UFO's: Unintended Flying Objects in the Shop

A look at speed, tenons, and materials for safety...and pleasure

Wells Shoemaker, December, 2020

The Craft Supply instructors smirk a little bit and repeat the turner's wisdom: "Speed is your friend*...except when it isn't."*

The Craft formula for RPM vs bowl dimension works reliably, but it has an asterisk.

Bowl diameter in inches X RPM = 6000 to 9000 *

For a 10" bowl, that works out to RPM in the range of 600 to 900. For a 4 inch bowl, that would be RPM 1500 to 2000. Doing a little arithmetic, a dot on the perimeter of a 10-12" bowl at 600 RPM is booking about 1800 feet (1/3 mile) a minute, or 20 miles per hour. At 900 RPM, that would be closer to 30 mph.

That RPM formula works for sound, round, balanced blanks...not ones like the juniper sculpture below.   Generally speaking, the more unbalanced the blank, the more defects and irregularities, the slower a smart turner goes until it's round and humming. For blanks with suspicious integrity—cracks, spalting, bark intrusions, loose knots—*speed is not your friend.* Little dislodged pieces become projectiles with nasty edges. The stresses on that tenon go up exponentially with velocity, and if it shears off, you might witness the launch of a UFO (Unintended Flying Object) right in your own shop.

WS: Desert hardened Juniper knuckle winged bowl, 2020.

The tenon [1] you cut also makes a difference with suspect wood.   If you have a shallow tenon which is gripping punky wood, soft cambium, or (*aargh!*) bark...it's vulnerable to failure, and speed increases the liability. Wood which separates easily between growth rings, such as peripheral rings in Doug fir, really begs you to make a deep tenon. For unstable, irregular, or suspect blanks, use as big a diameter tenon as you feasibly can, gripped properly with the full circle of your chuck, with a perfectly cut dovetail, and make it as deep as your chuck can accommodate (7/16” - 1/2"). *If you don't have a big enough diameter chuck, put that blank aside until you do.* There are also chucks that will grip a 1" or even deeper tenon (Oneway and Vicmarc)...and that's for your “201” course. If you're not sure, check with an old hand turner before courting a contusion.   The wood will wait patiently for you.

Going too fast with your RPM’s is a problem, but going too slowly also has its drawbacks in several situations:

1. If a blank has deep voids and irregularities, and your lathe is running really slowly, your gouge will have time to plunge into that hole, and then the trailing edge of the hole will grab it. This is not conducive to temperate language. Better to avoid the plunge by skipping along at a little faster RPM and trim the blank down in judiciously small increments with a freshly sharpened tool.

2. If the wood has a native tendency to chatter, as you'll find with Doug fir, oak, and other woods with a big contrast in density between summer wood and winter wood, same issue. You'll dig into the soft stuff and then hit the hard rings, and it "chatters." The soft summer wood is also more likely to tear out. Go at faster RPM’s, take smaller incremental cuts, and you minimize that aggravation, which, by the way, can’t be sanded out. Sharpen up as soon as the chatter comes back.

3. If you are using lots of arm strength to force the gouge into the wood, that's a bad idea in any case and definitely a bad idea with a raggedy blank. Muscling a tool will betray you with a scraper, too. Your pressure makes all mistakes more likely and more dramatic. Better brains than brawn.   If you feel like you need to apply lots of force to cut, you’re probably driving a dull tool or presenting it improperly, or both.

4. If you want to finish in a hurry, especially during rough out stages, you can either take bigger, wider cuts...or turn the blank faster. You'll instinctively know when you're digging too deep, or the lathe will remind you. Slightly higher RPM's with more modest cuts get the job done more pleasurably...curlicue shavings wafting peacefully in the air instead of all that sweaty adrenaline and abrupt imprecations.

All of that said, I very rarely use the high velocity register on bowls...on spindles, yes. For just about all of my practical sized bowls, the max RPM in the low register (1200 +/-) is plenty.

More speed and tenon safety pointers—next page!

[1] See Appendix on pp 13-14 for illustrations

Vibration: A heavy lathe, just about every modern lathe 16” or larger, will absorb a lot of vibration, but it's not unlimited. You can mount a blank, start it out slowly and crank up the RPM's gradually until the lathe starts to dance, then back off. When the irregularities have been trimmed, you can try the same thing again and probably find it tolerates more speed. Meanwhile, if your blank is jumping in front of you, the chance of a catch that breaks the tenon is too high to tolerate. Slow down a bit. Also consider:

- Feet? If your lathe wants to samba at modest RPM’s, it’s possible the leveling leg bolts have vibrated out of position. The lathe needs to be rock solid at rest to have any chance of handling a big load at speed. It’s worth checking this occasionally.

- Ballast? It's possible to use the brackets molded into the legs of many modern lathes to install a couple 2x4's and a plywood sheet to make a shelf to hold bags of sand or other ballast to better dampen vibration. It’s a personal opinion, but I've never needed that with a lathe with cast iron legs...and it makes clean up a nuisance.

On and Off Uh-Oh’s: When a craftsperson turns off the lathe to check progress and maybe use the calipers...something we do frequently...most leave the RPM setting unchanged. However, if you are shutting down for the day or changing a blank, there's a real danger if you turn on the lathe when it's set at a higher RPM than you intended. Also, it’s not rare to have inadvertently bumped the speed control with your movements. Flying saucer comes to mind. Get into the habit of dialing the variable speed back down to low or even stop, and bring it back up with the new work.

Standing in harm's way: When you start up the lathe with a new blank, stand to the side! That seems like a "Duh," but egad, that's a common cause of injuries. Objects that fly off the chuck typically follow rules of physics and take off tangent to the arc, in the plane perpendicular to the axis of the drive shaft. Think David and Goliath. But that's not guaranteed. A wayward blank can ricochet off the tool rest...or a wall...or a rafter...and go looking for your head. It can throw a curve ball, too, if the tenon peels off irregularly. Those uninvited dismounts have happened to everybody, and will again.

Face Shields have limitations: A face shield is engineered to protect your eyes from dust, shavings, and flying bits of grit...lightweight stuff. It is an essential, sensible precaution, but that device is absolutely ***not a hard hat***. You'll read dubious testimonials about how *"the face shield saved my life"* from an abruptly dismounted blank. That's fake news and dangerous counsel. A piece of wood that weighs 5, maybe 10 pounds, moving at 30 mph is going to leave a serious mark on anything it hits, and a little piece of pliable plastic isn't going to help you much.

Think of it this way: you're standing by the side of the road on a beautiful spring day, maybe admiring the wildflowers or fiddling with your derailleur or checking the Giants score, when, *POW!* A piece of firewood flies out of a pickup bed at 30 MPH velocity...and conks you on the head.

You'll be lucky if all you get is a bruise. It's smarter to stand out of the line of fire.

Materials Flaws and "Features" that Spell Danger for Turners

Confession: When I was an undergraduate engineering student, I majored in Materials Science...metallurgy with crystals and plastics and clever electrons thrown in. Turns out "materials" have really different properties, and they respond to stress in extremely variable ways. This is definitely true for the pieces of different kinds of trees we use to make bowls and bats, rattles and rings, pens and platters. It's a practical science.

R. Bruce Hoadley's remarkable book, *Understanding Wood,* needs to be on your list. Honestly, any serious woodworker needs to commit a month to reading this book, and accept that you'll want to read it again to pick up the points you missed. Some highlights relevant to suspect wood as seen by my learner-turner eyes:

Shrinkage Causes Checks and Cracks. A tree is essentially a bundle of vertically aligned, microscopic tubules—imagine a hand full of straws. The straws in a fresh log are surrounded by water in a living tree, and they also hold water internally. When water leaves a freshly cut wet log, the early evaporation involves water *between* the tubules of wood...it just drips out. This is called "free water," or *inter*cellular fluid.[2] The log loses weight as the free water leaves, but since the tubules are still plump with trapped water, the log doesn't change shape initially. Subsequently, when the free water is gone, the drying process starts pulling moisture out of the tubules. That's called *intra*cellular water. Those tubules gradually collapse, and then the log begins to shrink. Water leaves the tubules faster through the microscopic openings at either end of the straws, and much more slowly through the walls.

Consequences that matter to turners:

1. The log shrinks along the radius of a cross cut, but it shrinks even more along the concentric circular growth rings. It shrinks only a miniscule amount, not even measurable with our tools, along the long axis of the tree.

2. This differential shrinkage means that, with extremely rare exception, as those growth rings shorten, something has to give, and cracks unavoidably appear. [3] They start at the center pith and run directly outwardly towards the periphery—radial cracks. (see photos next page)

3. The wood at the cut ends of a log dries faster than the wood in the middle of the log, simply because there is less distance for the moisture to move, and that's why "checks" or cracks appear there first. That's why we apply sealants to end grain to slow down the moisture loss so that the whole log dries more evenly. That really helps with some species, but for others, especially notoriously shrinking wood species[4] , it's just nearly impossible to keep an intact log from checking.

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[2] This is the water that flies out of a fresh wet blank on the lathe—sometimes a drenching amount!

[3] Heat and chemical treatments are beyond the scope of this paper. We're only looking at environmental drying.

[4] Locally, those dynamic shrinkers include madrone, sycamore, and coast live oak (coefficients of shrinkage 11-12%). By contrast, old growth redwood is remarkably stable (coefficient 4%) and relatively easy to handle without destructive splits. Maple, walnut, cherry, bay laurel, fruit woods, and most conifers tend to be in the middle. Hoadley's book has a compendious table in his fabulous chapter on moisture and wood.

4. Any piece of wood that's thinner in one region than another will dry unevenly, meaning the fast drying, thin sections are likely to crack. That goes for a bowl, too.

Above: Extreme radial crack in Coast Live Oak, a dynamic shrinker species, with a "bonus" ring shake near the center. I keep this in my shop to remember.

Below: Detail—radial cracks originating at center pith in drying walnut (it got worse later). Walnut center pith is worthless for turning—soft, erratic, splitty—good only for firewood.

Mitigating Splits for Turners

To mitigate splitting so we have sound blanks to turn, we try to cut our rounds early, as soon after the tree goes down as possible. We intentionally delete the center pith (see the walnut photo previous page), and ideally rough turn early to a uniform wall thickness to minimize splitting. Warping will occur, predictably, often converting a rough turned circle into an ellipse, but that's manageable if we make the wall thickness roughly 10% of the overall blank diameter—standard green wood handling. (Another article perhaps)

If, however, you get a log that has been drying out in the open for months, especially in the heat, you are going to have splits. You'll likely sacrifice the 3-6" at either end of a log, and hope the central portion still is intact. With the big shrinkers (see footnote #4), you're probably looking at BTU's for the wood burning stove.

If you mount a cracked piece of wood on the lathe, and start cutting away some of the wood which may have buttressed the crack and held the blank in one piece, it can sing like Patsy Cline and "fall to pieces." [5] You don't want to be in the way of that!

There's an especially dangerous kind of crack for turners—known as **ring shake or ring check.** In this situation, a split runs circumferentially along a growth line. We see this typically for a tree which crashed down hard, as well as trees with a big contrast between soft summer growth and hard winter growth (Doug fir), or irregular growth. *This one can hurt you.* Think "shrapnel." Its destiny lies in the fireplace, not the shop.

(left) Ring Shake in a conifer with irregular growth and unbalanced stress, and (right) madrone (Thank you, Dan Aldridge, for the artistic embellishment)

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[5] Some local species of wood split very easily. We know these as great kindling—like Doug fir, pine, soft maple, redwood, cypress, and madrone. They typically are straight grained with relatively weak bonding between the tubules side by side. Other species have interlocked grain which makes them substantially harder to split with a maul or a wedge, e.g. eucalyptus, sycamore, oak, and willow. The former species are ones I wouldn't want to mount on a lathe with visible, large cracks. You can get away with that for some of the latter, with precautions described in the text. Wood with "figure" such as crotch grain, quilting, tight knots, or swirls won't split as easily as straight grain wood, either on the kindling block or the lathe. Burl is a special case—it doesn't crack much, but it has other challenges...see text p 10.

What Can You Do with Cracks in a Blank You Want to Keep?

Try to keep it together, of course.

1. Standard wood glue won't reliably hold a visible split. If you can stick a playing card into the crack, the wood surfaces are too far apart for glue to secure it reliably. That's especially true if the blank is still moist (moisture content 16-24%), meaning it's going to keep shrinking.

2. Hairline cracks can be secured with low viscosity CA glue if the wood is reasonably dry. CA glue tends to be brittle, and it has unreliable strength for larger gaps. PVA glue is too viscous to penetrate well.

3. Epoxy glue in the crack, without a mechanical member to secure it, can simply pull off the adjacent wood and crack anyway. It's more likely to last with wood down at turning moisture content—10-14%. Instead of "5 minute epoxy," which may be too viscous and too fast setting to get in deep, use a slower setting structural epoxy and let gravity coax it to seep in. Ask an experienced club member who knows this stuff.

4. Large splits can be secured with "butterfly" or "bow tie" inserts running perpendicularly to the split. These clever "fixes" are the artistic marks of a skilled craftsman who recognized compensatory virtues in a piece of wood he or she was unwilling to toss into the fireplace. The remaining crack can be filled with decorative inlay, pewter, or resin...or can be carved into something novel.

John Wells, Walnut with bow tie and pewter, 2020

5. Mounting a blank with splits means armor up—padded garments and tough gloves ...and consider a real hard hat in addition to your face shield (a chainsawyer's helmet with a face screen does both).

6. Lots of turners approaching suspect blanks will use stretchy clear plastic on rollers—the stuff used commercially to secure pallets of boxed goods. Wrap it on with multiple layers after shaping the outside of a bowl to keep the fragments from flying if they do split off. That precaution allows you to hollow out the middle and then check for integrity without having to duck. Blue painters' tape isn't strong enough. Duct tape or Gorilla tape is strong enough but can leave sticky residues.

What about Knots and Safety?

Knots, of course, are essential for trees—it's where branches originate and venture out into the canopy. A tight knot can be structurally sound, and the figured wood adjacent to the knot can add beautiful intrigue, as you can see below.

Linda Anderson, knotty tanbark oak bowl, 2020

WS, knotty Monterey Cypress, 2020

A loose knot, by contrast, can dislodge and go flying, sometimes with nasty shards. Turners have a choice of stabilizing the knot with epoxy...or knocking it out and discarding it, leaving the gap as a "feature." Alternatively, they can fill the void with some decorative inlay or clever insert.

Setting it spinning at 800 RPM and hoping for good luck, however, is not a good option.

Burls Just Want to Have Fun

Burls deserve all the adulation they routinely receive. They're really works of natural artistry as well as fortitude...the sign of a tree absolutely committed to heal assaults by men, bugs, fire, fungi...and amputations. They soldier onwards towards the sun.

Burls rarely make long cracks vulnerable to fragmentation, since the "grain" is really a tangle of fibers that look like a dishwashing "scrubby" pad under a microscope. These structures grow around themselves and hold together...most of the time. However, burls often hide crumbly spots and voids, and they can let fly little chunks the size of lima beans. This is one place where the imperative for a face shield is not something to be challenged even by the most authority-defiant turner in the class.

A burl which has laid on the ground a long time...something we do encounter in the Santa Cruz Mountains...can be structurally weak. Get some advice from one of our seasoned pro's before spinning that puppy. Advanced techniques like pressurized resin infusion can save these for posterity...but don't try this at home unless you've done it before.

Raf Strudley, 2019, Manzanita root burl. Note structural steel for security

WS, Redwood burl, 2015 *Morgan Taylor 2020*

Above: Roy Holmberg, redwood burl and blacksmith art
Below: John Wells, maple burl platter

Spalted Wood

Seri Robinson, Professor of Wood Science at Oregon State University, is the worldwide authority on spalting...as well as a marvelous speaker and author of the definitive text. [6] She defines spalting as a combination of structural and pigmentary changes in wood brought about the action of living fungi. The patterns, especially those intriguing, circuitous black lines, have generated plenty of admiration (and commission dollars).

However, remember that fungal action on fallen wood—after all, cellulose is a source of nutrition for them—is a step towards decay, a process that continues inexorably towards the eventual degradation of wood into the soft humus which will nurture new baby trees. Wood loses strength and density as the fibrous structure is degraded. Spalted sections of wood tear out easily with turning and commonly need to be solidified (usually with CA glue or other, nastier chemicals) before they are finished.

More to the point for this paper, the natural bonds between sequential growth rings as well as adjacent longitudinal fibers are breaking down with spalting. That's why you can break a rotting 3" branch of Coast Live Oak over your knee. Unfortunately, if you are putting soft wood in a chuck, or expecting a 2-3" tenon to hold a 10 pound blank, you can pay for the delusion if that blank tears off its moorings and takes flight.

Larger diameter, deeper tenons work better than little ones, even if you desperately hate wasting gorgeous wood. If you are using a mortise instead of a tenon, be wary. Make them fairly large diameter, deeper than you would with sound wood, with a generous ring of wood around the opening. Otherwise they can blow out. Faceplates work nicely, but don't skimp on the number of screws, because some of them may be sunk into punky wood.

Dwain Christensen, Spalted, Quilted Maple bowl with Purple Heart Rim, 2020

[6] Sara G. Robinson, *Spalted Wood: The History, Science, and Art of a Unique Material,* 2016

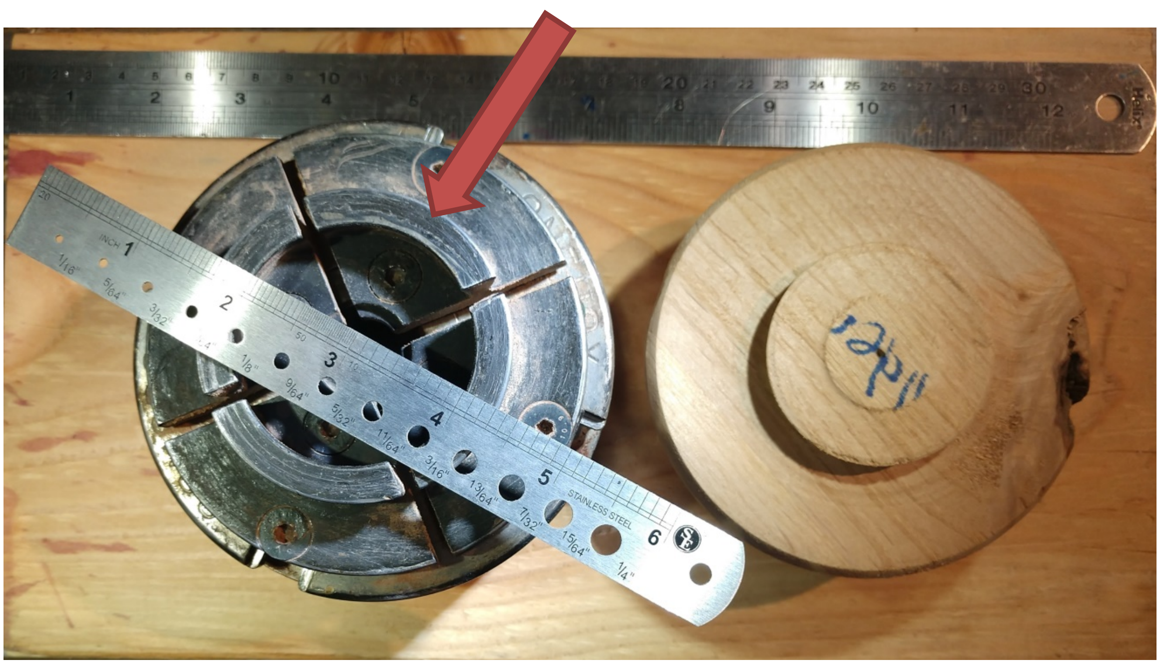
Appendix: Optimal spacing of chuck jaws for tenons and mortises

Chuck jaws with 77° dovetail angles are clearly the most popular, efficient, and safe design, since the dovetail itself holds the blank mechanically, as well as by compression grip. In addition, the flat, forward facing surface of the jaw (red arrow below) binds against the blank for additional grip as well as assurance of true running with re-chucking.

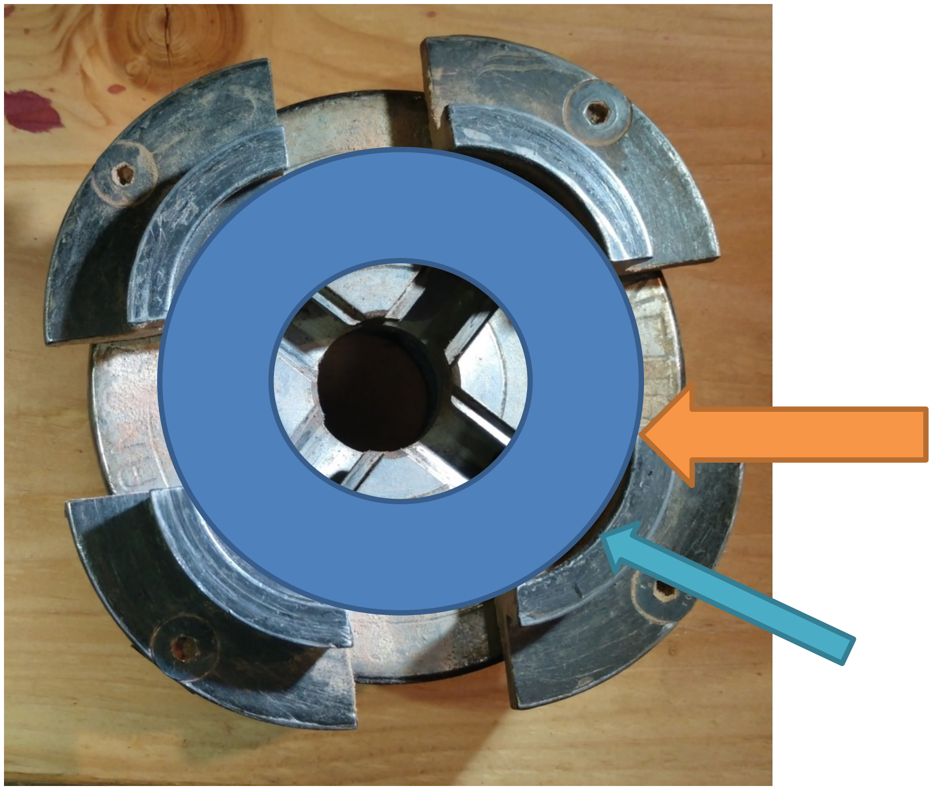
Jaws with a cylindrical grip, often with serrated gripping contours, are less effective, loosen more easily when the gripped wood deforms, and when that happens...more likely to lose control. It's a personal choice, but most of my cylindrical grip jaws now reside in a drawer I rarely open.

All manufacturers produce a graduated range of jaw sizes, for little objects all the way up to 22" platters and big gnarly baulks of irregular wood. In the photos below, we're looking at Oneway #2 "smooth" dovetail jaws. The others follow essentially the same rationale, just larger diameter.

Each jaw set can open for a wide range—in the case of this one, 2" up to 3 1/4". However convenient that may be at times, the jaws work best when collapsed to just 1/8" above to the minimum diameter—which also corresponds to a complete circle. For challenging blanks as discussed in this paper, turners are virtually always going to choose the most secure configuration for both tenons (gripped by compression) and mortises (gripped by expansion).



Chuck jaws set at optimal diameter to grip tenon (right). When tightened, the jaws grip the tenon in nearly a complete circle, maximizing the contact of steel and wood and also making the dovetail security a full circumference virtue. The flat steel rim (red arrow) also binds against the blank to keep it true with re-chucking.



Chuck Jaws open to maximum. In this case, because the arc of the tenon is larger than the arc machined into the jaw, each of the 4 jaws bites into the wood just on the points (orange arrow), leaving a gap (light blue arrow). This grip is not remotely as strong as the one on the previous page. Widely opened jaws will hold decently in a pinch, and it comes in handy at times, but it's definitely not ideal for suspect blanks where security is imperative.

Chuck jaws set for mortise. When the jaws expand, you get nearly a full circumferential contact of steel to wood, with the additional security of a dovetail grip. Not as strong as a tenon.

That's not the whole story, but a good start for now. It's worth working with wood with features...which some "linear" people call flaws. Imperfect wood, like imperfect people, can be a lot more interesting than righteous straight arrows with rigid attitudes and smug demeanor. Both can test your patience but also prod your ingenuity, and, with care, lead to exceptional beauty and enlightenment. On the other hand, both can be dangerous if treated with unsound assumptions. Avoid that last bit and stay safe in your shop.

Have a blank with question marks? Take it to an experienced hand for advice! It will be time well spent, and learning assured! Pay it forward, because we all want to learn.

Enjoy your shop in the rainy months to come,

Wells Shoemaker MD
President, Santa Cruz Woodturners, Closing days of 2020

Myoporum bowl with a feature and a visitor. Thank you, Larry, for the challenging blank! 2017