 Trade and small industries

The palm family represents one of the economically most important plant groups, both as far as the number of species used is concerned and with regards to overall economic importance of palms as a whole. At a global scale, the African oil palm (Elaeis guineensis), which is grown in plantations in the tropical zone all around the world, is undoubtedly the single most important palm species. Oil palms are grown extensively in Colombia, Bolivia, Ecuador and Peru with the plantations in Ecuador alone covering ca. 250,000 ha (ANCUPA 2012). Whereas the cultivation of the African oil palm is ecologically very problematic (Clay 2004) there is also a wide range of native palms in north-western South America, which are extensively used, namely ca. 86 palms species in Bolivia, 136 each in Ecuador & Peru and an extraordinary 233 palm in Colombia (Pintaud et al. 2008). Around 200 of these native species are used in one way or the other by humans in this region (Macia et al. 2011); Ca. 160 native palm species are currently used in Colombia, 105 species in Ecuador, 104 species in Peru and 44 in Bolivia (de la Torre et al. 2011, 2013; Macia et al. 2011; Galeano & Bernal 2010). Most of the raw materials obtained from wild palms are used in subsistence, i.e. they are used locally and domestically to meet the daily needs and are not commercialized at all, or are bartered or commercialized at a local level only, often in marginal amounts (Brokamp et al. 2011; Galeano & Bernal 2010).

4.1.3.3.1 Use categories — The main use categories for native palm products are (I) materials used in construction (timber, thatch), (II) food products (fruit pulp – mesocarp and seed – endosperm, including beverages and oil obtained from them; and palm heart) and animal fodder, (III) materials used in the manufacture of handicrafts (fibres, wood and seeds) and (IV) palm derived products used in cosmetic and healthcare preparations (fruit, oil and roots; Brokamp et al. 2011).

4.1.3.3.2 Multiple and conflicting uses — Most palm species can be assigned a single “primary” use, i.e. one use that is generally the overruling use category, but most individual species are used in various, sometimes conflicting ways. Thus, 62 different products are obtained from ca. 30 palm species in Ecuador alone (Brokamp et al. 2013). Many palm species are “multipurpose species” and exploited for different plant parts (i.e. trunk, leaves, fruit), which may result in the use of several different raw materials and in the commercialization of many different products from an individual species, with the primary product obtained from an individual species often differing in different regions. Thus, in Euterpe spp. both the palm heart and the fruit (ácaí) are used. Palm heart – the economically most important palm product — In terms of trade volume and commercial value today palm heart and vegetable ivory products are economically by far the most important native palm products from north-western South America. Palm heart is commercialized in all four countries and is therefore the individually most important product overall. In the past all (exported) palm heart came from uncontrolled wild collection (mostly from Euterpe species), whereas today it partly comes from controlled farming of a domesticated Bactris gasipaeas-hybrid (Ecuador: 16,106 ha; MAGAP SIAGRIO 2011), which was introduced to Ecuador from Costa Rica (Borchsenius and Moraes 2006). However, the bulk of exported palm heart from Peru, Bolivia and Colombia still comes from wild collection of mainly Euterpe precatoria and E. oleracea (Vallejo et al. 2011) with a severe impact on natural populations (Borgttof Pedersen 1993). The trade in – mostly cultivated – canned palm heart from Ecuador is more or less continuously rising in past years: In 1990 Ecuador exported around 600 t of canned palm heart with a value of around 1 Mio. USD (free on board, FOB), since then the trade volume increased more than 50 times to 32,000 t with a value of 75 Mio. USD (FOB; Banco Central del Ecuador, 2012). Since 2001 Ecuador has been the largest exporter of palm heart worldwide, followed by Costa Rica, with France, Argentina and Chile as the principal importing countries. Bolivia is another important source country of palmito, with almost all palm heart extracted non-sustainably from the wild from Euterpe precatoria. Bolivia exported ca. 8000 metric tons of palm heart in 2012, with a value of over 16 Mio USD. For Colombia, data are available only up to 2009, here the overall trade volume is only a fraction of that of Ecuador, at ca. 400 t/a and an export value of ca. 1.2 Mio USD. For Peru, only data from a single company (CAMSA) are available, showing that this individual company sold a similar amount as all of Colombia (ca. 380 t) for a
similar value (ca. 800,000 USD). In all three series of figures a clear slump around the years 2002/2003 is recognizable, with a subsequent recovery of the trade. Vegetable ivory – the second most important palm resource — Colombia, Ecuador and Peru also export the hard seeds of Phytelephas (vegetable ivory) to some degree, but Ecuadorian P. aequatorialis, is by far the most important source. It is most coveted because it produces the largest seeds in the genus and has a long history in international trade (Acosta Solis 1960; Brokamp et al. 2011). Up to the national level most of the tagua is commercialized as figurines and jewellery, of which a major proportion is sold to tourists as souvenirs. Buttons, rosaries, jewellery and other handicrafts are also exported, the bulk of tagua exports, however, are tagua discs, which represent precursors in the production of buttons, known as animelas or fichas.

Native palm oils — Not least due to the international success of the African oil palm much research has been invested in the oils of native palms in South America, with a well-developed market already existing in Brazil. Such native palm oils that may be extracted from the fruit’s mesocarp and/or kernel may easily find application in the production of food and cosmetic products. There are promising species in the genera Phytelephas and Wettinia, which on a local level already serve as sources of edible oils (Koziol & Borgtoft-Pedersen 1993; Borchsenius and Moraes 2006). The oil from the endosperm of Parajubaea cocoides has been reported to have a high potential as edible oil (National Research Council 1989).

Palm fibre — In north-western South America, there are generally two different types of fibres that derive from palms, which are used for different types of products. The first type of fibres represent those that originate from the leaf sheaths and petioles of Aphandra natalia and Attalea funifera and Leopoldinia pissaaba, which are used in the production of brooms. A general proportion of these brooms are manufactured by small companies and individual family businesses in Ecuador and Colombia. Different sizes and qualities of brooms are available and commercialized throughout the region. A small proportion of brooms are exported from Ecuador, mostly to Peru (ca. 20 t valued at around 50,000 USD, FOB, in 2011; Banco Central del Ecuador, 2012). The second type of palm fibres are extracted from the young leaves of Astrocaryum species. Fibres extracted from the leaves of Astrocaryum stellatum and A. malybo are used in the manufacture of bags, hammocks, vases, carpets and furniture, which are sold at street markets, souvenir shops or directly by the producers in their communities. Especially in Colombia the manufacture of fibre products is highly sophisticated and some of the products (carpets, vases) fetch notably high prices.

Palm heart — The massive growth of the market share for cultivated Bactris gasipaes in the past decades clearly indicates that the days of wild-harvested palm heart are numbered and that the countries with an industry based on the wild harvest of Euterpe species will likely lose their market share in the near future, or will switch to cultivated Bactris.

4.1.3.3.3 Value chains and marketing — For a range of products from different countries the value chains were investigated in detail. Value chains are highly heterogeneous and depend on the type of product, the market access of individual stakeholders, the number of intermediaries involved and the geographical extent of the trade. Value chains of locally to regionally commercialized palm products requiring only a low degree of processing (e.g. sale of fruits, handicraft manufacturing, oil processing) are typically in the hands of a single family (sometimes including paid workers, sometimes including a specialized retailer). Value chains of exported products (palmito, tagua products, furniture), where sophisticated processing is required, and where quality control plays a more important role, comprise several steps, typically in the hands of several (3–6 or more) different stakeholders (harvest, sourcing, processing, transport, wholesale, retail).

4.1.3.3.4 Future developments in trade and sustainability — An extensive investigation of future trends is hampered by a rudimentary understanding of the past and present levels of commercialization due to the lack of statistical data. However, some rough predictions can be made:

Palm wood — Palms also provide wood products, but because the fibrous wood produced by palms is structurally different from that of dicotyledonous plants and gymnosperms, they are legally treated as Non Timber Forest Products (NTFPs; de la Torre et al. 2013). These wood products include pillars and slats used as raw material in the construction of houses, sheds and fences or for building up supporting structures for banana plants and flowers, which are grown for export (Altamirano 2012). Palm wood is also used in the manufacture of multiple different crafts ranging from art parquet and furniture through to manifold handicrafts, such as traditional and non-traditional souvenirs and natural jewellery. Iriartea deltoidea, Socratea exorrhiza, Bactris gasipaes and Wettinia quinaria represent the main species that are commercialized here, however, there are many more arborescent palm species whose stems are used and sold to a minor extent (Brokamp et al. 2011).

Vegetable ivory — Vegetable ivory has largely maintained or increased its markets in the past years. Vegetable ivory is generally considered as a resource that is largely managed sustainably. However, there is considerable conflict in the use of Phytelephas, since the proportion of the final sales price reaching the primary producer is very low and the primary producers earns more by harvesting the leaves and selling them as thatch (Brokamp et al. 2013). In this case, an adjustment of the value chain could encourage a concentration on vegetable ivory as the main product, ensuring the supply of a valuable commodity.

Vegetable oils — There are numerous smaller and larger initiatives investigating the development of native palm oils. Production figures are largely considered as heterogeneous and depend on the type of product, the market access of individual stakeholders, the number of intermediaries involved and the geographical extent of the trade. For a range of products from different countries the value chains were investigated in detail. Value chains are highly heterogeneous and depend on the type of product, the market access of individual stakeholders, the number of intermediaries involved and the geographical extent of the trade. Value chains of locally to regionally commercialized palm products requiring only a low degree of processing (e.g. sale of fruits, handicraft manufacturing, oil processing) are typically in the hands of a single family (sometimes including paid workers, sometimes including a specialized retailer). Value chains of exported products (palmito, tagua products, furniture), where sophisticated processing is required, and where quality control plays a more important role, comprise several steps, typically in the hands of several (3–6 or more) different stakeholders (harvest, sourcing, processing, transport, wholesale, retail).

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Vegetable oils — There are numerous smaller and larger initiatives investigating the development of native palm oils. Production figures are largely considered as confidential by the private enterprises and official statistics are not available for the largely regional and local markets. It is therefore difficult to know the trends with certainty. However, with current retail prices native palm oils can at best occupy a niche market for the affluent parts of society, since prices are much higher than those of other, established plant oils, including African palm oil. Most oil is produced in more or less sophisticated forms of cottage industry, which lack the usual standards and quality control of industrial production.

Fruit for human and animal nutrition — The local and regional nature of fruit use for human and animal nutrition mean that few clear statistical trends are recognizable. Mauritia flexuosa in Peru is the single most important product in this segment and it is commercialized to an enormous extent in lowland Amazonia
4.1.3.4 Harvest intensity — Another factor that determines the sustainability of palm harvest, besides the technique used to reach the structures used, is harvest intensity (Bernal et al. 2013). A particular case of unnecessarily destructive harvesting is the extraction of sugary sap from palm meristems. This destructive practice is common among illegal harvesters in the Amazon, where it is used to produce a type of sugar that is highly prized among indigenous populations. The situation has been corrected in recent decades with the introduction of appropriate harvesting tools, and the palm populations are now recovering.

Another example is the felling of Astrocaryum chambira palms in Panama to reach the spear leaves, from which a prized fibre is extracted for weaving various items. In some areas, particularly in the Darién, the spear leaves of Astrocaryum standleyanum, have been used to create a type of fabric that is highly valued among indigenous populations. The practice has been locally decimated in some areas, to the point that it is now difficult to find female palms, and most surviving individuals are males. Although there have been campaigns in some areas, destructive harvest persists in most regions.

4.1.3.4.1 Necessarily Destructive Harvest — Necessarily destructive techniques are associated with uses that require felling the palm in order to obtain the desired product. The most obvious case is that of the palms that are cut for their wood, as Iriartea deltoidea, which is used throughout the study area for construction (Mancia et al. 2011) and in Ecuador and Colombia for making furniture (Altamirano & Valencia 2013, Navarro 2013). Another kind of necessarily destructive use is the acquiring of palm heart from various species, mainly Euterpe oleracea in Colombia (Vallejo et al. 2011), Prestoea acuminata in Ecuador (Escobar & Montufar 2013), and Euterpe precatoria in Peru and Bolivia (Summers et al. 2001). Other cases of necessarily destructive use have a lower impact, as they are practiced on a smaller scale and, in general, only for domestic consumption. Cutting down palms for collecting the larvae of beetles that breed in them is a practice that has been documented throughout the region (Beckerman 1977, de la Torre et al. 2013, Paniagua Zambrana 2011) as beetles are considered a delicacy among indigenous people.

4.1.3.4.2 Non-destructive Harvest — In most cases, leaves, fibres, and fruits can be harvested non-destructively, reaching them by using very basic tools. In palms up to about eight meters tall, the crown can be reached by using a ladder or a pole with steps carved into it, which acts as steps. The simplest and lightest is a bamboo stem, as used in Colombia to harvest the leaves of the wine palm, Attalea butyracea, or in Ecuador for reaching the leaf fibers of Aphandra natalia (Bernal & Valencia 2013). Another option is to reach the desired product from the ground, by the use of a sharp blade fixed at the end of a long pole. These blades are inexpensive and are available at hardware stores. Its introduction to the Lower Rio San Juan, in western Colombia, in the late 20th century, for harvesting the spear leaves of Astrocaryum standleyanum, brought an end to the severe depletion of the palm near the Indian villages (Bernal et al. 2013).

A slightly more sophisticated climbing technique is to make a ring with a vine or a rope around the palm to be climbed, leaving space wide enough on each side of the stem, to fit a foot between the ring and the palm. The feet are introduced in the ring down to just below the ankles, and the soles are pressed against the stem while the legs are widely open. The estrobo is a system commonly used throughout north-western South America to climb telephone poles. It consists of two rings of rope, each of which has a total length about four times the circumference of the stem to be climbed. The distal ends of the wooden rods are tied with string, thus forming a triangle that encloses the stem. The triangle located on the harvester’s side is closed with another stick of wood. To climb the palm, the harvester sits on the upper marota and pulls up the lower one with his feet as high as possible. He then stands on the lower marota, and pushes up the upper one as high as possible, and then sits again on it, and repeats the operation.

4.1.3.4.3 Unnecessarily Destructive Harvest — In many cases, palms are felled in order to harvest their fruits, leaves or sap, although these products could have been obtained without cutting the trees. However, harvesters often prefer the destructive option because it is easier and faster (Bernal et al. 2011). The most alarming case in our region is the fruit harvest of Oenocarpus bataua and Mauritia flexuosa, and the harvest of fibres from Astrocaryum chambira. The case of Oenocarpus is particularly disturbing, as the fruits are highly appreciated throughout north-western South America, and cutting down the palms is a widespread malpractice wherever it grows (Bernal & Galeano 2010). In the case of Mauritia, the malpractice is widespread mostly along the Amazon River, where the palm has been locally decimated in some areas, to the point that it is now difficult to find female palms, and most surviving individuals are males. Although there have been campaigns in some areas, destructive harvest persists in most regions.

In the case of Astrocaryum chambira palms are often felled to reach the spear leaves, from which a prized fibre is extracted for weaving various items. In some areas in the Amazon, hundreds of palms are needlessly destroyed for this purpose, which has caused a severe reduction of the populations at some places in Colombia, Ecuador, and Peru (Linares et al. 2008, Valderrama et al. 2011) leading to a decrease in the supply of raw material. A similar situation took place at the Pacific Coast of Colombia during the last two decades of the 20th century with the spiny Astrocaryum standleyanum. Baskets woven with the fibres of this palm had a great success in national and international markets, which generated a strong pressure on wild populations, eventually leading to resource depletion around indigenous villages. The situation has been corrected in recent decades with the introduction of appropriate harvesting tools, and the palm populations are now recovering (Bernal et al. 2013). A particular case of unnecessarily destructive harvesting is the extraction of sugary sap from palm meristems. This destructive practice has been documented only in Colombia, where it is practiced with Acrocomia aculeata and Attalea butyracea.

4.1.3.4.4 Harvest intensity — Another factor that determines the sustainability of palm harvest, besides the technique used to reach the structures used, is harvest intensity (Bernal et al. 2013). A particular case of unnecessarily destructive harvesting is the extraction of sugary sap from palm meristems. This destructive practice has been documented only in Colombia, where it is practiced with Acrocomia aculeata and Attalea butyracea.
intensity. Palms produce their leaves one by one, and each species has a specific leaf production rate. This production rate is lower in seedlings and gets progressively faster as the palms become adult. For the most useful palms in our area, leaf production rate in adults ranges from 1.4 to 11 per year. Knowing leaf production rate for each species during its different developmental stages is an essential step for planning their sustainable use. Finally, in species that have multiple stems, it is necessary to know the rate of production of new shoots and the growth of these, in order to regulate the cutting of the stems, either for use as timber or for obtaining palm heart.

4.1.3.4.5 Factors that affect management — In many cases, management is affected by factors other than the palms themselves, such as land tenure and market pressure. When palm products are harvested in somebody else's land or in collectively owned land, the fate of the species involved seems to have a lower importance for harvesters than when harvested in their own grounds. This lower interest is often reflected in poor, often destructive harvesting practices. In the case of products that are harvested in somebody else's lands, the harvester is using a resource for which access in the long term is uncertain, and for that reason the future of the plant is not of much importance for him. In the case of products that are extracted from common lands, like fruits of Oenocarpus bataua or leaves of Lepidocaryum tenue, resource mismanagement or overharvest often results from the simple reasoning "if I don't cut it today, someone else will cut it tomorrow". This is what Hardin (1968) called "the tragedy of the commons".

4.1.3.4.6 Conservation through use — Although there is a potential risk that the commercial exploitation of a palm at some level may affect its wild populations, for some species that commercial exploitation is at least one conservation option. When harvest is forbidden altogether, palms are considered useless or unproductive by the land owners, and they are at risk of being eliminated. For example, landowners in Ecuador protect palms of Ceroxylon echinulatum and Phytelephas aequatorialis if they can get any income from their spear leaves or their fruits, respectively, but otherwise, they lose interest in them (Bernal and Valencia 2013). Similarly, in the Magdalena Valley, in Colombia, land owners protect vegetable ivory palms (Phytelephas macrocarpa) if they can earn income by selling their seeds (Bernal et al. 2011).

4.1.3.4.7 Recommendations for guaranteeing a sustainable harvest — Implementation of a few simple harvest practices will help guarantee that palm harvest will be sustainable in the long run. Most of these practices require no investment or just a low investment just once, and they all are easy to develop. Although there are appropriate practices that are specific for each species, which are compiled in the dissemination booklets, the following general practices will apply for most palm species throughout the area.

1. Do NOT cut a palm to harvest its leaves or its fruits. Some palm species are so abundant in the forest, that people are often misled to think that they are inexhaustible. As it turns out, however, it takes an adult palm several decades to reach its height, and populations cannot cope with a continuous cutting down of adult trees. As it is just tall palms that produce seeds, populations that are harvested by felling the palms, will inevitably disappear in the long run.
2. Reach the leaves or the fruits by using a sharp blade mounted on a long pole. The moist useful blade is one that is shaped like an S, with both concave sides sharp. With this tool you can harvest palms that are up to 8 m tall.
3. Climb tall palms. Palms that are over 8 m tall can be climbed by using the estrobos or the marota (see detailed description in the text). Both tools are easy to use and to carry about in the forest, and with any of them you can climb a palm 20 m tall in 2-4 minutes. The estrobos are the lightest tool; the marota allows you to climb spiny palms.
4. Do not harvest all leaves. If you harvest leaves for thatching, do not collect all leaves in a palm crown. Spare at least one third of the number of leaves, and in no case leave the palm with less than four leaves.
5. Harvest every other spear leaf. If you harvest spear leaves for obtaining fibre, do not harvest every spear leaf that the palm produces, as this will lead to the palm eventually being depleted of all its leaves. Instead of that, you should always harvest at most every other leaf.
6. Follow any scientific recommendations. Follow any specific recommendations that researchers make on one of the palms you are using. These recommendations are often very specific for a particular palm species in a particular area, and the best practice is to follow the experts' advice.

4.1.3.4.8 Monitoring system Any recommendations made to assure the sustainability of palm harvest (or of any other resource indeed) must be accompanied by a periodic monitoring. This monitoring is intended to 1) inspect the appropriate application of the recommended harvest practices; 2) check the state of the palm populations as a result of the harvest pressure applied; 3) receive feedback from the harvesters; 4) assess market pressure; 5) introduce any required corrective measures. Monitoring periodicity varies depending on the life cycle of the species that is being harvested, the palm structure harvested, and the estimated or observed market pressure. Smaller palms with faster growth may require a closer monitoring, whereas large palms may need a more spaced monitoring. Palms being harvested for their stems or their palm heart need a very close monitoring, less so for those harvested for their leaves, even less for those harvested for their fruits, and only a light monitoring for palms harvested for their leaf fibre. In general monitoring intervals range between 2 and 5 years. Monitoring harvested palm populations in intervals shorter than 2 years may not reveal noticeable changes.

A monitoring system should include the following steps, which should not necessarily be developed in that order. Local conditions will determine the most appropriate procedure.

1. Visit the area and discuss with local people the sustainable harvest program that was originally implemented. Interview harvesters independently and arrange for a workshop at the end of your visit. Use semi-structured interviews to gather information. These are usually less intimidating to resource users. The following aspects of the process should be particularly asked: a. Have they found any difficulty in implementing the recommended practices? b. Is everyone using the recommended techniques? c. Have they noted some change in the quality of their work? Is it easier, more difficult, faster, slower? d. Has there been any change in the availability of the resource? e. Has there been any change in the demand of the palm products? f. Have there been any changes in the price of products.
2. Carry out participant observation, whereby harvesters obtain their palm products as they claim they are normally doing, while you accompany them. This will allow you to identify any flaws in the application of the recommended practices. During these field days, you can make preliminary observations on the state of the palm populations. Are there seedlings and juveniles? Are there any felled palms? Are there any palms that look overharvested? Any observation suggesting mismanagement should be promptly brought to the attention of your local hosts, so that they do not feel censured.
3. Unless the soundness of the management is extremely obvious, it is advisable to establish some one-time plots where the population structure can be determined, following the protocol described elsewhere in this document. Comparison of this observed population structure with the original one whereupon the management recommendations were based, will be vital for understanding any changes that may have occurred.
4. Make any necessary adjustments to the original recommendations, based on the new data obtained during the monitoring. For example, palms that are harvested for their leaves or their spear leaves and look depauperate, may be suffering some kind of overharvest. A strong reduction in the number of seedlings or juveniles may indicate an overharvest of fruits and/or a negative effect of forest treading.
5. Discuss the results of your monitoring with local people during workshops, and do any required field work to implement or discuss any required changes.
4.1.3.5 Legislation and policy
Here we analyse regulations that affect commercial harvest of palm products from wild populations and how these regulations are enforced and whether they contribute to the sustainable use of palm products. In our analysis we look at the regulations from both the users’ point of view, both small users and large companies. We also look at the theme from the point of view of government officials and decision makers. In the end of the section we describe several actions which are currently taken to improve the legal system. This includes some where the PALMS project WP6 on policies of sustainable use and management contribute.

4.1.3.5.1 Legal Instruments — Commercial harvest of palm products from forests, whether state forest or private forests, is governed by the Forestry Law and its regulations which have been published by the Ministry for Environment (Ministerio del Ambiente, MAE) in a document that unifies the secondary environmental legislation (Texto Unificado de Legislación Ambiental Secundaria; TULAS). The purpose of the law is to encourage forestry activities in order to reduce poverty, improve the environmental conditions and promote the economic growth of the country.

The needed guiding instrument is a management plan which should secure that the resource is used sustainably. If a proposed plan is approved by the Ministry of Environment, it will emit a Patente for the management of wild plant resources or a licence to make use of products that are not timber. On private lands it is necessary to make a plan for the use to obtain a Special Licence (Licencia Especial). Other documents are required to legalize the transport, processing, national commercialization, and export of Non Timber Forest Products (NTFP). If the idea is to establish a company, many different documents must be presented. For instance if it is a company producing food, medicine or cosmetics more than 20 different documents are required including sanitary permits and others from the Ministry for Health.

It is possible to harvest wild palm products in the protected areas (Sistema Nacional de Áreas Protegidas, SNAP) and in the National System of Protected Forests (Sistema Nacional de Bosques Protegidos, SNBP), depending on their management category. Nonetheless, there are no technical specifications that regulate the sustainable use of NTFPs by category (palm heart, stem, fruit, seed, leaf) and by species; also there are no regulations to determine the maximum volumes of extraction that can be harvested and that takes into account the vulnerability and resilience of the species. All we have at this point is a proposal for norms which has been under discussion for the past four years.

4.1.3.5.2 Species that are illegal to harvest — Four species of wax palms (Ceroxylon amazonicum, C. echinulatum, C. parvum y C. ventricosum) cannot be harvested because they are listed in the Red Book for Endemic Plants in Ecuador (Valencia et al. 2000). Even if this source points out that the two last ones are not endemic, their harvest is seen as destructive and affecting the survival of the parrot Ognorhynchus icterotis, which is a critically endangered species (Appendix I of the Convention on International Trade of Threatened Species of Animal and Plants, CITES), and of the parakeet Leptosittaca branickii, which is an endangered species (Appendix II, CITES). It is permitted to exploit and commercialize the palm hearts of other species of wax palms (C. alpinum, C. parvifrons, C. vogelianum), if the established requirements for use of NTFP are followed.

The mentioned prohibitions may have contributed to the survival of populations of the wax palms in such cases where the palms would otherwise have been felled to harvest the young leaves, but many harvesters never harvested the young leaves and in addition the palms often grow in secondary forests where they may be quite abundant (Montufar et al. 2010). Now, these farmers conceive the wax palms as a resource that cannot be used and they are losing interest in conserving it. The greatest threat to these palms is the destruction of their habitat (Duarte and Montufar 2012).

4.1.3.5.3 Implementation of the regulations — Since the regulations were approved towards the end of 2012, seven management plans for management of wildlife have been approved (Yanez 2005, Alarcon and Garcia 2006, Sanches and Aguirre 2006a, b, Tituquina 2006, Palacios 2009, Cueva 2011), but only two are for palm. They establish general regulations for the harvest of the fruits of Oenocarpus bataua in Shuar and Achuar communities in south-eastern Ecuador (Alarcon and Garcia 2006, Palacios 2009). There are, however, cases where licences for use of palm products have not been obtained because it was not clear how a sustainable use should be achieved. This does not mean that there is no harvest and commercialization of NTFPs. Actually the extraction and transport of about 30 species and their NTFPs have been legalized over the past decade through the emission of transport permits by the National Forestry Department (Dirección Nacional Forestal, DNF). These include transportation of products derived from four palm species: Phytelaphes aequalatus seeds as vegetable ivory and leaves for that; Triarteae deltoidea for poles and a variety of wood products; Wettinia spp for posts; Aphandra natalia for fiber. Regardless of the advances which follow having management plans for harvest and transport of NTFP products, it is our strong impression, that the great majority of NTFPs are harvested and transported at the margin of the law and generally in unsustainable ways. One cause for the lacking legalization of such activities could be the high costs of legalizing commercial harvest of NTFPs (de la Torre et al. 2011) which stand in contrast to the low prices obtained by the local producers of these products (Brokamp et al. 2011, 2013). The costs are related to producing the management plan and pay the administrative fees for forestry and sanitary permits, patents, authorizations, transport rights and rights for use. These expenses must be paid before the materials can be harvested, processed and sold, which is practically difficult for local producers or small companies.

Another disturbing situation for the users, apart from the problems created for the authorities, is the discrepancies between the Forestry Law and the TULAS (de la Torre et al. 2011). For instance the two use different definitions for various non-wood forestry products. For that reason the same harvest process needs two documents, one from PFNM for commercial harvest and one from the Ministry of Environment to authorize the extraction. In practical terms the overseeing of commercial uses of palm products is divided in ambiguous ways between the National Forestry Authority (DNF) and the National Authority for Biodiversity (Dirección Nacional de Biodiversidad, DNB). For instance harvest of Oenocarpus bataua fruits and young leaves of wax palms (Ceroxylon spp.) are controlled by the National Authority for Biodiversity (DNB) whereas the wood products from Triarteae deltoidea and vegetable ivory seeds from Phytelaphus aequalatus are controlled by the Forest Authority (DNF).

The few human and economic resources available do not allow and effective control of the harvest and commercialization of NTFP (de la Torre et al. 2011). Control posts are few and the need for human resources to carry out the control goes far beyond the available budgets. This happens in the technical offices of the Ministry of the Environment (MAE) all over Ecuador, where the few government officials who function have a large number of functions to see to, which means that transport permits may be issued without the needed control of the products and the quantities, and in even fewer cases with control out in the field. This obviously means that the statistics relating to commercialization of NTFPs, which are based on the transportation permits, must be imprecise. In addition to the limited resources for the work it is inherently difficult to control products that being produced in small quantities enters storage markets and processing companies (de la Torre et al. 2011).

4.1.3.5.4 Improvements in the legal system — Over the past four years initiatives to improve the regulations for harvest and commercialization with NTFP have multiplied. In the latest constitution for the republic of Ecuador the public interest in the conservation of ecosystems and biodiversity has been declared and it is said that the state must secure a sustainable model for development. This has opened the door for such projects as PALMS and Biocomercio GEF-CF to
contribute with initiatives and collaborate directly with DNB and MAE. These projects have components that seek to improve the current legislation by offering instruments and fundamental scientific information to decision makers, and facilitate the legalization of the commerce based on biodiversity. The following advances have happened in this context:

- A new norm will enter into function. It will regulate how sanitary permits are obtained for natural products such as medicines, food and cosmetics with origin in the wild native flora and fauna. This norm will include as a requisite the support from the Ministry of Environment which will certify the origin of the raw materials.
- Legal reforms have been proposed that clarify and facilitate the processing for legalizing commercial harvest of palm products such as (1) solving the ambiguity in the definition of Non Timber Forest Products, (2) unify the document that permits the commercial harvest of NTFPs, and (3) clarify the functions of Forest Authority (DNF) and the Biodiversity Authority (DNB) with respect to NTFPs (Suárez & Castro 2012). One option would be to adopt the term Non Timber Forest Products (NTFPs) as defined by FAO but excluding cultivated products and limiting the definition to such ones derived from natural forests.
- We have identified 30 palm wild palm species which are commercialized in the form of 62 NTFPs. These 30 species were categorized according to their harvest vulnerability, in six categories of management with the purpose of facilitating the legal use, and respecting the limits for harvest. It was also the intention to be as rigorous as possible when we were dealing with vulnerable species for which harvest threatens their conservation. In each case we recommend the areas where the species can be harvested and the health of its populations as well as volume and scale of commercialization of the products. In the most vulnerable categories we included species such as Irriartea deltoidea and Wettinia quinaria when they are used for wood production. It has been suggested that this use of palm wood could be moved to the regulations for wood to secure a more efficient control of their harvest (Altamirano & Valencia 2013), in which case the harvest should be accompanied by management plans for each species and not a common management plan for the harvest of all species in one place, as is the case with other timber species.
- The categorization mentioned contribute to the identification of palm species and populations which can be made available for harvest under sustainable management. An important aspect to take into account is the regulations, is the genetic structure of the populations of the same species in separate localities, for instance west and east of the Andes (Trenel et al. 2008). Such studies make it possible to evaluate how much of the genetic diversity of palms is expressed in their populations and already protected within protected forest administered by SNAP, SNBP, and SocioBosque and how much is without protection in threatened populations.
- The Biodiversity Authority (DNB) of the Ministry of Environment (MAE) has plans to develop technical norms for the use of palms of economic importance such as the wax palms, Ceroxylon spp, and the vegetable ivory Phylemphas aequatorialis. Such norms should include the participation of all stakeholders and they should consider the practicalities of harvesting the products. In the case of vegetable ivory both the harvest of the seeds that are used as vegetable ivory and the leaves which is an important material for thatch which has a negative effect on the palm’s growth when it is excessive (Montufar et al. 2013).
- At the same time the activities of the large companies that export vegetable ivory under the regulations of the Law for Competition, Regulation and Control of the Market Forces through the Ministry of Agriculture, Cattle ranching, Aquaculture and Fishing (MAGAP).

4.1.3.5.5 The application of the improvements — The new norms could improve the sustainable harvest of palm products, especially if they are effectively applied. It is important that the suggested reforms and the functioning norms become known by the users and that following them should not be seen as an obstacle. There should be incentives to respect and practice sustainable palm harvest. Being legal should pay off and it should not create unneeded problems for the legal harvest of NTFPs compared to illegal harvest.

The recommendations for the sustainable use of palms proposed in this guide should reach the local harvester, storages and companies through the governmental staff in the offices of the Ministry of Environment. Researchers who study the impact of palm harvest play a fundamental role in the distribution of the information and for the technical aspects needed for sustainable harvest of palm products.

As far as control goes, the proposed measures should be accompanied with more efficient supervision using the IT systems already in place in the ministries such as the Forest Administrative System (SAF) and the National Biodiversity Information System (SIB). These should be available for the government officials in the technical offices and control posts. SAF for example, could help to secure that transport permits are only given for authorized harvest and transport activities. It could also be used to locate areas of intense exploitation and high levels of transport of materials to help allocating resources for control. The systems could also be used to help focusing the resources on vulnerable species and on the most commercialized ones. SIB could be provided with photographs that would help in the identification of the species and products that are being transported, but this remains to be implemented.

The control should be extended to the places where palms are harvested, stored, and processed. This could help correcting unsustainable harvest techniques to sustainable ones and could also help in installing appropriate methods for storage and processing which could improve the quality of the products and the efficient use of the prime materials. It could also be used to identify adulterations and secure that the materials are derived from places that have permits for harvest and that the volumes agree with what has been authorized. The control measure should be developed together with the ministerial staff in the technical offices who will have to implement the subsequently and who have local knowledge of the areas where they work.

In order to secure the effectiveness of the norms it is very important to involve harvesters and users at an early stage so that they gain ownership to the norms. This can be achieved through their participation in the regulatory systems and in the management, for instance participating in the development of management plans, although these should always be based on sound documentation and knowledge of the harvested palms’ biology and the impact that their harvest has on the ecosystems.

Potential Impact:

4.1.4 The potential impact (including socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

The expected impacts of the PALMS project are that it will:

(http://www.fp7-palms.org/index.php/about/potential-impact/expected-impacts)

1. Improve local management of palm resources in North-Western South America (Colombia, Ecuador, Peru and Bolivia) through the provision of alternatives to unsustainable management practices to local producers and users of palm products
2. Improve local government’s regulation of the use and trade of palm resources, through well founded analysis of advantages and disadvantages of different alternatives.
3. Improve national level policy regarding uses of products harvested from natural populations of palms through analysis of existing policies, and provision of alternative policies to the national bodies that regulate extraction, harvest, trade and commercialization of natural resources and in particular products from palms.
4. Improve the scientific understanding of the complexity of extraction, trade and commercialization of natural products from intact and disturbed ecosystems, and in particular of palm resources from the tropical forests of northwestern South America.

PALMS was implemented in the biologically richest part of the world; the humid forests of northwestern South America. There, plants, birds, and other biological groups reach their maximum global diversity. Many species are restricted to small areas threatened by expanding human populations particularly in the mountain and foothill forests, making it urgent to define and implement more sustainable uses of the region’s ecosystems. The overwhelming diversity with many plants and animals being little known or even unknown to science complicates management and monitoring. The palm family will serve as a proxy for the regions biological diversity, and the impact of use and trade on its biodiversity and ecosystems. Palms are well suited for this purpose because local people and scientists alike recognize them easily, and they are diverse and abundant, and palm products have major economic importance. The research has focussed on ecological-economic systems providing important palm products. Case-examples representing different ecological, socio-economic and ethnical conditions have been investigated across the humid forests of northwestern South America.

Dissemination activities and exploitation of results

All collected project data has been made publicly available (http://www.fp7-palms.org/index.php/products/data)

• WP1 completed the palm transect data collection in all four involved countries. The data from the transects have all been uploaded on the GBIF web-page (see http://data.gbif.org/datasets/resource/14087); In total 500 transects with georeferenced data on 532,939 palm records have been uploaded and are freely accessible. The location of the transects are shown on the map below taken from the GBIF web-page (http://www.fp7-palms.org/index.php/products/data/ecological-data-wp1).

• As part of WP1 and WP2 activities at IRD, new molecular markers have been recently published in order to support the genetic and phylogenetic analyses conducted in the project. Namely, two low-copy nuclear genes, Agamous 1, a transcription factor involved in floral structure, and Phytochrome B, a gene involved in environmental response through far red light sensing, have been optimized for phylogenetic use in the palm family, with specific PCR primers designed, and their utility evaluated in the subtribe Bactridinae (Ludena et al., in press). A set of 100 new DNA chloroplast primer pairs has been designed and optimized in Monocotyledons through a joint effort of the PALMS project and two other projects on yams and African cereals at IRD (Scarcelli et al. 2011). These new markers are currently used in phylogen待new studies of South American palm communities (Eiserhardt, AAU), phylogeographic studies of the genus Ceroxylon (Sanin, UN) and phylogenetic/speciation studies of Astrocarum (IRD).

• WP3 and WP7 have published all data on www.palweb.org

• WP4, WP5 and WP6 have deposited all data on the project webpage (www.fp7-palms.org)

Dissemination of scientific results

• The projects scientific results have been disseminated at 115 conferences with posters and abstracts in conference proceedings (http://www.fp7-palms.org/index.php/products/publications-2/51-products/561-palms-abstracts-from-scientific-meetings)

• and about 60 scientific paper have already been published in peer-reviewed journals and 20 or more papers are still under way (http://www.fp7-palms.org/index.php/products/publications-2/51-products/562-list-of-scientific-publications-from-palms)

• The project has published 12 books ranging from very popular science to books for specialists (see the projects webpage for a list and for links to all books; http://www.fp7-palms.org/index.php/products/publications-2/books)

• PALMS has produced 11 booklets and educational posters for popular dissemination of the results with special emphasis on the villages where fieldwork was carried out (http://www.fp7-palms.org/index.php/products/outreach/booklets)

• PALMS has set up a blog at the high tire journal Annals of Botany (http://www.fp7-palms.org/index.php/products/outreach/blogs)

• PALMS has produced six videos for YouTube and for distribution in the villages studied (http://www.fp7-palms.org/index.php/products/outreach/videos)

Dissemination through training

• PALMS has supported 41 thesis projects, 10 first degrees theses, 15 MSc theses and 16 PhD thesis. Of these 31 have already been defended and the thesis are uploaded on the PALMS webpage (http://www.fp7-palms.org/index.php/products/theses). The 10 remaining thesis will be defended during 2014. A list of these pending theses and the planned dates for the defence can be found on the PALMS website.

Total list of dissemination products

• A total list of products from the PALMS project can be seen on the project webpage: (http://www.fp7-palms.org/images/FILES/products/2013_10_18_List%20of%20divulgative%20materials_PALMS.pdf)

Activities related to dissemination

• PALMS researchers and students have attended a series of conferences and meetings where the project’s result has been presented. The most important meetings are listed on the PALMS website at: (http://www.fp7-palms.org/index.php/activities/meetings)

• PALMS researchers and students have organized three public conferences in Leticia, Colombia in August 2011, in Tingo Maria, Peru in April 2013 and in La Paz, Bolivia in August 2013 (http://www.fp7-palms.org/index.php/activities/meetings-organized-by-palms)


• PALMS steering committee and researchers have met with the project Local Advisory Committees seven times during the five year. In Peru in July 2009, in Ecuador in October 2009, in Bolivia in July 2010, in Colombia in August 2011, in Ecuador in September 2012, in Bolivia in August 2013 and finally in Peru in September 2013 (http://www.fp7-palms.org/index.php/activities/meetings-of-the-local-advisory-committees)

Dissemination through interaction with the local political level

PALMS has interacted with the administrative-political system in the entire region and in each of the countries throughout the projects duration, starting in 2009 and continuing towards the project termination by the end of 2013, and with plans to continue post-project.
The Local Advisory Committees have included several members from the administrative-political systems in Colombia, Ecuador, Peru and Bolivia. As documented on the PALMS webpage there has been a two way dialogue between the PALMS researchers and the members of these committees. All WP leaders have presented their work, and the local advisory committees (with administrative-political members) have commented on PALMS’ activities and made suggestions for improvements in the project, whereas PALM researchers provided the members with insights from the projects that were useful for their work. There have been seven such meetings with the local advisory committees and the best documented one is the last one held in Lima in September 2013. The webpage includes all PowerPoint presentations from the meeting, and a document that cites all comments and suggestions from the committee members in Spanish AND ENGLISH. The other meetings have been equally detailed, even though the documentation on the webpage is not so detailed.

COLOMBIA

As a result of activities developed by WP5, and the contacts made by project members with government officers, the Ministry of the Environment has launched a National Program for Palm Conservation. This Program, to be formulated by members of WP5, will be delivered in early 2014, and it will be the bases whereupon specific actions will be taken by local environmental authorities for each of the palm species needing particular attention in the country. A launching workshop took place in Bogotá in September 2013, with attendance of representatives of several local environmental authorities and other state agencies. And although stemming from before the PALMS project started, it is worth mentioning that he Colombian PALMS team has experience in interacting with political powers in the country; for instance researcher (who are now members of the PALMS team) convinced the Catholic Church to ban the use of Ceroxylon leaves for Palm-Sunday. This use had reached very high levels and constituted a threat to the Andean populations of these palms.

ECUADOR

In Ecuador PALMS has worked closely with the Ministry of the Environment, and more specifically with its program BIOCOMERCIO. PALMS researcher Lucia de la Torre has been contracted by the ministry to help out developing an Ecuadorian regulatory framework for extraction of Non Timber Forest Products (NTFPs). Based on the original WP6 publication (de la Torre et al. 2011) reforms to and standardization of protocols for commercial extraction of NTFPs in Ecuador. Management practices were proposed for 317 NTFPs including 30 species of palms and 62 palm-NTFPs. Currently the interaction with this administrative-political level involves the Dirección Nacional Forestal (DNF) and the Dirección Nacional de Biodiversidad (DNB) and lawyers from both departments. This work is to produce management guidelines derived from the PALMS project. The Ecuadorian team collaborates with the project National Forestry Evaluation (Proyecto Evaluación Nacional Forestal) of the Ministry of Environment which sees palms as important elements of the ecosystem services and PALMS is providing relevant information for this purpose. Following the Local Advisory Committee meeting in Lima (September 2013) the WP6 team located in Ecuador has provided Peruvian officials from the Ministry of Agriculture with the legal documentation gathered and the comparisons between the four countries under study in PALMS.

PERU

The Peruvian PALMS team has had close contacts to the Ministry of Environment and the Forestry Ministry. PALMS researcher Betty Millan was appointed by the Government to represent Peru at the 16th SBSTTA meeting of the Convention of Biodiversity (CBD) in Montreal in 2011. She was also appointed to represent PERU at the 11th Conference of the Parties (COP11) in Hyderabad, India in 2011. She functions as the Governments expert on the CITES-Flora panel within the Ministry of the Environment (MINAM). She is appointed by the Government as responsible for the technical group for the Application of the Global Plant Conservation Strategy and for the Technical Group for the Taxonomy Initiative, both under the Convention for Biodiversity (CBD). Betty Millan is also the Peruvian Government’s responsible for the Network for Conservation Centres ex situ under the National Commission for Biological Diversity (CONADIB).

BOLIVIA

In Bolivia WP8 has had a constant interaction with the Ministry of Environment and Water coordinating the research activities including collecting of botanical material and specimens of palms in different parts of the country. These contacts have been with the ministry’s staff in the departments dealing with biodiversity, forest management, and access to genetic resources. An integral part of the contact has been to keep the authorities updated with all materials and recommendations produced by the PALMS project, especially the materials produced for outreach. The contacts have been both by the PALMS researchers, but also more officially on behalf of PALMS by the dean of the Faculty of Natural Sciences of UMSA. When the project started in 2009 the director of the Biodiversity section of the Ministry of Environment and Water, Ing. Aldo Claure was invited to join the local advisory committee of the PALMS and subsequently he has participated in meetings organized by PALMS. These contacts led to forward looking discussions with the biodiversity section regarding the establishment of a Plan for Conservation of Palms in Bolivia. Changes in the Bolivian Government slowed down that process during 2010-2012, but recently the work with this plan has resumed. Most recently UMSA organized a workshop in August 2013 and invited the biodiversity section where this theme has been taken up. Other contacts have been established and in particular with the vice-minister for Science and Technology of the Ministry of Education where PALMS results and recommendations were presented. Among other institutions, WP8 leader Monica Moraes was asked to coordinate a network of biodiversity researchers, and the PALMS project was officially registered in the ministry. Also Monica Moraes was designated as national contact of the ministry for Environment from 2009*. The vice-minister for Science and Technology responded to these contacts by participating in the WP8 organized meeting in August of 2013 and made the closing remarks on this occasion.

Dissemination through collaboration with other institutions not directly involved in PALMS Researchers and institutions participating in the FP7-PALMS project are involved in several other related activities that are not funded by the project. These associated activities may, however, provide important background and in some cases additional input to understanding the problems that FP7-PALMS deals with.

For PALMS-WP1 these collaborations have involved the following ones: • PALM COMMUNITY ECOLOGY ON THE YUCATAN PENINSULA: A PhD project at Unidad de Recursos Naturales (CICY), Mérida, Mexico. PhD student: Arturo Alvarado Segura Supervisors: Rodrigo Duno de Stefano & Luz Maria Calvo-Irabien External Supervisor: Henrik Balslev. Results: Result of our collaboration with colleagues at CICY were presented at the “Congreso de Estudiantes de CICY” in April 2010 and at the Mexican Botanical Congress held in Guadalajara in November 2010 (link to poster). 5th Conference of the International Biogeography Society in Heraklion Greece. “Diversity and composition of palm (Arecaceae) communities in Quintana Roo México” (see poster 2011) Congreso Mesoamericano para la Biología y la Biodiversidad. “Composición, abundancia y diversidad de palmas (Arecaceae) en la península de Yucatán, México (participación oral, 2011) ”• XI Congreso Mexicano de Botánica del 20 al 25 de octubre de 2013 - “Principales determinantes de los patrones de diversidad de especies en comunidades de palmas del sureste mexicano” A small article about the project in ITSSY. A scientific paper published in Nordic Journal of Botany (link). A PhD thesis at Centro de Investigacion Cientifica en Yucatan (CICY). A manuscript accepted by the journal PALMS. A manuscript in preparation for the journal Vegetation Science

• ECOSYSTEM SERVICES PROVIDED BY PALMS IN SOUTHEAST ASIA: Henrik Balslev presented a poster on Ecosystems Services Provided by Palms in
Southeast Asia at the SEA-EU-NET (http://www.colbud.hu/current/sea-eu-net/poster.php) meeting in Budapest by Henrik Balslev on 23-24th November 2010. link to poster

• COLLABORATION WITH UNIVERSIDAD NACIONAL DE LA AMAZONIA PERUANA: Essentially all our fieldwork in Amazonian Peru has been done with the collaboration of Cesar Grandez from the Facultad de Ciencias Biologicas, Universidad Nacional de la Amazonia Peruana (UNAP), Iquitos, Peru. Although not part of the PALMS group of researchers he has participated in many of our publications:

• COLLABORATION WITH UNIVERSITY OF TURKU (FINLAND) AND INSTITUTO DE PESQUISAS DO AMAZÔNIA (MANAUS, BRAZIL): In 2012 we organized a joint expedition with colleagues from Turku University, Finland (Hanna Tuomisto, Kalle Ruokolainen) and from INPA, Manaus, Brazil (Thaise Emilio, Gabriel Moulalat, Fernando Figueiredo). The expedition lasted six weeks on the Rio Jurua in Amazonia. During the expedition we were able to collect data in 38 standard (5x500 m) transects along the 1000 km long stretch from Carauari to Eurinepe. Simultaneously our colleagues collected data in the same transects but relating to other plant groups (Ferns, Melastomataceae and Zingiberaceae). The project has as its purpose to determine to which degree different plant groups respond similarly or not to variation in ecological conditions. The stretch investigated crosses a major geological border between the Ica formation (west) and the Pebas formation (east). The results are currently being analysed for a research paper.

• BIODIVERSITY IN TROPICAL AREAS AND ITS CONSERVATION: Rommel Montufar (PUCE, Quito) as part of his collaboration with WP1 was supervisor of the master thesis of Zamir Alejandro Pérez Durán. He made his master degree at the master program of BIODIVERSITY IN TROPICAL AREAS AND ITS CONSERVATION (in Quito) of the Universidad Internacional Menendez Pelayo (Spain), during the academic year 2011-2013. The title of his thesis is: Oligarchies and regional palm community patterns in the Western Amazon. Zamir Pérez worked with the data base of palm transect (WP1), and the goal of his research was to find regional patterns for palm diversity and the palm communities.

For PALMS-WP2 these collaborations have involved the following ones:

• RESILIENCE OF THE KEY STONE CLOUD FOREST PALM CEROXYLON. Initial conceptual and practical developments on ecological and genetic resilience of the keystone cloud forest palm Ceroxylon echinulatum in Ecuador were achieved by a joint funding of the FP7-PALMS project and the Ecuadorian government funding to Rommel Montufar and Fabien Anthelme (ECOFONDO grant n°019-ECO7-Inv1) in 2009-2010, to study this endangered palm. Subsequently, the experience gained with this project was used to extend the study to Colombia and Peru.

• DNA MARKERS DEVELOPMENT. In the initial phase of the project, much emphasis has been made in WP2 on the development of the appropriate genetic markers that will be needed subsequently for the different case studies.

• DEVELOPMENT OF NEW NUCLEAR DNA MARKERS FOR PALMS. This aspect has been realized in conjunction between the FP7-PALMS project and the IRD Flowering Genes Initiative (DRV grant 2008-2009), which aimed at understanding the genetic basis of flowering induction in tropical plants.

• DEVELOPMENT OF NEW CHLOROPLAST DNA MARKERS FOR PALMS. This aspect has been realized in conjunction between the FP7-PALMS project and IRD Initiative on African Ceraceae and Tuber Crops. This association allowed producing a large set of markers usable for the entire Monocots phylum.

• PHYLOGENY AND EVOLUTION OF ASTROCARYUM. This aspect has been developed within a Marie Curie Action (PIEF-GA-2006–251702, Intra European Fellowship program for Julissa Roncal, with supervision of Jean-Christophe Pintaud, 2011-2012), in relation to the researches of FP7-PALMS WP2 about the geographical structuration ofAstrocaryum diversity in eastern Peru, and an IRD funding to promote interdisciplinary research between biology and geology of the Andes and Amazonia (PPR AMAZ 2011-2013).

• ECOLOGY OF CEROXYLON ECHINULATUM. Rommel Montufar (PUCE, Quito) co-supervised Diana Rodriguez, MSc student from Forest and Landscape Department of Copenhagen University, Denmark. Diana developed her research in the ecology of Ceroxylon echinulatum with the technical and academic support of PALM project in Quito. The result of this cooperation (PALMS-PUCE-Copenhagen University) was published in the Open Journal of Ecology.

For PALMS-WP3 these collaborations have involved the following ones:

• We established collaboration with Dr. Rainer W. Bussmann from the William L. Brown Center of the Missouri Botanical Garden to share ethnobotanical fieldwork in different localities of Peruvian Amazon and Andes. We prepare a series of six books to give back palm ethnobotanical knowledge with their participation:

For PALMS-WP4 these collaborations have involved the following ones:


For PALMS-WP5 these collaborations have involved the following ones:

• PALM COMMUNITY ECOLOGY IN THE COLOMBIAN CHOCÓ. In collaboration with the Colombian Instituto de Investigaciones del Pacífico (IIAP), a MSc student developed his thesis on palm communities in Central Chocó. MSc student: Giovanny Ramirez. Supervisors: Gloria Galeano

• FIELD GUIDES TO THE PALM FLORAS OF AMAZONIAN RESEARCH CENTERS. Collaboration with the Grupo de Ecología de Ecosistemas Terrestres Tropicales-Universidad Nacional de Colombia-Sede Amazonía, and the Corporación para el desarrollo Sostenible del Sur de la Amazonía- Corpoamazonia, resulted in the following publications:

• NATIONAL COLLECTION OF COLOMBIAN PALMS. Collaboration with the Quindío Botanic Garden in Calarcá, Quindío, Colombia, has resulted in the development of the National Collection of Colombian Palms, which now has 70 % of all Colombian palm species represented as living plants. The following publications have been derived from that collaboration

• MARINE INCURSIONS IN AMAZONIA. As a by-product of one of PALMS field trips, a large scale project studying Miocene marine incursions in Amazonia is being developed by Rodrigo Bernal in collaboration with the Department of Biological and Environmental Sciences, University of Gothenburg (Dr. Alex Antonelli), the Paleoecology and Landscape Ecology, Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam (Dr. Carina Hoor), the Smithsonian Tropical Research Institute, Panama (Dr. Carlos Jaramillo), the Nederlands Centrum voor Biodiversiteit Naturalis, Leiden (Dr. Frank P. Wesselingh), and the Universidad Industrial de Santander, Colombia (Dr. Christine Bacon).

• COLLABORATION WITH WAGENINGEN UNIVERSITY, THE NETHERLANDS

Dr. Pieter Zuidema, of the Forest Ecology and Forest Management group, Wageningen University, The Netherlands, collaborated with WP5 in the analysis of
demographic data and as a result he visited the Universidad Nacional de Colombia, where he taught a course on Integrated Projection Models for the study of plant populations.

For PALMS-WP6 these collaborations have involved the following ones:

• COLLABORATION WITH CHANKUAP FOUNDATION. Chankuap helps to promote sustainable use and commerce of PALMS. Our study case with unguarhaua (Oenocarpus bataua) was carried out in a community sponsored by Chankuap. We offer advice to the Foundation and the community to improve the harvest practices.

• COLLABORATION WITH SMITHSONIAN INSTITUTION AN OHIO STATE UNIVERSITY. Smithsonian Tropical Research Institute (STRI) and Queensborough lab (OSU).

For PALMS-WP7 these collaborations have involved the following ones:

• EDIT – THE EUROPEAN DISTRIBUTED INSTITUTE OF TAXONOMY. EDIT was an EU FP6-funded network of excellence that ran for five years until early 2011 and was a partnership between the major taxonomic institutions in Europe (www.e-taxonomy.eu/). One of the main aims of EDIT was to create tools for conducting and delivering taxonomy in a web environment. Palmweb (www.palmweb.org) was a product of this and is the mechanism through which FP7 PALMS WP7 achieves its information dissemination objectives. FP7 PALMS overlapped with EDIT and the early months of the FP7 PALMS software developer position at KEW were co-funded by EDIT.

• BGBM – THE BOTANICAL GARDEN AND BOTANICAL MUSEUM, BERLIN. The BGBM led the work package focused on web taxonomy in EDIT, resulting in the EDIT Platform for Cybertaxonomy. Palmweb (www.palmweb.org) is built upon this platform. The FP7 PALMS software developer at KEW worked closely with the BGBM in making modifications to Palmweb to accommodate FP7 PALMS data.

For PALMS-WP8 these collaborations have involved the following ones:

• PALMS OF BOLIVIA, KNOWLEDGE, CONSERVATION AND DISTRIBUTION. In collaboration with Fundación Amigos de la Naturaleza the following contributions were presented in scientific meetings.

• PALM DISTRIBUTION PATTERNS OF BOLIVIA. In collaboration with the science department of the Fundación Amigos de la Naturaleza (FAN) in Santa Cruz, a database of palm information was created as a framework for evaluating distribution patterns of Bolivian palms. The following publications were produced:

• FRUIT CHEMISTRY AND PRODUCTIVE POTENTIAL OF PALMS. As a collaboration with the Department of Chemistry at UMSA we got funds from the Bolivian Government Fund to hydrocarbon evaluate biochemical components and production potential of six native useful palms of Bolivia. A graduate thesis and following publications were generated:

• MANAGEMENT PLAN OF AN ENDEMIC PALM. Collaboration with the Fundación Natura Bolivia and WWF in Bolivia as well as with local producers of the sunkha palm, workshops and reports were elaborated in order to produce a publication for further dissemination:


• ADVISORY COMMITTEE TO AN ACADEMIC PROJECT FUNDED BY DANIDA IN BOLIVIA. In collaboration with the Universidad Pontificia Autónoma Francisco Xavier de Chiquisaca in Sucre, advice to a MSc.

• CONSERVATION AND SUSTAINABLE MANAGEMENT OF PLANTS AND VEGETATION OF BOLIVIA. In collaboration with the Biodiversity section of the Bolivian Ministry of Environment and Water as well as with other Bolivian institutions we produced publication.

Dissemination through media, popular journals, exhibits etc.

The PALMS project has disseminated results and recommendations through a series of public media such as newspaper, popular journals, videos, web-pages and so forth. A detailed listing of these can be found on the PALMS webpage (http://www.fp7-palms.org/index.php/publicity).

List of Websites:

1.5 The address of the project public website, if applicable as well as relevant contact details

www.fp7-palms.org

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