Trees in the City? Past, Present and Future

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Consequences of urbanisation

By concentrating humans and the resources they consume, metropolitan areas alter:

- soil drainage,
- water flow
- light availability.

Furthermore they concentrate:

- waste
- energy demand

http://www.esf.edu/es/mhall/EST220_lectures/urbeco2_2007.ppt.

The Dilemma……

Grey cities or……….

Green cities?


GO GREEN
Reduce
Reuse
Recycle
Rebuy

Green cities need trees

Being green means not just to act "green", but also to build sustainable cities where trees have a primary role

We need to shift from the reactive policy to a proactive policy

Research projects start with a puzzle or question

Main issues in the field of AUF

1. Tree and climate change (physiology, new ecotypes selection)*
2. Trees and infrastructures (infrastructures and trees) *
3. Trees and pollution (pollution and trees) *
4. Trees and parasites
5. Trees renewal (see point 9)
6. Veteran tree management
7. Tree biomechanics
8. Exploring new tools (i.e. for studying root system underneath the pavements)
9. Tree “integralism”
10. “Green communication”

How trees will react to climate change????

Questions on plant material selection in a global change scenario

- Which species are more suitable to face the global change?
- Which species should be planted to maximize CO_2 sequestration and storage?
- Can the natural tolerance of some species increased using sustainable management techniques
- Native or exotic?

What are the main effects of climate change and which are the impacts on trees?

Climate change

cause	effect	impact
Higher mean temperature	Longer growing season	Shift in plant distribution
	Advanced bud-burst	Late frost damage
	Higher pest survival rates	Higher incidence of pest
	More smog days	Damages to leaves
Higher extreme events frequency	Heat waves	Heat stress on trees
	Drought	Drought stress on trees
	Increase of rainfall intensity	Increase flooding, erosion, runoff

From Bindi, Ferrini and Moriondo, 2009

Research at DiSPAA

Research Unit CLimate chAnge SyStem and Ecosystem (CLASSE) - University of Florence, Florence, Italy

WaVe (Water & Vegetation) Research Unit, Università degli Studi di Firenze, Florence, Italy

Research group:

Massimiliano Tattini, Senior researcher National Research Council of Italy

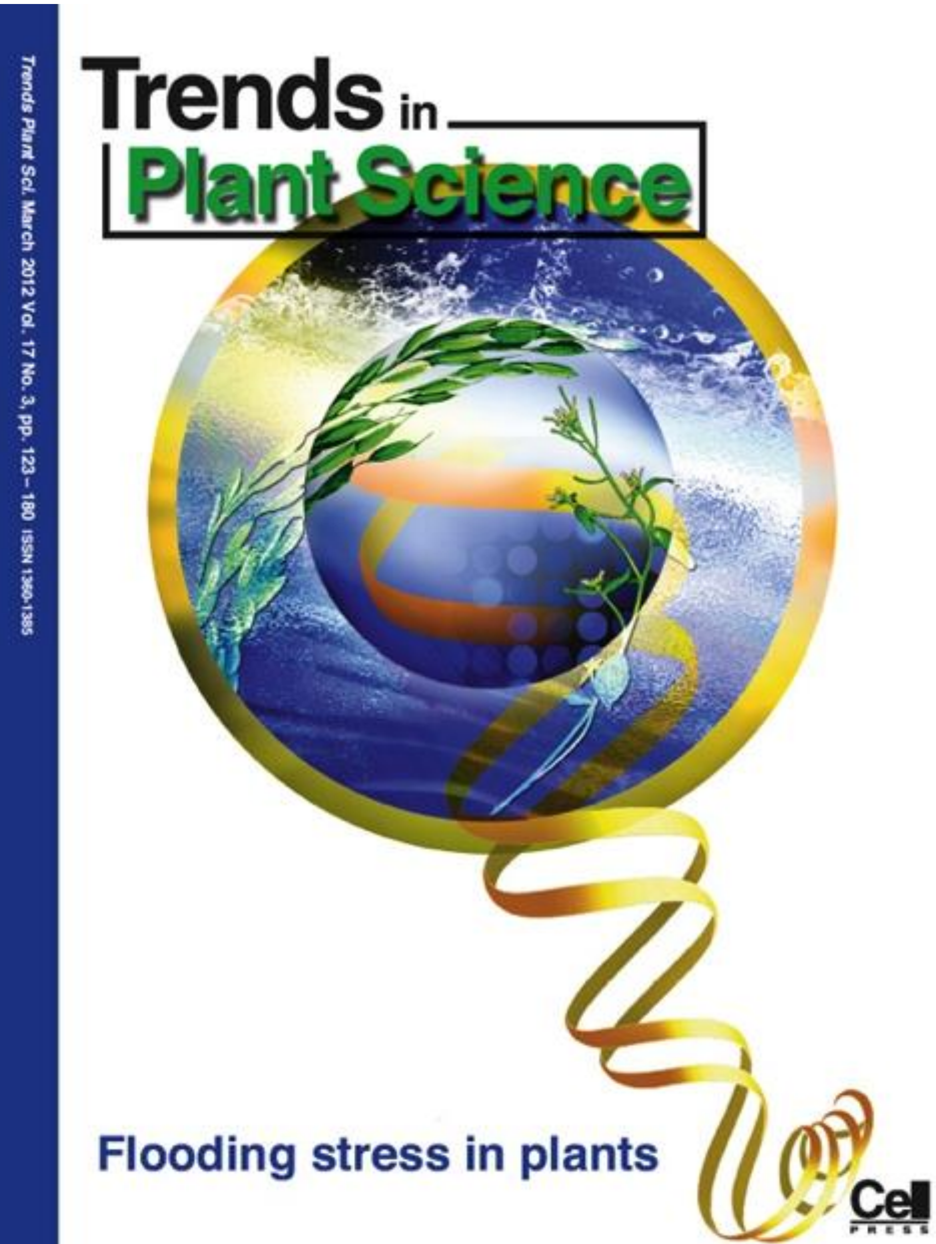
Alessio Fini , PhD researcher

Cecilia Brunetti, PhD Student

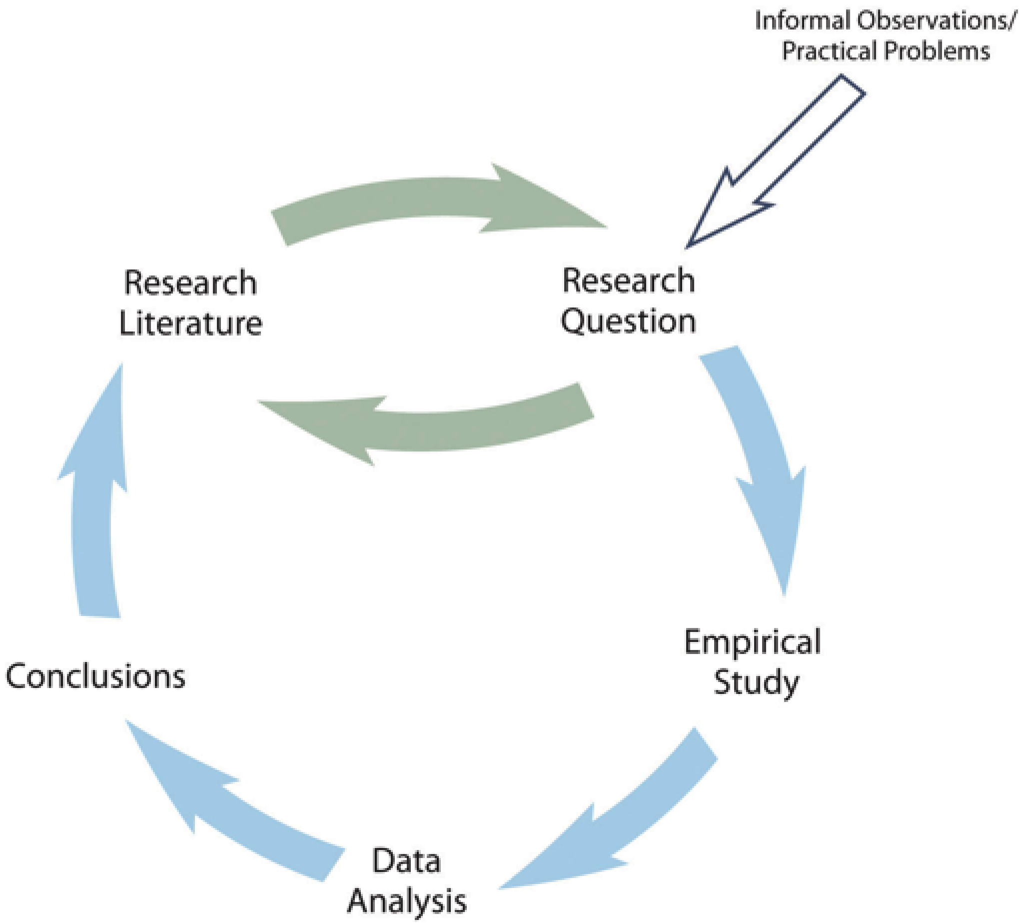
Antonella Gori, Phd Student

Martina Di Ferdinando, PostDoc

Hot topics in tree research



Philosophy: Simple research, deep investigation



Thermal desorber for gas chromatography
TurboMatrix 100 TD

The TurboMatrix 100 TD from Perkin-Elmer offers notable optimal analytical performance in a single tube, model pneumatics model. This employs simultaneous TD and GC operations to improve throughput and increase productivity with fast startup times. Also, the unit comes with an automatic leak detection system that prevents extensive error damage.

The Biodome experiment (DISPAA - Firenze)

1 – Present - Rural Environment (2012) - Tday = Xd; Tnight = Xn [CO_2] = 380 ppm.
2 - Future - Urban Environment (2050) - Tday = Xd + 4 °C; Tnight = Xn + 8 °C [CO_2] = 450 ppm.
Xd = average monthly temperature, measured at daytime in the rural environment; Xn = average monthly temperature, measured at night-time in the rural environment.

Tree species for the city of tomorrow

Quercus pubescens

Quercus cerris

Quercus ilex

(Photo courtesy Morales, 2014, in press)

Response mechanisms to multiple environmental stressors in Mediterranean woody species (*Phyillirea, Ligustrum, Olea, Fraxinus*) and on in some native shade tree species (*Platanus, Quercus, Celtis*), in cooperation with UNIPI e IPSP-CNR

How various mechanisms actually integrate to support acclimation to unfavorable conditions (cross-tolerance)

Special emphasis to the functional role of secondary metabolites, particularly flavonoids in countering stress-induced oxidative damage


Answers needed for present and
future plant selection

Adaptive strategies for urban design

Plasticity: how species are adaptable to a wide range of environmental conditions?

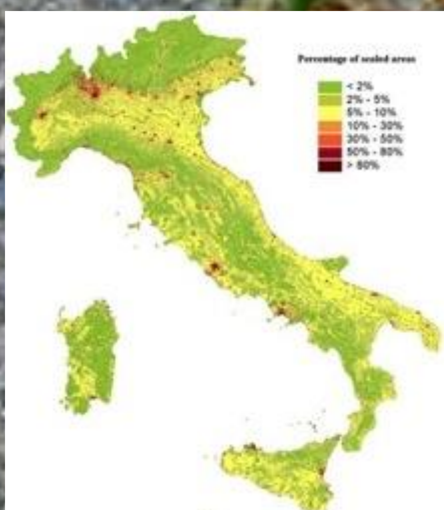
- Temperature
- Soil humidity
- Pollution tolerance
- Waterlogging
- Drought

Ecological resilience: what is the capacity of an ecosystem to maintain its functions after environmental disturbance?

Structural diversity: describes the spatial complexity offered by plant shape and is generally applied to a set of plants, rather than to an individual. The diversity of physical or architectural form within a set of plants produces structural diversity.

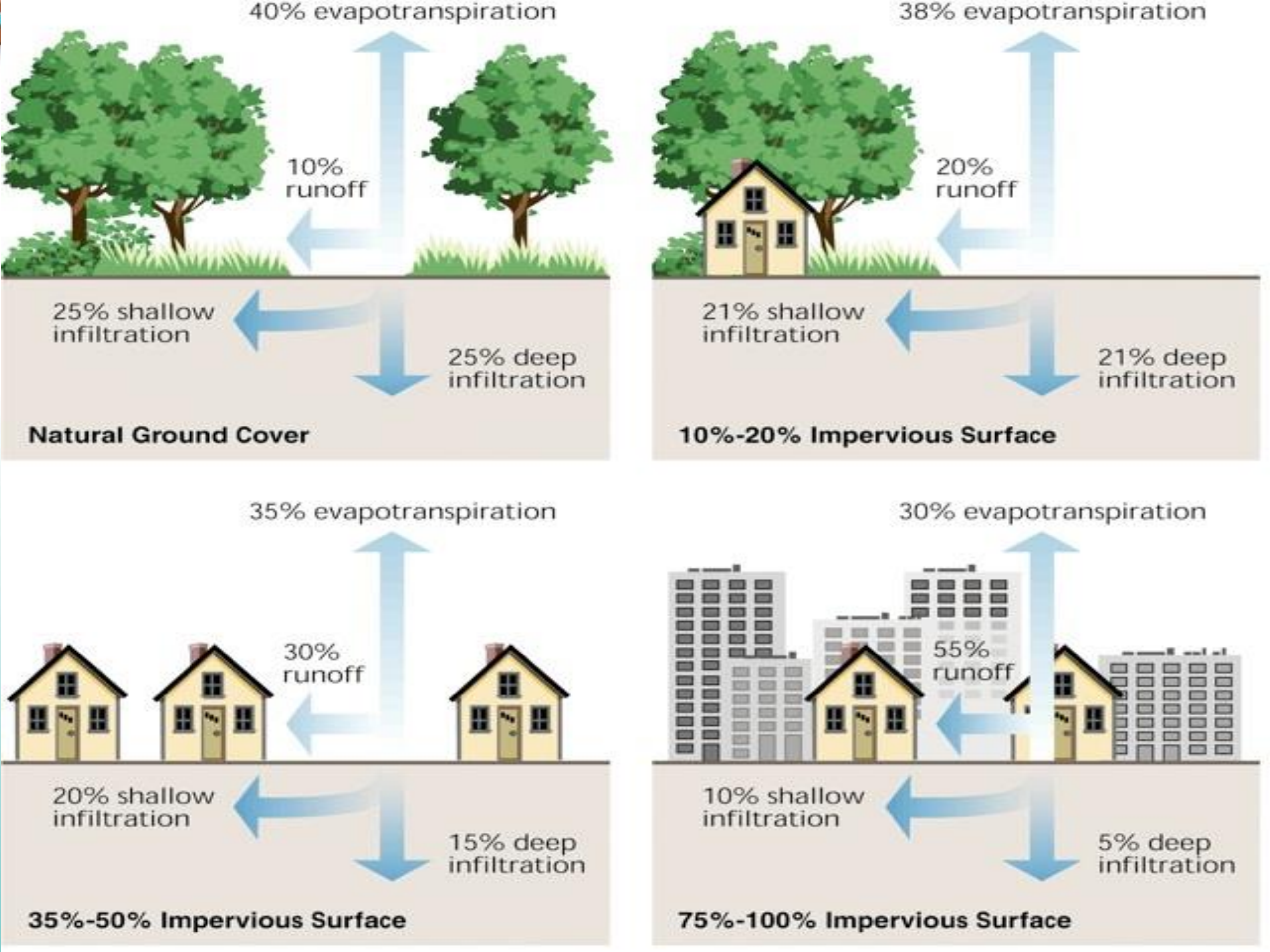
2) TREES AND THE BUILT ENVIRONMENT

SOIL SEALING



http://www.eea.europa.eu/soer/countries/it/land-use-state-and-impacts-italy/figure-5/image_large

Sealed surface 7.6% equal to 23000 km^2. Milano and Brianza highest percentage of sealed soil: 42%. 700 kg of cement/per capita. First in Europe


40% evapotranspiration
10% runoff
25% shallow infiltration
25% deep infiltration
Natural Ground Cover
38% evapotranspiration
20% runoff
21% shallow infiltration
21% deep infiltration
10%-20% Impervious Surface
35% evapotranspiration
30% runoff
20% shallow infiltration
15% deep infiltration
35%-50% Impervious Surface
30% evapotranspiration
55% runoff
10% shallow infiltration
5% deep infiltration
75%-100% Impervious Surface

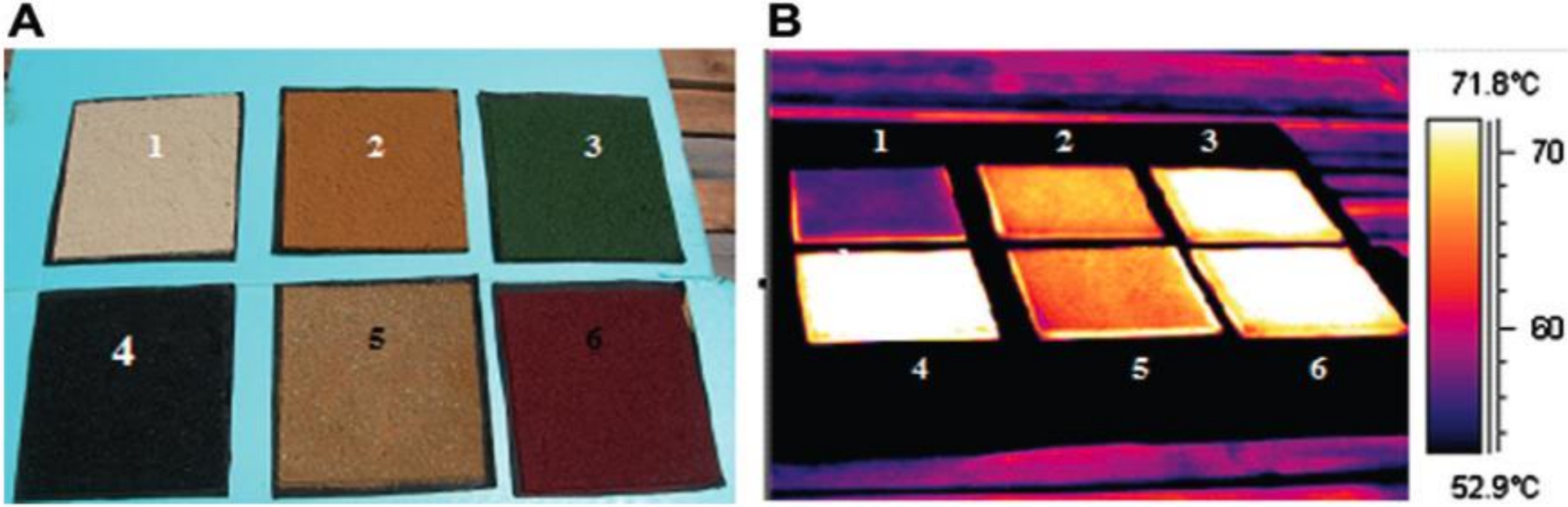


Figure 17. Visible (A) and infrared (B) images of the five colour thin layer asphalt samples and black conventional asphalt sample: 1. off-white, 2. yellow, 3. green, 4. black (conventional) 5.beige, 6. red.

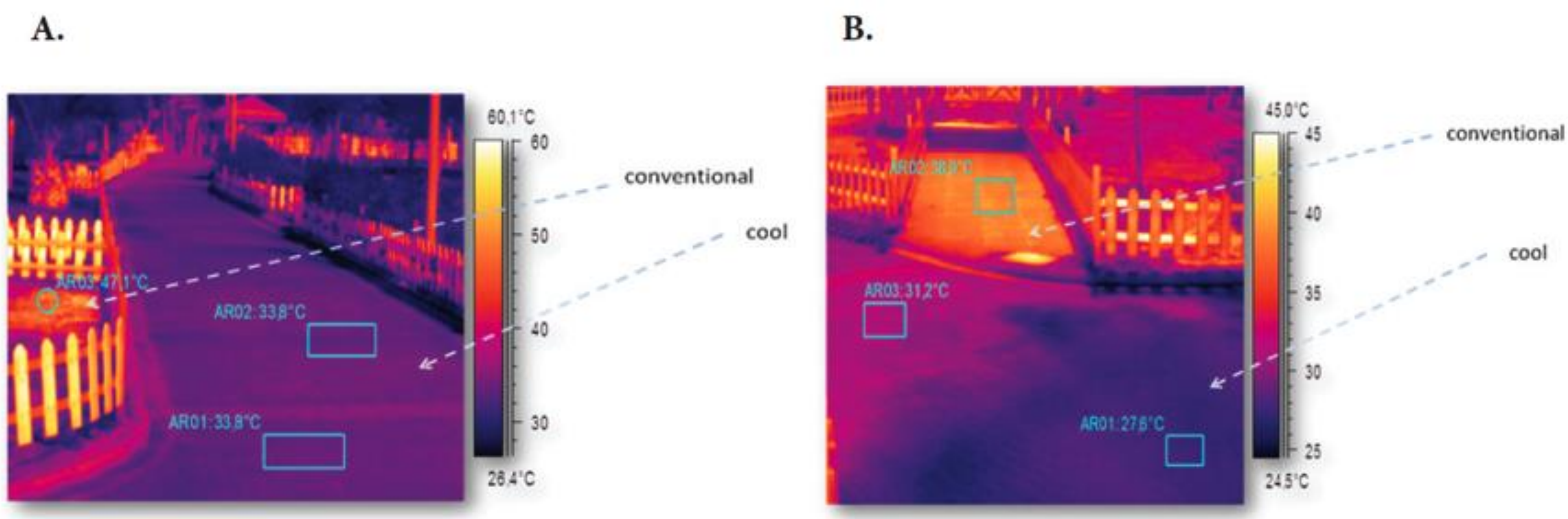


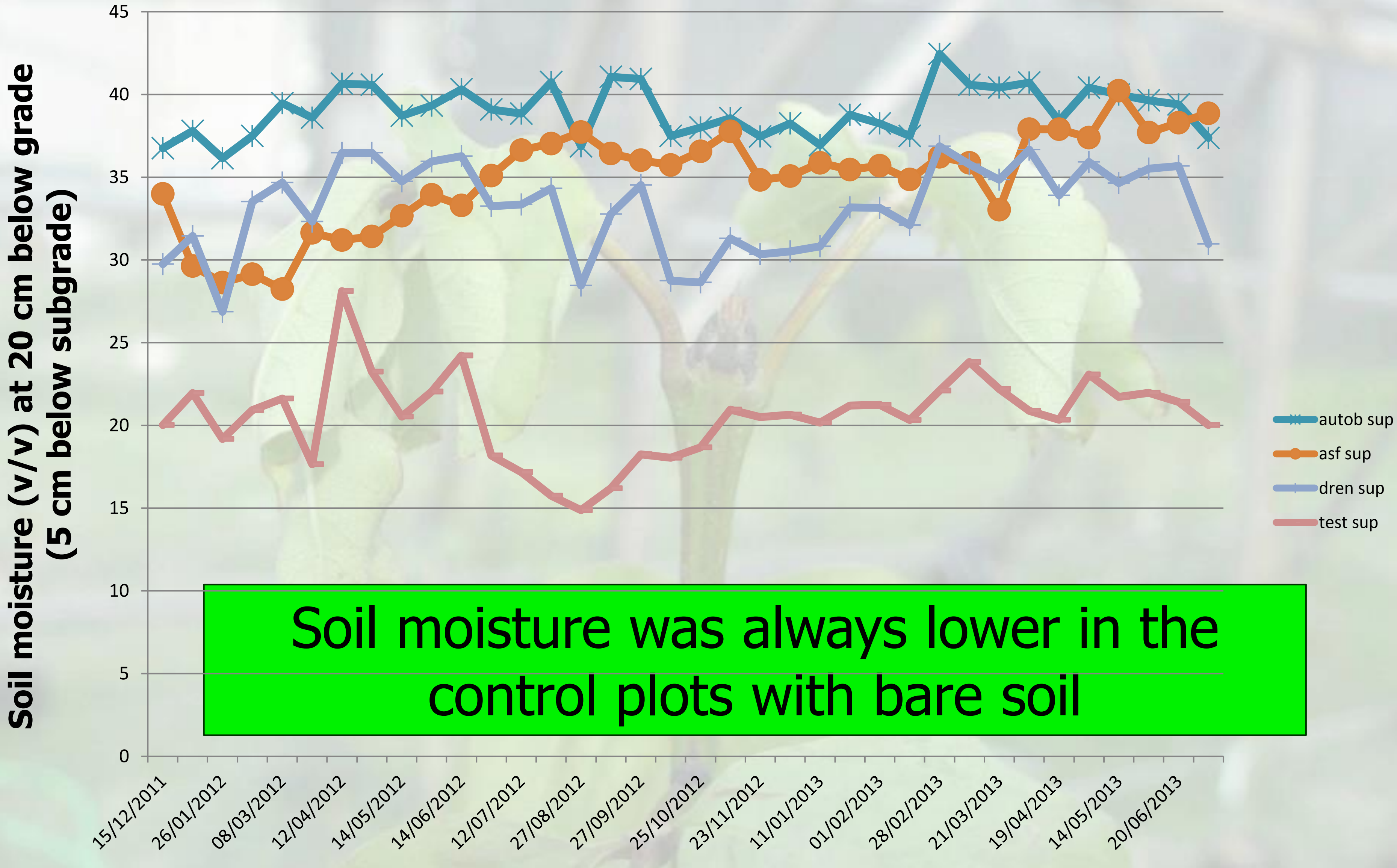
Figure 18. Thermal images demonstrating the cooling effect of using cool paving materials. a.) conventional materials are 47.1ºC. Cooler materials are 33.8ºC. b.) conventional materials are 38.9ºC. Cooler materials are 27.6ºC and 31.2ºC.

Effects of different pavements on growth and physiology of two shade tree species

Effects of different pavements on growth and physiology of two shade tree species

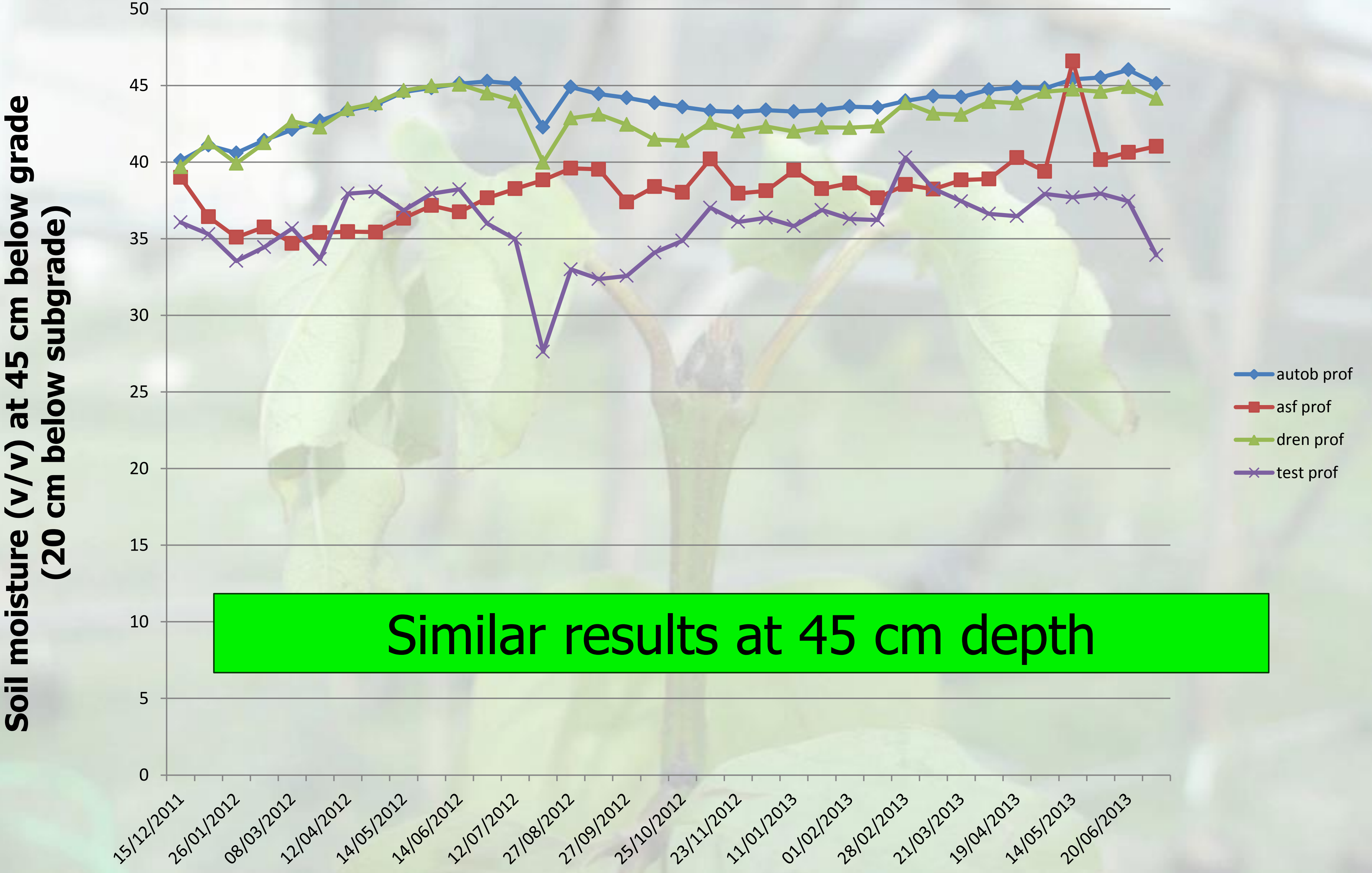
Pavements were laid in fall 2011; trees were planted in spring 2012

How is soil moisture affected by pavements?



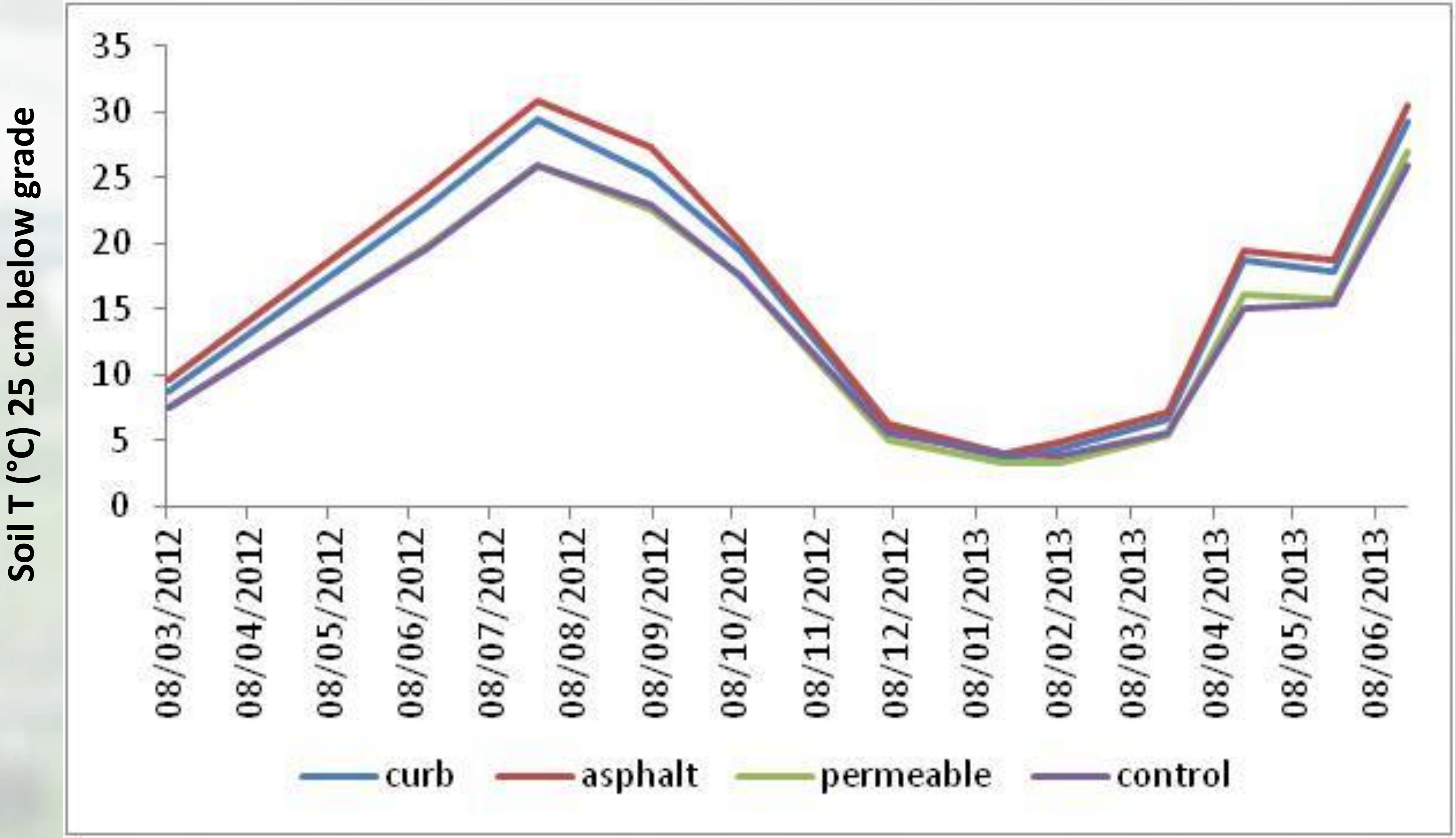
Soil moisture was always lower in the control plots with bare soil

How is soil moisture affected by pavements?



These values were obtained in the central part of each plot, where still no roots have yet to grow, and where evaporation is the main cause of water loss from soil.

What about soil temperature?



Difference were higher in the summer period, reaching 5°C in August

We're still working on plant responses and soil-atmosphere gas exchange

Parameters which are being measured include:

- CO_2 efflux from soil
- Soil O_2 content
- Leaf gas exchange
- Chlorophyll fluorescence
- Pre-dawn water potential

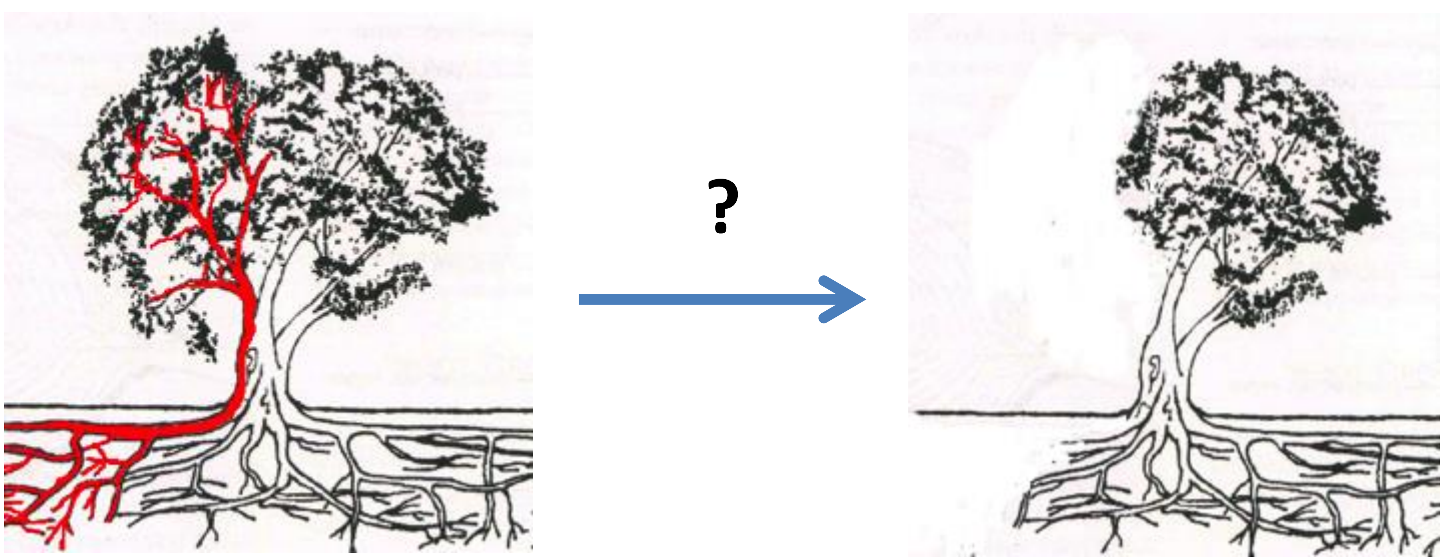
2) TREES AND THE BUILT ENVIRONMENT

Effects of root severance by excavation on growth, physiology and uprooting resistance of two urban tree species

Root severance and excavation damage

The aim of this work was:

1) to evaluate the effect of two different levels of root severing on tree growth, physiology and stability;
2) to evaluate the response to root damage by two species supposed to differ in tolerance to root manipulation;
3) to determine if root severance on one side of the tree affects leaf gas exchange over the whole canopy, or if the effect is restricted to the branches attached at that side of the tree.



Methods: plant material

48 uniform European limes (*Tilia x europaea*) and 48 horsechestnuts (*Aesculus hippocastanum*) were planted in 2004 in a loamy soil and allowed to establish for five years

Tilia has been previously reported to better tolerate root manipulation than *Aesculus* (Matheny, 2005)

2004

2009

Methods: treatments

Control - **C**

Trenching on 1 side of the tree - **MD**

Trenching on 2 sides of the tree - **SD**

Trenches (70 cm deep) were excavated 40 cm from the root flare in June 2009.
The side of the tree where MD treatment was severed will be referred as "**damaged**", the side where treatment MD was left untouched will be referred as "**undamaged**".

The experiment was a randomized block design with 4 trees per species and treatment in each block and 4 blocks. Plant growth and physiology were measured for 4 growing seasons to see how trees recover from this stress

What about tree stability??

WE CALCULATED UPROOTING RESISTANCE

CONCLUSIONS

• The change in absorbing root surface caused by root loss definitely induced stress to trees and to the photosynthetic apparatus in particular, and evidences of this stress was given by reduced leaf gas exchange, temporary photoinhibition of PSII, and less favorable water relations

• Both species responded similarly to root damage, showing reductions in growth and gas exchange. However, these reductions were of greater amplitude in the supposedly sensitive species (horsechestnut) than in the supposedly tolerant one (linden)

• Root severance on one side of the tree affects growth and gas exchange of the whole canopy, and its effects are not confined to the same side of the canopy

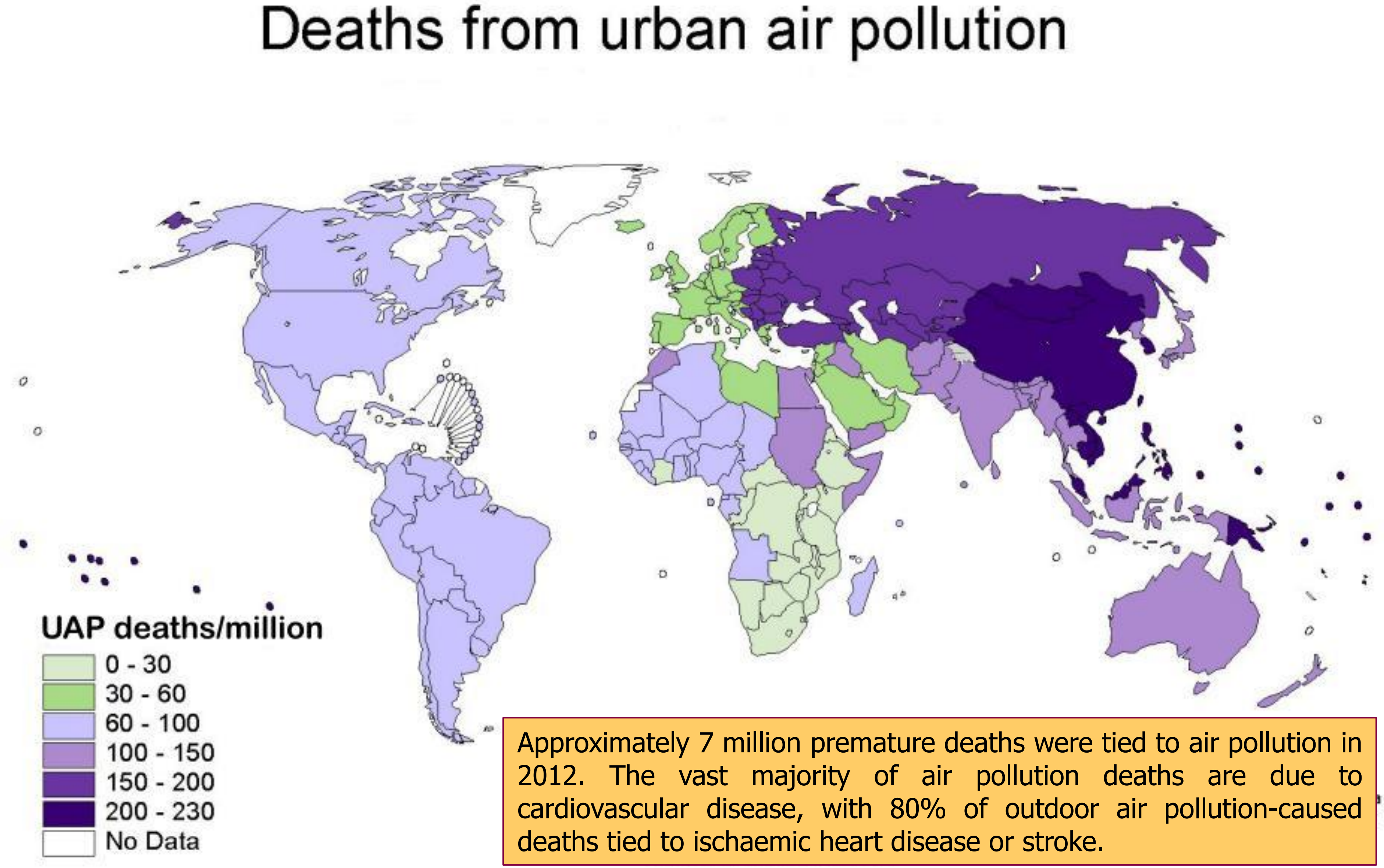
• Fine root regeneration occurred in the 26 months after trenching. Therefore, trees used in the experiment (25-30 cm circ. at the time of excavation), were able to partly recover their physiological processes

• Recovery of stability takes longer time, since the regeneration of support roots is slower

• 3) Trees and pollution (pollution and trees)

http://www.emeraldinsight.com

Pollution in US 200-300 killed/year about 1:10.000

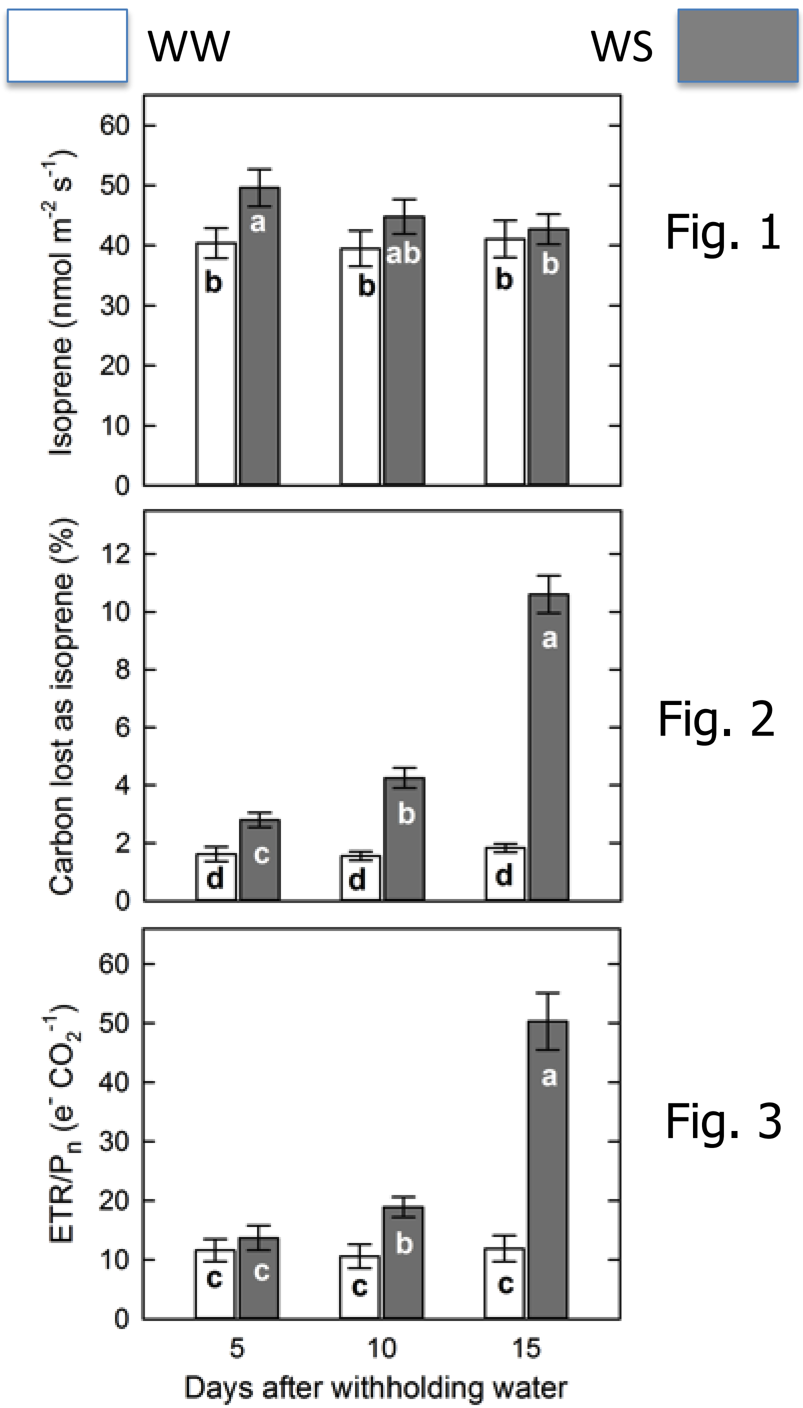


Approximately 7 million premature deaths were tied to air pollution in 2012. The vast majority of air pollution deaths are due to cardiovascular disease, with 80% of outdoor air pollution-caused deaths tied to ischaemic heart disease or stroke.

Urban trees and VOCs productions in relation to urban stresses in cooperation with IPSP-CNR

UNIVERSITÀ
DEGLI STUDI
FIRENZE
DISPAA
DIPARTIMENTO DI SCIENZE DELLE PRODUZIONI AGROALIMENTARI E DELL'AMBIENTE

ISTITUTO PER LA PROTEZIONE DELLE PIANTE
CNR



Isoprene emission varied little (10%) in response to drought, though isoprene emission significantly increased (+23%) in response to mild stress. Isoprene emission was comparable in WW and WS leaves at the end of the experiment (as isoprene emission declined by from mild to severe drought in WS leaves, Fig. 1). This is remarkable as P_n in WS leaves accounted for only 16% of P_n in WW leaves. Consistently, the carbon lost as isoprene (emission, Fig. 2) was significantly greater in WS (on average 5.9%) than in WW leaves (on average 1.6%), particularly when drought was severe (in WS leaves ~11% of fresh assimilated carbon was lost as isoprene). The percent loss of carbon to isoprene emission was linearly correlated (R^2 = 0.988; $P < 0.0001$) to the ratio of ETR to P_n (Fig. 3), indicating that isoprene biosynthesis greatly depends on the unbalance between carbon fixation and electrons available for this fixation.

Qualiviva - La qualità nella filiera florovivaistica nazionale attraverso l'utilizzo e la divulgazione delle schede varietali e di un capitolato unico di appalto per le opere (see E. Resta)

ROBINIA PSEUDOACACIA

Specie decidua, invasiva in Italia, originaria dell'America nordorientale.

ATTENZIONE: Specie invasiva. STOP

Forma chioma: espansa.

TASSO DI CRESCITA

Crescita dei germogli: 30-60 cm/anno.

Altezza a maturità: 9-15 m.

ESIGENZE

Suolo:

- **Tessitura:** nessuna esigenza particolare, anche suoli calcarei e magri.
- **pH:** 4.5-8

Esposizione: pieno sole e mezzombra.

Temperatura minima: -30 °C.

Trapiantabilità: buona.

USI SUGGERITI

Specie invasiva. Pianta singola o in gruppo. Parchi e giardini. Parcheggi. Alberatura stradale. Piazze, piazzali ed aiuole. Grandi e medi spazi. Alta adattabilità alle condizioni urbane.

PROBLEMATICHE GESTIONALI

Moderate esigenze di manutenzione: sono da evitare le posizioni troppo esposte ai venti perché i rami sono piuttosto fragili. Per fiorire in modo ottimale necessita di posizioni soleggiate. Le sue radici sono superficiali. Moderata tendenza a sporcare: i fiori ed i frutti possono causare problemi di manutenzione e spine ed aculei possono essere pericolosi e creare disagi.

PROGETTO QUALIVIVA
AZIONE 2 – Schede tecniche

ROBINIA PSEUDOACACIA

PRINCIPALI PARASSITI E PATOGENI

Generalmente esente da patogeni o malattie di grave entità. Funghi: Cancri rameali; carie del legno; marciume del colletto da phytophthora. Insetti: eriofide della robinia.

POTENZIALE EMISSIONE VOCs

Classe di composti: Isoprene e Monoterpeni.

Quantità: media+alta.

STOCCAGGIO CO_2

	CO_2 stoccata (kg)	CO_2 assimilata (kg/anno)
Nuovo impianto	8	4
Esemplare maturo	499	142

ABBATTIMENTO INQUINANTI

	(kg/anno)			
	O_3	NO_2	SO_2	PM_{10}
Esemplare maturo	<0.05	0.1	0.2	<0.05

TOLLERANZA AGLI STRESS ABIOTICI

Siccità: medio alta.

Salinità: alta.

Compattazione: media.

Sommersione: bassa.

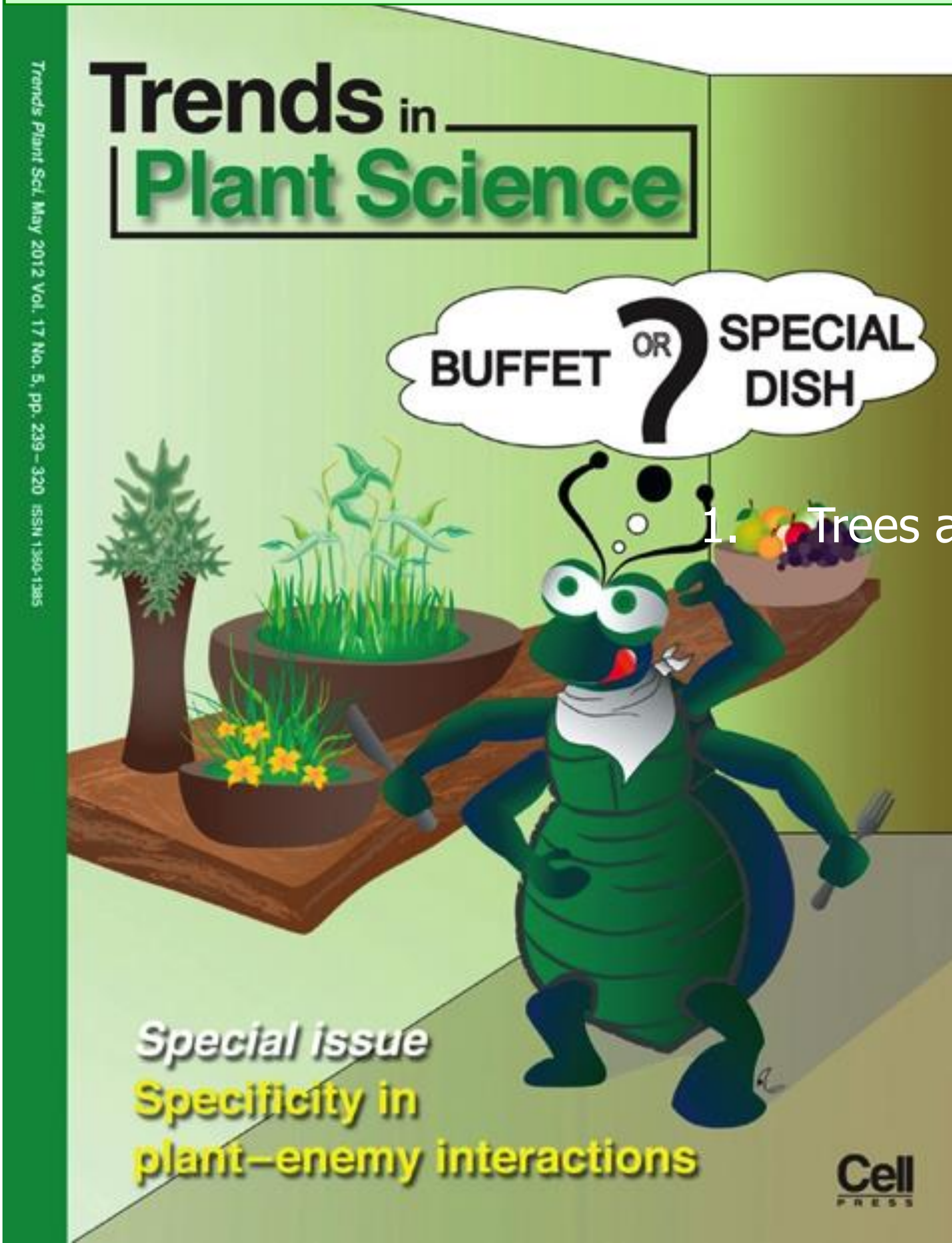
Inquinanti: alta.

ALTRI COMMENTI

Pianta con uso officinale. Il fiore è edule. Pianta mellifera.

© Prof. F. Ferrini, Piante MATI®, Commons wikimedia

4) Trees and parasites relationship as influenced by climate change



1. Trees and parasites

5) Trees and senescence (managing renewal)

People must know the difference between senescent trees and veteran trees

Management of avenues: not only a technical matter

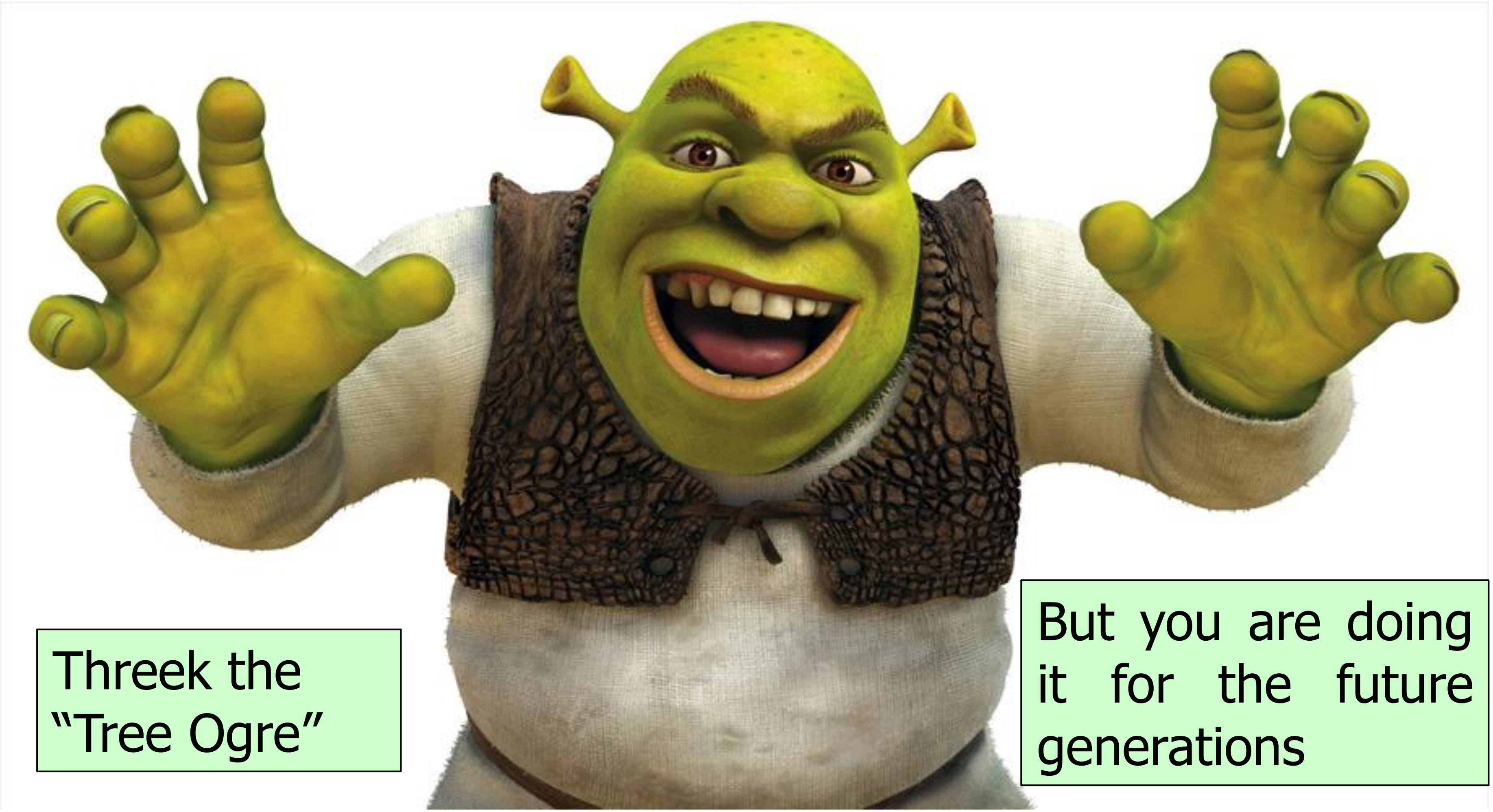
- Historical implications – house, setting, etc.
- Landscape, architectural, archaeological considerations
- Wildlife conservation
- Public opinion
- Future management
- Cost

Management of avenues - alternatives

- Do **NOTHING**
- Manage existing trees to prolong their safe, useful lives
- Replant – either completely or partially

Management of avenues - alternatives

Sometimes it's hard and painful to take the decision to remove old trees and planting young and healthy ones. If you decide to do so, you are not necessarily….



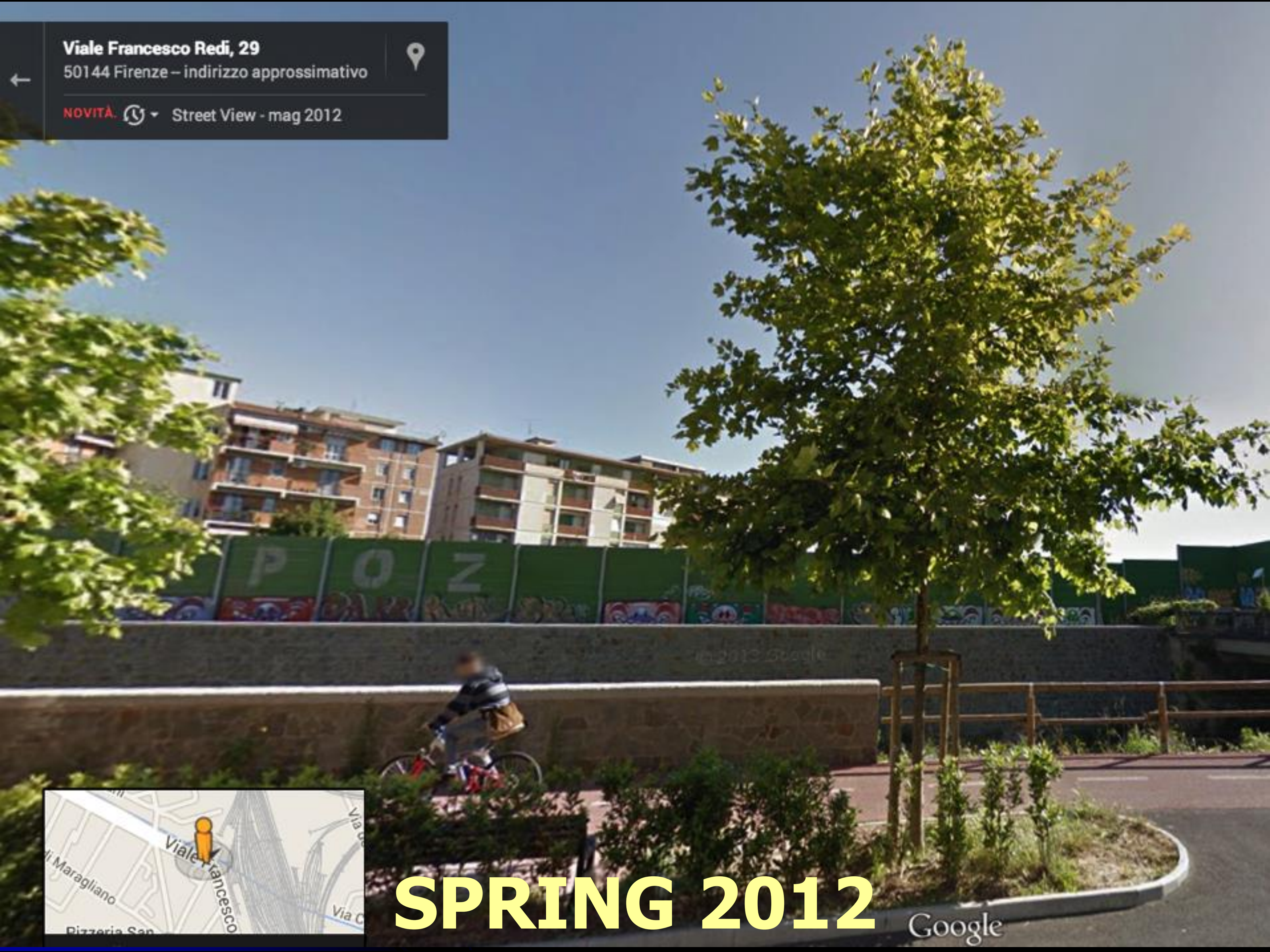
Threek the "Tree Ogre"

But you are doing it for the future generations

FALL 2009

WINTER 2010

SPRING 2010


Viale Francesco Redi, 29
50144 Firenze – indirizzo approssimativo
NOVITÀ
Street View - mag 2012
P O Z
Viale Francesco
Maragliano
Via
Google

SPRING 2012

May 2013

May 2014

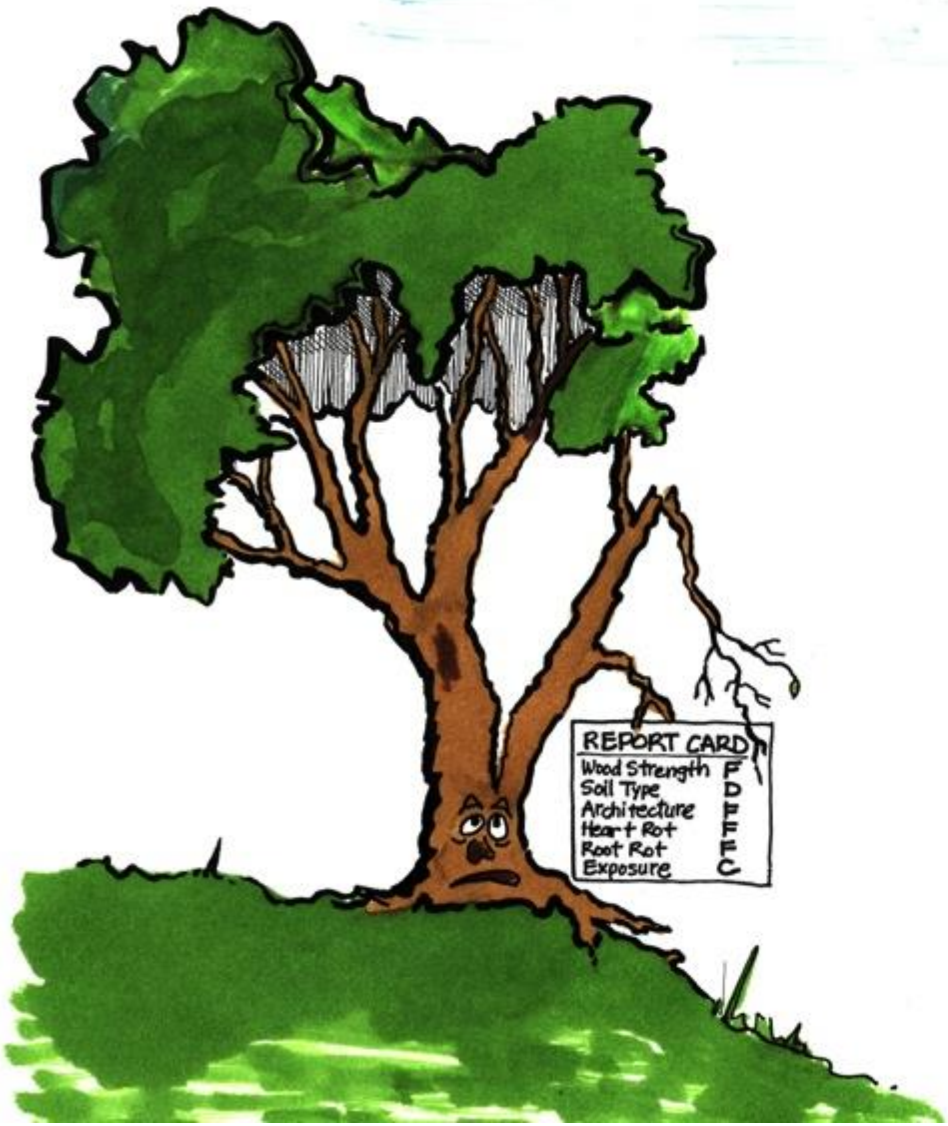
6) (Veteran) tree management

Management techniques of veteran trees

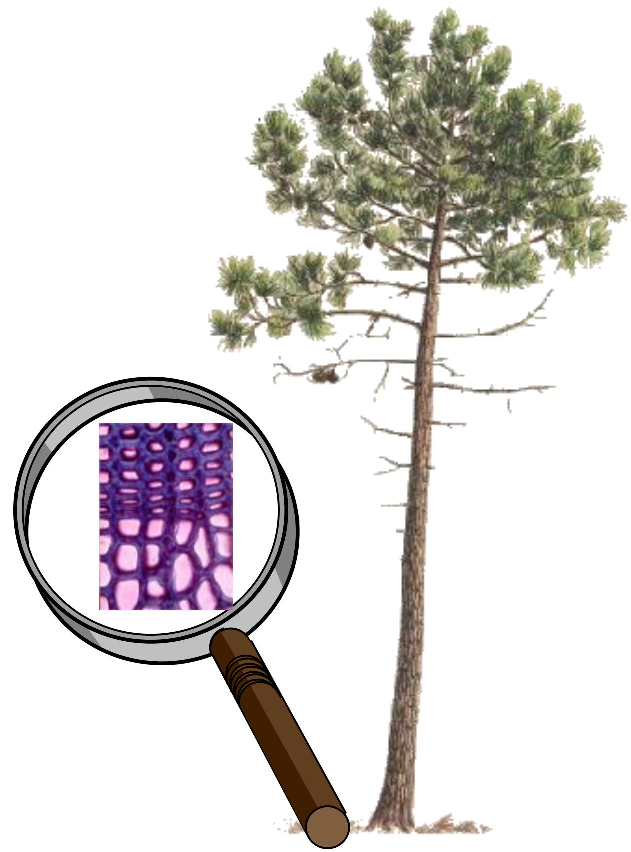
The problem which quite frequently arises is whether it is worth spending money on very old trees in order to lengthen their existence, or whether they should be left alone and a young tree planted somewhere in the vicinity.

We should be aware that as trees age and grow larger or assume particular forms, their contributions and value to the landscape notably increase.

7) TREE BIOMECHANICS



From Telewski, 2011



From Stokes, 2011

Schmidlin T.W., 2009. Human fatalities from wind-related tree failures in the United States, 1995–2007. Natural Hazards (2009) 50:13–25 DOI 10.1007/11069-008-9314-7.

Average 31 deaths (1:100.000)

Dunster J., pers. Comm. (in the worst case (2011) – approx. 1:25.000

Table 1. Five year summary - United States of America.

Year	killed by tree	injured by tree	killed by limb	injured by limb	# of incidents	total killed	total injured
2008	37	5	11	4	49	48	9
2009	45	39	15	18	97	60	57
2010	66	71	9	28	165	75	99
2011	132	120	15	42	221	147	162
2012	83	124	13	52	193	96	176

Table 2. Five year summary - Canada

Year	killed by tree	injured by tree	killed by limb	injured by limb	# of incidents	total killed	total injured
2008	3	5	-	-	5	3	5
2009	1	-	-	-	1	1	-
2010	1	-	-	-	1	1	-
2011	4	6	-	1	11	4	7
2012	3	3	-	-	6	3	3

Risk	Annual Deaths	Lifetime risk
Heart disease	652,486	1 in 5
Cancer	553,888	1 in 7
Stroke	150,074	1 in 24
Hospital infections	99,000	1 in 38
Flu	59,664	1 in 63
Car accidents	44,757	1 in 84
Suicide	31,484	1 in 119
Accidental poisoning	19,456	1 in 193
MRSA (resistant bacteria)	19,000	1 in 197
Falls	17,229	1 in 218
Drowning	3,306	1 in 1,134
Bike accident	762	1 in 4,919
Air/space accident	742	1 in 5,051
Excessive cold	620	1 in 6,045
Sun/heat exposure	273	1 in 13,729
Shark attack*	62	1 in 60,453
Lightning	47	1 in 79, 746
Train crash	24	1 in 156,169
Fireworks	11	1 in 340,733

How and Why do Trees Fall Down:

A Biomechanical Perspective on What We Don't Know

Cornell University

Karl J. Niklas
Department of Plant Biology

Summary

Trees must sustain their weight and dynamic forces.

Dynamic forces (wind) are the most dangerous.

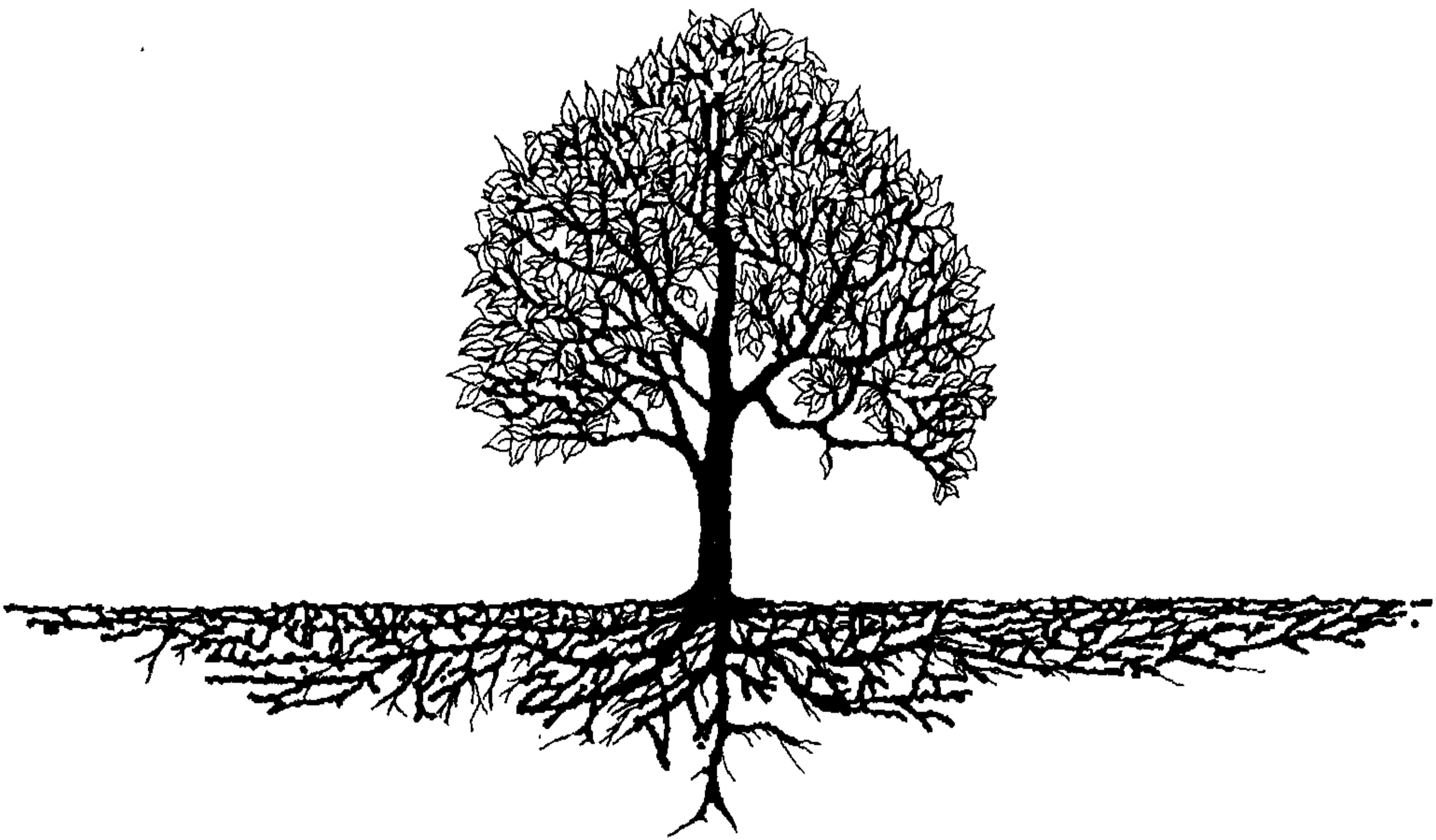
Factors of safety differ in a tree's branching architecture.

Factors of safety change (decrease) with age.

Even healthy trees will fail ----
by uprooting
by torsional failure near their base.

8) EXPLORING NEW TOOLS

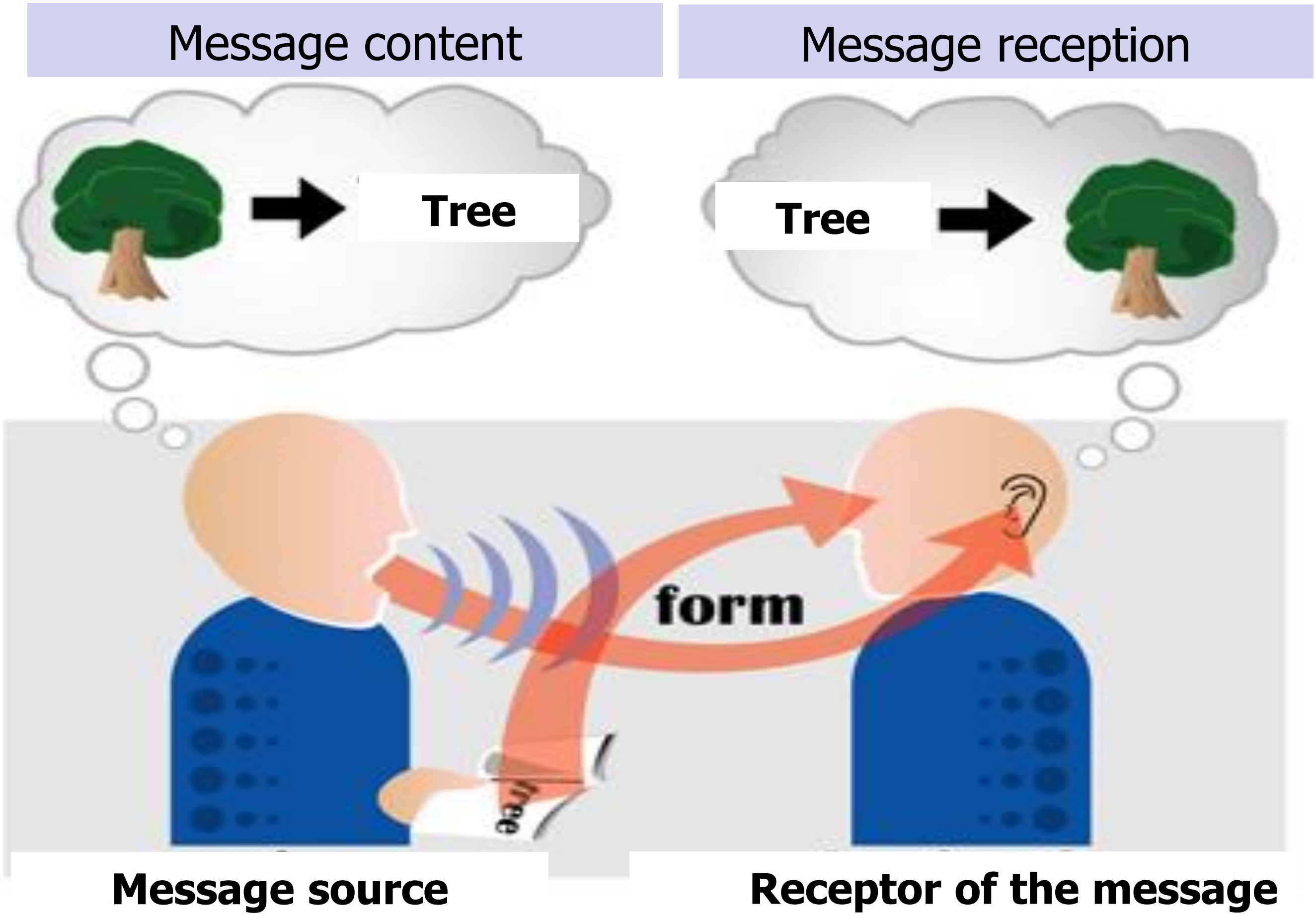
(I.E. FOR STUDYING ROOT SYSTEM UNDERNEATH THE PAVEMENTS)



9) DEAL WITH TREE "INTEGRALISM" OR HOW TO "EDUCATE" THE "SUNDAY ENVIRONMENTALISTS"

http://maxfaqs.files.wordpress.com/2011/09/sign2.jpg

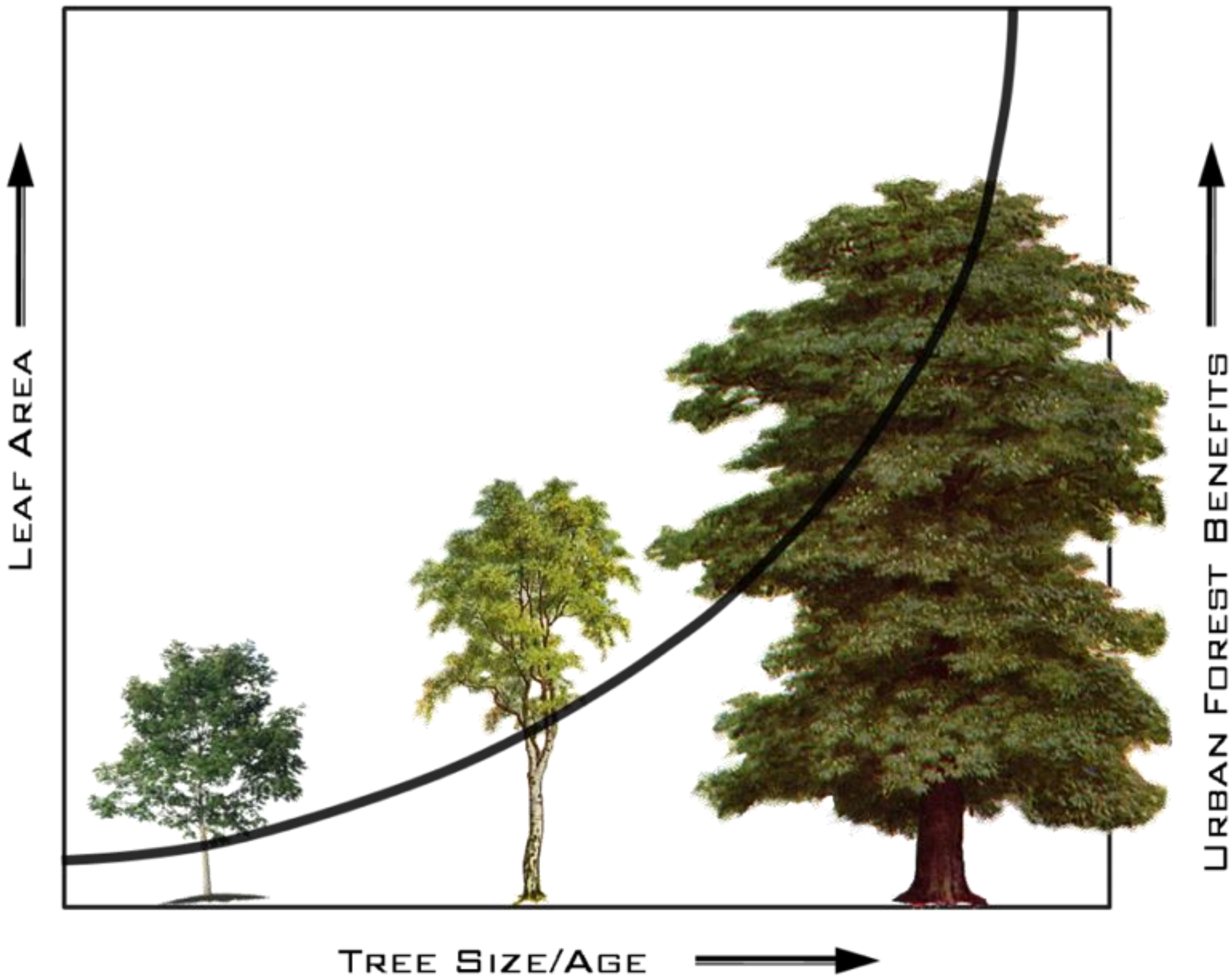
10) "Green communication"



Mission of the International Society of Arboriculture

Through research, technology, and **education**, the International Society of Arboriculture will promote the professionalpractice of arboriculture and foster a greater worldwide awareness of the benefits of trees.

Trees in the City? Past, Present and Future



WHAT SHOULD WE PLANT????

ALSO WHERE WE SHOULD PLANT MUST BE KNOWN!!!!

Species/cultivar widely grown in the urban areas in Europe

Acer platanoides	***Platanus x acerifolia***
Acer pseudoplatanus	***Populus spp***
Aesculus hippocastanum	***Quercus spp.***
Celtis australis	***Robinia pseudoacacia***
Fraxinus excelsior	***Styphnolobium japonicum***
Ginkgo biloba	***Tilia cordata***
Liquidambar styraciflua	***Tilia x europaea***
Liriodendron tulipifera	***Tilia tomentosa***
Pawlonia tomentosa *(imperialis)*	***Ulmus spp.***

Species which might be used as street trees in Europe

Acer buergerianum (slow growth)

Acer campestre (Queen Elizabeth) (medium/slow growth)

Acer opalus (medium growth)

Acer cappadocicum (medium growth, produces suckers)

Aesculus indica A. glabra (medium growth)

Brachychiton populneus (fast growth)

Corylus colurna (medium growth)

Gleditsia triacanthos ♂ (codominant branches, fast growth)

Ginkgo biloba ♂ (medium/slow growth)

Gymnocladus dioicus ♂(medium growth)

Koelreuteria paniculata (medium/fast growth)

Juglans nigra (medium/fast growth)

Maclura pomifera ♂(fast growth)

Melia azedarach (fast growth)

Nyssa sylvatica (transplant crisis, slow growth)

Phellodendron amurense ♂ (medium growth)

Pistacia chinensis (fast growth)

Pyrus calleryana (medium/fast growth)

Quercus muehlenbergii (medium/slow growth)

Quercus shumardii (medium/slow growth)

Quercus suber (slow growth)

Robinia pseudoacacia (fast growth)

Styphnolobium japonicum (medium/fast growth)

Tipuana tipu (fast growth)

Ulmus parvifolia (codominant branches, fast growth)

Zelkova serrata (codominant branches, (medium/fast growth)

Proactive in....Predicting future pests or diseases

Da Stephens, 2011

Introducing the concept of "Visual uniformity – Biological diversity"

SAME SPECIES… IF NOT WHICH IS WHICH?

Visual uniformity – Biological diversity (from Bassuk et al. 2002)

Aesculus hippocastanum

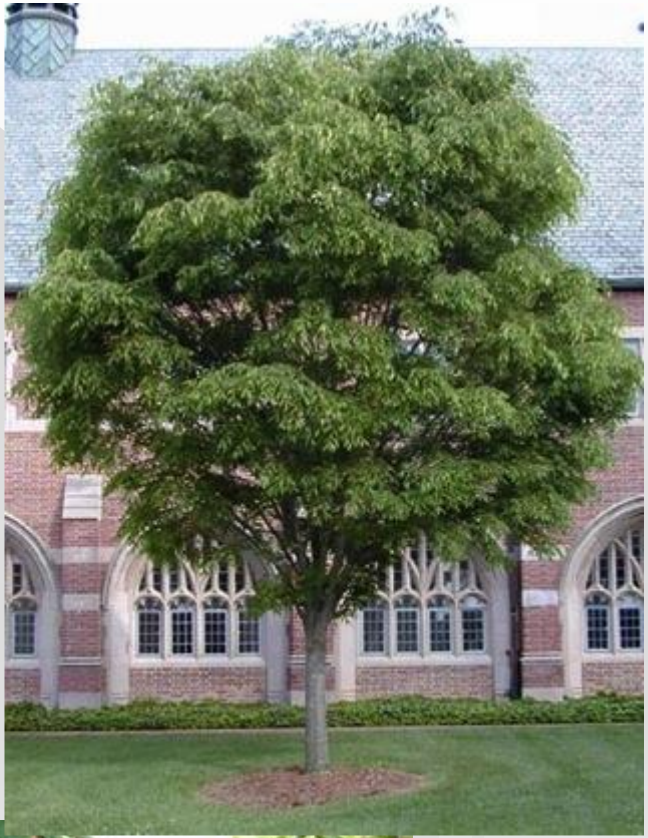


Aesculus indica




Aesculus glabra

Visual uniformity – Biological diversity (from Bassuk et al. 2002)



Zelkova serrata

Celtis australis

Visual uniformity, biological diversity ((from Bassuk et al. 2002)

Acer pseudoplatanus

Acer opalus

Acer obtusatum

A. opalus subsp. obtusatum


Diversity can be the key against adversity

Native vs Exotic

An introduced, alien, exotic, non-indigenous, or non-native species, or simply an introduction, is a species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental

Native site for *Alnus glutinosa* in the North of Italy

Results of urban planting a few hundreds meters from the native site

So, what is the real meaning of native in an un-native environment???

Are *all* non-native species a problem?

About 85% of exotic plants and animals pose no substantial environmental problems.

– *America's Least Wanted*,

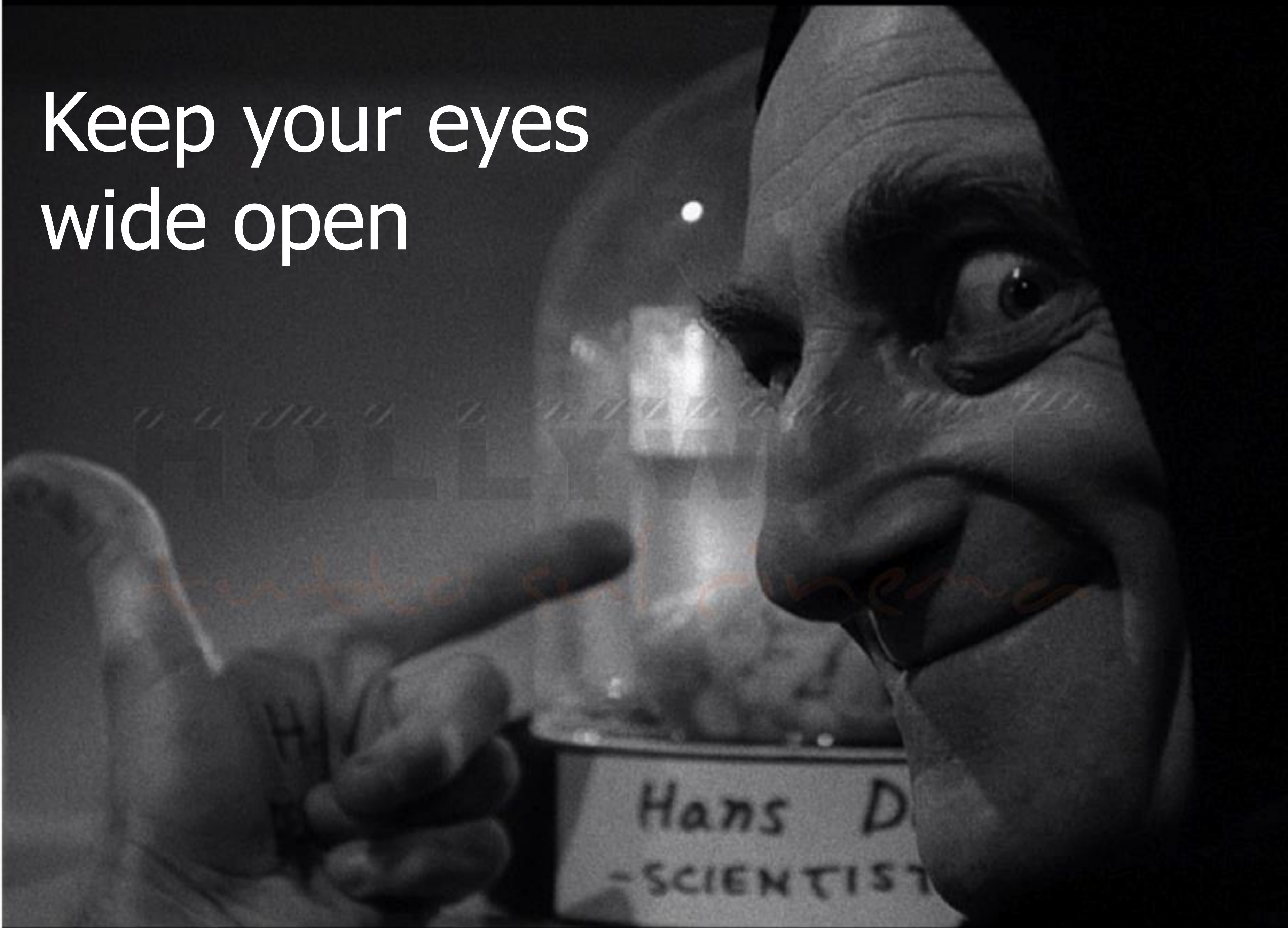
The Nature Conservancy


Don’t be scared of exotic species or don’t
be too fundamentalist in your choice!!!!!

Slide courtesy J. Grabosky

SPECIES	STATE	Tree count	Parking lots	Parking lot age	Canopy radius and area reduction at 20m^2 unpaved space relative to unlimited soil for trees on the parking lot edge.	
Acer rubrum	NJ	233	8	18-23 yrs	42.2% of edge	80% reduction
Prunus serrulata	NJ	313	9	18-23 yrs	71.6% of edge	49% reduction
Pyrus calleryana	NJ	427	11	18-23 yrs	42.1% of edge	80% reduction
Quercus palustris	NJ	209	9	18-23 yrs	66.2% of edge	56% reduction
Zelkova serrata	NJ	354	10	18-23 yrs	59.8 % of edge	64% reduction
Platanus occidentalis	FL	78	3	11-24 yrs	71.8 % of edge	49% reduction
Ulmus parvifolia	FL	287	4	12-24 yrs	55.2 % of edge	70% reduction
Quercus schumardii	FL	43	2	20+ yrs	71.4 % of edge	49% reduction
Quercus laurifolia	FL	41	1	16 yrs	89.9 % of edge	19% reduction
Quercus virginiana	FL	241	6	12-24 yrs	- - -	

Keep your eyes wide open



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Thanks for your attention