Report of Short Term Scientific Mission (STSM)

SHORT ROTATION COPPICES IN GERMANY

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I. Markoff,

Forest Research Institute in Sofia

Host:

Prof. Erik Findeisen,

Fachhochschule Erfurt

Fakultät für Landschaftsarchitektur, Gartenbau und Forstwirtschaft

Fachrichtung Forstwirtschaft

Professur für Waldarbeit, Forsttechnik und Forstnutzung

AIMS

This STSM has been made having in mind to promote modern coppicing in Bulgaria. Bulgarian coppices occupy 1 998 033 ha or 48% of the country's forest area. In addition, according to some estimates, Bulgaria has about 1 000 000 ha of unproductive agricultural land suitable for afforestation.

The main aim of this mission was to define the technical parameters of modern coppicing: short rotation coppices (SRC) and traditional coppices, incl

- growth data and growth models
- planting, harvesting evtl. thinning operations
- machinery, productivity and cost efficiency issues
- biomas use

IMPLEMENTATION

To achieve this aim, appointments were made with scientists and practical specialists. The final discussion was made in the host institution. The course of the appointments (time, place, persons and topics) was, as it follows:

19.04.2016.

Dresden, OGF Ltd, Dr. Denie Gerold, biomass use

OGF Ltd is a private company delivering services in the forestry sector – inventories, management plans, financial analyses, appraisal of forest estates and even forest management for the forests of 2 communes incl. annual plans (*Jahresplanung*). The company is often engaged in ressearch projects and innovative practices e.g. inventury with sample plots which is increasingly popular in Germany. They also participated in promoting SRCs. The beginning was promising, but later on a stagnation followed. For the time being, SRCs have not yet realised their potential in Germany. The available German experience is presented in a study of Gerold and Schneider (GEROLD ET AL., 2014). The general conclusions of this study were:

1. Energetic use of dendrobiomass requires a good **elaboration of supply chains**.
2. **The market of woodchips is essentially local**.
3. Promoting the energetic use of biomass requires organised efforts: consulting, state aids and research.
4. **The ecological impact of SCRs is positive**.

20.04.2016

Erfurt, Fachhochschule, Prof Dr. Dirk Landgraf, SRCs

SRC are termed KUPs (*Kurzumtriebsplantagen*) in German which is literally 'short rotation plantations'. The difference is small since SRCs are made exclusively with broadleaved species (poplar, willow, locust) which are always **coppiced several times (in general 3x) before being replanted.**

The tree species used to establich a SRC are poplar, willow and locust, at least in Germany. Locust (Robinia Pseudoacacia) grows well on very poor soil (*Grenzertragböden*), poplar and willow require water. **Paulownia has proven inadequate** – it gets frozen every winter.

The presentday tree-species composition of German SRCs is:

Species	Share	Location
Poplar	80%	South, West
Willow	10%	North
Locust	10%	East (because of sandy soils)

The usual rotation times are:

mini-rotations	midi-rotations	maxi-rotations
2-4 years	6-12 years	14-20 years

The most common rotation time is 3 years. The most common use is the energetic one. However, for the locust, a midi-rotation of 8 years starts being preferable because of a material use (*stoffliche Verwertung*) as fence posts. As in Germany the game populations are too dense, natural regeneration of broadleaved stands is only possible when protected with fences for which locust is very suitable and well sold.

The SRCs are no more considered forests – they are classified agricultural plantations. A recent amendment (*Novelierung*) of the federal forest act made this changement. It is judged favourable because it stimulates the farmers to establish SRCs. **This ammendment is due to EU legislation, thus a similar regulation must be also valid in Bulgaria.**

The main consequences are

- For the land owner, establishing a SRC is no more a fatal step, unlike afforestation;
- The farmers continue receiving agricultural aids (*Förderung*).
- There is no fixed minimal rotation time.

According to German legislation, there are fixed minimal ages of final cut (*Mindeststandzeit im Wald*) for all forest stands. This makes converting of a forest into a SRC impossible - it is no problem to plant poplar on forest land, but it can not be cut before the age of 30.

The SRCs are close related to agroforestry which combines tree farming and agriculture on the same spot. Most common are rows of belts of forest trees integchanging with belts of crops. In May, an Agroforest Congress will be held in Montpelier.

There are 6000 ha of SRCs in Germany which are registered as such by the authorities (*amtlich bekannt*) because they receive bonusses (*Prämien*). On the other hand, in the South (Bavaria, Baden-Würtemberg) and still more in Austria there are farmers who establish SRCs to meet their own needs of energy by producing wood chips (*Hackschnitzel*). In most cases that are single farms difficult to supply (*Einzelgehöfte*). They do not claim aids and their number is not known officially. They are very important nevertheless, because their existence proves that the idea has its prospectives.

The Swedish energy concern Vattenfall – a state-owned company operating also in Germany – has planted 2 000 ha SRCs around Berlin in order to demonstrate compatibility with green ideas.

There is a stagnation in the process of establishing SRCs due to recent declining oil and gas prices. This stagnation coincides with financial shortages of other nature so that the German authorities prefer to use the favorable conjuncture on the fossile fuel markets. For the time being the auhtorities do not invest in research and promotion of SRCs although its prospectives are not under question.

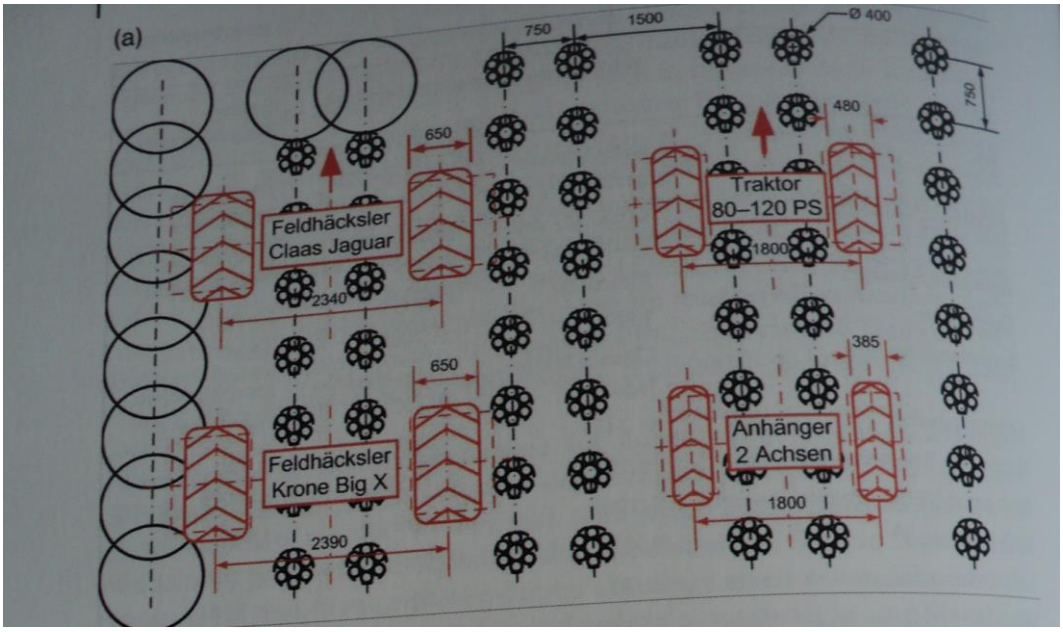
For SRCs, poor and poorest sites are used (*schwache Standorte u. Grenzertragsböden*). That are corn-fields too poor, too dry or too little to be used as corn-fields. Also wasteland can be used for SRCs. Of course, the SRCs would feel very well on better sites but the farmers prefer to use the latter for agricultural production.

Grassland, i.e. meadows and pastures, can not be used for SRCs because of the grassland protection policy of the EU (*Grünlanderhaltungsgebot der EU*) which states that the total area of meadows and pastures may not decline. If one wants to create a SRC on his meadow, he has to convert something else into meadow, which is not practical. This excludes practically meadows and pastures from the possible SRC ground. The conservation of meadows and pastures is made for ecological reasons – they are indispensable for ground-nesting birds (*Bodenbrüter*).

SRCs are economically possible for productivity levels not lower than 8t, i.e. 8 atro t/ha/y (Schweier & Becker, 2013). On the best sites (good water supply, in Bavaria) they can produce even 20 t. **The agricultural soil fertility index BWZ has proved irrelevant** (BWZ or *Bodenwertzahl* is Germany's usual measure of agricultural soil fertility. It varies from 15 to 100, 15 being the absolute minimum, e.g. the value for mine recultivation sites). By contrast, water is crucial. River beds may lay in many kilometers away, but **the subsoil water level must not lay deeper than 2 m in sommer.** Rain is as favorable as river water, but the final criterion is that subsoil water level (*Wasserspiegel*) must not lay deep.

The production of SRCs is used mainly for combustion, i.e. as fuel. **They are harvested mainly with forage harvester** (*Feldhächsler*). Initially, the Swedish 2-rows plantation pattern was used everywhere involving 2 rows of plants close together (less than 1 m) with a broader distance to the next 2 rows (about 2-m) giving space to the tires of the tractor to pass (fig 1).

Fig. 1. The 2-rows planting pattern of SCRs (Reeg et al., 2009)



This system is still considered suitable for willow plantations but no more for poplar: after each rotation the trunc resprouts from lateral buds and with poplar it becomes effectively wider. After 3 rotations (or 9 years) the effective diameter is so large that the forage harvester can not handle 2 rows. That is why the 1-row system started being recommended for poplar.

Fig. 2. The 1-row planting pattern of SRCs

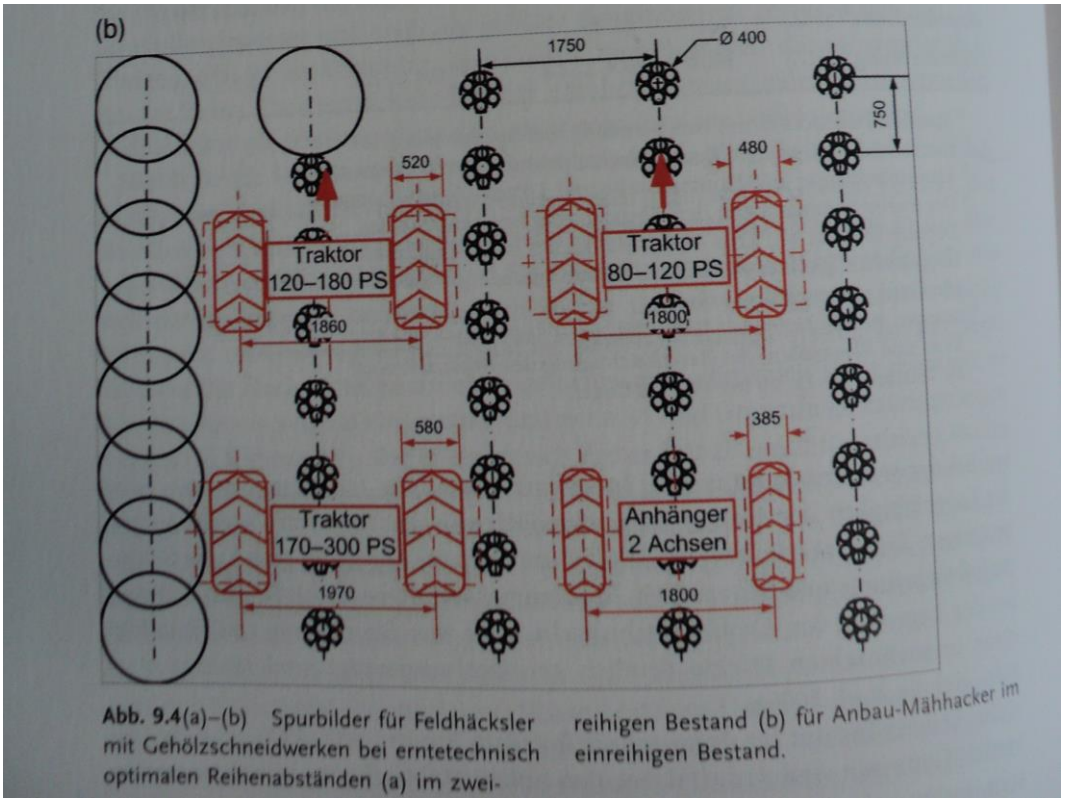


Abb. 9.4(a)–(b) Spurbilder für Feldhäcksler mit Gehölzschneidwerken bei erntetechnisch optimalen Reihenabständen (a) im zweireihigen Bestand (b) für Anbau-Mähhacker im einreihigen Bestand.

There are 2 types of forage harvesters – self-propelled ones (*selbstfahrende Feldhächsler*) with a purchase price about 400 000 €, carried on low loaders (*Tieflader*), producing 1 t/h, or tractor-attached ones (*Anbau-Feldhächsler*), attached to every type of agricultural tractor and transported with a pickup, producing 0,6 t/h, and a purchase price about 50 000 €. The latter do allmost the same job and are far more practical.

Delivery distance (*Lieferdistanz*) for woodchips

via autobahn	100 km
via other roads	50 km

C.A.R.M.E.N.e.V. publishes prices for woodchips

120 – 130 €⁄atro t	South, West
80 €⁄atro t	East

Prof. Röhle in Tharand has developped a calculator for SRCs (poplar and willow) that can be downloaded for free. It is an Excel-file (Röhle et al., 2015).

The German law about forest reproduction materials (*Forstvermehrungsgutgesetz*) is also applied to SRCs of poplar and locust, but not to the ones of willow. The law defines a fixed list of allowed tree species, proveniences and clones which is annually actualized by the the

federal institute of agriculture and food (*BLE – Bundesanstalt für Landwirtschaft und Ernährung*). Tree species, proveniences and clones are examined in order to permit planting them. The permission is often valid only in a restricted region in Germanty. The infraction against it is a crime.

21.04.2016.

Erfurt, Fachhochschule, Heike Schlehahn, growth models and yield tables.

The use of yield tables is being disputed in Germany. Perhaps because of the climate change, German forests grow some meters higher than the yield tables predict. Several models have been developed to explain this. Nevertheless, the practical foresters use the yield tables.

Yield tables in Germany are traditionally local. The provinces (*Länder*) have different tables. The yield tables for Thuringia have been editted by Prof. Anka Nicke. A whole-Germany impact have the yield tables of Schober. As coppices are rare in Germanny, most yield table collections have no yield tables for coppices. Groos has publisched a yield table for coppice oak in the 50s (Groos, 1953).

22.04.2016

Erfurt. Nature Foundation ‘David’.

Dr Dierk Conrady, project manager (*Projektleiter*).

Traditional coppices and coppice ecology.

The foundation promotes nature conservation in the East of Germany. According to its experience, t**he sustained nature conservation must comply with the interests of the owners.** That is why the foundation always tries to combine nature conservation with the interests of local residents. Otherwise things use to go wrong. At the start, the stakeholders use to be reticent. Transparence and realism create the confidence. A.e. the foundation participates to the conservation project "Hohe Schrecke - Old Forest with a Future". Hohe Schrecke is a hill region between Thuringia and Saxonia-Anhalt designated as a nature reserve. In the surroundings of the reserve, the foundation and the Government of Thuringia promote sheep breeding in order to strengthen both the local economy and the maintain of grass land and orchards. The sheep grase in the orchards which maintains both orchards and grass cover and contributes this way to biodiversity. In order to foster sheep breeding, the market chain Weidewonne™ has been established aiming the local realization of lamb. The benefits of the projects are a pasture range without chemistry and quality meat supply without gen-modified fodder (i.e. without soya beens which are almost always gen-modified – soya beans are an import product rarely cultivated in Europe).

Another experience of the David-foundation is **that nature conservation need not be always done with establishing of reserves.** E.g. it is no use to put under permanent protection the forests where there are nests of the lesser spotted eagle (Clanga pomarina) because they are abandonned after being used about 5 years.

About coppices: **All traditional coppices (*Niederwald*) in Germany are being transformed into coppices with standards (*Mittelwald, tailis sou futaie*).** The advantages of coppicing with standards are better assortments and natural regeneration from seed. Almost all coppices

are communal or private – the owners are cooperatives and communes. In some localities coppicing is an old tradition – up to 800 years. **The rotation time is 20 years as a rule, for vigorous stands 15, on dry sites – 25.** The most important use is the fire wood for heating. Fire wood is used at least for additional heating, especially in autumn and spring. Everybody have gas installations, but they also keep the heating stoves.

The ecological value of the coppices is due to the fact that they give refuge to a variety of species. The refuges help the nature to recover after human activities reducing biodiversity. The coppices give refuge to species that usually inhabit forest glades and meadows. They also give refuge to species that are exterminated from the cultivated landscape (corn fields etc.) by the use of chemistry and fertilizers. The use of fertilizers eliminates many plant species. The coppices with standards are also a habitate of species that like sunny tree crowns – insectivore and vegetarian birds, insects and reptiles. However, in the coppices there are no dead-wood inhabitants – the high forest is better for them.

For the preservation of biodiversity, maintaining of coppices is fostered. Besides of maintaining of the coppiced area, the spatial order of clearcutting can be important for the ecological effect: **it is recommended to cut adjacent areas in order to facilitate the migration of some species.** Fig. 3 illustrates this idea for a coppice forest with a rotation time of 20 years. The cells represent the woodcutting areas of a 20-year period and the numbers – the order of cutting. With this spatial distribution each new-cut plot is adjacent to a yound and an old stand which allows small species to find their habitual biotop nearby.

Fig. 3. Recommended spatial order of clearcutting a coppice

1	2	3	4	5	6	7	8	9	10
20	19	18	17	16	15	14	13	12	11

25.04.2016 Erfurt

Prof. Erik Findeisen, Heike Schlehahn

Pests and SRCs.

Pests infest mainly the poplar SRCs. The leaves are damaged by Chrysomela populi (*Pappelblattkäfer*) and sometimes the Tenthredinidae (*Blattwespen*) damage the stems. **The SRC damages due to pests are not significant.** Only one SRC is known to have perished up to 90% because of pests. With the climate of Germany sommer droughts are not fatal either.

Comparison SRCs and traditional coppices

It is not certain whether the SRCs are better paying than traditional forests. From the financial point of view, the short rotation times are very advantageous. However, the SRCs are likely to exhaust the soil productivity whereas the traditional forests are known to accumulate it. For the final monetary valuation, the technology is crucial. In general, **forage harvesters are better paying than bundling machines**.

Market situation

Because of low petroleum prices, the demand for woodchips is weak at present. Many wood-processing enterprises are near to shut down because they can not get rid of the industry waste ususlly sold as woodchips.

27.04.2016 TU Dresden

Prof. Bemmann.

SRCs and East European forestry.

Woodchips are consumed locally. Far transportation of woodchips is too expensive, even via the Danube. A possible consumer of Bulgarian woodchips is Kronospann which produces particle board in Bulgaria.

The regeneration of oak is also problematic in Sibiria and Kasakhstan. Recently, German experts visited this region because of pedunculate oak problems. The most prominent German expert in oak is Prof. S. Wagner.

The discrepancy between German yield tables for oak (after Wimmenauer and after Jütner) and Balkan-countries yield tables (Armașescu in Roumania and Nedyalkov in Bulgaria) may be due to different height growth of pedunculate oak and sessil oak – German yield tables pertain mainly for pedunculate oak which is rare in Bulgaria.

Prof. Röhle: forest modelling.

Germany is going to abandon the traditional yield tables and to switch over to the use of growth models. The growth models used in Germany are single-tree based ones (they deal with single trees) and take account of the concurrence between individual trees, the concurrence between tree species, the growth of the understory (*Unterschicht*) and the climatic change. There are two models that find real application in Germany:

1. BwinPro, freely downloadable, applied in the North, recently also in Saxony in the South (Nagel et al., 2006),
2. Silva, not freely downloadable, developed at the TU München, applied in Bavaria (Pretzsch et al., 2002).

A very good publication, elucidating German models, is the dissertation of Jens Schröder about the forests of beech and spruce (Schröder 2004). Very good is also the dissertation of Münder about the forests of beech and pine (Münder 2005). Both can be fulltext-downloaded.

The problem of SO_2 faded away after 1990-95 and is no more considered actual. On the opposite, the German forests have started growing faster. In the last years the annual rings became obviously broader. There is no universally recognized and definitive explanation. Growth-and-yield experts (*Ertragskundler*) discuss following 3 hypotheses:

1. Increased growth may be due to liming, which is still done on a large scale in Germany and is a kind of fertilization;
2. The climatic change is favorable for German forests;

3. The introduction of high thinning (*Hochdurchforstung*, thinning from above) about 1990 should also have enhanced growth.

The taper functions (*Schaftfunktionen*, stem profiles) and volume equations (*Volumen-funktionen*) applied in Germany are set out in the publications about the national forest inventory (*Bundeswaldinventur* BWI, s. Kublin 2007). They are free to download.

Prof. Deegen,

Valuation of investments (*Investitionsrechnung*) and forest appraisal (*Waldbewertung*).

Although there are data and publications showing that the long term real interest rate decreases, the German regulations and institutions still operate with a real interest rate of 4%.

There is no actual up-to-date manual in forest valuation in German. Klemperer's American manual is recommended (Klemperer, 1996) also for the estimation of financial efficiency.

The federal state Nordrhein-Westfalen publishes the best collection of costs and prices that can be used for calculations.

The Federation has an instruction for forest appraisal which it applies but the federal states have own instructions they apply unless the Federation is involved. Instructions are not binding in all cases. The most common cases which require an appraisal (*Bewertungsfälle*) are:

1. **Sales** (voluntary private transactions). The forest to sell is usually valuated after market prices of forests and forest land. The board of trustees for forest appraisal (*Kuratorium für Waldbewertung*) keeps statistic records, whose results are not public, however. In order to obtain preliminarybinformation, the interested parties can look up values in the tables which use to be attached to instructions.
2. **Damage claims**, when private persons claim damage against other private persons. The instructions are often applied although not binding (auxiliary *hilfsweise* use).
3. **Alienation** (*Enteignung*), when the state compensates expropriated forests. This is the case when the instructions are the only criterion.

Prof. Bitter: Forest inventory.

About the legacy of Narewa (the modelsystem and the data bank of GDR's forests) – after the turnaround (*die Wende*, the Greman reunification), the data bank was continued independently by the federal states, but only for the state-owned forests. Some federal states have remade the software. The private forests are inventoried by private companies like OGF.

Besides of growth models, another new tendence is the use of sampling methods. They are increasingly applied in state-owned forestry enterprises and also in the big private ones, e.g. the foresty of the prince of Turn-und-Taxis. The sampling method is close to the method of Schmit-Haas. The sampling provides reliable total values for the enterprise's forests. The stratification is made after tree species (broadleaved and conifers) and age (age classes). For the first survey in a forestry enterprise, 500 sample plots are sufficient regardless of its size. According to its results the sample may be densified. Finally, for large enterprises, the density of 1 sample plot for 7 ha is the rule, for smaller ones the rule is 1 sample plot for 2 ha, which correspond to a raster 200×100 m.

The standard books in forest inventory in Germany are

1. The guide of Kramer and Akca (Kramer, 2002)
2. The book of von Gadow (v. Gadow, 2006)

Traditional forest inventory has heavily underestimated the growing stocks in Germany. In a forest enterprise here in Saxony we stated 350 m³/ha using sample plots against 250 m³/ha after the traditional inventory made some years before that. The local colleagues promptly denied our results. Nevertheless, their own índicative plots manifested similar results to ours. (The indicative plots are forest stands used to train the eyes of the inventorists. These stands are always carefully measured in order to compare estimation by sight with reality). Then, we have looked for the cause of the difference and we have found it: the main source of the discrepancy was that they set the stocking rate down to 1 when they calculate from the yield tables a stocking rate higher than 1.

The functions of Brink and Riemer (parameter-scarce taper functions) are known. Riemer was a PhD-student of Saborowski. Saborowski himself has contributions dealing with spline functions which have a bigger impact on real life.

Final discussion – possible applications in Bulgaria

Prof. Erik Findeisen,

Erfurt

The situation of Bulgarian coppices has been discussed in detail:

Bulgarian coppices occupy 2 000 000 ha which is the half of the country's forest area. **Most of the coppices (1 500 000 ha) are in process of conversion to high forest,** 250 000 ha are plantations of black locust which are regularely coppiced (*Niederwald*) and 250 000 ha are natural stands of Oriental hornbeam (Carpinus orientalis Mill.) which are rather abandoned. There are no coppices with standards, no short rotation coppices and no maquis. **80% of the conversion forests are dominated by oak** (sessile oak, Hungarian oak and Turkey oak) and the rest is dominated by beech and hornbeam. Bulgaria has about 20 000 ha of poplar plantations which are not coppices. Their usual rotation is 20 years.

One third (29%) of the coppices are not state-owned, half of this are the private ones. **The average slope of the coppices is 19°,** which is indicative for the possible use of machinery. The rotation ages for the conversion forests are 60-100 years, for Turkey oak 40-60. **The average age of conversion forests is 45 years, i.e. they are already aging.** The rotation age for black locust is 20, its average age is 16.

In Bulgaria, the conversion started fairly late and is still going on. Conversion of the coppices to natural stands is a policy dating back to the 50s, but the main efforts started in the early 60s. This policy aimed to improve both productivity and quality of forests. Indeed, although the coppices occupy 50% of the woodland, they give only 39% of the harvested wood, at that mainly industrial wood and firewood – the sawlogs are 5% of the harvested wood against 23% for the broad-leaved high forest and 36% for the conifers. Nowadays, the rising prices of energy wood give cause to reconsider this policy. Firewood prices rise in Bulgaria, too. Nevertheless, firewood is still the cheapest energy. All the Bulgarian countryside uses firewood for heating. The communes and the local population favor traditional coppicing. Their aim is better supply of fire wood.

Examination of mean increment shows that the optimal rotation time for Bulgarian coppices should be about 20 years if the production of biomass is the aim. At that age the stands do not produce seed and should regenerate by re-sprouting. However, **resuming the coppicing in Bulgaria will be a silvicultural challenge because of the aging of the coppices and the oak regeneration problems. Recently, private forest owners often clear-cut their coppices but the aged coppices re-sprout poorly.** The sustained management of such forests requires making use of the available natural seedlings to renew the root system. Most suitable is the femel-cut with a regeneration period from 15 to 20 years. Where the natural regeneration with seedlings is impossible or has failed, acorns have to be sown, in the autumn and after a soil preparation aiming to reduce the competing vegetation.

beach coppice in Bulgaria on a typical steep slope

Taking into account the situation of coppices in Bulgaria and the quoted German experience, following conclusions have been made:

CONCLUSIONS

1. Because of the abundance of coppices in Bulgaria, no special care needs to be taken on biodiversity topics. Besides of that, an important part of Bulgarian coppices are protected by Natura 2000. A possible task is to study whether the regime of Natura 2000 protects adequately the coppices and whether all types of coppices are covered by Natura 2000.
2. The tree species, used in Germany for SRCs – poplar, willow and locust, are popular and well known in Bulgaria, too, and the sites suitable for them seem to be also well known and already occupied by them. Thus, promoting German experience in Bulgaria would mean introducing mini- and midi-rotations instead of maxi-rotations in

already existing plantations. The prospectives of a dramatical shortening of rotation times depend on the demand of woodchips which is the only product of SRCs with a mini-rotation.

3. For the time being there is no international demand for woodchips produced in Bulgaria. A realisation on the local market should be considered, the main clients being the communes, farmers and some wood-processing enterprises like Kronospan Bulgaria.
4. For oak and beech, maxi-rotation coppices with 20-years-rotations are suitable. **The coppicing with standards (*Mittelwald, tailis sou futaie*) has to be recommended.** Conventional forestry machinery is to be used. The main economic aim is the local supply of fuel wood.
5. The potential of tree farming on agricultural land have to be studied. A favorable political condition is that SRCs are no more considered forests.
6. Paulownia is inadequate for Bulgarian continental climate.
7. Because of the negative attitude of the Bulgarian foresters, a good preliminary study has to be made in order to inform the decision makers about potential and possible scope of coppicing.
8. Possible international cooperation can concern the topics: ecology of coppice forests (Bulgarian coppice forests are abundant and in a relatively natural condition), technology transfer (Bulgarian forestry sector is in process of re-mechanisation) and growth modelling (Bulgarian growth models for oak need revising). Possible participants are, besides Bulgaria, Germany (advanced in mechanisation and modelling), Romania (similar natural conditions, good functionning forestry sector) and perhaps Italy (experience in coppicing, wood pellet imports from Bulgaria).

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