

A Friction Fire Inquiry: Hand Drill

by storm

I can think of no other stone age skill that satisfies and intrigues me as much as the hand drill method of friction fire. Since learning about it two years ago, I have been consumed by its delicate intricacies, temperamental nature, and its sheer power to transform physical prowess into self-reliance. What an absolute miracle it is to start with twigs and branches (or roots or shelf fungi!), add refined kinesthetic form and determination, and be able to coax not only the essence of combustion out of a seemingly inert material but finally one of the most important catalytic tools humankind has ever harnessed! Hand drill can provide an exacting metaphor for the span of human life—from the obvious anatomical symbolism of human union between the genders to the birth of a spirit in need of nourishment and encouragement in order for it to be sustained and grow into a breathing and consuming (and perhaps *sentient*, for it seems to be drawn toward its needs) entity, distinct from its genesis.



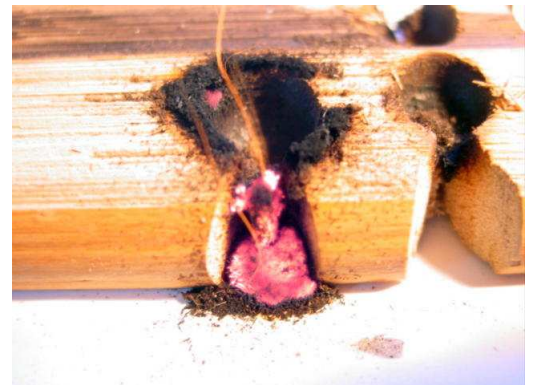
In order to better understand this evolution from friction to fire, I gathered spindles from 52 native and 22 non-native species of trees, shrubs, forbs, and lianas (plus one grass) and applied them via hand-powered rotational friction to four species of hearthboards (clematis, two redwood pieces of different densities, CA buckeye, big-leaf maple). There were many aspects to the nuances of hand drill that I was curious about, and my results are outlined below. Throughout these experiments I took care to adhere to the technological parameters afforded by the paleolithic and mesolithic standards that I aspire to emulate—no metal implements were used.

The Baseline Data

Table 1 displays the successes and failures I incurred trying to attain an ember with each of the 370 possible wood combinations. I also offer a very subjective effort rating for each attempt, with a 1 representing a low expenditure of energy (around a minute or less in duration), a 2 corresponding roughly to a two minute endeavor, while a score of 3 defined what felt like an average effort (three to four minutes). A 4 was given to a successful attempt that took longer than around four minutes and required multiple sockets (having burned through the first one). I assigned a 5 to failed ember attempts.

The fifteen woods that proved easiest to use as spindle materials are: yarrow, horsetail, box elder, CA buckeye, mule fat, blue elderberry, coast redwood, cattail, big-leaf maple, mugwort, bull thistle, scotch broom, Douglas fir, CA figwort and sow thistle.

Wanting to somehow check the accuracy of this effort rating system, I calculated the average effort for all attempts (4.0). By definition, this number should have been much closer to my arbitrary average rating of 3. A



previous, similar bow drill exploration of 1,946 wood combinations (go to www.stoneageskills.com for that data) gave me an average of 3.2 from all effort ratings—a figure that exhibits a more consistent estimation of effort comparison. This tells me that, since hand drill is generally more difficult than bow drill, I tend to misjudge the relative ease and difficulty of hand drill attempts more than with bow drill.

The Role of Wood Density

Given my interest in the discussion of the merits in having a softer spindle versus a softer hearthboard, which has been entertained in some primitive skills publications, in Table 2 you will see my measurements of the specific gravity, or *density* relative to that of water, of all the woods. The paucity of relative density data for our tree species in California caused me to measure it myself as follows:

Measuring Relative Density

1. Fill a tall, narrow vessel with water (bucket, graduated cylinder, capped PVC pipe).
2. Slowly submerge your spindle or hearth board until it begins to float. I like to dip the non-working end (the tip of the spindle that doesn't end up in the hearth board's socket) first—there's something counter-intuitive about purposefully dunking your fire sticks underwater. You want to notice where the floating water line is, so don't let your wood bounce into the water. You can mark the water line with a pencil—otherwise you can see the boundary between wet and dry wood.
3. Measure the length of the portion of your wood specimen that was underwater and divide that into the total length of the wood to get a percentage. If the piece of wood totally submerges under the water, then it is denser than water (*Lignum vitae*, a vine found in Florida, does this) and will result in a specific gravity of over 1.0. Most woods will only partially submerge, giving you a fraction under 1.0. The number you get, in of itself, is not important. It is only when you compare two findings, such as poison hemlock's 0.14 specific gravity against snowberry's 0.90, that you can derive some meaning (the latter is six times denser than the former).

Please note that every species of wood, even from the same tree or even the same branch, can vary in its density.

It is interesting to observe that the aforementioned fifteen best spindle woods have an average density of 0.42. Compared with an average density of 0.53 for all spindle woods, one could suggest that using softer spindles can increase your chance for success (but keep in mind that I'm not a statistician and offer only anecdotal supposition). Further support for this theory comes from evaluating spindle performances on the two redwood hearthboards of different densities. On the softer redwood board, the lighter 50% of the spindles performed better (3.32 average effort) than the denser 50% (4.36 average effort). On the harder redwood board, the lighter 50% of the spindles also performed better (3.46 average effort) than the denser 50% (4.32 average effort). This may indicate that it is more advantageous to use a softer wood for your spindle, irregardless of the density of your hearthboard. It makes

sense that difficulty would arise when trying to use denser wood combinations in general (but we already knew that, didn't we!).

Green vs. Dead vs. Nascent Growth

A friend of mine once noted that nascent growth (otherwise known as sucker sprouts, stump sprouts, adventitious growth) spindles seemed to work better than wood from regular branches. I like nascent growth for its straight form, as seen with big-leaf maple, CA buckeye, CA Bay, and other softer hardwoods. Table 3 shows my efforts comparing the use of nascent growth, green-cut and dead-cut spindles on CA buckeye and redwood hearthboards. The limited data doesn't support the advantage of nascent growth but does show the value of collecting dead wood for use as spindles.

Non-Notched Hand Drill Embers



Finally, I tried my hand at producing hand drill embers without carving the notch into the socket. I wanted to see if I could take a step out of the process in order to make it easier. Table 4 illustrates that I was able to produce an ember only 28% of the time, which re-enforces the value of the notch (unless a person sticks to those woods that generated embers).

I hope that this endeavor proves useful to you. I encourage you to experiment with your local woods and share your findings. I hear some people are compiling a national database of good friction fire woods—please feel free to add this data.

Table 1. Hand Drill Effort Ratings

HEARTHBOARDS

Scientific Name	Common Name	Clematis	Buckeye	Redwood (H)*	Redwood (S)*	Big-leaf Maple	Effort Average
<u>Acacia sp.</u>	<u>Acacia</u>	5	5	5	5	4	4.8
<u>Acer macrophyllum</u>	<u>Big-leaf Maple</u>	2	2	3	4	2	2.6
<u>Acer negundo</u>	<u>Box Elder</u>	2	2	2	2	3	2.2
<u>Achillea millefolium</u>	<u>Yarrow</u>	3	1	2	2	2	2.0
<u>Aesculus californica</u>	<u>CA Buckeye</u>	2	2	2	3	2	2.2
<u>Alnus rhombifolia</u>	<u>White Alder</u>	4	5	3	2	5	3.8
<u>Arbutus menziesii</u>	<u>Madrone</u>	5	5	5	5	5	5.0
<u>Artemisia californica</u>	<u>CA Sagebrush</u>	5	3	3	3	5	3.8
<u>Artemisia douglasiana</u>	<u>Mugwort</u>	3	3	2	2	3	2.6
<u>Baccharis douglasii</u>	<u>Marsh Baccharis</u>	4	4	5	5	5	4.6
<u>Baccharis pilularis</u>	<u>Coyote Brush</u>	5	5	5	5	5	5.0
<u>Baccharis salicifolia</u>	<u>Mule Fat</u>	1	2	3	2	3	2.2
<u>Calocedrus decurrens</u>	<u>Incense Cedar</u>	5	5	5	4	5	4.8
<u>Ceanothus thyrsiflorus</u>	<u>CA Lilac</u>	4	5	3	3	5	4.0
<u>Chlorogalum pomeridianum</u>	<u>Soaproot</u>	5	3	3	4	5	4.0
<u>Cirsium vulgare</u>	<u>Bull Thistle</u>	2	3	2	3	3	2.6
<u>Conium maculatum</u>	<u>Poison Hemlock</u>	5	5	5	5	5	5.0
<u>Coryza canadensis</u>	<u>Horseweed</u>	1	3	2	2	2	2.0
<u>Cornus sericera</u>	<u>American Dogwood</u>	3	5	4	3	3	3.6
<u>Corylus cornuta</u>	<u>Hazelnut</u>	5	5	5	4	5	4.8
<u>Cupressus macrocarpa</u>	<u>Monterey Cypress</u>	5	5	5	5	5	5.0
<u>Cydonia oblonga</u>	<u>Quince</u>	5	5	5	5	4	4.8
<u>Cytisus scoparius</u>	<u>Scotch Broom</u>	3	2	2	2	5	2.8
<u>Dipsacus fullonum</u>	<u>Fuller's Teasel</u>	5	2	5	5	3	4.0
<u>Erigeron sp.</u>	<u>Fleabane Daisy</u>	2	2	4	5	3	3.2
<u>Eriophyllum staechadifolium</u>	<u>Seaside Woolly Sunflower</u>	5	3	4	5	3	4.0
<u>Escallonia macrantha</u>	<u>Escallonia</u>	5	5	5	2	5	4.4
<u>Eucalyptus globulus</u>	<u>Blue Gum Eucalyptus</u>	5	5	5	5	5	5.0
<u>Euonymus occidentalis</u>	<u>W. Burning Bush</u>	5	3	3	4	5	4.0
<u>Grindelia stricta</u>	<u>Marsh Gum Plant</u>	5	5	5	5	4	4.8
<u>Hedera helix</u>	<u>English Ivy</u>	5	5	5	5	5	5.0
<u>Helianthus sp.</u>	<u>Garden Sunflower</u>	3	3	3	5	3	3.4
<u>Heteromeles arbutifolia</u>	<u>Toyon</u>	5	5	5	5	5	5.0
<u>Holodiscus discolor</u>	<u>Ocean Spray</u>	4	3	4	4	5	4.0
<u>Juniperus communis</u>	<u>Common Juniper</u>	5	5	5	5	5	5.0
<u>Larix sp.</u>	<u>Tamarack</u>	4	5	5	4	5	4.6
<u>Lithocarpus densiflorus</u>	<u>Tan Oak</u>	5	5	5	4	4	4.6
<u>Lonicera hispidula</u>	<u>Hairy Honeysuckle</u>	4	4	2	4	3	3.4
<u>Lupinus arborus</u>	<u>Tree Lupine</u>	5	5	5	5	5	5.0
<u>Madia elegans</u>	<u>Tarweed</u>	4	4	5	5	5	4.6
<u>Malus sp.</u>	<u>Apple</u>	5	5	5	5	5	5.0
<u>Mimulus aurantiacus</u>	<u>Sticky Monkeyflower</u>	5	5	4	3	5	4.4
<u>Myrica californica</u>	<u>Pac. Wax Myrtle</u>	5	5	2	3	5	4.0
<u>Phyllostachys sp.</u>	<u>Bamboo</u>	5	5	5	5	4	4.8
<u>Prunus cerasifera</u>	<u>Cherry Plum</u>	5	5	3	3	5	4.2
<u>Pseudotsuga menziesii</u>	<u>Douglas Fir</u>	2	4	3	3	2	2.8
<u>Pteridium aquilinum</u>	<u>Bracken Fern</u>	5	5	4	4	5	4.6
<u>Pyrus sp.</u>	<u>Pear</u>	5	5	5	5	5	5.0
<u>Rhamnus californica</u>	<u>Coffeeberry</u>	5	5	5	5	5	5.0
<u>Rhododendron macrophyllum</u>	<u>Pacific Rhododendron</u>	4	5	5	5	5	4.8
<u>Rhododendron occidentale</u>	<u>Western Azalea</u>	5	4	4	5	4	4.4
<u>Ribes menziesii</u>	<u>Canyon Gooseberry</u>	5	5	5	5	5	5.0
<u>Rosa gymnocarpa</u>	<u>Wood Rose</u>	5	4	4	3	5	4.2
<u>Rubus discolor</u>	<u>Himalayan Blackberry</u>	4	3	5	5	3	4.0
<u>Rubus parviflorus</u>	<u>Thimbleberry</u>	4	4	3	3	4	3.6
<u>Rumex crispus</u>	<u>Curly Dock</u>	5	5	5	5	5	5.0
<u>Salix lutea</u>	<u>Yellow Willow</u>	5	5	5	5	4	4.8
<u>Salix sp.</u>	<u>Willow</u>	5	4	3	2	3	3.4
<u>Sambucus mexicana</u>	<u>Blue Elderberry</u>	1	2	3	2	3	2.2
<u>Scrophularia californica</u>	<u>CA Figwort</u>	3	2	2	4	3	2.8
<u>Sequoia sempervirens</u>	<u>Coast Redwood</u>	2	2	2	3	3	2.4
<u>Silybum marianum</u>	<u>Milk Thistle</u>	3	3	4	3	5	3.6
<u>Solidago spathulata</u>	<u>Coast Goldenrod</u>	4	3	3	4	3	3.4
<u>Sonchus oleraceus</u>	<u>Sow Thistle</u>	2	1	3	4	5	3.0
<u>Symphoricarpos albus</u>	<u>Snowberry</u>	5	4	5	4	5	4.6
<u>Tamarix parviflora</u>	<u>Smallflower Tamarisk</u>	5	3	4	5	5	4.4
<u>Thuja plicata</u>	<u>Western Red Cedar</u>	5	5	3	3	4	4.0
<u>Typha latifolia</u>	<u>Cattail</u>	3	2	1	2	4	2.4
<u>Ulmus minor</u>	<u>Smooth-leaved Elm</u>	5	5	5	5	5	5.0
<u>Umbellularia californica</u>	<u>CA Bay Laurel</u>	3	3	3	3	4	3.2
<u>Urtica californica</u>	<u>Stinging Nettle</u>	3	5	3	4	3	3.6
<u>Vaccinium ovatum</u>	<u>Evergreen Huckleberry</u>	5	5	5	5	5	5.0
<u>Verbascum thapsus</u>	<u>Common Mullein</u>	3	3	3	2	5	3.2
<u>Vitis californica</u>	<u>Wild Grape</u>	2	4	4	4	4	3.6

1 (easiest) to 4 (very difficult); 5=unsuccessful

* (H)=Heartwood; (S)=Sapwood

Table 2. Specific Gravity for Hand Drills

Scientific Name	Common Name	Sp. Gravity
<u>Conium maculatum</u>	Poison Hemlock	0.14
<u>Dipsacus fullonum</u>	Fuller's Teasel	0.19
<u>Helianthus sp.</u>	Garden Sunflower	0.24
<u>Chlorogalum pomeridianum</u>	Soaproot	0.25
<u>Rubus discolor</u>	Himalayan Blackberry	0.25
<u>Verbascum thapsus</u>	Common Mullein	0.25
<u>Rumex crispus</u>	Curly Dock	0.26
<u>Sambucus mexicana</u>	Blue Elderberry	0.28
<u>Phyllostachys sp.</u>	Bamboo	0.28
<u>Cirsium vulgare</u>	Bull Thistle	0.30
<u>Achillea millefolium</u>	Yarrow	0.34
<u>Artemisia douglasiana</u>	Mugwort	0.34
<u>Pteridium aquilinum</u>	Bracken Fern	0.34
<u>Silybum marianum</u>	Milk Thistle	0.35
<u>Solidago spathulata</u>	Coast Goldenrod	0.35
<u>Typha latifolia</u>	Cattail	0.35
<u>Urtica californica</u>	Stinging Nettle	0.36
<u>Acer macrophyllum</u>	Big-leaf Maple	0.38
<u>Artemisia californica</u>	CA Sagebrush	0.38
<u>Scrophularia californica</u>	CA Figwort	0.40
<u>Aesculus californica</u>	CA Buckeye	0.41
<u>Acer negundo</u>	Box Elder	0.42
<u>Sonchus oleraceus</u>	Sow Thistle	0.42
<u>Conyza canadensis</u>	Horseweed	0.43
<u>Baccharis douglasii</u>	Marsh Baccharis	0.46
<u>Madia elegans</u>	Tarweed	0.47
<u>Alnus rhombifolia</u>	White Alder	0.47
<u>Erigeron sp.</u>	Fleabane Daisy	0.48
<u>Rosa gymnocarpa</u>	Wood Rose	0.50
<u>Cytisus scoparius</u>	Scotch Broom	0.51
<u>Lonicera hispidula</u>	Hairy Honeysuckle	0.52
<u>Pseudotsuga menziesii</u>	Douglas Fir	0.53
<u>Salix sp.</u>	Willow	0.53
<u>Rubus parviflorus</u>	Thimbleberry	0.54
<u>Vaccinium ovatum</u>	Evergreen Huckleberry	0.54
<u>Cornus sericera</u>	American Dogwood	0.55
<u>Escallonia macrantha</u>	Escallonia	0.55
<u>Eucalyptus globulus</u>	Blue Gum Eucalyptus	0.55
<u>Vitis californica</u>	Wild Grape	0.55
<u>Holodiscus discolor</u>	Ocean Spray	0.56
<u>Umbellularia californica</u>	CA Bay Laurel	0.56
<u>Baccharis pilularis</u>	Coyote Brush	0.56
<u>Lupinus arborus</u>	Tree Lupine	0.56
<u>Baccharis salicifolia</u>	Mule Fat	0.57
<u>Rhododendron macrophyllum</u>	Pacific Rhododendron	0.57
<u>Tamarix parviflora</u>	Smallflower Tamarisk	0.58
<u>Corylus cornuta</u>	Hazelnut	0.60
<u>Rhododendron occidentale</u>	Western Azalea	0.60
<u>Sequoia sempervirens</u>	Coast Redwood	0.61
<u>Rhamnus californica</u>	Coffeeberry	0.62
<u>Euonymus occidentalis</u>	W. Burning Bush	0.63
<u>Grindelia stricta</u>	Marsh Gum Plant	0.63
<u>Myrica californica</u>	Pac. Wax Myrtle	0.63
<u>Pyrus sp.</u>	Pear	0.64
<u>Thuja plicata</u>	Western Red Cedar	0.64
<u>Calocedrus decurrens</u>	Incense Cedar	0.65
<u>Lithocarpus densiflorus</u>	Tan Oak	0.65
<u>Ceanothus thyrsiflorus</u>	CA Lilac	0.66
<u>Acacia sp.</u>	Acacia	0.66
<u>Hedera helix</u>	English Ivy	0.66
<u>Ulmus minor</u>	Smooth-leaved Elm	0.67
<u>Juniperus communis</u>	Common Juniper	0.68
<u>Cupressus macrocarpa</u>	Monterey Cypress	0.68
<u>Eriophyllum staechadifolium</u>	Seaside Woolly Sunflower	0.69
<u>Malus sp.</u>	Apple	0.70
<u>Salix lutea</u>	Yellow Willow	0.70
<u>Prunus cerasifera</u>	Cherry Plum	0.73
<u>Mimulus aurantiacus</u>	Sticky Monkeyflower	0.79
<u>Ribes menziesii</u>	Canyon Gooseberry	0.83
<u>Heteromeles arbutifolia</u>	Toyon	0.84
<u>Larix sp.</u>	Tamarack	0.85
<u>Cydonia oblonga</u>	Quince	0.89
<u>Arbutus menziesii</u>	Madrone	0.90
<u>Symphoricarpos albus</u>	Snowberry	0.90

Specific Gravity for Hearthboards	
Clematis	0.45
CA Buckeye	0.49
Redwood Heartwood	0.39
Redwood Sapwood	0.53
Big-Leaf Maple	0.34

Table 3. Green vs. Dead vs. Nascent Growth Spindles

HEARTHBOARDS

Name	Condition When Procured	Buckeye	Redwood
Acer macrophyllum	green	3	3
(Big-leaf Maple)	green-nascent	2	4
	dead	2	2
Acer negundo	green	5	5
(Box Elder)	dead	2	2
Aesculus californica	green	3	2
(CA Buckeye)	green-nascent	2	2
	dead	2	2
Baccharis douglasii	green	4	5
(Marsh Baccharis)	dead	4	5
Ceanothus thyrsiflorus	green	5	3
(CA Lilac)	dead	5	3
Cirsium vulgare	green	3	2
(Bull Thistle)	dead	3	2
Conyza canadensis	green	3	4
(Horseweed)	dead	3	2
Cornus sericera	green	5	4
(American Dogwood)	dead	5	3
Dipsacus fullonum	green	4	5
(Fuller's Teasel)	dead	2	5
Euonymus occidentalis	green	4	4
(Western Burning Bush)	dead	3	3
Holodiscus discolor	green	4	4
(Ocean Spray)	dead	4	3
	dead-nascent	3	3
Lonicera hispidula	green	4	2
(Hairy Honeysuckle)	green-nascent	4	4
	dead	3	2
Lupinus arboreus	green nascent	5	5
(Tree Lupine)	dead	4	3
Pseudotsuga menziesii	green	4	3
(Douglas Fir)	dead	3	3
Rhododendron macrophyllum	green-nascent	5	5
(Pacific Rhododendron)	dead-nascent	5	4
Rubus discolor	green	5	5
(Himalayan Blackberry)	dead	4	5
Sambucus mexicana	green	3	3
(Blue Elderberry)	green-nascent	2	3
	dead	2	2
Sequoia sempervirens	green	3	4
(Coast Redwood)	dead	2	2
Salix lutea	green	5	5
(Yellow Willow)	green-nascent	3	5
Silybum marianum	green	4	4
(Milk Thistle)	dead	3	3
Sonchus oleraceus	green	4	3
(Sow Thistle)	dead	1	2
Umbellularia californica	green	3	3
(CA Bay Laurel)	dead-nascent	3	3
	dead	2	4

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Effort Averages
Nascent Overall--3.60
Green Nascent--3.64
Dead Nascent--3.50
Green-Cut--3.66
Dead-Cut--3.00

Table 4. Non-Notched Hand Drill Embers

HEARTHBOARDS

Scientific Name	Common Name	Buckeye	Tan Oak
<u>Acacia sp.</u>	<u>Acacia</u>	N	N
<u>Acer macrophyllum</u>	<u>Big-leaf Maple</u>	Y	Y
<u>Acer negundo</u>	<u>Box Elder</u>	N	Y
<u>Achillea millefolium</u>	<u>Yarrow</u>	N	Y
<u>Aesculus californica</u>	<u>CA Buckeye</u>	Y	Y
<u>Alnus rhombifolia</u>	<u>White Alder</u>	N	N
<u>Arbutus menziesii</u>	<u>Madrone</u>	N	N
<u>Artemisia californica</u>	<u>CA Sagebrush</u>	N	N
<u>Artemisia douglasiana</u>	<u>Mugwort</u>	N	Y
<u>Baccharis douglasii</u>	<u>Marsh Baccharis</u>	N	N
<u>Baccharis pilularis</u>	<u>Coyote Brush</u>	N	N
<u>Baccharis salicifolia</u>	<u>Mule Fat</u>	N	Y
<u>Calocedrus ducurrens</u>	<u>Incense Cedar</u>	N	N
<u>Ceanothus thyrsiflorus</u>	<u>CA Lilac</u>	N	N
<u>Chlorogalum pomeridianum</u>	<u>Soaproot</u>	Y	Y
<u>Cirsium vulgare</u>	<u>Bull Thistle</u>	Y	N
<u>Conium maculatum</u>	<u>Poison Hemlock</u>	N	N
<u>Conyza canadensis</u>	<u>Horseweed</u>	Y	Y
<u>Cornus sericera</u>	<u>American Dogwood</u>	N	N
<u>Corylus cornuta</u>	<u>Hazelnut</u>	N	N
<u>Cupressus macrocarpa</u>	<u>Monterey Cypress</u>	N	N
<u>Cydonia oblonga</u>	<u>Quince</u>	N	N
<u>Cytisus scoparius</u>	<u>Scotch Broom</u>	N	Y
<u>Dipsacus fullonum</u>	<u>Fuller's Teasel</u>	N	N
<u>Erigeron sp.</u>	<u>Fleabane Daisy</u>	N	Y
<u>Eriophyllum staechadifolium</u>	<u>Seaside Woolly Sunflower</u>	Y	N
<u>Escallonia macrantha</u>	<u>Escallonia</u>	N	N
<u>Eucalyptus globulus</u>	<u>Blue Gum Eucalyptus</u>	N	N
<u>Euonymus occidentalis</u>	<u>W. Burning Bush</u>	N	N
<u>Grindelia stricta</u>	<u>Marsh Gum Plant</u>	Y	N
<u>Hedera helix</u>	<u>English Ivy</u>	N	N
<u>Helianthus sp.</u>	<u>Garden Sunflower</u>	Y	Y
<u>Heteromeles arbutifolia</u>	<u>Toyon</u>	N	N
<u>Holodiscus discolor</u>	<u>Ocean Spray</u>	N	Y
<u>Juniperus communis</u>	<u>Common Juniper</u>	N	N
<u>Larix sp.</u>	<u>Tamarack</u>	N	N
<u>Lithocarpus densiflorus</u>	<u>Tan Oak</u>	N	Y
<u>Lonicera hispidula</u>	<u>Hairy Honeysuckle</u>	N	Y
<u>Lupinus arborus</u>	<u>Tree Lupine</u>	N	N
<u>Madia elegans</u>	<u>Tarweed</u>	N	Y
<u>Malus sp.</u>	<u>Apple</u>	N	N
<u>Mimulus aurantiacus</u>	<u>Sticky Monkeyflower</u>	N	N
<u>Myrica californica</u>	<u>Pac. Wax Myrtle</u>	N	N
<u>Phyllostachys sp.</u>	<u>Bamboo</u>	N	N
<u>Prunus cerasifera</u>	<u>Cherry Plum</u>	N	N
<u>Pseudotsuga menziesii</u>	<u>Douglas Fir</u>	N	N
<u>Pteridium aquilinum</u>	<u>Bracken Fern</u>	N	N
<u>Pyrus sp.</u>	<u>Pear</u>	N	N
<u>Rhamnus californica</u>	<u>Coffeeberry</u>	N	N
<u>Rhododendron macrophyllum</u>	<u>Pacific Rhododendron</u>	N	N
<u>Rhododendron occidentale</u>	<u>Western Azalea</u>	N	N
<u>Ribes menziesii</u>	<u>Canyon Gooseberry</u>	N	N
<u>Rosa gymnocarpa</u>	<u>Wood Rose</u>	N	N
<u>Rubus discolor</u>	<u>Himalayan Blackberry</u>	Y	Y
<u>Rubus parviflorus</u>	<u>Thimbleberry</u>	N	Y
<u>Rumex crispus</u>	<u>Curly Dock</u>	N	N
<u>Salix lutea</u>	<u>Yellow Willow</u>	N	N
<u>Salix sp.</u>	<u>Willow</u>	N	N
<u>Sambucus mexicana</u>	<u>Blue Elderberry</u>	Y	Y
<u>Scrophularia californica</u>	<u>CA Figwort</u>	Y	N
<u>Sequoia sempervirens</u>	<u>Coast Redwood</u>	Y	Y
<u>Silybum marianum</u>	<u>Milk Thistle</u>	Y	N
<u>Solidago spathulata</u>	<u>Coast Goldenrod</u>	Y	Y
<u>Sonchus oleraceus</u>	<u>Sow Thistle</u>	Y	N
<u>Symphoricarpos albus</u>	<u>Snowberry</u>	Y	N
<u>Tamarix parviflora</u>	<u>Smallflower Tamarisk</u>	N	N
<u>Thuja plicata</u>	<u>Western Red Cedar</u>	N	N
<u>Typha latifolia</u>	<u>Cattail</u>	Y	Y
<u>Ulmus minor</u>	<u>Smooth-leaved Elm</u>	N	N
<u>Umbellularia californica</u>	<u>CA Bay Laurel</u>	N	N
<u>Urtica californica</u>	<u>Stinging Nettle</u>	N	Y
<u>Vaccinium ovatum</u>	<u>Evergreen Huckleberry</u>	N	N
<u>Verbascum thapsus</u>	<u>Common Mullein</u>	Y	Y
<u>Vitis californica</u>	<u>Wild Grape</u>	N	N

Spec. Gravity of Hearthboards

CA Buckeye--0.39

Tan Oak--0.68

Specific Gravity for Hand Drills—measured myself						Specific
Scientific Name	Common Name	Alive (A)	Dead (D)	A, Nascent	D, Nascent	Gravity
<u>Acacia sp.</u>	<u>Acacia</u>	0.66				0.66
<u>Acer macrophyllum</u>	<u>Big-leaf Maple</u>	0.43	0.32			0.38
<u>Acer negundo</u>	<u>Box Elder</u>		0.42			0.42
<u>Achillea millefolium</u>	<u>Yarrow</u>		0.34			0.34
<u>Aesculus californica</u>	<u>CA Buckeye</u>	0.46	0.36			0.41
<u>Alnus rhombifolia</u>	<u>White Alder</u>		0.47			0.47
<u>Arbutus menziesii</u>	<u>Madrone</u>	0.90				0.90
<u>Artemisia californica</u>	<u>CA Sagebrush</u>	0.38				0.38
<u>Artemisia douglasiana</u>	<u>Mugwort</u>		0.34			0.34
<u>Baccharis douglasii</u>	<u>Marsh Baccharis</u>	0.57	0.35			0.46
<u>Baccharis pilularis</u>	<u>Coyote Brush</u>		0.56			0.56
<u>Baccharis salicifolia</u>	<u>Mule Fat</u>	0.57				0.57
<u>Calocedrus decurrens</u>	<u>Incense Cedar</u>		0.65			0.65
<u>Ceanothus thyrsiflorus</u>	<u>CA Lilac</u>	0.61	0.70			0.66
<u>Chlorogalum pomeridianum</u>	<u>Soaproot</u>		0.25			0.25
<u>Cirsium vulgare</u>	<u>Bull Thistle</u>		0.30			0.30
<u>Conium maculatum</u>	<u>Poison Hemlock</u>		0.14			0.14
<u>Coryza canadensis</u>	<u>Horseweed</u>	0.40	0.46			0.43
<u>Cornus sericera</u>	<u>American Dogwood</u>	0.54	0.55			0.55
<u>Corylus comuta</u>	<u>Hazelnut</u>	0.60				0.60
<u>Cupressus macrocarpa</u>	<u>Monterey Cypress</u>	0.68				0.68
<u>Cydonia oblonga</u>	<u>Quince</u>	0.91	0.84	0.92		0.89
<u>Cytisus scoparius</u>	<u>Scotch Broom</u>		0.51			0.51
<u>Dipsacus fullonum</u>	<u>Fuller's Teasel</u>	0.19				0.19
<u>Erigeron sp.</u>	<u>Fleabane Daisy</u>		0.48			0.48
<u>Eriophyllum staechadifolium</u>	<u>Seaside Woolly Sunflower</u>	0.69				0.69
<u>Escallonia macrantha</u>	<u>Escallonia</u>	0.55				0.55
<u>Eucalyptus globulus</u>	<u>Blue Gum Eucalyptus</u>		0.55			0.55
<u>Euonymus occidentalis</u>	<u>W. Burning Bush</u>	0.71	0.55			0.63
<u>Grindelia stricta</u>	<u>Marsh Gum Plant</u>	0.62	0.64			0.63
<u>Hedera helix</u>	<u>English Ivy</u>		0.66			0.66
<u>Helianthus sp.</u>	<u>Garden Sunflower</u>		0.24			0.24
<u>Heteromeles arbutifolia</u>	<u>Toyon</u>		0.84			0.84
<u>Holodiscus discolor</u>	<u>Ocean Spray</u>	0.88	0.83			0.86
<u>Juniperus communis</u>	<u>Common Juniper</u>	0.63	0.72			0.68
<u>Larix sp.</u>	<u>Tamarack</u>		0.85			0.85
<u>Lithocarpus densiflorus</u>	<u>Tan Oak</u>		0.65			0.65
<u>Lonicera hispidula</u>	<u>Hairy Honeysuckle</u>	0.58	0.45			0.52
<u>Lupinus arborus</u>	<u>Tree Lupine</u>		0.44	0.68		0.56
<u>Madia elegans</u>	<u>Tarweed</u>	0.51	0.42			0.47
<u>Malus sp.</u>	<u>Apple</u>	0.79	0.52	0.71	0.76	0.70
<u>Mimulus aurantiacus</u>	<u>Sticky Monkeyflower</u>	0.79				0.79
<u>Myrica californica</u>	<u>Pac. Wax Myrtle</u>	0.63	0.63			0.63
<u>Phyllostachys sp.</u>	<u>Bamboo</u>		0.28			0.28
<u>Prunus cerasifera</u>	<u>Cherry Plum</u>	0.73				0.73
<u>Pseudotsuga menziesii</u>	<u>Douglas Fir</u>		0.53			0.53
<u>Pteridium aquilinum</u>	<u>Bracken Fern</u>	0.34				0.34
<u>Pyrus sp.</u>	<u>Pear</u>		0.64			0.64
<u>Rhamnus californica</u>	<u>Coffeeberry</u>		0.62			0.62
<u>Rhododendron macrophyllum</u>	<u>Pacific Rhododendron</u>			0.65	0.49	0.57
<u>Rhododendron occidentale</u>	<u>Western Azalea</u>	0.60				0.60
<u>Ribes menziesii</u>	<u>Canyon Gooseberry</u>	0.83				0.83
<u>Rosa gymnocarpa</u>	<u>Wood Rose</u>		0.34	0.66		0.50
<u>Rubus discolor</u>	<u>Himalayan Blackberry</u>		0.25			0.25
<u>Rubus parviflorus</u>	<u>Thimbleberry</u>	0.54				0.54
<u>Rumex crispus</u>	<u>Curly Dock</u>		0.26			0.26
<u>Salix lutea</u>	<u>Yellow Willow</u>	0.64		0.76		0.70
<u>Salix sp.</u>	<u>Willow</u>	0.53				0.53
<u>Sambucus mexicana</u>	<u>Blue Elderberry</u>	0.32	0.23			0.28
<u>Scrophularia californica</u>	<u>CA Figwort</u>		0.40			0.40
<u>Sequoia sempervirens</u>	<u>Coast Redwood</u>	0.73	0.48			0.61
<u>Silybum marianum</u>	<u>Milk Thistle</u>	0.38	0.32	senescing: 0.36		0.35
<u>Solidago spathulata</u>	<u>Coast Goldenrod</u>		0.35			0.35
<u>Sonchus oleraceus</u>	<u>Sow Thistle</u>	0.54	0.30	senescing: 0.28		0.42
<u>Symphoricarpos albus</u>	<u>Snowberry</u>	0.90				0.90
<u>Tamarix parviflora</u>	<u>Smallflower Tamarisk</u>	0.58				0.58
<u>Thuja plicata</u>	<u>Western Red Cedar</u>	0.64				0.64
<u>Typha latifolia</u>	<u>Cattail</u>	0.35				0.35
<u>Ulmus minor</u>	<u>Smooth-leaved Elm</u>	0.67				0.67
<u>Umbellularia californica</u>	<u>CA Bay Laurel</u>	0.61	0.50			0.56
<u>Urtica californica</u>	<u>Stinging Nettle</u>		0.36			0.36
<u>Vaccinium ovatum</u>	<u>Evergreen Huckleberry</u>		0.54			0.54
<u>Verbascum thapsus</u>	<u>Common Mullein</u>		0.25			0.25
<u>Vitis californica</u>	<u>Wild Grape</u>	0.58	0.52			0.55

Kneeling. Favored by hand drill practitioners because it allows your upper-body weight to bear down onto the spindle.

[Speaking of pressure, I performed hand drill (Mule Fat on Sotol) a few times on a doctor's scale to measure the downward pressure necessary to generate an ember. Using the regular technique—7.8lbs. Using solely the floating method—4.4 lbs.]



Sitting. Although it takes more exertion to generate an ember in this position, some folks (like myself) find this more comfortable.



Contact Point. Notice how the "working end" of the spindle nestles into a pre-drilled socket (carved by a stone knife or quartz crystal-tipped hand drill). The removed wedge provides a place for the char, or disintegrated wood powder, to accumulate.



Floating. These two photos illustrate the fluid, alternating, U-shaped motions that the hands perform in order to sustain spindle-rotation—which may result in quicker ember formation.



Ember. The miracle of friction fire reveals itself. Transfer this fire-egg to a tinder nest and hatch it into flame.

