CITES TREE SPECIES PROGRAMME
Conservation and Sustainable Management of *Osyris lanceolata*, for Economic Development in East Africa

OUTPUT 3.1: CONDUCTING FOREST INVENTORIES, MANAGEMENT MEASURES, PRODUCTION WITH A VIEW OF ESTABLISHING HARVESTING QUOTA: FIELD STOCK INVENTORY IN NAROK COUNTY, KENYA

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SYNONYMS AND ACRONYMS

ASALs: Arid and Semi-Arid Lands

CITES: Convention on the International Trade in Endangered Species of Wild Fauna and Flora

CoP: Conference of Parties

DBH: Diameter at Breast Height

EA: East Africa

EC: European Commission

EU: European Union

KEFRI: Kenya Forestry Research Institute

KFS: Kenya Forest Service

KWS: Kenya Wildlife Service

LH: Lower Highland zone

NDFs: Non Detriment Finding studies

NEMA: National Environment Management Authority

NMK: National Museums of Kenya

TA: Tropical Alpine

UH: Upper Highland Zone

UM: Upper Midland zones

SUMMARY

The listing of the East African Sandalwood (*Osyris lanceolata* Hochst. & Steud, Santalaceae) in the three East African range states (Kenya, Uganda, Tanzania), on CITES Appendix II and subsequent decisions, necessitated an encompassing regional response. Through this regional and multi-institutional project, these range states embarked on a detailed study of *O. lanceolata* populations within their borders. In this report, Kenya aims to provide an account on the density, standing stock, utilization and harvesting and propose a harvesting quota for the selected population. This study was conducted in Narok County in South East Kenya. It covers *O. lanceolata* populations in Loita, Narok East and Narok West sub-counties. This locality is part of the natural range for Osyris in Kenya, it is easily accessible, served by several ports of exit/entry and there have been reports of illegal harvesting and trade in *O. lanceolata*. The species is valued by the local Maasai community as a beverage (alternative to tea leaves) and for medicinal purposes. The community is aware of the issues surrounding exploitation of *O. lanceolata* and proscribed international trade. Stock inventories were conducted using 15m radius circular plots located in three vegetation types that dominate the study area (grassland, bushland and dry upland forest). During the study, presence absence was established, life stage, quantity, density and biophysical characteristics of the species habitat were established. All the *O. lanceolata* individuals were found in bushlands indicating that this is the preferred habitat type. No individual was recorded in the forest and grassland habitats. Generally, biophysical characteristics were found to have significant influence on the population distribution of Osyris (H = 2.07). The total volume of wood computed was 8.19 m^3. The volume per hectare of the sampled area was 2.1m^3. Olangasasi recorded the highest average volume 0.16 m^3/plot, followed closely by Kisokon (0.15 m^3/plot), in south eastern parts of Narok county. From the results the density of Osyris trees was noted to be low and scattered. Based on volume and current recommended merchantable diameter (about 15 cm), harvesting is not viable and should be discouraged. Recovery strategies that include re-stocking, controlled grazing, institutional, management and legislative frameworks and domestication is proposed.

Keywords: *Osyris lanceolata*, stock inventory, Trade, Kenya

1.0 INTRODUCTION

Since the inception of this CTSP Osyris programme in 2018, substantive information about local and international use and trade, ecology, policy and legal framework in management and conservation of *Osyris lanceolata* Hochst. & Steud, (Santalaceae) have been deposited in libraries and online. Notably, Ochanda, (2011); Gathara et al, (2014); Kamondo et al., 2014; Andiego et al., (2019); Mumbu et al., (2019) as student theses, scientific publications or reports. Others include Google digitized documents (Anon., 1950), as well as popular articles (Mwai, 2005; Mabatuk & Wesangula, 2015; KNA, 2015). Considered individually, they all point to the fact that pressure on *O. lanceolata* in Kenya and the region has been increasing over time. If the Range states do not have data on the standing stock individually or collectively, the challenge posed by illegal international trade in the species will linger, probably push the Osyris population over the ecological threshold, and can easily affect existing trade relations.

O. lanceolata is widely distributed in the Arid and Semi-Arid Lands (ASALs) in East Africa and Kenya, particularly woodlands (Mukonyi et al., 2011). Notes from the EA herbarium sheets indicate that the species is quite widespread, but the populations tend to have few individuals (Beentje, 1994). Specific localities in Kenya include; Amboseli, Baringo, Bogoria, Narok, Pokot, Turkana, Samburu, Kajiado, Gwasi Hills, Kitui, Chyulu hills, Kikuyu escarpment forest, Taita hills, Mt. Kulal, Marsabit, Makueni, Mbeere, Narok, Ol donyo Sabuk, and Oloitokitok.

O. lanceolata has many uses, both in its distribution range in Kenya and internationally. Among the documented local uses, roots and bark are infused as teas by Maasai community or tonic in soups and fruits are eaten as emergency food (Gachathi, 1989; Beentje; 1994; Orwa et al., 2009). Roots and heartwood extracts have medicinal, palliative and preservative properties (Anon., 1950; Orwa et al., 2009; Ochanda, 2011). The wood is very hard, strong and heavy and is used for carvings, kitchen mortars and pestles, pegs, for poles and bed frames and burns hot, so it is also used as firewood (Orwa et al., 2009). It also provides environmental services. In gardening circles, it is considered quite untidy, but the decorative fruits, fissured bark and weeping bluish green foliage make it an ornamental tree (Orwa et al., 2009; Anon., 2020). The tree is important in soil conservation as it provides erosion control (Orwa et al., 2009; Mumbu et al., 2019). Therefore, *O. lanceolata* has multiple uses that are not complementary to each other.

O. lanceolata recently entered the international market as a substitute of the traditional sandalwood oil originally sourced from Asia and Australia. Sandalwood has over centuries been traded for its fragrance, medicinal value, religious value and wood carving potential. The main traded products include aromatic oils extracted from the heartwood, timber for handicrafts, and saw dust for making incense. The oil is useful in perfumery, pharmaceutical and religious practices. The limited supply, coupled with high demand and escalating prices of sandalwood oil

from the traditional source countries have led to exploitation of the East African sandalwood as a preferred alternative.

1.1 Background

In 2013, at the 16th Conference of Parties (CoP) to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), in Bankok Thailand, the East African Sandalwood (*O. lanceolata*) was listed in Appendix II as a threatened species. The proposal presented by Kenya, listed the populations in the three East African Countries - Kenya, Uganda and Tanzania. The CoP, alongside the species listing, adopted Decisions 16. I 53 & 46. 454 on actions for implementation to enhance the conservation of the species across its range. Further, the Plants Committee and subsequent COP 17 upheld the recommendations, necessitating the Eastern African Range States of *O. Ianceolata* to gather information on the conservation status, trade in and use of the species, as well as assess what data is required to develop Non-Detriment Finding studies (NDFs) and carry out capacity building in the country and the region. Subsequently, the ban on trade in *O. lanceolata* in Kenya, has been enforced to date and, with the support of EU CITES Tree Species Programme, Kenya has embarked on implementing the decisions through this regional and multi-institutional project.

Kenya lacks inventory data on plant species in trade including many CITES-listed species and *O. lanceolata* is not an exception. Data on available standing stocks would inform harvest management, volume, the products, derivatives and value addition for indigenous non-timber plants. The management of *O. lanceolata*, faces many challenges as it is not a plantation species. Hence, the species lacks a sustainable product development and trade management framework. In addition, the products are mostly wild-harvested and with this the concession management challenges. Challenges associated with the lack of inventory data in the case of *O. lanceolata* in Kenya are complicated by the changing land–use and land tenure issues where it occurs and natural history of the species. Overall, this species lacks a sustainable production and product management framework. Standing stock inventory is necessary to address most of these management-related challenges. Many studies have been carried out on *O. lanceolata* as it has been a species of interest in Kenya and the region. They broadly cover taxonomy, propagation, domestication, countrywide distribution, genetic variation, role in the ecosystem and trade. However, standing stock is unknown. On this premise, Kenya CITES Scientific and Management Authorities and the Kenya Forest Service, led by the Kenya Forestry Research Institute found it necessary to jointly undertake this detailed field inventory of *O. lanceolata* in South Eastern County of Narok.

1.2 Justification for Field inventory of *O. lanceolata*

A fundamental obligation of CITES member countries, prior to any export of a product listed in Appendix II of this Convention, is a non-detriment finding (NDF). This report must be issued by a credible scientific authority, which certifies that the export volume requested of the provider country, is not detrimental to the conservation of this species in the wild. This document requires factual information on the location, distribution, stock, growth, and ecology of the said species. This requirement, forms the basis of the inventory that was carried out on the status of *O. lanceolata* in Narok, one of the areas known to exist naturally in Kenya (The small budget allocated could not allow to undertake an inventory covering the whole Kenyan range of *O. lanceolata).* The results reflect a snapshot of the status of the species in most parts of its range in the country and the region at large. The study looked at the status of Osyris in three dominant ecosystems in the region namely the closed forest, bushland and grassland.

1.3 Aim of the study

The aim of this study was to determine the density, standing stock, utilization and harvesting practice and propose harvesting quotas for selected populations. The objectives of this study were;

To determine the distribution and standing stock of *O. lanceolata* in Narok, Kenya

To determine the yield, and inform the harvesting quota of *O. lanceolata* from Narok, Kenya

2.0 METHODOLOGY

2.1 Climate and Physiography of Narok County

The study area was Narok County. This was purposively selected since it is one of the areas in Kenya where *O. lanceolata* is naturally found. The county has diverse topography, with an extensive plateau. The attitudinal range is from 1000-2350 m A.S.L in the South rising to 3098 m at the highest peak of Mau escarpment in the North. The county lies in K6 vegetation zone, with four agro-ecological zones; Tropical Alpine (TA), Upper Highland Zone (UH), Lower Highland zone (LH) and Upper Midland zones (UM). For agricultural and forestry purpose, Narok has five agro-climatic zones namely the humid, sub-humid, semi-humid, semi-arid and arid zones. Rainfall is bi-modal, with long rains recorded in Mid-March to June and short rains in September-November. Rainfall is under influence of the Inter-Tropical Convergence Zone (ITCZ). However, the rainfall is unevenly distributed and the high potential areas receive 1200-1800mm p.a, while the lower altitude, drier areas receive less than 500mm p.a. Temperature also averages 10^0C in the high altitude Mau escarpment to 20^0C in the lower south eastern parts in Mara triangle. Diurnal temperature ranges are also drastic.

2.2 Soils of Narok

Soil types are determined by the characteristics of the underlying basement rock and weathering. The main soil types in the County include Andosols, Luvisols, Phaeozems, Vertisols and Acrisols. Areas with deep and well-drained soils include hilly and mountainous areas of Mau escarpment, Ngorengore, Shatuka, Suswa and Loita hills (NEMA, 2009). However, pockets of Loita plains and Maasai Mara, in East and South east to Nguruman escarpment and the surrounding hilly country have shallow and poorly drained soils.

2.3 Vegetation and land-use

Narok County is expansive and supports diverse economic activities ranging from intensive plantation agriculture to world-famous game tourism. The variable ecological zones support wildlife, tourism, livestock, timber, farming and human settlements (NEMA, 2009). The main land-use types are livestock, game ranching, tourism, agriculture and forestry. Cash crop farming is a major land-use type and the crops grown are variable including sugarcane, tobacco, sunflower, wheat, maize, horticultural crops and fruits. Subsistence crops such as pulses, vegetables etc are also grown in Narok. Dryland forests thrive in the sub-humid, semi-arid and arid areas in the South East. Forestry is thus a major land use class and the woody species are used for timber, posts, charcoal production, utensils, fodder, artefacts, medicine and cultural uses.

2.4 Land tenure

There are three categories of land tenure/ownership in the county.

- Government land; managed under the Land Act No. 6 of 2012 (Revised Edition 2019) Part II & III. This land is owned and managed by the government for development.
- Community land: administered under the Community Land Act No. 27 of 2016 and managed by the County Government on behalf of the community e.g. the Maasai Mara Game Reserve.
- Private land: administered under the Land Act No. 6 of 2012 (Revised Edition 2019) Part V. This is privately owned land under freehold or leasehold tenure with registration and individual land titles.

Each category of land tenure has unique implications on access to and management of biological resources naturally found on it and this includes sustainable production of *O. lanceolata.*

2.5 Socio-economic activities

Narok County has high poverty prevalence rate at about 64% and women are the most vulnerable. This is due to the patrilineal nature of the Maasai community as has been the case with most Kenyan communities. Whether one is poor or not is influenced by the socio-economic opportunities, market accessibility, land productivity, gender disparity, governance, influence of culture and traditional beliefs, occurrence of natural disasters and other externalities such as insecurity, though these are infrequent.

2.6 Study sites

The specific study sites were also purposively selected as areas where the species is found naturally. *O. lanceolata* was surveyed in Loita sub-county including Mausa tiasilal, Mausa Tor's, Kapune mausa, Oldoinyo ngurumaut, Elkakari, Kidongidon, Entashara Kisokon, Muladaiwa, Olngarua, Oladaare, Navolosa, Morinjo, Oloingoni, Olengasasi and Olangasasi. These sites encompass the larger Loita forest. Sampling was also done in Narok East sub-county Ntulele area and Narok West sub-county including Lemek, Olo ololo and Mara Rianda (Fig. 1). The study sites comprised of three vegetation types namely forest, bushland and grassland and all the three vegetation types were targeted for the inventory.

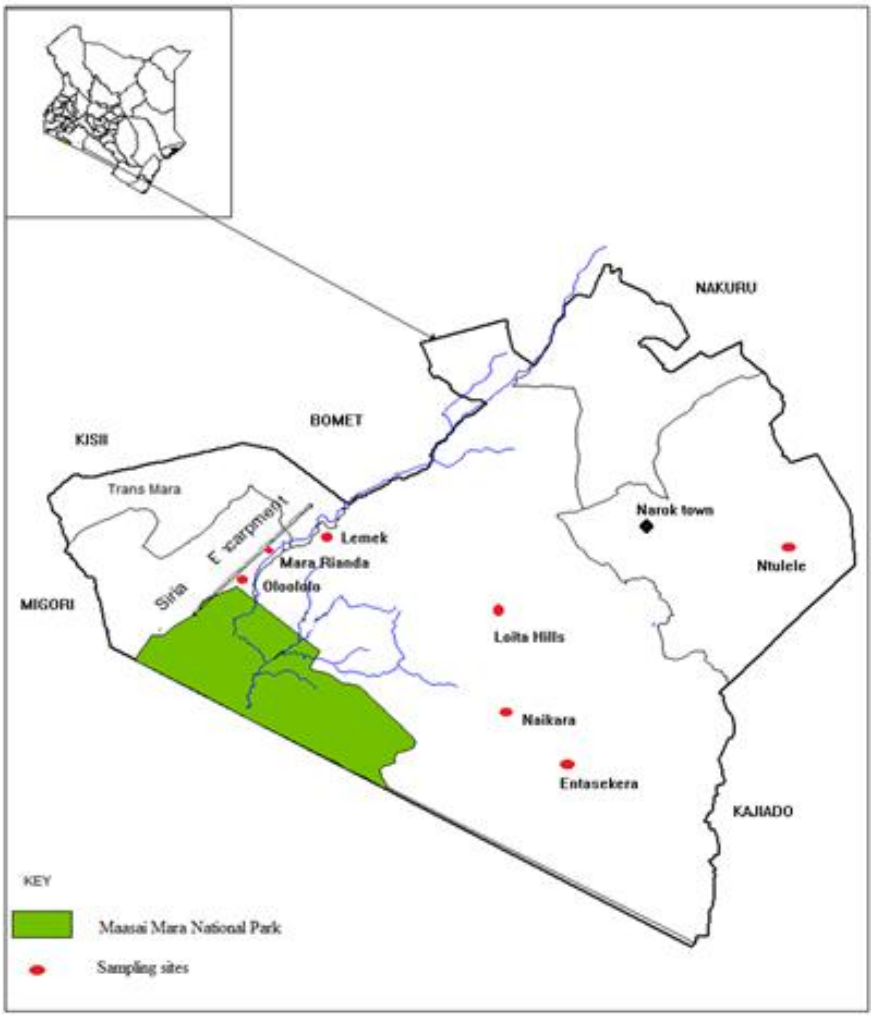

Figure 1. Study area in Narok County.

2.7 Sampling approach

Sampling plots (Fig. 2) were systematically laid after every one-kilometer interval. Circular plots of 15m radius were used in assessing the *O. lanceolata* trees over 1.5m height. The presence or absence of Osyris was established by systematically checking in the four quadrants of each plot. Saplings (between 0.5-1.5m height) were assessed in a 5m radius plot nested in the larger plot from the centre. The seedlings (less than 0.5m height) were also assessed in two nested 2m radius plots which were laid down on east and west direction at 5m from the centre of the larger plot. For each plot, the GPS co-ordinates, altitude, disturbance indicator, slope, soil type, vegetation type and land ownership were also recorded. Only the Osyris trees DBH and height were measured using a diameter tape/ caliper and tenimeter respectively. The sex of the trees was also determined with the help of diagnostic features and associated plant species within the plot were recorded.

Figure 2 The sampling plot design

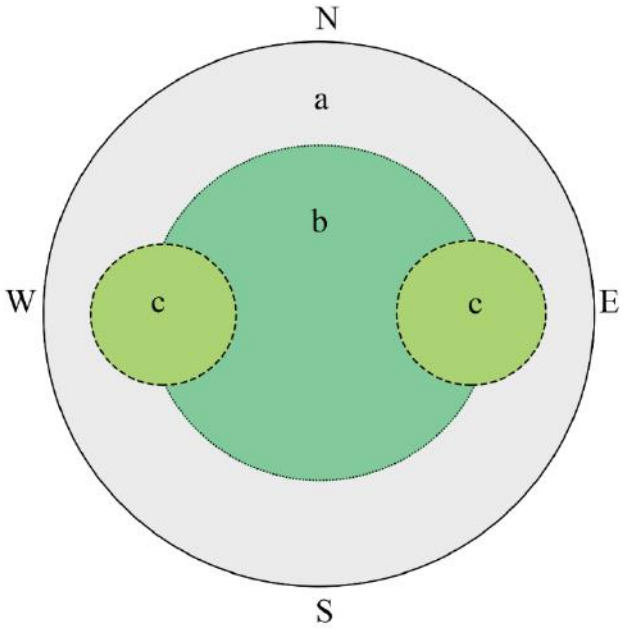

Figure 2. Sampling plot layout (Adopted from Muchiri *et al*. 2016).

Key

a – 15m radius sampling area for Osyris trees and associated plant species

b – 5m radius sampling area for Osyris saplings

c – 2m radius sampling area for Osyris seedlings

2.8 Botanical methods

To understand the distribution of *O. lanceolata* in relation to the host and associated species and its conservation, data was collected from natural stands. Data recorded included plants encountered to describe the habitat of *O. lanceolata* and the general vegetation of the forests studied. For plants that could not be identified in the field, herbarium specimens were collected following standard collection procedures (Bridson & Forman, 1992) for confirmation. A checklist of the plants associated with O. lanceolata was prepared. In addition, high-resolution images of the specimen and the area were taken. Plants encountered were identified in the field based on expert knowledge, literature and the reference collection at the EA herbarium. The checklist of associated species is included in appendix I.

3.0 RESULTS AND DISCUSSION

3.1 Presence absence data

A total of 118 individual stumps of *Osyris lanceolata* were assessed in 56 sampling plots within Narok County. Since *O. lanceolata* is known to be multi-stemmed in nature, a total of 250 stems were measured in the 118 stumps. Out of the 56 sampled plots, Osyris trees were recorded in 39 plots while 17 had none. The male plants were 34.7% while females were 65.3% with majority fruiting and a few others flowering. The density of *Osyris* was 63 stems per hectare. Olangasasi sampling site had the highest average height of 5.7m/plot and average DBH of 8.1cm/plot. Oldoinyo followed closely with an average DBH of 7.2cm and an average height of 2.8m. Other areas; Entashara, Kisokon, Olngarua, Muladaiwa also recorded significant parameters of Osyris (Fig. 3). It was noted that Osyris measured at North-western parts of Narok County showed lower averages in height and DBH when compared to South-eastern parts.

Generally, much of the Osyris was found in the bushlands and none in the closed canopy forests or grassland vegetation types. Of the three vegetation types, the bushlands comprise about half of the vegetation type in this ecosystem and occupy the mid latitude zone. They are interspersed by grasslands, while the higher altitude areas are occupied by forest type vegetation. Bushlands are constantly grazed by livestock and wildlife, and *O. lanceolata* being a browse species has not been spared.

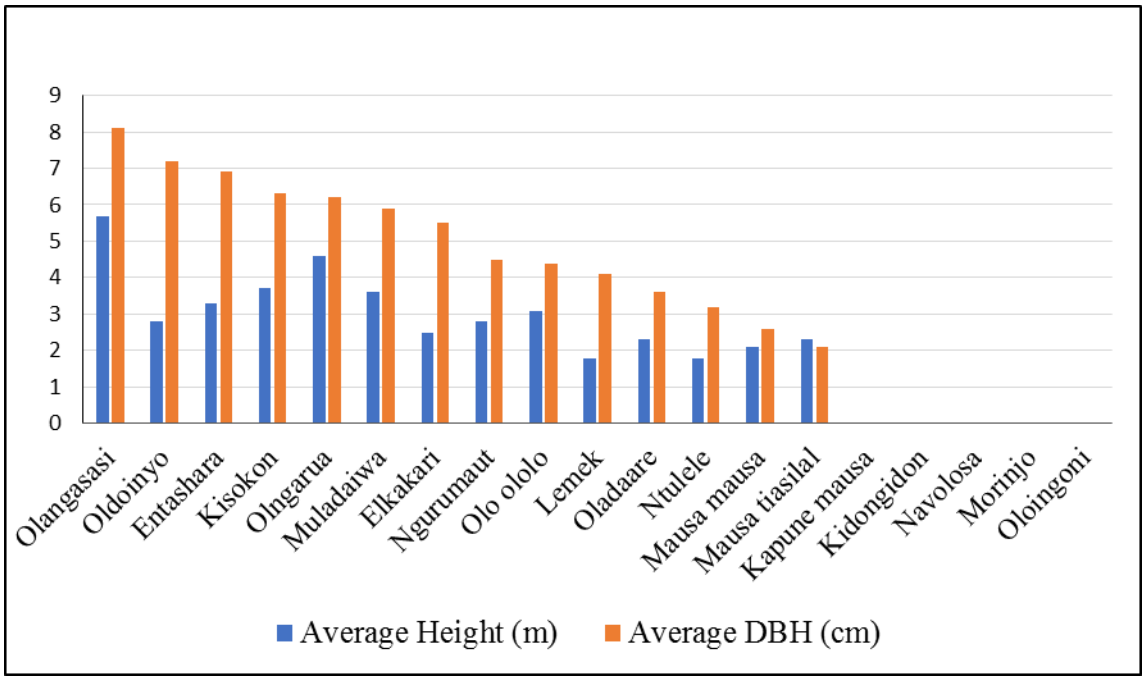

Figure 3: Osyris Lanceolata height and DBH distribution across sampling sites in Narok County.

In *the field, O. lanceolata* individuals were recorded in most of the transects sampled, but in some individual plots, not a single individual was recorded. Table 1 presents summary of data.

Table 1. *Osyris lanceolata* sampling data summary

Site name	Altitude	Slope	Disturbance	Vegetation	Soil type	Osyris (n)	Volume (m^3)
Elkakari	2136	Gentle	Grazing	Bushland	Sandy loam	9	0.592
Entashara	2047	Steep	Grazing	Bushland	Sandy loam	8	0.754
Kapune mausa	1858	Steep	Undisturbed	Forest	Loam	0	0
Kidongidon	2145	Steep	Grazed	Bushland	Loam	0	0
Kisokon	2043	Gentle	Grazed	Bushland	Sandy loam	4	0.891
Lemek	2030	Steep	Gazed/paths	Bushland	Rocky loam	15	0.598
Mausa masa	1832	Steep	Grazed	Bushland	Sandy loam	8	0.136
Mausa tiasilal	1826	Steep	Grazed	Bushland	Sandy loam	6	0.053
Morinjo	2120	Flat	Grazed	Bushland	Black cotton	0	0
Muladaiwa	2300	Steep	Grazed	Bushland	Sandy loam	5	0.606
Navolosa	2156	Gentle	Grazed	Bushland	Sandy loam	0	0
Ngurumaut	2167	Gentle	Grazed	Bushland	Sandy loam	6	0.205
Ntulele	1854	Gentle	Paths/Cut	Bushland	Sandy loam	6	0.05
Oladaare	2254	Steep	Grazed	Bushland	Loam	10	0.226
Olangasasi	2215	Steep	Grazed	Bushland	Sandy loam	4	0.937
Oldoinyo	2189	Flat	Grazed	Bushland	Sandy loam	3	0.177
Olngarua	2290	Steep	Undisturbed	Bushland	Loam	3	0.385
Olo ololo	1736	Gentle	Grazed/paths	Bushland	Rocky loam	31	2.583
Oloingoni	2099	Flat	Grazed	Grassland	Black cotton	0	0
					Total	**118**	**8.193**

3.2 Distribution of *O. lanceolata* by diameter class

Osyris lanceolata usually grows as multi-stemmed tree. During the survey, both the main stem as well as secondary stems were measured. A total of 250 stems were measured and grouped in the diameter ranges of 0.1-5 cm (181), 5.1-10 cm (53), 10.1-15 cm (15), and only 1 in 15.1-20 cm category (Fig. 4). *O. lanceolata* heartwood is of great importance and there should be a threshold in the stem diameters in determining the harvesting period. Indeed, majority of the trees found are juvenile, based on the stem diameter.

According to Page *et al*. (2012), the most experienced farmers say that sandalwood develops heartwood rapidly when it is grown in shallow soil or soil with a high level of stone inclusions, together with a distinct annual dry period and exposure to full sunlight. The expected period of harvest under these conditions was 15-20 years, but may be as much as 30-40 years for trees growing in areas of deep fertile soil, high and evenly distributed rainfall throughout the year, and a shaded canopy. The time needed to develop enough heartwood for harvest will vary between trees and growing environments. Tree size is a good indication of when the tree is ready for

harvest. In Vanuatu, the minimum size at which a tree can be harvested is a trunk diameter of 15cm at breast height, which corresponds to a tree with a basal diameter of about 20cm. Under good growing conditions, a tree of this size is approximately 15-20 years old. This implies that in this survey, only one stem, measuring 18cm diameter qualifies for harvesting.

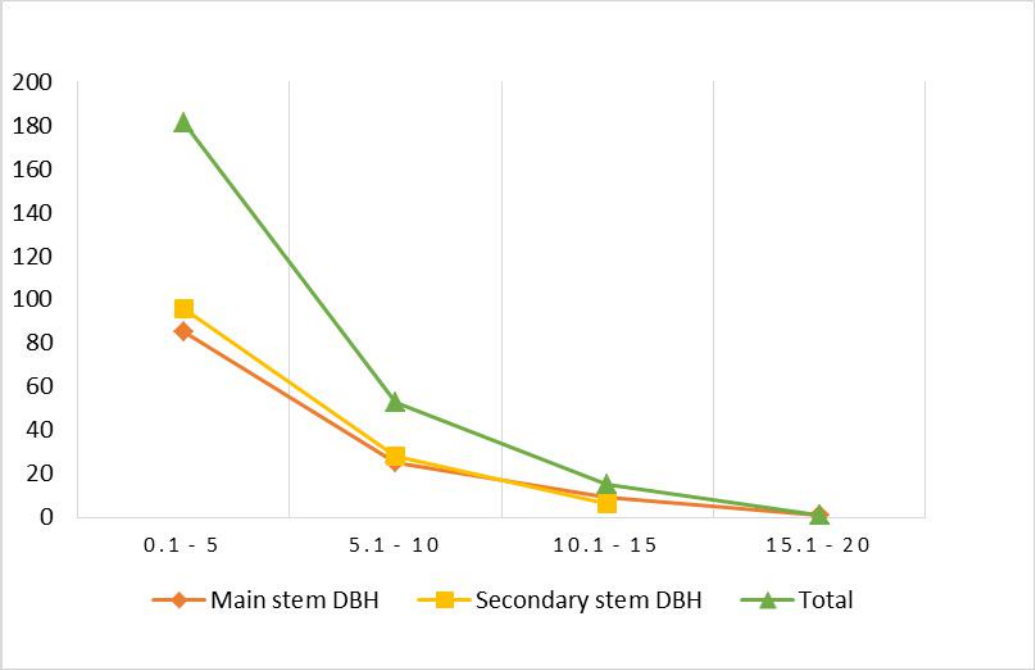

Figure 4. Distribution of Diameter classes of *O. lanceolata*.

3.3 Volume of *Osyris lanceolata* computed

The volumes of the trees were determined using measured diameters and height. This was calculated using the formula $V=\pi r^2 h$, where *r* is half of the measured diameter in centimeters and *h* is height of the tree in metres. The total volume of wood computed was 8.19 m^3. The volume per hectare of the area sampled was 2.1 m^3. Olangasasi recorded the highest average volume (total volume divided by the number of individuals in every plot) of 0.16 m^3/plot, followed closely by Kisokon (0.15 m^3/plot), all located in South eastern parts of Narok County. However, the highest total volume of *Osyris* trees was recorded at Olo ololo sampling site (2.58m^3) (Table 2). The average and total volume per plot for the area sampled was 0.04 m^3 (σ =0.05) and 0.43 m^3 (σ =0.61), respectively (Table 2).

Table 2. *Osyris lanceolata* average volume and total volume per plot in every sampling site

Site name	**Average volume** (m^3/plot)	**Total volume** (m^3/plot)
Olangasasi	0.16	0.94
Kisokon	0.15	0.89

Site name	Average volume (m^3/plot)	Total volume (m^3/plot)
Muladaiwa	0.06	0.61
Olngarua	0.06	0.39
Olo ololo	0.05	2.58
Elkakari	0.05	0.59
Entashara	0.04	0.75
Lemek	0.04	0.60
Oldoinyo	0.04	0.18
Ngurumaut	0.02	0.21
Oladaare	0.02	0.23
Mausa masa	0.01	0.14
Mausa tiasilal	0.01	0.05
Ntulele	0.01	0.05
Kapune mausa	0.00	0.00
Kidongidon	0.00	0.00
Morinjo	0.00	0.00
Navolosa	0.00	0.00
Oloingoni	0.00	0.00
Total average	*0.036*	*0.431*
Standard deviation (σ)	*0.046*	*0.612*

3.4 *Osyris* biophysical preferences

All the *Osyris lanceolata* individuals were found in bushlands indicating that this is the preferred habitat type. No *O. lanceolata* was recorded in the forest or grassland habitats. *Osyris* individuals were numerous on steep slopes (59), gentle slopes (56) and very few on flat areas (3) (Table 3). Sandy loam and rocky loam soils showed high records compared to black cotton soil. Grazed and other slightly disturbed sampling sites also showed higher populations of Osyris suggesting that perhaps it prefers more or less open grounds with less graminoid and herbaceous cover. Generally, from the Shannon diversity index analysis $\{H = -\sum[(pi)log(pi)]\}$, biophysical characteristics were found to have significant influence on the population distribution of Osyris ($H = 2.07$) (Table 3).

Table 3. Biophysical preferences of *Osyris lanceolata* in Narok County.

Biophysical	Variable	Osyris (n)	Volume (m^3)	[(pn)log(pn)]
Slope	Gentle	56	4.31	-0.35
	Steep	59	3.70	-0.35
	Flat	3	0.18	-0.09

Biophysical	Variable	Osyris (n)	Volume (m^3)	[(pn)log(pn)]
Vegetation type	Bushland	118	8.19	0.00
	Forest	0	0	
	Grassland	0	0	
Soil type	Loam	13	0.61	-0.24
	Sandy loam	59	4.40	-0.35
	Rocky loam	46	3.18	-0.37
	Black Cotton	0	0	
Disturbance indicator	Grazed	109	7.76	-0.07
	Cutting	6	0.05	-0.15
	Undisturbed	3	0.39	-0.09
		118	**8.19**	**H = 2.07**

3.5 Regeneration

Some 4 saplings and 7 seedlings of *O. lanceolata* were recorded from the 56 sampling plots indicating that the regeneration is very low. Browsing and trampling by livestock may be a major threat to recruitment and survival of young trees. Modalities for improving restocking are needed through seed collection, artificial propagation and enrichment planting that targets *O. lanceolata* and its range of hosts.

Table 4. Saplings and seedlings of *O. lanceolata* recorded in sampling plots.

Site name	Saplings	Seedlings
Oladaare	**3**	0
Mausa masa	**1**	2
Muladaiwa	0	**5**
Kidongidon	0	**2**
Elkakari	0	0
Entashara	0	0
Kapune mausa	0	0
Kisokon	0	0
Lemek	0	0
Mausa tiasilal	0	0
Morinjo	0	0
Navolosa	0	0
Ngurumaut	0	0
Ntulele	0	0
Olangasasi	0	0
Oldoinyo	0	0
Olngarua	0	0
Olo ololo	0	0

Oloingoni	0	0

3.6 Associated species

O. lanceolata was found to grow in association with a number of indigenous plant species among them, *Rhus natalensis (35), Tarchonanthus camphoratus (26), Maytenus senegalensis (20), Carrisa edulis (17)* which were among the most frequently recorded species. Others were *Acokanthera oppositifolia, Euclea divinorum,*and *Warburgia salutaris,* among others (Table 5 & Appendix 1).

Table 5. Associated plant species with the highest occurrence.

Plant Species	**Occurrences**
Rhus natalensis	35
Tarchonathus camphoratus	26
Maytenus senegalensis	20
Carrisa edulis	17
Acokanthera oppositifolia	14
Euclea divinorum	14
Warburgia salutaris	13
Ocimum kilimandscharicum	12
Lippia javanica	12
Combretum molle	12
Trimeria grandifolia	12

4.0 CONCLUSION AND RECOMMENDATIONS

The density of Osyris trees is low and the trees are scattered in the Narok forests including Loita Hills. Osyris preferred the bushland vegetation type as none was recorded in the closed canopy forest or grassland areas. Bushland also supports livestock and game ranching and shifting cultivation to some extent, hence it is threatened by competing land-uses. Indeed, browsing by livestock and game was evident mostly among the young stems which impacted negatively on the regeneration of the species. Majority of the trees recorded were juvenile based on the stem diameter. This indicates some recent rampant harvesting, on-going illegal harvesting, browsing and or heavy subsistence use. The presence of fruiting and flowering female trees, at a ratio higher than the males, indicates a potential for improvement of the recruitment of Osyris seedlings in natural forests if browsing is managed. The following are the recommendations;

- Based on computed volume and documented merchantable diameter (about 15 cm) of *O. lanceolata*, only one stem was above, hence harvesting should be discouraged.
- On-farm planting and enrichment planting of Osyris in both private and public lands should be promoted to increase the population and optimize on-farm production.
- Grazing should be managed so as to reduce browsing and trampling of young plants.
- The communities should be sensitized on the importance and proper management of Osyris to realize its full potential in enhancing livelihood support.
- The capacity of relevant institutions and stakeholders should be built and strengthened for effective management and forest law enforcement.

APPENDIX 1. Species naturally associated with Osyris lanceolata

Acacia brevispica	*Gardenia volkensii*	*Ficus thonginii*
Acacia drepanolobium	*Gomphocarpus fruticosus*	*Rapanea melanophloeos*
Acacia gerrardii	*Gomphrena globosa*	*Rhamnus staddo*
Acacia hockii	*Grewia bicolor*	*Rhoicissus tridentata*
Acacia nilotica	*Grewia similis*	*Rhus natalensis*
Acacia xanthophloea	*Grewia tembensis*	*Rhus vulgaris*
Acokanthera oppositifolia	*Gutenbergia cordifolia*	*Sansevieria suffruticosa*
Aloe morijensis	*Hibiscus cuscus*	*Schrebera alata*
Aloe secundiflora	*Hibiscus ficus*	*Scolopia theifolia*
Apodytes dimidiata	*Indigofera lupatana*	*Scolopia zeiheli*
Asparagus falcatus	*Jasminum fluminense*	*Scurtia myrtina*
Asparagus racemosa	*Juniperus procera*	*Senecio candiensis*
Aspilia mossambicensis	*Kalanchoe densiflora*	*Sida acuminata*
Barleria obtusa	*Kleinia petraea*	*Sida acuta*
Berberis holstii	*Lantana camara*	*Sida cordifolia*
Biden pilosa	*Lantana rhodesiensis*	*Sida rhombifolia*
Cadaba farinosa	*Lantana trifolia*	*Solanecio mannii*
Carissa edulis	*Lipia javanica*	*Solanum campylacanthum*
Celtis africana	*Lipia kituiensis*	*Tarchonanthus comphoratus*
Cissus cactiformis	*Lycium europeaum*	*Teclea nobilis*
Clausena anisata	*Maytenus gillettii*	*Tinnea aethiopicum*
Clerodendrun buchananii	*Maytenus senegalensis*	*Toddalia asiatica*
Clerodendrun myricoides	*Myrsine africana*	*Trimeria grandifolia*
Combretum molle	*Mystroxylon aethiopicum*	*Triumfetta flavescens*
Combretum apiculata	*Obetia pinatifida*	*Turraea mombassana*
Combretum molle	*Ocimum kilimandscharicum*	*Vangueria madagascariensis*
Commiphora africana	*Ocimum suave*	*Vepris nobilis*
Crotalaria agatiflora	*Okwato - luo*	*Vepris simplicifolia*
Crotalaria agatiflora	*Olea africana*	*Vernonia brachycalyx*
Croton dichogamous	*Olea europeaum*	*Warbugia salutaris*
Croton megalocarpus	*Oloitodor aik - maasai*	*Warbugia ugandensis*
Cussonia holstii	*Olokildia - maasai*	*Ximenia americana*
Cyphostemma	*Oloodokiok - maasai*	*Zanthoxyllum usambalensis*
cyphopelatum	*Ormocarpum kirkii*	*Zanthoxylum chalybeum*
Dichrotachys cinerea	*Ozoroa insignis*	
Dodonea angustifolia	*Pappea capensis*	
Dombeya torrida	*Passiflora subpeltata*	
Elaeodendron buchananii	*Phyllanthus sepialis*	
Elkarmalasiai - Maasai	*Physalis sepiaris*	
Entulelei entim - maasai	*Pistacia aethiopica*	
Erythrococca bongensis	*Plectranthus barbatus*	
Euclea divinorum	*Plectranthus tetradenifolius*	
Euphorbia candelabrum	*Plumbago zeylanica*	
Euphorbia gossypina	*Psidia punctulata*	
Faurea saligna		

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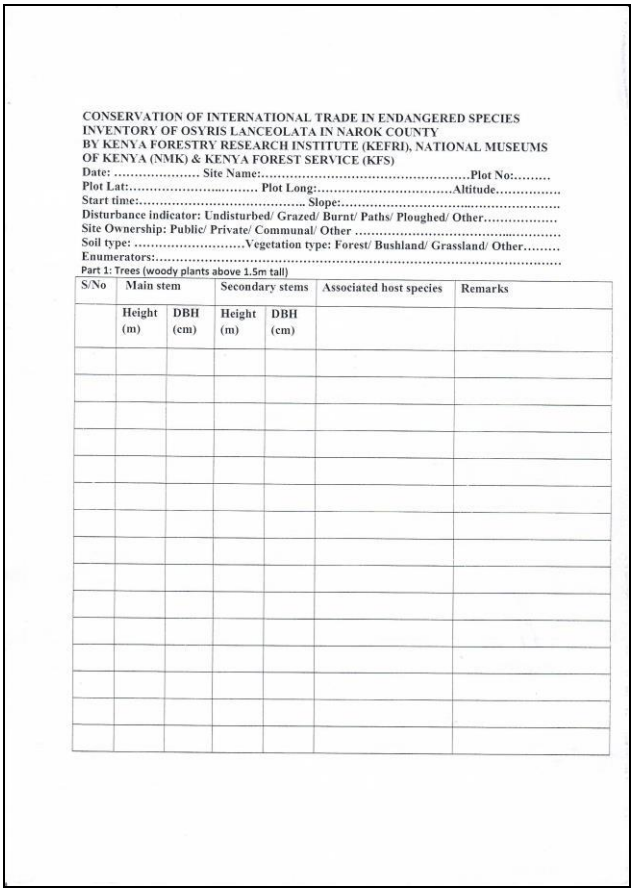
ANNEX 1: FIELD INVENTORY FORM

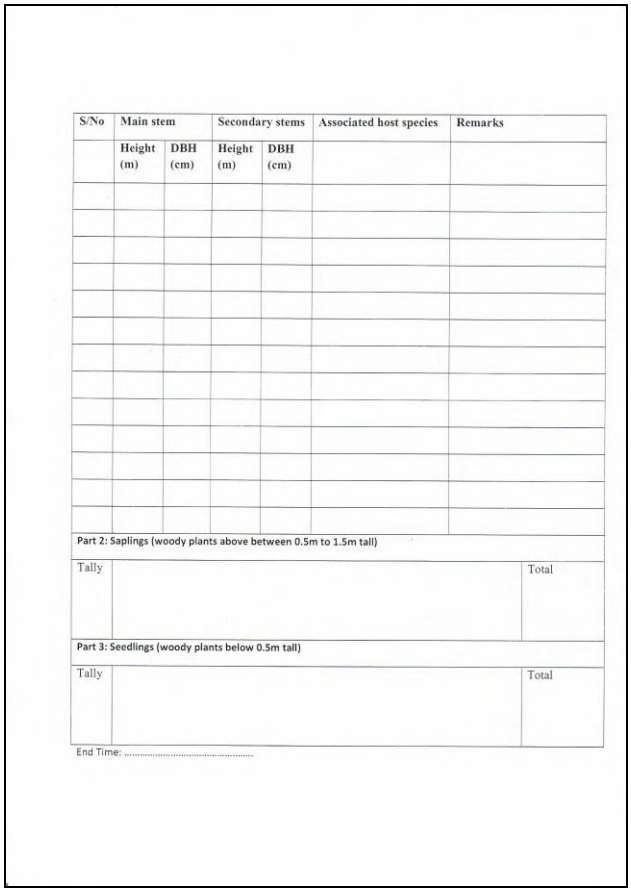


CONSERVATION OF INTERNATIONAL TRADE IN ENDANGERED SPECIES
INVENTORY OF OSYRIS LANCEOLATA IN NAROK COUNTY
BY KENYA FORESTRY RESEARCH INSTITUTE (KEFRI), NATIONAL MUSEUMS OF KENYA (NMK) & KENYA FOREST SERVICE (KFS)

Date: ..... Site Name:.....Plot No:.....
Plot Lat:..... Plot Long:.....Altitude.....
Start time:..... Slope:.....
Disturbance indicator: Undisturbed/ Grazed/ Burnt/ Paths/ Ploughed/ Other.....
Site Ownership: Public/ Private/ Communal/ Other .....
Soil type: .....Vegetation type: Forest/ Bushland/ Grassland/ Other.....
Enumerators:.....

Part 1: Trees (woody plants above 1.5m tall)

S/No	Main stem		Secondary stems		Associated host species	Remarks
	Height (m)	DBH (cm)	Height (m)	DBH (cm)		



S/No	Main stem		Secondary stems		Associated host species	Remarks
	Height (m)	DBH (cm)	Height (m)	DBH (cm)		

Part 2: Saplings (woody plants above between 0.5m to 1.5m tall)

Tally	Total

Part 3: Seedlings (woody plants below 0.5m tall)

Tally	Total

End Time: .....

ANNEX 2: FIELD INVENTORY PHOTOS

Field Inventory Planning Meeting

Courtesy call-KFS Narok

Loita Hills

Consulting the local Community

Osyris seedling

Heavily browsed osyris
On coppicing stump

Multistemmed nature of osyris

Severly debarked Osyris

Osyris seeding

Remnant of *O. lanceolata* rootstock

Differentiation of Osyris sexes

Laying out of plot

Demarcation of main plot and subplots

Transect alignment

Recording GPS and altitude

Recording of *O. lanceolata* count

Measuring tree height

Identifying stems of Osyris

Measuring stem diameter

CITES TREE SPECIES PROGRAMME

Conservation and Sustainable Management of *Osyris lanceolata*, for Economic Development in East Africa

Final report for Output 3.2: Conducting a detailed study on production, harvesting, processing, transport, trade, control and monitoring of *Osyris lanceolata* with a view of establishing a fair tracking/control system

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ACRONYMS AND SYNONYMS

ACP FLEGT:	African, Caribbean and Pacific countries Forest Law Enforcement, Governance and Trade
CITES:	Convention on the International Trade in Endangered Species of Wild Fauna and Flora
CoP:	Conference of Parties
EA:	East Africa
EC:	European Commission
EU:	European Union
FMU:	Forest Management Unit
ITTO:	International Tropical Timber Organization
IUCN:	World Alliance for Nature/International Union for Nature Conservation
KEFRI:	Kenya Forestry Research Institute
KFS:	Kenya Forest Service
KRA:	Kenya Revenue Authority
KWS:	Kenya Wildlife Service
LC:	Least Concern (IUCN Category)
NDFs:	Non Detriment Finding studies
NMK:	National Museums of Kenya
POWO:	Plants of the World Online database

SUMMARY

This report presents findings of field studies undertaken from April to May, 2022, to inform Non Detriment Findings studies for *Osyris lanceolata* population from forests in Narok County in South Eastern Kenya. Data was collected about standing stock and production, harvesting, processing, transport, trade, control and monitoring. This was to specifically inform NDF steps 4-8 (conservation concerns, biological risk, assessment of harvest impacts, trade impacts and management measures in place) and to augment information provided by consultants. The dryland forests in Narok have been cited as major sources of *O. lanceolata* in cross-border trade. The trip extended, to parts of South Eastern Kenya, to augment data on production, harvesting, processing, transport, trade, control and monitoring along *O. lanceolata* trade routes and to proximate border points. Specific sites visited included Narok, Oloitoktok, Namanga, Taita Taveta, Mombasa and Nairobi Kenya. During the visit, data was collected with reference to the Narok population and consignments of Osyris transiting through the respective ports of exit. Information was collected with the help of a questionnaire based on: CITES CoP 15 Doc. 16.3, CITES CoP 15 Doc.16.7 (Rev. CoP 17) Annex 1. Informants were mainly Community leaders and members, resource users and field officers in charge of managing forest resources, trade officers and other relevant stakeholders. Notes and opinions were also noted. For NDF steps 1, 2 and 3, reports are available and key findings by the consultants are provided. No previous NDF had been prepared for Osyris population in South Eastern Kenya and Narok. Hence the need to proceed with this first NDF for this particular population. NDF steps 4-8 were undertaken through project activity 3.1 and 3.2. The information for activity 3.2 was analyzed and is presented in this report. Notes collected have been used to explain the trends observed in the field and opinions included in the recommendations.

1.0 INTRODUCTION

1.1 Non Detriment Findings (NDF)

According to Articles II, III, and IV of the Convention, Parties shall only allow trade in specimens of species included in Appendices I and II in accordance with its provisions. An export permit shall only be granted when a Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of the species being traded (i.e. non-detriment finding or NDF), an essential requirement for CITES implementation;

In Resolution Conf. 10.3 (Designation and role of the Scientific Authorities), the Conference of the Parties recommends that:

> c) Management Authorities not issue any export or import permit, or certificate of introduction from the sea, for species listed in the Appendices without first obtaining the appropriate Scientific Authority findings or advice (NDF);
>
> and
>
> h) the findings and advice of the Scientific Authority of the country of export be based on the scientific review of available information on the population status, distribution, population trend, harvest and other biological and ecological factors, as appropriate, and trade information relating to the species concerned;

Scientific Authorities of exporting countries, and sometimes also of importing countries, are continually challenged to define whether a particular export will be detrimental to the survival of a species, thus the need for non-legally binding guidelines, methodologies and other documents to assist in making non-detriment findings to improve the implementation of the Convention;

NDFs are at the core of the role of CITES in ensuring the sustainability of trade in wild species and a diversity of methodologies for NDFs exist, including the outputs of the Cancun workshop and the experience of the Parties.

Following some regional and species-specific workshops, exercises have been developed on technical and biological aspects of making NDFs. These exercises have been successful in compiling relevant information and methodologies needed to formulate NDFs for some plant and animal species, thus providing single-species guidance. Now, Parties need to build on these efforts in the light of current experience.

1.2 Production of *Osyris lanceolata* in Kenya

1.2.1 Identification and Biology of *O. lanceolata*

Osyris lanceolata Hochst. & Steud., (Santalaceae), commonly known as East African sandalwood, is hemi-parasitic androdioecious multi-stemmed small tree or shrub. The great variation in leaf size and shape has elicited a considerable synonymy (about 21 accepted Synonyms) (POWO, 2019; The Plant List, 2013; African Plant Database, 2012). It is distributed in almost all regions of

tropical East Africa and is widespread in Africa from Algeria to Ethiopia and south to South Africa; Europe (Iberian Peninsula and Balearic Is.), Asia (India to China), and Socotra (Polhill, 2005, African Plant Database, 2012).

The species grows in upland dry evergreen forest and mist forest, with associated bushland and grassland, extending down rivers and from there marginally into deciduous woodland; It is found in the altitudinal range (50–)900–2700 m (Polhill, 2005). It is usually found in rocky places, or where original vegetation has been cleared; forest margins; grassland; and rocky thickets and usually associated with shrubs of woody species, including *Apodytes dimidiata*, *Brachystegia spiciformis*, *Catha edulis*, *Clutia benguelensis*, *Combretum spp*, *Euclea divinorum*, *Harrisonoa abbysinica*, *Juniperus*, *Lantana camara*, *Maytenus acuminata*, *Podocarpus*, *Rhus natalensis* among others.

O. lanceolata flowers throughout the year with peak flowering observed between January to April and August to December (Kamondo *et al*., 2014; Beentje 1994). The fruits ripen between May and September (Aoko, 2009). It is not a prolific seeder (Kamondo *et al.*, 2014), and in a study in Kibwezi, the tree is said to produce seeds in the rainy season (Ochanda, 2014). A mature tree was reported to produce up to 14kgs of seeds annually, with 50% of the seeds lost to pest attack (Ochanda, 2014).

O. lanceolata seeds at the end of the rain season and therefore immediate germination upon seed maturation is limited by water scarcity. This, combined with the recalcitrant nature of the seeds plays a major role in dictating the rate of natural regeneration in the wild. In addition, the seeds are highly predated on by birds and beetles (*Dismegistus sargumeus*) and suffer high pathogenic attack (Herrera, 1988; Mwang'ingo *et al*., 2004). In their studies, Mbuya *et al.*, (1994) and Msanga, (1998) reported poor and sporadic seed germination hardly reaching 50% in a spread period of upto six weeks and attributed this low success to the species' seed dormancy. In nature, germination is likely compromised by unsteady or scanty rainfall.

The root and stem of *O. lanceolata* are the points of interest in this species, as these are the parts traded internationally. *O. lanceolata* relies on host plants to overcome the limiting resources of its physical environment, water and nutrients (Kamondo *et al*., 2014; Herrera, 1988). It is said to have a poor root system (Kamondo *et al*., 2014) that is quite massive compared to its stem (Ochanda, 2014). This observation agrees with Herrera's (1988) work in which he observed extensive areas of contact with host plants and the presence of haustorium producing roots. Sandalwoods show different growth patterns on different host species. The export market sources the rootstock and part of the mature stem near the soil surface and shape does not seem to matter.

1.2.2 World distribution of the species

The native range of the species is Canary Islands, S. Iberian Peninsula Balearic Is., Sahara to S. Africa, Socotra, Indian Subcontinent to S. China and Indo-China Fig. 1). In Africa, it is widespread from Algeria to Ethiopia and South to South Africa.

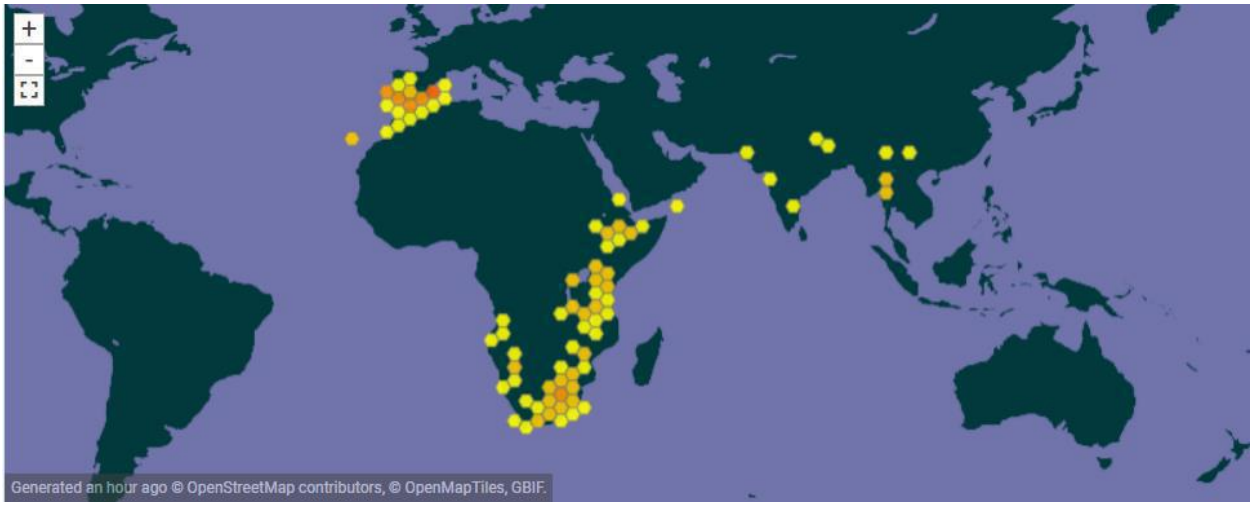

Figure 1. Geo-referenced records of Osyris lanceolata. (Source: GBIF.org).

1.2.3 Distribution of *O. lanceolata* in Kenya

In Kenya, *O. lanceolata* is found in North Eastern province to Mt Kulal, Taita, Central and much of the Eastern province, westwards through much of the Rift valley to the South and to Western Kenya. It grows in rocky sites, in forest margins, evergreen bushland, grassland and thickets at altitude ranging from 900 - 2550 (Beentje, 1994), with mean annual rainfall of 600 to 1600 mm (Kamondo *et al*., 2014). However, research done by Ochanda (2014) in Kibwezi established that the species was seen to prefer cooler areas around the hills with rocky volcanic soils/ash known as 'kivuthii' in Kamba with predominant soil type of ash, andisols and alfisols, and becomes abundant as one ascends Chyulu hills, compared to low areas, becoming more abundant in the forest, contrary to reports that it preferred disturbed areas.

The species grows in areas whose natural typical vegetation is dry woodland and bushland in ecological zone IV (Fig. 2), dry forest and moist woodland in ecological zone III and moist to dry forest in ecological zone II (Kamondo *et al*., 2014).

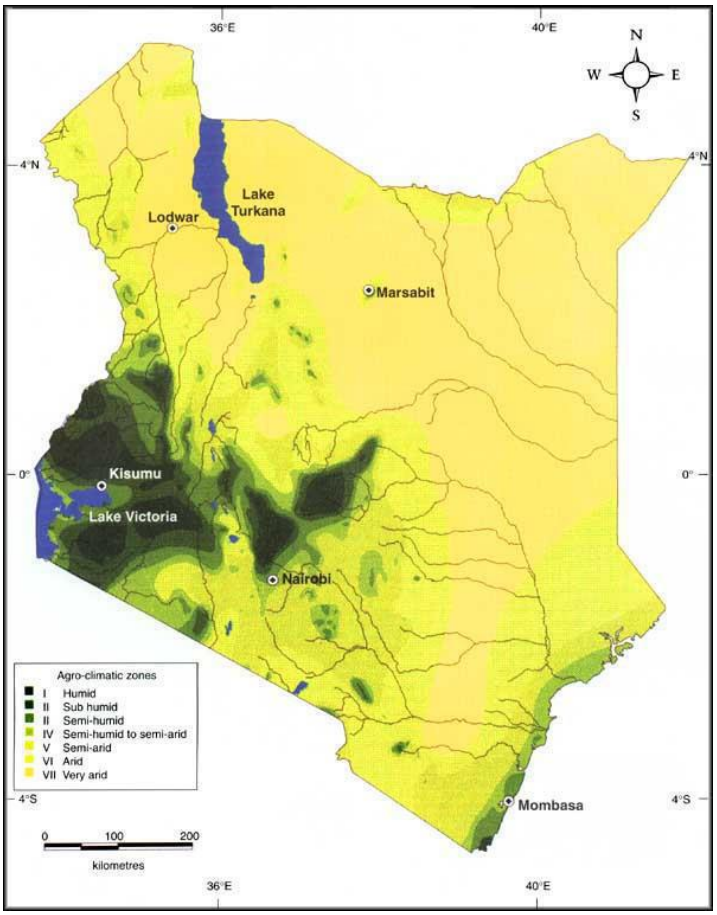

Figure 2. Agro-ecological zones of Kenya (Maundu et al., 1999).

1.3 Uses of *O. lanceolata*

Osyris lanceolata has many uses, in its distribution range in Kenya and internationally. Among the local uses, roots and bark are infused as teas or tonic in soups, and fruits are eaten as emergency food (Gachathi, 1989; Beentje; 1994; Orwa et al., 2009). Roots and heartwood extracts have medicinal, palliative and preservative properties (Anon., 1950; Orwa et al., 2009; Ochanda, 2011). The wood is very hard, strong and heavy and is used for carvings, kitchen mortars and pestles, pegs, for poles and bed frames and burns hot, so it is also used as firewood (Orwa et al., 2009).

The main products in international trade are essential oils, fragrances, cosmetics and toiletries, containing the Sandalwood oil, handicrafts made from the timber and sawdust used in the manufacture of cones or incense sticks (Ochanda, 2011; Mumbu et al., 2019; Orwa et al., 2009). As a substitute for other "sandalwood" producing genera i.e. *Santalum* and *Pterocarpus* species that are currently in short, supply.

The extraction of essential oil from root stocks and stem wood, for international cosmeceutical use is the main reason that *O. lanceolata* has been over-exploited, heavily threatening it in Kenya and the East African range states (Mabatuk & Wesangula, 2015; Bekele et al., 2019). Therefore, *O. lanceolata* trees have combined benefits for local and international markets as medicinal plants, for aromatic oil and durable wood.

1.4 Harvesting of *O lanceolata*

Kenya lacks accurate data on harvesting of *O. lanceolata* both for subsistence use and for commercial exploitation and to inform sustainable harvesting. A handful of studies have been conducted in Kenya to assess the population status of *O. lanceolata*. They include (Mukonyi *et al*., 2011), on conservation and use (Ochanda *et al*., 2011; Mumbu et al., 2019). For market data, a study conducted in some local peri-urban markets in South Eastern Kenya, in 2018 returned *O. lanceolata* as the most frequently traded medicinal plant (Ann Mwaura Pers. Comm.). Other market data from border towns shows that *O. lanceolata* is among the 20 widely traded species (Lusweti *et al*., 2018) in biotrade. The resource status and its future market prospects remain largely unknown, because not all populations and biotrade markets have been considered.

While there is little research on the dictates of plant age on quantity and quality of oil content, the local community reportedly believe the older the tree the higher the quantity and quality with trees >60 years having the best content (Ochanda 2014). However, (Kamondo *et al*. 2012) posit that, trees 15 – 20 years old and above would be good targets for seed collection and oil production.

The harvesting practice is usually by debarking for subsistence consumption and uprooting of root stocks for export trade. The product is often disguised as firewood. Debarking, if not managed can decimate local populations. Worse, the complete removal of the mature rootstock including the collar, removes seed sources, leading to population decline and habitat destruction.

1.5 Processing and Biochemistry of the species

Osyris lanceolata is exported as raw wood stocks or semi-processed wooden chippings, almost the crude product, which fetches very low prices. Local people and middlemen believe that female plants yield better quality oil that is more scented and of higher medicinal value. However, Studies done in Kenya and elsewhere, though limited, have established that there is no significant variation in oil yield and quality between male and female plants within population (Mwang'ingo *et al*. 2010; Aoko 2009). Hence, influence of geographical location on quantity and quality of oil and composition of its active ingredients remain inconclusive. Mwang'ingo *et al*. (2003) found that wood portions close to the ground had higher quantity and quality oil decreasing towards the root and shoot tips. In addition, they established that populations in relatively arid climates produced better quality and quantity of oil than in humid climates.

Extracts of *O. lanceolata* wood stock, have antioxidant as well as antimicrobial activity potential as well as a number of secondary metabolites that are active ingredients, mainly agarofuran sesquiterpene polyesters, pentacyclic triterpenoids, phenols, flavonoids (Yeboah & Majinda, 2009; Yeboah *et al*., 2010; Yeboah & Majinda, 2013; Aoko, 2009; Mbunde *et al*., 2017). Yeboah *et al*. (2010) isolated 3 dihydro-β-agarofuran sesquiterpenes and 2 pentacyclic triterpenoids from chloroform extract of the root bark, all of which demonstrated antifungal activity against *Candida albicans*, and Gram positive *Bacillus subtilis* and *Staphylococcus aureus* and Gram negative *E. coli* and *Pseudomonas aeruginosa*.

1.6 Transport of *O. lanceolata* raw products

The wood stocks of *O. lanceolata* are transported using variable modes of transport. The aim is to disguise the product or hoodwink authorities in charge of transport services. At the harvest site, they are carried by porters on foot or on motor cycles to a local market for bulking. Once a substantive amount has been acquired, they are loaded on to larger capacity vehicles and transported to the designated border or factory site. The wood maybe disguised as firewood, may be carried in gunny bags or as contraband under other household products such as firewood. Cross border consignments are overtly carried in freight containers after being issued with 'documentation'. According to ACP FLEGT, in (Anon., 2013) the Kenya Plant Health Inspectorate Service has indicated that at times oil tankers are used to covertly transport Sandalwood from Kenya to Tanzania making it difficult to monitor the trade.

1.7 Trade in *O. lanceolata*

The East African Sandalwood trade in Kenya has been described as covert trade (Mabatuk & Wesangula, 2015), in which the players are unknown, but with a ready market (Mathenge et al., 2005). Indeed, accounts about trade in *O. lanceolata* before the 2000s are not readily available, but it appears that due to reduction in Santalum oil supply from the traditional source countries i.e. Australia and India, in that period, demand for *O. lanceolata* oil as a substitute or adulterant started growing. The market identified S. Africa and Tanzania (Mwang'ingo et al., 2003), India, Indonesia and Australia are the main producers of Sandalwood oil while the United States and France are the two largest importers of Sandalwood oil. The high demand for the Sandalwood oil and restricted access to traditional sources due to diminishing supply has led to demand and overexploitation of *O. Ianceolata*, as the alternative source. Also, the competing use of sandalwood for dyes and tannins in the SA Cape region may have pushed the buyers further north into Tanzania (Mwang'ingo et al. 2003; Mwang'ingo et al. 2007). As the sources diminished in the south, the interest moved further north into Kenya, specifically to the Kyulu hills in the Southern and Southeastern parts of Kenya through Kilimanjaro area (Mwang'ingo et al. 2003; Mwang'ingo et al. 2007; Machua et al., 2009). By 2004, trans-border trade in wood stocks disguised as 'firewood' between Kenya and Tanzania, was frequent as the harvesting spread further inland. The 2014 Kenya Taskforce on Wildlife Security retraces early large scale harvesting and smuggling to the Kyulu hills, Tsavo area (Mukonyi et al., 2011; Mabatuk & Wesangula, 2015). Harvesting rapidly spread to Taita, Amboseli, Kajiado, Narok, and Baringo. Subsequently to the central parts of Kenya, targeting the dry forests and woodlands in the Rift Valley in Elementaita, Baringo; then to Northern parts of Kenya including Isiolo, Samburu and Marsabit (Mukonyi et al., 2011; Mabatuk & Wesangula, 2015).

About the year 2004, the local prices for *O. lanceolata* crude wood stocks were KES 10-30 (USD 0.1-0.3) per kilogram at the farm gate and KES 700/kg (USD 0.17) in international markets (Cheboiwo et al., 2018). The farm gate price was quoted at KES 200-300 (USD 2-3) in the year 2015 (Mabatuk & Wesangula, 2015), which were quite lucrative, considering the daily casual wages then. The high prices offered, make poaching from land belonging to other persons particularly, an attractive option (Ochanda, 2011). Kenya has reported massive uncontrolled wild harvesting, while in Tanzania, a sandalwood factory in Tanga closed due to scarcity of raw

materials. There are no clear records on trade in *O. lanceolata* but it is estimated that 1, 000 tonnes are annually harvested from Africa, mostly from East Africa. Mukonyi *et al*., (2011) had projected that, the East African Sandalwood would contribute significantly to global Sandalwood oil trade in the coming 5-10 years, but this remains a mirage, due to the persistent lack of an acceptable trade management framework.

1.8 Trafficking and trade control of *O. lanceolata*

Frequent media reports in Kenya, on untenable trade volumes attracted the attention of the authorities and the 3-year ban on *O. lanceolata* harvesting was decreed in February 2007. Between 2007 and 2011, records show that over 250 tonnes of Sandalwood were illegally harvested and traded. Some consignments were confiscated in Kenya by Law enforcement agencies while in transit (Table 2). The peak of over-harvesting and illegal trade in *O. lanceolata* can be estimated to have been between years 2005 and 2009. The latest seizures in Kenya, of *O. lanceolata* materials destined for export was documented in 2018 in Mombasa, (Ann Mwaura pers. Comm. 2020), most recently in January 2020 (Citizen digital, 29 Jan. 2020).

Table 1:Records of confiscated Sandalwood in Kenya between 2007-2011

Station holding seized material	**Weight of Seized materials (Tonnes)**
KWS Maralal	50
KWS Tsavo West	31.361
KWS Chyulu	152.834
KWS Nakuru	22
KFS Mombasa	15
Marsabit Station	5
KFS Headquarters	5
Total	**281.195**

A crude trafficking chain for *O. lanceolata* involves about five players; harvesters (local people), linkmen/intermediaries (local people), transporters (local people), secondary buyers (Kingpin) and international pharmaceutical and cosmetic companies, and consumers (medicine, perfume companies). This covert trade chain is best illustrated in Figure 3.

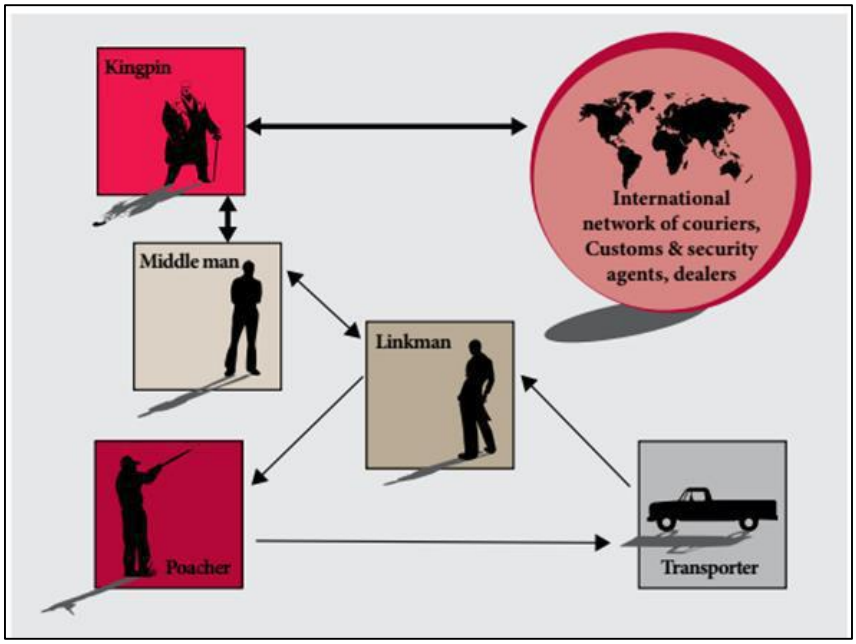

Figure 3. Illustration of the poaching and trafficking network (Weru 2016).

1.9 Monitoring and Traceability

The discordant documentation of *O. lanceolata* trade is the best indication of Kenya's lack of trade control and lack of traceability mechanisms. It is typified by the lack of authentic documentation, including no certificate of origin, inadequate description of materials in transit, miss-declaration or mislabeling, and plain fraudulent documentation (Mukonyi et al., 2011). For instance, a consignment at the port of Mombasa for re-export had papers showing its origin as Uganda, but lacking mandatory customs stamp (Solomon Kyalo pers. comm. 2020). Of particular concern for Kenya, sandalwood is semi-processed in Tanzania into chips and the product is illegally re-exported through Mombasa, Kenya, indicative of poor regional trade cooperation and control.

Traceability refers to the ability to track and trace a product along the supply chain (Andrade & Voora, 2015). In the case of EA sandalwood, traceability can give the conscious consumer the confidence that the santalum oil is sourced responsibly and sustainably from the wild or plantations. Unfortunately, law enforcement challenges with respect to *O. Ianceolata* production and trade in Kenya persist, due to weak forest law enforcement by the respective agencies.

2.0 AIM OF STUDY

Kenya had not established the population status of *O. lanceolata* to guide any level of commercial harvesting. Also, *O. Ianceolata* was and is exclusively harvested from the wild. Continuing trade without a management framework, inadequate corporation and cross-border trade regulation, makes the species vulnerable. This study therefore aimed to assess production, harvesting, processing, transport, trade, control and monitoring of Osyris lanceolata with a view of establishing a fair tracking/control system that supports a harvesting quota if proposed.

3.0 METHODOLOGY

The study area was Narok County in South Eastern Kenya, and encompassing populations of *Osyris lanceolata* in this area. This was purposively selected since it is one of the areas in Kenya where *O. lanceolata* is naturally found. Specific sites visited included Narok, Oloitoktok, Namanga, Taita Taveta, Mombasa and Nairobi Kenya. During the visit, data was collected with reference to the Narok population and consignments of Osyris transiting through the respective ports of exit. Information was collected with the help of a questionnaire based on: CITES CoP 15 Doc. 16.3, CITES CoP 16.7 (Rev. CoP 17) Annex 1, in combination with CITES Non-detriment Findings Guidance for Perennial Plants. A nine-step process to support CITES Scientific Authorities making science-based non-detriment findings (NDFs) for species listed in CITES Appendix II. Informants were mainly Community leaders and members, resource users and field officers in charge of managing forest resources, trade officers and other relevant stakeholders. Notes and opinions were also noted. The information was assessed and scored using a scale ranging from 0-6, where 0-1 represented none or minimal risk or impact, 2-3 low to moderate, 4-moderate,5 -high risk and 6- unknown.

4.0 RESULTS AND DISCUSSION

4.1 NDF steps 4-8

Figure 4 below shows aspects probed during the interviews in a radar chart.

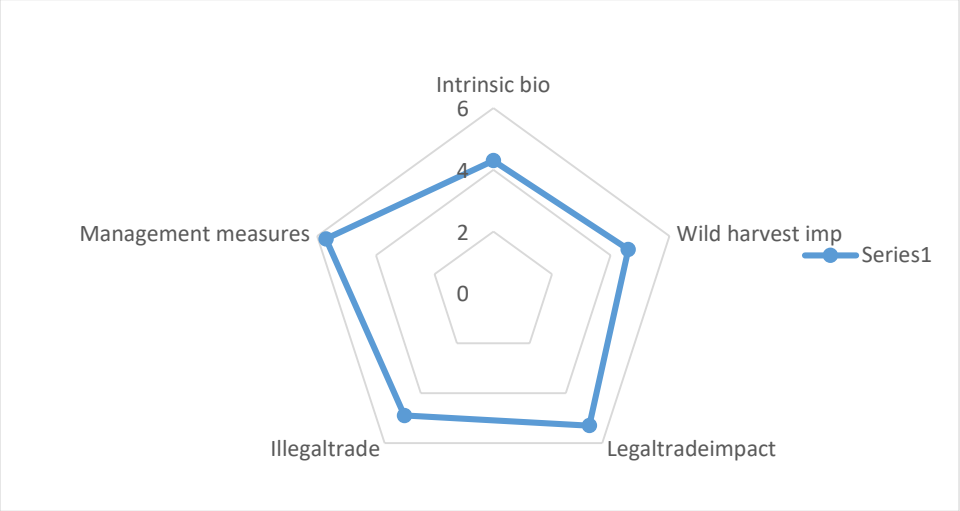

Figure 4. NDF Radar chart for O. lanceolata in Narok, Kenya.

The risk to *O. lanceolata* is moderate to high overall. However, the highest risk stems from the lack of management measures, followed by legal trade impacts, then illegal trade impacts. Trade seems to have high impacts, particularly owing to the fact that besides being sought after by international traders, it is a popular beverage sold in most local markets. Unfortunately, all the bark traded in the market is wild-harvested by local women purportedly for domestic use, but subsequently dried and diverted to local markets as a beverage. There is no license and no control or management of this practice, increasing impacts associated with it. The individual factors are subsequently discussed here below.

4.2 Conservation status assessment: Step 4

From the interviews, few respondents know the IUCN redlist status of *O. lanceolata*. According to IUCN (2020), the populations of *O. lanceolata* in Europe are considered stable. Raimondo *et al*. (2009) designated *O. lanceolata* as being of least concern (LC), after evaluating it against the five IUCN criteria. This species does not qualify for the categories Critically Endangered, Endangered, Vulnerable nor Near Threatened. In assessing the severity of conservation concern relevant to harvest area; most respondents said they considered it endangered or threatened internationally, regionally and nationally. Indeed, most respondents consider the local population mostly endangered. However, this view seems to be influenced by their proximity to information on the species in nature and conservation matters (field officers and some community members tended to describe it as endangered). Others did not seem to be aware of any conservation status assessments (ports of entry/exit).

4.3 Intrinsic Biological Risks: Step 5

Biological risks are associated with the species lifeform, parts harvested for export markets, population distribution, its reproductive capacity and the niche that it occupies. *O. lanceolata* is a shrub or small tree, that reaches mature height of about 6-8m in 15-20 years at which age it would have attained its merchantable diameter (>12cm). The parts harvested are; stem, roots/root base, bark depending on desired product/use. The Maasai community shares the species range and mostly exploits the bark of mature trees, but this is a rampant practice and this product which is used in teas is common in all local markets. Demand for bark (tea) has increased in recent times, with urban dwellers sourcing from local markets. Further, Maasai women have turned this trade into a livelihood activity that is unregulated by local authorities (Silantoi pers. Comm., 2022). Cutting and debarking, can kill the plant (Ketuta, Pers. Comm., 2022). The root base and mature branches are preferred by the export markets.

The geographic distribution of *O. lanceolata* is wide, but populations are rarely described as abundant, more or less scanty, making this factor medium to high risk. Areas where it grows include K1 in North Eastern, Baringo, Laikipia, K4 Rift Valley, Kibwezi, Kitui, Chyulu, K5 Mt. Elgon, K6; Narok county, Loita, Mara triangle, Magadi, K7; Taita, Taveta, Tsavo. In parts of Narok, specifically Lemek, access is limited by the presence of Wild animals specifically the Elephants which roams freely (Parmat Pers. Comm., 2022). However, the population size was unknown to field officers and was assessed as low (Low) and scattered, hence at high risk.

The species is habitat-specific, preferring hilly areas or rocky outcrops in dry upland and riverine forests, forest edge, riverbanks, lowland bush and in arid and semi-arid areas. This habitat is extremely vulnerable as it is not in protected areas, but mostly on communal and private land. However, since it's rocky and sloping land, it is not easily cultivated (Lilach, pers. Comm., 2022). The Species is also threatened by human livelihood activities including an ongoing land subdivision in the areas where Osyris occurs naturally and extractive activities such as charcoal burning. It is also prone to browsing by wildlife and livestock in parts of Narok, where ranching takes place (Silantoi Pers. Comm., 2022).

The reproductive capacity of *O. lanceolata* is described as low and mostly weather-dependent meaning the factor is high risk (High). It reproduces through seeds, born on the female and which are bird-dispersed. The viability of such seeds is thought to be low (Ndambuki, Pers. Comm., 2022). In some areas, it's common to find either male or female trees dominating and the opposite sex can be rare in these cases, further compromising its ability to reproduce.

O. lanceolata rarely grows alone or in pure stands, mostly in association with other species. As a hemi-parasite, it is dependent on a variety of hosts, including *Tarconanthus camphoratus, Rhus natalensis, Maytenus senegalensis, Combretum* spp. among others. It is commonly browsed by elephants, giraffes, livestock and other browsers. The main source of information was the community and level of confidence is high.

4.4 Wild harvest impacts: Step 6

On individual plants, the impact is high, due to the fact that the plant is chopped down to ground level and debarked and in extreme cases, it is extracted including the roots (uprooted).

On target population, impact is high and comments included the fact that the species is decimated in areas like Taita Taveta. In Narok, 10-15% of the women who trade in herbal medicine, stock the bark of *O. lanceolata*.
Impacts on national population is assessed as medium to low. However, the impact on other species harvested in combination, look alikes and or non-target species is becoming more apparent with the suite of species now including; Olarioi, Enkoma, Olmaroroi-*Acocanthera schimperiana, Rhamnus staddo* and *Rhamnus prunioides* (Silantoi pers. Comm., 2022). *Combretum apiculatum* (Melonyie, pers. Comm., 2022), *Carissa edulis*, Osentoi-*Tarconanthus camporatus*, Enkoma (Mole, pers. comm., 2022), *Acacia* spp., and *Maytenus senegalensis*.

4.5 Trade impact: Step 7.

Kenya does not allow export of the species and has not designated any harvest quotas. Overall, impacts of illegal trade were assessed as being mostly high (High). Communities reported poaching of the species for trade (Saitabau pers. Comm., 2022). The materials are said to be piled for transport in Taita Taveta. In 2013-2014 some 11 vehicles were impounded. In 2016, 2-3 containers were seized, subsequent years, some 5-6 containers were impounded (Nyamohanga pers. Comm., 2022). Change from traditional freight vehicles to smaller vehicles including Salon cars and SUVs has been noted (Bakari, Pers. Comm. 2022). At the ports of entry/exit, control, engenders scanning and profiling containers suspected to be ferrying illegal consignments/contraband goods in transit (Sale Hassan, Pers. Comm.). There have not been any recent arrests at the Port, but there have been arrests in some areas upcountry like Nakuru following tip-off (Mwandigha pers. Comm 2022). Harvesting practice that targets complete root excavation, is destructive and limiting to regeneration, but where root boles have been left intact, coppicing has been reported.

4.6 Management measures in place: Step 8

Currently, there are no guidelines for harvesting. Local community members alluded to indigenous guidelines for bark harvesting, though undocumented (Saitabau, pers. Comm., 2022). Communities should be educated on best harvesting practice, so as to allow extraction of the different products to the local and export markets and to minimize damage to the species in the wild (Nyamohanga, pers. Comm., 2022).
Setting harvesting area: None in place, but in preparation at KWS. Local communities mostly harvest bark from plants near their homes (Saitabau, pers. Comm., 2022).
Harvest seasonality; None or unspecified, but in preparation through KWS.
Max-offtake control; None existent, but protocols in preparation by KEFRI.
Equipment control; None, farm implements are often used. Local communities use knife or machetes to harvest bark (Saitabau, pers. Comm., 2022).
Population monitoring; This species mostly occurs in communal and private land and rarely in protected areas. Therefore, it is difficult to monitor its population unless with the help of land owners.

4.7 Domestication as an alternative to wild harvesting

There are a few domestication initiatives for *O. lanceolata* in the species range States. In Kenya, KEFRI, working with local communities in selected areas of the Osyris range, is in the process of refining technology of raising Sandalwood seedlings. Domestication of Sandalwood can reduce pressure on wild populations, provide markets with sustainable stocks, generate revenues and improve livelihoods. The species is a candidate tree for agri-business and can spur income growth from the rural areas. Kenya has developed propagation technology for production of Sandalwood seedlings through seeds and air-layering in supporting domestication of this species.

5.0 CONCLUSION AND RECOMMENDATIONS

The kind of information needed to prepare a full NDF report is often difficult to obtain, the process is expensive and time-consuming. The listing of *O. lanceolata* from the three range states in EA on CITES Appendix II is a major contribution to the conservation of this species in East African countries. This act has drawn the attention of the national and international communities to the dangers of uncontrolled exploitation and export of *O. lanceolata*. A fundamental obligation of CITES member countries, prior to any export of a product listed in Appendix II of this Convention, is a non-detriment finding (NDF). This report must be issued by a credible scientific authority, which certifies that the export volume requested by the country is not detrimental to the conservation of this species in forests. Another obligation is that the CITES Management Authority must certify that the volumes exported have been legally obtained, hence documentation is key All documents require factual information.

There is still need to continue regulating the international trade in *O. Ianceolata* to ensure exploitation is not detrimental to the survival of the species in the wild, and more importantly to promote its sustainable production through domestication. Hence, the need for international cooperation within the framework of CITES.

The current state of EA sandalwood in Kenya and EA region has been contributed by inaction and bad decisions on investments in local natural resources, lack of land-use planning and bad decisions spanning decades. As a result, EA sandalwood remains at risk since global demand for sandalwood oil has not waned at all. On the contrary, demand is projected to grow as the market grows and the products find more industrial applications. This poor state of sandalwood subsector needs to be remedied. Largely, Kenya requires a sandalwood management framework and to invest in dryland forests as well as putting extra support on the domestication and commercial propagation in order to meet supply demand as well as a livelihoods support.

In addition, there is need to invoke national legislative instruments to ensure greater protection as provided for in Forest Conservation and Management Act 2016 Section 40.

With the field and media reports, *O. Ianceolata* is neither categorized as threatened nor as vulnerable as Kenya needs to craft such a framework for conservation.

Domestication programmes to supplement the wild populations, species status and ecological assessments and complimentary control measures including appropriate policies and other enablers are needed.

For the EA Sandalwood, traceability needs to be initiated which may begin with the existing records, field reports and use of new technology such as DNA Barcoding to combat illegal wildlife trade.

The EA region urgently needs to put in place the requisite collective trade policy and other enablers for sustainable exploitation to improve local livelihoods as well as ensure conservation of this tree species.

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ANNEX 1: NDF QUESTIONNAIRE

DATA SHEET FOR NDF FOR OSYRIS LANCEOLATA IN KENYA

Species:----------Vern:----------

Name:	Phone No:	Location:	Date:

Conservation Concern

4.1 Conservation Status Assessments

Conservation Status	International	Regional	National	Information Sources Used	Threats Noted In Assessment	Confidence Level

4.2 Severity of Conservation Concern Relevant To Harvest Area

IUCN assessment	E	CR	T	LC	U

Step 5: Intrinsic Biological risks

Factor	Risks	High	Med	Low	Unk	Information Sources Used	Confidence Level
Plant lifeform							
Part(s) harvested							
Population size							
Geographic distribution							
Population size/Abundance							
Habitat specificity							
Habitat vulnerability							
Regeneration: recovery capacity							
Reproductive capacity/Regular flowering, ease of dispersal							
Role of sp. in ecosystem/other spp. Depend on it?							

Step 6: Wild Harvest impacts

Factor	Describe Impacts	High	Med	Low	Unk	Information Sources Used	Confidence Level
.1 On individual plant							
-Practice							
-Quantity							
-Frequency							
Allowable offtake							
6.2 On target population							
6.3 On national population							
on other species							
-In combination							
-Look alikes							
-Non tgt spp.							

Step 7: Trade impacts

Factor	Impacts	High	Med	Low	Unk	Information Sources Used	Confidence Level
7.1 Legal trade							
-Nos/vol/ in trade viz abundance							
-Demand/multiple uses							
-Licensing/CITES permit							
7.2 Illegal trade							
-Nos/vol/ viz abundance							
Vol and frequency of seizures							

Step 8.1: Management Measures in place

Harvest Management Measures	Information Sources Used	Confidence Level-HMLU
-Guideline for harvesting		
-Setting harv. Area		
-Harvest seasonality		
-Max off-take control		
-Equipment control		
-Population monitoring		

MINISTRY OF WATER AND ENVIRONMENT

KENYA Forest Service

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ANNEX 2: NON-DETRIMENT FINDINGS (NDF) INTERVIEWS

Safari Opiyo-KFS Narok

Stephen Ndambuki-KWS Mara

Benson C. Nyamohanga- KWS Longisa

Mike Onsere-KEPHIS-Namanga

Paul Nduati-Administration Police Namanga

Edwin Rotich-Police Namanga

Moses Namuya-Customs Namanga

Samuel Kihara-KWS Namanga

Loitokitok Border

Gordon O. Anyiko-KFS Loitokitok

James Nyaga-KWS Loitokitok

Taita Taveta Border

Harun K. Makange KFS Taita Taveta

Apolinary J. Mwandigha-KFS Mombasa

L-R Khamis Bakari-KFS Mombasa, J. Mwamodenyi, KFS, Saleh Hassan-Customs Mombasa, B. Khayota NMK, M. Oluoch-NMK

ANNEX 3: CTSP REPORT WRITING AND VALIDATION WORKSHOP DRAFT AGENDA

CITES Tree Species Programme (CTSP) Report Writing and Validation Workshop. Wildlife Research and Training Institute (KWRTI) 26-28th June 2022

DRAFT AGENDA

DAY 1: 26/06/2022

Time	Subject	Facilitator
12.00 Noon	Travel from Nairobi to Naivasha	Agnes Lusweti

DAY 2: 27/06/2022

Time	Subject	Facilitator
	Session Chair: James Mwamodenyi	
0830 - 0845	Introductions	All
0845 - 0930	Opening Remarks: • National Coordinator • Regional Coordinator • Director KWRTI	 James Mwamodenyi Dr. Beatrice Khayota Dr. Patrick Omondi
0930 - 1000	Introduction and overview of the CTSP	Dr. Beatrice Khayota
1000 - 1030	**HEALTH BREAK**	
1030 -1115	Non-Detriment Findings – Draft report	Agnes Lusweti
1115 -1130	Questions & Comments	Solomon Kyalo/Dr. Beatrice Khayota
1130 -1215	*Osyris lanceolata* Inventory Draft report	Peter Gachie
1215 – 1230	Questions & Comments	
1230 - 1400	**LUNCH BREAK**	
	Session Chair: Dr. Beatrice Khayota	
1400 -1430 1430 - 1600	Video screening Report review by teams.	 All
1600	**HEALTH BREAK & END OF DAY**	

DAY 3: 28/06/2022

Time	Subject	Facilitator
	Session Chair: Fred Ojuang	
0900 - 1000	Report reviews by teams	All
1000 - 1030	**HEALTH BREAK**	
1030 - 1200	Presentations of reviewed reports	
1200 - 1230	Questions & Comments	
1230 - 1400	**LUNCH BREAK AND DEPATURE**	
1400 - 1445	Next Steps	Dr. Beatrice Khayota
1445-1500	Closing Remarks	Peter Gachie
1500	**HEALTH BREAK & END OF DAY**	

DAY 4: 29/06/2022

Time	Subject	Facilitator
0900	**DEPARTURE FOR NAIROBI**	

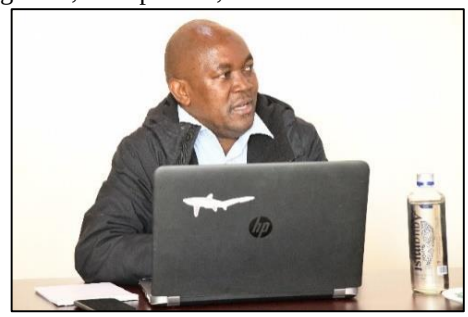
ANNEX 4: CTSP REPORT WRITING AND VALIDATION WORKSHOP PHOTOS

Workshop session

F, Ojuang-KFS, S. Kipkoech, P. Gachie KEFRI

Peter Gachie-KEFRI

Agnes Lusweti-NMK



Solomon Kyalo-KWS

Solomon Kipkoech

L-R J M Mwamodenyi-KFS, Fredrick Ojuang KFS