Reversible variations in some wood properties of Norway spruce (Picea abies Karst.), depending on the tree felling date

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REVERSIBLE VARIATIONS IN SOME WOOD PROPERTIES OF NORWAY SPRUCE (*PICEA ABIES* KARST.), DEPENDING ON THE TREE FELLING DATE

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ABSTRACT

Traditional knowledge, in the form of so-called rural rules, indicates that the date of tree felling has an important influence on wood quality. The main factor, after the season of the year, is said to be the position of the moon. The object of the research presented here was to study the variability of some user-related properties of wood, by analyzing measurable parameters. The material stems from four different Swiss sites and is representative of central European conditions. The study involved 576 trees — Norway Spruce (*Picea abies* Karst.) and Sweet Chestnut (*Castanea sativa* Mill.) — felled on 48 dates throughout the fall and spring of 2003–2004 (always on Mondays or Thursdays). Before the start of the experiment, one sample was taken on the same day from each of the tested trees, to serve as reference. Wood properties analyzed are: water-loss, shrinkage under controlled drying, air drying and oven drying density. The statistical analysis of the complete data series reveals (in addition to a seasonal trend) a generally weak, but highly significant role of the synodic and sidereal moon cycles and, to a lesser extent, the tropical cycle.

The lunar-related differences are more marked for the middle months of the trial. The most obvious variation in Spruce occurs between samples of trees felled immediately before the Full Moon and the samples immediately following

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Full Moon. Smaller series of Spruce samples were tested on hygroscopicity, compression strength and calorimetry. Here too, the strong value shifts observed around the Full Moon found a clear confirmation. The main variation factor for water uptake is however the type of forest and the site, a naturally grown mountain forest producing a clearly less hygroscopic wood. The results from this study bring some transparency and objectivity into a mainly unexplored field of traditional knowledge, a field subject to controversial discussions. Further research in chronobiology of wood could lead to an ecological technique enhancing specific wood properties.

Keywords: Wood properties, Forestry traditions, Moon phases, Drying, Water sorption, Compression strength, Calorimetry.

RECENT DEVELOPMENTS

The idea of a relationship between plant growth and moon cycles has often been considered by scientists as due to old superstitions. An interesting corpus of well documented experimental work is exists and suggests objective phenomena interacting at different levels. An extensive review of the available data and interpretations has recently been published in a book on botany (Zürcher 2008, 2011), based on a series of 88 scientific publications related to this topic.

Since we started working on the field of tree chronobiology linked to lunar rhythms, it has been possible to observe significant relationships for different aspects of tree life and wood properties. Here is a short overview:

- The germination and initial growth of some tropical trees show a decided rhythmic character. Speed of germination, percent of germination, average height, and maximum height after 4 months are systematically related to the timing of sowing in relation to the moon phase (Zürcher 1992, 2000).
- An interdisciplinary reworking of previously published, long-term tree-physiological research results (variations of tree diameters obtained by extensometry) has enabled researchers to consider an unexpected aspect: the synodic (time required for the moon to complete a full phase, i.e., usually 29.53 days) moon-rhythm at a daily level (gravimetric tide-rhythm) could be established for trees held under constant conditions (darkness) (Zürcher, Cantiani, Sorbetti-Guerri and Michel 1998).
- Data of trees measured in open conditions, reanalyzed recently with more sophisticated tools, brought spectacular confirmation of the role of lunar tides in tree physiology (Barlow, Mikulecky and Strestik 2010). In the meantime, it was possible to detect the same type of fluctuations by measuring with a high-sensitivity device the low-potential electric currents along the trees' stems, depending on the physiological phase of the trees (Holzknecht and Zürcher 2006).
- The drying behavior (water loss/shrinkage) and the final density of wood systematically and coherently vary in function of the tree felling date, if analyzed in relation to the season and to the position of the moon (Zürcher and Mandallaz 2001). The observed fluctuations are yet more complex than mentioned in forestry traditions existing all over the world (Zürcher, Schlaepfer, Conedera and Giudici 2010).

Traditional knowledge and practices concerning agricultural and forestry activities - so-called rural rules - are still widespread in various cultures on different continents. Among them, rules exist about effects of the tree-felling date on the properties of wood (Hauser 1973, Broendegaard 1985, Oldeman 1999, Cole and Balik 2010). The first written evidence of this knowledge dates back to Theophrastus of Eresos (372-287 BC), who in his History of Plants (V, 1, 3) states that there is an appropriate season for cutting the trees and – within the season - if cutting at the beginning of the waning moon, the wood is harder and less likely to rot. This popular knowledge has been passed down to our times and to the local practices of felling trees during different moon positions depending on the specific forms of wood utilization (Zürcher 2000). Despite such a broad and antique tradition in referring to the moon phases for determining the most suitable date for agricultural (e.g. seeding) and forestry (e.g. tree-felling) activities, there are relatively few scientific research works on this topic. For an extensive scientific review about lunar periodicities in Biology see Endres and Schad (1997).

In wood physics, the wood-water relations have been extensively studied (Skaar 1988; Navi and Heger 2005), but not yet including "time" as a possible initial, rhythmic factor of variation in the sample properties; the role of this factor appears at present mainly in the sorption hysteresis and in the viscoelastic behavior. Two publications can nevertheless be cited in relation to the apparently fluctuating plant-water relations at issue, where the time factor "Moon" plays an essential role in living vegetals. Experimental based studies with Bean seeds (*Phaseolus vulgaris*) exist on the lunar cycle dependent water uptake during immersion by a dormant reproductive material (Brown and Chow 1973, Spruyt et al. 1987).

Concerning the role of the lunar phase at the felling date, three almost simultaneous, geographically independent research studies investigated selected wood properties of Norway Spruce with 120 trees in Dresden (Triebel 1998), 60 trees in Freiburg i.Br. (Seeling and Herz 1998, Seeling 2000) and 30 trees in Zürich (Rösch 1999, Bariska and Rösch 2000) respectively. However, none of these three investigations, with 6 felling dates each, could at first significantly confirm the influence of the moon-correlated felling date on the wood properties tested.

The data collected from the 30 trees by Rösch (1999) were reanalyzed, regarding oven-dry wood density as a dependent variable in the same sense as water-loss and shrinkage (Zürcher and Mandallaz 2001, Zürcher 2003). This approach led to encouragingly significant results on the criteria water-loss, shrinkage and relative density (oven-dry density in percent of initial fresh / "green" density).

LARGE SCALE RESEARCH

In order to fill the existing gaps in the choice of the previous experimental felling dates and to obtain a suitable data set for a broader statistical analysis, we set up a large (in terms of number of trees, experimental sites and felling dates) and systematic (always at the same days of the week) tree-felling experiment. The aim was to test the existence of a physical phenomenon of lunar-related variations in some selected wood properties as suggested by the ancient, traditional rules and practices.

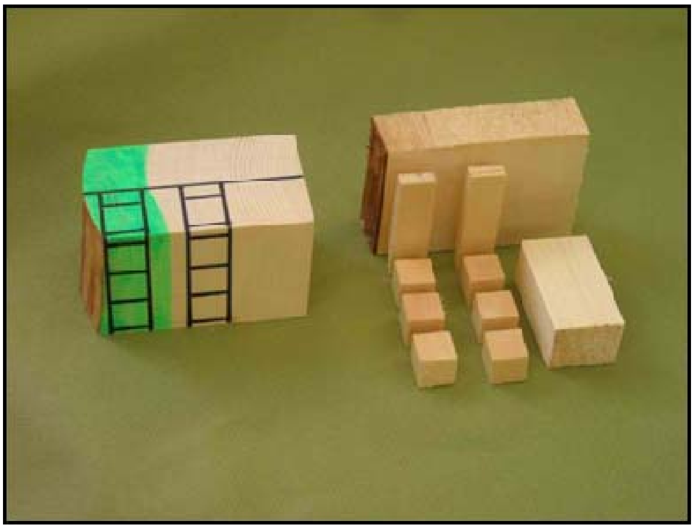

Figure 1. Preparation of test samples from Spruce (left: sapwood / right: outer heartwood).

In particular, we wanted to examine the occurrence of rhythmic, time-dependent cyclic variations in the wood-water-relation in correlation with three different types of moon rhythms or cycles. Moreover, different tree species (Norway Spruce and Sweet Chestnut) and different wood types (sapwood and heartwood) within the tree were analyzed separately.

The wood material tested comes regularly and simultaneously from four different Swiss sites representative for Central European conditions. Per main site, 144 Norway Spruce (*Picea abies* Karst.) trees or Sweet Chestnut (*Castanea sativa* Mill.) trees have been felled. These 576 trees were felled at 48 dates (06.10.2003 - 18. 03.2004, always on Mondays and Thursdays). Before the start of the experiment, one reference sample had been taken in the same day from each of the later felled trees (prismatic sample at breast height). Spruce samples were taken both from sap- and outer heartwood (Figure 1), Chestnut samples from heartwood only – the sapwood zone being too narrow in this species. This report presents the obtained variations in values of water loss under controlled drying, relative density (ratio oven-dry density / fresh density) and hygroscopicity of previously dried samples for the main studied species - Norway Spruce.

The data are reported here in a descriptive and graphical way, the statistical analysis being presented in Zürcher, Schlaepfer, Conedera and Giudici (2010). To illustrate the discovered lunar-related phenomena, we will concentrate on one representative site (Château d'Oex) and one type of wood (sapwood), adding the results of mechanical tests and analysis of energy content (calorimetry) on specific smaller series.

In all cases, strong time-dependent and inter-dependent variations were observed. According to variance analyses based on the totality of data (4032 values per criterium), a highly significant part of the changes in the values for water loss, shrinkage and relative density (oven-dry density green density) occurs in tune with the moon phases and its astronomical positions (synodic, tropic and sidereal rhythms).

The implication of the time-independent reference-density of each tree allows us to confirm the significance of the tested lunar models and to estimate their respective explicative power.

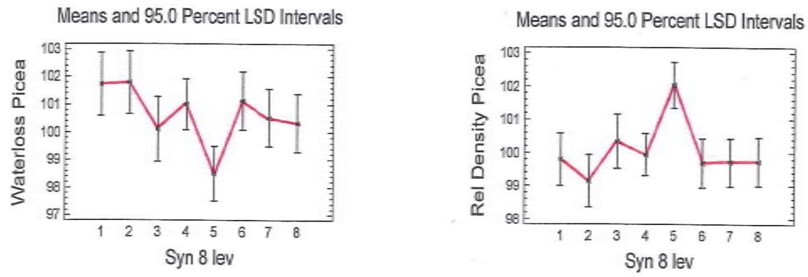

Figure 2. Lunar synodic variations of Water Loss (A) and Relative Density (B) of Norway Spruce (sapwood and heartwood), when dried from "green" to oven-dry state. Mean values with 95% least significant differences. The vertical bold lines indicate the times of full moon, the dotted lines the times of new moon.

If the synodic lunar month (4 quarters) is subdivided in 8 periods of about 3.5 days each ("syn1" to "syn 8"; "syn 1" beginning with the New Moon NM, "syn 5" beginning with the Full Moon FM), one of the strongest "jumps" is occurring around FM, from "syn4" to "syn 5". The clearly opposite variations in Waterloss (Figure 2 A) and Relative Density (Figure 2B) illustrate the importance of the wood-water interface, which obviously undergoes lunar-correlated reversible changes. The variance analysis relatively to the sidereal Moon cycle (position of the Moon in the zodiacal constellations) showed very high levels of significance as well, compared to the synodic cycle.

Therefore, these results confirm the existence of the "Moon" factor as mentioned in traditional knowledge, but in a much more complex form (Theophrastus' rule seeming to be nearest to the synodic phenomena observed here on Spruce).

FOCUSING ON ONE REPRESENTATIVE SITE

These systematic variations in the course of the synodic lunar month can be illustrated on the variation curve of the criteria "Relative Density" (Figure 3) and Water Loss (Figure 4) among the 48 successive felling dates, for a representative series: Sapwood samples from the site Château d'Oex (even-aged planted mountain Spruce stand). The following table indicates what fellings occurred directly before and directly after Full Moons, with the 6 corresponding dates (Table 1).

Table 1. Tree fellings around Full Moons, and their exact dates

Felling dates (before FM / after FM)	Days of Full Moon (FM)
2 / 3	October 10, 2003
10/11	November 9, 2003
19/20	December 8, 2003
27/28	January 7, 2004
36/37	February 6, 2004
44/45	March 7, 2004

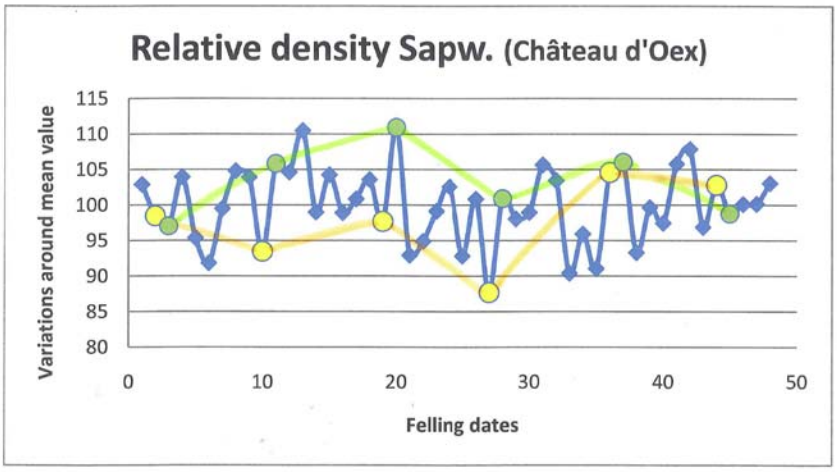

Figure 3. Variation curve of Relative Density of sapwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: O = fellings in the 3.5 days before FM / O = fellings in the 3.5 days after FM. Each point represents 12 values (here without std.dev.).

Table 2. Values of Relative Density in the 3.5 days before Full Moon (bFM), compared to the values in the 3.5 days after (aFM) and their difference, for the winter period November to February

Relative density (Sapwood)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	93.5	97.7	87.7	104.6	-	Increase
aFM (syn5)	-	105.8	110.9	100.9	106	-	
Variation [%]	-	12.3	13.2	13.2	1.4	-	+ 10.0

As can be observed, during the four winter months, from November (felling 10/11) to February (felling 36/37), the values before FM are always lower than the ones after. Before and after this core period in the first and the last weeks of the trial (October and March), the variations do not seem to follow the same lunar-related rule. The corresponding values for the middle 4 months around the global site mean (100%) are given in the Table 2, with their differences and an estimation of the mean increase in Relative Density (10%).

The cause for these variations in Relative Density lies in similarly fluctuating values in the loss of free and bound water during the controlled drying process, but also in an opposite sense (Figure 4 / compare also Figure 2A with 2B). Here too, marked differences around Full Moons occur in middle winter months only. Table 3 indicates the respective variations around the FM during this period, the general mean being a reduction in Water Loss of 4.5%.

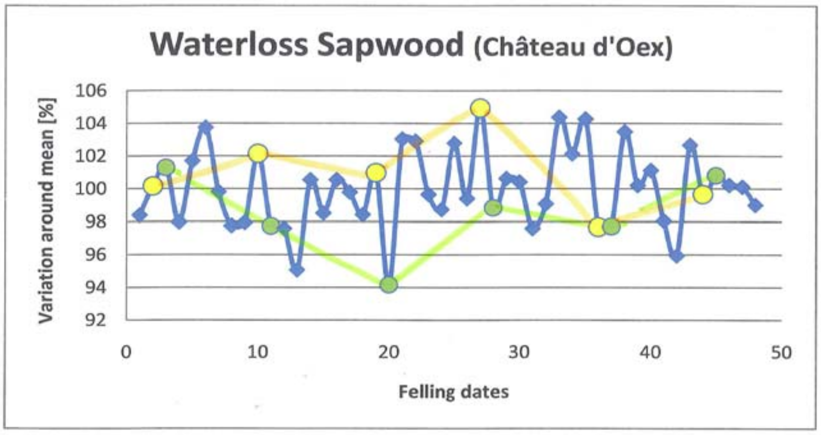

Figure 4. Variation curve of Water Loss of sapwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: O = fellings in the 3.5 days before FM / O = fellings in the 3.5 days after FM. Each point represents 12 values (here without std.dev.).

Table 3. Values of Water Loss in the 3.5 days before Full Moon (bFM), compared to the values in the 3.5 days after (aFM) and their difference, for the winter period November to February

Waterloss (Sapwood)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	102.2	101	104.9	97.7	-	
aFM (syn5)	-	97.7	94.2	98.3	97.7	-	Reduction
Variation [%]	-	-4.5	-6.8	-6.6	0	-	- 4.5

TESTS ON WATER SORPTION (AFTER DRYING)

One of the most important physical properties of wood, decisive for weathering behavior and for decay resistance is its hygroscopicity. This feature is usually expressed as Equilibrium Moisture Content EMC under a given atmosphere, or as Fiber Saturation Point FSP, below which the loss of bound water in the drying process provokes shrinkage. The test method chosen for estimating the expected variations of hygroscopicity was to expose the samples to direct contact with water. One series was made of air-dried and conditioned sticks with dimensions of 16*7*65 mm (see Figure 1). These were all fixed together (12 * 48 = 576 samples per site) at one end to a plate, 5 mm, with the other end being immersed for 9 minutes in a basin of water colored with ink. The capillar ascent of water was estimated by calculation of the relative weight increase. Figure 5 shows the variations of water sorption by capillarity in samples collected during this period of 24 weeks (48 tree fellings). Both the limitation of the "lunar effect" on the 4 winter months and the systematic drop directly after the FM is very similar to what was observed on initial Water Loss. A noticeable fact is that for capillarity, the mean amplitide of this decrease (25.9%) is much more pronounced (see Table 4).

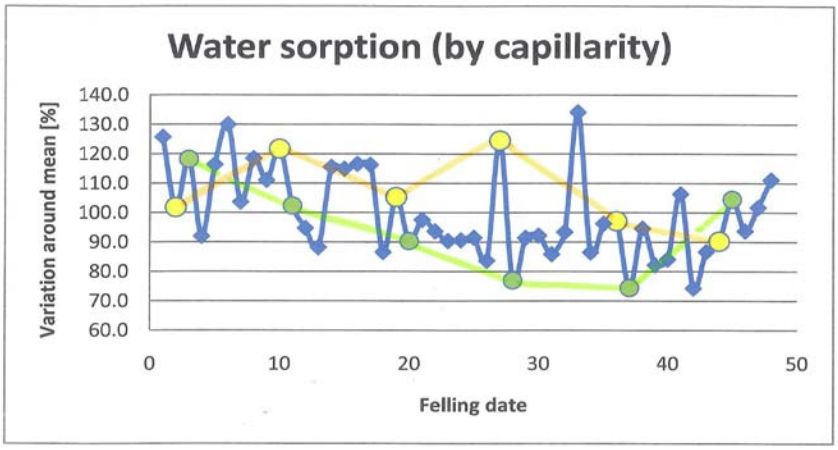

Figure 5. Variation curve of capillar Water Sorption of sapwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: O = fellings in the 3.5 days before FM / O = fellings in the 3.5 days after FM. Each point represents 12 values (here without std.dev.).

Table 4. Values of capillar Water Sorption in the 3.5 days before Full Moon (bFM), compared to the values in the 3.5 days after (aFM) and their difference, for the winter period November to February

Water sorption (by capillarity)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	121.7	105.3	124.6	96.3	-	
aFM (syn5)	-	102.4	90.3	77	74.5	-	Reduction
Variation [%]	-	-19.3	-15	-47.6	-21.8	-	-25.9

The second test method for hygroscopicity was applied by immersion of the samples previously used for density determination. In a similar way, 576 cubic samples for each site (4 per tree, 12 per felling date) were dipped into water (20°C) for 7 days (168 hours).

The sorption is given by the mass percentage increase. The variation curve (Figure 6) is represented relative to the general mean of the whole series. Here too, the systematic lunar variations of sorption occur in obvious coherence with the Water Loss, and inversely to the Relative Density. Table 5 indicates that the mean reduction in sorption from the days before to the days after the Full Moon is 12.6%, half the value obtained for capillar water uptake.

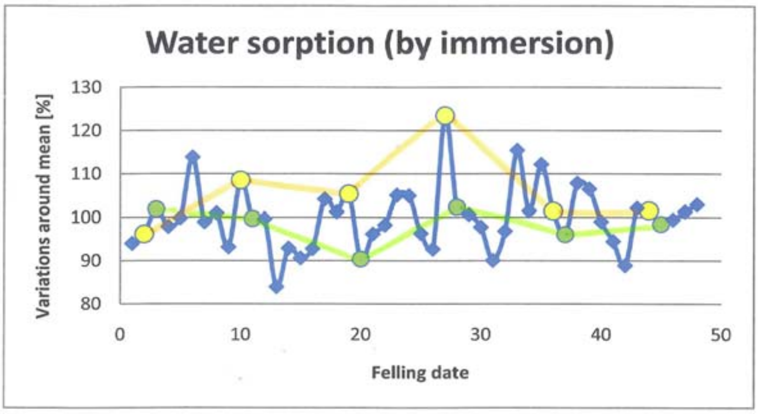

Figure 6. Variation curve of Water Sorption by immersion of sapwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: O = fellings in the 3.5 days before FM / O = fellings in the 3.5 days after FM. Each point represents 12 values (here without std.dev.).

Table 5. Values of Water Sorption by immersion in the 3.5 days before Full Moon (bFM), compared to the values in the 3.5 days after (a FM) and their difference, for the winter period November to February

Water sorption (by immersion)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	108.5	105.4	123.5	101.5	-	
aFM (syn5)	-	99.7	90.4	102.4	96.1	-	Reduction
Variation [%]	-	-8.8	-15	-21.1	-5.4	-	-12.6

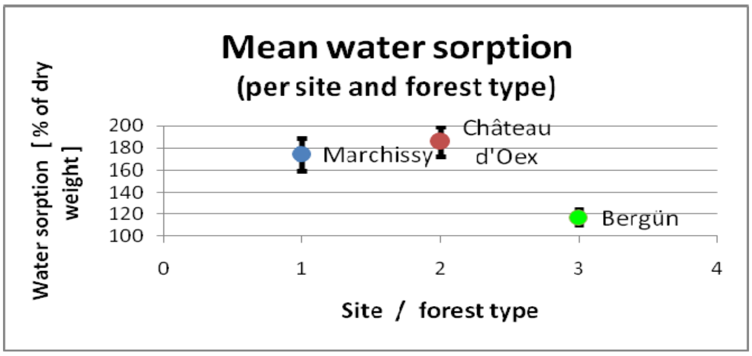

Figure 7. Mean water sorption after 7 days immersion (in % of dry weight, with standard deviations) of samples from Spruce plantations (Marchissy, sapwood / Château d'Oex, sapwood), compared to samples from a naturally grown mountain forest (Bergün, heartwood). Each mean value represents 576 samples.

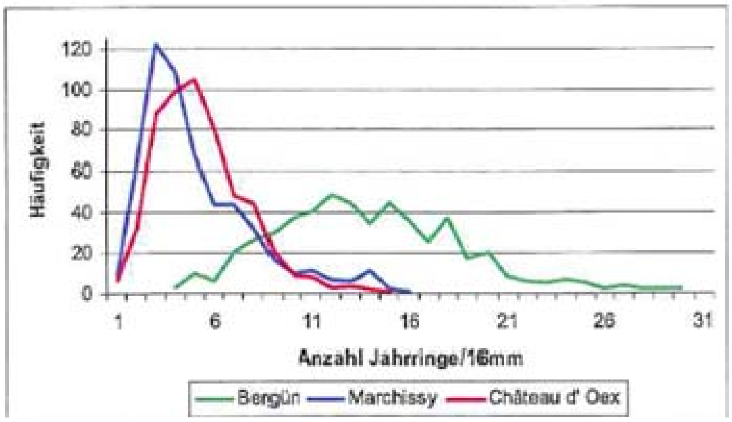

Figure 8. Distribution of growth ring numbers on 16 mm-samples from 2 plantation sites (Marchissy and Château d'Oex) and one natural mountain forest (Bergün). X-axis: Number of growth rings per 16 mm-samples / Y-axis: Frequency.

It must be stressed that lunar or seasonal variability in water sorption plays a secondary role compared to the much more pronounced effect of forest type, site and sample provenance in the stem. Wood from naturally grown alpine forests (Bergün, 1550 m) was compared to wood from planted Spruce trees in an alpine site as well (Château d'Oex, 1200 m) as from a planted stand in low altitude (Marchissy, 650 m), in terms of absolute values of water sorption during 7 days of immersion (all samples having been previously dried at the same level).

For this comparison, heartwood samples have been used from the Bergün material (slow-grown mountain timber showing a narrow peripheral sapwood zone) and sapwood samples were used from the fast-grown plantation wood of Château d'Oex and Marchissy (where this outer zone is much wider and usually present in parts of sawn products).

The difference in hygroscopicity is considerable - the Bergün samples absorbing 43% less than the Marchissy samples and 46% less than the Château d'Oex samples (Figure 7).

Additional tests with naturally grown alpine wood have shown that this difference is not due to the fact that the Bergün samples came from the heartwood zone: in such a situation, the permeability of sapwood is only slightly higher than the one of heartwood.

Possible differences in density do not explain this exceptional hygroscopic behavior, all three sample series having a similar low weight: the oven-dry density of the Bergün samples was 0.401 g/cm3 (Stdev 0.018), the one of the Marchissy samples 0.398 g/cm3 (Stdev 0.032) and Château d'Oex 0.379 g/cm3 (Stdev 0.021). As an expression of the respective growth dynamics, the Marchissy and Château d'Oex samples have a similar growth ring configuration (generally fewer rings per sample), compared to Bergün, with significantly more rings per sample (Figure 8). Despite the fact that a certain number of Bergün samples were wide-ringed and some Marchissy / Château d'Oex samples narrow-ringed, there was no such superposition in their hygroscopicity (Figure 7). This underlines clearly the importance of the forest type and sylviculture at the origin of a strongly different sorptive behavior (in immersion as well as by capillarity) - wood from natural mountain forests showing an unexpected advantage (presented here for the first time).

COMPLEMENTARY TESTS ON COMPRESSION STRENGTH

Complementing the experiments on hygroscopic behavior of Spruce wood, mechanical tests have been performed in order to determine a representative feature: the compression strength parallel to the grain. Samples of transverse section 20 mm x 20 mm have been tested according to the current DIN/EN standards with a universal test machine "Zwick/Roell" (2050).

Out of the complete test series dealing with 548 samples, the values corresponding to the tree felling dates around the Full Moons (6 x 2 = 12 dates), based on 132 samples, are presented here. This allows direct comparisons with the lunar-periodic reversible variations in density and in hygroscopicity. A similar fluctuation can be observed here as for the Relative Density (Figure 9, to be compared with Figure 3). Additionally, the same mean amplitude of increase is calculated for the 4 winter months (Table 6), the global difference being significant too (P-value = 0.004).

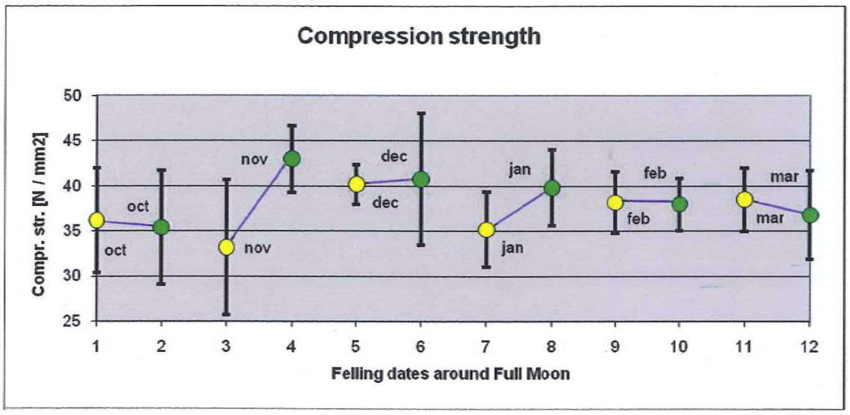

Figure 9. Variations of compression strength parallel to the grain of sapwood /outer heartwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: 1, 3, 5, 7, 9, 11, marked by O , for fellings in the 3.5 days before FM / 2, 4, 6, 8, 10, 12, marked by O , for fellings in the 3.5 days after FM. Each point represents in average 11 values (here with corresponding std.dev.).

Table 6. Values of Compression strength parallel to the grain in the 3.5 days before the Full Moon (bFM), compared to the values in the 3.5 days after (aFM) and their difference, for the winter period November to February

Compression strength (in N / mm2, parallel to the grain)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	33.2	40.2	35.2	38.2	-	
aFM (syn5)	-	43.0	40.8	39.8	38.0	-	Increase
Variation [%]	-	+ 29.5	+ 1.5	+ 13.1	- 0.5	-	+ 10.9

COMPLEMENTARY TESTS ON CALORIMETRY

The calorific value is another important physical feature of wood, decisive for its energetic use. This value is usually expressed per unit of weight, with an average amount of ca. 19 MJ/kg for absolutely dry wood (Fengel and Wegener 2003). In a more practical way, the energy content of wood can also be determined per unit of volume (the form in which commercialization occurs), taking into account differences in density inside one species, but also between species.

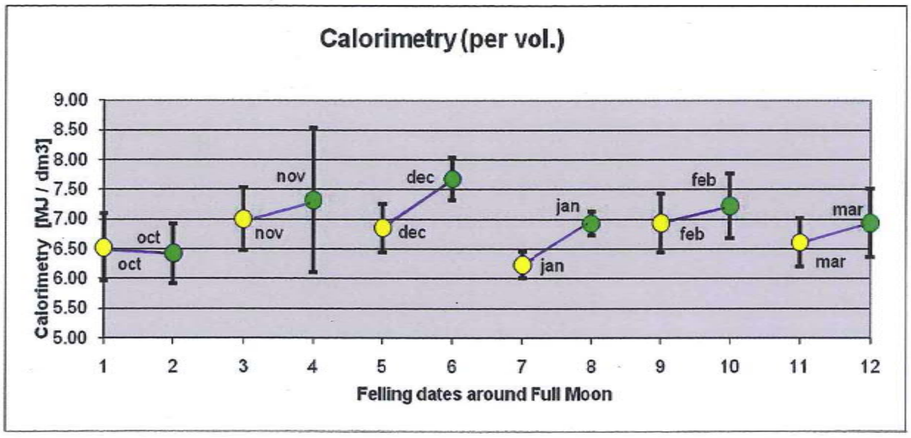

Figure 10. Variations of calorific values per volume of sapwood /outer heartwood samples of Spruce from Château d'Oex. Legend of fellings around Full Moon: 1, 3, 5, 7, 9, 11, marked by O , for fellings in the 3.5 days before FM / 2, 4, 6, 8, 10, 12, marked by O , for fellings in the 3.5 days after FM. Each point represents in average 9 values (here with corresponding std. dev.).

Table 7. Values of calorimetry in the 3.5 days before Full Moon (bFM), compared to the values in the 3.5 days after (aFM) and their difference, for the winter period November to February

Calorimetry (in MJ / dm3)							
Variation from value before FM (syn 4) to value after FM (syn 5)							
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean [%]
bFM (syn4)	-	7.00	6.85	6.24	6.94	-	
aFM (syn5)	-	7.32	7.68	6.93	7.23	-	Increase
Variation [%]	-	+ 4.6	+ 12.1	+ 11.1	+ 4.2	-	+ 8.0

A number of 102 Spruce sapwood samples of cubic shape ca. 16 mm x 16 mm x 16 mm in size have been tested according to the current ISO 1716 standards with a calorimetry device from Fire Testing Technology U.K., using a “calorimetric bomb” from Parr Instrument Company, Illinois, USA. For each of the felling dates around the Full Moons (6 x 2 = 12 dates), 3 samples from 3 trees (9 samples in total) were tested (in two cases, only 6 samples were available), which made a total of 102 calorimetric tests (Rambert 2011). While the mean calorific value per unit of weight was 19.92 MJ/kg, with a standard deviation of 0.25 - representing a variation coefficient of only 1% - the mean calorific value per unit of volume was 6.90 MJ/dm3, with a standard deviation of 0.67 - representing a considerable variation coefficient of 10%. A similar fluctuation can be observed here as for the Relative Density (Figure 10, to be compared with Figure 3). Additionally, an analogous mean amplitude of increase is calculated for the 4 winter months (Table 7), the global difference for the months November - February being highly significant here as well (P-value = 0.002).

CONCLUSION

From these results and observations, following 4 points can be stressed:

- Moon-related reversible variations are not limited to Water Loss, Relative Density (and Shrinkage) during the drying process: they are an even more marked phenomenon at the level of water sorption (capillary and by immersion) by previously dried wood samples
- The variations in hygroscopicity (water sorption) are however much weaker than the differences due to the site and to the type of sylviculture, samples from a naturally grown mountain forest showing a much lower water uptake than samples from planted Spruce stands
- The mechanical and calorimetric tests show moon-related reversible variations as well, consistent with the variations in density. It must be stressed that in addition to the calorific value, combustibility (ability to burn easily) plays an important role in energetic use of wood. Specific laboratory tests on samples of Château d’Oex showed similar variations around the Full Moon as for Waterloss, but in a much lower amplitude. This result would be consistent with the traditional rule that good firewood is obtained during the waxing Moon (before Full Moon)
- These systematic and coherent lunar rhythmicities occur clearly only during the 4 months November to February, which indicates that both season and lunar cycles are involved
- These encouraging results need to be confirmed by durability tests before drawing a definitive conclusion in the sense of general outdoors applicability for Spruce. The plausible difference in terms of decay resistance of Spruce wood can nevertheless be supposed as follows: lower durability from fellings shortly before Full Moon - higher durability from fellings immediately after Full Moon between November and February.

Table 8 gives a general overview of the obtained results:

Table 8. Changes in the presented criteria, for samples of Spruce wood from the 3.5 days before Full Moon, compared to the values of samples from the 3.5 days after FM

Comparative changes around Full Moon (in the months November, December, January, February)		
Features	Samples from 3 ½ days before Full Moon (syn.4)	Samples from 3 ½ days after Full Moon (syn.5)
Relative Density	lower	Higher
Water Loss	higher	Lower
Water Sorption (by capillarity)	higher	Lower
Water Sorption (by immersion)	higher	Lower
Compression strength	lower	Higher
Calorific value (per unit of volume)	lower	Higher

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