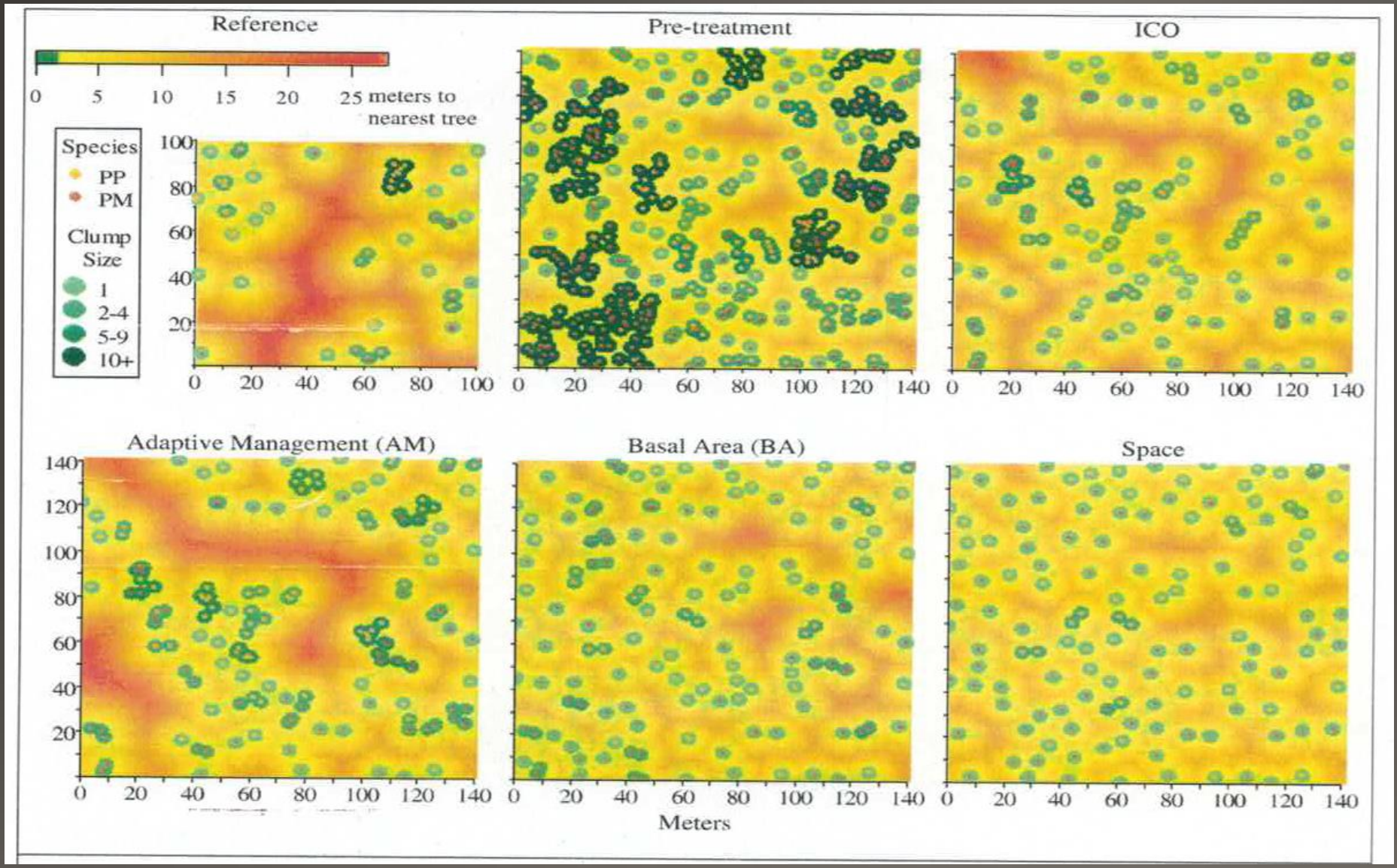
Assessing fuels treatment effectiveness in improving tree and stand health

Nancy Grulke PNWRS, WWETAC
Craig Bienz TNC Klamath Falls

Photo credit:USGS

Individual/clumped/open (ICO), 'clumpy/gappy,' or variable density thinning

Churchill et al. 2013

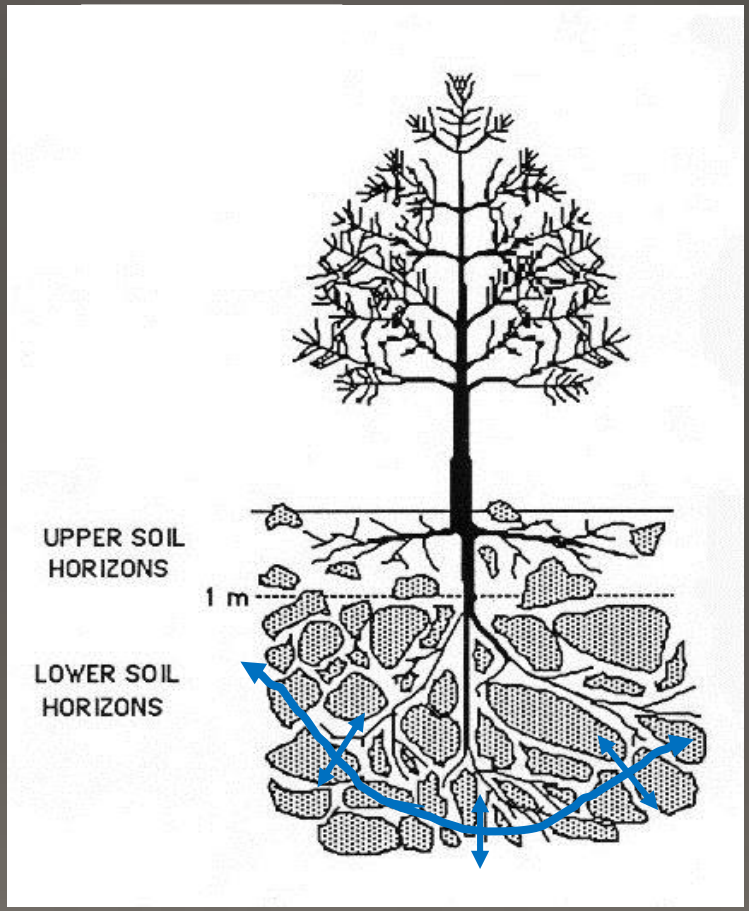


TREE SELECTION IS BASED ON ABOVE-GROUND PATTERN

…BUT HOW DO YOU KNOW WHICH TREES HAVE ACCESS TO WATER?

Site water availability: flat terrain

- Trees have access to upper soil horizons, plus water trapped under rocks and cracks in weathered bedrock
- Action : reduce stand density : more water for each tree, lower tree drought stress, less susceptibility to pests/paths, lower probably for outbreaks, and increase water output from watershed
- Susceptibility : in a severe drought, multiple yrs of <80% of ave ppt or single yrs of <60%, much of the stand will likely be susceptible

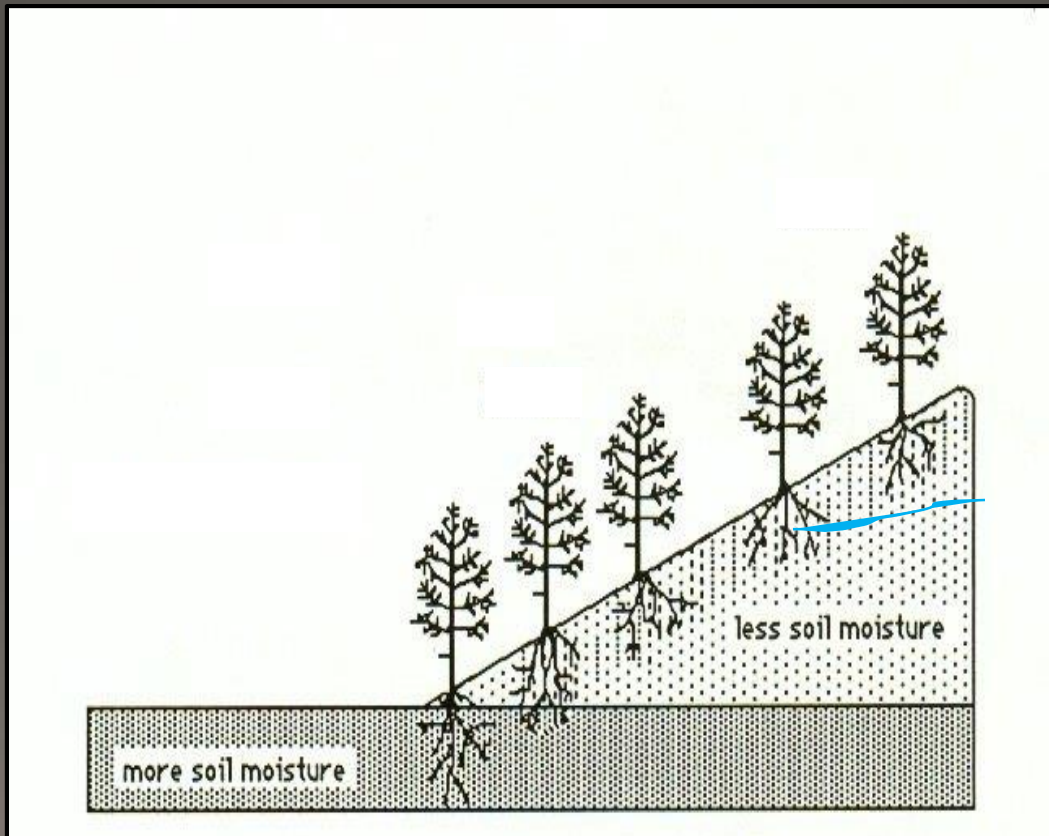


grulke et al. 2009

Site water availability: sloped terrain

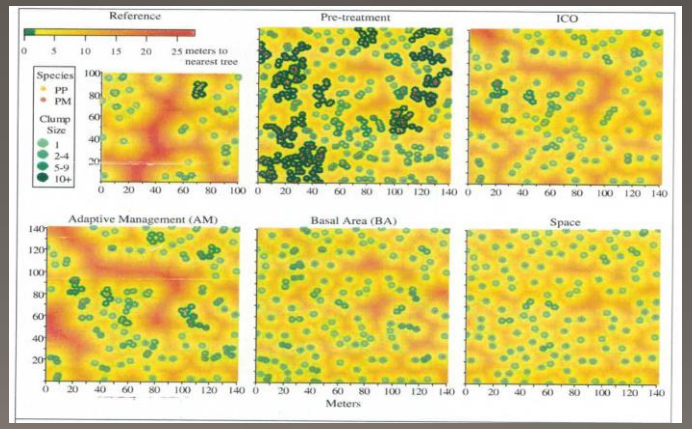
- Shallow upper soil horizons : trees may or may not have access to springs which increases within-stand differences in tree susceptibility to drought stress
- Action : reduce stand density: may be more water availability for some, but not most trees; increase water output in watershed
- Susceptibility : in a severe drought, not all trees will be susceptible : in an outbreak, most trees will still be attacked, with differing capacity to resist attack
- Differing capacities include ability to find soil moisture, capacity to control plant water loss and upregulate defenses

sequoia nat'l park: grulke et al., 2003a; 2003b;



Fuels treatments objectives:

- Decrease severe wildfire risk
- Improve long term tree/forest health
- Increase forest resilience to extreme conditions (drought, heat, …)
- Improve wildlife habitat
- Increase recreational opportunities
- Aesthetics



How are common fuels treatments affecting tree/stand/forest health?

Variable density treatments were designed to replicate historic, reconstructed patterns of dry pine forest stand structure.

Does it still work? Will it work for the future?

Is the ICO treatment effective in:

Improving tree health?

Reducing severe fire risk?

And if its not effective, how can it be modified to have better outcomes?

WHAT LOW-TECH MEASURES CAN BE MADE TO DETERMINE WHETHER A TREE IS DROUGHT-STRESSED?

MEASURED 40+ WHOLE TREE AND CANOPY ATTRIBUTES

Grulke & Lee, 1997; Grulke 1999; Grulke 2002; Staszak et al., 2007; Grulke et al., 2009

TREE WATER BALANCE

% OF MAXIMUM NEEDLE LENGTH

BRANCHLET LENGTH

NUMBER OF NEEDLE AGE CLASSES

TREE CARBON BALANCE

BRANCHLET DIAMETER

NEEDLE YELLOWING (CHLOROSIS)

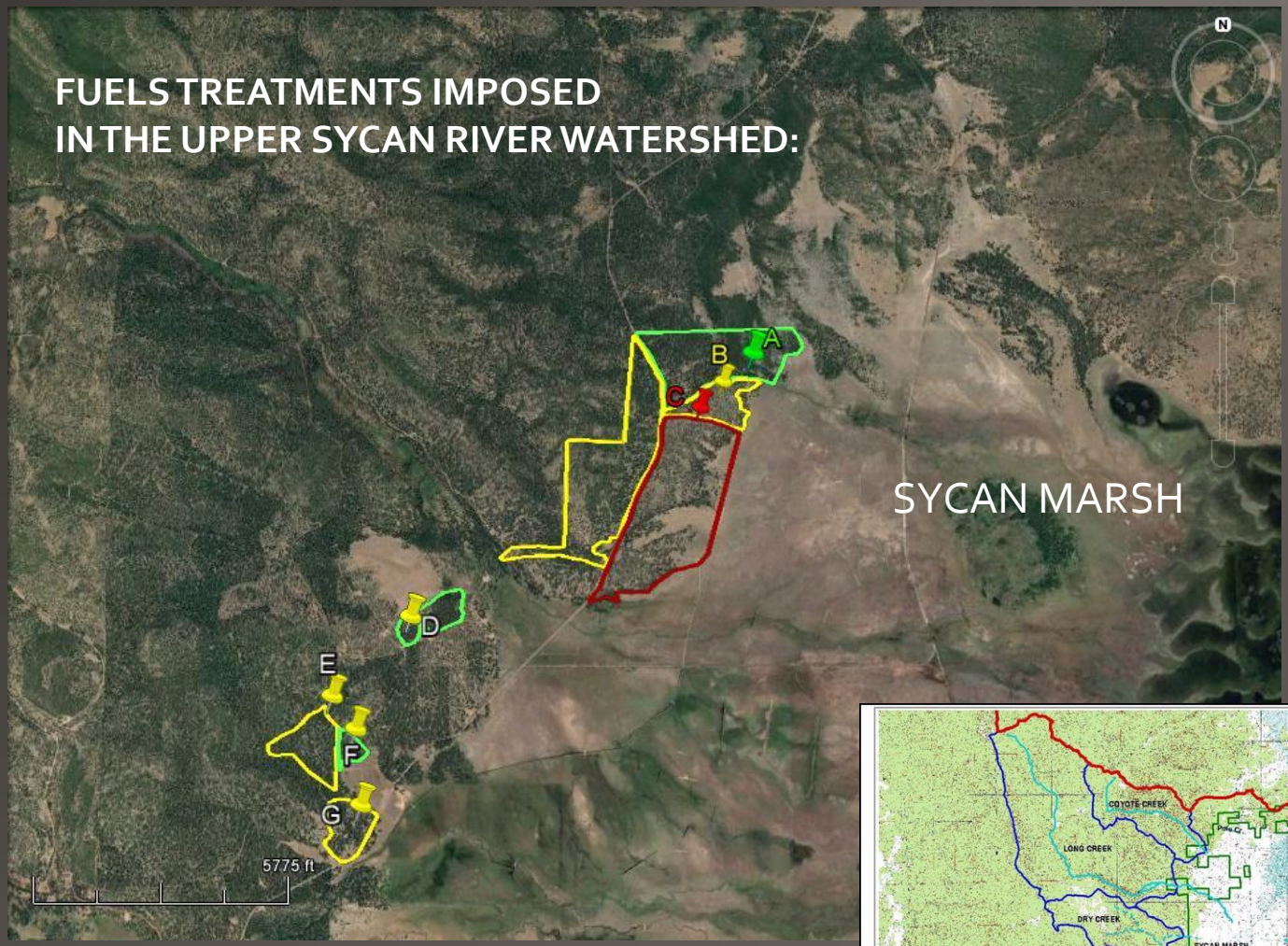
INSECT AND DISEASE

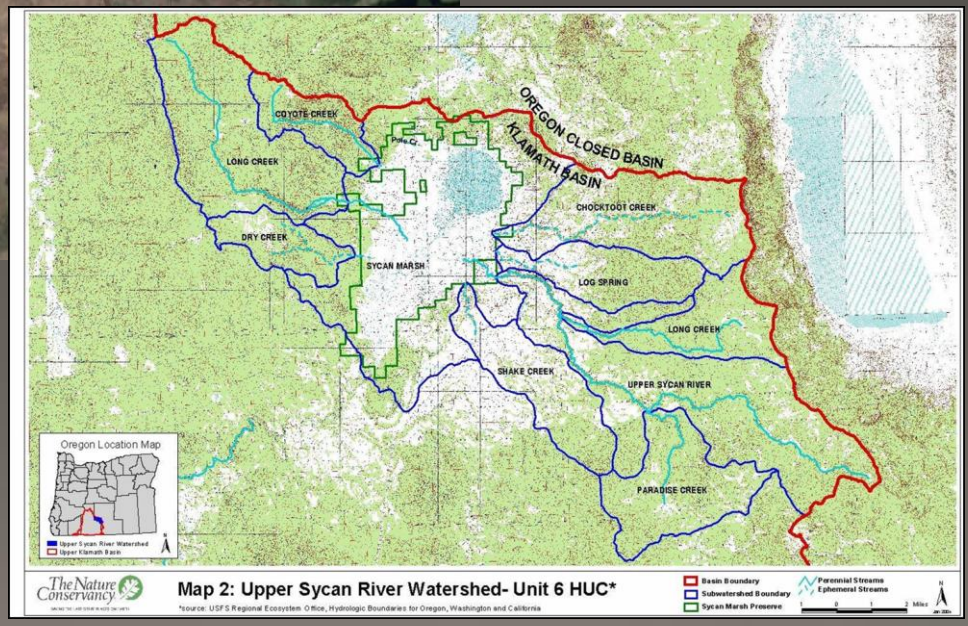
FREQUENCY OF NEEDLE FUNGUS, DEFOLIATORS, PHLOEM FEEDERS, BARK BEETLES, WOOD BORERS, DWARF MISTLETOE RANK

WHOLE TREE INDICATORS OF TREE DROUGHT STRESS

- Bottom up drying
- Bottom up excision of primary branches
- Needle desiccation: color change
- Needle loss and early senescence
- Growing point abscission
- Dispersed distribution of stressed trees in the landscape

FUELS TREATMENTS IMPOSED IN THE UPPER SYCAN RIVER WATERSHED:





'NAÏVE' POPULATION OF WESTERN YELLOW PINE IN SOUTHERN OR :
<60% OF AVE PPT OCCURRED ONCE IN LAST 40 YRS.
2014 AND 2015 WERE SEVERE DROUGHT YRS

TNC & Fremont NF fuels treatments

LOWLAND:

- No harvest
- Harvest
- ICO
- Harvest + Rx
- Rx only

UPLAND:

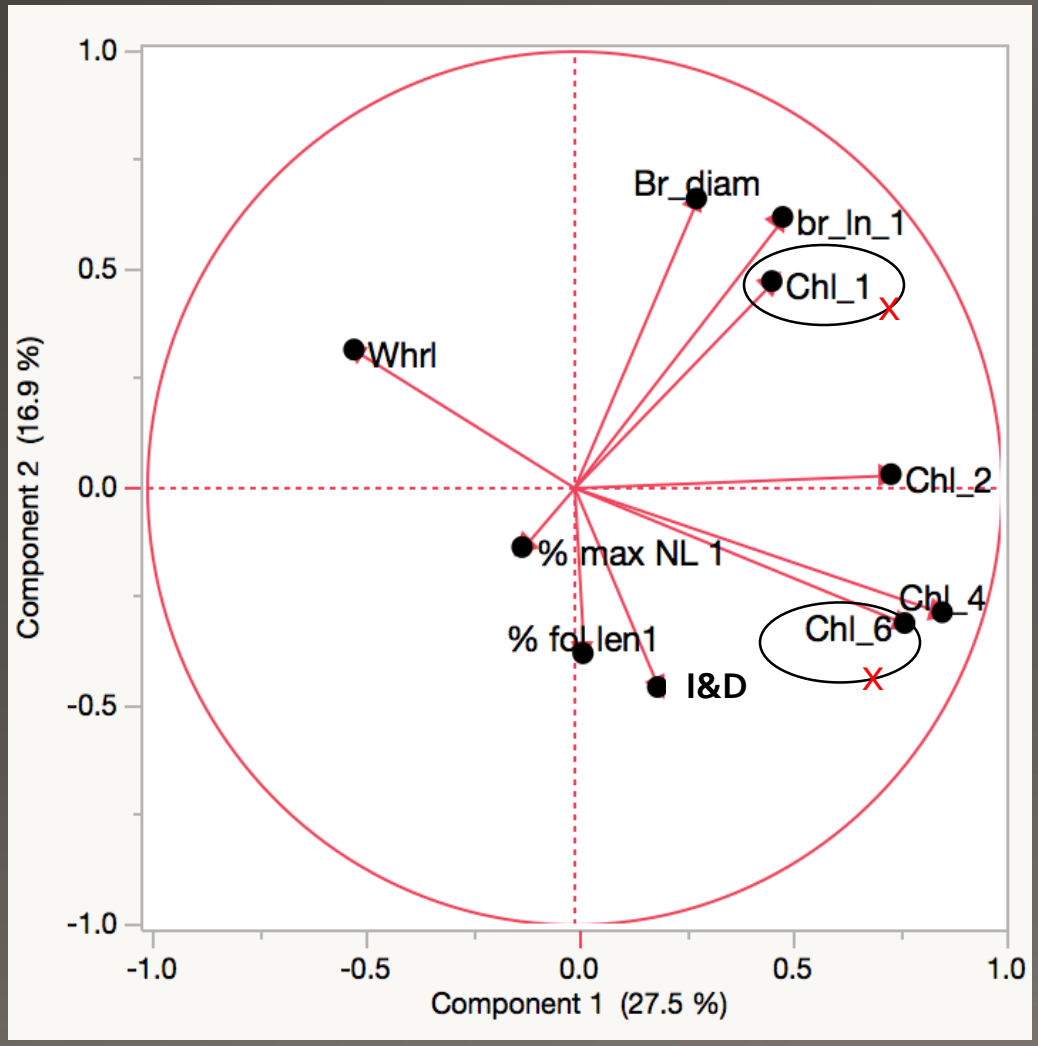
- No harvest
- Harvest
- ICO

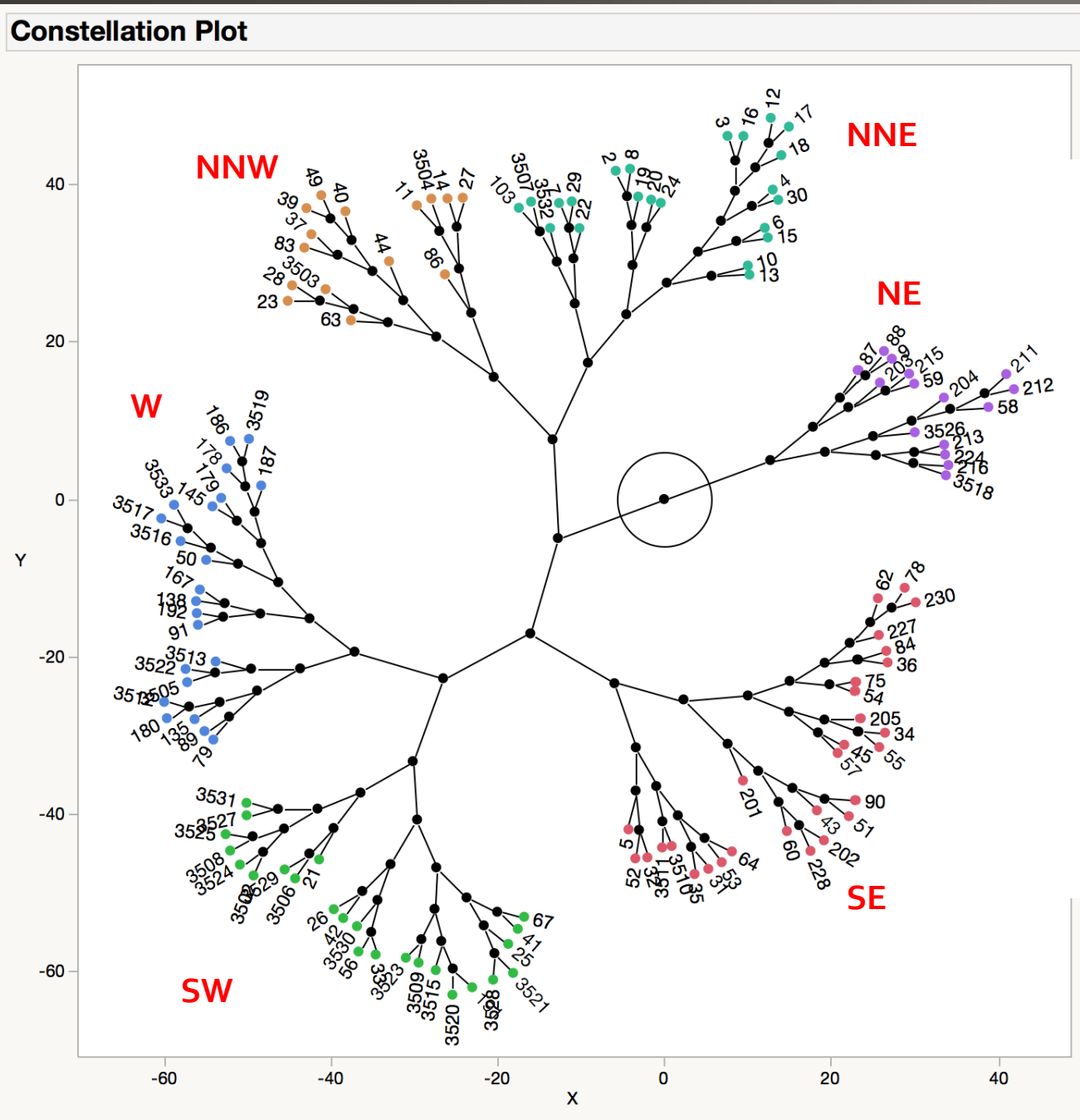
OF THE 40+ MEASURES, IDENTIFIED SIGNIFICANTLY CORRELATED ATTRIBUTES

	BR DIAM 2	% FOL LN 1	CHL 1	CHL 2	CHL 4	CHL 6
BR DIAM 2	1					
% FOL LN 1		1				
CHL 1			1			
CHL 2			0.57* (<0.00)	1		
CHL 4				0.53 (<0.00)	1	
CHL 6				0.38 (<0.00)	0.77 (0.01)	1
WHRL				-0.31 (<0.00)	0.47(<0.00)	-0.32 (<0.00)
BR LN 1	0.52 (<0.00)		0.36 <(0.00)	0.26 (0.02)	0.27 (0.01)	0.22 (0.031)
% MAX NL 1		0.32 (<0.00)				0.22 (0.031)
ES			0.23 (0.02)	0.24 (0.02)		
I&D					0.25 (0.02)	0.29 (<0.00)

*Adj. r^2 and its significance

EVALUATED THE RELATIONSHIP AMONG ATTRIBUTES TO UNDERSTAND/ELIMINATE REDUNDANCIES IN CORRELATIONS





USED A HIERARCHICAL CLUSTER ANALYSIS OF THE SUBSET OF ATTRIBUTES TO GROUP TREES WITH LIKE EXPRESSION OF ATTRIBUTES (6 GROUPS)

SINCE THESE ATTRIBUTES ARE STRONGLY LINKED TO WATER STATUS, CARBON STORAGE, AND PEST INCIDENCE, THEY ARE LIKELY TO BE GOOD INDICATOR OF MEDIUM TO LONG TERM TREATMENT OUTCOME

GROUPS	BR DIAM2	% FOL LN1	CHL2	CHL4	WHRL	BR LN1	% MAX NL1	ES	I&D
NNW	5.2 (0.3)	72 (2)	5 (1)	36 (6)	5.3 (0.2)	16 (1)	86 (2)	0.1 (0.0)	0.42 (0.01)
NE	6.0 (0.2)	72 (3)	4 (1)	18 (3)	6.6 (0.2)	15 (1)	86 (1)	1.0 (0.0)	0.41 (0.01)
NNE	6.4 (0.2)	71 (1)	3 (0)	21 (3)	6.6 (0.2)	16 (1)	75 (1)	0.0 (0.0)	0.47 (0.01)
W	4.9 (0.2)	68 (3)	1 (0)	8 (1)	6.7 (0.2)	12 (1)	92 (1)	0.0 (0.0)	0.41 (0.01)
SW	6.5 (0.2)	74 (2)	2 (0)	11 (2)	6.0 (0.1)	23 (1)	88 (1)	0.0 (0.0)	0.41 (0.01)
SE	6.5 (0.2)	59 (2)	3 (0)	11 (1)	6.7 (0.2)	17 (1)	77 (1)	0.0 (0.0)	0.35 (0.01)

RED VALUES DECREASE VIGOR; GREEN VALUES CONTRIBUTE TO INCREASE VIGOR

INTERIOR PONDEROSA PINE IS PHENOTYPICALLY AND GENOTYPICALLY PLASTIC: IT HAS SEVERAL STRATEGIES IN COPING WITH [DROUGHT] STRESS

THIS STATISTICAL APPROACH IDENTIFIES THE RESPONSE STRATEGY AND THE MECHANISM OF RESPONSE TO THE TREATMENT

ALTHOUGH COURT-DEFENSIBLE IN TERMS OF EVALUATING EFFECTIVENESS OF A FUELS TREATMENT, WE NEED A RAPID FIELD ASSESSMENT TO MAKE IT OPERATIONAL…

TRANSLATION OF QUANTITATIVE MEASURES OF TREE HEALTH TO FAST FIELD RANKING OF AT-RISK TREES

POOR (=AT-RISK)

MEASURES:

- LOWEST AMOUNT OF NEEDLES RETAINED
- PREMATURE LOSS OF NEEDLES/ EARLY SENESCENCE
- GREATEST NEEDLE YELLOWING
- LOWEST BRANCHLET DIAMETER

TRANSLATION:

FADED NEEDLE COLOR, FEWER NEEDLES/ THINNER CANOPY, AND HIGH FREQUENCY OF NEEDLE AND BRANCH INSECTS & PATHS

AVERAGE

MEASURES:

- INTERMEDIATE NUMBER OF NEEDLE AGE CLASSES
- INTERMEDIATE AMOUNT OF NEEDLE YELLOWING
- HIGH BRANCHLET DIAMETER (α BAI)

TRANSLATION:

OK HEALTH, BUT NOT ROBUST

ABOVE AVERAGE

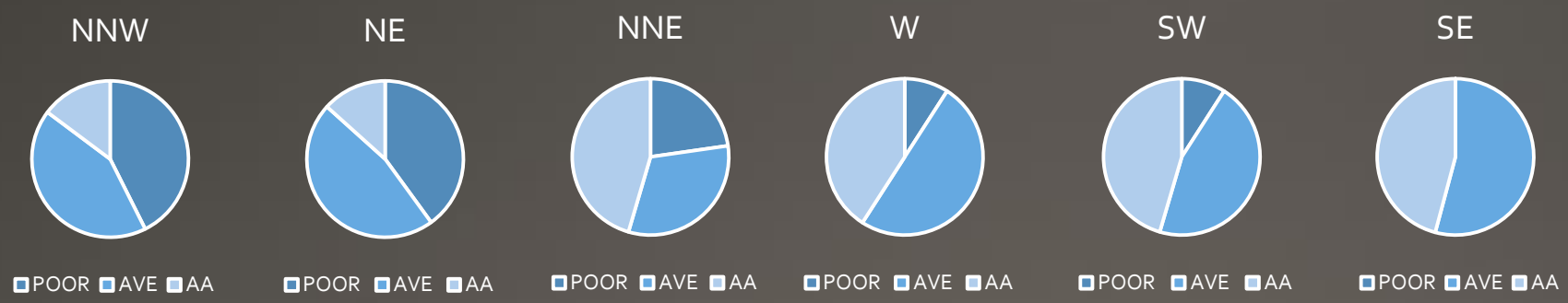
MEASURES:

- HIGHEST NUMBER OF NEEDLE AGE CLASSES
- LOWEST LEVEL OF NEEDLE YELLOWING
- HIGH BRANCHLET DIAMETER (α BAI)

TRANSLATION:

BRIGHT GREEN NEEDLES, HIGH NEEDLE MASS, THICKER BRANCHES

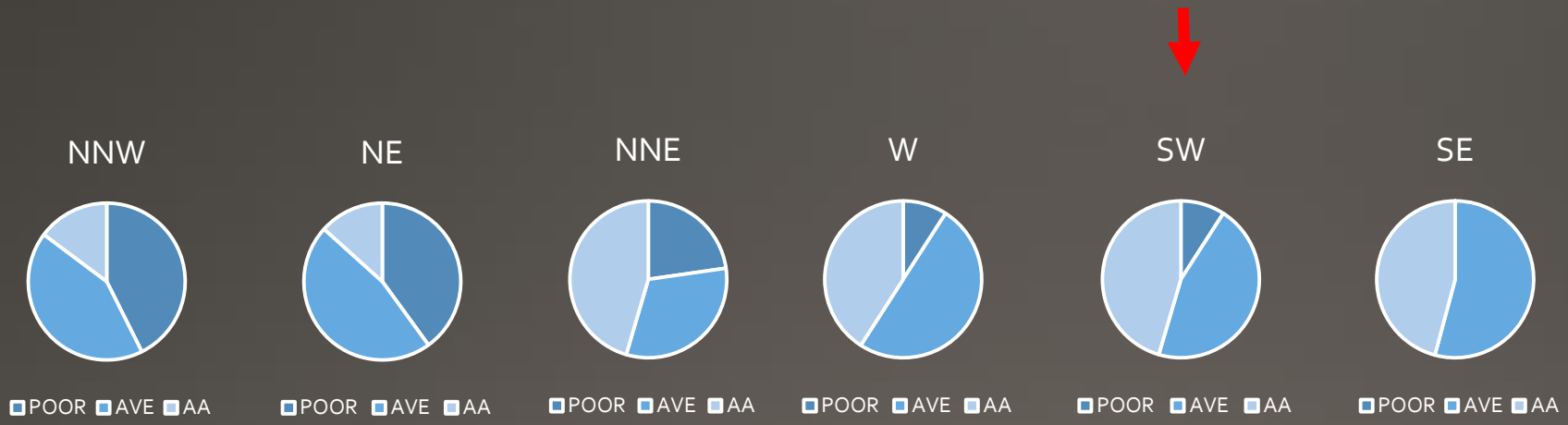
GROUPS	BR DIAM 2	% FOL LN 1	CHL 2	CHL 4	WHRL	BR LN 1	% MAX NL 1	ES	I&D	RANK	POOR	AVE	AA
NNW	5.2 (0.3)	72 (2)	5 (1)	36 (6)	5.3 (0.2)	16 (1)	86 (2)	0.1 (0.0)	0.42 (0.01)	2.3 (0.2)	0.38	0.38	0.13
NE	6.0 (0.2)	72 (3)	4 (1)	18 (3)	6.6 (0.2)	15 (1)	86 (1)	1.0 (0.0)	0.41 (0.01)	2.3 (0.2)	0.40	0.47	0.13
NNE	6.4 (0.2)	71 (1)	3 (0)	21 (3)	6.6 (0.2)	16 (1)	75 (1)	0.0 (0.0)	0.47 (0.01)	1.8 (0.2)	0.23	0.45	0.32
W	4.9 (0.2)	68 (3)	1 (0)	8 (1)	6.7 (0.2)	12 (1)	92 (1)	0.0 (0.0)	0.41 (0.01)	1.7 (0.1)	0.09	0.50	0.41
SW	6.5 (0.2)	74 (2)	2 (0)	11 (2)	6.0 (0.1)	23 (1)	88 (1)	0.0 (0.0)	0.41 (0.01)	1.6 (0.1)	0.09	0.45	0.45
SE	6.5 (0.2)	59 (2)	3 (0)	11 (1)	6.7 (0.2)	17 (1)	77 (1)	0.0 (0.0)	0.35 (0.01)	1.7 (0.1)	0.00	0.45	0.38



PROPORTION OF TREES IN EACH GROUP IN POOR, AVERAGE, AND ABOVE-AVERAGE HEALTH

THIS STATISTICAL APPROACH IDENTIFIES THE RESPONSE STRATEGY, THE TREATMENT EFFECT, AND ALSO PERMITS COMPARISON AMONG TREATMENTS:

<IDENTIFIES TREATMENTS WITH EQUIVALENT OUTCOMES IN STAND HEALTH>



LO/NO FIRE	H2xRx	H	ICO & Rx ONLY	**Rx ONLY**	H1xRx
HIGH CHL	HIGH ES, MOD CHL	MOD CHL, HI I&D	LOW CHL	LOW CHL	LOW CHL, I&D
LOW DIAM, LOW FOL	MOD BRANCH, HI ELONG	HI DIAM	LOW DIAM, ELONG	HI DIAM, ELONG GROWTH	LESS FOL, HI GROWTH

OK

EQUIVALENT (POORER) OUTCOME

EQUIVALENT (GOOD) OUTCOME

BEST

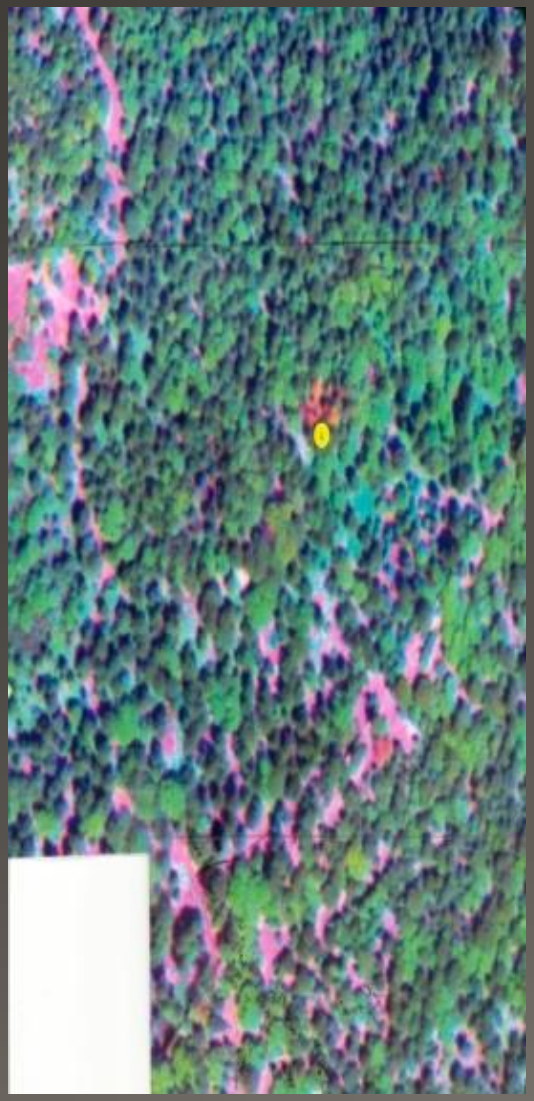
RECOMMENDATION:

- CHEAPEST/EASIEST: APPLY Rx ONLY (NOT SO GOOD FOR REC)
- NEXT BEST: IDENTIFY AND REMOVE POOR HEALTH TREES FIRST (TREES-AT-RISK)
  - THIS IS THE MOST CRITICAL ACTIVITY WE CAN DO TO PROMOTE HEALTHY FORESTS IN THE SHORT AND LONG TERM
  - LOOK AT THE CANOPY
- THEN LAY OUT THE DESIRED TREATMENT WITH AN EYE TOWARDS WHERE THE OLDEST TREES ARE/WERE (COVINGTON'S STRATEGY) – THOSE ARE PLACES WHERE TREES HAVE ALREADY FOUND ACCESS TO DEEP WATER SOURCES AND ARE MORE LIKELY TO SURVIVE HIGHER FUTURE TEMPERATURES AND MORE VARIABLE INTRA- AND INTERANNUAL PPT
- USE REMOTE SENSING TO SCALE TREE SELECTION TO THE LANDSCAPE LEVEL

Canopy spectral signature ID's 'trees-at-risk'

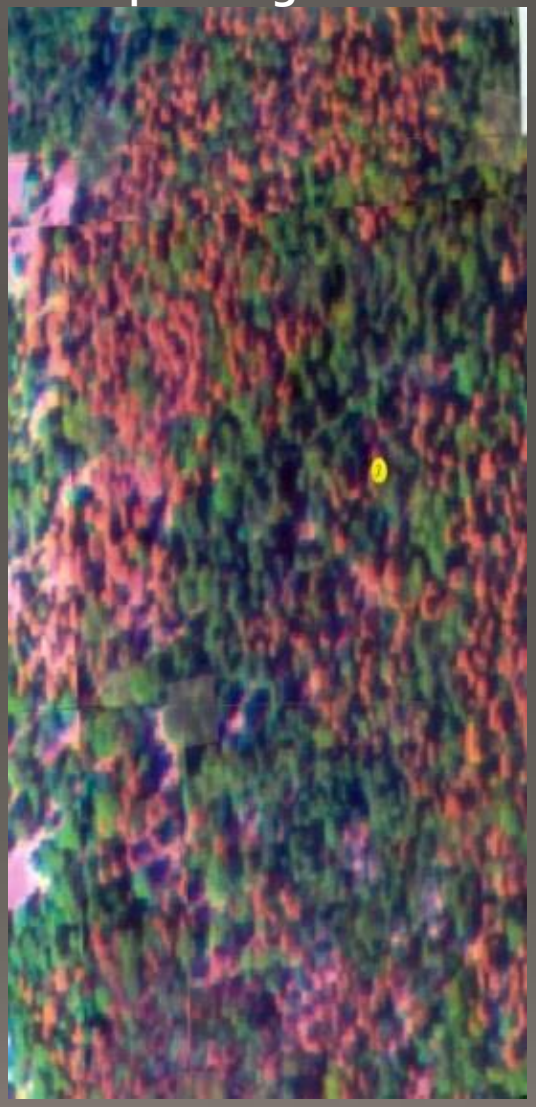
HIGH RESOLUTION (<1'), MULTISPECTRAL IMAGERY (RED + NEAR INFRARED + THERMAL)

3 yrs chronic drought



+ 1 yr acute drought

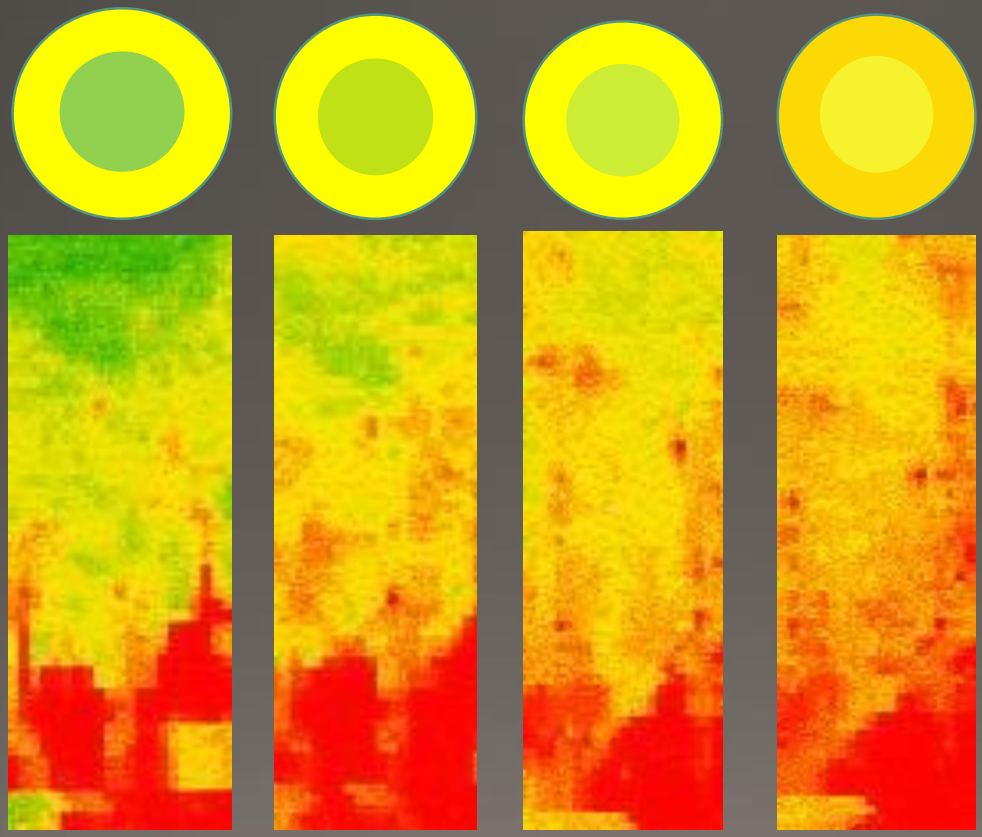
1 yr long summer multiple BB generations



Grulke et al., 2010)
Imagery from PJ Riggan, PSW Research Station

IMPORTANCE OF THERMAL BAND TO DETECT PHYSIOLOGICAL DROUGHT STRESS

GREEN IS TRANSPIRING, COOLER;
YELLOW: STOMATA SHUT, NEEDLES WARM



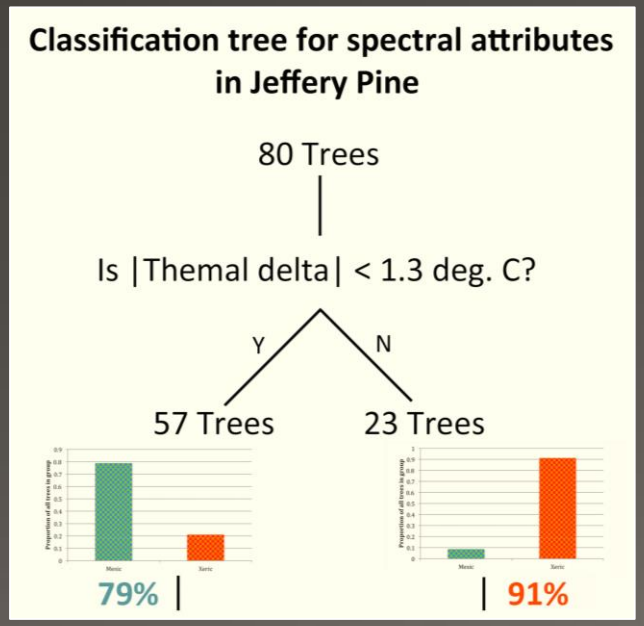
CHANGE IN CANOPY TEMPERATURE FROM 10 am to 1 pm

Imagery from PJ Riggan, PSW Research Station

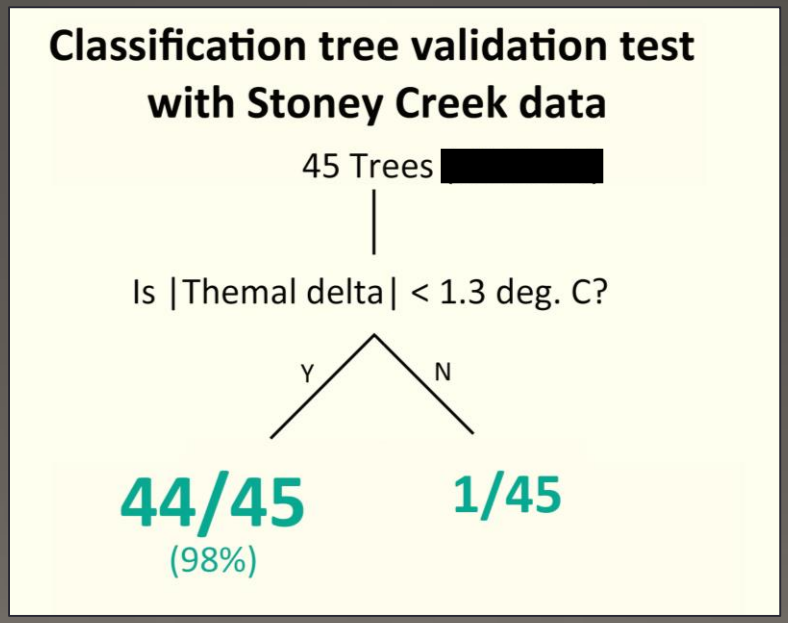
Remotely sensed foliar temperature can be used to ID drought stressed-trees

- THE DIFFERENCE IN TEMPERATURE BETWEEN UPPER AND MID CANOPY ALONE CAN IDENTIFY DROUGHT STRESSED TREES
- ADDING THE DIFFERENCE IN NDVI IMPROVED PREDICTIVE CAPACITY

Initial classification tree model:



2nd site for partial validation:



Physiology of trees in mesic and xeric microsites: Grulke et al., 2002a; 2002b)
Grulke, et al. Remote detection and attribution of Jeffrey pine canopy health and drought stress in the south central Sierra Nevada. (in prep)

Canopy spectral signature ID's 'trees-at-risk' : each tree is georeferenced, with image uploaded to an iPad for logger; could eliminate need for marking

Grulke et al., 2010)
Imagery from PJ Riggan, PSW Research Station

Project status

- Currently re-checking the spectral signature for interior ponderosa pine, with tests to determine whether we need separate signatures for mature vs. old growth or lowlands vs. uplands using just red and near infra-red (available annually on request from Regions)
- TNC has the iPad application developed, ready for the signature
- Prototype by early fall… 2 districts on the Fremont NF want to use it.
- Next step: apply a free-running prescribed fire through adjacent treatments to assess treatment effectiveness from resulting burn severity (Russ Parsons RMRS; Phil Riggan PSWRS; Nicole Vaillant WWETAC; Fremont NF, + original team)

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