Long-term Impacts of Tapping and Sap Collection on Tree Growth and Health

Photo: Mark Isselhardt, UVM Extension

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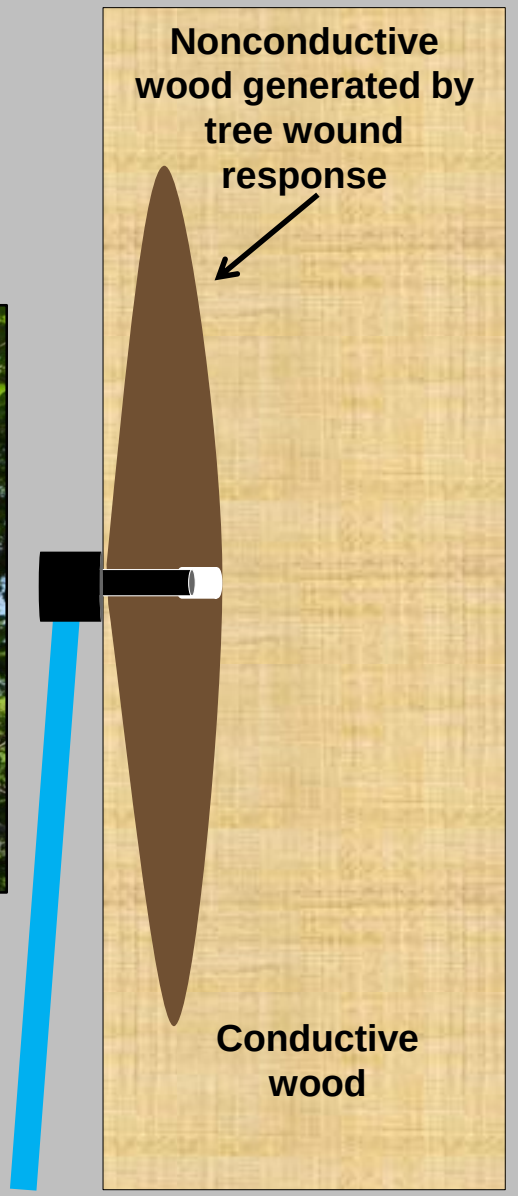
Annual tapping for sap collection:

Generates permanently nonconductive wood (NCW)

Removes carbohydrate reserves

Diameter growth *adds* conductive wood (CW)

Photo: Mark Isselhardt



“Sustainable” sap collection

What determines whether tapping is sustainable?

Addition of new **Conductive Wood (CW)** outpaces amount of **Nonconductive Wood (NCW)** generated by tapping, and volume of CW in the tapping zone remains high

Functional water transport, low risk of disease/decay (**Health**)

High probability of hitting clean, CW when tapping (**Yields**)

Radial growth rates underlie sustainability of tapping practices for both tree health and yields

…and tree health affects growth rates…

How does tapping and sap collection impact radial growth?

How does tapping and sap collection impact radial growth?

Studies that use tree cores to investigate the impacts of tapping on tree growth have some important limitations

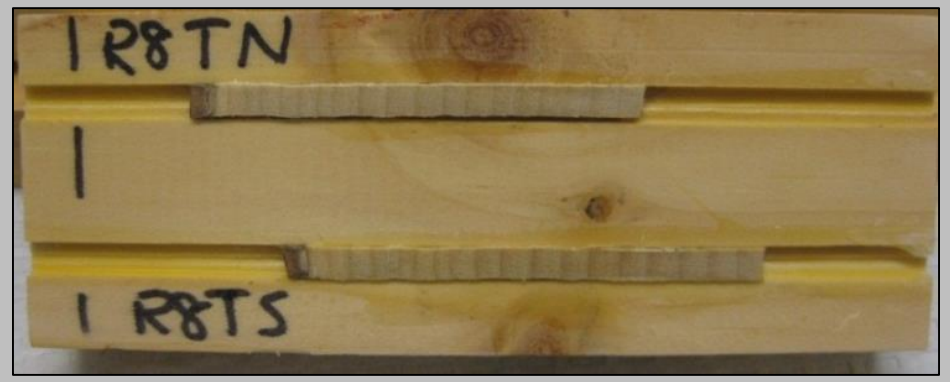


Table 3. Mean growth rates (BAI) of sugar maple trees tapped with high-yield sap collection practices within each of 18 sites in Vermont.

	Diameter class																	
	8 in.			10 in.			12 in.			14 in.			16 in.			18 in.		
Site	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
	(in.²/yr)																	
A	2.6	0.2	12	2.8	0.2	9												
B	1.2	0.04	2	1.4	0.1	11	1.7	0.1	8	3.0	0.3	5	2.8	0.4	9	3.4	0.8	3
C				1.5	0.2	4	1.7	0.2	18	2.7	0.3	7	2.9	0.3	6	4.1	0.7	4
D				2.1	0.1	2	2.9	0.3	7	3.5	0.7	5	4.0	0.4	8	5.6	0.7	5
E				1.8	0.3	2	0.8	0.1	4	2.1	0.2	4	2.9	0.8	3			
F										2.4	0.3	6	2.2	0.5	3	3.8	0.6	3
G				1.0	0.1	3	1.4	0.2	5	2.0	0.2	10	2.6	0.3	6	3.2	0.8	5
H				1.9	0.4	2	2.7	0.2	7	3.8	0.4	10	3.7	0.8	4	3.7	0.8	5
I	1.3	0.03	2	1.8	0.2	8	2.0	0.2	14	2.5	0.3	6	2.9	0.4	12			
J				1.4	0.2	13	2.0	0.3	12	1.9	0.2	7						
K				1.3	0.2	8	2.1	0.3	4	2.9	0.3	14	3.6	0.5	7	4.3	1.1	4
L				0.9	0.2	5	1.4	0.2	11	1.1	0.2	6	1.5	0.1	7	1.9	1.0	2
M							2.3	0.6	3	2.6	0.4	8	2.0	0.5	9	1.6	0.03	3
N				4.1	0.9	3	3.0	0.2	9	3.9	0.4	13						
O				1.9	0.5	2	1.2	0.1	3	2.8	0.9	6	1.9	0.2	4	2.2	0.3	9
P	1.0	0.3	3	0.9	0.1	3	2.7	0.3	9	2.7	0.4	9	3.3	0.4	7	3.5	0.6	3
Q	1.3	0.2	7	3.0	0.4	8	3.6	0.5	5	2.2	0.3	6				2.8	0.3	6
R				1.1	0.2	2	1.9	0.2	14	3.7	0.5	8	3.2	0.4	10	5.3	0.7	8
Total no. of trees			26			85			133			130			95			60

Trees had codominant or dominant canopy positions and had been tapped annually with a single spout for at least 10 years. *n* is the number of trees.

van den Berg, A.K., Perkins, T.D., Isselhardt, M.L., and Wilmot, T.R. 2016. Growth rates of sugar maple trees tapped for maple syrup production using high-yield sap collection practices. *Forest Science* 62(1):107–114.

How does tapping and sap collection impact radial growth?

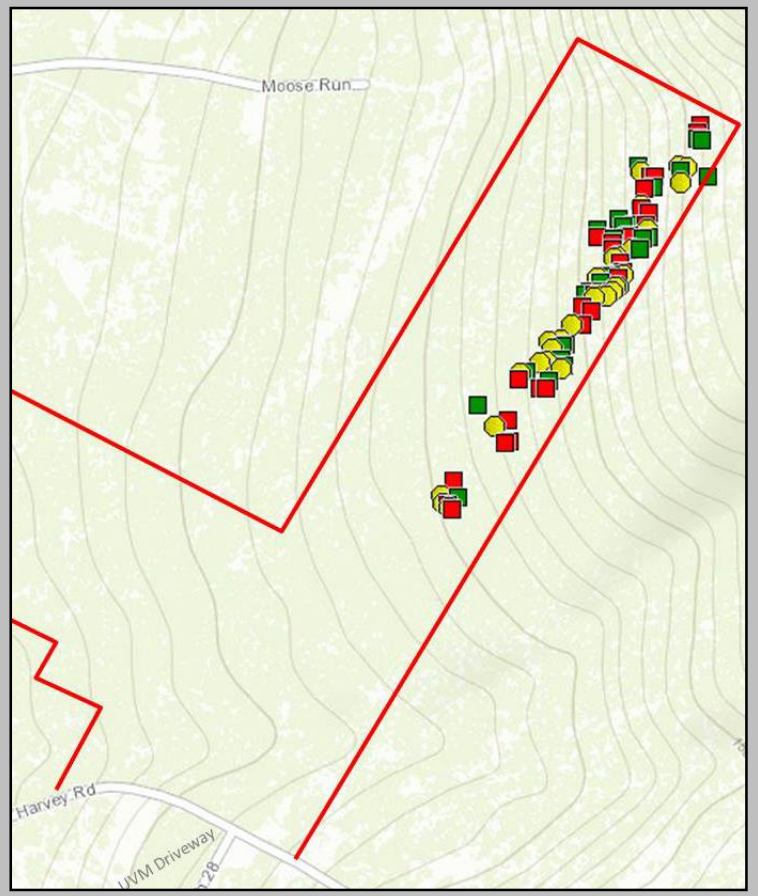
2013 – began controlled experiment to examine long-term effects of tapping and sap collection on growth and health

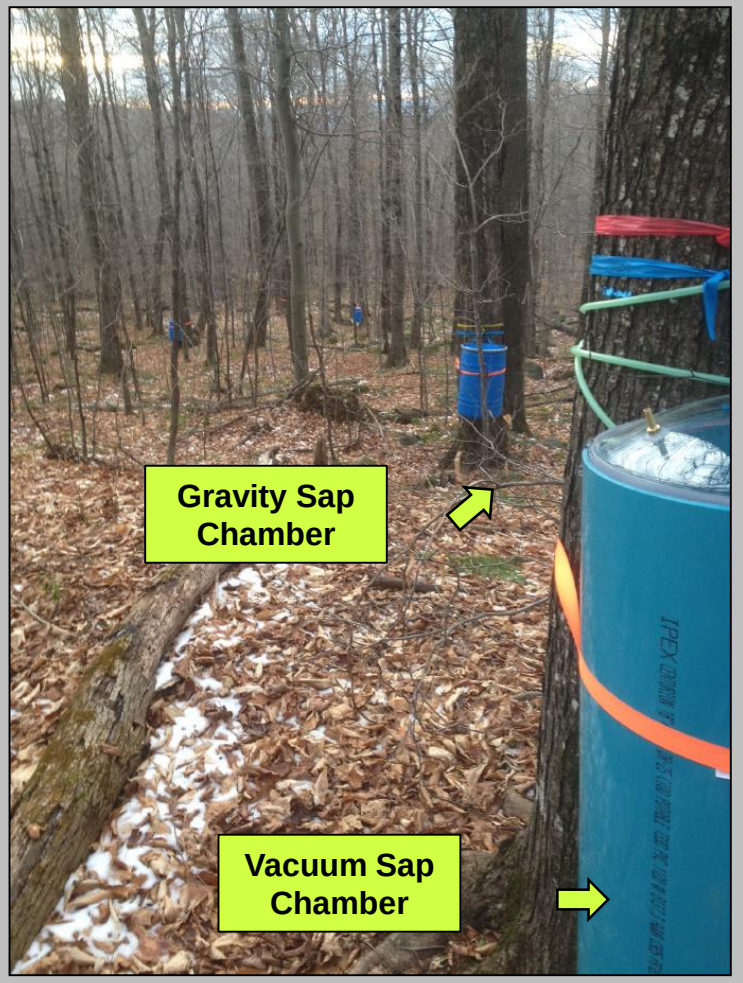
Single uniform stand
93 trees (never tapped)
Healthy, Dom/Codom
2013-2023(+)

3 Treatments:

- 31 Control (untapped)
- 31 Low extraction (“Gravity” sap collection)
- 31 High extraction (Vacuum sap collection)

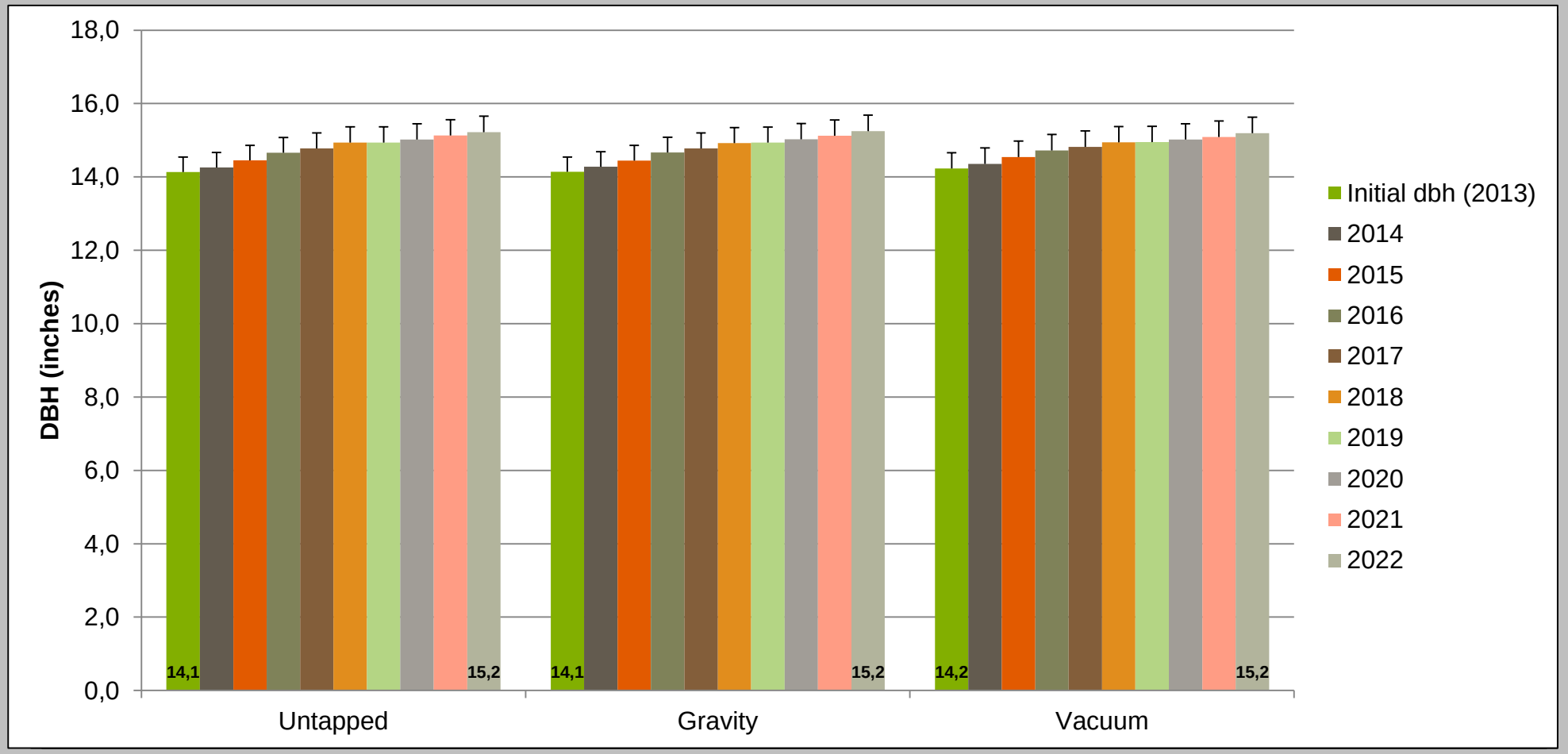
Sap yield, sugar content, diameter, health indices measured each year





Funded by: USDA Hatch, Chittenden County Maple Sugarmakers Association

How does tapping and sap collection impact radial growth?



No significant difference

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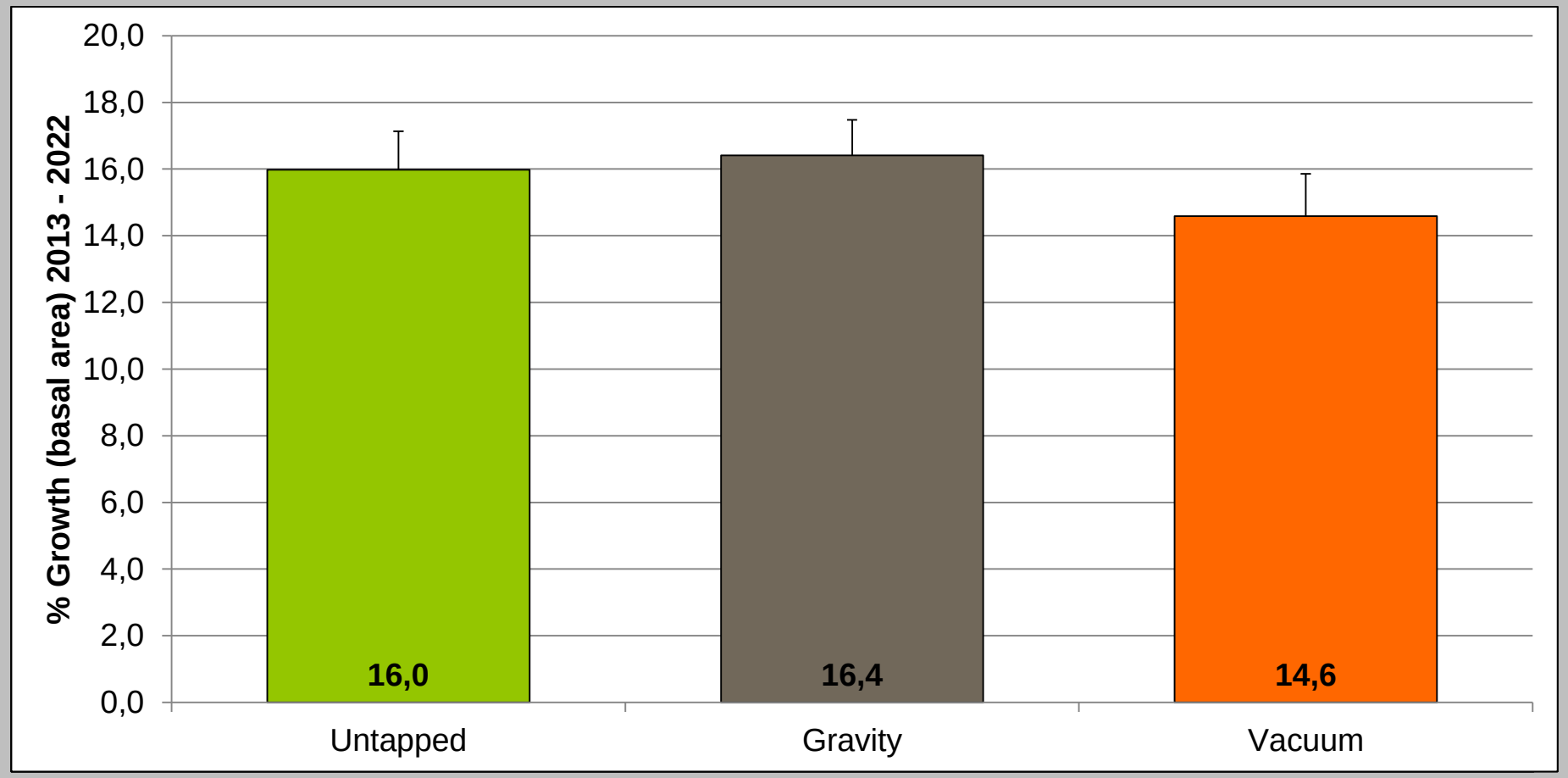

No significant difference

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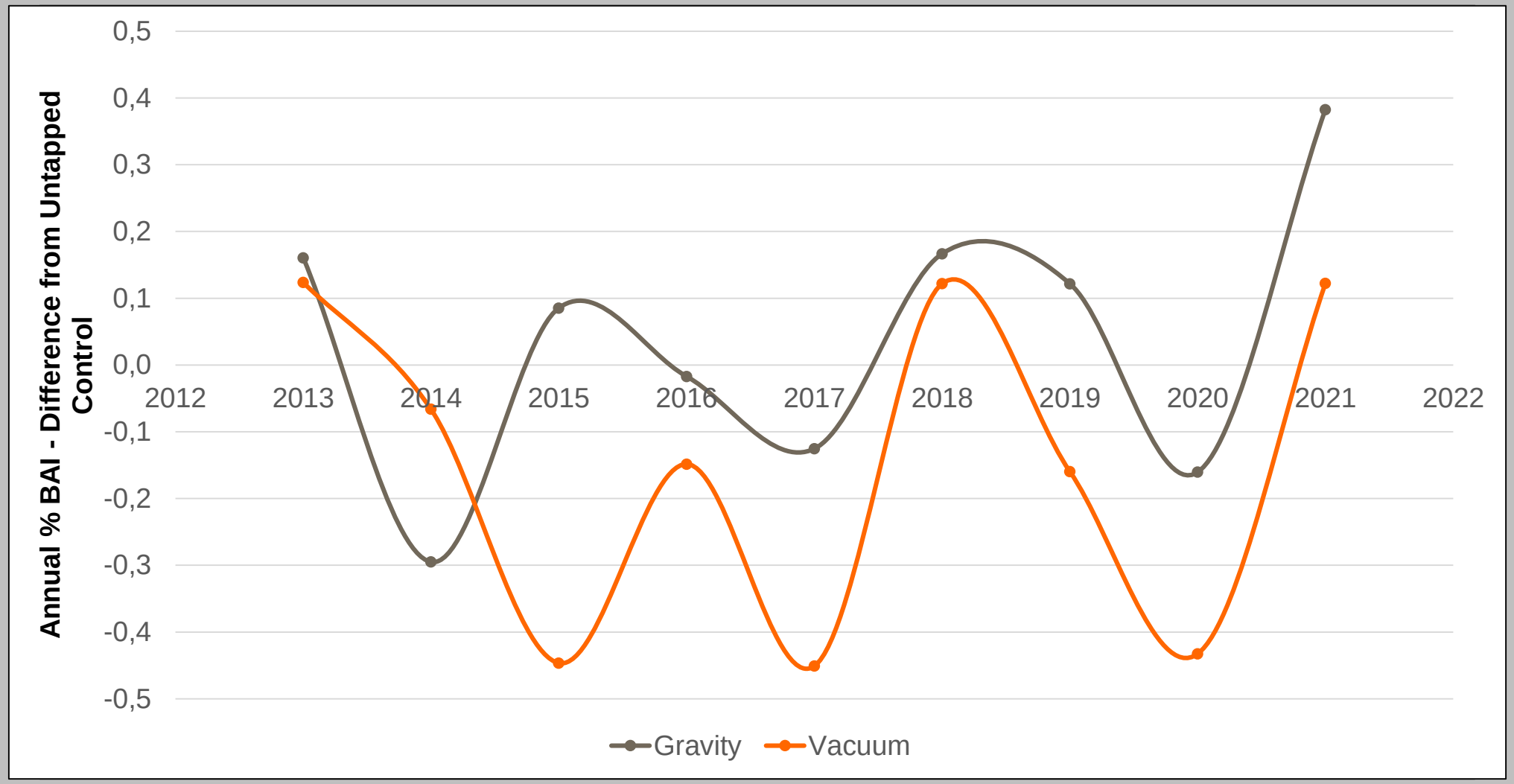
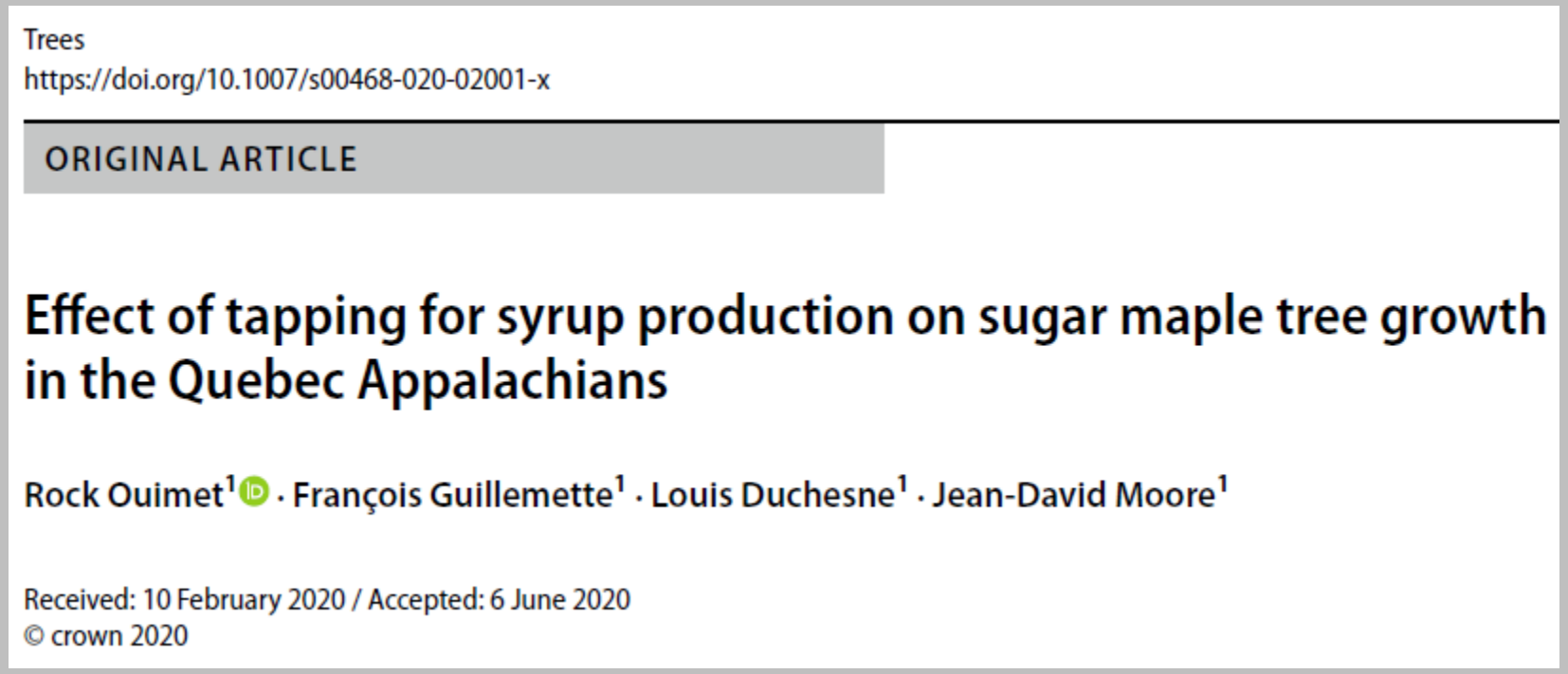


On average since 2013: Trees tapped with vacuum %0.15 lower annual basal area increment than untapped trees (Not a significant difference)

How does tapping and sap collection impact radial growth?



Trees
https://doi.org/10.1007/s00468-020-02001-x

ORIGINAL ARTICLE

Effect of tapping for syrup production on sugar maple tree growth in the Quebec Appalachians

Rock Ouimet[1] · François Guillemette[1] · Louis Duchesne[1] · Jean-David Moore[1]

Received: 10 February 2020 / Accepted: 6 June 2020

Soil fertility could play a role in determining if sap collection impacts radial growth

How does tapping and sap collection impact radial growth?

Project started in 2017:
Expanded long-term, controlled experiment on impacts of tapping and sap collection on tree growth and health:

13+ sites

Begin with untapped stands

Monitor growth, health of matched tapped and untapped trees within stands to determine if significant effects exist

Project Years 1-3: USDA NIFA Organic Transitions Program
Project Years 4-9: North American Maple Syrup Council Research Fund

How does tapping and sap collection impact radial growth?

50 trees at each site

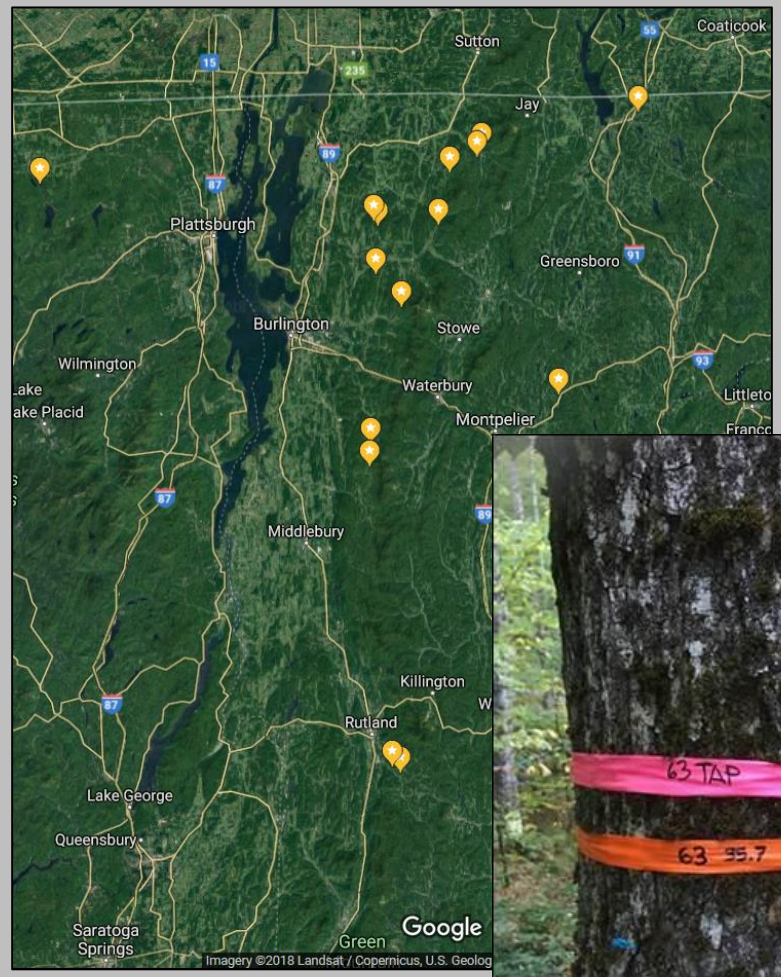
Never tapped

25 Tap (vacuum)/25 No-tap controls

10 each: 6,8,10,12,14”

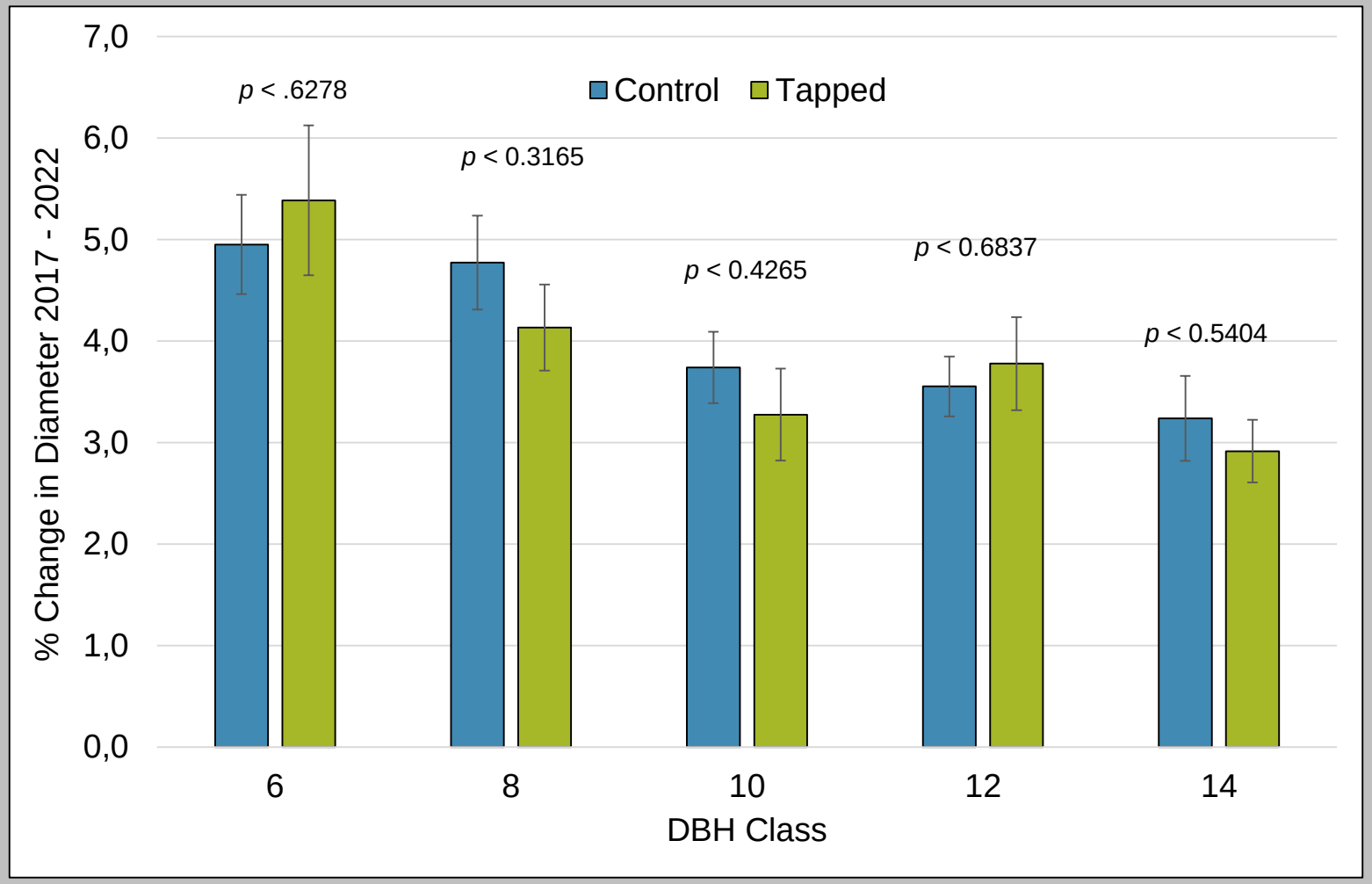
Measure annually: diameter growth, crown condition

First tapped 2018



How does tapping and sap collection impact radial growth?

Average percent change in diameter of Control (Untapped) and Tapped sugar maple trees in 5 size classes after 5 years of tapping and sap collection in previously untapped stands at 13 sites in VT and NY
(At each site, *n*=5 for each treatment in each size class)



No significant differences in growth of Tapped and Control trees

Next?

Maple sap collection is not a short-term endeavor

Both the PMRC and expanded multi-site study will continue for 10+ additional years (pending funding availability)

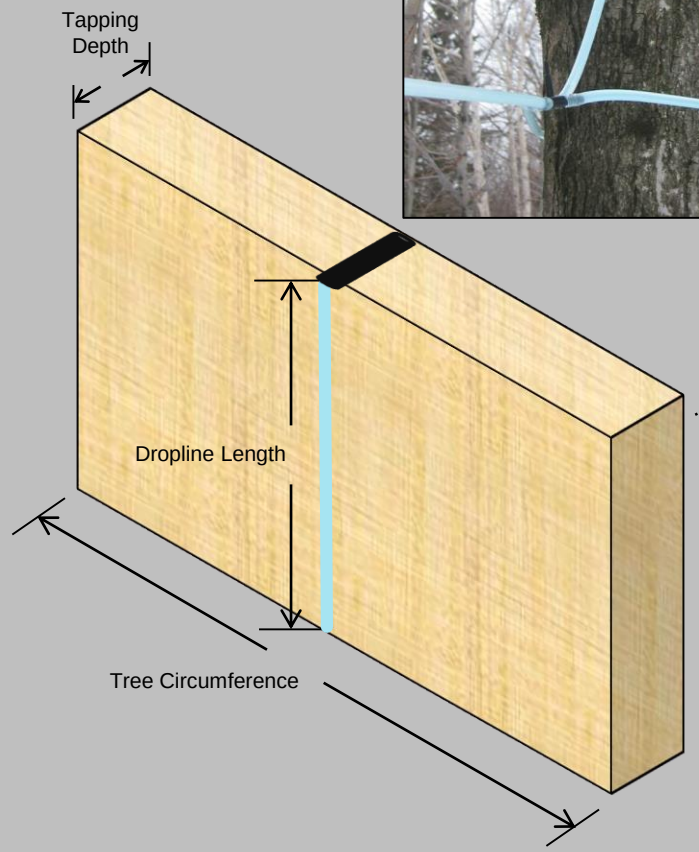
Photo: Mark Isselhardt, UVM Extension

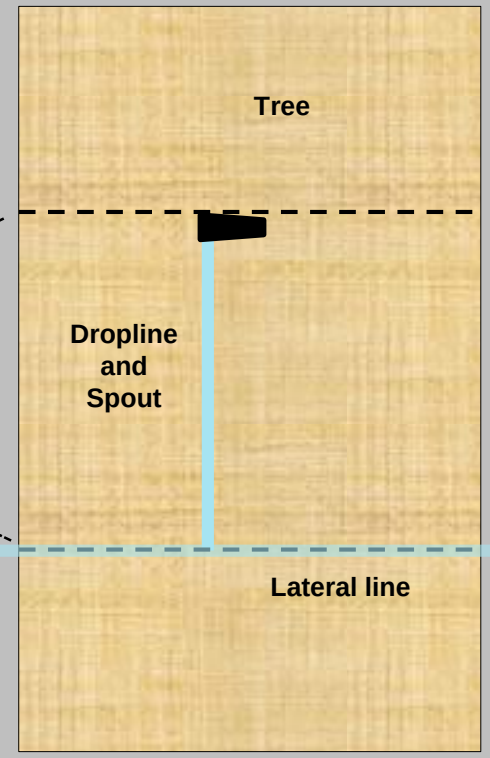
Why is growth rate so important?

The total size (volume) of the **Tapping Zone** determines the maximum potential amount of clear, **Conductive Wood (CW)** available for tapping

Dropline length × Tapping Depth × Tree circumference

The “Tapping Zone”

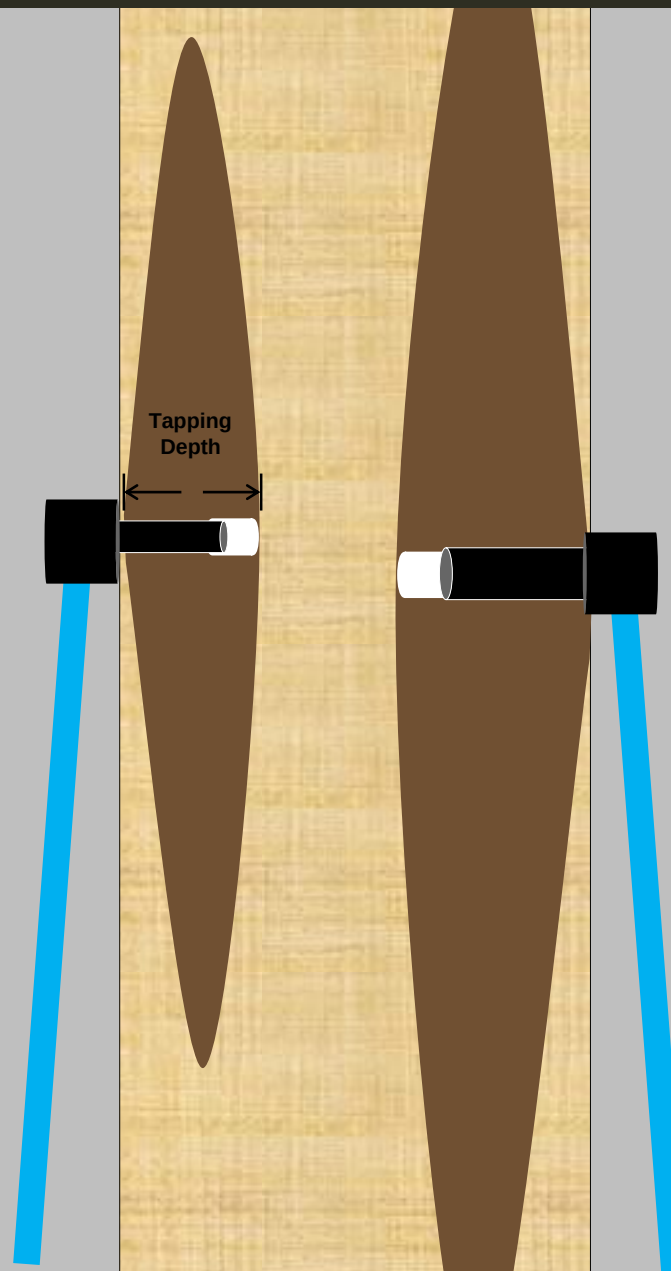




Why is growth rate so important?

Each year, new
Nonconductive Wood (NCW)
is generated in response to the taphole wound

(proportional to the size of the taphole)



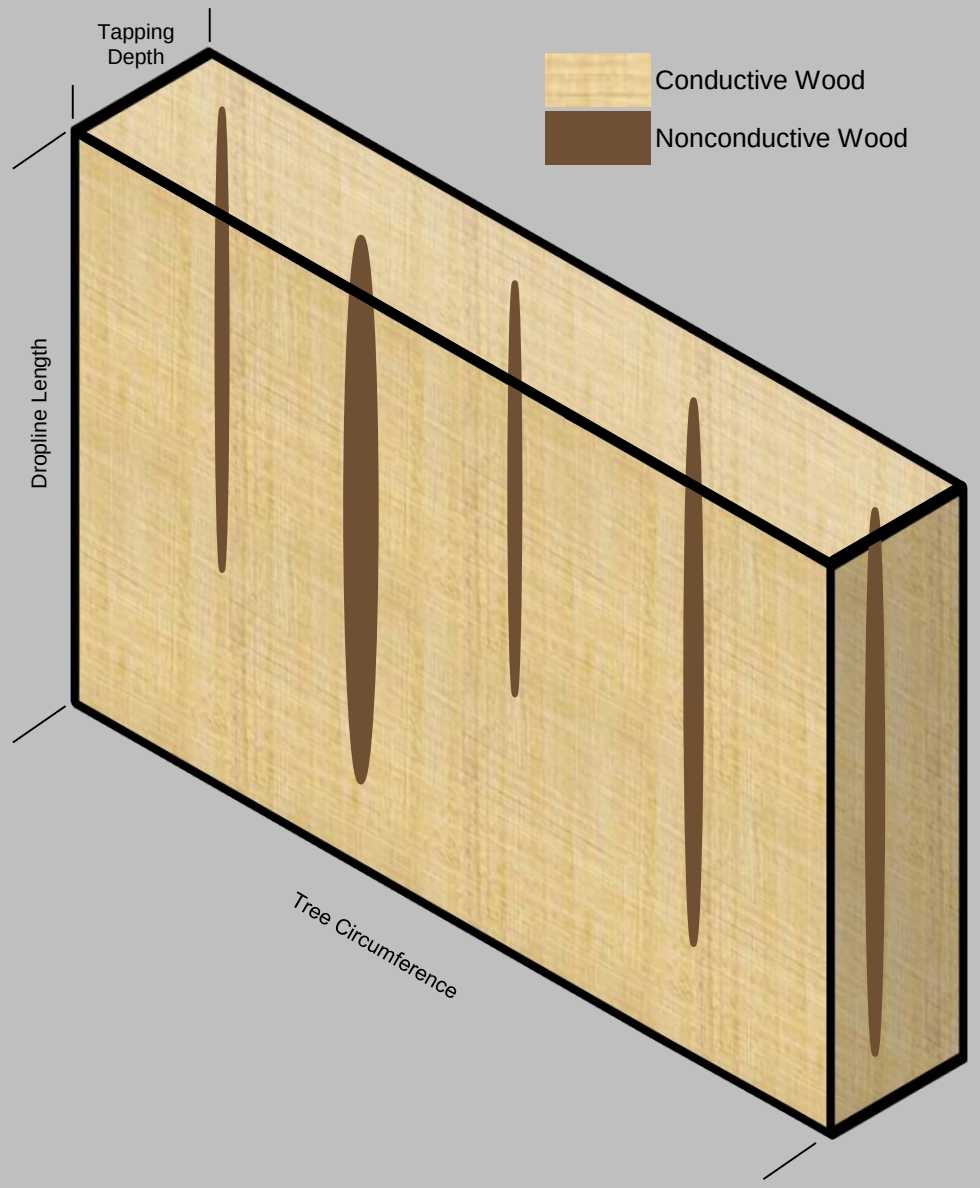
Why is growth rate so important?

Proportion of the Tapping Zone that is Nonconductive Wood (NCW) = Chance of hitting NCW when tapping

20% of the Tapping Zone is NCW = 20% chance of hitting NCW

60% of the Tapping Zone is NCW = 60% chance of hitting NCW

Chances increase as NCW increases



Why is growth rate so important?

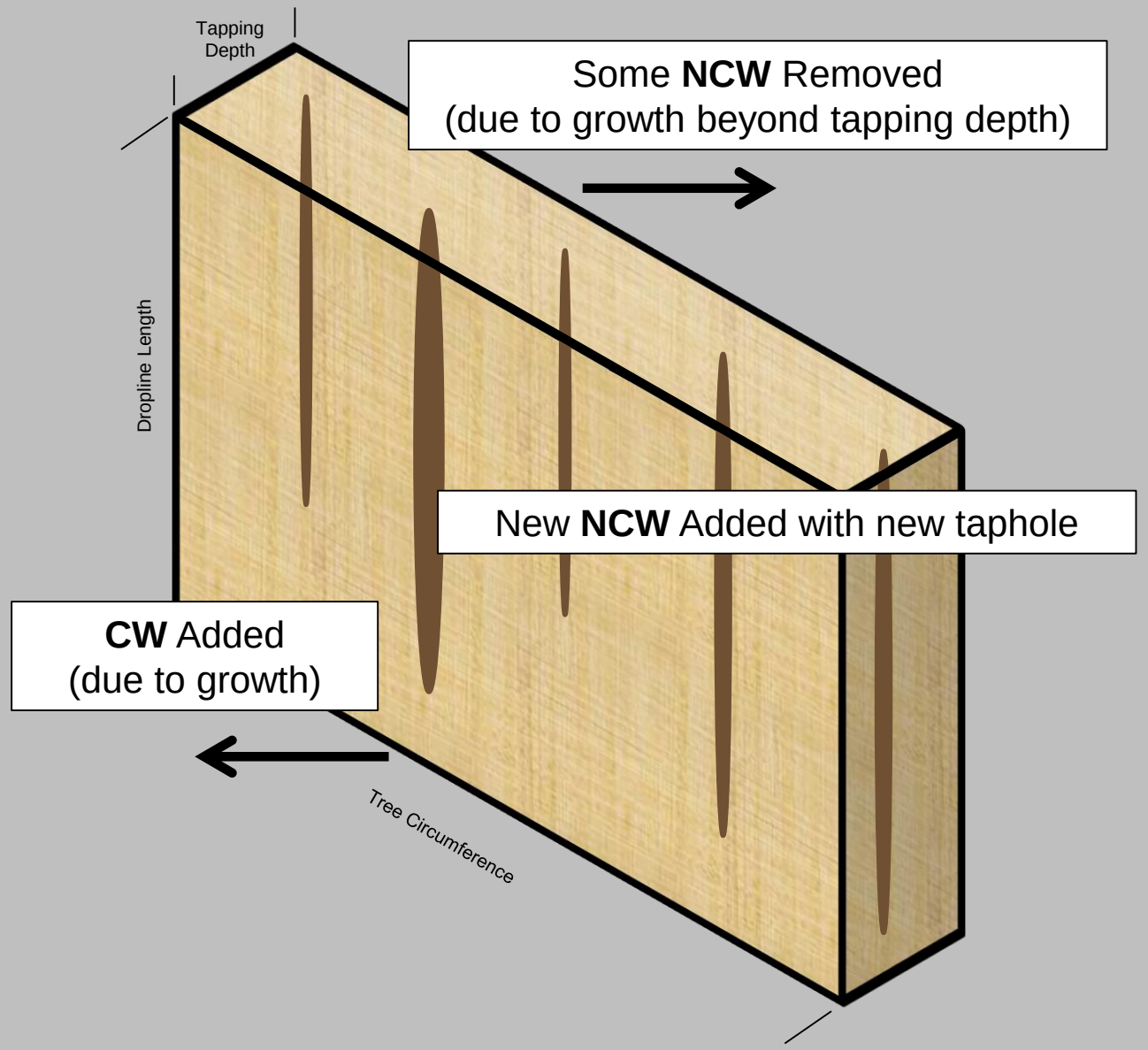
Tree diameter growth underlies <u>everything</u>

Determines:

How much CW is added to the tapping zone annually

How much NCW “grows out”

And, therefore, the proportion of NCW and CW present, and the chances of tapping into either



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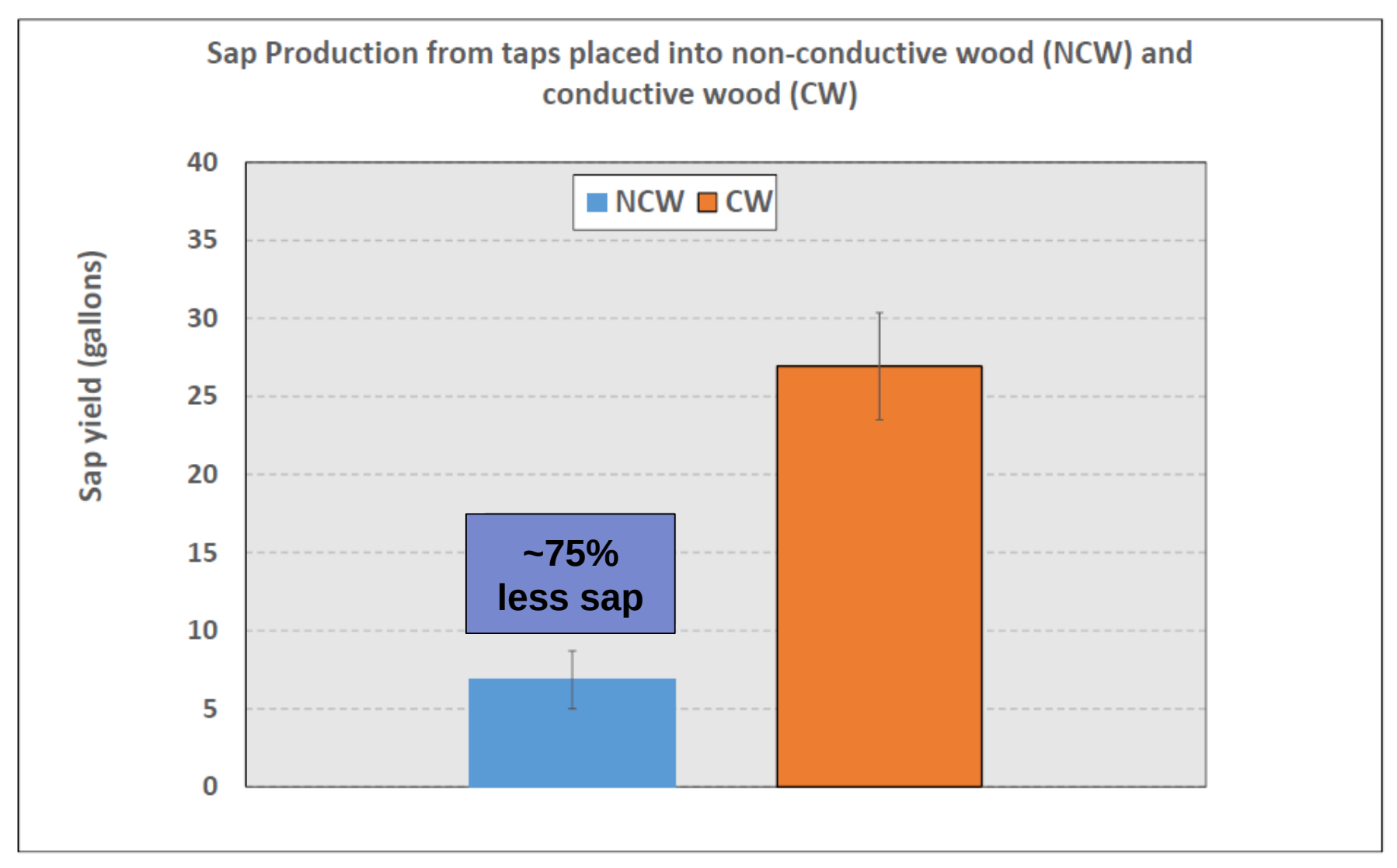


Yields are **significantly** lower from tapholes drilled into NCW

Greater the chances of hitting NCW, greater the chances of significant reductions in yield

Isselhardt, M.I. Reduced sap yields when tapping into nonconductive wood. 2022. *The Maple Digest* 61(1): 4-14.

Tapping Practices Impact Yields and Nonconductive Wood

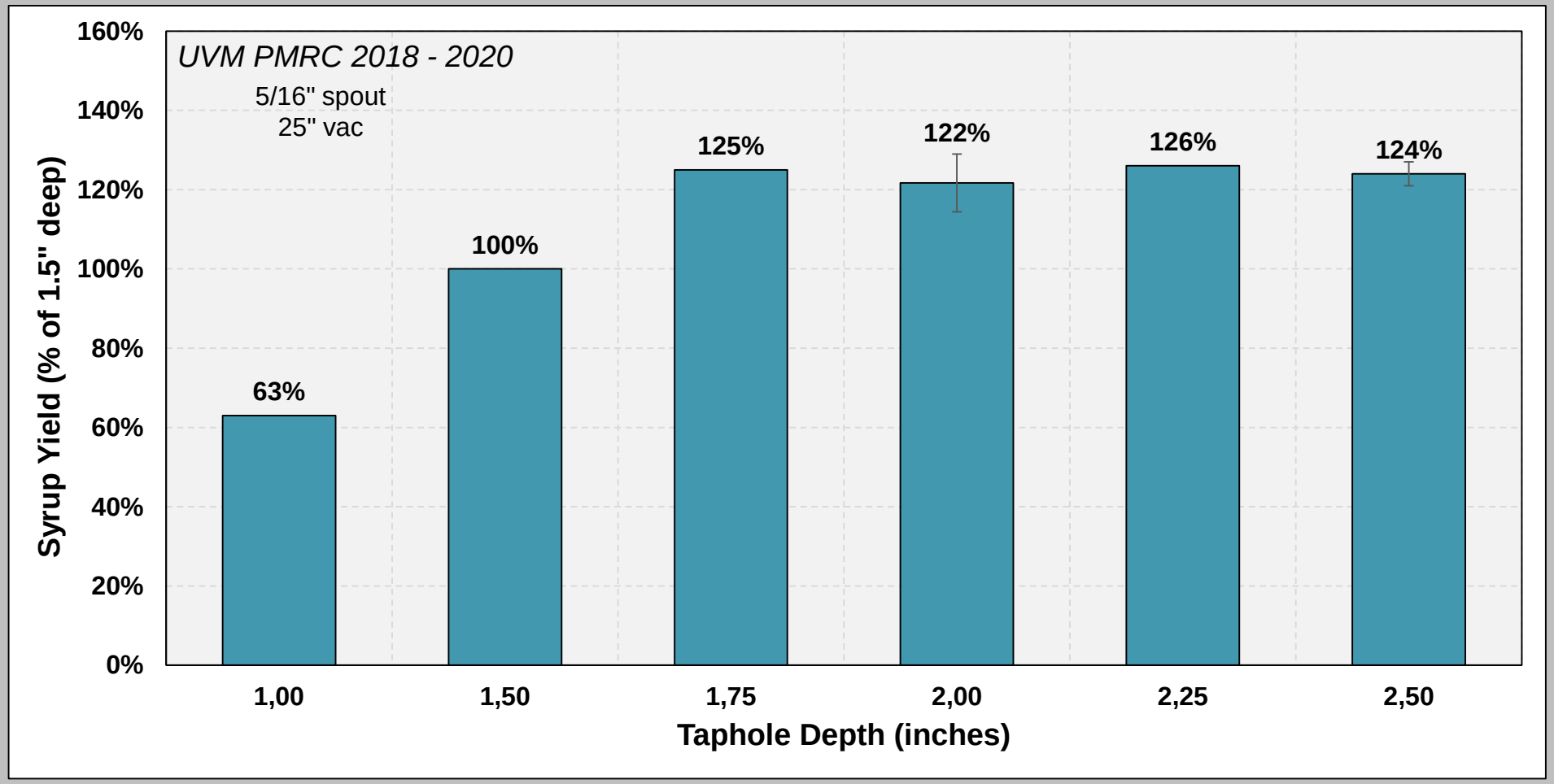
To maximize yields we want to minimize the amount of NCW in the tapping zone…
But our choice of tapping practices influences NCW *and* yields in the current season…

Photos: Mark Isselhardt, UVM Extension

Deeper and larger tapholes, more taps per tree = higher yields

But also = more nonconductive wood

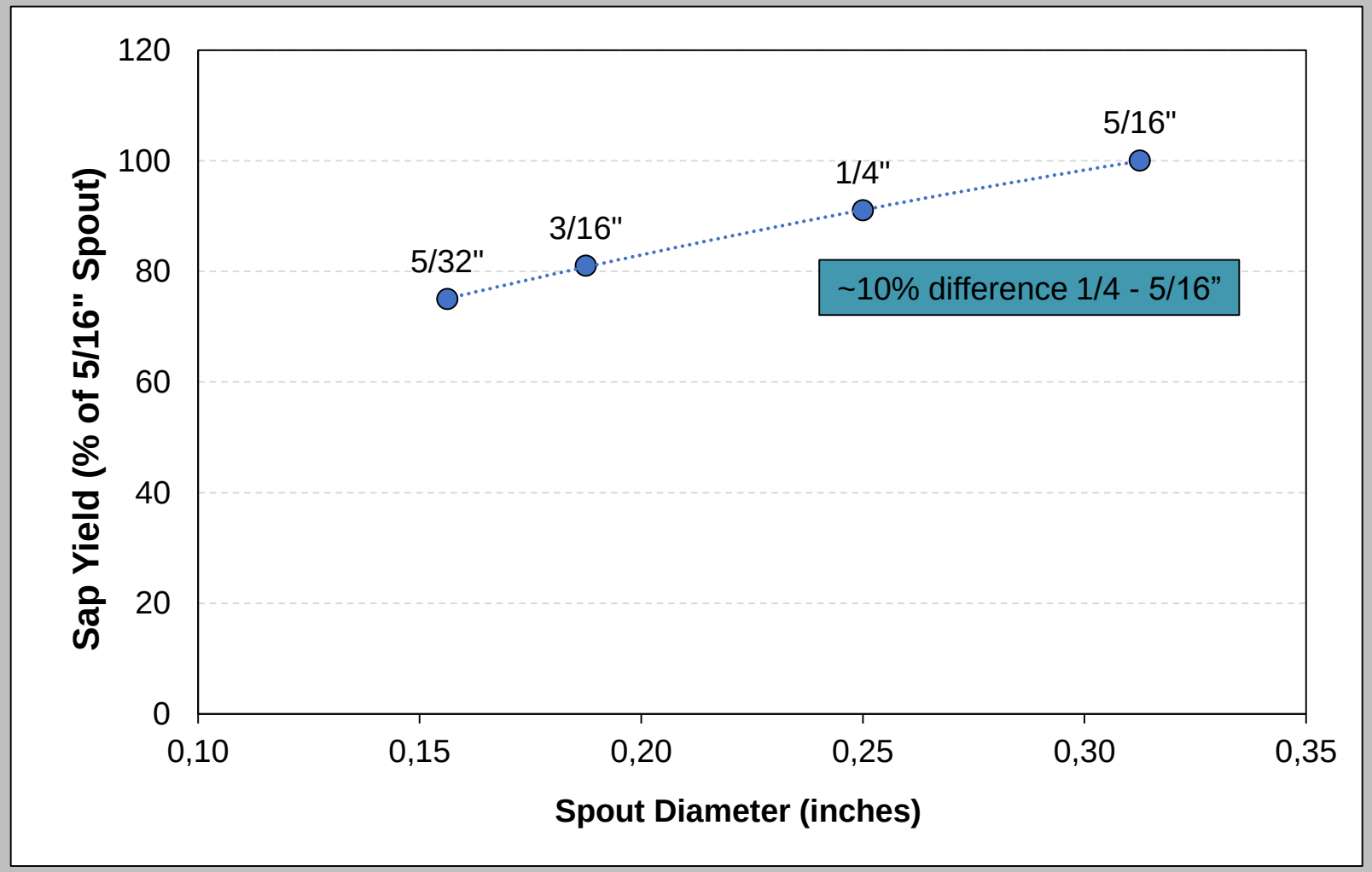
Tapping Practices Impact Yields – *Taphole Depth*



Deeper tapholes result in greater yields (up to a point)

Perkins, T.D., van den Berg, A.K., and Bosley, W.T. 2021. Effects of tapping depth on sap volume, sap sugar content, and syrup yield under high vacuum. *The Maple Digest* 60(1): 8-12.

Tapping Practices Impact Yields – *Taphole Diameter*

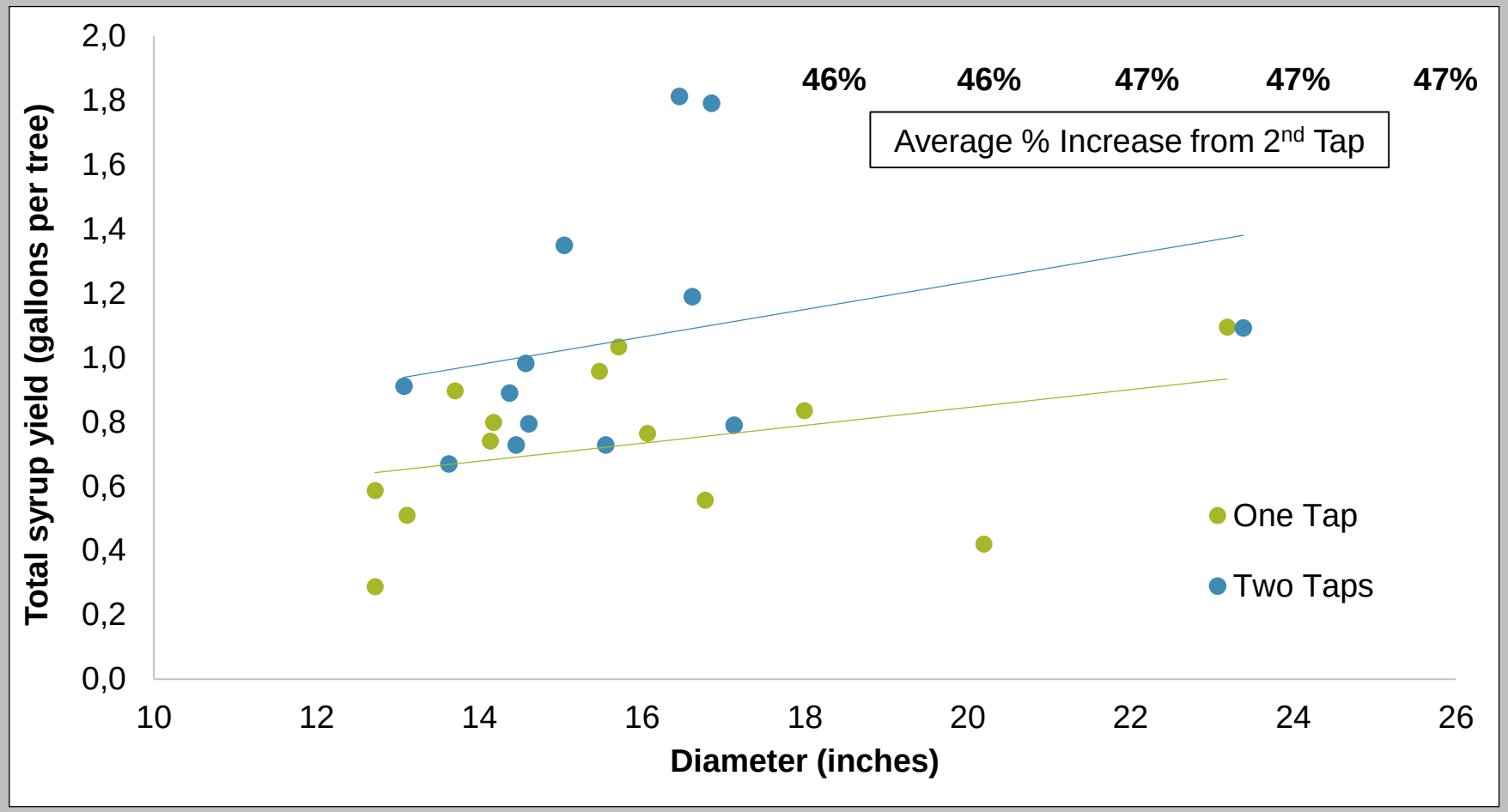


Yields increase with increasing taphole diameter

(same spout material and equal attention to leak checking)

Perkins, T.D. and van den Berg, A.K. 2019. Effect of spout diameter on sap yield. *The Maple News* August: 5.

Tapping Practices Impact Yields – *Number of Taps per Tree*



Yields from a second tap in trees of appropriate size can be substantial

van den Berg, A., Perkins, T., Isselhardt, M., Boutin, J., Bosley, W., Haynes, B. 2023. Tapping practices to maximize yields over the long-term. *La Technique CDL* (Vol. 3)

Tapping Practices to Optimize Long-term Sustainability and Yields:

To “maximize yields” for the *long-term*:

Tapping practices must balance current yields ***and*** NCW accumulation (as a function of tree growth, size, tapping history), as this will determine ***future*** yields:

As NCW accumulates, chances of hitting it (and reduced yields) increase

Growth rates are the fundamental key that underlies it all, enabling practices that can result in greater sap yields, sustainably, over the long-term

Optimize **Yields**

Photos: Mark Isselhardt, UVM Extension

Tapping Practices to Optimize Long-term Sustainability and Yields:

Tapping practices that promote maximum yields and sustainability in the long-term begin with forest management

Promote growth (and health) of trees

Thinning (& other forest mgmt.)

Liming or soil amendments (where needed)

Other best practices – soils, roads, care during logging/thinning

Photo: Mark Isselhardt, UVM Extension

Tapping Practices to Optimize Long-term Sustainability and Yields:

Balance yields and sustainability

Chosen as function of the growth rates and health of trees, and existing accumulation of NCW

Tapping practices that will result in the maximum yields possible to result in a sustainable level of NCW/CW for the growth rates and health (and pre-existing amount of NCW) of your trees

Photo: Mark Isselhardt, UVM Extension

Current tapping practices determine ***future*** yields

Photos: Mark Isselhardt, UVM Extension

Thank you!
Questions?

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Tapping Practices to Optimize Sustainability and Yields:

TABLE 6.1 Tapping guidelines based upon tree diameter,[1] tree condition, and sap collection method.

Tree Conditions[2]	Collection Practices[3]	Spout Diameter (inches)	Tapping Depth[4] in / cm	Minimum Tree Diameter[5] in / cm	Number of Taps
Conservative					
Optimal	Gravity	7/16	1–2.5 / 2.5–6.4	12+ / 31+	1
Suboptimal	Gravity or Vacuum	1/4–5/16	1–1.5 / 2.5–3.8	12+ / 31+	1
Standard					
Optimal	Gravity or Vacuum	1/4–5/16	1.5–2 / 3.8–5	9–12 / 23–31	1
				18–22[6] / 46–56	2

[1] Tree diameter should be adjusted downward to an "effective" diameter if there is evidence of stem defects (insect or animal damage, logging wounds, trunk cracks or scars, cluster tapping, etc.).

[2] *Optimal* conditions include trees that are healthy, with good growth rates, no history of overtapping, and NCW (stained wood) is not frequently encountered during tapping. *Suboptimal* conditions are trees that have slower growth rates, are in a "suppressed" position in the forest canopy, have been recently stressed or are exhibiting signs of stress (dieback, fine twig mortality, slow wound healing, etc.), have a history of overtapping, or if NCW (stained wood) is frequently encountered during tapping. Conditions are a range—the more *"Suboptimal"* conditions that are observed, the more conservative the practices (shallower depths, smaller-diameter spouts, larger minimum tree diameter for first or second tap, etc.) that should be selected. Likewise, the more *"Optimal"* conditions that are observed, the less conservative tapping practices can be selected.

[3] All practices assume a dropline length of 36–42 inches (92–107 centimeters) for collection with tubing.

[4] Tapping depth includes bark. If the stand has a preponderance of older, thickly barked trees, up to an additional ½ inch of depth may be added.

[5] To convert diameter to circumference, multiply the diameter by 3.14.

[6] The lower portions of the diameter range should be used with gravity and vacuum collection at less than 20″Hg. The upper portion of the diameter range should be used with vacuum collection greater than 20″Hg since the additional yield from a second taphole is negligible in trees of smaller diameters at high vacuum levels. In many cases producers using high vacuum will only use one tap per tree regardless of size.

Perkins, T.D., van den Berg, A.K., Boutin, J., Childs, S., Wilmot, T.W. 2022. Chapter 6: Sap Collection. *In* North American Maple Syrup Producers Manual., 3rd ed. Perkins, T.D., van den Berg, A.K., Heiligmann, R.B. and Koelling, M.R., Eds.