Pruning to death: effect of topping on plant growth and physiology and on microclimate conditions

Francesco Ferrini[1], Alessio Fini[2], Marco Napoli[1], Simone Orlandini[1], Piero Frangi[3], Luciano Massetti[4], Martina Petralli[1]

[1] Department of Agrifood Production and Environmental Sciences – Università di Firenze, taly
[2] Department of Agricultural and Environmental Science – Production, Landscape, Agroenergy, Università di Milano, Italy.
[3] Fondazione Minoprio, viale Raimondi 54, Vertemate con Minoprio, Como, Italy
[4] CNR-IBIMET – Consiglio Nazionale delle Ricerche, Sesto Fiorentino, Florence, Italy.

UNIVERSITÀ DEGLI STUDI FIRENZE

World Forum on Urban Forests
Mantova 2018

Pruning can be one of the best things an arborist can do for a tree and one of the worst things an arborist (??) can do to a tree (Shigo, 1989).

World Forum on Urban Forests
Mantova 2018

What do we really know about ornamental tree pruning?

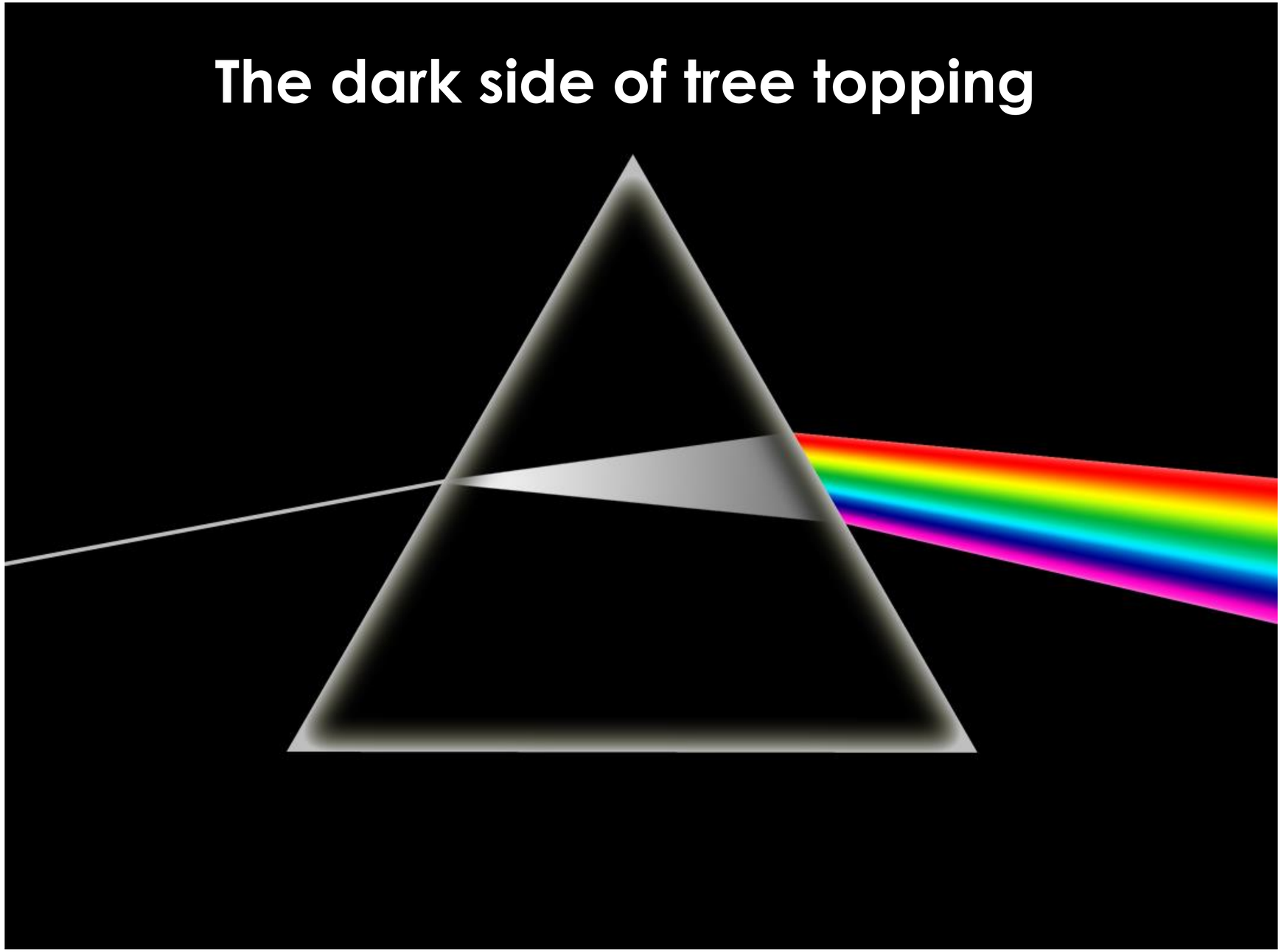
- **Pruning severity and timing** *(Mierowska et al., 2002; Gilman and Grabosky, 2009, AUF; Fini et al., 2013; Purcell, 2015)*
- **Tree response to wounding** *(Solomon and Blum, 1977; Neely, 1979; Dujesiefken et al., 2005; O'Hara, 2007; Schwarze, 2008)*
- **Compartmentalization of wood decay fungi** *(Shigo and Marx, 1977; Schwarze, 2001; O'Hara, 2007; Schwarze et al., 2007)*
- **Tree response in the wind** *(Gilman et al., 2008a, 2008b; Pavliset al., 2008; James et al., 2006; James, 2010; James and Hallam, 2013)*

What don't we know?

Little information on pruning methods on the long-term structure and physiology of urban trees and that the effects of different pruning methods on tree physiology have received little attention and deserve further research (Clark and Matheny, 2010)

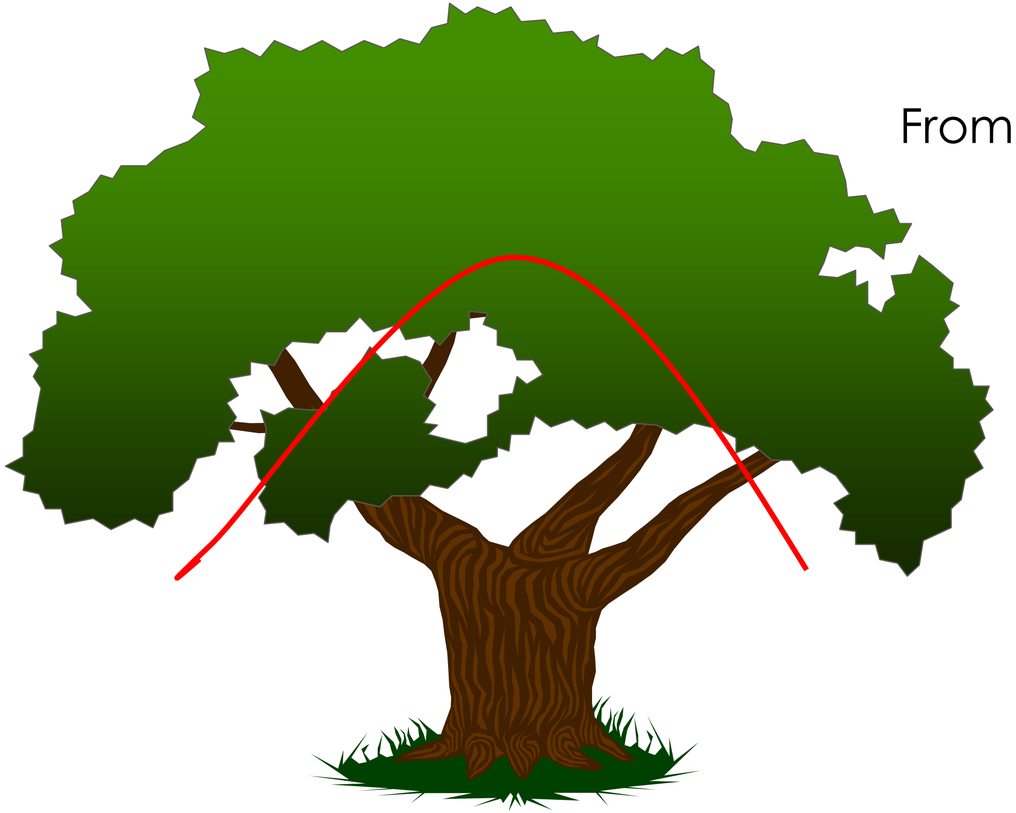
World Forum on Urban Forests
Mantova 2018

The dark side of tree topping



World Forum on Urban Forests
Mantova 2018

Heavy pruning



From Balder, 2008 readapted

Decrease of the photosynthesis rate

Reduction of assimilates

Lost of vitality

Attack of wood destroying fungi

Uneven hormone situation

Sun damages on the stem

Lost of the crown architecture

Mobilisation of reserve substances

World Forum on Urban Forests
Mantova 2018

TOPPING also known as heading, stubbing or dehorning trees has several negative effects

- ✓ Topped trees need to be topped continuously and require more attention in the future
- ✓ Topping will not invigorate trees: fewer leaves or the reduction of leaf surface may have negative effects on the root system. Removal of large portion of leaf bearing crown produces starving in trees
- ✓ Shoots of topped tree are weakly attached to the tree because they originate from buds near the surface

World Forum on Urban Forests
Mantova 2018

- ✓A topped tree may more easily become a hazard because it causes wood decay
- ✓Weakened trees are more vulnerable to insect and disease hazard
- ✓Iper-topping can kill a tree
- ✓Topped tree are more expensive in the long run and may cause property value to drop
- ✓Topped tree are ugly, disfigured and their natural form is destroyed and can never be regained

World Forum on Urban Forests
Mantova 2018

Why people top trees?

- **No national legislation** ruling the best practices for pruning
- Privates top trees **because of lack of information** (every one is an arborist…)
- **Fear of injury or to cause damage** to their own or someone else property (that tree is too big. It must be dangerous…it's taller than my house. How dares it?
- Topping seems **quicker and cheaper**
- Despite the best pruning should be hardy noticeable, people want to see trees pruned…**I want to see the pile of wood!!!!**

World Forum on Urban Forests
Mantova 2018

Research on pruning ornamental trees at the University of Florence

Urban Forestry & Urban Greening 14 (2015) 664–674

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Effects of different pruning methods on an urban tree species: A four-year-experiment scaling down from the whole tree to the chloroplasts

A. Fini[a,d,*], P. Frangi[b], M. Faoro[b], R. Piatti[b], G. Amoroso[b], F. Ferrini[a,c,d,e]

[a] Department of Agri-food Production and Environmental Science, University of Florence, viale delle Idee, 30, 50019, Sesto Fiorentino (FI), Italy
[b] Centro MiRT – Fondazione Minoprio, viale Raimondi 54, 22070 Vertemate con Minoprio, CO, Italy
[c] Research Unit CLimate chAnge SyStem and Ecosystem (CLASSE), University of Florence, Florence, Italy
[d] LABVIVA (Laboratorio per la Ricerca nel Settore Vivaistico-Ornamentale, University of Florence), Italy
[e] Trees and Timber Institute (IVALSA), National Research Council, Italy

Photo taken from: https://entretien-elagage-jardin-78.fr/taille-elagage-95/

World Forum on Urban Forests
Mantova 2018

Conclusions

We provide some evidence supporting old knowledge:

Myth: topping will make trees easier to maintain

FAKE: topped branches grew faster, more slender and codominance often occurred

Myth: topping invigorates trees

FAKE: topping altered tree physiology, providing a shift to a more pioneer behavior (each individual shoot grows as fast as possible), but at expenses of stress tolerance. Inefficiency increases within the tree.

- **Pruning method, not only its severity, modulates the morpho-physiological response of trees.**
- **Removal cut provides minimal disturbance to tree physiology**
- **Reduction cut preserved normal branching pattern and had little effects on leaf structure and photosynthetic performance**

World Forum on Urban Forests
Mantova 2018

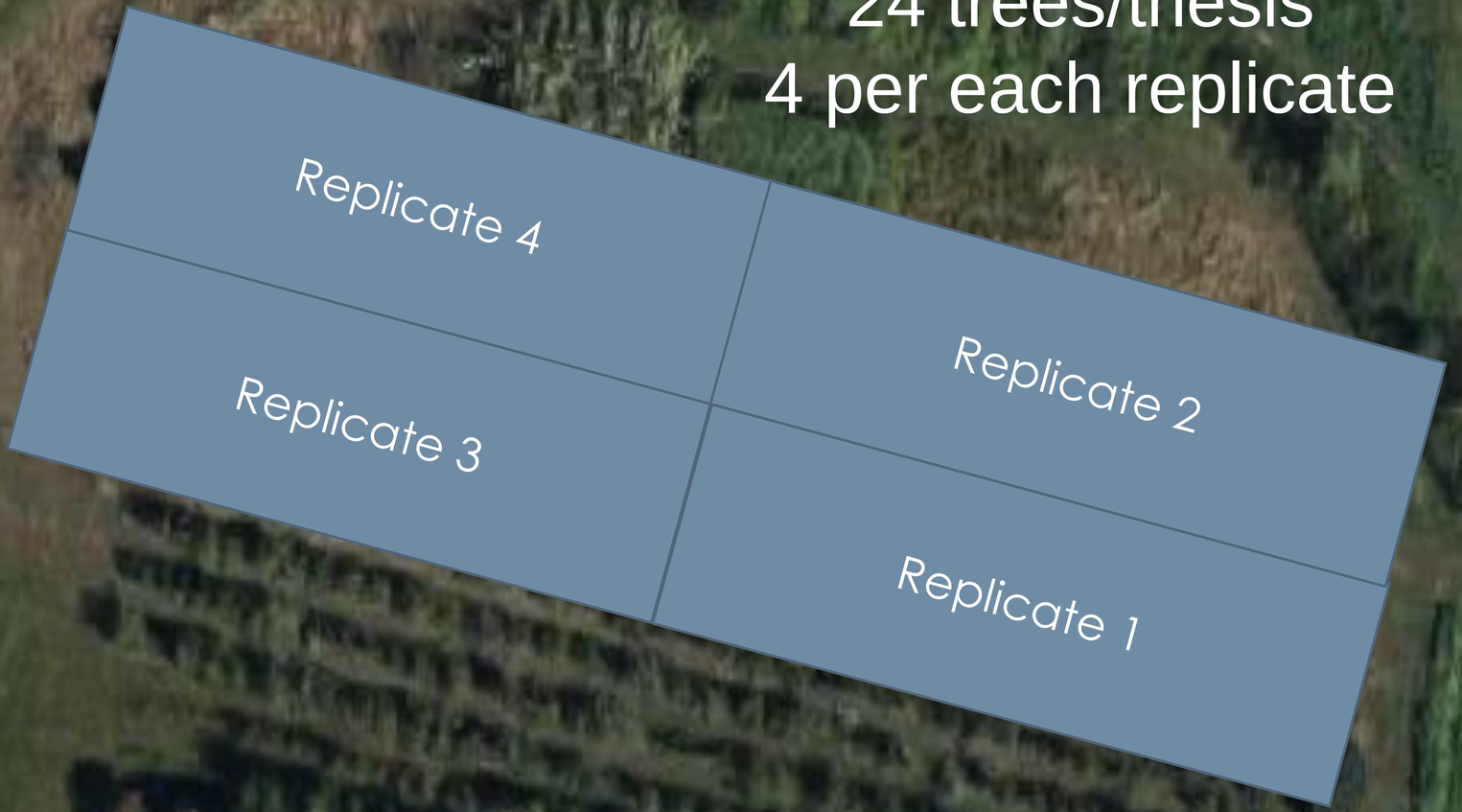
Effect of topping on microclimate condition and on human comfort (ongoing first results)

supported by Tree FUND

World Forum on Urban Forests
Mantova 2018

Experimental plot

24 trees/thesis
4 per each replicate



Fondazione Minoprio – Vertemate con Minoprio (Como)
45.728340 N, 9.0821562 E (a bit farther than Minneapolis)

World Forum on Urban Forests
Mantova 2018

Parameters measured

- Phenological phases budbreak date, leaf yellowing and leaf fall)
- Biometric data shoot length, trunk diameter, crown width, leaf area)
- Ecophysiology leaf gas exchange, A/Cc curves)
- SPAD value
- Thermal imager photos with drone + NDVI with drone
- Climate data (from 2016) every 15 minutes with 6 sensors HOBO Temperature/Relative Humidity Data Logger

World Forum on Urban Forests
Mantova 2018

Results refer to **2017** sampling and measurements

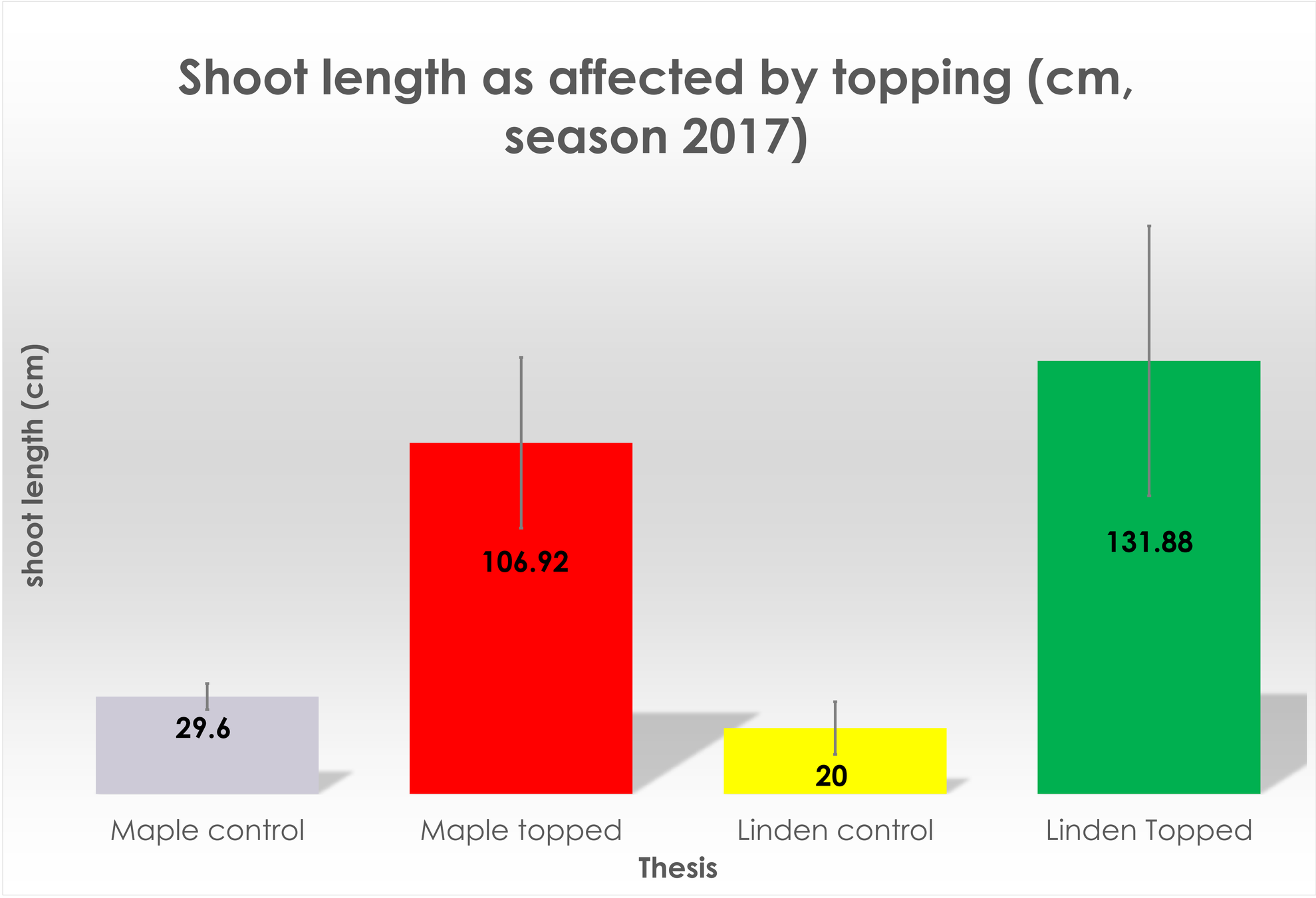
Results

World Forum on Urban Forests
Mantova 2018

Morphological and physiological data

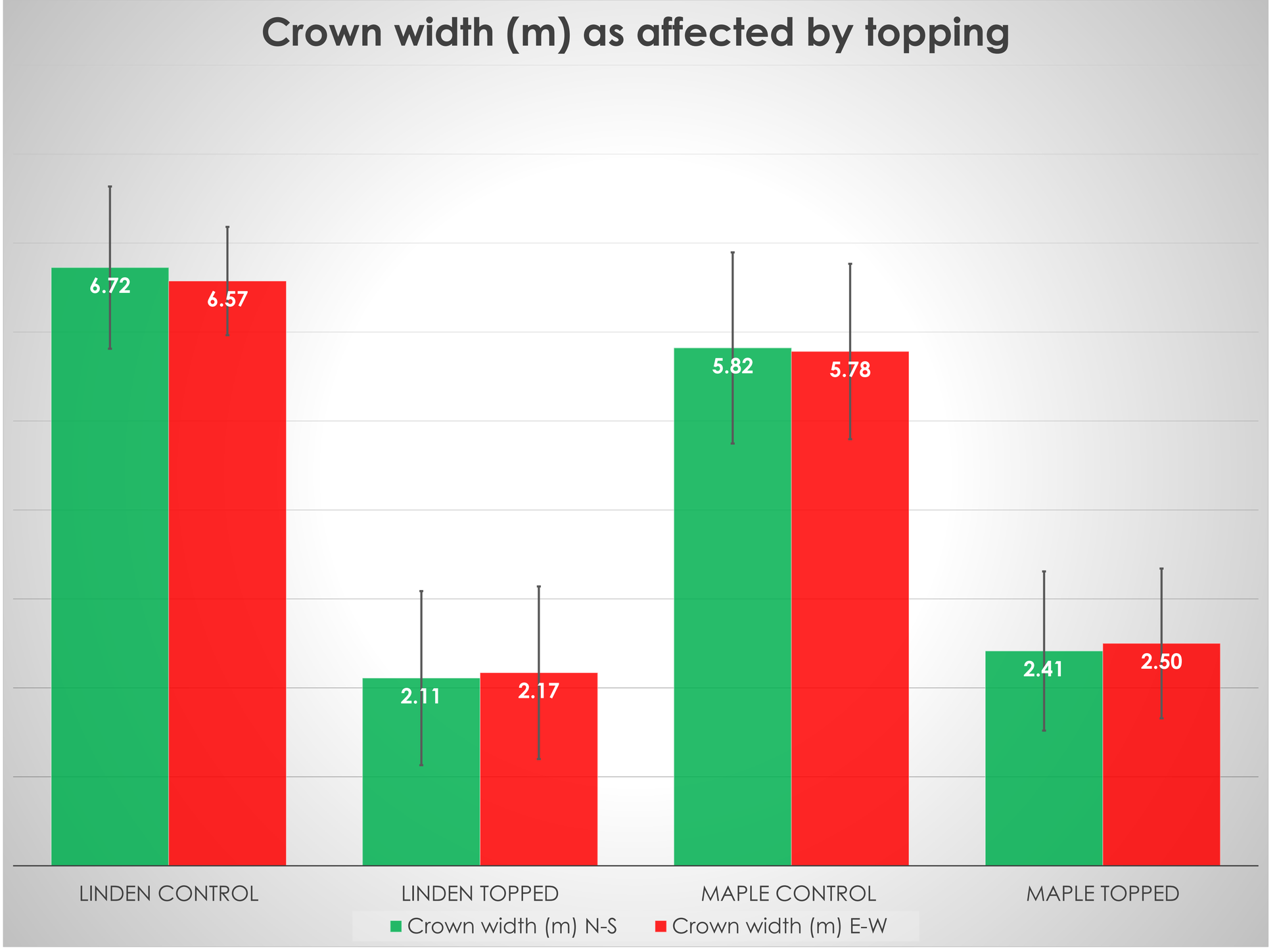
World Forum on Urban Forests
Mantova 2018

Topped trees had much longer shoots compared to the unpruned trees



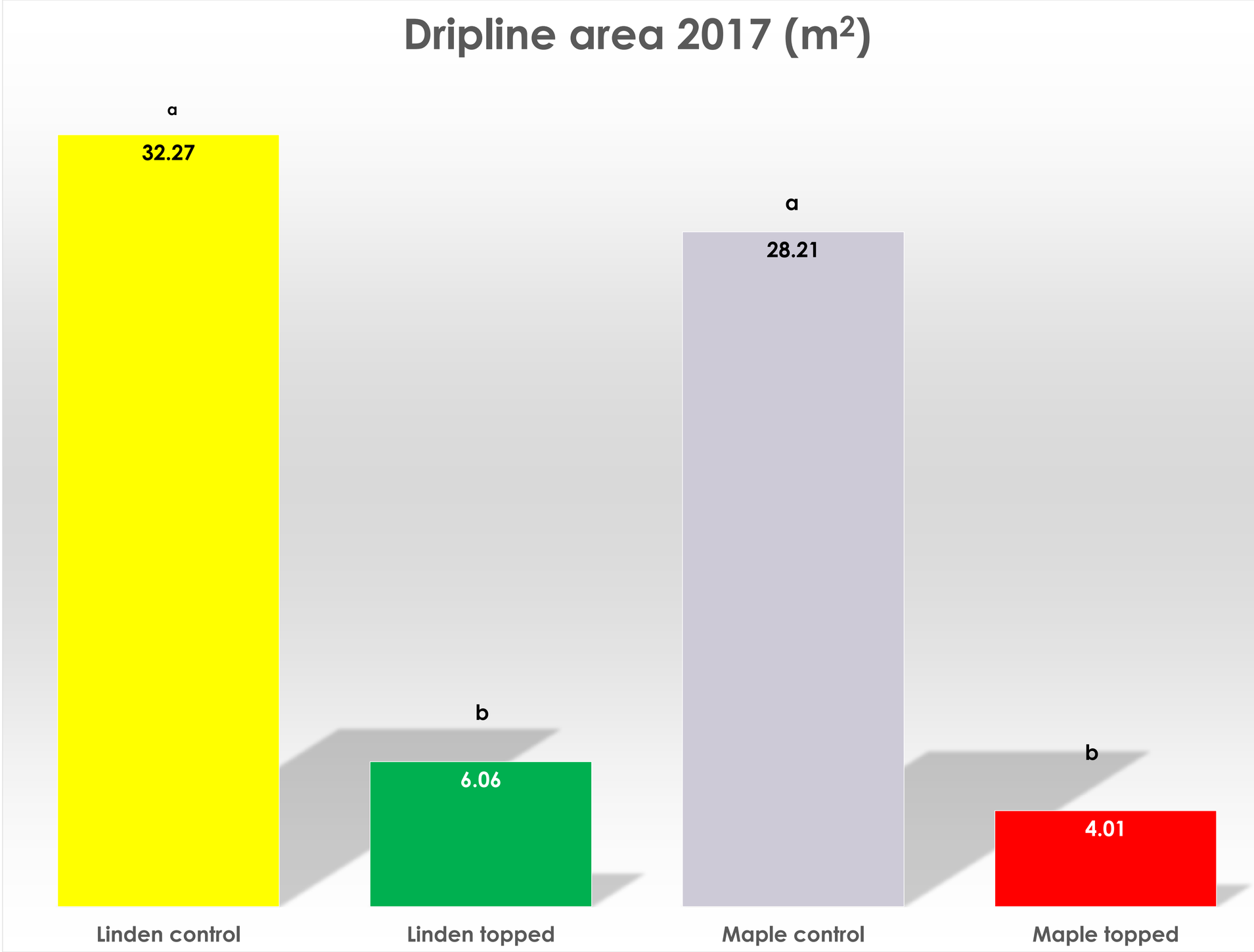
World Forum on Urban Forests
Mantova 2018

Crown width was clearly affected by pruning



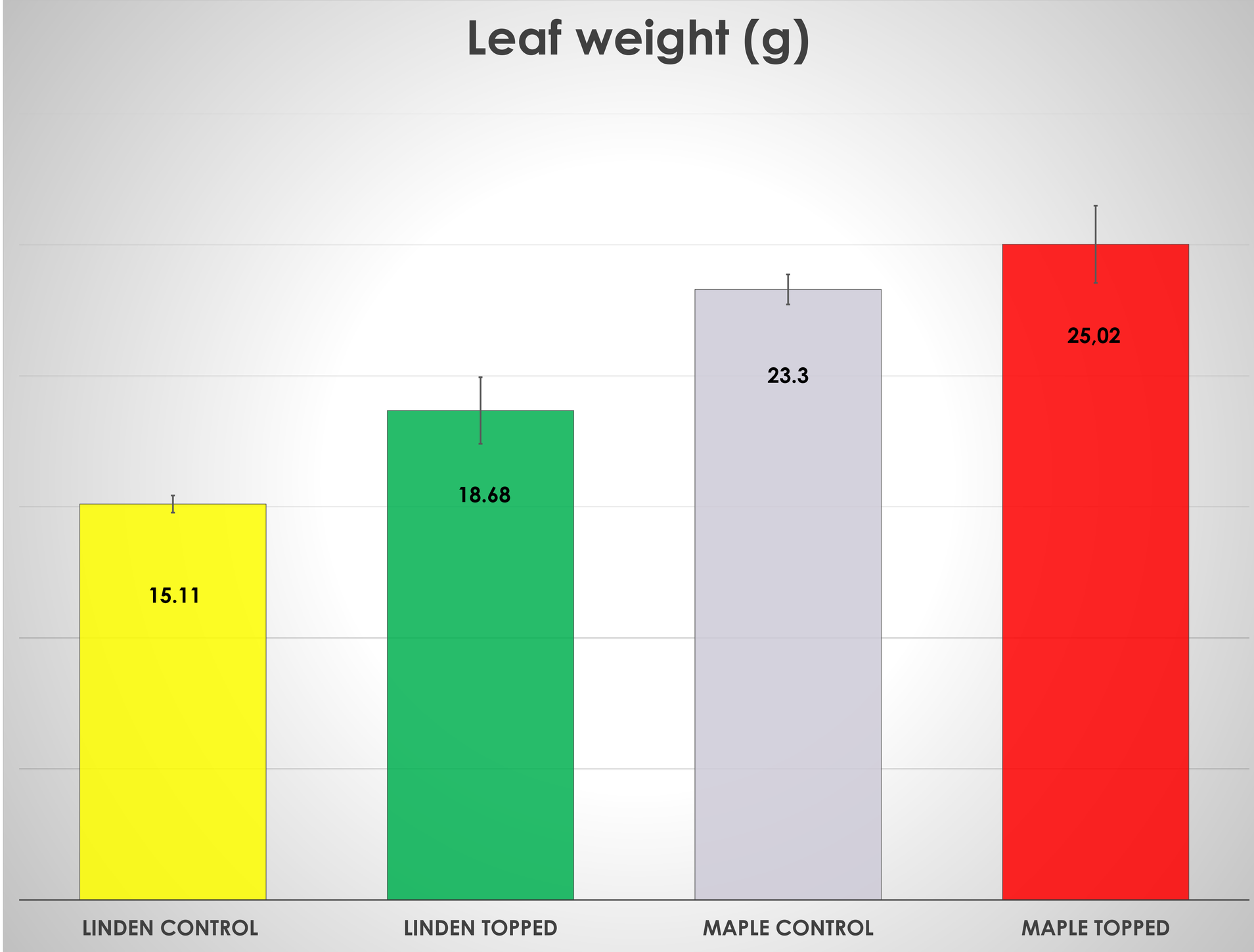
World Forum on Urban Forests
Mantova 2018

As a consequence also the dripline are was much bigger in the control trees



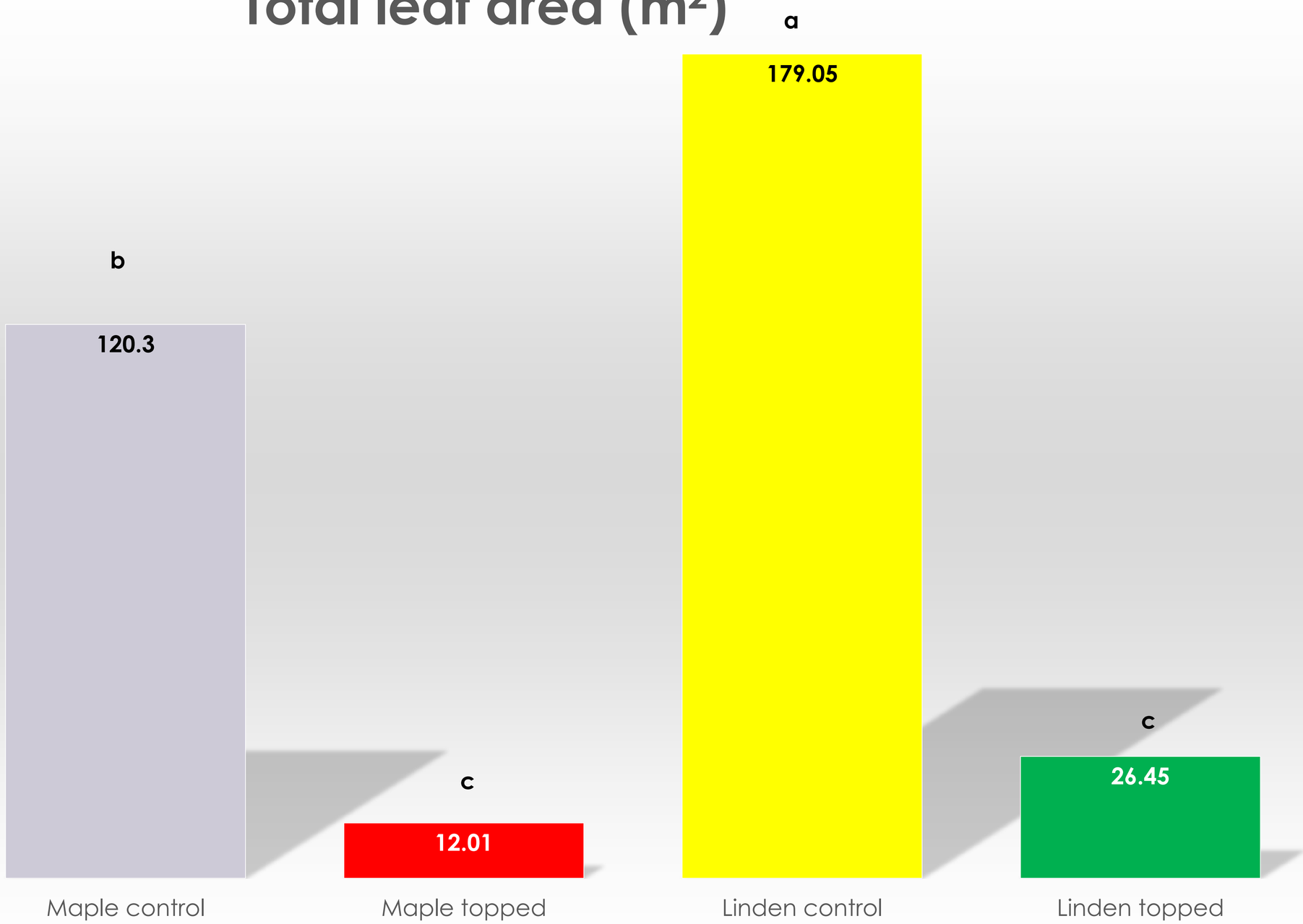
World Forum on Urban Forests
Mantova 2018

Topped trees had higher leaf weight on a single leaf basis compared to the unpruned trees in both specie



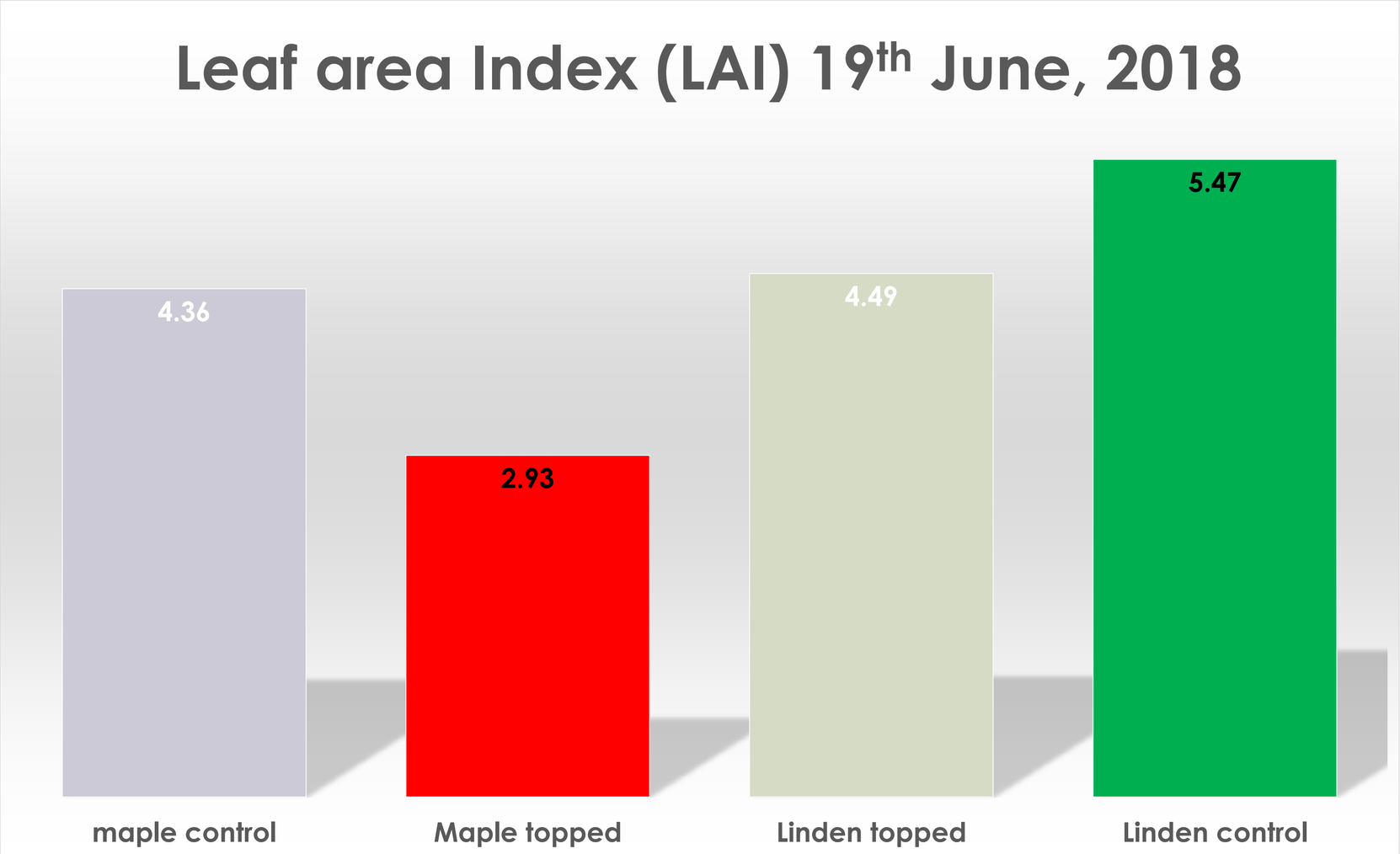
World Forum on Urban Forests
Mantova 2018

Control trees had much higher total leaf area compared to the unpruned trees



World Forum on Urban Forests
Mantova 2018

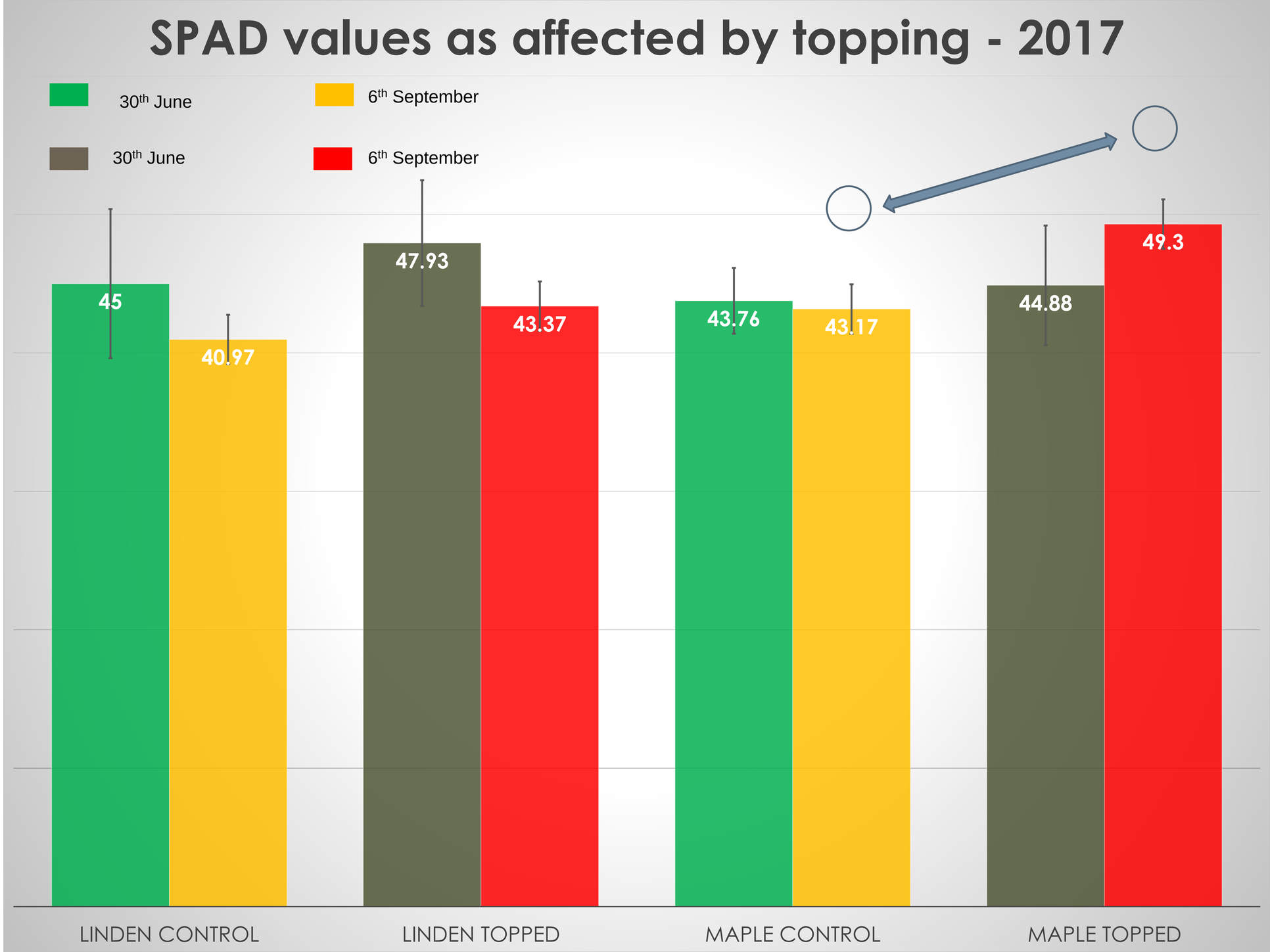
Control trees had higher LAI compared to the unpruned trees



LAI is used to predict photosynthetic primary production, evapotranspiration and as a reference tool for crop growth. LAI can be determined directly by taking a statistically significant sample of foliage from a plant canopy, measuring the leaf area per sample plot and dividing it by the plot land surface area. Indirect methods measure canopy geometry or light extinction and relate it to LAI.
Breda, N (2003). "Ground-based measurements of leaf area index: A review of methods, instruments and current controversies". Journal of Experimental Botany. 54: 2403–2417. doi:10.1093/jxb/erg263

World Forum on Urban Forests
Mantova 2018

Limited effect on the SPAD index though topped tree sometimes showed higher value



World Forum on
Urban Forests
Mantova 2018

Microclimatic data

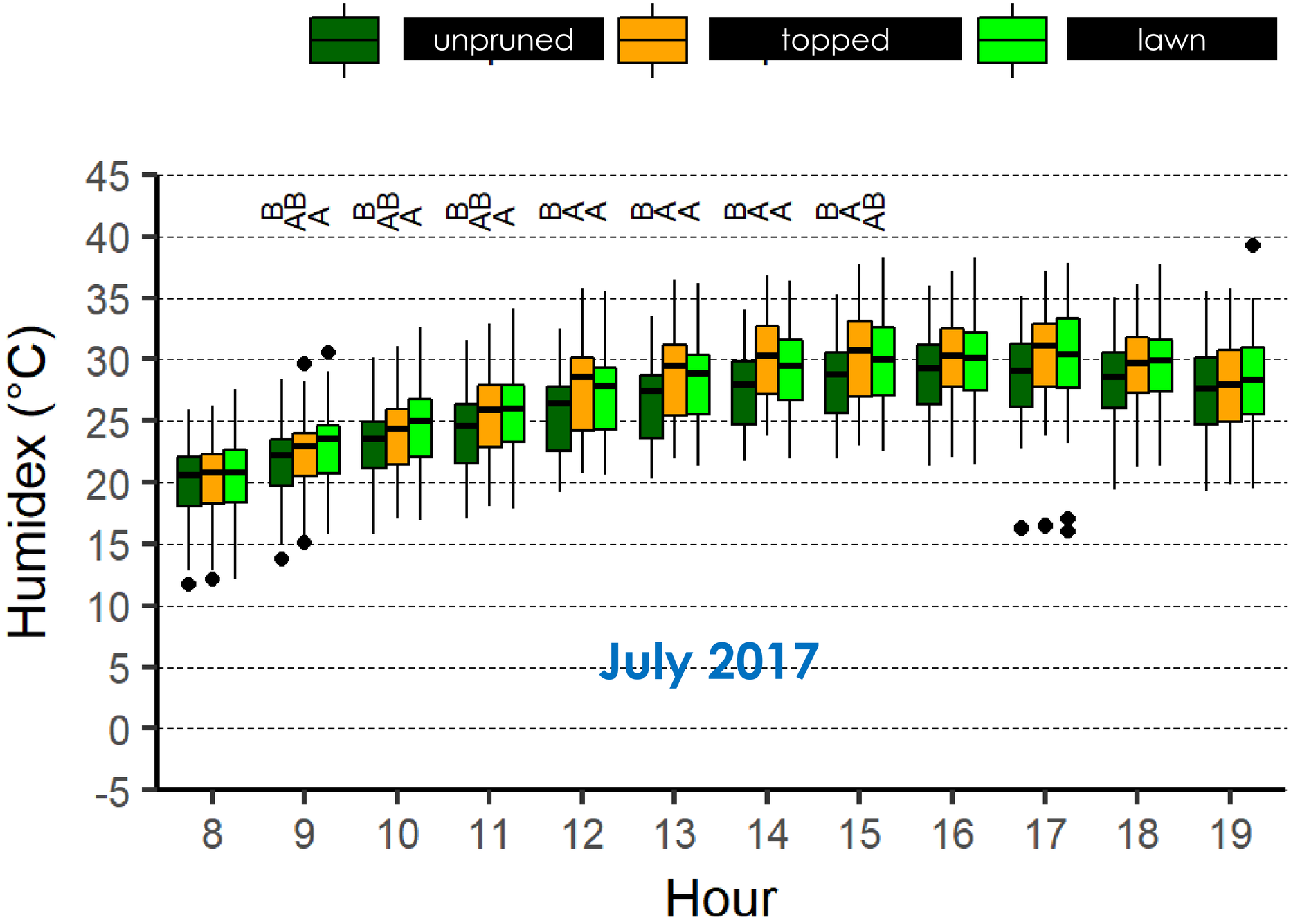
World Forum on Urban Forests
Mantova 2018

Humidex developed in Canada (Masterson and Richardson, 1965) reviewed in 1979 (Masterson and Richardson, 1979). It's still used by the Canadian Meteo Service **to estimate the perceived temperature in high temperature and humidity conditions**. H = Ta + (0,5555 x (Pa – 10))
Where H= Humidex; Ta= Air temperature(°C) and Pa= Vapour pressure (kPa)(Conti *et al.*, 2005).

Class	HUMIDEX	Degree of comfort
0	H<27	Comfort
1	27≤H<30	Some discomfort
2	30≤H<40	Great discomfort
3	40≤H<55	Dangerous
4	**H≥55**	**Very dangerous (heatstroke imminent)**

World Forum on Urban Forests
Mantova 2018

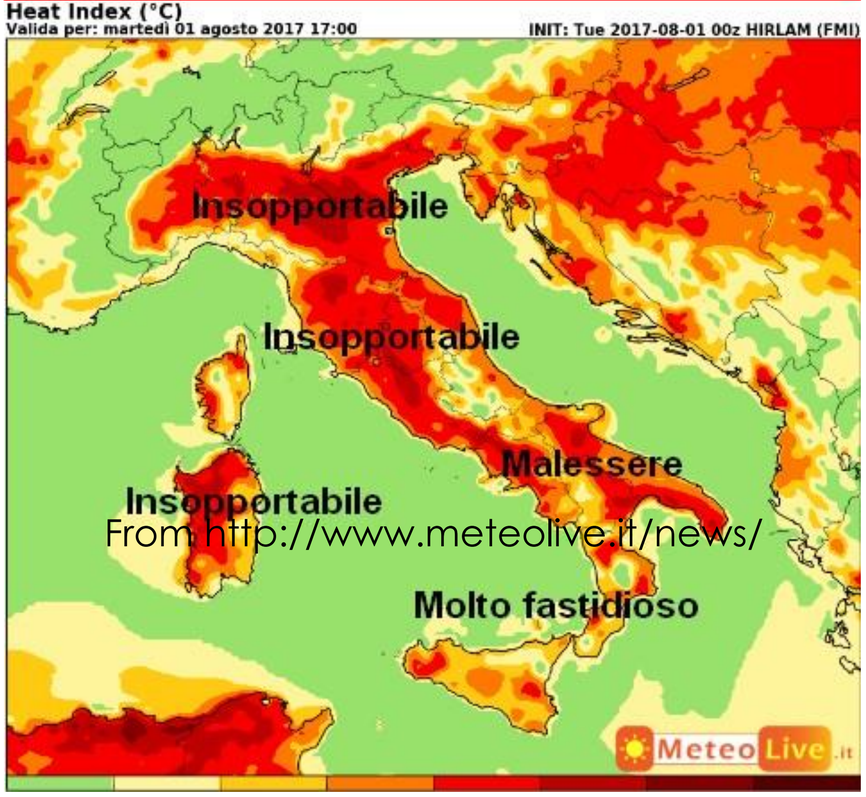
This index was higher in the «topped plots» for the whole season, especially during the central part of the day



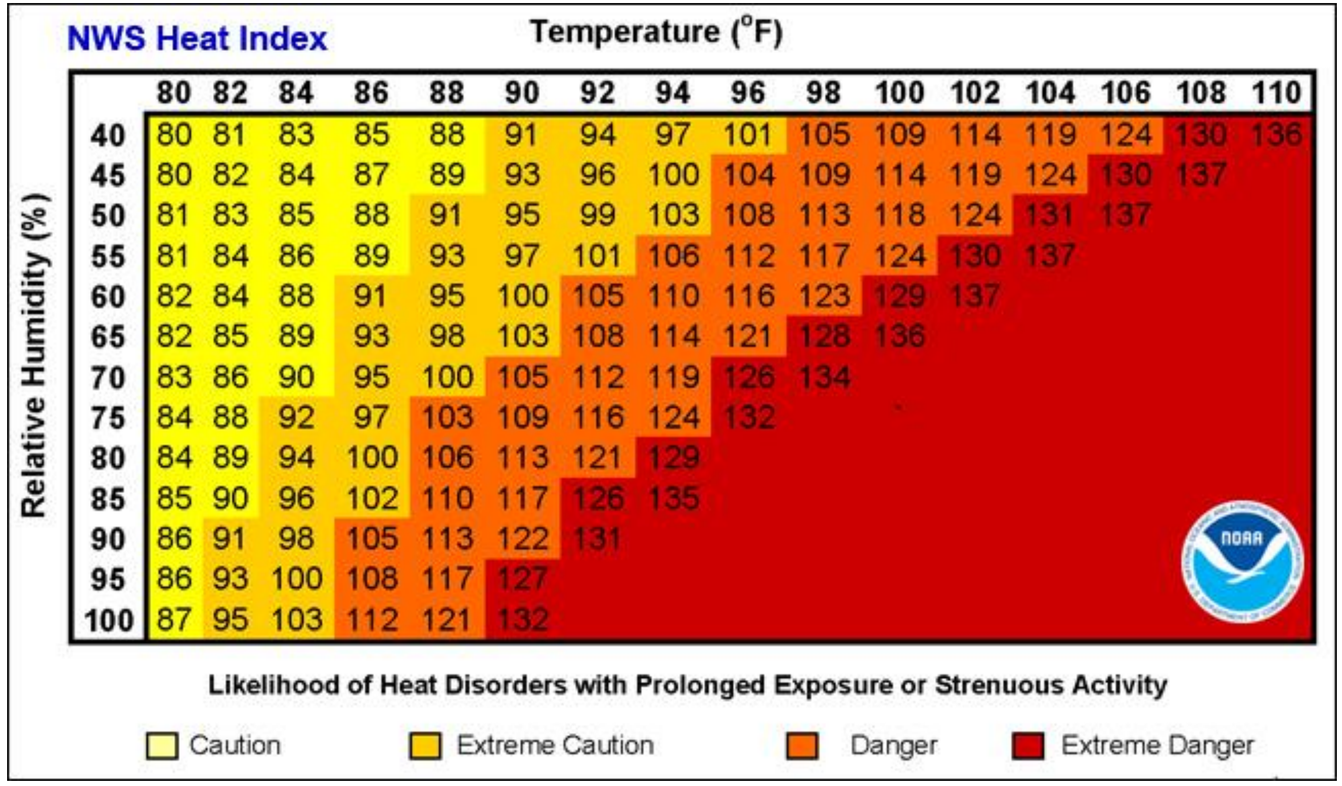
World Forum on Urban Forests
Mantova 2018

ATI - Apparent Temperature Index: Developed by Steadman (Steadman, 1979) reviewed by (Steadman, 1994) which **combines in a formula the temperature and wind (Wind Chill) or temperature and humidity (Heat Index)** for the indicated hour

Heat discomfort index 1st August, 2017

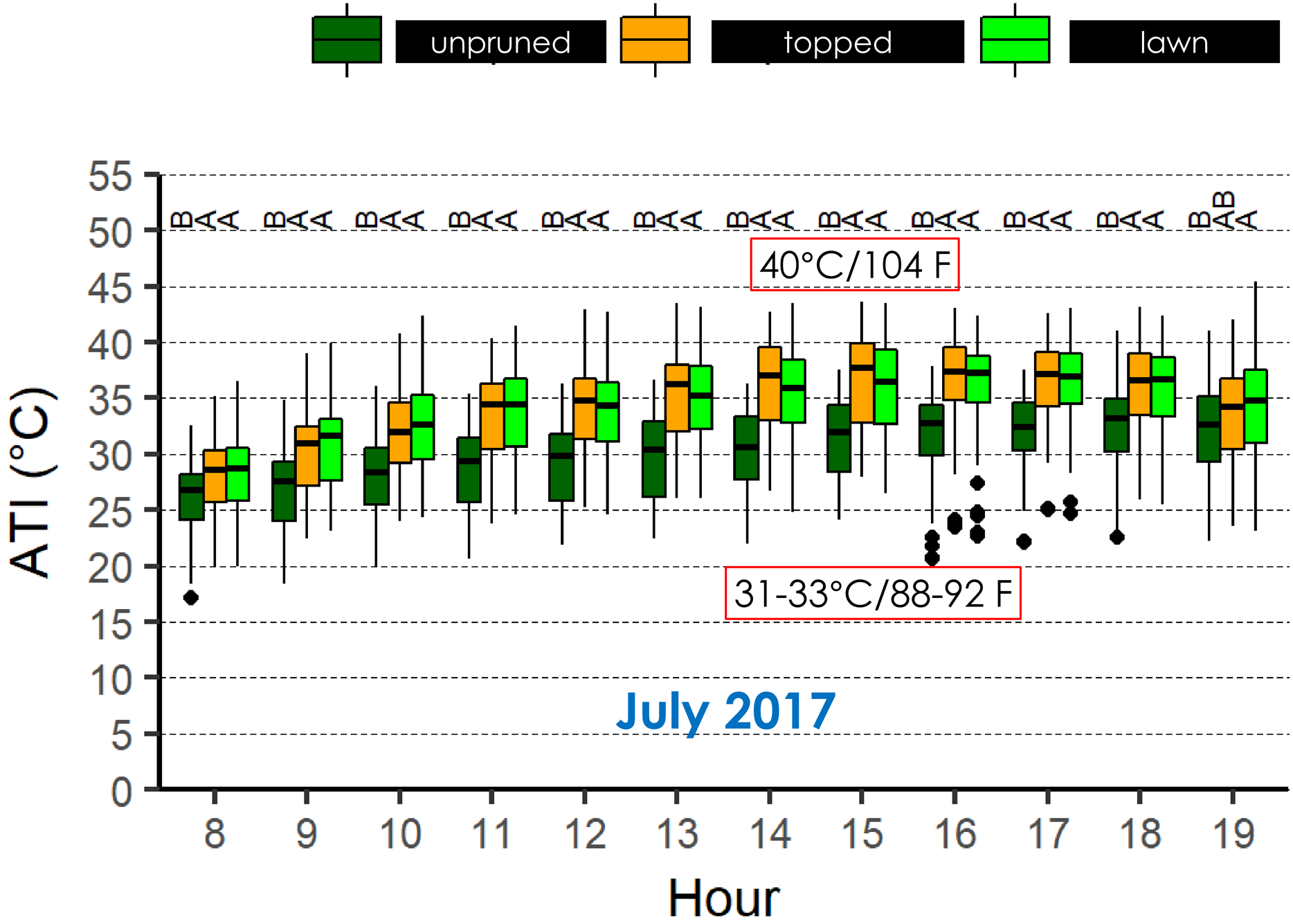


From http://www.meteolive.it/news/



World Forum on Urban Forests
Mantova 2018

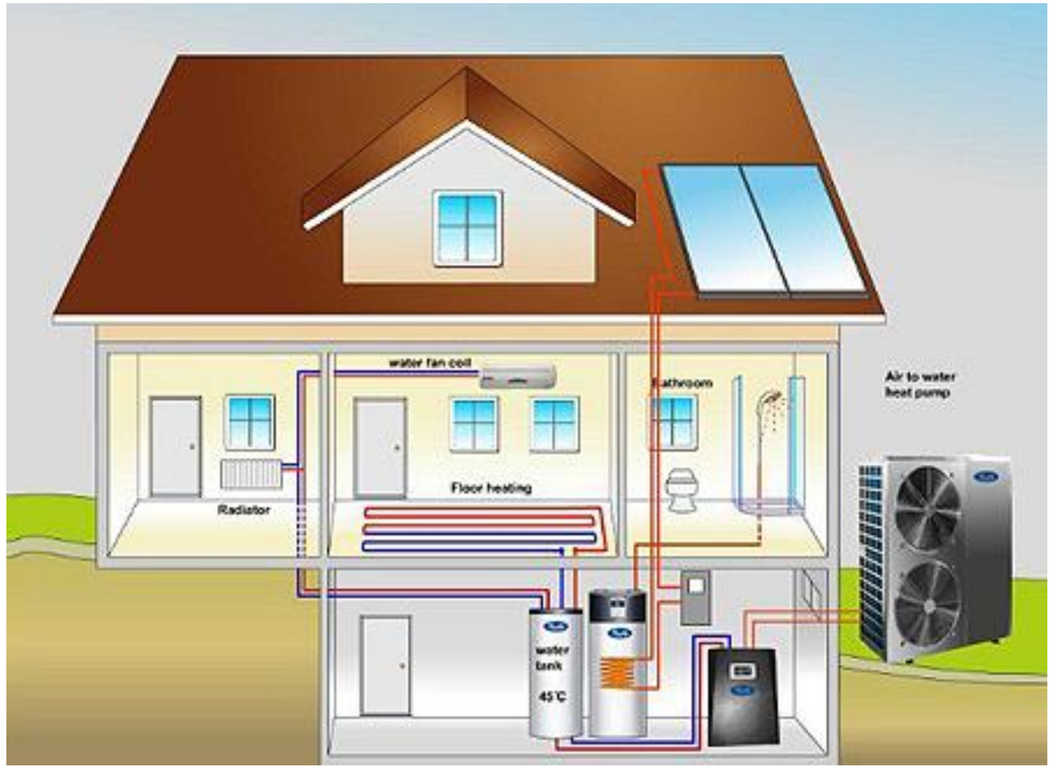
This index was higher in the «topped plots» for the whole season, during the whole day and this happened for all



World Forum on Urban Forests
Mantova 2018

P = 25 x 10 x 10 x 3 = 7500 Watt equivalent to 25.500 Btu/h (British thermal units). 1 BTU = 1,055 joules, 252 calories, 0.293 watt-hour or the energy released by burning one match. 1 watt is approximately 3.412 BTU per hour. About 7.5 Kwatt/hour

Metri Qadri	Btu / ora	K watt / ora
20 mq	5.000	1,5
30 mq	8000	2,3
40 mq	11000	3,2
50 mq	13000	3,8
60 mq	16000	4,7
70 mq	19000	5,6
80 mq	21000	6,1
90 mq	24000	7
100 mq	27000	7,9
110 mq	30000	8,8
120 mq	32000	9,4
100 mq	27000	7,9
110 mq	30000	8,8
120 mq	32000	9,4



A domestic air conditioning system that operates for 8 hours a day for 4 months will consume approximately 1,000-2,000 kWh (of which about 1/10 only to power the fan), assuming a cost of electricity 0.22 euros / kWh corresponds **to a charge of 220-440 euros for summer cooling…**

Photo courtesy: http://www.consulente-energia.com/iq756.jpg

World Forum on Urban Forests
Mantova 2018

Conclusions

1) Phenological phases were delayed in topped trees (data not shown)
2) Shoot growth was much higher in topped trees
3) Leaf area and LAI where much lower
4) Physiological data (not shown in this presentation) confirm what found in the previous research: topped trees have an altered tree physiology that determines a shift to a more pioneer behavior
5) **Microclimate was strongly affected by topping**

World Forum on Urban Forests
Mantova 2018

RESEARCH SUPPORTED BY TREE FUND:
EFFECT OF TOPPING ON MICROCLIMATE CONDITION AND HUMAN COMFORT

Jack Kimmel International Grant in the amount of $10,000.00