Non Timber Forest Products

Protocols for Harvest

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PROTOCOLS for HARVEST

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NOTE FOR THE READER

Sustainable harvesting of Non Timber Forest Products (NTFP) has been an important topic amongst different stakeholders working in this field. This Resource Pack aims to cover aspects concerning harvests of specific plant parts and seeks to address institutions, NGOs and researchers working with harvester communities for addressing sustainable forest based livelihoods/enterprise. This Resource Pack will be useful to ensure that an ecological view of resources is followed through the set of thumb rules provided.

The pack has information and suggested methodologies for community based ecological monitoring. Steps elaborated ensure that ecological parameters, indigenous knowledge and traditions are incorporated in the simple methods suggested. A set of presentations make these methods easy to follow. The thumb rules related to harvesting are presented as posters so that they can be replicated and translated in different languages, specifically for harvesters from different communities.

The protocols were first discussed and put together through an Ecological Monitoring Workshop that was held in November 2005 jointly organized by People and Plants International (PPI), Ashoka Trust for Research in Ecology and the Environment (ATREE), University of Hawaii (UH) and Keystone Foundation (KF) at Auroville. The protocols for different plants parts were developed by:

Flower/Fruit/Seed	– Nitin Rai, ATREE
Leaf	- Tamara Ticktin, PPI & UH
Bark	– Tony Cunningham, PPI
Resin	– Snehlata Nath, KF
Honey	- Pratim Roy, KF
Whole Plant	- R.Ganesan, ATREE
Lichens	- Siddappa Setty, ATREE

Subsequent to the first set of protocols, numerous changes were made and many more methods added on. The resource assessment methods used and developed by KF for the ecological monitoring of NTFPs were written by Anita Varghese and Senthil Prasad of KF. The protocols went through numerous edits and reviews, firstly by Line Holtberget and Ellen Lagrell from Sweden and later on by Lisa Mandle (UH). The final reviews were done by Tamara Ticktin, Madhu Ramnath, Rajeev Khedkar and Mathew John.

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Keystone Foundation
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INTRODUCTION

Forests are under constant pressure from changing land use, poaching and indiscriminate harvest of different non timber forest produce (NTFP). There is a need to counter some of these actions and at the same time suggest regulatory mechanisms that ensure conservation and livelihoods go together.

For centuries, wild produce has been harvested and bartered, items like honey being the earliest. A simple view of the forests and forest produce, has been that they were not tended like agricultural lands, yet they yielded and therefore they will continue to yield!

Growing awareness on the status of forests is changing these views. Harvesters are commenting on the gradual decrease in yields, weather fluctuations are affecting flowering patterns and conversion of forest lands mean lesser area for the forest produce to grow.

A set of methods is being proposed through this document for monitoring of natural resources, especially NTFPs. These methods are applicable when the area and volume of harvest is large. Harvesting of forest produce for subsistence use, does not necessitate monitoring unless it is a rare plant that shows low population density.

High demand by the herbal sector has seen many medicinal and aromatic plants become extinct in the wild especially in parts of Central and North India. Some herbs like *safed musli (Chlorophytum borivillianum)* and *sarpagandha (Rauwolfia serpentina)* are now being cultivated in farms and have become an important source of income for some farmers in Madhya Pradesh.

Some of the questions to be asked are:

a) why have these species become extinct
b) what is the method of harvest
c) what is the status of the population
d) which is the season of harvest
e) what parts of the plant are harvested
f) what made the harvests unsustainable

The answers would lead to a complex of ecological and economic reasons, which need to be analysed. For a decade and more, Keystone Foundation (www.keystone-foundation.org) has been working closely with forest produce and their harvesters. A protocol for monitoring of harvests has been in place from the beginning, which has instilled a sense of care for the produce in the harvester, concern for biodiversity in the consumer and helped put the process on the road to sustainability.

A forest based enterprise must have a set of protocols for

- Ecological parameters
- Harvest methods
- Raw produce quality
- Production & Processing standards.

Ecological parameters that ensure communities participate in the monitoring of the resource

Harvest methods that ensure the product is harvested sustainably and the source is conserved

Standards for raw produce quality that will ensure that harvest takes place at the right time and non destructively

Production and processing standards that ensure hygiene, quality and shelf life

Through this document we seek to frame guidelines that will help formulate harvest thumb rules which can be adapted for each produce and area. The protocols play a role in ensuring that harvest of NTFPs are done not only as a matter of right but even as a matter of responsibility.

Role players in the process: In today's context we see that there are many role players in the whole business of NTFPs.

Stakeholders	Monitoring parameters
Harvesters	Maturity, time for harvest, viability of harvest (worth time/effort)
Traders	Yields, markets, trade routes, selection of harvest groups
Forest managers	Yields, weeds, fire, parasites
Biologists	Regeneration, population dynamics, productivity, harvesting methods

While all the role players are involved in gathering information, very little information flows between stakeholders.

Impacts of harvest on plant species: Poster 1 gives a picture of the impacts of harvest on the individual plant. In each section, which deals with the different plant parts, impacts at the population, ecosystem and genetic level are discussed separately.

Timing of harvest: In Keystone's experience with honey hunting, observations have been made on the significance of honey harvest at the right time. When only the honey portion is removed after the honey cells have been capped the bees rebuild the honey portion again in a period of 15 days. The capped cells indicate that the honey is mature and removal of only the honey portion ensures that the brood is left intact.

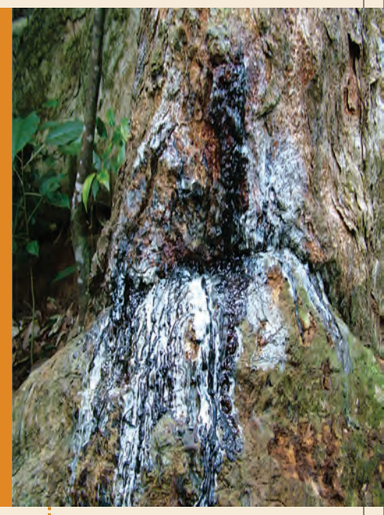
Methods of harvest: Product quality is directly dependant on the method of harvest especially in the case of resin of *Canarium strictum* and vice versa. In the Nilgiri Biosphere Reserve, three methods of harvest were observed. An assessment was made on the status of the plants under different harvest methods.

Natural Fissure Tapping

Trees with over 150cm girth at breast height were harvested.

Many trees above 200cm girth at breast height

Regeneration medium



Tapping

Trees with over 100cm girth at breast height were harvested.

Few trees above 200cm girth at breast height (Many fallen trees)

Regeneration high

Fire & Tapping

Trees above 50cm girth at breast height harvested.

Absence of trees above 200cm girth at breast height

Low level of seedlings.

Potential benefits provided by monitoring	Description
Information for sustainable resource management	Provides key baseline and management data for both communities and managers, using methods appropriate for both
Formation/strengthening of partnerships between communities and managers	Linkages can help reduce the 'fear' and 'policing' elements common in community-manager relationships; in this way informed negotiations can take place
Formation/strengthening of partnerships between communities and researchers	Monitoring is internalized by communities through research and helps build partnerships
Improvement of trade	Monitoring provides ecological guidelines to improve trade decisions or benefits based on how much of the material is conserved
Increase in environmental awareness	Monitoring improves environmental awareness about larger ecological issues that are linked to local practices
Increase in understanding of sustainability on a larger scale	Monitoring allows for comparisons across resource rich and poor zones can allow for understanding of ecological processes and sustainability on a larger scale

Once a change in harvest practices is introduced it needs to be backed up by a monitoring protocol that ensures information on the pulse of the harvested system is being recorded.

These guidelines are presented at a generic level of fruit, leaf, root, bark, stem, fruit & seed. Adaptive management strategies can be drawn up for each plant part harvested.

The four steps recommended in this pack are uniform for all forest produce irrespective of which part is harvested. These steps ascertain the status of the harvested populations and also take into account the knowledge of the people dependant on the product.

STEP 1

Traditional Tenures & Forest Domains - "Where is the resource located and who has access to it ?" - A baseline survey of harvester villages, their knowledge of the area and produce can be made. This helps in delimiting resource areas. Each village/community /clan has clearly marked areas of resource collection and it is important to establish this at the outset. Details of this methodology can be accessed in the PPT 1 which forms a part of this pack. Please read the notes below each slide.

STEP 2

Traditional Knowledge - "What are the people already doing with the produce ?" – Is the produce sold, is it processed in some way, is there a method of harvest that is followed like a thumb rule or a customary norm? In parts of Orissa and Chattisgarh, many adivasi communities have festivals to mark the beginning of a harvest, often to maximise the availability of mature seeds. Why is it followed? Are such practises threatened, if so can they be revived? Given in Poster 2 are some of the generic questions that could be asked. The forum can either be at a meeting of harvesters at the village or when the harvesters bring the produce for sale to the procurement center.

STEP 3

Status of the forest health - This requires a walk through different forest collection areas with the harvesters. The routes can be fixed and a date set annually for this walk. This will ensure a periodical assessment. The walk or reconnaissance will be done with harvester groups and will look at different aspects and make observations on the status of all the resources, both harvested and non-harvested. The ecosystem is best considered as a web of interlinked processes and actors of which none are dispensable. Details of this methodology can be accessed in the PPT 2 which forms a part of this pack. Please read the notes below each slide.

STEP 4

Population status of the species - Here, one may undertake detailed studies on the status of the plant that is harvested. This may be done through plots or transects. The individual as part of a population fills an important function in the ecosystem which might be withdrawn if it declines due to over harvest. Details of this methodology can be accessed in the PPT3 which forms a part of this pack. Please read the notes below each slide.

Having Post Harvest and Pre Harvest meetings with harvester groups is a good strategy for the long term. This forum can take a number of decisions based on visits to the site about the time for harvest and volume of harvest based on the flowering, rainfall, fire, pest attack or other factors. The forum can also decide on action to be taken when rules are not followed.

FLOWER, FRUIT & SEED HARVESTS

Why do plants need flowers, fruits and seeds . . .

There are several stages along the life cycle of an individual plant as it progresses from seed to adult. An adult plant produces flowers which need to be pollinated to produce fruits with seeds. Only some seeds germinate when they are dispersed (or fall under the parent plant) and make it to the sapling stage; likewise, only a few saplings make it to the adult stage of a mature plant. Only a fraction of the seeds in nature actually survive to become adult plants.

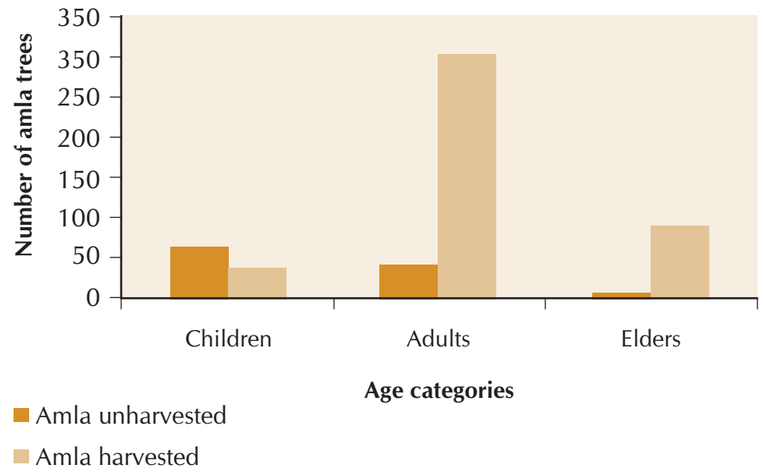
A flower that is collected in large quantities is *dhawai* (*Woodfordia floribunda*). It yields a yellow-red dye. The leaf and bark are also collected for tanning. There are many medicinal uses of this plant amongst traditional communities in Central India.

Immature fruits of *Terminalia chebula* called *baby kadukai* or *bal hirda* in trade are collected in western parts of Maharashtra for the Ayurvedic industry. This is a cause of concern for plant survival as fewer mature seeds are available for regeneration.

A growing demand for the fruit of *amla (Phyllanthus emblica)* is common across India. When the volume to be supplied is high (the fruits also spoil easily after they are plucked), branches of the tree are lopped for quick harvest of large quantities of fruit. When the fruit can be dried and stored for trade, sustainable harvest of trees has been observed.

In many places, this results in stressed wild populations and severe fluctuations in yields. The following figure is based on the data collected by Keystone Foundation in the forests of Kotagiri and shows the stress of harvested populations. The number of saplings are less and this will have a bearing on the overall growth of the population. The un-harvested populations have less individuals but more stable populations.

Population status of amla trees in the forests of Kotagiri



IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual level: Removal of the reproductive parts like flower, fruit and seed may directly affect the regeneration, survival and life cycle of the plant. Depending on the timing, intensity and frequency, harvest of flowers may affect the individual by causing it to limit vegetative growth and put all its energy on flowering and fruiting to counter the threat.

At the Population level: Populations of many species are resilient to the harvest of fruits/seeds when some are left for regeneration and destructive harvest methods (such as lopping branches) are not employed. However, populations that are subject to overexploitation of flowers, seeds or fruit could have lowered rates of regeneration. This can have a negative effect on the long term continuity of the species.

At the Ecosystem level: As part of the ecosystem, other species depend on the fruit for survival. Essentially flowers, fruits and seeds are important to the life cycle of any plant. Flowers attract pollinators who in turn assist the fruit setting. Fruits are eaten by the frugivores who carry them to neighbouring areas thereby helping to disperse the seeds. Many seeds germinate better when they have been through the digestive tract of an animal.

Fruits are consumed by a range of species from mammals to birds to insects. While the removal of flowers could affect pollinators, removal of fruits will impact the feeding behaviour of foragers which in turn will affect the seed dispersal process. For instance, if all fruits are harvested from an area, frugivores will be forced to switch their diet to other resources. This might result in those fruits that are left behind being unable to find their way to micro-habitats that would enhance their chances of germination.

At the Genetic Level: When fruits are removed, the best quality and color are picked for consumption and those of a poorer quality are left behind. Germination of these seeds and the population that results from these seeds may, over successive generations emerge as a weaker and less diverse subset of the parents. This can make populations more vulnerable to any new threats they may face over the long-term, such as pests, disease, climate change etc.

The impacts of harvest will also be different when flowers and fruits are harvested in conjunction with other plant parts. A set of thumb rules and questions that can be adopted for harvest of flower, fruit and seeds are attached as Poster 3.

LEAF HARVEST

Leaves are harvested as NTFP for a variety of uses. Edible young leaves are often an important source of food. Sturdy, fibrous leaves have value in weaving, basketry and thatching. Leaves may even be harvested from the wild and sold for use in floral arrangements.

There are many examples of commercial leaf harvests in India. *Sal (Shorea robusta)* leaf, both for subsistence and commercial use, is extensively collected in Central and Eastern India. The multi crore business of ***kendu*** *(Diospyros melanoxylon)* leaves, used for rolling ***bidis*** in the same region, also exists, with well determined markets, collection and post harvest management. *Siali (Bahunia vahlii)* is also collected in Andhra Pradesh and adjacent areas for leaf plate making, a thriving industry in the region.

Other examples of large scale leaf harvest in the Western Ghats is of the *Phoenix* sp. for broom making and the decorative leaves of the endangered species *Cycas circinalis*.

Why do plants need leaves . . .

Leaves allow plants to acquire energy from the sun through photosynthesis. This energy is used for growth and reproduction. Fibre, lignin and other chemical compounds present in leaves serve the plant as a defense against herbivory and physical damage.

The potential for sustainable harvest of leaves will depend on various factors including the type of leaf harvested, the species from which it is extracted, and the type and intensity of harvest.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual level: Harvesting of leaves may impact the growth, reproduction and survival of individual plants. Removal of leaves means removing some of the capacity of the plant to obtain energy (photosynthesize) and therefore may decrease the growth and reproduction of the harvested plants. For the same reason, over time it may also lead to the production of smaller frond or leaf sizes. By

removing its capacity to obtain energy for defenses, leaf harvest may also make the plant more susceptible to herbivores. In some cases, leaf harvest has been found to lead to short-term increases in growth and reproduction. However, it is unlikely that these increases can be sustained over the long term. Mortality of individual plants may increase if entire branches or the whole plant is harvested, even when only the leaves are used.

At the Population level: Alterations to the growth, reproduction and survival of harvested plants can lead to changes in population structure and persistence. When leaf harvest has a negative impact, it may lead to declines in population size. Leaf harvest may also lead to shift from sexual to vegetative reproduction within a population. However, when management practices support harvest under optimal conditions, many populations can be resilient to leaf harvest.

At the Ecosystem level: Herbivores, including grazers, may depend on leaves for food. Heavy harvest may diminish their food supply. In addition, because of the nutrient content of leaves in some species, their removal may deplete important nutrients from the ecosystem.

At the Genetic Level: If removing desirable leaves reduces the reproduction of the harvested individual, this may favor the reproduction of plants without the desired traits (e.g. size, chemical composition, fibre strength) if these characteristics are genetically determined. It may also reduce the overall genetic diversity. This can make populations more vulnerable to any new threats they may face over the long-term, such as pests, disease, climate change etc.

The impacts of harvest will also be different when leaves are harvested in conjunction with other plant parts. A set of thumb rules and questions that can be adopted for harvest of leaf are attached as Poster 4.

GUMS & RESINS

Gums and resins are plant secretions which are abundant in many trees. They are among the most widely used and traded forest produce. Traditionally they have been used as preservatives for torch wood and bamboo, for caulking of boats & coffins, for food & food processing, for decoration of temples, as incense and for medicinal purposes.

There are many industrial uses of gums and resins like varnish and lacquer, paints and pharmaceuticals wood-work, waterproofing, ceramics, inks, coating, textiles, adhesives and more. In food and drinks they are used for their thickening and stabilizing properties. The industrial use of many gums and resins has declined due to availability of cheaper and synthetic alternatives.

Some indigenous communities use gums and resins for religious ceremonies and in these communities they have been an item of barter and now trade. India is one the worlds major producers of gums and resins and also the third largest exporter. Therefore, most of the harvest today is done for commercial purposes.

The most important collection in India is of *Sterculia urens* or Gum Karaya. Intense harvest takes place in Andhra Pradesh, where efforts have also been made to work on its quality, method of harvest and market. Other gums like *dhawda (Anogeissus latifolia)* and *Pterocarpus marsupium* are collected in select areas – sometimes in large quantities for trade, as in the western forests around Karjat, Maharashtra. Gums are usually edible and used in the food industry. In the case of *dhawda* gum the small trees get fissures, the gum seeps out and is then collected. In large trees, this does not happen as the bark is already thick. Similarly, white dammer *(Boswellia serrata)* is also collected from branching points, where big deposits are located due to naturally occurring fissures.

Usually incisions are required for resins to exude as in most Dipterocarps; likewise in the case of *Canarium strictum*, in the Western Ghats. Over harvesting in some places and the use of fire in others is a major cause of concern and effective measures are required to ensure sustainable harvesting. However, in some places like in the Nilgiris, an internal system of tenure and traditional practices make harvests more sustainable, yielding high quality resin.

Why do plants need gums and resins . . .

Gums are scentless, some may be bitter or sweet. They are a part of the metabolism of the plant. In some cases,5 the gum is produced when fungi attack the plant. A gum may ooze out of the plant on its own or due to injury. Trees produce resins which are exuded when an injury is caused to the plant. The resin is formed in the plant through a process of polymerization and reduction of carbohydrates, primarily starches. Resins may not be of any use in the growth of the plant but may seal up wounds and prevent their dessication, protect against attack of insects and fungi, and prevent further injury through decay. Usually resins are not exuded except when the plant has been injured, therefore tapping has to be done for collection of the resin.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

Resins are to be found in canals in the bark and wood which, when damaged cause the resins to flow out. Therefore, the impacts of unsustainable harvest of resins and gums are most evident at the individual level. However, this is no reason to ignore impacts at other levels since they are closely interlinked.

At the Individual level: Harvesters generally say that resin yields decrease over time. It has also been observed that termites attack trees at the points where incisions have been made.

These trees will have higher mortality rates. Field observations in the Nilgiris have shown that many tapped trees fall easily. This may be due to a weakened base which makes the tree susceptible to termite attacks or simply more weak. Some tree families are also vulnerable to fungal attack when their bark is removed. Apart from increasing vulnerability to pest attack, removal of bark also causes loss of nutrients and moisture. Since tapped plants may be paying a higher physiological price when exudates are removed as they need to be resythesized, rates of growth, flowering and fruiting may also decrease. Heavy tapping of some species over the long-term can lead to early mortality.

At the Population level: Much remains to be understood about the effects on the population. In forests of the Nilgiris where resin has been harvested, populations show a low rate of regeneration. There are theories that the seed quality might be affected from resin harvest. This can lead to decreases in population size over the longer term.

At the Ecosystem level: Each individual in a population has an indispensable function in the ecosystem which should be maintained. Therefore, impacts of all levels affect the ecosystem. If resin or gum harvest reduces the production of flowers and fruits, it could affect the pollinators and/or frugivores who depend on them. In addition resin is used by bees and other insects for hive building; changes in the populations could affect them negatively. It is important to note that apart from harvest of plant parts other factors - climate, fire, weeds, soil erosion could accentuate the impacts of unsustainable harvest practices.

At the Genetic Level: When the harvest of gums and resins from desirable individuals reduces the ability of these plants to reproduce, the less-desirable or unhealthy plants are left to produce the next generation. Over time, due to unsustainable harvests, plants may show a decrease in desirable characteristics and a loss of genetic diversity. This can make populations more vulnerable to any new threats they may face over the long-term, such as pests, disease, climate change etc.

A set of thumb rules and questions that can be adopted for harvest of gums and resins are attached as Poster 5.

BARK HARVEST

Bark and bark extracts are used for a range of products including herbal medicines, paper, dyes and spices. It finds a high use in many of the medicines used by local healers.

In India, the *Terminalia* spp. are harvested for bark for medicinal and chemical processes. The presence of tannins in bark is a reason for their extensive collection. Indiscriminate collection of the bark has led to a depletion of the tree in parts of Central India. Over the years, large scale planting of *Terminalia arjuna* took place in these belts and now, can also be seen along highways in Chattisgarh.

The harvesting of Cinnamom bark *(Cinnamom zeylanicum)*, used as a spice, is found in the Western Ghats. The tree is severely lopped and bark removed from the branches. The remaining wood is used as firewood. Recently, in the Uttara Kannada district in Karnataka this destructive lopping created a big controversy on the use of bark, its method of collection and tenure aspects. Another extensively used bark is *menda (Litsea sebifera)* for incense sticks, leading to an endangered status of the tree in most parts of India.

Why do plants need barks . . .

The bark functions like a protective skin of the plant, surrounding the xylem and phloem tissues that transport water and food. The bark also protects the plant against fires, fungal and insect attacks; it is often rich in chemical compounds that increase the protective capacity and play a role in medicine and dyes.

The impact of bark harvest on individual plants is generally high relative to the harvest of leaves, fruits or flowers. It is also variable across different plant families and under different ecological situations for the same species. Sustainable harvest of bark is important to the income, livelihoods and herbal health-care of many people. It may be possible to maintain sustainable levels of bark harvest for subsistence purposes from fast growing trees. Sustainable commercial harvest of bark from wild populations may not be possible for all species. Cultivation in home-gardens, agroforestry systems and through enrichment plantings should also be considered.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual Level: Removal of bark is likely to have a negative impact on the growth, reproduction and survival of individual plants. Individual plants harvested for bark lose water and nutrients and are often more susceptible to attacks from insects, fungi and other pathogens. Certain groups of plants are more resilient to bark harvest than others. Members of the Proteaceae and Podocarpaceae families are particularly susceptible to pathogens followings bark removal. On the other hand, plants in families such as Euphorbiaceae, Moraceae and Canellaceae are more resilient to bark harvest.

At the Population Level: Through its negative impact on the reproduction and survival of harvested plants, bark removal can lead to changes in population structure and threaten population persistence. Decreases in seed production may result in decreases in the smaller size classes, and eventually to decreases in population size. The impact of harvest on populations depends on both the type of plant and the environmental conditions of the site.

At the Ecosystem Level: Plants harvested for bark may have an important function in the ecosystem in which they occur. Animals may rely on the tree for its leaves, fruit or seeds and decreased seed production and increased mortality may diminish these important resources. Increased abundance of insects, fungi or other pathogens as a result of bark harvest may also have larger effects on the ecosystem.

At the Genetic Level: When the harvest of bark from desirable individuals leads to their mortality or reduces the ability of these plants to reproduce, the less-desirable or unhealthy plants are left to produce the next generation. Over time, due to unsustainable harvest, plants may show a decrease in desirable characteristics due to the loss of genetic diversity.

The impacts of harvest will also be different when bark is harvested in conjunction with other plant parts.

A set of thumb rules and questions that can be adopted for harvest of barks are attached as Poster 6.

HARVEST OF BELOW GROUND PLANT PARTS: ROOTS, TUBERS, BULBS, CORMS & RHIZOMES

The below ground parts of plants are frequently used for food, medicine, fiber and dyes.

A large category of medicinal plants fall into this category and they have been the ones which have become rare and endangered.

Shatavari *(Asparagus recemosus)* and ***Mahaghali kizhangu*** *(Decalepis hamiltonii)* are some of them in this category. Due to high demand and diminishing stocks in the wild, many of them are used as adulterants or substitutes. A study done by the Kerala Forest Department shows that 51% of the NTFPs collected for medicine are roots, tubers, bulbs, corms and rhizomes. Many of the indigenous communities depend on the tubers of the *Dioscorea* spp. for food. In many parts of Central India it is the only food during famine.

Why do plants need the below ground part . . .

Though often overlooked, the underground parts serve many important functions for plants. Roots are anchors, allowing plants to support above-ground growth. Roots also allow plants to obtain water and nutrients. Plants may store energy underground, and reproduce vegetatively by resprouting from underground parts.

The potential for sustainable harvest of underground parts varies greatly depending on the plant and on the harvesting technique used. Even when only the below-ground parts are used, harvest often results in the death of the whole plant. Due to the possibility of below ground harvest to be particularly destructive, careful development, monitoring and adjustment of harvesting practices is important to maintaining these NTFP resources.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual Level: Harvesting of belowground parts may impact the growth, reproduction and survival of individual plants. Removal of roots reduces the ability of plants to acquire water and nutrients. It may result in the death of the whole plant. Plants from the Proteaceae and Lauraceae families are particularly susceptible to fungal attack following root harvest. Removal of storage organs reduces the energy available for growth and reproduction. However, for some plants, root damage may increase aboveground regeneration, at least over the short-term.

At the Population Level: Alterations to the growth, reproduction and survival of harvested plants can lead to changes in population structure and persistence. When root harvest has a negative impact, it may lead to declines in population size and threaten the persistence of populations. Root harvest may also alter patterns of vegetative reproduction within the population.

At the Ecosystem Level: Herbivores may depend on both the below and above ground parts of plants for food. However, these food supplies may be diminished by the over harvesting of roots, especially when this results in the death of the whole plant. Disturbing the soil to harvest belowground parts may also increase soil erosion.

At the Genetic Level: If harvest of below ground parts kills or reduces the reproduction of the harvested individual, this may favor the reproduction of plants without the desired traits (e.g. size, chemical composition, fibre strength) if these characteristics are genetically determined. Harvest may also reduce the overall genetic diversity. This can make populations more vulnerable to any new threats they may face over the long-term, such as pests, disease, climate change etc

The impacts of harvest will also be different when roots are harvested in conjunction with other plant parts.

A set of thumb rules and questions that can be adopted for harvest of below ground parts are attached as Poster 7.

WHOLE PLANT HARVEST

Whole plant harvest here refers to the practice of harvesting whole plants including herbs, shrubs and herbaceous climbers. Whole plants are harvested for their use as wild foods and for medicinal purposes to extract the chemical components in the leaves and stems.

In some cases, whole plants are uprooted to collect only the tubers, roots, seeds or other parts, while the aerial parts are discarded. However, for some species the whole plant & all its parts are used. Most plants for which underground parts are used, lose their whole plant. This practice is not included here as part of whole plant harvest.

Some examples are *Aegle marmelos* and *Sida rhombifolia*. Unless found in abundance, survival of these species is threatened due to full plant removal. Very often these plants are taken up for cultivation.

What can happen when whole plants are removed. . .

As whole plant harvest necessarily results in the death of the plant, it is often considered to have the greatest negative impact on the regeneration of plant resources relative to the harvest of only specific plant parts. However, overharvesting is possible no matter what plant part is considered. Improved harvesting practices in combination with ecological monitoring can help reduce the risk of overharvest and ensure that the availability of the plant resource is maintained for both the benefit of the harvesters and the ecosystems.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual Level: Harvesting of the whole plant results in the death of the individual plant. If the plant is harvested before it sets fruit and disperses its seeds, the plant will not have had the chance to reproduce and contribute to future generations.

At the Population Level: Overharvesting can lead to declines in population size and persistence. Unsustainable harvest has the potential to wipe out plant populations, particularly when plants are harvested before setting seed. Plants that are monocarpic – i.e. that reproduce only once in their lives or those that take a long time to reach reproductive maturity are particularly vulnerable to overharvest when harvest occurs before reproduction.

At the Ecosystem Level: The harvesting of whole plants may also have ecosystem-level effects. Herbivores may depend on the plants for food and over harvest may diminish their food supply. If whole plants are harvested before flowering or setting fruit, birds or insects that rely on floral resources or frugivores that rely on fruit may also be impacted.

At the Genetic Level: When whole plants are over harvested, and only the less-desirable or unhealthy plants are left behind to reproduce, plants may over time show a significant decrease in size or other desirable characteristics and a loss of genetic diversity. This can make populations more vulnerable to any new threats they may face over the long-term, such as pests, disease, climate change etc

A set of thumb rules and questions that can be adopted for harvest of whole plants are attached as Poster 8.

HONEY HARVEST

Apis cerana honey is also found in medium volumes and eaten as such. The honey of the *Apis florea* and stingless bees are prized for their medicinal properties. The honey and wax produced by *Apis* spp. and the dammer bees, play an important role in the livelihood of forest dwelling communities.

Apis dorsata is an economically important bee species in the Nilgiri Biosphere Reserve (NBR) region due to the large quantities of honey produced. It is also the largest social bee present in the NBR and requires vertical structures such as cliffs and tall trees for hive construction. They occur across India and South East Asia and are migratory, following the availability of floral resources. *Apis cerana* are medium sized bees that are not known to migrate large distances and are widely distributed through tropical and subtropical regions of Asia.

Apis florea is distributed in tropical and subtropical Asia and has nesting preferences for areas of dense vegetation. This species builds single comb nests and tends to migrate locally. The stingless bees (Apidae: Meliponini), are small (a few mm in length) and resident species which nest among boulders, old walls, dead trees and tree cavities. They are widely distributed in tropical and temperate regions of the world.

Honey is probably one of the oldest forms of sugars/sweeteners known to human beings. Honey of the *Apis dorsata* has always been eaten and valued. The large volumes of honey that can be produced in a comb make it the most easily marketable produce.

Why do bees make honey. . .

Honey is the ingredient of the food for the brood and it is the food that the bees have before they make their long migratory journeys. It is stored in special chambers and sealed so as to prevent moisture from getting in.

IMPACTS DUE TO UNSUSTAINABLE HARVEST

When honey is removed frequently the bees could be denied their survival food.

At the Individual Level: Periodic harvests may cause the individual bees to be stressed and the energy they could put into reproduction and foraging will decrease when they are robbed of their stored food.

At the Population Level: The stress that individuals in the colony face may lead to more aggressive behavior. It may also result in overall weak populations that cannot go long distances for foraging.

At the Ecosystem Level: If honey harvest affects the size of the colony and the health of the individual bee, the bees will forage over shorter distances or they may not return to an area. This could deny the ecosystem the important role of pollination that bees are expected to play there.

At the Genetic Level: The increased stress due to lack of foraging material or constant removal of honey may cause more aggressive behavior in the bees. It may also result in the evolution of weaker strains that may be more susceptible to disease and pest attacks.

A set of thumb rules and questions that can be adopted for harvest of honey are attached as Poster 9.

LICHEN HARVEST

Lichens are a composite organism consisting of a fungus and an algae living in a symbiotic association. Lichens may absorb certain mineral nutrients from any of these substrates on which it grows. Lichens growing on trees are not parasites, but epiphytes using the tree as a home.

Lichens growing on rocks, though, may release chemicals which speed the degradation of the rock into soil, and thus promote production of new soils. Lichens may dry completely when moisture is unavailable. Several studies have shown serious impacts on the growth and health of lichens resulting from factory and urban air pollution. Lichens obtain nutrients from the air (including dust), water and some from the substrate they are growing on. There are about 20,000 species of lichen worldwide.

Lichens hold importance as traditional medicines. Lungmoss *(Lobaria pulmonaria)* was used against lung diseases while Leather moss *(Peltigera* sp.*)* was a cure against rabies. Icelandic moss *(Cetraria islandica)* is still processed in cough-mixtures. Species like *Evernia prunastri* and *Pseudevernia furfuracea* are used in perfumes while *Umbilicaria esculenta* is on the banquet-menu in Japan.

What role do lichen play . . .

The presence of lichens can be an indicator of the health of a forest. However, in some forests, lichens may be absent due to natural causes.

Lichens are important as bio-weathering agents of rocks. Lichen growth rates changes as they respond to new gradients of light and moisture availability

IMPACTS DUE TO UNSUSTAINABLE HARVEST

At the Individual Level: Harvesting of the lichen before it reproduces will result in loss in regeneration.

At the Population Level: Overharvesting can lead to declines in population especially when harvest occurs before reproduction.

At the Ecosystem Level: The harvesting of lichen can have ecosystem-level effects. Herbivores may depend on the lichen for food and over harvest may diminish their food supply. In the harvest process, barks and other epiphytes are also removed.

At the Genetic Level: A set of thumb rules and questions that can be adopted for harvest of lichen are attached as Poster 10.