Can We Use Dormant Almond Orchards for Groundwater Recharge?

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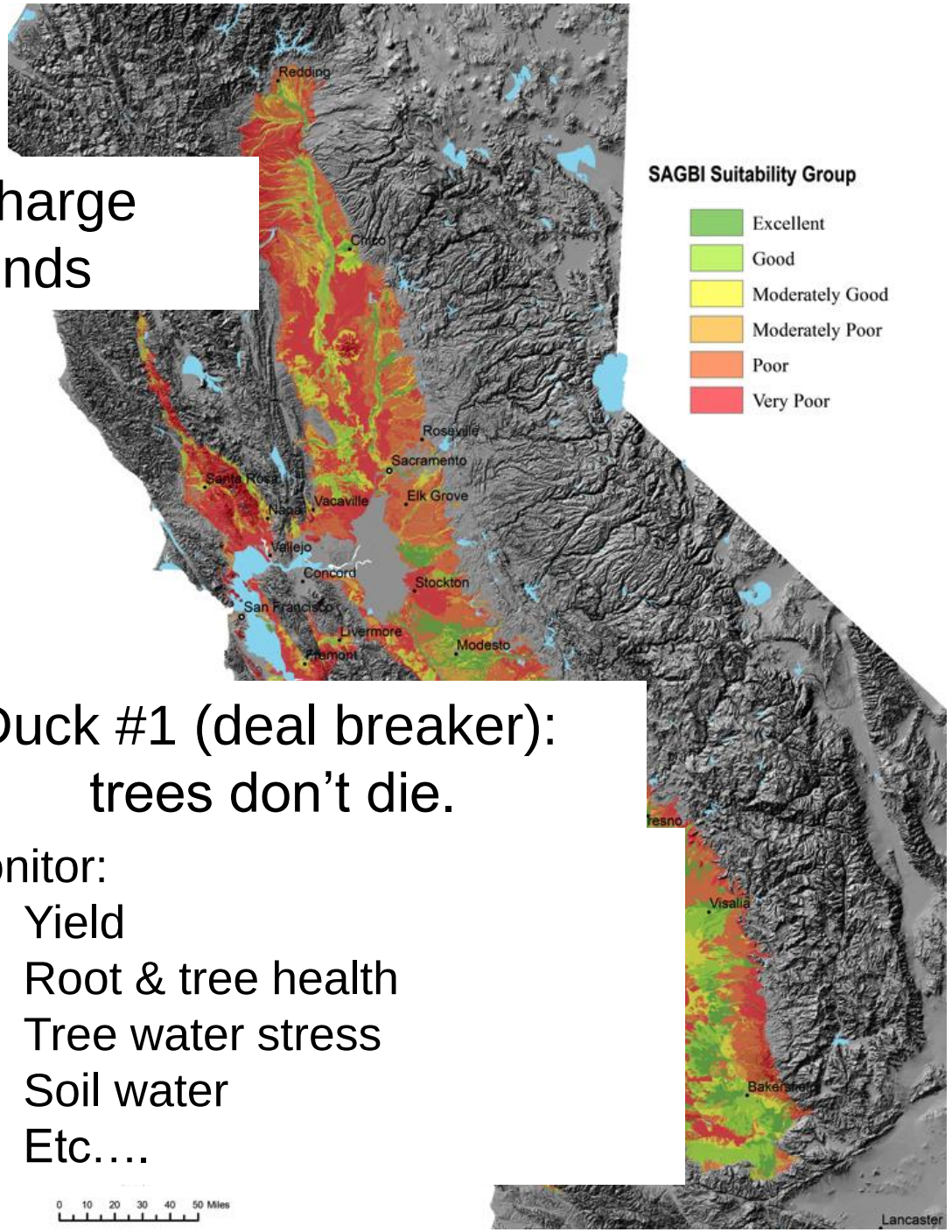
Using Orchards for Winter Recharge

Many ducks need to be in a row for winter recharge flooding to be a sustainable strategy in almonds



Duck #1 (deal breaker): trees don't die.

Monitor:

1) Yield
2) Root & tree health
3) Tree water stress
4) Soil water
5) Etc….

Saturated Soils: Generally BAD for Almonds

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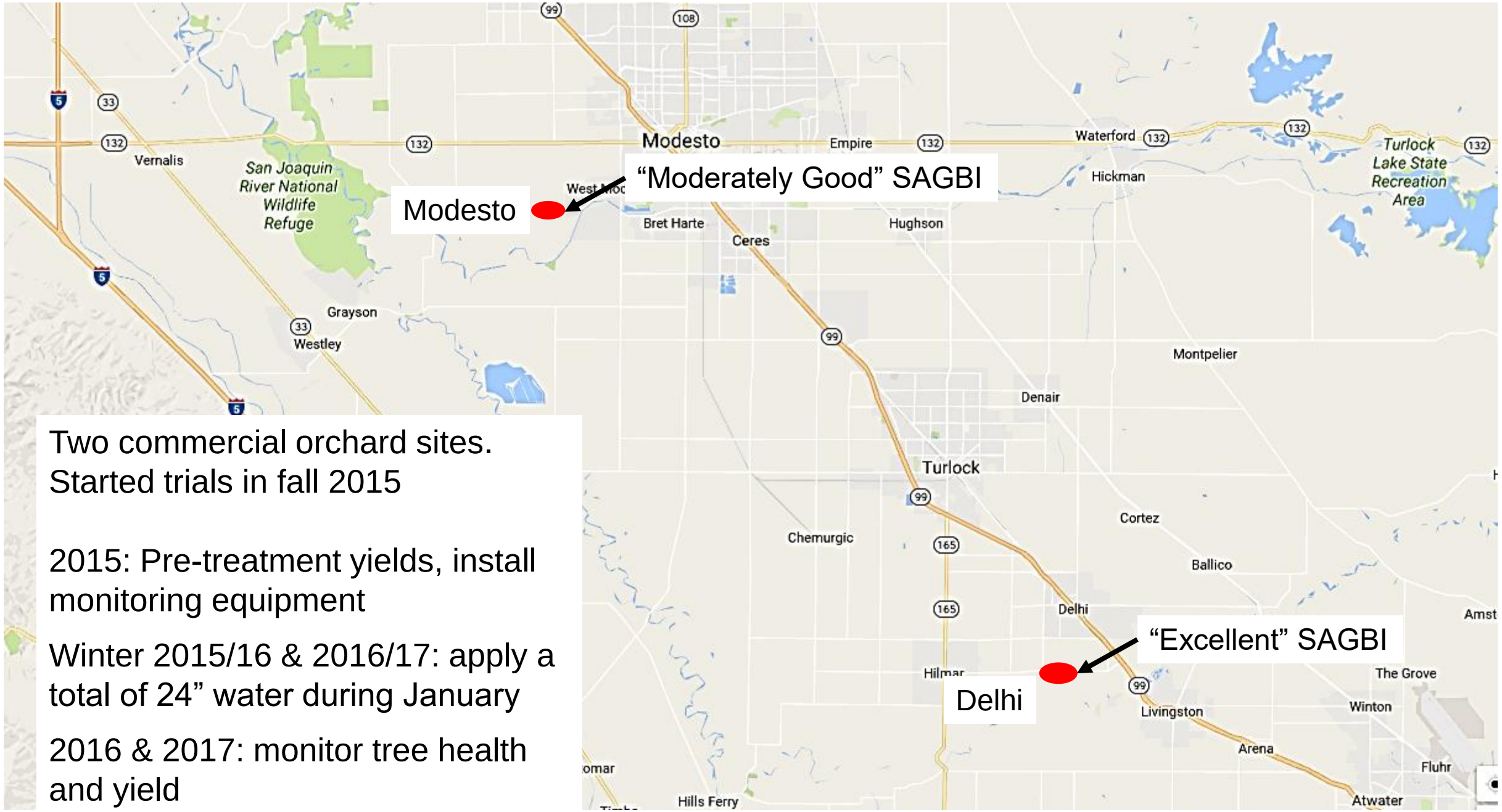
Questions:

1. Is it OK for Almonds if the trees are dormant (Dec/Jan)?
2. What happens to root and tree health over the long run?
3. What about leaching of N, pesticides, salts, etc.?



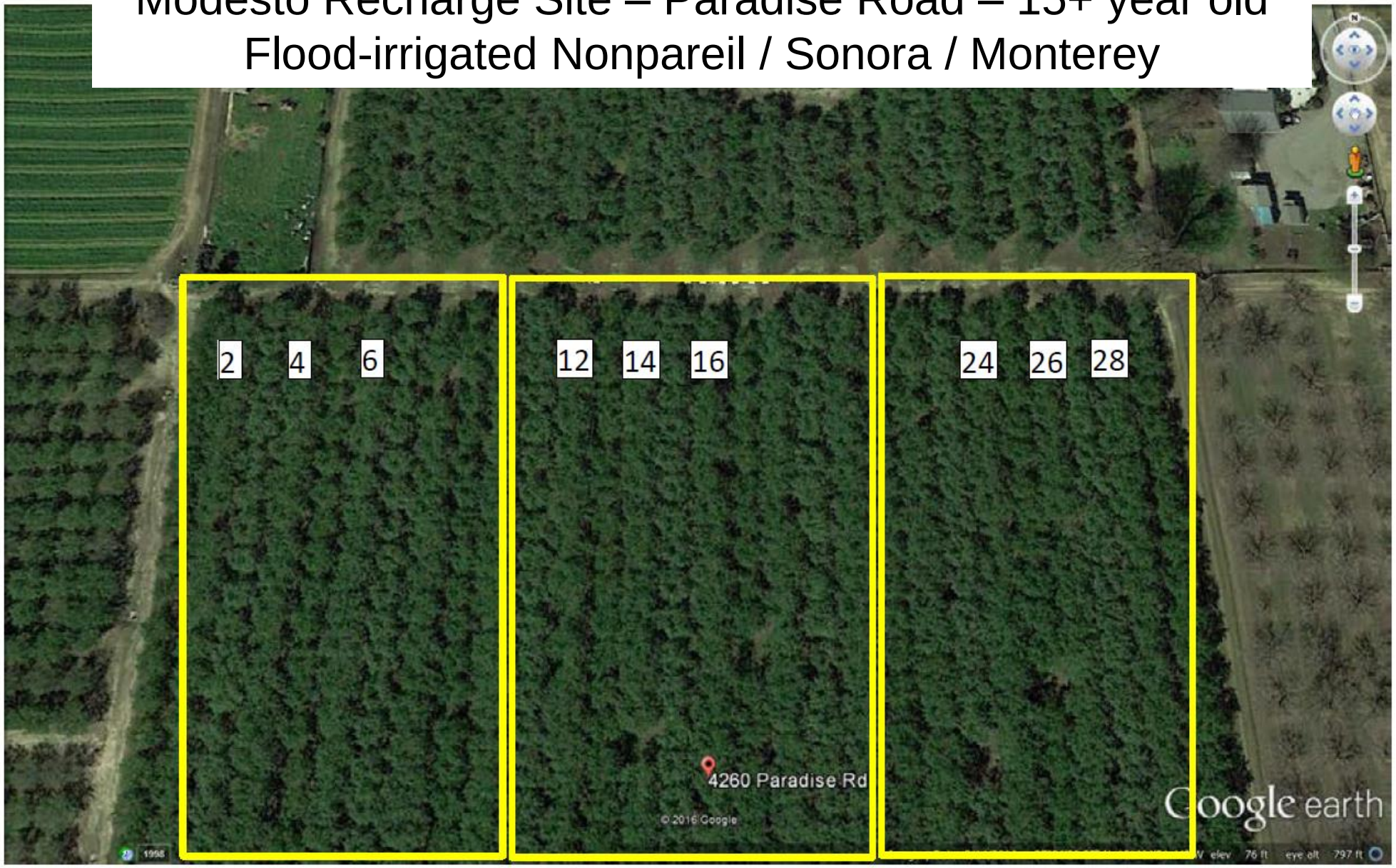
Two commercial orchard sites. Started trials in fall 2015

2015: Pre-treatment yields, install monitoring equipment

Winter 2015/16 & 2016/17: apply a total of 24” water during January

2016 & 2017: monitor tree health and yield

Modesto Recharge Site – Paradise Road – 15+ year old Flood-irrigated Nonpareil / Sonora / Monterey



Grower control

One irrigation (not used)

Two acre feet

Modesto Irrigation District Captured Storm Water Runoff

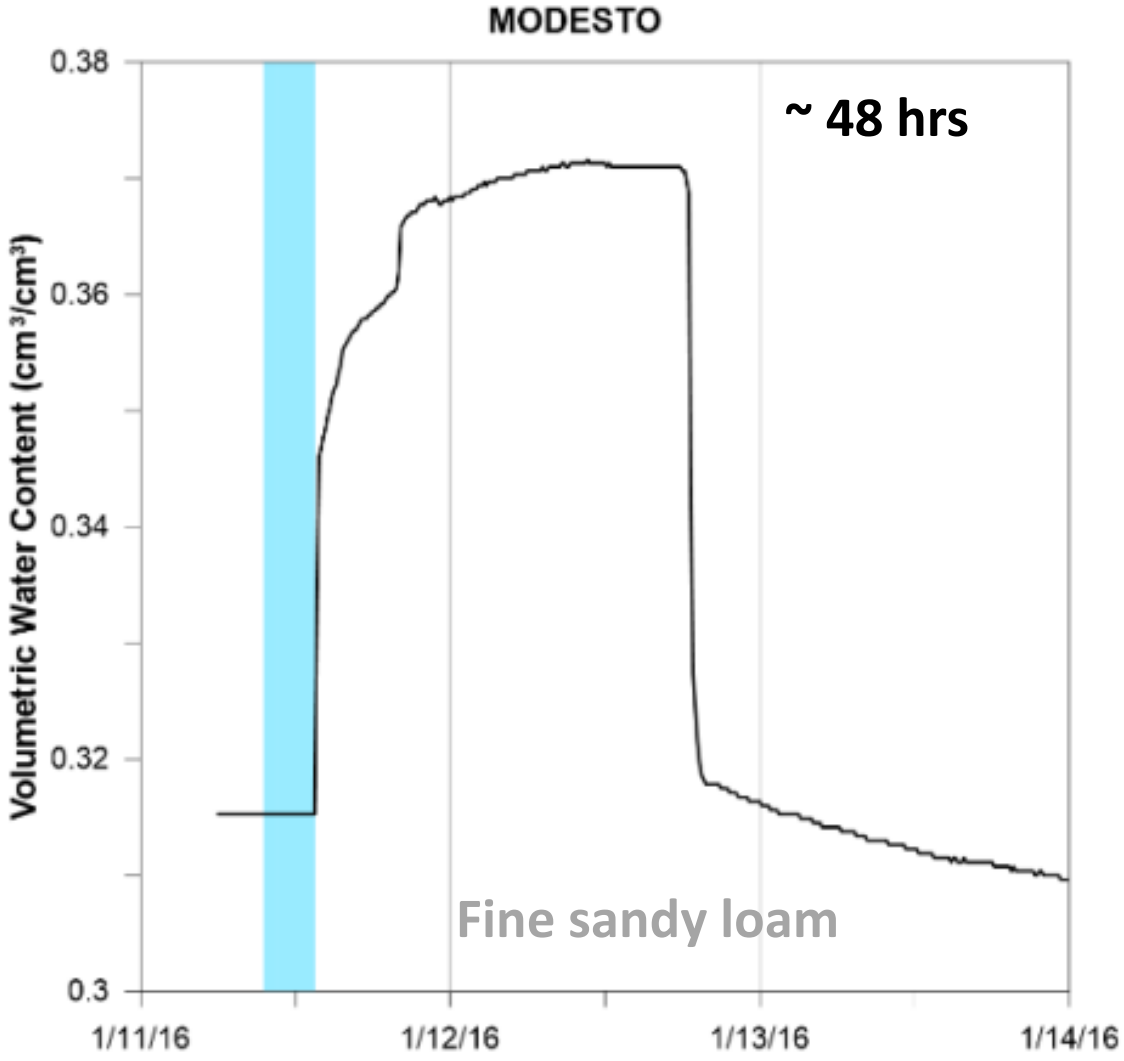
Six inches of water applied for four consecutive weeks in January

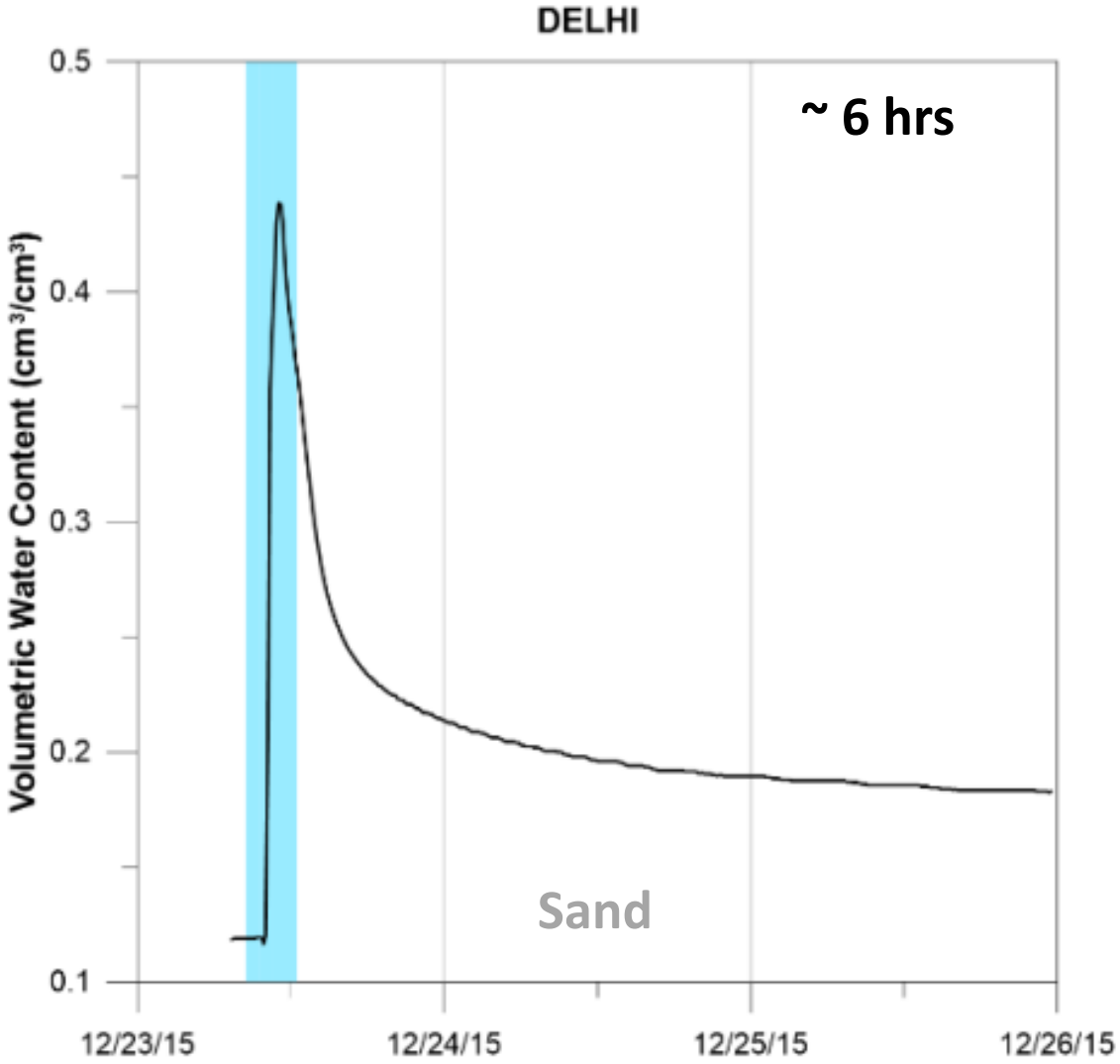
Compared against adjacent section with no winter irrigation

A suite of measurements:

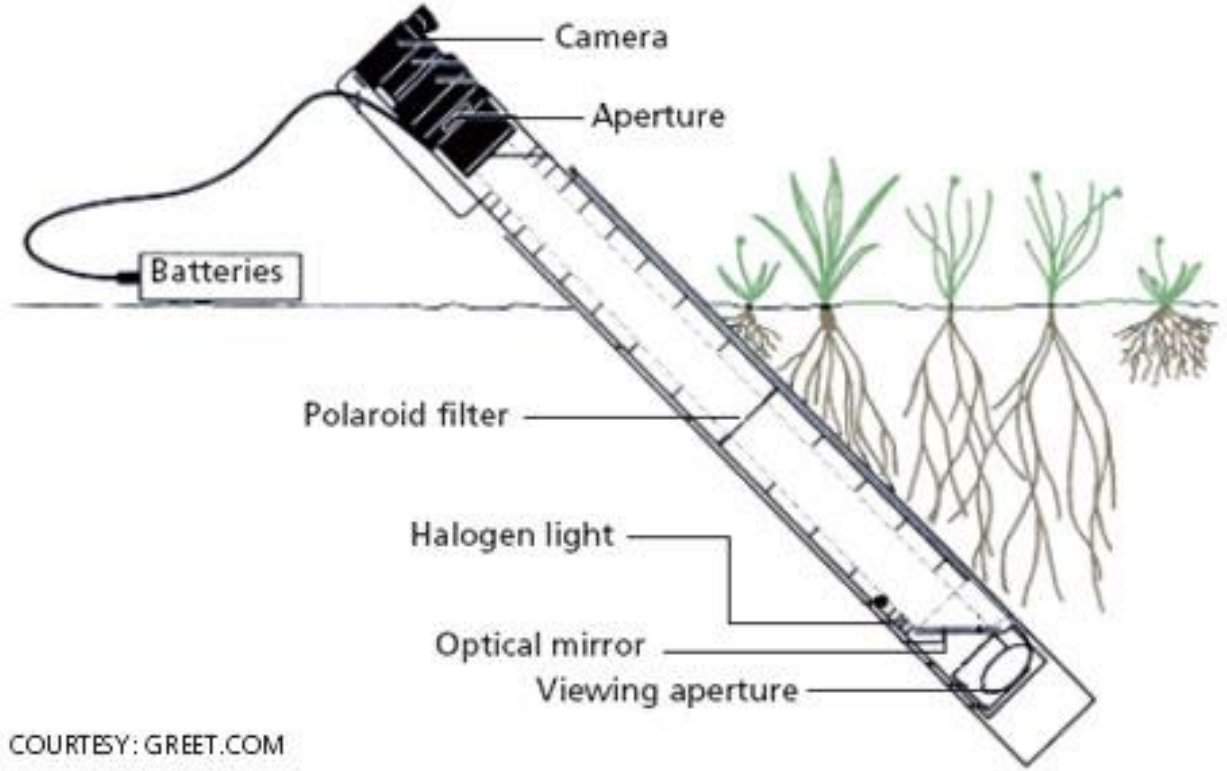
- water infiltration
- Leaching of NO_3, salts, etc.
- Root growth, tree “stress”, bloom, growth, yield, etc.

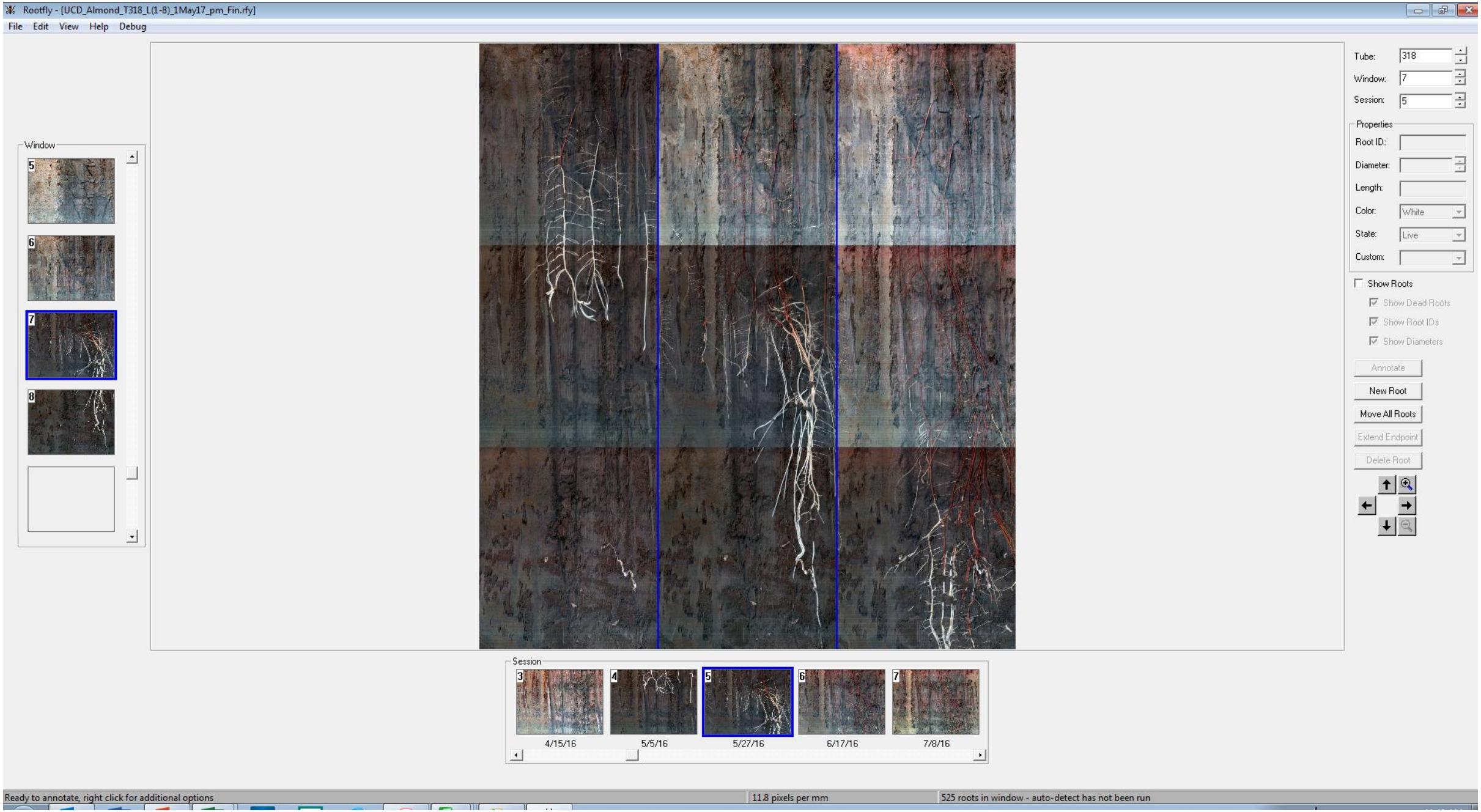
Root zone hydrology – quickly drained in Delhi sand but root zone saturated for 48 hours in Modesto Site





‘Mini-rhizotron’ method to observe root growth and ‘health’




Rootfly - [UCD_Almond_T318_L(1-8)_1May17_pm_Fin.rfy]
File Edit View Help Debug
Window
5
6
7
8
Tube: 318
Window: 7
Session: 5
Properties
Root ID:
Diameter:
Length:
Color: White
State: Live
Custom:
Show Roots
Show Dead Roots
Show Root IDs
Show Diameters
Annotate
New Root
Move All Roots
Extend Endpoint
Delete Root
Session
3 4/15/16
4 5/5/16
5 5/27/16
6 6/17/16
7 7/8/16
Ready to annotate, right click for additional options
11.8 pixels per mm
525 roots in window - auto-detect has not been run

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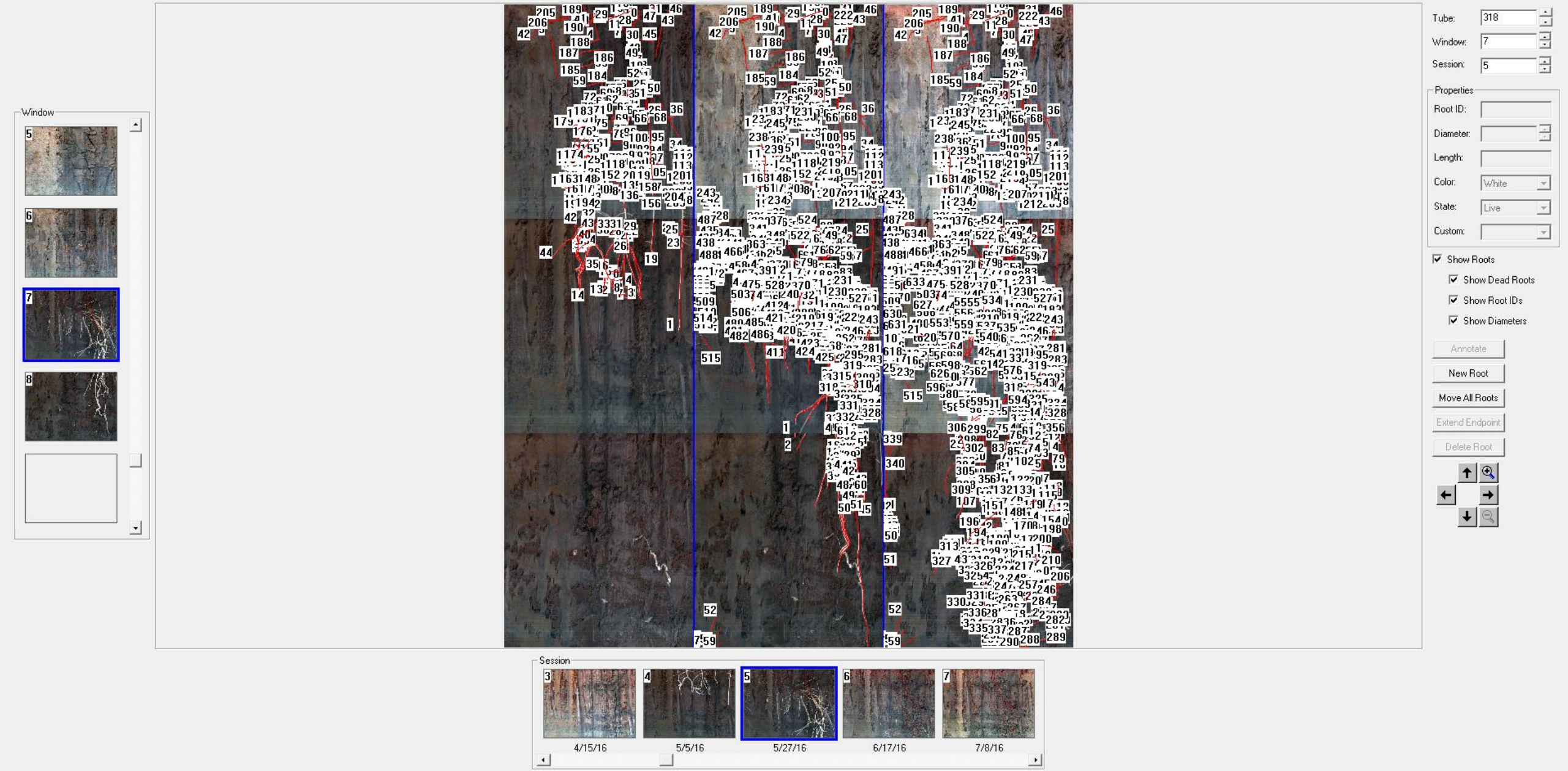
File Edit View Help Debug



Tube: 318
Window: 7
Session: 5

Properties
Root ID:
Diameter:
Length:
Color: White
State: Live
Custom:

Show Roots
Show Dead Roots
Show Root IDs
Show Diameters

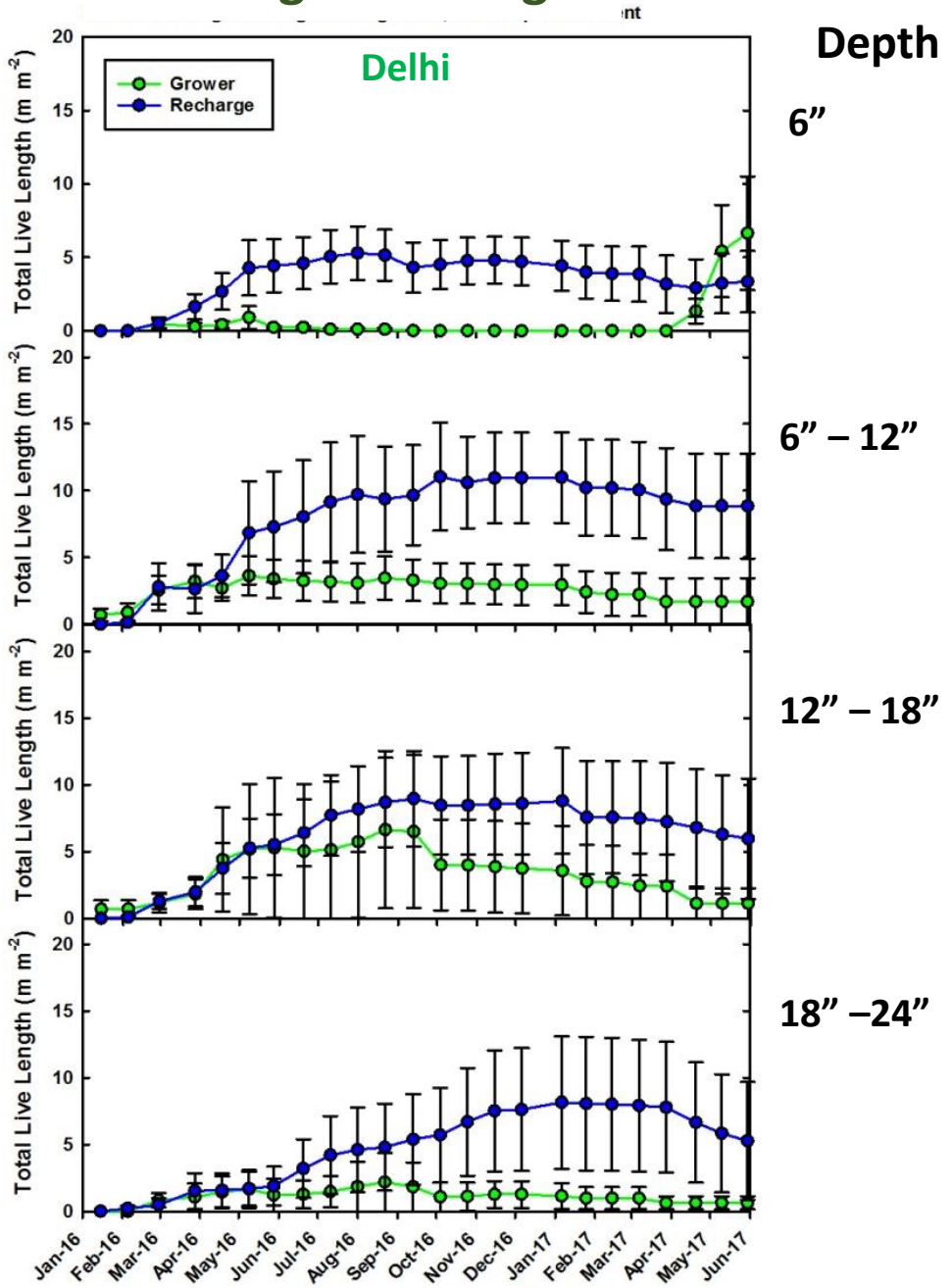
Annotate
New Root
Move All Roots
Extend Endpoint
Delete Root

Ready to annotate, right click for additional options | 11.8 pixels per mm | 525 roots in window - auto-detect has not been run

11:41 AM
7/27/2017

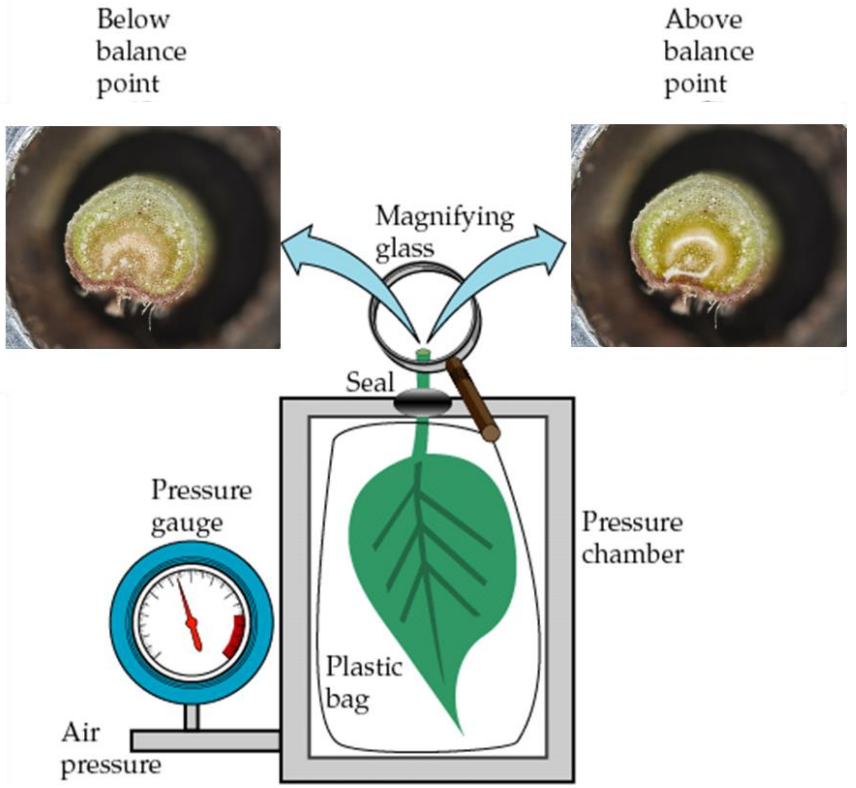
Root growth

- Trees in Recharge treatment showed higher standing root length:
  - Standing root length: rate of root production minus rate of root death
  - Greater standing root length = longer root lifespan
- Median lifespan of roots was about 30-70% longer in the Recharge treatment than in the Control
  - Lifespan increased with depth except for 18-24” depth
  - Greatest difference between Control and Recharge treatment at 6-12” depth

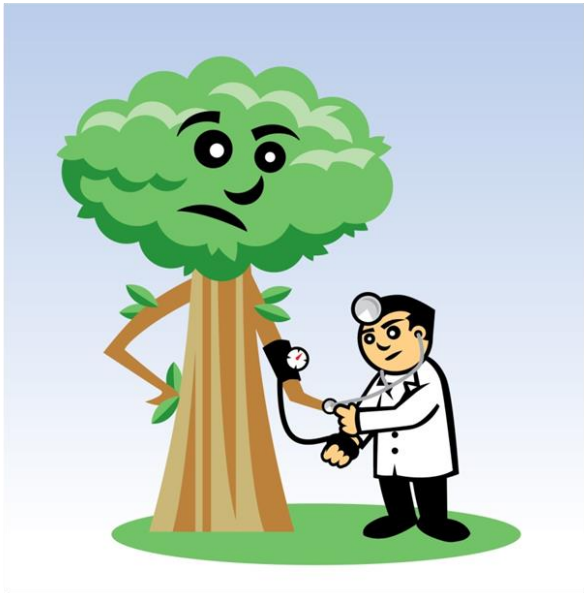


Checking root health by testing for tree water stress: Are roots able to supply the water that the tree needs?

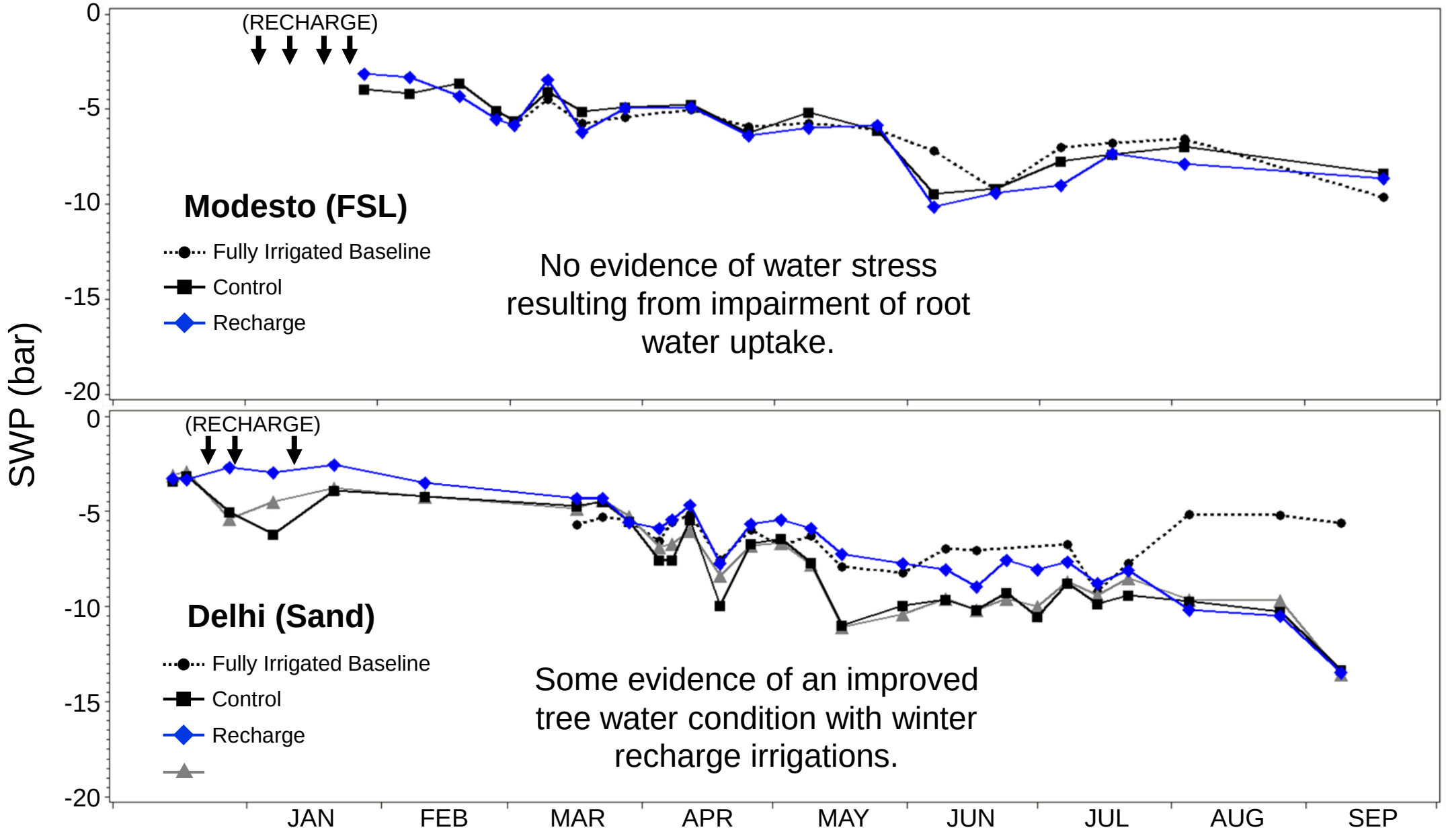
Pressure chamber method for measuring the level of water suction in the plant: midday stem water potential (SWP)

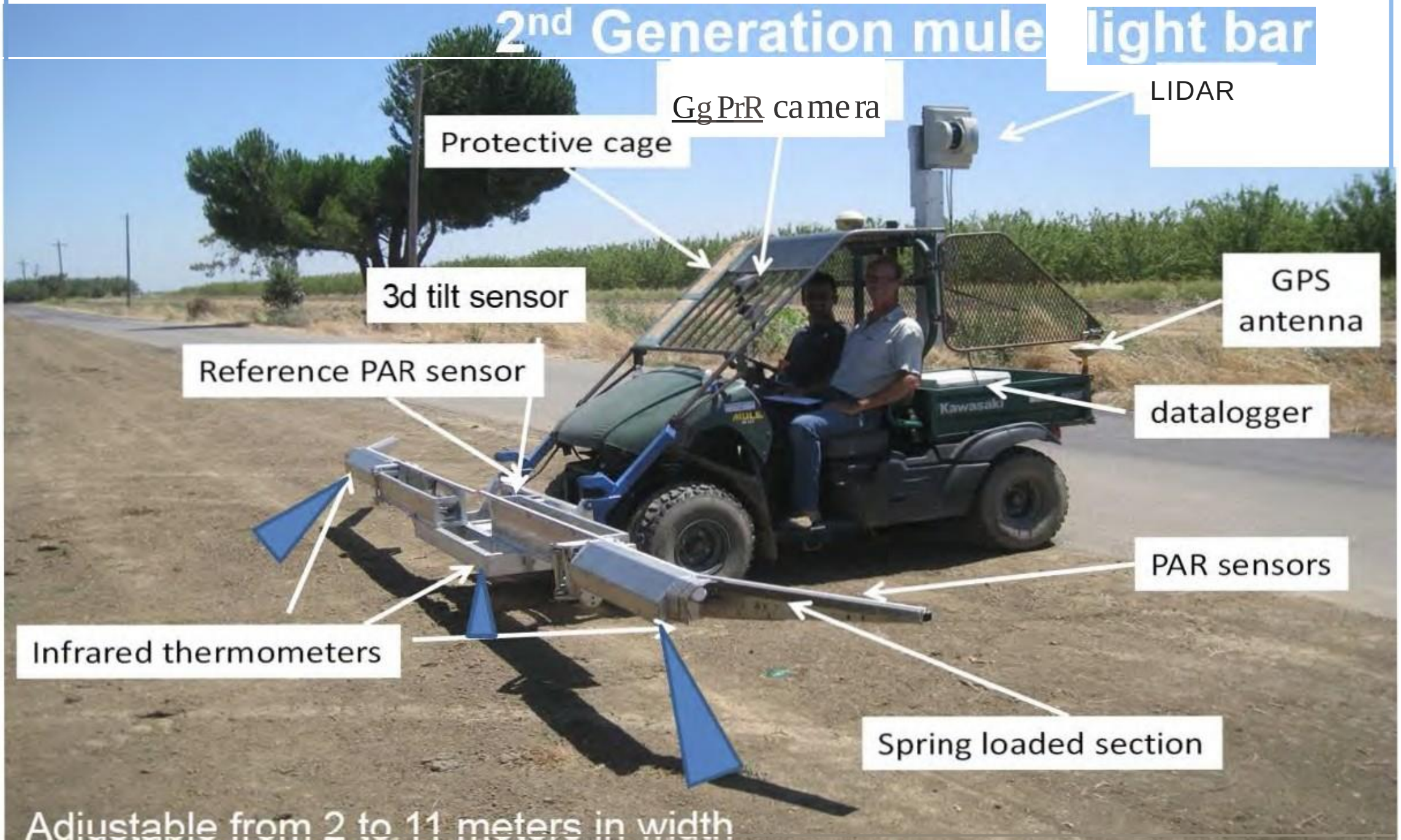


Like measuring the “blood pressure” of the plant



Testing for water stress during the growing season




2nd Generation mule light bar
LIDAR
GgPrR camera
Protective cage
3d tilt sensor
GPS antenna
Reference PAR sensor
datalogger
PAR sensors
Infrared thermometers
Spring loaded section
Adjustable from 2 to 11 meters in width

Measuring PAR (Photosynthetically Active Radiation) = shade

Impact on Canopy Growth

Delhi

	2016	2017	Change
Control	72.0 a	65.3 a	-6.7
Recharge	75.8 a	65.4 a	-10.4

Stanislaus

	2016	2017	Change
Control	88.8 a	75.1 a	-13.7
Recharge	85.2 a	77.2 a	-8.0

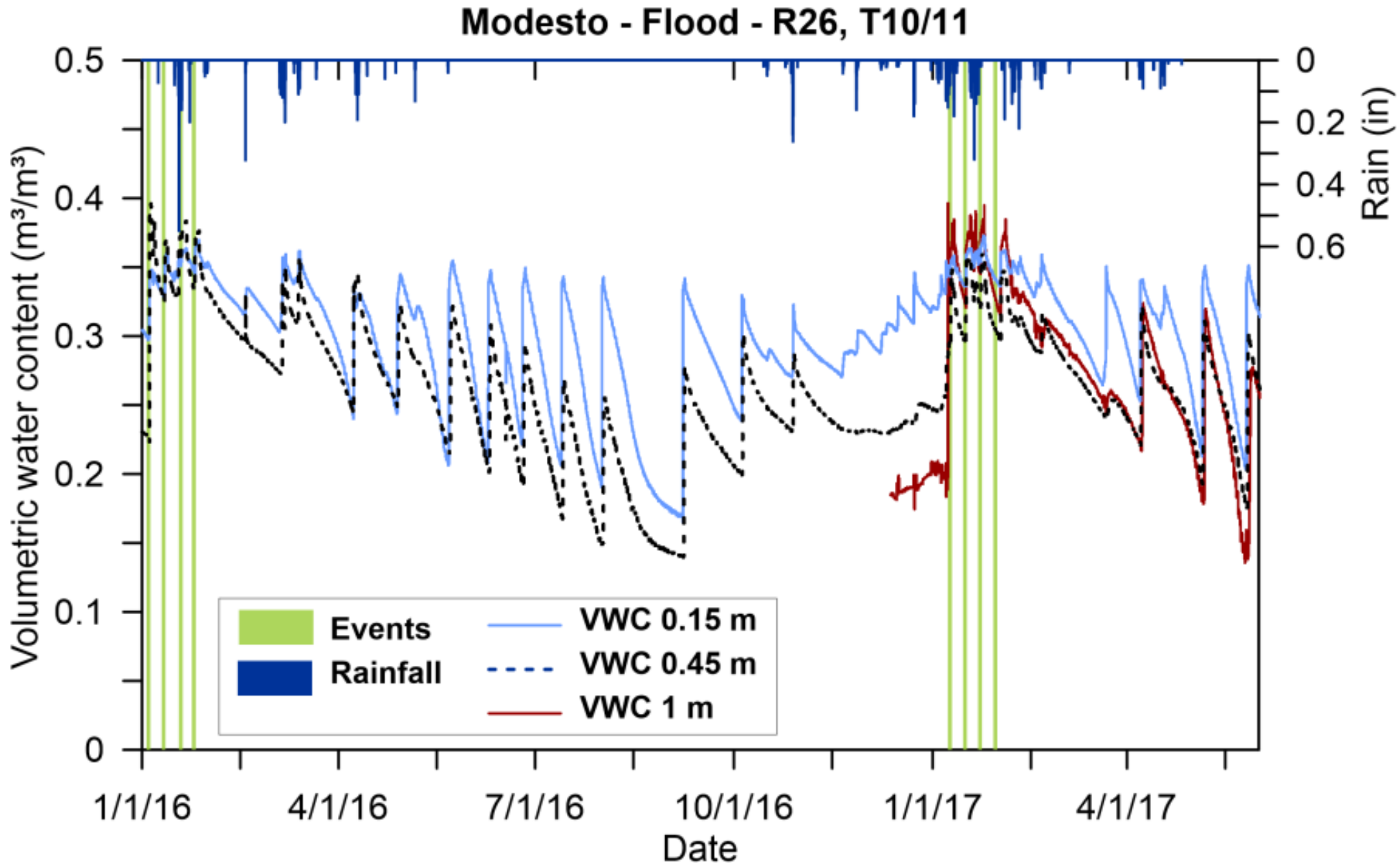
No difference in canopy growth in recharge areas vs. control

Yield Data

		Year		
	Treatment	**2015**	**2016**	**2017**
		(pre-treatment)		
Modesto	No Recharge	3360	3290	2980
	Recharge	3430	3130	2990
Delhi	No Recharge	1190	1140	2640
	Recharge	1410	1200	3110

*Bottom line: no apparent negative effect on yield from winter flooding

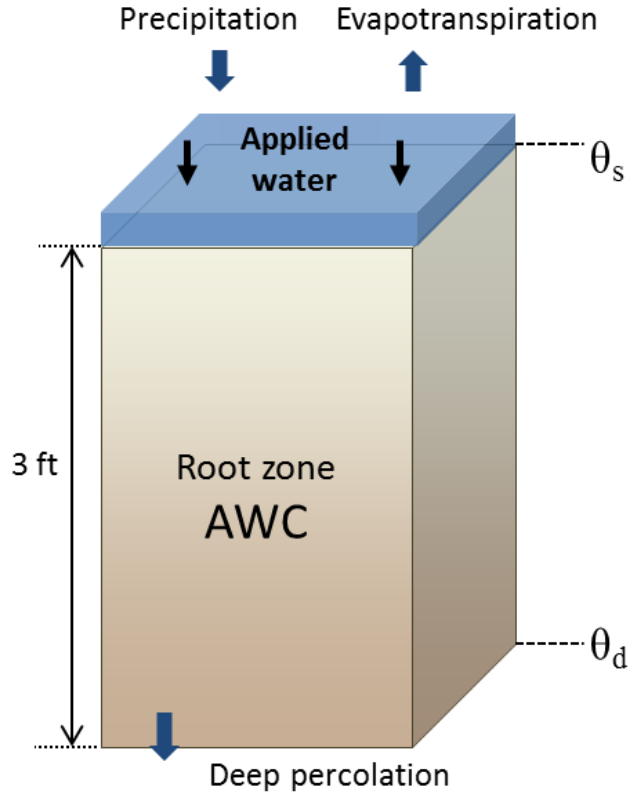
Root zone hydrology



How much of applied water went to recharge?

Summary of water inputs (rain & applied water) for October-March.

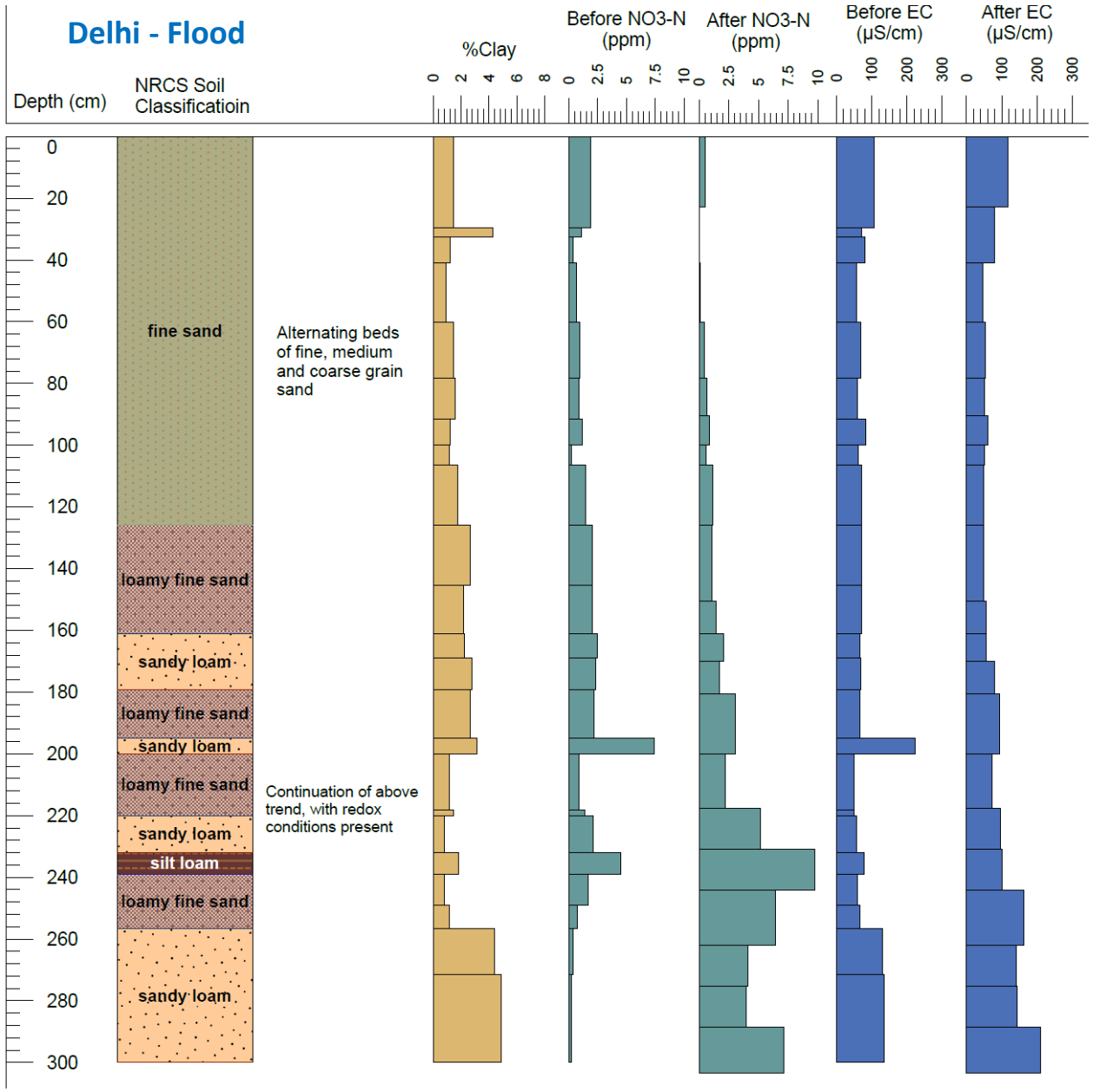
		Rain	Applied Water	Total deep percolation	Deep Percolation from rainfall	Deep Percolation of applied water		Applied water stored in rootzone	
		inches	inches	inches	inches	inches	%	inches	%
2015/16	Delhi	12.94	26.15	29.09	4.79	24.30	93%	1.84	7%
	Modesto	9.91	24.00	21.90	2.55	19.35	81%	4.65	19%
2016/17	Delhi	17.44	25.80	33.03	7.43	25.60	99%	0.20	1%
	Modesto	12.46	24.00	27.94	4.78	23.16	96%	0.84	4%



- >80% of applied water went to deep percolation..

AWC = available water content

Soil Nitrate



How much residual soil nitrate is leached during groundwater recharge events?

- Soil cores (12 ft) were taken before November) and after(February) recharge events
- Soil analysis: texture, pH, EC, soil nitrate, DOC
- Nitrate and salts pushed deeper into soil profile

Soil Nitrate – Nov. vs Feb. - Modesto

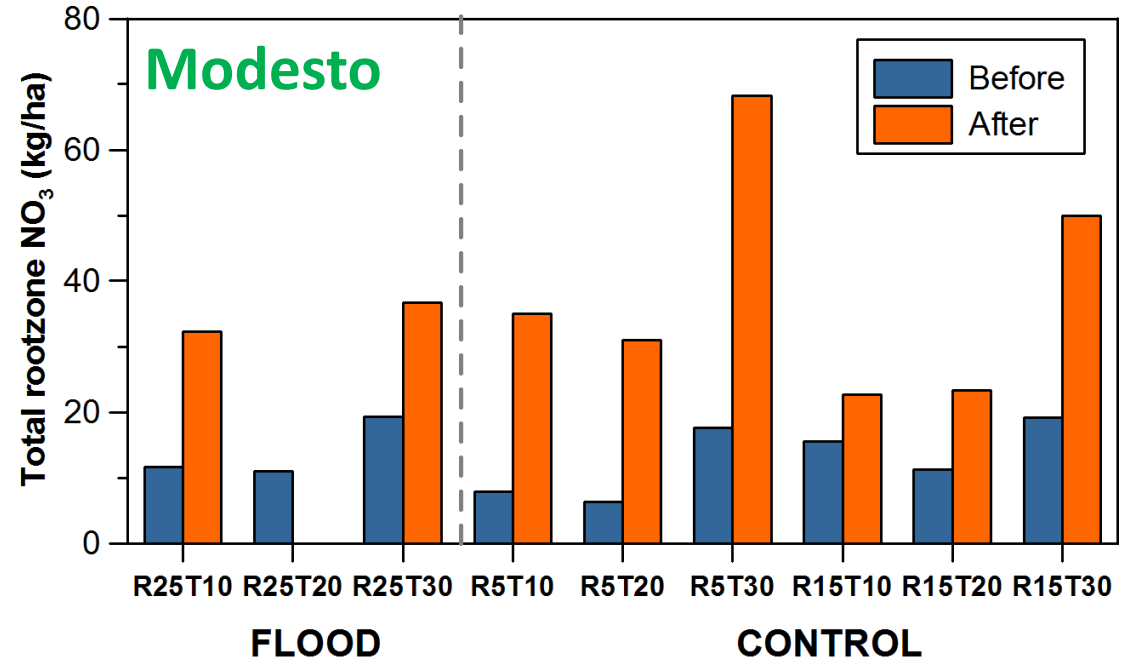
- Root zone (upper 3 ft):
  - 56% ***increase*** in Flood treatment
  - 220% ***increase*** in Control

- Entire profile (12 ft):
  - 107% ***increase*** in Flood treatment
  - 20% ***increase*** in Control

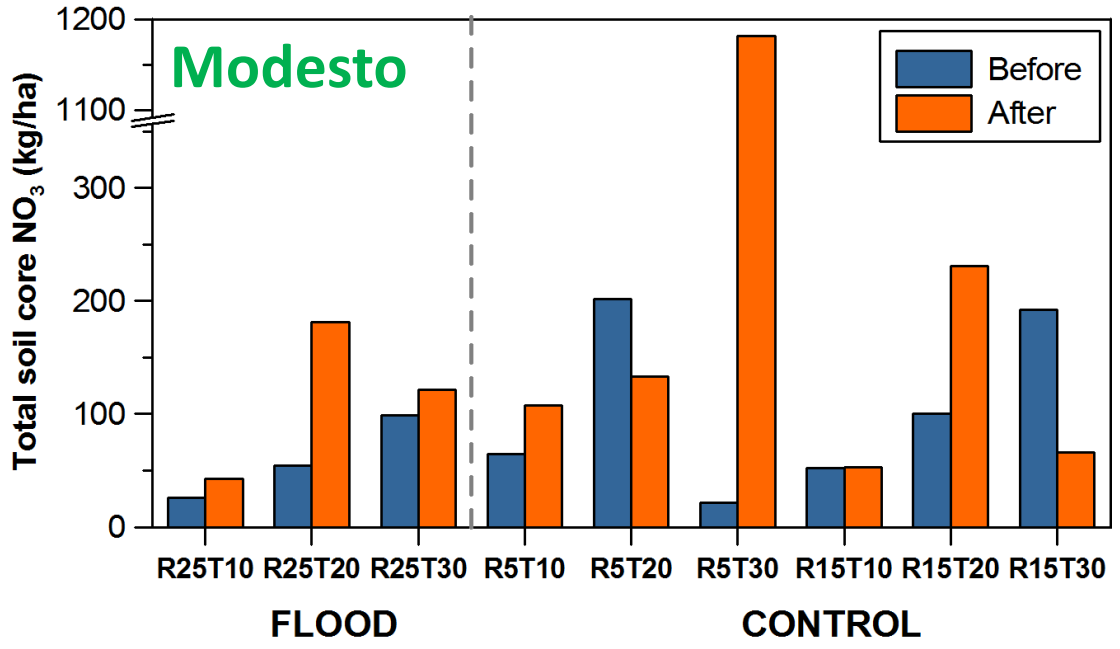
➢ Most of the increase in soil nitrate in the root zone occurred is the result of nitrification

➢ Most of the increase of nitrate deeper in soil profile is a <u>result of leaching</u>

ROOT ZONE



12 ft PROFILE



Conclusions

- No obvious warning signs that winter irrigation (Dec/Jan) for groundwater recharge negatively affects trees
- What about February / March??
- Trees on sandy sites might benefit from winter flooding
- Sandy soils (Delhi) – clear nitrate loss from recharge
- What about other leaching of other pollutants / pesticides? Regulations??