Incense Tree (*Aquilaria sinensis*)

Species Action Plan

2018-2022

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Compiled by the Agriculture, Fisheries and Conservation Department

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1. Introduction

Trees of the genus *Aquilaria* produce a dark aromatic resin at wounds as a reaction against fungal infection. Sections of tree trunks or branches that contain patches of such fragrant, resinous wood enter into the trade under the name "agarwood" (沉香木). Incense Tree, *A. sinensis* (土沉香/牙香樹), is a major source of such premium-priced agarwood, which are mainly used as sculpting materials and perfume ingredient in Mainland China. The balm (resin) produced and accumulated from the wood is also traditionally utilised as a precious Chinese medicine called "Chen Xiang" (沉香). The strong monetary incentive for harvesting has led to a sharp decline in the wild population of large Incense Tree in Southern China.

A. sinensis is currently categorised as "vulnerable" in the International Union for Conservation of Nature (IUCN)'s Red List of Threatened Plants. The genus *Aquilaria* is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). At the national level, the species is listed as an endangered species in the "China Plant Red Data Book: Rare and Endangered Plants" and on the country's "List of Wild Plants under State Protection (Category II)". In Hong Kong SAR, *A. sinensis* is protected from unauthorized vandalism, damages or felling under the Forests and Countryside Ordinance (Cap. 96) and the Country Parks and Special Areas Regulations (Cap. 208A) if they are found within Country Parks and Special Areas. Depending on the circumstances of individual cases, the Police may initiate prosecutions under the Theft Ordinance (Cap. 210), which imposes a heavier penalty. Being listed in Appendix II to the CITES, international trade of agarwood is scrutinised by a licensing system and regulated under the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586), which is the local legislation that gives effect to CITES.

Hong Kong witnessed an increasing trend of illegal felling of Incense Tree from 2010 to 2015. Cases of illegal felling and cutting of Incense Tree were reported in different regions of Hong Kong such as Sai Kung, Sha Tin, Sha Tau Kok, Tai Po, Lantau Island, Lamma Island and Hong Kong Island. Given that the populations in Hong Kong represent some of the best remaining healthy populations of the species, this Species Action Plan (SAP) is devised to provide a pragmatic framework of conservation measures to achieve the long-term viability and sustainability of the local Incense Tree populations. The recommended actions will be undertaken through collaborations among the government's conservation authority, enforcement agencies, academic institutions, NGOs and local communities.

2. Background Information

2.1 Taxonomy

The Incense Tree is under the following taxonomic hierarchy (Cronquist, 1988):

Class Magnoliopsida
Order Myrtales*
Family Thymelaeaceae
Genus *Aquilaria*
Species *Aquilaria sinensis* (Lour.) Spreng.

To date, there are 21 *Aquilaria* species recorded (Lee and Mohamed, 2016), and they are mostly distributed in Southeast Asia, of which two species, *A. sinensis* and *A. yunnanensis*, are native to Mainland China. It is generally difficult to distinguish *A. sinensis* from other *Aquilaria* species based on morphological characteristics, but recent studies have shown that DNA barcoding technology can improve species identification of *Aquilaria* species including *A. sinensis* (Jiao *et al.*, 2013; Lee *et al.*, 2016). Some morphometric and genetic data of the species are currently available (e.g., Zhao and Zhao, 2007; Zhang *et al.*, 2010; Zou *et al*., 2012; Wang *et al.*, 2016). Yet past studies have not revealed any cryptic species among populations of *A. sinensis*.

2.2 General description

Major morphological characteristics of *A. sinensis* are shown in Annex I. Incense Tree is often named as "Pak Muk Heung" (白木香) because of its white to yellowish wood. It is an evergreen tree which can grow up to 15-20m tall, and its branchlets are terete, puberulous and glabrescent. It has a smooth tree bark of grayish to dark grey colours. Its leaves are alternately arranged and obovate, with 15 to 20 pairs of inconspicuous and nearly parallel lateral veins. Flowers of the species are small, green and fragrant, and there are 10 petals and 10 stamens in one whorl. Its fruits are woody capsules with an outer covering of short grey hairs, opening in two flat valves when ripen, and hanging down like green pendants

*Order Malvales if following APG IV, Angiosperm Phylogeny Group, 2016

2.3 Biology and ecology

Incense Tree occurs in semi-evergreen monsoon forest up to altitudes of 400m (Sun, 1998). It has a flowering season from March to May, and a fruiting season from September to October. A recent study has revealed that noctuid and pyralid moths are the most effective pollinators of *A. sinensis,* and hornets may play an important role in long-distance seed dispersal of the species (Chen *et al*., 2016) as well as other *Aquilaria* species (e.g., *A. malaccensis,* Manohara, 2013). Nevertheless, based on the analyses of genetic markers, Zou *et al*. (2012) suggested that gene flow between populations of *A. sinensis* could be restricted due to factors such as low seed dispersal and isolation of populations.

The older trees (usually over 15 years) of *A. sinensis* may produce a dark aromatic resin (Annex II) as a response to wounding or fungal infection (Liu *et al*., 2013) but not all of the trees that have wounds would be naturally infected by fungi. In a natural environment, wounds of the trees could be caused by insect attack, lightning strike, animal grazing and microbial invasion, but there are also various artificial wounding and inoculation methods adopted by farmers to induce resin production (Liu *et al*., 2013). Resin-impregnated heartwood (i.e., agarwood) that is fragrant has been a highly valuable non-timber forest product excessively demanded for the production of medicines, incense and perfumes across Asia and the Middle East (Barden *et al*., 2000). The resin in agarwood is also a precious Chinese medicine called "Chen Xiang", which has reported medicinal effects as a sedative and carminative, and to relieve gastric problems, coughs, high fever and rheumatism (Liu *et al*., 2013). *A. sinensis* has, therefore, been regarded as an important medicinal plant since thousands of years ago (He *et al.*, 2005). Production of "Chen Xiang" is, however, a slow process and thus the supply of agarwood from wild sources is far less than the market demand (Liu *et al*., 2013). Due to its rarity, agarwood has also become a popular collectible item, which is sold in auction markets. The high-quality agarwood products could be sold up to US$10,000 per kg, whereas the distilled Agarwood oil may fetch up to US$30,000 per kg (TRAFFIC, 2012).

2.4 Population status

2.4.1 Mainland China

Natural populations of *A. sinensis* in the Mainland have severely diminished due to uncontrolled exploitation, habitat destruction and the lack of effective recovery plans. Remaining viable populations of the species are found only in a few mountainous regions in Hainan and Guangdong provinces (Zou *et al*., 2012). Some of these existing

populations may have originated from cultivation as agarwood production and trading were once very well-developed especially in the Guangdong Province in early days. To cope with the immense demand for agarwood, over 20 million of *A. sinensis* have been widely cultivated in Hainan, Guangdong and Yunnan provinces (Liu *et al*., 2013).

2.4.2 Hong Kong

Hong Kong has some of the best remaining healthy populations of *A. sinensis* but these populations are currently under threats of illegal felling. Nevertheless, seedlings and young trees are still commonly seen throughout the countryside of Hong Kong.

2.5 Distribution

The species is native to Southern China, restricted to Yunnan, Guangdong, Guangxi and Hainan Island (Sun, 1998). Locally, it is known that *A. sinensis* was once widely planted in Hong Kong for producing the raw materials of incense, which were then traded to regions such as the Mainland, Southeast Asia and places as far away as Arabia (Iu, 1983). The incense industry was likely the origin of Hong Kong's Chinese name "fragrant harbour" or "harbour exporting incense" (Iu, 1983; Liu *et al*., 2013). Since *A. sinensis* regenerates in the wild with vigour in local environment, the species is often considered as native to Hong Kong. AFCD has been keeping records of *A. sinensis* encountered in routine vegetation surveys, and the data hitherto collected show that the species is generally found in lowland habitats all over Hong Kong (e.g., New Territories, Lantau, Lamma and Hong Kong Island), and it is particularly abundant in Fung Shui woods behind rural villages and in country parks. The species was recorded in 89 out of the 116 Fung Shui woods surveyed by AFCD in 2002-2003 (Yip *et al*, 2004). According to the Hong Kong Herbarium, the species has been recorded in over 100 locations in Hong Kong since 2002.

2.6 Conservation

Under the Forests and Countryside Ordinance (Cap. 96), any person who unlawfully fells or damages any trees on Government land is liable to a maximum penalty of $25,000 fine and one-year imprisonment. The Country Parks and Special Areas Regulations (Cap. 208A) also prohibits cutting, picking or uprooting of any plants, including *A. sinensis*, in Country Parks and Special Areas. The maximum penalty is $2,000 fine and imprisonment for three months. Offenders involving in illegal felling of *A. sinensis* were, however, mainly prosecuted under the Theft Ordinance (Cap. 210) as it imposes a heavier penalty

with a maximum of 10-year imprisonment. The prosecution figures in 2010-2017 are listed in Annex III. Most of the prosecution cases involved two-way permit holders, as well as some illegal immigrants and few Hong Kong residents.

Under the Protection of Endangered Species of Animals and Plants Ordinance (Cap. 586), any person found guilty of importing, exporting or re-exporting CITES Appendix II specimen without the required licence is liable to a maximum fine of $500,000, imprisonment for one year and mandatory forfeiture of the specimens. In order to impose a stronger deterrent effect and demonstrate the Government's determination to combat the smuggling of animals and plants, the maximum penalty for offences involving a CITES Appendices II and III species, including Incense Tree, has been increased to a fine of $1 million and imprisonment for seven years as the Protection of Endangered Species of Animals and Plants (Amendment) Ordinance 2018 came into force on 1 May 2018.

2.7 Threats

The depletion of the wild populations of *A. sinensis* in Southern China, which had exacerbated the shortage of agarwood in the Mainland, and thus an extension of illegal exploitation to Hong Kong. The facilitated access across border between Hong Kong and mainland China and the enormous influx of visitors have also enhanced cross-border crimes including illegal felling of *A. sinensis* for harvesting agarwood (Jim, 2015). In the past, poachers often wounded the trees to induce resin production, marked the wounds, and returned after several years to harvest agarwood. With the increasing demand for agarwood, poachers to-date tend to indiscriminately cut down the trees to search for agarwood even though the quantity of agarwood obtained from each felling is usually extremely low (Soehartono and Newton, 2001). For such cases, they also return to harvest agarwood, if any, from the remaining living stumps.

There was a surge of reported cases of illegal felling of *A. sinensis* in 2014 and 2015 as noted from the figures provided by the Police (Annex III). Large mature trees (i.e., ≥ DBH 20cm) were the major victims due to the higher chance of finding resins from them. Even if these trees were not completely cut down, the damages that caused by poachers were often so serious that the trees could no longer survive. In 2016, reported cases of illegal felling of *A. sinensis* appeared to dwindle by more than half when compared to the previous two peak years (Annex III). The reduction of felling activities may be due to the declining stock of large mature trees in the wild as well as the enhanced enforcement effort to deter poachers. Given that *A. sinensis* is widely distributed in the countryside, the detection of illegal felling activities and timely follow-up actions remain a major

challenge for law enforcement. Although the Police and AFCD have stepped up patrol at the black spots of illegal felling of *A. sinensis* and remained vigilant in attending to reported cases, prosecution of poachers is very often not successful because of failures or delays in detecting illegal activities and collection of crime evidence.

2.8 Stakeholders

The Police, the Customs and Excise Department (C&ED) and AFCD jointly undertake enforcement actions associated with felling of *A. sinensis*. The Police conducts criminal investigations into all suspected cases while AFCD renders assistance in inspecting the exhibits, providing expert advice and serving as expert witness on identification of the trees concerned in the court proceedings. C&ED and AFCD also work in tandem to enforce the import and export/re-export control under Cap. 586. The two enforcement agencies have conducted a series of joint operations at export control points to combat smuggling of endangered species including agarwood.

Two NGOs are particularly active in conservation issues associated with *A. sinensis*, namely the Association for the Ecological and Cultural Conservation of *Aquilaria sinensis* and the Association for Tai O Environment and Development. The former has conducted numerous joint patrols and site investigations and shared useful intelligence with the enforcement agents, whereas the latter has organised a range of education programmes funded by AFCD's subventions to promote the cultural value of *A. sinensis*.

3. Action Plan

3.1 Aim

The aim of this action plan is to lay down a framework of conservation actions which will ensure long-term viability and sustainability of the local *A. sinensis* populations.

3.2 Objectives

(i) To step up enforcement actions against illegal tree felling;
(ii) To augment surveillance and enforcement in the countryside;
(iii) To facilitate border control against agarwood smuggling;
(iv) To foster effective communication and cooperation with the Mainland enforcement agents;
(v) To strengthen protection for high-risk specimens;
(vi) To restore the damaged populations and establish new populations;
(vii) To improve scientific knowledge;
(viii) To establish long-term monitoring of important populations; and
(ix) To raise public awareness regarding the cultural and conservation values of the species

3.3 Timeframe

The actions are to be taken from 2018 to 2022, and will be refined over consecutive five-year plans.

3.4 Actions

3.4.1 RISK-BASED PATROLS

To step up enforcement against illegal felling of *A. sinensis*, AFCD has established a special task force to step-up patrols in the countryside. The task force has also started to conduct a series of intensive surveys to update the baseline information including sizes and locations (GPS readings) of *A. sinensis* identified. The locations of the damaged and intact trees are mapped using a GIS software, together with intelligence from various sources (e.g., the Police and concern groups), to identify healthy populations and black spots, for planning and prioritising patrol efforts based on risks (Fig. 1). When signs of irregularities are found, the patrol team reports the case to the Police promptly for further

investigations. Joint operations between AFCD and Police have also been increased to deter illegal felling of *A. sinensis* at black spots.

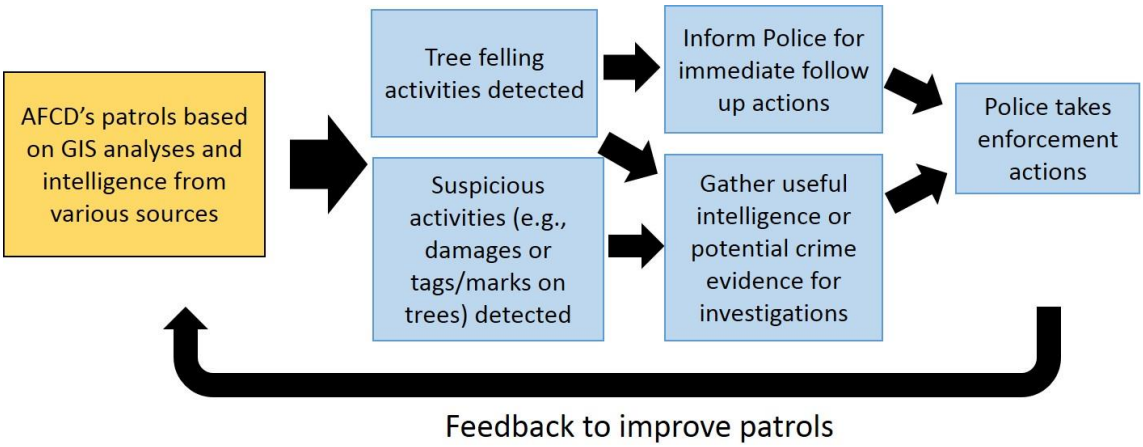

Figure 1. A schematic diagram showing the risk-based approach for patrols.

AFCD will continue to conduct patrols using a risk-based approach, targeting healthy populations and black spots.

3.4.2 SURVEILLANCE IN THE WILD

To facilitate gathering of crime evidence and ensuring swift enforcement against illegal felling of *A. sinensis* in the countryside, AFCD has conducted trials of a surveillance device called the Infrared Sensor Camera Trap (IRSCT) at strategic locations. The IRSCTs are triggered by moving heat objects such as human activities close to the target trees to take multiple pictures instantly. The pictures will then be sent immediately to a designated mobile device via e-mail. Based on the results of the trial runs, management of IRSCTs are very costly as it requires 24-hour monitoring by staff to check the pictures taken, frequent batteries replacement (once 2-3 weeks), and labour-intensive screening of non-useful signals (e.g., detections of animals and hikers). AFCD and the Police have developed an operation protocol to facilitate swift enforcement actions upon the detection of illegal felling activities by the IRSCTs. The feasibility and cost-effectiveness of extending the IRSCT system to a territorial scale will be closely monitored and reviewed.

To ensure swift enforcement actions, supports from residents living in the countryside are also vital. With the support of concern groups, stronger collaboration has been established with residents of rural areas where *A. sinensis* are found, to enhance intelligence exchange and facilitate early detection of illegal activities.

AFCD will continue to work closely with the Police in conducting 24-hour surveillance of A. sinensis at several strategic locations using IRSCTs under a pilot scheme. AFCD and the Police will also continue to build a collaborative network with countryside residents, and encourage them to report timely any illegal felling *activities.*

3.4.3 BORDER CONTROL

AFCD has been conducting training sessions to help frontline staff of C&ED identify agarwood and detect illegal activities. In addition, the fragrant nature of agarwood may serve as a clue to allow detection by trained dogs. AFCD is conducting a pilot scheme of training dogs from the Quarantine Detector Dog Programme to detect smuggling of agarwood.

AFCD will continue to provide training for frontline staff and train up quarantine detector dogs to assist in combating agarwood smuggling at border control points.

3.4.4 COMMUNICATION WITH RELEVANT MAINLAND AUTHORITIES

AFCD, C&ED and the Police have stepped up joint efforts to strengthen export control and intelligence exchange with the enforcement agencies of the Mainland to combat smuggling of items derived from *A. sinensis*. AFCD has also contacted its CITES counterpart in the Mainland, drawing their attention to the matter and requesting them to liaise with their relevant agencies to step up enforcement actions in the Mainland. An enforcement training workshop to further strengthen the collaboration between the enforcement agencies from the two sides will be held in July 2018.

AFCD, C&ED and the Police will enhance communication and cooperation with the enforcement agencies in the Mainland in combating illegal activities associated with A. sinensis.

3.4.5 PROTECTION FOR HIGH-RISK SPECIMENS

Large mature trees (i.e., ≥ DBH 20cm) are more likely to form resins and are more often the targets of the poachers. AFCD has been installing metallic tree guards and mesh fences to protect these high-risk trees in certain Fung Shui Woods and other appropriate locations throughout Hong Kong. The tailor-made metallic tree guards are about 2m tall, robust and tolerant to mechanical damage, designed to protect the trunks of the trees (Annex IV). Meanwhile, mesh fences (about 1.8m tall) constructed using bamboos and metallic mesh

are less resistant to sawing or cutting, but are cheaper and quicker to install. The results of the pilot scheme indicted that the guards/fences were only a means to discourage poachers, but not an effective tool to prevent determined poachers from cutting the unprotected parts of the tree. Nevertheless, by identifying high-risks trees to call for enhanced monitoring by the neighbourhood, and creating physical barriers to tree-cutting, these guards/fences are still considered as a useful means to protect high-risk specimens in easily accessible locations. On the other hand, there are concerns on the installation of protective barriers, such as the likelihood of exposing intact populations to poachers, potential impact on the aesthetic value of the trees and compatibility with the natural environment, as well as possible damages to the root systems of the trees during installation. As such, there are a number of factors for consideration to determine whether tree guards or fences should be installed for *A. sinensis*, including:

- Size (only trees ≥ 20cm DBH);
- Health and physical conditions;
- Historical and cultural values;
- Level of isolation (avoiding exposure of large populations to poachers);
- Land status (only for trees on Government land); and
- Stability of substratum (for tree guards to stay firm).

With due consideration of the condition of trees and the suitability of site, AFCD will continue to deploy tree guards and mesh fences as a means of deterring illegal felling of high-risk specimens.

3.4.6 ARTIFICIAL PROPAGATION AND REPLANTING

AFCD has increased the production of seedlings of *A. sinensis* in the past few years to around 10,000 seedlings per year for the restoration of *A. sinensis* populations. Most of these seedlings were planted extensively in country parks. Considering habitat suitability based on preliminary trials, seedlings were also planted at strategic sites including Fung Shui woods. Recently, a total of about 100 individuals (including seedlings and young trees) have also been planted and established in some secure locations for generating new populations. In addition, AFCD has provided seedlings to support several tree planting programmes in schools.

AFCD will continue to produce around 10,000 seedlings per year and restore populations of A. sinensis in country parks, as well as establish new populations in other secure locations identified. Seedlings will also be provided, if needed, to any

planting programmes in secured places such as schools, within the boundary of institutions, government premises, urban parks, etc.

3.4.7 SCIENTIFIC STUDIES

AFCD would encourage relevant research and commission scientific studies that could enhance the conservation of *A. sinensis*. For example, studies on inter-population genetic variations of *A. sinensis* within Hong Kong and between Hong Kong and nearby areas could potentially inform compensatory planting and facilitate law enforcement. For example, if distinctive genetic variations between individuals or populations can be identified, such genetic information may be used as 'fingerprints' to trace the source of origin, for gathering crime evidence. AFCD has also been working with an academic institution to conduct trial tree surveys using aerial drones.

AFCD will encourage research institutions to conduct scientific studies that could enhance the conservation of Incense Tree.

3.4.8 LONG-TERM MONITORING

AFCD is conducting a trial to tag the high-risk specimens (i.e., ≥ DBH 20cm) in the countryside with microchips for continuous monitoring, and is testing whether the microchips can be readily detected by receiver probes and hence allow rapid location detection of the tagged trees in the countryside. AFCD will also conduct a trial to test an alternative approach by locating trees using a high-precision Global Positioning System (GPS). Surveys will be conducted to monitor the conditions (cut / wounded / remain intact) of the tagged trees from time to time. The data gathered from the surveys will be integrated into the GIS mentioned above in order to conceive patrol strategy.

AFCD will continue to conduct the trial using microchips and will also conduct a trial using high-precision GPS with an aim to providing continuously monitoring for the large A. sinensis specimens in the countryside.

3.4.9 PUBLICITY AND EDUCATION

AFCD has included the *A. sinensis* in its regular education and publicity programmes. Agarwood specimen has also been displayed in the AFCD Endangered Species Resource Centre. Poster has been displayed at various visitor centres, information boards of country parks and District Offices (Annex V). To raise the awareness of the public about the

offences of illegal felling of *A. sinensis*, an episode of the *Police Report* involving both the Police and AFCD was broadcasted in 2015. Propaganda materials on the subject have also been distributed to all land boundary control points by AFCD for display (Annex V).

Joint effort between AFCD and different NGOs in promoting biodiversity conservation in Hong Kong has been increased in the last two years, through the platform of the Hong Kong Biodiversity Festival and Subventions on Biodiversity Education. AFCD will continue this collaborative annual event, and provide funding support to NGOs for conducting education programmes about biodiversity conservation including the conservation of *A. sinensis*. AFCD has also been working with NGOs, such as the Association for the Ecological and Cultural Conservation, to conduct tree planting programmes in schools. AFCD would produce publicity materials and provide seedlings to support these tree planting programmes.

AFCD will continue to support NGOs in conducting publicity and education programmes related to the Incense Tree, and will also contribute to materials, seminars and technical support in these programmes, if needed.

3.5 Action timetable

#	**Action**	**Agency(-ies)**	**Timeframe**
1	Risk-based patrols	AFCD*, HKPF, NGOs	Ongoing
2	Surveillance in the wild	AFCD*, HKPF, villagers	Ongoing
3	Border control	AFCD, C&ED	Ongoing
4	Communication with relevant Mainland authorities	AFCD, HKPF, C&ED	Ongoing
5	Protection for high-risk specimens	AFCD	Ongoing
6	Artificial propagation and replanting	AFCD, relevant departments and authorities, NGOs	Ongoing
7	Scientific studies	AFCD, academic institutions	2018-2020
8	Long-term monitoring	AFCD	Ongoing
9	Publicity and education	AFCD, other funding agencies, NGOs	Ongoing

Remarks:
* indicates the leading agency
Abbreviations: AFCD – Agriculture, Fisheries and Conservation Department; C&ED – the Customs and Excise Department; HKPF – Hong Kong Police Force; NGO – Non-governmental Organization
"Ongoing" refers to action currently being implemented and should continue

4. Implementation and Review

AFCD has consulted relevant stakeholders, including government's enforcement agents (HKPF and C&ED) and a number of NGOs, at the 3rd Meeting of Wildlife Crime Task Force (WCTF) held on 13 March 2018 on this Species Action Plan. These stakeholders will be invited to review the present SAP through the platform of WCTF in late 2022. Interim review of the plan may also be called for if necessary. The emphasis of the review is anticipated to be focused on the effectiveness of the various measures to protect and restore the wild *A. sinensis* populations, as well as the means to detect and deter any felling activities. In this regard, data such as the latest prosecution figures, the changes in the condition (e.g., remain intact / wounded / cut) of tagged trees under Action 8 and trees protected under Action 5 or monitored under Action 2, as well as the condition of the newly established trees in the secure locations under Action 6, could serve as indicators for evaluating the effectiveness of the conservation measures. However, sensitive data (e.g., locations of the *A. sinensis*, camera traps and newly established populations) should not be disclosed.

Majority of the funding required to put forward the proposed actions will be provided by AFCD. Given the substantial implication of 24-hour surveillance on financial and manpower resources, cost-effectiveness of such measures and the availability of long-term resources to sustain the intensive enforcement efforts would be the key considerations in future reviews.

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Annexes

Annex I: Pictures showing features of *A. sinensis*

Whole tree

Tree bark

Leaves and flowers

Fruits

Annex II: Pictures of healthy (top) and resin-impregnated (bottom) heartwood of the *A. sinensis*

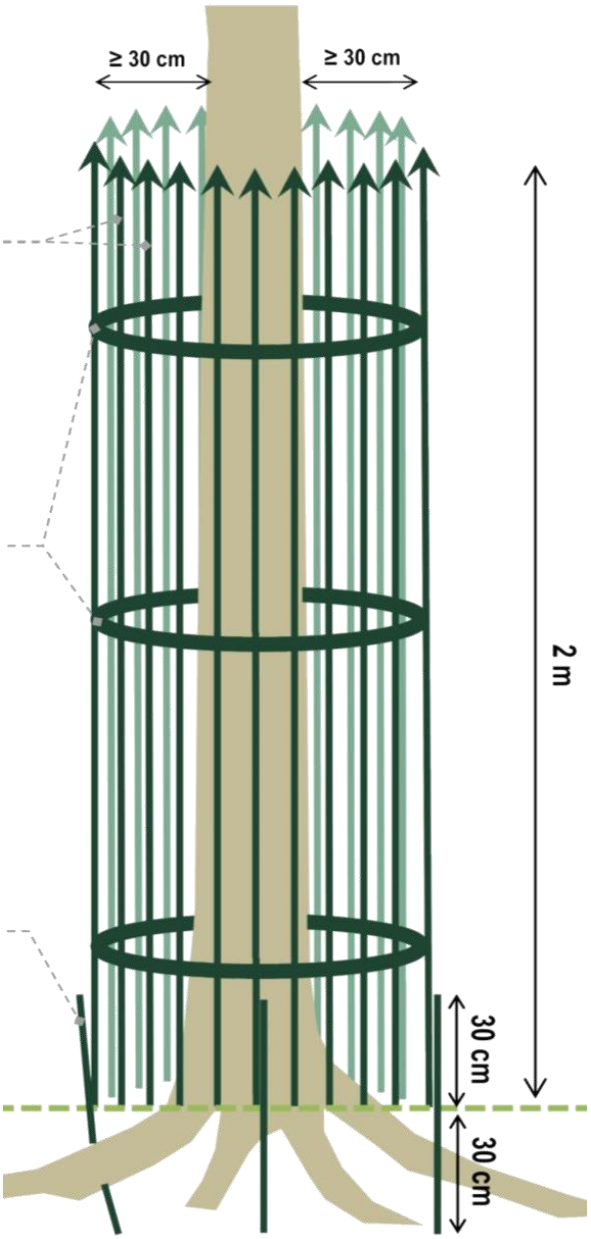
Healthy heartwood

Resin-impregnated heartwood (agarwood)

Annex III: Police's figures of illegal felling or damaging of *A. sinensis* in the past eight years

Year	Number of Reported Cases	Number Arrested (Person)	Number of Prosecutions (Case)	Number of Convictions (Case)
2010	19	16	9	9
2011	72	65	28	28
2012	67	64	29	27
2013	96	41	21	18
2014	134	65	26	26
2015	120	16	5	3
2016	54	22	8	5
2017	53	9	1	1

Annex IV: An illustration of the metallic tree guard



Annex V: Pictures for the publicity materials related to *A. sinensis*

Poster titled “No Unauthorised Tree Felling”

Display at Man Kam To Control Point