APPENDIX 15 - Management Guidelines for Mature Trees

Management Guidelines for Mature Trees

GREENING, LANDSCAPE AND TREE MANAGEMENT SECTION
DEVELOPMENT BUREAU

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CONTENTS

1.0 Introduction

1.1 Mature trees, in particular those with good health and structure, are important assets to a city. They constitute key natural components of urban ecosystems and contribute to many aspects, including that of environmental improvement, aesthetic enhancement, ecological and biodiversity enrichment, and economic, social and health benefits (Jim and Zhang, 2013). Mature trees are of particular value, and proper care is required to preserve these valuable landscape assets.

1.2 Tree biology is dynamic, changing as a tree ages (Clark, 1983). Mature trees are those being close to maximum height and exhibiting reduced shoot elongation (either as decreased elongation or a reduced number of flushes per year) (Clark and Matheny, 1991). When trees age, they become slower in growth as they approach maximum age, and become more vulnerable to disease, wind and other causes of death (Goff and West, 1975). Understanding the biology of mature trees is thus an integral component for developing proper tree management strategies and programmes.

1.3 The "Management Guidelines for Mature Trees" (Guidelines) serve as a reference for the management departments responsible for regular maintenance of trees with a view to promoting the health and structural stability of mature trees and optimising their longevity. Due to large quantity of trees in the territory, the Guidelines are focusing on mature trees with individual trunk(s) over 750mm DBH (Diameter at Breast Height[1]) growing in areas with intensive use (i.e. Category I zone under tree risk assessment) and Old and Valuable Trees (OVTs). It is necessary for managerial staff to disseminate the message in the Guidelines to staff at frontline and supervisory levels and also contractors and consultants for successful implementation.

2.0 Biological Aspects for Mature Trees

2.1 At maturity, the degree of apical control frequently lessens and a rounded crown results. Mature trees generally possess sound structure, even though inherent structural problems and numerous internal compartments may

[1] The measurement of DBH should follow Nature Conservation Practice Note No. 2 issued by the Agriculture, Fisheries and Conservation Department.

be present. They appear healthy and vigorous and may persist in this condition for long period of time; indeed, for much of their life span (Clark and Matheny, 1991).

2.2 Trees obtain energy through photosynthesis for biological functions. Surplus energy is stored in reserve to overcome periods of stress when energy production cannot meet demand. Young trees have a high photosynthetic area to biomass ratio and generate surplus of energy as reserve which facilitate rapid growth and tolerate change or stress. Mature trees have a lower ratio and most of the energy produced by the leaves is used for maintenance of existing tissues, defence against pests and diseases and reproduction through seeds and fruits but less for growth. The reserve for stored energy in mature trees is minimal when comparing with young plants and their ability to tolerate change or stress is therefore low.

2.3 Urban trees are often confronted with a lot of environmental stresses such as compaction, lack of nutrients, damage by construction and roadwork activities, etc. In the changing environment like Hong Kong, the main predisposing causes of their decline were related to root damage and soil disturbance (Jim, 2005). **Table 1** highlights the patterns of death in landscape trees. The damage on trees is cumulative and irreversible. Trees have to alter their growth patterns and relocate their resources in order to establish the internal balance with the environment. For mature trees, they are in a delicate balance with their environment and exposure to multiple or chronic stress will aggravate the health problem leading to decline due to limited energy reserve. The characteristics of mature and declining trees are listed in **Table 2**. Therefore, it is important to maintain a stable environment around mature trees to prevent or minimise stress and avoid entering the mortality spiral, where a series of sequential events result in death (Clark and Matheny, 1991). Degradation of growth space or disturbance adversely affecting the growing

Structure failure	Branch, crown and stem failure, uprooting, decay, girdling
Environmental degradation	
Acute	Flooding, fire, vandalism, construction injury, drought, high or low temperature
Chronic	Soil toxicity, soil compaction, air pollution, restricted growing space, low fertility, severe pruning
Parasitic invasion	Insect, fungus, bacterium, virus, mycoplasma-like organism, parasitic plant

Table 1 – Patterns of death in landscape trees (Clark and Matheny, 1991)

conditions of mature trees should be avoided as far as practicable.

Character	Mature tree	Declining tree
Shoot elongation -		
extent	normal for species	greatly reduced
pattern	normal for species	single flush only
Crown form	normal - some loss of apical control	stag-headed, dieback
Foliage development	normal	reduced size and density
Foliage retention (evergreens)	normal	poor
Presence of epicormic shoots	generally absent	present
Compartmentalization response	normal for species	reduced
Wound-wood formation	normal for species	inhibited/reduced
Integrity of bark	strong	weak
Susceptibility to parasites	normal for species	increased
Reproductive behaviour	normal, may be cyclic	may produce stress crops
Stress response	normal	reduced
Fall colouration	normal	premature

Table 2 – Characteristics of mature and declining trees (Clark and Matheny, 1991)

2.4 To delay the transition from maturity to decline and death, tree management programmes should be proactive rather than reactive and treatment should be applied preventively to maintain tree health rather than remedial once decline begins (Fraedrich, 1999).

3.0 Management Strategies of Mature Trees

3.1 A stable tree structure can reduce the incident of tree failure. Causing wounds on mature trees will demand tree's extra resource for defence. Wounds are also vulnerable to decay and entry of pathogens which will adversely affect both tree health and structure.

3.2 Site disturbance and unfavourable growing condition will create constraints on resource availability and induce stress on mature trees. These will weaken tree health and make them more susceptible to disease problems. The disease problems will draw mature trees' scarce resource for defence and the result can lead to irreversible tree decline and death. For site disturbance involving excavation or compaction within root zone, it may cause damage to structural roots which will adversely affect tree's stability.

3.3 Mature trees have limited ability to recover from stress and damage, proactive and preventive measures are the critical elements in the formulation of management strategies for mature trees. The goal of arboricultural management should aim at creating a stable crown structure, minimise

detrimental disturbance and to minimise parasite infection so that the onset of decline and the entry into the mortality spiral will be delayed to enhance longevity (Clark and Matheny, 1991). The key practices to enhance longevity are listed in **Table 3**. Based on the biological characteristics of mature trees, the key management strategies are:

- to maintain a stable tree structure by reducing the chance of damage due to tree failure, and
- to promote tree health by minimising stress through the provision of a stable and favourable growing environment.

Promotion of a stable environment	Plant the right plant in the right place Irrigate according to species requirement Maintain existing/adequate drainage Monitor and maintain soil fertility Develop a pest management programme Minimise soil compaction Minimise grade and other soil change
Development of stable structure	Plant material with well-developed structure (root and crown) Develop early crown training programme Prune to natural targets Minimise mechanical injury

Table 3 – Arboricultural practices that enhance longevity (Clark and Matheny, 1991)

4.0 Tree Inspection

4.1 Regular tree inspection is an essential means in proactive tree management to identify changes in tree conditions and site disturbance which may be corrected before irreversible decline occurs. It should be a continuous and long-term monitoring process rather than a one-off exercise. It is recommended that detailed tree inspection for mature trees with individual trunk(s) over 750mm DBH growing in areas within Category I tree risk zone should be conducted at least annually. For OVTs, inspection should be conducted at least at least twice a year to cover changes over wet and dry seasons. Supplementary inspection should also be conducted in situations when the trees require close monitoring due to health or structural problems or after severe inclement weather in order to identify the need for remedial measures.

4.2 A standard report format to record all findings during inspection covering the assessment on tree health and structural conditions as well as site

information is required. The use of "Form 2" under the "*Guidelines for Tree Risk Assessment and Management Arrangement on an Area Basis and on a Tree Basis*" issued by the Greening, Landscape and Tree Management Section, the Development Bureau (GLTMS) for inspection of these large mature trees is recommended. Inspection should be conducted by staff with relevant training, qualification and work experience as specified in the guidelines.

4.3 During inspection of mature trees, particular attention should be drawn to the following aspects for a systematic and thorough checking of tree conditions:

4.3.1 Cross checking with the previous inspection and maintenance records to identify any significant changes requiring attention that should be recorded. For monitoring of major structural defects such as cavities, cracks and decayed or damaged areas developed on mature trees, physical measurement on their dimensions should be conducted, preferably fixed reference points should be set to facilitate long-term monitoring.

Photo 1 - Conduct sounding test by a mallet to assist in estimating the presence of internal decay

4.3.2 Sounding test in trunk and/or accessible scaffold limbs should be performed to assist in identifying the presence of internal decay. If severe decay is suspected, additional assessments such as tomographic and/or resistographic testing should be performed to evaluate more accurately the extent of decay and monitor the change in the remaining sound wood over time.

4.3.3 Root collar inspection should be conducted to identify defects which will adversely affect structural stability. Hand tools, if required, should be used with care to excavate soil to check for suspected decay and damage in tree roots. Sufficient space clear of vegetation at the

base of trees should be maintained as dense vegetation obstructs thorough tree inspection at the lower trunk and root zone. Constant replacements of annuals/seasonal flowers disturb tree roots and create a moist environment which promote decay and therefore should be avoided. For details, please refer to "*Proper Planting Practice – Keep Sufficient Space Clear of Vegetation at the Base of Trees*" promulgated by the GLTMS.

Photo 2 – Maintain sufficient space clear of vegetation at the base of trees

Photo 3 - Dense planting around trunk base should be avoided as it will affect root collar inspection and cause soil disturbance within root zone during horticultural maintenance

4.3.4 For mature trees with tree supporting system installed, the need for adjusting the hardware and stability condition should be checked.

4.3.5 For trees in areas with frequent use and suspected structural defects which may be difficult to inspect at ground level, it is recommended that aerial inspection should be conducted to assess the structural conditions and the need of mitigation measures.

4.3.6 Site disturbances, e.g. cutting of roots, compaction and construction works, etc., should be identified to facilitate assessment of the extent of damage and the need of remedial measures.

4.3.7 The need of soil and/or foliar tests for the mature trees would be necessary to evaluate any fertility/soil problems, especially when there have been changes of site conditions after the construction activities in the vicinity.

5.0 Tree Maintenance

5.1 The maintenance operations should be carried out by trained personnel under supervision in accordance with good arboricultural practices. In line with the management strategies for mature trees, the following paragraphs outline the major tree maintenance operations.

5.2 Arboricultural Practices

5.2.1 Trees growing in urban areas are usually exposed to harsh man-made environment and the adoption of appropriate arboricultural practices, e.g. pruning, irrigation and fertilisation, would ameliorate the growing conditions and reduce stress to facilitate healthy establishment of trees. However, improper arboricultural practices can also induce stress and cause decline in tree health. Knowledge of proper arboricultural practices is important to avoid unnecessary tree damage and promote tree health. An optimal management programme should begin early in the life of the tree for creating a continuum of stability. While the long term programme of tree care are beneficial, the application of arboricultural practices to mature trees that have not had such care represents a change in their environment. As such these arboricultural practices may be a stress on the trees, the tree management personnel has to assess the pros and cons of each practice before application (Clark and Matheny, 1991).

5.2.2 Pruning

5.2.2.1 Pruning is the most common maintenance operation in tree care. Pruning for mature trees are quite different than those used for young trees. Structural pruning for young trees can eliminate many future problems associated with problematic branching and poor branch structure. It is generally more efficient to prune trees early and with small cuts than to delay pruning until trees

Photo 4 - Formation of woundwood over large pruning wound is difficult and it will lead to decay

aged and have serious structural problems (Gilman, 2012). For the general guidance on proper pruning, please refer to "*General Guidelines on Tree Pruning" and "Do's and Don'ts in Pruning*" promulgated by the GLTMS.

5.2.2.2 No trees should be pruned without first establishing clearly defined objectives (Gilman and Bisson, 2007). Pruning of mature trees must be done judiciously. For pruning large and mature trees, the focus should be on ensuring human safety and passage, minimising limb failure and total tree failure near targets and maintaining tree health and vigor. Crown cleaning should be conducted to remove dead, dying, diseased and broken branches and the living tissues should be kept intact in order to maximise the retention of energy producing surface and limit the extent of wounding. For trees suffering from stress or in declining conditions, it is crucial to refrain from removing any live foliage because they need as much sugar-generating capacity as possible (Gilman, 2011).

Photo 5 - Improper pruning caused by excessive removal on inner branches results in over lifting of crowns and lion-tailing.

5.2.2.3 Lion-tailing shifts the centre of gravity higher where wind speed is greater, and creates substantially weakened branches that may break easily in storms or simply under their own weight (Gilman, 2012). This will also hinder the development of proper branch taper and weaken the tree structure. For situations which have justified objectives for selective crown thinning or reduction involving live branches, pruning should be concentrated on branch ends and lion-tailing should be avoided.

5.2.2.4 Removal of too many live branches in a single operation can deplete energy reserve and induce physiological stress on mature trees which should be avoided as far as possible. Extent of live branch removal should be minimised as far as practicable. For old and weak trees,

the pruning percentage of live branches should be reduced. Splitting of pruning works into sessions separated by months or years to reduce the impact on mature trees should also be considered.

5.2.2.5 For the mature trees that suffer from damage due to storms or previous improper pruning treatments, crown restoration should be carried out by sprouts management which involves selective removal, reduction and retention of sprouts for development into permanent branches (Gilman and Partin, 2007). This may require several pruning cycles and years to train the sprouts into new branches to restore the tree structure.

5.2.3 Irrigation

5.2.3.1 Water is essential for plant physiological functions. Over irrigation, however, can encourage root rot infections and cause root suffocation. Water requirements for individual trees vary by species, age and environmental conditions. Maintaining suitable amount of water in soil to avoid moisture stress is crucial for tree growth.

5.2.3.2 In general, mature trees growing in natural setting, such as hillside, have established extensive root system and therefore artificial irrigation may not be necessary. However, in urban areas, water availability in confined planting space is generally limited and as a result irrigation may be required as supplemental water source to promote tree growth and prevent moisture stress during droughts. In such situation, tensiometer or other soil moisture sensors can be used to monitor the soil moisture content and the need of irrigation to facilitate development of watering schedule for mature trees.

Photo 6 - Tensiometer installed in root zone to monitor soil moisture

5.2.3.3 Irrigation, if required, should be applied on root zone for thorough infiltration of water into the soil. Watering at lower trunk or trunk

flare should be avoided as it encourages fungal growth and root collar diseases which will adversely affect the health and stability of mature trees.

5.2.3.4 Irrigation without adequate drainage is equally detrimental to tree health and provision of adequate drainage is essential. Where soil becomes persistently waterlogged due to improper drainage, it should be corrected by installing drainage pipes or trenching with care to reduce root damage.

5.2.4 Fertilisation

5.2.4.1 Nutrients are substances required by plants for growth and metabolic functions. These nutrients are normally present in sufficient quantities in a natural habitat. However, in an urban environment, topsoil rich in organic matters is frequently removed which disrupts the return of nutrients to soil. Imported soil may not have sufficient nutrients and the activity of beneficial soil microorganisms is limited. Fertilisation should be considered for trees growing in urban setting with poor health due to nutrient stress.

5.2.4.2 However, incorrect application of fertilisers may increase susceptibility to pests and diseases and result in tree decline. To determine the need of fertilisation and nutrient problems, soil test and/or foliar analysis should be considered to determine the nutrient deficiency. In selecting a suitable fertiliser, soil pH should also be considered as it will affect availability of nutrients.

5.2.5 Mulching

5.2.5.1 Mulches are materials placed on soil and the use of organic mulches made from plant matters such as wood chips or shredded bark is preferred. Mulching can reduce environmental stress by providing trees with a more

Photo 7 - Provision of a layer of organic mulch in the root zone can improve the rooting environment for trees

moderate root environment to improve root growth. It can improve moisture retention, suppress weed, encourage growth of beneficial soil organisms, relieve soil compaction and release nutrients to soil.

5.2.5.2 For proactive mature tree management, application of mulching in the root zone on flat or gentle area to create a favourable rooting environment is encouraged. The mulched area is recommended to extend over as much of the root system as possible which can be allowed by other site usage requirements. Piling of mulches against trunk base is inappropriate as it will increase the vulnerability of root collar diseases.

5.2.6 Pest and Disease Management

5.2.6.1 Pests are organisms which adversely affect tree health, structure and appearance resulting in damage or nuisance. Examples include insects, ticks, spiders, fungi, bacteria, viruses, snails, rodents, weeds and parasitic vines. Pest problems are usually associated with other primary causes such as environmental or cultural factors. Therefore, accurate diagnosis is fundamental to address pest problems.

5.2.6.2 Parasitic invasion including that of insect, fungus, virus, bacterium, parasitic plant may cause death of a mature tree. Integrated Pest Management (IPM) approach combining both preventive and control tactics through physical, biological, cultural and chemical methods should be employed to minimise adverse impact to plant health.

5.2.6.3 Attention should be drawn to pest, e.g. termite, which may affect structural stability causing tree failure. Prompt treatment to eradicate such pest problem is required and this may involve the use of registered pesticides approved by the Agriculture, Fisheries and Conservation Department (AFCD) in the link: http://www.afcd.gov.hk/english/quarantine/qua_pesticide/qua_pes_pes/qua_pes_pes.html. The application methods for registered pesticides should follow recommendations from the manufacturers.

5.2.6.4 Invasive and parasitic plants such as Mikania (*Mikania micrantha*) and Dodder (*Cuscuta* spp.) should be removed (please refer to the

approaches to control Mikania as recommended by AFCD in the link: https://www.afcd.gov.hk/english/conservation/con_flo/About_Mikania/about_mikania.html#c). Generally, other non-parasitic epiphytic plants growing on trees can be retained unless they cause overloading of tree crowns or excessive moisture leading to decay.

5.2.6.5 *Phellinus noxius* is an aggressive fungal pathogen that causes Brown Root Rot (BRR) disease. It is highly pathogenic and infectious which will cause root decay and may lead to tree collapse. When a tree management department identifies typical signs and symptoms of BRR disease infection, a report for the suspected case should be made promptly to the Tree Management Office of the GLTMS. As BRR disease may spread to adjacent plants, special care and treatment on trees infected with BRR disease should be undertaken in accordance with "*Guidelines on Brown Root Rot Disease*" issued by the GLTMS.

5.2.7 Aerial Roots Management

5.2.7.1 Chinese banyan (*Ficus microcarpa*) is one of the most common mature tree species found in Hong Kong. They have the ability to develop an extensive aerial root system to capture water and nutrients from the surroundings to become lignified that give support to the tree.

Photo 8 - Installation of guiding tubes to facilitate development of lignified aerial roots to the ground for additional supports

5.2.7.2 One of the best management treatments for the mature banyan is to make use of this growing characteristic to improve stability of the trees. For details of various treatments of aerial roots to improve the structural stability, please refer to the "*Management Guidelines for Stonewall Trees*" issued by the GLTMS.

5.3 Mitigation Measures

5.3.1 It is not uncommon for mature trees to have health and structural

defects due to aging as well as impacts from the natural and man-made environment. As mature trees have limited ability to recover when declining, timely mitigation measures would be necessary.

5.3.2 Continuous monitoring is also required to determine the effectiveness of the remedial measures and the need for additional or alternative treatments. The following paragraphs outline the key remedial measures applicable for mature trees.

5.3.3 Minimise Compaction and Grade Changes

5.3.3.1 Prevention against damage to trees is the best mitigation measure. It is important to protect the growing space both above and below ground from degradation. Soil compaction and grade change around the tree should be minimised in order to protect the root zone. To balance the need of development and the preservation of trees, adequate tree protection measures should be implemented to prevent tree damage, particularly before and during construction activities. These include the provision of Tree Protection Zone (TPZ) and erection of a robust protection fence to protect from disturbance, at the onset of construction. It is important to note that the planning for proper tree protection starts early in the initial planning and design stage and implements through detailed documentation process and subsequently through careful supervision during construction. The requirements of TPZ are detailed in ETWB TC(W) No. 29/2004 '*Registration of Old and Valuable Trees, and Guidelines for the Preservation*' and DEVB TC(W) No. 10/2013 '*Tree Preservation*' and '*Management Guidelines for Stonewall Trees*'.

Photo 9 - Excavation within tree protection zone will cause significant damage to root system

5.3.3.2 Construction traffic within TPZ should be avoided by careful site planning for alternatives. For temporary traffic within TPZ which cannot be avoided, adequate protection against compaction should be provided e.g. use of plywood sheet over thick mulching on top of soil to reduce localised compaction.

5.3.3.3 Grade changes within TPZ should be avoided by proper site planning and design. Open trenching and excavation within TPZ should be avoided. Alignment of underground utility should be diverted away from TPZ. Alternative construction methods, e.g. micro-tunnelling underneath root zone, should be proactively considered wherever applicable to minimise the impact if adjustment of the alignment is not practical. Further information on "*Tree Protection Measures*" and "*Tree Care during Construction*" etc. are available in the http://www.trees.gov.hk.

5.3.3.4 Sufficient space for tree growth is necessary for the long term health and stability of trees. Growing trees in open soil and planting area should be given priority instead of in a tree pit, where space is available. For situations where tree pits are necessary, they should be large enough to support the long term growth of trees. Adjacent paving design is also important for providing a desirable environment for tree growth, keeping the tree in good health condition, and avoiding future maintenance problems. In general, a tree should not be surrounded by concrete around the root collar, and sufficient space should be allowed at the base of trees. Permeable paving which allows penetration of air and water in general is recommended. Please refer to the "Guideline on Pavement Renovation Works and Tree Stability" issued by the GLTMS for more information.

5.3.4 Tree Support Systems

5.3.4.1 Tree support systems involve the installation of hardware in trees to offer supplemental supports by limiting the movement of limbs or trunks, providing additional supports for trees. A properly installed tree support system can reduce the risk of tree failure and extend the lifespan of a tree.

5.3.4.2 For large mature trees, the combination of pruning operations and installation of tree support systems may mitigate the risk of failure. The contact points between the supporting system and tree parts should be designed to minimise damage to the bark.

5.3.5 Soil Improvement

Photo 10 - Improvement by enlargement of planting area around a mature tree has been carried out at the above site

5.3.5.1 Soil compaction is one of the most common problems accountable for the decline of urban mature trees. Compacted soil imposes physical resistance to root growth, reduces soil oxygen level and inhibits water retention which are detrimental to root growth. Similar to other stresses, it is easier to avoid compaction with proper design and protection during construction than to correct it after occurrence.

5.3.5.2 Increasing the area of permeable surface and proper soil cultivation can help to enhance water and air movement to the roots and alleviate stress induced by compaction. For mature trees growing in confined pits or planters surrounded with concrete paving or structures, consideration can be given to enlarge the planting areas to improve growing conditions. In carrying out the improvement works, precautionary measures should follow the "*Guideline on Pavement Renovation Works and Tree Stability*" issued by the GLTMS.

5.3.5.3 Soil cultivation is a measure that can mitigate the impact of compacted soil. This can be done manually by hand tools to increase pore spaces. Other methods include the use of equipment such as air spade.

5.3.6 Decay and Cavity Treatments

5.3.6.1 Most mature trees grow in association with some degrees of decay and wounds. Application of wound dressing is not recommended as it cannot facilitate wound closure and may encourage accumulation of

moisture which will cause decay. Exposed wood should preferably be left untreated, particularly if it is stable and in good condition. Partial removal of decayed wood may be beneficial to minimise food source for development of wood-rotting fungi.

5.3.6.2 The best remedial measure is to improve the growing conditions for mature trees to encourage woundwood and new wood formation to compensate for the weakened structure due to decay.

5.3.7 Tree Removal

5.3.7.1 Tree removal should be the last resort when there is no practical alternative to cure the tree or to reduce the risk of tree failure to an acceptable level. When a tree poses imminent danger to life and property, felling the tree should be carried out in a timely manner to address public safety.

5.3.7.2 Since old trees have cultural and emotional attachment to the community, communication with the public to explain the tree conditions and measures adopted before removal would be desirable. This can address the public concerns and provide an opportunity to present the tree problems from the professional side so that a mutual understanding on the required tree works can be achieved.

5.3.7.3 If tree removal is considered appropriate, replacement planting of suitable species to suit the site conditions should be considered to restore the greenery. The procedure for tree removal should follow '*Development Bureau Technical Circular (Works) No. 10/2013 – Tree Preservation*'. For removal of OVTs, the procedure in ETWB TC(W) No. 29/2004 '*Registration of Old and Valuable Trees, and Guidelines for the Preservation*' should be followed.

6.0 Record and Monitoring

6.1 The maintenance records should be properly documented. The reports for maintenance operations should contain information such as date of operation, party and/or person responsible for maintenance works, relevant tree information, operation details (e.g. dosage and materials), photographic records

showing the trees before and after treatment, preferably from the same view angle.

6.2 The inspection and maintenance records are essential to facilitate monitoring of tree condition, determining the effectiveness of treatment and formulating alternative follow up measures. For trees requiring continuous monitoring due to health or structural concern, they should be uploaded to the Tree Register in order to facilitate community-wide surveillance.

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