

## Extinction Risk Assessments at the Species Level: National Red List Status of Endemic Wild Cinnamon Species in Sri Lanka

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**ABSTRACT.** *Cinnamomum* is one of the most important genera among the crop wild relatives in Sri Lanka. Out of the eight *Cinnamomum* species that grow in Sri Lanka, *Cinnamomum verum* is indigenous, *Cinnamomum camphora* is introduced while the other remaining *Cinnamomum* species are endemic to Sri Lanka. The main objectives of this study were to determine the national red list status of the endemic wild cinnamon species and to assess the extinction risk of them. Only the seven endemic wild cinnamon species were included in the study. The study was mainly based on the eco-geographical survey which consisted of the study of the herbarium specimens to collect reliable secondary data and development of potential distribution maps using available data. DIVA-GIS software was used to develop potential maps. Thereafter, high potential areas were identified using the above maps and field visits were made to collect primary data. Collected primary data were analyzed and national red listing criteria were applied. According to the ecogeographical survey, *Cinnamomum dubium* found in wet zone forests was the most common species. Average red listing scoring value (ARLSV) of *Cinnamomum dubium* was 1.375 and was considered as Not Threatened (NT). *Cinnamomum ovalifolium* was distributed only in Nuwara Eliya, Kandy and Badulla districts. ARLSV of this species was 2.25 and national red list status was considered as Indeterminate (I). *Cinnamomum litseaefolium* was limited to Kandy and Matale districts with ARLSV of 3.125 and nationally red listed as Threatened (T). *Cinnamomum rivulorum* was limited only to Sinharaja forest reserve and was a very rare species. ARLSV of this species was 3.5 and nationally red listed as Threatened. *Cinnamomum sinharajaense* was distributed in Sinharaja forest reserve and it was a rare species with 3.625 ARLSV and was considered as Threatened. *Cinnamomum capparucoronde* was limited to the low country wet zone rain forests and was also considered as a rare species. ARLSV of this species was 4 and considered as Highly Threatened (HT). *Cinnamomum citriodorum* was limited from Balangoda to the Haputale region with scattered distribution and ARLSV of this species was 4.5. Therefore, this species was also considered as Highly Threatened. Lack of awareness, habitat destruction, urbanization and unsuitable agriculture practices were the major threats to wild cinnamon.

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## INTRODUCTION

Close relatives of cultivated plants are called Crop Wild Relatives (CWR). N.I. Vavilov a Russian Botanist first realized the importance of crop wild relatives in the early years of the 20<sup>th</sup> century (Vavilov, 1926). In addition, crop wild relatives are essential components of natural ecosystems and agricultural ecosystems. Hence, they are indispensable for maintaining healthy ecosystems (Wijesundara, 2006). Thus, conservation and sustainable uses of them are very important for improving cultivated crops, increasing food security and maintaining ecosystem health.

In Sri Lanka, cinnamon seems to have originated in the central hills where several species of cinnamon occur sporadically in places such as Kandy, Matale, Belihul Oya, Haputale and the Sinharaja forest range (Wijesinghe and Pathirana, 2000). Although cinnamon (*Cinnamomum verum*) cultivation is presently concentrated along the coastal belt stretching from Negombo to Matara, it has also made inroads to the inlands of Kalutara, Ambalangoda, Matara and Ratnapura. The importance of cinnamon in the economy of Sri Lanka since European colonization to post independence era is well documented by Pethiyagoda (2007).

According to the records of the National Herbarium of Sri Lanka, 661 species of crop wild relatives have been identified. Out of these, 122 species are endemic and 159 species are naturalized exotic species. One of the most important genera containing crop wild relatives is the genus *Cinnamomum*. Nine species belonging to the genus *Cinnamomum* were recorded in Sri Lanka (Sritharan, 1984). Among these species seven are endemic. This study was mainly focused on the endemic wild cinnamon species. According to the National Red List of Sri Lanka, published in 2000, *Cinnamomum capparucoronde* and *Cinnamomum litseaefolium* were threatened and *Cinnamomum citriodorum* was highly threatened (IUCN Sri Lanka, 2000). Other species have not been analyzed by IUCN due to lack of information and primary data have not been used for the 2000 IUCN national red listing analysis. Another weakness of the IUCN study in 2000 was some of the assessment methods used do not fit the Sri Lankan conditions. For example, the method used to calculate the Area of Occupancy (AOO) is not relevant to a small country like Sri Lanka. Therefore, National Red Listing assessing criteria used by IUCN in 2000 need to be modified to fit the conditions in Sri Lanka.

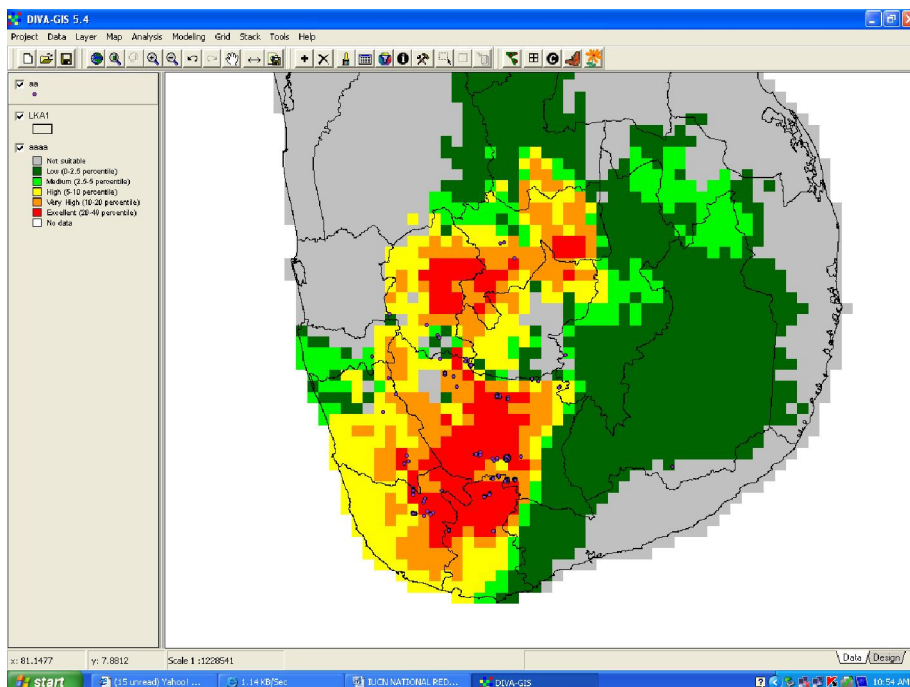
Wild cinnamon species are secondary gene pools of cultivated cinnamon. Therefore conservation of the secondary gene pool is important. Apart from that, most of these wild cinnamon species have been used for medicinal purposes and therefore there is a high ethnobotanical value. However, the information about the current status of endemic wild cinnamon in Sri Lanka is limited. Therefore, all endemic wild cinnamon species were analyzed using primary data collected by a field exploration and from reliable secondary data to determine the national red list status of the endemic wild cinnamon species and to assess their extinction risk.

## MATERIALS AND METHODS

This study was mainly based on an eco-geographical survey which consisted of the study of the herbarium specimens to collect reliable secondary data and development of potential distribution maps using available data. DIVA-GIS software was used to develop potential maps. The high potential areas were identified using the above maps and field visits were

made to collect primary data. Collected primary data were analyzed and national red listing criteria were applied (Guarino, 2005).

During the collection of secondary data for potential map preparation, all *Cinnamomum* specimens available at the National Herbarium were observed and locations, date of collection, name of the collector, morphology and habitat information were recorded. Collected secondary data were transformed into GPS data and were plotted on the map of Sri Lanka by using DIVA-GIS 5.4 software and potential distribution maps for each species were developed (Fig. 1).



**Fig. 1. Potential distribution map**

The prepared potential maps were carefully studied and high potential areas were identified. Field visits were made to the high potential areas and also to the previously recorded locations. During the field visits, visual encounter survey (VES) was carried out. Population data were not collected due to wild cinnamon species being distributed in large areas of the Island and therefore not practically feasible. For the collection of primary data during the field visits, line transects were used to monitor and collect the samples in every forest patch visited.

During each field visit, collection date, GPS readings, morphological characters of plant, ecological condition of surrounding area, altitude, slope, aspect, ethno-botanical uses and main causes of threat were recorded. Furthermore, 2-3 twigs from a representative plant of each location were also collected to prepare herbarium specimens. Ethno-botanical uses and causes of threats were recorded from an interview of villagers/users.

Data were analyzed using IUCN 2000 national red listing criteria (Table 1). For more reliable results, the Area of Occupancy (AOO) was calculated using 2 x 2 km<sup>2</sup> grid map (IUCN, 2008). All the red list criteria values used and relevant red list group are given in Table 2.

Extinction risks were assessed from field observations and Anthropological data. Constant scoring scale was used for assessing the severity of threats. Threats identified for each location, were given a severity scale value and finally a total value was calculated. Threats with the highest severity values were identified as major threats of wild cinnamon. In addition, highly threatened locations were identified from field observations.

**Table 1. Criteria and Scoring System**

<b>CRITERIA</b>	<b>Score of 5</b>	<b>Score of 4</b>	<b>Score of 3</b>	<b>Score of 2</b>	<b>Score of 1</b>	<b>Score of 0</b>
<b>Extent of geographical range and rarity</b>	Very rare; found in one zone	Very rare; found in more than one zone	Rare; found in one zone	Rare; found in more than one zone	Common, but found in one zone	Common and found in more than one zone
<b>Area of Occupancy (km<sup>2</sup>)</b>	≤ 8	09 -20	21 – 40	41 - 120	121 - 200	> 200
<b>Restricted populations</b>	Very restricted	-	-	-	-	-
<b>Habitat status</b> (per cent of habitat under protection)	0 – 25 %	26 - 40 %	41 – 55 %	56 - 65 %	66 - 75 %	> 75%
<b>Intrinsic characters</b>	≥ 10+	9+ to 8+	7+ to 6+	5+ to 4+	3+	≤ 2
<b>Human impact on the habitat</b>	≥ 8+	7+ to 6+	5+ to 4+	3+ to 2+	1+	Recorded as no impact
<b>Recorded human impact on the species</b>	10 points	9 points	8 to 7 points	6 to 5 points	4 to 3 points	2 points
<b>Endemism/global threat status</b>	Endemic		Globally threatened			Others

**Table 2. Cut off point of national red listing criteria average values**

<b>Category</b>	<b>Highly Threatened</b>	<b>Threatened</b>	<b>Indeterminate</b>	<b>Not Threatened</b>
Average Score	≥ 4	3.9 – 3	2.9 – 2	1.9 - 0
Abbreviation	HT	T	I	NT

## RESULTS AND DISCUSSION

Wild cinnamon species were recorded in twelve districts of Sri Lanka. Among these districts wild cinnamon species are commonly found in Ratnapura, Galle, Matara, NuweraEliya, Badulla and Kandy districts (Fig. 2). Endemic wild *Cinnamomum* species were mainly concentrated in and around Sinharaja forest reserve, Enasalwatte-Deniyaya, Kanneliya forest reserve, Walankanda forest reserve, Horton Plains N.P., Gilimale-Erathne proposed reserve, Peak-Wilderness sanctuary, Knuckles conservation area and Haldummulla – Halpe regions. Considerable variations in morphology were observed among these locations. This may probably be due to the diversity in climate among these locations.

*Cinnamomum dubium* has a good survival rate in different areas and it is a common species (Table 3 and Fig. 3). *Cinnamomum ovalifolium* was mainly limited to the up country forest area. Therefore, it is a common species in higher elevations of Sri Lanka (Table 3 and Fig. 4). *Cinnamomum capparu coronde* has a scattered distribution in low country rain forests and it could be considered as a rare species (Table 3 and Fig. 5). *Cinnamomum litseaefolium* was recorded only in Knuckles conservation areas where it is commonly available (Table 3 and Fig. 6). *Cinnamomum sinharajaense* and *Cinnamomum rivulorum* seemed to be very rare species and recorded only in Sinharaja forest reserve (Table 3 and Fig. 7 and 8). *Cinnamomum citriodorum* is only recorded in Balangoda to Haputale regions showing a scattered distribution (Table 3 and Fig. 9).

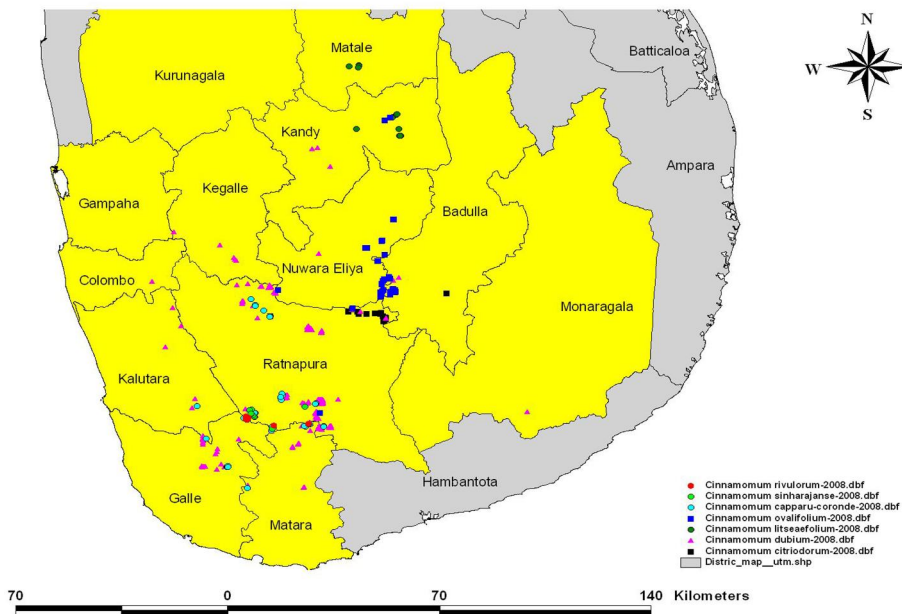


Fig. 2. Wild cinnamon distribution map

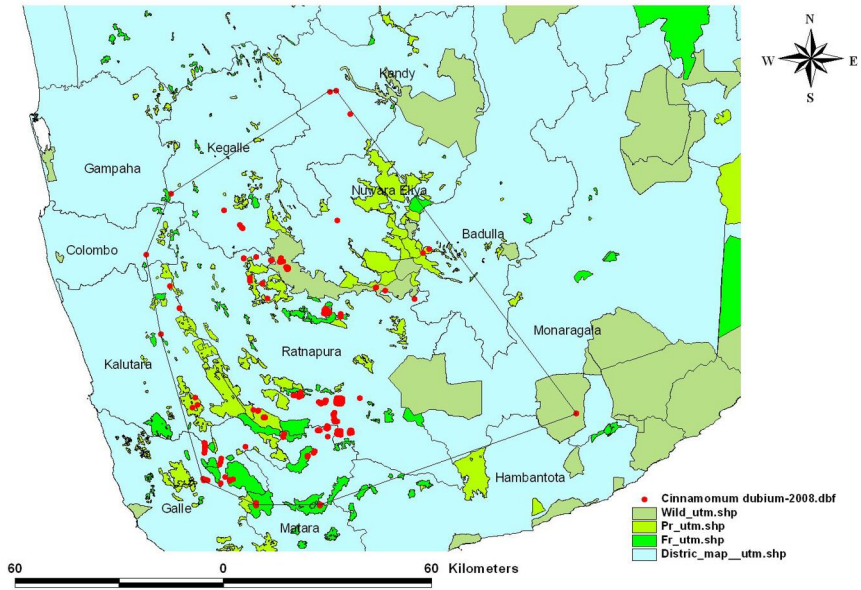


Fig. 3. *Cinnamomum dubium* distribution map with protected areas

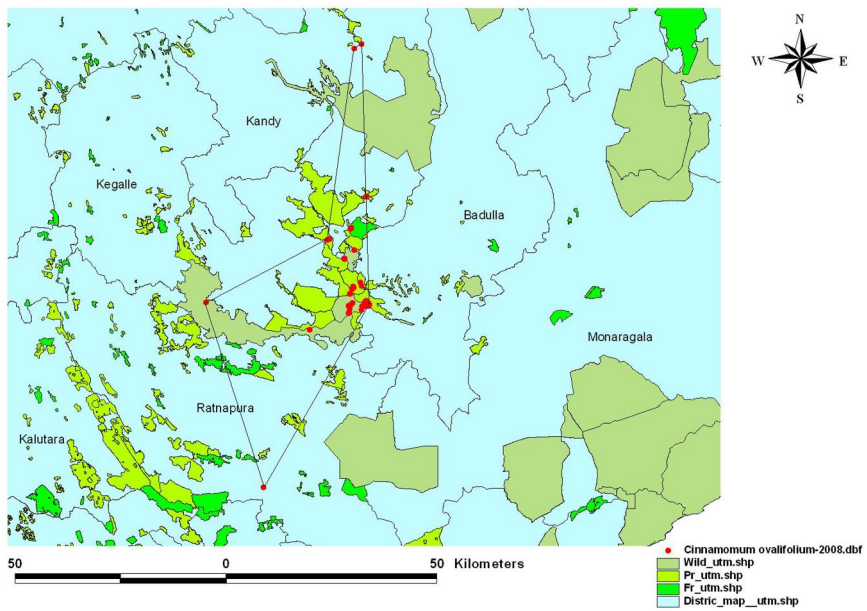


Fig. 4. *Cinnamomum ovalifolium* distribution map with protected areas

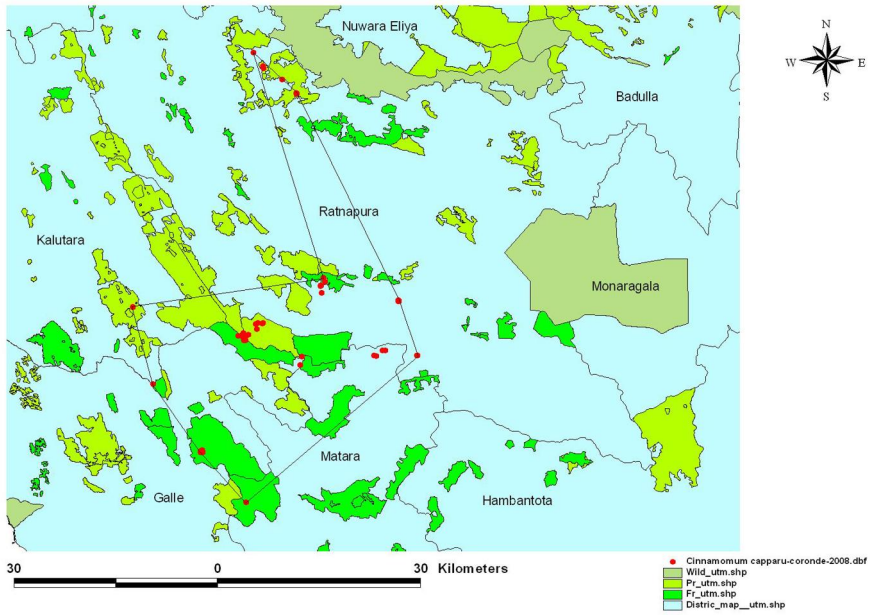


Fig. 5. *Cinnamomum capparucoronde* distribution map with protected areas

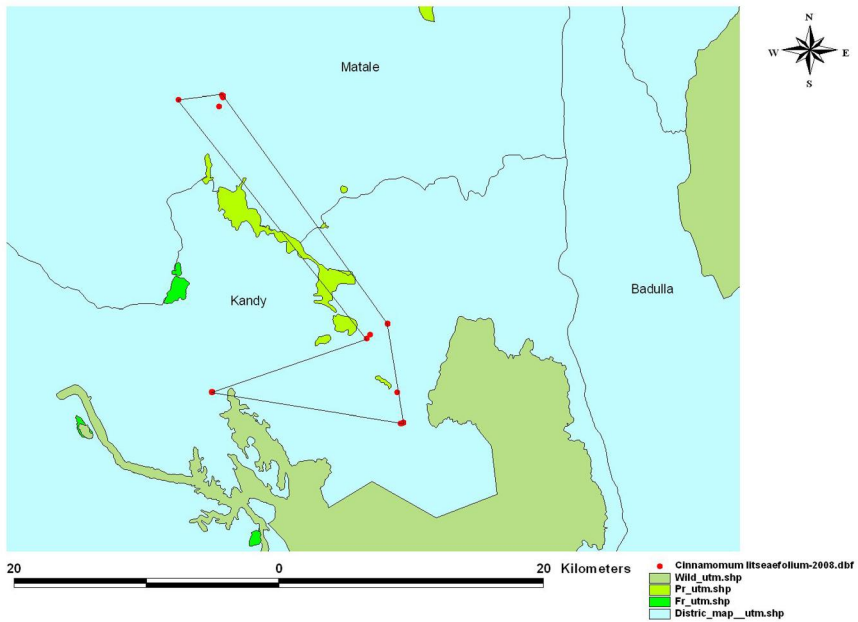


Fig. 6. *Cinnamomum litseaefolium* distribution map with protected areas

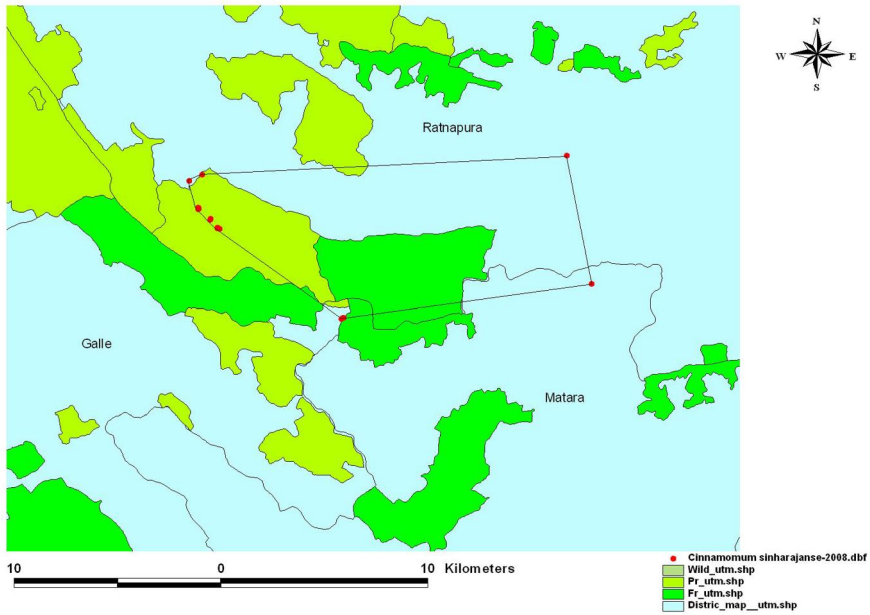


Fig. 7. *Cinnamomum sinharajaense* distribution map with protected areas

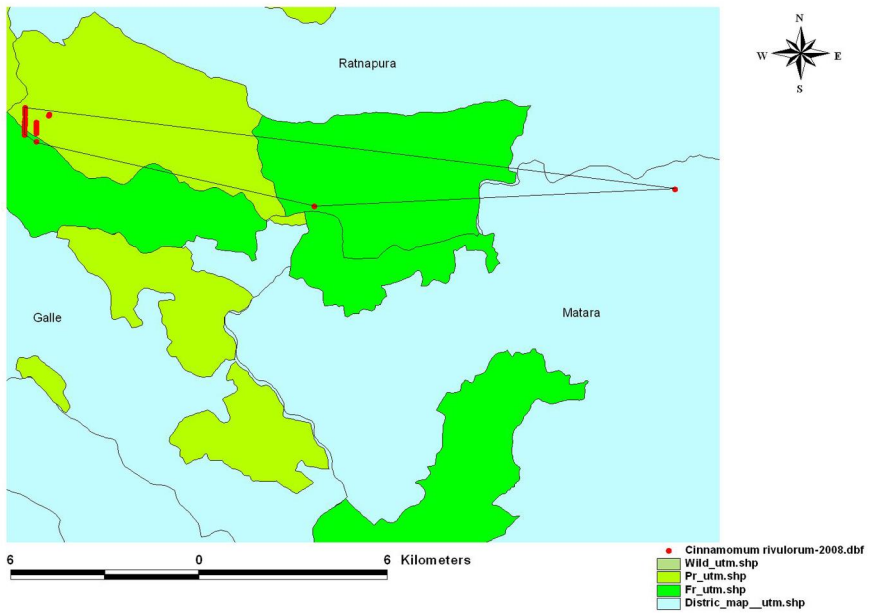


Fig. 8. *Cinnamomum rivulorum* distribution map with protected areas



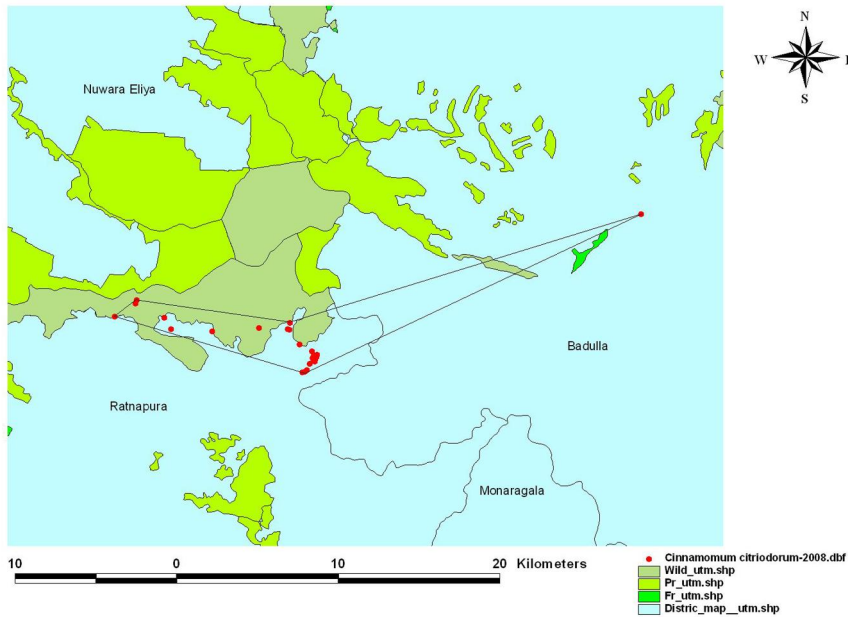


Fig. 9. *Cinnamomum citriodorum* distribution map with protected areas

Table 3. Distribution of endemic wild cinnamon species

Species name	Distribution (Districts /Locations)
<i>Cinnamomum dubium</i>	Galle, Matara, Kalutara, Rathnapura, Kegalle, Colombo, Gampaha, Badulla and Kandy districts
<i>Cinnamomum ovalifolium</i>	Kandaploa-Sita Eliya PR, Hakgala S.N.R., Horton N.P., Peak Wilderness Sanctuary, Kikiliyamana PR and Mahakudugala PR
<i>Cinnamomum capparu-coronde</i>	Sinharaja FR, KDN complex, Gilimale-Erathne PR, Gongala PR, Enasalwatte PR, Walankanda FR, Kalugala PR and Haycocks FR
<i>Cinnamomum litseaefolium</i>	Knuckles Conservation Area
<i>Cinnamomum sinharajaense</i>	Sinharaja FR
<i>Cinnamomum rivulorum</i>	Sinharaja FR
<i>Cinnamomum citriodorum</i>	Halpe, Norwood and Haputale region

Red listing analysis values were calculated according to the national red listing criteria given in Table 4. *Cinnamomum dubium* and *Cinnamomum ovalifoium* showed minimum analysed values. Therefore, these two species have very low threatened level. *Cinnamomum litseaefolium*, *Cinnamomum rivulorum* and *Cinnamomum sinharajaense* show medium values and therefore these species have reached the threatened level. *Cinnamomum capparu coronde* and *Cinnamomum citriodorum* have shown highest values and therefore these two species are in the highly threatened and unprotected category.

**Table 4. Average red listing criteria value**

Species name	Average scoring value	Red list category
<i>Cinnamomum dubium</i>	1.375	Not Threatened (NT)
<i>Cinnamomum ovalifolium</i>	2.250	Indeterminate (I)
<i>Cinnamomum litseaefolium</i>	3.125	Threatened (T)
<i>Cinnamomum rivulorum</i>	3.500	Threatened (T)
<i>Cinnamomum sinharajaense</i>	3.625	Threatened (T)
<i>Cinnamomum capparum-coronde</i>	4.000	Highly Threatened (HT)
<i>Cinnamomum citriodorum</i>	4.500	Highly Threatened (HT)

According to the field observation and *Anthropological* data, lack of awareness, habitat destruction, urbanization and poor agricultural practices were found to be the major threats to the wild cinnamon species. In addition, the following forest patches (habitat locations) were identified as currently unprotected due to above reasons.

1. Sinharaja division – Enasalwatte (Matara district)
2. Ihalakurulugala – Enasalwatte (Matara district)
3. Wavul lena kanda – near Haycock forest reserve (Galle district)
4. Idigastanne - Halpe (Ratnapura district)
5. Tumbatanne - Halpe (Ratnapura district)
6. Donawa Mukalana – Ratganga (Ratnapura district)
7. Great western forest – Radalla (Nuwera Eliya district)
8. Namunukula proposed reserved – (Badulla district)
9. Gilimale Errante proposed reserve – (Ratnapura district)
10. Knuckles conservation areas – Hunnasgiriya – (Kandy district)
11. Walankanda forest reserve – (Ratnapura district)
12. Hadapan Ella proposed reserve (Ratnapura district)

## CONCLUSIONS

*Cinnamomum dubium* is a common species in mature tropical rain forests and in secondary forests, that falls into the Not Threatened (NT) category. It shows a good survival rate under different climatic conditions. *Cinnamomum ovalifolium* falls into the Indeterminate (I) category and considered as a common species in Montane forests in high elevations. *Cinnamomum litseaefolium* is a Threatened (T), rare species and only found in the Knuckles conservation area. Both *Cinnamomum rivulorum* and *Cinnamomum sinharajaense* are Threatened (T) very rare species and only found in the Sinharaja forest reserve. *Cinnamomum capparum-coronde* is a Highly Threatened (HT) rare species, showing scattered distribution and only found in the low country rain forest. *Cinnamomum citriodorum* is a Highly Threatened (HT), rare species and only found in the Belihul oya – Halpe – Haputale region. These species were threatened mainly due to lack of awareness, habitat destruction, urbanization and unsuitable agriculture practices.

*Cinnamomum citriodorum* and *Cinnamomum capparum coronde* should be conserved immediately. In addition, *Cinnamomum rivulorum*, *Cinnamomum sinharanjaense* and *Cinnamomum litseaefolium* are threatened and in the near future these will come into the highly threatened category. Therefore, conservation practices of these species are also needed.

## ACKNOWLEDGEMENT

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