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

Twenty-ninth meeting of the Animals Committee
Geneva (Switzerland), 18-22 July 2017

Species specific matters

Terrestrial species

Snakes (Serpentes spp.)

CONSERVATION, SUSTAINABLE USE OF AND TRADE IN SNAKES

1. This document has been submitted by the Secretariat and prepared by the International Union for the Conservation of Nature (IUCN). The IUCN report in the Annex to the present document is submitted in compliance with Decision 17.279.

Recommendation

2. The Animals Committee is invited to review the guidance concerning the making of non-detriment findings for trade in Appendix-II listed snakes in the Annex to the present document, and make recommendations to the Standing Committee as appropriate.

Version 1.2

July 2017

Non-Detriment Findings for Snakes: Guidance for CITES Scientific Authorities

IUCN-SSC Boa and Python Specialist Group

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i) Acknowledgements

This report was made possible with the help of financial support from the CITES Secretariat.

It is the result of many years of work on snakes in trade, and discussions with a large number of people from government and intergovernmental organisations, NGOs, scientists and industry. These individuals are too numerous to name, but are thanked for contributing their time and expertise to improving our understanding of snake conservation and trade.

Special mention must be made of staff from the CITES Management and Scientific Authorities of Indonesia and Malaysia, discussions with whom have improved the usefulness of these guidelines. In addition, we are grateful to the many people directly involved in the international trade in snakes, who over the years have openly discussed trade with us and allowed us to study the snakes at their premises.

We would also like to thank Fundación Biodiversidad - Argentina for contributing with the Yellow Anaconda Management Program example and providing general advice.

Jessica Lyons, Dena Cator and Richard Jenkins are thanked for their valuable contributions towards improving the quality of the final report.

Several members of the CITES Animals Committee Intersessional Working Group on Snakes as well as anonymous reviewers from the BPSG provided insightful comments that enriched the outcome of our work.

Finally, this guidance benefitted from input provided by participants of an Expert Workshop on the Making of Non-Detriment Findings for CITES Appendix II listed snakes, held in Kuala Lumpur, Malaysia, in May 2017.

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1.0 Introduction and background

1.1 Introduction

Millions of snakes of numerous species are traded internationally every year to meet the demand for skins, food, pets, medicines, and a variety of other purposes. Approximately 150 species are listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) because international trade may become, or is known to be, a risk to their long-term survival in the wild. For many species of snakes, wild harvesting and trade have occurred for centuries, often supporting the livelihoods of rural people. Ensuring snake harvesting is sustainable and does not result in declines that could lead to extinction contributes to the conservation goal of maintaining snakes as an integral part of functioning ecosystems. Similarly, maintaining the ability of people to use local and renewable snake resources, to benefit their livelihoods, has become an increasingly recognised goal of management (CITES Res. Conf. 8.3 and 16.6).

Article IV of the CITES Convention requires international trade in CITES-listed snakes, or their parts and derivatives such as skins and meat, to be subject to Non-Detriment Findings (NDFs) by exporting Parties. Although Parties understand the importance of NDFs and are committed to complying with CITES obligations, many times they lack the capacity, tools and guidance to effectively undertake NDFs. This situation is often true for snakes, many of which continue to be traded in the absence of information about the impact such use is having on their populations.

This document aims to guide CITES Scientific Authorities in how to complete NDFs for CITES-listed snakes. These NDF Guidelines are separated into two parts:

i) The first part is the basic NDF Guidelines, which offers an overview of (1) how non-detriment is best determined, (2) the management context for snakes, and provides (3) step-by-step guidance on how to evaluate whether harvest and trade is non-detrimental. The NDF Guidelines are aimed at simplicity, and contain the bare minimum information Scientific Authorities need to complete an NDF for snakes – they are essentially the "what is needed to complete an NDF".

ii) The second part is an Annex that provides further information, discussion of conceptual issues, and more a detailed explanation on how to carry out NDFs and implement monitoring and management programs. Parties are encouraged to refer closely to the Annexes when using the NDF Guidance.

For further explanation and background on the genesis of this guidance, see Section I in Annex A.

1.2 How to use this guidance

The two parts of this NDF guidance are designed to complement one another. The Annex has been made available for users to find further information and detail on topics in which they have a particular interest or require further clarification. To simplify movement between the main NDF Guidance and the Annex, each section of the Guidance includes several hyperlinks. These hyperlinks take the user to the specific section of the Annex where additional information can be found on that topic. Each section of the Annex is also hyperlinked to the related section in the main NDF Guidance, to facilitate ease of return to each section. These hyperlinks should simplify the electronic use of this Guidance.

1.3 CITES and Snakes – NDF guidelines and challenges for their implementation

Of the approximately 3,600 recognized species of snakes in the world (http://www.reptile-database.org/db-info/SpeciesStat.html), at the time of writing 130 (3.7%) are listed in CITES Appendix II, which allows regulated sustainable trade in these species to take place. Of these, only 25% (33) are regularly found in international trade. Two thirds of CITES Appendix II listed species are representatives of the families Boidae and Pythonidae (the boas and pythons). These large-bodied and often colorful snakes are traded primarily for their skins, meat and as pets, and comprise the bulk of trade in terms of species and volume. Geographically, more than half of the CITES-listed snake species being currently traded (61%, 20) are sourced from Southeast Asia, which also accounts for 73% of the world's trade in snakes and their derivatives by volume (UNEP-WCMC CITES Trade Database, 2015). Many more species of snakes (e.g., Homalopsine water snakes and some rat snakes in Southeast Asia) are also traded internationally in large numbers, but are not listed in the Appendices of CITES.

Because commercial trade is largely restricted to Appendix II species, Parties are required to comply with Article IV of CITES and only grant an export permit for an Appendix II listed snake species when:

(1) The designated Scientific Authority of the exporting Party has advised that trade will not be *detrimental to the survival of the species in the wild*, and

(2) Once exports are underway, the Scientific Authority has monitored the actual levels of export to ensure that the species *is maintained throughout its range at a level consistent with its role in the ecosystem and well above the level at which the species might become eligible for inclusion in Appendix I*.

Whenever a Scientific Authority doubts that the export of Appendix II-listed specimens is non-detrimental, it shall advise its corresponding Management Authority of suitable measures to be taken to limit the grant of export permits for specimens of that species. If the export is deemed to be non-detrimental, then it can proceed without intervention. This process is termed the CITES Non-detriment finding (NDF). Assessing the likely detriment of removing animals from the wild for trade, and making an NDF, is at the core of regulations for CITES Appendix II species and thus at the foundation of the Convention (Jenkins, 2009). Yet in practice, it is difficult for many Parties to provide robust NDFs for all exports.

An NDF can be very simple and straightforward for some species in some contexts, but highly complex and challenging for others in different contexts. Although CITES does not prescribe how Parties should determine "non-detriment", Parties are usually encouraged to review available information on the population status, distribution, population trends, harvest, trade, and other biological and ecological factors of the traded species, as appropriate. Parties are also encouraged to take into account the Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity published by the Convention on Biological Diversity (2004), as well as relevant Resolutions of the CITES Conference of the Parties.

Despite such guidance, many Parties lack the capacity and resources to execute anything but the simplest of NDFs (Nash, 1993; Apensberg-Traun, 2009; Jenkins, 2009). In many cases, the biological information available to Scientific Authorities only reflects the staff's own knowledge on the species or that of traders/industry, which is not necessarily the best information available. As a result of these cumulative difficulties, Parties often export Appendix II-listed species without undertaking sufficient evaluations of the effects of international trade on wild populations, and so in many cases are not fulfilling their obligation to ensure trade is "non-detrimental" to these species (Jenkins, 2009).

This problem is exacerbated further because in the past, NDF guidelines have almost always relied on the assumption that the population trend of the species is or should be known. In reality, this is rarely the case. For example, the IUCN Guidelines to assist CITES Scientific Authorities with conducting NDFs identify 26 criteria considered relevant to the species of interest. Criteria for assessing detriment focus on the biology, protection, incentives, monitoring, control, management, and status of the species and its trade (Rosser and Haywood, 2002). Complete knowledge of these attributes can assist in predicting the likelihood of detriment, but provide little indication of how a species is actually fairing in the wild. For example, a species that has life history attributes that make it resilient to use (e.g., fast growth and high fecundity), is common and well protected, and occupies a large distribution, may still experience unsustainable levels of harvest. This is because despite possessing multiple attributes that make the species resilient to use, the rate of harvest may be so high that declines in its abundance cannot be arrested. Without a more thorough knowledge of population change to feed into an NDF evaluation, unsustainable harvests can go unnoticed if not well monitored and can remain unchanged without good management.

1.4 Non-detriment and captive breeding

Captive breeding of Appendix II listed snakes for commercial purposes is common in many range States, as well as in countries outside the species' range. CITES-listed specimens traded using source code C or D do not require an NDF. Nevertheless, among other requisites, exporting Parties using the source code "C" for captive-bred are still required to comply with CITES Article IV and establish that exports are not detrimental to the survival of wild populations (Resolution. Conf. 10.16).

For species bred in captivity in compliance with national legislation and with regard to wild stocks entering captive breeding facilities, "*the method used to make a non-detriment finding for a specimen known to be of non-wild origin may be less rigorous than that for a specimen of wild origin* (Resolution Conf. 16.7). However, there are obvious difficulties in situations where captive breeding production systems are intimately linked to on-going wild harvest that is not compliant with domestic legislation. Such situations may occur when illegally harvested wild specimens are laundered through legal breeding facilities, and when harvests of wild specimens as parent stock is unsustainable. In these situations, Article IV (para. 2b) requires export permits be issued only if *"a Management Authority of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State for the protection of fauna and flora".*

1.5 Non-detriment and illegal trade

When illegal trade is occurring in contravention of national laws, international trade in such specimens is in contravention of both international law and CITES. The impact of illegal trade on wild populations is usually difficult to detect, because such trade is inherently clandestine and not reported. The situation becomes more complicated when illegal use and trade is occurring in concert with legal use and trade. Such situations occur when snakes are illegally harvested from the wild and mis-declared as captive-bred, or when specimens in excess of national quotas are simply smuggled out of a country. When volumes of illegal harvest are unknown, the methods suggested in this document can be used to infer a level of sustainability of that harvest. However, even if such a task could be achieved, the harvest is still illegal and is thus a matter of compliance and enforcement, even if deemed to be "non-detrimental".

2.0 Defining "non-detriment"

In many cases involving snakes, words such as *un-sustainable*, *over-utilisation*, *overexploitation or detrimental* are used interchangeably. Therefore, before beginning an NDF for exports of specimens of snakes it is important to define what is meant by *detriment*, and hence what the criteria are for determining when a particular export is "non-detrimental".

Although harvesting inevitably results in populations declining in abundance, it does not automatically follow that the harvest is "detrimental". The variables promoting population growth or recovery may still be greater than those causing population decline (in this case, harvest). If a new level of abundance can be maintained over time by management, then the population is being harvested sustainably, and can theoretically continue to be harvested forever. The main issue concerning CITES is when neither the decline in abundance nor the harvest level can be controlled or managed, for one reason or another, and the population's capacity to recover is compromised even if harvesting ceases. In these cases, the species concerned may ultimately qualify for inclusion in Appendix I.

Hence, in many instances, ensuring that populations of a species in trade are being used in a sustainable way ("the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining the potential to meet the needs and aspirations of present and future generations") may be the most practical means of ensuring *non-detriment*. This is especially true for Appendix II species, which are not threatened with extinction by trade. For example, for Appendix II listed species, the goal is to maintain them at levels well above those at which they might become eligible for inclusion in Appendix I (Article IV, para. 3). However, determining when a species has declined to a point where management interventions can neither prevent further declines nor control the harvest, thus rendering it detrimental, can be challenging. On the other hand, demonstrating that populations are being managed and used in a sustainable way essentially satisfies the wildlife management obligations within Article IV by offering a flexible and precautionary means of ensuring non-detriment (Webb et al. 2003).

Thus, this NDF guidance focuses on establishing that trade is non-detrimental by ensuring it is sustainable. Non-detrimental (sustainable) trade can be achieved by satisfying two basic questions:

1) Is the harvest and use sustainable over time (are there indications of a declining trend, or other negative impacts on the wild population of the species?); and

2) Are the impacts of harvest and trade being controlled within prescribed (sustainable) limits?

A variety of different indices can be used to answer these questions, including: changes in distribution; changes in density; changes in population structure; collection areas (proportion of total distribution; change of areas); catch per unit effort; legal issues; and other threats (habitat loss, climate change, pollution, etc.) (Cancún CITES NDF Workshop, 2008).

By ensuring harvesting and trade is sustainable (non-detrimental), CITES Scientific Authorities can also be satisfied that the species is being maintained at a level consistent with its role in the ecosystem.

For further discussion of harvest theory and the interrelationship between *sustainable use* and *detriment*, see **Section II, Annex A****.**

3.0 The management context for snakes

Snakes are particular in that they possess a suite of attributes, such as their cryptic and highly sedentary nature, that make it difficult to conduct conventional assessments of population status based on field studies. The result is that for many species of snakes, there is simply not enough information available to make well-informed evaluations about whether a level of trade is detrimental or not. To complicate the situation, the traditional, field based, scientific approach to snake management is often not able to provide answers about potential detriment in the time scale managers demand.

Although it is possible to draw conclusions about the likelihood of sustainable trade in snake populations, and make recommendations based on a set of indicative criteria (life history traits, area of occupancy, etc.), the only way of knowing with certainty what will happen when a wild population is manipulated is through testing and experimentation, which requires the implementation of an appropriate monitoring system for species subject to harvest regimes.

For these reasons, and to provide the most benefit for managers and decision makers, NDFs for snakes should be:

- Precise. The information must be guaranteed in terms of quality of data, by using the best available scientific information;
- When possible, use information derived from management itself, particularly easily measured indicators (e.g., biology of harvested specimens, harvest yield, effort versus yield, proportion of sexes, harvest demography based on live animals or skin sizes, analyses of trends, etc.) rather than requiring completely independent research and monitoring programs;
- Simple and cost-effective, in terms of the amount and quality of information required to examine the most important indicators.

For further discussion about the challenges that make NDFs for snakes difficult see Section III, Annex A.

4.0 Guidelines for making NDFs for snakes

The CITES NDF is an evaluation of whether ***a given level of harvest for international trade is non-detrimental***.

The first step for completing an NDF for exports of snakes is to (1) correctly identify the specimen(s) to be traded, (2) confirm their source (W, R, F, C, etc.), and (3) verify their legal acquisition. If any of these criteria are not met then exports should not proceed. It is not the aim of these guidelines to assist Parties in determining the taxonomy, source, or the legality of snakes in trade. Each of these criteria should be reviewed and confirmed by the Party's CITES Management Authority, with technical input from the CITES Scientific Authority. If further expert consultation is required to assist with this process then contact should be made with national museums, universities, relevant NGOs and other networks of experts such as the IUCN-SSC Boa and Python Specialist Group (BPSG). The aim of these guidelines is to help CITES Parties determine whether harvesting and trade is non-detrimental to wild populations of snakes.

This can be achieved by following the steps in **Figure 1**. The International Expert Workshop on CITES Non-Detriment Findings reptiles working group (Cancún CITES NDF Workshop, 2008) proposed a two level approach to NDFs: (a) risk assessment; and (b) monitoring and management. After considering various scenarios with snakes, we propose a five-step approach ranging from simple to more complex, depending on the likely impact of trade for each situation:

Step 1. Undertake a *Primary Evaluation* of the risk that harvesting for trade is threatening, or may threaten, the species with extinction.

Step 2. If on the basis of the *Primary Evaluation* it is not possible to satisfy non-detriment, then a *Secondary Evaluation* is needed. This incorporates new data, if available, or results obtained from monitoring and management procedures.

Step 3. Where revised monitoring and management procedures are required to satisfy non-detriment, but are not yet implemented, they should describe which monitoring and management interventions are planned, and how the results are going to be interpreted in terms of non-detriment.

Step 4. If after Steps 1 – 3 have been completed there is sufficient information to determine that trade is non-detrimental then exports can commence or continue as usual. However, if there is sufficient reason for the Party to believe the harvest may be detrimental, it may be appropriate to issue a negative NDF and voluntarily restrict exports until the non-detriment requirement can be satisfied.

Step 5. NDFs are not single events. Situations change for a variety of reasons, and NDFs should be regularly repeated and updated to reflect these changes.

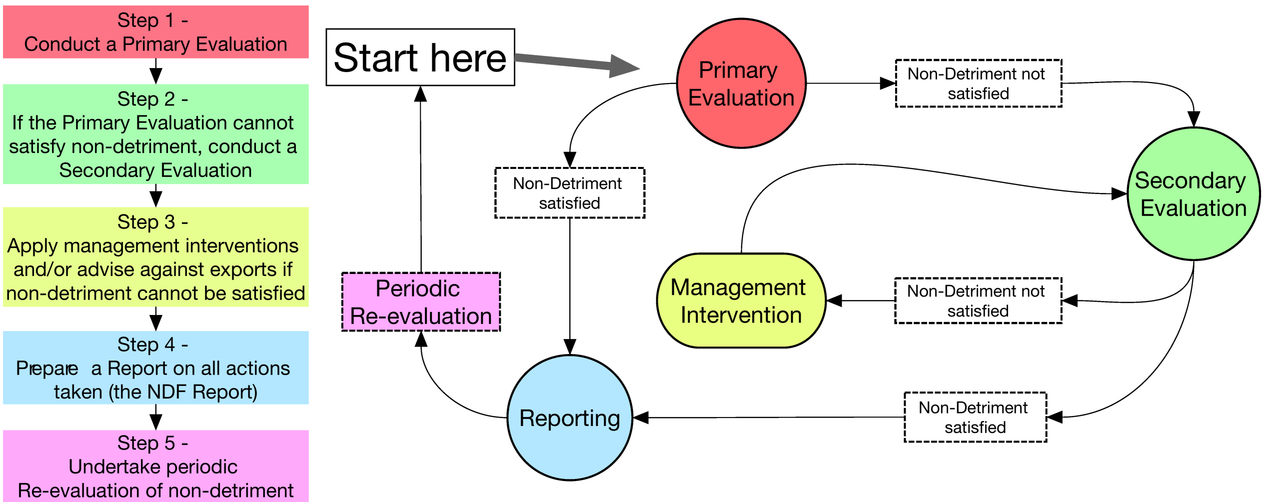


Fig. 1. The step-by-step process to be undertaken to establish non-detriment for exports of CITES Appendix II listed snakes.

4.1 Information sources for completing an NDF

A key component of the Non-Detriment Finding (NDF) is information or even inference of a species' harvest level, area of occupancy, likely extent of the population, harvest rate and life history parameters. The available information used to inform an NDF, with sources and references where appropriate, should be documented. These Guidelines are in line with CITES Resolution Conf. 16.7, which recommends the sources of information that may be considered when carrying out either a Primary or Secondary Evaluation as part of an NDF can include, but not be limited to:

i. relevant scientific literature concerning species biology, life history and distribution;

ii. details of any ecological risk assessments conducted;

iii. scientific surveys conducted at harvest locations and at sites protected from harvest and other impacts;

iv. details of monitoring or management systems for the species of interest;

v. relevant knowledge and expertise of local and indigenous communities;

vi. consultations with relevant local, regional and international experts; and

vii. national and international trade information such as that available via the CITES trade database maintained by the UNEP World Conservation Monitoring Centre (UNEP-WCMC), publications on trade, local knowledge on trade and investigations of sales at markets or through the internet, for example.

4.2 Step 1: *Primary Evaluation*

The purpose of a *Primary Evaluation* is to establish whether non-detriment can be established easily using basic information. This involves the provision of scores for four basic criteria:

- **i.** Annual harvest level
- **ii.** Area of occupancy, and
- **iii.** Life history traits
- **iv.** Additional risk factors

Scores can be applied by determining where each of the three criteria of interest belongs based on the matrix in **Table 1**, which are applicable to all species of snakes. The maximum score for each category is three and the minimum score is one.

Table 1. Scoring criteria for the four 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	
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			

Step 1. Once a species' harvest level, area of occupancy, life history traits and additional risk factors have been established, a *Primary Evaluation* score can be assigned to determine if trade may be detrimental.

Step 2. Record the *Primary Evaluation* scores for each criterion in the *Primary Evaluation* worksheet provided (in **Annex B**), together with justification about why the particular score was attributed to each criterion.

Step 3. Based on the score from **Table 1**, establish whether a *Secondary Evaluation* is required to establish non-detriment by using the guidance in the "Evaluating Non-Detriment" box below.

Evaluating Non-Detriment

Primary Evaluation score lower than five (5) = trade is non-detrimental (**record the score and justification in the *Primary Evaluation* worksheet provided (in Annex B). This can be used for Step 4 of the Non-Detriment Finding**).

If the *Primary Evaluation* score is equal to or greater than five (5) then the non-detriment requirement cannot be satisfied, warranting additional information based on other indices to evaluate detriment. **A *Secondary Evaluation* should be undertaken**.

4.3 Guidance for completing a *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 (NDF). Scientific Authorities may not be able to grant a positive NDF using the *Primary Evaluation* alone, but that does not automatically mean that harvest 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 annual 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 be required before exports take place.

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 other factors be potentially impacting wild populations (illegal trade, invasive species, pollution) 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 scoring a three (3) in any category listed in **Table 1** 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:

Annual harvest level

The level of harvest experienced by a population of any animal is the most important variable to consider when assessing risk of detriment in a *Primary Evaluation*. If harvest levels are very low, then it may not matter that a species 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 (*sensu* 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 (definition from IUCN Red List Criteria). 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 result in a smaller 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 impacted by) harvest is lower.

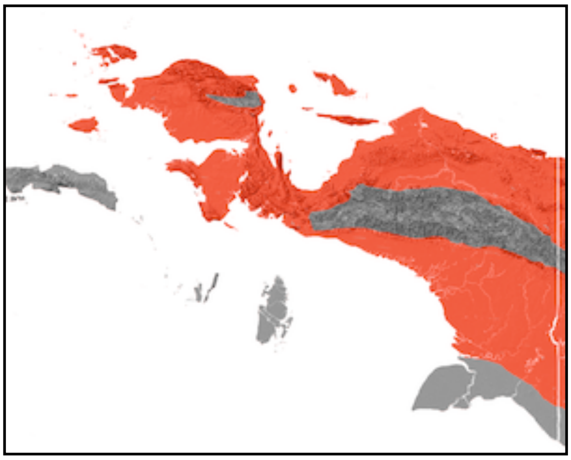
A species' area of occupancy is different to a species' distribution. In some cases, the area of occupancy can be almost identical to the distribution or extent of occurrence, but in others it is not. For example, the Boa Constrictor (*Boa constrictor*) has a large distribution in South and Central America, 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. Area of occupancy estimates should be applied at the national level, not the level of the sub-population being harvested.

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 (**Inset 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* is only found 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 (**Inset B**).

Inset A. The area of Indonesia.



Inset 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 (**Fig. 2**). Conversely, a species that grows and matures rapidly and has many offspring every year is likely to recover more quickly. Scientific Authorities conducting a Primary Evaluation should take into account all aspects of a species' life history and make the best judgment they can (acknowledging that there are no set or quantitative criteria for "fast", "medium" or "slow").

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 characteristics to the species of interest. Nevertheless, Scientific Authorities should endeavor to increase their knowledge of a species' biology by undertaking field studies or studying snakes as they are collected for trade.

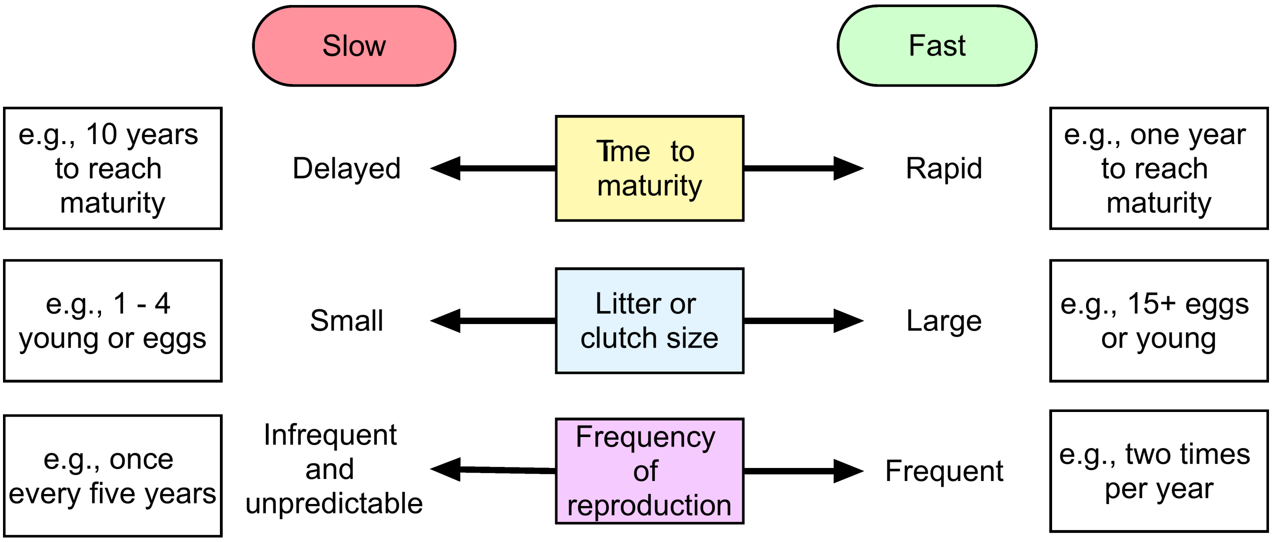


Fig. 2. Diagram of life history trait gradients, highlighting the difference between "fast" and "slow" life histories (modified with permission from Fitzgerald, 2017).

Additional risk factors

CITES NDFs should consider 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 **Annual 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.

In addition, other threatening processes acting on a species may compound the risk of harvesting for trade. For example, the likelihood of a harvest being detrimental may be greater for a species of snake that is impacted by invasive predators than one that is not. Therefore, as a precautionary measure, Scientific Authorities should check the species' IUCN Red List status when completing a *Primary Evaluation*. If the species is listed as Vulnerable, Endangered or Critically Endangered, then a maximum score of "**1**" should be given under this criterion. Inclusion of this criterion is a useful way to assess a broad range of additional risks, while at the same time keeping the *Primary Evaluation* simple and effective for users.

Completing a *Primary Evaluation* with limited data

The *Primary Evaluation* has been designed so that it can be completed using minimal information about a species. Hence, there should be few instances where a cursory level of knowledge is unavailable. For example, harvest or export levels should be known, because the CITES Management Authority will contact the Scientific Authority to receive input for exports of a given number of specimens. Similarly, some knowledge of the species' area of occupancy should be known, because a type locality for the species is available. If no other information is known about the species, or if its life-history traits are unknown or cannot be inferred through knowledge of closely related species, then a precautionary approach should be applied.

Note on the criteria used

The values used for the three main criteria in the *Primary Evaluation* are based partly on values provided in the IUCN Red List Criteria. They have been tested and applied to all CITES Appendix II listed snakes currently being ranched or harvested from the wild for trade. *Primary Evaluation* scores for all CITES-listed snakes species can be found in Annex B. Although the criteria used in the *Primary Evaluation* are specific and managers might not have perfect information about a species (e.g., the area of occupancy might be higher than estimated), the categories are broad. Therefore, the likelihood that managers will evaluate a species based on the correct category for any given attribute is very high.

For worked examples of *Primary Evaluation* for CITES-listed snakes see Annex B.

4.4 Step 2: *Secondary Evaluation*

Having completed a *Primary Evaluation*, if non-detriment cannot be easily established then a *Secondary Evaluation* is needed. Using available information, Scientific Authorities must aim to reject the following criteria:

An observed, estimated, inferred or suspected continuing decline in any of the following:

- **i.** population abundance,
- **ii.** national area of occupancy,
- **iii.** number of locations or subpopulations,
- **iv.** number of mature individuals,
- **v.** mean body sizes,
- **vi.** minimum sizes at sexual maturity,
- **vii.** catch per unit effort, and/or
- **viii.** other factors indicative of unsustainable harvesting

These criteria have been modified from the IUCN Red List criteria for threatened species and the criteria used by the CITES Parties to assess the need for inclusion of species within Appendix I (Res. Conf. 9.24). Each of these criteria are common indices used by wildlife managers to assess the sustainability of offtake. If any of the criteria above are being met, then use may not be sustained, which may lead to detrimental trade and require management intervention to prevent further declines. Go to **Step 3**.

If sufficient information is available to reject each of the criteria above, then a positive NDF can be made and reported at **Step 4**.

4.5 What should a *Secondary Evaluation* look like?

A *Secondary Evaluation* can be simple or complex, and the data needed to ensure trade is non-detrimental should be commensurate with the level of risk. For example, non-detriment may be easily satisfied for a species if 80% of its range occurs within protected areas, resulting in only 20% of the species' population being available for harvest. Alternatively, simple monitoring data may be sufficient to satisfy non-detriment. For example, CITES Scientific Authorities may have data showing that annual harvest or export volumes, and the numbers of permits issued, has remained constant over time, and periodic field surveys have shown that the species can still be found with relative ease throughout its range. Such simple data may be sufficient to complete a *Secondary Evaluation* and satisfy non-detriment.

In other cases, more complex monitoring may be required to satisfy non-detriment with sufficient confidence. In all of these cases, however, Scientific Authorities should be focusing their efforts on ensuring that declines in the attributes listed above are not occurring.

For further information on monitoring methodologies that can be used to inform the *Secondary Evaluation* see Section IV in Annex A.

For worked examples of *Secondary Evaluations* see Annex C.

4.6 Step 3: Management intervention

Where revised management procedures are required to ensure non-detriment, but are not yet implemented, Parties should describe which monitoring and management interventions are planned, and how the results are going to be interpreted in terms of non-detriment in **Step 4**.

The types of management interventions to be implemented, and the severity of those interventions, will be dependent on the species, the risk of harvesting and trade, and the country specific context. For example, some harvests may require slightly narrower size limits for specimens that can be harvested. In other cases, management interventions may include significant reductions in harvesting quotas, or in cases where monitoring has revealed more severe population declines – suspension of exports. Commonly used management interventions include:

- Size restrictions
- Season restrictions
- Effort restrictions
- Quotas
- Export suspensions

Further guidance on the types and ways to implement specific management interventions is available in Section V, Annex A.

4.7 Step 4: Reporting

The NDF report should detail the steps taken to establish non-detriment. For many species this may simply be a completed *Primary Evaluation*, but for others requiring a *Secondary Evaluation* it may include basic analyses of harvest trends through to detailed monitoring and management protocols. **The results and explanation of monitoring protocols or management systems used to complete the *Secondary Evaluation* do not need to follow a specific format.**

4.8 Decision making in situations of poor data availability

When data are insufficient or unavailable to reject the criteria within the *Secondary Evaluation*, then Scientific Authorities should endeavor to improve monitoring protocols (using guidance on monitoring systems in **Section IV, Annex A**) or implement precautionary management interventions to ensure trade will not be detrimental (using guidance in **Section V, Annex A**).

5.0 Managing snake populations

Managing the harvest of snakes for trade can be simple or complex, with a system's complexity depending largely on the aims of the managers and the benefits to be derived from the resource. For example, where the probability of unsustainable harvesting is low, little or no harvest management may be required. Where detriment is suspected, simply reducing the harvest and exports may be a better use of resources than implementing sophisticated harvest management systems. On the other hand, sophisticated harvest management systems may be needed to improve the maximum sustainable yield of the resource to provide greater economic returns or to improve confidence that harvesting at a given level is non-detrimental to the species. Regardless of the type of management systems implemented, it should ideally incorporate ongoing monitoring to detect future changes in the harvested population and allow follow-up corrective action to be taken when necessary.

These NDF Guidelines do not prescribe what a management system should look like. Parties can implement different management systems to assist NDFs for CITES-listed snakes and each can be evaluated based on its respective merits.

Tools that can be used to manage harvest of snakes are presented and discussed in Section V, Annex A. Examples of management system and specific management intervention for snakes are provided in Annex C.

5.1 Designing an appropriate management system

The design of a case-specific management system for trade in a species is often complex. The uncertainties involved and the desire to allow trade only when complete knowledge of species biology and harvest level is attained can hinder proper management. In reality, complete knowledge is often unattainable and management systems must rely on an adaptive management approach. Adaptive management is widely recommended as a means of dealing with extreme uncertainty in population management and decision-making (including within CITES Resolution Conf. 16.7 on NDFs). The basic principle is that management decisions should be treated as deliberate, large-scale experiments; hence, achieving an optimal management system is done via a constant process of trial and error. Adaptive management is particularly important for snakes, whose populations are inherently difficult to survey in the field with accuracy (discussed in **Section 3.0**). This difficulty is commonly compounded by a lack of information such as population immigration rates, movement patterns of snakes and age-specific survival. Nevertheless, through a process of constant testing, evaluation and refinement, it is possible to arrive at management solutions that benefit snakes, people, and the environment.

An appropriate management system should thus incorporate both monitoring and management so that management interventions can be applied if monitoring reveals potentially detrimental changes in the harvested population. Three important steps should be incorporated in the design of a holistic management system for snakes:

1) Understanding the natural history and trade dynamics of the species concerned;

2) Deciding on and implementing an appropriate and case-specific monitoring system (**Guidance in Section IV, Annex A**);

3) Deciding on and implementing appropriate management interventions to ensure harvesting remains within sustainable levels (**Guidance in Section V, Annex A**).

5.2 Dedicated funding

No management or monitoring system can be developed, implemented and maintained without dedicated funding. Because appropriate management can maintain healthy populations of snakes, and the economic benefits derived from them, it is in the best interest of Parties and the people involved in the harvest and trade in snakes to allocate funds to monitoring and management of species in trade. Thus, when designing a management system as part of a CITES NDF, a dedicated funding mechanism should be included. Whether the funding is sourced from the Government allocated budget, procured from levies taken from the industry itself is not of concern. Without a strong funding framework in place, the continuity of any monitoring and management system will be jeopardized, and may prevent Parties from completing satisfactory NDFs in the future. Caution must be exercised concerning cost-effectiveness. Management or monitoring plans should be designed to fit available economic resources and implemented in harmony with potential benefits derived from the use of the resource. Some management plans become so rigorous and sophisticated that they are eventually no longer economically viable in cost-benefit terms.

Annex A

Additional Guidance on CITES NDFs for Snakes

Section I . Background to this guidance

This Non-detriment Findings (NDF) Guidance for snakes is the result of Decision 16.102 from the Sixteenth Meeting of the Conference of the Parties to CITES (Bangkok, Thailand, 03-14 March 2013). At CoP16, the Parties requested the CITES Secretariat to:

"*compile information and develop guidance that can assist Parties in the making of non-detriment findings, management systems for wild populations and the establishment of export quotas for Appendix-II snake species in trade, by undertaking relevant research, consulting with relevant experts, examining suitable examples and case-studies, and building on the results of the International Expert Workshop on CITES Non-Detriment Findings (Cancún, 2008) and recommendations on the making of non-detriment findings from the Conference of the Parties.*" http://www.cites.org/eng/cop/16/doc/E-CoP16-57.pdf

The CITES Secretariat in turn commissioned the IUCN, through the IUCN-SSC Boa and Python Specialist Group (BPSG), to assist this task. This report is the result of this work and aims to provide CITES Scientific Authorities with guidance in monitoring, management and implementation of effective NDFs for snakes, so trade can continue to benefit people while ensuring wild populations are not negatively impacted.

This Guidance was refined in May 2017 at an Expert Workshop on the Making of CITES Non-detriment Findings for Appendix II listed snakes held in Kuala Lumpur, Malaysia.

Click here to return to the Introduction.

Section II . Definitions and concepts

This section 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 the principles of harvest biology, and how this might be applied to developing the basic capacity to make NDFs. 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 CITES Convention 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**).

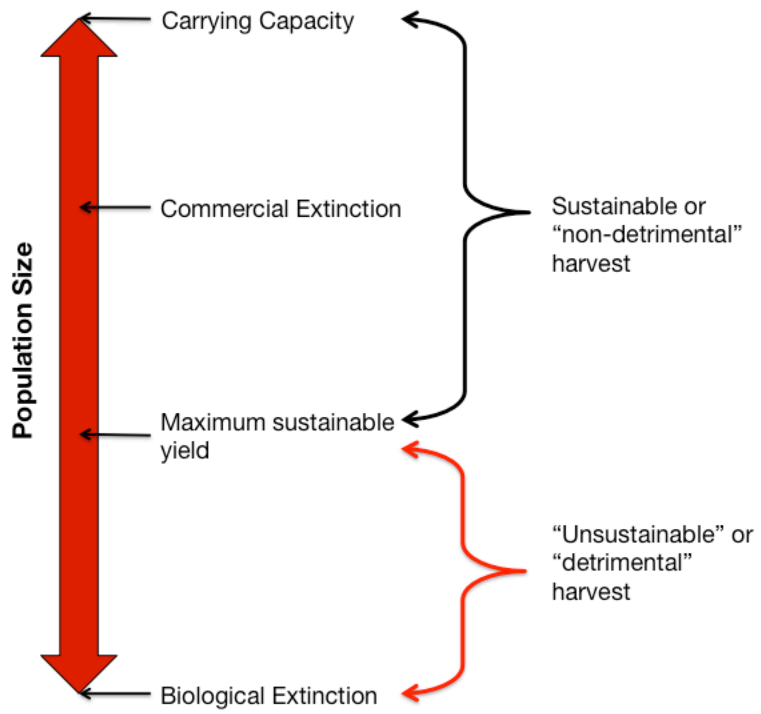


Fig. 1. Hypothetical visual representation of how several concepts of sustainable use and detriment interact, and their application to a population of snakes.

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 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 population sizes 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 sustainable 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).

As 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.

Click here to return to return to Defining "Non-detriment".

Section III – 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 and 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 and 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 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 snakes 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, people 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 collectors. 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.

Click here to return to Management context for snakes.

Section IV . Additional guidance on completing a *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 or use of basic information). For example, although a species may have qualified for a *Secondary Evaluation*, 80% of its population may occur in protected areas, making a secondary assessment straightforward. However, for those Parties for which such information is not available, it may not be possible to make a decision about non-detriment with reasonable confidence. 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 detrimental trends in snake populations. This is because snake populations exhibit enormous variability and unpredictability in annual 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 tip, 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 not define another. In addition, the trade dynamics and market forces that act upon different snake supply chains vary among species, between countries, and over time. This inevitably results in no two non-detriments findings being the same, 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.

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 a harvest can be monitored. These are:

- Hunters and collectors (the first people in the trade chain that are capturing the snakes)
- Traders and exporters (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 pet collectors 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 V**). **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.

Natusch et al., (2016) offers a useful example of harvesting monitoring data being used to assess sustainability in a heavily traded snake.

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 are recorded. • Two of the five 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 implement a management intervention to ensure 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, 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.	• Annual visits are made to four snake hunters in Province A and four snake hunters in Province B to examine harvest rates and gather other harvest information. • 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 is known • Export volumes are recorded in the CITES Trade Database.	Visits to hunters in Province A reveal that the number of snakes collected and harvesting effort has remained stable. However, hunters in Province B are collecting the same number of snakes, but claim 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 reveal the number of snakes collected, their body sizes, and their sexes, have remained stable. In Province B, the number of snakes collected has remained stable, but the average size of snakes has decreased from 1.5 to 1.1 metres and, unlike previous years, the harvest has become heavily skewed towards males. The CITES trade database suggests that meat exports are slowly decreasing.	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 implement a management intervention to improve the sustainability. 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 3.0**, 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. Too much time may be required 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 implement a management intervention 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 a management intervention should be implemented to improve sustainability.

Section V . Managing snake populations

Harvest management tools

If population changes are observed when monitoring (using either harvest or population field monitoring described in **Section IV**), 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.

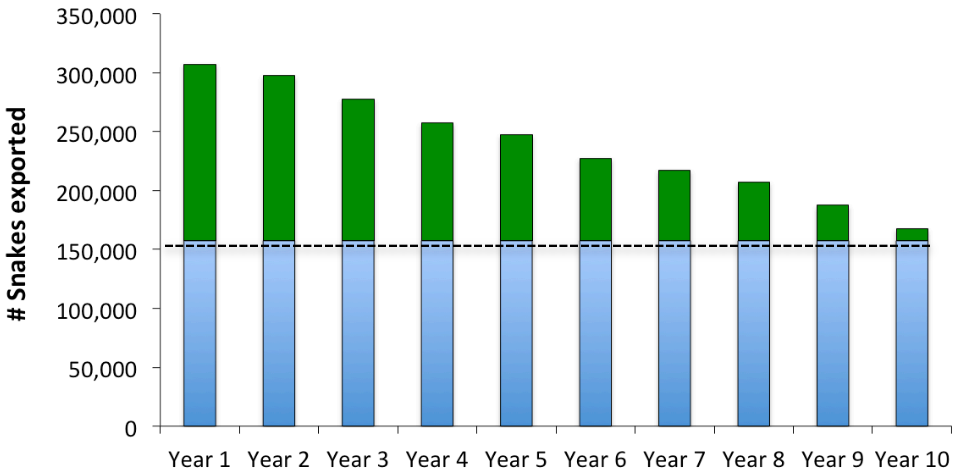


Fig. 2. A scenario where the effect of harvesting is hidden by a quota. The legal exports (blue columns) remain constant, giving the impression that sustainability has been achieved, when in reality the overall harvest has been declining as indicated by the decrease in illegal trade (green columns).

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 is a useful tool 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 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 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 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 for 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.

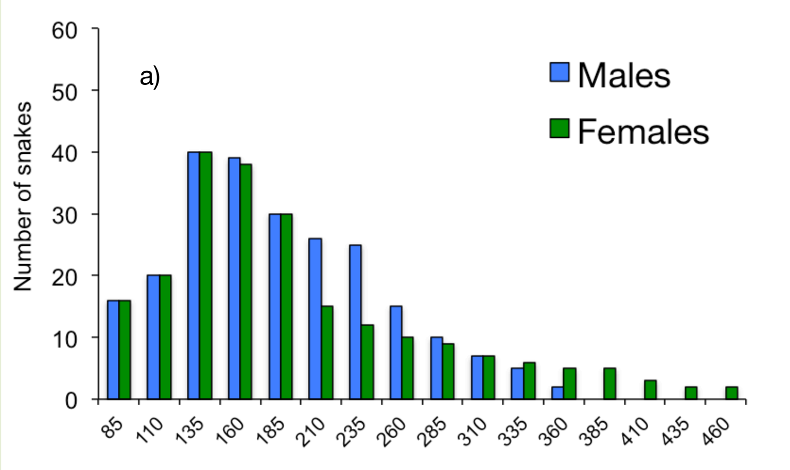


Fig. a). A hypothetical snake population showing the total number of males (blue) and females (green) within each size class. It can be seen that females grow larger than males.

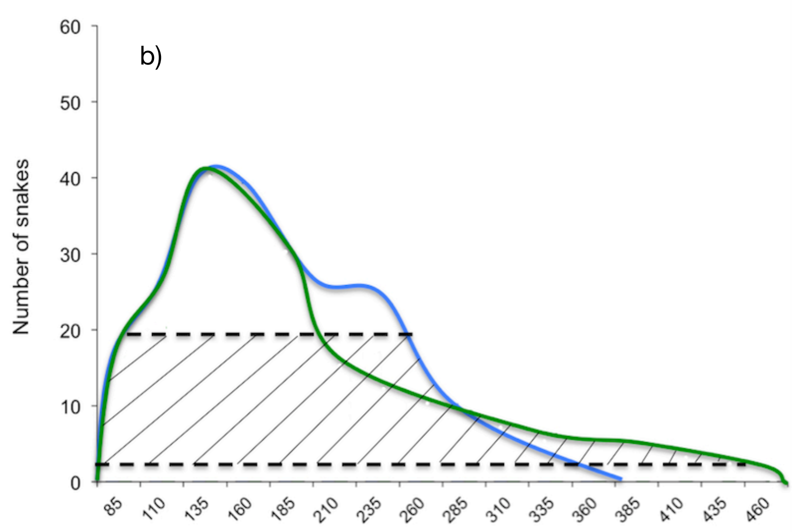


Fig. b). The same snake population with a set quota. The hatched area depicts the total number of snakes that can be legally harvested. Note that the quota restricts the number of individuals that can be harvested, but it does not discriminate the types (e.g., sizes or sexes) of individuals that can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

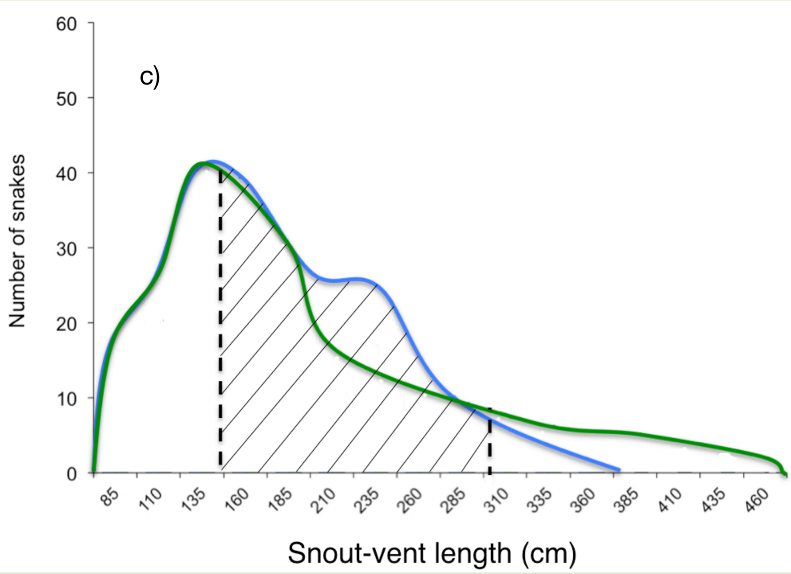


Fig. c). The same snake population with a size restriction only allowing the harvest of individuals between 150 and 300 cm in length. The hatched area depicts the total number of snakes that can be legally harvested. Using this method, small immature individuals and large females can be protected from 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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Annex B

Primary Evaluation template and examples for CITES NDFs for snakes

CITES Non-detriment finding

Primary Evaluation Template

Text in italics is explanatory and should be deleted in completed documents. Please refer to the NDF Guidelines document for further explanation on how to complete this evaluation.

Species name	
Range state name	
Report compiled by	
Date compiled	

Section One: Summary

Please provide a short overview (1-2 paragraphs) of the trade in this species in the country of interest.

Section Two: Primary Evaluation score

Please score each attribute listed within the table below and sum these to provide a total.

	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	
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			

Section Three: Justification – Annual harvest level

Please provide an explanation with appropriate references to justify the score given.

Section Four: Justification – Area of occupancy
Please provide an explanation with appropriate references to justify the score given.
Section Five: Justification – Life history
Please provide an explanation with appropriate references to justify the score given.
Section Six: Justification - Additional risk factors
Please provide an explanation with appropriate references to justify the score given.
Section Seven: Conclusion, course of action and determination on exports
Please provide an overall conclusion on the perceived threat of trade to the species and details on whether further course of action will be taken to complete an NDF for the species. .

Section Eight: Literature cited
Please provide references to all the reports and literature cited in this evaluation.

CITES Non-detriment finding

Primary Evaluation Template

Text in italics is explanatory and should be deleted in completed documents. Please refer to the NDF Guidelines document for further explanation on how to complete this evaluation.

Species name	Boa Constrictor (*Boa constrictor constrictor*)
Range state name	Suriname
Report compiled by	Suriname CITES Scientific Authority (**example only**)
Date compiled	2011 to 2012 (**example only**)

Section One: Summary

Please provide a short overview (1-2 paragraphs) of the trade in this species in the country of interest.

Boa constrictor is harvested from the wild in Suriname and is exported for the pet trade. They are harvested from throughout the country and approximately 200 – 300 specimens are exported annually. An export quota of 1010 individuals per annum is currently in place.

Section Two: Primary Evaluation score

Please score each attribute listed within the table below and sum these to provide a total.

	Number of points			Score
Criteria	**1**	**2**	**3**	
Annual harvest level	Low (<2,000)	Medium (2,000 - 20,000)	High (>20,000)	**1**
Area of occupancy	Large (>20,000km^2)	Medium (2,500 – 20,000km^2)	Small (<2,500km^2)	**1**
Life history	Fast	Medium	Slow	**2**
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			**0**

Section Three: Justification – Annual harvest level

Please provide an explanation with appropriate references to justify the score given.

A harvest quota of 1,010 individuals is allocated for harvest in all of Suriname annually. There is no evidence of illegal trade and only 1/3 of this quota is realised each year (exports between 200 – 300 individuals per year). This justifies the harvest level score of **1** (low).

Section Four: Justification – Area of occupancy

Please provide an explanation with appropriate references to justify the score given.

Boa constrictor occurs throughout Suriname. It is a generalist species that thrives in modified and anthropogenic habitats (including cities) (Henderson et al. 1995). For this reason we deem the area of occupancy within Suriname to be the total land area of the country: 163,821 km^2. This extent is considerably larger than 20,000 km^2 and thus justifies an area of occupancy score of **1**.

Section Five: Justification – Life history

Please provide an explanation with appropriate references to justify the score given.

Boa constrictor is a livebearer with a high reproductive output, producing an average of 27 young in a litter and up to 65 young in large females (Bertona and Chiaraviglio, 2003; Pizzatto and Marques, 2007). They are fast growing, but probably only produce litter bi-annually (Bertona and Chiaraviglio, 2003; Pizzatto and Marques, 2007). For this reason we follow a precautionary approach and give a life history score of **2** (medium).

Section Six: Justification - Additional risk factors

Please provide an explanation with appropriate references to justify the score given.

There is no evidence of illegal trade in *Boa constrictor* from Suriname. For this reason we assign a score of **0**.

Section Seven: Conclusion, course of action and determination on exports

Please provide an overall conclusion on the perceived threat of trade to the species and details on whether further course of action will be taken to complete an NDF for the species.

The sum of scores for the attributes listed above is **4**. All scores four and below do not require that a secondary evaluation be completed. Based on the information presented above, we can be confident that harvesting for trade does not affect the viability of *Boa constrictor* populations in Suriname.

This primary evaluation is a sufficient NDF for *Boa constrictor* in Suriname. Exports are deemed to be non-detrimental. Trade is allowed to continue and no further course of action will be taken to monitor or manage harvests.

Section Eight: Literature cited

Please provide references to all the reports and literature cited in this evaluation.

Bertona, M., and Chiaraviglio, M. (2003) Reproductive biology, mating aggregations, and sexual dimorphism of the Argentine Boa Constrictor (Boa constrictor occidentalis). Journal of Herpetology. 37, 510-516.

Henderson, R., Waller, T., Micucci, P., Puorto, G., and Bourgeois, R. (1995). Ecological correlates and patterns in the distribution of neotropical Boines (Seprentes: Boidae): A preliminary assessment. *Herpetological Natural History*, **3**, 15-27.

Pizzatto, L., Marques, O.A.V. (2007): Reproductive ecology of Boine snakes with emphasis on Brazilian species and a comparison to Pythons. South Am. J. Herp. 2: 107-122

CITES Non-detriment finding

Primary Evaluation Template

Text in italics is explanatory and should be deleted in completed documents. Please refer to the NDF Guidelines document for further explanation on how to complete this evaluation.

Species name	White-lipped python (*Leiopython albertisii*)
Range state name	Indonesia
Report compiled by	Indonesian CITES Scientific Authority (**example only**)
Date compiled	2011 to 2012 (**example only**)

Section One: Summary

Please provide a short overview (1-2 paragraphs) of the trade in this species in the country of interest.

Leiopython albertisii is harvested from the wild in Indonesia and is exported for the pet trade. All specimens are harvested from the wild in the provinces of Papua and West Papua. An annual harvest quota of 400 individuals is allocated. There is evidence that some wild specimens may be illegally exported as captive bred. Nevertheless, total annual exports are only 800 specimens.

Section Two: Primary Evaluation score

Please score each attribute listed within the table below and sum these to provide a total.

	Number of points			Score
Criteria	1	2	3	
Annual harvest level	Low (<2,000)	Medium (2,000 - 20,000)	High (>20,000)	**1**
Area of occupancy	Large (>20,000km^2)	Medium (2,500 – 20,000km^2)	Small (<2,500km^2)	**1**
Life history	Fast	Medium	Slow	**2**
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			**0**

Section Three: Justification – Annual harvest level

Please provide an explanation with appropriate references to justify the score given.

A harvest quota of 400 individuals is allocated for harvest in the provinces of Papua and West Papua annually. There is some evidence that this quota may be exceeded and individuals are exported as captive-bred. Even if this is occurring, annual exports are approximately 800 individuals, which justify the harvest level score of **1** (low).

Section Four: Justification – Area of occupancy

Please provide an explanation with appropriate references to justify the score given.

L. albertisii occurs in the Indonesian provinces of Papua and West Papua (Natusch and Lyons 2012). It primarily inhabits primary rainforest and secondary regrowth habitats below 800 m above see level (O'Shea 1996). The extent of primary and secondary rainforest in Papua is 176,750 km^2 (Johns et al. 2006). This extent is considerably larger than 20,000 km^2 and thus justified an area of occupancy score of **1**.

Section Five: Justification – Life history

Please provide an explanation with appropriate references to justify the score given.

L. albertisii has a high reproductive output, producing 15 to 20 eggs in a clutch (Natusch and Lyons 2012; Parker 1982). Studies of closely related species inhabiting tropical areas suggest that growth rates are likely to be high. However, like closely related species, *L. albertisii* probably only reproduces every second year (Madsen and Shine, 2000). For this reason we follow a precautionary approach and give a life history score of **2** (medium).

Section Six: Justification - Additional risk factors

Please provide an explanation with appropriate references to justify the score given.

There is evidence of small volumes of illegal trade, where wild-caught snakes may be being mis-declared and exported as captive-bred (Natusch and Lyons, 2012). Even so, total exports of *Leoipython albertisii* from Indonesia (from all sources) is only approximately 800 individuals annually. Even if all of these individuals are taken from the wild, this level of harvest is deemed to have no impact on the species and as such is given a score of **0**

Section Seven: Conclusion, course of action and determination on exports

Please provide an overall conclusion on the perceived threat of trade to the species and details on whether further course of action will be taken to complete an NDF for the species.

The sum of scores for the attributes listed above is **4**. All scores of four and below do not require that a Secondary Evaluation be completed. Based on the information presented above, we can be confident that harvesting for trade does not currently affect the viability of *L. albertisii* populations.

This primary evaluation is a sufficient NDF for *L. albertisii*. Current exports are deemed to be non-detrimental. Trade is allowed to continue and no further course of action will be taken to monitor or manage harvests.

Section Eight: Literature cited

Please provide references to all the reports and literature cited in this evaluation.

Johns, J., Shea, G., and Puradyatmika, P. (2006). Lowland vegetation in Papua. In Marshall, A.J., and Beehler, B.M. (eds.). 2006. The Ecology of Papua. Singapore: Periplus Editions.

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Annex C

Secondary Evaluation examples for CITES NDFs for snakes

CITES Non-detriment finding

Primary Evaluation Template

Text in italics is explanatory and should be deleted in completed documents. Please refer to the NDF Guidelines document for further explanation on how to complete this evaluation.

Species name	Caicos Islands Dwarf Boa – *Tropidophis greenwayi*
Range state name	Great Britain (British Overseas Territory – **example only**)
Report compiled by	The CITES Scientific Authority (**example only**)
Date compiled	2017 (**example only**)

Section One: Summary

Please provide a short overview (1-2 paragraphs) of the trade in this species in the country of interest.

The Caicos island boa is a small species of boa endemic to the Turks and Caicos Islands. Two species are recognised – *T. greenwayi greenwayi* from Big Abergis Island and *T. greenwayi lanthanus* from the rest of the Turks and Caicos. The species is traded occasionally for pets, and each year a legal harvest of 100 specimens is allowed from throughout the species range*.

*This is a hypothetical scenario using a real species. *T. greenwayi* has been chosen for illustrative purposes only, but there is currently no known trade in this species from the Turks and Caicos Islands.

Section Two: Primary Evaluation score

Please score each attribute listed within the table below and sum these to provide a total.

	Number of points			**Score**
Criteria	**1**	**2**	**3**	
Annual harvest level	Low (<2,000)	Medium (2,000 - 20,000)	High (>20,000)	**1**
Area of occupancy	Large (>20,000km^2)	Medium (2,500 – 20,000km^2)	Small (<2,500km^2)	**3**
Life history	Fast	Medium	Slow	**3**
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			**1**

Section Three: Justification – Annual harvest level

Please provide an explanation with appropriate references to justify the score given.

The quota and annual harvest level for *T. greenwayi* is small (100 individuals). There is no evidence of substantial illegal trade. This justifies the harvest level score of 1 (low).

Section Four: Justification – Area of occupancy

Please provide an explanation with appropriate references to justify the score given.

T. greenwayi is endemic to the Turks and Caicos Islands, meaning it is found nowhere else in the world (Edgar, 2009; Henderson and Powell, 2009). The islands have a combined total area of 612 km^2 (Reynolds, 2011; Reynolds and Gerber, 2012). *T. greenwayi* is known only from the larger islands in archipelago (Reynolds et al. 2010), hence the area of occupancy is considerably smaller than 2,000 km2 and thus justifies a score of 3 (small).

Section Five: Justification – Life history

Please provide an explanation with appropriate references to justify the score given.

T. greenwayi has been poorly studied, and there is little is known about it life history. However, captive specimens are known to breed annually, and reach sexual maturity at small sizes (Iverson, 1986). These attributes may suggest a fast life history, however, the species only has between 1- 3 offspring in a litter, which is a small number (Henderson and Powell, 2009). Due to the lack of detailed information about this species, and the small litter sizes, a precautionary score of 3 (slow) has been given for life history.

Section Six: Justification - Additional risk factors

Please provide an explanation with appropriate references to justify the score given.

There is no evidence of illegal harvesting taking place, and *T. greenwayi* has not been assessed by the IUCN. However, much of the Turks and Caicos Islands has experienced significant development and associated habitat loss for the tourism industry (Reynolds, 2011; Reynolds and Gerber, 2012). In addition, several introduced species have become established on the islands. The small size of *T. greenwayi* suggests it may be severely impacted by introduced pests (Reynolds and Niemiller, 2010). For these reasons, an additional risk factor score of 1 has been given.

Section Seven: Conclusion, course of action and determination on exports

Please provide an overall conclusion on the perceived threat of trade to the species and details on whether further course of action will be taken to complete an NDF for the species.

.

T. greenwayi scored an 8 in the primary evaluation, suggesting the species is highly susceptible to threatening processes. A more detailed Secondary Evaluation is required to ensure current harvest and trade levels are non-detrimental.

Section Eight: Literature cited

Please provide references to all the reports and literature cited in this evaluation.

Edgar, P. 2009. *The Amphibians and Reptiles of the UK Overseas Territories, Crown Dependencies and Sovereign Base Areas: Species Inventory and Overview of Conservation and Research Priorities*. Herpetological Conservation Trust, Dorset.

Iverson, J.B. 1986. Notes on the natural history of the Caicos Islands Dwarf Boa *Tropidophis greenwayi*. *Caribbean Journal of Science* 22:191–198.

Henderson, R. W., and R. Powell. 2009. Natural History of West Indian Reptiles and Amphibians. University Press of Florida, Gainesville.

Reynolds, R. G., G. P. Gerber, and J. Burgess. 2010. *Tropidophis greenwayi greenwayi* (Big Ambergris Dwarf Boa). Geographic distribution. *Herpetological Review* 41:520.

Reynolds, R. G., and M. L. Niemiller. 2010. Island invaders: Introduced reptiles and amphibians of the Turks and Caicos Islands. *Reptiles & Amphibians* 17:117–121.

Reynolds, R. G. 2011. Status, conservation, and introduction of amphibians and reptiles in the Turks and Caicos Islands, British West Indies. Pp. 377–406 in A. Hailey, B. S. Wilson, & J. A. Horrocks, eds. Conservation of Caribbean Island Herpetofaunas. Volume 2: Regional Accounts of the West Indies. Brill, Leiden, The Netherlands.

Reynolds, R.G., and Gerber, G.P. 2012. Ecology and conservation of the endemic Turks Island Boa (*Epicrates c. chrysogaster*: Serpentes: Boidae) on Big Ambergris Cay. *J. Herpetol*. 46, 578–586.

Schwartz A. 1963. "A new subspecies of *Tropidophis greenwayi* from the Caicos Bank". *Breviora* 194:1-6.

Example *Secondary Evaluation* - Caicos Islands Dwarf Boa *Tropidophis greenwayi**

*This is a hypothetical scenario using a real species. *T. greenwayi* has been chosen for illustrative purposes only, but there is currently no known trade in this species from the Turks and Caicos Islands.

Trade monitoring data

Over the past 10 years, a single trader has been permitted to collect and export specimens of *T. greenwayi*. The annual harvest quota has been set at 100 individuals per year, with harvest occurring on all islands. The number of boas exported each year has remained stable, and all individuals are exported to the United States for the pet trade. The exporter is located on the most developed island in the Turks and Caicos group – Providenciales.

Interviews with the exporter have revealed that collection from the wild occurs whenever US animal traders place an order for the species. The exporter claims that collection of specimens could occur relatively rapidly in the past, but lately it taking more time to fulfil an order. The exporter claims that this is because habitat loss has meant collectors need to travel to other islands within the archipelago to find snakes. The exporter claims that the species is still common on less populated islands.

Population monitoring in the field

T. greenwayi has always been a difficult species to locate during field surveys in the wild. This is due mainly to their small size, semi-fossorial habits (they live in leaf litter) and nocturnal activity patterns (Iverson, 1986). Most specimens captured for trade are done so opportunistically after heavy rains. Nevertheless, the species is one of the more common snakes encountered during cover-board surveys that have been conducted on several islands. Other related species of insular boid snakes are very common on some islands where suitable habitat persists (Reynolds and Gerber, 2012). The main prey species of *T. greenwayi* (Anoles and geckos) are common on the islands. In summary, it is unknown whether the apparent rarity of *T. greenwayi* is due to naturally low densities, poor detectability, or declines from former levels of abundance (or all three)?

Current management protocol

Current management protocols are limited to the annual harvest and export quota of 100 individuals. No other management protocols are in place.

Non-detriment finding conclusion

At present, *T. greenwayi* remains very poorly known. This lack of information, coupled with anecdotal information about declines on some islands, increasing development and habitat loss, and the threat of invasive species, does not allow the CITES Scientific Authority to make a positive NDF for an annual harvest and export of 100 specimens of this species from the Turks and Caicos Islands.

Proposed management interventions and research to ensure non-detriment

In order to grant a positive non-detriment finding for this species, the CITES Scientific Authority advises the CITES Management Authority to take a precautionary approach and implement the following management interventions:

i. Reduce the harvest of *T. greenwayi* from 100 specimens per year to 30 specimens per year,

ii. Only allow the harvest and export of specimens smaller than 22 cm SVL, which coincides with sexual maturity in females and thus protects reproductive individuals. Harvesting of juveniles is relatively biologically safe as those specimens have a higher probability of succumbing to natural mortality.

iii. Inspection of exports of the species should be undertaken to ensure adherence by the exporter to the legal size limit,

iv. Only allowing harvesting to take place on the relatively large islands of North, Middle and East Caicos islands,

v. Ensure harvesting does not take place on Big Ambergris Cay, where the sub-species *T. greenwayi greenwayi* is found,

vi. With the aid of herpetology students, undertake bi-annual cover-board surveys on North and Middle Caicos Islands (where harvest is allowed to take place), as well as two unharvested islands, to assess the relative abundance of *T. greenwayi* in harvested and unharvested landscapes.

Implementation of these management interventions will result in a positive NDF for this species. The NDF should be repeated and harvests reassessed in two years time, once results from the cover-board surveys become available.

Literature cited

Edgar, P. 2009. *The Amphibians and Reptiles of the UK Overseas Territories, Crown Dependencies and Sovereign Base Areas: Species Inventory and Overview of Conservation and Research Priorities*. Herpetological Conservation Trust, Dorset.

Iverson, J.B. 1986. Notes on the natural history of the Caicos Islands Dwarf Boa *Tropidophis greenwayi*. *Caribbean Journal of Science* 22:191–198.

Henderson, R. W., and R. Powell. 2009. Natural History of West Indian Reptiles and Amphibians. University Press of Florida, Gainesville.

Reynolds, R. G., G. P. Gerber, and J. Burgess. 2010. *Tropidophis greenwayi greenwayi* (Big Ambergris Dwarf Boa). Geographic distribution. *Herpetological Review* 41:520.

Reynolds, R. G., and M. L. Niemiller. 2010. Island invaders: Introduced reptiles and amphibians of the Turks and Caicos Islands. *Reptiles & Amphibians* 17:117–121.

Reynolds, R. G. 2011. Status, conservation, and introduction of amphibians and reptiles in the Turks and Caicos Islands, British West Indies. Pp. 377–406 in A. Hailey, B. S. Wilson, & J. A. Horrocks, eds. Conservation of Caribbean Island Herpetofaunas. Volume 2: Regional Accounts of the West Indies. Brill, Leiden, The Netherlands.

Reynolds, R.G., and Gerber, G.P. 2012. Ecology and conservation of the endemic Turks Island Boa (*Epicrates c. chrysogaster*: Serpentes: Boidae) on Big Ambergris Cay. *J. Herpetol*. 46, 578–586.

Schwartz A. 1963. "A new subspecies of *Tropidophis greenwayi* from the Caicos Bank". *Breviora* 194:1-6.

CITES Non-detriment finding

Primary Evaluation Template

Text in italics is explanatory and should be deleted in completed documents. Please refer to the NDF Guidelines document for further explanation on how to complete this evaluation.

Species name	Yellow Anaconda (*Eunectes notaeus*)
Range state name	Argentina
Report compiled by	Fundación Biodiversidad Argentina (**example only**)
Date compiled	2015 (**example only**)

Section One: Summary

Please provide a short overview (1-2 paragraphs) of the trade in this species in the country of interest.

Eunectes notaeus is harvested from the wild in Argentina for its skin. Approximately 3,500 specimens are harvested and exported annually, largely from the province of Formosa in northern Argentina. No harvest quota is established, and local people are allowed to harvest as many snakes as they want between specific sizes and in a defined hunting season.

Section Two: Primary Evaluation score

Please score each attribute listed within the table below and sum these to provide a total.

	Number of points			Score
Criteria	**1**	**2**	**3**	
Annual harvest level	Low (<2,000)	Medium (2,000 - 20,000)	High (>20,000)	**2**
Area of occupancy	Large (>20,000km^2)	Medium (2,500 – 20,000km^2)	Small (<2,500km^2)	**2**
Life history	Fast	Medium	Slow	**2**
Additional risk factors	Other factors influencing the risk of harvesting should be taken into account. Specifically, if there is evidence of illegal trade and/or the status of the species is listed as vulnerable, endangered, or critically endangered on the IUCN Red List, give a **maximum score of 1 point**			**0**

Section Three: Justification – Annual harvest level

Please provide an explanation with appropriate references to justify the score given.

There is no fixed limit on the number of individual snakes that can be harvested annually from Argentina. As a result, annual harvests and exports fluctuate. Nevertheless, the average annual offtake is approximately 3,500 snakes (up to a maximum of 6,000 snakes per year). There is no evidence that illegal harvest or trade is taking place. Based on this information, we provide a harvest score of **2** (medium).

Section Four: Justification – Area of occupancy

Please provide an explanation with appropriate references to justify the score given.

Within Argentina *E. notaeus* occurs only in aquatic inland ecosystems, specifically swamps, seasonally flooded marshes, or riverine habitats, associated with the Paraguay River and the middle sector of the Paraná River (Strüssmann and Sazima, 1993; Henderson et al., 1995; Dirksen, 2002) The yellow anaconda's extent of occurrence in Argentina encompasses about 120,000 km^2 (Micucci et al., 2006). Assuming a conservative 1:3 wetland/dry land ratio throughout this wetland-dominated area, we estimate that the total area of occupancy within Argentina is not less than 40,000 km^2. Nevertheless, because most of the yellow anacondas captured for trade originate from the La Estrella Marsh, which covers an area of 3,500 km^2, we conservatively assign an Area of Occupancy score of **2** (medium).

Section Five: Justification – Life history

Please provide an explanation with appropriate references to justify the score given.

E. notaeus has a high reproductive output, producing a mean of 24 offspring per litter. Growth is rapid, with females reaching sexual maturity after two to three years. However, data from dissections of individuals captured for trade shows that frequency of reproduction varies among populations and between years, with female snakes reproducing only every two to three years (Waller et al. 2007). Based on this information we assign a life history score of **2** (medium).

Section Six: Justification - Additional risk factors

Please provide an explanation with appropriate references to justify the score given.

There is no evidence of a current illegal trade in wild specimens of *E. notaeus.* The species has not been assessed by the IUCN, however, we know of no other major threatening processes for this species. We allocate a score of **0**.

Section Seven: Conclusion, course of action and determination on exports

Please provide an overall conclusion on the perceived threat of trade to the species and details on whether further course of action will be taken to complete an NDF for the species.

The sum of scores for the attributes listed above is **6**. All scores of five or higher should result in a Secondary Evaluation being completed for the species. Although *E. notaeus* possess a number of attributes that make them resilient to harvesting, because up to 6,000 individuals are harvested annually from a relatively small area of Formosa, we require more information to confidently satisfy non-detriment.

This Primary Evaluation is not a sufficient NDF for *E notaeus* in Argentina. For this reason we have completed a Secondary Evaluation for this species (see below).

Section Eight: Literature cited

Please provide references to all the reports and literature cited in this evaluation.

Dirksen, L. 2002. *Anakondas. Monographische revision der Gattung Eunectes Wagler, 1830 (Serpentes, Boidae).* Natur und Tier-Verlag, Münster.

Henderson, R.W, T. Waller, P. A. Micucci, G. Puorto, & R.W. Burgeois. 1995. Ecological correlates and patterns in the distribution of Neotropical boines (Serpentes: *Boidae*): a preliminary assessment. *Herpetological Natural History* 3(1):15-27.

Micucci, P. A., T. Waller, & E. Alvarenga. 2006. Programa Curiyú. Para la Conservación y Aprovechamiento Sustentable de la Boa Curiyú (*Eunectes notaeus*) en Argentina. Etapa experimental piloto 2002-2004, Formosa. In: M. L. Bolkovic and D. E. Ramadori (eds.) "Manejo de Fauna en Argentina: Proyectos de Uso Sustentable". Dirección de Fauna Silveste Secretaría de Ambiente y Desarrollo Sustentable, Buenos Aires, Argentina.

Strüssmann, C. & I. Sazima. 1993. The snake assemblage of the pantanal at Poconé, Western Brazil: faunal composition and ecological summary. Studies on Neotropical Fauna and Environment 28(3):157-168.

Waller, T., P. A. Micucci & E. Alvarenga. 2007. Conservation biology of the Yellow Anaconda (*Eunectes notaeus*) in Northeastern Argentina. Pp. 340-362 In R. W. Henderson and R. Powell (Eds.), Biology of the Boas and Pythons. Eagle Mountain Publishing, LC. Utah. 438pp.

CITES Non-detriment Finding Secondary Evaluation – The Yellow Anaconda Management Program

This document has been prepared by Fundación Biodiversidad Argentina* on behalf of the IUCN/SSC Boa and Python SG

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1. Introduction

The yellow anaconda (*Eunectes notaeus*) is one of four species of anacondas that occur in South America. This boa is the largest snake and one of the three existing species of boa found in Argentina.

Yellow anacondas have been historically considered a very valuable resource and have been largely exploited for their skins. In the past, harvests of anacondas were carried out in a very informal way, sometimes illegally, and not based on scientifically sound sustainable use guidelines or biological information. According to the CITES Trade Database, up to 320,000 skins were traded worldwide between 1982 and 2001, exported mainly from Argentina and Paraguay, before a complete ban entered into force in both countries.

In 2002, Fundación Biodiversidad devised a management system for the yellow anaconda in Argentina: the Yellow Anaconda Management Program (YAMP), aimed at promoting the conservation of this species based on its value as a renewable wildlife resource. To our knowledge, the Program is the only existing management plan designed to ensure the sustainable trade of skins of a snake species; since its inception, the Program has been able to produce a total of approximately 50,000 skins in a sustainable manner.

Because a Primary Evaluation could not easily determine non-detriment for exports of *E. notaeus* from Argentina, a Secondary Evaluation is suggested. This document is the result of that Secondary Evaluation, and summarizes the main components of the YAMP to provide an example of a management plan that is being implemented. It is intended to be read as an integral part of the NDF Guidelines for Snakes document prepared under Decision 16.102 of the Sixteenth Meeting of the Conference of the Parties to CITES.

2. Background of the yellow anaconda trade

a) International trade

Like many boa and python species, *Eunectes notaeus* is considered a valuable resource for its skin and the species is in high demand in the market for exotic leather goods (Jenkins and Broad, 1994). According to CITES import data, between years 1984 and 2013 (30 years), 296,748 whole yellow anaconda skins were traded worldwide (Fig. 1). This figure does not include a significant number of skins traded as skin pieces or reflected in the statistics by length or weight, nor does it comprise exports of thousands of skins manufactured into finished products such as belts, shoes or bags exported during the same period. Italy was the main importing country, followed by Germany and the USA (the three countries together accounting for 91% of the trade).

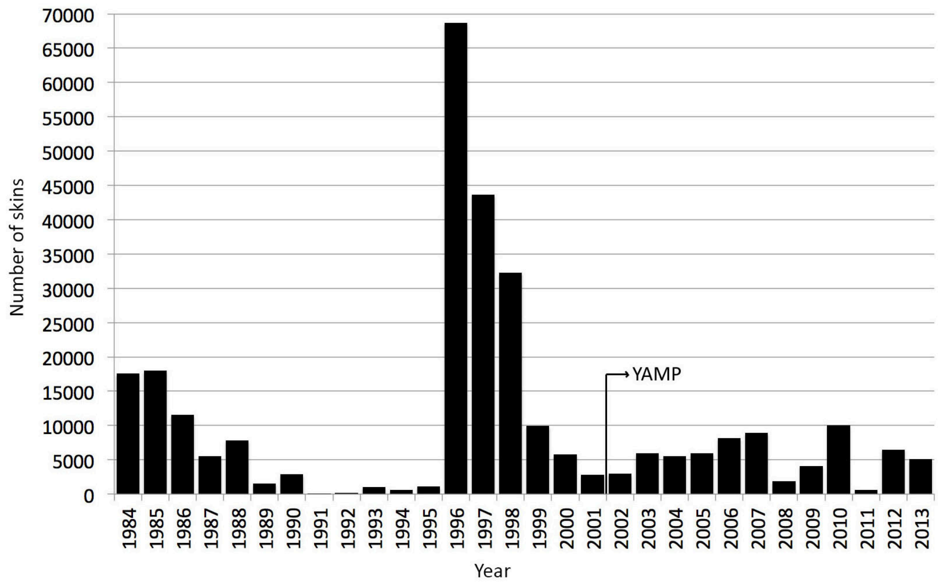

Figure 1. Minimum net trade for *Eunectes notaeus* whole skins between 1984 and 2013 (Source: CITES Trade Database). YAMP: Yellow Anaconda Management Program, started in 2002.

Most skins globally marketed during the last 30 years originated from Argentina, Paraguay and Bolivia. Argentina, however, accounted for 62% of the skins traded (CITES Trade Database). There are no export records from Brazil. Approximately 140,000 skins provided to the market by Argentina during the late 1990s originated from stockpiles accumulated as a result of a ban established in 1986. These skins were released for export between the years 1996 and 2000 (Micucci et al., 2006; T. Waller unpublished data). Thus, 78% percent of the trade recorded between 1984 and 2013 in fact took place before the year 2002; thereafter, the international trade in yellow anaconda skins diminished significantly due to control measures adopted by exporting countries (Micucci et al., 2006). Paraguay introduced a voluntary suspension on trade of all CITES Appendix II-listed species in 2003, while Argentina finished the export of stockpiles of yellow anaconda in 2000 and, subsequently, implemented the Yellow Anaconda Management Program (YAMP) in 2002 (Micucci et al., 2006).

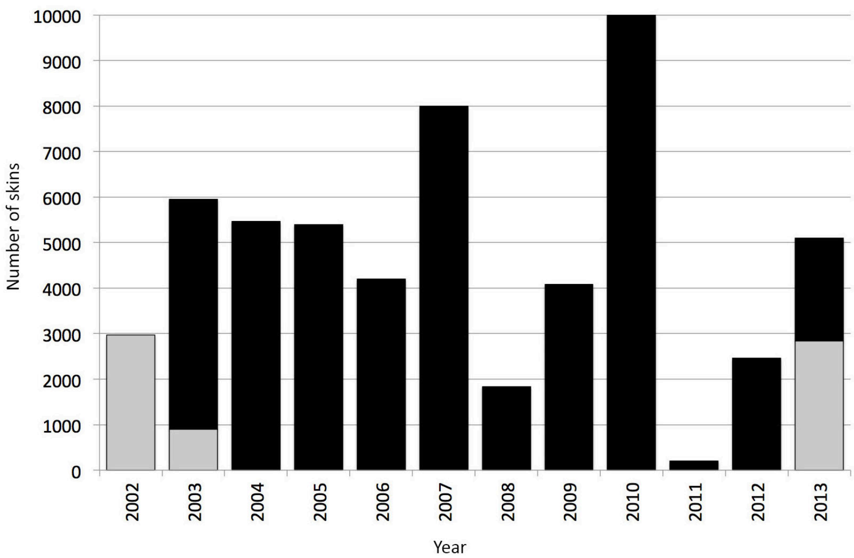

Figure 2. Gross exports of *Eunectes notaeus* skins from range countries between 2002 and 2013 (Source: CITES Trade Database). Black bars: Argentina; grey bars: Paraguay. *Note*: Usually YAMP skins are exported in the year following the harvest, with some exceptions. In years 2007 and 2010 skins were exported in the same year together with the skins from the previous year (2006 and 2009, respectively); this explains the peaks in 2007 and 2010 and the small number of skins exported in 2008 and 2011.

As is the case with almost all reptile species in trade (Dodd, 1993; Scott & Seigel, 1992), in the past exploitation of yellow anacondas was carried out very informally, often illegally, and not based on scientifically sound sustainable use guidelines or any biological criteria at all (Waller et al., 2007). However, from 2002 and to this day, the YAMP became the main source of yellow anaconda skins entering international trade (Fig. 2). Indeed, Argentina produced 88% of the 55,660 skins exported by range countries in recent years (2002-2013) (CITES Trade Database). The difference (12%) is due to Paraguay, yet these skins came from stockpiles obtained before 2003, when a voluntary suspension on CITES-Appendix II species was established. Most skins produced by Argentina (and Paraguay) between 2002 and 2013 were destined to tanneries in Italy (>90%; most of them imported through German ports), and the rest to the United States.

By contrast, trade in live specimens has been negligible, involving 477 specimens in 30 years, about half of them wild-sourced and exported by Paraguay before 2003. The USA has been the main importer of live anacondas. Due to their aggressive nature, anacondas in general are not particularly sought after as pets compared to other more docile constrictor snakes.

b) Domestic utilization and trade in range States

E. notaeus is occasionally collected for food or medicine by indigenous communities from northern Paraguay (Aquino-Shuster et al., 1991), Argentina (Gallardo, 1977) and presumably by some communities in Bolivia, but in general terms this is not a widespread practice (Waller, unpublished information).

Undoubtedly, obtaining skins to supply the local and international leather industry has been the main purpose for removing yellow anacondas from the wild. Nothing is known about the particulars of this trade in Bolivia. In fact, the last formal export from this country dates back to 1984, 32 years ago (2,950 skins; CITES Trade Database). In any case, Bolivia, Paraguay and possibly Brazil were directly or indirectly major suppliers of yellow anaconda skins to the international market, directly or indirectly, in particular between the 1960s the 1980s. Most of this trade took place surreptitiously across the borders, in such a way that it is difficult to establish the real origin of the skins traded internationally during those years; in fact, depending on differences in prices, regulations and law enforcement efforts, skins reaching the international market could have originated in any range country (Argentina, Bolivia or Paraguay) (Waller & Micucci, 1993).

Trade in snake skins began in Argentina possibly in the 1930s, with the establishment of the first tanneries specializing in reptiles, but peaked during the 1940s (Micucci et al., 2006). Annual exports from Argentina at that time were estimated to involve around 60,000 boa constrictor and yellow anaconda skins between 1940 and 1950, 30,000 skins in the mid-50s and 21,000 skins between 1975 and 1985 (Godoy, 1963; Gruss and Waller, 1988). These figures from official national records do not clearly distinguish exports from re-exports. In fact, in the early 1950s Argentina enacted new wildlife legislation banning the trade in this species. However, the local harvest and international trade continued uninterrupted, basically due to a sophisticated fraud mechanism involving the declaration of temporary imports and re-exports that ultimately facilitated the laundering of illegally harvested skins. This mechanism, that lasted 40 years, actually came to an end in the late 1990s, when hunting, inter-provincial movements, trade and imports of *E. notaeus* specimens and by-products were expressly prohibited in Argentina.

Furthermore, the export of a huge stockpile of approximately 140,000 skins, which had been accumulated by traders during the late 1980s, was authorized in 1996 with the requisite of tagging all the skins and a deadline to carry out the export. These stocks were exhausted by the year 2000, creating the conditions for the establishment of a management plan once the stocks had reached zero.

In 2001, and after a complete ban in trade was implemented, a field study was carried out to analyze the feasibility of establishing a harvest program for the species in northern Argentina. The study focused both on social and ecological aspects, collect information on the perception of local inhabitants about the utilization of anacondas and experimented with innovative management policies (Micucci et al., 2002). As a result of this research, in 2002 the national government commissioned a local NGO to design a management program for the species. After a three years experimental period (2002 to 2004) the Yellow Anaconda Management Program was definitely established in Argentina.

3. Legal framework

a) International

E. notaeus is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since February 4^{th}, 1977, when the whole family Boidae was listed. There are no CITES quotas established for this species in any of the range countries. The yellow anaconda is included in Annex B of Council Regulation (EC) No 338/1997 of the European Union, which has since then been periodically updated (e.g. Commission Regulation (EU) No 1320/2014). It is not included in the Endangered Species Act of the United States; however, it has been recently listed as an "injurious species" under the Lacey Act, so that the introduction of live specimens of *E. notaeus* into the USA is prohibited since 2012. The yellow anaconda is the only commercial large snake species whose skins can be traded in California (this US State banned the trade in python skins in the 1970s).

b) National

Argentina: Argentina is a Party to CITES since 1981 (Ley 22344/1980). Argentina is a federal country. Provinces retain the right to administer their natural resources within their territories but the federal government has competence in exports, imports and inter-provincial movements. Further details on the legal status of the species in Argentina are provided in Section 6.d. *Bolivia*: The hunting and export of *E. notaeus* individuals (or their parts and derivatives) are currently banned. Bolivia is a Party to CITES since 1979. *Brazil*: Brazil has been a Party to CITES since 1975. Hunting and export of *E. notaeus* individuals (or parts and derivatives) are prohibited. *Paraguay*: Paraguay has been a Party to CITES since 1977. Export and hunting of wild *E. notaeus* specimens (or parts and derivatives) are currently prohibited. This country established a voluntary moratorium (suspension) on exports of all CITES species, including yellow anacondas, in 2003. It has recently lifted this voluntary suspension of trade only as relates to export of stockpiles of reptile skins collected between 2001 and 2003. The stockpiles included 5,300 yellow anaconda crust tanned skins that were exceptionally allowed for export.

4. Understanding the species

A thorough understanding of the species' biology is essential to devise and implement a management system. Until recently, biologically meaningful data to use as a basis for management of the yellow anaconda (*Eunectes notaeus)* were scarce, and mainly originated from general surveys, observation, or the study of a few specimens kept in zoos or museum collections. Petzold (1982), Waller and Micucci (1993), Dirksen (2002), and Reed and Rodda (2009) comprehensively compiled and summarized most of the published information on the species. More recently, Waller et al. (2007) presented basic population and biological data for *E. notaeus* in northern Argentina as a result of the ongoing field monitoring of the species under the YAMP.

a) Nomenclature

Four species of anaconda are currently recognized within the genus *Eunectes* Wagler (1830), including the largest snake in the world, the green anaconda (*Eunectes murinus*; www.reptile-database.reptarium.cz/). Anacondas are aquatic snakes that occur in South America. They are members of the family Boidae, which includes species from the Americas, Europe, Africa, Asia and many islands (O'Shea, 2011). *E. notaeus* was first described by Cope (1862) and represents the southernmost species of anaconda, distributed in Bolivia, Brazil, Paraguay and is the only species of anaconda that exists in Argentina (Giraudo and Scrocchi, 2002; Henderson et al., 1995). The taxonomy of this species remains largely unchanged and includes only one synonymy (*Epicrates wieningeri* Steindachner, 1903; Waller, 2000). *E. notaeus* is locally known as "*curiyú*" in Argentina and Paraguay, "*sicurí amarilla*" in Bolivia, and "*sucurí amarela*" or "*sucuridjú*" in Brazil (Waller et al., 1995; Dirksen, 2002). Trade names include "yellow anaconda", "southern anaconda", "*anaconda amarilla*" and "*curiyú*".

b) Coloration and identification

The background coloration of *E. notaeus* ranges from yellow to olive-brown yellow. The dorsum is covered with black 8-shaped blotches, which are separated from each other by lighter coloured scales. The sides exhibit smaller blotches and black spots. The ventral side is yellow with small black flecks. The head normally has five black stripes, three on the dorsal side and two post-ocular (Petzold, 1982; Waller et al., 1995; Dirksen, 2002; Reed and Rodda, 2009; O'Shea, 2011; Fig. 3).

E. notaeus is easily distinguished from other boids by their coloration and/or scale size and shape. However, it is more difficult to differentiate *E. notaeus* from two other closely related species, *E. deschauenseei* and *E. beniensis*, and demands closer scrutiny of coloration and pattern. Nevertheless, no trade has been recently reported for anaconda species other than *E. notaeus* and *E. murinus*. Unbleached *E. notaeus* skins and their by-products exhibit a very recognizable pattern (Fig. 3). More information for identification can be found in the CITES Identification Manual.

Figure 3. Left: *Eunectes notaeus* in the wild. Right: a bag made with three skins in parallel, exhibiting the natural pattern of *E. notaeus*.

c) Distribution and habitat

The known range of *E. notaeus* encompasses approximately 15 degrees in latitude throughout the Paraguay River and lower Paraná River basins, from Bolivia and Central Brazil in the north (ca. 15°S), to northeastern Argentina in the south (ca. 30°S; Henderson et al., 1995; Fig. 4). Periodical floods often carry individuals downstream to higher latitudes, some even reaching Uruguay, but there is no evidence of a reproductive population in this country (Waller and Micucci, 1993).

Figure 4. Left: The Approximate Extent of Occurrence (EoO) of *Eunectes notaeus* in South America (shaded area). The dark dots represent known records of occurrence. Right: *E. notaeus* is found in a variety of aquatic habitats, such as swamps, seasonally flooded marshes, lagoons and riverine habitats.

Throughout its range, *E. notaeus* occurs in aquatic inland ecosystems of the *Pantanal* and Wet *Chaco* eco-regions, specifically swamps, seasonally flooded marshes and riverine habitats, which are associated with the Paraguay River and middle sector of the Paraná River (Strüssmann and Sazima, 1993; Henderson et al., 1995; Dirksen, 2002). The majority of this region is a poorly drained plain without major geographic features. Seasonally flooded savannahs with palm trees, grasslands, and riparian forests are important landscape components (Strüssmann and Sazima, 1993; Waller et al., 2007; McCartney-Melstad et al., 2012; Kershaw et al., 2013; Fig. 4).

The Extent of Occurrence (EoO) of *E. notaeus* encompasses approximately 400,000 km^2 (Micucci et al., 2006). The Area of Occupancy (AoO) is difficult to define, however, assuming a conservative 1:3 wetland/dry land ratio throughout this wetland dominated area, we estimate that the total AoO for this species is not less than 130,000 km^2. EoO in Argentina was estimated in 120,000 km2 (Micucci et al., 2006), while AoO assuming a conservative 1:3 wetland/dry land ratio can be estimated in 40,000 km^2.

Sympatry with *E. murinus* occurs at the border between the *Pantanal* and the *Cerrado* regions, as well as in some of the large rivers that crosses the *Pantanal*, in Brazil and Bolivia (C. Strüssmann, pers.comm.).

d) Size, population structure and dimorphism

E. notaeus is a heavy-bodied medium sized boa that can grow to four metres in total length (Petzold, 1982; Strüssmann and Sazima, 1993; Dirksen, 2002). There are a few individuals recorded above this size, however most of these are based on the skin measurement that can stretch 25-30% more than the original length (Dirksen, 2002; Micucci and Waller, 2007). Most *E. notaeus* captured during field sampling in Paraguay and northern Argentina were on average half that size (Dirksen, 2002; Waller et al., 2007; Fig. 5).

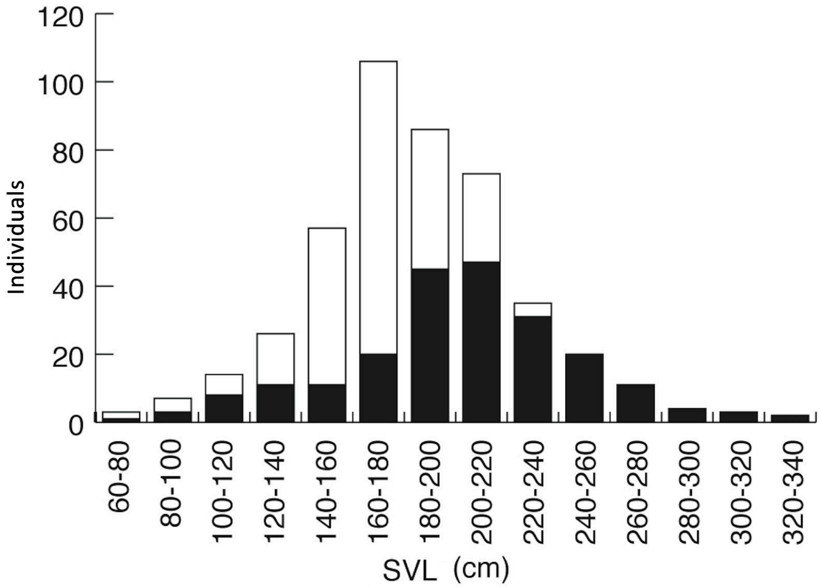

Figure 5. Snout-vent length (SVL) of *E. notaeus* males (black column) and females (white column) from a population in northern Argentina (N=449; Waller et al., 2007).

Sex ratio in clutches from wild populations in northern Argentina is 1:1 (Waller et al., 2007). *E. notaeus* are highly sexually dimorphic; males exhibit proportionately longer tails and larger spurs than females (Petzold, 1982; Dirksen, 2002; Waller et al., 2007). Sex can be determined by observing tail length and spur size, even in skins (Micucci et al., 2006; Fig. 6). Females can grow longer than males; the largest male and female found by Waller et al. (2007) after studying 1,555 individuals during field work in northern Argentina measured 2.6 m and 3.4 m SVL, respectively, and weighed 10.5 kg and 29 kg, respectively. The average SVL and weight for males was 1.7 m and 3.5 kg and 2 m and 6.3 kg for females.

As a result of these sexual differences in size, and the fact that the industry always seeks for medium to large skins (above 2 m), trade in *E. notaeus* indirectly relies on the harvesting of females (Micucci and Waller, 2007).

Figure 6. Male *E. notaeus* exhibit large spurs (left and arrow in right), which can be used to determine sex on dry skins (right).

e) Reproductive maturity

Age and size at maturation is a variable trait that depends on the availability of resources that directly impact on growth rates during early life stages. For this reason it is not feasible to determine an exact age at first reproduction for *E. notaeus*. Average size at physiological sexual maturity appears to be a relatively fixed trait and was established by the authors to be between 1.28 and 1.43 m SVL for males and 1.45 and 1.85 m SVL for females, approximately at the age of 2 or 3 years in northern Argentina (Waller et al., 2007);

however, this does not mean that a female will actually reproduce at that size. First reproduction for females in northern Argentina may occur between 1.5 m SVL and 2.9 m SVL; some females in this population appear to avoid reproductive opportunities until reaching a size that permits them to maximize fecundity. This means their SVL at first reproduction is the result of their individual life history trajectories (Waller et al., 2007). Individual life trajectories vary greatly and render generalizations with regard to this trait meaningless.

f) Reproductive timing

Populations in Argentina show great seasonality and synchronicity in reproduction (Waller et al., 2007); males and females exhibit late summer to winter gonad recrudescence (February to October). *E. notaeus* are viviparous and secondary oviductal follicles were found from early October (Waller et al., 2007). Based on semi-captive experiments with wild specimens, mating in occurs in early spring (September to October) with parturition after 160-180 days of gestation, in the autumn of the following year (March to April; Waller et al., 2007). Hatchlings are large (41 to 59 cm SVL and 61 to 135 g), very aggressive and fast growing (Waller et al., 2007). There may be variations in the reproduction timing between populations of *E. notaeus*, as is to be expected in a wide-ranging species (Reed and Rodda, 2009), however, a similar pattern to the one depicted for Argentina has also been observed for the Brazilian Pantanal (Christine Strüssmann, pers.comm.). Furthermore, unpublished datasets from different Argentinian provinces and the south of Paraguay suggest that this cycle is generalized (T. Waller unpub. data). This dataset also shows that *E. notaeus* does not breed during the winter (May to August), which is traditionally the season preferred by hunters for harvesting *E. notaeus* in Argentina (Micucci et al., 2006).

g) Reproductive output

Reproductive output is the result of reproductive frequency and fecundity, both of which are strongly influenced by environmental conditions. Although the majority of *E. notaeus* males studied in Argentina by Waller et al. (2007) presented a constant annual reproductive frequency (99%, N=326), females reproduced every two years on average (54%, N=515), depending on fat reserves. However, this proportion can differ among years and between regions. For example, 200 females were surveyed in 2002 from two sites in Argentina; 51% of females exhibited secondary ovarian follicles (ready to reproduce in the next season) in one site compared to 29% in another site. The proportion of reproductively able females in northern Argentina changed from 44% in 2002 (N=200) to 60% in 2003 (N=283). The literature indicates that *E. notaeus* produces 5-37 hatchlings per clutch, but sources do not always distinguish between wild and captive datasets (Dirksen, 2002; Reed and Rodda, 2009). In Argentina, mean clutch size in 11 wild females that reproduced in "semi-captive" conditions was 19.5 with a range of 7-42. Based on a large sample of 246 wild specimens from northern Argentina, oviductal scars suggests an average clutch size of 24 with a range of 7-65 (Waller et al., 2007). Female SVL was significantly correlated either with clutch size (r^2=0.62, P<0.01), number of oviductal scars (r^2=0.67, P<0.001) or number of secondary follicles (r^2=0.44, p<0.001) (Waller et al., 2007; Fig. 7). Reproductive output also depends upon the body condition of females; populations of *E. notaeus* that exhibited heavier individuals were more prolific compared to those composed of lighter snakes. A good body condition offers other advantages with regard to population dynamics (i.e. a higher somatic growth rate, early maturity), which results in a higher population growth rate in some sites (or periods) compared to others.

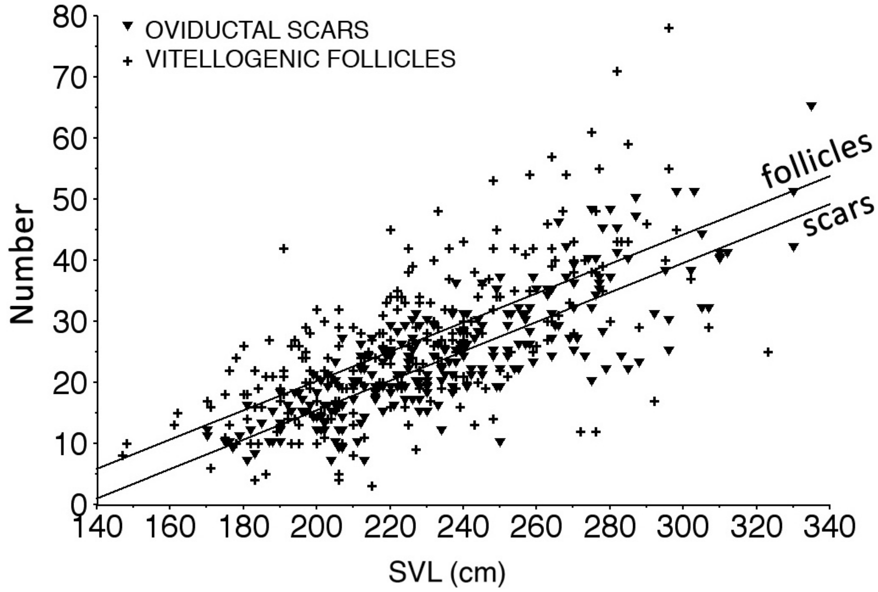

Figure 7. Relationship between female size (SVL) and number of oviductal scars and vitellogenic follicles (from Waller et al., 2007).

h) Growth

There is no conclusive data available on *E. notaeus* growth rates. This species shows rapid growth rates in captivity, with individuals increasing 40-60 cm each year depending on sex, until reaching sexual maturity, at which time growth rates diminish to 20-30 cm per year; females grew on average 20% faster than males (Petzold, 1982; Waller and Micucci, 1993; Norman, 1994; Dirksen, 2002). Growth appears to be relatively fast in wild populations from northern Argentina, with males and females capable of doubling their size in the first year of age and reaching sexual maturity in the second or third year of age (Waller et al., 2007). Consequently, this trait is expected to exhibit great spatial and temporal variations.

i) Longevity and survivorship in the wild

There is no data available on longevity or survivorship of wild *E. notaeus*. Captive individuals can live for more than 20 years (Snider and Bowler, 1992), but longevity is expected to be significantly less in the wild. Hatchlings are exposed to a variety of predators, however, the relatively large neonatal size, fast growth rates, and fierce temperament of this species, suggest that hatchlings and juveniles may be able to elude predation by outgrowing vulnerable offspring sizes in a few months (Waller et al., 2007). Extreme variability in wetland water levels is another potential cause of mortality. In northern Argentina, *E. notaeus* exhibited significant cyclical peaks and troughs in body condition (and reproductive frequency) in direct response to water levels (Waller, unpublished data). *E. notaeus* populations are also effected by extreme droughts and fire, local people killing snakes from fear and being killed crossing the road. Collection for the skin or live pet trade is currently negligible in most of the *E. notaeus* range.

j) Spatial ecology

E. notaeus appears to be active all year-round in most of its range. In summer, they are preferably nocturnal and become almost undetectable underwater when dispersed across seasonally-flooded savannahs. Often they are detected only when crossing roads or when they ambush prey on the shores of lagoons and creeks. Depending on the water level, they spend the majority of the time in densely vegetated water or resting on dry land near ponds during the dry season (Waller, pers.obs.). In northern Argentina, *E. notaeus* is often found concealed inside hollowed palm tree trunks or at the base of dense shrubs during droughts. In northern Paraguay, they seek shelter from the extreme summer heat in small caves in the vegetated mud banks of creeks and rivers (L. Aquino, pers. comm.). In Argentina, *E. notaeus* becomes more sedentary and detectable during the winter months (June to August), and can often be found basking to facilitate gonadogenesis and digestion (Waller et al., 2007); hunters take advantage of this (Micucci and Waller, 2007; Waller et al., 2007). Unpublished information from radio telemetric studies shows that *E. notaeus* in the southern tip of its range in Argentina may actually stay inactive for a few days or weeks during winter, staying underwater or under dense vegetation mats particularly during extreme cold weather.

Females utilize defined home ranges; adults (~2 m) utilized a range of ~15 ha compared to larger individuals that utilize ~50 ha. During the summer, adult *E. notaeus* travel long distances (~2 km) while smaller individuals move more often. Gravid females do not move for several months during gestation. A radio-tracked gravid female remained in the same position during the final 3 months of the gestation period (Waller, unpub. data). As with other large dimorphic snakes, smaller male *E. notaeus* are less territorial and better at dispersing compared to larger, heavy females. McCartney-Melstad et al. (2012) found that rivers and their associated floodplains are important in the dispersal of *E. notaeus*. Gene flow between *E. notaeus* populations was positively correlated with distance along the rivers connecting them, rather than with the straight-line distance between populations. The low dispersal ability of females due to their size and weight and the subtle natural barriers to dispersal represented by a complex river and wetland configuration possibly explain the significant differences in population structure among populations studied in northern Argentina (McCartney-Melstad et al., 2012; Kershaw et al., 2013).

k) Diet

E. notaeus is an aquatic trophic generalist that employs ambush predation and active search for capturing its prey (Dirksen, 2002; Henderson et al., 1995). Like most boas and pythons, *E. notaeus* kills its prey by constriction. Fish scavenging has also been reported (Strüssmann, 1997). Although considered aquatic in their behavior, *E. notaeus* have also been observed to ambush prey from trees < 2.5 m (Strüssmann and Sazima, 1991), in small bushes when basking, or on the shore of ponds and creeks (Waller, unpub. data). Their diet consists of fish (not identified), snakes (*Hydrodynastes gigas*, *E. notaeus*), caimans, small turtles, aquatic birds (cormorants, storks) and their eggs, and mammals (small rodents, capybaras; Strüssmann and Sazima, 1991; Strüssmann, 1997; Dirksen, 2002; Waller et al., 2001, 2007). There is an ontogenetic shift in prey size dependent on the size of the snake; in northern Argentina, juvenile *E. notaeus* prey on eggs and small rodents, while larger individuals prey on water cobras, large birds (egrets and cormorants), and mammals (capybaras; Waller et al., 2007). Predation usually occurs during the dry period, when wetlands have reduced and the concentration of prey is high surrounding remaining water bodies (Strüssmann, 1997; Waller et al., 2007). In northern Argentina predation also occurs during the flooding season, when water rats (*Holochilus chacarius*) and other small rodents are concentrated in the top of the emergent bushes.

l) Population abundance

Although absolute population sizes are unknown, available data suggests that *E. notaeus* are common and abundant. This is one of the commonest snake species in the Brazilian Pantanal (Strüssmann, 1997) and represents 15.1 per cent of all snake specimens captured in a collection of snakes from that region; it was second in capture frequency only to the false water cobra (*Hydrodynastes gigas*; Strüssmann and Sazima, 1993). During the filling of the reservoir of Yacyretá dam, in the Paraná River at the border between Argentina and Paraguay, approximately 1,500 *E. notaeus* were rescued from the flooded islands (Waller et al., 2001). The sustained harvest of *E. notaeus* each year by hunters for the skin trade from a single wetland, during more than a decade under the YAMP, confirms that this species is capable of reaching high population densities in suitable habitat. Logistical and methodological constraints impede rigorous density estimates, however, Micucci and Waller (2007), based on intensive sampling during daily hunting sessions in northern Argentina, broadly suggested a density of 30-60 *E. notaeus* per km^2. These preliminary estimates of an average of 0.5 *E. notaeus* per ha, extrapolated to an AoO of over 12 million ha, suggests a population size of several million snakes for the entire range.

m) Population trends, conservation threats and status

There is no evidence on negative trends for any *E. notaeus* population. Habitat availability is very high and remains fairly stable in most of their range (Waller et al., 2007). Conversion of wetlands to cultivated land probably represents the greatest threat for the species at the local level. Land drainage and systematization for rice cultivation and livestock rearing affects some marginal habitats in northern

Argentina; these processes may be less significant through the species' habitat in Bolivia, Paraguay and Brazil due to landscape complexities limiting these initiatives. It should be noted however that the species also benefits from some man-made habitats, like artificial ponds and roadside channels (Waller et al., 2007), as well as vegetated dams or water reservoirs and rice fields (Waller, pers. obs.). People often kill snakes out of fear and road kill are other threats at the local level. International trade of *E. notaeus* skins peaked in the late 1990s, but stopped almost completely throughout the whole range of the species approximately 20 years ago (Micucci et al., 2006). There is little or no demand for *E. notaeus* skins locally and the unique source of skins for the international trade is the YAMP; that occurs in a negligible proportion of the total range of the species in Argentina. Furthermore, trade is now regulated, the trade system organized and populations are being continuously monitored under YAMP. In this sense, trade on skins, legal and illegal, is not a major threat to the species anymore. With these considerations, it is reasonable to assume that the overall population of the yellow anaconda is stable. *E. notaeus* is currently being assessed by the IUCN Red List, but available information on population status and trends suggests that this species should be classified as non-threatened. *E. notaeus* is listed as CITES Appendix II.

5. Understanding the traditional harvest of anacondas in Argentina

E. notaeus have always been captured serendipitously or actively searched for in rivers, marshes and lagoons during favorable weather conditions. No traps or sophisticated methodologies have been used to harvest anacondas. *E. notaeus* were collected by hand and killed immediately by hitting the head with a blunt implement, such as a pole or stick. They were skinned in situ or at the hunter's home, and the carcass was discarded. Wet skins were sun dried then sold or exchanged locally for merchandise (Micucci et al., 2006).

E. notaeus were harvested mostly during the cooler winter months (June to August), when they emerge to thermoregulate (Micucci et al., 2006). Trade figures from one skin trader in the late 1980s confirmed the harvest season peaked in the coldest months of July and August (Fig. 8). Harvests extended through winter until detectability declined abruptly due to an increase in temperature from the onset of spring.

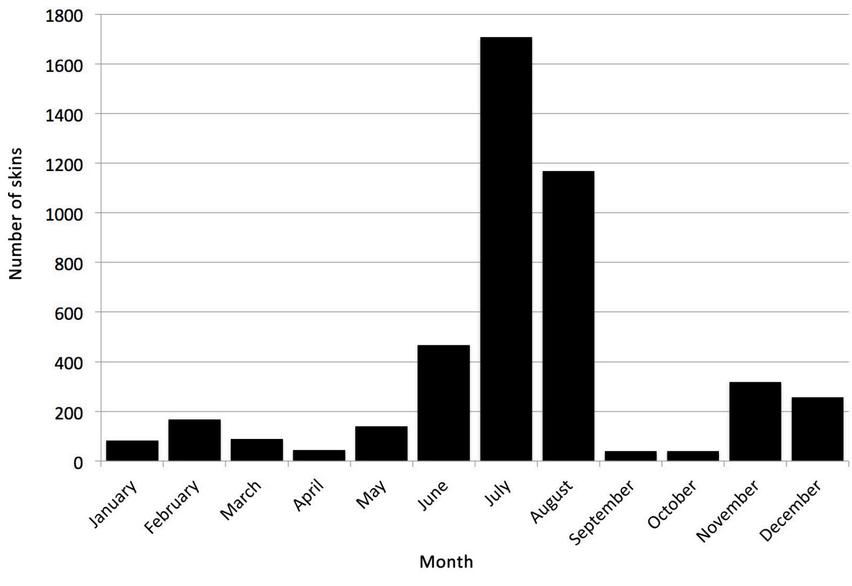

Figure 8. Number of *E. notaeus* skins received every month by a trader during the year 1988 (T. Waller, unpub. data).

According to local traders, the traditional harvest included skins over 15 cm in width; this corresponds to a total length of ~150 cm for dry skins and ~135 cm SVL for live snakes (Micucci et al., 2006). In 1995, approximately 500 skins were seized and measured in Paraguay and clearly included skins from immature individuals (Fig. 9). *E. notaeus* older than 1.5 years were vulnerable to unregulated hunting and market-driven demands (Micucci and Waller, 2007; Waller et al., 2007).

Skins > 20 cm wide (equating to ~200 cm for total length of dry skin and ~175 cm SVL for live snakes) commanded higher prices and were locally known as "full price"; smaller skins < 20 cm wide and poor quality skins were half the price. Fig. 9 clearly shows that the half price skins did not discourage hunting and these skins represented approximately 60% of the traditional harvest in those years.

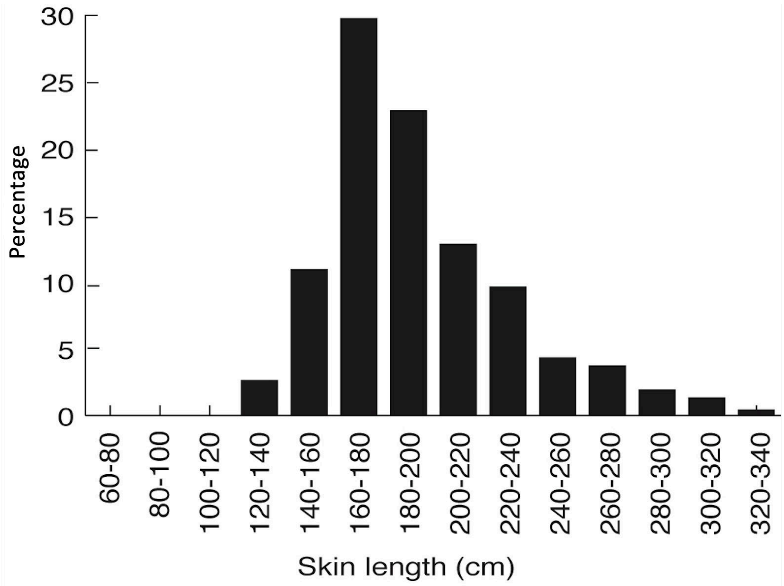

Figure 9. Proportion of skins for each size class in a lot of 526 commercial skins seized and measured in Paraguay in 1995 (Micucci and Waller, 2007).

Hunters were disregarded under this informal harvest system and revenue was mainly distributed among storekeepers, middlemen, transporters and exporters. Trade was not traced and the origin of skins was ignored. Skins and by-products were traded locally and circumvented local controls or were transported to neighbouring countries. Despite this, wild populations of *E. notaeus* have not presented any evidence of deterioration after years of unrestricted hunting (Micucci et al., 2006).

6. The Yellow Anaconda Management Program (YAMP)

a) Aims

The YAMP was devised in 2001 and sought to reconcile the traditional utilization of *E. notaeus* with its long-term conservation, in addition to promoting biological research and appreciation of the species and its habitat by local inhabitants. The YAMP also aims to maximize local income through sustainable harvest (Micucci et al., 2006).

b) Conceptual framework

The YAMP framework was developed on two basic concepts: the precautionary approach and adaptive management.

Some of the basic premises of the YAMP include the following:

- Implement operative measures. The development of a successful management plan requires concrete measures for all stakeholders involved, with clear and achievable yet fundamentally flexible obligations, which may vary with time and circumstances.

- Convene key stakeholders, such as hunters, to participate in the process. This allows managers to make realistic and just decisions and raise awareness for those in direct contact with the resource they are seeking to manage. A management plan that aims at valuing natural resources must be designed from the "bottom up"; from indigenous and rural communities to the end users, taking into account the cultural and historical relationships that may exist between the local inhabitants and the resource.

- Use the best available information. This implies that decisions are based on available scientific and technical information, including traditional knowledge of indigenous and local communities.

- Apply the principles of adaptive management. The adaptive management approach provides the ideal conceptual framework to deal with cryptic species, such as *E. notaeus*, when population monitoring by standard methods is not feasible and there are several uncertainties. Adaptive management is defined by the National Research Council (2005) as:

"…a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."

The basic assumptions of adaptive management are the following:

- Supervise, based on appropriate indicators, the impacts of management decisions and actions;
- Promote research in order to reduce uncertainty;
- Warrant periodic assessment of results;
- Capitalize lessons learnt, and review and adjust, as needed, actions taken or decisions made;
- Establish an efficient and effective control system.

This method has been successfully used for other species that due to their biological features and CITES status could not be managed using traditional methods, such as fixed quotas or direct surveys. Adaptive management of *E. notaeus* has established a protocol to obtain data that guarantees the traceability and control of skins. Due to the difficulties associated with monitoring cryptic snake populations, adaptive management has become a fundamental, cost effective and reliable tool.

c) Location

The Province of Formosa in the north of Argentina was selected for implementing the harvest program due to the abundance of suitable habitat, a favourable governmental disposition towards sustainable use and a long stranding hunting tradition.

Formosa encompasses and area of approximately 72,066 km^2 and is a flat plain where the most conspicuous landscape elements are large rivers, small creeks, forests and wetlands. The entire are is within the Chaco eco-region; the weather is subtropical to tropical with a mean annual temperature of 23°C and annual rains decreasing in an east to west gradient (1200 to 600 mm). Winter is mild but occasional freezes occur during July and August.

For the purpose of YAMP, we divided Formosa in two regions (Fig. 10): a) Eastern Formosa, a 35,000 km^2 area characterized by the presence of savannahs with palm trees and forest patches interspersed with wetlands on one side, and the Paraguay river basin on the other; and b) Western Formosa or La Estrella Marsh, a seasonal floodplain extending over a distance of 250 km and covering an area of nearly 3,500 km^2. This seasonal wetland, located in western Formosa, was originated by the progressive regression of the Pilcomayo riverbed. Large grasslands, savannahs with palm trees, and standing dead Chaco forest patches that during the flooding season are covered with climbing plants (locally called "*champales*"), combine to form this landscape matrix. La Estrella Marsh represents the entire available habitat for *E. notaeus* in the dry west of the province.

E. notaeus is abundant in Formosa and the Eastern region offers the largest proportion of habitat for the species, potentially harboring the largest population. However, the YAMP has been particularly successful in managing *E. notaeus* in La Estrella Marsh, where a poor rural and indigenous community coexists with a highly productive and suitable habitat for the species. The more developed east region exhibits a different land tenure regime and best working opportunities for people that affect the adoption of this kind of initiatives (Micucci et al., 2007).

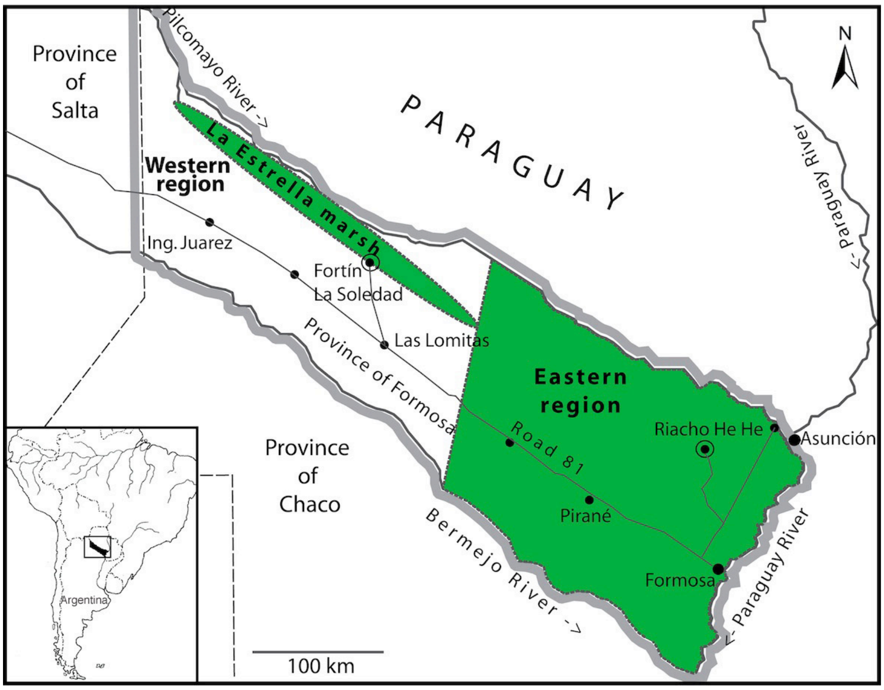

Figure 10. The Yellow Anaconda Management Program (YAMP) takes place in the Argentinian province of Formosa at the Chaco eco-region. *E. notaeus* naturally occurs in the eastern plains (shaded green) and the La Estrella Marsh, a 3,000 km^2 floodplain created by periodical flooding of the Pilcomayo River.

d) Institutional and legal framework

Argentina is a Federal country. Wildlife conservation and utilization is regulated at the national level by the *Ley de Conservación de la Fauna No. 22421/1981*. Importation of live *E. notaeus* and their parts and derivatives are expressly prohibited (*Resolución SAGP No. 53/1991*) to avoid local specimens laundering. Hunting, inter provincial movements, domestic trade, and exports of *E. notaeus* and their parts and derivatives have been also banned in the past to protect the species from unregulated harvest (*Resolución SAGP No. 24/1986*). With regard to YAMP, the national authority coordinates the program at the national level, providing the general framework, regulating inter-provincial movements and exports of dry skins, and controlling control compliance with CITES requirements. Since 2002, the production and exports of *E. notaeus* skins under the YAMP are excluded from the hunting and trade ban established for this species. Main provisions of the YAMP were established at the national level by *Resolución SADS* No. 1057/2002, *Resolución SADS* No. 115/2004, *Resolución SADS* No. 30/2005, *Resolución SADS* No. 204/2006, *Resolución SADS* No. 443/2009 and *Resolución SADS* No. 1173/09 (for more information see www.ambiente.gov.ar/?aplicacion=normativa&IdSeccion=3&agrupar=si). Every year the Province of Formosa establishes the procedures of the management program at the local level.

Fundación Biodiversidad (FB) was appointed under an agreement with the provincial government to lead and execute the technical aspects of the YAMP. Annual tasks and budget are detailed in operative plans submitted each year for approval by the provincial wildlife authorities. Exporters finance the YAMP under a mechanism originally established by the central government. Under federal regulations, project benefits (skins) are distributed among the exporters proportionally to the funds each one has contributed to the total fund. Depending on the results from different years, dedicated funding has been approximately US$ 6 to 12 per skin.

7. Harvest control and procedures under YAMP

a) Harvest control variables

Harvest season.- Harvest of *E. notaeus* is permitted in winter from June to August. This corresponds to when *E. notaeus* emerge from the water to bask and are easily detectable. During the remainder of the year, *E. notaeus* usually remain underwater, which reduces detectability. This brings numerous benefits: 1) the species is protected from hunting during the breeding season; 2) the harvest season is short in duration; 3) hunters are deterred from illegal harvesting outside of the harvesting period due to extreme temperature, which reduces control costs; and 4) hunters are able to capture dormant *E. notaeus* by hand and to visually appraise their size before killing them. Depending upon the YAMP research requirements, *E. notaeus* are usually killed in situ or transported live to the hunter's home for data collection before being killed.

Minimum size requirement.- The YAMP has a minimum size requirement of 230 cm measured from the neck to the anal scale; this size corresponds to a live specimen of approximately 200 cm SVL. Since female maturity occurs on average at 165 cm SVL (Waller et al., 2007), this precautionary provision is intended to allow female *E. notaeus* to have one reproductive opportunity before being harvested. According to interviews with traders and local dealers, the production of Formosa involved ~20,000 skins per year above 15 cm wide (Micucci *et al.* 2002, 2006). This width corresponds to a dry skin length of 150 cm from a live *E. notaeus* approximately 135 cm SVL (Micucci et al. 2002). This equates to approximately 90% of *E. notaeus* older than 1 to 1.5 years of age, which were vulnerable to being hunted under a market-driven regime (Fig. 11; Waller *et al.* 2007). With the current minimum size policy (230 cm skin or 200 cm SVL live) we are able to substantially reduce overall harvest levels, for juveniles and adults, compared to the historical volume of trade. Current production, without mediation of quotas, represents a management-derived reduction of harvest to a quarter of historical values for Formosa (5,000 vs. 20,000 skins), and a 40% reduction of female vulnerability to hunting (Micucci and Waller 2007).

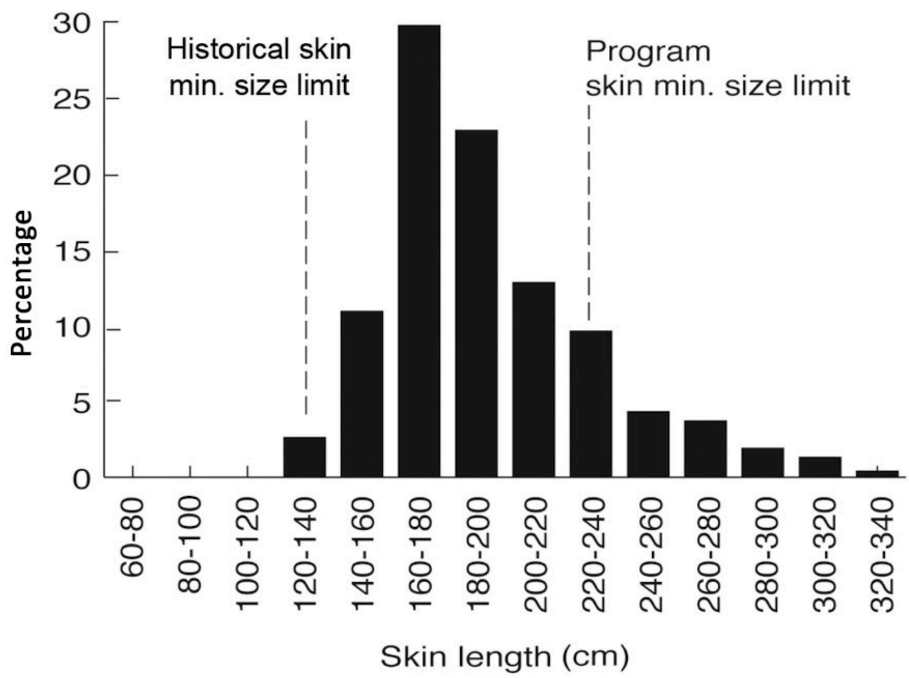

Figure 11. Skin length of 526 illegal dry skins seized in Paraguay (Micucci and Waller 2007). Current minimum size limits established by the YAMP are substantially more conservative than historical minimum sizes of skins in trade.

<u>Skinning pattern.-</u> Taking into consideration the anal spurs and other features of the skin, the YAMP skins can be recognized by altering the skinning technique and resulting pattern each year. For example, one year the skin must bear both spurs on one side and have the head skin attached or the following year one spur on each side without the head. Unique skinning patterns allow the YAMP to avoid illegal hunting and stockpiling outside of the harvest season (Fig. 12).

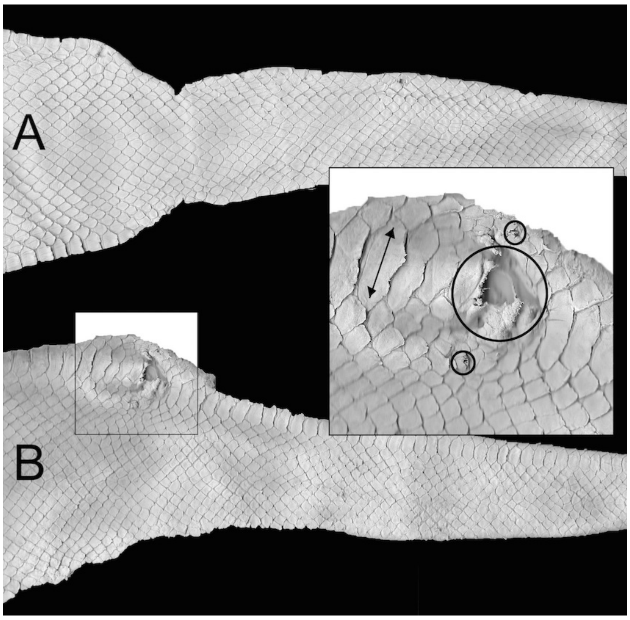

Figure 12. Tail region of *E. notaeus* crust tanned skins comparing two different skinning patterns: A) Traditional mid ventral cut exhibiting a symmetrical shape where mid ventral scales are divided to each side of the skin, B) Skinning pattern where all the cloaca region, including adjacent spurs (limb remnants), cloaca opening, and entire ventral scales, are left untouched at one side of the skin.

b) Harvest control procedures

The harvest of *E. notaeus* is strictly related to three fundamental economic stakeholders: *collectors, local skin buyers* (LSBs) and *exporters* (Fig. 13).

<u>Hunters.-</u> These are rural and indigenous community members (Pilagá, Toba) subsisting partially from livestock breeding but also from hunting and fishing. Approximately 200 to 300 families take part in hunting *E. notaeus* in Formosa, most of them (90%) from the surroundings of La Estrella Marsh.

<u>Local skin buyers.-</u> These are the people who buy the skins from the collector. They are usually a food supplier or market-man that trades basic supplies and skins (cows and goats) with the hunter and have the logistical means for transporting and stockpiling skins. Between 6 and 8 LSBs participate in a harvest season, with a mean number of 35 hunters per LSB.

<u>Exporters.-</u> These are the final acquirers of *E. notaeus* skins. They act jointly by designating a representative or purchase agent to acquire the skins from the LSBs under the YAMP supervision. They also pay for the YAMP implementation expenses.

Every year during April and May, before the start of the hunting season, a series of trips are organized to register and inform LSBs on the year's provisions and eventual modifications to the YAMP guidelines. These activities are aimed at regulating hunting effort; although the YAMP provides no limitations on the number of hunters (in reality there is a finite number), they have a close relationship with the LSBs due to economic and cultural reasons. LSBs have to pay hunters in cash for skins. According to the YAMP guidelines, the exchange of goods for skins is forbidden, unless by specific request of an indigenous community. To ensure compliance, at the end of each harvest season the YAMP carry out random polls to hunters, including specific requests on prices and payout modality.

During the last week of May, and immediately before the opening of the harvest season in June, the YAMP notify the LSBs on the *minimum skin size* limit and on the *skinning pattern* to be used in the forthcoming season. Most of the hunting requirements are implemented when the hunters bring their skins to the LSBs for sale, since the skins that do not comply with the YAMP standards are worthless for the LSBs.
Periodically the LSBs facilities are visited by the exporters' representative, a purchase agent, together with a provincial wildlife officer and a YAMP team member to buy skins. *E. notaeus* skins are examined for compliance with the year-specific skinning pattern and minimum size guidelines; skins that comply with the YAMP standards are individually tagged in situ for control and future tracking. Visits to LSBs facilities occur at an interval of two to three weeks on average. At the same time the LSBs should file an official form, called the '*effort form'*; a legal document that contains the number of skins, name of hunter, date and place of harvest. This document is needed to permit the legal transport of *E. notaeus* skins within the province. The content of the document are crosschecked with the result from periodical polls to hunters. In the case of irregularities, LSBs could be penalised with the cancellation of their license.

The purchase agent is the only person authorised to transport *E. notaeus* skins to the warehouse in Formosa city where they are inventoried. At the end of the harvesting season, and before leaving the province, skins are sexed (by their spurs and bone remnants), measured, and export tags that comply with federal regulations replace field tags. The export tag is required before transporting skins out of the province and to issue a CITES export permit. Wildlife inspectors of Formosa, and eventually from the central government, as well as a representative of the YAMP, supervise this procedure.

Once skins are tagged and all data gathered, the skins are 'released' for distribution among the exporters. In order to transport *E. notaeus* skins to tanneries or export ports, Formosa authorities must issue a Transport Guide to each exporter, that will be enclosed with the shipment to destination and, at the appropriate moment, will be required by CITES Management Authorities in order to issue the pertaining CITES export permit.

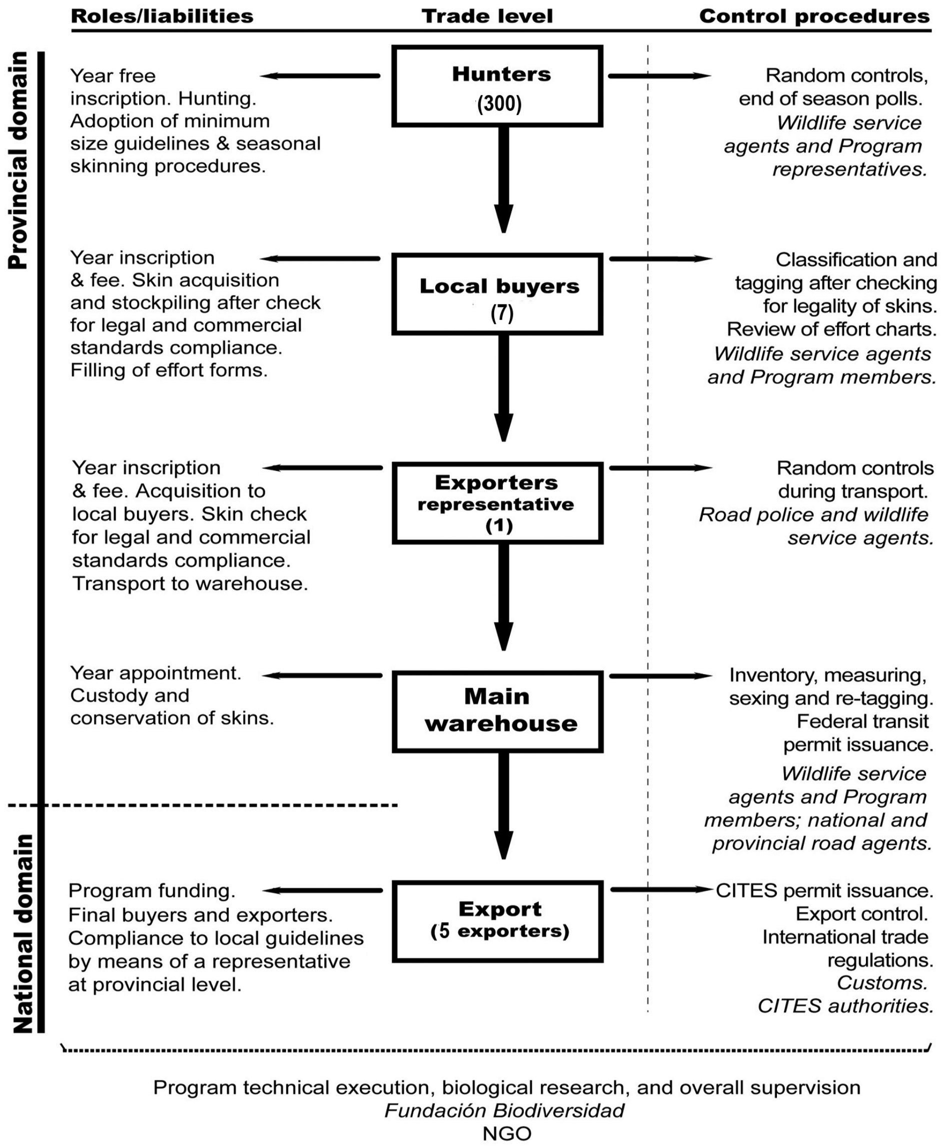

Figure 13. The YAMP operative scheme (modified from Micucci and Waller 2007).

8. Harvest monitoring under the YAMP

a) Monitoring effort instead of establishing a quota

A harvest can be controlled either by placing a quota on off-take or by controlling effort, which means setting a hunting season or limiting the number of people harvesting a population or the time they spend hunting, or both. *E. notaeus* are managed under 'sustained yield' harvest theory, so the YAMP makes no attempt to directly control the number of individuals harvested. Specifically, the YAMP apply the surplus-yield production model (Schaefer, 1954; Fox, 1970), which has been successfully used for many species, including terrestrial species, but was developed for use by fisheries management. Monitoring effort is usually a safer means of regulating a harvest than a quota (Caughley and Sinclair, 1994). Harvesting a constant number of individuals each year is hazardous, particularly when the population is effected by environmentally factors, such as drought, flooding and fire, or when surveying populations is a major constraint (Caughley and Sinclair, 1994); both situations are likely to occur with *E. notaeus* as they inhabit highly seasonal savannahs. There is a maximum rate at which a reduced population can recover (the rate of increase). The maximum harvest can be obtained and sustained when the population is reduced to a level stimulating the maximum recovery (Caughley and Sinclair, 1994; Webb, 2002). These monitoring techniques are combined with direct assessments of harvest attributes and are usually compared with actual population samples obtained by researchers directly in the field (field monitoring).

b) Monitoring harvest parameters

A management plan for the exploitation of a natural resource requires some indicator of the impact of such an activity on the wild population. As adaptive management is selected as the YAMP theoretical framework, the use of indicators that allows managers to adjust management actions is essential. For the YAMP, the following indicators were selected:

- Effort
- Yield
- CPUE as a function of Effort applied to obtain yield curves (surplus-yield models)
- Sex ratio
- Harvested skins average size and size distribution.

c) Yield, Effort and CPUE

Yield is defined as the total volume or number of a resource obtained in a given year. The total number is constructed by adding partial catches, i.e., the results obtained by each hunter in a given site. Yield is influenced mainly by the environmental conditions that predominate during the hunting season and by the composition, in terms of quantity and skill, of each hunter. In this sense, an analysis of yield alone, unrelated to other factors, does not provide sufficient information on the global functioning of the system, and monitoring of trends in the mid-term is strongly recommended. Fig. 14 shows the yield of skins from the YAMP between 2004 and 2014.

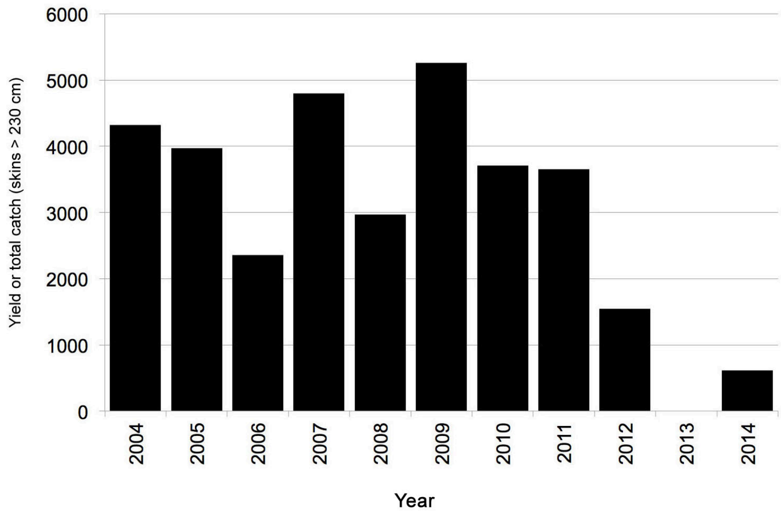

Figure 14. Yield of skins above 230 cm from the YAMP between 2004 and 2014. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

Since the rationale of sustained yield models implies that a harvest represents a specific proportion of the total population, a reduction of the crop would be expected, for instance, in the case of a population constraint by natural conditions (i.e. drought, fires), but this does not necessarily imply that over-harvesting has occurred in that year (Caughley and Sinclair, 1994). Temperatures play a significant role in *E. notaeus* harvested under the YAMP; they are more vulnerable to hunting, thereby increasing hunting success (Fig. 15).

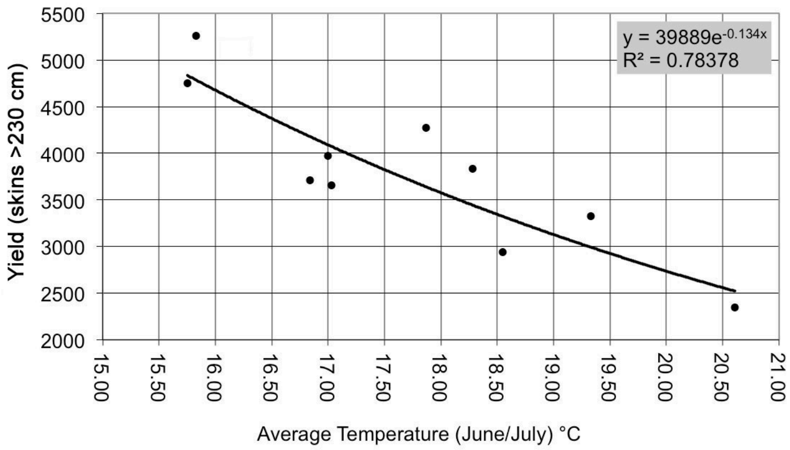

Figure 15. Annual yield of *E. notaeus* versus annual average winter temperatures for 2002 and 2011. High winter average temperatures reduce their vulnerability to hunting because they do not need to bask, reducing overall capture rate.

A decline in yield may not be indicative of the status of the harvested population if, for example, effort also decreases. As expected, yield and effort values are clearly related in the YAMP (Fig. 16). However, yield monitoring may provide useful information to analyze the system more thoroughly and make interventions, whenever feasible. For example, 2006 was a 'bad' year of captures in the YAMP because a low number of hunters participated in the activity, which means that the overall effort for that year diminished in relation to previous harvest seasons. This responds to an increase of traditional labor demand and to the massive distribution of unemployment benefits to hunters and their families by the government since 2003. For instance, if skin price is not continuously updated to compensate for inflation, the yield will continue dropping to new levels in which exporters' actual profits will be totally consistent with actual economic structure. If exporters do not increase skin price as a means of discouraging hunter desertion the system will tend to the commercial extinction. In an effort-mediated system a commercial collapse precedes a biological collapse. A similar situation was recorded in 2012 (low skin prices compared to unemployment benefits) that fostered an unprecedented reduction in effort aggravated by a progressive drought that peaked in 2013, when the harvest was suspended to avoid affecting the population stock. Yield in 2014 was the result of a short post-drought experimental harvest season (45 days instead of 90 days).

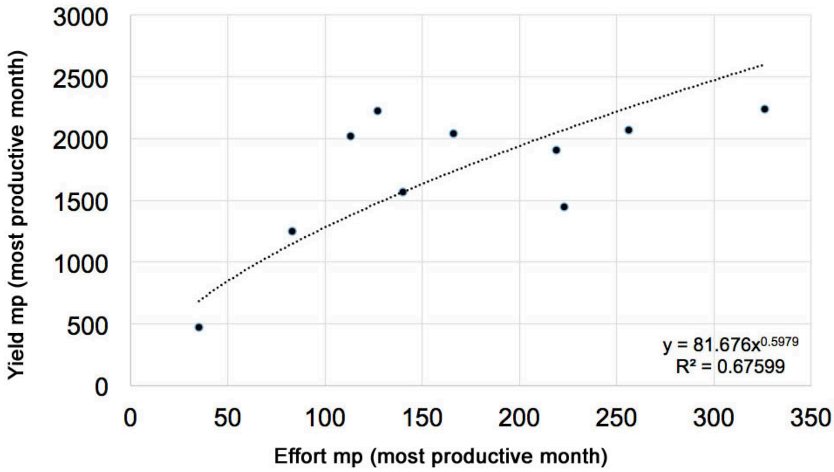

Figure 16. Relationship between yield and hunter effort during the most productive month of July from 2004 to 2014. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

Catch per capita is another indicator used, also known as the Capture per Unit of Effort (CPUE). Monitoring CPUE as a function of effort detects changes in abundance, particularly when active search for individuals is difficult or costly, as in the case of most snakes. Those species in which surveys are viable may be monitored using both techniques (CPUE or census), whereas in most snake species it is only possible to use the CPUE. Substantial differences between both techniques are the cost, scale or degree of resolution, and aim of monitoring. Since there is a commercial activity involved, the necessary data to assess CPUE are obtained at a low cost. The difficulty of this method is undoubtedly the impossibility of making comparisons between results obtained in the extraction area and the situation in a protected area.

The condition to obtain reliable monitoring based on catch per unit effort (CPUE) is an adequate selection of the effort unit (number of hunters, number of hunters per day of harvest, man hours, etc.) and monitoring of the ratio catch/effort units. In the early years of the YAMP, several effort units such as hours/men or days/men were used, leaving aside others such as men/boat (means of transportation) due to the great variation among hunters. As the YAMP progressed, the development of the harvest was found to follow a distribution in time with the shape of a curve (Fig. 17), with the month of July being the most intense period. In July, temperature favors detection of *E. notaeus*, i.e. vulnerability increases, and most of the hunters are active, i.e. maximum effort, and consequently the impact is also at its peak. Since the time unit is a single month, the time variable disappears and the effort unit is simplified to the number of hunters participating in the harvest. We calculate the CPUE for the most productive month (July) as the ratio between yield and the number of hunters for that month (Effort mp).

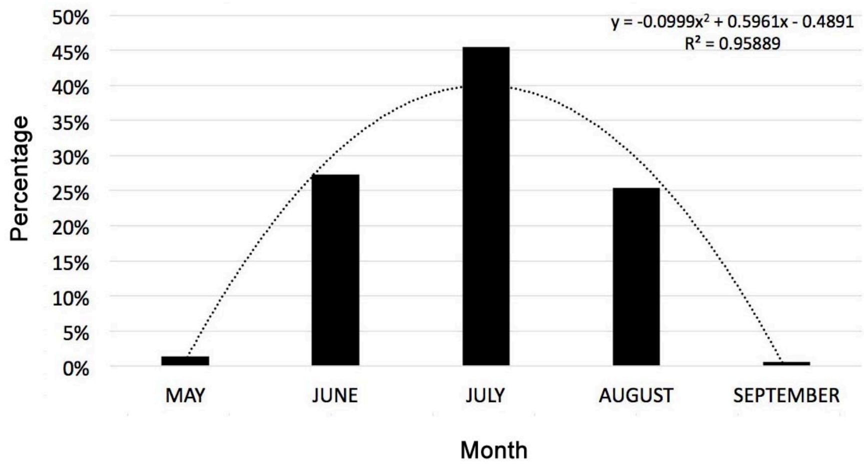

Figure 17. Proportion of the total capture obtained per month by hunters between 2004 to 2008, showing July as the most productive month.

As an indicator, the CPUE provides more information than yield as it is an isolated variable that allows "instantaneous" comparisons between years. However, an increase in the value of the CPUE may be explained by an increase in catch and by a decrease in effort applied (Fig. 18). After several years of monitoring, the YAMP uses the relationship between CPUE and Effort to construct the yield curves and to compare results obtained with the Fox (1970) and Schaefer (1954) model. The aim is to monitor the effort applied as a function of the MSY (Maximun Sustainable Yield) curve (Figs. 19 and 20).

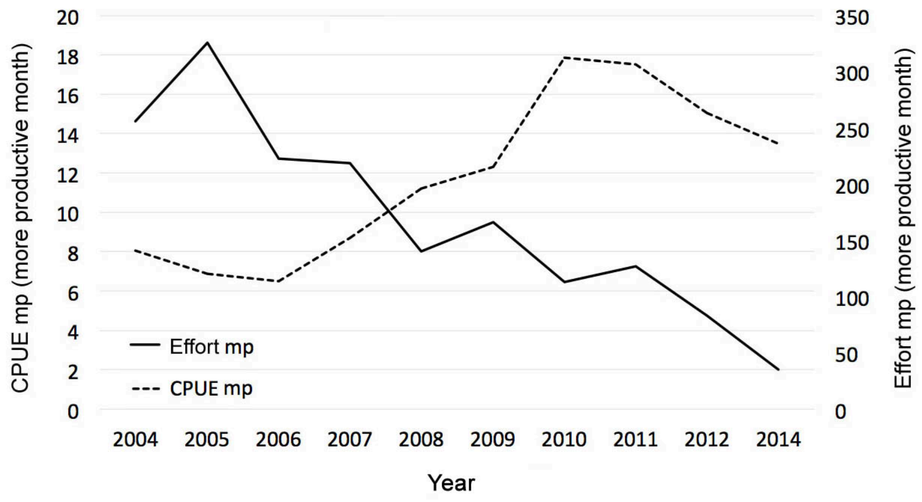

Figure 18. Evolution of CPUE and Effort in the YAMP between 2004 and 2014 showing the strong interaction between both variables. CPUE is the capture per hunter during the month of July and Effort is the number of active hunters during July. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

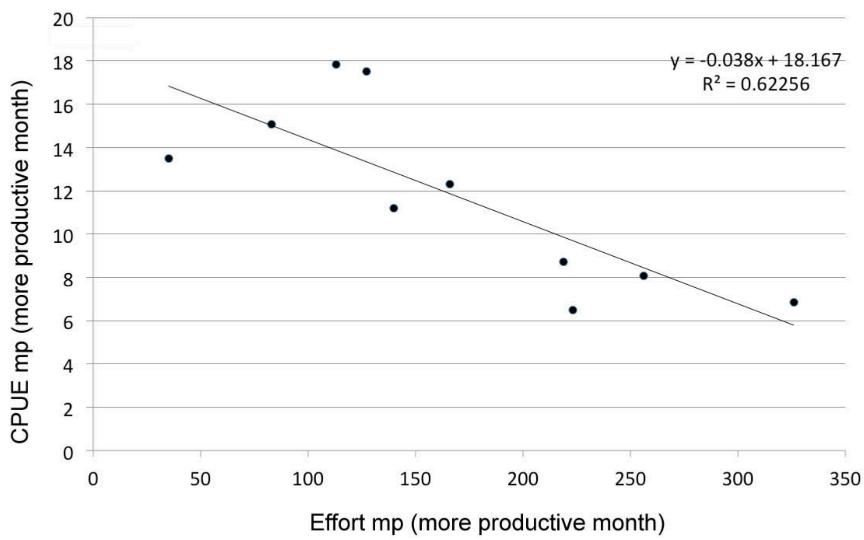

Figure 19. CPUE is inversely related to Effort, here for years 2004 to 2014. CPUE is the capture per hunter during the month of July and Effort is the number of active hunters during July. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

After twelve years of YAMP, a gradual decrease of catch Effort has been observed. This decrease can be attributed to several factors. The YAMP began in a highly unfavorable economic environment for the local inhabitants of the marshland; low demand for workforce, a very low income/expenses rate and an unstable currency value. This situation gradually improved and the State adopted a policy of economic assistance to rural inhabitants. On the other hand, labor demand increased as a consequence of land planning carried out by the provincial government, which permitted regularization of land tenure, intensive deforestation and cattle rearing. Many hunters who started at between the ages of 35 to 40 began to retire and younger people were not attracted by the prices offered for skins and access to education was improving as a result of provincial policies. In this context, the decline in effort (Fig. 21) has been the main cause of decrease in yields and the rise of CPUE, with this value always below the MSY predicted by the surplus-yield models (Fig. 20).

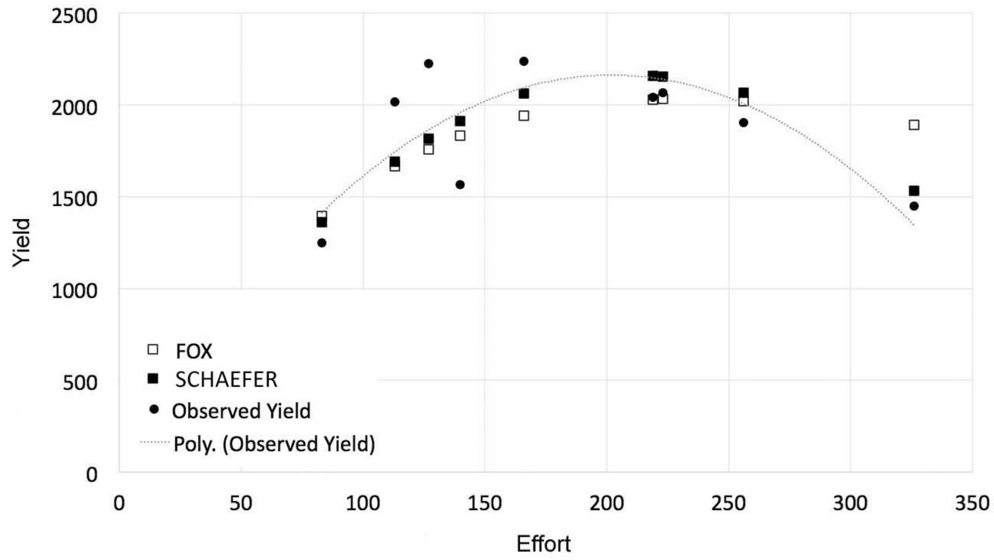

Figure 20. Maximum Sustained Yield curve for July for the years 2004 to 2014 based on Schaefer (1954) and Fox (1970) models. Black dots represent actual yield values; black squares represent Schaefer model prediction; white squares represent Fox model prediction; and dotted line represents the polynomial regression for actual yield values. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

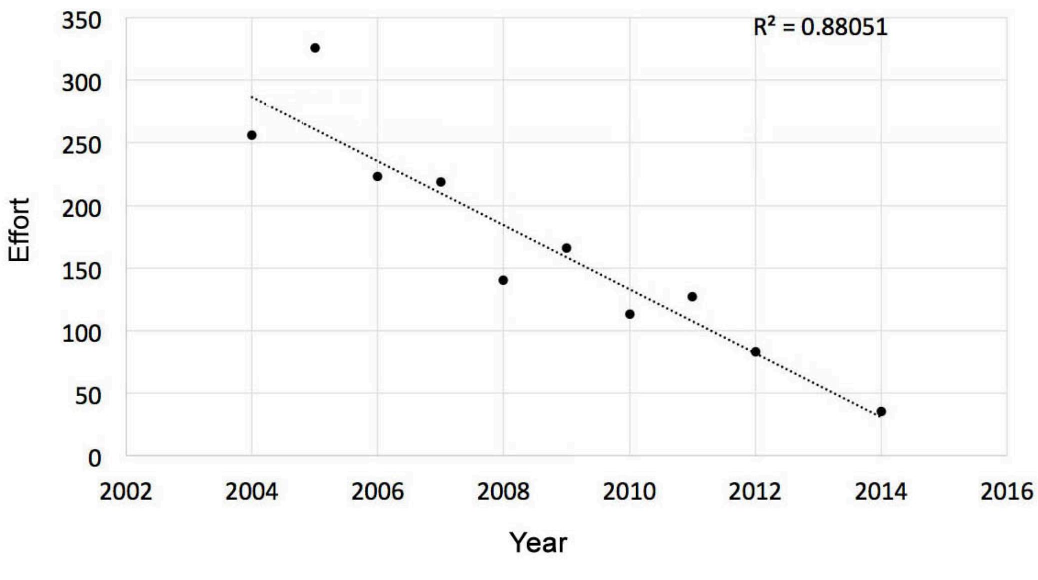

Figure 21. Effort (number of hunters) for the most productive month of July between 2004 and 2014. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

d) Size structure and average size of harvested skins

Size structure, although often fluctuating due to natural causes (Webb, 2002), permits observation of significant changes in the natural pattern, or at least in the pattern established as natural, prior to a significant activity of extraction. A random sample of all snakes from all sizes classes is compared to that obtained from the YAMP harvest of *E. notaeus*, to detect possible differences in the relative frequency distributions. However, in the case of skins, like in the YAMP, the best approach has been to compare the evolution of the harvested skins size structure in time (Fig. 22).

Size structure fluctuated between years but exhibits a decrease in the relative frequency of larger size classes after 2011 (Fig. 22). This decline coincides with a decline in CPUE after that year (Fig. 18). Applied effort and overall harvest also diminished in the last years for reasons already explained (Fig. 21), so observed trends in size structure appear to be related to a severe dry period that affected the region between 2010 and 2013 that led to the suspension of the harvest in the latter year. Droughts are expected to affect large individuals (mostly females) more, compared to the smaller juveniles and adults (mainly males). *E. notaeus* are well suited to traverse long distances and conceal themselves in dry areas when searching for prey or awaiting better environmental conditions.

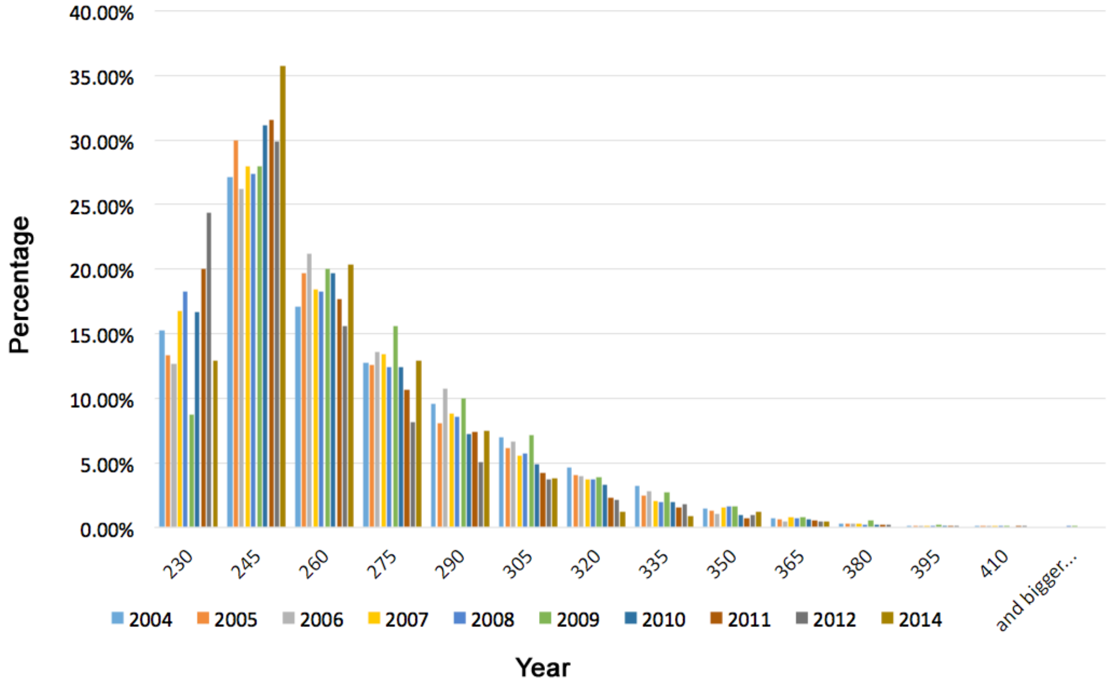

Figure 22. Size structure of harvested *E. notaeus* skins > 230 cm from 2004 to 2014. Relative frequency expressed as percentage of total sample for each year. Each 15 cm interval class is represented by the upper limit value. First interval exhibits the proportion of undersized skins (<230 cm) in the harvest. Harvest was not permitted during the year 2013 due to a serious drought affecting the main harvest area.

Monitoring average skin size or length, in addition to using other descriptive statistics, such as standard deviation, mode, median, etc., also provides useful information on the local effect of harvest on *E. notaeus* in the short term. However, the fact that larger individuals are normally the easiest to detect and the first to be collected should be taken into account. When the value of *E. notaeus* lies in the skin, measurements may allow the manager to forecast commercial viability of the activity in the future, when there is a minimum size that should be respected; the YAMP uses a minimum size so that all analyses are carried out on the skin population within the legal size range. Usually, however, there is a percentage of skins below the minimum size permitted, or “illegal” skins, but the proportion of such skins varies with enforcement effort and cannot be attributed to any cause of analytical value.

After twelve years of harvest data, the YAMP observed a decrease in the average value of *E. notaeus* skins by around 3%. The current value of the mean skin size (251 cm) indicates that most of the harvest affects mature individuals that may have already experienced a reproductive event (Waller et al., 2007). In this context, and assuming that there is a constant inter annual decline attributable to the harvest (which is very unlikely), commercial extinction for the *E. notaeus* population being studied in the YAMP could occur in 30 years (230 cm minimum skin size limit), whereas the breeding stock would not be affected for more than 50 years (200 cm skin, equivalent to a 170 cm live, or the age at maturity). This suggests that even in the worst-case scenario, commercial extinction would greatly anticipate (and prevent) biological extinction for this *E. notaeus* population.

e) Sex ratio

Sex ratio is known from the literature and is generally an excellent indicator when the species exhibits sexual dimorphism. A low impact extraction is not expected to alter the sex ratio. In the case of *E. notaeus*, differentiating skins by sex is an easy practice requiring little training; just observing the presence of spurs (Micucci et al., 2003, 2005). The size limit established in the YAMP permits the hunting of *E. notaeus* > 200 cm SVL; since females attain larger sizes than males, the harvest was expected to include more females than males, in a fairly constant and predictable proportion, according to the serendipitous nature of the hunting and sex and size structure of *E. notaeus* populations. Since both sexes are equally available (Waller et al., 2007), males and females were expected to be relatively equal in their vulnerability to capture with actual harvest sex ratio resulting from the minimum size limit established (~75% females). In the YAMP, sex ratios of harvested *E. notaeus* have been relatively constant, with slight fluctuations attributable to environmental factors (e.g., the dry period that started in 2010 that apparently diminished the survival of large individuals, mainly females).

Conclusion

The harvest and trade of Yellow Anaconda (*E. notaeus*) in Argentina has been transformed from historical misuse to a robust and sustainable management system. The YAMP has succeeded in designing and establishing specific management policies for a traditionally exploited snake species from the beginning, organizing the hunters, traders, and the government on a same path and with a same long term objective. The tools applied to control and monitor the harvest have been adequate and cost-effective, providing evidence that the harvest has not been detrimental to the survival of the wild population. Our knowledge of the species has increased exponentially, and legal trade is sustained through a balance simple yet robust regulation together with incentives for local people to trade legally.

The YAMP satisfies the Secondary Evaluation as part of the NDF Guidelines for CITES listed snakes. Importantly, the system is managed adaptively. Even if our monitoring system identifies population declines due to harvesting, we do not automatically move to make a negative non-detriment finding and cease trade. Instead, the framework is in place for us to make simple management interventions to ensure sustainability while continuing trade.

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