CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

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LESSONS LEARNT FOR NON-DETRIMENT FINDINGS

The attached information document has been submitted by the CITES Secretariat[1].

El documento informativo adjunto ha sido presentado por la Secretaría CITES[2].

Le document d'information joint est soumis par le Secrétariat CITES[3].

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Lessons learnt for non-detriment findings from CITES Secretariat commissioned projects.

Report for the CITES Secretariat by Martin Jenkins.
Project S-310. March 2009.

The making of non-detriment findings: what experiences from CITES-sponsored studies can tell us

Introduction

Under Article IV of CITES, Parties to the Convention undertake to ensure, through their Scientific Authorities, that export of any species included in Appendix II of CITES should not be detrimental to the survival of that species and, moreover, where necessary should be limited in order to maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which it might become eligible for inclusion in Appendix I. This part of a Scientific Authority's work is generally referred to as the making of non-detriment findings and is at the core of regulation in trade in Appendix-II listed species.

Over the years, but particularly since the mid-1980s onwards, the Parties to CITES have devoted considerable effort to looking at trade in Appendix-II listed species, most notably under the Review of Significant Trade. This tries to determine, for Appendix-II species traded in significant amounts, whether the provisions of Article IV are being adequately implemented in exporting countries or not and, if not, to propose remedial actions to be taken (culminating if necessary in recommendations to importing Parties that they suspend imports in those species from relevant exporting countries).

The Significant Trade Process has generated a great deal of information on a wide range of Appendix-II listed species. In addition, the Convention has sponsored work on a number of other groups, most but not all included in the Appendices. Exceptions, that is non-CITES listed species that have been the subject of work supported by the Convention include the sea-cucumbers (Holothuroidea), one species of which is included in Appendix III (*Isostichopus fuscus* in Ecuador). This study draws on the range of work carried out under CITES, particularly in the past ten years, to try to clarify some of the most important issues involved in making non-detriment findings and to identify common threads, and differences between, the major groups in trade.

Scope and representativeness of the work

Species in all the major groups included in the appendices have been the focus of at least some work under CITES (although very little directed work has been carried out on mammals in trade in the past decade, with the exception of elephants). The amount of work carried out on each species is extremely variable. In general the resources that have been available to carry out work have always been limited, sometimes extremely so. The majority have been examined under standardised procedures within the Review of Significant Trade. Species chosen for individual review under this process have generally been the subject of desk-based studies, each of a few days' duration. These studies have reviewed existing literature, published and unpublished, and available trade data and have sought input and review from relevant specialists. They are generally successful in gathering together existing information but do not as a rule generate new information. Some quite large groups, particularly of plants (e.g. cycads, with nearly 300 species and East African aloes, with around 200 taxa) have been reviewed as a whole so that effort expended on each individual species within the group is necessarily very small. Some species, such as the medicinal plant *Prunus africana,* have been subject to considerably more detailed reviews. Some species or groups of species have further been the subject of study missions (e.g. the fauna and flora of Madagascar, reptiles in Togo and Benin). This has enabled novel information on the mechanics of the relevant trade to be gathered. However, in only a very few cases have resources been available to carry out field-work on particular species in the wild. The most significant example is the African Grey Parrot *Psittacus erithacus*, which has been the subject of a series of country missions several of which have involved surveys of wild populations as well as assessments of the trade. More recently, lignum vitae *Guaiacum sanctum* has also been the subject of field surveys under CITES-funded work. In addition to studies of individual species, work has also been done on developing more general guidelines and advice.

The species chosen for work under the Significant and other processes in CITES are by and large those for which some concerns have been raised regarding the possible conservation impacts of trade. It is not surprising therefore that for many it has proven difficult to make unequivocal non-detriment findings. However, experience under the Convention indicates that the issues raised by these species are very widely applicable, and indeed that those species for which it is relatively straightforward to make non-detriment findings (and further use these as the basis for managing wild collection and trade) may be the exception rather than the rule.

Major lessons learnt

1. Availability of information on wild populations

The amount of information on biological and environmental parameters of wild species harvested for trade is extremely variable but in almost all cases is patchy and incomplete. The amount of information available on any given parameter depends on the ease with which that information can be obtained and the effort that has been expended in gathering it. The former is a product of the intrinsic properties of the species concerned, and also the accessibility of wild populations. The latter is driven by different factors, primarily economics but also fashions in scientific research.

Some generalisations that emerge regarding the ease with which information can be obtained are:

- For all taxonomic groups, information on distribution and population densities is easier to obtain for species that occur in open, terrestrial habitats (grasslands and arid and semi-arid lands) than for those that occur in forests or aquatic habitats.
- Amongst animals, conspicuous and diurnal species are generally better known than cryptic and nocturnal ones.
- For open country, conspicuous, diurnal animal species there are often some data on population densities based usually on limited samples; for other species these data may be entirely lacking.
- Basic biological data regarding potential reproductive rates, diet and habitat preferences are available for most animal groups in trade. Often data on reproduction and diet are based on animals in captivity.
- Data on the age-structure of populations, 'intrinsic' population growth rate and natural mortality rates in the wild are very scarce for animal populations.
- There are very few plants for which there is any substantial information on natural population densities. The main exception is some commercial timber species.
- Similarly, there is extremely little information on the population dynamics of most wild plant species in trade.
- In some cases in all groups, taxonomic uncertainties or difficulties in identifying species or both, may present problems.
- In all taxonomic groups there is very little evidence of any ongoing monitoring of populations of target species or quantification of the impacts of harvest on populations. In some cases there is qualitative assessment of likely impacts of collection based on perceptions of changes in abundance through time, or general comparisons of abundance of populations in harvested and unharvested areas. There are virtually no examples of any kind of multivariate analysis that tries to separate the effects of harvest from other factors.
- As an extension of this, there are, it appears, no experimental studies where the impacts of different harvest regimes have been tested.
- Red list assessments can provide useful indications but should be used with great caution. Data standards within the red list process are highly variable, identification of threats is often unreliable (assessors tend to be "tick-happy", indentifying a wide range of factors as potential threats, even if concrete data are lacking) and, in the case of harvested species, circularity often applies. Species that are harvested are likely to be identified as threatened because they are harvested, in the absence of quantitative information on wild status (e.g.

2. Quantifying harvest and trade

Any kind of non-detriment finding needs as a minimum some estimation of amounts of the target species harvested for trade. The ease and accuracy with which these amounts can be measured or estimated also varies greatly both with and between different taxonomic groups.

- It is easier to quantify trade where this is largely or entirely in whole specimens rather than in parts or derivatives.
- Trade in live animals is generally easier to monitor than that in plants.
- It is easier to quantify trade where source and market countries are widely separated, because trade in this case is channelled through a limited number of routes (usually air or sea) that can be relatively easily monitored. This applies particularly to live animal whose transportation generally requires specialised forms of carriage and which are relatively difficult (though of course not impossible) to transport clandestinely. Trade across land borders in any commodity is much more difficult to monitor.
- Taxonomic and identification issues can make monitoring trade difficult in all major groups traded.
- It is easier to quantify harvest where domestic use is non-existent or small-scale compared with international trade, because assessing the extent of the former (whether subsistence or market-based or both) is almost always very difficult.
- The existence of any substantial illegal or undeclared trade can clearly make it very difficult to quantify trade levels. From what information exists it is evident that prevalence of such trade is highly variable both between and within the major groups in trade. The degree to which such trade exists is dependent on the incentives to trade illegally, social mores, governance levels and the efficacy of enforcement in exporting and importing countries. Its importance in making non-detriment findings is not in its absolute volume in any given case, but in its volume relative to declared or recorded trade. Illegal or undeclared trade can apparently be important in both high-volume low- (or relatively low) value trade, such as that in South-east Asian chelonians for food and in low-volume high-value trade such as that in Saker Falcons. In some groups, such as most of the reptiles and amphibians that are traded as live animals for the international exotic pet trade, indications are that illegal or undeclared trade is not an important issue in terms of assessing impacts of harvest on wild populations.

3. Quantifying the effects of harvest on wild populations

Assessing the impact of a given volume of product in trade on a wild population requires at least some understanding of the relationship between trade levels and harvest levels and of the nature of the harvest involved. CITES-sponsored studies have shown that the following factors may be important:

- Wastage or mortality levels between harvest and market or point of export. There is often little quantified information on this, although where information is available, indications are that it is highly variable. In the live animal trade indications from species as varied as African Grey Parrots and Malagasy Mantella frogs indicate that mortality rates to point of export of 25-50% are not unusual. For reptiles harvested for the skin trade, there is little information on wastage or discard rates. For plants in general there is also little quantitative information, although indications are in the case of most medicinal plants and those collected for the horticultural trade that wastage rates may be relatively low. For some kinds of timber, such as Guaiacum or timber extracts (notably agarwood) recovery rates may evidently be low,

- The elements of a population that are targeted. A given level of harvest may have very variable impact depending on whether, for example, juveniles or reproductive individuals are targeted. Harvest of mature, reproductive specimens may have a disproportionate effect on reproductive capacity and growth rate of the population as a whole. This may be exacerbated where females are targeted, as is the case in the Saker Falcon.
- In the case of harvest of parts, whether such harvest is destructive or not. This applies for example to harvest of bark of *Prunus africana* and to bark and leaves of Himalayan Yew *Taxus wallichiana*. A given volume of bark harvest will have a completely different impact on the wild population depending on whether the trees targeted have been killed in its harvesting (by complete ring-barking) or not.

4. Quantifying the effects of harvest on non-target populations

Harvest techniques can vary greatly in their wider environmental impact and in their impacts on non-target species. Destructive harvest techniques (eg. felling of trees to obtain epiphytes, dynamite fishing or use of cyanide or rotenone) can have a greater long-term impact on wild populations of target species than the actual harvest (that is removal of individuals from the population) does. In addition, some forms of harvest may also take non-target species that may be rare or threatened. Impacts on non-target populations are of major importance in most commercial fisheries and large scale timber operations. In general, these impacts seem to be less important in many of the species traded under CITES. where harvest is often specifically directed and harvest techniques often do not have large-scale environmental impacts.

5. The meaning of non-detriment – sustainability and evidential standards

It is evident from the foregoing that the amount of information available on all aspects of harvest of wild species, and the quality, detail and reliability of the information that is available is highly variable. For all species harvested there are considerable levels of uncertainty and for the majority there are large gaps in knowledge and in understanding of the impacts of trade on species and the ecosystems of which they are a part.

Any determination of whether a given level of trade or harvest might be non-detrimental to wild populations as understood under the terms of Article IV of the Convention needs to deal with this uncertainty. It is clear therefore that evidential standards and the degree of precaution demanded are crucial factors in the making of non detriment findings. There is no absolute for these. Different people will demand different levels of precaution or different standards of evidence to be convinced of non-detriment, and indeed many people may apply different standards in different circumstances (experience under CITES, for example, indicates that evidential standards and degrees of precaution imposed for the trade in live terrestrial vertebrates are almost invariably higher than those imposed on say, fishes traded for food, or plants of any kind).

There are also basic disagreements as to what a non-detriment finding means, both under the terms of Article IV of CITES and more widely. The most extreme view would argue that only harvest (or trade leading to harvest) that has no observable impact on the target population in even the short term (usually taken to be a year) should be considered non-detrimental, that is a harvest that takes only a proportion of annual productivity and for which it can be shown that there is a compensatory decrease in other causes of mortality. In practice the only forms of harvest for which this can be shown unequivocally are controlled non-destructive forms (eg. harvest of elephant ivory resulting from natural mortality; controlled harvest of leaves or fruits, seeds and other propagules). At the other extreme it may be argued that harvests that have a major impact on target populations but that leave enough individuals to allow the population to recover in the medium or long term should be considered non-detrimental. In the context of CITES this may apply to some tropical tree species

(*Prunus africana, Guaiacum,* agarwoods), where mature specimens may be harvested out, but where young specimens or propagules remain, allowing long-term regeneration.

From an interpretative point of view, the most problematic part of Article IV of CITES is the reference to maintaining a harvested species at a "level consistent with its role in the ecosystems in which it occurs". The concept of an ecosystem 'role' for an individual species eludes easy understanding at a theoretical level. Even if agreement on the role of a given species could be reached, it is not clear how it could be determined to what level a population would have to be reduced so that it was no longer consistent with such a role. None of the studies reviewed here have given any clear guidance on this.

The problem of interpretation is compounded in cases where specimens are harvested from modified ecosystems and even more so where harvested populations may be managed or manipulated to increase productivity. An example of the former is the tree-fern *Cyathea contaminans* which is a common species (described as a weed) in tea-plantations in Indonesia. Examples of the latter include the snowdrop *Galanthus woronowii* in Georgia which is semi-cultivated in agricultural lands some of which are apparently outside its natural range in the country, and various kinds of giant clam *Tridacna* and *Hippopus* that have been introduced or reintroduced in various island nations in the South Pacific. More generally, there is often a blurring between different production systems, particularly with plants, with many gradations from harvest of essentially unmanaged wild populations to closed-cycle artificial cultivation.

5. Making non-detriment findings: using models, conservative quotas, filling gaps in data

The problems outlined above notwithstanding, it is clearly possible in a wide range of cases to arrive at some agreement that a particular trade is not detrimental or, conversely, that it is.

Perhaps the simplest cases for demonstrating non-detriment, other than those of completely non-destructive harvesting, are where it can be shown that harvest comprises only a tiny proportion of the plausible wild population. The clearest examples of these in the cases studied are some reptiles and amphibians in the live animal trade for which there is a relatively low level of international trade (usually a few hundreds or thousand of specimens a year), little or no domestic demand, and plausible population estimates in the hundreds of thousands or millions. For these cases it is straining credulity to believe that trade is in overall terms detrimental or that it poses a threat to the species in the wild (although it is of course not possible without more detailed information to show that this trade does not have some more definite local impact).

At the other extreme, trade can be shown to be clearly detrimental where observed numbers in trade are close to or exceed annual productivity over a protracted period. This is the case with the Saker Falcon, where a relatively simple population model can show that levels of trade in the early 2000s would lead to complete collapse of the wild population within a few years.

The vast majority of cases lie between the two extremes: there is normally simply too much uncertainty to tell whether existing harvest or trade is detrimental or not (even assuming that some agreement on what this means can be reached).

Sometimes it should be possible to reduce the level of uncertainty relatively simply: in the case of Malagasy *Phelsuma* geckos, for example, some relatively simple population sampling should allow minimum population estimates to be derived, as has been done with some Malagasy chameleons, and Dabb lizards *Uromastyx* in North Africa and the Middle East. Export quotas could be set at a highly conservative level compared with these estimates to ensure that harvest was not detrimental.

In other cases, though, the causes of uncertainty are more complex, and solutions are more intractable. This applies to much of the medicinal plant trade for example. It will require a great deal of research to determine levels of harvest and local use in many of these species, and even if such data can be obtained, lack of understanding of the population dynamics of the harvested species will make it hard to evaluate impacts.

In some cases, the investment required to obtain basic parameters to determine non-detriment is likely to be large in comparison with the value of the trade, making such an exercise economically unviable.

6. Applying the IUCN Guidelines on non-detriment findings

IUCN guidelines were developed in the early 2000s to assist Scientific Authorities in the making of non-detriment findings, and published in the form of a checklist (Rosser and Heywood, 2002). In the work reported on here carried out since then, the guidelines have been used or explicitly referred to in just three cases: agarwood, where the checklist was tested for usefulness in Indonesia and Peninsula Malaysia; *Prunus africana* where reference to it was made in the significant trade review (Cunningham 2006); and *Mantella* (Malagasy frogs) where the significant trade review carried out by IUCN in 2008 noted that participants in a working group in Madagascar who met in 2004 to advise the Scientific Authority on non-detrimental export quotas for *Mantella* had used the checklist as the basis for their work. In this last case, the checklist was evidently found very useful, while in the cases of agarwood and *Prunus africana* it appeared less so.

However, it should be noted that this should not be taken as a indication that there is little overall uptake of the checklist, or that it is widely considered not very useful: as noted above, the species and species groups reviewed here are very largely those for which there has been concern, usually over a protracted period, that harvest for export may be detrimental, or at least that non-detriment findings are not being made. These are therefore likely to be intrinsically cases where the checklist and other such tools have not been taken up or applied. A full test of the usefulness of the checklist would need also to look at cases were export was well-managed and non-detriment findings were being made – such cases would not be expected to need the kinds of review or project work that is the subject of this report.

7. Implementing non-detrimental harvest systems

Assurance of non-detriment is intimately linked with effectiveness of management and control of collection and export. For some (perhaps most) species it may be possible to establish sustainable levels and systems of harvest on a biological basis but it may be extremely hard to enforce these. For some species, sustainable harvest levels may be considered not economically viable.

8 The feasibility of establishing taxon-specific guidelines or rules for the making of non-detriment findings

In making non-detriment findings for a particular species, the biology of the species, and in particular how populations react to harvest, is clearly of paramount importance. The biology of a species is in part determined by its taxonomy: particular taxonomic groups clearly share features in common, with the number of shared features generally indicative of the degree of relatedness of the species. However, species in any given taxon may also vary greatly in their biology, including in their resilience to harvest. Moreover, as discussed at length above, establishment of non-detriment depends on far more factors than the biology or autecology of the species in question. These factors include: the kind of harvest carried out; the products traded; and the governance regimes under which the species is harvested and exported. It is not evident from this review that taxonomic relatedness is the most important factor – that is for example whether reptiles harvested principally for the live animal trade have, for the purposes of making non-detriment findings, more in common with birds harvested for the live animal trade than they do with reptiles harvested principally for the skin trade. Similarly, orchids and succulents harvested for the horticultural trade may have more in common than orchids harvested for horticulture and those harvested for food or medicine. Given this, it may be difficult to establish taxon-specific guidelines or rules that go much further than the IUCN guidelines (Rosser and Haywood, 2002).

Analysis of trade in some major groups

Animals

A. Amphibians and Reptiles

Introduction

A relatively large number of species of reptile and a somewhat smaller number of amphibians have been the subject of various CITES studies relevant to the making of non-detriment findings. As well as reviews of individual species undertaken as part of the Significant Trade process, reptiles and amphibians formed a significant proportion of the species covered in the country-based Significant Trade review for Madagascar and reptiles (along with scorpions (qv)) were the subject of a project in Togo and Benin.

Amphibians

Experience under CITES within the past ten years is confined to Malagasy amphibians, most notably the genus *Mantella*, small, often brightly coloured terrestrial frogs that are exported as live animals for the exotic pet trade. These species have featured as part of the overall Madagascar Significant Trade review and were also included as a genus for separate review under the Significant Trade process in 2007. Earlier work under CITES has looked at south and central American poison frogs (Dendrobatidae), which have similar biological characteristics and are traded in the same way. The Indian bullfrog (*Hoplobatrachus tigerinus*) was subject to a Significant Trade review in the 1980s. This is traded almost exclusively as a food item.

Lizards

Recent work under CITES has concentrated on species that are exported as live animals for the exotic pet trade, namely five species of spiny-tailed lizards *Uromastyx* from North Africa and the Middle East and three species of day-gecko *Phelsuma* and one species of chameleon from the Comoro Islands and East Africa. The Madagascar Significant Trade review also covered a wide range of lizard species, both CITES and non-CITES listed, including day-geckos, leaf-tailed geckos *Uroplatus* (recently included in Appendix II) and the chameleons *Brookesia* (also recently included in Appendix II), *Calumna* and *Furcifer*. Earlier work has covered some other species traded live, including African chameleons *Chamaeleo* and the Green Iguana *Iguana*, but also groups traded primarily as skins, namely various monitors *Varanus*, and tegus *Tupinambis*.

Snakes

Cobras *Naja,* traded almost exclusively as skins, have been the focus of recent work and the Indian Rat Snake *Ptyas mucosus* is the subject of an ongoing study. In the past various boas Boidae and pythons Pythonidae have also been reviewed. These are also largely trade as skins, although live trade in a few species such as the West African Royal Python *Python regius* and the Central American boa *Boa constrictor* is also significant.

Tortoises and turtles (chelonians)

Species reviewed include a range of terrestrial and freshwater chelonians, generally traded live for the pet trade or to supply Asian food markets. Recent studies have looked at three species of Asian box turtle *Cuora,* an Asian soft-shelled turtle *Lissemys punctata,* the Asian painted terrapin *Callagur borneoensis* and two tortoises (the Greek Tortoise *Testudo graeca* and the Malagasy flat-tailed tortoise *Pyxis planicauda*, transferred from Appendix II to Appendix I in 2003). The last two of these are, or were, traded chiefly for pets, the remainder for food.

Biological and environmental parameters
For the majority of species that have been studied, some basic biological and environmental parameters are available. Fecundity levels (clutch or brood sizes) and number of broods per year, often based on captive animals, are usually known, sometimes for the species in question or sometimes more approximately for the genus concerned. Some longevity data and age at maturity may also be available, although almost invariably based on captive animals. There is also usually general information on diet and habitat preferences. However, data on mortality rates in the wild and age-structure of wild populations are almost invariably absent

For species that are indiscriminately and comprehensively collected (chiefly food species) it may theoretically be possible to gain some indication of the age-structure of wild populations through sampling of shipments, but this is not known to have been done.

Field evaluation and sampling methodologies
Distribution
The amount of information available on extent of distribution in the wild is highly variable. The vast majority of species have not been comprehensively surveyed. However, under the Global Amphibian Assessment, at least preliminary attempts have been made to map the distributions of all species and provide indications of either 'extent of occurrence' or 'area of occupancy' or both. The Global Reptiles Assessment, which should eventually generate similar information for reptiles, is currently under way. However, at present distributional information for reptiles is much more variable. Some species have been characterised in detail while others remain little known. For a high proportion of species, particularly aquatic or semi-aquatic species such as many south-east Asian chelonians, although the rough boundaries of the distribution may be known, there is extremely little information on the actual extent of suitable habitat within the range, it being notoriously difficult to measure the extent of inland water habitats, and even less on the proportion of suitable habitat occupied by the species concerned.

Population
Studies undertaken under CITES have confirmed what is more widely known: that many reptile and amphibian species are very difficult to census. This applies particularly to species that are cryptic or nocturnal, fossorial (burrowing), highly arboreal or aquatic, and that are solitary.

For diurnal species that are not too cryptic and that live at medium to high densities, preferably in open habitats, transect surveys are feasible. These have been carried out, for example, on chameleons in Madagascar, monitor lizards in West Africa and *Uromastyx* in Israel and the UAE. Crocodilians have been successfully surveyed using nocturnal eye-shine counts. Local population densities in aggregating breeding amphibians (notably Malagasy *Mantella* spp.) have been estimated using mark-and-recapture techniques.

Where surveys have been carried out, they typically only cover small areas, sometimes extremely small areas and are rarely stratified by habitat. There are virtually no cases of repeat surveys or systematic monitoring of particular populations over an extended period. For a number of groups, including south-east Asian chelonians and snakes, there are virtually no reliable quantitative data on population densities at all. In some cases there are qualitative or anecdotal observations, indicating that species appear to have changed in abundance (invariably by becoming rarer). In the case of the Indian Rat Snake a decrease in abundance has been inferred from a decrease in the average size of skins appearing on the market

Numerical and/or graphical analysis

In cases where populations have been surveyed, such surveys generally only cover a tiny proportion of the overall range of the species in question. However, normally more than one area has been sampled, allowing some indication of variations in population density. These, combined with estimates (often very approximate) of area of suitable habitat have allowed rough global population estimates to be made. Almost invariably, confidence limits are very wide, with upper and lower population estimates sometimes varying by two orders of magnitude. There are very rarely enough data to allow more rigorous or precise population modelling.

Where the species concerned have not been surveyed at all, it is sometimes possible, much more tentatively, to suggest possible population densities based on ecologically similar species, for example, in lizards where there are recent reviews that collate results from a range of studies on different species. Where the distribution of the species in question is known reasonably well, it is possible at least to put boundaries round possible population sizes.

From these extremely crude models, it has proven possible to provide indications that some species in trade (eg. species of *Uromastyx, Phelsuma* and various genera of chameleon) have populations that are at minimum almost certainly several hundred thousand, and more likely to be in the millions. For such species annual export quotas of a few thousand individuals or less represent a very small percentage (sometimes a fraction of a percent) of even minimum estimated population sizes. Such quotas are extremely likely not to be detrimental overall to the wild population of the species concerned.

For other species, such as virtually all south-east Asian chelonians, there do not appear to be sufficient data to establish even the crudest of models.

Other factors (precautionary measures and collateral impacts)

Post-capture mortality is only of relevance for species that are collected for the live animal trade. There is very little quantitative information on this, or on survivorship rates for reptiles that are collected to lay eggs or produce young in captivity and then released again. One estimate (for *Mantella* in Madagascar) indicated that 50-100% more individuals would normally be collected than were actually required for export to account for post-collection mortality.

Anecdotal information gathered in these studies indicates that survivorship rates are likely to be highly variable, depending on the species concerned, the length of time individuals are held before export, and, crucially, the conditions under which they are held and transported. Some groups, such as chameleons and small frogs such as *Mantella* and the dendrobatids, are known to be relatively fragile and to suffer high mortality rates unless given high standards of care. Others, such as many chelonians, are known to be much more robust and generally to suffer quite low post-capture mortality.

Assessing overall intensity of collection – domestic use and illegal export

Live animal pet or collectors' trade

In some cases, notably many of the species that are collected for export for the exotic pet trade, there is no or very little domestic use. Moreover, because this is a relatively specialised business, in any one country only a small number of operators is normally actively engaged in export. Typically countries of import are far away and consignments travel by air, making them relatively easy to monitor. Levels of export, particularly for CITES-listed species, are generally therefore reasonably well documented. In most such cases illegal trade, although it almost always takes place at some level, is believed to be rarely on a large scale, so that declared exports are a reasonable indication of actual export levels (exceptions to this normally involved Appendix-I species or those that otherwise banned from trade). There have, historically, been problems with mis-declaration of the origin of specimens for export, with wild-collected specimens declared as captive-bred or ranched. Ground visits to dealers' premises can usually determine whether this is the case. Overall, however, it reasonably easy to infer likely overall levels of collection in these cases.

Determining local impacts of collection is much more difficult, and requires considerable investment of time and effort. Exporters may be reluctant to disclose the sources of their specimens and collectors may sometimes be operating on the margins or the law or outside it (collecting inside protected areas, or outside the legal collection season).

As with almost any kind of export of wild specimens, taxonomic issues can be problematic. However, because much of the trade is aimed at dedicated hobbyists, considerable importance is usually attached to specific identification, so that problems are most likely to arise from the use of different classification systems which can normally be relatively easily resolved.

Food trade

The trade in reptiles and amphibians for food presents a very different set of problems, In the context of this study the most important such trade is that in freshwater and terrestrial chelonians from South-east Asia for oriental food markets. This trade is also almost entirely in live animals. However, much of it is across land borders and a high proportion is, or has been, unreported or illegal. Declared levels of trade are unlikely therefore to reflect real levels. There is also normally some domestic use, the level of which and impact of is extremely hard to gauge without extensive market surveys. In addition, with one or two exceptions (such as the Three-banded Box turtle *Cuora trifasciata*), the precise identity of the specimens traded is evidently not regarded as crucial. Consignments are often not identified to species level, are misidentified or comprise mixed species. Determining actual levels of and trends in trade in any one species is therefore highly problematic. Information on this, and on the presumed impacts of the trade on wild populations, is generally taken from limited market surveys and spot observations on prices.

Skin trade

Assessing levels of trade in skins and relating this to individuals caught is usually problematic, particularly where there is a significant level of trade in manufactured or semi-manufactured products, as is the case with cobras and rat snakes. There is also a significant local market in products from these species. Even where this is not the case, and most of the trade is in skins for processing elsewhere, analysis is hampered by the range of different units typically used in reporting trade (eg. individual skins, weight, area and length).

Collateral impacts

Evidence from studies undertaken under CITES indicate that, in general, there is relatively little collateral impact from harvest of reptiles and amphibians for the exotic pet trade. There is likely to be some minor habitat disturbance (turning over of stones, cutting down of branches and so forth) but destructive harvest techniques are not reported to be used. There is less information available on collection of reptiles for the food trade, but again there is little indication of destructive harvest techniques.

B. Birds

Introduction

Only four species of bird have been the subject of ongoing review and study under CITES in the past decade, all under the Significant Trade process. These are the Saker Falcon *Falco cherrug,* the Hill Myna *Gracula religiosa* and two species of parrot, the Senegal Parrot *Poicephalus senegalus* and the African Grey Parrot *Psittacus erithacus*. Wild birds in international trade were also examined under the Madagascar Significant Trade process. Three species were of note: two parrots *Coracopsis* spp. and the Malagasy Lovebird *Agapornis cana*. Both the Saker Falcon and the African Grey Parrot have been the subject of more detailed work. Several country reviews have been carried out under the auspices of CITES on the African Grey Parrot which have in some cases included field surveys of the species. The Significant Trade Review of the Saker Falcon has drawn on extensive field work on the species, much of it supported by the United Arab Emirates Environmental Research and Wildlife Development Agency.

Biological and environmental parameters

For these species, as for a large number of birds, basic biological parameters are reasonably well known. That is, there is information on age at maturity, reproductive rate (average clutch size, number of clutches per year), sometimes longevity (based often on captive individuals), diet and habitat preferences. For the African Grey Parrot and the Saker Falcon there are estimates for some areas of the proportion of the population breeding in any one year. There is generally little information on natural mortality and survivorship rates, although fledging survival rates have been estimated for some populations of Saker Falcon.

Limits of the range in most cases are reasonably well known. Knowledge of population status is very variable. The Saker Falcon is by far the best characterised species. It is a relatively large, generally open-country species whose nests are relatively easy to observe and which is the focus of a great deal of field work. This has allowed unusually precise country-by-country estimates of the breeding population to be made, leading to a very well defined global population estimate (3900-5250 pairs in 2002, 3600-4260 in 2003). The African Grey Parrot is also reasonably well known in some areas, although population estimates are in all cases far more approximate than those for the Saker Falcon. The species occurs in forested or wooded habitats – species in these habitats are in general much harder to survey than those occurring in open habitats. However, the African Grey Parrot is a large, conspicuous bird that gathers together in habitual roosts and is therefore considerably easier to survey than many forest species. In some countries of its range it has been possible to make estimates of population with relatively close confidence limits (95% upper and lower confidence limits varying by a factor of two or three). In some places there are estimates of breeding density (nest per hectare) with similar confidence limits. Even for this species, however, the population status in large parts of its range remains speculative. Estimates are based on limited surveys, or largely anecdotal observations and inferences drawn from population densities found in other, better known parts of the range.

For the Senegal Parrot and the Hill Myna, there are very few quantitative population data. Observations are qualitative, with descriptions such as ‘common’ or ‘reasonably abundant’ or ‘rather scarce’ typically used. Comparative data are sometimes available, again almost invariably qualitative in nature, with observers indicating for example, that the population in a given place still seems reasonably abundant, or that the species is no longer common in a place where it was once frequent.

Field evaluation and sampling methodologies

Ranges of bird species can be determined relatively easily and, because of the large number of active bird-watchers, are already reasonably well characterised for most species in trade. Deriving reliable population estimates for many species, particularly those that occur in forest environments, is much less easy. For a conspicuous, open country species such as the Saker Falcon that occurs in small number in much of its range, total counts of breeding pairs are available for some countries, while in others sample counts cover a significant proportion of the range, allowing relatively precise estimates of breeding population to be made. However, even for a species as well studied as this, the number of non-breeding birds in any population remains speculative.

For species such as the African Grey Parrot that use communal roosts, reasonable estimates can be obtained by head-counts at known roosting sites and extrapolation to other areas. For other birds that do not form easily countable aggregations, estimates are normally derived from transect surveys in appropriate habitat. Such surveys are likely to be limited in extent and for wide-ranging species (such as, in this case, the Senegal Parrot and Hill Myna) extrapolation is highly problematic, as occurrence is often patchy, with considerable variation in population density across the range. Nevertheless, it should theoretically be possible to combine data from even small scale surveys with basic habitat maps and such qualitative observations as do exist to produce some minimum population estimates.

Other factors (precautionary measures and collateral impacts)

Post-capture mortality

In all live-capture there is some additional mortality at various stages in the export-chain, from point of capture to import. The studies of the African Grey Parrot have shown that this is highly variable, but may be significant, with mortality rates to point of import sometimes approaching 50%. Different capture techniques may also have different impacts on the harvested population, depending for example on whether juvenile birds only are targeted or whether adult birds are also taken (the latter having a greater demographic impact). Similarly, in the Saker Falcon females are overwhelmingly preferred in the chief market countries (only females are large enough to hunt Houbara Bustards, the main prey species for falconry). Virtually all exported individuals are females, and this has a disproportionate impact on reproductive capacity of harvested populations.

Generally, trapping techniques do not appear to have major collateral environmental impacts, but some may adversely affect target populations – persistent disruption of roosts or targeting of particular nesting-trees may drive birds away, and affect reproductive success of the population in that and subsequent seasons, although concrete data on such impacts are almost entirely lacking.

Illegal harvest and trade

For the birds studied, and particularly the African Grey Parrot and Saker Falcon, there is ample evidence of substantial illegal harvest and trade, for example, collection of birds in protected areas, undeclared transborder trade and, in some cases, 'laundering' of birds by declaring them as captive-bred or as originating in a different country. This trade makes it much more difficult to establish non-detriment findings, particularly in terms of ensuring sustainability of harvest from particular countries or parts of a country. Although it is almost impossible to determine the magnitude of the illegal undeclared (as opposed to mis-declared) trade, observations in market countries incorporated into the significant trade reviews generally indicate that, in the case of the parrots at least, such trade is not orders of magnitude greater than the declared trade. That is, the latter gives a reasonable indication of the magnitude of the trade, from which numbers overall harvested annually can be roughly estimated, allowing some assessment of whether the harvest is in global terms detrimental or not. The existence of substantial illegal harvest and trade not only makes it difficult to determine the size of the harvest, it also makes it much more difficult for investigators to obtain accurate information on the dynamics of the trade as those involved are, understandably, reluctant to disclose potentially self-incriminating information.

For three of the four species examined, domestic markets are believed to be much smaller than export markets, again allowing an easier determination of non-detriment. In the case of the Hill Myna there is believed to be a substantial, though unquantified, domestic market in at least some range States, making determination of the impact of harvest difficult.

C. Invertebrates

Introduction

Six species of giant clam in the genera *Hippopus* and *Tridacna*, the Queen conch *Strombus gigas* and sea cucumbers in the families Holothuriidae and Stichopodidae have been the subject of work under CITES in the past decade. All are marine invertebrates that have been and continue to be heavily exploited, largely or exclusively for food. The sea cucumbers represent an unusual case, in that no species is currently included in Appendix II (*Isostichopus fuscus* is included by Ecuador in Appendix III). The giant clams and the Queen conch have been reviewed under the Significant Trade process. The Queen conch is also relatively unusual in having been included in the process twice, and has been subject to relatively detailed review over a protracted period.

Biological and environmental parameters

The biology and environmental requirements of the giant clams and the Queen conch are relatively well known, largely because both have been the subject of extensive mariculture efforts. Data are also available for some sea-cucumbers. However, in all cases there are gaps in understanding of the biology of wild populations, most importantly in recruitment rates and larval survivorship and dispersal.

All the species, except for a few sea-cucumbers, are widespread; information on distribution is usually patchy, and population data based on limited sampling or inferred from catch data. Giant clams are relatively easy to survey (and exploit), being large, sedentary and generally confined to shallow waters (≤ 20 m depth). Sea cucumbers are much more variable in biology and ecological requirements. Some occur at abyssal depths and are therefore highly inaccessible both to surveys and to exploitation. Queen conches normally occur at depths of between 10 and 30 m and are also reasonably easy to survey.

Field evaluation and sampling methodologies

As noted above, all three groups have been the subject of extensive field work, but this has not been a direct component of any of the CITES-supported work.

Numerical or graphical analysis

Giant clams and Queen conch have been the subject of considerable fisheries work, involving modelling and numerical analysis. These have been drawn on in the CITES reviews, although these have not involved any new work. As in almost all the cases reviewed here, it has been difficult to relate the results of such modelling to actual fisheries – in particular, there has apparently been little work done on the effects of different fisheries regimes, although there are observations (mostly anecdotal or based on limited survey data) on the recovery or lack of recovery of populations of all three groups following the cessation of fisheries, either because the fishery is no longer commercially viable or because of a change in fishery regime, for example through declaration of protected areas.

Other factors (precautionary measures and collateral impacts)

In all cases, determining the impact on marine invertebrates of collection for legally declared export has proved problematic. Domestic use of the resource is a compounding factor in some cases, although in a significant number of others (particularly small island States) it is clear that collection for export is by far the most driver for wild harvest. Illegal and unreported or under reported fisheries and exports are, however, clearly widely important, making it in many cases difficult to assess harvest rates accurately. In all cases, the major product in trade (meat, or rather dried body wall in the case of sea-cucumbers) may be difficult to identify to species level, hampering assessment of volumes of particular species in trade.

For giant clams, a compounding factor in the assessment of the impacts of trade on wild populations is the growth of mariculture and 'ranching' efforts for the group in a number of giant clam range States. In some cases, it is not clear whether species exported were even originally native to the country in question; in others it is not known whether harvest stock represents grow-outs from artificially seeded sites or may be from original populations. In either case, it is far from clear how non-detriment in the sense of Article IV may be established.

Plants

C. Geophytes and epiphytes

Introduction

Three species of orchid (*Dendrobium nobile* and *Christensonia vietnamica* from Asia and *Myrmecophila tibicinis* from Belize) and one snowdrop (*Galanthus woronowii* from the Caucasus) have been reviewed in the past few years under the Significant Trade process. In addition, Malagasy orchids have been considered under the Madagascar Significant Trade review. Of the four species subject to specific review, *Dendrobium nobile* is primarily in trade as a medicinal plant, but is also traded as an ornamental; the remainder are all ornamental plants.

Biological and environmental parameters

For the three orchids reviewed, the most significant finding is the general paucity of information on the biology of the species in the wild. There are virtually no data on growth rates, reproductive rates or dispersal ability, other than the general observation that the species are slow-growing. Habitat preferences are characterised in a relatively general way. The ranges of the three species are generally not well known. One (*Christensonia vietnamica*) was only ever known from one location, where it may now. One (*Dendrobium nobile*) is known to be widespread in the Himalayan region within a given altitudinal range, but the limits of distribution are not well characterised. The third (*Myremcophila tibicinis*) has a range that is known to country level, with relatively little more detailed information. In all cases, the difficulty of identifying the species in the wild when not in flower has made accurate determination of range difficult. This has been compounded in the case of *Myrmecophila*, where recent taxonomic revision of the genus has led to some confusion as to which species particular populations should be assigned to.

In the case of the snowdrop, the range of the species and its habitat preferences are reasonably well known, although as with the orchids, confusion with other snowdrop species occurring in the region has made accurate determination of range difficult. The rate of increase by offset production is also known, although seed production and growth rate of seedlings are less well characterised.

Field evaluation and sampling methodologies

Little field evaluation of the status of the orchid species is known to have been carried out. The exception is a study of *Myrmecophila* in Yucatán, Mexico, which provided some estimates of population densities of plants in terms of individuals per hectare. Other than this, observations on the status of the species in the wild have been essentially anecdotal and general in nature. No evaluations have been carried out to determine possible sustainable levels of offtake of particular populations or stands, nor have any data been located indicating rates of recovery (if any) after exploitation.

In the case of the snowdrop, some estimates of densities of harvestable bulbs (individuals per metre square) have been made in the plots that are harvested. However, details of the methodology employed are not entirely clear making it difficult to extrapolate from the sample plots to larger areas.

Numerical and graphical analysis
In the case of the orchids reviewed it may be possible to map likely extent of distribution using published records and herbarium specimens. It may also be possible to make a very crude estimate of possible maximum area of occupancy by overlaying up-to-date habitat maps where these are available and using these to measure, for example, extent of forest cover in the altitudinal ranges known to be occupied by the species concerned. However, in the absence of field surveys, it would be difficult to determine what proportion of this area were in fact occupied, and at what densities. The one species for which some density data are available (*Myrmecophila tibicina*) showed a range of from 1 plant to nearly 400 plants per hectare. Without further study to determine the reasons behind such variation, any extrapolation from these figures to provide population estimates for larger areas would produce estimates with such high variation as to be essentially meaningless. In the absence of any studies on natural productivity or regeneration rates it is also not possible to determine what percentage of a given population could be harvested without long-term detrimental impact.

In the case of the snow-drop, enough data are available to provide some indications of a likely sustainable harvest. The extent of the area harvested (comprising chiefly land cultivated for other crops) is known, as is the harvest regime (not very systematic rotation of areas harvested). There are approximate estimates of densities of harvestable bulbs and of rates of crop increase. Approximate figures for 2001 were: 90 ha of harvested land, very roughly 50 harvestable bulbs per square metre (equivalent to 500,000 per hectare) and three of four offsets produced by each parent bulb each year. These figures, if reliable, indicated that existing annual quotas of 15-18 million bulbs should be sustainable. This shows that in some cases very large numbers of individuals can be produced in a small area (90 ha is a tiny fraction of the range of *G. woronowii*), so that high export volumes are not *per se* necessarily indications of unsustainable harvests.

Assessing overall intensity of collection – domestic use and illegal export
Extent of domestic use and likely extent of illegal trade are highly variable in this group of plants. Amongst the orchids studied, one species (*Myrmecophila tibicins*) was reported to be subject to relatively intensive collection for the domestic market, believed likely to be more important than the international market. However, no quantitative data were available on extent of collection for this market. One species (*Christensonia vietnamica*) was not known to be used domestically at all, while the third (*Dendrobium nobile*) is believed to be used domestically to some extent, but with international trade thought to be much more important than domestic use. There is believed to be no significant domestic market for the snowdrop.

Assessing the extent of illegal or undeclared trade is always problematic. However, there were indications of extensive illegal trade in at least one species (*Dendrobium nobile*) making assessment of the impact of harvest even more difficult. In the case of the snowdrop there are indications of some irregularities in trade in *Galanthus* species originating in the Caucasus. If these are extensive, they should be taken into account in assessing possible detriment of harvest for export.

Collateral impacts
Very little information was available on harvest techniques for the orchid species looked at. It is likely that in the case of collection of epiphytes some harvest will be destructive, as trees bearing substantial numbers of orchids are likely to be felled to ease collection. In the case of the snowdrop, registered harvest is from cultivated land, so that impacts on natural habitats are minimal.

In both orchids and bulbs, it may be difficult or impossible without using specialised techniques to distinguish between different species when they are not in flower. It is very likely therefore that species are collected and possibly traded under the name of the species in question, either accidentally or deliberately.

Succulents and cycads

Introduction

All cycads (nearly 300 species in the families Cycadaceae, Stangeriaceae and Zamiaceae) have been subject to a study under the Review of Significant Trade. In addition, East African members of the genus *Aloe*, comprising ca 200 species, and two South African species of *Pachypodium* have recently been reviewed. The principal trade in cycads and in the pachypodiums is as ornamentals, while the aloe species in question are generally traded for medicinal purposes, although there is some very limited trade from the region in ornamental plants. Cycads are traded as whole plants and as seeds; the impact on wild populations of harvest is clearly very different in the two cases. The pachypodiums are traded as whole plants. The aloes are principally traded as extracts and derivatives, sometimes as leaves. Aloe harvest normally entails defoliation, allowing recovery of plants *in situ,* although sometimes whole plants may be dug up.

Biological and environmental parameters

The studies of cycads and East African aloes covered large numbers of species, and did not review each species in detail. The cycads in particular occur in a wide range of habitats and have variable life histories, although have a number of factors in common of importance when assessing impacts of harvest (slow growing, long lifespan and often long period to first fruiting, dioecious, seeds with no dormant period). For the pachypodiums, habitat requirements were relatively well characterised, though few life-history parameters (other than the very general observation of slow growth and long lifespan) were available.

Information on distribution for cycads and aloes was also highly variable. With the exception of a number of highly threatened species (most notably some Appendix-I listed *Encephalartos* species, in which in some cases all known wild individuals are mapped) distribution is only known in general terms and there are virtually no population data. In the case of the two pachypodiums distribution, based mainly on herbarium specimens, could be reasonably well characterised, but information on population was anecdotal at best.

Field evaluation and sampling methodologies

Field components were not a part of any of the studies.

Numerical or graphical analysis

Using very simple GIS analysis and the collecting locations of herbarium specimens it proved possible to derive estimates for area of occurrence of the two pachypodium species. In the case of the cycads, although no modelling or numerical analysis was carried out as part of the project, an modelling study of productivity and response to harvest of two *Encephalartos* species, based on ten years of field data (Raimondo and Donaldson, 2003), was quoted. This found that, as might be expected, wild populations were extremely sensitive to the removal of mature individuals, with sensitivity dependent on growth rates and longevity. Results from the modelling indicated that, by contrast even small populations were relatively resistant to seed harvest, particularly in species subject to mast seeding (intermittent production of very large amounts of seed).

Assessing overall intensity of collection – domestic use and illegal export

The cycad study noted that many countries had domestic markets for cycads. In some countries (e.g. Australia, China, Thailand, South Africa, Viet Nam), collection for domestic markets was believed to have a greater impact on wild populations than collection for international trade, although concrete data were lacking. The proportion of plants in trade in range States that is wild collected is currently unknown. While some illegal international trade is known to exist, this was believed mainly to concern Appendix-I species, and to be in small quantities. For these species, illegal collection for domestic markets, e.g. in South Africa, was thought to be of more importance.

For the aloes, species were reported to be widely used domestically, although the intensity of harvest for domestic use, and its impact on wild populations, remained unknown. Export from East Africa was mainly in the form of extracts and derivatives which it is not currently possible to identify to species level, so that it is impossible to relate volumes in trade to harvest levels of and impacts on particular species.

Collateral impacts
These are believed to be relatively unimportant in all cases.

Trees
Introduction
In recent years agarwood-bearing trees (some *Aquilaria* and *Gyrinops* spp.), *Guaiacum* or lignum vitae, Afromosia *Pericopsis elata,* African Stinkwood *Prunus africana,* Red Sanders *Pterocarpus santalina,* and Himalayan Yew *Taxus wallichiana* have been subject the subject of CITES-sponsored work, the last three of these (and *Aquilaria malaccensis*) under the Review of Significant Trade process. Of these *Guaiacum, Pericopsis elata* and *Pterocarpus* are significantly traded as timber; the remainder are principally in trade for extracts used in medicines or perfumery (*Pterocarpus* is also traded for these). In the case of agarwood, the product in trade is resinous deposits in the heartwood, probably produced as a result of wounding or infection and not found in every tree. In *Prunus africana* the product in trade is bark and extracts derived from bark; in *Taxus wallichiana* it is bark, leaves and extract. In both cases harvest is not necessarily destructive.

Biological and environmental parameters
Habitat requirements of the tree species studied are generally reasonably well characterised. Some information is normally available on basic biological parameters such as growth rates, age/size at maturity, longevity of seeds (degree of recalcitrance), conditions needed for germination and seedling growth. However, in these as in virtually all other tree species, rate of growth, age at maturity and fecundity may vary greatly with different environmental conditions and it is never clear to what extent figures quoted are generally applicable. Moreover, these figures sometimes seem to be based on general statements about tropical or subtropical tree species in general.

Knowledge of distribution is variable but is always incomplete. In the case of some agarwood species even country-level distribution is not known for certain. In the case of *Guaiacum,* modelling based on locations of herbarium specimens and various ecological overlays (e.g. altitude, rainfall, soil type, forest cover) was used to generate a likely distribution in Mexico. For *Taxus wallichiana*, taxonomic issues make it difficult to delimit the range.

Similarly, population data are of variable quality but always highly limited. In the case of *Prunus africana* reasonably recent inventories have been carried out in a few areas across the range. *Guaiacum* populations were the subject of field studies under CITES-supported projects (see below). For other species it has proven difficult to find any recent, reasonably extensive inventory data at all.

Field evaluation and sampling methodologies
Distribution
As noted above, distributional information for the tree species studied has been based directly or indirectly on published material or herbarium specimens.

Population

In only one case – *Guaiacum* – has there been field inventory work associated with CITES-supported projects. In this case, rapid assessments were made at eleven sites within the distribution of *Guaiacum sanctum* in Mexico. At each site 10 plots of 50 x 2 m were sampled, with all individuals of *G. sanctum* with trunk diameter at breast height (dbh) ≥ 1 cm were counted, and placed into various size classes. Measures of various other ecological parameters and of human disturbance were made at each site. Using the results from this and the distributional modelling, the range of the species in Mexico was divided into three classes depending on whether *G. sanctum* populations might be expected to occur at low, medium or high abundance. In addition, a study of demography and population dynamics was made on two one-hectare permanent study plots, one disturbed and one undisturbed. Survival, growth and fecundity rates were measured at each over a period of one year.

Numerical or graphical analysis

For *Guaiacum sanctum* a matrix model was developed using demographic data gathered in the field surveys. The model was used to explore the possible outcomes of various harvesting scenarios. The modelling indicated that it should be possible to establish a harvest regime that would not deplete the population in the long term (a cut of ≤ 50% of trees with dbh ≥ 35 cm once every 10 years), provided that recruitment was guaranteed. However, long-term population trends were very sensitive to mortality rates of smaller trees: any annual rate higher than around 4% would lead to long-term population decline.

In the case of *Prunus africana,* although no additional analysis was carried out under the review, the latter could draw on existing work, based on similar models to those for *Guaiacum*, enabling theoretical conditions for a sustainable (non-detrimental) harvest to be derived. As with many other long-lived trees the model indicated that survival of the species in any area depended on the maintenance there of a viable population of large trees. A harvested population could be maintained if: it was first returned to pre-harvest conditions, with positive population growth; if bark harvest were confined to medium-sized trees only; if the interval between harvests from any tree were greater than 10-15 years. The report concluded that for various reasons such a regime was under current socio-economic circumstances highly unlikely in any range State for the species.

For agarwood, as part of the study, the IUCN *Checklist to assist in making non-detriment findings for Appendix II* (Rosser and Haywood, 2002) was tested for its applicability to agarwood. Radial plots of responses to questions in the checklist were prepared for agarwood production and export in Indonesia and Peninsula Malaysia. Overall, the study concluded that, while a useful starting point, the generic IUCN checklist had limitations in terms of its applicability to certain tree species and countries, noting that the case of agarwood was very different from other CITES-listed tree species harvested for their timber.

Assessing overall intensity of collection – domestic use and illegal export

Domestic use

All the tree species examined were to some extent harvested for domestic use. However, with the possible exception of *Pterocarpus santalinus* export was in all cases evidently the major driver for directed harvest, so that export figures could be used to derive an indication of harvest pressure on the species concerned.

In several cases (agarwood, *Pericopsis elata, Pterocarpus santalina, Taxus wallichiana*) illegal or unreported trade was clearly at a relatively high level. In almost all cases (except *Prunus africana*) taxonomic or identification problems, or both, made it very difficult to be certain of the identity of products in trade.

All species were subject to deforestation, identified in some cases (e.g. *Guaiacum*) as the principal reason for decline. Some kinds of deforestation (e.g. for slash-and-burn cultivation) may be viewed as undirected use, although this is difficult to quantify.

Collateral impacts
Impacts of logging on the wider ecosystem in natural or semi-natural forests have been widely investigated, but were not the specific subject of study in any of the cases reported here. With the exception of *Pericopsis elata,* the collateral impacts of harvest in these cases are likely to be relatively small, as in some cases (*Taxus* and *Prunus africana*) harvest does not generally involve felling, while in those that it does, size and population density of the target trees is small enough that major impacts are unlikely.

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