The terminal portion of the plant hydraulic continuum: branch and leaf vulnerabilities to hydraulic dysfunction

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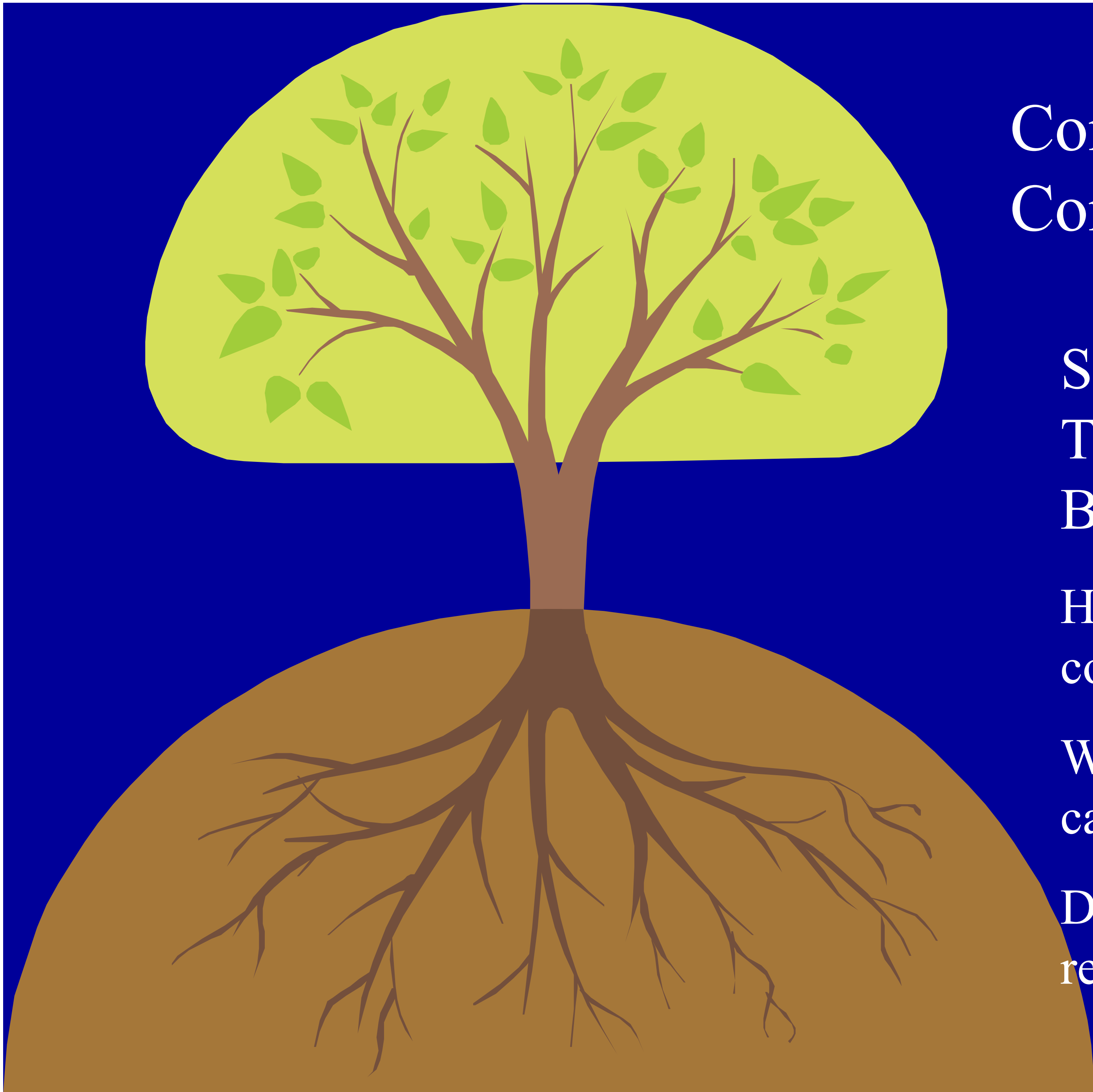
Background

- In order to:
  - 1) prevent runaway embolism
  - 2) allow maximum carbon gain
- Entire hydraulic pathway has to be tightly coordinated, from stomata upstream
- However, few studies have looked at the entire pathway
- Objective – compare branch and leaf resistance to hydraulic dysfunction

  - Overarching – compare properties of entire axial pathway from root to leaf



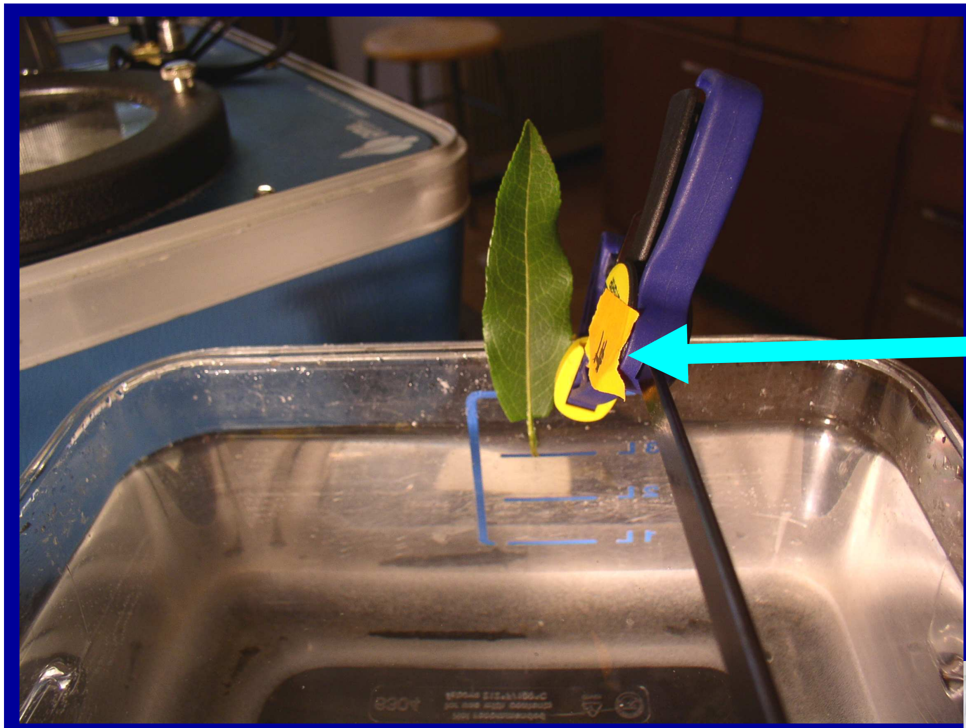
Conductances/ Conductivities

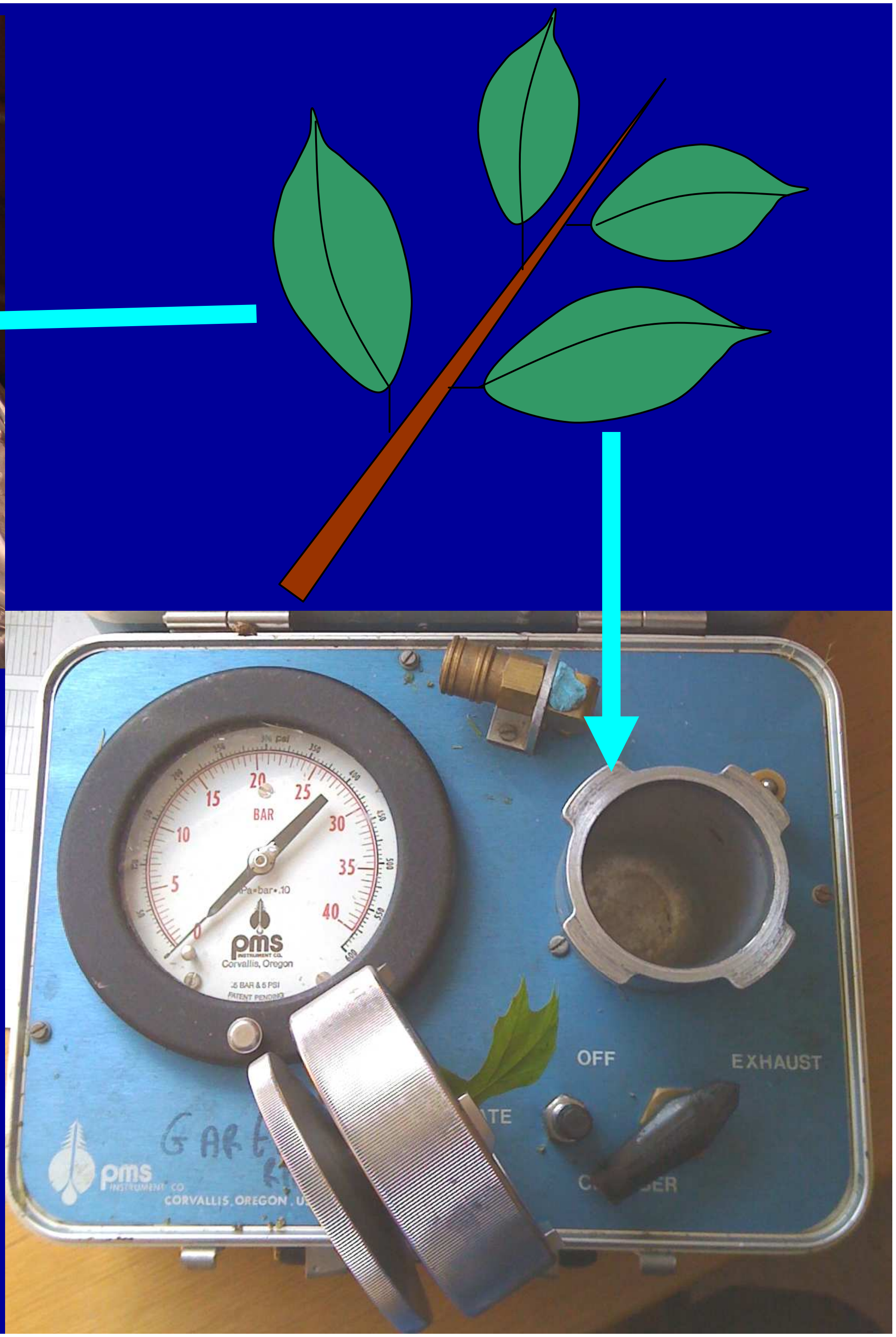
Soil → Root → Trunk → Branch → Leaf

How are they coordinated?

What about capacitance?

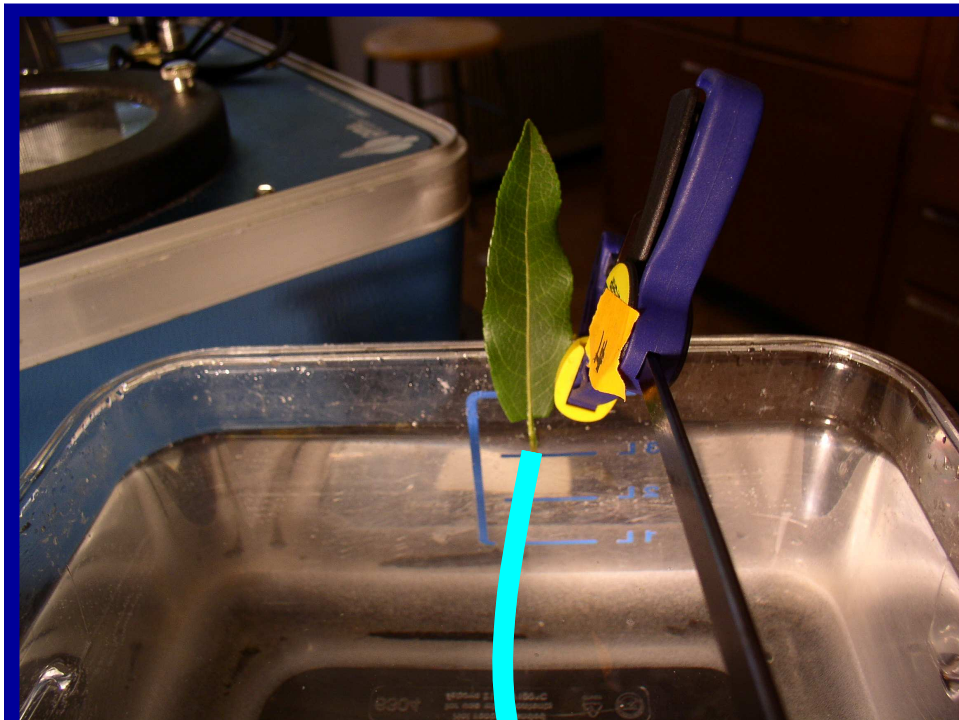
Diel decline and recovery?

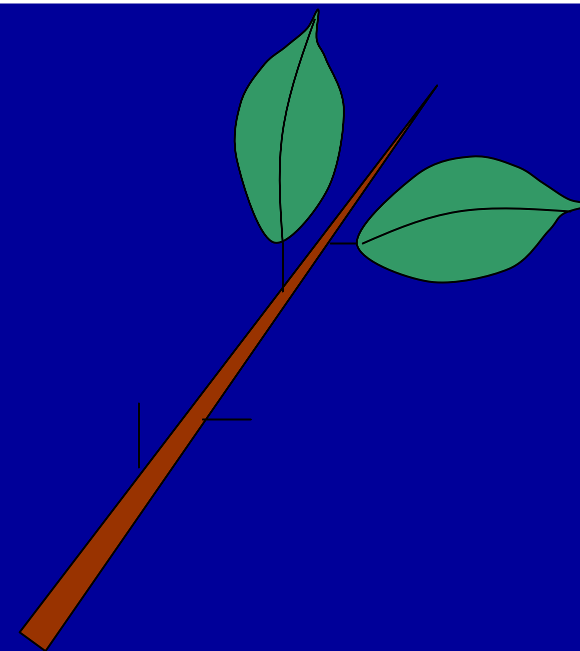




Timed rehydration technique

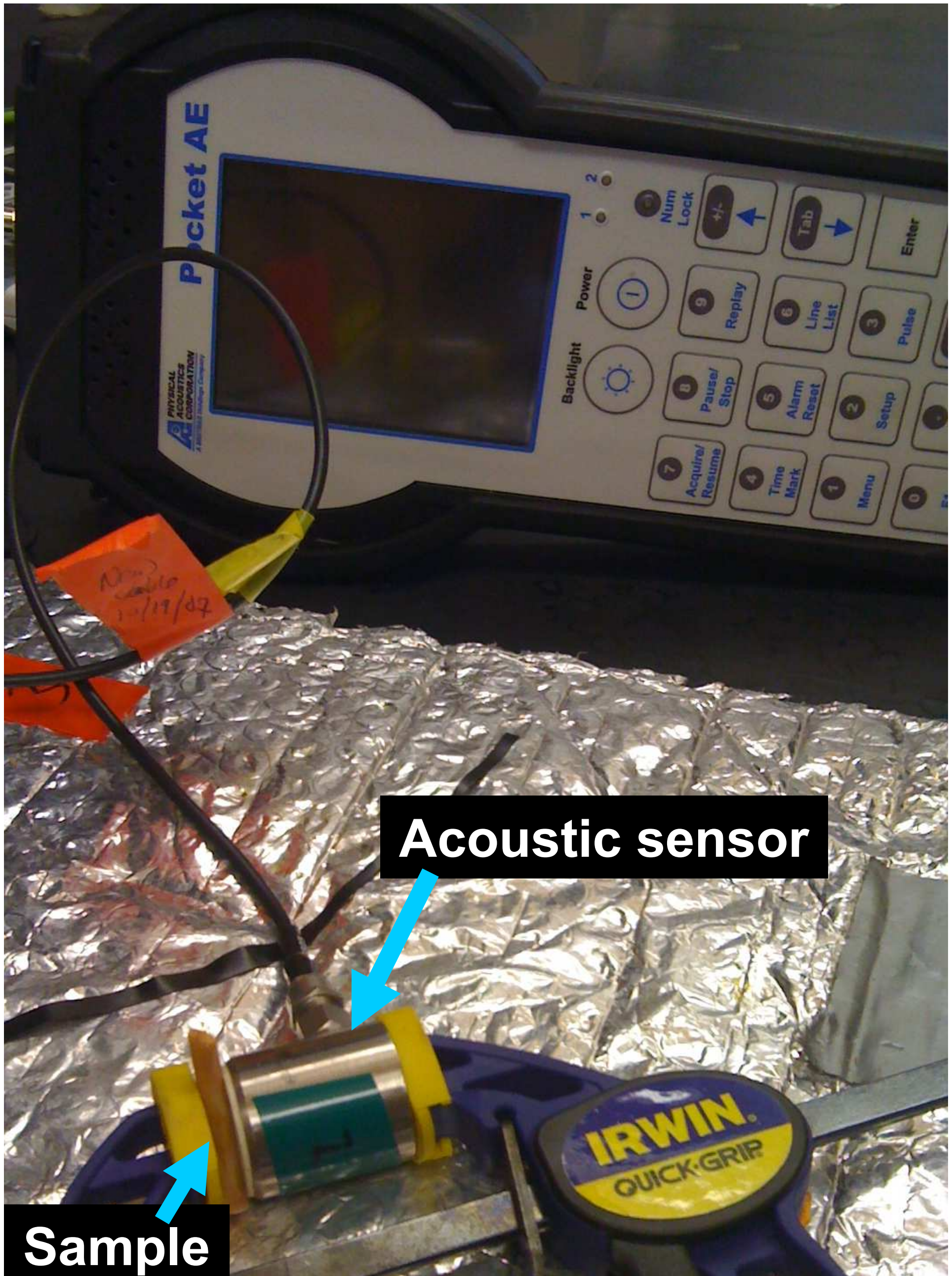
Brodribb & Holbrook 2003

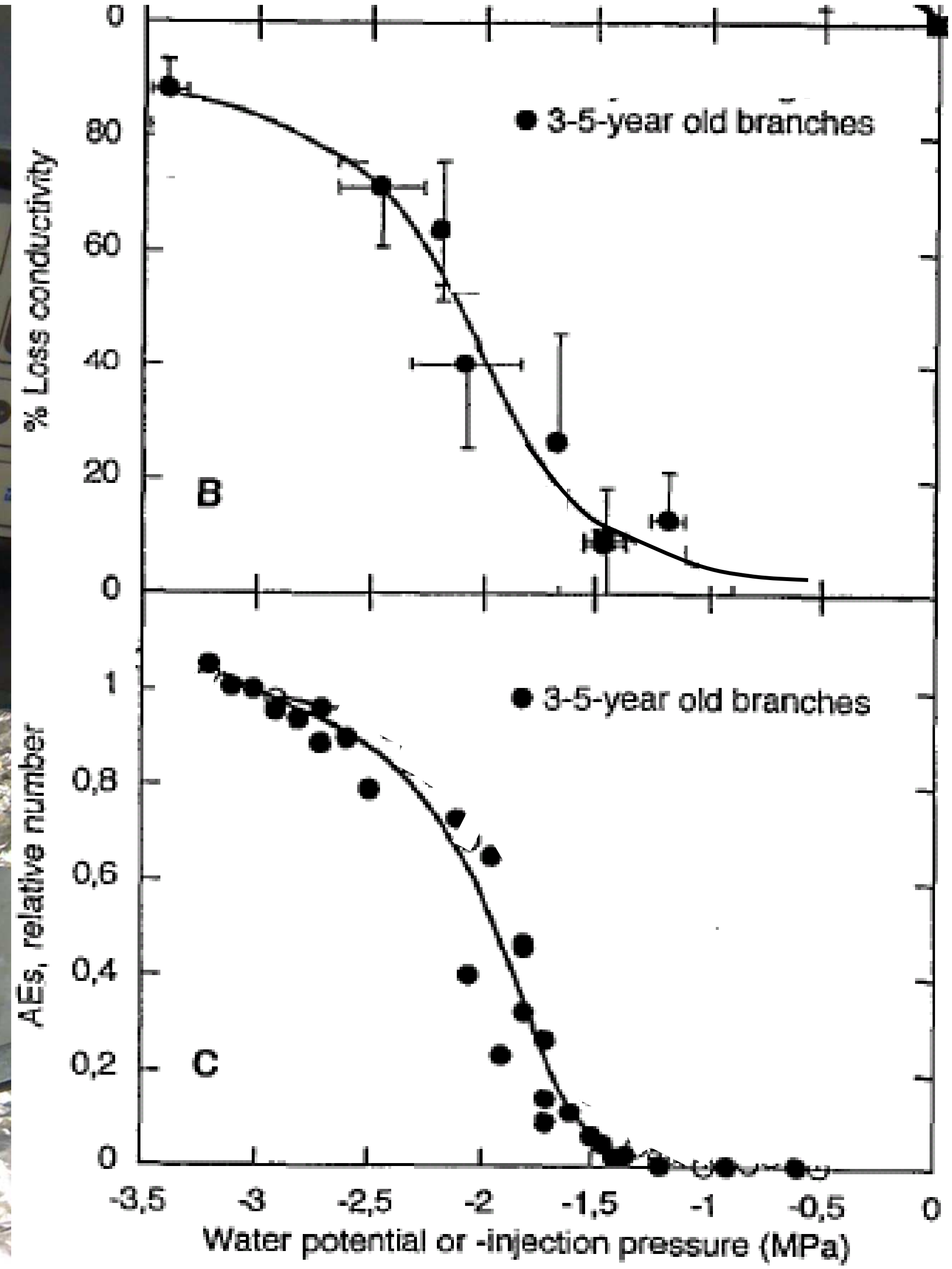




Leaf hydraulic conductance

$= C \ln(\Psi_0/\Psi_f)/t$

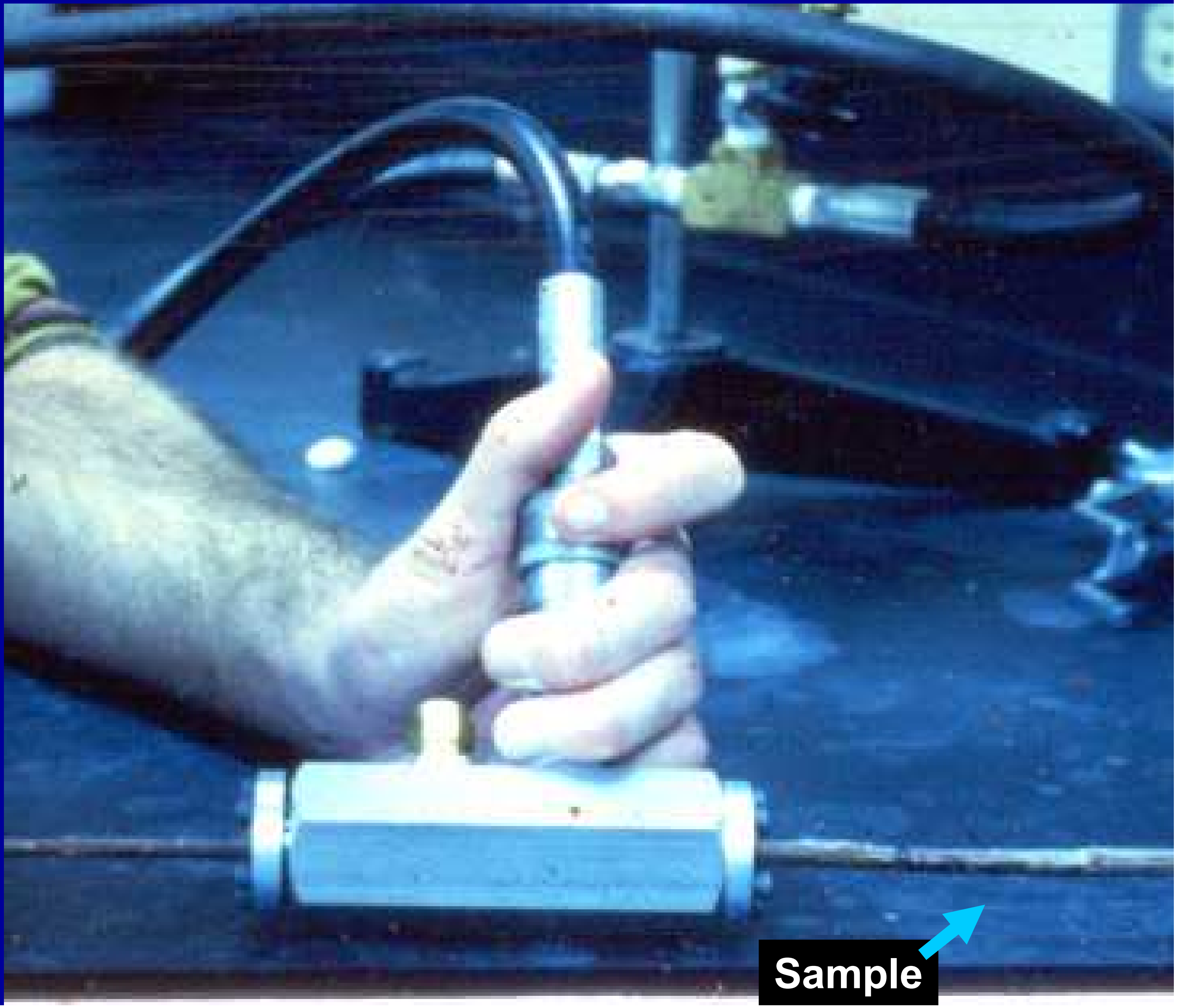


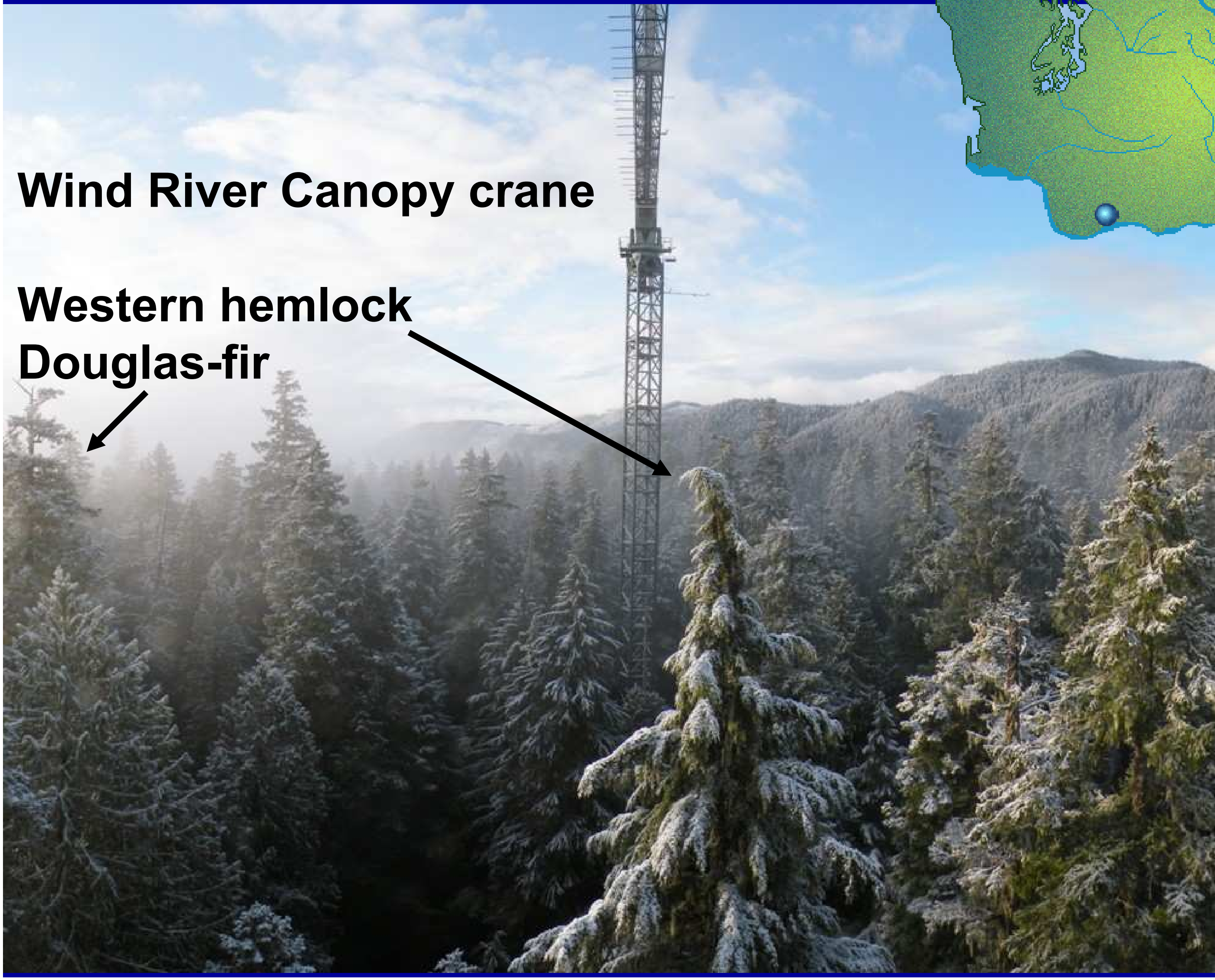


Acoustic emissions

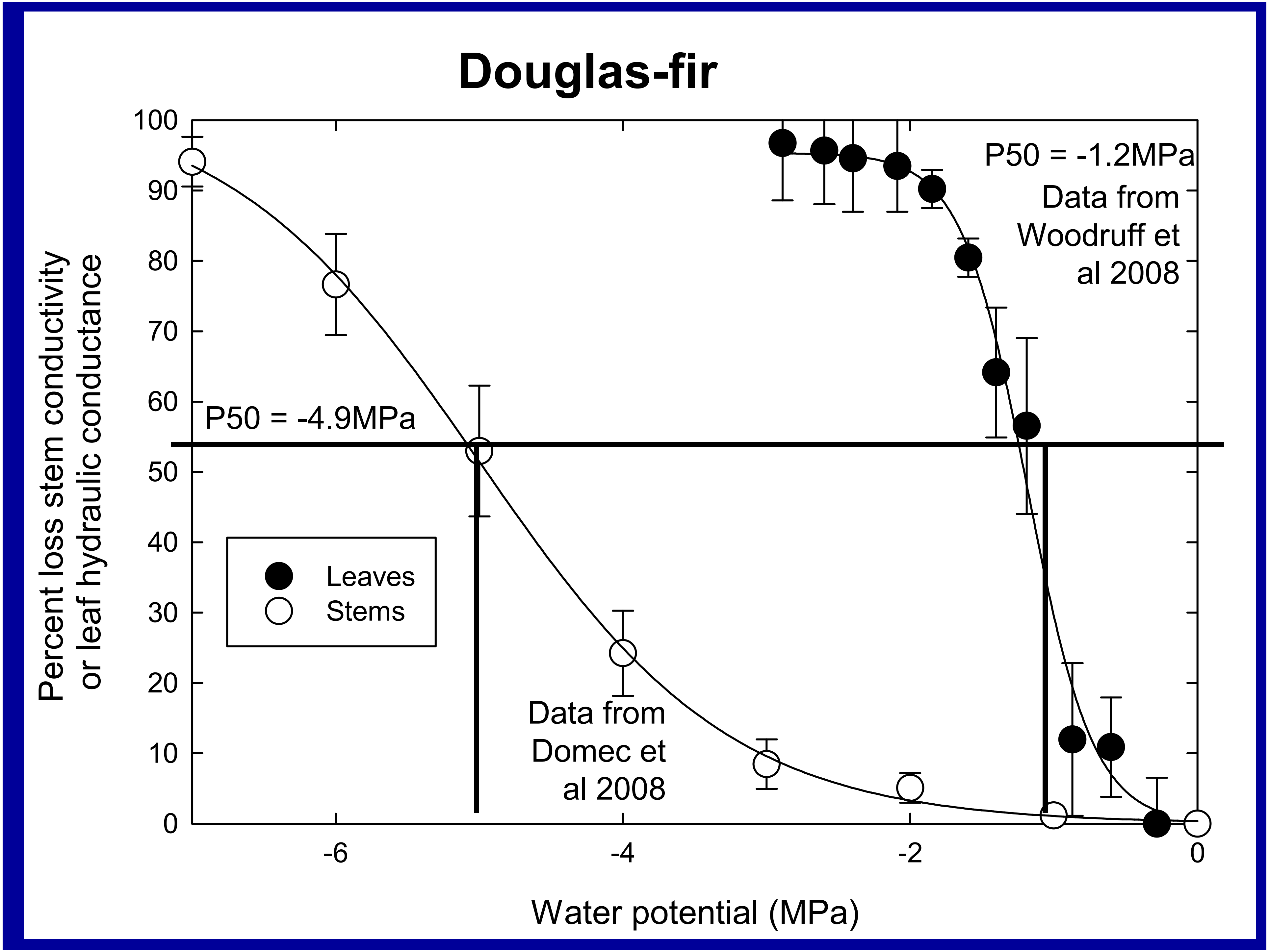
Hacke & Sauter 1996

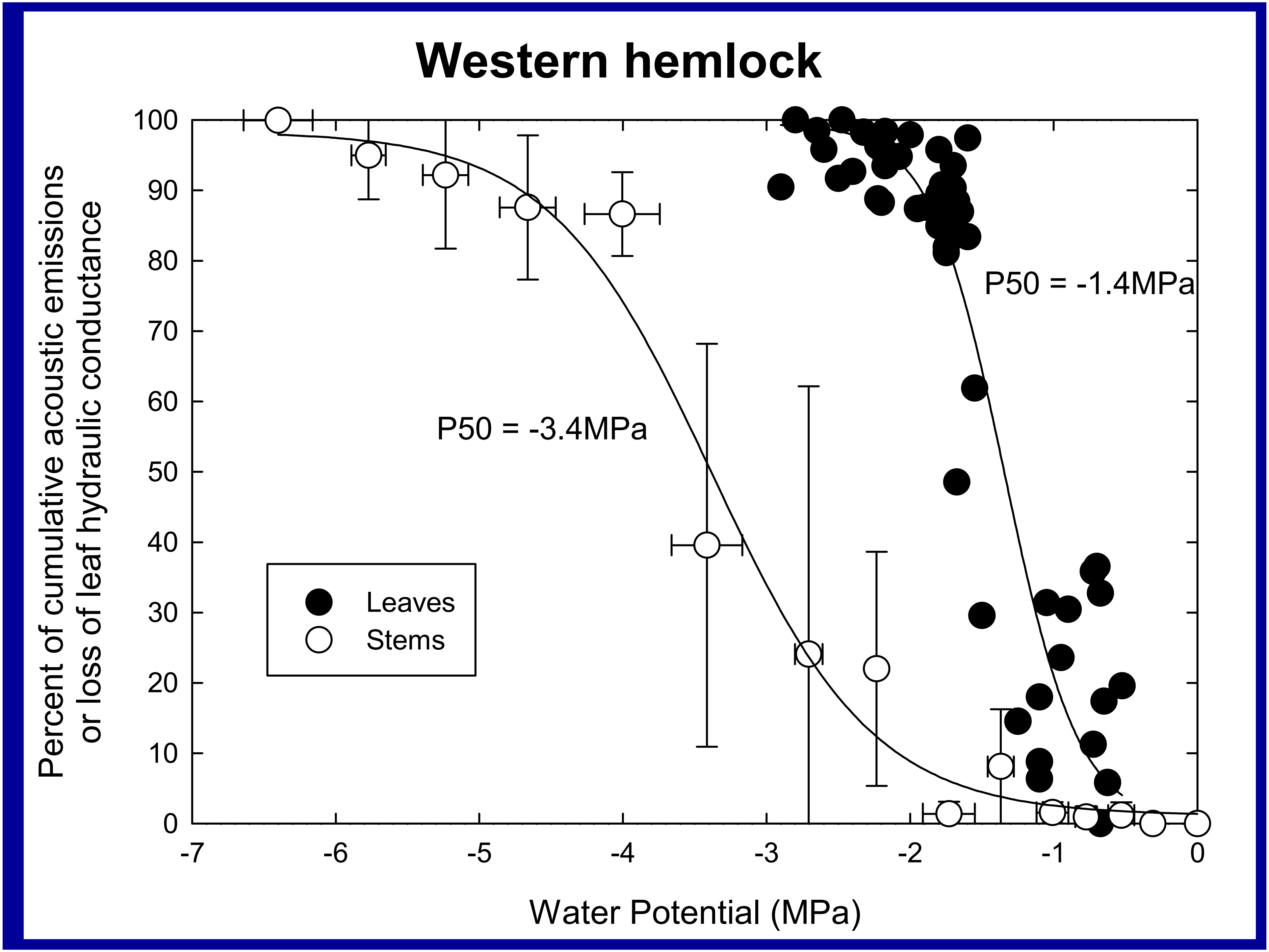
Air-injection method



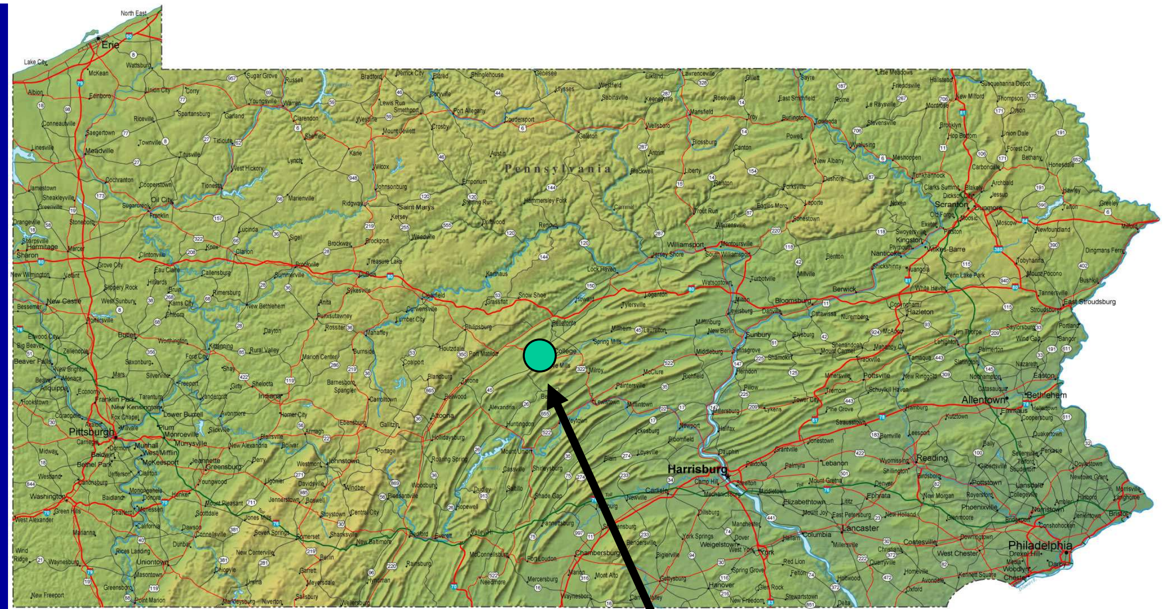

Wind River Canopy crane
Western hemlock
Douglas-fir


Washington


Douglas-fir
P50 = -1.2MPa
Data from
Woodruff et
al 2008
P50 = -4.9MPa
Leaves
Stems
Data from
Domec et
al 2008
Percent loss stem conductivity
or leaf hydraulic conductance
Water potential (MPa)
100
90
80
70
60
50
40
30
20
10
0
-6
-4
-2
0



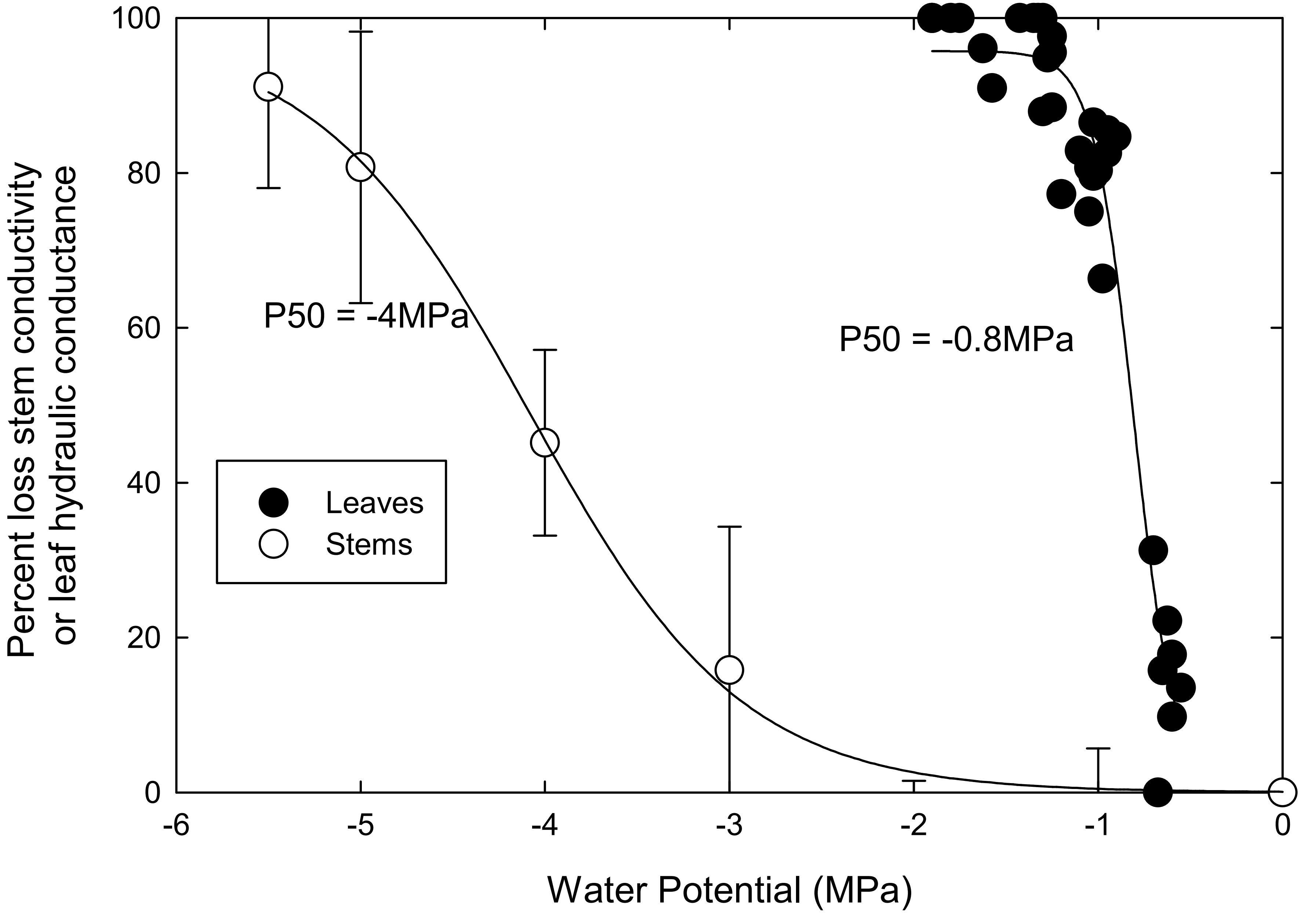
Western hemlock
Percent of cumulative acoustic emissions or loss of leaf hydraulic conductance
100
90
80
70
60
50
40
30
20
10
0
-7
-6
-5
-4
-3
-2
-1
0
Water Potential (MPa)
P50 = -1.4MPa
P50 = -3.4MPa
Leaves
Stems



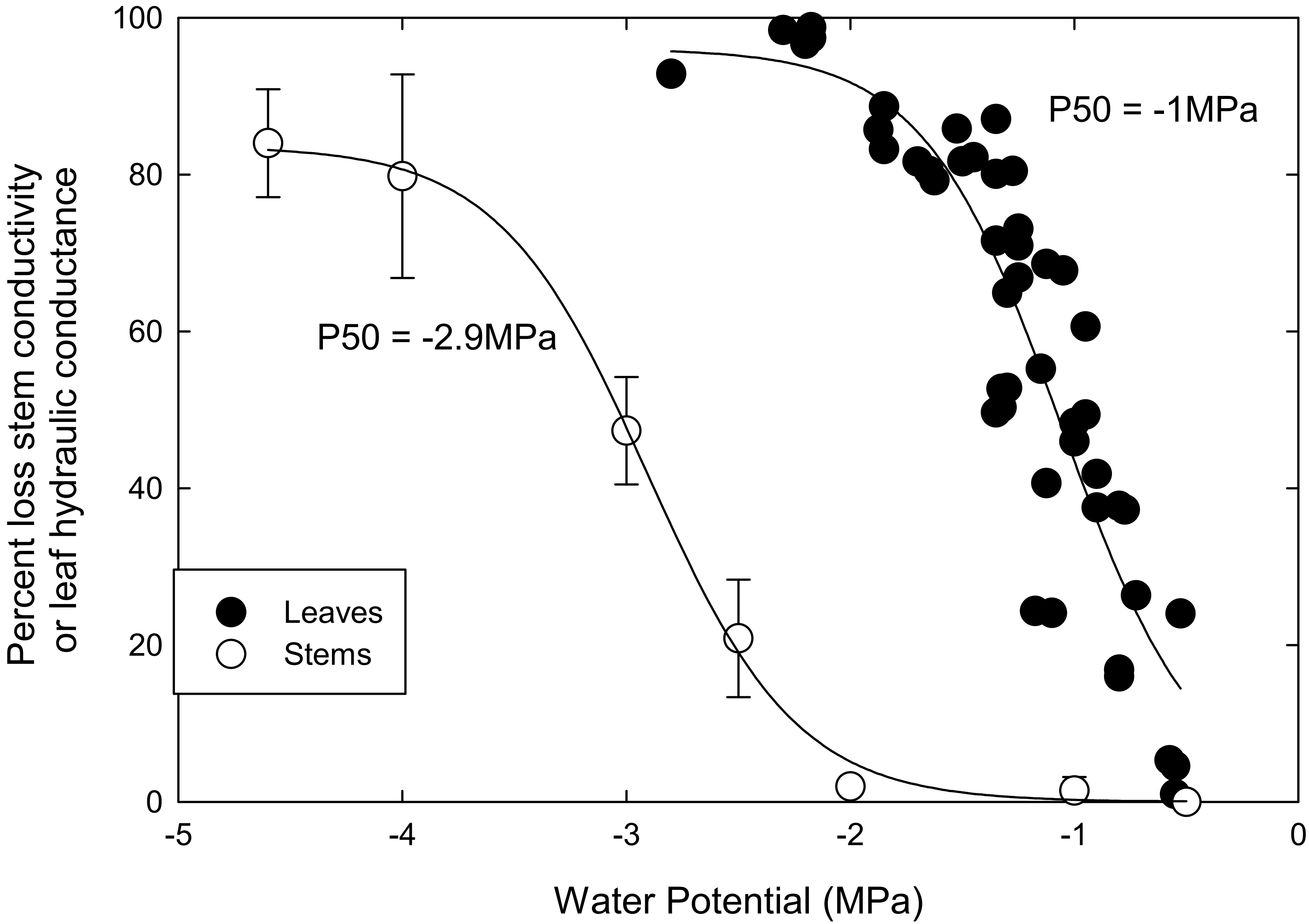
State College, PA

Virginia pine
Tulip poplar
Red oak

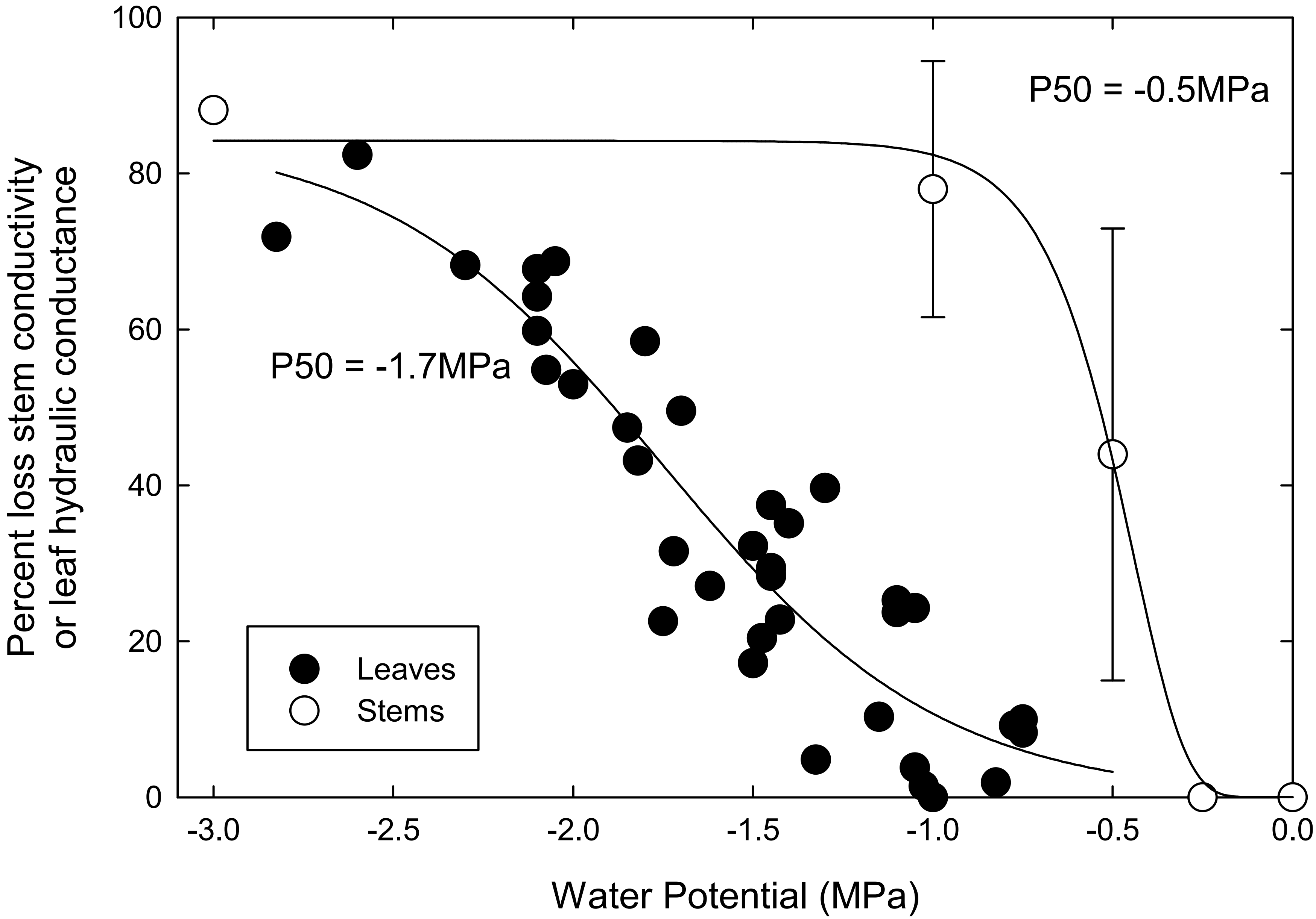
Virginia pine



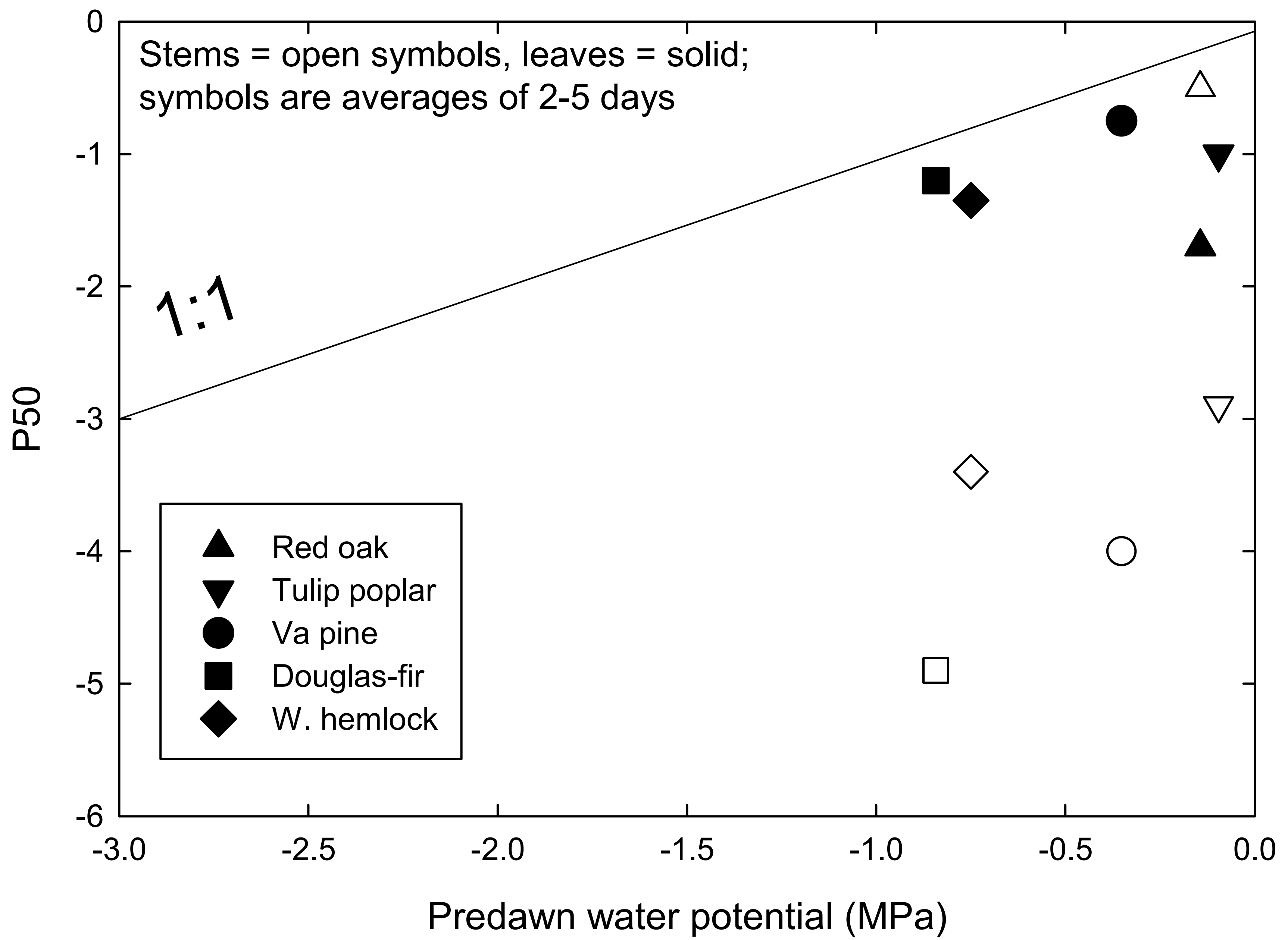
Tulip poplar



Red oak



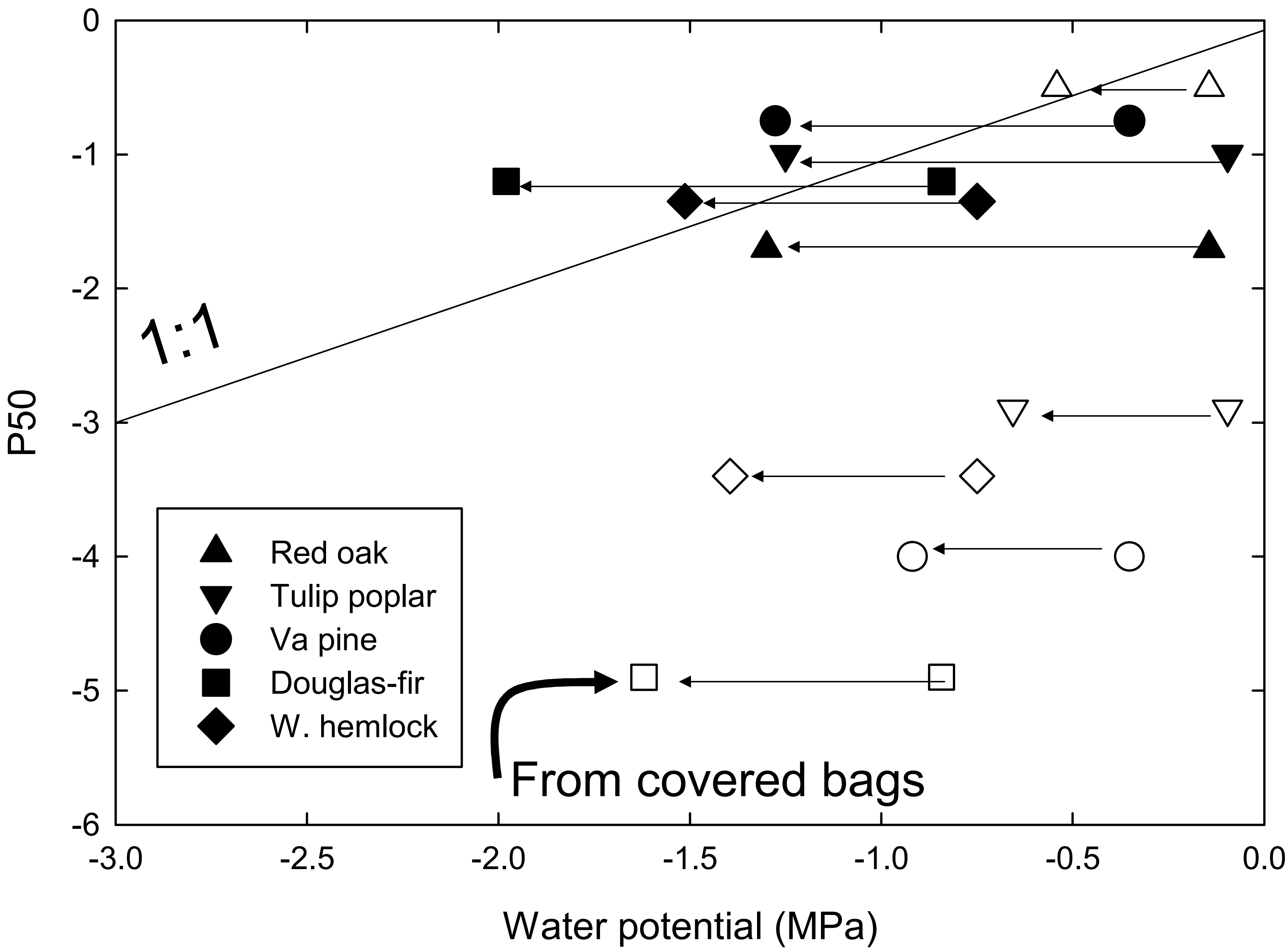
P50 = -0.5MPa
P50 = -1.7MPa
Leaves
Stems
Percent loss stem conductivity
or leaf hydraulic conductance
Water Potential (MPa)
100
80
60
40
20
0
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0



Stems = open symbols, leaves = solid;
symbols are averages of 2-5 days
1:1
P50
Predawn water potential (MPa)
0
-1
-2
-3
-4
-5
-6
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
Red oak
Tulip poplar
Va pine
Douglas-fir
W. hemlock

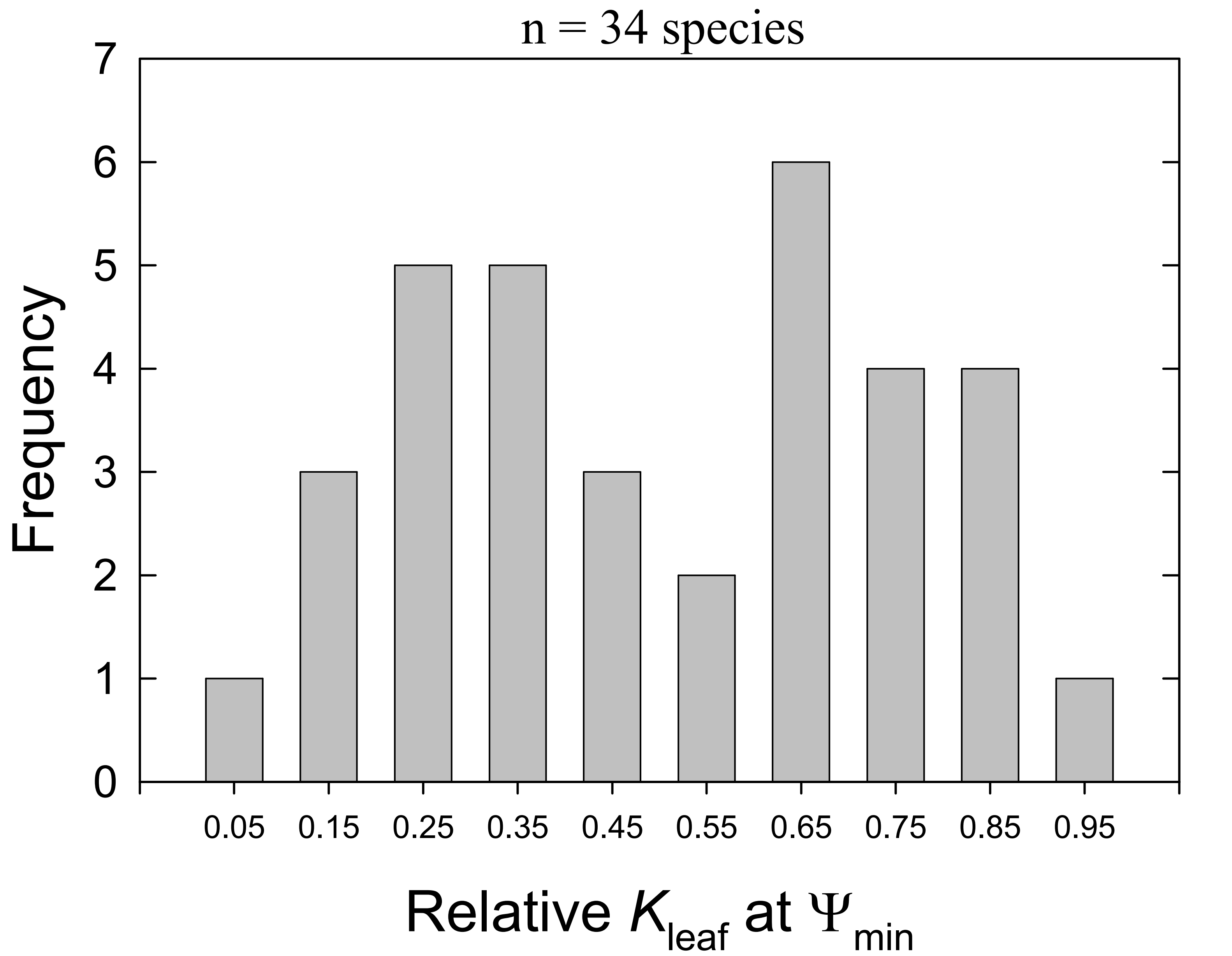
Plastic bag covered with aluminum foil

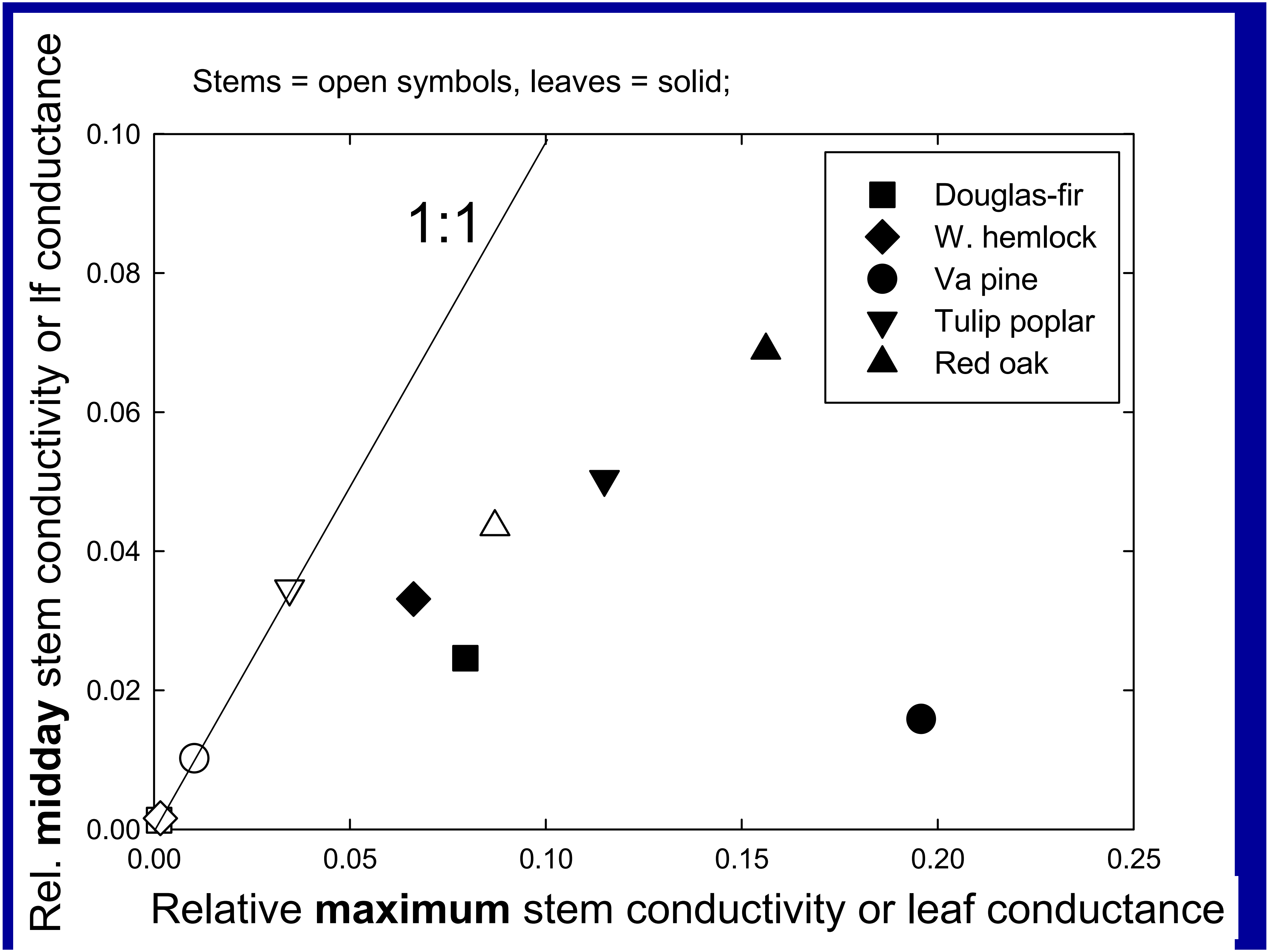
Very tall, old tree



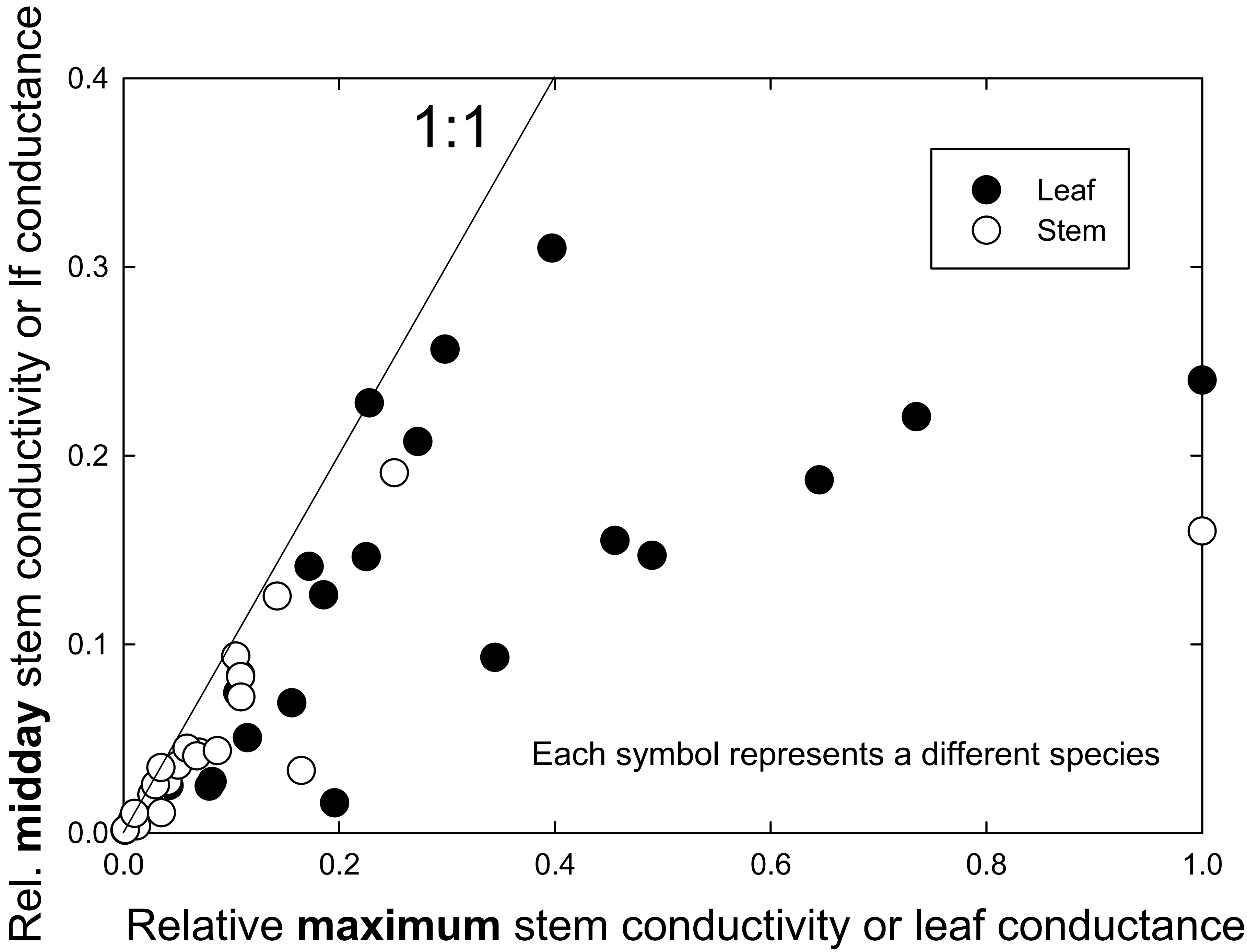
0
-1
-2
-3
-4
-5
-6
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
P50
Water potential (MPa)
1:1
Red oak
Tulip poplar
Va pine
Douglas-fir
W. hemlock
From covered bags

Patterns of daily K_{leaf} loss





Stems = open symbols, leaves = solid;
1:1
Douglas-fir
W. hemlock
Va pine
Tulip poplar
Red oak
0.00
0.02
0.04
0.06
0.08
0.10
0.00
0.05
0.10
0.15
0.20
0.25
Rel. midday stem conductivity or lf conductance
Relative maximum stem conductivity or leaf conductance



Rel. **midday** stem conductivity or lf conductance
Relative **maximum** stem conductivity or leaf conductance
1:1
Leaf
Stem
Each symbol represents a different species
0.0
0.1
0.2
0.3
0.4
0.0
0.2
0.4
0.6
0.8
1.0

Oaks????

Reference	**Species**	**PLC at midday WP**
This study	*Q. rubra*	50%
Tognetti et al 1998	*Q. pubescens*	60-80%
	Q. ilex	60-80%
Taneda & Sperry 2008	*Q. gambellii*	84%

Summary

- Stems were generally more conservative than leaves
- Many leaves lost conductance midday
- Several oaks did lose branch conductivity and in *Q. rubra*, branches were more vulnerable than leaves
- There may be a tradeoff between maximum conductivity and vulnerability

Acknowledgements

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