TWO COMPLEMENTARY INDICATORS TO RANK VARIOUS OAK WOOD DEFECTS ACCORDING TO DIFFERENT USERS' ADVICE*

S. CAVAIGNAC†, G. LE MOGUÉDEC, and G. NEPVEU

Equipe de Recherche sur la Qualité des Bois (Wood Quality Research Team),
Laboratoire d'Etude des ressources Forêt Bois (LERFoB),
INRA – Centre de Recherches de Nancy, 54280 Champenoux, France

(Received for publication 1 November 2005; revision 2 June 2006)

ABSTRACT

Oak is the most important species in French forestry. This wood is purchased by a great variety of firms, with prices that can range on a scale from 1 to 100. The main determinant of wood use is its quality and this depends on the presence or absence of defects in the wood. There is a great diversity of defects, but their importance for estimation of wood quality is not well-known. We have formulated a methodology for measuring the severity of defects in the final use of the wood. The measurement is based on two complementary indicators. The first one evaluated the drop in price caused by the presence of defects on individual logs sold during German sales of felled logs. As prices are linked not only to the severity of defects and as we did not come across a complete range of users or defects during this sale, a second indicator was constructed to complement the first one. This second indicator was based on a survey in which people were asked to sort virtual logs in order of preference. This methodology is useful for an initial approach to the problem but some improvements are needed to provide complete answers.

Keywords: wood quality; wood prices; defects ranking; preference analysis; users' advice; *Quercus robur*; *Quercus petraea*.

INTRODUCTION

The two main French oak species (*Quercus robur* L. and *Quercus petraea* Liebl.) are important in French forest management. Oak accounts for almost one-third of the forest area (Barry-Lenger & Nebout 1993). Broadleaved forest is the most extensive and oak species have the greatest representation (Pradeille 2002).

---

* Based on a paper presented at IUFRO WP S5.01.04 Fifth Workshop on Wood Quality Modelling, 20–27 November 2005, Waiheke Island, New Zealand

† Corresponding author: cavaigna@nancy.inra.fr

Consequently, these species feature in forest policy questions, such as production optimisation (Nepveu *et al.* 2002), biodiversity (Ducousso & Jarret 2001), landscape (Pausas *et al.* 2004), forest employment (Picard & Gizard 2001), or carbon sequestration (Cannel 1995; Linder 1998).

Because of this, it seems important to focus on oak defects for two main reasons. On the one hand, the defects determine the wood quality and thus the future utilisation and prices, and this is required information for the forest manager or for studying the oak wood industry. On the other hand, simulations of forest systems contribute to the answers to questions tackled previously. The LERFoB growth and yield simulator, called Fagacées (Dhôte 1994), already provides a large range of information such as tree dimensions, diameter, and scrolling of different compartments (bark, sapwood, hardwood, knotty heart). These parameters allow the effects of silviculture on the quantity and quality potential for destined products to be estimated. Nevertheless, the results provided by simulations are too optimistic in terms of yield or product quality (Bucket 2005). The main reason is that a lot of peculiarities are not yet taken into account by the simulator. Wood classification standards show that more than 40 types of defects can be distinguished but it is not possible to model all of them, nor is it worth it.

In spite of this potential interest, only a few studies make the link between defects and their consequences for the wood users in terms of global quality evaluation. One reason could be the high level of subjectivity in this evaluation: according to the sawmill size or location, the kind of product made, or the experience of the buyer, users could have different feelings about the quality of the wood. A second reason is the high variability according to different considerations: the log (size, colour, density, and quality), the sale (felled sale, standing sale, or contracts), and the user (type, size, age, financial health, and technology of the firm). This could explain why the comparison of defects is more often based on the opinion of experts than on objective indicators.

The purpose of this document is to propose a way of understanding the consequences of log defects on the value for different wood users. As it is not helpful to ask potential buyers directly which defects are important for them, because the answer is that all defects have their importance and a lot of factors have to be simultaneously taken into consideration (such as use, defect position, or market), the process adopted was to find indicators for the value of the defects according to the different user types. Two complementary indicators were defined and built. This work was done within the framework of a PhD study which is in progress; therefore the article deals more with methodology than with results.

The first indicator is the wood price. Based on the principle that if buyers agree to pay a large sum for a log with a defect it means that this defect has low importance for them, it was decided to model oak wood prices. The first part of the document summarises the main ideas of this modelling.

It is known that prices are also influenced by market business and that defects are not the only determinants. Moreover, during sales it is not possible to control the type of defects or buyers present. That is why a complementary approach is needed. The second indicator, presented in the second part of this article, is a measurement of log preference from an adapted survey.

The final part presents a discussion and some perspectives of this work.

INDIVIDUAL LOG PRICES AS QUALITY INDICATOR

Context

Oak prices during a sale can spread on a scale from 1 to 100 (CRPF 2003). This high variation is due to the difference of use, wood for pulping being very cheap in comparison with wood for coopers. At the same time, the wood quality required for these uses is not the same (CRPF 2002). The goal of the approach outlined here is to evaluate how we can link the quality and the prices and thus find a way to measure the importance of the defects.

A first study was made on French National Forest Office (ONF) felled sales (Cavaignac 2004). In French eastern departments, wood commercial transactions are mainly completed during felled sales. This means that ONF chooses and fells trees itself. These trees are then processed into logs which are measured and classified into quality groups from A to D. Different parameters have to be taken into consideration to classify the logs. There are first some dimensional criteria (minimum length or diameter) for entry into a class. Then some defects lead to the exclusion from a quality (for example unsound knots are not admitted in quality A). Finally, the class is determined by the frequency of defects. Logs are then brought together into more or less homogeneous parcels in terms of quality. These parcels are sold during auction sales. There is a good match between the quality grade and prices. It would be interesting to have such grades in the simulator, but the problem remains that too many defects are to be considered simultaneously to apply the classification norm. This study shows that it is possible to use prices as a quality indicator, but does not really allow us to reveal which defects are not correctly taken into account in our modelling. The next step is thus to link prices and defects directly.

Materials and Method

In order to model individual log prices, two kinds of data are needed: the individual log price, and the inventory of the defects on the log. The method ued to gather these data is presented here.

Individual log prices

Individual log prices are not in principle easy data to access. Most of the time, in France, wood is sold as standing trees in a compartment, or with other logs in a felled sales parcel. Neither is it really easy to ask buyers directly for individual log prices because they are reluctant to reveal personal market strategies. However, there is a solution: significant numbers of good quality logs in Germany are sold individually. They are gathered at sale places and sold at auction by secret tender. Thanks to the cooperation of the German Forest Office, it was possible to access the tenders and to obtain the activity field of the bidder. These activities could be summarised in five groups: commercial, coopers, handicraftsmen, sawyers, and veneer makers.

Felled sales are very interesting for several reasons. Potential buyers take time to observe and analyse each log they are interested in. The fact that logs are cut allows them to look closer than external defects and to have a view of the cross-section and so the texture which is a good indicator of wood density. According to buyers, this information is enough to obtain a good idea of the log quality — even if sometimes there could remain some "bad surprises" when it is sawn.

Close description of the logs

As presented in Fig. 1, logs are laid side by side to be presented to potential buyers. This arrangement and the context of the sale place constraints on the description of the logs:

- Logs have to be visible and presented the same way for all the bidders. It is not possible to move them or spoil them. The method has to be non-destructive, adaptable outside, and ergonomic.
- There are constraints of time: logs are presented for only a few weeks.

FIG. 1–Log setting for felled sales.

- The method has to be adaptable to objects ranging from 2 to 10 m.
- Finally, information has to be provided on the number, position, and seriousness of external defects.

The decision was thus made to use photogrammetric tools. In the field, around 30 numeric photographs of each log were taken. These photographs are then used with software called PhotoModeler (EOS 2003). The principle is to use the photographs to tag features of interest. For our study ribbons and poles with targets were put on and around the log. Then the work involved tagging these targets on each photograph and showing the software which were the same targets on different photographs. The software then combines the data and locates the marked features in three dimensions. It is thus possible to extract measurement and 3D models from photographs. A log rebuilt in a 3D model is shown in Fig.2.

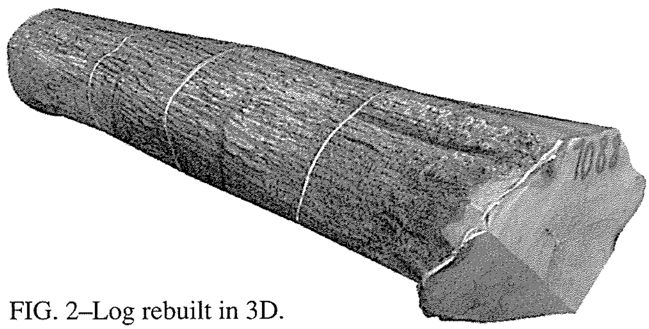


FIG. 2–Log rebuilt in 3D.

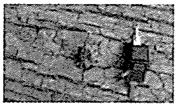
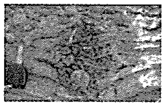
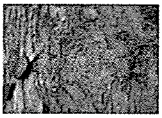
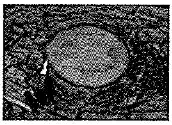
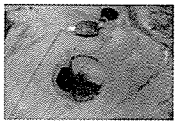
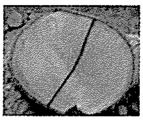
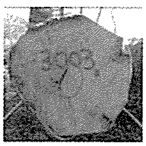
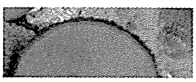
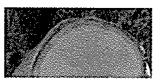
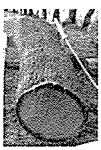
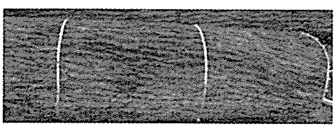
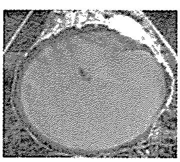
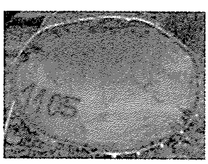
On the photographs used, defects were identified and referenced. The use of the measurement tools of the software allows the main defects to be measured, as is shown in Table 1.

The database of information on prices and characteristics of the logs is then used to model individual log prices. Variables that are not only a function of the defects but also of the dimensions or the users are used to link log quality and price. Different ways of modelling this link have been tried, and the most promising ones are:

- Linking the price to a usable volume. Within this concept, the different defects involve a yield decrease and therefore also a price decrease. A general linear model is used to evaluate these effects.
- Using defects to classify logs into a price bracket, thanks to Classification and Regression Trees.
- Evaluating the importance of defects through modelling the probability of a buyer making a bid knowing log quality. Logistic models are used in this case.

The next section deals chiefly with the pros and cons of this method.

TABLE 1–Defects and measures.

Defect	Illustration	Measurement
Epicormic	 	Spatial coordinates and visual qualitative appreciation of the severity.
Rose		Spatial coordinates and visual qualitative appreciation of the severity.
Knot	 	Spatial coordinates and visual qualitative appreciation of the severity. The diameter and the state (sound or unsound) are taken into consideration.
Shake		Shake length.
Ring shake		Shake diameter and length.
Sapwood width	 	Sapwood average width on the section.
Crook		To measure the crook, three points are referenced in the same plane — two at the edges and one at the centre of the log.
Spiral grain		Spiral grain is the relative angle between the main axis of the tree and the grain angle..
Eccentricity		Eccentricity is the distance between the pith and the geometric centre of the section. It is given as a percentage of the average diameter.
Ovality		Ovality is the difference between the longest and the smallest diameters. The measure is given as a percentage of the longer diameter.

Advantages and Limitations

The advantages and limitations of this method will be presented in three parts: the first one concerns the general protocol, the second one the photogrammetric approach, and the last one the data exploitation.

General protocol

The general protocol provides the needs, i.e., gathering information on individual log defects and prices during a felled sale. Moreover, this experimentation is done without interaction with the potential buyers. It is thus possible to work on real material without changing the behaviour of the item studied. The weakness of this protocol is that we can not control the defects or buyers present during the sale. The protocol is based on a particular kind of sale, and only one sale is studied. The value of the log prices then depends on the overall economic situation. Some buying strategies could also affect the fall in log value due to defects. Information on the seriousness of the defect has thus to be considered rather with the idea of relativity (defect A is more important than defect B) than with a notion of value (defect A induced a drop of 15 Euros/m^3).

Photogrammetric tools

Photogrammetric tools are very adaptable and fit well with the constraints presented above. When price models are established from a quality grade, a subjective appreciation comes into play. Then, according to the toughness or experience of the judge, the resulting grade can fluctuate. With photographs and measurement of the defects, the method is more objective: there is no global grade function of the observer and the measure becomes reproducible.

However, there are some limits. It is not possible to get all the information that exists about the log. Pictures cannot be taken of the underside of the log. But neither can buyers see the underside of the logs during the sale. Some defects are really negligible and thus it is not possible to distinguish them with the definition of the camera used (as with some epicormics, for example). Then there is sometimes over- or under-exposure of the logs, which creates difficulties for rebuilding in 3D and for recognising defects.

Data exploitation

This first method has the advantage that data are collected outside and there are no time constraints on exploiting them and making all the measurements needed or wanted inside. The inconvenient aspect is that the 3D rebuilding in order to measure the logs is time-consuming. To make a log 3D model, to recognise and measure all the defects, one full day is needed. The modelling of prices is also a step needing a lot of time considering the complexity of the topic studied.

This first approach gives access to very interesting material which can provide useful information on a complex topic. But it is still not possible to give a more accurate answer to the problem of the seriousness of defects for the different users. A second indicator which complements the first one is thus needed.

A COMPLEMENTARY INDICATOR: THE USERS' PREFERENCE

Context

Price studies could bring sharp and quantitative evaluations of the consequences of the presence of defects. As was presented in the previous part, there are, however, limits to this approach. The main one is that we are spectators of the sale. It is thus not possible to control the defects or the collection of defects presented, nor to force buyers to give an evaluation of all the studied logs. The method used to gather data also presents some disadvantages. All these limitations help to establish the specifications of a new indicator. This will be a complementary indicator. It has to be possible to choose defects and users. The indicator has to be less linked to the economic situation. And of course it has to give us information on the value of logs seen by the users.

Method

The method has to answer the questions raised above in order to fill the gaps of the previous indicator. In order to be able to select the defects and the users it was decided to make a survey. It would have been really difficult to find a log with the exact distribution of defects we were looking for, and then it would either have been difficult to move the logs to the users or to ask users to come and see the logs. Considering the evolution of computer tools in terms of 3D modelling, it was thus decided to create completely virtual logs with appropriate criteria of dimension and quality.

In order to decide which logs should be created, we had to choose between two options. The first one was to try to test a maximum of defects in combination with different users. To do that, logs presented to one user differed from those presented to the others. A specific experimental design was needed which took into account the field of the user, the size of his firm, and the defects presented. The advantage of this option is that it tests the effects of a high number of defects and interactions. The disadvantage is that the number of persons to interview is fixed by the design. In other words, it is difficult to add a user to the survey when the plan is finished and the plan is more fragile if some users cannot answer. The work needed to build the virtual logs shown to users is also more important when the number of interviewed persons increases.

The other possibility is to have a factorial experimental design. This time it is the same questionnaire for all the interviewed persons. The advantages are to limit the number of logs to build and to present the same questionnaire. It is thus possible to add a person and it is not weighty if one user cannot answer. Among the different factorial designs, the choice must be made of the number of defects and levels of severity presented. Then the level of interaction also has to be selected.

Considering the different advantages and disadvantages of the both possibilities, the second one was chosen. As it was a first study, it was decided to test a maximum of defects without interactions instead of fewer defects with their interactions. Lastly, in order to make a questionnaire short enough to be acceptable by the people interviewed, it was decided to show around 30 logs. The best factorial design we found to answer these constraints was a plan with 27 logs, 13 defects, and 3 modalities of severity for each defect. The plan fixed for a log the level of severity for each defect (A, B, or C). To be more precise, among the three levels there is a level attributed to the absence of the defect and the two others concern two levels of severity for this defect. But it is possible to attribute the greater severity to level A and the lower to level B and make the opposite for another defect. In fact some logs are without interest. For example, the ones with the whole defects at the lower or higher severity level are easy to evaluate without any survey. We thus had to get logs as similar as possible to average logs, i.e., if grade –1 is given to the lower level of defect, grade 1 to the upper, and 0 is the average, the sum of defect for each log must be close to 0. As we had to choose 13 defects, we took the more frequent and those that were not supposed to be fully random.

Due to the limited number of logs, we could not afford to test interactions between defects nor effect of their location. So it was decided to take logs which were tall enough to limit these effects. That is why all logs are 5 m long and 65 cm in diameter.

At this step all the information needed to construct virtual logs was available (Fig. 3). The first step was to create the basic shape of each log. The general shape was defined thanks to the taper curve for sessile oak (Dhôte *et al.* 2000). This shape was corrected with defects as oval section or crook. The software Blender was used. The second step was to create the texture. The experimental design was exploited to choose the type and number of defects. The defects were put randomly with different laws of probability function of the defect and the height. On the basis of these defects, two kinds of texture were realised. The first one was made from numeric photographs of defects and thus provided a more realistic output. The second one was a schematic view.

The survey involved presenting the logs in groups of three and asking the person interviewed to rank the logs according his preference in reponse to a particular question. The composition of the group of logs must be well thought out. As we like to classify all the logs, a mesh had to be done to have a maximum of comparisons between the different logs. The logs would thus be presented twice, which makes

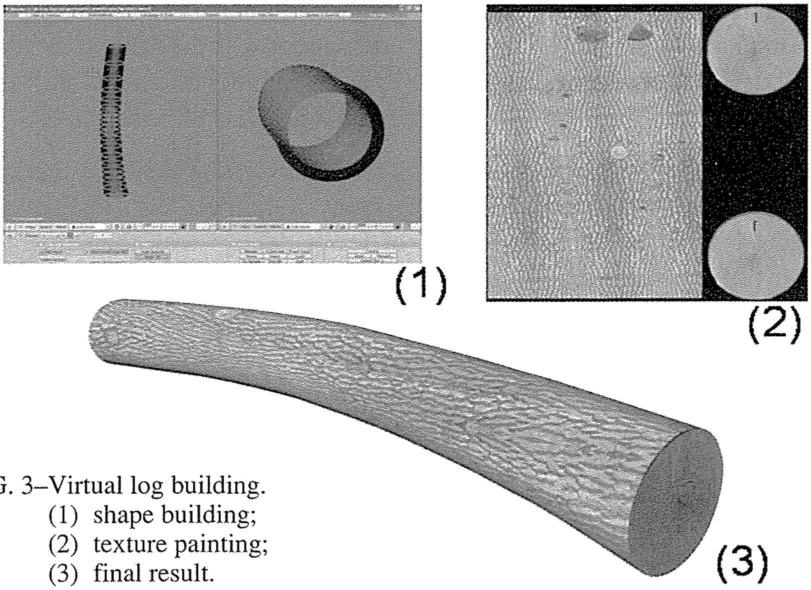


FIG. 3–Virtual log building.
(1) shape building;
(2) texture painting;
(3) final result.

18 questions. Let us stipulate that in the first question Log 1 is compared to Log 2 and Log 3, and in the second Log 4 is compared to Log 5 and Log 6. We have no element of comparison between the three logs of the first question and the three of the second. That is why the second time there is a question with a log of the first group and one of the other. Due to the number of defects, one defect has the same level of severity in the three logs presented simultaneously. In order to get as many elements of comparison as possible, it is never the same defect which is present at this common level between two questions.

Once ready, the survey was tested with users of oak wood to validate the method. Interviewed persons then had to be selected. To select them and know the weight to give to their answers, a list is planned thanks to data from the national field survey. Our time and financial limits allow us to consult around 40 persons and focus on three geographic areas famous for their oak industry (East, Centre, and South-west).

During the survey two items are shown to the person interviewed. Firstly he can manipulate the 3D representations of the logs. Then the schematic view is shown on the cards (Fig. 4). These cards summarise information about log quality. The three cards describing logs of the same group are given to the interviewed person.

Survey results will be analysed with sensorial analysis tools. Using the rank of the logs in each question, it is possible to make a general ranking of the logs and then to explain this order thanks to defects present on the log.

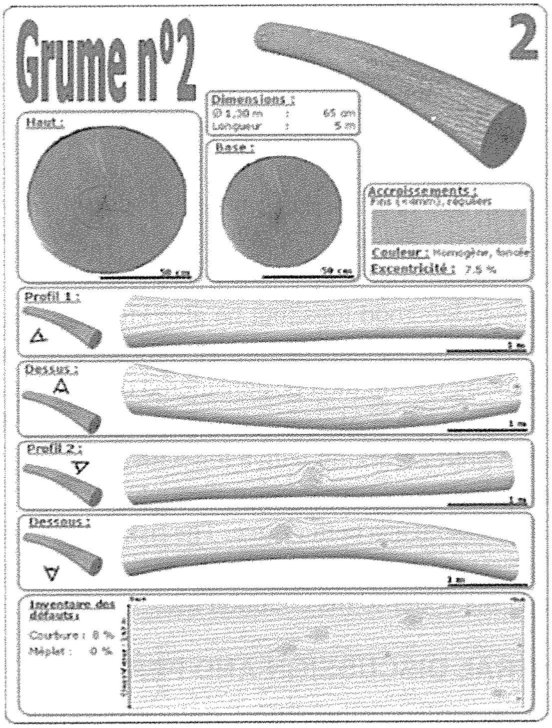


FIG. 4–Synthetic card for simulated logs.

Advantages and Limitations

As presented in the first part, the two methods are built to be complementary. It is thus logical that the strong points of this method are linked to the weak points of the previous one. That is to say, this time present defects are controlled and all the defects are presented to all the users which are also chosen specifically. Although the survey concept and realisation on the field take a long time, the use of the data was thought out within the survey concept and thus data analysis is speeded up.

Nevertheless the choice of the number of defects and their level of severity is still limited by the time a questionnaire can reasonably last. In this case it is not possible to test interactions between defects, so then the studied material is fully virtual. The test phase of the survey showed that the interviewed person did the exercise easily and managed to class the three logs of each group quite fast. But it is not really possible to go further — asking him, for example, a price for the presented logs.

Moreover, the choice of the experimental design supposes that the perception of global quality is in a way a kind of a sum of the severity of each defect. It has to be verified to what extent this hypothesis can be accepted. But as it is a quite innovative approach, simple effects have to be tested before doing more complicated experiments.

Finally, asking a user to rank logs according to his preference is not as simple as it seems. As the same logs are presented to all the users, some of them are totally unusual for their common uses. Take the case of bad logs for veneer-makers, for example. As they generally do not accept bad logs, will they be able to make a ranking between different bad logs? The possibility of tie is accepted in order to answer this problem. But the opposite one is trickier. A sawyer used to using the worse logs can easily judge good logs, but he also knows that these logs are not accessible for his use because he can not afford to pay the price that other users are ready to pay. The ranking should then be considered only as regards uses and not potential prices. And this notion of use is also important regarding a defect. For example, a user could prefer working with a log with a heterogeneously coloured section rather than with a log bearing epicormics, whereas it is known that on the market the second one is sold at a better price. The risk is thus that the interviewed person says that he prefers the second one because it is usually more expensive whereas the first one fits better to his common use.

GENERAL DISCUSSION AND PERSPECTIVES

Trying to sort defects according to their effect on the perception of wood quality for different users is a complex task because of the high diversity of wood quality, wood supply, and wood users. In order to simplify the study, it is possible to decrease this diversity by controlling some of its components. Doing this operation, a part of the problem is not studied and has to be apprehended otherwise. It was here proposed to base the comparison of the defects on two complementary approaches. The different points of these approaches are summarised in Table 2.

This article emphasises the complementarity of the two approaches. It is also possible to underline common points. In the two cases this study is a restriction of the subject to high quality logs. Therefore some high levels of defects (in terms of severity or quantity) were not taken into consideration. Then some uses are not met — for example, pallets, wood for railways, firewood. In these kinds of uses, we think that price is more based on the volume available than on the quality in terms of defects present. Moreover, as the conception of the survey limits the number and level of seriousness of defects, it was decided to deal with the higher qualities and create logs which have always a part usable for each user. Both methods are also based on oak wood. This is due to the importance of this wood in our region and the need to improve the local oak growth simulator. It is possible to extrapolate this approach to other species since they present enough variability in quality and uses.

It must not be forgotten that results are in a way linked to the economic context. For example, if the wine market is in difficulty, coopers will be more strict on quality

TABLE 2–Comparison of advantages and disadvantages of the two methods

	Price modelling	Survey
Quality indicator	• Individual price.	• Log preference.
Nature of the studied material	• Real logs. • Defects and combination of defects are not controlled.	• Virtual logs: the user could not feel at ease with this material. •Possible to control presented defects.
Nature of information	• Quantitative data: prices and measures of the defects	• Qualitative ordered data: preference rank of the logs.
Interaction with users	• Users are present during the sale, they are not chosen and they don't give their advice on all the logs. • They are not disturbed.	• Users chosen. Give their advice on all the logs. • They have to take time to answer the survey.
Possible bias	• Prices are influenced by the market. The bidder could also have buying strategies that influence his price.	• The question of prices is not evocated. • The user can answer the question "what is the more expensive log" as "which is the one you prefer for your use". • The user can be afraid of revealing personal strategy.
Constraints	• Limited to the duration of the sale. • Limited to this kind of sale.	• Possible to extend the study. • The questionnaire has to be short enough: defects and interactions studied have to be selected. • The number of users interviewed is limited.
Fast phases	• Field phase. • Gathering sale data.	• Data analysis.
Long phases	• Logs rebuilding. • Data analysis.	• Conception of the survey.

and then be very severe with some defects, whereas they would have been less concerned if the market had been better. Another example is the fashion effect. Nowadays in France clear woods without defects are preferred to make floors whereas in other times or in other areas dark woods or woods with epicormics were preferred (Mazet 1989; Lambillon 1996). Whereas we are most interested in a relative ranking of the defects in logs compared to the others, this ranking is in some ways linked to the time of the survey.

Finally, before the final step which is the simulation of the defects, some points have to be studied thoroughly. Knowing the classification of a defect is important but not sufficient to decide the priority of modelling. This rank should be weighted by the economic importance of the potential user or the frequency of the defect. Moreover, as it is a first approach, the interactions between defects are not fully taken into consideration. This work would have to be done among defects selected. It would then be possible to choose tracks of improvement for growth simulators and give forest managers objective information on importance of defects.

ACKNOWLEDGMENTS

This research is supported by the ONF (Contract ModelFor). The help and data provided by the Baden Wurttemberg German Forest Office are gratefully acknowledged.

REFERENCES

BARRY-LENGER, A.; NEBOUT, J-P. 1993: "Le Chêne". Editions de Perron. 604 p.

BOURCET, J. 2000: Le Coeur de Chêne. *Revue Forestière Française LII*: 239–248.

BUCKET, E.; LE MOGUEDEC, G.; MOTHE, F.; NEPVEU, G. 2005 : Une modélisation des bilans « environnement » et « produits » de sylvicultures contrastées. *Revue Forestière Française LVII*: 311–330.

CANNEL, M. 1995: Forest and the global carbon cycle in the past, present and future. *European Forest Institute Research Report 2*. 66 p.

CAVAIGNAC, S. 2003: Elaboration d'un modèle de prix du bois de Chêne (*Quercus petraea* Liebl. et *Quercus robur* L.) à partir de ventes en régie et comparaison à d'autres methods d'estimation. Master report, Ecole Nationale Supérieure d'Agronomie et des Industries Alimentaires, Nancy. 41 p.

CRPF Aquitaine 2002: Pour reconnaître les bois à merrain. *Forêt entreprise n°144*: 32-

——2003: Produire du chêne de qualité. *Forêts de France n° 466*: 34–38.

DHOTE, J-F. 1994: Un modèle hyperbolique pour l'ajustement de faisceaux de courbes hauteur-diamètre. *Canadian Journal of Forest Research 24(9)*: 1782–1790.

DHOTE, J-F.; HATSH, E.; RITTIE, D. 2000: Forme de la tige, tarifs de cubage et ventilation de la production en volume chez le Chêne sessile. *Annals of Forest Sciences 57(2)*: 121–142.

DUCOUSSO, A.; JARRET, P. 2001: Diversité génétique des chênes et gestion forestière. *Revue Forestière Française numéro special 2001*: 133–140.

EOS SYSTEMS INC. 2003: Photomodeler 5 Pro. User Manual. 488 p.

LAMBILLON, J-M. 1996: Anomalies et singularités peuvent-elles valoriser un bois? *La Forêt Privée n°231*: 49–61.

LINDER, M. 1998: Implementing carbon mitigation measures in the forestry sector — a review. Pp. 167–184 *in* "Carbon Dioxide Mitigation in Forestry and Wood Industry", Springer.

MAZET, J-F. 1989: Recherche de critères pour l'aspect (dessin et couleur) des placages de bois de Chêne. *Les cahiers de l'analyse des données XIV*: 365–376.

NEPVEU, G.; LE MOGUEDEC, G.; DHOTE, J.F.; GUILLEY, E.; CONSTANT, T.; MOTHE, F. 2004: Optimizing the chain from the plant to the plank in Sessile oak (*Quercus petraea* Liebl.) taking into account considerations related to sustainable management. Pp. 622–631 *in* Proceedings of the Fourth Workshop IUFRO WP 5.01.04 "Connection between Forest Resources and Wood Quality: Modelling Approaches and Simulation Software", Harrison Hot Springs, British Columbia, Canada, 8–15 September 2002.

PAUSAS, J.G.; BLADE, C.; VALDECANTOS, A.; SEVA, J.; FUENTES, D.; ALLOZA, J.A.; VILAGROSA, A.; BAUTISTA, S.; CORTINA, J.; VALLEJO, R. 2004: Pines and oaks in the restoration of Mediterranean landscapes of Spain:New perspectives for an old practice — a review. *Plant Ecology 171*: 209–220.

PICARD, O.; GIZARD, M. 2001: Développer l'emploi en Forêt. *Forêt enterprise n°141*: 15–46.

PRADEILLE, M. 2002: Les Chênes en France : volumes, qualités, usages. *Forêt enterprise n°144*: 19–22.