Riparian Cottonwoods:
Hydrology, Hydraulics and Health

Stewart Rood, David Pearce, Karen Zanewich and Larry Flanagan

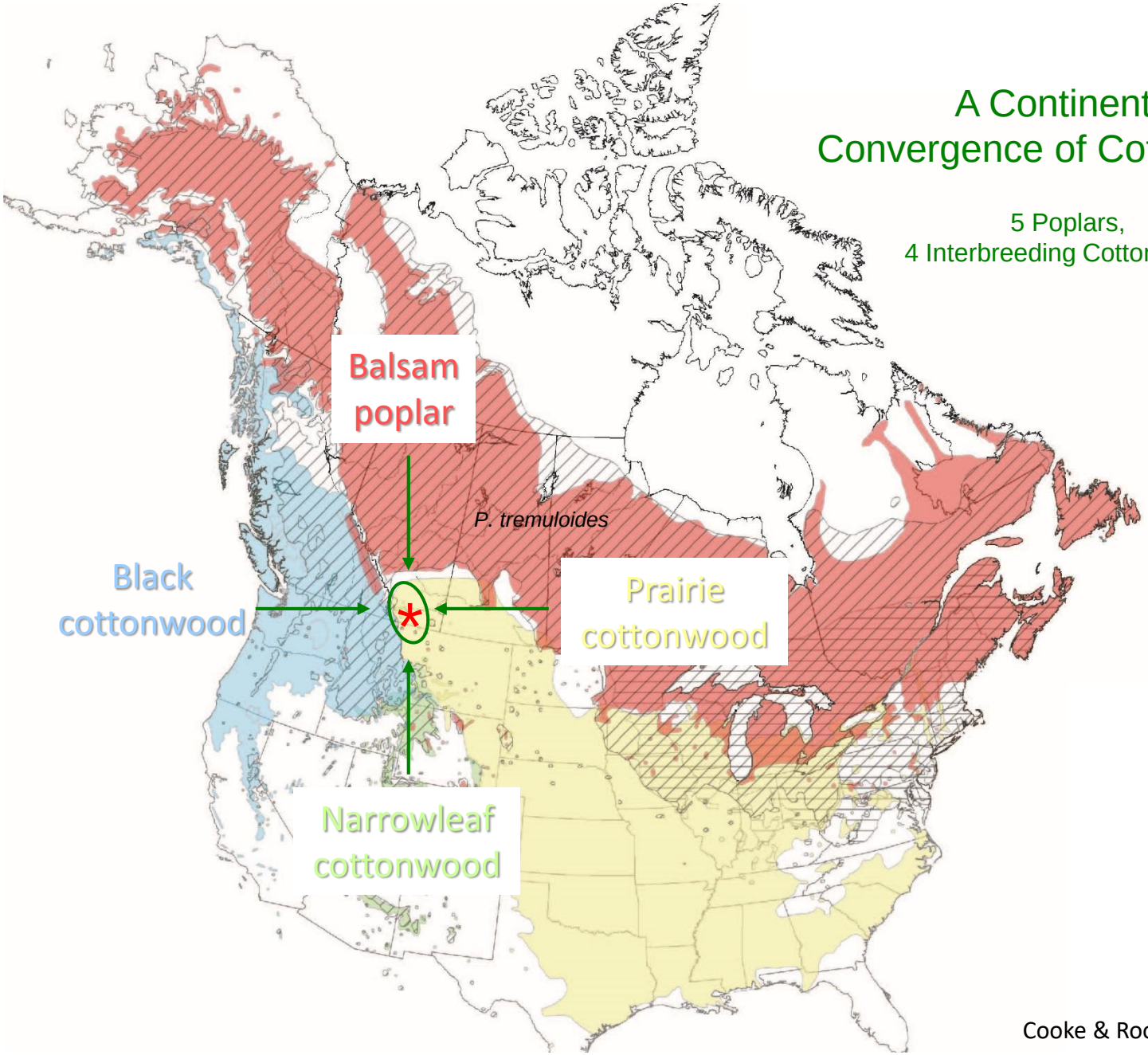
Cottonwood Park
Lethbridge, AB

January
2019

RiversEdge West
ALBERTA INNOVATES
Alberta Environment and Parks
NSERC CRSNG

A Continental Convergence of Cottonwoods

5 Poplars,
4 Interbreeding Cottonwoods



Cooke & Rood (2007) Botany

Water Potential (Ψ, psi) – Water availability

Hydrology – Water in open systems

$\Psi \approx 0$ MPa

Stream Flow: Declining due to human use & climate change

Alluvial Groundwater: Recharged with stream flow

Hydraulics – Water in constrained systems

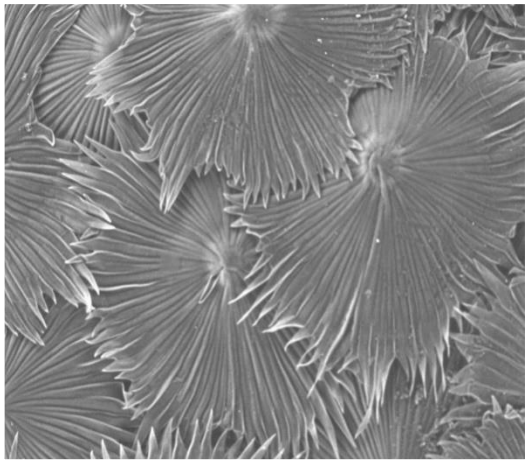
$\Psi \neq 0$ MPa

Plant Hydraulics: $\Psi < 0$ MPa, negative tension

Transpiration, Tension, Cohesion

Xylem water: strands

Dry air, Ψ -100 MPa
Vapor Pressure Deficit
Demand



peltate trichomes
Elaeagnus commutata

Leaf Ψ

Pre-dawn -0.5 MPa
~ Root zone Ψ

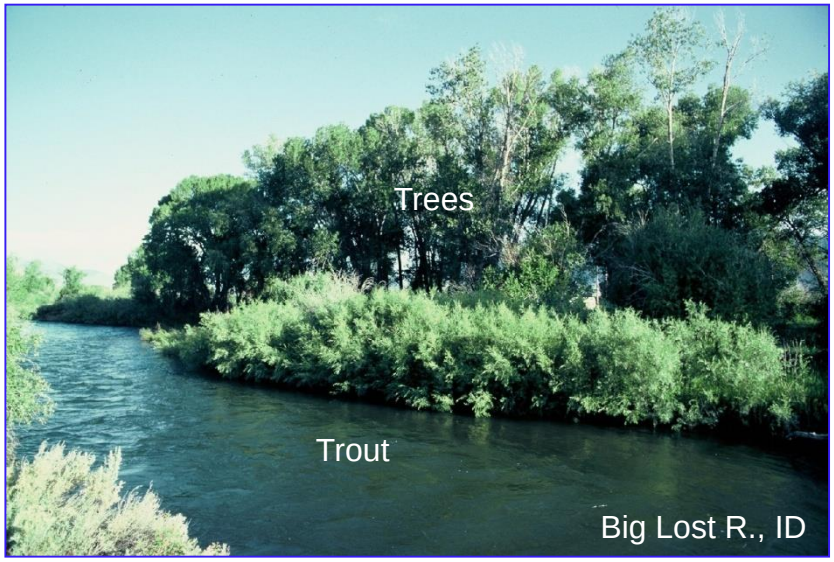
Mid-day -2 MPa
> Cavitation thresholds = Healthy

Pressure
Chamber
$2K

Water tracking – $^{2}H,^{18}O$

Health

Aquatic and Riparian Ecosystems Require Instream Flow



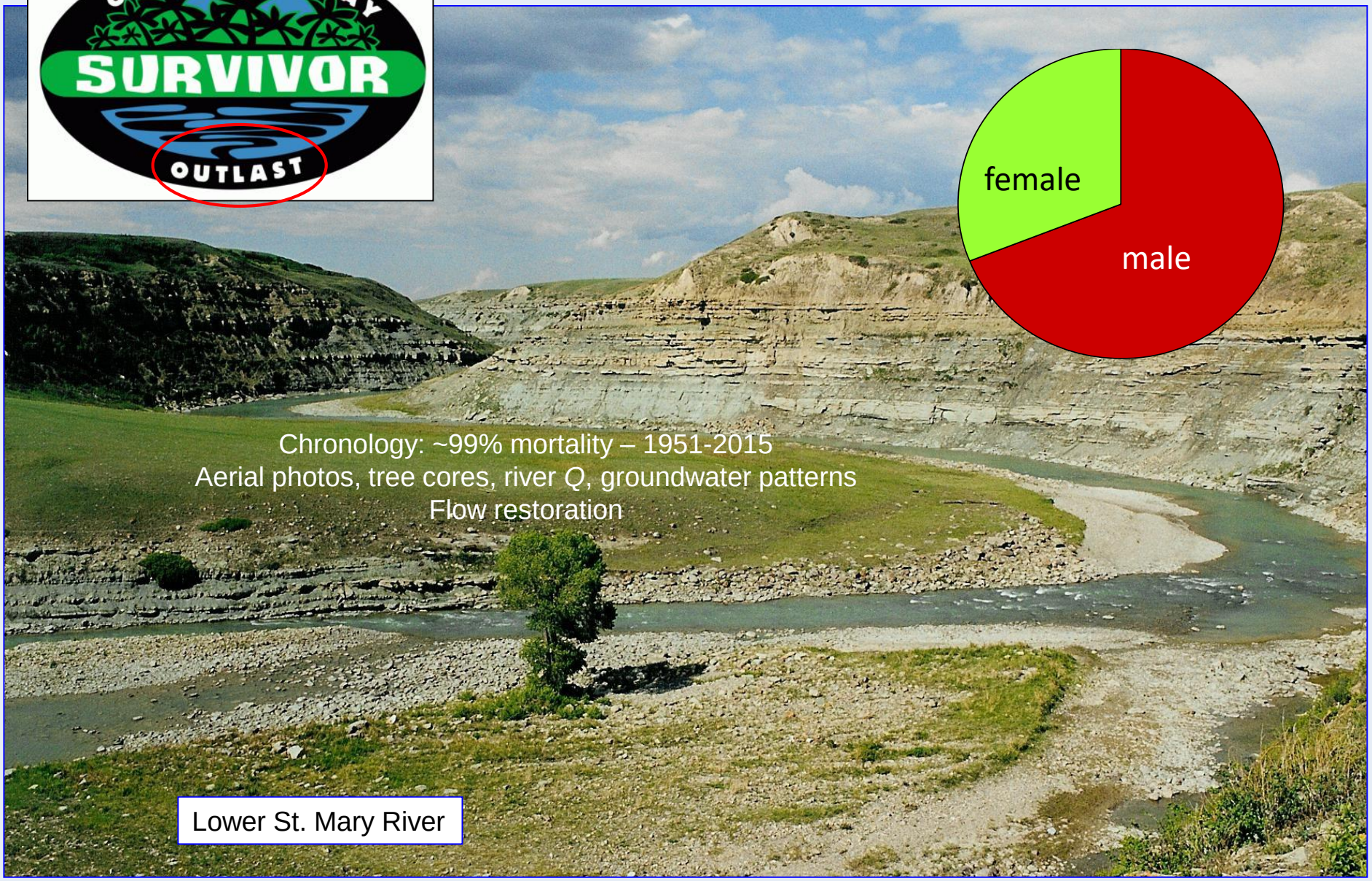
Healthy

Unhealthy

Stressed

(Dead)

Rood et al. (2003) Tree Physiol



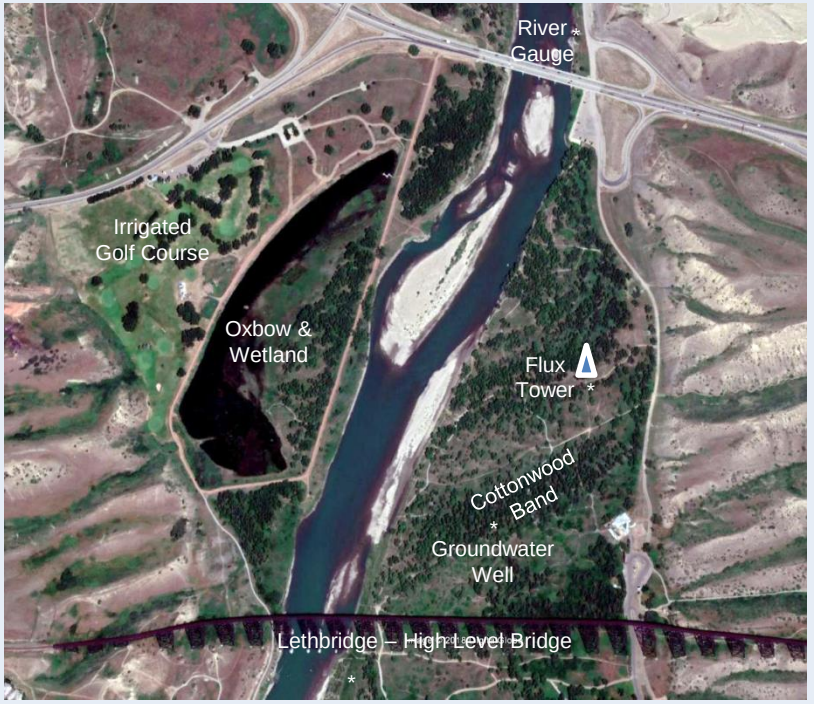
Rood et al. (2016) River Res Appln

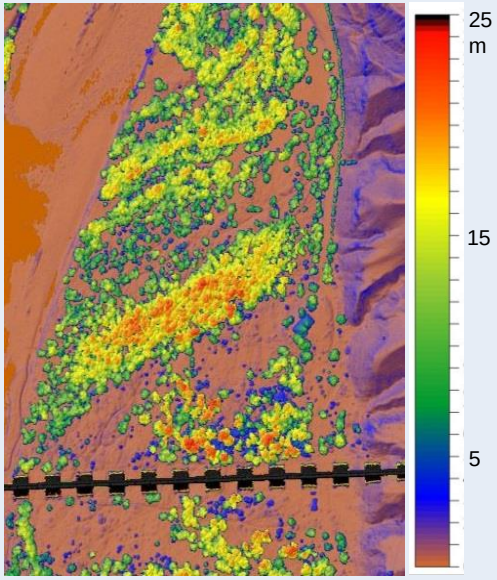
Indicators = Health Measures

Diagnostic
Quantitative
Near Real-Time

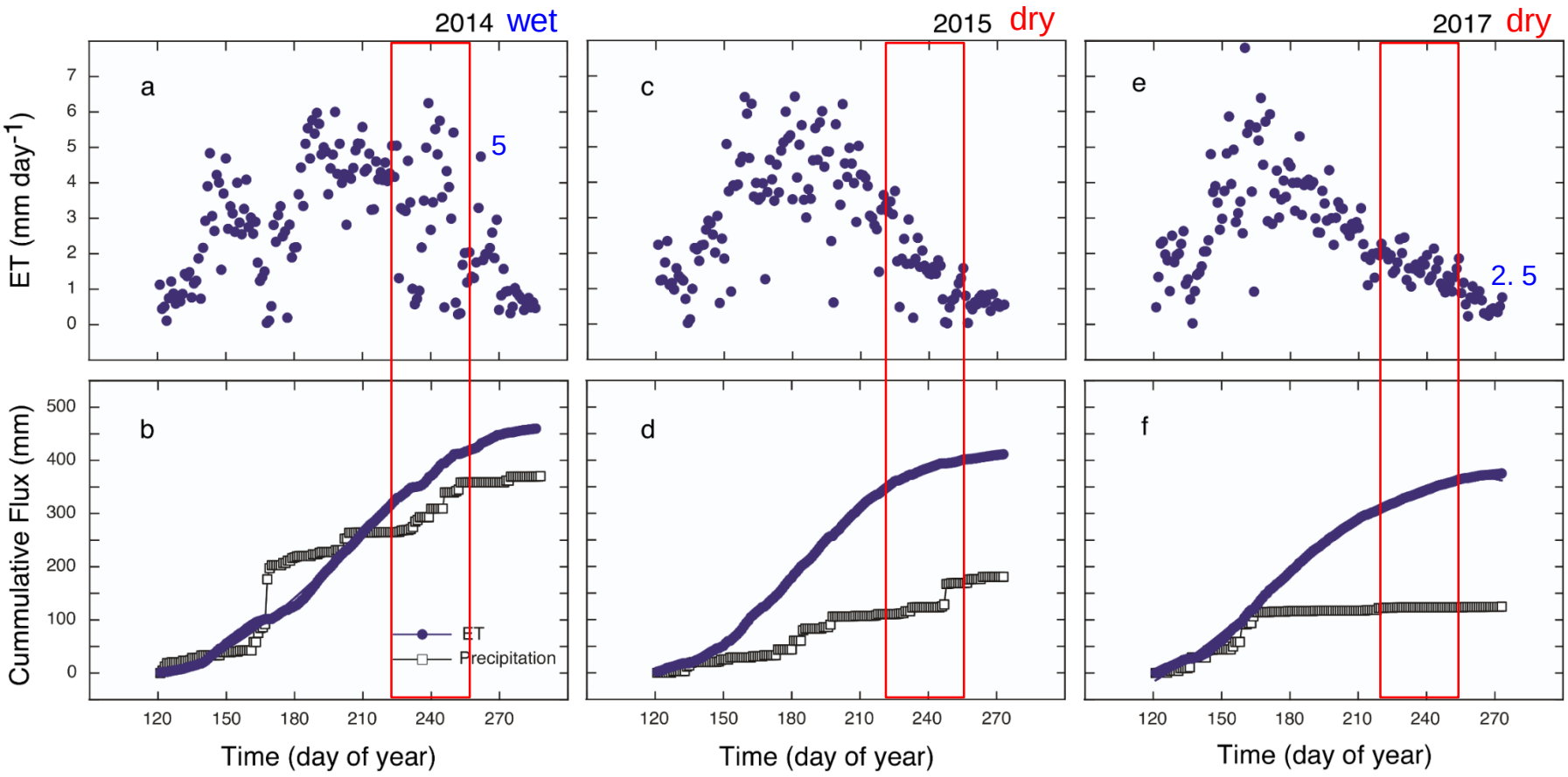
‘Dendroscope’


Bridge Grove


River
Gauge
Irrigated
Golf Course
Oxbow &
Wetland
Flux
Tower
Cottonwood
Band
Groundwater
Well
Lethbridge – High Level Bridge


25
m
15
5

Seasonal & Interannual Variation

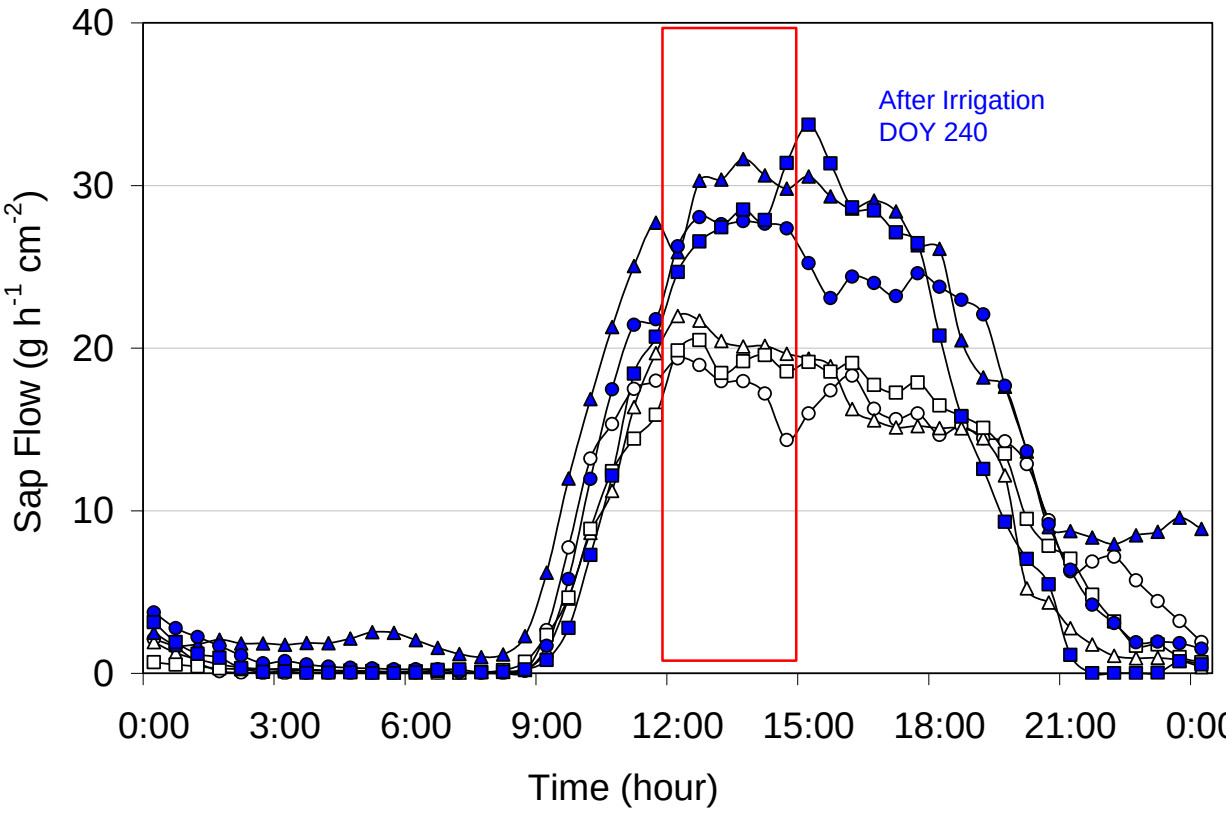


Yang, Rood, Flanagan (in press) Ag For Meteor

'Maria' – *P. angustifolia*

Diurnal Variation

Thermal Dissipation Probes
(TDPs)



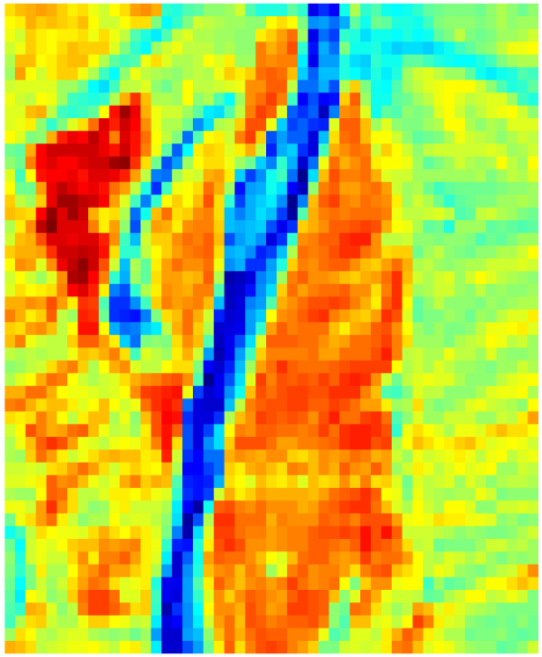
~(Cox et al. (2005) W N Am Nat)

Normalized Difference Vegetation Index (NDVI, below), and

Near Infrared Reflectance of Vegetation (NIR_V; Badgley,Field,Berry (2017) Sci Advances)

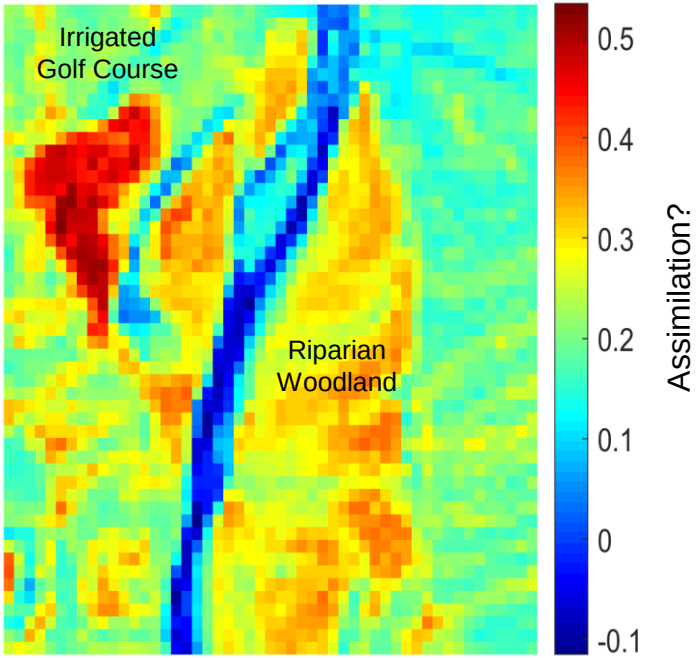
High Flow & Wet = Healthy

8/13/2014

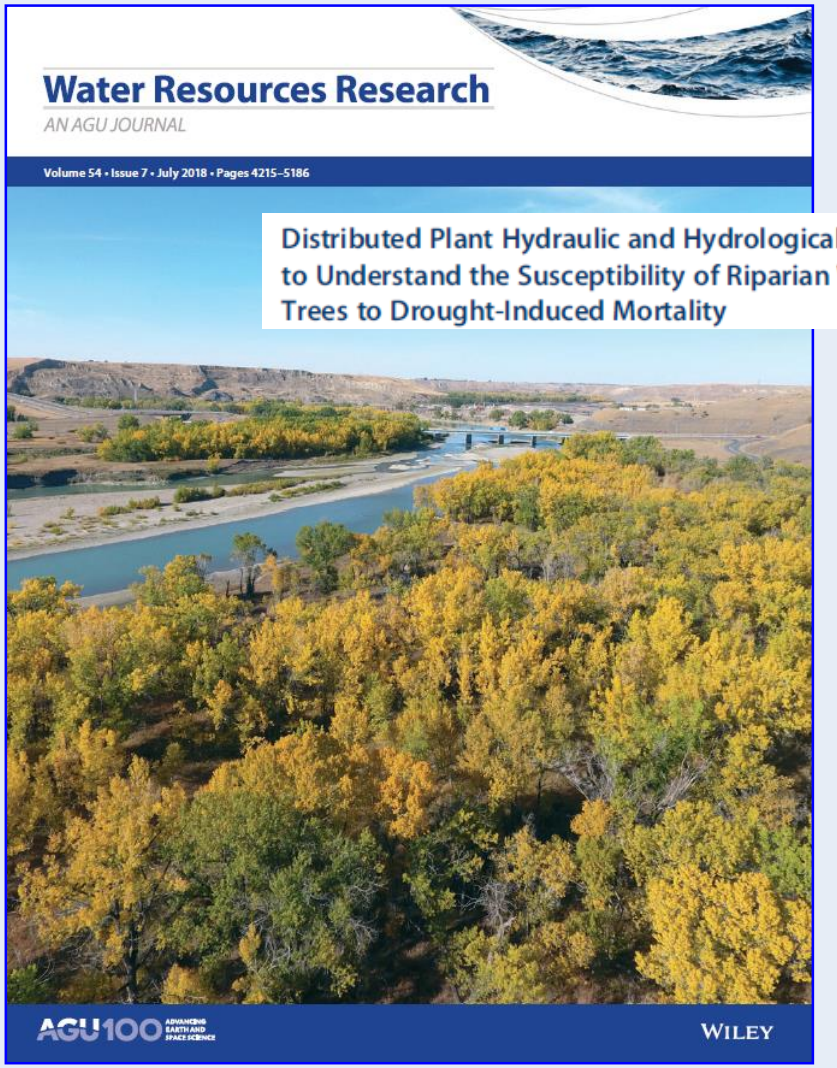


Low Flow & Dry = Stressed

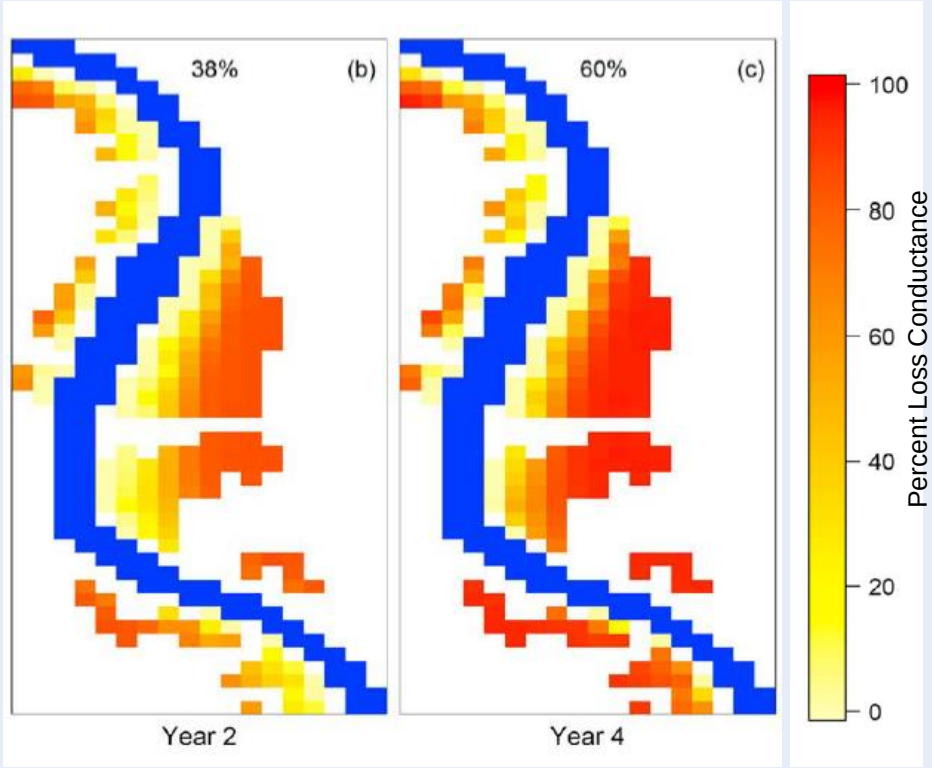
8/8/2018



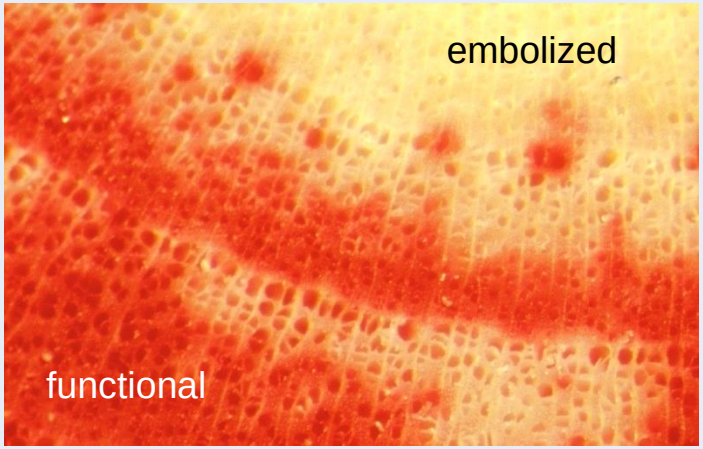
What does this reveal?

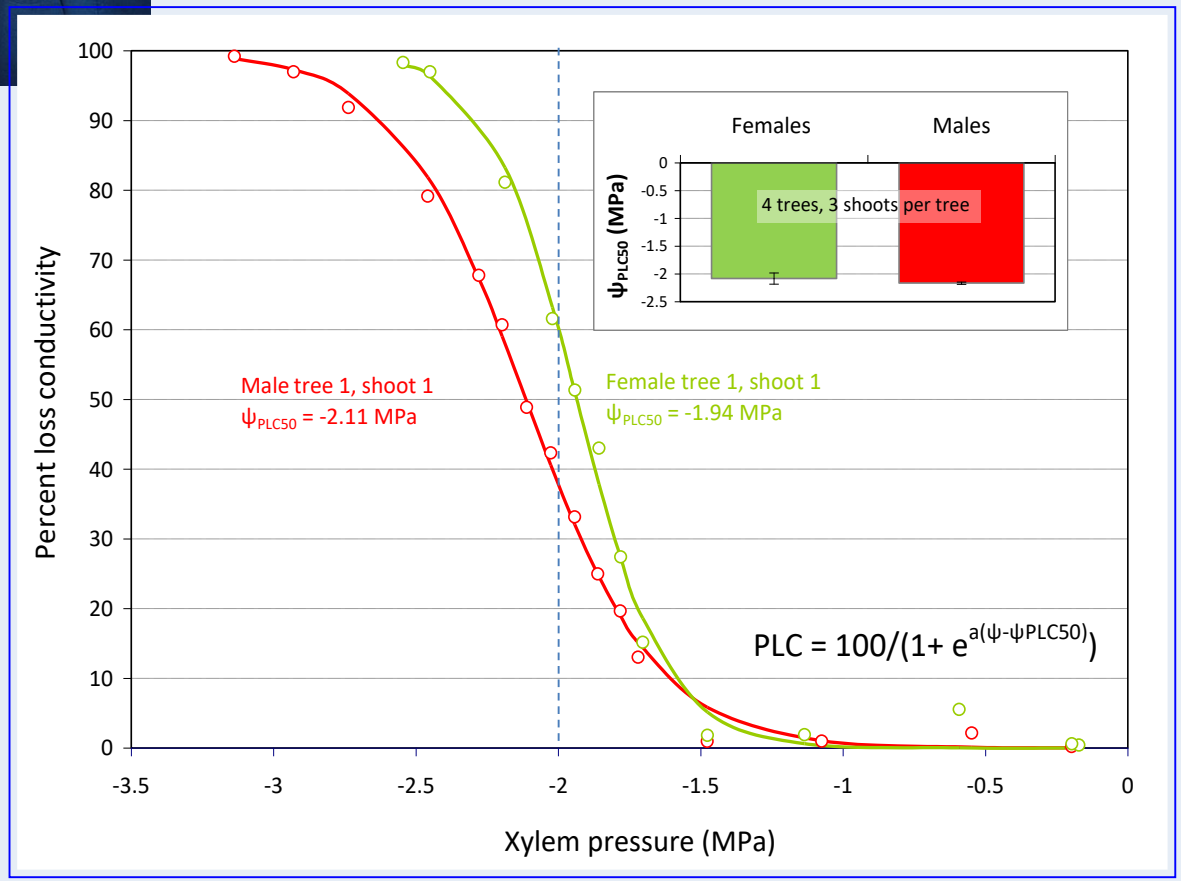


Tai, Mackay, Sperry, Brooks, Anderegg, Flanagan, Rood, Hopkinson




Cavitron

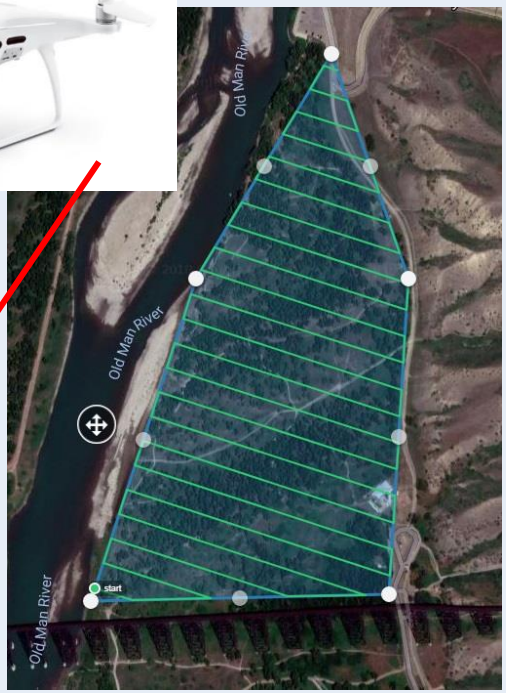

embolized
functional


Percent loss conductivity
Xylem pressure (MPa)
Males
Females
4 trees, 3 shoots per tree
Male tree 1, shoot 1
ψPLC50 = -2.11 MPa
Female tree 1, shoot 1
ψPLC50 = -1.94 MPa
PLC = 100/(1+ e^a(ψ-ψPLC50))

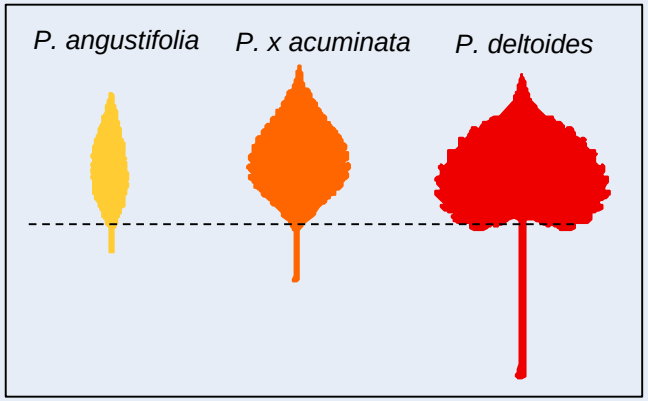
Stewart B. Rood · Sandra Patiño · Krista Coombs
Melvin T. Tyree

Branch sacrifice: cavitation-associated drought adaptation of riparian cottonwoods

$2K



Complexity or Opportunity?



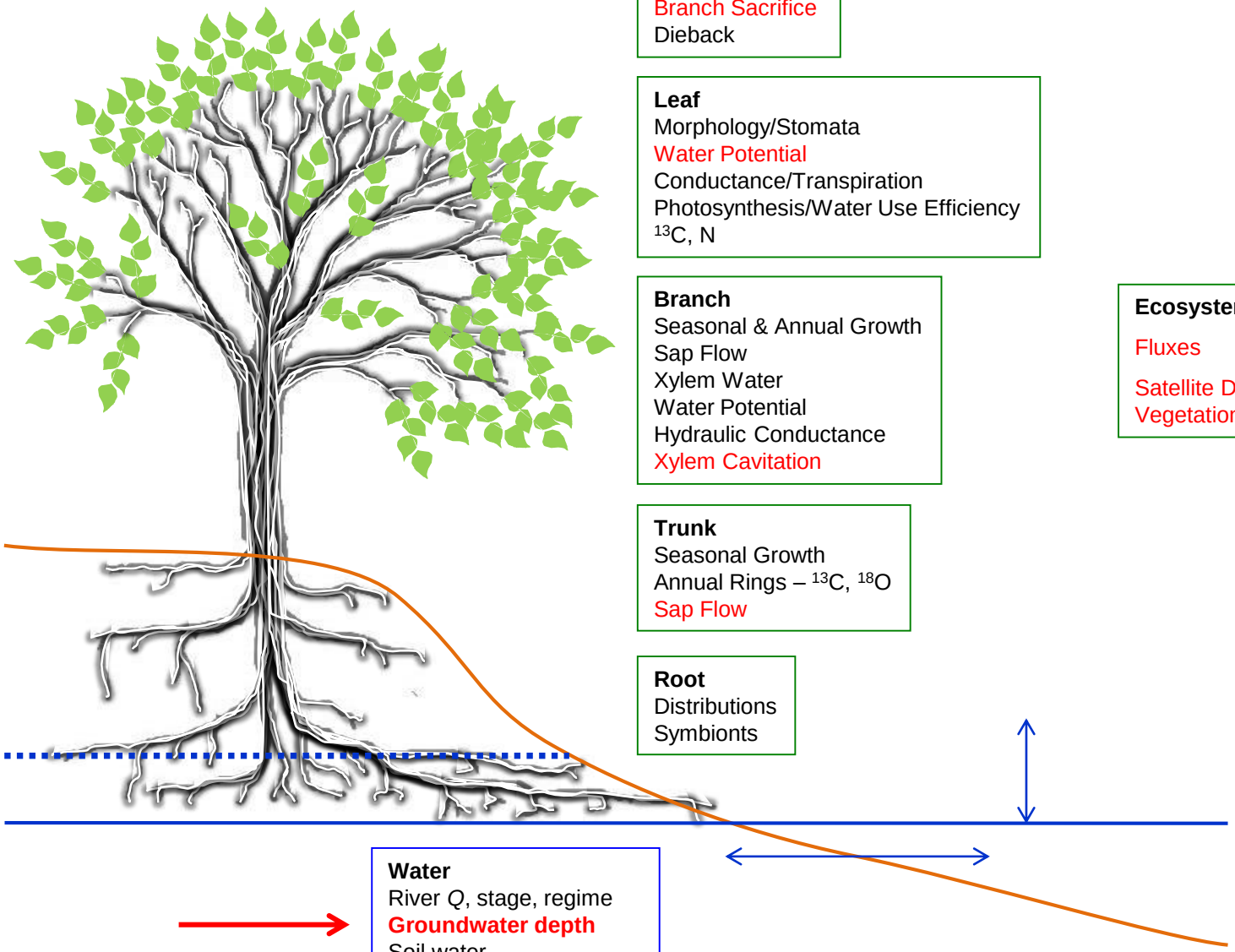
Hydrology – Hydraulics

Health Indicators

Canopy
Leaf Area Index
Phenology
Thermal Imaging
Branch Sacrifice
Dieback

Weather: T, Ppt
Vapor Pressure Deficit

Leaf
Morphology/Stomata
Water Potential
Conductance/Transpiration
Photosynthesis/Water Use Efficiency
^{13}C, N



Branch
Seasonal & Annual Growth
Sap Flow
Xylem Water
Water Potential
Hydraulic Conductance
Xylem Cavitation

Ecosystem

Fluxes

Satellite Derived
Vegetation Indices

Trunk
Seasonal Growth
Annual Rings – ^{13}C, ^{18}O
Sap Flow

Root
Distributions
Symbionts

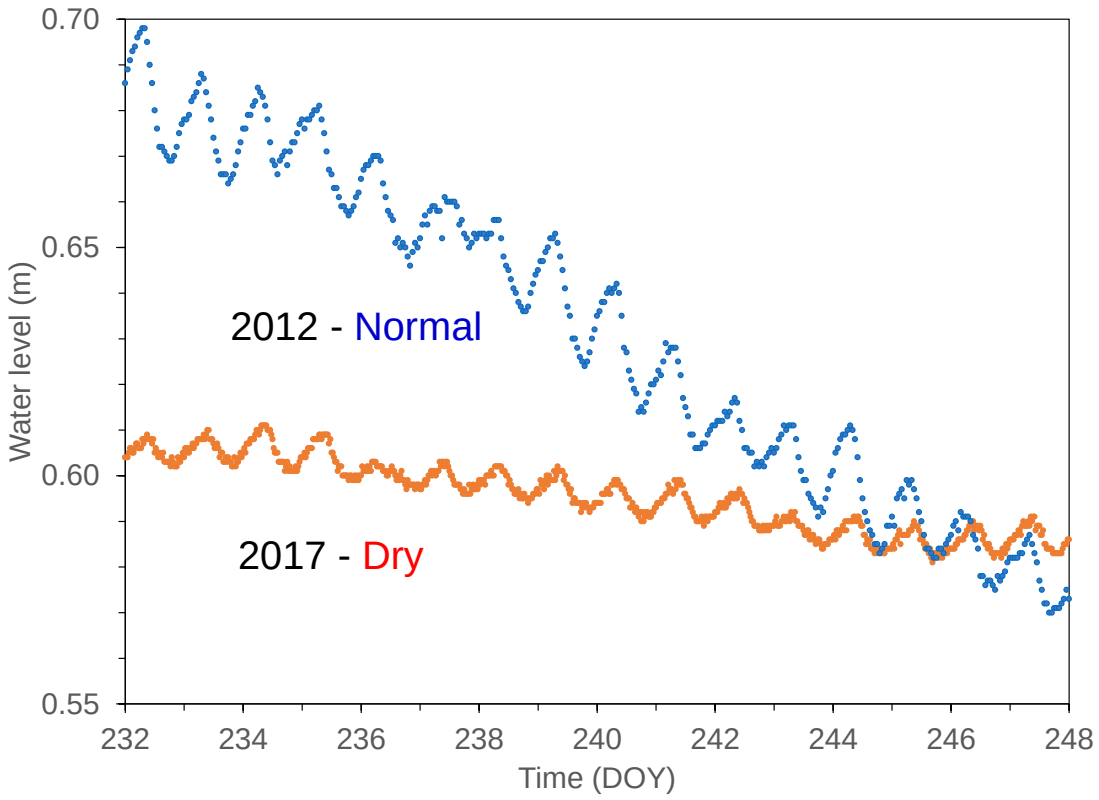
Water
River *Q*, stage, regime
Groundwater depth
Soil water
Source tracking – ^{2}H,^{18}O

Water Table

Daily Drawdown

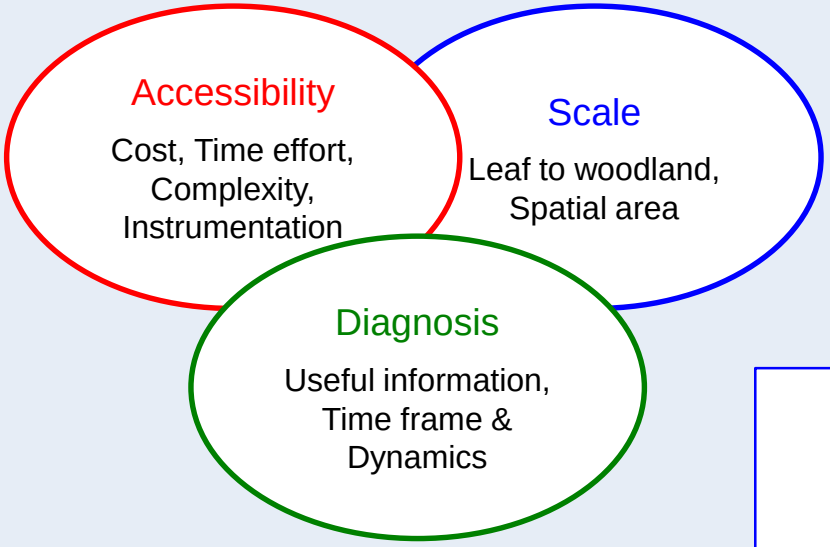
Year	Diurnal Amplitude	Phreatic Water Use	Condition
2012	~ 2 cm	5 mm/d	Healthy
2017	~ 1 cm	2.5 mm/d	Stressed

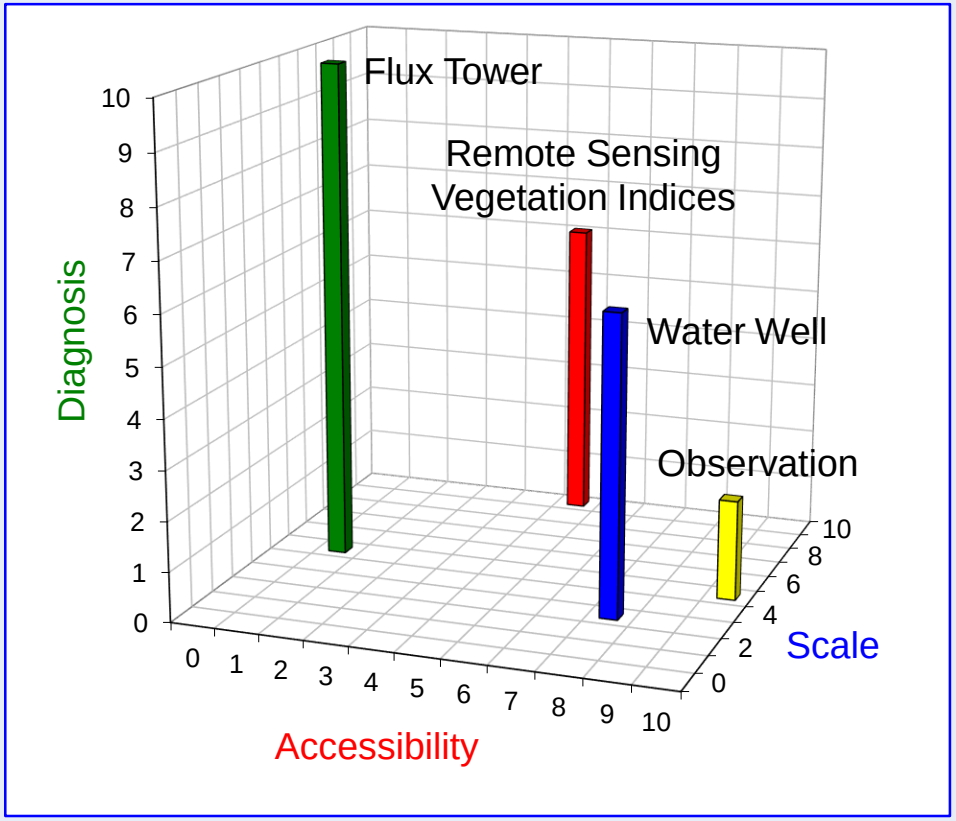
specific yield



$2K – 2 & telemetry

Rood et al. (2013) Plant Cell Environ


Accessibility
Cost, Time effort,
Complexity,
Instrumentation
Scale
Leaf to woodland,
Spatial area
Diagnosis
Useful information,
Time frame &
Dynamics


Flux Tower
Remote Sensing
Vegetation Indices
Water Well
Observation
Diagnosis
Accessibility
Scale
0
1
2
3
4
5
6
7
8
9
10

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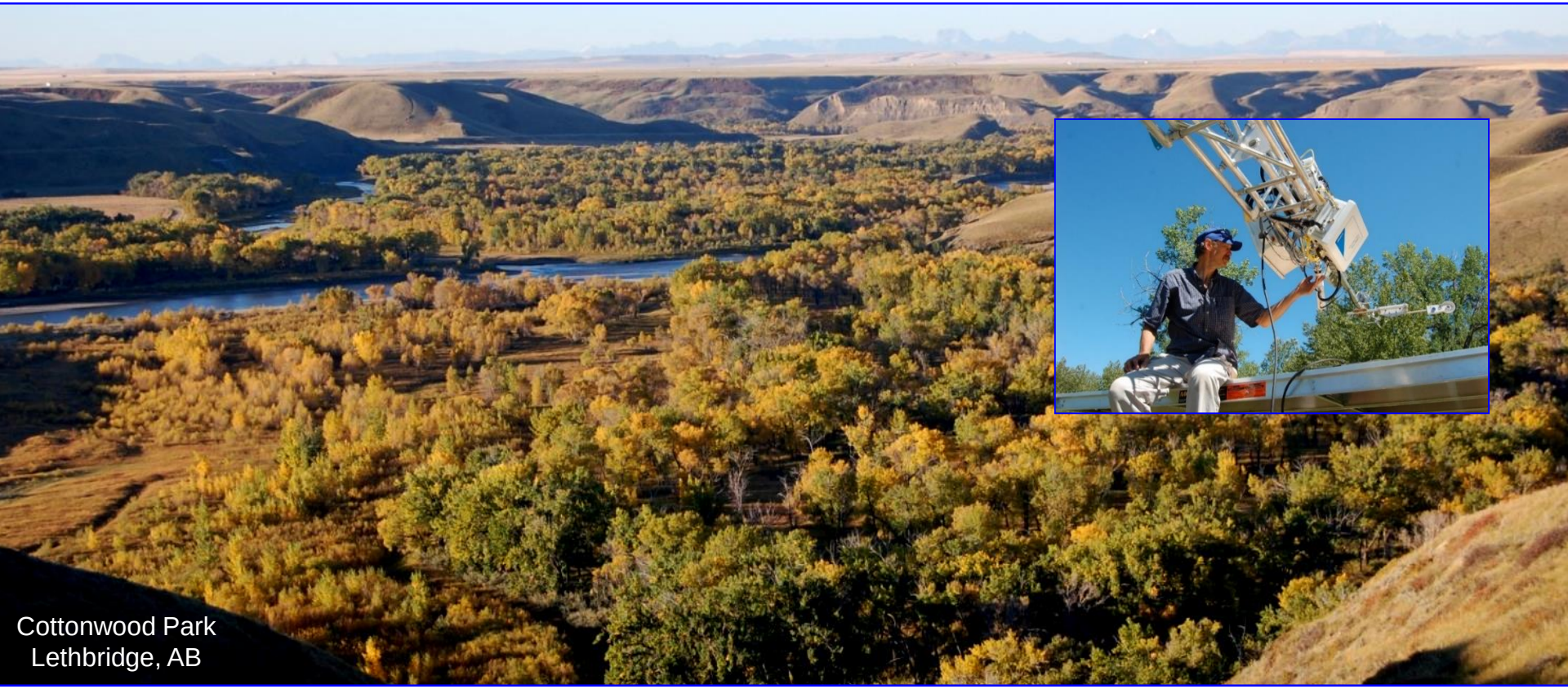

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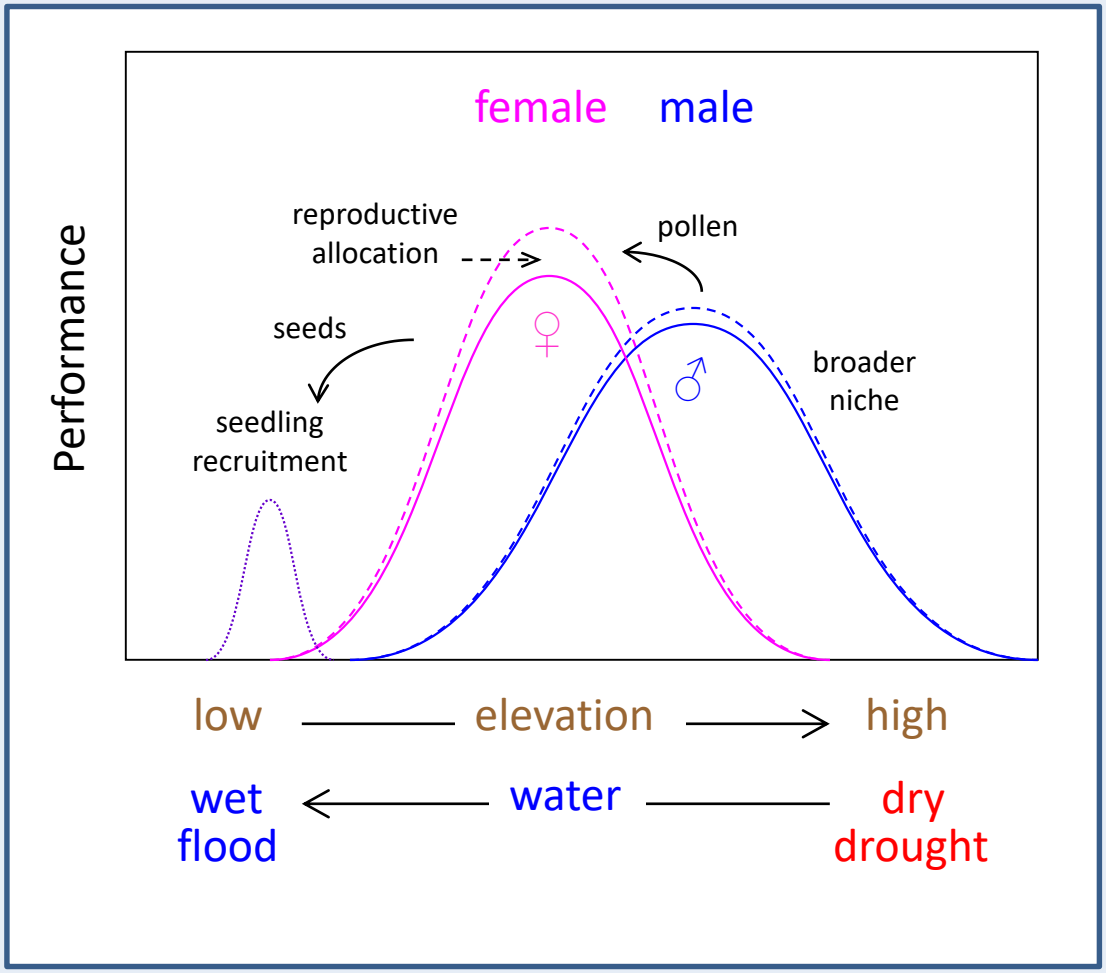
female
male
Performance
reproductive allocation
pollen
seeds
seedling recruitment
broader niche
♀
♂
low
elevation
high
wet
flood
water
dry
drought