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.

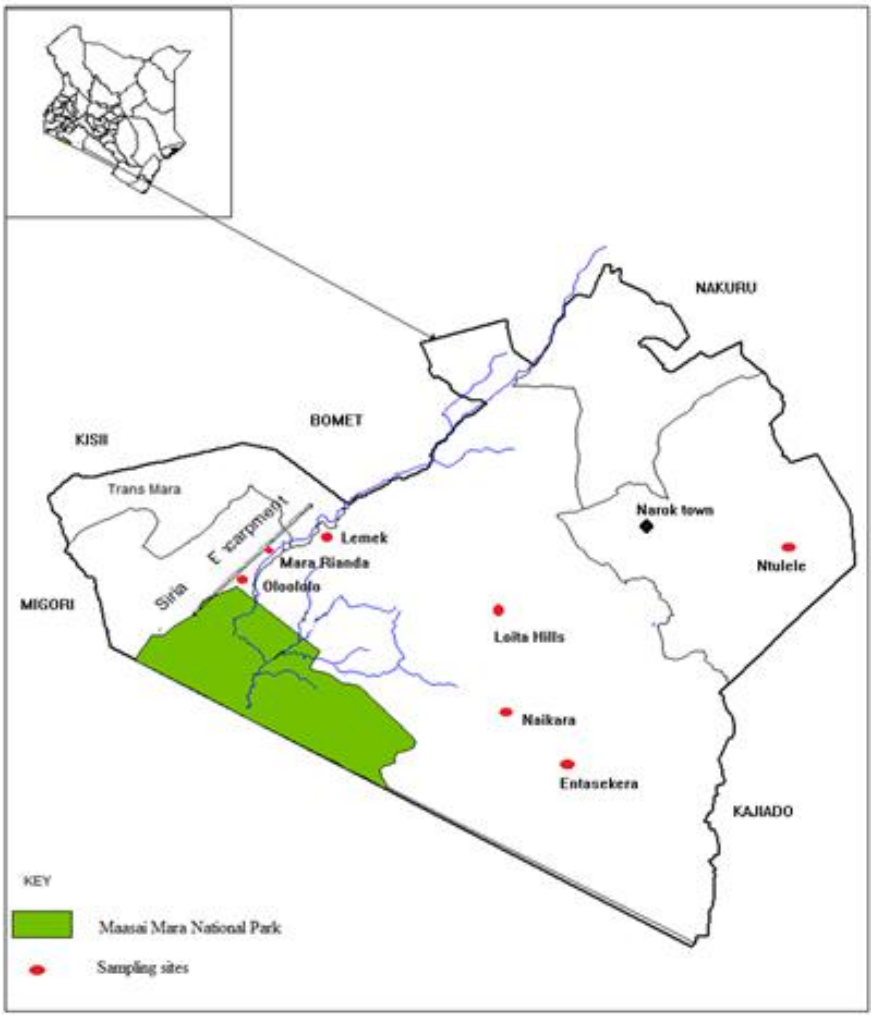

Figure 1. Study area in Narok County.

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

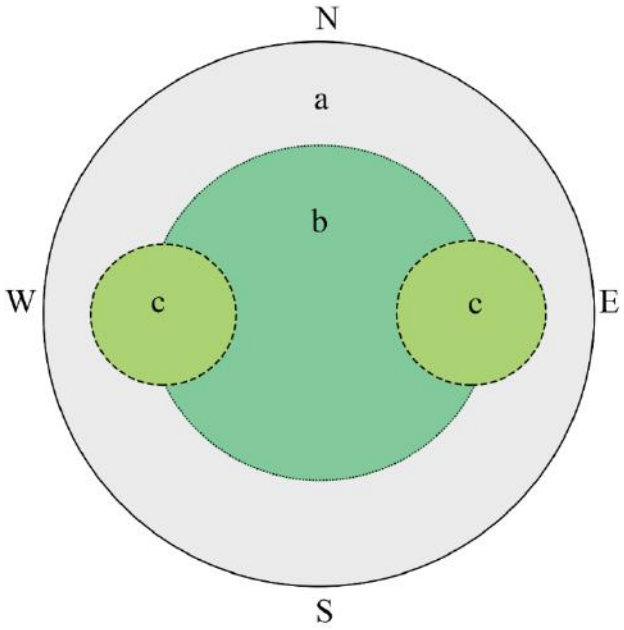

Figure 2. Sampling plot layout (Adopted from Muchiri *et al*. 2016).

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.

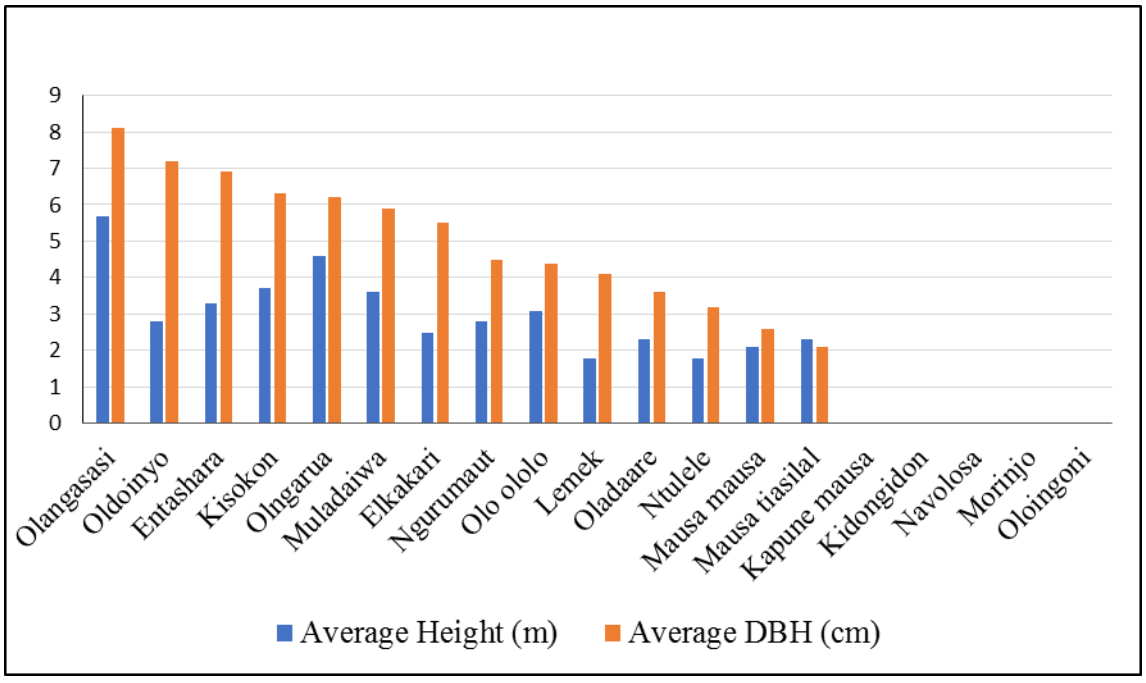

Figure 3: Osyris Lanceolata height and DBH distribution across sampling sites in Narok County.

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.

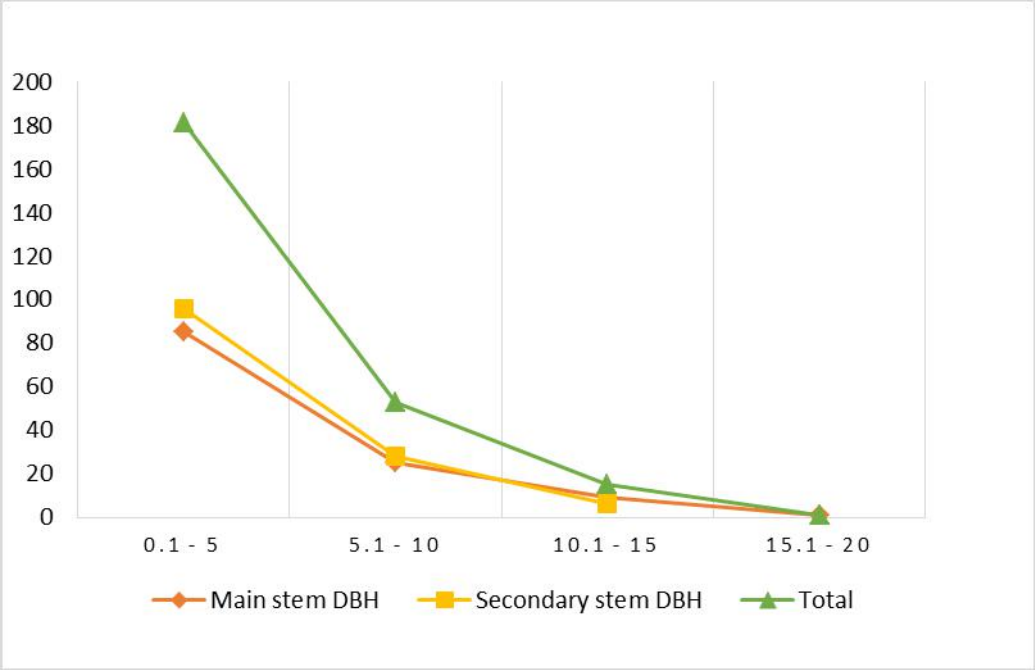

Figure 4. Distribution of Diameter classes of *O. lanceolata*.

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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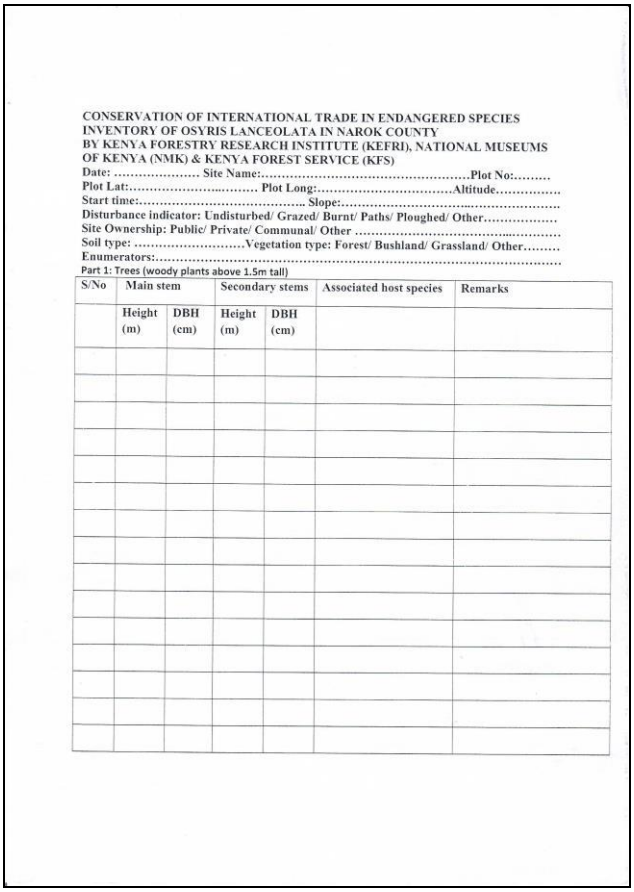
ANNEX 1: FIELD INVENTORY FORM

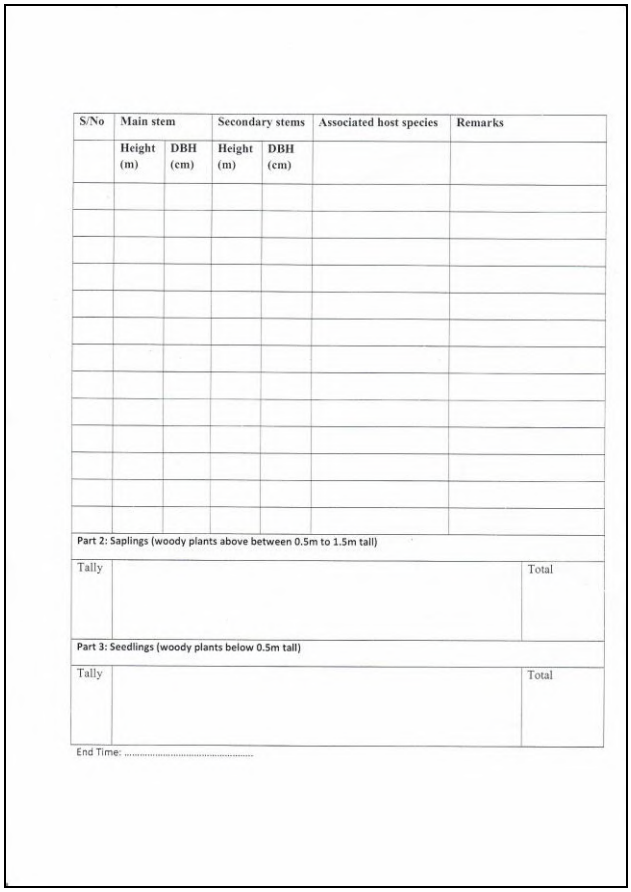


CONSERVATION OF INTERNATIONAL TRADE IN ENDANGERED SPECIES
INVENTORY OF OSYRIS LANCEOLATA IN NAROK COUNTY
BY KENYA FORESTRY RESEARCH INSTITUTE (KEFRI), NATIONAL MUSEUMS OF KENYA (NMK) & KENYA FOREST SERVICE (KFS)

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