KENYA FORESTRY RESEARCH INSTITUTE

Management and Control of *Cestrum aurantiacum* in Kenya

A guide for forest managers, farmers and extension agents

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Jared Amwatta Mullah, Boaz Ngonga and Samson Ojunga

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Caption for cover photograph:
Cestrum aurantiacum plant with flowers and fruits in Cherangany Hills Forest.

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FOREWORD

Cestrum invasion poses substantial threats to agriculture, biodiversity, and delivery of ecosystem services in Kenya. When the species is not controlled, Cestrum forms dense stands in degraded forest gaps, abandoned farmlands, open areas and consequently prevents establishment of other plant species in forest areas. The species competes aggressively with native species mainly due to its allelopathic properties and in turn prevents regeneration and establishment of natural forests. Cestrum is also a major weed in key commercial plantations and croplands in some parts of the Country. Invasion may significantly affect management and economic returns on commercial plantation species such as; Pine, Cypress, Cedar, and Podo among other tree species. Apart from its ability to suppress regeneration of other tree species, Cestrum is also poisonous to livestock and may indirectly affect human health.

The extent of Cestrum invasion in water catchments, commercial forest plantations, rangelands and farmlands has captured the public attention. The main challenge with Cestrum invasion is the insufficient information and capacity for its management due to lack of appropriate policies and awareness among government officials and other stakeholders. Cestrum invasion has negatively impacted biodiversity, water resources, crop and pasture production, human and animal health and economic development. However, there is insufficient information to enable management of the invasion.

Beware of the argument that introducing a whole bunch of new tree species to an ecosystem or landscape is a good thing "because it increases the tree cover or biodiversity". Though biodiversity is a global concept, increasing local biodiversity by introducing new species from elsewhere can actually reduce global biodiversity if the introduced species cause extinction of endemic species that are found only in our ecosystem and nowhere else in the world. The enormous diversity of ecosystems and wildlife species are source of livelihood and central to the economy of the country thereby being indispensable to achieving the aspirations outlined in Vision 2030.

This guide on Cestrum management therefore intends to assist extension officers, forest managers, and farmers to improve planning and management of the species in order to stem the enormity and the growing severity of the invasive species in our forest landscapes.

This publication contains practical advice and knowledge and I encourage its use by concerned stakeholders. The guideline is an addition to the available tools for use by extension agents, forest managers and communities; and should result in an effective action against not only Cestrum species but many other invasive plant species in our forests and other landscapes.

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Director - Kenya Forestry Research Institute

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DEFINITION OF TERMS

Invasive alien species	Species introduced deliberately or unintentionally outside their natural habitats where they have the ability to establish themselves, invade, out-compete natives and take over the new environments
Vectors	Specific mechanism by which a species is moved along a pathway (clothing, vehicle, boat hulls, packaging, soil in potted plants and animals)
Pathways	Routes along which plant species are moved or moves itself (road, disturbance corridors, shipping lanes, rivers and trade) from its native area into a new area
Biocontrol ***(biological control)***	A method of controlling an invasive species by introducing a natural enemy, such as an insect or fungus that specifically attacks the target species and does not attack native or economically important species
Prevention ***(biosecurity)***	A procedure or measures designed to protect the population against spread of invasive species across country, county, ecosystem, farms borders, including between farms
Containment	The act of keeping an invasive species within a defined area
Control	The ability to reduce the population of an invasive species from an area
Eradication	Process of complete elimination of an invasive species from an area
Monitoring	Programs and measures to detect change in distribution of invasive species and the success of invasive species management projects
Indigenous species	Species that occur naturally in a specified area, having either evolved or arrived at a specific locality without human intervention

1.0 INTRODUCTION

1.1 Background

During colonization era in the seventeen and eighteenth centuries, many Europeans emigrated with numerous plant species for ornamental purposes, botanical gardens, and nurseries. Some of the plant species later escaped from their intended niche and became invasive. In the late 20th century, scientists have also been responsible for introduction of other invasive plant species. Few invasions in Kenya have been documented. These documentations give a broad picture of susceptibility of the forested habitats to spread of introduced woody species. However, on local and landscape scales, there is limited documentation due to; poor recording, under-reporting, and failure to appreciate the spatial spread of a species. There are few notable documented species in the country which have escaped into the forested habitats including; *Lantana camara, Maesopsis eminii, Solanum mauritanianum, Fraxinus pennsylvanica, Acacia mearnsii, Acacia melanoxylon,* and *Cestrum aurantiacum.*

Human-induced environmental degradation, such as destruction of natural landscapes, soil erosion, habitat destruction and water pollution are key drivers in proliferation of invasive species. The uncontrolled spread of invasive plant species has adversely affected the capacity of natural forests to sustainably provide ecosystem, ecological, biodiversity, and environmental functions.

KEFRI conducted a reconnaissance survey in 2016 to document all potential woody invasive species in Cherangany, Mt. Elgon, and Mau forest ecosystems. Cestrum was found to be the main invasive species in these ecosystems. Observed and recorded management interventions currently used in the forest ecosystems to contain the spread of Cestrum have different levels of success. These variations in success could be attributed to inadequate availability of information on suitable management options.

1.2 Description of *Cestrum aurantiacum*

Cestrum aurantiacum Lindl. commonly known as yellow cestrum or night-blooming jasmine is native to North and South America and belongs to the Solanaceae family. It is an evergreen, slightly scrambling shrub or small tree that grows to a height of up to 180 cm. It has brilliant tubular orange flowers that have a powerful citrus like smell, especially at night. The fruits are berries which are white in color and contain approximately 4 seeds. Cestrum was first introduced in Kenya in Tigoni, Kiambu County in 1921 and promoted as live fence and in gardens by the colonial government. The species was

introduced in Cherangany, Mau, and Mt. Elgon areas in mid-1960s for the same purposes. All parts of Cestrum plant are poisonous and toxic to both livestock and human. Veterinary department in 1948 reported the first case of Cestrum livestock poisoning in their annual report. In 2013, sheep and cattle poisoning was reported in Cherangany.

1.3 Justification and objectives for the guideline

The rate of spread of Cestrum in the forest ecosystems and adjacent farming landscape is increasing rapidly. The spread of this species is a threat to biodiversity, natural resources, food security, economic development, human health, and ecosystem services such as water resources, and nutrient cycling. The number of cases of successful control and management of Cestrum reported or documented are low, and available information scanty. Awareness creation for forest managers, extension staff, and farmers in target areas is therefore urgently needed.

This guide highlights: Cestrum invasion in degraded forests and farmlands; Pre-management of Cestrum species; Cestrum management techniques and goals for specific landscapes; and post-management restoration. This document gives guidance to assist management of Cestrum by preventing introduction of the species in new areas, and controlling or eradication of the species in already invaded areas.

2.0 CESTRUM INVASION IN DEGRADED FORESTS AND FARMLANDS

Cestrum invasion is characterized by specific patterns and mechanisms at different invasion stages in various ecosystems and landscapes. Practitioners should therefore use management strategies that explicitly target an invasion stage and ecosystem to enhance effective prevention of invasion. Characteristics of the severity of invasion and the type of landscape affected which may include; disturbed natural forest, degraded plantation forest, or farming landscapes, should to determined in order to develop targeted management and control strategies.

2.1 Degraded natural forests

These are forests which have experienced; excessive harvesting of wood and/or non-wood forest products, poor management, repeated incidences of fire, and over-grazing, leading to open patches hence heavily invaded by Cestrum. The high level of invasion delays natural regeneration of key indigenous forest tree species. In such open forest sites Cestrum seedlings dominate the forest floor (Figure1) while mature Cestrum trees form part of the canopy (Plate 1).

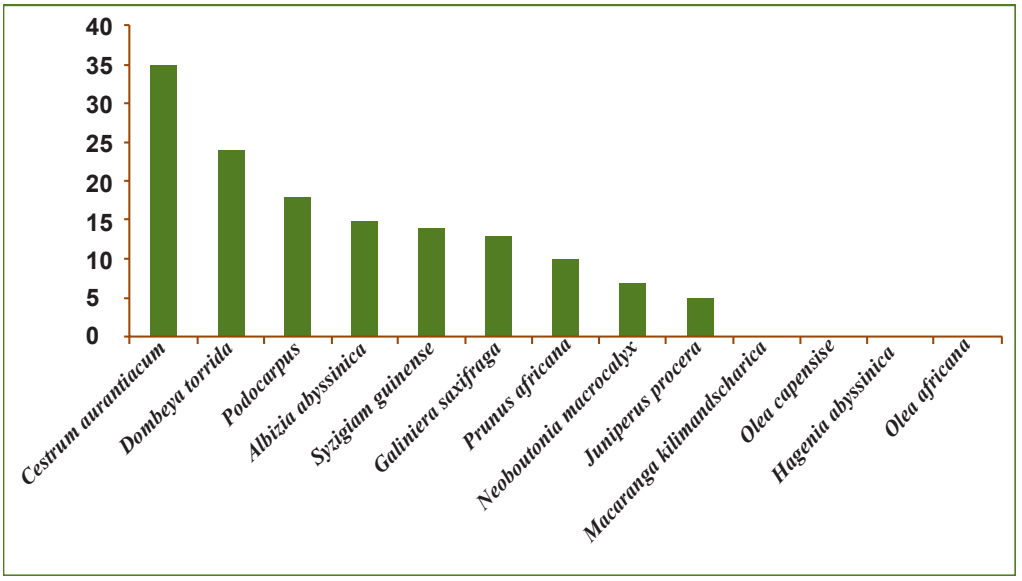

Figure 1: Seedling density of Cestrum compared with other indigenous species in Mau Forest

Plate 1: Cestrum in the canopy of degraded natural forest in Kobujoi in South Nandi forest block

2.2 Degraded riverine woodlands

These are narrow forest strips found in alluvial plains, along rivers and streams which due to; grazing, forest fires, cultivation, and lack of sources of regeneration propagules, have been invaded by Cestrum. The invasion has led to blocking of river-flow and access to water by both humans and livestock. Such degraded riverine woodlands are characterized by bushlands dominated by Cestrum and very few trees of other species (Plate 2).

Plate 2: A riverine woodland invaded by Cestrum in Kapcherop

2.3 Degraded commercial forests

These are areas which were previously cleared of most of their original forest cover due to either; illegal timber harvesting, charcoal production, settled agriculture, conversion to pasture lands, road construction and failed plantations, and systematically planted with either exotic or indigenous tree species. In such degraded commercial forests, Cestrum has spread and dominated the other species during natural re-establishment. In extreme cases Cestrum has modified the invaded sites resulting in close to monoculture plantation by aggressively regenerating, out-competing, and suppressing other plant species to form thick mat in the forest floor (Plate 3).

Plate 3: *Cestrum aurantiacum* in Cypress plantation at Kacherop forest block in Cherangany

2.4 Cestrum in farming landscapes

Cestrum provides evergreen live hedge around homes, farm boundaries, and barrier around farms. Cestrum live hedges are still very popular in some parts of farming landscapes in the country. However, due to poor maintenance of the live hedges, Cestrum has overgrown producing seeds which are dispersed to neighboring areas and progressively spread far beyond where it was deliberately introduced (Plate 4).

Plate 4: *Cestrum aurantiacum* regeneration in a maize plantation in Maji Mazuri, Mau Forest

3.0 PRE-MANAGEMENT OF CESTRUM SPECIES

3.1 Concepts and requirements for management of Cestrum invasions

Before initiation of management interventions for Cestrum invasion several approaches are considered. These include the following:

a) ***Identifying invaded sites, mapping the extent of invasion, and delineation of areas based on degree of invasion***. Such database will help in effective management and monitoring success of interventions applied.

b) ***Understanding the underlying causes of Cestrum invasion and whether it is on-going or contained***. Characteristics of the invasion should be carefully evaluated to enable identification of the severity, for selection of suitable intervention techniques.

c) ***Specifying the purpose of carrying out management interventions***. Management may focus on containment, hastening recovery of tree species in invaded areas, ameliorating soil conditions before planting trees, or eradicating Cestrum trees.

d) ***Selection of appropriate management techniques***. For instance, selection should help to identify whether the site simply requires protection from further disturbance to allow natural regeneration or if it requires re-introduction of certain tree species to out-compete Cestrum.

3.2 Conceptual planning in management of Cestrum invasions

The logical conceptual steps necessary to understand and plan for management of invaded areas include:

i. Identifying the invaded site location and delineating boundaries. Use of Global Positioning System (GPS) to map invaded area is important in making informed reference of the affected ecosystem.

ii. Specifying objectives of management for ease of monitoring success of the management intervention.

iii. Elaborating management goals. This is an expression of the degree to which management goals can be achieved.

iv. Identifying priority audiences for awareness programs, including decision makers, local communities and young people, especially groups involved in implementation of actions for invasive management or who may influence management success.

v. Collating existing knowledge about current levels of awareness and attitudes towards invasion and management methods, and carry out further surveys where necessary.

vi. Identifying strategies for short and long-term protection, and management of rehabilitated sites. This ensures that the site will be protected and properly managed into the indefinite future. External threats can be reduced by buffers and building partnership/collaborative commitments from neighboring communities

3.3 Methods for Cestrum management and control

Once the site targeted for control is well understood and objectives are clear, suitable management technique to be used should be decided before proceeding with the management interventions. Common management methods include; prevention, mechanical, chemical, and biological control.

i. Preventative measures

Newly established Cestrum should be destroyed before they flower and produce berries. This is necessary as birds eat the berries, dispersing the seed to new areas. It is advisable not to plant Cestrum in gardens, as this acts as a potential point of dispersion. Roadside infestations should be controlled through regular clearing and burning the debris. Land which is over-grazed and therefore has limited plant competition, should be regularly checked for new infestations. Cestrum is extremely difficult to control because of its vigorous re-growth and long seed lifespan hence any established plant should be cut down, and roots dug out. However, monitoring and continuous application of preventive measure is essential to prevent regrowth.

ii. Mechanical control

Mechanical control involves digging up plants by hand-held implements and removing all plant material including roots. Cestrum grows vigorously if left uncontrolled. Through its extensive, shallow roots system, the species can produce many new plants from suckers, particularly after root disturbance or injury. Continuous monitoring and physically destroying any re-growth and suckers is often required. Control using an application of mulch to cover and suppress growth of seedlings and suckers can also be used.

iii. Chemical control

Chemical control involves spot-spray application of herbicides and is used in heavy infestations to eliminate mature stands. Alternatively, a basal bark application using a dropper bottle can be used on isolated plants. Timing of chemical application is important and should be done prior to seed setting. Suckering and seedling growth may occur later and therefore follow-up chemical application is required.

iv. Biological control

Cestrum spreads through production of massive seedlings which out-compete seedlings of other plants. Planting of fast growing tree species in invaded areas can be used to control growth of Cestrum seedlings. Choice of the tree species to out-compete and reduce the Cestrum regeneration should have at least some of the characteristics shown in Table 1.

Table 1: Desirable tree attributes for rehabilitation of invaded forest areas

Desirable tree attribute	Forest rehabilitation benefits
Indigenous tree species	Enhance biodiversity conservation
Fast-growing species	Suppression of herbaceous vegetation
Species attractive to fruit-dispersing birds	Seed dispersal
Ecologically beneficial species	Enhance ecological functions
Economically / socially beneficial species	Provision of forest goods and services
Rare / endangered / over-utilized species	Enhance abundance and diversity
Fire tolerant species	Suppression of forest fires
Species tolerant to harsh site conditions	Nurse trees

3.4 Choice of management goals

Once the management technique and the affected sites have been identified, other factors that need to be considered include; control methods, suitability of the methods, management costs and the ecological impacts to the environment. A hierarchical approach should be adopted during choice of management goals in the order of priority as shown in Table 2.

Table 2: Hierarchy of Cestrum management goals

Priority	Management goal	Techniques used	Cost characteristics	Most useful for
1	Prevention	Avoid planting invasive species in the ecosystems	Cheapest method for multiple species	Species not yet present
2	Eradication	Mechanical (slashing, cutting, uprooting), Chemical	High initial cost but minimal after eradication achieved	Species present in small areas, including new arrivals
3	Reduction in population size, vigour or impact	Biological control, management	Cost high for new agents, Low for well-known ones, and minimal after effective agent established	Widespread, damaging to the ecosystem or environment
4	Containment	Mechanical, chemical or genetic techniques	Highest cost	Useful but damaging to other species; new arrivals
5	Long-term population management	Mechanical, chemical or genetic techniques	Highest costs	Widespread, damaging species for specific goals

4.0 CESTRUM MANAGEMENT TECHNIQUES AND GOALS FOR SPECIFIC LANDSCAPES

4.1 Invaded natural forests

Mechanical control is not considered economically viable, except on land of high conservation and biodiversity value such as water towers, national parks, game reserves, river banks, and irrigation canals. For effective eradication and control of Cestrum invasion in natural forests and woodlands the following practices are applied:

- Initiating non-invasive tree species recovery by planting fast-growing tree species to suppress the invasive individuals and improving the environment thus facilitating establishment of indigenous tree species.
- Accelerating tree seedling establishment by reducing competition from weedy species such as grasses and vines (within 0.5m radius), slashing, hand-weeding, and thinning of clumps of woody seedlings to liberate the desired species.
- Preventing further invasions by removing or carefully managing disturbance agents e.g. fires, grazing, which interrupt succession and recovery of indigenous tree species.
- Monitoring and eradication of woody species invasion as an essential component of forest rehabilitation programme.

Plate 5: Promoting growth of desired tree species through clearing of Cestrum seedlings and saplings, and removal of unwanted bushes and shrubs

4.2 Cestrum in commercial plantations

Mechanical control by slashing with panga and cutlasses is commonly used, especially during the initial stages of land preparation for commercial plantation establishment. After slashing, the material is left to dry for a few days to allow the brush to dry, and is then burnt. The slashed stumps are usually uprooted with hoe or mattock. New regenerations on farms from the very large seed bank are removed by hoeing. This approach followed by planting of food crops and good farm maintenance in the Plantation Establishment and Livelihood Improvement Scheme (PELIS) system often yields good results. Where PELIS is not used, high seedling survival rate (85%) should be maintained so that there is limited niche for Cestrum recruitment. A well-stocked commercial plantation should be able to suppress the emerging Cestrum plants through shading.

Plate 6: A newly established Cypress plantation on site where Cestrum seedlings, saplings and stumps have been uprooted in Kapcherop, Cherangany Forest

Plate 7: Heavy regeneration of Cestrum in a cypress plantation in Maji Mazuri, Mau Forest (left) A plantation in Trans Nzoia cleared of Cestrum saplings and poles (right)

4.3 Cestrum in the farming landscape

Mechanical control by slashing with panga and cutlasses is used during the initial stages of land preparation for farming. The slashed material is left to dry for a few days after which it is burnt. The slashed stumps coppice profusely and should be uprooted with a hoe or mattock. Repeated weeding of the food crops ensures eradication of the very large seed bank that frequently germinate.

Some farmers also use a combination of slashing, burning, and herbicides to suppress the Cestrum seedlings. However, herbicides should be used with caution to avoid environmental and health hazards posed by indiscriminate use of chemicals.

Plate 8: Digging out young Cestrum plants during land preparation in Kapcherop, Cherangany Forest

4.4 Cestrum hedges

Cestrum live fences should be regularly maintained as hedges to avoid seeding. However, Cestrum seedlings should not be raised in any tree nursery. There is need to enhance education efforts that target land users, foresters, extension workers and private nursery practitioners, so that they stop propagation and sale of Cestrum seedlings as well as need for maintainance of Cestrum live fences as paramount.

Plate 9: A bushy Cestrum live fence with flowers and seed source that can invade neighboring farms

Plate 10: A well maintained Cestrum live fence in Kapsowar, Cherangany Forest

4.5 Cestrum on forest roads

Cestrum invasion also occurs in forest roadsides and paths to the extent of completely interfering with traffic safety, aesthetics and visibility. Roadside management of Cestrum involves use of caterpillars and tractors that uproot the trees (by chaining) and deep ploughing the site during road maintenance. Chain pulling involves the use of two or more slow moving caterpillar and tractors to fully sever the tree roots, but this is effective only if there are few large trees.

Plate 11: Cestrum invasion along a forest road (left) and path in Kimothon Forest Block, Mt. Elgon (right)

5.0 POST-MANAGEMENT RESTORATION

Success in forest rehabilitation will greatly depend on management of the restored site. Overall long-term intervention will focus mainly on protection, maintenance and monitoring.

Management interventions for restored sites include:

i) *Protecting rehabilitated sites from human interference and animal damage*

Security of the rehabilitated site should be reviewed and appropriate protection measures put in place in consultation with the forest adjacent communities. It is recommended to use organized community groups in protection but such groups must be adequately sensitized and facilitated to participate in forest protection.

Livestock grazing and browsing by wild animals remains the biggest threat to rehabilitation efforts in all the natural forests. Where necessary, barriers should be erected and maintained to keep out the browsers and grazers including livestock.

ii) *Regular monitoring of restored sites*

Restored sites should be inspected frequently especially during the first and second year following rehabilitation intervention.

Promote, improve and adopt best-practice techniques for monitoring the spread of introduced species within ecosystem or landscape especially sensitive natural areas and other high-risk sites.

Ensure that all management programmes for invasive species are followed by long-term monitoring and evaluation of outcomes, including the expected recovery of native species, ecosystems and other impacted values.

Everyone has a role to play

Cestrum invasion is a problem in our forest and agricultural landscapes. Remind people that **individuals are not powerless -** each citizen can combat Cestrum invasion through their own decisions and behaviour. What plants they choose for their garden, live fences, and how they look after them, how they manage their land - all these are things each person can do responsibly. Convince people of 'the power of one' to set an example: apart from your job battling Cestrum, avoid planting them in your garden or live fences or taking fruit of Cestrum or stems to areas where they are not present!

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Appendix I: Areas invaded by Cestrum in the Cherangany Hills Forest and adjacent farming landscapes

Forest Block	Station	Invaded areas
Kapkanyar Kiptaber	Kapcherop	Forest edges, cattle tracks; foot paths, Forest neighbouring farms, Commercial plantations, degraded riparian and abandoned fallows in Chesai, Kipsero, and Kipsotit, Invading Plantations in compartments 2B, 1L, 1K, 1C, 1H, 1O, 1B 1A and 1G in Kapkutung, and 1C, 1F and 1L in Kipsongoi block
Kaisungur	Cheptongei	Forest edges, cattle tracks; foot paths, abandoned fallows, gaps in forest Spreading into open areas, abandoned fallows in Cheptongei Network of Cestrum hedges on forest neighboring the farms and homes in Kapsomai areas
Kapolet	Kapolet	Degraded areas in the lower Kaibos areas and Phase II Network of Cestrum hedges on the farms in Kiambu area and Phase I
Saiwa National Park	Saiwa	Forest edges, foot paths within the Park and in the bordering farms on the eastern side Spreading very fast towards the riparian areas of River Saiwa
Kitale Township	Ecosystem Conservator	Whole natural and plantations in the Kitale block Common hedge on the eastern side of Kitale town Farms neighboring KALRO Kitale Kitale-Eldoret –Bungoma road junction

Appendix II: Areas invaded by Cestrum in the Mt. Elgon Forest

Forest block	Compartment/village	Forest type
Kimothon and Forest neighbouring community	2N, 2J, 3J, 2A Forest community camp Masaba beat	Eucalyptus plantation Cypress and Pinus plantation Farms invaded unstocked plantation
Kiptogot	1R. 2B, 2A, 2E, 4, 5 Acacia confined to compartments 4 (K, C, H, F and D)	Plantations and Riparain areas
Saboti	1E, 1F, 1C, 3Q Saboti station	Plantation and natural forest
Kaberua	Labot, Oboo, Chepyetich-Ogiek	Plantations Farms Natural forest
Suam	Forest station	Planted and natural forest
Kaboywo	Kaboywo Forest Station Sosio River Chorbatai	Planted and natural forest

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