

The Wind in the Woods

A Lesson in Tree Biomechanics

EVERSOURCE Energy Center

Storm Damage Forecasting

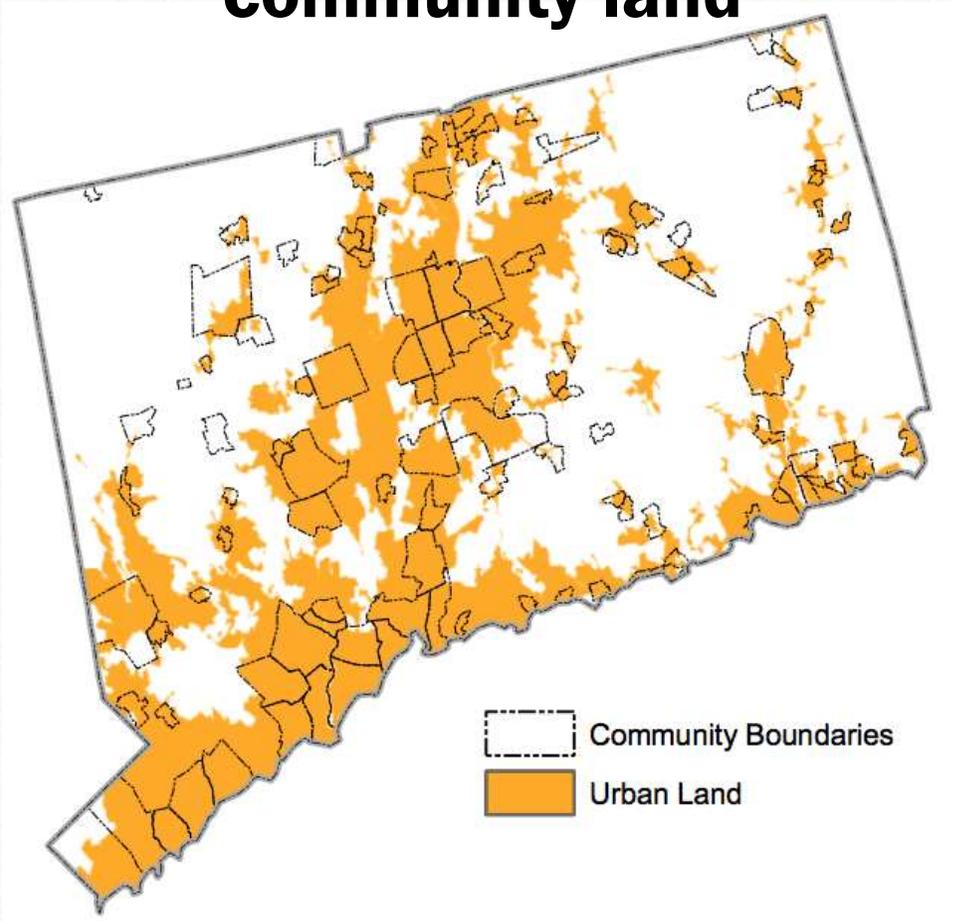
Stormwise Forest Management Program

Electric Grid Reinforcement

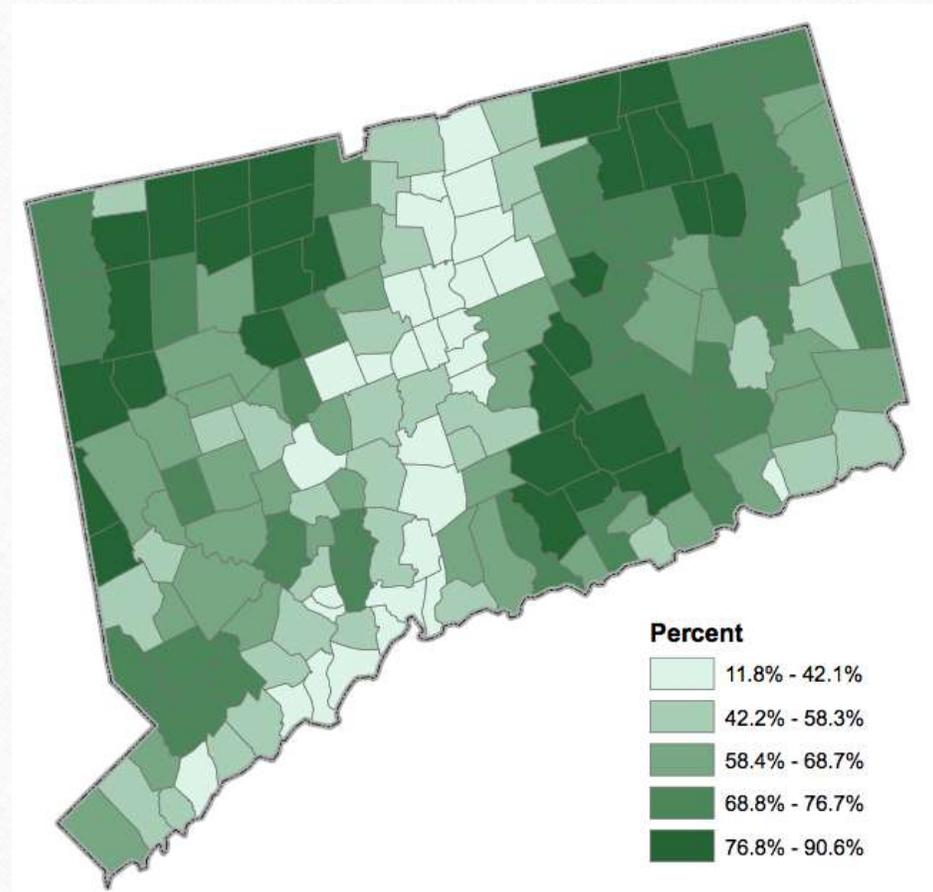
Reducing Power Outages by Creating Healthy Roadside Forest

- Forest and utility mapping
- Value recovery and wood products
- Management Demonstration Sites
- Human Dimensions of urban woodlands
- **Tree Biomechanics**
 - Amanda Bunce
Graduate Research Assistant at UCONN

Urban or community land



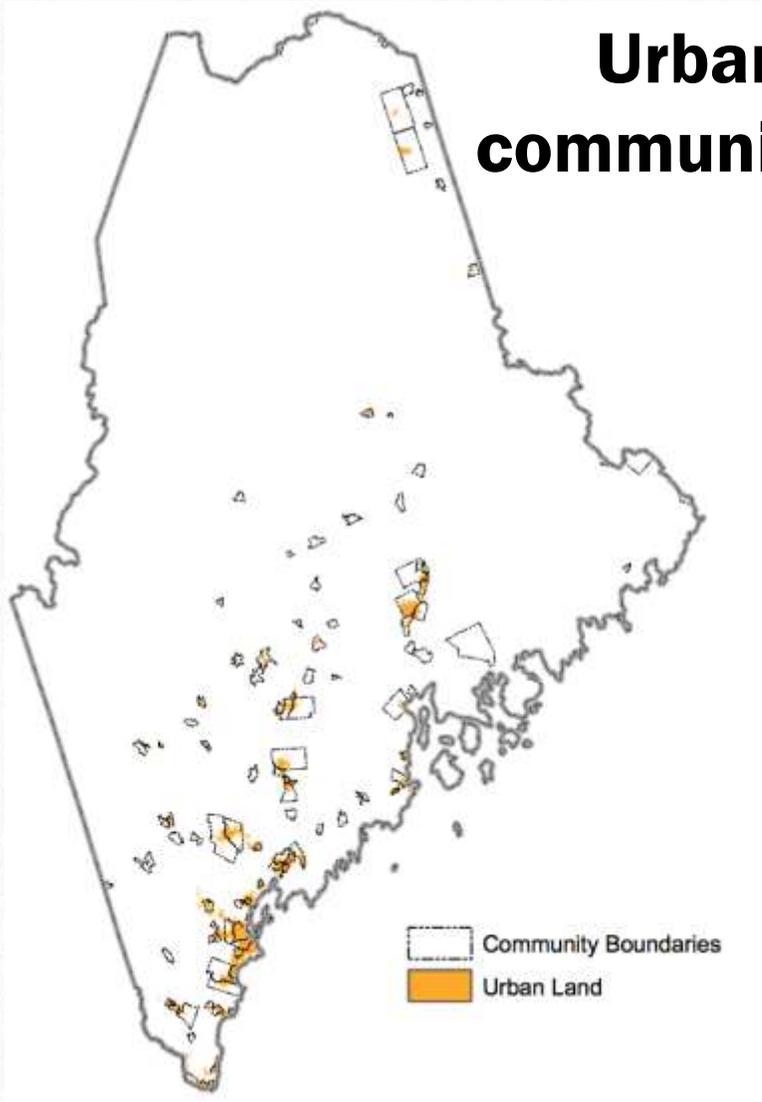
% Forest cover



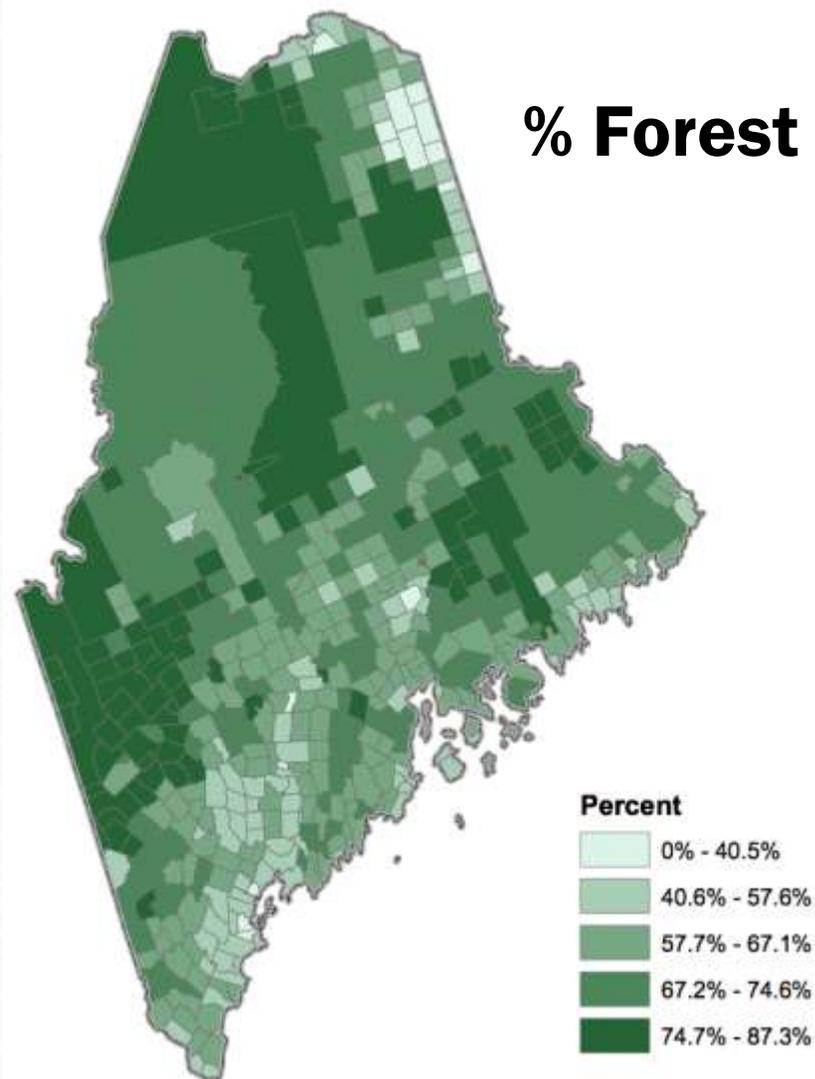
65%

(Maps from Nowak, 2008)

Urban or community land



% Forest cover



20%

(Maps from Nowak, 2008)

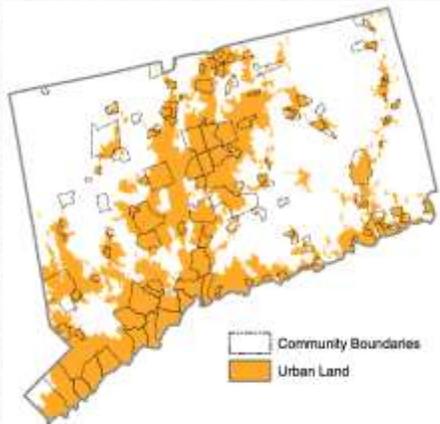


Figure CT-1.—Urban or community land in 2000; urban area relative to community boundaries.

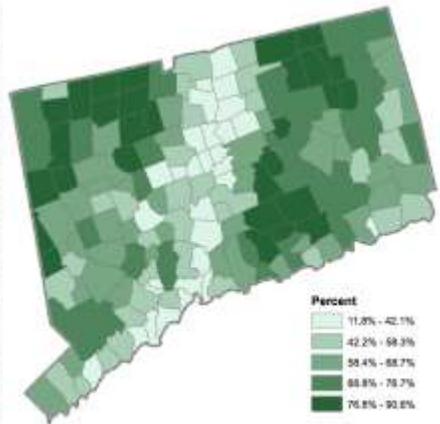


Figure CT-5.—Percentage tree canopy cover within county subdivisions.



- 121.9 million trees
- 23.3 million metric tons of C stored (\$531.2 million value)
- 767,000 metric tons/year of C sequestered (\$17.5 million value)
- 17,380 metric tons/year total pollution removal (\$145.1 million value)





Power lines and trees knocked down by
Superstorm Sandy on Davis Hill Road in Weston, CT.
Photo by Sgt. Mike Ferrillo. November 8, 2012. <https://internationalmedicalcorps.org>



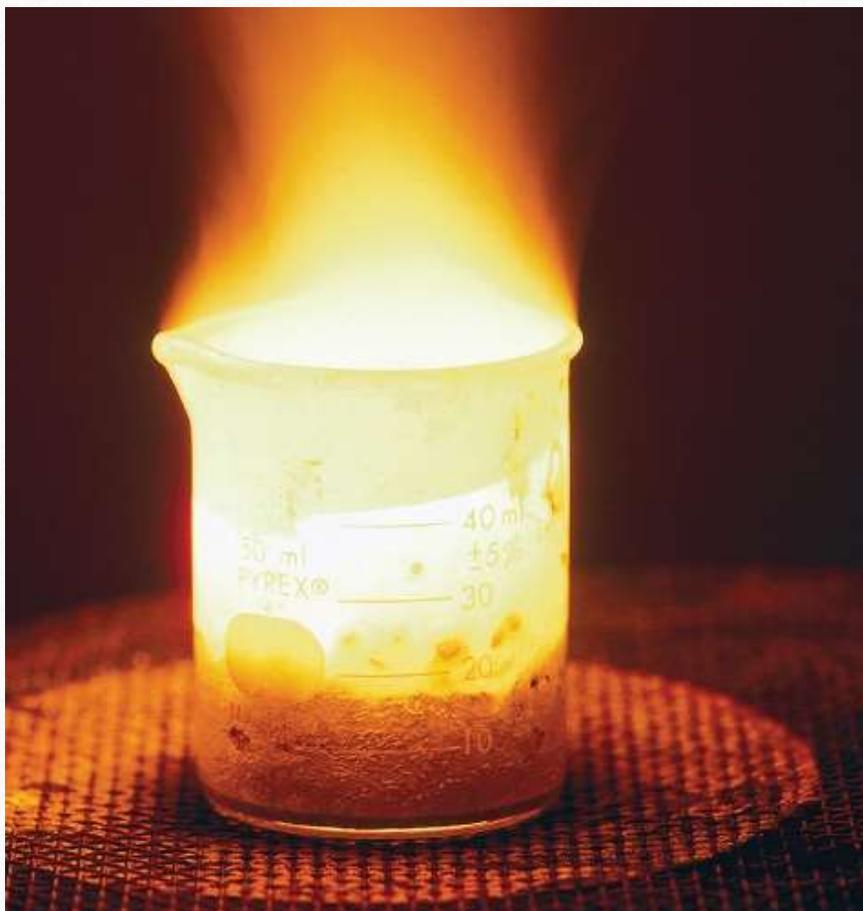
How Trees Interact with the Wind



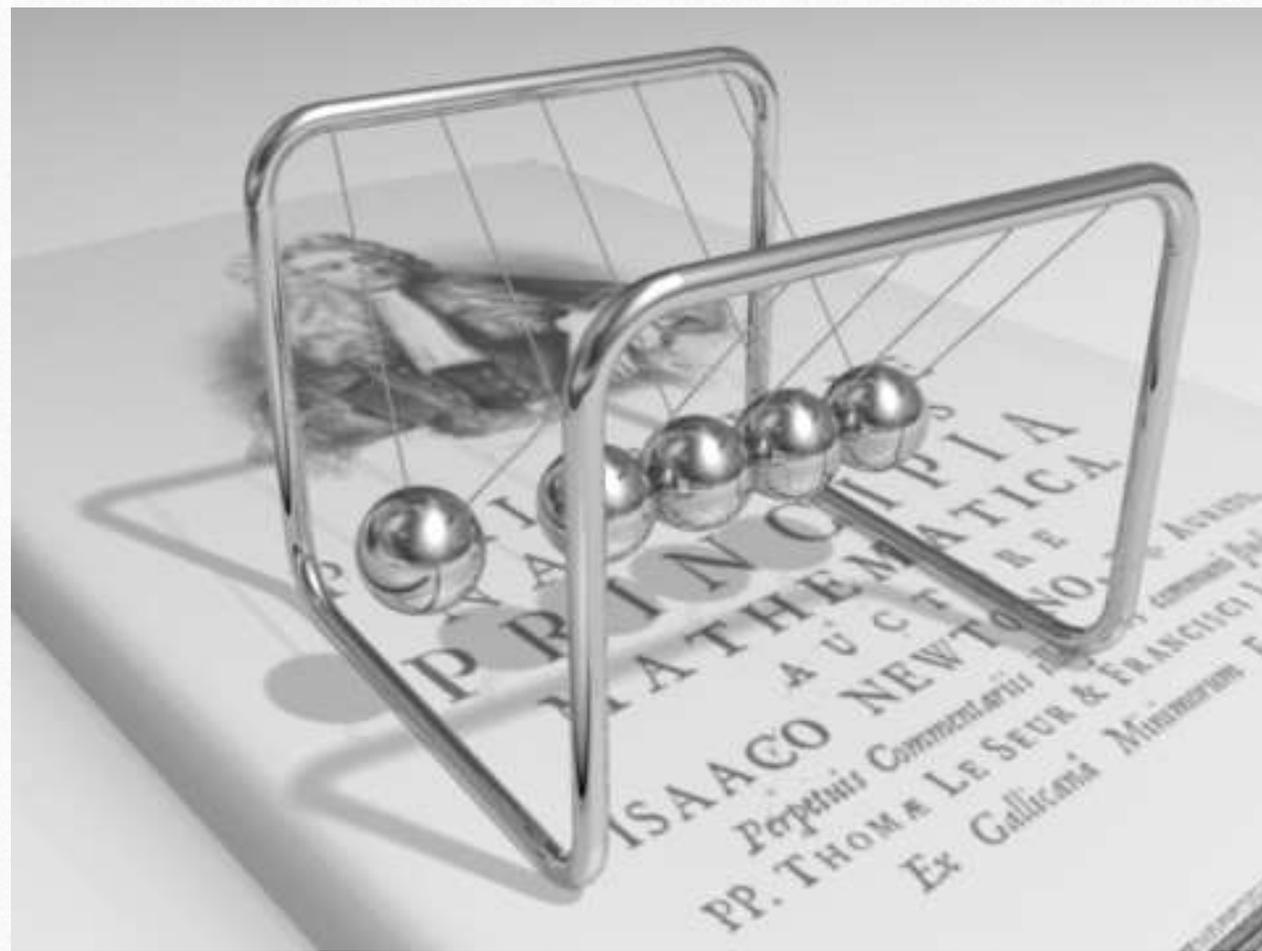
1) Immediate kinetic reaction.
a.k.a. “sway”

2) Long-Term reaction
Developmental and adaptive
a.k.a. “thigmomorphogenesis”





<http://factfile.org/10-facts-about-chemical-reactions>



https://upload.wikimedia.org/wikipedia/commons/e/e8/Newtons_cradle_animation_book.gif



Tree Sway: A Periodic Motion

Frequency : How fast the tree sways occur

Amplitude : How far the tree bends

Tree Sway: A Periodic Motion

Motion Damping : Coming to a stop

Streamlining : Avoiding the wind force

Motion Damping

Crown Clashing

50%



Motion Damping

Crown Clashing **50%**
Aerodynamic Damping **40%**
Or “Drag”



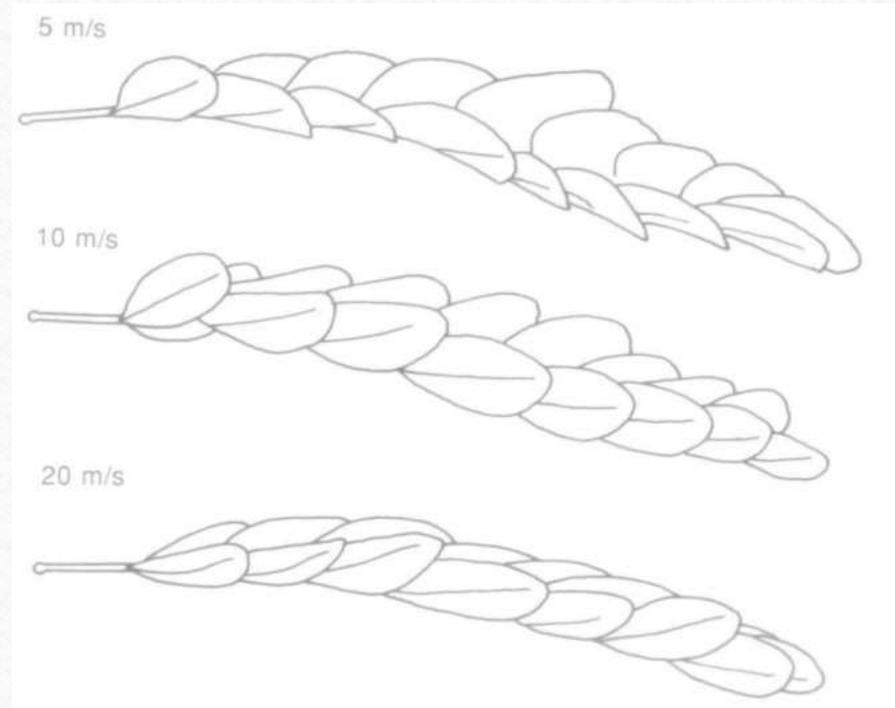
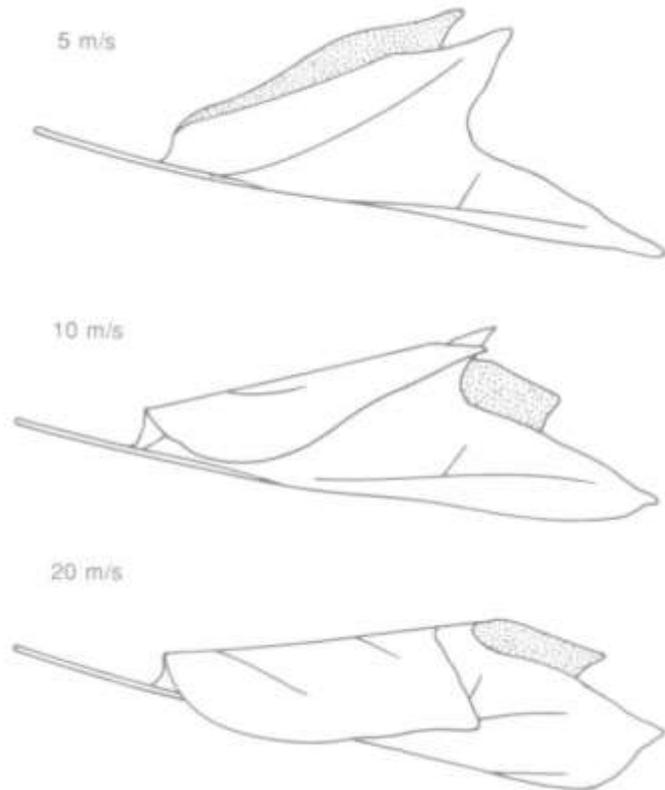
Motion Damping

Crown Clashing	50%
Aerodynamic Damping Or “Drag”	40%
Viscous or Internal Damping	10%

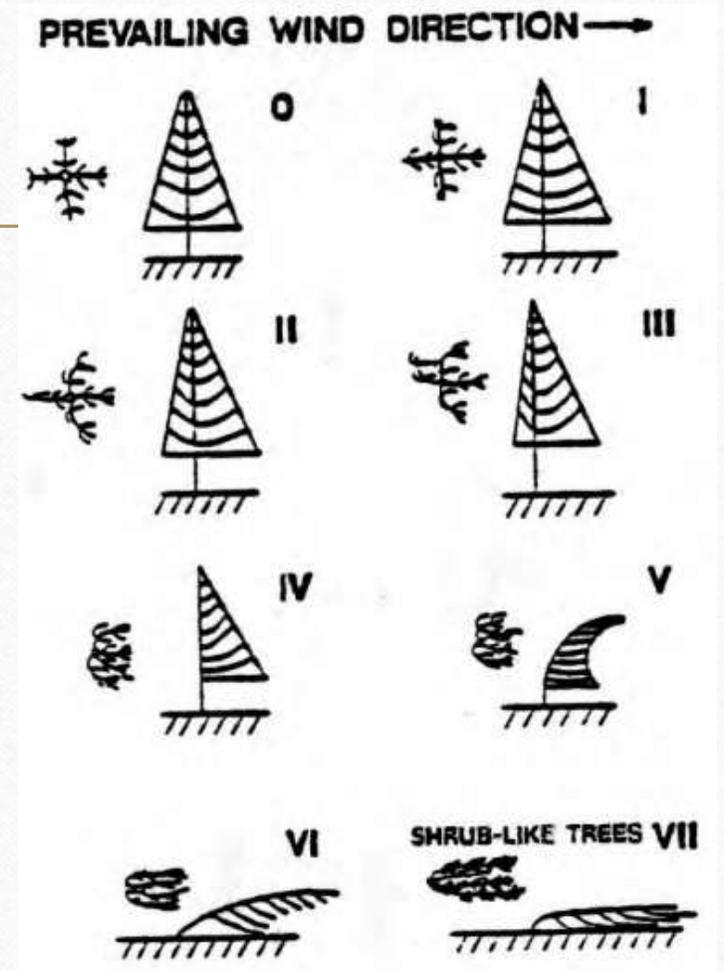
(Milne, 1991)



Streamlining



Streamlining



Risk of sway #1

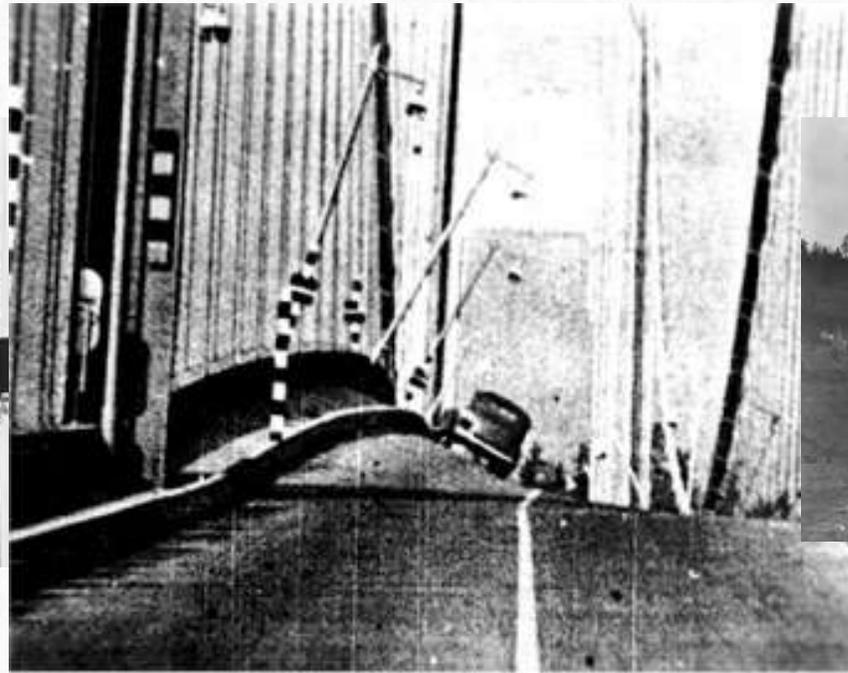
Amplitude Greater than Capacity



Risk of sway #2 Resonance



Resonance

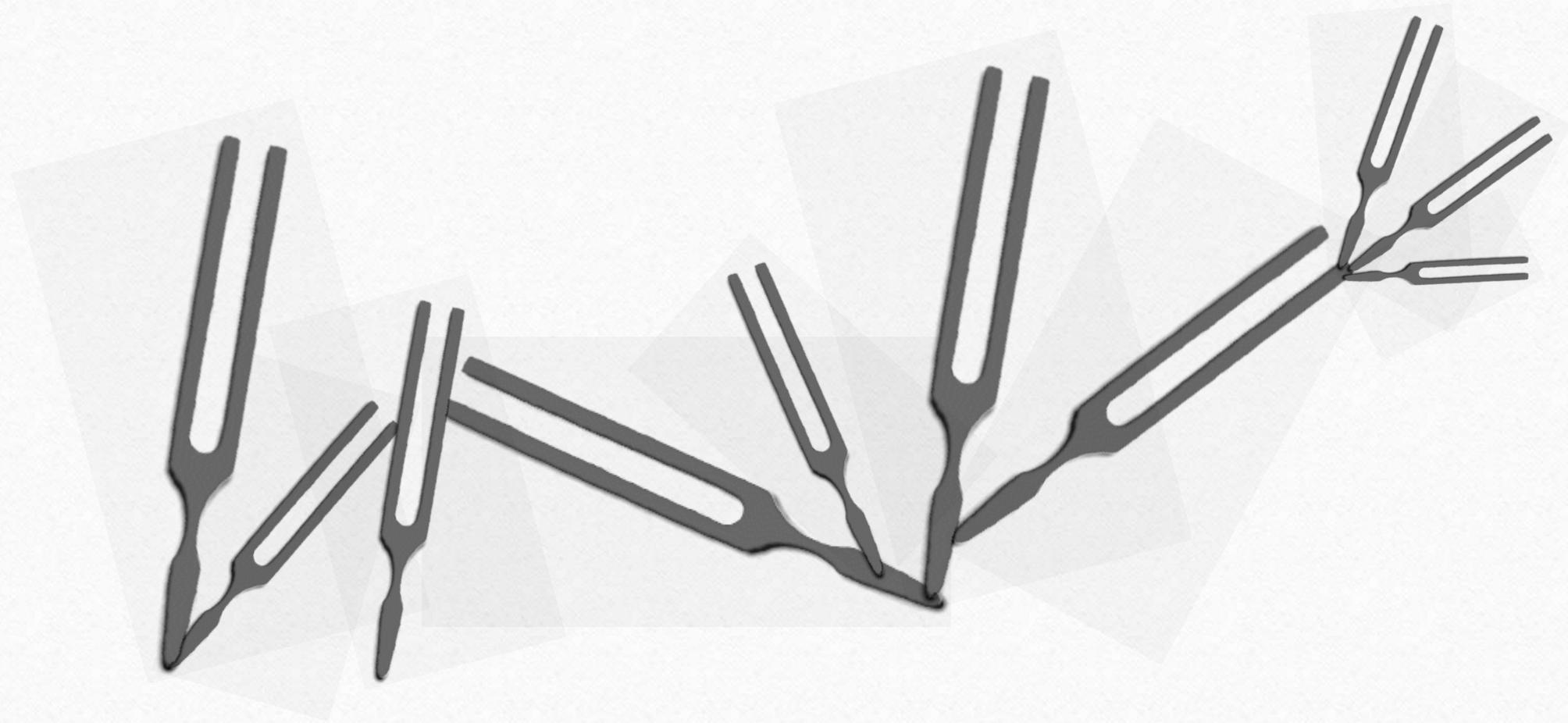


Tacoma Narrows Bridge collapse, 1940.

Only a 35 mph wind was blowing.

University of Washington Libraries, Special Collections, FAR016



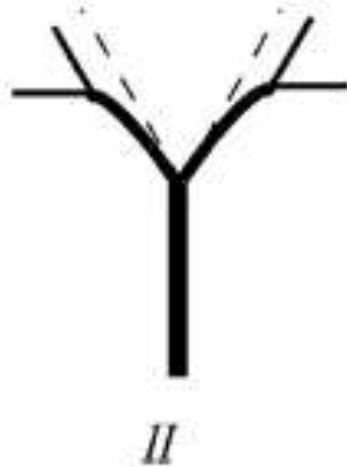




Model of an idealized branched tree



I



II



III

**3 different orders of
branching**

**Corresponding to
3 frequency modes**

1) Immediate kinetic reaction.
a.k.a. “sway”

2) Long-Term reaction
Developmental and adaptive
a.k.a. “thigmomorphogenesis”

Thigmomorphogenesis

A growth response to mechanical stimuli

Coined in 1973

Jaffe, Mordecai J. "Thigmomorphogenesis: the response of plant growth and development to mechanical stimulation." *Planta* 114.2 (1973): 143-157.



Jaffe, M. J. "Morphogenetic responses of plants to mechanical stimuli or stress." *Bioscience* 30.4 (1980): 239-243.



<http://lifeofplant.blogspot.com/2011/01/thigmomorphogenesis.html>



Gerald and Buff Corsi © California Academy of Sciences



Charles Webber © California Academy of Sciences
<https://www.fs.fed.us/database/feis/plants/tree/pinjef/all.html>



Improved root anchorage

Larger, flared base

Streamlining

Lesser shoot elongation

Greater diameter growth

more tapered shape

Shorter internodes and branches

Thicker branch nodes

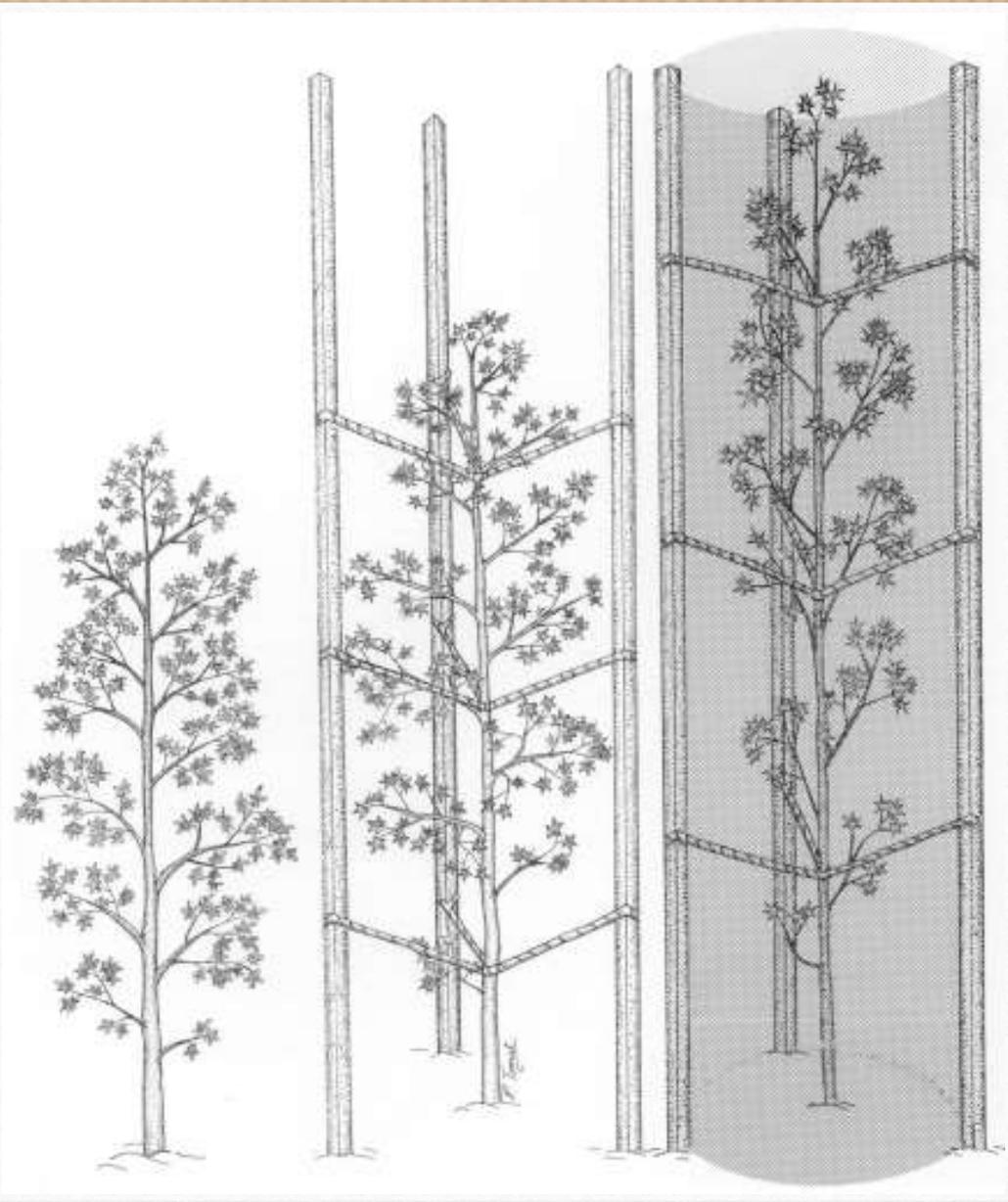
Smaller leaves

Increased flexibility and density

Changes in cellular structures and division

Compression and tension wood





Where do tree/wind dynamics come into play?

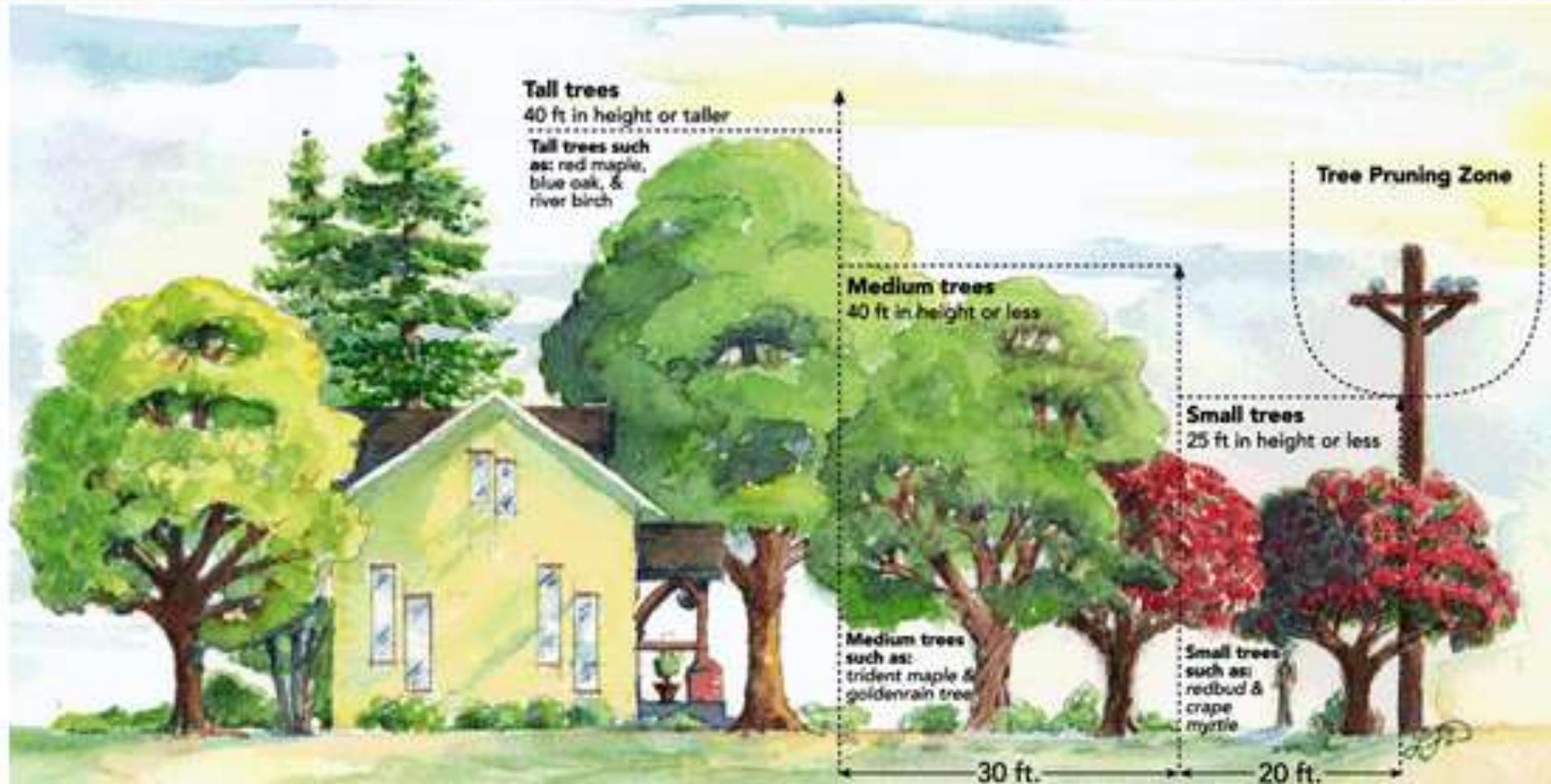
Planting and Species Selection

Staking for new trees

Pruning

Forest management

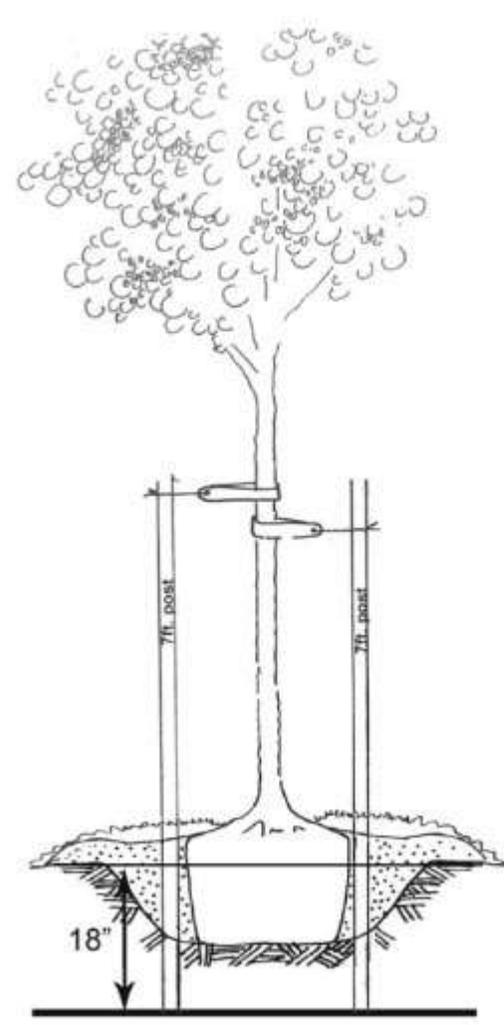
Species Selection



Right tree right place

http://www.state.nj.us/dep/parksandforests/forest/community/Tree_Planting.htm

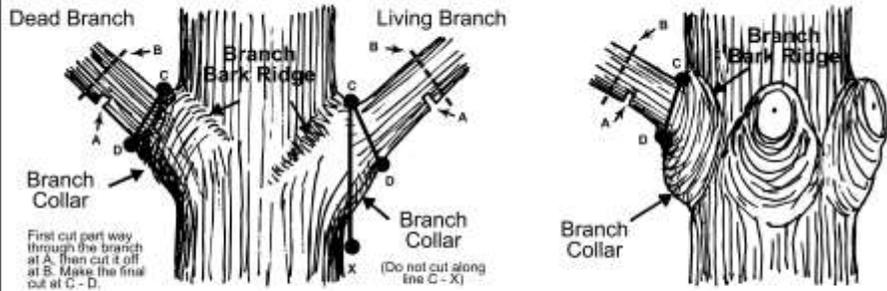
Staking: Pros and Cons



<http://www.treeservicesmagazine.com/tree-health/caring-for-newly-planted-trees/>

https://www2.bgky.org/tree/planting_stakingcare.php

Proper Pruning Principles



Hardwoods

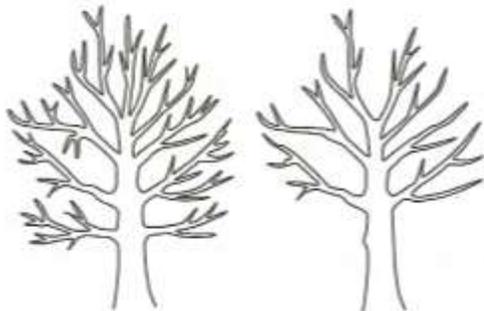
Conifers

Arbor Day Foundation®

Pruning



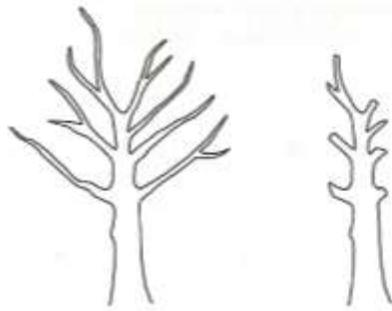
YES



Plan pruning work in advance

Remove up to 25% of crown for healthy tree

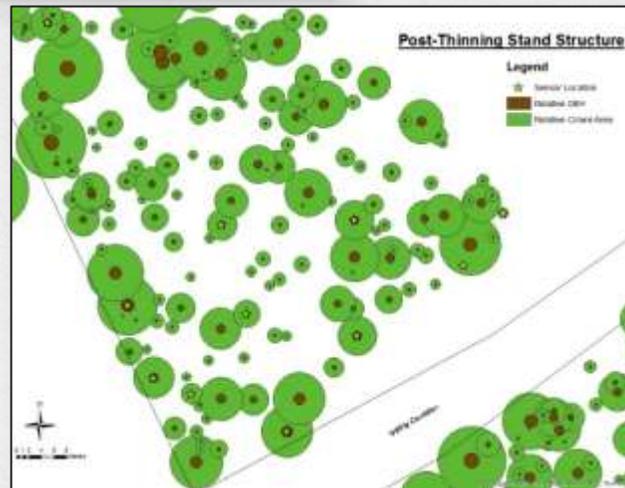
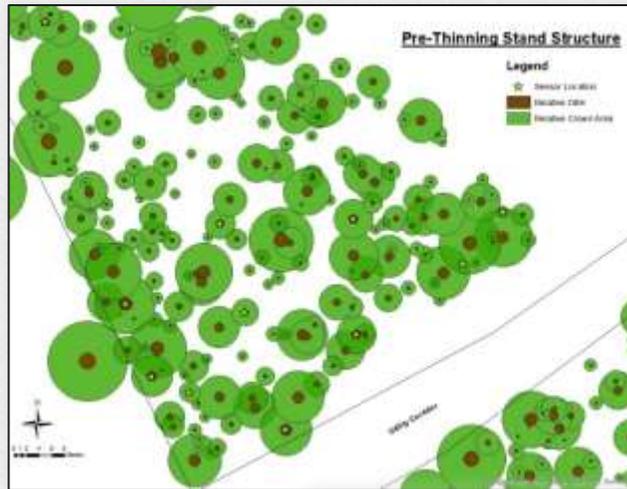
NO



Heavy pruning should be done over several seasons

Topping is very harmful to trees. DON'T DO IT!

Forest Management



Thank you!

Questions

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