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Исследования древесного топлива и культивирования лесных плантаций с коротким оборотом рубки в Отделении Лесных наук Тарандта за 20-летний период

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Two decades of woodfuel and short rotation coppice research at the Forest Sciences Branch in Tharandt

Butler Manning, David (Dresden`s Technical University)

Presented in the paper is an overview of the research into woodfuel and the cultivation of short rotation coppice plantations carried out at the Forest Sciences Branch of the Technische Universität (TU) Dresden's Faculty of Environmental Sciences. These topics have been one of the core areas of research at the Forest Sciences Branch in Tharandt over the last twenty years and have been the focus of a number of large collaborative research projects involving partners from across Germany. The paper covers some of the reasons for this focus on woodfuel research, an introduction to short rotation coppice in Germany and outlines some of the major findings with regard to cultivation of fast-growing trees as agricultural crops with a particular focus on yield, economics and nature conservation aspects. Some recent experiences gleaned in the transfer of these findings from research to practice are highlighted.

The new problem areas in the cultivation of short rotation coppice plantations are analyzed. In spite of the difficulties, short rotation coppice remains a dynamic area of research and the great deal of work done by the Forest Sciences Branch in Tharandt and its many partners in this area.

Key words: Tharandt, woodfuel, short rotation coppice, poplar, willow

Исследования древесного топлива и культивирования лесных плантаций с коротким оборотом рубки в Отделении Лесных наук Тарандта за 20-летний период

Butler Manning, David (Дрезденский технический университет)

В статье представлен обзор исследований древесного топлива и культивирования лесных плантаций с коротким оборотом рубки, осуществляемых в Отделении Лесных наук Факультета Экологических Наук Дрезденского Технического Университета. Указанные темы были одним из основных направлений исследований в Отделении Лесоводства в Тарандте за последние двадцать лет и находились в центре внимания ряда крупных совместных исследовательских проектов с участием партнеров по всей Германии. В статье рассматриваются некоторые причины повышенного внимания к исследованиям древесного топлива, а также плантаций с коротким оборотом рубки в Германии и излагаются некоторые из основных выводов в отношении культивирования быстрорастущих деревьев, как сельскохозяйственных культур, с особым упором на аспекты урожайности, экономики и сохранения природной среды. Отмечается некоторый недавний опыт, почерпнутый в использовании выводов исследований на практике. Проанализированы новые проблемные аспекты выращивания плантаций с коротким оборотом рубки. Несмотря на трудности, плантации с коротким оборотом рубки остаются динамичной областью научных исследований, и Отделением Лесных наук в Тарандте и его многочисленными партнерами проделана большая работа в этой области.

Ключевые слова: Тарандт, древесное топливо, короткий оборот рубки, тополь, ива

Butler Manning, David – Technische Universität Dresden, Chair of Eastern European Forestry and Forest Products, Project manager, researcher, Dr. rer. Nat., B. Ag. Sc. (hons.)

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Organisation: Technische Universität Dresden

Postal address: Pienner Str. 19, 01737 Tharandt, Germany

Phone number: +49 (0)35203 383 1819

Fax: +49 (0)35203 383 1283

E-mail: david.butler-manning@forst.tu-dresden.de

Introduction

Established in Tharandt in the year 1811, the Forest Sciences Branch of the Technische Universität (TU) Dresden's Faculty of Environmental Sciences boasts a long history of forest education and research. Indeed, upon its establishment by the renowned forester Heinrich Cotta, the then Forest Academy was the earliest of its kind in Germany and one of the very first in the world. Today the branch comprises nine institutes and 17 chairs, covering the core forestry disciplines, such as silviculture and forest growth and mensuration, topics with a greater environmental emphasis such as biodiversity and nature conservation as well as more applied areas of technical research including forest machinery and wood chemistry.

At present an average of 125 Bachelor and 90 Master students enrol at the Forest Sciences Branch in any given semester, with roughly 180 students graduating annually. In addition to the basic Bachelor's degree in forestry, the branch offers three Master's programmes: forest sciences, tropical forestry and management, and wood technology and products. Graduates of the Forest Sciences Branch in Tharandt go on to take up a wide range of careers, including professions directly in the forest and wood sectors but also vocations much further afield.

The impetus for the publication of this paper in the 'Proceedings of the St. Petersburg Forestry Research Institute' was provided by the Workshop for International Research Cooperation hosted by the St. Petersburg Forestry Research Institute on 11 November 2013. The purpose behind the paper is to present an overview of one the core areas of research carried out by various institutes within the Forest Sciences Branch over the last two decades, namely the issue of woodfuel and short rotation coppice, in order to communicate some of the findings and potential areas of cooperation to the staff of the St. Petersburg Forestry Research Institute and to the wider forestry, wood and bioenergy communities in Russia. A particular focus of the paper will be on the findings of two large collaborative research projects coordinated from Tharandt and involving a range of institutions and enterprises from across Germany. These include research institutions such as the Th nen Institut, the Martin Luther University Halle-Wittenberg, the University of Hannover, state bodies such as the Sachsen State Office for Environment, Agriculture and Geology, industrial partners like Vattenfall and various agricultural and forestry enterprises.

Woodfuel research in Tharandt

Just one of the many areas of research engaged in at the Forest Sciences Branch over the last two decades has been the issue of woodfuel – the production and supply of wood for use in the provision of energy. This field of research, largely instigated and coordinated by the Chair of Eastern European Forestry and Forest Products, has been the focus of a number of significant national collaborative research projects funded by the German federal government. Incorporating partners from a range of institutions covering a wide variety of relevant disciplines, the two most important projects in this area coordinated by the TU Dresden, namely Agrowood (2005-2009) and AgroForNet (2010-2014), were awarded funding by the German Federal Ministry of Education and Research within the framework of the 'Sustainable Forest Management' and 'Sustainable Land Management' programmes.

The earlier of these projects, Agrowood, was the first federally funded research project into short rotation coppice and woodfuel implemented at a national scale in Germany to be coordinated from Tharandt. At the time of its commencement, short rotation coppice management was still a largely theoretical land use in Europe. Its implementation in practice was rare and there was only limited scientific foundation for its application. One notable exception in Europe was Sweden, where considerable areas of willow have been cultivated in short rotation since the time of the first international Oil Crisis in 1973. The area of short rotation coppice in Germany when Agrowood began was negligible. By the time Agrowood concluded in in the year 2009, the researchers from Tharandt and the other project partners, as well as scientists involved in

other parallel projects such as Novalis, Dendrom [Murach et al., 2010], Agroforst [Reeg et al., 2010] and ProLoc, had produced a considerable volume of scientifically-based knowledge with regard to short rotation coppice management in Germany. Meanwhile researchers in other European countries were doing their part to advance the existing knowledge of this novel land use alternative, such as Spinelli [1995; 2006] in Italy and Liebhard [2007] in Austria. Parallel to these projects, the Chair of Forest Botany of the TU Dresden was involved in two major tree breeding studies, namely FastWOOD and ISOWOOD-Breeding, looking into means to optimise the characteristics of fast growing species such as poplar.

In spite of this greater knowledge base produced by these various studies, however, the coppice area in Germany in 2009 was essentially no larger than it had been previously. This reflected a gap in the communication of research findings, not only to farmers but also to various agricultural and forestry authorities, and importantly also to nature protection NGOs, where it was clearly apparent that the potential benefits associated with short rotation coppice management remained unknown [Bemmann et al., 2010]. Symptomatic of this was the very fact that in Germany, where land use classifications are widespread and serve important regulatory functions, there was no clear legal definition of short rotation coppice until 2010, nor whether it was in fact a form of forestry or an agricultural land use [see Schulte et al., 2010; Michalk et al., 2013].

The reasons for pursuing woodfuel research

The impulse for the research into woodfuel carried out at the Forest Sciences Branch in Tharandt stemmed from a complex of contributing factors. The introduction by the European Economic Community (EEC) in 1988 of the 'set-aside scheme' [Regulation (EEC) 1272/88], which became compulsory in 1992, saw farmers rewarded for setting land aside, i.e. taking land out of agricultural production. The initial target was to set-aside 15% of the European agricultural area, reduced to 10% in 1996. The purpose of the scheme was to reduce the large food surpluses produced by European agriculture at the time. More or less simultaneously, throughout the forestry sector in Europe an ever growing emphasis was being placed on the promotion of sustainable forest management, implying in many instances lower harvesting volumes, an increase in wood residues left in stands (for nutrients and as habitat) and an expansion of the area of forests attributed protected status with greater limitations—and in some cases strict bans – on wood use. One manifestation of this greater emphasis on sustainable forestry in Germany was the installation of national goals to gradually transform large areas of planted conifer forests to more site-appropriate broadleaf species. In addition to the many potential environmental benefits, this changed emphasis also gave rise to a spectre of potential future wood shortages and severe negative consequences for industry further down the line. The third factor in the complex was the growing awareness of the finite nature of fossil fuels and the need to advance alternative, renewable sources of energy, in the form of wind, solar radiation, geothermal energy and also energy from biomass.

This set of circumstances prompted a small number of institutions in Germany, including the TU Dresden's Chair of Eastern European Forestry and Forest Products, to look more closely at the potential inherent in short rotation coppice management as a means to address a number of the prevailing issues with respect to land use and resource production. Although not a new form of land use—there was some research into fast growing poplar species in Germany from the 1950s [e.g., Schönbach, 1957; Fröhlich & Grosscurth, 1973; Melchior, 1985] and with the Oil Crisis of 1973 interest in coppice plantations flourished briefly—the potential of short rotation coppice as a productive use of set-aside agricultural land and as an additional source of wood (and by extension of energy), while at the same time reducing the pressure on the forests, re-emerged as a land use worthy of consideration and in great need of research.

In the intervening period the prevailing framework conditions affecting woodfuel and short

rotation coppice have changed drastically. The set-aside scheme ended in the year 2008 and with the introduction of the European Union's 2020 targets in 2007, which included the goal that 20% of Europe's energy demand be met by renewable sources of energy, there has been a renewed intensification of agriculture in recent years and an unprecedented demand for the finite resource land in many European countries, including Germany. At present in Germany, renewable sources of energy account for 12,5% of the end energy consumption [BMU, 2012]. Of this, wind accounts for 2%, water for <1%, solar, photovoltaic and geothermal energy approx. 1% and biomass 8,5% (figure 1). In spite of technological advancements in wind and solar energy, biomass will remain important for the foreseeable future for the simple reason that it can be stored.

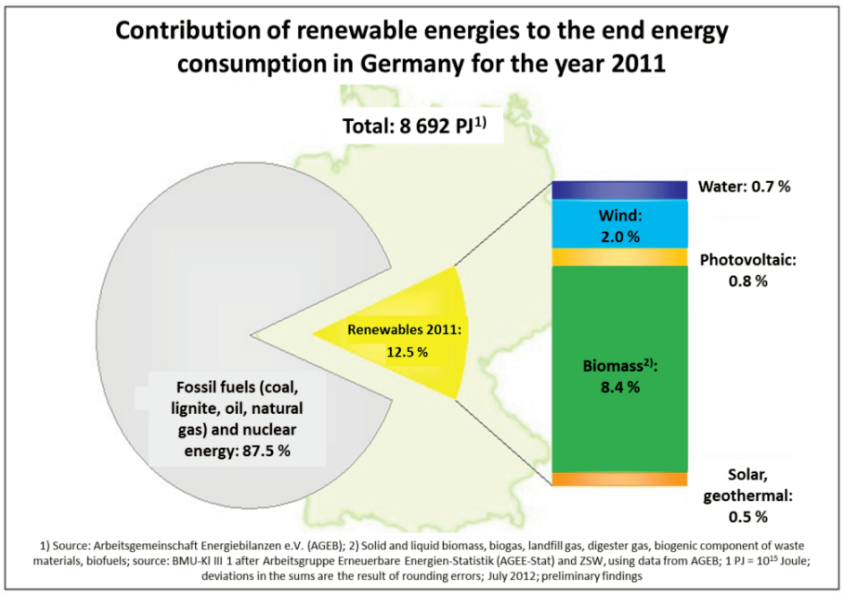

Figure 1. The proportion of renewable sources of energy relative to the end energy consumption for Germany in the year 2011 [BMU, 2012]

Of the biomass component of the renewable energies, the greatest part is wood. This is a hugely significant development and has seen the German timber market turned on its head within a matter of years. Since the start of the 20th century, the war time periods excluded, wood had dwindled in importance as source of energy in Germany to the extent that in the late eighties, only about one fifth of the wood traded on the market was used as fuel. By 2012, however, for possibly the first time in over one hundred years, the volume of wood used for fuel actually exceeded the wood used for material purposes (figure 2) [Mantau, 2012]. The actual difference is likely to be even greater than suggested in the figure, however, as the volumes of wood harvested by private owners for sustenance heating are notoriously difficult to assess and not wholly accounted for in the graph. It is also important to highlight here that, even with the increase in the wood used for fuel, there has been no corresponding decline in the volume of wood used materially. Consequently, the quantity of wood used in Germany has essentially doubled over the last 15 years. The volumes of timber harvested annually have effectively reached the levels that can be achieved within the context of sustainable forest management, yet the demand for wood looks set to increase. Observers of the wood market have predicted that by the year 2030, Germany will be facing a supply gap on the market of as much as 40 million m per annum [Wendisch, 2010].

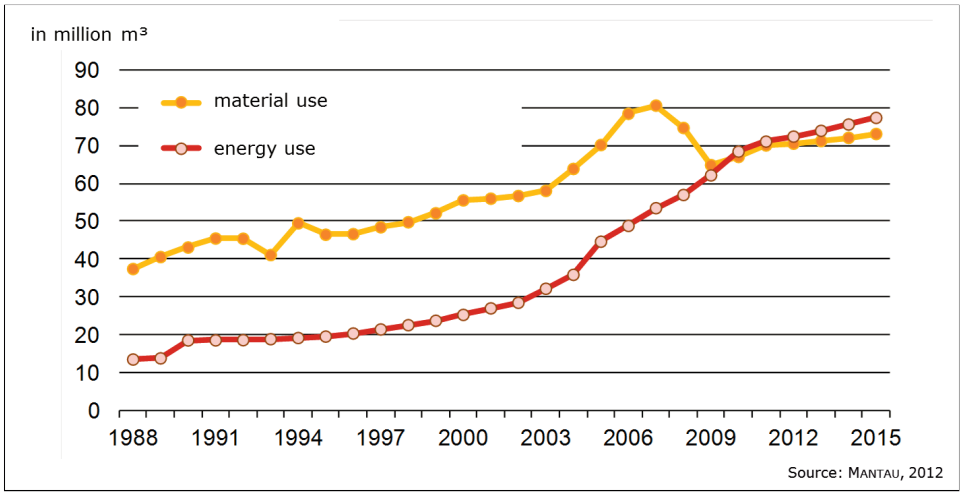

Figure 2. Development of the German markets for wood for material and energy use from 1988 to today and projected up to the year 2015 [Mantau, 2012]

These developments mean that Germany requires more wood if it is to sustain its wood-based industry while also continuing to increase the contribution of renewable sources of energy to the total energy consumption, and at the same time manage its forests sustainably. Already today, firms in the wood-based sector, not only in Germany but in many European countries, are facing severe challenges due to the increased demand for the resource. Three possible strategies to address the wood resource issue include:

In the short term the demand can be met by increasing wood imports but this wood must come from sustainable sources and the fact of its export may impinge upon the ability of the exporting country to maximise the potential of its own resources.

In the short to medium term the domestic wood supply for fuel purposes, and potentially also for certain material applications, can be enhanced by producing wood on agricultural land by means of short rotation coppice management.

A possible long term strategy involves reconsidering current national and state forest management objectives and again placing a greater emphasis on more productive, faster growing conifer species such as Norway spruce (Picea abies) and the exotic Douglas fir (Pseudotsuga menziesii), where these are appropriate, if not necessarily indigenous.

The focus of this paper is on the second of these options.

The German definition of short rotation coppice management

In spite of the initiation of research into short rotation coppice and its inclusion in various national strategy documents as a land use with the potential to contribute to resource requirements and renewable energy targets, until the summer of 2010 short rotation coppice had no firm legal basis in Germany. It was only with the revision of the Federal Forest Act (Bundeswaldgesetz, BWaldG) in June 2010 that short rotation coppice was officially excluded from the forest definition and so designated an agricultural land use [Michalk et al., 2013]. Due to the EU subsidies paid per hectare of agricultural land, the stricter conditions placed on the use of forest land, and the correspondingly lower monetary value of forest land, this legal clarity is important as previously most owners of agricultural land were unwilling to risk endangering the status of their valuable cropland by using it to plant trees. This belated legal clarification of short rotation coppice as a form of agricultural land use was due in no small part to the work carried out in research projects such as Agrowood and Dendrom.

As a coppice plantation has the potential to become a ‘forest’, depending on the management,

additional criteria are included in the legal definition of short rotation coppice. Although a plantation may be cultivated on a particular site indefinitely, to remain agricultural land the trees must be harvested at least once within a period of twenty years. If the trees are not harvested within this timeframe, the land on which the crop is growing becomes forest. Additionally, only certain species are approved for use. The Federal Office for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung, BLE) maintains a list of the species that may be used in Germany. At present the list comprises nine species (table). Of these, only poplar and willow are of practical importance. With ongoing research into short rotation coppice and investigations of the attributes of various other species, breeding programmes, etc., it is to be expected that this list will continue to be added to.

Table

The BLE list of species permitted for use in short rotation coppice in Germany of 17 December 2010

No.	Genus		Species	
1	Common name	Latin name	Common name	Latin name
2	Willow	*Salix*	all species	
3	Poplar	*Populus*	all species	
4	Locust	*Robinia*	all species	
5	Birch	*Betula*	all species	
6	Alder	*Alnus*	all species	
7	Ash	*Fraxinus*	European ash	*F. excelsior*
8	Oak	*Quercus*	Pedunculate oak	*Q. robur*
9	Oak	*Quercus*	Sessile oak	*Q. petraea*
10	Oak	*Quercus*	Red oak	*Q. rubra*

The establishment and management of short rotation coppice

In practice, short rotation coppice plantations are crops of fast growing trees cultivated on tillage land in rotations of between two and twenty years, and most commonly between three and five years. The trees are harvested at approximately 20-30 cm above the ground in the winter months with the stumps left in the soil to resprout in the spring (figure 3).

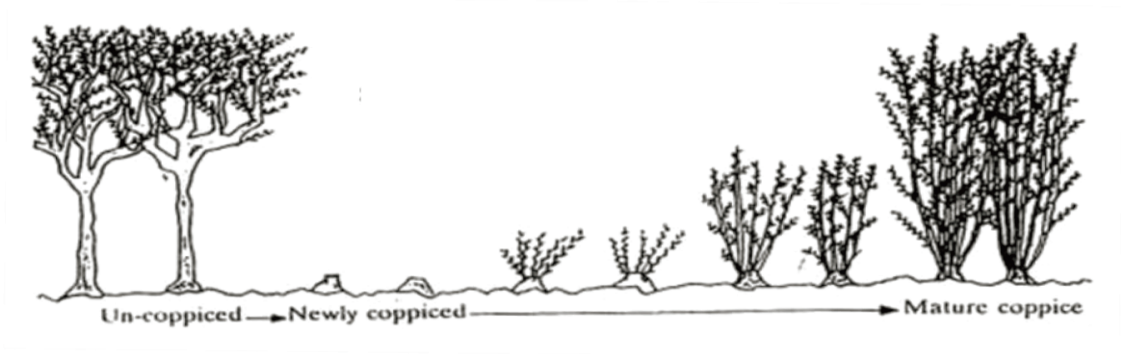

Figure 3. Stages of coppice development (www.dorsettreeworx.co.uk)

The species most commonly used for short rotation coppice in Germany are poplar and willow as these exhibit the fastest growth and the greatest capacity for coppicing. On sandy sites to the east of Germany, where water availability is a problem, black locust (Robinia pseudoacacia) is occasionally used. Whereas in the first rotation each tree consists of merely a single shoot, after the first harvest each possesses multiple shoots, resulting in increased productivity from the second rotation on. As most of the existing coppice plantations are still relatively young, there is little definitive data as yet as to the maximum lifetime of a plantation but it is expected that the stools begin to decline in vitality after about thirty years of intense production, at which point either a new plantation should be established to maintain high productivity levels or the trees may be replaced by some other agricultural crop. For financial and operational reasons, a minimum plantation size of 3 ha is advantageous. Many current plantations are smaller, however. Even though their size is not ideal, as these often occupy marginal, remote sites, and plots generally difficult to manage, even here this use represents an increase in the value to the farming enterprise generally. Figure 4 illustrates the various stages of short rotation coppice development and management from sites in Germany.

Figures 4. Harvesting short rotation coppice (left, photo: Knust), poplar stumps after the first harvest (centre, photo: Butler Manning) and a poplar plantation one year after the first harvest (right, photo: Butler Manning)

Short rotation coppice plantations can be established at planting densities of anywhere between <3000 and 16000 trees per hectare, depending on the production goals, the rotation lengths and the species used [Landgraf, 2013]. The production of high volumes of wood chips in short rotations for use as fuel demands higher stocking densities, whereas the production of higher quality wood for material use generally involves wider spacings and longer rotations. For harvesting purposes, rows should be planted between 2 and 3 m apart, with plants spaced at 0.4 to 0.8 m within the rows. In the past, short rotation coppice plantations where often planted in double rows, but experience garnered in Germany in recent years has shown that this is only suitable for willow plantations.

Over the course of the Agrowood project coordinated by the TU Dresden, and subsequently also in AgroForNet, lots of research work was carried out into the site requirements of coppice plantations [Petzold et al., 2009; 2010; Landgraf & Böcker, 2010], the establishment procedures and the various species, clones and varieties [Schildbach et al., 2009; 2010; Wolf et al., 2010; Knust et al., 2013]. Together with various partners research has also been undertaken to evaluate harvesting systems [Becker et al., 2010; Große et al., 2013] and the appropriate means of drying and storing wood from coppice plantations [Brummack, 2010; Brummack & Peschel, 2013], as well as into the means of integrating this new form of land use into common agricultural practice [Gerold et al., 2009; Landgraf

& Böcker, 2009; Heinrich et al., 2010]. Studies of the diverse sources of biotic and abiotic damage that can impact upon plantations have been carried out [Helbig & Müller, 2009a; 2010; Georgi et al., 2012; 2013a; 2013b; Helbig et al., 2013] and at present an expert system for pest monitoring and forecasting in short rotation coppice is being developed at the Forest Sciences Branch.

Yield assessment in short rotation coppice

Given the relative novelty of the land use, and the fact that it corresponds to neither forestry nor agriculture, it was necessary to develop new yield assessment methods as the yield tables used in forestry in Germany are not suitable. Röhle et al. [2009] developed one such method based on biomass functions. Ali [2009] and Röhle [2010] subsequently applied these methods to predict yields from short rotation coppice depending on site factors and stocking densities at a regional level for the German state Sachsen (figure 5), with Murach et al. [2009] employing a similar approach for the state Brandenburg. Based on data collected from numerous sites in the first rotation, the authors calculated yields (measured in oven dry tonnes, odt) for poplar of between 2 and 14 odt ha-1 a-1 and between 4 to 10 odt ha-1 a-1 for willow. The yields from forests in Sachsen by contrast are considerably lower, even on the best sites. Norway spruce, for example, produces only 7,2 odt ha-1 a-1 [Bemmann et al., 2011]. Research into the yields from short rotation coppice plantations continues in Tharandt to ascertain the biomass quantities that can be expected in later rotations. Given that few plantations in Germany have as yet been harvested on more than one or two occasions, limited data is available at this moment in time. An online-tool has also been developed allowing farmers to estimate the yields they can expect should they choose to establish short rotation coppice on their own land [http://www.energieholz-portal.de/248-0-KUP-Kalkulator.html].

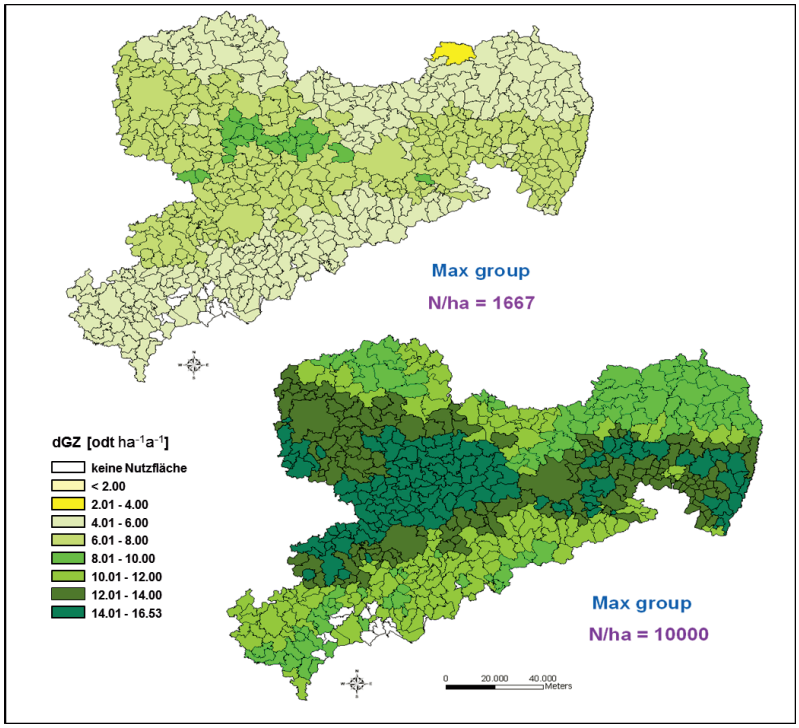

Figure 5: Mean total biomass increment (dGZB) on agricultural land in the German state Sachsen for the poplar clone Max managed in a nine year rotation and with a stocking density of 1667 trees ha-1 (top) and 10000 trees ha-1 (bottom) [Röhle et al., 2010]; dGZ = mean total increment; odt = oven dried tonnes

Economic and social implications of short rotation coppice

Just as it was necessary to produce yield tables for this new form of land use, any future success of short rotation coppice also requires a basis for economic assessments of the crop. As coppice is cultivated in an agricultural setting but is subject to very different (non-annual) cash flows to typical annual crops, it has been necessary to develop a new method of calculation in order to make possible financial comparisons with alternative annual crops. The approach that has largely been adopted as the standard for Germany in the last few years was developed during the Agrowood project by cooperating researchers from the Martin Ludwig University in Halle-Wittenberg and from the Th nen Institut in Hamburg [Wagner, 2009; 2012; Kr ber et al., 2010; 2013]. Parallel to this, social scientists from Tharandt also assessed the implementation of this new land use not just in financial terms but with respect to its socio-economic and ethical aspects [Skodawessely & Pretzsch, 2009; Pretzsch & Skodawessely, 2010]. Studies of the motivations of landowners in choosing to adopt or not to adopt short rotation coppice are ongoing [Neubert et al., 2013; Boll et al., 2013].

Short rotation coppice and nature conservation

Ultimately some of the decisive arguments that may help to establish short rotation coppice management in Germany may not be financial, or relate to the resource at all, but might have more to do with the associated environmental and nature conservation benefits [Schmidt & Glaser, 2009; 2010]. Short rotation coppice is a non-intensive form of agriculture. Unlike other crops, heavy machinery only crosses the land at establishment, at the end of the plantation lifetime when the site is being restored and every 3 to 10 years during harvest. The fact that the soil remains undisturbed for many years (no ploughing) means that the soil properties are greatly improved and the potential to sequester carbon is considerably higher than for other agricultural crops (in wood and in the soil). As harvesting takes place in winter, after the leaves have fallen, very little is removed from the site in terms of nutrients [Lamersdorf et al., 2010]. As a consequence, short rotation coppice management requires no fertiliser and herbicides are only necessary in the first year of the crop to remove weed competition during establishment. Compared to conventional tillage, short rotation coppice has considerably higher biodiversity and in very open landscapes can serve to provide structure and habitat [Helbig & Müller, 2009b; Glaser & Schmidt, 2010; Grunert & Wilhelm, 2013a], and so also reduced water and wind erosion [Grunert & Wilhelm, 2013b] and a better microclimate. A comparison of the energy efficiency of the various bioenergy lines [Bemmann & Große, 2011] also clearly demonstrates the advantages of short rotation coppice. Whereas the ratio of energy output to input for maize is between 3:1 and 15:1, for oilseed rape it is only 2:1 to 7:1, in the case of a poplar plantation the ratio is as high as 60:1. This clearly demonstrates the potential of short rotation coppice as a highly efficient pathway to biomass production for renewable energy.

From research to practice: implementing short rotation coppice

In spite of the vast amounts of scientific data collected over the course of projects like Agrowood, Agroforst and Dendrom, it was apparent that the knowledge generated was not reaching land managers and that short rotation coppice was not being implemented in practice. As a consequence, the AgroForNet project was initiated with the purpose of bringing together scientists, land managers, enterprises and communities to create wood-based value chains for the provision of renewable energy at a regional level. The objective of the ongoing project is to bring to life a small number of real examples that can serve as role models for rural areas across Germany.

One example of a value chain being pursued as part of the AgroForNet project concerns a cement factory in the northern part of the German state Sachsen, which is currently seeking to switch from gas to energy derived from renewable sources. The motivation for this switch is a combination of cost, image considerations and a desire to become

independent of the large energy concerns. Currently the factory uses gas to produce the 10000 MWh of steam needed annually in its cement production process. As part of the AgroForNet project a partner willing to install and operate a small biomass-fuelled combined heat and power plant on the factory site was found. This partner is to be responsible for all the cement factory's energy needs. Together with this partner the scientists in AgroForNet calculated the quantity of wood needed to produce the necessary steam, which essentially amounts to 3500 t wood chips annually. The next step is finding land owners in the vicinity of the factory willing to provide the necessary wood from their forests and also by establishing coppice on their agricultural land (figure 6). In this, the project will provide support to land owners in the establishment and management of the plantations and they will work with all partners to produce innovative business models that work to the benefit of all partners in the long term.

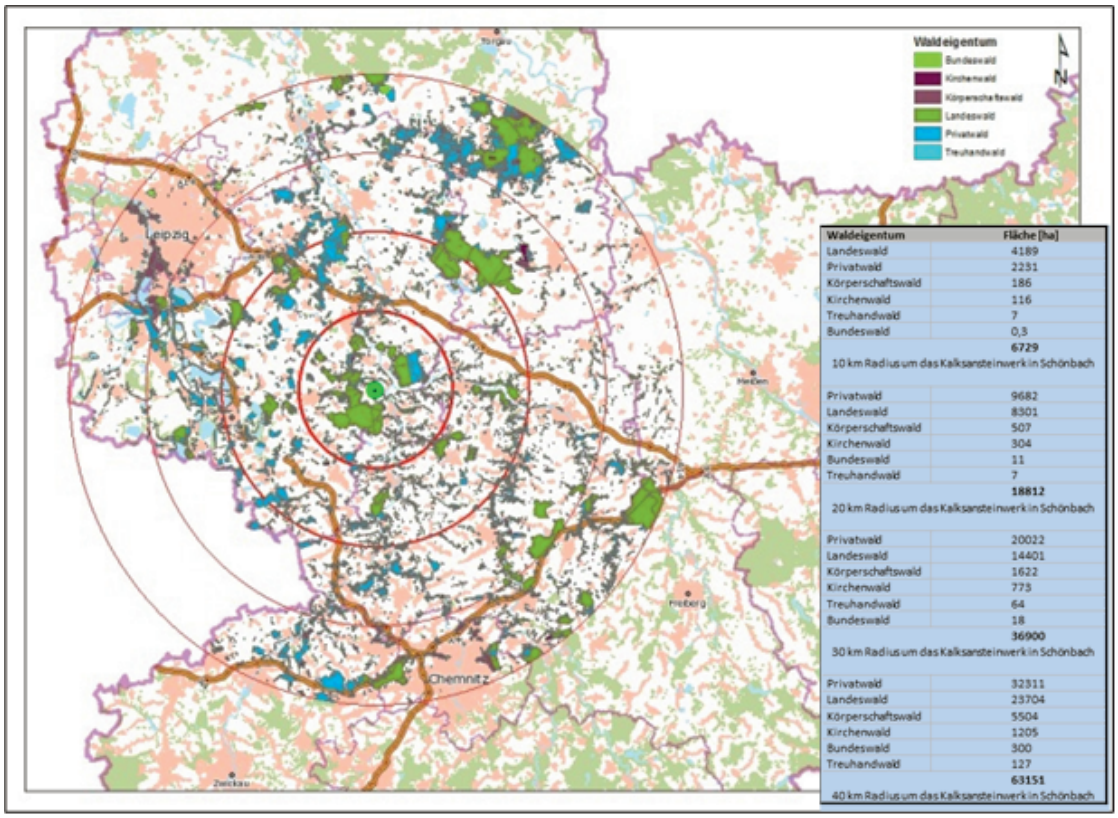

Figure 6: Concentric circles indicating wood catchment areas within specific radii of the cement factory in northern Sachsen. The potential wood reserves – from private forests and that can be produced in short rotation coppice – available within each circle are inventoried. Priority is given to the reserves within the closest circles to minimise transport distances and so also costs [Bitter & Schönbach, unpubl.]

Conclusion

In spite of the numerous benefits associated with short rotation coppice management in terms of providing a much needed resource, the energy efficiency relative to other bioenergy crops, the environmental benefits and the strategic importance attributed to this land use by many at various policy levels [Bemmann et al., 2007; Nitsch, 2008], this importance is not reflected in actions at regional and national administrative level, and so it is not

being implemented in practice. A clear political position with regard to short rotation coppice is not apparent in Germany, and this often translates in an inadequate and often contradictory information service by the responsible authorities. Consequently, the knowledge with respect to cultivation, marketing and the perspectives offered by short rotation coppice at the land owner level is low. Central advisory services for short rotation coppice, as exist for forestry and agriculture, are lacking.

In the context of the highly subsidised agricultural landscape prevalent in the EU, the absence of clear grant scheme for short rotation coppice [see Marx & Michalk, 2013] in most of the German states is a distinct disadvantage and where grants are available, these are often highly complex, difficult to access and frequently conflict with other grant schemes. Another new problem area is the increasing rejection of all bioenergy crops at various levels generally, due primarily to the negative perceptions of maize and oilseed rape, and the implications this may have for woodfuel grown on agricultural land.

In spite of the difficulties, short rotation coppice remains a vibrant and dynamic area of research and the great deal of work done by the Forest Sciences Branch in Tharandt and its many partners in this area, the successes that have been achieved, as well as the many advantages offered by woodfuel, offer great encouragement and will hopefully pave the way for more research in the years to come.

REFERENCES

Ali, W. (2009): Modelling of biomass production potential of poplar in short rotation plantations on agricultural land of Saxony. Dissertation, Fachrichtung Forstwissenschaften, TU Dresden, 130 pp.

Becker, R.; Scholz, V.; Wegener, J. (2010): Maschinen und Verfahren für die Ernte von Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 88-102.

Bemmann, A.; Gerold, D.; Schweinle, J. (2007): Holz aus Kurzumtriebsplantagen – ein wichtiges Rohstoffpotenzial. 7. Internationaler BBE-Fachkongress für Holzenergie. Augsburg. Tagungsband, 293-305.

Bemmann, A.; Große, W. (2011): Effiziente Landnutzung – ein Beitrag zur Zukunftssicherung. Vision der Professur für Forst- und Holzwirtschaft Osteuropas. In: Bonn, S.; Erler, J.; Herzog, S. (eds.): Tharandt 2011 – 200 Jahren Ideen für die Zukunft. Forstwissenschaftliche Beiträge Tharandt/ Contributions to Forest Sciences, Beiheft 12, 16-37.

Bemmann, A.; Nahm, M.; Brodbeck, F.; Sauter, O.H. (2010): Holz aus Kurzumtriebsplantagen: Hemmnisse und Chancen. Forstarchiv, 81(6), 246-254.

Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 340 pp.

Bemmann, A.; Butler Manning, D.; Röhle, H.; Skibbe, K. (2011): Potenziale, Chancen und Hemmnisse einer Kurzumtriebswirtschaft. AFZ-Der Wald, 11, 10-12.

Boll, T.; Neubert, F. P.; Zimmermann, K. (2013): Großes Interesse – geringer Anbau. Joule, 2, 76-77.

Brummack, J. (2010): Aufbereitung von Hackschnitzeln für eine energetische Nutzung. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 117-129.

Brummack, J.; Peschel, T. (2013): Vom Erntegut zum Brennstoff. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 74-85.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) (2012): Erneuerbare Energien 2011 – Daten des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit zur Entwicklung der

erneuerbaren Energien in Deutschland im Jahr 2011 auf der Grundlage der Angaben der Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat). Vorläufige Angaben. Berlin.

Fröhlich, H.-J.; Grosscurth, W. (1973): Züchtung, Anbau und Leistung der Pappeln. Sauerländers Verlag, Frankfurt am Main.

Georgi, R.; Helbig, C.; Müller, M. (2013a): Biotische und abiotische Schäden in Kurzumtriebsplantagen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 42-48.

Georgi, R.; Helbig, C.; Müller, M.; Graichen, K.; Schubert, M. (2013b): Blattwespen-Massenvermehrung in Kurzumtriebsplantagen mit Pappel. AFZ-Der Wald, 4, 14-16.

Georgi, R.; Helbig, C.; Schubert, M. (2012): Der Rote Pappelblattkäfer in Kurzumtriebsplantagen. AFZ-Der Wald, 12, 11-13.

Gerold, D.; Landgraf, D.; Wolf, H.; Schildbach, M. (2009): Bewirtschaftungsstrategien von Kurzumtriebsplantagen. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 73-82.

Glaser, T.; Schmidt, P. (2010): Auswirkungen von Kurzumtriebsplantagen auf die Phytodiversität. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 153-161.

Große, W.; Harling, H.-M. von; Peschel, T. (2013): Ernte von Kurzumtriebsplantagen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 62-68.

Grunert, M.; Wilhelm, E.-G. (2013a): Kurzumtriebsplantagen und Biodiversität. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 139-145.

Grunert, M.; Wilhelm, E.-G. (2013b): Bodenschutz vor Wind- und Wassererosion mit Kurzumtriebsplantagen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 48-52.

Heinrich, J.; Bemmann, A.; Gerold, D. (2010): Integration einer Kurzumtriebswirtschaft in landwirtschaftliche Betreibe sowie innovative Managementsysteme. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 139-146.

Helbig, C.; Georgi, R.; Müller, M. (2013): Die Weidenblattkäfer an Weiden und Pappeln im Kurzumtrieb. AFZ-Der Wald, 4, 17-19.

Helbig, C.; Müller, M. (2009a): Abiotische und biotische Schadfaktoren in Kurzumtriebsplantagen. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 83-98.

Helbig, C.; Müller, M. (2009b): Habitatqualität von Kurzumtriebsplantagen für die epigäische Fauna am Beispiel der Laufkäfer (Coleoptera, Carabidae). In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 147-152.

Helbig, C.; Müller, M. (2010): Naturale Risiken und Grundzüge des Schadensmanagements in Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 74-83.

Knust, C.; Schua, K.; Wolf, H.; Feger, K.-H. (2013): Schnellwachsende Baumarten, Klone und deren Standortsansprüche. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 19-29.

Kröber, M.; Heinrich, J.; Wagner, P.; Schweinle, J. (2010): Ökonomische Bewertung und Einordnung von Kurzumtriebsplantagen in die gesamtbetriebliche Anbaustruktur. In: Bemmann, A.; Knust, C. (2010):

Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 217-229.

Kröber, M.; Heinrich, J.; Wagner, P.; Schweinle, J. (2013): Betriebswirtschaftliche Bewertung und Vergleich der Wettbewerbsfähigkeit von Kurzumtriebsplantagen mit annuellen Kulturen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 95-105.

Lamersdorf, N.; Petzold, R.; Schwärzel, K.; Feger, K.-H.; Köstner, B.; Moderow, U.; Bernhofer, C.; Knust, C. (2010): Bodenökologische Aspekte von Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 170-188.

Landgraf, D. (2013): Etablierung von Kurzumtriebsplantagen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 53-58.

Landgraf, D.; Böcker, L. (2009): Regionale Wertschöpfungsketten im Rahmen der Nutzung von schnellwachsenden Baumarten im ländlichen Raum am Beispiel Südbrandenburgs. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 125-134.

Landgraf, D.; Böcker, L. (2010): Kurzumtriebsplantagen auf Sonderstandorten. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 54-64.

Liebhard, P. (2007): Energieholz im Kurzumtrieb. Leopold Stocker Verlag, Graz, Stuttgart, 123 pp.

Mantau, U. (2012): Holzrohstoffbilanz Deutschland, Entwicklungen und Szenarien des Holzaufkommens und der Holzverwendung 1987 bis 2015. Hamburg, 65 pp.

Marx, M.; Michalk, K. (2013): Förderung von Kurzumtriebsplantagen. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 120-134.

Melchior, G.-H. (1985): Züchtung von Aspen und Hybridaspen und ihre Perspektiven für die Praxis. Allgemeine Forst- und Jagdzeitung, 156, 112-122.

Michalk, K.; Marx, M.; Schulte, M. (2013): Rechtlicher Rahmen für eine Kurzumtriebswirtschaft. In: Bemmann, A.; Butler Manning, D. (eds.): Energieholzplantagen in der Landwirtschaft. Agrimedia Verlag, Clenze, 105-120.

Murach, D.; Hartmann, H.; Murn, Y.; Schultze, M.; Ali, W.; Röhle, H. (2009): Standortsbasierte Leistungsschätzung in Agrarholzbestanden in Brandenburg und Sachsen. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 29-40.

Murach, D.; Knur, L.; Schultze, M. (2008): Endbericht Dendrom – Zukunftsrohstoff Dendromasse. Systemische Analyse, Leitbilder und Szenarien für die nachhaltige energetische und stoffliche Verwendung von Dendromasse aus Wald- und Agrarholz. Verlag Kessel, Remagen-Oberwinter, 504 pp.

Neubert, F.P.; Boll, T.; Zimmermann, K.; Bergfeld, A. (2013): Chancen und Hemmnisse von Kurzumtriebsplantagen – Online-Umfrage unter Praktikern. AFZ-Der Wald, 4, 4-6

Nitsch, J. (2008): Weiterentwicklung der ‚Ausbaustrategie Erneuerbare Energien' vor dem Hintergrund der aktuellen Klimaschutzziele Deutschlands und Europas. Leitstudie 2008. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin, 196 pp.

Petzold, R.; Feger, K.-H.; Schwärzel, K. (2009): Wasserhaushalt von Kurzumtriebsplantagen, In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 181-192.

Petzold, R.; Feger, K.-H.; Röhle, H. (2010): Standörtliche Voraussetzungen für Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 44-53.

Pretzsch, J.; Skodawessely, C. (2010): Sozio-ökonomische und ethische Aspekte der Kurzumtriebswirtschaft. In: Bemmann, A.; Knust, C. (eds.): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 230-242.

Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 355 pp.

Röhle, H.; Ali, W.; Hartmann, K.-U.; Steinke, C. (2010): Wachstum und Biomasseproduktion schnellwachsender Baumarten in Kurzumtrieb. In: Bemmann, A.; Knust, C. (eds.): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 103-116.

Röhle, H.; Hartmann, K.-U.; Steinke, C.; Murach, D. (2009): Leistungsvermögen und Leistungserfassung von Kurzumtriebsbeständen. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 41-56.

Schildbach, M.; Grünewald, H.; Wolf, H.; Schneider, B.-U. (2009): Begründung von Kurzumtriebsplantagen: Baumartenwahl und Anlageverfahren. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 57-72.

Schildbach, M.; Hofmann, M.; Wolf, H. (2010): Anlage und Etablierung von Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 65-73.

Schmidt, P.; Glaser, T. (2009): Kurzumtriebsplantagen aus Sicht des Naturschutzes. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 161-170.

Schmidt, P.; Glaser, T. (2010): Naturschutzfachliche Bewertung von Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 162-169.

Schönbach, H. (1957): Die bisherigen Ergebnisse der Züchtungsarbeiten mit verschiedenen pappelarten der Sektion Leuce. In: Günther, H.; Joachim, H. F.; Polster, H.; Schönbach, H.; Thümmler, K.; Regler, W. (eds.): Beiträge zur Pappelforschung. Akademie Verlag, Berlin, 149-178.

Schulte, M.; Michalk, K.; Glaser, T.; Knust, C.; Lohner, P.; Bemmann, A. (2010): Rechtliche Rahmenbedingungen für Kurzumtriebsplantagen. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 15-29.

Skodawessely, C.; Pretzsch, J. (2009): Akzeptanz des Energieholzanbaus bei Landwirten. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 217-226.

Spinelli, R. (1995): Biomass production from short rotation coppices. Terra e Sole; 50(636), 318-332.

Spinelli, R. (2006): Short rotation coppice (SRC) production in Italy. CNR-Ivalsa, Sesto Fiorentino, 9 pp.

Wagner, P.; Heinrich, J.; Kröber, M.; Schweinle, J.; Große, W. (2009): Ökonomische Bewertung von Kurzumtriebsplantagen und Einordnung in die Anbaustruktur landwirtschaftlicher Unternehmen. In: Reeg, T.; Bemmann, A.; Konold, W.; Murach, D.; Spiecker, H. (2009): Anbau und Nutzung von Bäumen auf landwirtschaftlichen Flächen. Wiley-VCH Verlag, Weinheim, 135-146.

Wagner, P.; Schweinle, J.; Setzer, F.; Kröber, M.; Dawid, M. (2012): DLG-Standard zur Kalkulation einer Kurzumtriebsplantage. DLG-Merkblatt 372, Frankfurt am Main, 26 pp.

Weih, M. (2004): Intensive short rotation forestry in boreal climates: present and future perspectives. Canadian Journal of Forest Research, 34, 1369-1378.

Wendisch, J. (2010): Eröffnungsrede 3. Symposium 'Waldstrategie 2020' on 12 April 2010. http://www.nachwachsenderohstoffe.de/waldstrategie/ (retrieved: 22 June 2012).

Wolf, H.; Schildbach, M.; Hartmann, K.-U. (2010): Plantagenbaumarten und deren Züchtung. In: Bemmann, A.; Knust, C. (2010): Agrowood – Kurzumtriebsplantagen in Deutschland und europäische Perspektiven. Weißensee Verlag, Berlin, 30-43.