



Acres with feeling: Cart horse Franziska and logger Michael Mallmann haul wood out of the forest in the Hunsrück Hills, without damaging the young trees.

Where turbotrees flourish

Forests as energy sources are now to help **reduce carbon emissions**. The search is on for land areas and suitable trees. Germany could have been a leader in this field, had it not squandered its head-start.

Written by Jürgen Heup, photographed by Martin Leissl

Franziska is soaked in sweat, steaming in the cold March air. Although she's fairly small – 500 kilograms – for a southern German draft horse, she easily makes up for it with her temperament. The mare works her way diligently through the deep forest, yanking 20-meter lengths of sawn-down birches and aspens from the standing stock and out to the forest track, then diving back into the boscage without a break. The lumberjack has barely enough time to refill his chainsaw.

Timber harvesting with horses isn't all that unusual in German forests, although

machines clearly predominate in forestry work. But what Franziska and a small group of foresters are doing on the Hunsrück heights in the early morning hours is something new. It's a firewood project, based on an old idea in the forestry world: to make double use of a given area by planting fast-growing tree species alongside fine wood-producing trees that thrive in a more leisurely way, producing a two-stage wood where rapidly progressing firewood is followed by quality timber. But can a fuel forest be harvested after 20 years without dam-

aging the slow-growing timber? Without destroying the young plants that grow in the shadows of the birches and aspens? And without the main tree species suffering a loss in production from spending too much time in the shadow of the turbotrees?

Preventing damage

Franziska knows her job inside out. Michael Mallmann, the logger, doesn't give her many commands apart from "giddap" and "whoa," because he can use the long reins to control speed and direction. Franziska trots

to the felled trees by herself and waits patiently for Mallmann to place the harness chain around the stem. Then she demonstrates the great strength of horses in forestry work. Franziska skillfully maneuvers the wood out of the dense vegetation without flattening the oak and beech trees, which are only as thick as broom handles. It looks like this powerful horse is keeping a close eye on the baby trees, as though she knows the ideal line to take through this dense forest and can take precise account of the long log she has in tow. If things get a little tight, Mallmann clicks his tongue. Franziska takes a few steps back, then goes a different way.

If a machine were used here, the collateral damage from logging could be very different, for the tracks made on wet surfaces by heavy forestry machinery are as ugly as those of army tanks. If the man on the cable winch gets distracted for a second, he can easily mow down a whole row of trees – a forester's nightmare. No longer would there be a double yield from the plantation; 20 years' worth of timber would be gone instead.

The birches and aspens in the Belg woodland didn't fly in as seeds, as these pioneer plants usually do. They were planted intentionally, along with the beech and oak trees, by scientists at Freiburg University's forestry institute, after the Wiebke storm in 1990. These are special varieties, the results of crossbreeding experiments that produced particularly fast-growing, high-yielding hybrids. They shot past the oaks and beeches even in their early years of life and are now, in their 20th year, four times as thick and four times as tall. In a forest consisting wholly of beech trees, thinning after 20 years would result in very reduced yields, and the work would probably cause additional cost. Fast-growing trees, on the other hand, make harvesting economically viable.

A stronghold of poplar research

Hannoversch Münden, in the extreme southeastern corner of Lower Saxony, is where the Werra and Fulda rivers combine to make the Weser, and half-timbered houses and the neighboring Reinhard Forest give the small town a picture-book backdrop. Karl Geb-

hardt has lived in Hann Münden, as the locals call it, for more than 20 years. With his doctorate in biology, however, it wasn't the rural idyll that brought him from Bavaria but his job on the Weser at the Research Institute for Fast-Growing Tree Species. The Prussians founded a forestry academy here in 1866, and by the end of the 20th century Hann Münden had blossomed into an international stronghold for plant breeding, especially for poplars and willows. In the 1950s and 1960s, German foresters feared an impending timber shortage as a consequence of the Second World War and its ensuing reparations. They hoped to get greater quantities of timber from American balsam poplars and aspens than from domestic tree species. Poplar plantlets from all over the world were meticulously brought together and crossbred in Hann Münden. Not without success, as Gebhardt points out with a photograph showing a mighty poplar, a hybrid called Brühl that draws crowds of astonished foresters. At just 34 years old, it is already 40 meters tall and contains 15 cubic meters of timber. A spruce would take perhaps 150 years to grow to that size, if it could even do so. There are poplar species that generate an annual yield of 18 tons of dry mass per hectare (see box). But the poplar boom didn't last long in Germany. The construction in-

dustry didn't like its soft wood, and the foresters found the spruce better for forests.

Karl Gebhardt's pride and joy thrives in the neon light of the cold chamber. Tiny seedlings in petri dishes, marshaled on man-high shelves, baby willows with sonorous names like *Salix viminalis* (Common Osier), miniature members of the poplar family, descendants of the European black poplar, and *maximowicii* from Japan, called Max 1 to Max 5 for short, while the "Weser" selection clearly indicates Hann Münden as its place of origin. Some results of crossbreeding can be achieved using a micropropagation technique. Gebhardt and his colleagues arrived at these reproductive variants for the first time in the mid-1980s. As there are barriers to crossbreeding between various poplar species, for example between the American balsam poplar and the European black poplar, pollination is helped along with brush and tweezers. If a pollinated seed is formed, under normal conditions it usually dies. The Hann Münden scientists bottle-feed it, so to speak, with their embryo rescue process. The new hybrids grow into small plantlets in vitro (outside the organism) in a special nutritive tissue in the cold store. The researchers divide up the shoots from these plants and propagate them again in the nutrient medium. Large numbers of ge- ▶

What is the return on short-rotation plantations?

Costs and yields determine the economic viability of short-rotation plantations. One expenditure is the cost of establishing the area, which means planting, any fences, and recultivation. Process costs include maintenance, harvesting, drying, transport and storage. The yield and market trends are quite crucial. According to calculations by the Lower Saxony Environmental and Agricultural Ministry, one-off investment costs are approximately EUR 2,200 per hectare (EUR/ha). Given a four-year planting-to-felling period, an annual yield of twelve tons of dry mass per hectare (tdm/ha), and a 20-year usage period, the resulting average annual process costs are EUR 950 per hectare. With an assumed yield of twelve tons, the unit cost of wood chips is around 80 EUR/tdm. By including per-hectare area support by direct payments and the energy-plant premium of EUR 45 per hectare, at least 70 EUR/tdm of wood chips should be achieved on the market. The Ministry thus calculates that a profit of approximately EUR 240 per hectare, equivalent to that of agricultural cash crops, is possible. At present, comparable forest wood chips are being traded at an average 80 EUR/tdm.



The willow (*Salix*)

Willows are particularly interesting for use in agricultural woods, since they don't come under the Act on Forest Reproduction Material (FoVG), so new varieties don't have to observe the ten-year testing period. Their mass yield moreover measures up to that of the poplar, and they sprout very vigorously, as well as stand up to nitrogen better than their near relatives. Willow plantations also yield salicin, which is used in the manufacture of painkillers.

The birch (*Betula*)

Very fast-growing: at just six years, it reaches a height of seven meters. It possesses the high energy density of 1,900 kilowatt-hours per cubic meter. Thanks to its ethereal-oil content, birchwood burns even when fresh.



Sawing for science: Forest manager Thomas Weich takes down a 20-year-old birch hybrid. He will evaluate the data later at Freiberg University's forestry institute.

netically identical descendants (clones) can be created within a few months. "Theoretically, this propagation functions with a factor of ten," says Gebhardt, calculating that each shoot yields ten new plant clones. In a year, the total number of descendants is in the millions. "In practice, we only achieve a factor of six," says Gebhardt. That's enough, however, to set up parent plant quarters in tree nurseries and to plant whole forests.

Knowing (not engineering) genes

The poplar wood has further benefits in the lab. American researchers have been able to completely decrypt the genome of poplars. It's now known which of the 520 million base pairs of the 19 chromosomes are responsible for a plant's budding time, leaf size and stem formation. By this means, the seedling of a new hybrid can already show what properties its descendants will have. Leaf size, for example, gives information about potential yield. This knowledge certainly doesn't change any part of the ten-

year process for researchers to license new forest plants in Germany. But breeders now know early on which of their randomly selected crossbreeding experiments (not the deliberate manipulation of genes) are successful. They used to have to wait until their baby hybrids had grown into trees. And that process required many attempts at propagation and possibly even unintended crossbreeding; only years later would one discover whether a sprinter variety that could yield more than twelve tons of dry mass per hectare per year had been reached – or an unhealthy, disease-prone plant. A forester or farmer who subsequently buys the cuttings (5,000 to 18,000 of them per hectare) also benefits from the genetic testing that assures them they haven't bought a pig in a poke.

Karl Gebhardt, in his late 50s and going a little grey at the temples, can tell you funny stories in the way Germany funds research. Over the decades, the Research Institute for Fast-Growing Plants has painstakingly established four "populets" (nurseries) con-



Horse or machine? Modern forestry needs both of them.

taining 800 different poplar clones, and a salicetum (willow garden) with 280 clones. That's an unequalled body of research. But the Hann Münden scientists have also had to accept serious setbacks. Their forestry faculty was withdrawn from them in the 1970s and transferred 50 kilometers away to Göttingen. In the 1990s, the forestry ministry of Lower Saxony cut off their resources and even explicitly banned the further breeding of poplars. In the end, the institute was completely shut down. Only with great difficulty were these dedicated scientists able to save their nurseries from being cut down, carrying out commissioned forestry research to keep the Institute alive.

"One day, a Swedish delegation stood at our doors," recalls Gebhardt with a forced laugh. "They greedily soaked up our results. We were able to teach them a few things about breeding poplars and willows." Things have since changed. Sweden realized the benefits of willows and poplars and created willow plantations on a grand scale,

pushing ahead with the mechanization of short-rotation plantations, and is now one step ahead in research. The one-time visitors themselves became breeders and founded Lantmännern Agroenergi, which now deals in willow hybrids throughout Europe and holds the lucrative plant variety rights.

The land needs new trees

You may feel that nothing more should surprise a scientist like Karl Gebhardt. But he says what's happened in Hann Münden in recent years is "already a renaissance" for him. Starting in 2005, German demand for research into fast-growing tree species boomed. Suddenly, rapid answers were in demand about short-rotation plantations and fast-growing woods, as was expert knowledge of poplars and willows, even in Germany. But a lead in research of many years had already been thrown away.

The Hann Münden institute is now part of the Northwest German Forest Research Station (NW-FVA). The states of Low-



The poplar (Populus)

Poplars are among the fastest growing woody plants in temperate latitudes. German black poplars can grow up to two meters in height per year, and special crossbreeds can grow to 3.8 meters. The latest breeding results from the Institute for Fast-Growing Plants in Hann Münden show hybrids that average 14 tons of dry mass annually per hectare.

The pseudoacacia (Robinia)

Robinia came from North America, to Germany in the 17th century. It is undemanding and can bind nitrogen from the air. Clones achieve annual growth in output of eight to 17 tons in Hungary and up to eleven tons of dry mass per hectare in Germany. However, it is difficult to dislodge once established.



Through thick and thin: With a horse, even the thickest undergrowth can be penetrated.

er Saxony, Hesse and Saxony-Anhalt provide its funds. The latest research project, “Fast Wood,” is supported by the highest authority, Germany’s Ministry of Economics. The name says it all; the Hann Münden scientists are to breed fast-growing tree species for short rotation, because “the currently limited species base is to be expanded markedly by 2011.” In its national biomass

program, the government hopes by 2020 to have transformed half a million hectares of agricultural land into short-rotation plantations, “Kups” in Germany. No form of biomass generation is better than wood at cutting down on carbon dioxide emissions. Moreover, conservationists also give a green light to such plantations, even though they constitute a monoculture. Woodlands are

seen as the most environmentally friendly kind of energy crop. The German Nature and Biodiversity Conservation Union (Naturschutzbund Deutschland) says that short-rotation plantations of poplars and willows offer hope, as they are of higher quality and more environmentally compatible than intensively farmed field crops.

Above all, the agricultural industry is making enquiries to the Forestry Institute in Hann Münden, says Gebhardt. The Agency for Renewable Resources (Fachagentur für nachwachsende Rohstoffe) in Güstrow, the Hesse Competence Center for Raw Materials and the Lower Saxon Network for Renewable Raw Materials, for example, are in close contact with the NW-FVA. “Farmers are more interested in our trees than foresters are,” Gebhardt admits with a smile. But this may change. Spruces, the number one tree species in Germany, are likely to fall victim to climate change. They are not good in high temperatures, so alternative trees are already being sought. Methods for compacting soft poplar wood have recently been developed in Dresden, in the hope of making it into a high-performance material, which could further boost its demand. And the paper industry, to secure its raw material supply, has announced its wish to create extensive short-rotation plantations in Germany.

What would happen if Franziska did her job so well that the Freiburg forestry institute project set a precedent, leading other foresters to plant fast-growing trees as a pre-harvested fuel forest? We would have to get used to living in a land where turbotrees flourish. ◀

Firewood not yet the focus

A third of Germany, more than eleven million hectares, is covered in forest. Storms and felling operations clear some areas every year, and the two storms “Wiebke” and “Lothar” deforested around 60,000 hectares in Baden-Württemberg on their own. “Unscheduled use” is what the Lower Saxony forestry authority calls it. Since the 1980s, the unscheduled share of total felling has risen from ten to 40 percent. Foresters have replanted these areas with their traditional main tree species, which in Germany are mainly beech, spruce and pine. The construction, furniture, and cellulose industries demand such wood. Poplar, birch, etc. – the softwoods eliminated as troublesome competitors from crops by the forestry industry for years – don’t yield any construction timber. They do, however, produce far more biomass in the short period between planting and felling, so the yield per area is higher than that from traditional forestry trees.

The forestry industry has previously largely ignored fuelwood species in its calculations, and firewood is even its term for a waste product. Interest in exploiting biomass to produce energy is growing, however, in view of ambitious targets for reducing carbon emissions and the rising cost of fossil energy. If, for example, the pre-harvesting model catches on, biomass production for energy purposes could rise by 150 cubic meters per hectare of forest, say the foresters at Freiburg’s Forestry Institute. That corresponds to 230 megawatt-hours per hectare.

For instance, through pre-harvesting, Baden-Württemberg’s annual wood-energy potential alone could be increased by 30 percent from its current 800,000 cubic meters of wood. So an additional 140,000 tons of carbon dioxide could be saved, the institute calculates.