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

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Species trade and conservation

Snake trade and conservation management (Serpentes.spp.)

DEVELOPING CITES NON-DETRIMENT FINDINGS FOR SNAKES: ANNEXES

The attached information document has been submitted by the Secretariat at the request of the International Union for Conservation of Nature (IUCN) in relation to agenda item 14.1.*

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Developing CITES Non-Detriment Findings for Snakes: Annexes

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Section I - Definitions and concepts

Section I provides further information and discussion about several aspects related to non-detriment, sustainability and harvest theory. This section is aimed at those seeking to understand some of the first principles of harvesting, and how this might be applied to developing the basic capacity to make Non-Detriment Findings. To begin, we provide a number of key points and discuss them in detail below:

1) In the majority of circumstances, ***animal populations can withstand some level of harvest***

2) Harvesting can result in large declines in species abundance, yet harvest can still be ***sustainable*** and well above the level at which it is deemed ***detrimental***.

3) ***Commercial extinction*** can result in a species becoming commercially unsustainable to harvest, even if the harvest is biologically sustainable and extremely safe from ***biological extinction***.

4) Thus, the main issue concerning CITES is when neither declines in abundance nor harvest levels can be controlled or managed and are in free-fall.

➢ Harvest theory

In its simplest form, sustainability is the ability to endure or keep something going (Erdelen, 1998; Webb, 2002). The text of the Convention of CITES does not mention the word sustainability, but merely that trade should not detrimentally impact the species being traded.

Theoretically, a non-harvested population, at carrying capacity, can be expected to have an abundance that fluctuates from year to year (due to various environmental and other factors), but is stable over time. The factors increasing the population (reproduction, immigration) are balanced against the factors decreasing the population (emigration, mortality), so there is zero population growth (**Fig. 1**).

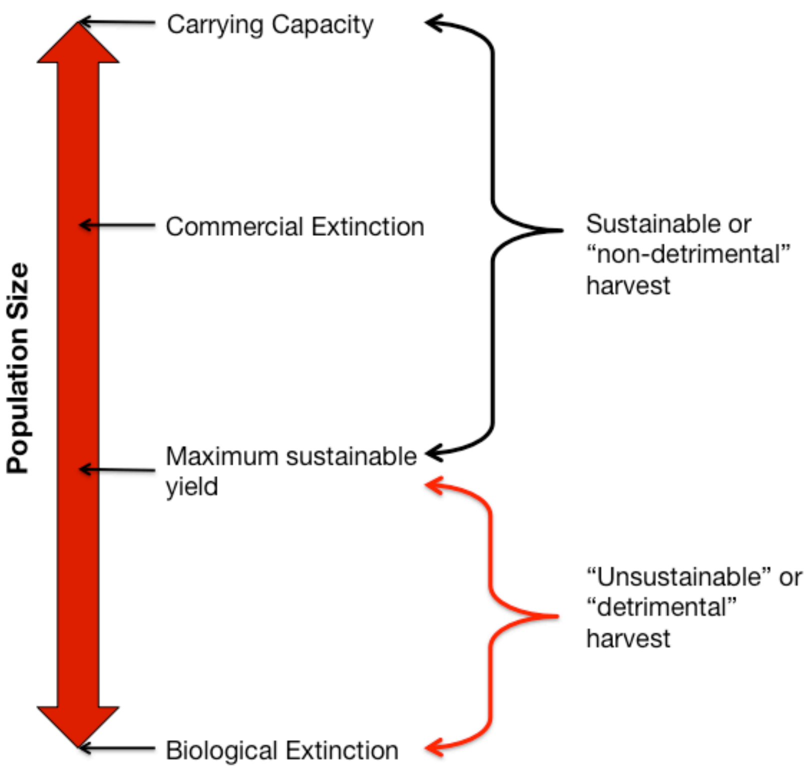

Figure 1. Hypothetical visual representation of how several concepts of sustainable use and detriment interact, and their application to a population of snakes.

When populations are harvested, abundance declines, but population growth is stimulated. This is because the resources available to a population are density-dependent - the remaining individuals within the population normally have access to relatively greater resources, and the factors favouring population growth increase relative to those favouring population decline (Caughley and Sinclair, 1994).

In every population there is an optimum level of population reduction, to a new and reduced level of abundance, in which population growth is maximised. If this level of abundance is sustained over time, by management, the annual growth component can stay maximised and be harvested - theoretically forever. This is sustainable use producing the *maximum sustainable yield*. If the level of population reduction does not reach the optimum level but the new level of abundance is sustained, then this remains *sustainable use* but not generating *maximum sustainable yield*. (**Fig. 1**).

Often the most important variable for wildlife populations is not the absolute volume of a harvest itself, but instead the rate of harvest. However, knowing that the rate of harvest comprises a high proportion of the population may not make that harvest unsustainable. For example, in managed animal populations, the total annual harvest can exceed the size of the standing population supporting the harvest (**Table 1**). Domestic animals provide a valuable example of highly productive animal populations. **Table 1** shows that harvest rates vary considerably depending on the life histories of the species concerned. Of significance is that the populations of pigs and chickens are well below the annual harvest rate for those same species, owing to their low mortality, high fecundity and rapid growth rates (Webb et al. 2003).

Table 1. Population sizes and sustainable harvest rates for Australian agricultural animals (Source: Australian Bureau of Statistics 2014)

Species	Population size	Harvest	Sustainable harvest rate
Cattle	26.4 million	9.7 million	36.70%
Sheep	75.5 million	33.4 million	44.20%
Pigs	2.0 million	4.7 million	235.10%
Chickens	84.0 million	572.1 million	681.10%

The main issue concerning CITES is when the rate of harvest exceeds the factors promoting population growth, and neither the resulting decline in abundance nor the harvest level can be controlled or managed. This is unsustainable use or overexploitation (**Fig. 1**), and may result when (from Caughley, 1992):

- the number of individuals harvested each year exceeds the maximum sustain yield of the species; or
- the percentage harvested each year exceeds the intrinsic rate of increase of the species; or
- harvesting reduces the species to a level at which it is vulnerable to other influences upon its survival.

It is in these situations that the risks of extinction escalate and ongoing harvest for trade is considered “detrimental” to the survival of the species.

For a useful and more detailed discussion of these concepts and harvest theory for CITES listed species see the following document from the Cancun CITES Non-detriment findings Workshop:

➢ Commercial vs biological extinction

CITES deals with the risk of biological extinction (a conservation problem). By contrast, commercial sustainability refers to decreasing productivity of a harvest, perhaps reaching commercial extinction – harvest of that species is no longer commercially viable (an economics problem)(Magnusson, 2002).

Just like in the case of fisheries, snake populations can be harvested “unsustainably”, leading to their commercial extinction, yet their wild population can still number in the millions (this typically occurs when the cost of locating and capturing individuals is greater than their sale price). Commercial extinction can therefore occur when a species’ population is healthy and stable, and at no risk of biological extinction (**Fig. 1**). This can create dangers when interpreting trade data to make inferences about the status of wild populations. For example, volumes of trade in a snake species may suddenly decline, suggesting that biological sustainability may be compromised. While in some cases this may be true, it may be equally plausible that the decline is a result of other variables, for example, employment in other sectors that are more economically lucrative than the snake trade. People may then stop harvesting snakes in search of better income earning opportunities, resulting in fewer individuals entering trade. This can give the false impression that population declines have occurred, when in reality the trade volumes rise again once snake harvesting becomes more profitable – either through increased export prices or falls in prices of goods in other sectors. Commercial extinction is thus not a static force. It can come and go, with little correlation with what is happening with populations of wild snakes.

Section II – The Management Context for Snakes

➢ Snakes are difficult to study

The population status of many species of animals can often be easily evaluated. Snakes do not offer such possibilities, largely due to their secretive, cryptic and sedentary nature, resulting in very low detection probability. Many snakes are difficult to capture in traps, cannot be detected by remote infrared cameras, nor identified by tracks. Snakes are thus notoriously difficult to census, which constrains our ability to monitor and evaluate their population trends – even when significant resources are dedicated to the task. The lack of a standardized methodology for monitoring remains a major limitation for the management of snake populations (Seigel & Mullin, 2009). In most countries there is a lack of experience in dealing with the innovative approach needed to manage snake harvesting. Parties are often confronted with strong demands, requesting profound academic knowledge on the population of the species being utilized. However, the expectation that Parties using snakes for domestic and export purposes should have perfect knowledge about the status of wild populations supporting those uses is unrealistic and scientifically out of reach in most contexts.

➢ Limited background information

As a result of the above-mentioned constraints, there is a lack of literature on snake demography for most traded species. This information gap prevents the use of modern analytical tools (such as Population Viability Analysis, etc) that have been widely used for assessing harvests in other vertebrate taxa (Dorcas & Willson, 2009). In general, snakes exhibit great intraspecific variation in many of their demographic and biological parameters, both at spatial and temporal scales. This means that basic biological parameters obtained for a specific place or time usually will be not be useful or applicable for making inferences in a different situation at a different time. Added to this, some snake species appear to become more productive in parts of their range where natural habitats are converted for agricultural purposes, whereas others may not. As Fitzgerald (2012) states: replicating estimates throughout the range of a commercially exploited species is simply not feasible.

➢ Resistance to snake research

Some CITES-listed snake species (e.g., cobras) are highly venomous, as are many traded snake species that are not listed on CITES. As a group, snakes are responsible annually for a higher number of human fatalities than all other wildlife species combined. There is thus an age-old conflict between humans and snakes, which lead to many that are encountered opportunistically being killed as pests, regardless of legal status. This also limits public interest and participation in snake research and conservation, which is reflected in a paucity of information available for most species. From a management perspective, hunters collecting wild snakes, and investigators working to understand their population biology, often have to contend with real risks. Added to this is a preference for the study of taxa deemed to be more charismatic than snakes, or those that receive greater funding, despite high levels of trade in many species of snakes. The negative values generally attributed to snakes have resulted in limited studies being conducted and for this reason there is little biological information available for many species.

➢ Attributes that assist sustainable trade

Despite snakes being difficult to study because of the attributes discussed above, these same attributes also confer a level of sustainability to harvesting for trade. The sedentary and cryptic nature of snakes, that makes surveying their populations so difficult, also makes them difficult to find for hunters. This difficulty allows many individuals within populations to remain undetected, and allows them to thrive even within urban environments. These characteristics are partly responsible for the very high, yet seemingly sustainable, volumes of harvest experienced by many snakes around the world.

➢ Improving knowledge

To improve basic knowledge about snakes in trade, managers are urged to learn as much as possible about snakes by examining individuals collected for trade. Gathering data from hunters, slaughterhouses or holding facilities can provide important biological and ecological information on species, such as: harvest rates, habitat preferences, breeding seasons, body sizes, sexual dimorphism, sex ratios, food habits, sizes at maturity and first reproduction as well as many other important attributes that could not easily be determined using traditional research survey approaches (e.g., Shine et. al. 1999; Waller et al. 2007; Natusch and Lyons 2012). In many cases this is a far more simple and cost-effective means of data collection than undertaking targeted field studies and can be carried out simultaneously with harvest management. Parties are urged to consider using this method to begin improving knowledge about the basic biology of snakes entering trade (see **Section III** for further details).

Section III – Non-Detriment Findings for snakes

➢ Primary Evaluation

The purpose of a *Primary Evaluation* is to establish whether non-detriment can be determined easily using basic information. It is not a "pass or fail" Non-Detriment Finding. Scientific Authorities may not be able to grant a positive NDF using the *Primary Evaluation* alone, but that does not automatically mean that harvesting and trade is therefore detrimental. It simply means that more information is required to determine detriment. The utility of the *Primary Evaluation* is that many species can essentially be "ruled out" of requiring complex NDF evaluations, allowing Parties to focus energy and resources on species that are in genuine need of more sophisticated assessment. For example the white-lipped python (*Leiopython albertisii*) occurs throughout the island of New Guinea, in diverse habitats, both natural and degraded, and has an annually harvest of only 400 individuals from less than 5% of the species' range. The species has clearly not been extirpated from the areas in which it is harvested, has life-history traits that allow it to recover from harvesting and a total wild population that is likely to comprise millions of individuals. There is no reasonable probability that such a scenario could cause species extinction and thus a complex and detailed NDF would not required before exports take place.

Table 1. Scoring criteria for the three variables of interest in the *Primary Evaluation*.

	Number of points			Score
Criteria	**1**	**2**	**3**	
Annual Harvest level	Low (<2,000)	Medium (2,000 - 20,000)	High (>20,000)	
Area of occupancy	Large (>20,000km^2)	Medium (2,500 – 20,000km^2)	Small (<2,500km^2)	
Life-history	Fast	Medium	Slow	
Illegal trade	If known, should be included under "Annual harvest level". If unknown, and suspected to be detrimental, give a **maximum score of 1 point**			

One of the key issues for the *Primary Evaluation* is determining the likely percentage of the population that is being harvested. This can be broadly evaluated by examining the level of harvest together with a proxy for the proportion of the population being harvested – in this case, the species' area of occupancy. In addition to this, it is useful to examine a proxy for the species' ability to recover from harvesting (in this case, life history traits). Finally, should high levels of illegal harvest be potentially impacting wild populations then this is also taken into account. In combination, these criteria can be used to make a judgement about the likelihood of a harvest posing a risk for species survival.

The *Primary Evaluation* assessment subscribes to a precautionary approach, in that any species that scores a three (3) in any category listed in **Table 2** will automatically qualify for a *Secondary Evaluation*. Regardless of the score assigned, for each criterion of interest a justification must be provided for why a particular score was given. If a species scores below five overall for the *Primary Evaluation*, then it is highly unlikely to be threatened by trade, and does not require a *Secondary Evaluation* to be completed. For many species an NDF can be made at this stage. Conducting a very basic NDF, using only small amounts of information, is completely acceptable and is agreed upon by the Conference of the Parties to CITES in Resolution Conf. 16.7, which states that:

"the data requirements for a determination that trade is not detrimental to the survival of the species should be proportionate to the vulnerability of the species concerned."

A *Primary Evaluation* should be updated regularly to keep abreast of potential criterion changes (such as reductions in area of occupancy due to habitat loss). Species that do not require a *Secondary Evaluation* in the first year may require one in the next. Explanation of how to determine a species' harvest levels, area of occupancy and life history traits, together with blank templates and completed example evaluations are provided below:

Harvest level

The level of harvest experienced by a population of any animal is the most important variable to consider when considering risk of detriment in a *Primary Evaluation*. If harvest levels are very low, then it may not matter that it has a small area of occupancy or a slow life history. For example, for the vast majority of snakes (with the possible exception of some insular sub-populations), a harvest of a few hundred individuals each year is not going to threaten the survival of the species in the wild. However, when determining harvest levels, Scientific Authorities also should attempt to estimate levels of illegal harvest (CITES Resolution Conf. 16.7). This can be achieved using a qualitative approach – firstly by attempting to determine whether illegal trade exists and, secondly, by estimating the suspected magnitude of illegal trade in general terms (e.g., low, medium, high).

Area of occupancy

Area of occupancy is defined as the area within a species 'extent of occurrence', excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur uniformly throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. This criterion is important because when a species has a small area of occupancy (e.g., montane or island endemics) it can be easier to access and harvest individuals from the entire population. Furthermore, because abundance is often density dependent, a smaller area of occupancy will mean a smaller the absolute population size. Conversely, species inhabiting a large area often have larger population sizes and the probability that all populations within the range are subject to, and will be impact by, harvest is lower. A species' area of occupancy is different to a species' distribution. In some cases, the area of occupancy can be almost identical to the distribution or extent of occurrence, but in others it is not. For example, the Boa Constrictor (*Boa constrictor*) has a large distribution in South and Central America, but almost an equally large area of occupancy as a result of its ability to thrive in human modified-environments. Conversely, the Emerald Tree Boa (*Corallus caninus*) has a large distribution within South America, but a smaller area of occupancy owing to its reliance on rainforest habitat and an inability to thrive in human-modified environments. An example of how area of occupancy can be estimated is provided in the inset box below. To estimate area of occupancy it is important to base calculations on current information, for example, including habitat that was converted or transformed and has become unsuitable for the species.

Example area of occupancy

Here we will examine the area of occupancy for *Leiopython albertisii* in Indonesia, a species of python inhabiting the island of New Guinea. Small numbers are harvested from Indonesian New Guinea each year to supply the pet trade.

- *L. albertisii* is found in Indonesia, which has a land area of 1,904,569 km^2 (Fig. A)
- However, *L. albertisii* is known to occur only in the Indonesian provinces of Papua and West Papua. The area of these provinces is 416,129 km^2
- Furthermore, *L. albertisii* only occur in rainforest habitats, which do not occur in the highlands, or in the south of Papua.
- Based on this information, the area of occupancy for *L. albertisii* in Indonesia is estimated to be **176,750 km^2** - the extent of lowland tropical rainforest in Papua and West Papua (Fig. B).

Fig. A. The area of Indonesia

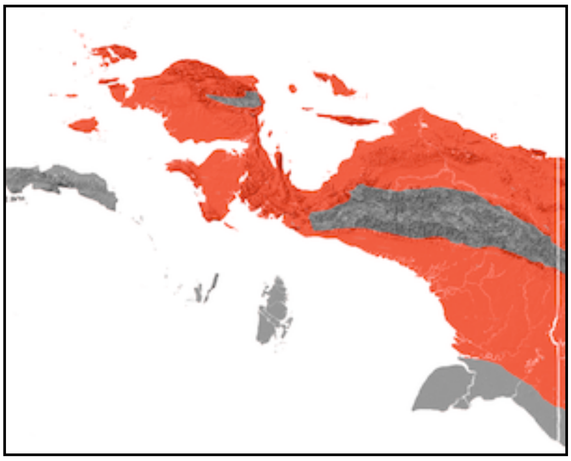

Fig. B. *L. albertisii* occurs in the lowland rainforest areas of Papua (red), but not in woodlands or the highlands (grey).

Life History

Life history concerns the traits a species possesses that affect its survival and reproductive potential, such as time and age at maturity, reproductive frequency and fecundity, and lifespan. In a broad sense, these traits play a significant role in determining a species' resilience to use. Although recovery from harvesting is influenced by more than just a species' life history (e.g., density-dependence), in general a species that takes a long time to reach maturity, breeds infrequently and produces only a small number of offspring, will take a long time to recover. Conversely, a species that grows and matures rapidly and has many offspring every year is likely to recover more quickly. In most cases a species' life history traits can be determined by consulting existing literature. Sometimes, however, no information is available to make a determination. In these instances Scientific Authorities can estimate such traits based on studies of related species, which are likely to exhibit similar characteristic to the species of interest. Nevertheless, Scientific Authorities should endeavor to increase their knowledge of a species' biology by studying snakes as they are collected for trade.

Illegal trade

CITES Non-Detriment Findings should take into account all offtake that is occurring for international trade. This criterion can be used as part of the *Primary Evaluation* to take into account suspected or estimated levels of illegal trade. If levels of illegal trade are known, or can be estimated approximately, then Scientific Authorities should include illegal trade levels under the **Harvest Level** criterion of the *Primary Evaluation*. If volumes of illegal trade are unknown, but are suspected to be detrimental, then a "**1**" score can be given. If illegal trade is suspected, but the likelihood that illegal trade is detrimental to the survival of the species is low, then the criterion should be left blank, or given a "**0**" score.

➢ Secondary Evaluation

What is a Secondary Evaluation trying to achieve?

The *Secondary Evaluation* as part of these NDF Guidelines aims to build up an understanding of how populations are changing over time and whether harvesting for trade may be negatively impacting those populations. For many Parties, sufficient information may already be available to establish non-detriment (from existing monitoring programs). However, for those Parties for which such information is not available, it may not be possible to complete the *Secondary Evaluation*. In this instance, the implementation of monitoring systems may be required to elucidate trends that indicate whether population declines are occurring. This Section provides guidance on how Parties can implement monitoring programs to adequately complete the *Secondary Evaluation* and establish non-detrimental harvest of snakes for trade.

Key Principles for successful monitoring programs

Ongoing monitoring – to predict the future we must look to the past

Long-term monitoring is the best way to reveal real and potentially detrimental trends in snake populations, largely because of the annual variability and unpredictability of abundance in response to environmental stochasticity. Although short term, single year studies can yield important information on population features (e.g., number of snakes, their sizes and sexes), their limited duration provides only a temporal snapshot, and cannot be used to determine population trends that can reveal population status or health. Because of this, resolving whether an observed population trend is normal for a species or the result of potentially detrimental declines due to harvesting, in many cases, may be impossible without long-term monitoring. This may in turn complicate management strategies and result in scarce resources being used to solve problems unrelated to harvesting. Establishing baseline knowledge of what a dynamic natural population looks like can help us recognize when unnatural and potentially detrimental changes may have occurred and allow us to apply suitable management interventions to ensure trade is sustainable in the future.

Consistency

Consistency can be the most important part of any ongoing species-monitoring program. When monitoring is carried out, managers must ensure the same sites are visited at the same times of year. The same variables of interest must also be measured, and effort must be made to ensure the same techniques and investigators (if possible) are also used. These should all remain consistent in order to properly tease apart what are real (environmental or anthropogenic) effects on the population and what are observer of methodological biases. For example, visiting a wildlife trader and counting snakes at a different time of year than the year before may erroneously suggest that populations are decreasing if fewer individuals are counted. Similarly, measuring snakes from the snout to the tail, when in previous years snakes were measured from the snout to the anus, may falsely indicate that the population's mean body size is increasing when it may not be. Such biases will reduce the power and effectiveness of monitoring schemes and may result in managers overlooking harvest effects and failing to implement proper management protocols.

Case by case application

All snake species are unique, and the characteristics that define one species may be different to those that define another. In addition, the trade dynamics and market forces that act upon different snake supply chains vary among species as well as between countries and over time. This inevitably results in no two non-detriments findings being the same (for different species or at different times), which requires evaluation of trade impacts to be determined on a case-by-case basis. When carrying out a *Secondary Evaluation* and implementing a monitoring program, Scientific Authorities must account for these differences and design systems that are most suited to the species and trade situation in question.

➢ Harvest monitoring

Harvest monitoring is often the simplest yet most important means of monitoring the sustainability of a harvest of snakes. Many Parties already adequately monitor their harvest of Appendix II listed snakes and the CITES Secretariat also contributes to trade monitoring by maintaining the UNEP-WCMC CITES Trade Database. This Section is aimed at providing Parties that do not presently monitor harvests of their traded species with a framework to do so.

Where is a harvest monitored?

Harvest monitoring can take place at any part of the trade chain. Some Parties may choose to monitor harvests at a single point in the chain such as the harvester, while others may choose to monitor at multiple points. Each situation involving different species will be unique and will depend on the type of trade being conducted (e.g., trade in skins or live snakes), the logistical feasibility of monitoring and the level of resolution that the Party wishes to monitor.

There are three main points at which harvest can be monitored. These are:

- Hunters and collectors (the first people in the trade chain that are capturing the snakes)
- Traders (this can include middlemen, agents, pet holding facilities, slaughterhouses, stockpilers, tanneries and exporters)
- National and International Trade Databases (e.g., the UNEP-WCMC CITES Trade Database, which provides data on exports of every CITES Appendix II listed species made by the Parties, based on data provided in the Annual Reports submitted by Parties on their exports and imports).

Often these levels of monitoring overlap. For example, many slaughterhouse operators are also exporters. Regardless of which level within the trade chain focus is placed, by regularly collecting information from actors at one or more of these points, managers are conducting harvest monitoring. If in a particular year a harvest begins to decline, this can be recognized because of resulting changes in the data collected in that year compared to previous years.

What level of trade should be monitored and how?

Determining where in the trade chain to monitor depends largely on the type of information to be gathered and the type of trade that is taking place. For example, for trade in pet snakes, the most logical points to monitor may be at the exporter level (to understand how many individuals are collected and obtain large samples on the body sizes and sexes of harvested snakes). On the other hand, for trade in snake skins it may be more logical to monitor at the slaughterhouse level than the tannery or exporter level because this can yield information on numbers traded, sizes, sexes and reproductive condition of snakes, before their skins are removed and this valuable information is lost. For those countries where there are no slaughterhouses because snakes are skinned by the hunters in the field, monitoring a sample of hunters would be preferable so that important demographic information can be gathered from snakes as they are killed. For larger samples and for making management decisions, analyzing information from skins at the first point of stockpiling may be the most useful option. Determining at what point to monitor may also be linked to the type and geographic scale of management system that is in place (**see Section IV**). **Table 3** summarizes information on the types of data that can be gathered and the limitations of monitoring harvests at different points of the trade chain.

Table 3. The types of data that can be gathered at different levels within the trade chain and the data limitations of each (modified from Fitzgerald, in McDiarmid et al. 2012).

Level of trade	Data to be gathered	Limitations
Hunters and collectors	• Numbers of individuals captured per unit effort. • Demography of the harvested individuals (sex, size and perhaps reproductive condition of snakes). • Information on hunting patterns. • Understanding of collection methods. • Collection date and geographic origin.	• Logistical difficulty in surveying many hunters regularly. • Small sample sizes. • Information often only anecdotal in nature. • Logistical difficulty to sample large harvesting areas.
Traders and exporters	• Large samples of snake body sizes (or skin sizes), sexes and reproductive condition that are representative over large areas. • Trends in individuals purchased per year and in different seasons. • Can often provide information on levels of illegal trade.	• Precise origins difficult to determine unless trade is traced. • Little information on hunter effort. • Lack of biologically meaningful information (sex, body size, reproductive condition) when dealing with skins only.
National and International trade databases	• National and global trends in import and export volumes and trade routes can be understood and compared.	• Often no information on domestic trade. • Need to be interpreted with caution due to many external forces (e.g., market forces) that influence trade.

What information is important and how is it interpreted?

Harvest monitoring aims to understand changes over time, and does so by examining trends in the medium term (3-5 years) to the long term (>5 years). When a database of knowledge about a harvested population has been consistently and rigorously gathered, ongoing monitoring can reveal changes to that population, which may be a direct result of harvesting pressure (e.g., see Lyons and Natusch, 2011, for an example of demographic changes over two years). Thus any wildlife monitoring program, regardless of which point in the trade is being monitored, is interested in *change*.

Specific types of change relevant to monitoring are discussed in detail as follows:

Changes in numbers of snakes harvested

Increases or decreases in harvest levels can be useful indicators that something in the wild population is changing. Data on the numbers of snakes harvested can be collected at the hunter level, middlemen, trader, slaughterhouse or exporter level, and at the export level. If sample sizes at the lower levels of the trade chain (e.g., hunter, slaughterhouse) are appropriate for analysis, then we should expect to see a correlation between the number of snakes collected by hunters and the number of snakes sold by exporters.

Unfortunately, however, data on the number of snakes collected (equivalent to “yield” in fisheries) does not provide a conclusive answer to the sustainability of trade. Other factors unrelated to the health of snake populations can result in changes in harvest levels, so overall trends need to be interpreted with accompanying data from other monitoring procedures and associated factors (see discussion below for examples).

Changes in hunting effort

The most common scenario for snake harvest systems is that many opportunistic hunters contribute few animals to trade, while a few expert hunters contribute many animals. Because of this, focusing monitoring effort on those expert hunters can be extremely useful. Not only can expert hunters provide important qualitative information about harvesting sites and trends, but they also allow managers to determine the effort needed to a capture a given number of snakes. Hunter effort may also be gained indirectly but efficiently from actors in other areas of the trade chain. For example, many hunters only sell snakes, or their parts and derivatives, to specific traders, pet collectors or slaughterhouses. Requiring these operations to record each hunter and the volume of snakes or their parts collected by them over known periods will provide managers will valuable information. This is called the catch per unit of effort (CPUE) and is a quantitative means of understanding the relationship between hunter effort and harvest numbers. For example, if hunter effort increases (e.g., the numbers of hunters increase or the same hunters spend more time or effort hunting) but the number of snakes harvested remains the same, then this may suggest that the population is in decline. Similarly, if hunter effort increases and the numbers of snakes harvested declines then it is possible that the population is rapidly being overexploited. Conversely, if hunter effort is decreasing but the number of snakes harvested remains the same, it may be that the population is increasing. When combined with data from other sources about trends in trade (such as total number of snakes harvested and population demography) robust conclusions can be drawn about whether such changes in the wild population are being caused by harvesting pressure.

Changes in the harvest demographic

Several studies on snakes have shown that prolonged harvesting can affect a species' population structure, which may make it more vulnerable to overexploitation (Lyons and Natusch, 2011). For example, a decrease in the average body size of snakes collected may mean fewer females are reproducing before they are harvested or that large highly fecund females are being disproportionately harvested. Both scenarios may result in a reduction in population growth. Monitoring the sex of harvested individuals is also important. For example:

- some sexes can be easier to capture than others (perhaps male snakes hunt in shallow water whereas females hunt in deep water);
- one sex may be more sought after (males display bright colours desired by the pet trade whereas females do not);
- the capture could inadvertently favor one sex over another (e.g., sexual dimorphism in body size may result in pet collectors targeting small females, whereas the larger males are not as sought after);
- or minimum capture size policies applied to highly dimorphic snakes (like boas, pythons or cobras) may favor the hunting of one sex over another.

In most cases, the best place to monitor the harvest demographic is at the trader, middlemen, slaughterhouse or pet collector level. Visits to these facilities allow investigators to cost effectively gather large amounts of demographic data that are representative of the entire harvest. Body size and sex can be determined either in live or dead animals. When live or dead animals are not available, as is the case when snakes are skinned in the field, consistent measuring of skins at the trader, middlemen, or tannery level, year after year, also provides useful information on trends in population structure.

Importance of collecting associated information

It is important that Scientific Authorities and wildlife managers consider how factors independent of harvesting pressure, such as market demand, currency exchange rates, environmental factors and changes in local economies, can influence the number of snakes harvested, hunter effort and population demography. For example, it may be tempting to interpret changes in harvest numbers, demography or hunter effort as evidence of overexploitation when in reality that is not the case. It is therefore important to incorporate secondary information in any analysis of harvest monitoring data.

Examples of when factors independent of harvest affect snake population estimates may include:

- A new hunting technique may be implemented that reduces hunter effort while increasing numbers of snakes harvested.
- Consumers may switch demands for pets from large adults to small juveniles, resulting in a shift in the harvest size demographic.
- End users may begin to request snake skins above a certain length, resulting in a change in harvest demographic in the exporting country.
- Many snakes are commonly encountered only in the wet season. Monitoring the population or harvest in the dry season may suggest that declines have occurred, when that may not be the case.
- Increased employment opportunities in other industries, or a rise in social or unemployment subsidies, may result in fewer people capturing snakes. The consequence is that fewer snakes will be harvested, which could be erroneously attributed to population declines.
- Recruitment of a new generation of hunters without experience in detecting snakes may result in differences in capture vs. effort data erroneously suggesting the snake population is decreasing.
- Sudden changes in price structure (like a change in the pricing policy for different snake lengths) may introduce distortions over the size structure of the harvested snakes.
- Environmental changes (exceptional droughts or floods) in a given year may affect the ability of hunters to reach snakes or even produce temporary reductions in snake populations that may be erroneously interpreted as a population decline due to harvest.
- Changes in fashion may reduce or increase the demand from the fashion or manufacture industry.

Examples

Examples of harvest monitoring programs for hypothetical populations of snakes are provided in **Tables 4, 5 and 6**.

Table 4. A hypothetical scenario and harvest monitoring system for the trade in snake skins.

Trade type	Scenario	Monitoring system	Hypothetical Result	Interpretation and course of action
Skin trade	A species of snake is harvested for skins in Country A to make traditional drums in Country B. The skins used for the drums need to be large, so no individuals smaller than one metre are collected. There are five slaughterhouses in the country that skin equal numbers of snakes each year.	• Fifteen professional hunters are visited once per year and their capture rates recorded. • Two of the snake slaughterhouses are visited once per year and data are gathered on the number of snakes killed, their body sizes and sexes. • Export volumes are recorded and published in the UNEP-WCMC CITES Trade Database.	Annual visits to the hunters show that the number of snakes being collected by each hunter is decreasing each year. Two hunters have stopped working and the others claim that the snake population is decreasing. Average body size of snakes brought to the slaughterhouses has decreased from 2.1 metres to 1.8 metres. The number of males and females collected has remained the same, but the total number of snakes brought to the slaughterhouse has been slowly decreasing, despite market prices for skins being high. Export volumes have been steadily decreasing despite market prices for skins being high.	All of the information gathered through the monitoring system suggests that the wild snake population is declining. Visits to hunters and slaughterhouses have revealed no other information that might explain these declines. The course of action is to modify the management system to improve the sustainability of the harvest. A negative NDF and voluntary restrictions on exports may be warranted (**Step 3 of the NDF Guidelines**).

Table 5. A hypothetical scenario and harvest monitoring system for the trade in snakes for pets

Trade type	Scenario	Monitoring system	Hypothetical Result	Interpretation and course of action
Pet trade	A species of snake is highly sought after for the pet trade. Individuals of all sizes can be harvested and exported.	• Visits are made to five snake hunters once every two years to examine harvest rates and gather other information about the harvest. • Visits are made to six out of ten exporters to examine body sizes and sexes and the number of snakes harvested. • Exports are recorded on the CITES Trade Database.	Visits to hunters every two years reveals that each hunter collected approximately the same number of snakes each year, but anecdotal information provided by the hunters suggests that their competitors have gone out of business, despite snakes still being easy to find. Visits to exporters reveal that the number of snakes exported has declined each year, which is supported by trade volumes in the CITES Trade Database. Body sizes and sexes of the harvested snakes have remained the same each year. Secondary information suggests that this is because importing countries are now breeding many snakes themselves and are not relying on exports of wild specimens from other countries. In addition, two more exporters have started trading that species, further lowering the demand for snakes from the exporters being monitored.	Although the declines in exports reported by the exporters may suggest a decline in wild populations of this species, the secondary information on demand, the relative ease of collecting wild snakes and the consistency in the harvest demographic suggest that the decline is due to market forces rather than unsustainable harvesting. No changes to the management system are needed.

Table 6. A hypothetical scenario and harvest monitoring system for the trade in snakes for meat.

Trade type	Scenario	Monitoring system	Hypothetical Result	Interpretation and course of action
Meat trade	A species of snake is collected, killed and butchered for the meat trade. Harvesting takes place in two provinces in Country A and there are three processing facilities in each province. The snake species exhibits female biased sexual dimorphism (females grow much larger than males). Snakes of all sizes are harvested, but large individuals are more valuable because they yield more meat.	• Once per year visits are made to four snake hunters in Province A and four snake hunters in Province B to examine harvest rates and gather other information about the harvest. • Visits are made to two processing facilities in each province and data are gathered on the number of snakes killed and their body sizes and sexes. • The relationship between the body sizes of whole snakes and the amount of meat they contain has been calculated in previous years. • Export volumes are recorded in the CITES Trade Database.	Visits to hunters in Province A reveal that the number of snakes collected has remained the same, and the effort taken to capture them has not changed. However, hunters in Province B are collecting the same number of snakes, but claim they have to travel twice as far to capture them and spend twice as long trying to find them compared to previous years. Visits to slaughterhouses in Province A show that the number of snakes collected, their body sizes, and their sexes, have remained the same as previous years. In Province B, the number of snakes brought to the processing facilities has remained the same, but the average size of snakes has decreased from 1.5 metres to 1.1 metres and, unlike previous years the harvest has become heavily skewed towards males. The CITES trade database suggests that meat exports have decreased slowly over the past several years.	The data from hunters and processing facilities in Province A do not suggest harvesting has impacted wild populations in that Province because use appears to be sustained (no change). However, data from Province B suggests snakes are becoming harder for hunters to find, suggesting populations may be declining. This would not be detected at the processing facility because the hunters are working harder to supply the same number of snakes to the facility each year. However, the average body size of snakes collected has decreased, and is now focused toward males. This suggests that trade has disproportionately impacted large females and there are now very few females reaching reproductive size. This may have negative consequences for population recruitment. Finally, the slow decrease in snake meat export volumes may appear inconsistent because the same numbers of snakes are being harvested annually. However, this fits with a reduction in snake body sizes, because export volumes are recorded in tons of meat rather than individuals. The volumes of export have only been dropping slowly because Province A still has a healthy population. The course of action is to modify the harvest management system to improve the sustainability of trade. A negative NDF and voluntary restrictions on exports may be warranted

➢ Field Monitoring

This section provides guidance to Parties on how to conduct field monitoring for snakes and discusses some of the variables and biases that should be taken into consideration. The methods presented here are by no means exhaustive. Extensive literature exists on how population field monitoring can be undertaken for snakes. Two of the most up-to-date sources include:

Snakes: ecology and conservation (2009). Edited by Stephen J. Mullin and Richard A. Seigel. Cornell University Press, USA.

Reptile biodiversity: standard methods for inventory and monitoring. (2012). Edited by Roy McDiarmid et al. University of California Press, USA.

Deciding when a field study is worthwhile

As discussed in **Section II,** snakes possess a number of traits that make field monitoring more difficult compared to other taxa. When determining whether it is worthwhile to conduct a population field study for a species of snake, the two most important variables are the species' distribution and detection probability. These are discussed below with examples of when a population field-monitoring program may be worthwhile. If a population field studied is not deemed to be worthwhile, then Parties should explore harvest-monitoring methodologies.

Distribution

Species of snakes with large distributions or with populations inhabiting variable landscapes may not be suitable for field studies aimed at making inferences useful for management because of different population dynamics among sites. For example, Reticulated Pythons (*Python reticulatus*) inhabit nearly every island in Indonesia, and are harvested from many of these. Known variability in the life-history traits of pythons from different islands means that extrapolating the results of field studies carried out in one area to make an inference about another, is problematic and possibly useless. The logistical difficulties involved in adequately surveying all harvested populations are insurmountable, meaning field studies for this species are not cost-effective or worthwhile. Species that are range restricted or harvested from only a few sites are better candidates for population field studies.

Detection probability

Many species of snakes are harvested in large numbers only because of the sheer number of people entering their habitats and opportunistically encountering them each day. However, these species may not be particularly easy to locate in a targeted way and require too much time for investigators to gather enough data in the field to make robust conclusions about harvest effects. Species whose detection probability is high, or when large samples can be gathered quickly, are best suited for field studies. Examples include species that are easily captured in traps, can be easily located during surveys, or congregate together during certain periods of the year (e.g., pythons basking together in rocky gorges during winter months or rattlesnake hibernacula). For example, Brooks et al. (2007) were able to assess abundance of Cambodian water snakes because the snakes are easy to capture in traps. In many cases, however, species that are easy for wildlife managers to capture are also easy for hunters to capture using similar methods.

Designing a population field study

Before implementing a monitoring system for a population of snakes, a decision should be made on the level of resolution that is required to understand changes in abundance. The researcher needs to decide whether they are attempting to determine the population size or density of snakes at a site (absolute abundance) or if it is merely sufficient to determine whether the population has changed since the last monitoring period (relative abundance). Because the purpose of monitoring is to investigate population change, these Guidelines suggest that in most cases an unbiased estimation of *relative abundance* is sufficient, particularly given logistical and financial limitations. Determining absolute abundance may be possible for species inhabiting small areas, and when logistical and financial impediments are not an issue.

What is the information of interest and how should it be interpreted?

In the same way that when conducting harvest monitoring we are looking for changes in the overall harvest and hunting patterns, population field studies are also looking for change over time (trends). In order to determine changes in abundance or population structure, a minimum of two years of monitoring is usually needed.

Thus, when conducting a field study, the information of interest is:

1) The number of animals captured in the sample (a proxy for overall population size), and

2) The size of the captured individuals in the sample (a proxy for overall population demographic which may signal if population is compromised)

A change in the number of individuals recorded in surveys, or changes in the body sizes of those individuals, may be a result of harvesting. As usual though, it is also essential to understand the biases that may be inherent in any field study. For example, field sampling may reveal that a population consists of predominantly large individuals. However, this may not reflect the true population demographic, but may be because trapping or survey methods are only suitable for large rather than small individuals. Ensuring consistency in survey methods, investigators and the timing of surveys from one sampling period to another is the best way to mitigate these types of biases. Environmental variations, like the impact of extraordinary droughts or floods, need to be considered in the interpretation of data, as climate phenomena have significant and wide-reaching effects on population numbers and structure that may obscure harvest effects.

Survey methods

A population monitoring field study aims to gather data from a representative sample of the total population. This can be achieved in a number of ways using both active and passive capture methods. The efficacy of different capture methods varies by snake species and can greatly alter results if inappropriate methods are used. For example, some species of snakes can be easily captured in traps, while others can only be captured by actively searching through areas of suitable habitat in the hope that individuals will be encountered.

Active survey methods

Active survey methods involve an observer or observers actively searching for snakes in areas (e.g., woodland or swamp) and at times (e.g., night or day) that the species of interest has a high probability of capture. Because of this, captures of snakes relies heavily on the competence of the observer, and is sensitive to observer bias. In order for a monitoring program to be successful, and to tease apart harvest effects from observer, behavioral or environmental effects, and survey methods must be standardized. This can be achieved by constraining the following variables:

Time – ensuring that snakes are searched for at the same time of day or night, and in the same season (for example, between 8-10 PM each night in August).

Effort – ensuring that the effort put into searching is kept constant (e.g., do not have one observer on some surveys and then two observers on others).

Space – ensuring that the same spatial area is surveyed on each occasion (e.g., defined transects or quadrats in the same area of forest or the same hibernacula each year).

Transects are a common active survey method for snakes. A transect is simply a line or path that passes through an area of interest from which systematic counts and measurements can be made. Transects can be curved instead of straight, and can follow natural or artificial paths. Examples include travelling along a section of river or lake and counting snakes in the trees on the bank (Plummer, 1997), or following a road to capture snakes crossing at night (McDiarmid et al., 2012). Another common surveying method is to visit areas where snakes are known to congregate at particular times of year. This may include snakes congregating to bask in the sun, congregating to mate or to hibernate. If the methods used to capture snakes are consistent then individuals captured in a defined area can be compared to those captured in previous monitoring occasions to make inferences about the status of the population and how it may have changed from one year to the next.

Passive survey methods

Passive survey methods involve trapping snakes. Although only certain species can be captured in traps, using traps is often preferable to active searching because they are insensitive to many biases and maximize repeatability. Nevertheless, quantifying the biases inherent in trapping studies is important. For example, some traps may sample only a portion of the population demographic traits if traps exclude a certain size of individual. This may lead to investigators overlooking harvest-related changes in body size because the size where change is occurring is not sampled by the capture method. Brooks et al. (2007) used gill nets to determine population density of water snakes in Tonle Sap in Cambodia. The gill net method captured small snakes, while hunters using reed traps and baited hooks capture a different size cohort within the population.

Combining population field studies with harvest monitoring

A pragmatic way to conduct population field monitoring is to combine it with harvest monitoring. When monitoring harvest at the hunter level, investigators can accompany hunters collecting snakes each year to understand how capture rates are changing. For example, investigators could travel for one week with hunters trapping aquatic snakes. The number and sizes of snakes captured within traps can be recorded accurately and efficiently. Repeating this schedule with the same hunters, using the same traps at the same time and place each year would quickly build a useful dataset to assess the status of the species of interest. The hunter's harvest effectively doubles as the field survey and is a pragmatic way of minimizing financial and logistical issues associated with conducting long-term population field studies.

Examples

Examples of field monitoring programs for hypothetical populations of snakes are provided in **Tables 7, 8 and 9**.

Table 7. A hypothetical scenario and population field monitoring system for the trade in snake skins.

Trade type	Scenario	Monitoring system	Hypothetical Result	Interpretation and course of action
Skin trade	An aquatic species of snake is harvested from three separate rivers for the skin trade. The hunters usually capture the snakes with fishing net snakes in which many of the snakes drown.	Each year, basket traps are set for one week in each of the three rivers to capture snakes. The number of snakes captured is recorded along with their body sizes and sexes. Halfway through the monitoring program a new type of basket trap is used to capture snakes. Basket traps are used because they do not kill the snakes when they are captured.	When monitoring first began the mean number of snakes captured in each trap was 10. The snakes had a mean body size of 80cm. After the new traps started to be used 15 snakes were captured per traps on average, but body sizes remained the same.	Despite the number of snakes captured over the course of the monitoring system increasing, this is unlikely to be related to a population increase. Instead, the increase is most likely due to a new, and more efficient, trap design being employed halfway through the monitoring period. No changes to the management system required

Table 8. A hypothetical scenario and population field monitoring system for the trade in snakes for pets.

Trade type	Scenario	Monitoring system	Result	Interpretation and course of action
Pet trade	A species of snake endemic to a small island is harvested for the pet trade. Although arboreal, the species hunts on the ground and at night is easy to detect by walking through the forest with a torch. The species is easiest to observe during the wet season.	Each year, three 1 km long transect surveys are carried out for two weeks at two separate sites in rainforest habitat. All surveys are carried out in the month of January during the wet season. All snakes located are captured and their body size and sex is recorded.	When monitoring first began, an average of three snakes per hour of searching was captured at both sites. The mean body size of captured snakes was two metres long. After five years of harvest, the number of snakes captured has fallen to only one snake per hour at both sites and average body size of captured snakes is now only 1.5 metres long.	Assuming that survey methods have remained the same, all of the information gathered through monitoring suggests that the population may be affected by harvesting. The course of action is to modify the management system to improve the sustainability of trade. A negative NDF and voluntary restrictions on exports may be warranted

Table 9. A hypothetical scenario and population field monitoring system for the trade in snake meat.

Trade type	Scenario	Monitoring system	Hypothetical Result	Interpretation and course of action
Meat trade	A species of large python is found over a wide area spanning several countries. Because of their large size, they are highly prized as bushmeat in Country A and populations have been severely depleted. In response, Country B has begun legally exporting meat to Country A, and some level of illegal trade is also known to occur. The species is known to congregate along rocky gorges to mate during spring.	Each year in spring, investigators survey two 1km long gorges in Country B and capture all pythons that have congregated there to breed. The snakes are measured, sexed, and released.	Over the course of the monitoring period the number of pythons located decreased from a mean of 36 individuals per survey (both gorges combined) to 20 individuals per survey. However, the average body size of pythons captured has increased slightly from 4.1 metres to 4.2 metres.	The steady decline in the number of snakes located in each gorge may be indicative of a harvesting affect. Although the data on body sizes does not reflect a change in population demographic, this may be because only individuals above a certain body size enter the gorge to breed so smaller animals are not represented in the sample. This bias may explain the decline in numbers of large individuals but not the absence of a demographic change. The course of action is to continue monitoring the population. If further declines are observed, then the management system should be modified to improve sustainability.

Section IV - Managing snake populations

➢ Harvest management tools

If population changes are observed when monitoring (using either harvest or population field monitoring described in **Section III**), and those changes are suspected to be a result of harvesting, a number of tools are available to assist management intervention. Wildlife management takes into consideration the complex interplay between social, biological and economic forces acting on wildlife populations. The management guidelines in this document touch upon each of these factors, where applicable. This is because harvest and trade is as much about managing people as it is about managing wildlife. If local people are not happy with a proposed management intervention, then there is a strong possibility that it will fail. So whenever we discuss different monitoring systems we focus on a set of variables, both natural and anthropogenic, to allow the application of the best management systems possible.

Quotas

Quotas are a fixed number, limiting the amount or share of the commodity of interest – in this case the harvest of snakes. Many Parties to CITES choose to implement quotas to assist in the management and regulation of harvests to ensure non-detriment. The setting of an export quota, advised by a Parties' Scientific Authority, effectively meets the requirement of CITES to make an NDF for species included in Appendix II (Res. Conf. 14.7). Indeed, this same Resolution states that when export quotas are established, they should be set as a result of a non-detriment finding by a Scientific Authority, and further establishes that a Non-Detriment Finding should be made before an export quota is established for the first time or revised, and reviewed annually. Unfortunately this is not always the case. In many instances, this assumption can have limitations because it reveals nothing about the science underpinning the quota. On the other hand, in many cases quotas are used as an administrative tool and do not reflect any sort of sustainable offtake, particularly for species whose populations may not be easily quantified. For example, applying a sustainable harvest quota may be relatively straightforward if the annual harvest of a species is only 20 individuals - such a harvest is unlikely to pose a threat because it would likely represent only a small proportion of the total population. However, if the quota is set for the harvest of 300,000 individuals, significant knowledge of the population is required to ensure that the quota does not exceed the maximum sustainable yield and put the species at risk.

Harvest or export quotas may only be effective if industry abide by them. Exceeding quotas coupled with high levels of illegal trade may do little to regulate harvests (Jenkins, 2009). In several countries, poor people collect snakes to directly improve their livelihoods and are often not aware that a quota exists. Others choose to ignore quotas to increase their income through harvesting. Often the capacity or incentives to exceed harvest quotas are substantial. In these situations, a quota can result in a number of issues that circumvent a wildlife manager's ability to ensure sustainable offtake and can create compliance issues for regulatory authorities. For example, if management relies only on a quota system, an incentive can be created to launder the excess through other sources in order to "meet" the "quota" during bad years, and when years are favourable, the excess may be smuggled or laundered through other countries. Furthermore, a fixed quota that is above the numbers easily produced during a bad year may foster an increase in hunting effort and prices to reach the "quota", rendering the harvest unsustainable. In such situations a quota has failed in its goal to regulate harvesting and the associated compliance issues can compound the difficulties of ensuring non-detrimental trade.

In addition to the potential for circumvention of quotas and illegal trade, quotas present difficulties for managers that are monitoring a harvest. For example, **Figure 2** depicts a scenario where a Party's quota is exceeded every year and the excess is exported illegally via neighbouring countries. Every year, the quota remains the same, as do the number of individuals annually exported via legal channels. The constant legal harvest may give managers the impression that sustainability has been achieved, when in reality the overall harvest has been rapidly decreasing and may be suggestive of unsustainable harvest. The application of a quota, in a trade situation where governance is poor and illegal trade is common, may result in mis-interpretation of harvest data. Even in situations where population declines can be observed, quotas often do little to ensure sustainable trade when used in isolation because they are indiscriminate to the types of individuals harvested and the timing when the harvest occurs. For example, even in situations where quotas are strictly adhered to, the quota alone cannot prevent the harvest of large reproductive individuals during the breeding season. Thus, harvest sustainability may be compromised even if the quota is not exceeded.

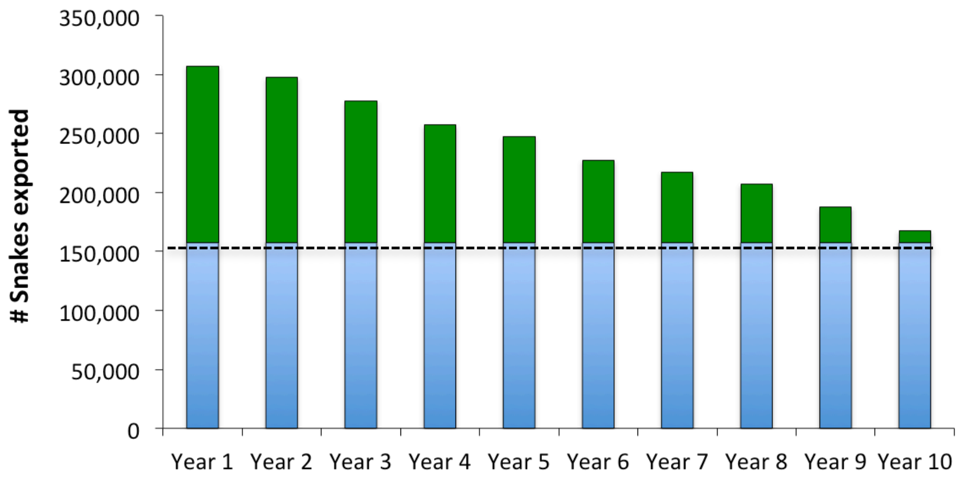

Fig. 2. A scenario where the effect of harvesting is hidden by a quota. The legal exports (blue columns) remain constant, giving the impression that sustainability has been achieved, when in reality the overall harvest has been declining as indicated by the decrease in illegal trade (green columns).

Size restrictions

Restricting the size of individuals that can be captured is a tool commonly used in fisheries management and aims to protect important life stages with the goal of maintaining high population recruitment. Typically, restrictions are placed on the minimum and/or maximum size of animals to protect immature and large, highly fecund, individuals, respectively. The underlying theory is that removal of individuals between such size limits is biologically safe, and likely to have the least impact on the viability of the population.

In principle, size restrictions act as a quota that takes into account natural population dynamics. From a biological point of view, and with constant hunting effort, we expect the harvest to represent some fraction of the existing population (Caughley and Sinclair, 1994; surplus yield models). This is because there are only a finite number of individuals within each size cohort that can be harvested at a given time. When the population increases because of favourable environmental conditions, the harvest increases - and vice versa.

Theoretically, a system in which size restrictions are being enforced can result in the harvest of the same number of individuals as a system in which quotas are being enforced. However, size restrictions have two advantages over quotas:

1) **Improved regulatory capacity.** Because the size of harvested specimens can be easily measured, size restrictions can be adequately enforced. It is very difficult to prevent quotas being exceeded because enforcement authorities cannot differentiate one individual from another.

2) **Ensuring sustainability through regulation**. Because harvest size restrictions can be set to protect specific life stages, managers can simply manipulate harvest sizes to better protect a specific demographic of the population. Similarly, if population declines are observed then harvestable sizes can be restricted to limit the total off take. This cannot be achieved with a quota.

We suggest that in a wide variety of cases involving harvest and trade in wild snakes, size restrictions are the most straightforward and meaningful way of managing populations to ensure harvest sustainability.

Effort restrictions

Restrictions on effort are useful tools for regulating wild snake harvests. Typically, restrictions are imposed on the number of hunters that are legally registered to harvest snakes, or the total number of individual animals that hunters are allowed to harvest (the bag limit). The principle behind this type of management tool is that each hunter can only collect a finite number of individuals over a specified time period. Limiting the number of hunters restricts the harvest to the cumulative total of individuals that each hunter can theoretically capture.

Scenarios of how harvest can be managed using effort restrictions are provided below using four different situations in four countries:

Country A – Places no restriction on the number of hunters permitted to capture snakes. The number of snakes that can be theoretically captured is limited only by the size of the snake population.

Country B – Places no restriction on the number of hunters allowed to capture snakes, but allows each hunter a bag limit of only 10 snakes. The number of snakes that can be theoretically captured is limited by the number of hunters participating in the harvest or by the size of the snake population.

Country C – Places no restriction on the number of snakes that each hunter can catch, but restricts the number of hunters allowed to participate in the harvest. The number of snakes that can be harvested is limited by the number of snakes each hunter can harvest or by the size of the snake population.

Country D – Restricts the number of hunters that can participate in harvesting to 20 individuals and sets a bag limit of 10 snakes per week. The maximum number of snakes that can be legally harvested is 10,400 individuals per year.

Only in Country D is the total number of snakes collected effectively restricted. Effort restrictions act as a type of quota by setting an upper limit on the number of individuals that can be harvested. Thus, effort management can suffer from the same disadvantages as quotas when illegal trade and non-compliance issues are present in the trade situation. In situations where governance and regulation is poor, compliance can often be monitored at the higher levels within a trade chain. For example, the 20 registered hunters in Country D (above) may all sell their snakes to a single slaughterhouse. If that slaughterhouse only buys from those hunters, yet attempts to on-sell 20,000 snakes at the end of the year, there is a strong possibility that additional, unregistered hunters are participating in the harvest, or that the registered hunters are exceeding their bag limits. In many situations involving snakes, effort restrictions may not be pragmatic. Small numbers of snakes are commonly harvested by a large number of people, who opportunistically collect snakes to boost their income. These collectors are often not registered with authorities, and the logistical task of doing so may not be practicable.

Season restrictions

In many countries, wildlife managers restrict hunting to specific times of the year. Such restrictions are often biologically meaningful and coincide with times when animals are at their most vulnerable. For snakes, season restrictions might most logically be imposed when species are denning together during the winter (to avoid over-exploitation by harvesting at times when collection is easy) or when they are laying eggs or giving birth (to allow female snakes a reproductive opportunity). From a management point of view, such restrictions work because only a finite number of individuals can be captured within a prescribed season. The total number of individuals harvested will thus be lower than if collection occurs throughout the year - because it allows a greater number of individuals (that escaped detection) an opportunity to contribute to population recruitment.

Similar to the other management tools that aim to restrict total numbers of animals captured (quotas and effort restrictions), snakes may continue to be captured during the off-season and stockpiled or laundered through legal channels. Thus season restrictions must be implemented only when strict controls and fail-safes are in place to minimize non-compliance (e.g., regular patrols during the no harvest season). This method may also not favor local people relying on the resource as a source of income. The loss of income at certain times of the year may jeopardize local livelihoods and create further incentives to circumvent harvest regulations.

Quotas vs. size restrictions

The figures presented provide examples of the different effects that quotas and size restrictions have on the demographic of a harvest.

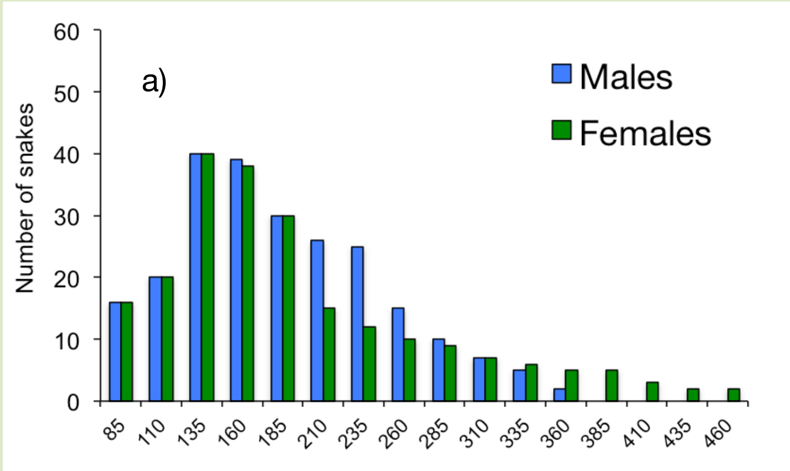

Fig. a). A hypothetical snake population showing the total number of males (blue) and females (green) within each size class. It can be seen that females grow larger than males.

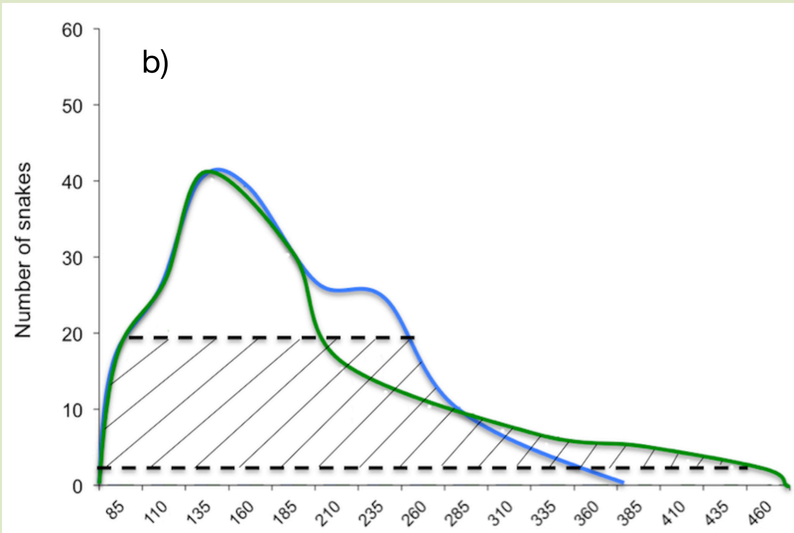

Fig. b). The same snake population with a set quota. The hatched area depicts the total number of snakes that can be legally harvested. Note that the quota restricts the number of individuals that can be harvested, but it does not discriminate the types (e.g., sizes of sexes) of individuals that can be harvested.

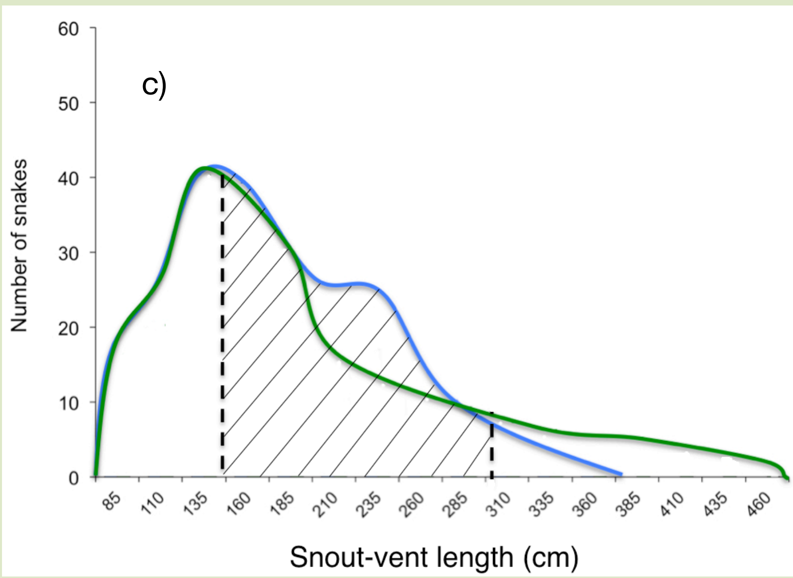

Fig. c). The same snake population with a size restriction only allowing the harvest of individuals between 150 and 300 cm in length. The hatched area depicts the total number of snakes that can be legally harvested. Using this method, small immature individuals and large females can be protected from the harvest without compromising the harvest yield.

Combining management tools

Many wildlife management systems do not rely on a single harvest management tool, but combine more than one method. For example, a system that restricts the number of people allowed to harvest within a set season, and only allows them to harvest a set number of animals within a given size range, uses all of the tools described above. The greater the number of management tools used, the greater control managers will have over the harvest. However, the financial and logistical costs also increase as management becomes more prescriptive. Each situation will be different and a balance between the amount of control and logistic feasibility needs to be struck. A summary of the pros and cons of each management tool is provided in **Table 10**.

Table 10. Pros and cons of the different management tools that can be used to regulate harvests of snakes.

Method	Pros	Cons
Quotas	• Can be a useful administrative tool for allocating harvests among provinces or states within a country. • Can be a useful administrative tool for handling minimum and very conservative export levels such that a management system is not required.	• Do not account for natural fluctuations in population size. • Cannot be easily monitored or enforced. • Can result in ongoing collection and stockpiling of specimens or smuggling. • Does not discriminate against sensitive age groups (e.g., immature individuals).
Size restrictions	• Can be biologically meaningful by protecting the most vulnerable or productive life stages. • Can be easily regulated and monitored. • Effectively acts a quota because only a finite number of individuals are available for harvest within a given size cohort. • Automatically accounts for the natural fluctuations of dynamic populations.	• Individuals outside the allowed size ranges can be harvested and illegally exported by captive breeding facilities or other countries where size restrictions are not in place. • Regulators do not have direct control over the yield of the population (as with quotas).
Effort restrictions	• Can naturally limit the number of individuals collected.	• Can be easily circumvented. • May negatively impact some hunters, especially when much of trade is opportunistic. • Can result in stockpiling or smuggling. • Difficult to enforce in many situations.
Season restrictions	• Can be biologically meaningful by preventing harvest at important period in a snake’s life cycle. • Effectively work as a quota because only a finite number of individuals can be harvested in the specified period. • Reduces the time and resources invested to a hunting season.	• May result in stockpiling of specimens and smuggling. • Difficult to enforce in many situations. • May negatively affect local people who must find alternative work during periods when harvest is not allowed.

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