AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

The restoration and protection of the swampy meadow within an agricultural landscape

Barbara Mactaggart[1,2], J Bauer[1], D Goldney[1,2] and A Rawson[1,2,3]

[1] University of Sydney, Faculty of Rural Management, Orange NSW Australia
[2] Charles Sturt University, Faculty of Science and Agriculture, Orange NSW Australia
[3] NSW Department of Natural Resources, Orange NSW Australia
bmac5947@usyd.edu.au

Contents

Abstract. This paper addresses some implications our limited understanding of the swampy meadow landform has on agricultural production and sustainable water management. The ecological and hydrological consequences of current water management practices have lead to a revaluation of natural approaches as an alternative to instream engineering solutions. One such approach would be the restoration/rehabilitation of the swampy meadow. These landforms act as buffering agents for floods and droughts, allow for the re-hydration of the floodplains, and have further positive effects on enhancing biodiversity and improving agricultural productivity outcomes. In this paper we examine the many confusing terms used to label the swampy meadow and postulate that this confusion, poor landform recognition, and a poor understanding of their functions within agricultural landscapes, have implications on our capacity to manage our drainage networks. Further, we argue that this situation may be exacerbated by current government legislation that as yet does not provide adequate protection of the swampy meadow and may, in fact, be hindering attempts to restore incised channels back to their unchannellised form.

Keywords: swampy meadow, chain of ponds, restoration, legislation, policy, degradation.

Introduction

In 1998 Wingecarribee Swamp broke up releasing more than 2 million cubic metres of peat into Wingecarribee Dam. Sainty (1999) observed that a lack of recognition of its value and the many competing interests affecting its management (e.g. peat harvesting, grazing, potato production, water capture, conservation) underpinned its decline and ultimate collapse. If such a fate did happen to Australia's largest montane swamp along with the loss of its attending significant environmental values should we now refocus our concern on the once widespread, albeit smaller and less recognised swampy meadow landform?

The swampy meadow, generally found in alluvial valley-floors not drained by continuous channels, is characteristically vegetated with dense tussock grass and sedge plants. These permanently or periodically water-saturated environments have been dramatically degraded since European settlement. In the contemporary agricultural and urban landscapes this once common landform is now relatively rare in its natural state, and pressures from current land use practices continue to threaten those remaining.

Although natural aggrading and degrading processes have occurred in swampy meadows over geological time (Prosser 1991, Fryirs and Brierley 1998), anthropogenic factors such as clearing, grazing, intentional swamp burning and draining for liver fluke control and so-called pasture improvement have significantly contributed to their widespread and rapid degradation and incision (Eyles 1977b, Prosser and Winchester 1996). The impacts of European settlement in changing these complex systems to incised gullies has been documented in the Australian literature (eg. Eyles 1977a, Wasson et al. 1998, Brierley et al. 1999) and in other parts of the world (Bull 1997). Significant consequences of swampy meadow degradation are channel incision with the progressive loss of sediment, altered hydrology, loss of biodiversity and decline in agricultural productivity.

The uninformed viewer of today's landscape may perceive incised creeks and gullies as natural landscape features. This perception fails to recognise that many of these landforms are degraded swampy meadows. This misconception is based on the following factors:

- poor system recognition;
- inadequate understanding of the system's complex ecological, hydrological and geomorphological interactions, and their inherent aggradation and incision processes; and
- vagaries in landform descriptions, confusing terminologies and differing characterisations.

Any restoration attempt based on these misconceptions, therefore, can be both controversial and likely to be ineffective.

In this paper we address the confusing terminology surrounding the term 'swampy meadows', attempt to clarify their many characteristics, and discuss the detrimental effects of degraded incised swampy meadows. We then highlight the implications of poor landform recognition, low appreciation of their value, and the effect that inadequate definitional precision has on their protection and restoration.

Confusing swampy meadow terminology

The term 'swampy meadow' has been adopted by several Australian authors (e.g. Prosser 1991, Butterworth et al. 2000, Rutherfurd et al. 2000, Zierholz et al. 2001), though confusion may arise as other terms, such as chain of ponds, swamp, cut and fill landscape, dell, mires and marsh, are at times used interchangeably. Uncertain and confusing terminologies and definitions are not only a scientific and research problem; they have significant ramifications for applying conservation legislation and policy, adopting management principles and restoration strategies, and in valuing agricultural and urban land (Mactaggart et al. 2006, in revision).

Swampy meadow

Mactaggart et al (2006, in revision) attempted to define the swampy meadow on ecological, hydrological and geomorphological attributes. Within this definition, the swampy meadow can be characterised as a low energy valley-fill system without a continuous channel that sometimes may contain pools (chain of ponds), that maintain permanent or periodically saturated soils and are dominated by grasses, sedges and rushes, and can exhibit phases of aggradation and incision. Plate 1 (Appendix) depicts sedge and tussock grass dominated valley-fill characteristic of an intact swampy meadow.

Chain of ponds

The term chain of ponds has often been used synonymously for the swampy meadow (Prosser 1991, Brierley and Fryirs 2000) though some usage may be erroneous when used to label landforms with characteristically different features. Further, some swampy meadows do not contain chains of ponds. In instances where they are contained within swampy meadows they are characterised by irregularly spaced, disconnected ponds separated by vegetated sediment bars or scour pools (Eyles 1977a). However, in the early part of European settlement in eastern Australia, accounts of 'chains of ponds' and chain of holes' were noted from the historical documents (e.g. Oxley 1818, Darwin 1836). A number of these referred not to swampy meadows but to water holes in rivers during periods of low flow or drought (Eyles 1977b). Interpreting the characteristic landform from the historical records, therefore, can be problematic if the different uses of the term 'chain of ponds' is not addressed (Mactaggart 2006).

Swamp

Definitions and characterisations of swamps are broad and varied across the international literature and, given this, are inclusive of the swampy meadow. While swamps are generally common and well recognised features in the wider landscape, swampy meadows are not. The separation of the landforms and application of the terms may cause confusion. The synonymous use of the terms is not always appropriate as swamps can occur in a number of environments dissimilar to the swampy meadow, for example, on valley-sides (Buchanan 1980), or in salt water and tidal environments (U.S. Environmental Protection Agency 2006). In addition, vegetation structures and types may not be typically herbaceous as for the swampy meadow. Therefore, use of the term 'swampy meadow' needs to consider its more specific attributes.

Cut and fill landscape

Many swampy meadows exhibit geomorphic processes of long phases of aggradation or sediment accumulation (fill) with short intervals of incision and sediment release or gullying (cut) (Prosser et al. 1994, Bull 1997, Fryirs and Brierley 1998). Accordingly, they have often been referred to as cut and fill landscapes - a construct based on geomorphic principles. Though not all valley fills with phases of aggradation and incision provide suitable environments for the development of swampy meadows. This is particularly the case when hydrological conditions limit the development of swamp characteristics or colonisation of hydrophytic herbaceous vegetation.

Dell

Some references to dells, such as that given by Young (1986) on the Hawkesbury Sandstone Formation south of Sydney, suggest a landform synonymous with the swampy meadow. The dells were described as small headwater valleys characteristically sediment choked and swampy, largely treeless and dominated by shrubs, sedges and restiads. A point of dissimilarity to the swampy meadow, in this case, is the inclusion of shrubs in the vegetation structure.

Mires and marsh

Mires and marshes often occur or are recognised as different landform features to the swampy meadow. Their characterisation is based on hydrology, chemical functioning and ecology – quite a different basis for understanding compared to the geomorphically well understood swampy meadow (Mactaggart et al. 2006, in revision). Mires are permanently wet and peat forming, whereas marshes are intermittently flooded and non-peat forming (Gore 1983). Given no morphological impediment, it is conceivable that, given particular environmental controls, a whole, or parts, of a swampy meadow system may be characteristically a mire or marsh.

Recognising impacts of incised swampy meadows

Swampy meadow incision, an advanced form of riparian degradation, was recognised soon after European settlement, e.g. by 1840 in the Southern Highlands of New South Wales (NSW) (Eyles 1977b). Swampy meadow degradation and incision was also widespread in other parts of southeast Australia (Bird 1985, Page and Carden 1998, Brierley and Fryirs 2000, Rutherfurd 2000). Three crucial landscape impacts of incision are briefly discussed, though they include many more.

Incision-based sediment and biodiversity loss

During the process of swampy meadow incision large and progressive losses of sediment, peat and biomass take place. This process reduces water quality, degrades downstream riverine ecosystems (by smothering bed habitat), and increases turbidity and nutrient loads (Rutherfurd 2000, Prosser et al. 2001). Further, the heterogenous mosaics of ecological patches, known to support a rich diversity of plant and animal life in riparian ecosystems (Boulton et al. 2004), become simplified following incision. This leads to consequent changes in the capacity of swampy meadows to support a diverse range of biota typical of intact systems. Plate 2 (Appendix) illustrates an incised swampy meadow in a highly degraded state showing diminished structural diversity in the vegetation, as well as in the bed and floodplain topographies.

Loss of functionality at the channel/floodplain interface

Energy and material fluxes into and out of highly disturbed incised sites are likely to differ markedly in both quantity and quality from those of original ecosystems (Ehrenfeld and Toth 1997). Incision of swampy meadows disconnects the channel from the floodplain resulting in floodplain drying and interruption of nutrient exchange (Roberston et al. 1999, Thoms 2003, Schilling et al. 2004). It also facilitates the loss of nutrients from agricultural land, and is responsible for much of the decline in water quality (Hill 1996), including an often substantial ongoing sediment source.

Losing the capacity to buffer landscapes from floods and droughts

Incised swampy meadows affect hydrological regimes and impact significantly on flood peaks and discharge velocities. By functioning as temporary water storage areas during times of heavy precipitation, swampy meadows can have a positive influence on the flood routing pattern in a catchment (Leopold 1974). Also, the stored water in swampy meadows tends to be released slowly (Leopold 1974), providing base-flow to the drainage system over an extended period (Burt et al. 2001). The pattern of flood routing has strong implications on in-stream, riparian and floodplain vegetation with the potential to influence streambank erosion, channel stability and floodplain productivity.

Implications for restoration and protection

Implications of a failure to recognise swampy meadows

The swampy meadow is not always readily recognised in the landscape by the uninformed viewer, nor their prior extent and distribution readily known. These shortcomings and uncertainties can potentially influence land management and restoration initiatives. Poor recognition is symptomatic of a landform that may resemble a treeless valley-floor, or in its degraded form like that depicted in Plate 3 (Appendix), an incised creek or a gully. Plate 4 (Appendix) shows the same drainage line as that shown in Plate 3 though with the swampy meadow remaining relatively intact.

Without the ability to recognise intact and degraded swampy meadows, and a failure to understand their complex functions, restoration outcomes may become inappropriate or ineffective. The past practices of gully remediation using concrete

chutes, diversion banks, and shaping and filling etc., while generally effective in ameliorating erosion processes, could not incorporate the ecological and hydrological benefits of the swampy meadow.

Problems with a poorly defined term in existing legislation

Terminological confusion and an imprecise definition of the swampy meadow can influence conservation, restoration, stream management, land development and exploitation outcomes. Currently, the existing legislation in NSW does not make adequate provision to protect or restore a swampy meadow. The lack of inclusion of this landform in the legislation is one issue facing land owners who attempt to improve management of their drainage networks and maximise the benefits of improved floodplain hydration. The current concerns are that obstructing water flow may deny downstream landowners their water entitlement and effect fish passage; also obstructions may fail during high flood events.

At the centre of this controversy is Peter Andrews from the Upper Hunter Valley of NSW. Andrews endeavours to create highly productive and hydrated swampy meadow systems, which over time create conditions typical of natural systems (Peter Andrews pers. comm. 2005). His land management principles have developed into a technique now known as 'Natural Sequence Farming', which involves the installation of leaky structures (obstructions) made from rock or log in incised channels. The government agencies, however, following the legislation (based on definitional uncertainty) treat incised swampy meadows as ephemeral rivers. As such, works implemented in such a restoration process have been controversial. His approach has been met with scepticism, even condemnation, while in other quarters it has received cautious support from some government authorities, scientists and other land managers.

Examining the legislative shortcomings further, the *Rivers and Foreshores Improvement Act (NSW)* (1948) (referred to herein as the RFIA) makes provision for the remediation and protection of protected lands and protected waters, which includes, by virtue of the RFIA, rivers and their associated banks (to a distance of 40 m) and beds.

The RFIA defines a 'river' as:

> *…any stream of water, whether perennial or intermittent, flowing in a natural channel, or in a natural channel artificially improved, or in an artificial channel which has changed the course of the stream of water and any affluent, confluent, branch, or other stream into or from which the river flows…*

In a critical analysis of the RFIA ,and the more recently proclaimed *Water Management Act (NSW)* (2000) (WMA), Taylor and Stokes (2005) suggest that the definition of a river fails to address the true spectrum of rivers in NSW. This failure includes the swampy meadow for two main reasons. First, the RFIA river definition, in principle, is not inclusive of the intact swampy meadow as they are not channelised landforms so are not correctly defined as rivers. Secondly, the Department of Natural Resources, the department administering the RFIA, informally recognise rivers with channels (and hence protected watercourses) as those indicated by a blue line on 1:25000 topographical map sheets and/or in catchment areas of less than 20 ha (Taylor and Stokes 2005). Thus the legislation excludes many upper catchment swampy meadow systems. It may be a moot point, but when a swampy meadow is degraded to the point where it has an incised channel, it can then be considered a river and have the legislation in place to protect it. If on the other hand it is not incised, but an intact swampy meadow, there is no legal provision for its protection. This ambiguous state of affairs not only compromises protection and restoration, but may also have legal implications.

Taylor and Stokes (2005) argue that the incomplete definition of a river, and its failure to include discontinuous channelled 'rivers' such as the swampy meadow, will perpetuate disagreement between land management authorities and landowners and will bring about further litigation in the Land and Environment Court. Further, Taylor and Stokes (2005) predict that poor definitional clarity in the RFIA will encourage poor land use and land management practices.

Protection by another name

As stated, there is no governance in NSW to specifically protect swampy meadows in the RFIA and WMA. However, if they were more widely accepted as a wetland analogue there would be improved outcomes for their protection and conservation within other governmental policy initiatives. A definition of a wetland used in Australia is: areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Department of Land and Water Conservation 1996, Environment Australia 1997, Environment Australia 2001).

In this context, some swampy meadows can be analogous to wetlands. Though, caution needs to be applied setting this principle as some swampy meadows are not characterised by wetland features, and therefore, could not be categorised as wetlands.

Policies dedicated to the conservation, management and restoration of wetlands are the Wetlands Policy of the Commonwealth Government of Australia (Environment Australia 1997), the NSW Wetlands Management Policy (Department of Land and Water Conservation 1996), the State Environmental Planning Policy No. 14 – Coastal Wetlands (Parliamentary Counsel's Office 2006), and the NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation 2002). The latter policy can potentially apply to the swampy meadows where groundwater dependent ecosystems occur.

Implications for land values

Landowners unable to appreciate the environmental values of the swampy meadow, along with fixed perceptions about their perceived unproductiveness, also have implications for land values. Swamps, including the swampy meadow, were and still are, often considered wastelands. They are often regarded as a useless or harmful area that can be improved for productive agriculture or urban development if drained. John Hughes (1878), an early settler in the Oberon district of NSW lamented that only wealthy settlers 'are men who carve their own fortune and do not buy bog and rock'. The poor image of landform, such as the swampy meadow, is now changing as there is increasing recognition of their immense value in flood control (Pearce 2004b), sediment and nutrient retention, and wildlife conservation (Moss 1988). Swampy meadows and their bad image also impact on the rural property market. In the NSW Central Tablelands, property agents have been quick to modify their terminology to serve a purpose. With increasing awareness of the effects of climate change and a greater reliance on permanent water for pastoral security, swampy meadows, once disparagingly known as swamps, are now more fashionably referred to as spring-fed gullies (D Crawford, pers. comm. 2005). By virtue of this name change, the swampy meadow becomes valued hydrologically, rather than devalued for its non-productiveness for grazing or cropping, or habitat for a life-stage of the parasitic liver fluke.

Conclusions

Riparian restoration and remediation of gullies will continue to require considerable investment of time and resources, with the outcomes driven by the current knowledge base of the practitioner. The scope of the restoration goal, then, will determine the outcome. Fully understanding and recognising the functions and characteristics of the swampy meadow, and how they affect the hydrological and ecological health of a catchment can refocus our efforts into more effective and appropriate restoration attempts. This change of thinking is already more advanced in other parts of the world.

In Australia, where water is more precious than in Europe, there is also a rethinking on water security and sustainability, particularly now under the cloud of climate change. In central Europe, thinking on river and floodplain management changed in the aftermath of a devastating flood catastrophe. Now, following a long legacy of getting rid of water as fast as possible, it is being replaced by reinstating river meanders, marshes and floodplains to slow the flow and improve groundwater recharge (Pearce 2004b). A cost:benefit analysis of wetland/floodplain features, such as the swampy meadow, now suggests that no engineering feat can replicate natural systems - even remotely (Moss 1988, Pearce 2004a).

While changes are taking place in the rural sector, some government authorities are not keeping pace with the demands for support and information. As such, some operators are 'going it alone'. The repercussions of this trend are unknown, with concerns that some restorative works may be ultimately destabilising, damaging to fish populations, and adversely changing catchment hydrology.

A reviewed and amended legislation is needed to support the increasing recognition of the importance of the swampy meadow. However, review and rewording of legislation and policy requires the understanding of the swampy meadows' functional complexity, geomorphological, ecological and hydrological characteristics and its phases of aggradation and incision.

Until legislation and policy inadequacies are considered, rising mountains of red-tape will disempower land owners and restorationists. Restoration will remain difficult or unfeasible because of what Whitten and Bennet (2005) call 'prohibitive policy transaction costs'. In the meantime, improving our understanding and recognition of the swampy meadow is an awareness building exercise that needs to

engage land owners, government agencies, scientists and other restoration practitioners.

References

Bird JF 1985, 'Review of channel changes along creeks in the northern part of the Latrobe River basin, Gippsland, Victoria, Australia', *Zeitschrift fur Geomorphologie,* 55: 97-111.

Boulton A, Mika S, Ryder D and Wolfenden BJ 2004, 'Raising the dead: Can we restore the health of subsurface aquatic ecosystems by recovering geomorphic complexity using conventional river rehabilitation techniques?' In G Albrecht (ed.) *Airs, waters and places - Transdisciplinary research in ecosystem health,* University of Newcastle, Callaghan, NSW.

Brierley G, Cohen T, Fryirs K and Brooks A 1999, 'Post-European changes to the fluvial geomorphology of Bega catchment, Australia: Implications for river ecology', *Freshwater Biology,* 41(4): 839-848.

Brierley G and Fryirs K 2000, 'River styles, a geomorphic approach to catchment characterization: implications for river rehabilitation in Bega catchment, New South Wales, Australia', *Environmental Management,* 25(6): 661-679.

Buchanan RA 1980, 'The Lambert Peninsula, Ku-ring-gai Chase National Park. Physiography and the distribution of Podzols, shrublands and swamps', *Proceedings of the Linnean Society of New South Wales,* 104(1): 73-94.

Bull WB 1997, 'Discontinuous ephemeral streams', *Geomorphology,* 19(3-4): 227-276.

Burt TP, Bates PD, Stewart MD, Claxton AJ, Anderson MG and Price DA 2001, 'Water table fluctuations within the floodplain of the River Severn, England', *Journal of Hydrology,* 262(1-4): 1-20.

Butterworth R, Wilson CJ, Herron NF, Greene RSB and Cunningham RB 2000, 'Geomorphic controls on the physical and hydrologic properties of soils in a valley floor', *Earth Surface Processes & Landforms,* 25(11): 1161-1179.

Darwin C 1836, 'Journey across the Blue Mountains to Bathurst in January, 1836', In G Mackaness (ed.) *Fourteen journeys over the Blue Mountains of New South Wales 1813-1841,* Horwitz-Grahame, Sydney, pp. 226-236.

Department of Land and Water Conservation 1996, *NSW wetlands management policy, action plan 1998-99,* NSW Department of Land and Water Conservation, Sydney.

Department of Land and Water Conservation 2002, *The NSW State Groundwater Dependent Ecosystems Policy,* Department of Land and Water Conservation.

Ehrenfeld JG and Toth LA 1997, 'Restoration ecology and the ecosystem perspective', *Restoration Ecology,* 5(4): 307-317.

Environment Australia 1997, *The wetlands policy of the Commonwealth Government of Australia,* Environment Australia, Canberra.

Environment Australia 2001, *A directory of important wetlands in Australia,* Environment Australia, Canberra.

Eyles RJ 1977a, 'Birchams Creek: the transition from a chain of ponds to a gully', *Australian Geographical Studies,* 15: 146-157.

Eyles RJ 1977b, 'Changes in drainage networks since 1820, Southern Tablelands, N.S.W.' *Australian Geographer,* 13: 377-386.

Fryirs K and Brierley GJ 1998, 'The character and age structure of valley fills in Upper Wolumla Creek Catchment, South Coast, New South Wales, Australia', *Earth Surface Processes & Landforms,* 23(3): 271-287.

Gore AJP 1983, 'Introduction', In AJP Gore (ed.) *Ecosystems of the World,* Vol. 4A, Elsevier, pp. 1-34.

Hill AR 1996, 'Nitrate removal in stream riparian zones', *Journal of Environmental Qual,* 25: 743-755.

Hughes J 1878, *Letter to the Sydney Mail Newspaper,*

Leopold LB 1974, *Water: a primer,* Freeman, San Francisco.

Mactaggart BG 2006, 'When history leads us astray: Examining historical documents for the reconstruction of swampy meadow/chain of ponds in the New South Wales Central Tablelands, Australia', *Unpublished manuscript under review Australian Geographer*.

Mactaggart BG, Bauer JJ, Goldney D and Rawson A 2006, 'Problems in naming and defining the swampy meadow - an Australian perspective', *Unpublished manuscript, under revision Journal of Environmental Management*.

Moss B 1988, *Ecology of fresh waters: man and medium,* Blackwell Science.

Oxley J 1818, *Journals of Two Expeditions into the Interior of New South Wales, undertaken by order of the British government in the years 1817-18*, http://etext.library.adelaide.edu.au/o/oxley/john/o95j/chapter1.html, 2005.

Page KJ and Carden YR 1998, 'Channel adjustment following the crossing of a threshold: Tarcutta Creek, Southeastern Australia', *Australian Geographical Studies,* 36(1): 289-311.

Parliamentary Counsel's Office 2006, *State Environmental Planning Policy No 14—Coastal Wetlands*, http://www.legislation.nsw.gov.au/, 2006.

Pearce F 2004a, *Keepers of the spring: reclaiming our water in an age of gobalization,* Island Press.

Pearce F 2004b In *New Scientist*, Vol. 181, pp. 26-29.

Prosser IP 1991, 'A comparison of past and present episodes of gully erosion at Wangrah Creek, Southern Tablelands, New South Wales', *Australian Geographical Studies,* 29(1): 139-154.

Prosser IP, Chappell J and Gillespie R 1994, 'Holocene valley aggradation and gully erosion in headwater catchments, south-eastern highlands of Australia', *Earth Surface Processes & Landforms,* 19(5): 465-480.

Prosser IP, Rutherfurd ID, Olley JM, Young WJ, Wallbrink PJ and Moran CJ 2001, 'Large-scale patterns of erosion and sediment transport in river networks, with examples from Australia', *Marine & Freshwater Research,* 52(1): 81-99.

Prosser IP and Winchester SJ 1996, 'History and processes of gully initiation and development in eastern Australia', *Zeitschrift fur Geomorphologie, Supplementband,* 105: 91-109.

Roberston AI, Bunn SE, Boon PI and Walker KF 1999, 'Sources, sinks and transformations of organic carbon in Australian floodplain rivers', *Marine & Freshwater Research,* 50: 813-29.

Rutherfurd ID 2000, 'Some human impacts on Australian stream channel morphology', In S Brizga and Finlayson, B (eds.), *River management: the Australian experience,* John Wiley & Sons, England.

Rutherfurd ID, Jerie K and Marsh N 2000, *A rehabilitation manual for Australian streams,* Cooperative Research Centre for Catchment Hydrology, Land and Water Research and Development Corporation.

Sainty G 1999, 'Wingecarribee Swamp - gone!' *Australia Nature,* 26(5): 80.

Schilling KE, Zhang YK and Drobney P 2004, 'Water table fluctuations near an incised stream, Walnut Creek, Iowa', *Journal of Hydrology,* 286(1-4): 236-248.

Taylor MP and Stokes R 2005, 'When is a river not a river? Consideration of the legal definition of a river for geomorphologists practising in New South Wales, Australia', *Australian Geographer,* 36(2): 183-200.

Thoms MC 2003, 'Floodplain - river ecosystems: lateral connections and the implications of human interference', *Geomorphology,* 56(3-4): 335-349.

U.S. Environmental Protection Agency 2006, *Terminological Reference System - Swamp*, http://oaspub.epa.gov/trs/trs_proc_qry.navigate_term?p_term_id=7752&p_term_cd=TERM,

Wasson RJ, Mazari RK, Starr B and Clifton G 1998, 'The recent history of erosion and sedimentation on the Southern Tablelands of southeastern Australia: sediment flux dominated by channel incision', *Geomorphology,* 24(4): 291-308.

Whitten SM and Bennett J 2005, *Managing wetlands for private and social good: theory, policy and cases from Australia,* Edward Elgar, Cheltenham, UK.

Young ARM 1986, 'The geomorphic development of dells (Upland Swamps) on the Woronora Plateau, N. S. W., Australia', *Z. Geomorph. N. F.,* 30(3): 317-327.

Zierholz C, Prosser IP, Fogarty PJ and Rustomji P 2001, 'In-stream wetlands and their significance for channel filling and the catchment sediment budget, Jugiong Creek, New South Wales', *Geomorphology,* 38(3-4): 221-235.

 © Copyright AFBMNetwork

Appendix

Plate 1. An intact swampy meadow in a natural forested catchment, Neville State Forest, Neville NSW

Source: BM 2004 Personal file.

Plate 2. An incised and degraded swampy meadow, south of Bathurst, NSW

Source: BM 2004 Personal file.

Plate 3. George's Plains Creek, South of Bathurst, NSW, may be unrecognised as a prior swampy meadow in its current incised state

Source: BM 2004 Personal file.

Plate 4. A relatively intact swampy meadow remains on a grazing property upstream of the gully shown in Plate 3. It is unchannellised and vegetated with tussock grasses, sedges and rushes.

Source: BM 2004 Personal file