The Role of Rootstocks in Achieving Vine Balance

Presented at:

Pennsylvania State University

Grape Day

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Acknowledgements

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  - American Vineyard Foundation
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  - California Rootstock Commission
- Team Members
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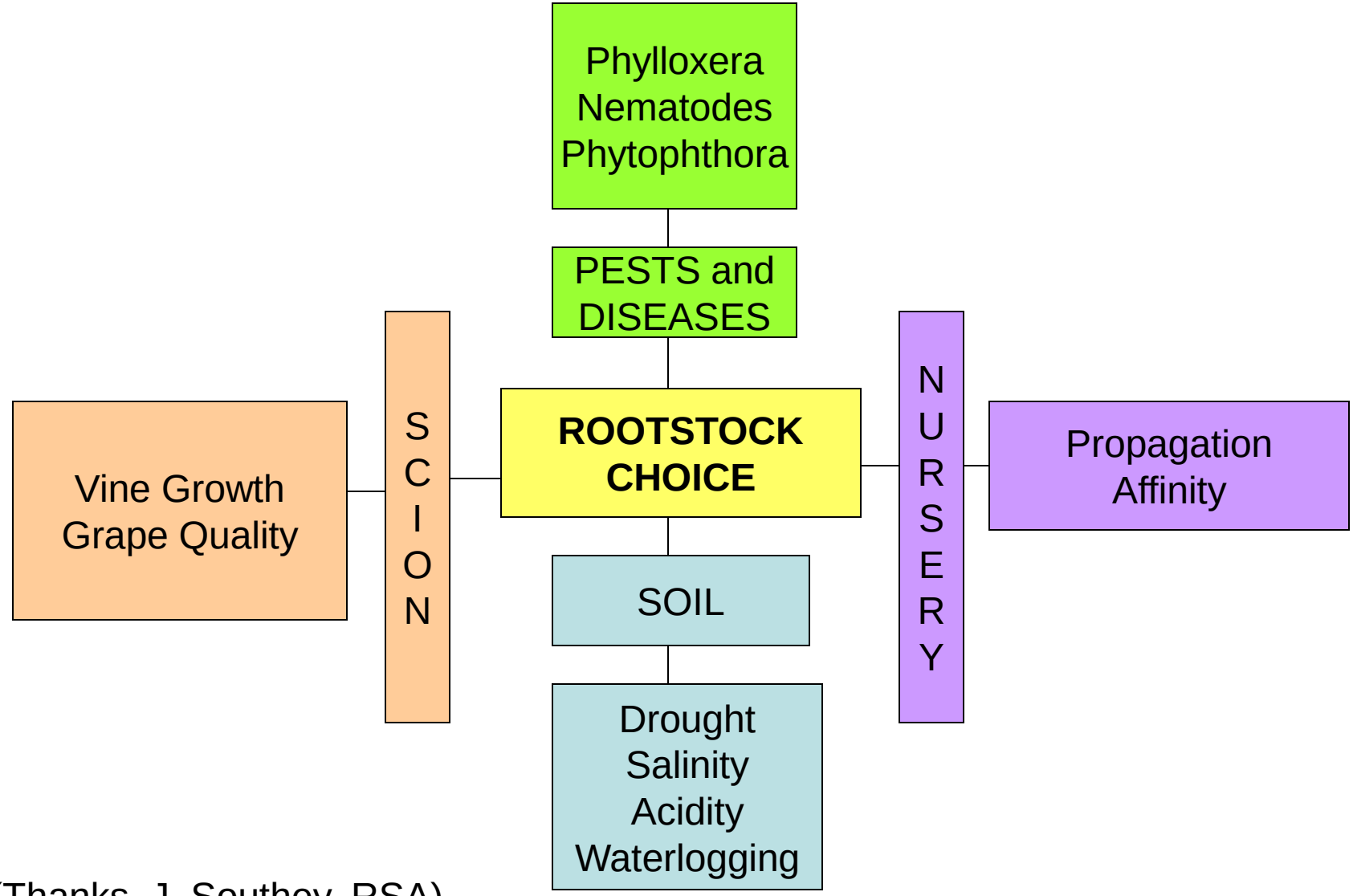
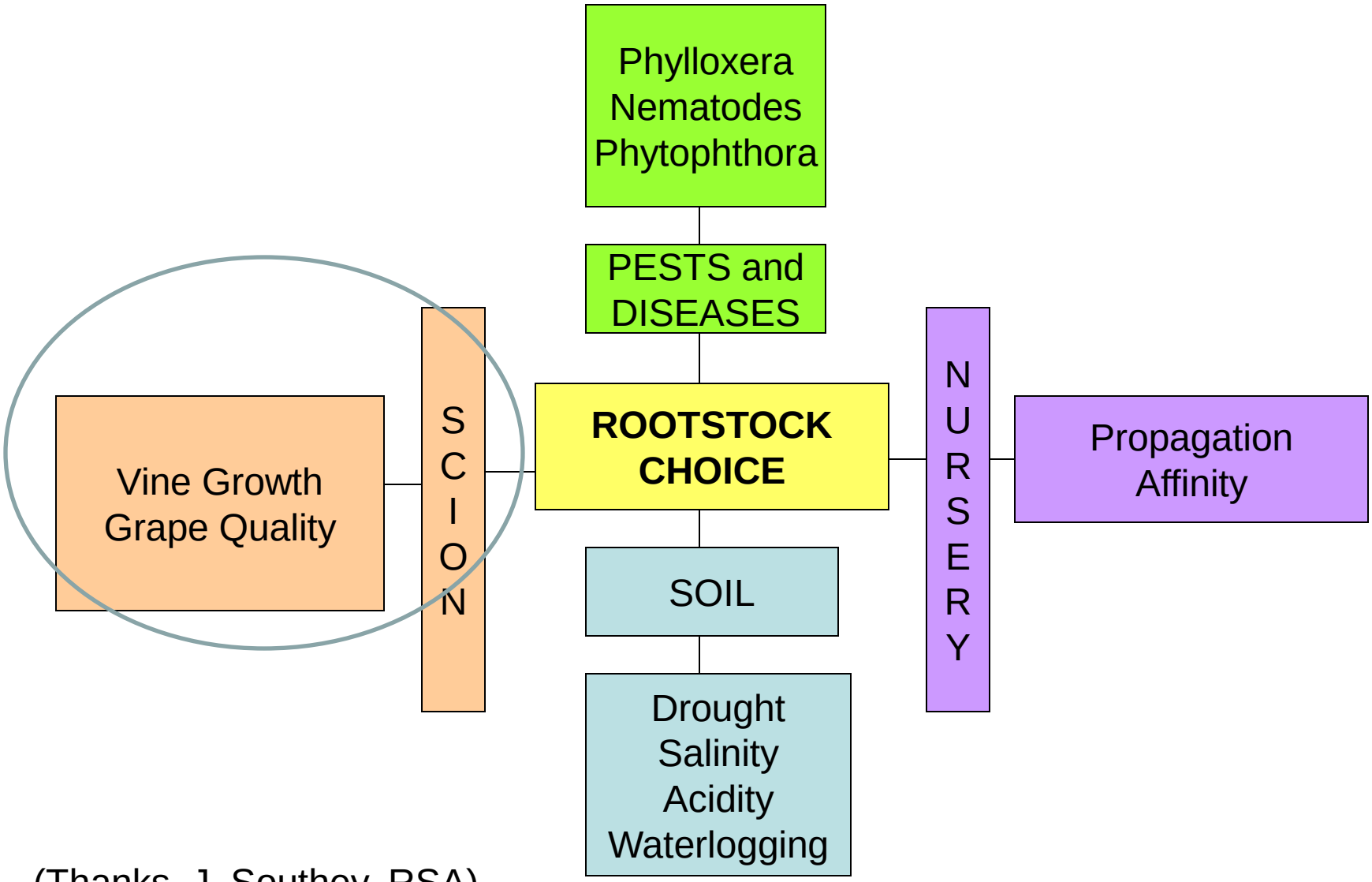


(Thanks, J. Southey, RSA)



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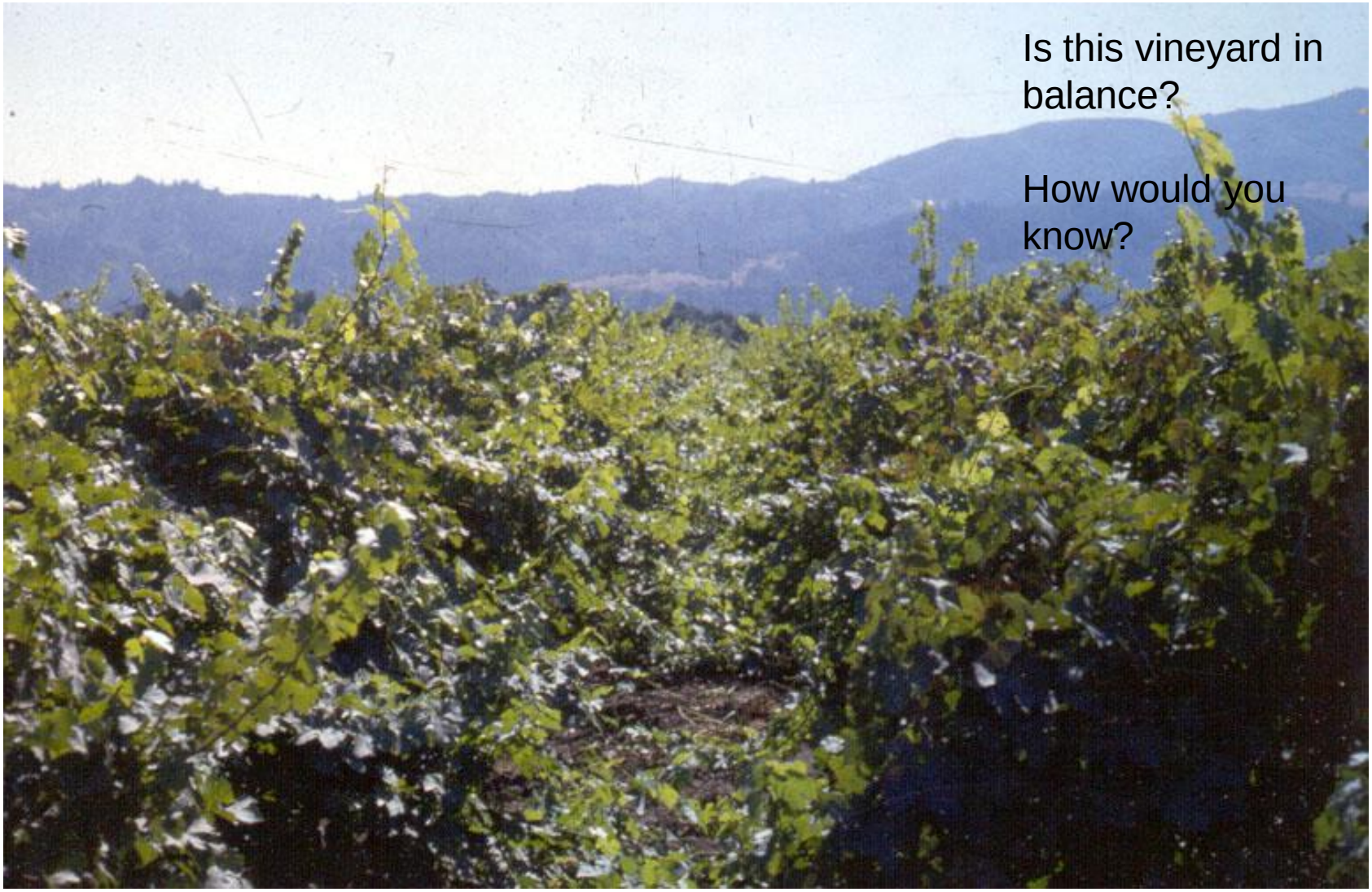
Talk Outline

- Vine balance principles
- Factors affecting balance
- Rootstock contribution to balance
- Conclusions
- Questions


Is this vineyard in balance?
How would you know?

Working Definitions

- Vine Balance
  - When leaf area and amount of fruit are in proper proportion
  - And, when grapevine growth is appropriate for the trellis and spacing
  - And, when yield meets the economic target
- Vine size = total growth/vine (large vs small)
- Vigor = wt/shoot
- Capacity = growth potential

Excellent reviews

- Planting density and physiological balance: Comparing approaches to European viticulture in the 21st century. Intrieri, C. and I. Filippetti. 2000.
- *In:* Proceedings of the ASEV 50th Anniversary Annual Meeting, pp 296-308
- *(Go to: asev.org and search for 50th Ann Proceedings, scroll down to the PDF)*
- Also, summarized in Wine Business Monthly, April, 2007

- Leaf area/crop weight ratios of grapevines: Influence on fruit composition and wine quality.

  Kliewer, W.M. and N.K. Dokoozlian. 2000.
- *In:* Proceedings of the ASEV 50th Anniversary Annual Meeting, American Society for Enology and Viticulture, Davis, CA.
- Reprinted: American Journal for Enology and Viticulture 56:170-181. 2005.

Two major contributors

- Conditions of balance are set during vineyard design (permanent)
  - Soil
  - Rootstock/scion
  - Spacing, row x vine
  - Trellis
- Conditions of balance are acted on by cultural practices (annual)
  - Pruning (bud number)
  - Shoot thinning (shoot number)
  - Fertilizer application
  - Irrigation or rainfall
  - Cover crops

Contributions to vine size

- Given
  - Site (more fertile vs less)
  - Scion (high potential vs low)
- Decisions
  - Rootstock (high potential vs low)
  - Spacing (wide vs narrow)
    - In-row (more important than between-row)
  - Trellis (divided vs undivided)

Two Scenarios

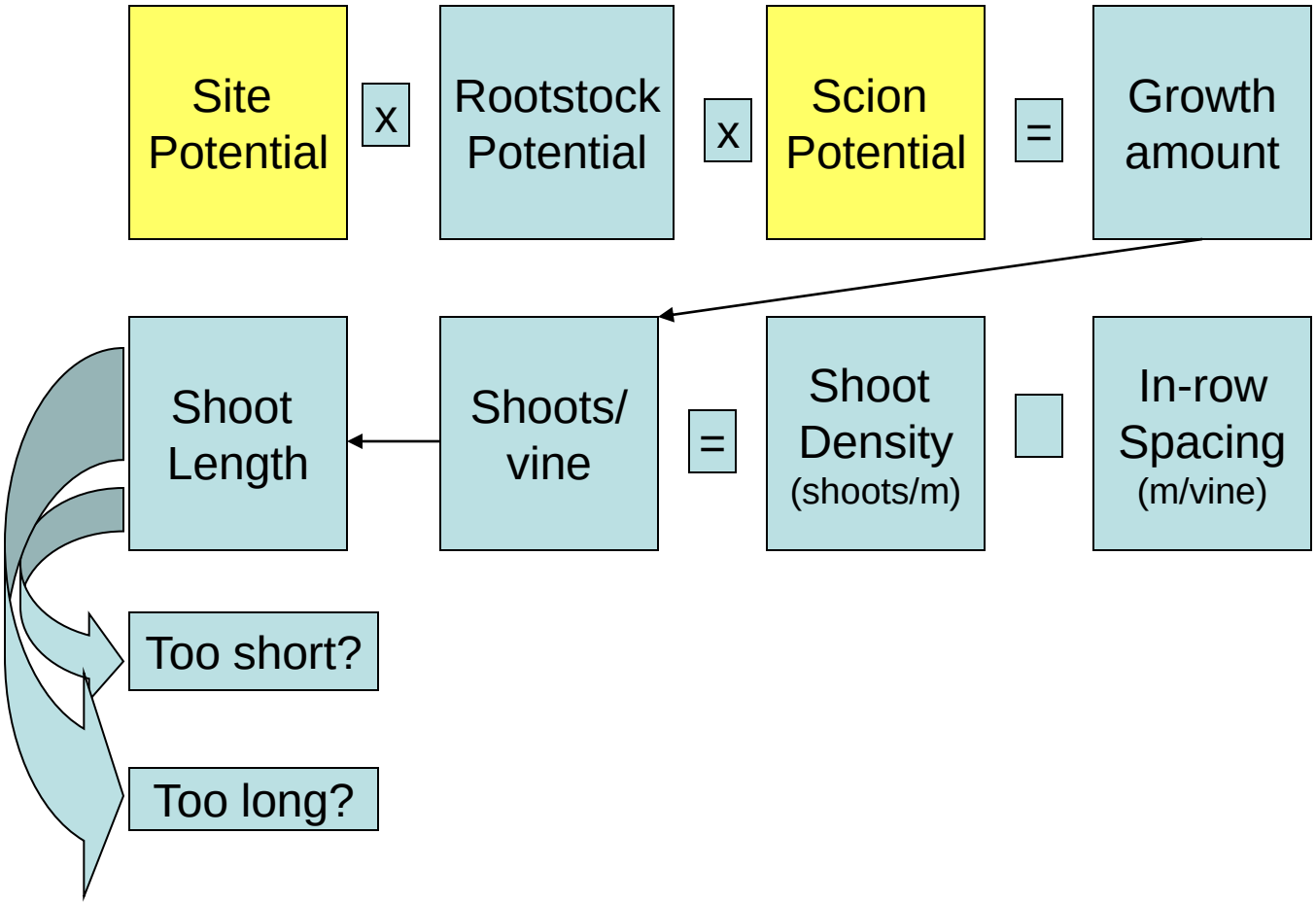
- Scenario 1
  - Given
    - Soil: Deep, fertile
    - Scion: Cab Sauv
  - Decisions
    - Rootstock: ?
    - Vine spacing: ?
- Scenario 2
  - Given
    - Soil: Shallow, infertile
    - Scion: Pinot noir
  - Decisions
    - Rootstock: ?
    - Vine spacing: ?

Decisions will drive vine balance within given scenarios

Two Scenarios

- Scenario 1
  - Given
    - Soil: Deep, fertile
    - Scion: Cab Sauv
  - Decisions
    - Rootstock: ?
    - Vine spacing: ?
- Scenario 2
  - Given
    - Soil: Shallow, infertile
    - Scion: Pinot noir
  - Decisions
    - Rootstock: ?
    - Vine spacing: ?

Are these two solutions the same?


Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth amount
Shoot Length
Shoots/ vine
=
Shoot Density (shoots/m)
In-row Spacing (m/vine)
Too short?
Too long?

Dokoozlian and Kliewer
Amer J. Enol. Vitic. 1995

- In too dense vine canopies:
  - High leaf layer number
  - High LA (>1.5 m^2/m)
  - Low PPFD (light) <2% of ambient
  - Low Red:Far-red light ratio
  - Low sunflecks in fruit zone
  - Low evaporative potential

- **All are correlated with pruning wt**

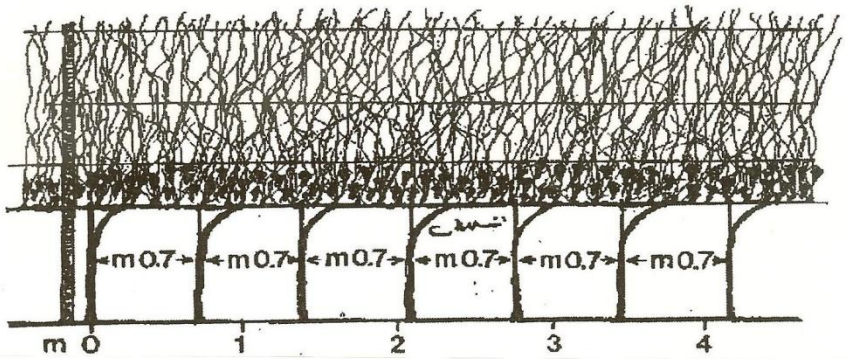
Growth measurement

- Pruning wt (Nelson Shaulis)
  - Expressed per vine is not informative
  - Expressed per meter is informative
- Pruning wt metrics
  - Smart and Robinson: 0.3 – 0.6 kg/m
  - Dokoozlian & Kliewer: 1.0 kg/m for Cab Sauv

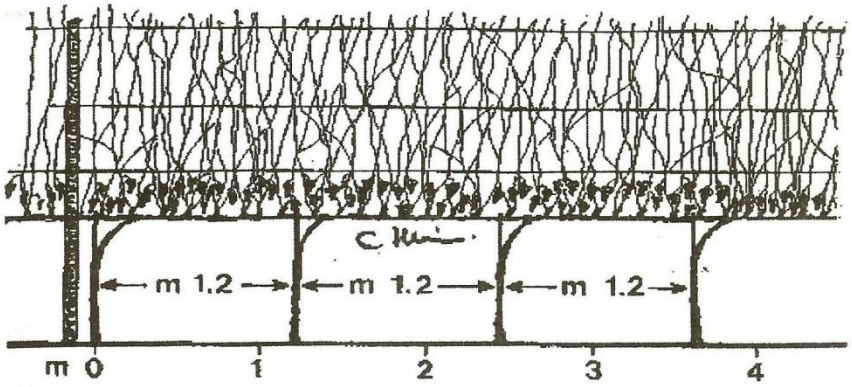
Even more informative than pruning wt alone

- Shoot number
- Shoot wt (calculated)

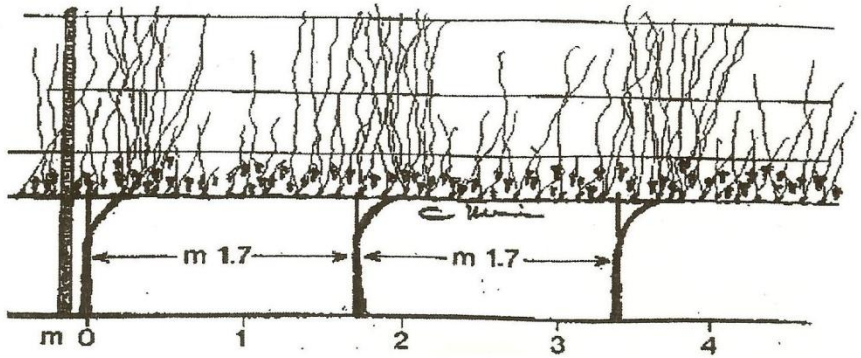
Too Narrow



Optimum



Too Wide



From: Intrieri and Filipetti American Journal of Enology and Viticulture, 50th Anniversary

Nelson Shaulis: 1st Cool Climate Symposium, 1984.

Grower Q: “My Pinot noir vineyard is spaced at 8 x 4 (row x vine) and everyone tells me that it is excessively vigorous; I already have a very competitive cover crop growing and it hasn’t helped. What do I do?”

Shaulis' Answer

- "If I owned your vineyard, as I perceive it to be now, I would seriously think about removing alternate vines and, in a row or two, I might think about removing them to a 12 ft spacing [i.e., remove 2 of every 3 vines]. The point being, I think you have to find from your research people, what is the adequate amount of vegetative growth per unit length of row that you have."

Shaulis goes on…

- “The control the viticulturist has on this is in the extent to which he stimulates the vine. Or, the extent to which he affords the room to display the shoots which he grows by his stimulation.”

Effect of vine spacing on root length and density

(Archer and Strauss, S. Afr. J. Enol. Vitic. 6:25-30. 1985.)

	3 x 3 (m)	**3 x 1.5** (m)	**2 x 2** (m)	**2 x1** (m)	**1 x 1** (m)	**1 x 0.5** (m)
Root length (m)	6.0	4.7	4.8	4.1	2.9	2.5
Root density (m/m^3)	1.1	1.7	2.0	3.4	4.9	8.2

Root density increases with increase in vine density

Shoot number

- Recommended shoot density
  (Smart and Robinson)
  - For cordon-trained, undivided canopies
  - 12-15 shoots/meter

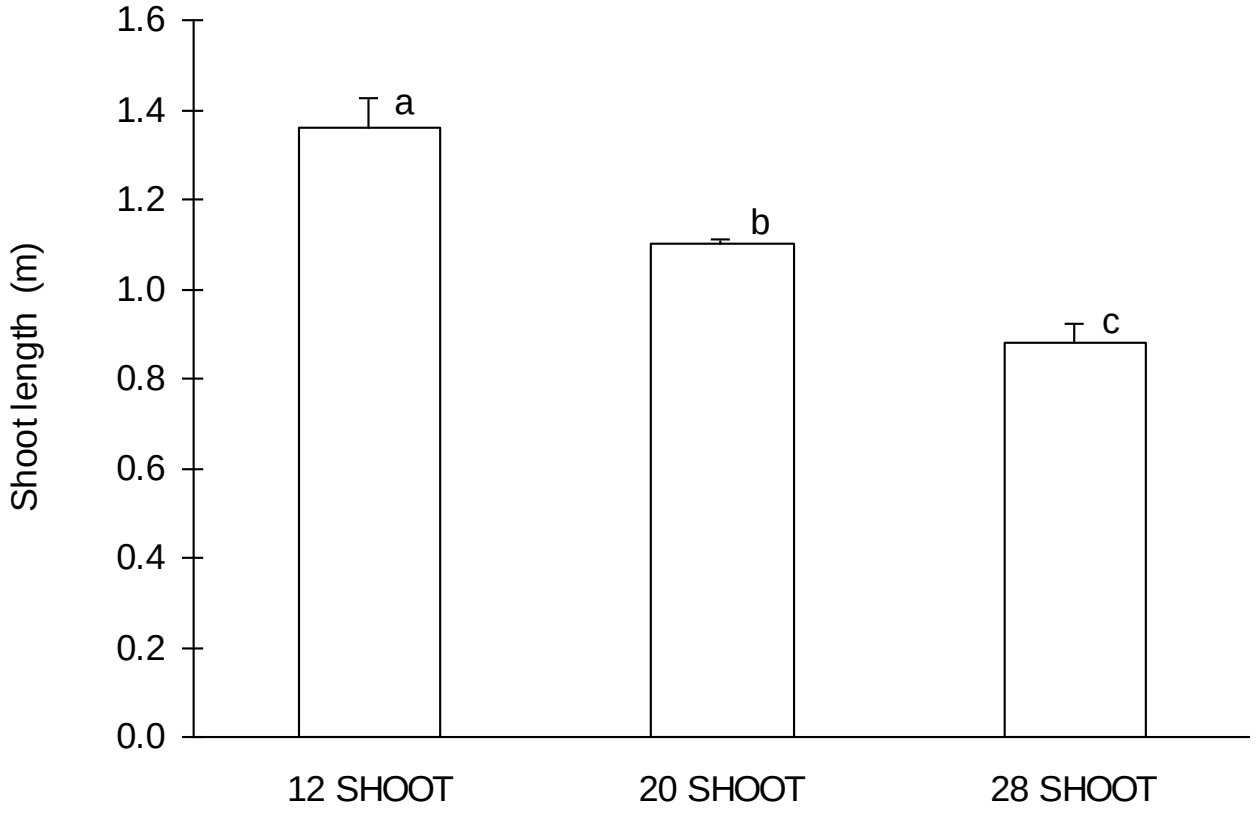
- One should not try to achieve optimum vine balance by adjusting shoot number out side this range.

Sangiovese Study

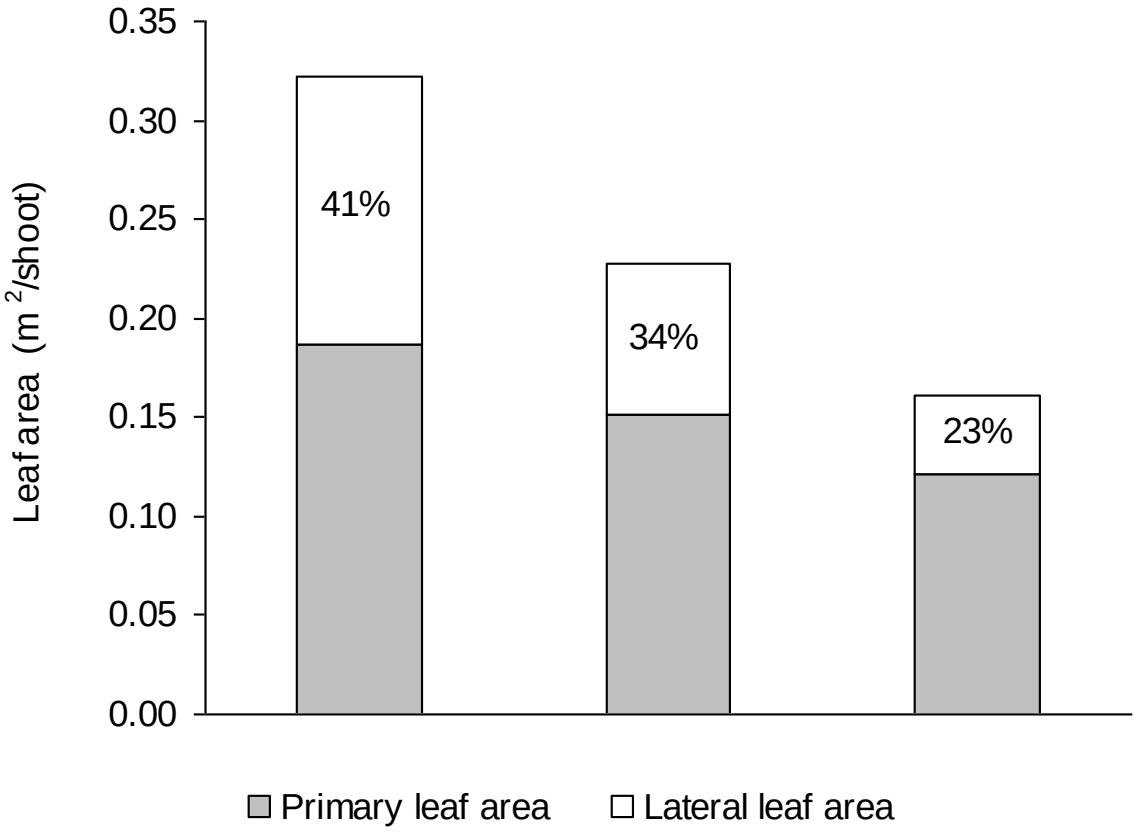
- Sangiovese/3309C (5th leaf)
- Atlas Peak Vineyards, Napa
- Three treatments
  - 12, 20 and 28 shoots per vine
- Adjusted in spring

- (Myers et al, 2008, American Journal of Enology and Viticulture 59:422-424)

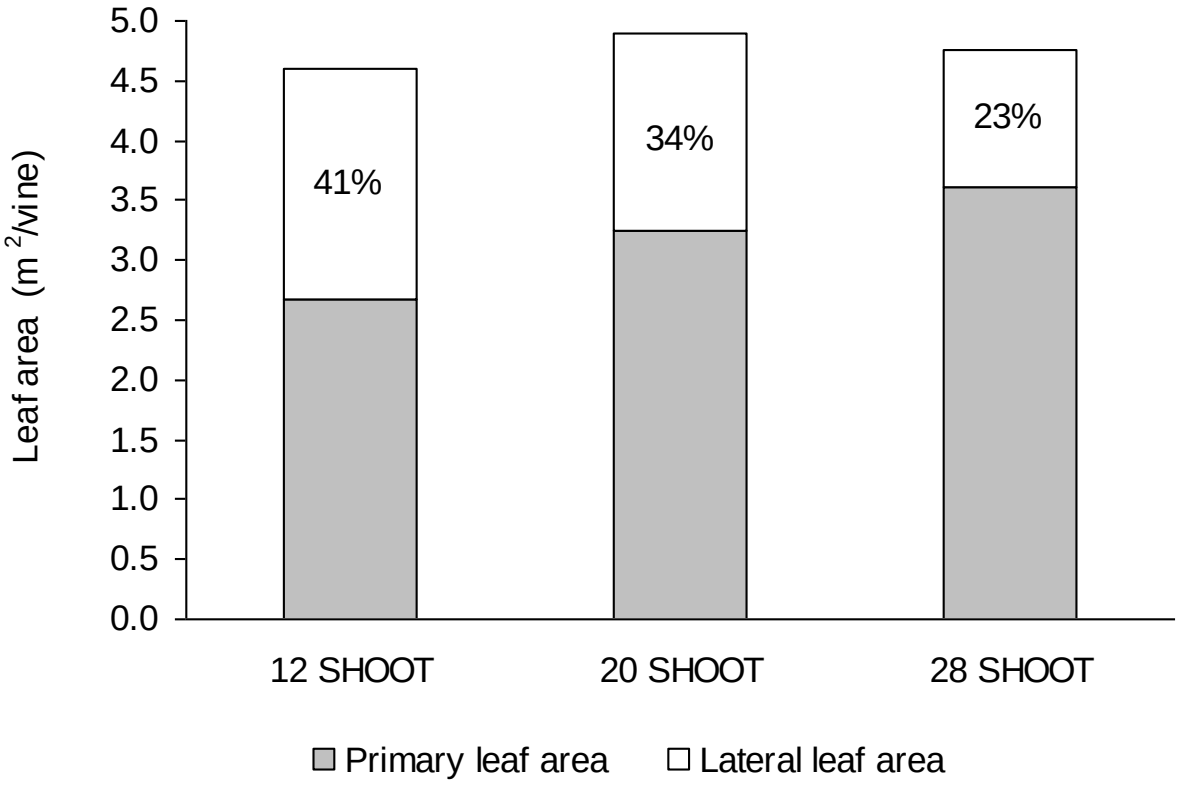
Shoot number affects shoot length



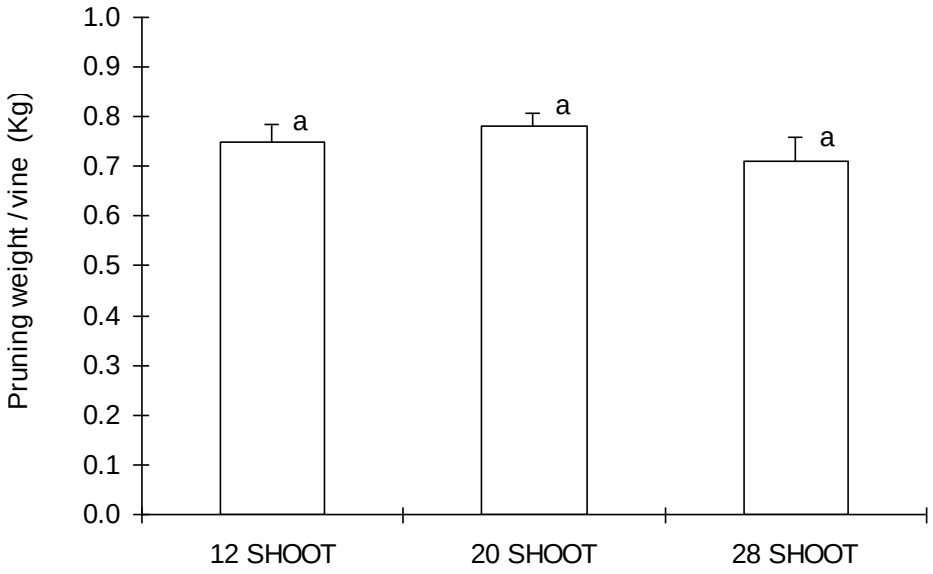
Longer shoots have more leaf area and have a greater % of leaf area as laterals



Manipulating shoot number per vine does not change leaf area per vine, but changes % primary vs. lateral



Pruning wt unaffected by shoot number

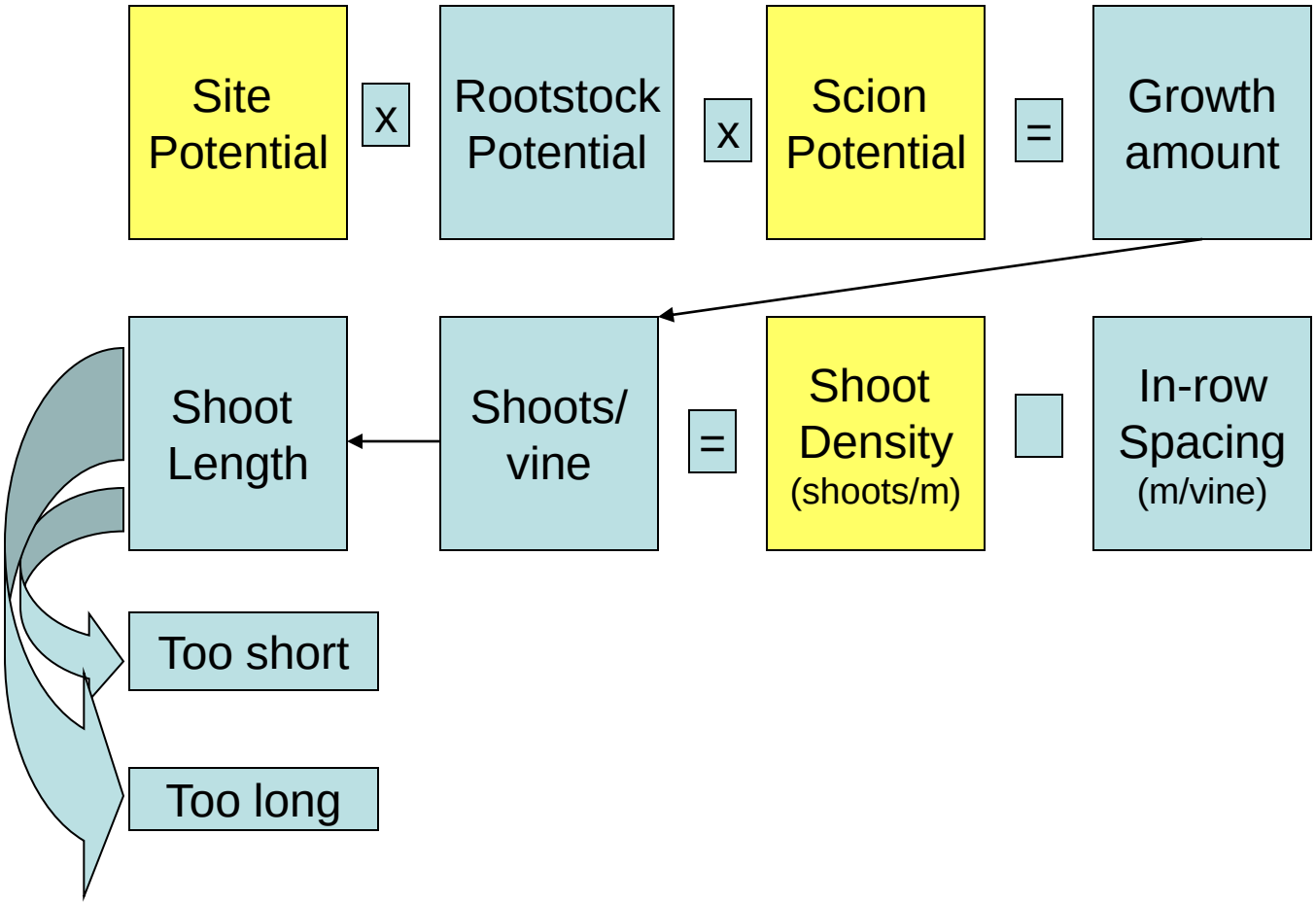


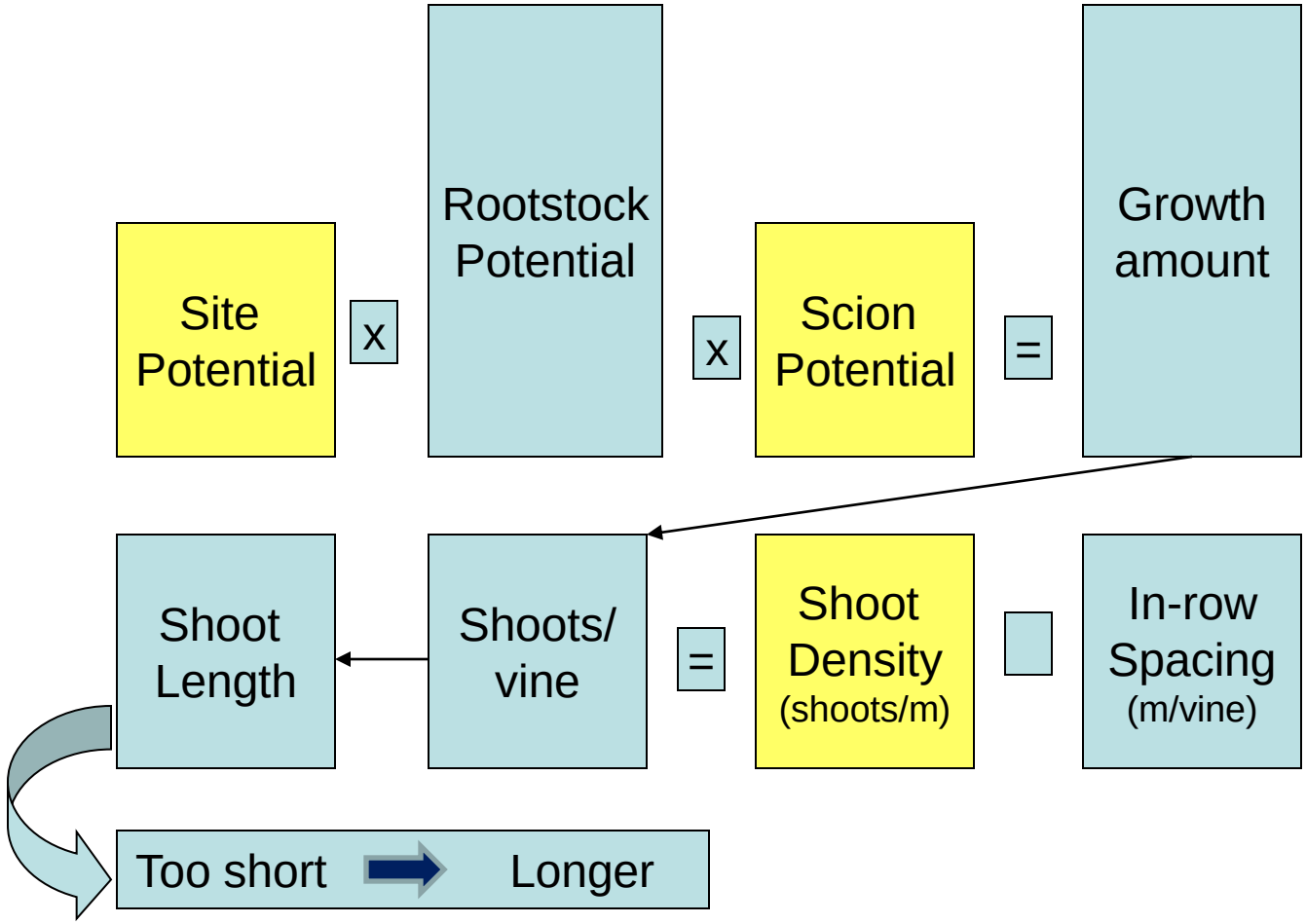
Other literature on shoot number

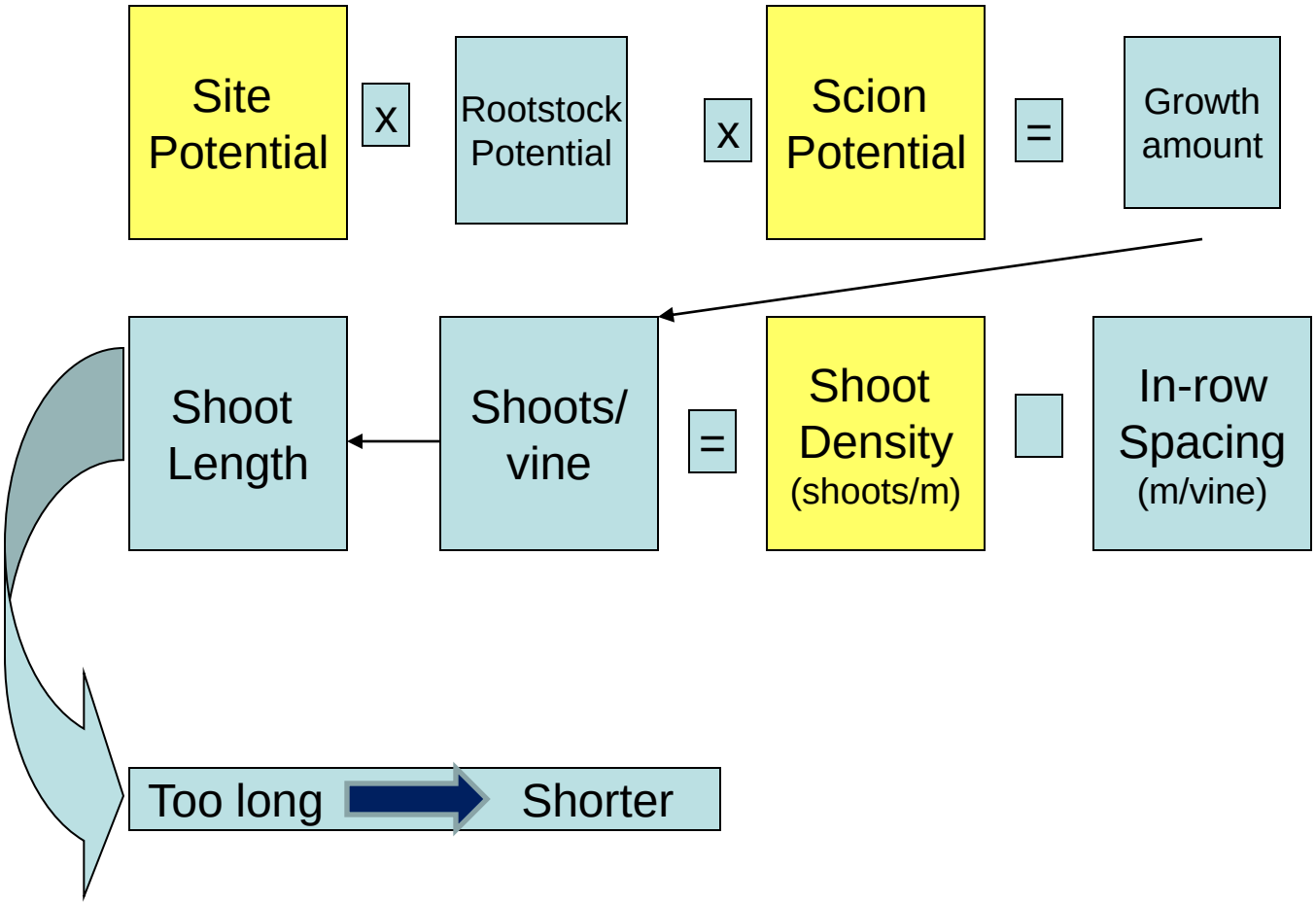
- No change in pruning wt with change in bud number at pruning
  - Freeman et al, 1979, using Shiraz in Australia
  - Reynolds et al, 1994, using Pinot noir in Canada
- No (little) change in LA/vine with change in bud number
  - Dokoozlian, 1990, using Cardinal in California
  - Miller and Howell, 1996, using Concord in Michigan

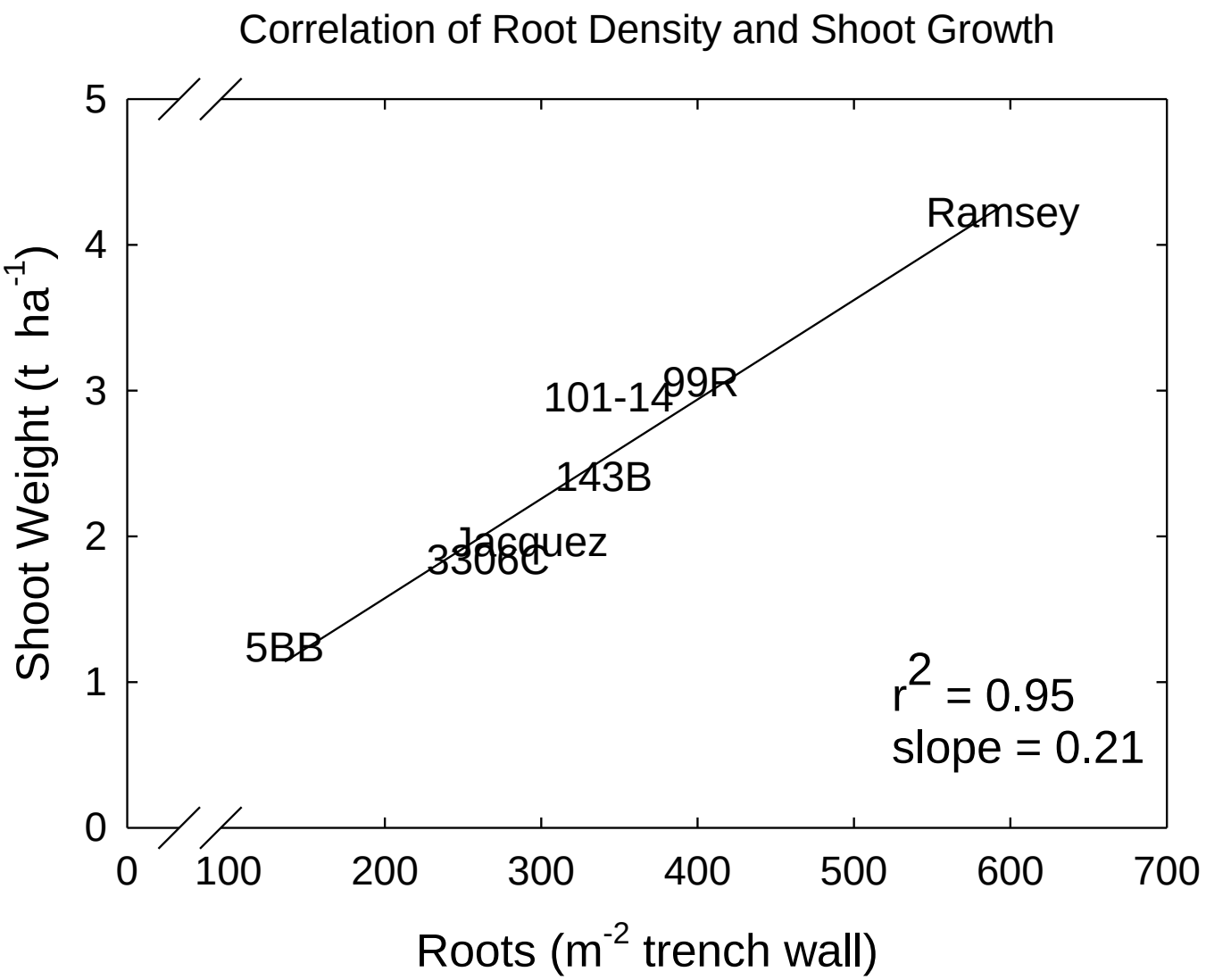
Conclusions from Shoot Number work

- For vines of a given vigor, decreasing shoot number :
  - Redistributes LA from shorter shoots to longer shoots and
  - Increases % lateral LA (in the fruiting zone?)
  - Increases the LA to fruit wt ratio (m^2/kg)
  - Decreases the fruit yield/cane prunings ratio (kg fruit/kg prunings)


Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth amount
Shoot Length
Shoots/ vine
=
Shoot Density (shoots/m)
In-row Spacing (m/vine)
Too short
Too long


Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth amount
Shoot Length
Shoots/ vine
=
Shoot Density (shoots/m)
In-row Spacing (m/vine)
Too short
Longer

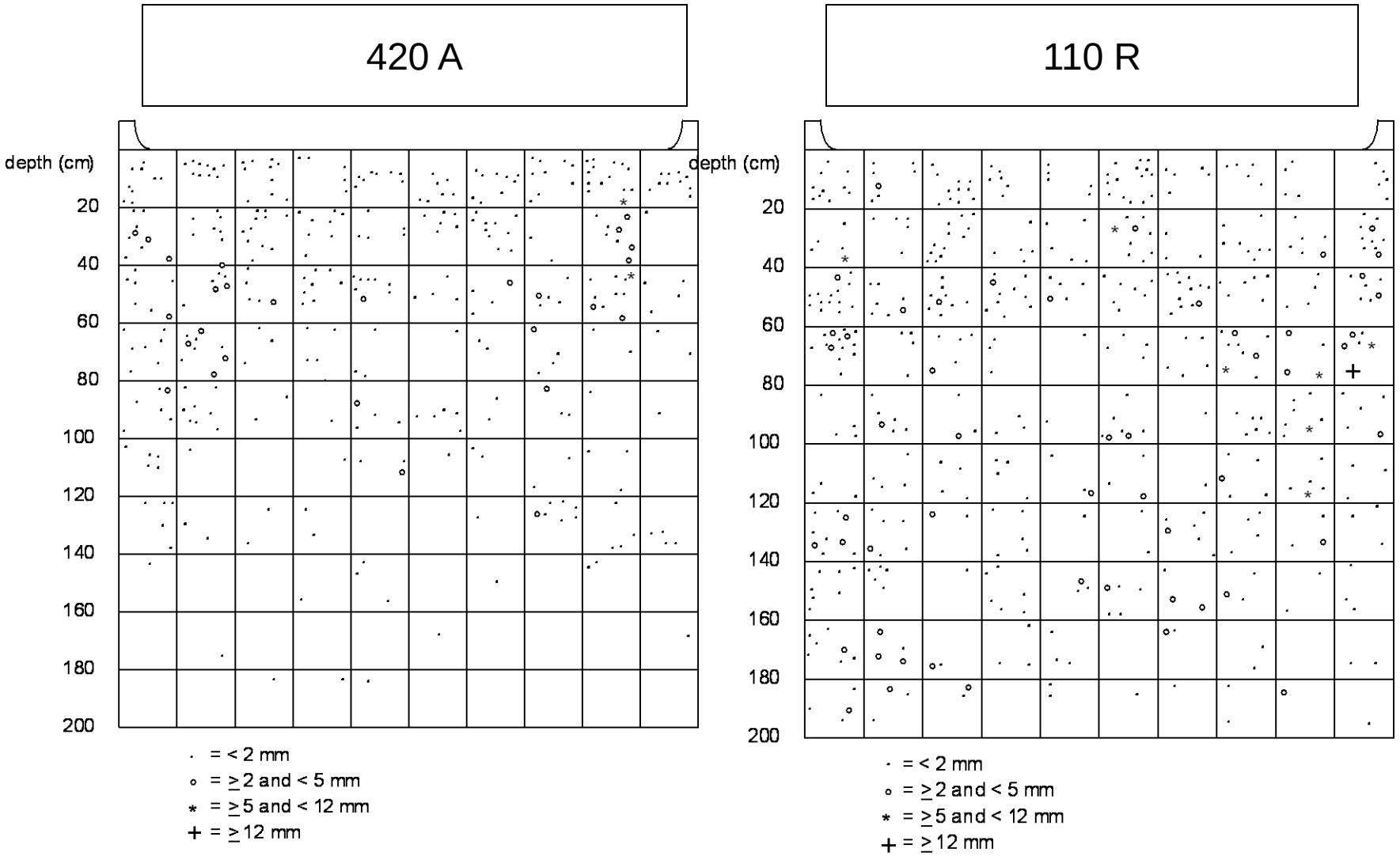

Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth amount
Shoot Length
Shoots/ vine
=
Shoot Density (shoots/m)
In-row Spacing (m/vine)
Too long
Shorter



Southey JM & Archer E, 1988. The effect of rootstock cultivar on grapevine root distribution and density. In: JL van Zyl (compiler) The grapevine root and its environment. Tech. Comm 215. Dept Agric Water Suppl.

Experiment, Napa Valley

- Cabernet Sauvignon
  - 3 Row spacings
    - 2m, 3m, 4m (~6, 9, 12 ft)
  - 2 In-row spacings
    - 1m, 2m (3, 6 ft)
  - 7 Rootstocks
    - 110R, O39-16, 3309C, 5C, 1616C, 420A (AxR#1)

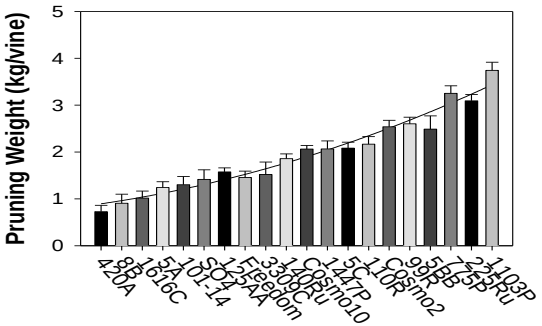

420 A
depth (cm)
20
40
60
80
100
120
140
160
180
200
· = < 2 mm
∘ = ≥ 2 and < 5 mm
* = ≥ 5 and < 12 mm
+ = ≥ 12 mm
110 R
depth (cm)
20
40
60
80
100
120
140
160
180
200
· = < 2 mm
∘ = ≥ 2 and < 5 mm
* = ≥ 5 and < 12 mm
+ = ≥ 12 mm

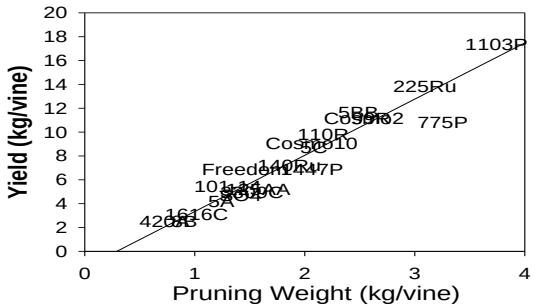
Main effects	Pruning weight		Crop/ pruning wt ratio	Shoot weight
Row space	(kg/vine)	(kg/m)		(g)
2 m	1.11	0.78	5.4	76
3 m	1.22	0.86	5.9	80
4 m	1.39	0.98	5.7	91
Prob > F	0.09	0.10	NS	0.07
Vine space				
1 m	1.02	1.02	5.5	69
2 m	1.46	0.73	5.8	96
Prob > F	0.0001	0.0001	0.04	0.0001
Rootstock				
110R	1.53	1.06	5.1	99
1616C	1.16	0.82	6.2	78
5C	1.19	0.84	6.0	80
3309C	1.28	0.90	5.3	85
420A	0.83	0.61	5.9	57
O39-16	1.44	1.02	5.5	94
Prob > F	0.0001	0.0001	0.003	0.0006
Interaction				
Row x vine	NS	NS	NS	NS
Row x root	NS	0.07	NS	NS
Vine x root	0.01	NS	NS	NS
Row x vine x root	NS	NS	NS	NS

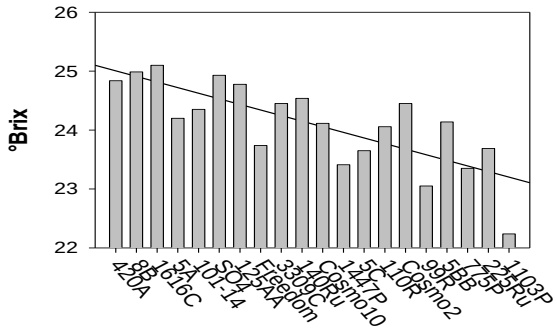
Rootstock x Vine Space Interaction, Cabernet Sauvignon, Oakville, 1991-1994
Pruning wt (kg/v)

Rootstock	Vine Spacing		Increase
	1 m	2 m	%
110R	1.20	1.85	54.2
O39-16	1.18	1.70	44.1
3309C	1.02	1.55	52.0
5C	0.98	1.39	41.8
1616C	0.98	1.34	36.7
420A	0.77	0.89	15.6

20 Rootstocks were evaluated for vegetative growth and productivity. Rootstocks were pruned to a pruning formula of 8 buds per 0.45 kg of prunings. Resulting pruning weights varied from 0.8 Kg/vine on 420A to 3.8 kg/vine for 1103P. Rootstocks varied in their ability to ripen the resultant crop load. Data is from 2000, 2001.





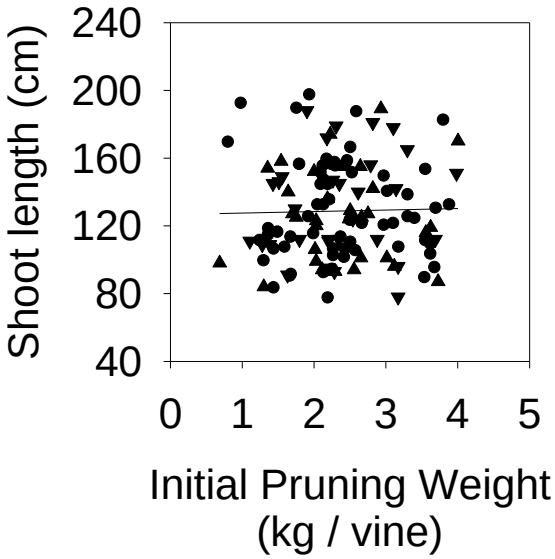


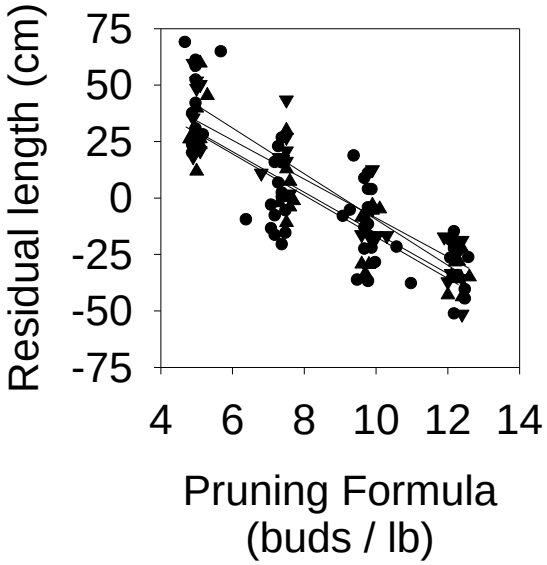
Next Question

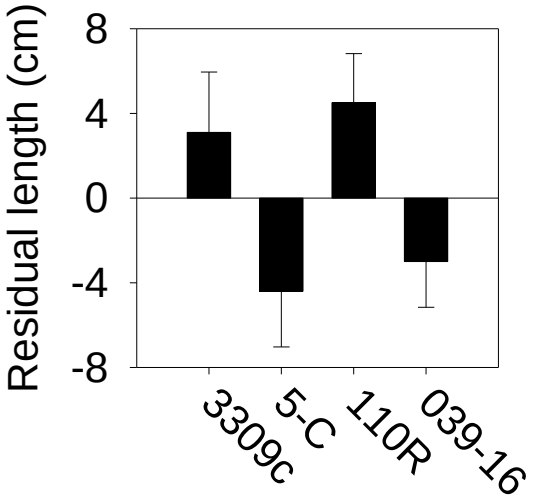
- When comparing rootstocks in their response to changes in growth potential, is it a case of:
  - An “apples and oranges” comparison?
  - OR
  - A “little apples and big apples” comparison?

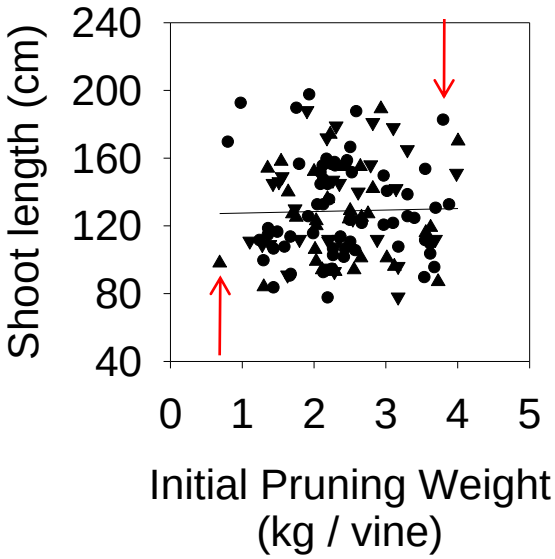
Oakville Cabernet Sauvignon

- Treatments
  - 4 Rootstocks: 3309C, 5C, 110R and O39-16
  - 4 Pruning levels: 5, 7.5, 10 and 12.5 buds per pound (0.45 kg) of prunings
- Conditions
  - Vine spacing was 3 m x 2 m (row x vine)
  - Cane-pruned, Scott Henry
  - Range of vine size from 1 to 4 kg/vine (0.5 kg/m to 2.0 kg/m)


Shoot length (cm)
240
200
160
120
80
40
0
1
2
3
4
5
Initial Pruning Weight
(kg / vine)


Residual length (cm)
75
50
25
0
-25
-50
-75
4
6
8
10
12
14
Pruning Formula
(buds / lb)


Residual length (cm)
8
4
0
-4
-8
3309c
5-C
110R
039-16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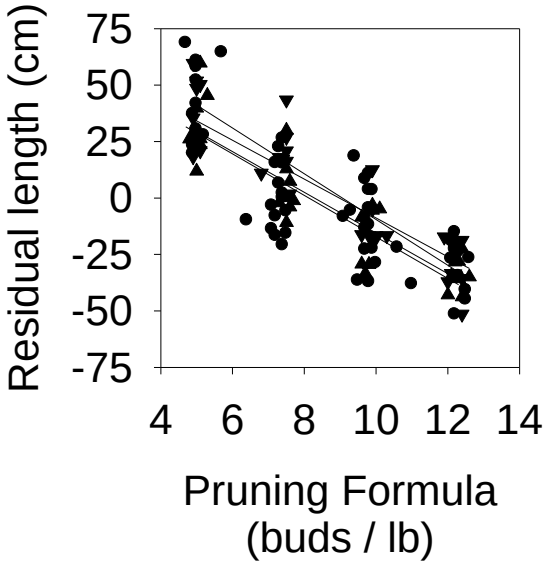
Residual length (cm)
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-25
-50
-75
4
6
8
10
12
14
Pruning Formula
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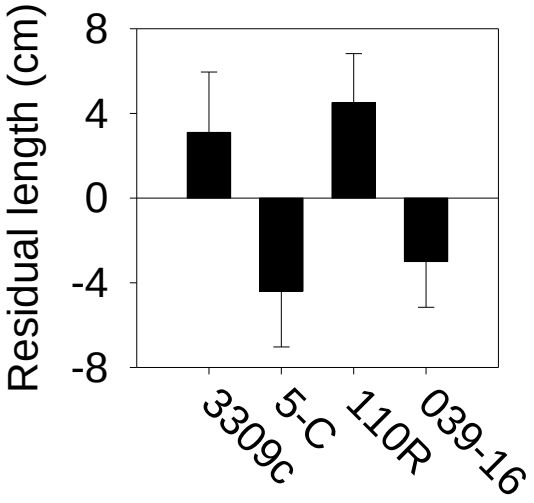
Residual length (cm)
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-4
-8
3309c
5-C
110R
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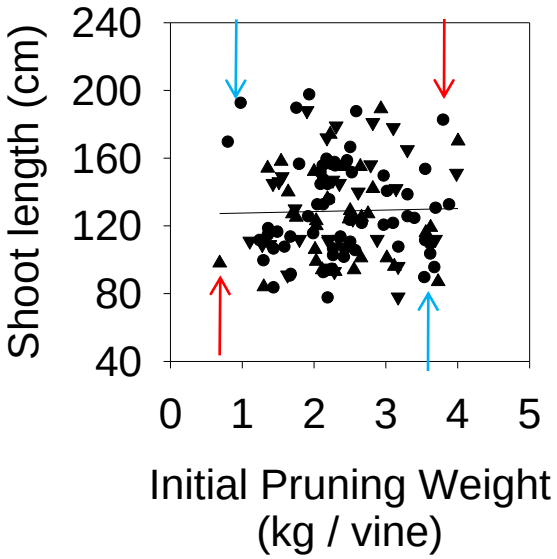

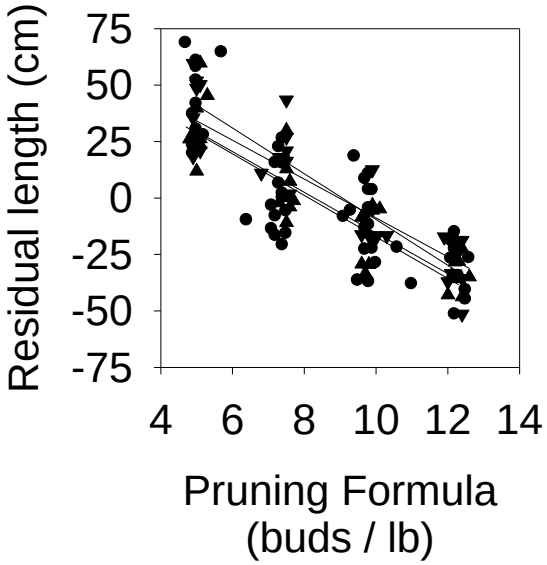

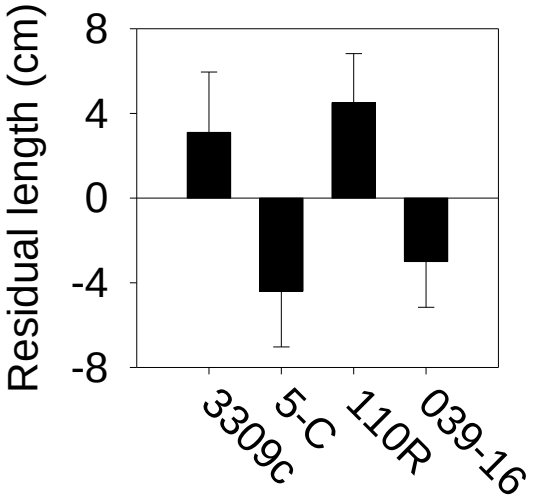

Q: Is average shoot length related to vine size (wt of prunings)?
A: No, it is related to the number of growing points.

Q: Are the rootstocks the same in this response?
A: Yes, there differences but they are small.

Summary of Oakville Cab Sauv

	Vine size (Final Pruning Wt)	Dormant Shoot Wt (Vigor)
Initial Vine Size (VS)		
- Rootstock	48%	17%
- Site Covariate	35%	2%
Rootstock (RS)	2%	2%
Pruning Formula (PF)	1%	63%
RS x PF	NS	NS
RS x VS	NS	NS
PF x VS	NS	NS
Total	**86%**	**84%**

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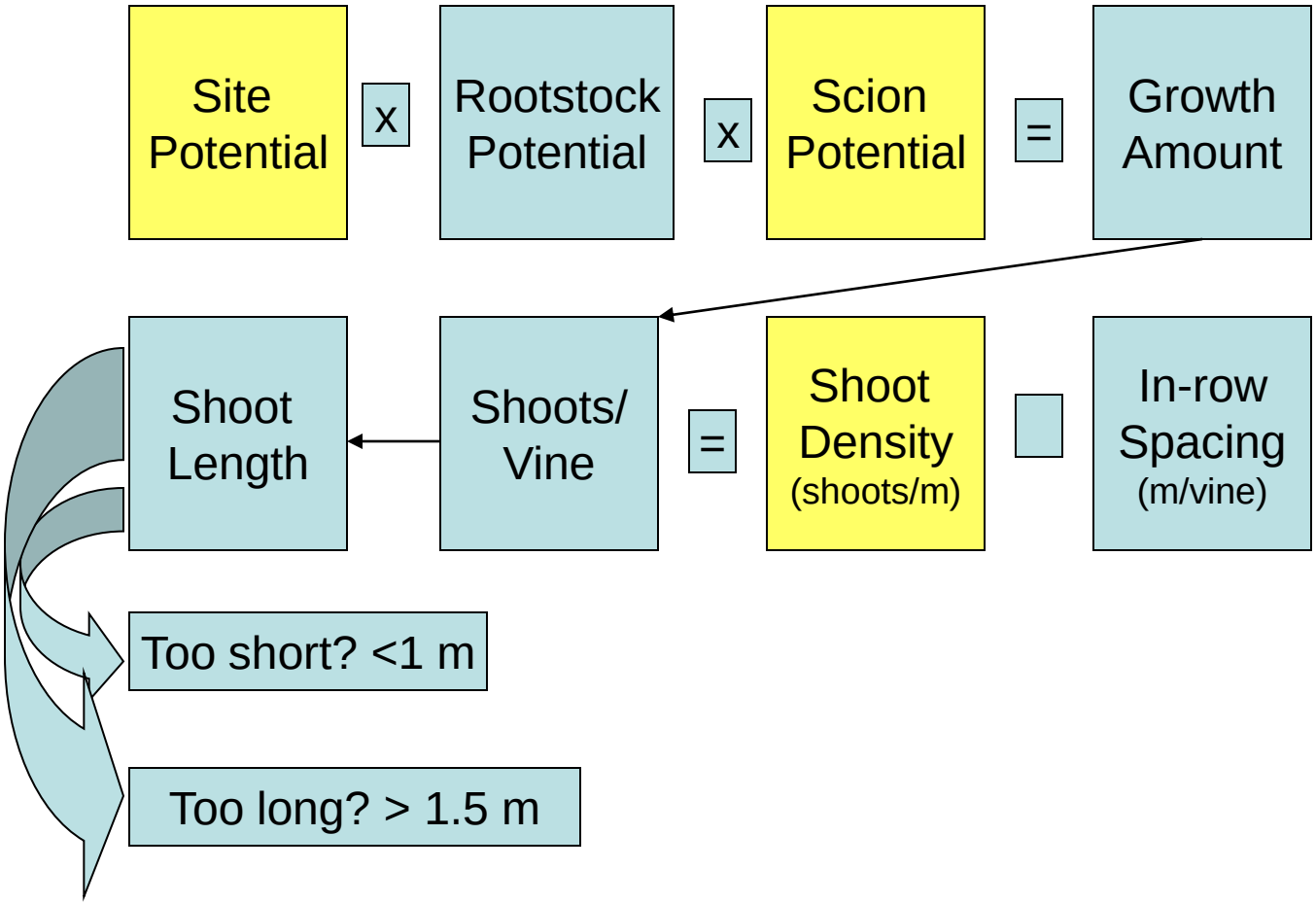
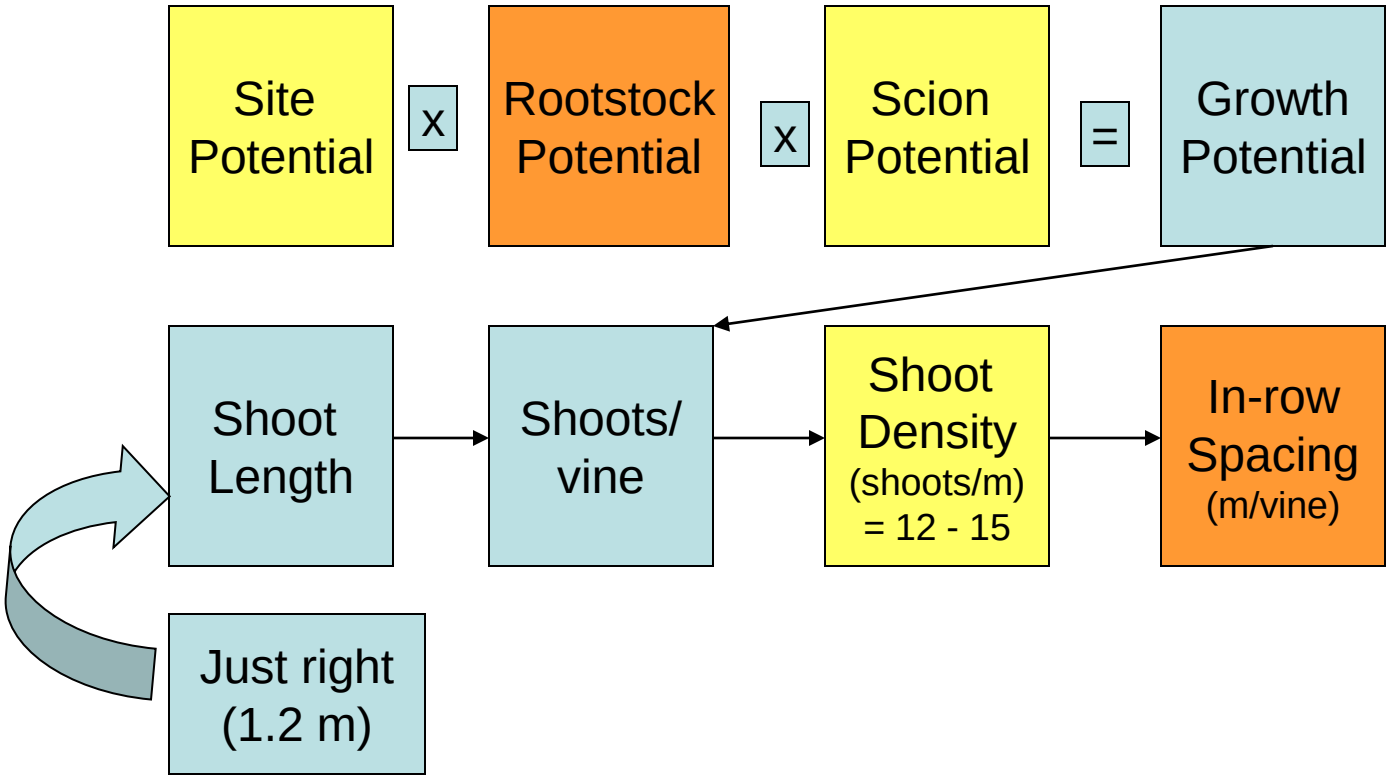

Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth Amount
Shoot Length
Shoots/ Vine
=
Shoot Density (shoots/m)
In-row Spacing (m/vine)
Too short? <1 m
Too long? > 1.5 m


Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth Potential
Shoot Length
Shoots/ vine
Shoot Density (shoots/m) = 12 - 15
In-row Spacing (m/vine)
Just right (1.2 m)

Rootstocks and Annual Practices

- Shaulis N. and R.G.D. Steel. 1969. The interaction of resistant rootstock to the nitrogen, weed control, pruning and thinning effects on the productivity of Concord grapevines. J Amer Soc Hort Sci 94:4522-429.

Rootstocks and Annual Practices

- Treatments
  - 3 Nitrogen (0, 50, 100 lbs lbs N/ac/yr)
  - 2 Weed control (Sod vs clean cultivated)
  - 2 Pruning levels (30+10 vs 60+10)
  - 2 Thinning levels (None vs 1 cluster/shoot)
  - 2 Rootstocks (Own vs. 3309C)
- 48 treatment combinations
  - (the original “Dr. Data”)

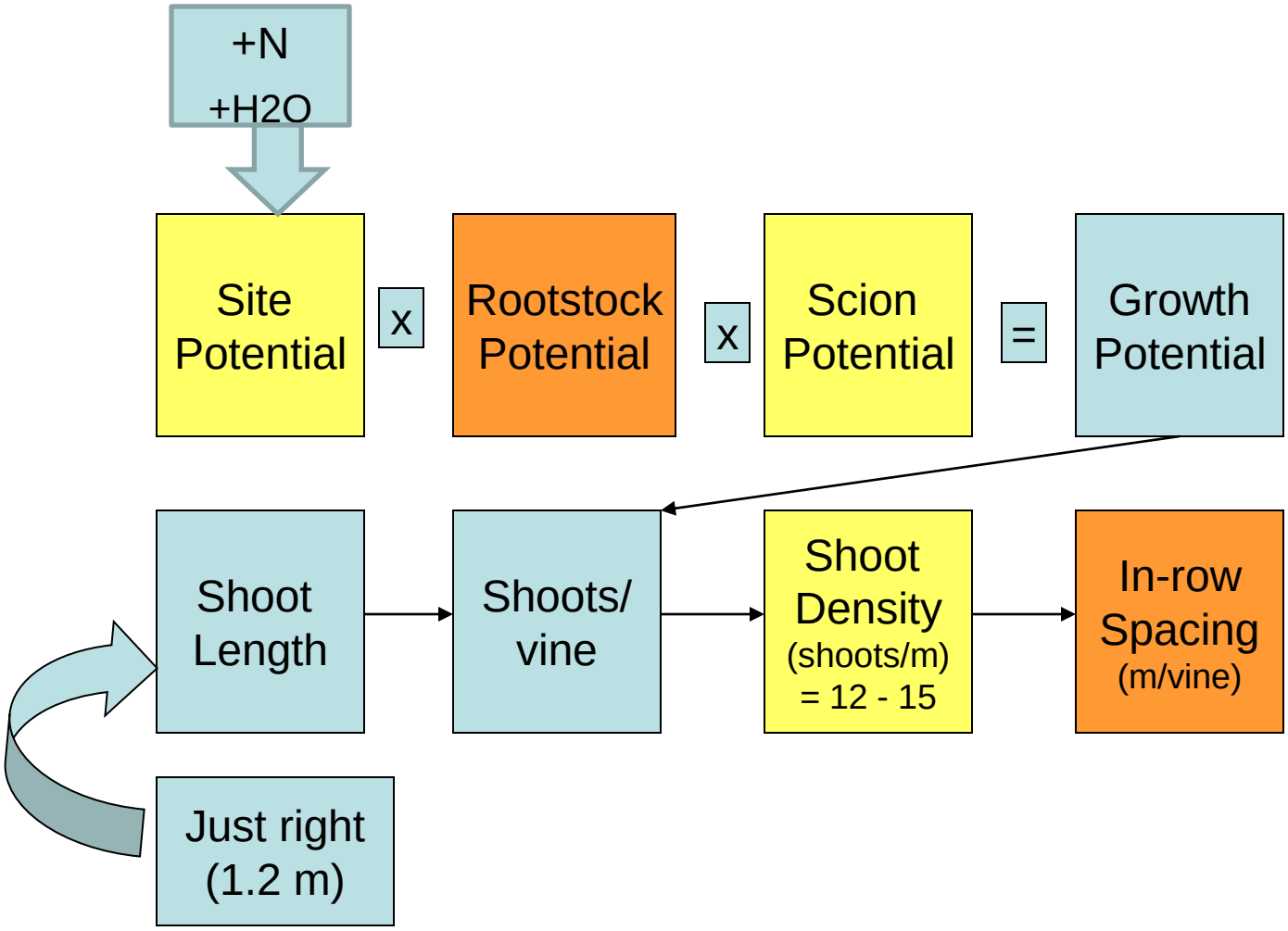
Rootstocks and Annual Practices

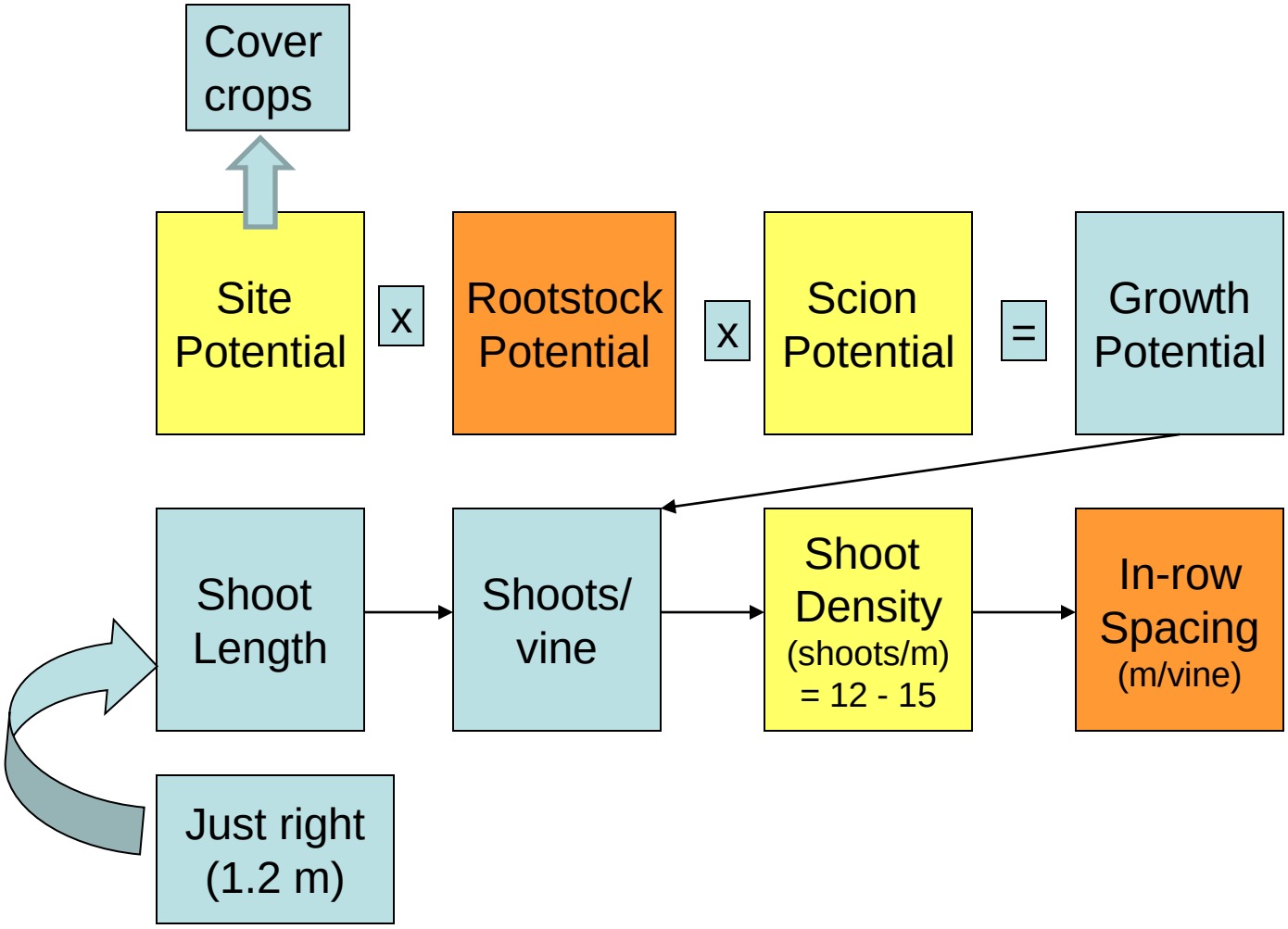
- Most vigorous treatment combination
  - N100, Cultivated, P30, Thinned, 3309C
- Least vigorous treatment combination
  - N0, Sod, P60, UnThin, Own-roots

Rootstocks and Annual Practices: Conclusions

- Young vineyard (i.e., more growth is good)
  - Treatments which improved growth resulted in more yield, but the rootstock effect was not unique.
- Mature vineyard (i.e., too much growth = shading)
  - Treatments which created more growth increased shading and decreased fruitfulness and sugar accumulation, but the rootstock effect was not unique

- *Caveat: Shaulis worked with Concord, a relatively simple system*


+N
+H2O
Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth Potential
Shoot Length
Shoots/ vine
Shoot Density (shoots/m) = 12 - 15
In-row Spacing (m/vine)
Just right (1.2 m)


Cover crops
Site Potential
x
Rootstock Potential
x
Scion Potential
=
Growth Potential
Shoot Length
Shoots/ vine
Shoot Density (shoots/m) = 12 - 15
In-row Spacing (m/vine)
Just right (1.2 m)

When we make mistakes

- Too much growth
  - Difficult to manage
    - Soils are rich and well supplied with winter rain
    - Growth is excessive prior to employing irrigation, i.e. deficit irrigation is not an option
- Too little growth
  - Options available are irrigation and fertilizer
    - Water is usually scarce
    - Nitrogen applications are inefficient
- **From a Sustainability perspective, it would be nice to get it right from the start**

Need To Model Vine Size Factors

- Predict soil fertility influence on vine size
- Accurately gauge scion potential (esp new cultivars)
- Choose rootstock
- Calculate in-row spacing (assuming 12-15 shoots/m)

Conclusions

- Vine Balance
  - Balance is best achieved by vineyard design
    - *We don't know as much about this as we should*
    - *Opinion: In California, we are at a greater risk of planting vines too close together than too far apart*
  - *Pruning severity is not one of the practices to achieve balance*
    - *When growth is too great: excessive shoot growth and shading will result*
    - *When growth is too little: shoot number can be reduced to increase individual shoot growth but cluster number will be reduced, affecting yield per acre.*
  - Annual practices can be tools to achieve balance
    - *Requires inputs that can be costly*
  - *Correct choice of rootstock is a critical decision in achieving balance*

Questions?

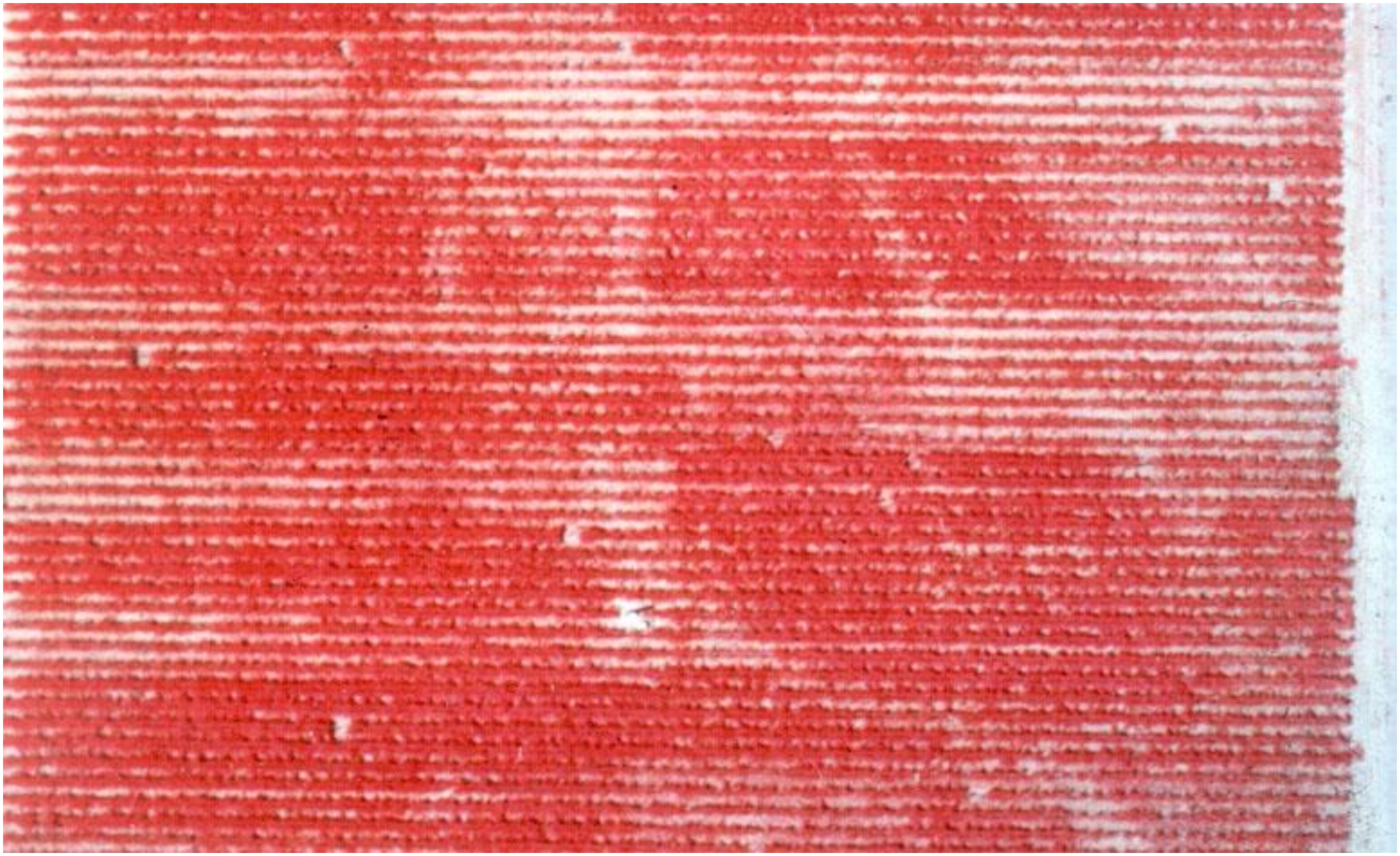
- Thank you for your attention.

Nelson Shaulis: 1st Cool Climate Symposium, 1984:

Comments on the adequacy of growth.

- “…it does seem to me that anybody in the room here would not have a great difficulty identifying a canopy that had inadequate area of leaves, or one that had excessive area of leaves. And we might not be too far apart if we talked about an adequate area of leaves.”

- “But I would like to argue very briefly here that one cannot be practicing multiple applications of nitrogen and irrigation and weed control, and then be complaining about perhaps excessive vine size. He has his foot on the accelerator and brake at the same time, you see.”



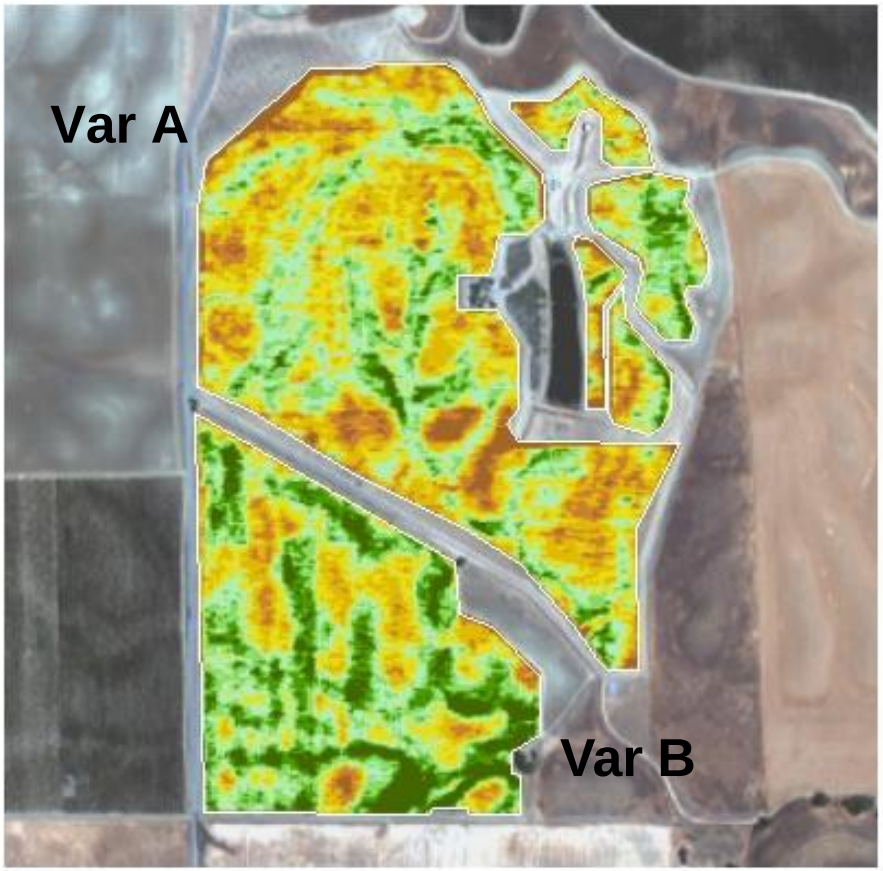
Soil Preparation for New Plantings

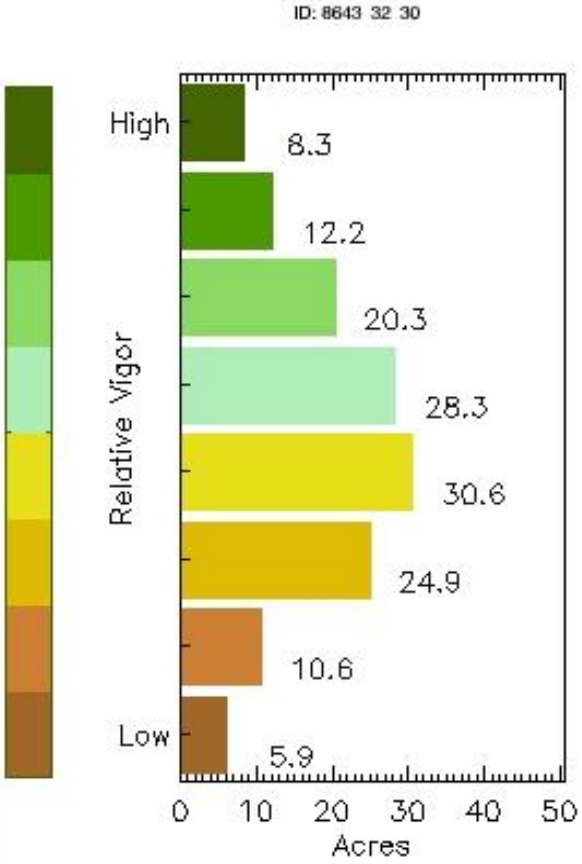
Courtesy: J-J Lambert

Variation in Vine Vigor

Field Variation Map Summary

141.1 Acres Acquired: 07/14/01 Processed: 10/10/2001 15:23 GMT





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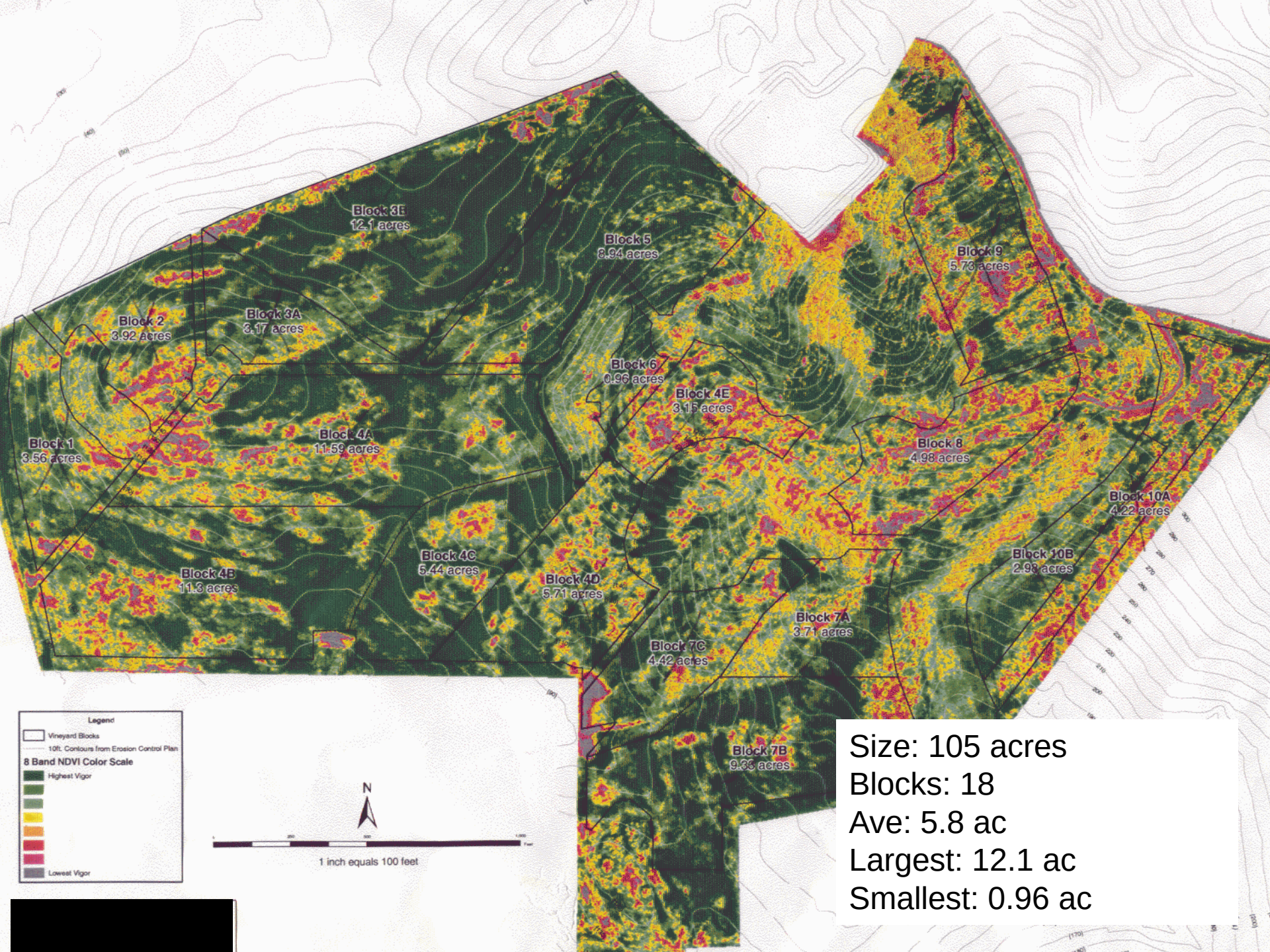
EarthScan NETWORK INC



Size: 105 acres
Blocks: 18
Ave: 5.8 ac
Largest: 12.1 ac
Smallest: 0.96 ac