FAO / APFNet Workshop Promoting the Role of Natural Regeneration in large-scale FLR 19th-21st June

Implications of species biology and landscape characteristics on regeneration success and establishment of diverse, resilient ecosystems

Riina Jalonen, Bandara Ariyaratna, Enrique Tolentino jr., Suwan Tangmitcharoen, Zheng Yongqi and **Chris Kettle***

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APFORGEN ASIA PACIFIC FOREST GENETIC RESOURCES PROGRAMME

Resilient Forest landscapes?

Must provide multiple benefits for Society

The change a system can undergo before crossing a threshold to an alternative stability regime

Drivers of Tree Recruitment Failure

Limited Seed dispersal




We still have a poor knowledge of realised seed dispersal in tropical trees likely to be insufficient for recolonization in fragmented habitat

Drivers of Tree Recruitment Failure

MONGABAY

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Trees need a little help to reclaim deforested land, study finds

13 February 2017

Researchers have found evidence that suggests even highly mobile birds like hornbills do not ensure successful movement of seeds between isolated forest fragments, making it extremely unlikely that trees can re-colonize degraded forest patches without help.

- *Scientists with the Swiss university ETH Zurich used forens*
- *dispersal and seedling establishment rarely occured more t*
- *seed tree in their 216-square-kilometer (about 83-square-mi*
- *landscape in India's Western Ghats.*
- *The scientists say theirs is the first large-scale, direct estim*
- *high-value timber tree — in this case, Dysoxylum malabaricu*
- *Endangered on the IUCN Red List.*
- *That means that many tropical tree species that are import*

THE HINDU

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KARNATAKA

Broken up by man, killed by inbreeding

Mohit M Rao

BENGALURU, APRIL 03, 2017 23:46 IST
UPDATED: APRIL 04, 2017 08:24 IST

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Drivers of Tree Recruitment Failure

Limited seed dispersal, so planting trees back in to forest is going to be essential for some species and to maintain diversity

Ismail *et al.* 2017

Dysoxylum malabaricum (Meliaceae)

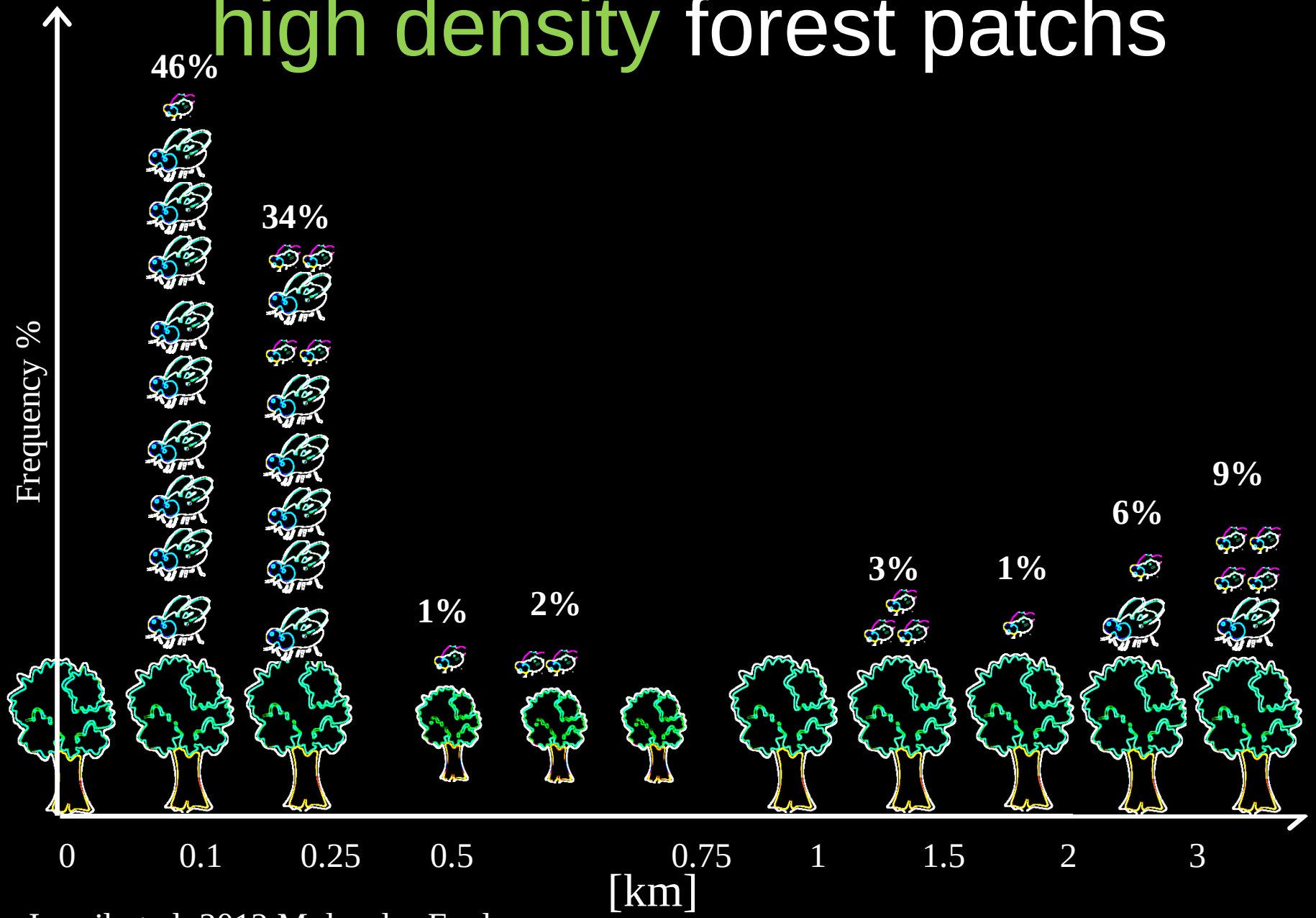
Average 47m to 95m (median 20m to 77m)
94% to 98% dispersed less than 200 m

Pollen dispersal in a forest mosaic

216 km^2

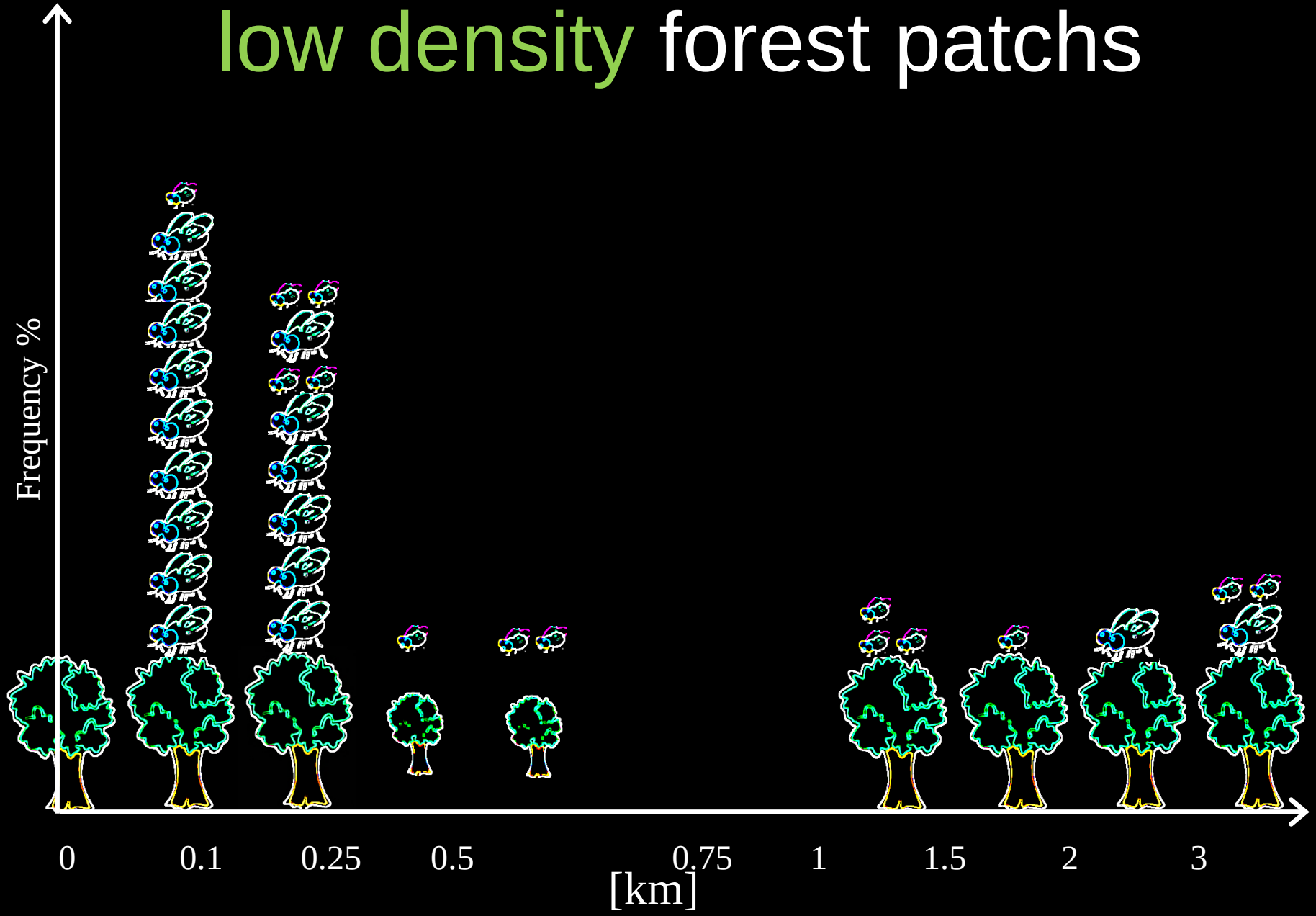
Dysoxylum malabaricum

high density forest patchs



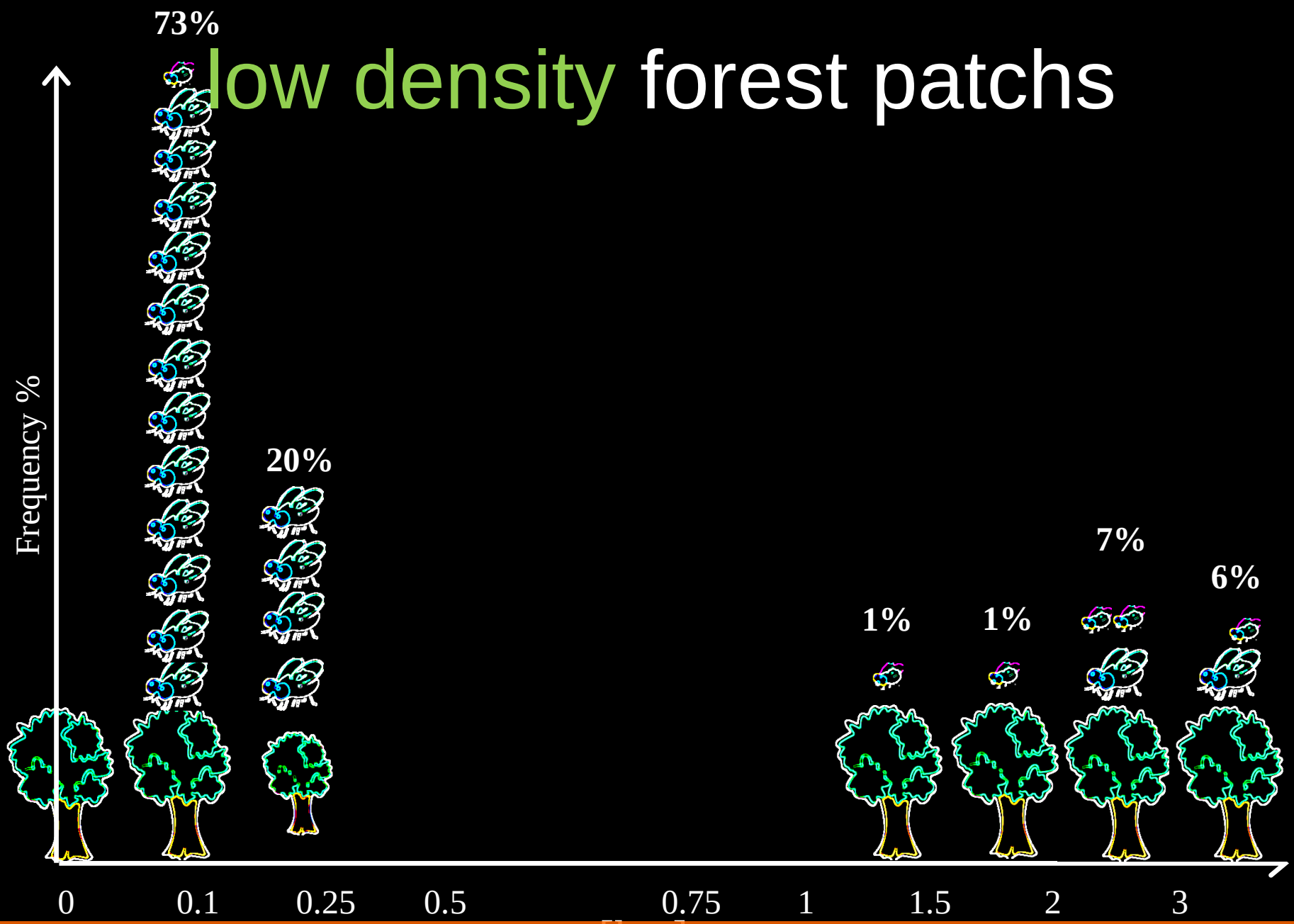
Ismail et al. 2012 Molecular Ecology

low density forest patchs



Ismail et al. 2012 Molecular Ecology

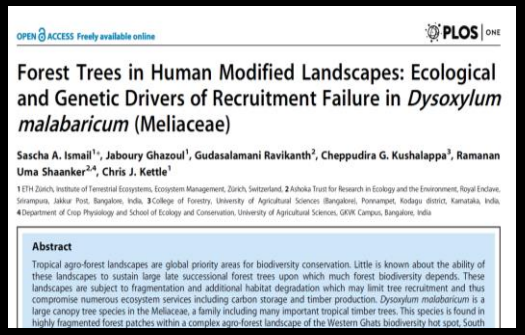
low density forest patchs



More short distance pollen dispersal at low densities

Drivers of Tree Recruitment Failure

Mating between related individuals = poorer performance



OPEN ACCESS Freely available online PLOS ONE

Forest Trees in Human Modified Landscapes: Ecological and Genetic Drivers of Recruitment Failure in *Dysoxylum malabaricum* (Meliaceae)

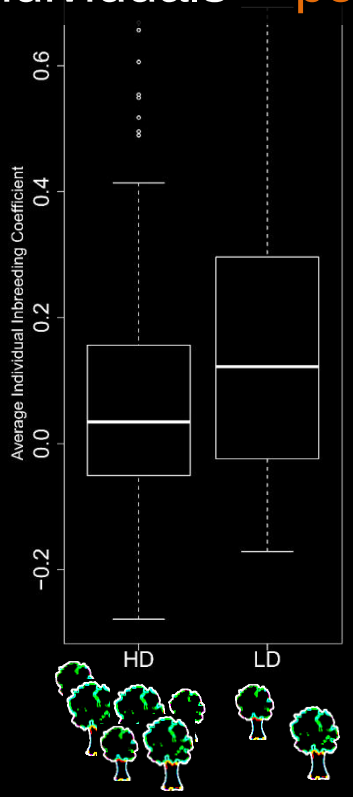
Sascha A. Ismail[1]*, Jaboury Ghazoul[1], Gudasalamani Ravikanth[2], Cheppudira G. Kushalappa[3], Ramanan Uma Shaanker[2,4], Chris J. Kettle[1]

1 ETH Zürich, Institute of Terrestrial Ecosystems, Ecosystem Management, Zürich, Switzerland, 2 Ashoka Trust for Research in Ecology and the Environment, Royal Enclave, Srirampura, Jakkur Post, Bangalore, India, 3 College of Forestry, University of Agricultural Sciences (Bangalore), Ponnampet, Kodagu district, Karnataka, India, 4 Department of Crop Physiology and School of Ecology and Conservation, University of Agricultural Sciences, GKVK Campus, Bangalore, India

Abstract

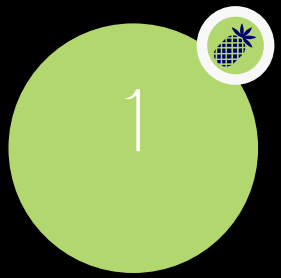
Tropical agro-forest landscapes are global priority areas for biodiversity conservation. Little is known about the ability of these landscapes to sustain large late successional forest trees upon which much forest biodiversity depends. These landscapes are subject to fragmentation and additional habitat degradation which may limit tree recruitment and thus compromise numerous ecosystem services including carbon storage and timber production. *Dysoxylum malabaricum* is a large canopy tree species in the Meliaceae, a family including many important tropical timber trees. This species is found in highly fragmented forest patches within a complex agro-forest landscape of the Western Ghats biodiversity hot spot, South

Dysoxylum malabaricum (Meliaceae)



Ismail et al. 2012 Molecular Ecology and Ismail *et al, 2014* PloS One

Why Forest Genetic Resources (FGRs) can't be taken for granted in restoration?



The difficulty for restoration practitioners to assess.

(Anna Bucharova , 2017)

The rapidly changing environment.

(Alfaro et al. 2014).

Reduced availability of seed sources

(Vranckx et al. 2012)

Seed sources are often fragmented or degraded

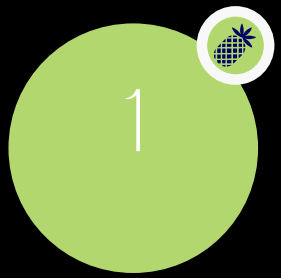
(Jalonen et al. in prep)

Inadequate seed selection or supply

(Broadhurst et al. 2006; Li et al. 2012; Sanchez et al. 2008)

Share 96.9% of DNA

Why Forest Genetic Resources (FGRs) can't be taken for granted in restoration?



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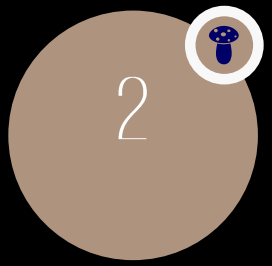
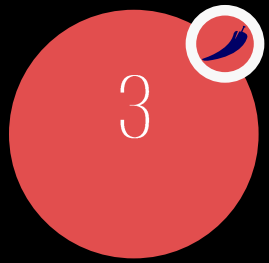


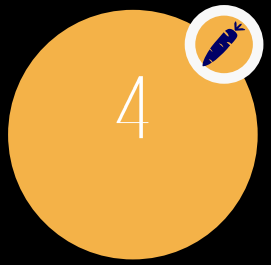
The rapidly changing environment.

(Alfaro et al. 2014).



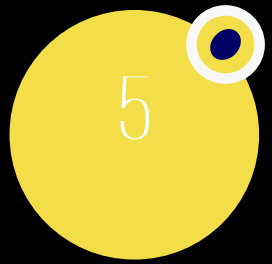
Reduced availability of seed sources

(Vranckx et al. 2012)



Seed sources are often fragmented or degraded

(Jalonen et al. in prep)



Inadequate seed selection or supply

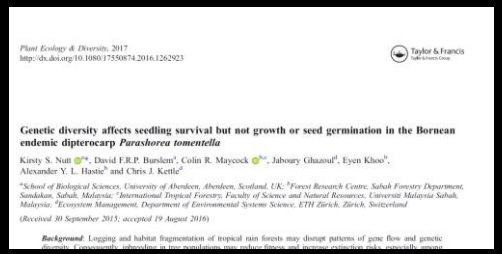
(Broadhurst et al. 2006; Li et al. 2012; Sanchez et al. 2008)

Forest giants of Borneo

The Dipterocarpaceae

Kettle *et al.* 2012, Biotropica, Vol 44 Issue 5

Evidence for effects of genetic diversity on fitness



Plant Ecology & Diversity, 2017
http://dx.doi.org/10.1080/17550874.2016.1262923

Taylor & Francis

Genetic diversity affects seedling survival but not growth or seed germination in the Bornean endemic dipterocarp *Parashorea tomentella*

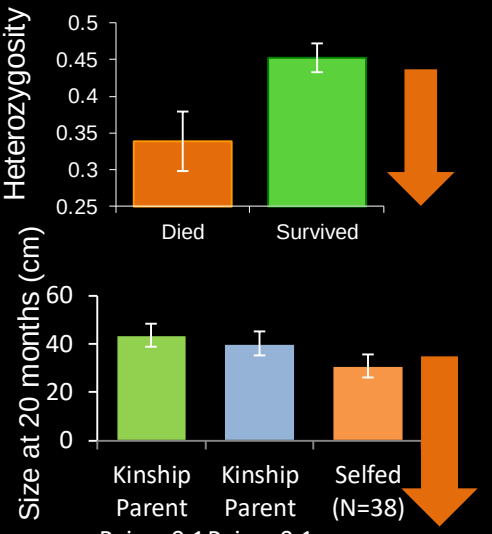
Kirsty S. Nutt[a]*, David F.R.P. Burslem[a], Colin R. Maycock[b,c], Jaboury Ghazoul[d], Eyen Khoo[b], Alexander Y. L. Hastie[b] and Chris J. Kettle[e]

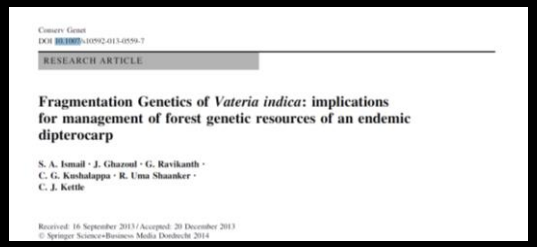
[a]School of Biological Sciences, University of Aberdeen, Aberdeen, Scotland, UK; [b]Forest Research Centre, Sabah Forestry Department, Sandakan, Sabah, Malaysia; [c]International Tropical Forestry, Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Malaysia; [d]Ecosystem Management, Department of Environmental Systems Science, ETH Zürich, Zürich, Switzerland

(Received 30 September 2015; accepted 19 August 2016)

Background: Logging and habitat fragmentation of tropical rain forests may disrupt patterns of gene flow and genetic

Nutt et al., 2017 *Parashorea tomentella*





Conserv Genet
DOI 10.1007/s10592-013-0559-7

RESEARCH ARTICLE

Fragmentation Genetics of *Vateria indica*: implications for management of forest genetic resources of an endemic dipterocarp

S. A. Ismail · J. Ghazoul · G. Ravikanth · C. G. Kushalappa · R. Uma Shaanker · C. J. Kettle

Received: 16 September 2013 / Accepted: 20 December 2013
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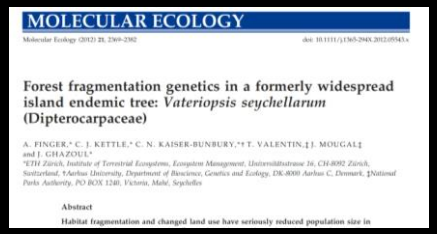
Ismail et al., (*2014*) *Vateria indica*



MOLECULAR ECOLOGY

Molecular Ecology (2012) **21**, 2369–2382 doi: 10.1111/j.1365-294X.2012.05543.x

Forest fragmentation genetics in a formerly widespread island endemic tree: *Vateriopsis seychellarum* (Dipterocarpaceae)

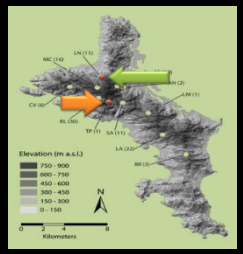
A. FINGER,* C. J. KETTLE,* C. N. KAISER-BUNBURY,*† T. VALENTIN,‡ J. MOUGAL‡ and J. GHAZOUL*

*ETH Zürich, Institute of Terrestrial Ecosystems, Ecosystem Management, Universitätstrasse 16, CH-8092 Zürich, Switzerland, †Aarhus University, Department of Bioscience, Genetics and Ecology, DK-8000 Aarhus C, Denmark, ‡National Parks Authority, PO BOX 1240, Victoria, Mahé, Seychelles

Abstract

Habitat fragmentation and changed land use have seriously reduced population size in

Finger et al., (*2012*) *Vateriopsis seychellarum*



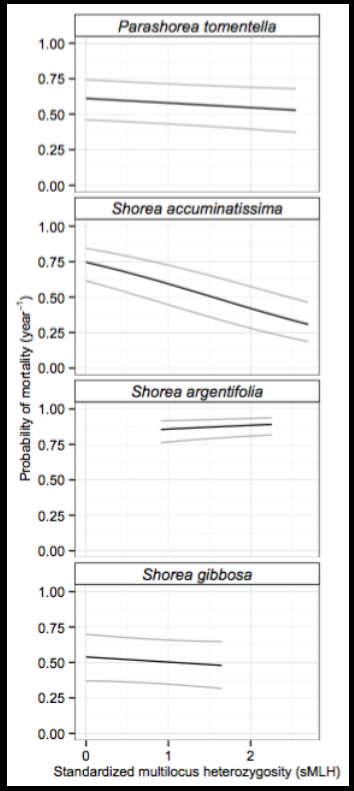
?

Does Genetic diversity influence growth and survival of seedlings?

- N= 1600 seedlings, 4 spp
- Growth and survival measurements over 3 years

Tito de Morais et al submitted (J of Ecology)

Does Genetic diversity influence survival of seedlings?



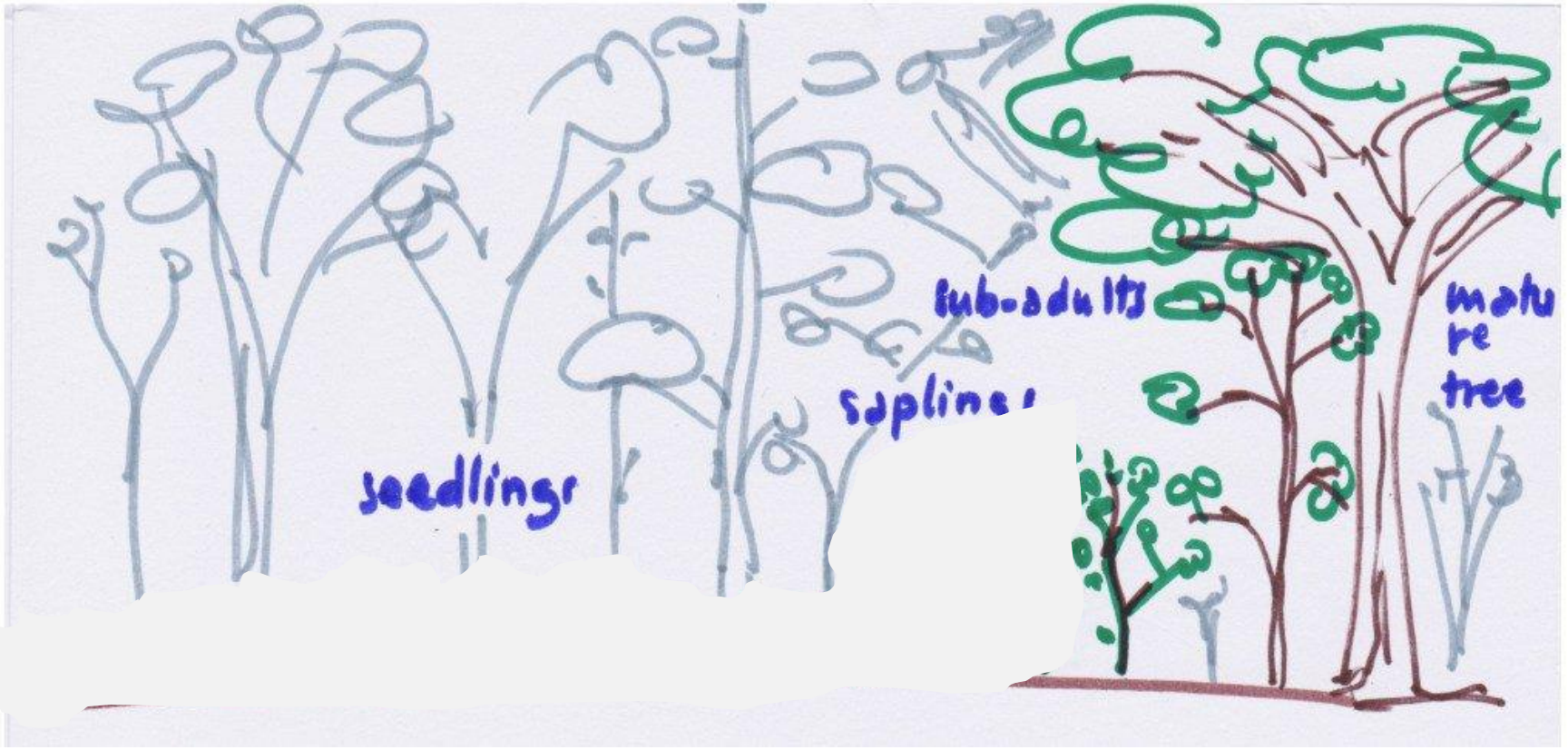
Genetic diversity → Mortality

In three species: more genetically diverse seedlings survive better

***Shorea argentifolia*: less genetically diverse seedlings survive better**

Tito de Morais et al submitted (J of Ecology)

Large numbers of seedlings do **not =** high genetic diversity



Natural selection important driver of seedling mortality

What Can Restoration Practitioners do?

- Improving connectivity of degraded/logged forest through enrichment planting
- Ensure seed collections from large populations (50 seed trees)
- Match source and recipient site
- Monitoring seed collection and performance

Enhancing capacity for seed collection and tracking FGR

What can Forestry officials and policy-makers do?

- Develop and implement climate smart seed zones
- Build capacity for adaptive management of FGRs
- Develop decision support tools for priority species and areas where NR will be possible and where not
- Conserve populations as important seed sources



Conclusions

- If we fail to consider genetic diversity, we will not achieve resilient forest landscapes restoration
- Many previous restoration efforts appear to have failed to consider FGRs
- This may be a significant driver of failure
- There are simple ways to integrate FGRs better in to restoration and to promote NR of resilient Forest landscapes

Some Guiding questions

- What has made some restoration successful from an ecological or technical perspective? Can they be scaled out; why/why not/how?
- What ecological criteria are needed to identify areas where natural regeneration is a suitable tool for forest restoration?
- What are priorities for further research and technical developments to help use of natural regeneration as a restoration method?
- How can regional collaboration help implement these priorities?

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APFORGEN ASIA PACIFIC FOREST GENETIC RESOURCES PROGRAMME

The Dipterocarpaceae

Kettle et al 2010 Science

Kettle et al 2011 Conservation Letters

Kettle et al 2011 Science

Kettle 2012

- Mast fruiting
- Recalcitrant
- Limited dispersal