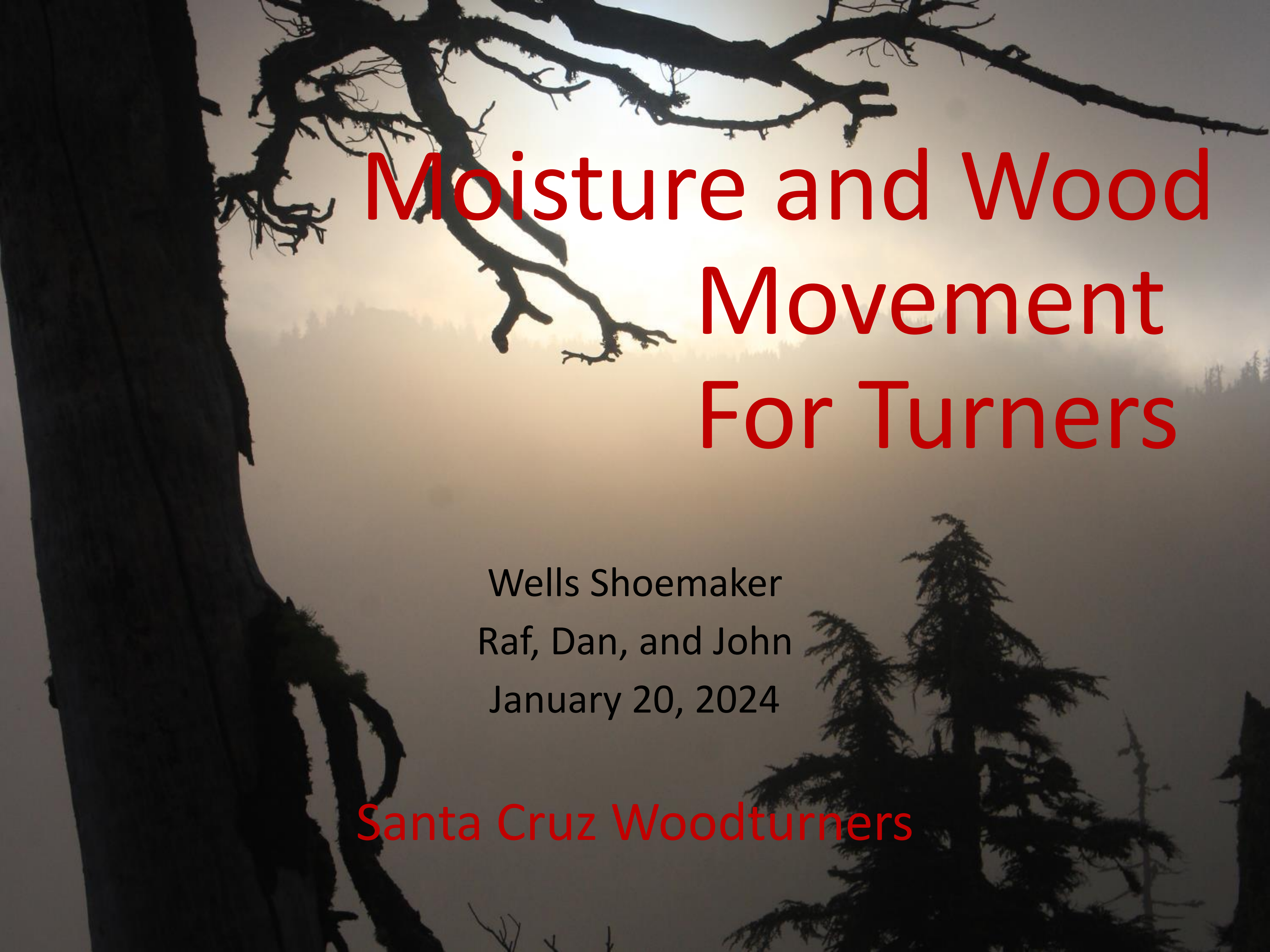


Moisture and Wood Movement For Turners

Wells Shoemaker
Raf, Dan, and John

January 20, 2024

Santa Cruz Woodturners

Our club conversations have often addressed the choices for processing of wet or damp blanks to **conserve the highest percentage of good bowl outcomes.**

We'll address in understandable terms the science of moisture effects on wood, shrinkage especially, and practical mitigations, so that your decisions are rational and your results consistent.

Fabulous cameos at the end regarding different approaches from Raf, Dan, and John!

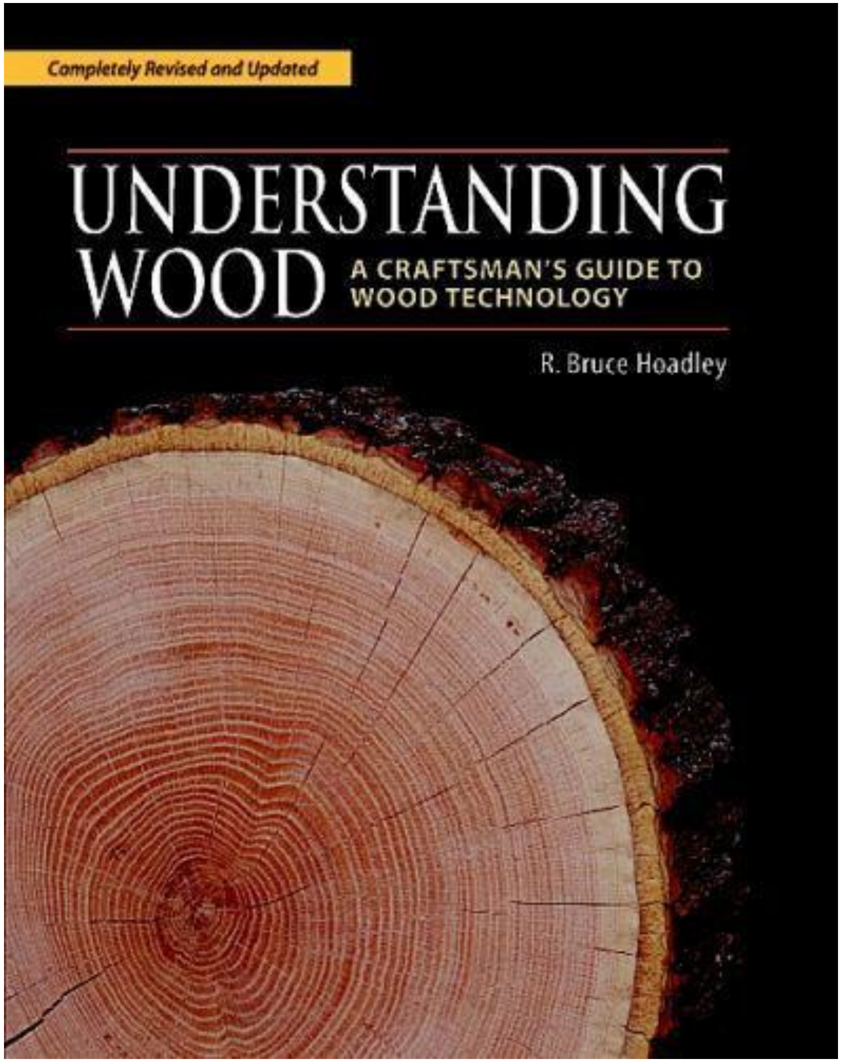
The Big Difference: Flat Vs Round...Dry vs Damp

Furniture makers use dry boards ...which move a wee bit

Turners often use wet and damp wood...which moves a ***lot***

Tan oak: 11.7% tangential shrinkage coefficient!

Homage to R. Bruce Hoadley



The essential “read” for any serious woodworker ...and precious for turners who are working with wet or damp wood.

Chapter 6 is gospel.

John Wells, thank you!

The Living Tree:
A Work of Air, Sun, Earth, and **Water**

Solitary Madrone, La Honda, 1975

Versatility, adversity, luck, and water shape the tree...and the wood inside

They all grow, sometimes fast, sometimes slowly

Happy Red Fir juvenile, Snow Mountain summit

Ancient Bristlecone, Telescope Peak, 11,000' Death Valley

Sometimes very tall

Sometimes rather short

Bonsai pinon pine, high Utah

Sometimes a little crooked

Kokopelli bonsai, high Utah

Sometimes a lot crooked

Sometimes bulgy and bumpy

Burls just want to have fun

They bend with the wind

Sometimes they break

Hemlock, Trinity Alps

They lean to the left

They get kinky

They bloom

They drift

They reflect

They die

They burn

And then

they turn

Blacksmith, turner, machinist, builder, episodic burner...our VP Emeritus Roy Holmberg

Through all of this...
The wood keeps moving

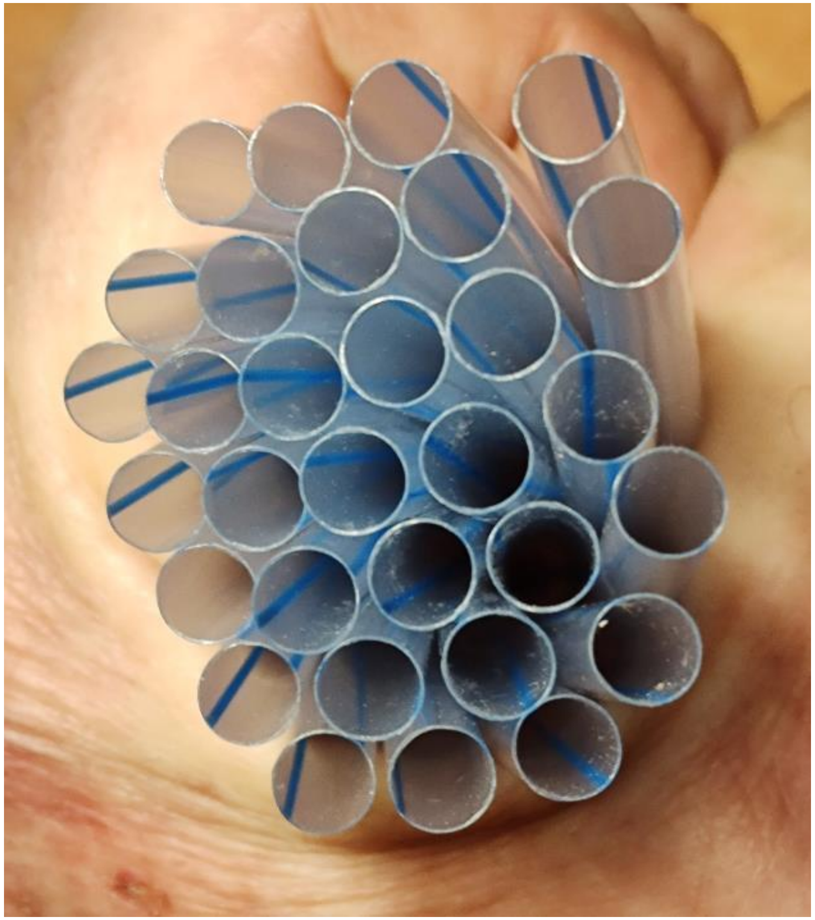
Moisture is the Driver

So let's dive in!

Anatomy of a Crosscut: Looking down into the trunk

Douglas fir—Note variation in growth rings, winter & summer

Endgrain Wood: We're looking down a bundle of microscopic "straws"



These long straws are filled with air...and the bundle is light. It would be a lot heavier if the straws were filled with water...

And heavier still if the whole bundle in turn were wrapped in a sealed case filled with water

Illegal exhibit...sorry

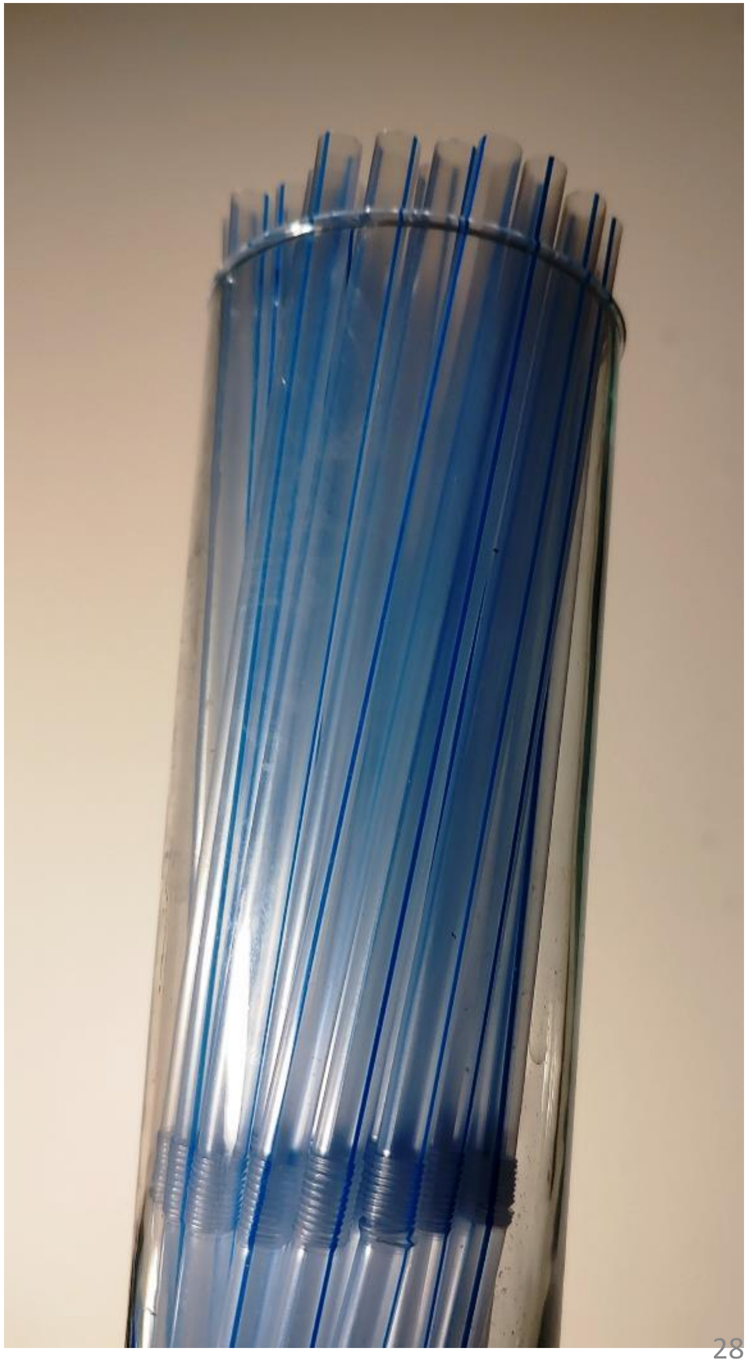
Think: Wood = Straws in a Vase

Imagine tubules in a "vase" of bark

Fill the vase...and the tubules...with water

Pretty heavy! Barely floats

This is a schematic for fresh cut wet wood



Two reservoirs of water in wet wood
This is really important for us today!

1. Water between the "straws" = "**inter**cellular" (between the cells) water. It's "free" and drains fairly fast.

2. Water inside the straws—inside the tubular cells & cell walls = "**intra**cellular" water. Also called **"bound water."** It's trapped and slow moving

Intracellular water seeps slowly through the open ends of the straws, and much more slowly still through the walls of the cells.

Sponge Metaphor

1. **Dry (equilibrated with environment)**
2. **Plunge into basin□ Fully soaked in water**
3. **Drips when removed...makes a little puddle**
4. **Squeeze it out—dimensions unchanged... but it's still damp...still holding moisture!**
5. **Dry it out on the window sill—shrinks and deforms like an orange peel**

Hoadley's analogy


Drying step 1: Drain free water
•Wood is fully wet when we cut down a living tree.
•Intercellular "free" water drains quickly.
•Visibly gushing from cut trunks if cut in Spring.
•It spits and slobbers when you whack it with a maul.

By the way...Water is heavy! *

- Everybody who has moved freshly cut wood knows how heavy it is. It's roughly half water!
    - A 12" diameter wet log, 18" long, 1.2 cu ft, weighs 75 lb.
    - An 18" diameter log, 18" long, 2.5 cu ft, weighs 150 lb
    - A 24" diameter one, 18" long, 4.5 cu ft, weighs 280 lb
- Don't be silly with lifts...

* 62.4 lb/cu ft

Free Water moves variably by species!

- The cellular structure of wood varies a lot in content, porosity, and movement of free water.
- Need an example? Roughing out freshly cut Sycamore? *It's gonna rain in your shop!* Wear a raincoat! Bill Arnold hung blue tarps and still got soaked.
- No surprise! Sycamore has nearly twice the amount of water in both heartwood and sapwood compared to average. Juicy wood! ...and it runs out exceptionally freely.

Ahab atop the Sycamore Whale

A lot of us got wet in the next week or two....

Species differences, part 2

- Tight grain, slow-growing hardwoods usually yield intercellular fluid in a more civilized way. Gives us a little more time for processing

Free water leaves fairly fast early, then slows down

- Like the squeezed-out sponge, freshly cut wood loses water weight but does not change dimensions...*yet*

- Free water is gone from wood when moisture content reaches **fiber saturation point**, FSP, around 27-30% MC.

   The remaining water is intracellular or “bound water.”

- At FSP, the wood hasn’t shrunk...yet...and it hasn’t started to check. But that’s coming soon!

‘Cause when life looks like Easy Street
*...there is danger at your door **

Segue to Phase 2!

Moisture Rules... Wood Moves

** Jerry Garcia, Robert Hunter, and the Grateful Dead*

Drying step 2: Bound Water

- **Intra**cellular fluid seeps out of the cells and into the atmosphere AFTER the intercellular fluid has drained. The pace is variable by species, ambient temperature, humidity, and ventilation

- It's overall slow, but faster through the ends of the tubular cells than the closed walls of the cells

   Just like a straw

Stage 2: ***Now* wood begins to shrink**

- The long, stiff, tubular cells maintain length, but they collapse inwardly when the water leaves. The wood compresses.
  - Think: water balloon with a pinhole leak

- But it is not even! Wood shrinks faster at the cut ends—closer to the open air—than the deep middle

- Cut ends of rounds check early, but the whole round does not split until later.

Firewood teaching example

- After 2-4 months go by, free water near the ends has mostly vacated. Wood at the ends then start losing bound water. The interior tubules are still plump, and the middle section hasn't changed much yet...but the ends start to check.

- Still heavy, but not as much as before...
- Firewood piles lose height & weight gradually if open to the air
- Note classic radial splits in this live oak piece.

Stage 2: When does it stop?

- Eventually moisture deep in the wood will equilibrate with the moisture in the air. It reaches Equilibrium Moisture Content, or EMC.

- When that happens, tubules stabilize, and shrinkage stops. Whew.

- The bigger the difference between wood moisture content and ambient humidity, the faster it changes...slowing down as it approaches EMC

Measuring moisture content

- Meters now readily available, run $50-100.
- Typically: 2 penetrating prongs which measure conductivity and calculate moisture content.
- Quality varies. Buy from a knowledgeable dealer. Worth it if you are deciding when to finish turn a prized blank!
- Never really urgent...this goes on for months. Maybe borrow one if you're only doing a few.

Like politics…Humidity is local

Panamint Valley, Death Valley NP

Blackwater Cypress Swamp, Eastern North Carolina

Relative Humidity: Key Measure

- Air holds moisture as vapor
- Hot air can hold more moisture than cold air
- For every temperature, there is a known, maximum moisture content before vapor precipitates as water
- Relative humidity is the ratio of:

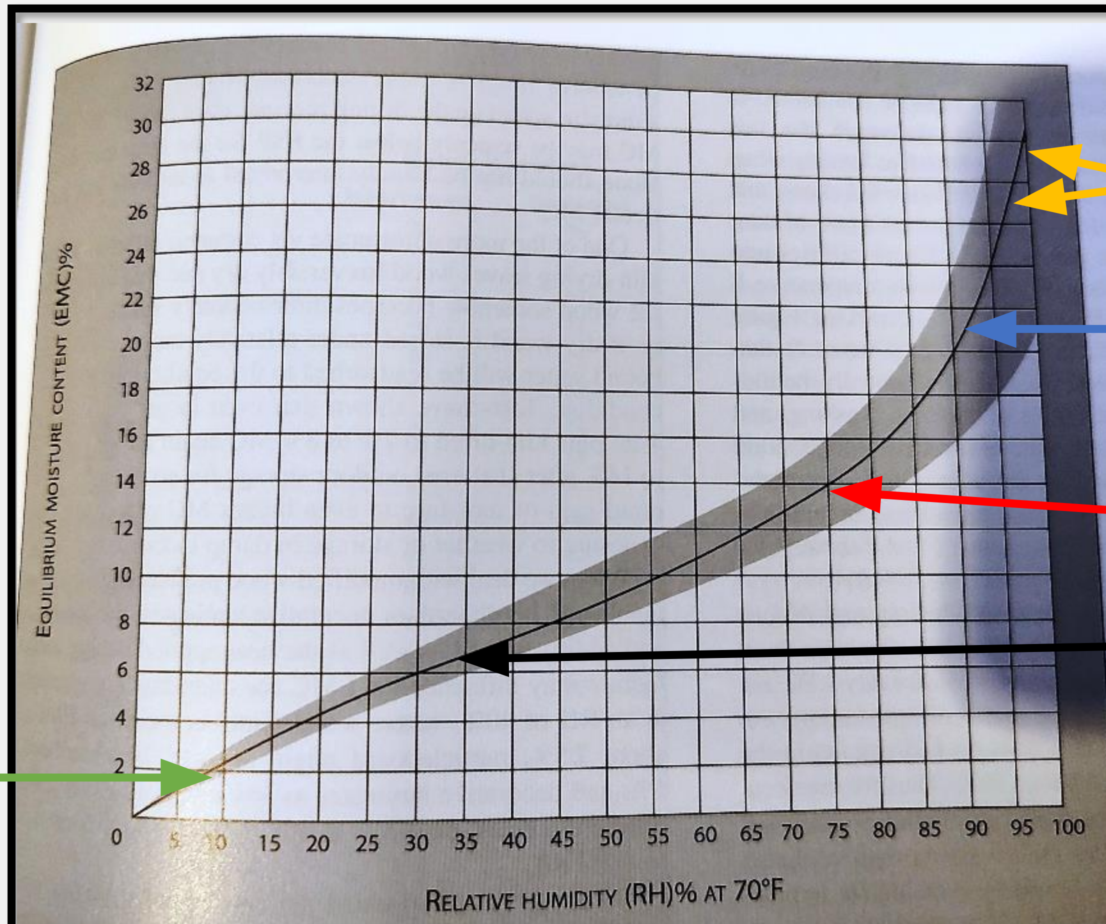
$$\frac{\text{Actual Moisture Content of Air}}{\text{Maximum Possible Moisture Content at that Temp}}$$

* When moisture in the air exceeds the capacity to hold it in vapor form, it precipitates as rain or dew. At night, when temperatures fall, the point at which the air can no longer hold vapor is called the Dew Point.

Air changes faster than wood

- Moisture content of air fluctuates day to day
- That's "weather"
- Temperature changes day to day
- Relative humidity changes day to day, too
- Temp and Rel Humidity average out over weeks
- Wood changes lots more slowly
- Faster on the surface than deep in the wood
- We look at averages over time...months, not days, when assessing Equilibrium Moisture Content

EMC vs. Relative Humidity



Fiber saturation Point range

Alligator habitat

Coastal Aptos

San Joaquin Valley in August

Death Valley

Hoadley says this is the most important table in his book

Tubules in dry wood may seem dead ...but they remain dynamic

- The tubules will still change volume with seasonal variations in humidity...meaning the wood can still swell and shrink.

- Aptos—Rel humidity rarely below 70%, higher in foggy/rainy season 80-100%. Not much seasonal change, and that means relatively stable dimensions of woodwork.

- Death Valley—humidity 10-15%...also fairly constant

Not so constant in New England!

- Muggy in summer months, relative humidity often >90%. Wood absorbs moisture and swells.
- Then winter comes. Cold air holds very little moisture compared to temperate or hot air.
- Bring that inside and crank up the central heating... house goes to Death Valley parch (relative humidity 10-15%). Wooden objects shrink.

Wood marks seasonal changes

- In climates with dramatic seasonal changes in humidity, drawers & doors start to bind as wood swells.   In lower humidity, windows, axe handles, and chair stringers loosen as wood shrinks.

- It affects bowls, too...spontaneous cracks may appear *(loud!)* when a bowl seasoned in Santa Cruz moves to Arizona in summer.

- Surface finishes slow down, but do not eliminate, moisture equilibration between the air and the wood. Reduces rapid, destructive changes

   Varnish that bowl for the Phoenix purchaser!

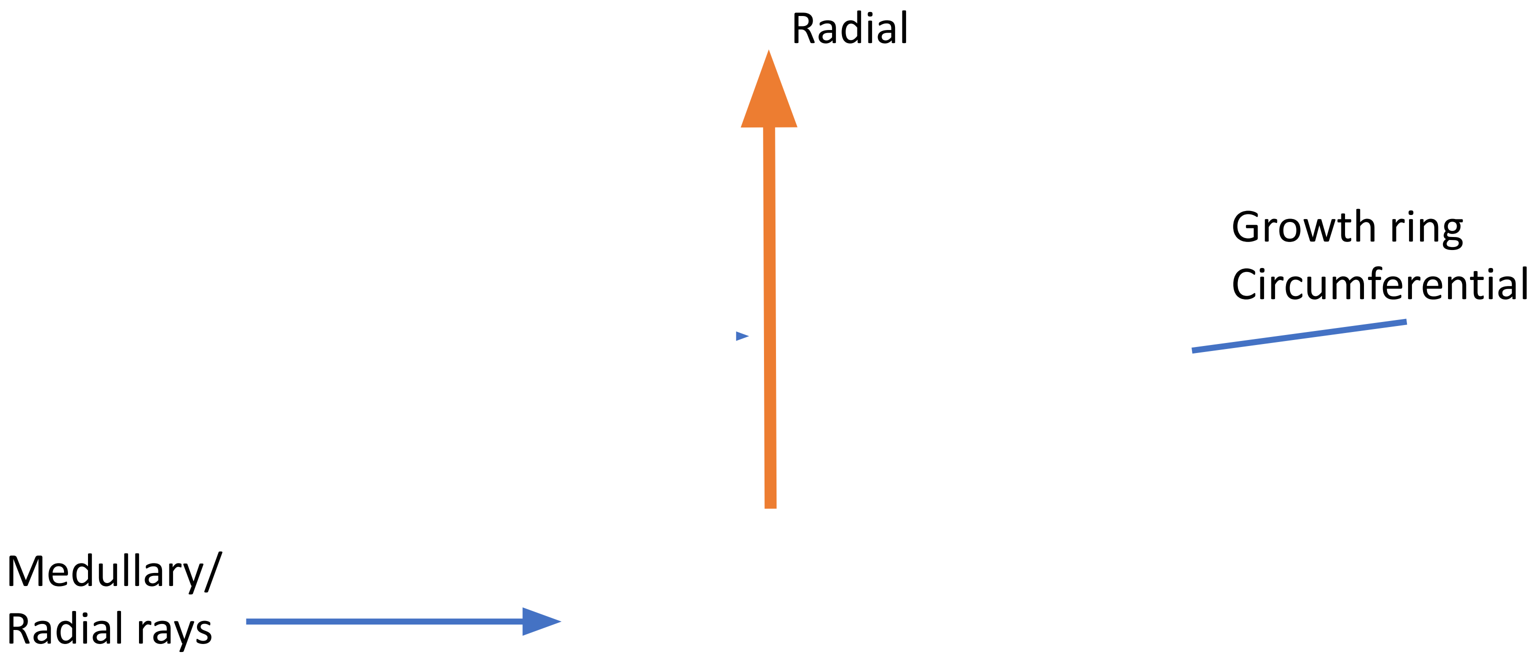
It gets ever more complicated

Wood does not shrink uniformly

Substantially more along the circumferential growth rings (6-10% common)

Much less along the radius (4-5%)

Diagram of an end cut



Why Radial shrinkage << Tangential?

- Hoadley: It's primarily the radial rays.* Those differ by species, but the important fact is that the fibers of the rays run sideways, crossing growth rings, effectively impeding or "splinting" the radial shrinkage.

Imagine looking down into the cut face w a magnifier

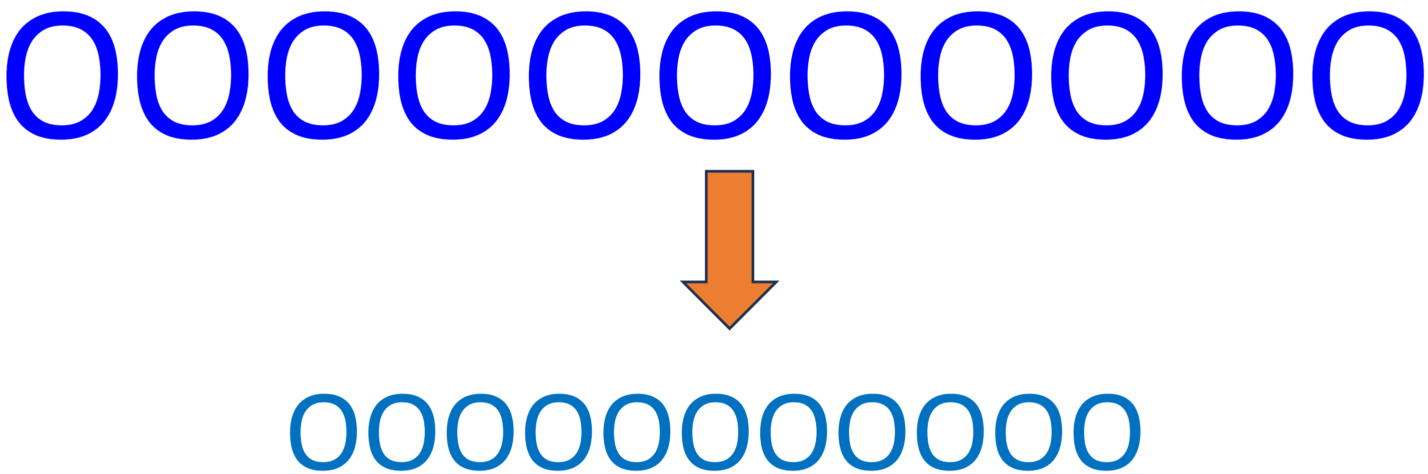
Think...
dividers
In a wine
box

Radial rays

Annual rings

Circumferential—no splinting

- In contrast, the adjacent, vertical fibers in the circumferential rings have little microscopic interference side to side. The rate of shrinkage is typically twice that of the radial.



So...How much shrinkage?

Woods differ. Coefficients of shrinkage available in tables!

- R. Bruce Hoadley, *Understanding Wood, p 117*
- www.wood database.com
- Google search
- Wood Shrinkage Table – WoodBin

Some local examples Sources @ slide #54

Wood	Coefficient Radial shrink %	Coefficient tangential %
Douglas Fir	4.8	7.6
Virgin Redwood	2.6	4.4 Wow!
2nd Growth Redwood	2.2	4.9 Wow, too!
Coast live oak	~6	~11 - 12 (approx)
Madrone	5.6	12.4 (That's 1" in 8"!)
Big Leaf Maple	3.7	7.1
Walnut	5.5	7.8
Ash	4.9	7.8
Monterey Cypress	3.5	6.3
Sycamore (Eastern)	5.0	8.4 prob higher here
Bay Laurel	3.0	9.0
Tan Oak	4.9	11.7

Consequences of differential shrinkage

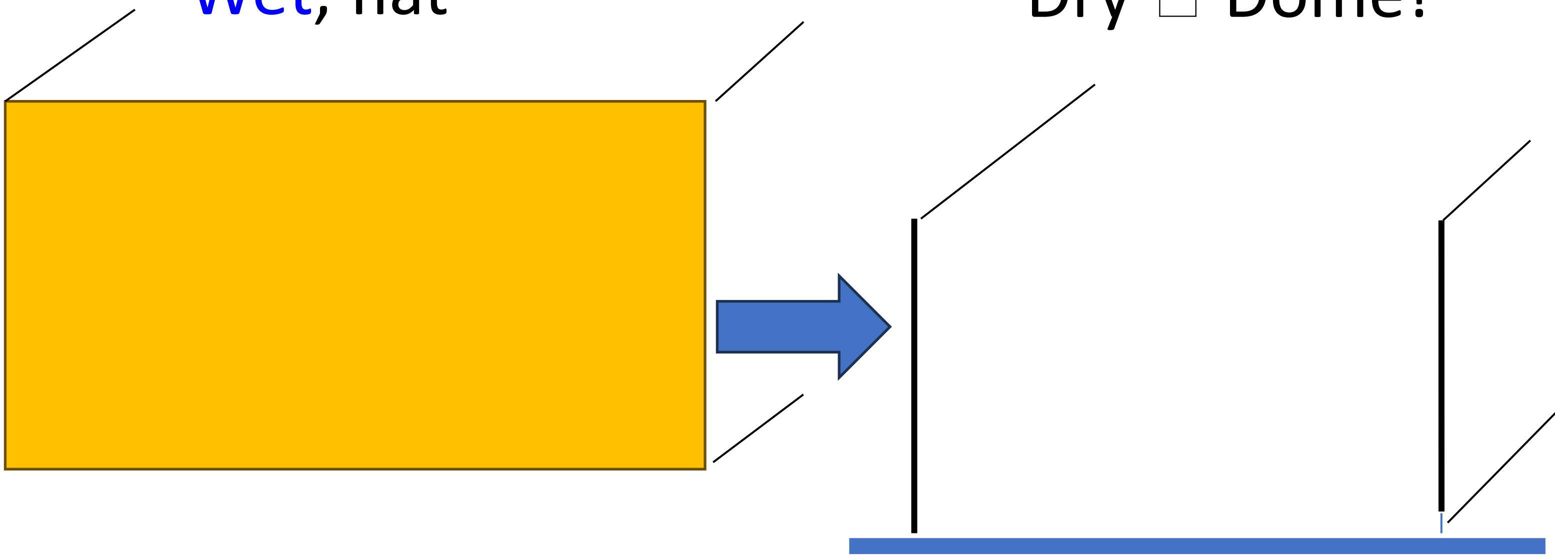
Ring shake
(bad news)

When the circumference shrinks, but the radius shrinks less...
something's gotta give. It's too stiff to stretch...it cracks.

Boards Shrink in cross section, too.
What happens to a wet 2x6 deck plank?

Wet, flat

Dry □ Dome!

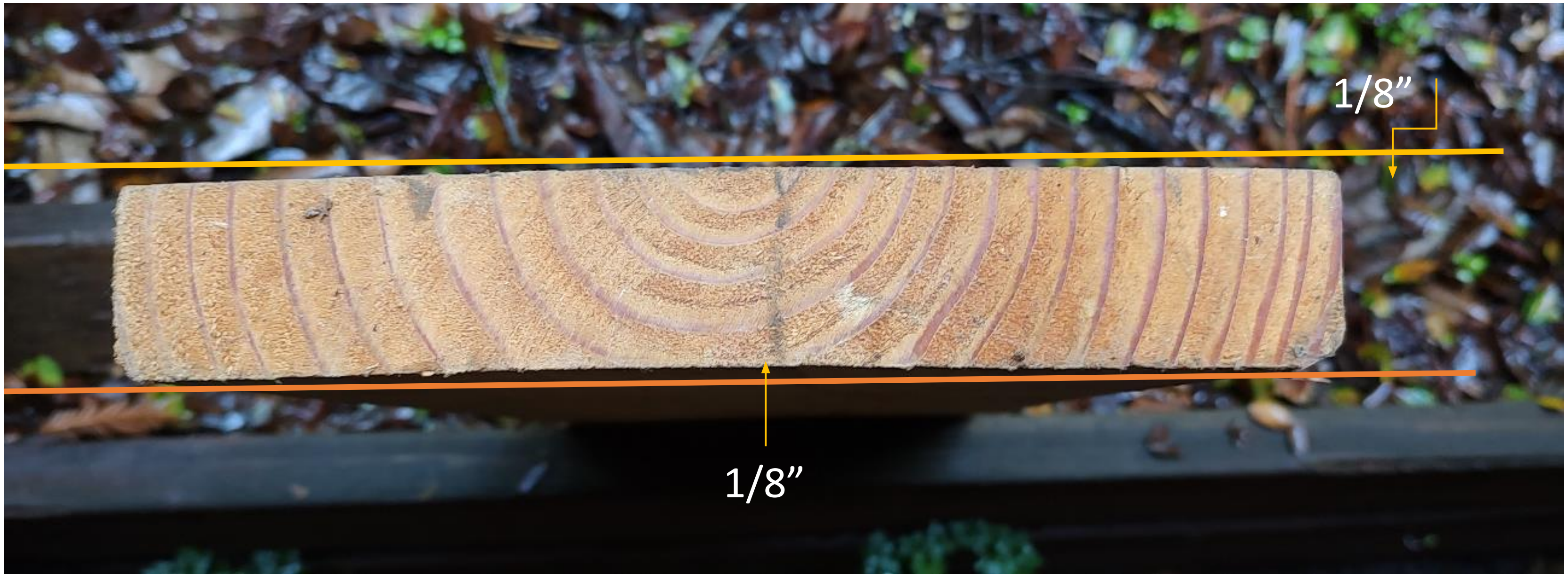


Joist

Pith up—shrinks convex up□
water shedding dome

Pith down—shrinks concave up
□ cups and holds water

Example



Doug fir 2x8, center pith up. Even a rather mild warp has impact on a deck!
Convexity up makes the difference between shedding rain....
or pith down, concavity up making a dangerous, slippery algae pond

Conversely...

- A flat, bone dry 2x6 deck board, installed pith up in summer, will absorb water in the rainy season and warp...to a concave contour on the *upper* side.

 Gulp...that's not what we wanted.

- Moral: Good builders know their materials and know how wood moves with moisture change, and they plan ahead!

It gets still more complicated

- Tubules compress side to side when they collapse, not end to end. Think squeezing a straw with your fingers
- Wood shrinks negligibly along the length!
- Micro at best: 1/16” in an 8 foot length. *Imagine framing a garage if this were not the case!*

- BUT—tension wood, juvenile wood, and figured wood can shrink longitudinally more...and unpredictably. Not that common in construction lumber...and not a huge problem for a bowl with exotic figure where we can finish turn

Scope limitation: ‘Nuf about boards

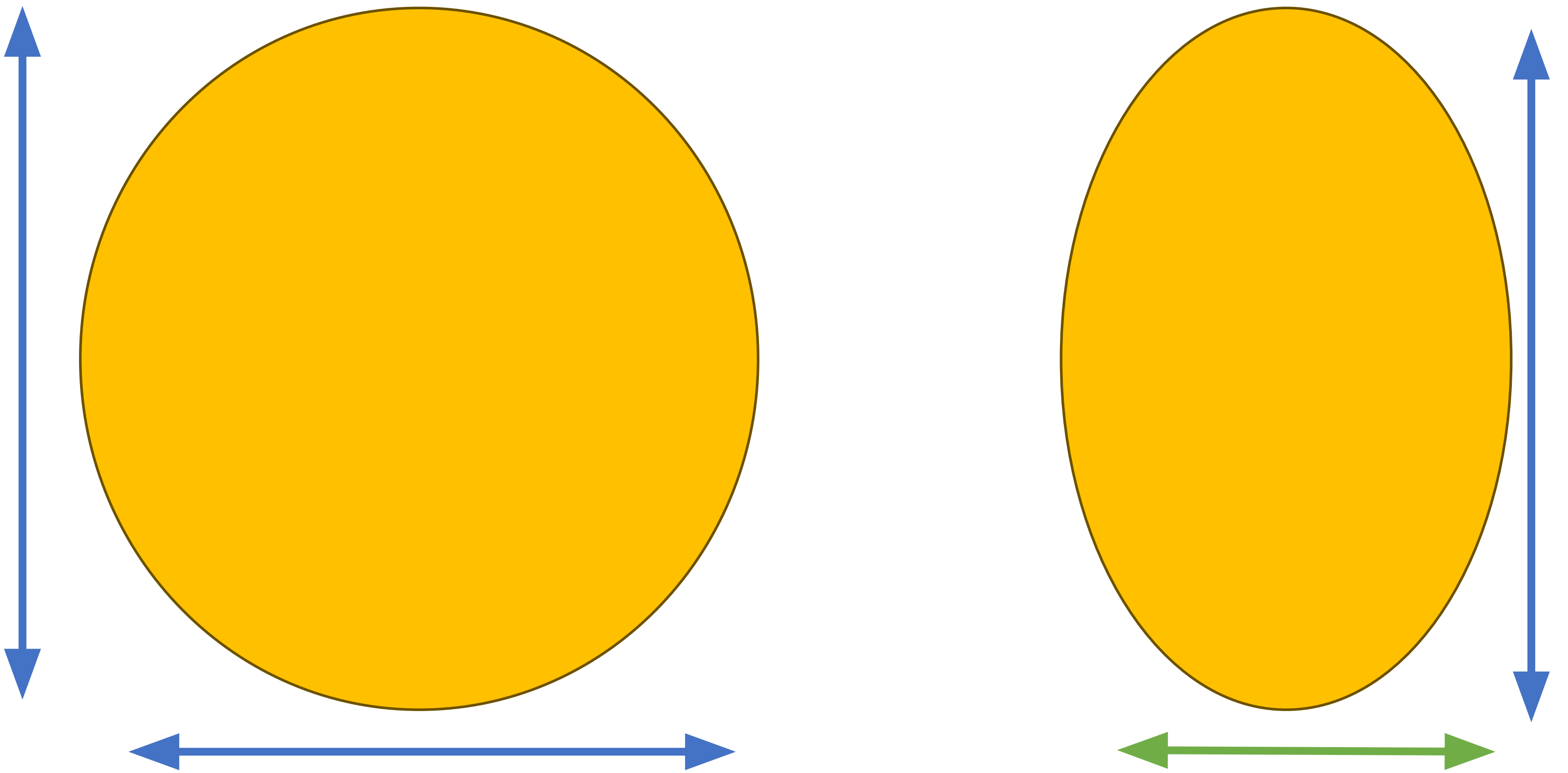
- Lumber shrinkage based on grain orientation—quartersawn, rift, and tangential—varies in important ways for furniture and carpentry.

- Hugely important...but out of scope for this talk.

Back to bowls!

Shrinkage affects round blanks. Circle changes to an ellipse

View of horizontal plane from above



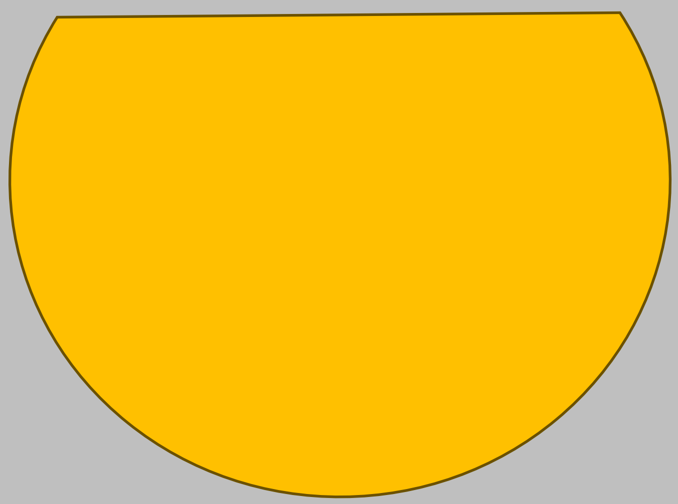
A perfect circular tenon also becomes an ellipse, but maybe not a perfect one. Important for chucking and safety!

- Grain “features” make irregular shrinkage, and some tenons can become wonky 3D peculiarities

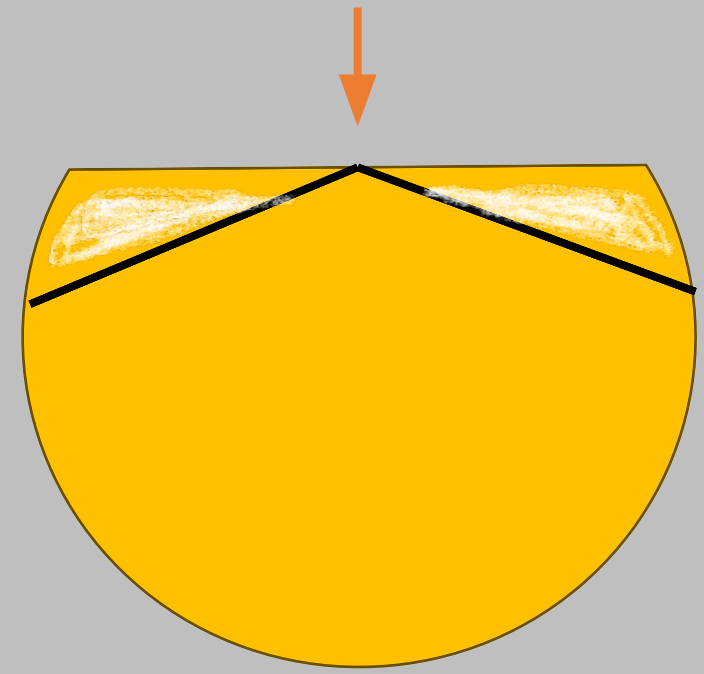
This was rather extreme!

The vertical contour changes, too

End grain view. It develops a “prow.”

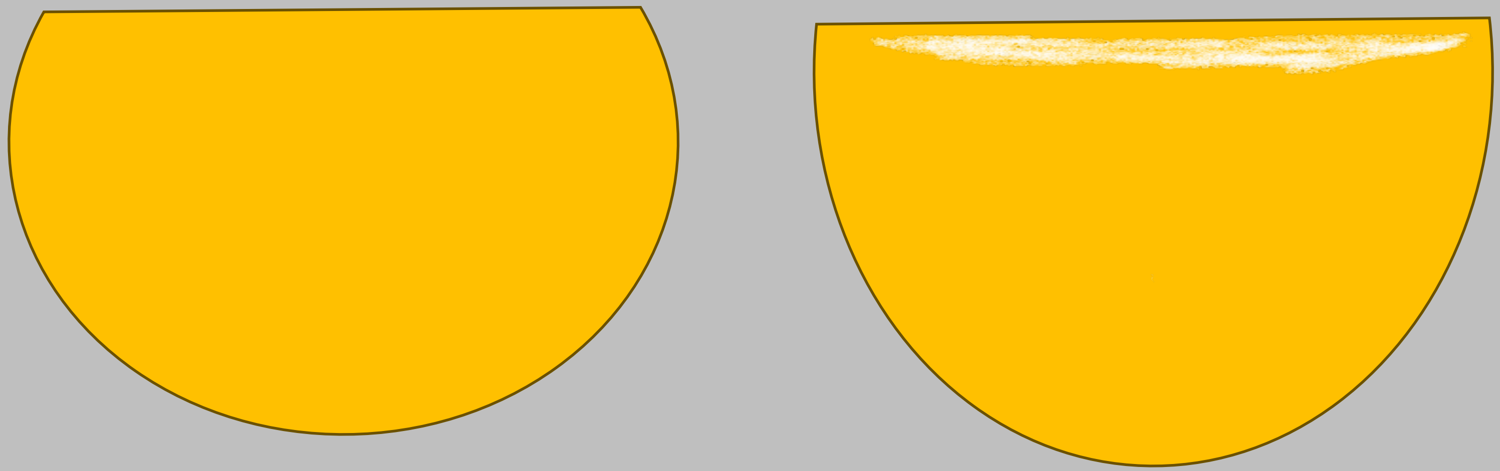


Before equilibration



After shrinkage

Side view: Flat top □ Dory shape



Here's a Madrone Dory Bowl Sanded and finished as-is after drying, not "trued"

End grain view (L) and side view (R) after shrinkage. This warped rather modestly for madrone

When roughed out, this opening was a clean, circular plane

Sycamore from the MH Tree

Turners have a choice…as usual.

1. We can true up the warped blank—make the ellipses back into circles, pare off the protrusions on the rim until it’s back to a flat plane.

2. That means the turner will lose some diameter as well as depth, and that’s what we usually do.

3. Or, just to be difficult, we can leave the warped “deformity” on purpose.

   John’s Demo coming

More challenges from bowl shrinkage

Dan Aldridge's Frankenbowl

Irregular grain shrinks...in irregular ways

- We turners love tangled grain and gaudy figure!
- That's going to move in unpredictable ways...which is OK if we're going to wait until it equilibrates, and then turn it round again with sharp steel

Lamination problems w moisture

- Laminated blanks can be pretty, but adjacent strips of wood w different shrinkage rates...or quartersawn vs tangential orientation...can make raised edges & glue lines, checks, warp, or even pop glue joints with seasonal moisture change.

- Make sure all laminations have fully equilibrated wood before glue-up, & don’t take Aptos wood to Provo and expect joy

Where only the Brave Dare Go

Dazzling, segmented bowl by Larry Dubia, Tank Driver,
Explorer on Large Motorcycles, Fearless Turner

Crooked Feet...not just for the elders!

- Once-turned and natural edge bowls are often turned damp
- A circular foot with a central concavity can warp and become wobbly.
- Solutions—make it deep so you can sand it to plane
- ...or make a tripod foot with a carving knife, Dremel, file, or abrasive

Some woods lose moisture very slowly. Patience...

- **Most dense woods equilibrate...“dry”...slowly**
- **Hastening to turn before equilibration...dry outsides, moist insides...trouble**
- Solution: Keep a stash of drying blanks so you can turn all day and never have to experience boredom

A Pitch…and a Moral

The Pitch:

Some conifers have sap seams that take many years to crystallize, even after the moisture content has totally equilibrated to 10-12% (Spruce, Pine, Doug fir, Redwood). It makes sticky seeps.

The Moral:

You are not obliged to turn every chunk of wood.

So this is where the Renaissance has led you...

Phil Ochs, 1969

- The impetus for this talk was to air the choices for early processing of wet or damp blanks to conserve the highest percentage of good bowl blanks. It has been a constant topic in our communications.

- Law of Eovaldi: There are 3 solutions to every challenge in turning. Sometimes more.

- People have differing opinions, as is our nature

Choice #1: Expeditious rough out

1. Hasten to rough out blanks to uniform wall thickness, about 10% of overall diameter

2. Seal and let slowly dry in a cool, dark place...with fairly constant temperature & humidity

3. Fine if you have the time, energy, & room. Not every turner does

4. Then finish turn when they reach equilibrium in 1-3 years. They're all different

Choice #2: The Water Chamber

- Stash the slabbed blanks in a sealed container above a layer of water in the bottom, essentially eliminating the slow intracellular water loss.

- This buys time when it’s hot or the turner is overwhelmed.

- Rough them out when it’s more convenient, then dry and finish similar to #1

- Raf and Dan are going to describe

Choice #3: Damp Shavings Under Wraps

- Stash a freshly roughed out blank in the damp shavings in a paper bag, cardboard box, or newspapers to slow down the rate of moisture migration

- Then seal and store until ready to finish

- Buys a little time, but iffy strategy in summer heat

Choice #4: Single Turn

- Finish turn right away and let them warp into exotic flower petals on purpose.

- Special challenges for John to describe!

Others...possibly less appealing

1. Kiln dry. Easily said...
2. Soak it in chemicals which replace the water. (Not too Santa Cruzy, and not for my salad)
3. Thermals: Boil it. Microwave it. Freeze it.
4. Claim that splits are novel “features” and patch them artfully

Even wall thickness: *This is on us!*

- Thin wood will lose moisture faster than thick wood, sometimes meaningful in a matter of days.
- If a blank has a thin upper lip and a thick bottom, the top will shrink faster than the bottom, and splits will be the rule, not the exception.
- Doesn't help much to modify the turning after the splitting has started.

Avoid Center Pith

- Radial cracks are common, almost inevitable
- Not always a bad thing, but...rarely on purpose
- Some species are merciless, others forgiving
- Less troublesome when there’s spalting
- Can’t avoid it with knots. Do the best you can.

Sealing: Helpful but not Miraculous

- Moderates difference between moisture loss from end grain (fast) vs side grain (slow). Reduces splits in damp blanks but won't compensate for widely uneven wall thickness or late application.

- Three popular choices:

1. PVA (white glue material), e.g. TreeSaver
2. Wax e.g. AnchorSeal
3. Latex Paint, good outlet for leftover partial cans
    - Oil based products don't work well w damp wood

We’re going to hear some experienced, alternate viewpoints. A veritable treasurers’ experience!

1. **Raf Strudley,** past treasurer, author of our 501.c.3, pro turner, and career educator.
2. **Dan Aldridge,** past treasurer, water engineer, prolific and generous blank whacker in a warm climate zone, laser innovator.
3. **John Wells**, past treasurer, past president, pro turner, perpetual teacher, cagey demonstrator, and sage counselor.

Lathers

Raf

Dan

John

Raf, the Man who Can

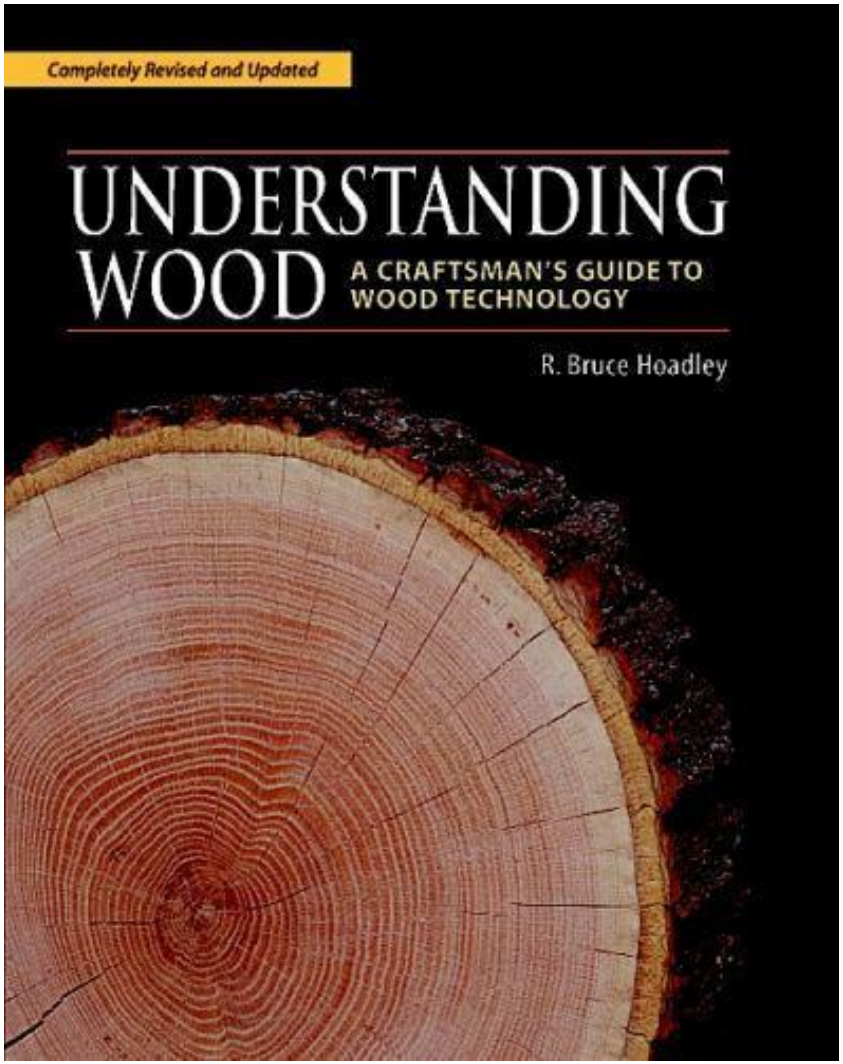
Raf: Bricklayer

Raf: Blankmaster

Wrap up

- A one-hour talk scratches the surface.
- Hopefully, it will spare you some avoidable errors and improve your yield of lovely works.
- Our club has experienced folks who will be happy to coach you if you have questions.
- They won’t always agree. It’s Santa Cruz, after all.
- Buy the book and read it.
- Repeat.

Gold mine reading for woodworkers



About $40 online

- Less than your dues
- One quart of finish
- 8 packets of sanding discs
- ¼ tank of gas for F150
- 1/3 of a gouge
- 1 plastic garbage can
- Fraction of a lathe

- Sweet deal!
- Chapter 6 is a must read

Mommy, what’s a hamburger?

Q & A


STIHL