DEPARTMENT OF FOREST PRODUCTS

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TO: Larry Swan, Winema National Forest
Klamath Falls, OR

FROM: Mike Milota

RE: Saw-dry-rip for juniper

The work to determine if juniper should be ripped prior to drying has been completed. Juniper will warp less if it is ripped after drying rather than before. This memo will discuss the drying, warp measurements, suggested schedules, and our protocol for measuring warp.

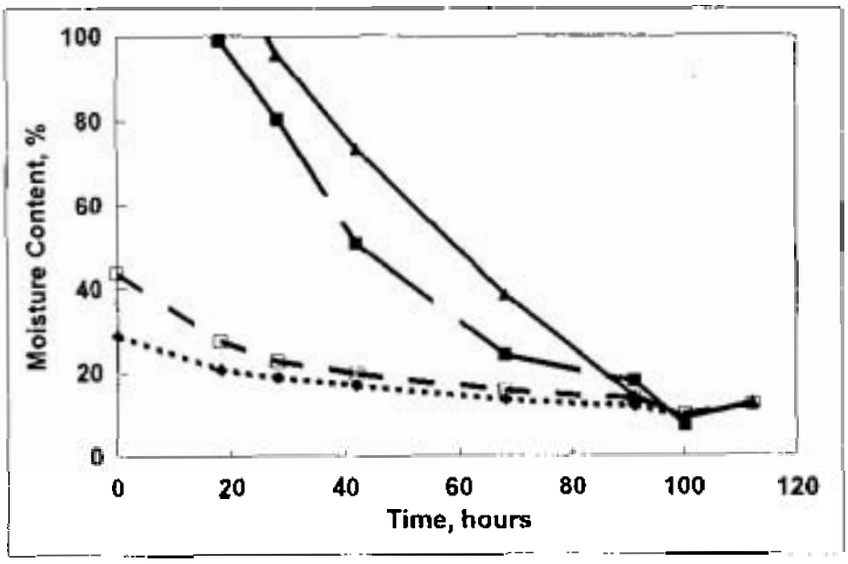
DRYING

The juniper provided was dried using the following schedule in which the temperatures are ramped between set points. This is similar to the other charges that we have dried. Four sample boards were weighed periodically to determine the moisture content over time, watch for defects, and cut samples to test for casehardening.

Time	Dry-bulb	Wet-bulb
0	80	73
2	130	123
24	135	125
48	140	135
72	150	135
94	180	140
94-100	180	140
	2-hour cool down	
12-hours	160	152

Drying proceeded quite well with the samples reaching a 7-10% moisture content range in about 100 hours. No defects were observed and transverse casehardening test showed that the stresses had be relieved. The moisture content data derived from the four sample boards are shown below:

	OD	SUN NOON	MON AM	MON PM	TUES AM	WED AM	THURS AM	THURS PM	FRI AM
Weights		0	18	28	42	68	91	100	112
1	2.8	7.6	5.57	5.05	4.22	3.47	3.29	3	cut
2	2.09	2.69	2.52	2.48	2.44	2.37	2.33	2.28	cut
3	2.02	5.51	4.52	3.95	3.5	2.8	2.3	2.2	2.27
4	5.38	7.74	6.85	6.6	6.43	6.22	6.1	5.9	6.03
Moisture Contents									
1		171.4	98.9	80.4	50.7	23.9	17.5	7.1	
2		28.7	20.6	18.7	16.7	13.4	11.5	9.1	
3		172.8	123.8	95.5	73.3	38.6	13.9	8.9	12.4
4		43.9	27.3	22.7	19.5	15.6	13.4	9.7	12.1



WARP

After the wood had dried and cooled, approximately 30 pieces were selected to be ripped. The warp in these 2.5" strips was compared to the warp in the 30 pieces that had been cut to a width of 2.5" before delivery. The warp observed in the preripped material was greater than in the material ripped after drying, approximately twice as much. Statistically, this is a significant difference at the 95% confidence level (based on a t-test). The values are shown below.

Cut off Wide Boards (A)		Narrow Boards (B)	
Sample	Warp, cm	Sample	Warp, cm
1	0.95	1	0.7
2	0.1	2	1.7
3	0.4	3	0.5
4	0.4	4	1.6
5	0.5	5	0.6
6	0	6	1.4
7	0.4	7	1.6
8	1.2	8	0.8
9	0.4	9	0.5
10	1	10	0.6
11	0.6	11	0.6
12	0.4	12	0.5
13	0	13	0.5
14	0.7	14	1.4
15	1.45	15	0.9
16	1.2	16	0
17	0.7	17	1.1
18	0.95	18	3
19	1.1	19	3.6
20	0.6	20	1.7
21	0.2	21	0
22	0.4	22	0
23	1.6	23	6.2
24	0.7	24	1.5
25	0.3	25	0.6
26	1.25	26	2.9
27	1.55	27	2
28	0.15	28	0.9
29	0.55	29	1.5
30	0.95	30	0.6
Avg.	0.69	Avg.	1.32
Std. Dv	0.45	Std. Dv	1.25

Warp values for 60 pieces, 30 ripped before drying and 30 ripped after drying. After drying, 32 boards were ripped, but two broke and could not be used for warp measurement.

The differences in warp observed should be expected. The only thing preventing the pre-ripped pieces from warping in the dryer is the restraint provided by the stickers. The unripped pieces are provided additional restraint by being a part of the larger board. This is the basic argument behind the Forest Service's saw-dry-rip program that has been promoted for hardwoods.

From a secondary manufacturing standpoint; however, this may not be the best alternative. If a warped piece comes into the operation, it can be chopped or chipped or otherwise dealt with depending on the degree of warp. However, if a board is ripped, one assumes that the sawcut is straight for further machining and gluing. If boards warp after ripping, they get into the system and by pass any inspections and remedies that have been used for incoming warped lumber.

SUGGESTED PINE SCHEDULES

I have two concerns if juniper is to be mixed with ponderosa pine. One is the risk of defects in the juniper, and the other is getting the two species out of the kiln at the same moisture content. Pine heartwood and sapwood are often separated before drying with the heartwood having a much faster drying schedule, probably too fast for the juniper. If anything, therefore, the juniper should be mixed with pine sapwood; however, it will probably reach the final moisture content before the pine.

The schedules provided by the USDA for ponderosa pine are not similar to what we have been using for the juniper. Therefore, it becomes very difficult to guess how well juniper would dry on one of these schedules. The USDA schedules probably are typical of what is used in industry.

The risk of surface checking and other defects increases as the drying rate increases early in the drying schedule. Higher temperatures and lower relative humidities make the wood dry faster and many pine schedules start out at fairly large wet-bulb depressions, 15-20°F, at 130-160°F. We have been starting the juniper at a 7°F wet-bulb depression and 130°F. We do know that nearly all drying defects are related to how fast the wood dries early in the schedule. Pine schedules are designed to dry fast and avoid brown stain.

Since we have not dried juniper on a pine schedule, so it's hard to predict what defects would occur and how long it would take. Juniper seems to be very forgiving and maybe one can get away with mixing the two species. At this point we simply don't know. We would have to either dry juniper on a pine schedule in a lab kiln, or mix the two in a commercial kiln and see what happens. I suggest just simply trying it in a commercial kiln to see what happens. This would be quicker and less expensive than doing it in a lab kiln.

To get around the final MC problem, find a kiln in which 1" pine sapwood is dried to as high a moisture content as possible. If the pine is dried to 7-10% moisture content, I am fairly certain that the juniper will be overdried. If the pine is dried to 12% moisture content, then the schedule is shorter and final equilibrium moisture contents do not need to be as low. Adjust the pine schedule so that the equilibrium moisture content never gets below 6-7% (about a 22-28°F wet-bulb depression). By doing this the juniper will not dry to less than 6-7% moisture content no matter how long it takes to dry the pine and it can just sit in the kiln until the pine is done.

I would not place the juniper at the top of the charge. Temperatures and drying rates tend to be greater higher in the load.

Removing the juniper if it is dry before the pine is not a good option because it will leave a void in the kiln charge and disrupt air flow for the pine. Additionally, the juniper needs to be conditioned with the pine and this is done at the end of the schedule. Be sure to do a conditioning period after drying. Whatever works for the pine should also work for the juniper.

PROTOCOL FOR WARP MEASUREMENT

To measure warp we have a table with a straight edge. A piano wire is stretched along the straight edge to verify that it is true. Boards are placed with the concave edge against the straight edge and the maximum deflection is measured using either a ruler or a taper gauge (wedge-shaped device used to measure gaps). If the desired number is simply the warp in a board, then this method suffices.

When making measurements before and after drying or sawing one encounters a problem. The edge to be measured may be concave for the first measurement, but convex for the second measurement. To handle the convex situation, the edge of the board is pushed against the straight edge so that the middle touches. Then the distance from the straight edge to the edge of the board is measured at each end of the board. Averaging these two values gives the warp. We usually record convex warp as negative and concave warp as positive.

These procedures should work for nearly every board. S-shaped board would be a problem, but we have not run into any. The flexibility of the wood can be a problem, especially when making the measurements on green lumber. One has to be sure not to drag the board across the table to the straight edge and increase or decrease the crook.