# Influence of the Lunar Phase of Tree Felling on Humidity, Weight Densities, and Shrinkage in Hardwoods (*Quercus humilis*)

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**Abstract**

The influence of the lunar phase of tree felling on the properties of wood has been debated for centuries, but it is only recently that it has been the subject of rigorous study. These scientific studies have essentially focused on softwoods, leaving unanswered the question of whether hardwoods follow the same pattern.

This article presents the results of the analysis of the lunar influence of the felling date on the humidity, specific weights, and shrinkage of wood. The random sample analyzed consists of 60 oaks (*Quercus humilis* Mill.) felled during the four lunar phases (15 trees per phase) throughout one lunar period. No significant differences were detected in any of the cases.

The question of the moon's influence on various biological aspects has been studied since antiquity, and can be found in the writings of Theophrastus (372 to 287 BC) and Cato the Elder (234 to 149 BC). One of the areas of greatest interest to the forestry sector is the possible relationship between the felling period of a tree and the characteristics of the wood obtained. In recent years, several researchers have published collections of traditional recommendations regarding felling dates in a series of scientific articles (Fellner 1991, Triebel and Bues 2000, Zurcher 2000, Bues and Triebel 2005, Torelli 2005). The studies by Fellner (1991) and Triebel and Bues (2000) on forestry legislation refer to previous centuries. Today, aspects relating to felling dates and lunar phases have been eliminated from the current legislation.

The effect of the lunar phase affects terrestrial fluids. This influence may be reflected in the movement and distribution of the sap contained in plant tissues, as well as in their composition.

Susceptibility to attack by biological agents focused mainly on the incidence of fungi (Wazny and Krajewski 1984, Niemz and Kucera 2000, Zurcher 2003), wood-destroying insects (Niemz and Kucera 2000), and scolytids (Jahn 1982). Although this aspect presented the most significant results (Jahn 1982, Zurcher 2003), lunar influence was not always a factor (Wazny and Krajewski 1984, Niemz and Kucera 2000).

Regarding physical properties, the research has centered on moisture content, weight density, and hygroscopic shrinkage. The impact on moisture content has been highlighted in studies by Seeling (1998, 2000), Bariska and Rosch (2000), Zurcher (2003), Ikeda (2006), Bues and Kretschmar (2008), and Zürcher et al. (2009). In the case of wood from *Picea abies,* Zurcher (2003) and Zürcher et al. (2009) indicate significant relationships between the felling period and the proportion of water in the cell lumen, while Seeling (2000) determines a weak, although significant, relationship with moisture content. In contrast, no significant values were obtained in the work by Bariska and Rosch (2000) and Bues and Kretschmar (2008) carried out on *P. abies* to enable any possible influence to be established. Ikeda (2006) obtained similar results from the analysis of the behavior of wood from *Cryptomeria japonica*.

The influence on wood drying is determined by analyzing dimensional shrinkage. The scientific studies in

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this respect all indicate that no significant values were obtained that relate behavior during drying to the lunar phase of the felling. This is the case in studies carried out on *P. abies* by Seeling (1998, 2000), Bariska and Rosch (2000), and Niemz and Kucera (2000). Ikeda (2006) also obtained similar results when working with wood from *C. japonica*.

Possible alterations in density were studied by Zurcher (2003) and Zürcher et al. (2009) by analyzing the relationship between green density and ovendry density. They detected a systematic alteration in this variable according to the lunar phases of felling in both heartwood and sapwood (particularly in the latter).

The influence of the lunar phase of felling on the combustibility of the wood did not give any significant results (Seeling 1998, Niemz and Kucera 2000).

Current European scientific studies are based mainly on the analysis of the behavior of *P. abies* (Jahn 1982; Seeling 1998, 2000; Bariska and Rosch 2000; Niemz and Kucera 2000; Zurcher 2003; Bues and Kretschmar 2008; Zürcher et al. 2009). Very occasionally these works focus on other species, as in the studies by Wazny and Krajewski (1984) carried out on *Pinus sylvestris,* and several studies by Asian researchers on *Cryptomeria japonica* (Ikeda 2006, Takabe and Yoshimura 2006, Okawara 2008). Only in one case was the species studied a hardwood: the work by Zürcher et al. (2009) carried out on sapwood and heartwood of *P. abies* and on heartwood of *Castanea sativa*.

The present work is designed to establish the relationship existing between the lunar felling date and alterations in the physical properties in a ring-porous hardwood. We selected the species *Quercus humilis* Mill. (=*Quercus pubescens* Willd.), commonly found in the provinces of Lleida and Huesca, belonging to the large genus of *Quercus*. The following characteristics were analyzed:

- Radial shrinkage
- Tangential shrinkage
- Volumetric shrinkage
- Green moisture content
- Weight density of green wood
- Weight density of ovendry wood

## Materials and Methods

The wood to be analyzed was obtained from the estate ''El Serrat,'' located in the district of Arén (province of Huesca), whose coordinates are latitude 42°15′26″N and longitude 0°43′12″E. The scrubland consists of a monospecific stand of *Quercus humilis* Mill., with poles originating from seeds and shoots.

A total of 60 trees of over 15 cm in diameter and 1.3 m in height were selected from around the stand. By using random numbers, four groups of 15 trees were formed, which were subsequently felled in the four lunar phases (full moon, last quarter, new, and first quarter) in the same lunar month. The felling dates were November 4, 11, 20, and 27, 2002.

A 40-mm-wide slice was removed from each tree at a height of 1.3 m and then immediately numbered and placed inside a sealed plastic bag. Within 24 hours, the slices were sent the Wood Laboratory at Lleida University, where they were marked with a bisecting line between the largest and smallest diameters. Two parallel cuts were made with a band saw 20 mm to each side of this line, which after subsequent cutting and planing, gave a radial section measuring 20 by 20 mm. Finally, two 20-mm cubes of pure sapwood were removed, each with a 20-mm edge (from each of the ends nearest the outside of the trunk), and another two cubes of pure hardwood (from the two ends furthest from the center of the rings) were removed. In some cases, this was not possible because of the limited thickness of the sapwood. Based on the stream obstruction of the transporter cells throughout heartwood formation, we were able to group the samples into sapwood and heartwood. These two types of wood behave differently because of changes in their permeability and moisture content.

The weight and the three dimensions (measured with a micrometer) were obtained for each sample in the three main hygroscopic conditions: newly cut wood, wood stabilized under laboratory conditions (equilibrium), and wood dried in an oven at 103°C. The following characteristics were calculated based on these values:

$$\mathrm{GMC} = \frac{W_g - W_o}{W_o} \cdot 100 \quad (1)$$

$$\mathrm{EMC} = \frac{W_e - W_o}{W_o} \cdot 100 \quad (2)$$

$$D_g = \frac{W_g}{V_g} \quad (3)$$

$$D_o = \frac{W_o}{V_o} \quad (4)$$

where

GMC = green moisture content,
EMC = equilibrium moisture content,
$D_g$ = green weight density,
$D_o$ = ovendry weight density,
$W_g$ = green weight,
$W_e$ = equilibrium weight,
$W_o$ = ovendry weight,
$V_g$ = green volume, and
$V_o$ = ovendry volume.

$$s_r = \frac{L_{rg} - L_{ro}}{L_{ro}} \cdot 100 \quad (5)$$

$$\alpha_r = \frac{L_{re} - L_{ro}}{L_{ro} \cdot \mathrm{EMC}} \cdot 100 \quad (6)$$

$$s_t = \frac{L_{tg} - L_{to}}{L_{to}} \cdot 100 \quad (7)$$

$$\alpha_t = \frac{L_{te} - L_{to}}{L_{to} \cdot \mathrm{EMC}} \cdot 100 \quad (8)$$

$$s_v = \frac{V_g - V_o}{V_o} \cdot 100 \quad (9)$$

$$\alpha_v = \frac{V_e - V_o}{V_o \cdot \mathrm{EMC}} \cdot 100 \quad (10)$$

where

$s_r$ = total radial shrinkage,
$s_t$ = total tangential shrinkage,
$s_v$ = total volumetric shrinkage,
$\alpha_r$ = radial shrinkage coefficient,
$\alpha_t$ = tangential shrinkage coefficient,
$\alpha_v$ = volumetric shrinkage coefficient,
$L_{rg}$ = radial green length,
$L_{re}$ = radial equilibrium length,
$L_{ro}$ = radial ovendry length,
$L_{tg}$ = tangential green length,
$L_{te}$ = tangential equilibrium length,
$L_{to}$ = tangential ovendry length,
$V_g$ = green volume,
$V_e$ = equilibrium volume, and
$V_o$ = ovendry volume.

Using these basic characteristics we studied the relationship between radial and tangential shrinkage in order to detect possible influences on the transversal deformation expressed both by the differences and by the quotients. We also calculated the value of the relationship between green density and ovendry density studied by Zürcher et al. (2009).

The statistical analysis was done using language R, applying the graphic interface R Commander. To prevent the *tree* effect from interfering in the results (as mentioned by Seeling 2000), the values analyzed were the mean of the two sapwood samples and the mean of the two heartwood samples from each tree.

The fit of the normal distribution of the samples was determined using the Kolmogorov-Smirnov test. Given that the number of samples is near 50 (the value at which this method is recommended), it was verified with the nonparametric Shapiro-Wilk test. The homoscedasticity of the sample was examined with Bartlett's homogeneity of variances test. Subsequently an analysis of variance test was done with one factor (taking the lunar phase during felling as the independent variable). Due to the fact that in 20 percent of cases the conditions of normality were not fulfilled, a verification was done using the nonparametric Kruskal-Wallis test.

As well as the basic physical properties, the relationships between transversal shrinkages (radial–tangential) and between weight densities (green–ovendry, as proposed by Zürcher et al. 2009) were also analyzed.

## Results

Tables 1 and 2 (referring to sapwood and heartwood, respectively) show the values obtained in the verification tests for normality and homoscedasticity.

The verification of normality using the Kolmogorov-Smirnov test indicates that none of the characteristics studied diverges significantly from the normal distribution. The verification using the Shapiro-Wilk test indicates three situations in which the $P$ values are less than 0.05 ($\alpha_r$ and $\alpha_t/\alpha_r$ in heartwood, $\alpha_v$ in sapwood).

Regarding the analysis of homoscedasticity using Bartlett's test (Tables 1 and 2), two cases were detected in which the conditions of homogeneity of variance were not met ($s_r$ in heartwood, and as in the previous case, $\alpha_t/\alpha_r$ in heartwood).

Apart from these four exceptions, the distribution of the data in the 20 remaining cases enabled the analysis of variance to be applied. When this was not possible, the values of the Kruskal-Wallis nonparametric analysis were calculated as shown in Table 3. This table shows that in no case (either in sapwood or in heartwood) does any property present significant results (less than 0.05). These values coincide with those obtained for conifers by Seeling (1998, 2000), Bariska and Rosch (2000), Niemz and Kucera (2000), Ikeda (2006), and Bues and Kretschmar (2008).

The relationship of the lunar phase of the felling date was also expressed using graphs showing the confidence intervals. Figure 1 shows the values of the relationship between green and ovendry weight density to verify the lunar effect indicated by Zürcher et al. (2009). Although the curves for sapwood and heartwood follow two parallel curves that reach a maximum at the full moon, it can be seen that the four intervals overlap, indicating that no significant values exist. It is worth noting that the behavior of this variable was equivalent (both in the relative position of the

*Table 1.—Values of the test to verify the normality of the distributions of the sapwood samples.*[a]

| | Kolmogorov-Smirnov | | Shapiro-Wilk | | Bartlett | |
|---|---|---|---|---|---|---|
| Parameter[b] | D | $P$ value | W | $P$ value | $X^2$ | $P$ value |
| $\alpha_r$ | 0.167 | 0.228 | 0.959 | 0.166 | 0.818 | 0.078 |
| $\alpha_t$ | 0.091 | 0.900 | 0.961 | 0.199 | 5.057 | 0.168 |
| $\alpha_v$ | 0.128 | 0.541 | 0.939 | 0.035* | 7.838 | 0.049* |
| $s_r$ | 0.074 | 0.982 | 0.981 | 0.754 | 1.992 | 0.574 |
| $s_t$ | 0.082 | 0.935 | 0.993 | 0.997 | 5.550 | 0.136 |
| $s_v$ | 0.061 | 0.997 | 0.990 | 0.972 | 3.189 | 0.363 |
| GMC | 0.116 | 0.671 | 0.951 | 0.088 | 3.667 | 0.300 |
| $D_o$ | 0.010 | 0.832 | 0.971 | 0.407 | 3.511 | 0.319 |
| $D_g$ | 0.115 | 0.679 | 0.956 | 0.128 | 1.739 | 0.628 |
| $\alpha_t/\alpha_r$ | 0.115 | 0.675 | 0.954 | 0.109 | 1.471 | 0.689 |
| $s_t/s_r$ | 0.105 | 0.786 | 0.973 | 0.471 | 0.986 | 0.805 |
| $D_g/D_o$ | 0.094 | 0.881 | 0.967 | 0.299 | 4.134 | 0.247 |

[a] Sample size = 39. D = Kolmogorov-Smirnov test statistic; W = Shapiro-Wilk test statistic; $X^2$ = Bartlett test statistic. * $P \leq 0.05$

[b] $\alpha_r$ = radial shrinkage coefficient; $\alpha_t$ = tangential shrinkage coefficient; $\alpha_v$ = volumetric shrinkage coefficient; $s_r$ = total radial shrinkage; $s_t$ = total tangential shrinkage; $s_v$ = total volumetric shrinkage; GMC = green moisture content; $D_o$ = ovendry weight density; $D_g$ = green weight density.

Table 2.—Values of the test to verify the normality of the distributions of the heartwood samples.[a]

| | Kolmogorov-Smirnov | | Shapiro-Wilk | | Bartlett | |
|---|---|---|---|---|---|---|
| Parameter[b] | D | *P* value | W | *P* value | $X^2$ | *P* value |
| $\alpha_r$ | 0.144 | 0.173 | 0.946 | 0.011* | 7.437 | 0.059 |
| $\alpha_t$ | 0.120 | 0.366 | 0.973 | 0.203 | 6.857 | 0.077 |
| $\alpha_v$ | 0.103 | 0.557 | 0.964 | 0.081 | 5.649 | 0.130 |
| $s_r$ | 0.695 | 0.938 | 0.967 | 0.115 | 10.080 | 0.0179* |
| $s_t$ | 0.101 | 0.589 | 0.983 | 0.568 | 3.390 | 0.335 |
| $s_v$ | 0.086 | 0.781 | 0.979 | 0.397 | 4.629 | 0.201 |
| GMC | 0.103 | 0.522 | 0.983 | 0.563 | 1.381 | 0.710 |
| $D_o$ | 0.095 | 0.655 | 0.980 | 0.437 | 1.014 | 0.798 |
| $D_g$ | 0.111 | 0.456 | 0.962 | 0.064 | 3.325 | 0.344 |
| $\alpha_t/\alpha_r$ | 0.117 | 0.394 | 0.9094 | 0.00033** | 7.8384 | 0.04947* |
| $s_t/s_r$ | 0.0721 | 0.9187 | 0.9847 | 0.6661 | 5.0316 | 0.1695 |
| $D_g/D_o$ | 0.117 | 0.3947 | 0.9767 | 0.3158 | 1.9042 | 0.5925 |

[a] Sample size = 59. D = Kolmogorov-Smirnov test statistic; W = Shapiro-Wilk test statistic; $X^2$ = Bartlett test statistic. * $P \leq 0.05$; ** $P \leq 0.01$.
[b] $\alpha_r$ = radial shrinkage coefficient; $\alpha_t$ = tangential shrinkage coefficient; $\alpha_v$ = volumetric shrinkage coefficient; $s_r$ = total radial shrinkage; $s_t$ = total tangential shrinkage; $s_v$ = total volumetric shrinkage; GMC = green moisture content; $D_o$ = ovendry weight density; $D_g$ = green weight density.

Table 3.—Results of the variance analysis and the Kruskal-Wallis test.[a]

| | Sapwood | | | | Heartwood | | | |
|---|---|---|---|---|---|---|---|---|
| | Variance analysis | | Kruskal-Wallis | | Variance analysis | | Kruskal-Wallis | |
| Parameter[b] | F | *P* value | K | *P* value | F | *P* value | K | *P* value |
| $\alpha_r$ | 0.392 | 0.759 | 2.878 | 0.411 | — | — | 4.620 | 0.202 |
| $\alpha_t$ | 0.362 | 0.781 | 0.196 | 0.978 | 0.491 | 0.690 | 2.411 | 0.492 |
| $\alpha_v$ | — | — | 0.985 | 0.805 | 0.698 | 0.557 | 3.322 | 0.344 |
| $s_r$ | 0.484 | 0.695 | 1.533 | 0.675 | — | — | 5.634 | 0.131 |
| $s_t$ | 0.224 | 0.879 | 0.599 | 0.896 | 0.308 | 0.820 | 1.997 | 0.573 |
| $s_v$ | 0.287 | 0.834 | 1.052 | 0.789 | 0.729 | 0.539 | 3.225 | 0.358 |
| GMC | 0.699 | 0.559 | 2.584 | 0.460 | 1.267 | 0.295 | 3.667 | 0.300 |
| $D_o$ | 0.185 | 0.906 | 0.418 | 0.936 | 1.909 | 0.139 | 4.801 | 0.187 |
| $D_g$ | 0.369 | 0.776 | 1.586 | 0.662 | 1.589 | 0.202 | 4.021 | 0.259 |
| $\alpha_t/\alpha_r$ | 0.787 | 0.5095 | 2.860 | 0.414 | — | — | 1.925 | 0.588 |
| $s_t/s_r$ | 0.562 | 0.644 | 1.360 | 0.715 | 0.872 | 0.461 | 2.467 | 0.481 |
| $D_g/D_o$ | 0.552 | 0.650 | 2.008 | 0.571 | 0.852 | 0.472 | 2.727 | 0.436 |

[a] The values of the analysis of variance which did not meet the criteria of normality or homoscedasticity have been eliminated. Sample sizes = 39 (sapwood) and 59 (heartwood). F = variance analysis test statistic; K = Kruskal-Wallis test statistic.
[b] $\alpha_r$ = radial shrinkage coefficient; $\alpha_t$ = tangential shrinkage coefficient; $\alpha_v$ = volumetric shrinkage coefficient; $s_r$ = total radial shrinkage; $s_t$ = total tangential shrinkage; $s_v$ = total volumetric shrinkage; GMC = green moisture content; $D_o$ = ovendry weight density; $D_g$ = green weight density.

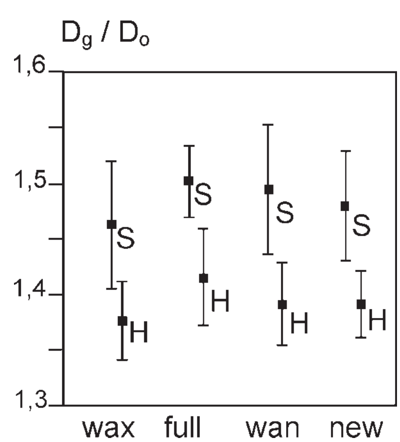


Figure 1.—Confidence intervals (95%) in the relationship between green weight density ($D_g$) and ovendry weight density ($D_o$). S = sapwood; H= heartwood; wax = waxing; wan = waning.

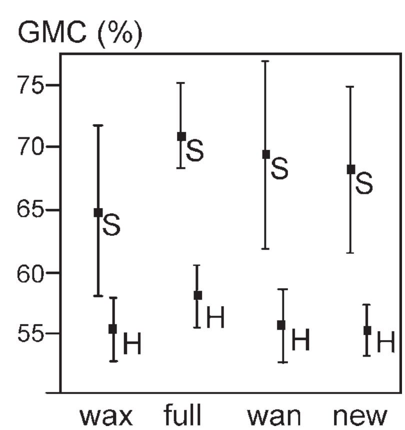


Figure 2.—Confidence intervals (95%) of green moisture content (GMC; in percentages). S = sapwood; H = heartwood; wax = waxing; wan = waning.

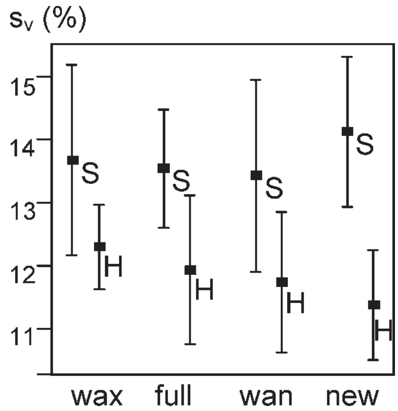


*Figure 3.—Confidence intervals (95%) of total volumetric shrinkage ($s_v$; in percentages). S = sapwood; H = heartwood; wax = waxing; wan = waning.*

means and in the breadth of the intervals) to the moisture content of the wood, as shown in Figure 2. This similarity leads us to surmise that it is preferable to study the moisture content rather than the relationship between weight densities because this relationship is a derived property.

Unlike the case of moisture content, in all the other characteristics the curves for sapwood and heartwood do not follow a parallel pattern. This can be seen for example in Figure 3, which contains the values for total volumetric shrinkage. The different trends in the behavior of sapwood and heartwood offer new evidence to argue against the alteration of the properties of wood due to the effects of the moon.

## Conclusions

The scientific study of the influence of the moon on wood has focused particularly on softwoods (*P. abies, C. japonica,* and *P. sylvestris*). Only one article was found in recent years that refers to tests carried out on hardwoods.

Despite the deeply rooted popular belief regarding the importance of the moon's phase on the date of tree felling, no significant results were obtained for any of the physical properties studied (moisture content, weight density, or shrinkage).

The results obtained in wood from *Q. humilis* coincide with those of most similar studies carried out using softwood.

We have confirmed the correctness of the elimination during the 20th century of the restrictions in forestry legislation regarding felling dates based on lunar phases.

The behavior of the variable for the relationship green weight density/wet weight density was equivalent to the variable for moisture content of the wood, so we recommend replacing it with the latter.

## Literature Cited


Bariska, M. and P. Rosch. 2000. Felling date and shrinkage behaviour of Norway spruce. *Schweiz. Z. Forstwes*. 151(11):439–443.

Bues, C. T. and K. Kretschmar. 2008. Moisture content and insect infestation at timber of Norway spruce (*Picea abies* [L.] Karst.), which was harvested at specific moon phases. *Forst Holz* 63(9):32–36.

Bues, C. T. and J. Triebel. 2005. The myth of moon timber. *Wiss. Z. Tech. Univ. Dresden* 54(1/2):70–76.

Fellner, J. 1991. Felling season and wood quality—A literature review. *Holzforsch. Holzverwert*. 43(1):25–28.

Ikeda, K. 2006. Green moisture content of sugi [*Cryptomeria japonica*] felled at the new of the moon and the full of the moon in every month. *Bull. Shizuoka Prefecture Forestry Forest Prod. Res*. 34:25–30.

Jahn, E. 1982. Studies on the attack of spruce trees by bark beetles in connection with moon phases during the period of cutting. *Anz. Schaedlingskd. Pflanzenschutz Umweltschutz* 55(10):145–149.

Niemz, P. and L. J. Kucera. 2000. Influence of the felling date in essential properties of Norway spruce—An investigation of published theses. *Schweiz. Z. Forstwes*. 151(11):444–450.

Okawara, M. 2008. Strength of sugi (*Cryptomeria japonica*) cut in woods on the day of the new moon of winter. *Bull. Saitama Prefect. Agric. Forestry Res. Cent*. 7:120–124.

Seeling, U. 1998. Doesn't non-wood shrink and burn? *AFZ/Der Wald, Allg. Forst Z. Waldwirtschaft Umweltvorsorge* 53(26):1599–1601.

Seeling, U. 2000. Selected wood properties of Norway spruce *Picea abies* (L.) Karst and its dependance on the date of felling. *Schweiz. Z. Forstwes*. 151(11):451–458.

Takabe, K. and T. Yoshimura. 2006. Biological evaluation of woods harvested at waning moon phase in winter. *Wood Ind*. 61(12):577–583.

Torelli, N. 2005. Moon timber—Myth or reality. *Zb. Gozdarstva Lesarstva* 76:71–101.

Triebel, J. and C. T. Bues. 2000. Reflections on the importance of felling date regulations dependent on moon-phases in forest regulations and other forestry-related literature from a forest history point of view. *Schweiz. Z. Forstwes*. 151(11):432–438.

Wazny, J. and K. J. Krajewski. 1984. Seasonal changes in the resistance of Scots pine to wood-destroying fungi. *Holz Roh- Werkst*. 42(2): 55–58.

Zurcher, E. 2000. Moon-related traditions in forestry and corresponding phenomena in tree biology. *Schweiz. Z. Forstwes*. 151(11):417–424.

Zurcher, E. 2003. Drying and weathering behaviour of Norway spruce Picea abies Karst wood felled according to moon phases. *Schweiz. Z. Forstwes*. 154(9):351–359.

Zürcher, E., R. Schlaepfer, M. Conedera, and F. Giudici. 2009. Looking for differences in wood properties as a function of the felling date: Lunar phase-correlated variations in the drying behavior of Norway Spruce (*Picea abies* Karst.) and Sweet Chestnut (*Castanea sativa* Mill.). *Trees—Structure and Function* 24:31–41. Published online August 26, 2009. DOI:10.1007/s00468-009-0376-2.