J. W. Gottstein Memorial Trust Fund

The National Educational Trust of the Australian Forest Products Industries

PRODUCTION FORESTRY IN RIPARIAN ZONES: EXAMPLES FROM BRAZIL, USA, GERMANY AND AUSTRALIA

PHILIP SMETHURST

2004 GOTTSTEIN FELLOWSHIP REPORT

JOSEPH WILLIAM GOTTSTEIN MEMORIAL TRUST FUND

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are,

1. Fellowships and Awards - each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate. Skill Advancement Awards recognise the potential of persons working in the industry to improve their work skills and so advance their career prospects. It takes the form of a monetary grant.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

Further information may be obtained by writing to,

The Secretary,
J.W. Gottstein Memorial Trust Fund,
Private Bag 10,
Clayton South, VIC 3169, Australia

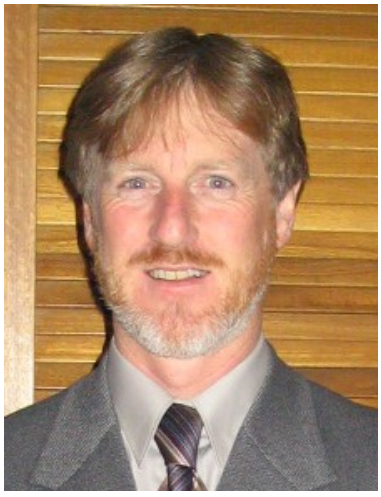
The information contained in this report is published for the general information of industry. Although all reasonable endeavour has been made to verify the accuracy of the material, no liability is accepted by the Author for any inaccuracy therein, nor by the Trustees of the Gottstein Memorial Trust Fund. The opinions expressed are those of the author and do not necessarily represent the opinions of the Trustees.

EXECUTIVE SUMMARY

I visited Brazil, USA and Germany to document examples of production forestry being conducted in riparian zones or stream side reserves, particularly in cleared agricultural landscapes. In Brazil, stream side reserves have been declared for all rural lands and have been implemented in the forested landscape already, but the agricultural landscape is in desperate need of such measures. Because harvesting is forbidden in such reserves, one perverse outcome is already evident, i.e. harvesting of non-native eucalypts is not allowed, yet it would probably be economic and environmentally favourable in many instances. Such regulations also discourage riparian forestry in the agricultural landscape, despite its potentially favourable impact on water quality. In the US and Germany, active management of riparian zones is taken for granted, albeit with special care for soil and water values. There are many examples from both countries of wood production from riparian zones while soil and water values are protected. Such practices include a range of silvicultural practices, including cultivation, weed control, fertilization, pruning, thinning and harvesting. Riparian forestry in the agricultural landscape in these two continents is likely to increase during the next decade as regulatory measures are taken to improve water quality and other aspects of stream ecosystems, e.g. as required by the EU Water Framework Directive. In Victoria, Australia, there is already an excellent example of riparian forestry, but it is unclear why such practices are not adopted more widely by other farmers in that state. In several other Australian states, riparian forestry in the agricultural landscape is likely to enhance environmental outcomes, but the codes of forest practice need to be revised to encourage this activity.

THE AUTHOR

Philip Smethurst was raised on a dairy farm in Gippsland, Victoria. After completing a Bachelor of Agricultural Science at the University of Melbourne he worked on farms in Canada and Sweden. While in Sweden he was also introduced to production farm forestry. He was employed in 1979 by A.P.M. Forests, Traralgon, Victoria, as a soils technician on various research projects. Concurrently, he completed an MSc (Botany) on legume intercrops for *Pinus radiata* plantations, also at the University of Melbourne. In 1984 he was recruited to CSIRO Division of Forestry, Mt Gambier, South Australia, where he researched organic matter dynamics and nitrogen availability in *P. radiata* plantations. Between 1989 and 1992 he completed a PhD in Soil and Water Science at the University of Florida with a dissertation on the mathematical prediction of phosphorus and potassium uptake by competing roots systems of *Pinus elliottii* and *Panicum* grass. Since 1992, he has lead soil and nutrition research in eucalypt plantations at CSIRO Forestry and Forest Products and the CRC for Sustainable Production Forestry, Hobart. Whilst in this role, he contributed to a revision of the Tasmanian Forest Practices Code, during which it became evident that improvements were needed on the topic that became the subject of this fellowship.



ACKNOWLEDGEMENTS

This study tour was kindly funded by the J.W. Gottstein Memorial Trust Fund, CSIRO Forestry and Forest Products, and the CRC for Sustainable Production Forestry. During the tour I gave several presentations on related topics, for which significant materials were generously provided by Greg Holz of the Tasmanian Institute of Agricultural Research, Graham Wilkinson and Peter McIntosh of the Tasmanian Forest Practices Board, and Rowan Reid of the University of Melbourne.

In Brazil, I was kindly hosted by Leonardo Gonçalves, Walter de Paula Lima and their collaborators at the University of São Paulo (USP) and by several forest companies. These people included Fernando Seixas, Marcos Wichert, José Stape, Cláudia, Maria, Camila Nardon, Marialice Poggiani and other staff and students at USP, José Luiz Gava and other staff at Suzano, Raul Chaves and other staff at Duratex, Guilherme de Andrade Lopes and other staff at Eucatex, Celina Ferroz do Valle, Claudio da Silva, Ernesto Norio Takahashi and other staff at VCP, and Polyana Wichert.

In the USA, I especially thank Joe Colletti and Dick Schultz at Iowa State University and their university and state department colleagues, i.e. Tom Isenhart, Lisa Schulte, Leigh Ann Long, Heidi Asbjordsen, Carol Elsberry, Josh Love, George Zaimes, Robert Grala, Erv Klaas, Jeri Neal, Gary Atchison, Christian Charbanneux, Andrew Arends, Rick Dahlman and other Minnesota DNR staff, and Jenna Fletcher. Several images in the USA section of the report were provided by Joe, Dick and Andrew.

In Germany, my visit to Baden-Württemberg was kindly arranged by Eberhard Aldinger at the Forest Research Institute of Baden-Württemberg (FVA) and Leo Sprich at the Forestry Office in Wehingen. I am indebted to them and their colleagues who spent time with me explaining their work or other relevant aspects, and showing me relevant sites. These people included Ian Bromley, Ulrich Rothfuss, Heiko Rinderspacher, Jörg Niederberger, Marie-Carmen Dacasa-Ruedinger, Maria Manso-Martin and Aikaterini Dounavi. I am also very grateful for the assistance provided by Giuliana de Florio.

In Australia, I am indebted to my wife Christiane and children Ben, Roland and Ingrid for allowing me to be away from home for so long.

INTRODUCTION

The poor quality of water draining from cleared agricultural landscapes throughout Australia commonly does not meet standards for temperature, pH, turbidity and concentrations of nutrients, salinity, herbicides, pesticides, and coliforms. There is an expectation that water quality would improve significantly if riparian zones[1] in a large proportion of these landscapes were fenced off to exclude stock and annual crops, and revegetated with herbaceous or tree species (e.g. Robins 2002). This expectation arises from the observation that riparian buffers offer potential for reducing the input of contaminants to streams by using the soil and plants in this zone to filter sediment and absorb nutrients and other chemicals. This potential effect of riparian buffers is well documented, but they work best if combined with in-field practices that minimise chemical inputs and sediment production (Barling and Moore 1994; Fennessy and Cronk 1997; Lowrance et al. 2002; Norris 1993) and they are located in priority reaches of a stream (Tomer et al. 2003). Two useful web-based biolographies that document the potential environmental benefits that can accrue from riparian buffers are: *www.landstewardshipproject.org/pdf/graze_biblio.pdf*, and *www.unl.edu/nac/ripzone03.htm*.

However, fencing and revegetation is unlikely to occur on a large scale unless there is an economic incentive for farmers, because there will be direct costs (e.g. fencing and weed control) and a real or perceived reduction in farm income. Based on conversations with colleagues several years ago, I assert that commercial plantation forestry could be one of the options considered for these zones (i.e. riparian forestry), because, if they are managed carefully, dual economic and environmental benefits are likely to follow.

Plantation forestry in Australia is largely regulated by codes of forest practice. Therefore, it is reasonable to ask if these codes are well adapted to encourage riparian forestry. The various state-based codes of forest practices in Australia have had three distinct phases of development. The first phase recognised that a native forest landscape was being harvested and it needed to be done in a more environmentally sensitive manner. The second phase recognised that plantations were being established on significant areas after harvesting, rather than being regenerated to native forest. Hence, guidelines were refined to include cultivation, weed control, fertilizing etc.. As I see it, we are now in the third phase, in which plantations are largely being established on a cleared agricultural landscape. These plantations are mostly broad-scale plantings by industrial companies or individual farmers who choose to plant up all or part of a farm for mainly pulpwood production. Although the codes are not uniform in content and how they apply to plantations on private land, generally they preclude or discourage forest management in riparian zones. Hence, riparian zones are rarely planted and commonly attract little or no active management. This situation might also lead to problems in the future if such zones become occupied by undesirable plants or animals that are left unmanaged. Hence, we should

[1] 'Riparian zone' and 'stream-side' reserve terminology are used almost interchangeably throughout this report and by forest regulators and managers through the world, but it is recognised that there is a difference. A riparian zone is a distinct unit of the ecosystem that has hydrological, soil, and vegetation conditions that reflect higher water availability than is found more distant from the stream. A stream-side reserve is a management unit that is often designated as a fixed width from a stream bank and does not necessarily match the width of the riparian zone.

consider revising to better cater for riparian forestry. However, I recognise at least one favourable exception in the code of one state, which is described later in this report.

However, even if the codes were revised to include riparian forestry with respect to broad-scale plantations, such development is likely to affect only a small proportion of the agricultural landscape, because most agricultural land will remain dedicated to that purpose for the foreseeable future. Hence, another problem exists in the way these codes apply to riparian zones in landscapes that will remain largely in agricultural production. It might be desirable to conduct commercial forestry (with care) in stream-side reserves while leaving the rest of the landscape for agricultural production. While some codes at least encourage forestry and understorey plantings in these zones, future access for harvesting is not ensured. Hence, these codes have developed in an unforeseen manner to discourage active management of riparian zones and thereby discourage what might be better environmental outcomes.

How can we remedy this situation? The codes probably need to be revised in regard to riparian forestry and farmers and other land managers need to have confidence in managing trees in riparian zones for dual economic and environmental benefits. These changes require the development and demonstration of appropriate management techniques, and evidence that such techniques will result in significant improvements in water quality and some economic return. Fortunately, there are some good overseas examples of commercial forestry in riparian zones. My objective here is to report on several of these examples and related work as practiced (or needed) in Brazil, USA, and Europe. An outline of my itinerary is provided in Appendix 1. Finally, I also discovered an excellent Australian example that deserves wider appreciation.

BRAZIL

Brazilian Context for Riparian Forestry

Discussions I had in Brazil about managing riparian zones for commercial as well as environmental objectives were very timely, because a recent law requires rural landowners in São Paulo (SP) state to have 20% of each property reserved for native vegetation. In some northern states, i.e. the Amazon region, the requirement is as high as 80%. Urban areas don't have a 20% requirement, but 30 m stream-side reserves are required where this remains possible. Although landowners have until 2030 to meet this requirement, the new law also requires this zoning to be indicated on individual land titles if and when they change ownership, after which the reservation requirement is immediately effective. The majority of remnant and 'rejuvenated' forests are in riparian zones.

This law raises several questions: What will happen to the species mix in these areas? Will the mix that develops always be desirable? How much and what sort of biodiversity is to be targeted? How is it to be measured, if at all? What degree of connectedness is required between patches? And most importantly, who will pay to manage these reserves, i.e. cover the costs of fencing, the control of weeds and other pests, tree planting and tending, and understorey management?

Stiff penalties apply in theory, but prosecutions are not being pursued yet. Instead, large forest plantation companies are expected to be actively pursuing compliance.

Separately, the Brazilian Forest Code requires a 30 m stream-side reserve in head-water streams (Photo 1), which already provides a substantial proportion of the native reserve requirement. It is somewhat interesting that forest companies are the main current target for compliance, because these companies manage only c. 3% of the total land area in SP state. Hence, if more significant reservation and restoration of riparian areas and other parts of the landscape is to be attained, other landholders will need to be encouraged to do so. While riparian zones in agricultural areas currently have serious erosion problems and minimal biodiversity, much of the landscape is managed by rather poor farmers how are unlikely to be able to manage these areas for environmental objectives alone. Hence, the issue is also a problem of social engagement. All these aspects have parallels in Australia.

Photo 1. This is a photo from São Paulo state, Brazil, showing areas of harvested eucalypt plantation (a), 4-month-old plantation (b), a stream-side (riparian) reserve in the gully that is owned or managed by the plantation company (c), pastures for grazing cattle (d), and native cerrado (savannah) vegetation on the horizon (e).

I noted that, like Australia, forestry is the main focus of a vocal public regarding environmental issues, while the main environmental concerns in the landscape from a technical point of view were in the agricultural sector. Agriculture in some parts of São Paulo state is dominated by approximately wall-to-wall sugar cane, but this receives virtually no attention in the public environmental debate. In other parts of the state, other crops are grown or pastures are grazed for cattle production. Although I was driven through a 10,000 ha orange grove that seemed to have a stream-side reserve system, there are generally few reserves (riparian or otherwise) in the agricultural landscape, which suffers from severe erosion (Photo 2 and 3).

Photo 2. Sugar cane is grown over much of São Paulo's landscape. Often, as in this photo, cattle are fenced in around the stream and cause the stream to erode and become turbid and contaminated with nutrients and coliforms.

Photo 3. Conservation measures were desperately needed in these grazed pastures, although the erosion appeared to be initiated or exacerbated by drainage from major roads.

Example of the Need to Manage Forested Riparian Zones

The Itatinga Forest Station of the University of São Paulo provided a good example of the need for commercial incentives and flexibility in the management of reserves. A reserve around a dam was established about 6 years ago and successfully replanted with native species. However, within this reserve are fine specimens of c. 40-year-old *Eucalyptus saligna* worth US$200-$300 each (Photo 4). Eucalypts are not native and

hence undesirable (in this situation, in the opinion of many local people), but it would be illegal to remove them even though removal would probably favour development of the surrounding native vegetation, would not significantly degrade soil or water values if done carefully, and provide an economic return.

Workshop on Monitoring of Flora and Fauna

The plantation companies are taking the reserve requirement seriously and responding in a variety of positive ways, e.g. replanting with native species, biodiversity monitoring, and research. The University of São Paulo has in recent years developed a research program into the germination and growth requirements of native tree species, genetics of their populations and a seed collection and supply business. A eucalypt plantation company, VCP, is funding a large biodiversity monitoring program in an age series of 'rejuvenated' and remnant forests in São Paulo state. Private consultants have been engaged to conduct the research in conjunction with universities. These initiatives also help the companies meet their Forest Stewardship Certification requirements. While attending a workshop that reported recent results of this research (papers are expected to be available at www.casadafloresta.com.br), I found several participants very interested in the concept of riparian forestry, but they were concerned that it would be very hard to change the law to something more likely to include an economic objective even though it would probably be more environmentally beneficial than the current law.

Proposal for Australian-Brazilian Research on Riparian Forestry

Building on earlier ideas and contacts on this topic, Dr Walter de Paula Lima, USP, and I advanced our plans for developing a CPWF (www.waterforfood.org.) project proposal to develop and demonstrate the methods of conducting riparian forestry in cleared agricultural landscapes. We also made important contacts in EMBRAPA (Brazil's national agricultural research agency) who are keen to join the project. However, after my visit, CPWF announced that it was not proceeding at this stage with another call for proposals.

In Australia, riparian forestry objectives have been included in the proposal for the CRC for Sustainable Forest Landscapes, the outcome of which is expected to be known by early 2005.

Photo 4. These are examples of stream-side reserves at Itatinga Forest Station containing large non-native eucalypts that were suppressing surrounding native vegetation. The reserve on the right had been planted with native species about 6 years ago; it would be illegal to harvest the eucalypts shown.

USA

Background

Iowa, USA, is an extreme example of a cleared agricultural landscape situated in the vast prairie zone of North America. When European settlers arrived they encountered a mosaic of prairie (grassland, with a substantial component of numerous colourful

herbaceous dicots), forests (mixed hardwoods and conifers) and savannah (open, grassy woodland). Prairies were maintained by burning as practiced by Indians and as initiated by wildfires. The soils are well-structured and fertile. Rainfall is plentiful. Hence, the prairies and forests were cleared for agriculture. Soils were also extensively drained by a system of tile drains and ditches. The two main crops are corn and soybeans, which are very productive. Cropping is sometimes combined with grazing of dairy and beef cattle (mainly along riparian zones, Photo 5 top), and intensive production of pigs and poultry in climate-controlled barns is widespread. Most streams are now quite degraded and water quality is poor. Water for domestic consumption is pumped from a shallow aquifer that still has quite good water quality. Minnesota, the next state north of Iowa, is quite well forested, but there too water quality is reduced by grazing in riparian zones. (Photo 5 bottom).

Photo 5. Two examples from Iowa (top) and Minnesota (bottom) of cattle grazing restricted to riparian zones, with corn dominating the landscape. Note destabilization of the stream banks and the potential for low water quality.

Conservation Programs

Recognising the need to improved the environment, to conserve natural resources, and to reduce corn and soybean production, the US government has introduced conservation reserve programs that make it financially attractive to take agricultural land out of production. One such program is the Conservation Reserve Enhanced Program, which also has a state component and therefore operates slightly differently in each state. Many of these reserves are targeted at riparian zones, and no economic activity is permitted in the riparian buffer for the period of the agreement. In Iowa, a farmer can sign up land at a rental rate of 120% that for corn land and also receive 90% of the costs of establishing the reserve, US$10 per acre per year of contract up-front incentive payment, and US$5/acre/year maintenance. Agreements are for 10 years for herbaceous reserves and 15 years for reserves with trees. Such programs seem quite attractive, but few farmers take up the tree option because it would restrict their flexibility to return the land to agriculture at the end of the agreement.

Apart from on-farm conservation programs, local and state governments occasionally buy land to establish parks and nature reserves. In Iowa, these programs usually involve re-establishment of prairie by cultivation and seeding, which is then maintained by annual burning. Savannah is also being restored in some areas. The Ada Hayden Park on the outskirts of Ames is an excellent example of local government and community groups cooperatively converting land from industrial and agricultural uses to conservation and recreational uses (Photo 6). The Neil Smith Prairie Learning Center is a much larger park (8000 ha) of acquired agricultural land that is being converted to prairie and savannah (Photo 6).

Regulations, BMPs, and Certification

Point-source pollution in agriculture (e.g. a pig unit) is regulated, albeit with questionable success in achieving desired water quality outcomes, but the only non-point source regulation requires compliance with label guidelines for the use of pesticides. Farmers are also not obliged to enter the conservation or set-aside programs. However, various types of certification schemes are being discussed for the agricultural sector that will probably encourage farmers to improve environmental management. Guidelines are available in Iowa for assessing environmental risks associated with fertilizer usage, and my guess is that, within several years, use of such guidelines might be a requirement imposed by governments and the market. Already there are examples that fertilizer usage per ha has decreased compared to several years ago, with little or no loss of production.

Forestry is more regulated than agriculture, but rather indirectly by two main drivers. To see some significant production forestry, I was shown mixed hardwood production systems in south-eastern Minnesota. Large areas of forest in that state are owned by the state or federal agencies which require their forests to be managed according to Best Management Practices (BMPs). Adherence to BMPs also facilitates voluntary certification (e.g. Sustainable Forestry Initiative, SFI) that is a driver for these organisations and for large private forestry companies. However, a significant amount of wood in Minnesota is sourced from small, private forests that have not yet adopted BMPs.

Photo 6. Top left: (L-R) Erv Klaas, Walt, and Lisa Schulte standing in restored prairie at Ada Hayden Park. Top right: Ada Hayden Park showing areas of restored prairie, restored wetlands (for treating agricultural and stormwater runoff), patches of restored savannah, and town buildings in the back ground. Bottom: Restored prairie and riparian vegetation at the Neal Smith Prairie Learning Centre.

Riparian Forest Management

There is considerable evidence that riparian zones in the US are considered zones of active management that include wood production, although BMPs recognise that management in these zones needs to be careful enough to protect soil and water values (Table 1). I saw soft- and hard-copy publications that such BMPs exist in the states of Iowa, Minnesota, North Carolina, South Carolina, Maryland, and Kentucky, and I was told that similar BMPs probably exist for every state. The wide-spread adoption of BMPs is not surprising, because the SFI is a US national certification system developed by the forest industry.

Table 1. Sources of information from the USA that indicate riparian forests are managed for a variety of values including wood production.

Source	Comment
www.buffer.forestry.iastate.edu. **Iowa** Department of Natural Resource Ecology and Management, Iowa State University; Leopold Center; USDA Forest Service; USDA Natural Resource Conservation Service.	An excellent website that describes the concepts and methods of riparian forestry, and provides a virtual photographic tour of case studies.
Sustaining **Minnesota** Forest Resources. Voluntary Site-Level Forest Management Guidelines. Minnesota Forest Resources Council	Guidelines are given for carefully managing riparian management zones for multiple objectives, including wood production.
Field Guide to Best Management Practices for Timber Harvesting in **Kentucky**. Kentucky Division of Forestry and Cooperative Extension Service, University of Kentucky.	Minimum disturbance zones are described based on stream type and slope. Harvesting is permitted, but, generally, 50% overstorey retention is required to shade the water.
Chesapeake Bay Riparian Handbook. USDA Forest Service; USDA Natural Resource Conservation Service; Cooperative Extension Service, University of Maryland.	Double CD set of educational material and guidelines. All routine silvicultural operations are recommended for use in riparian zones, with care, i.e. roading, harvesting, site preparation, planting, weed control, fertilization, and thinning.
Stream Restoration A Natural Channel Design Handbook. **North Carolina** Stream Restoration Institute; North Carolina State University; North Carolina Sea Grant.	Guidelines for restoring stream channels.
Farming for Clean Water in **South Carolina**. South Carolina Department of Natural Resources; USDA Natural Resources Conservation Service.	A handbook of conservation practices that guide farmers in stream protection.

Bear Creek National Restoration Demonstration Watershed, Iowa

Bear Creek is a permanent stream that 15 years ago was experiencing severe bank degradation due to cattle grazing (Photo 7) and inputs of nutrients and other chemicals from adjacent fields. Water quality was very low. Restoration work that commenced along several km of the creek in the early 1990s has led to an example of international significance (Photo 8). The basic design followed was one that divides the riparian zone into at least 3 zones of different vegetation and purpose: Zone 1 (c. 2 m wide) is the stabilised stream bank consisting of species like willows that are maintained as small trees or shrubs by coppicing. Zone 2 (c. 12 m wide) is a production forest, e.g. poplars for firewood, plywood, pulpwood etc.. Zone 3 (c. 10 m wide) is a grass filter strip that captures sediment arriving as overland flow from the adjacent fields. Occassionally, another zone is included between zones 2 and 3 that includes smaller trees or shrubs with some commercial potential, e.g. conifers for Christmas trees that aid wind movement over the taller production forest. In addition, some in-stream engineering has been done to control bank or bed erosion.

In the revegetated reach of Bear Creek, banks have been stabilised (Photo 8 top), sediment trapped in filter strips (Photo 9), and forests established that have so far yielded Christmas trees (Photo 10) and firewood (Photo 11).

Photo 7. Two photos showing the condition of Bear Creek prior to restoration works commencing.

Photo 8. Close-up (top) and aerial views (bottom) showing the condition of Bear Creek after restoration.

Photo 9. Dick Schultz standing in a grass filter strip at Bear Creek. Sediment in surface run-off is trapped within the first few meters adjacent to the corn crop; the soil level was noticeably higher underfoot in the grass filter strip.

Photo 10. Christmas trees have already been harvested from this commercial conifer plantation (right) and firewood from the poplars (left) planted as part of a riparian buffer at Bear Creek.

It is an interesting but disappointing anecdote that, although the Bear Creek Demonstration Watershed is arguably the best example of riparian forestry in a cleared agricultural landscape in the US, and frequently pointed to as an example to follow, I was also told that participating farmers are ineligible for any subsidies because their good work pre-dated the subsidy programs!

Southern Minnesota

In contrast to Iowa, the state to its north, Minnesota is well forested and has an active forest industry sourcing wood from state and federal forests, large private forests, and

small farm-forests. A large proportion of the forest estate is managed for high-value oak and other deciduous species, or conifers for multiple end uses. Pulpwood is generally sourced from both conifer and broadleaved forests that cannot be used for higher value products. Most forests except small farm-forests are managed in accordance with BMP's that meet SFI criteria. Clear-cutting in Minnesota is currently 18% of what it was in 1986, which reflects the swing to uneven-aged, single-tree management. This trend is controversial, because some foresters see it as a political solution to a non-problem.

As an example of forest management in riparian zones I was shown forests in the Monkey Creek Unit in south-east Minnesota near Rushford (Photo 11). The 1400 acre unit was acquired in 1966 and includes riparian zones adjacent to the Root River, which is a major permanent stream. The forest, especially adjacent to and in the riparian zone, is managed and used intensively for recreation (e.g. walking, cycling, hunting) (Photo 12) as well as for wood production and biodiversity. These goals are achieved by individual tree, uneven-aged management, and interventions as required to redress problems caused by diseases, weeds, or storms (Photo 13). Cattle were grazed in the unit prior to acquisition, but more recent exclusion of cattle has enabled the understorey to partially regenerate. Stream-side reserve (SSR) definitions, currently being reviewed, depend on trout, recreational, and water supply status. The Root River is currently classified as a recreational non-trout stream that requires 50 m SSRs for uneven aged management or 33 m SSRs for even-aged management.

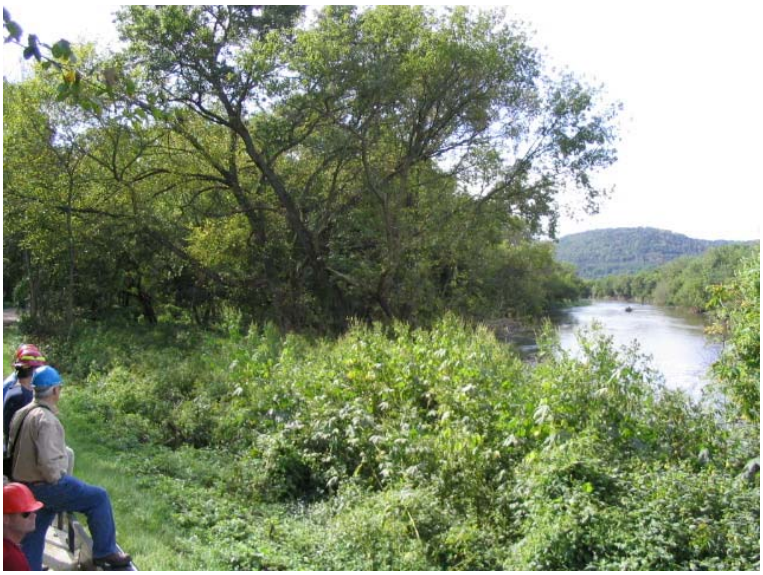


Photo 11. The Root River, Minnesota and its riparian zone. This zone is used intensively for recreation by walkers, cyclist etc. along the track to the left, which is parallel to the river that is also used for canoeing and fishing. The zone of forest between the track and river is managed for amenity, recreation, water, soil and wood production values,

Photo 12. Recreation (tractor and trailer ride) in the riparian zone of the Root River. The forest is managed as an uneven-aged mixture of broad-leaved species.

Photo 13. Storm damage in the riparian zone of the Root River. There were plans to salvage harvest the patches of storm damage, kill the weeds with herbicides, and plant the cleared patches with desirable tree species.

In these SSRs, machinery is allowed to operate, e.g. for harvesting, cultivation and weed control, but special precautions are taken to avoid significant soil and water damage. For example, harvesting is delayed until winter when soil strength is highest due to snow pack and partial freezing, and slash is used for cording. Over-mature trees on the edge of the river can be harvested. Clear-cutting to the river edge is allowed if soil and water values are protected. Any significant rutting that occurs is levelled in summer with low-pressure equipment. Harvested or cleared areas, e.g. after storm damage, are windrowed, cultivated and planted, or bare-soil is direct seeded, and herbicides are used according to guidelines as required (e.g. Roundup and Oust).

In Minnesota, there was also evidence that riparian forestry in cleared agricultural catchments was desirable for reducing erosion and improving water quality (Photo 14). There are several examples where this conversion has been achieved using cultivation, weed control, and planting (Photos 15-17).

Photo 14. A reach of the Root River that still has intensive cropping associated with active erosion and probably nutrient and chemical leakage into the stream. Some areas like this are being targeted for reforestation when funds are available and landowners voluntarily desire this change of land use.

Photo 15. Riparian forest establishment on cropped land in southern Minnesota. The river can be seen adjacent to the top left of the planted area.

Photo 16. Application of herbicide in a riparian zone prior to planting trees in southern Minnesota.

Photo 17. Planting trees in cultivated and herbicided strips in a riparian zone in southern Minnesota.

Photo 18. A newly established riparian forest in southern Minnesota.

GERMANY

I visited forests in the two most southern states of Germany, i.e. Baden-Württemberg (BW) and Bavaria, which together provide about 40% of Germany's wood production. There are four classes of forest ownership, i.e. federal forests, state forests, private forests and community (local government) forests, for which planning and most operations are coordinated by district forest offices in units of about 10,000 ha per office. Some private forests are large, e.g. 10,000 ha and are rarely contiguous, but most are small, e.g. 1 ha.

This type of district-level planning has been in place since the 1800s when there was an extreme shortage of wood after centuries of exploitation. Leo Sprich, District Forester for the Wehingen forest district in BW, who has also worked in an under-developed country, explained that, in relation to forestry, Germany then was similar to an under-developed country by today's standards, i.e. people were poor, wood was very scarce and the forests had been exploited to a level where there were only small

areas of healthy forest remaining. I was shown forest plans for his district that dated back to 1885. Since then there has been a lot of reafforestation, mainly with needle trees, i.e. spruce (*Picea abies*), white fir (*Abies alba*), pine (*Pinus sylvestris*), and also natural regeneration mainly with broad leaf trees, i.e. beech (*Fagus sylvatica*), maple (*Acer pseudoplatanus*), and ash (*Fraxinus excelsior*).

Since 1885, standing wood volume in the Wehingen forest district has increased c. 6-fold. Some spruce forests are now into their third rotation. Most spruce forests were planted at narrow spacing such that most light is captured and there is no understorey. Spruce monocultures are disliked by many conservationists and other German citizens because of their relative monotony and instability when exposed to storms, snow, bark beetles and fungi. Hence, spruce in German and radiata pine (*Pinus radiata*) in Australia are similar in some respects.

Most private owners prefer to plant and harvest the most valuable species, i.e. Norway spruce, in largely monocultures, but state and federal forests are being managed to achieve a 'close-to-nature', mixed conifer-broad-leaved forest. Non-wood values are very important for forest management (recreation, water, erosion control, climate, hunting, aesthetics, honey etc.), the complexity and cost of forest management is exacerbated by numerous small ownerships (Photo 19).

Photo 19. A small unit of forest ownership in southern Germany that was approximately 14 m wide and 150 m long. Survey pegs marked the boundary. This was apparently privately owned, because it had been planted with 100% spruce at a stocking of 4000 trees ha^{-1}, and weeds had been manually controlled.

I was told by forestry professionals that forest management in relation to soil and water quality is never a concern of the general public as evidenced by the lack of such items in the print and electronic media. Actually, for most German citizens, forestry is generally a much more acceptable practice than agriculture as long as the aesthetics of a village-farmland-forest mix are maintained. Relevant regulations or accepted practices are:

- Clearfelled areas should not exceed 1 ha, except in special circumstances.

- Adjacent areas are not to be clearfelled within a few years of each other.
- Very little cultivation is used, except by spade at planting.
- Herbicide or fertilizer use should be avoided.
- Shooting is strongly regulated to control browsing mammals.
- The only chemicals used are (1) a mixture applied to the apical bids of white fir (*Abies alba*) to protect them from browsing mammals, (2) insecticides sprayed on logs damaged by bark-beetles (*Ips* spp.) at the landing soon after salvage (compulsory), and (3) occasional spraying of blackberries, which is very rare because it is frowned upon.
- Special care is needed next to streams to avoid excessive rutting and damage to the bank. Because of the intensive network of roads in the forest, machinery never needs to enter a waterway.

It has long been accepted that forestry and any other type of land use, e.g. agriculture or urban activities, requires active management of riparian zones. The concept of SSRs is almost non-existent in Germany, except that some subsidies are provided to farmers who convert agricultural land to permanent non-agricultural use, some of which is targeted at narrow strips adjacent to streams.

Active management of riparian forests includes harvesting spruce along streams and replanting to mixed broad-leaved species such as ash, birch and poplars. I saw numerous examples of active forest management in riparian zones that included harvesting and replanting or regeneration (Photos 20-25).

Riparian forests in the flood plains of large rivers like the Rhine River require special consideration with regard to the choice of species that can tolerate several weeks of flooding during the wet season and several weeks of drought during the dry season (Photo 26). There are major research projects underway to identify suitable genotypes of ash, poplar, sycamore and other species for these areas (Photos 27-28).

Photo 20. Harvesting spruce in a riparian zone in southern Germany.

Photo 21. Harvesting spruce in a riparian zone in southern Germany.

Photo 22. This mixed broad-leaved forest in a riparian zone in southern Germany had recently been thinned.

Photo 23. This is another example of a mixed broad-leaved forest in a riparian zone near Freiburg, southern Germany that had recently been thinned. Farmland can be seen in the background through the c. 30 m wide SSR.

Photo 24. An example of a mixed spruce-broad-leaved forest in a riparian zone in southern Germany that had recently been thinned. Note thinning slash in the foreground. I was standing on the edge of the access track. The bed of the small stream (Steppach) is evident in the left of the photo. The large spruce between me and the stream will probably be harvested during the next thinning.

Photo 25. Another example of a mixed spruce-broad-leaved forest in a riparian zone in southern Germany that was managed to the edge of the stream (Harrasbach).

Photo 26. Flood-damaged poplar in the flood plain of the Rhine River, Germany. Bark malfunction and splitting that leads to decay below the flood line results in death of the tree.

Photo 27. A field experiment to identify suitable genotypes for planting in the flood plain of the Rhine River, Germany.

Photo 28 . A glasshouse experiment to identify indicators of water logging tolerance in ash that would then assist the search for suitable genotypes for planting in the flood plain of the Rhine River, Germany.

There is likely to be an increase in riparian forestry in the agricultural landscape of Germany and other countries in the European Union (EU) during the next decade as measures are taken to comply with the EU Water Framework Directive 2000 (directive 2000/60/EC; *http://europa.eu.int/comm/environment/water/water-*

framework/overview.html; http://projects/dhi/dk/waterdir/). As explained to me by Dr Heiko Rinderspacher, Forest Research Institute of Baden-Württemberg (FVA), Freiburg, this directive arose from the realisation that it was highly desirable to improve the water quality and other conditions of streams throughout the EU, that most of these improvements are needed in the agricultural landscape, and that riparian management is central to achieving these improvements. Members of the EU are required to set and attain high quality stream conditions by 2015. These stream condition goals, which encompass all aspects of the ecosystem including riparian zones, are based on an assessment of a condition that is 'close-to-nature' for each stream unit. Germany and other member states are at the stage of defining stream quality goals and assessing current conditions, and the effort is split between the forestry and agricultural sectors. Already there are programs within catchments of each large river in Germany that indicate about 6 progress points during the next decade. Such information was provided to me by the Tuttlingen Water Authority. Within the next year or two, mechanisms will be put in place with the aim of achieving the 2015 goal, e.g. through regulatory frameworks or voluntary schemes with or without subsidies. In the agricultural part of the landscape, Dr Rinderspacher expects that 10 m SSR will be established within which only low intensity management will be permitted. There is an expectation that commercial forestry will be permitted in such zones. In forested areas, a 20 m SSR will probably be established.

In BW there are 45-50k km of streams, 50% of which are in forests, but this doesn't include many quite small streams. Small streams are classified as such if the tree canopies meet over the stream. There is no separation between permanent and intermittent streams. Assessments so far have indicated that there is a much higher frequency of road-stream intersections in the forests than in agriculture, and that many crossings do not allow fish movements. Hence, a major cost of meeting the EU directive in the forested landscape will be associated with up-grading stream crossings. It was also noted by Dr Jörg Niederberger, FVA, that SSRs will not solve all stream water quality problems, because it is known that 10 m of grass does not provide adequate protection from sediment delivery on land with moderate slope and that more judicious use of fertilizers will be needed on adjacent farmland to bring down and keep nutrient inputs to streams at acceptable levels.

Management of trees within a couple of metres of small streams is already common and has been practiced for decades. Although cattle are rarely graze outdoors these days, where this does occur these narrow riparian forests don't prevent cattle entering the stream (Photo 29). Such narrow riparian forests are commonly managed for small-diameter firewood (Photos 30-31), but occasionally also for larger diameters destined for sawn timber or veneers (Photos 31-34).

The degree of access and channelisation desired needs to be considered when planning riparian forests. If no maintenance and channelisation is permitted, it might result in the long-term in flooding and realignment of the stream. Water authorities in Germany are required to compensate landowners if the stream meanders by more than 5 m. These are serious considerations when initiating networks of SSRs (Photo 31).

Photo 29. Cattle in a stream near Buchenbach in southern Germany.

Photo 30. A riparian forest (foreground) managed for firewood production near Buchenbach in southern Germany. In the middle-ground is a spruce forest that would have been planted on former farmland. In the back-ground on the steeper and higher part of the landscape is a mixed species forest, part of which has been harvested after storm damage. There is a strong desire to retain these sorts of aesthetics.

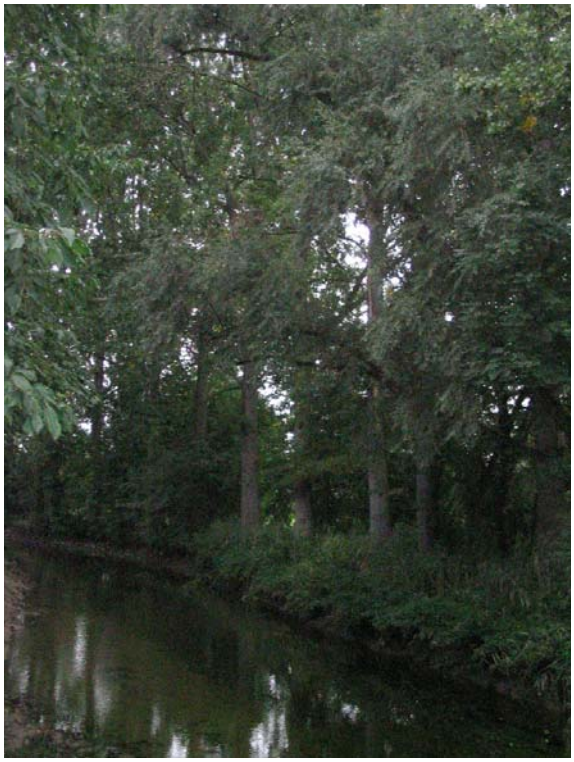


Photo 31. A narrow riparian forest managed for firewood and timber production in southern Germany (top). This stream is highly canalized and requires access for maintenance. A 10 m SSR between a major river and farmland that now contains only one row of large-diameter poplar plus a smaller diameter understorey (bottom).

Photo 32. A single tree row (2 m) SSR between a small stream and a road (surrounded by farmland) managed for large-diameter logs.

Photo 33. Harvesting (after storm damage) in a SSR between a major river and farmland.

AUSTRALIA

Since accepting the Gottstein Fellowship I discovered that there is an excellent example of riparian forestry in Victoria. The Victorian code of forest practice apparently accommodates riparian forestry by encouraging planting of these zones and allowing harvest at a later date. Rowan Reid, Lecturer in Agroforestry at University of Melbourne, started managing a property in 1987, partly with the aim of demonstrating various agroforestry techniques, including riparian forestry. The property was practically treeless in accessible, productive areas and managed as pastures for dairy and beef cattle and sheep. Stock had access to the stream, which was actively eroding. The streams were fenced off and the stream banks stabilised with willows and grass. Concurrently, eucalypts, pines, acacias and other species were planted in cultivated spots, weeds controlled, and fertilizer applied. These trees were grown for high-value products and therefore pruned and thinned to a wide spacing. Eventually the willows were killed to leave a stabilised stream bank, better water

quality (probably), and a grove of high-pruned plantations trees, some of which have already reached a harvestable size and have indeed been harvested (Photo 34; Reid and Washusen 2001).

Photo 34. An excellent example of riparian forestry on Rowan Reid's property 'Bambra' in the Yan Yan Gurt catchment, near the Otway Ranges, Victoria. What was once a mostly treeless valley floor used for grazing with actively eroding stream banks has been transformed into a supplementary source of income that also provides valuable stream protection whilst still offering the potential for grazing-based enterprises. Note the pruned eucalypts with a grassy and shrub understorey that surround the stream as it flows in a meandering channel down the valley.

Several other farmers in the same catchment have also adopted riparian forestry practices, to the extent that the length of the stream protected by riparian vegetation increased from 7% to 50% between 1990 and 2002 (Reid and Burk 2004). However, it is apparent that this practice has not been adopted widely outside this catchment. One must ask why this is the case, when it seems to have very positive environmental and economic benefits for landowners and the wider community.

CONCLUSIONS

I conclude that there are numerous examples from the U.S.A. and Germany of managing forests in riparian zones for dual environmental and economic benefits. Management needs to be particularly careful in these zones to protect soil and water values, but it is widely accepted in these countries that riparian forests require active management that includes timber harvesting. It is also evident that a very significant increase in the use of riparian forestry for environmental benefits is likely to occur in the US and Europe during the next decade, and that agricultural landscapes in many other countries (e.g. Brazil) would also strongly benefit if such practices were adopted.

REFERENCES

Barling, R.D. and Moore, I.D. (1994) Role of buffer strips in management of waterway pollution: a review. Environmental Management 18:543-558.

Fennessy, M.S. and Cronk, J.K. (1997) The effectiveness and restoration potential of riparian ecotones for the management of nonpoint source pollution, particularly nitrate. Critical Reviews in Environmental Sciences and Technology 27:285-317.

Lowrance, R., Dabney, S. and Schultz, R. (2002) Improving water and soil quality with conservation buffers. Journal of Soil and Water Conservation 29:1200-1205.

Norris, V. (1993) The use of buffer zones to protect water quality: a review. Water Resources Management 7:257-272.

Reid, R. and Lawrence, B. (2004) Family forestry in the Yan Yan Gurt catchment. Otway Agroforestry Network field tour notes of the Australian Forest Growers Biennial Conference, Ballarat, Victoria, 3-5 May 2004.

Reid, R. and Washusen, R. (2001) Sawn timber from 10-year-old pruned *Eucalyptus nitens* (Deane & Maiden) grown in an agricultural riparian buffer. In Rutherford, I., Sheldon, F., Brierley, G., and Kenyon, C. (eds) Proceedings of the 'Third Australian Stream Management Conference: The Value of Healthy Streams', 27-29 Aug. 2001, Brisbane Queensland, pp. 545-550.

Robins, L. (2002) Managing Riparian Land for Multiple Uses. RIRDC Publications, 45p.

Tomer, M.D., James, D.E. and Isenhart, T.M. (2003) Optimizing the placement of riparian practices in a watershed using terrain analysis. Journal of Soil and Water Conservation 58:198-206.

APPENDIX 1: ITINERARY

Period	Location	Host	Other contacts
16 Aug - 2 Sept	Forestry Department, University of São Paulo, Brazil	Walter Paula de Lima, Hydrologist	*University of São Paulo:* Leonardo Gonçalves Staff at: *Duratex, Eucatex, Suzano, and VCP*
3 - 17 Sept	Natural Resources and Environmental Management, Iowa State University, USA	Joe Colletti, Forest Economist	*Iowa State University*: Dick Schultz, Tom Isenhart, Lisa Schulte, Leigh Ann Long, Heidi Asbjornsen, Erv Klaas, Mark Tomer, Jan Thompson, Gary Atchison *Leopold Center for Sustainable Agriculture*: Jeri Neal *Minnesota Department of Natural Resources*: Andrew Arends Rick Dahlman *Minnesota Forestry Council:* Jenna Fletcher
27 - 29 Sept	Forest Research Institute of Baden-Württemberg, Freiburg, Germany	Eberhard Aldinger, Botanist and Leader of the Site Classification Section	*Forest Research Institute of Baden-Württemberg:* Ian Bromley, Ulrich Rothfuss, Heiko Rinderspacher, Jörg Niederberger, Marie-Carmen Dacasa-Ruedinger, Aikaterini Dounavi
1 – 6 Oct	Wehingen Forest District, Baden-Württemberg, Germany	Leo Sprich, District Forester	*Tuttlingen Regional Water Authority*: Mr Hilscher