PROGRAM

Sunday 25th April

Arrival and pre-workshop meal at 19-30 (Club bar) for 20-00 (Lochnagar Suite)

Monday 26th April (Crathie Room)

Session 1.* Overview of buffer strip use, design and management across the EU.** — ***Chairperson: Marc Stutter, UK

09:00 - 09:20	Welcome and setting the scene	Marc Stutter, UK
09:20 - 09:40	Overview of buffer strips in Switzerland	Laurent Nyffenegger, Switzerland
09:40 - 10:00	Buffer zones in Norway	Anne-Grete Blankenberg, Norway
10:00 - 10:20	Nitrogen removal effectiveness in narrow buffer strips: some examples from the river Po catchment (Northern Italy)	Raffaella Balestrini, Italy
10:20 - 10:50	*Coffee break (Lochnagar Suite)*	
10:50 - 11:10	Dimensioning of buffer strips in the Slovak Republic	Jaroslav Antal, Slovak Republic
11:10 - 11:30	How do riparian buffer strips influence the nutrient uptake efficiency of small agricultural headwater streams?	Gabriele Weigelhofer, Austria
11:30 - 12:00	General discussion	
12:00 - 13:30	*Break for lunch (Lochnagar Suite)*	

Session 2a.* Plot- to catchment-scale evaluations of buffer strip processes and effectiveness** — ***Chairperson: Brian Kronvang, Denmark

13:30 - 13:50	Modular approaches to the control of diffuse water pollution from agriculture: buffer zones, bioreactors, ditches and ponds	Tegan Darch, UK
13:50 - 14:10	Function and effect of vegetated buffer strips on nutrient emission at tile-drained field sites	Johanna Frings and Sandra Schonemann, Germany
14:10 - 14:30	Buffer system implementation with increased infiltration and nitrate retention capacity - A case study from Brittany, France	Andreas Matzinger, Germany
14:30 - 14:50	Are narrow vegetated riparian buffer strips functioning as a barrier against sediment and phosphorus in Scotland?	Marc Stutter, UK
14:50 - 15:10	A rainfall simulation study on P removal in buffer zones amended with Fe and Ca compounds	Jaana Uusi-Kämppä, Finland
15:10 - 15:40	*Coffee break (Lochnagar Suite)*	

15:40 - 16:00	Influence of linear flow structures on the effectiveness of buffer strips	Rosemarie Hösl, Austria
16:00 - 16:20	Water infiltration into soils under riparian buffer strips	Ararso Etana, Sweden
16:20 - 16:40	Representing grassed buffer strips' hydrology in a regional scale model	Aurore Degre, Belgium
16:40 - 17:10	General discussion	

17-30 - 20-00	*Visit to Lochnagar distillery (coach departs front of hotel at 17-30)*
20-00 -	*Dinner at hotel (Lochnagar Suite)*

Tuesday 27th April

08:30 - 12:00	Field trip (coach departs 08-30 from front of hotel)
12:00 - 13:30	Lunch (Lochnagar Suite)

Session 2b.* Plot- to catchment-scale evaluations of buffer strip processes and effectiveness** — ***Chairperson: Wim Chardon, The Netherlands

13:30 - 13:50	Buffering diffuse pollutants in agricultural catchments at the edge-of-field using constructed wetlands	John Quinton, UK
13:50 - 14:10	Measuring buffer strip efficiency under deltaic circumstances	Marius Heinen, The Netherlands.
14:10 - 14:30	Modelling the effectiveness of unfertilized field edges in the Netherlands.	Piet Groenendijk, The Netherlands.

Session 3.* Managing buffer strips for multiple pollutant and biodiversity benefits** — ***Chairperson: Wim Chardon, The Netherlands

14:30 - 14:50	Are environmental win-wins achievable on Scottish dairy farms	Davy McCracken, UK.
14:50 - 15:10	Importance of stream and buffer zone characteristics for bank erosion and phosphorus inputs to surface water	Brian Kronvang, Denmark.
15:10 - 15:40	*Coffee break (Lochnagar Suite)*	
15:40 - 16:00	Diversity and distribution of riparian plant communities in relation to stream size	John Dybkjær, Denmark.
16:00 - 16:20	Evaluating the effectiveness of buffer strips using riparian plants and beetles as indicators	Jenni Stockan, UK.
16:20 - 16:40	Seed germination from deposited sediments during high winter flow in riparian areas	Brian Kronvang, Denmark
16:40 - 17:10	General discussion	

17:10 - 19:00	Poster session (Lochnagar Suite)	
19:30-	*Workshop dinner (to be seated by 20:00, Lochnagar Suite).*	

Wednesday 28th April

Session 4. **Combining biophysical knowledge, socio-economics and practicalities.**	**Chairperson: Marc Stutter, UK**

09:00 - 09:20	Cost-effective targeting of buffer strips for phosphorus mitigation: The case of Roscobie Loch	Bedru Balana, UK.
09:20 - 09:40	Buffers for biomass - a review and synthesis of options and practicalities in Denmark	Benjamin Christen, Denmark
09:40 - 10:00	General discussion	
10:00 - 10:30	*Coffee*	
10:30 - 12:00	Break out discussion groups	
12:00 - 13:00	Reporting back	
13:00 - 14:00	*Lunch*	
14:00 - 14:45	Concluding remarks and plans for workshop outputs	
15:00-	*Coffee and departure (coach for Aberdeen departs at 15-30)*	

Field trip (Tuesday morning)
On Tuesday morning we will travel to the nearby Tarland catchment where a number of agricultural best management practice and habitat improvement initiatives have been undertaken and studied in partnership between the estate, land managers, local residents and scientists. We will view some riparian improvement works that include buffer strips (weather permitting) so come dressed for a short country walk! We will then go to the local hotel for talks about the projects in this area.

Poster session *(Tuesday evening)*
We would encourage all poster presenters to be ready to give a 3-5 minutes spoken summary of their poster at the start of this session. This will help ensure that all posters get full coverage at the workshop.

Break out sessions (Wednesday morning)
These will be structured around smaller group discussions. These groups will then report back to the wider group. The discussions can be initially stimulated by (but not limited to) the following questions and other that may arise from the sessions:

1. If site specific conditions are crucial to the functioning of buffer zones, then should a baseline width be set by countries? If so, what should this be and should it differ for varying land activities? Do we have the evidence to support such requirements?

2. If enhanced measures for ‘problem areas’ are required what is the best way to implement, coordinate and assess these requirements for different situations? What should enhanced measures include? (wider buffers vs. linked activities that limit sources and transport before the buffers etc).

3. What is the most effective way to pay for buffers?
(i) the farmer pays - out of stewardship for the natural environment (his primary resource)
(ii) the consumer pays - maybe via a premium on environmentally-friendly branded food
(iii) private industry pays - e.g. water companies - as cleaner water is cheaper to process
(iv) governments pay through agri-environmental schemes

4. If the land taken out of production was to be the same for each scenario then what makes better pollution control and ecological sense?
(i) thinner continuous buffer strips along streams (habitat corridor, continuous low level of pollutant trapping), or
(ii) strategically-placed wider buffer zones (enhanced ‘hot spot’ pollutant trapping and ‘ecological stepping stones’)?

5. Given restricted space in European agricultural land, is making room for multiple functions in buffers an acceptable trade-off with agricultural production? Are the potential water quality, biodiversity, recreational benefits valued highly enough by society?

ABSTRACTS

SESSION 1

Overview of buffer strip use, design and management across the EU

Chair: **Marc Stutter**, The Macaulay Land Use Research Institute, UK

Overview Buffer Strips in Switzerland

Laurent Nyffenegger
Swiss Federal Office for Agriculture, Switzerland

Direct payments (Subsidies) are only paid to Swiss farmers satisfying ecological requirements (cross compliance). Buffer strips are part of the requirements. The presentation contains the followings points:

- Presentation of the situation in Switzerland regarding water quality (pesticides residues and nutrients) and biodiversity (agri-environmental objectives)
- Introduction of new measures concerning the establishment of grass strips in Switzerland: Since 2008 the width of buffer strips is 6 meters wide. The goal is to reduce phytosanitary residues in streams by drift and the content of nutrients from manure (reducing of runoff).
- It is also broadening the areas close to a natural state (without fertilizer or plant products) to encourage biodiversity.
- Information on requirements to be met and the amounts of contributions for the Swiss farmers.
- Combination with the potential to reduce safety distances contained in the authorization of pesticides.
- Presentation of difficulties encountered in orchards and vineyards (perennial crops) for the establishment of buffer strips.

References

Agricultural Report 2009
http://www.blw.admin.ch/dokumentation/00018/00498/index.html?lang=en

Objectifs environnementaux pour l'agriculture
http://www.bafu.admin.ch/publikationen/publikation/00097/index.html?lang=fr

Buffer Zones in Norway

Anne-Grete Buseth Blankenberg
Bioforsk Norwegian Institute for Agricultural and Environmental Research, Norway

From 2005 to 2008 approximately 5500 km of 8-10 meter wide buffer zones have been established in Norway. The presentation outlines the Norwegian experiences with buffer zones as a measure to prevent diffuse water pollution from agricultural runoff.

Agricultural runoff causes loss of soil particles, nutrients and pesticides into rivers and lakes causing water quality problems. In addition to focus on the agriculture management through best management practice (BMP) on arable fields, measures such as buffer zones and constructed wetlands in first and second order streams reduce downstream loads of nutrients through mechanisms such as sedimentation, uptake by vegetation and microbial degradation. Buffer zones reduce erosion, nutrients and pesticides from surface runoff. The retention is about >70% for particles, > 50% for total phosphorus and > 30 % for nitrogen in the Norwegian buffer zones. The farmers in Norway get financial contribution for building the buffer zones.

The paper present data from the Morsa catchment area and lake Vansjø, which is the most important "pilot-area" in Norway with respect to implementation of the WFD. The catchment, located in the South-Eastern part of Norway, is 690 km^2 whereof 16 % is agriculture and 80 % is forest. All water bodies in the Morsa catchment are characterised. Large areas are not at risk. However, there are water quality problems in the lake Vansjø and its tributaries. The water quality problems are mainly caused by high phosphorus inputs from the catchment area. Agriculture and in particular the diffuse nutrient losses have been identified as the major source of anthropogenic phosphorus inputs. In this catchment it is constructed 370 buffer zones, approximately 7-10 meter wide, and 18 % of the runoff from agriculture land enters buffer zones before water enters the water-recipient.

My presentation will also give examples of other benefits than improving water quality by using buffer zones.

Nitrogen removal effectiveness in narrow buffers strips: some examples from the river Po catchment

Raffaella Balestrini, Cristina Arese, Carlo Andrea Delconte and Alessandro Lotti
Water Research Institute, Italy

In many Countries the use of vegetated buffer strips represent an important best management practice (BMP) for controlling the diffuse pollution deriving from agriculture (Dosskey 2002). Some financial incentives programs have been established in Italy to support the installation and the restoration of vegetated buffers for ecological objectives and for the protection of water quality. However, watershed planners need to select the key factors for buffer effectiveness and to establish guidelines to optimize the buffer management. One of these factors closely related to the landowners interests is the buffer width. Despite the similarity of purpose, there is a great heterogeneity in the width recommended in the local guidelines. From a scientific point of view there is not yet a consensus for what constitutes optimal riparian buffer design or proper buffer width to achieve maximum nitrogen removal effectiveness. Most studies conducted so far have not shown a direct relationship between the size of riparian strips and efficiency in removing nitrogen (Mayer et al. 2005). Many Authors observed that the drastic reduction of nitrate occurred just in the first few meters (3-5 m) of vegetated buffer (Haycock & Pinay, 1993, Balestrini et al, 2007, Balestrini et al., 2008).

On the basis of these and previous results on narrow buffer strips, we examined the buffering capacities of narrow riparian strips (5-15 m) along irrigation ditches and relatively natural springs. These small water bodies receiving large nutrient input are very common in the agricultural lowlands of the Po basin. The results obtained from the chemical monitoring of the subsurface water in each experimental plots along with the rates of potential denitrification, were discussed considering different environmental features. Particular attention was given to the groundwater dynamic, the soil features, the geomorphology, the vegetation type, the organic carbon availability and the agricultural practises.

References

Balestrini et al. (2007). Verh. Int. Verein. Limn. 29/5, 2217–2220

Balestrini et al. (2008). Hydrol. Earth Syst. Sci. 12, 539–550

Dosskey (2002). Environmental Management 30, No. 5, 641–650

Haycock et al. (1993). J. Environ. Qual. 22: 273-278

Mayer et al. (2005). EPA/600/R-05/118

Dimensioning of buffer strips in the Slovak Republic

Jarolsva Antal, Lucia Maderkova
Slovak University of Agriculture, Slovak Republic

Localization, width, and vegetation cover of buffer strips depend on their planned purpose. Anti-erosion contour buffer strips, as their name says, are often placed in the direction of contour lines. The distance between them may not exceed so-called critical slope length – L_{cr}, which we calculate with using 3 types of the equations. In the Slovak Republic, we use two equations for the calculation of the minimum width of contour buffer strips - D_{min}. In the first equation (Cablík-Jůva, 1963) is the width of contour buffer strips a function of the L_{cr}, design rainfall intensity, infiltration capacity of soil on adjoining slope and infiltration capacity of soil on contour buffer strips. In the second equation (Antal,1986). is the width of contour buffer strips a function of L_{cr}, depth of design rain, the value of the CN of adjoining slope and the CN value of contour buffer strips.

Consideration that the localization of riparian buffer strips is already determined by location of the stream, it is necessary to dimension their width, eventually propose vegetative species selection. Currently is used no formula to calculate the width of the riparian buffer strips in Slovak Republic. There are only recommended values of riparian buffer strips width, where a minimum value of riparian buffer strips width is 4.5 m and maximum recommended value of grass riparian buffer strips width is 26 m, depending on the adjoining slope steepness and on the erosion intensity of the adjoining slope (Muchová-Vanek et al, 2009).

Nowadays we are working on the equation for calculation of the minimum riparian buffer strips width - D_{min}, which takes into account not only the characteristics of adjoining areas, but that would take into account the required riparian buffer strips functions, too.

References

Antal J. (1986). A New Method of Designing Buffer Strips. (In Slovak) Proc. Of VI NC Košice, 196-201

Cablík J. and Jůva K. (1963). Erosion Control to Protect the Soil. (In Czech) SZN Prague, p. 324

Muchová Z. et al. (2009). Methodical Standards of Landscape Planning. (In Slovak) SPU Nitra, p.396

How do riparian buffer strips influence the nutrient uptake efficiency of small agricultural headwater streams?

Gabriele Weigelhofer and Thomas Hein
Interuniversity Centre for Aquatic Ecosystem Research, Austria

The north-eastern part of Austria as well as the south-eastern part of the Czech Republic is characterized by intensive agriculture as the dominant land use in the catchment, thereby imposing multiple pressures on the headwaters in these areas. Besides receiving high loads of nutrients from the surrounding fields, the streams have been heavily regulated, showing straightened and incised channels with scarce bank vegetation. Riparian buffer strips are usually small, exhibiting V-shaped reed-vegetated profiles whose management is subordinated to flood protection. As a result, many agricultural streams have a bad ecological status according to the EU WFD.

The aim of the three-year research project ProFor Weinviertel – Jižni Morava (2009-2011) is to identify efficient management options for those small, heavily degraded agricultural streams which have the potential to improve the on-site retention of nutrients and restore the good water quality of the streams. The focus of the research lies on the complex, often non-linear effects of bank and stream morphology, including riparian buffer strips management, on the stream metabolism and the in-stream uptake, storage, and release of nutrients.

Bank morphology and bank vegetation not only have impacts on the nutrient retention before entering the stream, but also on the nutrient uptake and/or release within the stream. Bank structures influence the channel morphology and heterogeneity and, thus, lead to changes in the surface area-to-volume ratio of the stream and in the available contact zone and time for nutrient processing (Gücker et al. 2008). The shading of a stream may alter the stream metabolism by shifting processes from primary production to respiration and organic matter degradation. In the presence of woody material, in-stream denitrification may be enhanced and function as an important sink for nitrogen (Craig et al. 2008). On the other hand, an inefficient restoration of bank and channel structures may lead to an unfavourable secondary release of sediment-bound nutrients and, thus, may override the positive effects of riparian buffer strips.

References

Craig et al. (2008). Front. Ecol. Environ. 6; doi:10.1890/070080

Gücker et al. (2008). Freshwat Biol x, 1-17; doi:10.1111/j.1365-2427.2008.02069

Modular approaches to the control of diffuse water pollution from agriculture: buffer zones, bioreactors, ditches and ponds

Martin S.A. Blackwell, Jane M. Hawkins, Steve Granger, Tegan Darch, Philip M. Haygarth and David Chadwick
North Wyke Research and Centre for Sustainable Water Management, Lancaster Environment Centre, UK

Despite the abundance of literature reporting both riparian and non-riparian buffer strip performance in the control of diffuse pollutants from agriculture, the spatial and temporal mechanistics of the processes involved are poorly understood. As a result, buffer zones have often been implemented incorrectly and have failed to deliver the benefits expected of them. One of the main challenges with buffer zone effectiveness has been found to be their by-passing by the passage of polluted water through sub-surface drains which in many regions of the UK has regularly been shown to greatly limit their value with regard to nutrient control [MAFF report, Leeds-Harrison 1996]. In addition, little work has been carried out on the role of additional, complementary structural buffering methods such as managed ditches and ponds, which may provide more benefits, especially if used either alongside or instead of the more conventional use of buffer strips. Also, the compatibility of buffers for both N and P retention has received little attention.

Here we describe a field scale experiment that forms part of a Defra funded project, which is using a multi-scaled approach to understand the abiotic and biotic drivers of the short-term and 'long-term' effectiveness of conventional grassed buffer strips over 5 years. At the field scale, we are using high resolution monitoring methods to compare the effectiveness of 6 m wide buffer strips along with other mitigation methods including buffer strips enhanced with subsurface bioreactors (to intercept drain water), managed ditches and ponds to control a range of water pollutants and hydrology. Each of the mitigation methods is being investigated both individually, and as part of a strategic modular network of mitigation methods in a purposely constructed and replicated experimental site. Preliminary data is presented, showing hydrological and chemical responses during individual storm events.

References

Leeds-Harrison et al. (1996). MAFF−English Nature Buffer Zone project CSA 2285, Cranfield University, Silsoe, Bedford, UK

SESSION 2a

Plot-to catchment-scale evaluations of buffer strip processes and effectiveness

Chair: Brian Kronvang, Aarhus University, Denmark

Function and effect of vegetated buffer strips on nutrient emission at tile-drained field sites

Bernd Lennartz, Johanna Frings and Sandra Schonemann
Institute for Land Use, University of Rostock, Germany

It has been shown in several studies that vegetated buffer strips have a positive impact on the reduction of sediment and nutrient transport to surface waters. It remains, however, unclear to what extent buffer strips influence water quality at artificially drained sites where it is believed that no filter mechanism is operational within the strip since nutrient loaded soil and groundwater is directly routed in pipes to the surface water resources.

The objective of this study was (i) to identify flow and transport processes operating within buffer strips at tile drained field sites and (ii) to quantify a possible nutrient reduction in artificially drained landscapes at the sub-catchment scale.
At a densely instrumented field site with several transects of groundwater wells, three widths of buffer strips (1, 3, 7 m) were established along a ditch receiving water from various tile drainage systems. In addition, two comparable sub-catchments only differing in the configuration of the buffer strips were subjected to regular water quality monitoring.

At high groundwater levels during winter, groundwater flows towards the ditch adjacent to the field site. However, hydraulic conductivity and resulting flux rate were low. Accordingly, nitrate concentrations decreased with decreasing distance to ditch and increasing depth with a minimum value for nitrate of < 1mg/l in 4 m depth and 1 m apart from the ditch. The buffer strip width had no impact.
The comparison of the water quality parameters of the sub-catchments revealed that the nitrate concentration level of drain pipes discharging into the ditches did not differ between sites. The concentration level in the ditch of the sub-catchment with a long established buffer strip was, however, slightly lower than at the other site where no buffer strip exists. In both ditches a natural attenuation of nitrate along flow direction from spring to outlet was observed indicating self-cleaning processes.

Buffer system implementation with increases infiltration and nitrate retention capacity – A case study from Brittany, France

Andreas Matzinger, Caroline Guegain, Bernard Sautjeau, Bjorn Krause, N. Litz and Kai Schroeder
Kompetenzzentrum Wasser Berlin, Germany

A mixed surface and sub-surface flow riparian zone in Brittany (France), which is mainly fed by water from drainage ditches, was monitored for nitrate retention over three years from 2005 to 2007. Results show high time-averaged nitrate retention of >90 % for sub-surface and ~70 % for surface passage. However, no retention could be detected during major rain events, which reduced the overall (flow-averaged) retention to ~40 %. Based on the findings, higher nitrate retention can be reached by increasing (i) the water residence time in buffer systems, (ii) the fraction of subsurface passage or (iii) denitrification rates in the system.
(i) is only feasible if (active) buffer volume is enlarged, which may be difficult in practice. In the case of Brittany an enlargement can also be reached by extending buffer systems into existing drainage ditches. (ii) is of particular importance in areas with low soil permeability. In such areas, addition of gravel or sand beds can be considered. Regarding (iii), denitrification turns maximal under anaerobic conditions if sufficient carbon sources are available. In straw- and bark-filled column experiments we found high nitrate retention rates of >99 % and ~40 %, respectively, during a comparably low residence time of ~5 hours. As a result, the addition of external carbon sources to buffer systems is suggested.
Currently, several pilot sites are constructed in the Ic watershed in Brittany attempting to take into account points (i) to (iii). For the following four buffer types, monitoring will start in February 2010:

- Two short drainage ditches, filled with carbon sources
- One drainage ditch and one riparian wetland, each filled with a gravel filter, and optional upstream addition of carbon sources
- One riparian surface wetland with optional upstream addition of carbon sources

Are narrow vegetated riparian buffer strips functioning as a barrier against sediment and phosphorus transport in Scotland?

Marc Stutter
The Macaulay Land Use Research Institute, UK

Riparian buffers in the agricultural environment of the UK are typically narrow (<2-5 m), unmanaged barriers comprising wild vegetation. Recent legislation in Scotland (General Binding Rules for Agriculture, 2008) further endorses narrow buffer strips by not allowing cropping or agrochemical inputs 2 m from watercourses. The creation of such a barrier brings great benefits for separating agricultural activities from the watercourse, for example stopping pesticide spray drift. However, we question how well the soils in such narrow barriers can continue to operate as interception and storage zones for sediments and nutrients. Our premise is that a wider buffer has better protection against (i) nutrients and sediments crossing the buffer, (ii) soil saturation of nutrients leading to leaching (especially P) and (iii) other functions not tested in this study (biodiversity and flood water storage).

We undertook a survey of buffer strip properties in regions of Scotland with contrasting agricultural management, geology and climate and hence differences in erosion risk and nutrient status. Locations on low order streams (1^{st} to 3^{rd}) were visited after being picked randomly. Characteristics recorded were: the presence and design of buffers, site potential for, and evidence of, soil erosion into and across the buffer. Soil cores were taken from buffers and adjacent fields for analyses of bulk density (a surrogate of infiltration capacity), water extractable nutrients and particulate nutrients (associated with digestion of the sub-silt size fraction of soil solids under a simulated erosion disaggregation test).

Our findings will help to determine the efficacy of a general principle of narrow vegetated buffer strips promoted everywhere, as compared to a system of enhanced protection (for example a wider buffer) in areas most at risk of nutrient and sediment transport to streams, with no buffers in low risk areas. Both the general narrow buffers and the targeted wider buffers approach could ultimately take a similar area of land out of production and therefore be comparable economically, but have different efficacies for diffuse pollution.

A rainfall simulation study on P removal in buffer zones amended with Fe and Ca compounds

Jaana Uusi-Kamppa, Eila Turtola, Aaro Narvanen, Lauri Jauhiainen and Risto Uusitalo
MTT Agrifood Research, Finland

Although vegetated buffer zones (BZs) along water courses decrease total losses of sediment and phosphorus (P) from field surface runoff, they appear ineffective in reducing dissolved reactive phosphorus (DRP) losses from boreal clayey soils. After soil freezing and thawing in spring, DRP losses can be considerable and they may even increase on BZs. To improve DRP retention, we added Fe and Ca containing compounds to the surface of BZs: gypsum ($CaSO_4$ x $2H_2O$), Fe-gypsum, ground calcium carbonate ($CaCO_3$) or granulated ferric sulphate (Ferix-3).

Altogether 40 undisturbed surface soil columns (depth 7 cm, Ø=24 cm) were cored from two BZ sites located on clay soils at Jokioinen and Pöytyä, SW Finland, in November 2008. Phosphorus status in surface soil (0–2 cm) measured by the method of NH_4-acetate acetic acid was 'fair' (6.4 mg L^{-1}) and 'excessive' (47 mg L^{-1}) in Jokioinen and Pöytyä, respectively. Gypsum (6 t ha^{-1}), Fe-gypsum (8.5 t ha^{-1}), $CaCO_3$ (3.3 t ha^{-1}) or Ferix-3 (0.67 t ha^{-1}) was spread on surface of four replicate soil samples, whereas eight samples served as untreated controls. Simulated rainfall (5 mm h^{-1}) was applied indoors to presaturated samples. After that, the soil samples were frozen (1–2 months), thawed (20 h, +6℃) and a second simulated rainfall was ap plied. A third rainfall was given after yet another freeze-thaw cycle. During each rainfall simulation, surface runoff was collected and analysed for DRP, total P (TP) and suspended solids.

Freezing and thawing increased the DRP concentration of control treatment up to 13-fold. For the samples treated with Fe and Ca compounds, the removal efficiency for DRP was increased in the order: gypsum<$CaCO_3$<<Ferix-3<Fe-gypsum. Both Ferix-3 and Fe-gypsum retained 74–85% of DRP and 47–64% of TP, whereas gypsum and $CaCO_3$ were not effective in the retention. Ferix-3 also retained 45% of suspended solids from surface runoff of Pöytyä soil columns.

Influence of linear flow structures on the effectiveness of buffer strips

Rosemarie Hosl and Peter Strauss
Institute for Land and Water Management Research, Federal Agency for Water Management, Austria

In intensively agriculturally used regions, surface runoff often contains sediments, pollutants and nutrients which may badly influence the stream water quality. One possibility to reduce nutrient and sediment input into surface waters is by installing buffer strips which are supposed to retain these pollutants. In Austria, buffer strips obtain funding within the Austrian agri-environmental programme (ÖPUL) when placed alongside permanent streams. However, flow convergence may take place in ditches or channels long before approaching the river system. Under these circumstances, buffer strips may not contribute effectively to reduce pollutant input.
To assess the dimension of such a scenario we carried out a detailed field survey in the Weinviertel area of Lower Austria, a region which is known to be highly affected by soil erosion and pollutant input into aquatic ecosystems. Ditches, channels and comparable linear structures known to concentrate convergent flow paths were mapped in five subcatchments of the Weinviertel region. Surface flow paths were modelled either automatically or by integrating these linear structures. The critical catchment areas which drained unprotected into the streams were identified for both cases.
Automatic calculation of surface flow paths was not able to identify critical unprotected areas compared to integrating the mapped linear structures. In three out of five subcatchments such critical areas were found. The size of these unprotected areas within the test subcatchments varied between 10 and 40% of the total area.

We also tested the impact of grid resolution and the implementation of different runoff algorithms. Three different DEM's and two different runoff algorithms were used for both the automatic and the mapped convergent flow situation. Application of a D8 versus D-infinity algorithm did not affect results, whereas the impact of grid resolution was slightly higher. The biggest influence by far was caused by the implementation of the mapped linear structures.

Water infiltration into soils under riparian buffer strips

Ararso Etana and Barbo Ulén
Swedish University of Agricultural Studies, Sweden

The infiltration capacity of the soil is a primary factor for the efficient retention of plant nutrients in riparian buffer strips. However, water repellency (hydrophobicity) due to vegetation is a widespread problem (Doerr, et al., 2000; Jarvis, et al., 2008). Accordingly, we investigated water infiltration as affected by vegetation cover, moisture condition and soil type. Permanent grass cover without cutting drastically reduced water infiltration into the soil after a long dry period. Soil texture had also significant influence on the infiltration capacity. To link the pathway of water outflow from riparian strips with phosphorus retention, a new research will be carried out during 2010-2012.

References

Doerr, S.H., R.A. Shakesby, R.A.. Walsh, R.P.D 2000. Soil water repellency: its causes, characteristics and hydro-geomorphological significance. Earth-Science Reviews, 51: 33-65.

Jarvis, N, Etana, A and Stagnitti, F. 2008. Water repellency, near-saturated infiltration and preferential solute transport in a macroporous clay soil. Geoderma, 143:223-230.

Representing grassed buffer strips hydrology in a regional scale model

Aurore Degre and C. Sohier
University of Liege, Agro-Bio Tech, Hydrology and Hydraulic Engineering, Belgium

In Walloon Region (Belgium), like in many other European countries, riparian buffer strips appear to become one of the most approved nutrient mitigation measures. Within the frame of the water framework directive, policy makers need nutrient mitigation forecasting at the scale of the surface water bodies (from 3 to 426 km² in Wallonia). It induces that the hydrological models have to deal with different designs of the buffers themselves and of their catchment areas.

Up to date, most of the studies focused on sediment deposition at field scale. They concluded that the grassed strips can be very effective; nevertheless, the measured effects are still very variable. More often, the way the runoff water passed through the buffer strip (diffused or concentrated flow) is not considered.

We adapted our regional hydrological model (physically based, spatially distributed over the 17.000 km² Walloon region (Sohier et al., 2009)) by developing a new "buffer strip subroutine" that identifies automatically the catchment area of all the buffer strips. This is done using a 10 m resolution DTM. The catchment area is then subdivided into an "area of flow concentration" that leads the water to pass through the buffer strip on a very small portion of it and into an "area of diffuse flow" that leads the water to pass through the buffer strip using its whole length. The daily fluxes of water, nutrient and sediments that pass through the buffer are calculated by the model using our dynamic geodatabases (soil, DTM, weather, land use, agricultural practices). Depending on whether the flow is diffused or concentrated the water depth can vary to a large extent; so does the deposition ratio (algorithm adapted from Deletic, 2001). The buffer itself is modelled as grassland without direct fertilisation. Water and nutrient coming from the watershed can be used by the grass, water can infiltrate, evaporate or runoff and denitrification can occur when the soil is saturated. The oral presentation will show our results at the water body level for different buffer strip scenarios considering sediments and nitrate reduction in surface water.

References

Deletic A., 2001. Modelling of water and sediment transport over grassed areas. Journal of Hydrology 248., 168-182

Sohier C., Degré A., Dautrebande S., 2009. From root zone modelling to regional forecasting of nitrate concentration in recharge flows – The case of the Walloon Region (Belgium). Journal of Hydrology
369 (2009) 350-359

SESSION 2b

Plot-to catchment-scale evaluations of buffer strip processes and effectiveness

Chair: Wim Chardon, Wageningen University and Research, The Netherlands

Buffering diffuse pollutants in agricultural catchments at the edge-of-field using constructed wetlands

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Across Europe, many rivers and lakes are polluted. In the UK, the Biodiversity Action Plan estimates that over 70% of lakes are eutrophic. Diffuse pollution from agriculture is currently of extreme concern, but pollution and flood risk can be mitigated by management activities. The use of in-field mitigation options such as reduced tillage has been found to be effective at reducing runoff, sediment and nutrient loss in overland flow, but pollutants can still be lost from hillslopes unchecked via subsurface flow pathways, some of which may contribute very high loads of nutrients to streams. Edge-of-field mitigation approaches, which can tackle both surface and subsurface pathways where they discharge into ditches and streams, therefore have greater potential as runoff control measures than in-field measures alone. In the UK, the implementation, effectiveness and functioning of seven new wetlands constructed at the edge of agricultural fields is currently being assessed. The constructed wetlands, of different designs, which are fed by different flow types and are located on different farm and soil types, are continuously monitored for discharge and turbidity at inlets and outlets, while storm sampling allows assessment of sediment and nutrient transfer into and out of the wetland at times when there is a high risk of pollutant transfer. Pond surveys and sediment sampling will take place annually, and tracer experiments will be carried out in the course of the project. The data will be used to generate information on water and sediment residence times, sediment and nutrient load reductions or wetland effect-iveness, and wetland sediment and nutrient budgets. In this paper we present the initial results, including novel high-resolution data from the first monitored events. Early outputs suggest that constructed wetlands which receive surface runoff inputs can retain flood waters and may reduce flood peaks, wetlands built to take drain outfalls may be effective but may not be practical management options in all circumstances, and that turbidity measurements may be a good indicator of sediment and total nitrogen and phosphorus concentrations and hence sediment and nutrient transfer through wetland systems.

Measuring buffer strip efficiency under deltaic circumstances

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There is experimental evidence from all over the world on the effectiveness of unfertilized buffer strips (BS) or riparian zones to reduce nutrient loads to surface water, but no experimental data is available on the effectiveness of BS (BSE) next to artificial drains in a deltaic plain with deep surficial aquifer, like the major part of the Netherlands. BSE is highly variable and influenced by many factors, but local hydrogeology is widely recognized as one of the key factors controlling BSE. In the delta a major part of the precipitation surplus is discharged to ditches via deep groundwater flow paths that do not interact with the BS. As most commonly used experimental methods that either focus on runoff or lateral subsurface groundwater flow are not suitable for deltaic plains, we had to develop a new method to measure BSE.

We installed 3 replicates of 2 treatments, each with a separate reservoir in the ditch, receiving water from the adjacent part of the field. The two treatments were unfertilized 5 m grass BS and a reference strip (RS). The RS was treated (fertilized) like the rest of the maize field. We measured discharge from BS and RS via the reservoirs and concentrations in water samples taken discharge proportionally to calculate nutrient loads from the treatments. Groundwater samples were taken at several distances from the ditch in the strips and adjacent field opposite each reservoir.

A clear decline in nitrate concentration was found in upper groundwater below the BS, compared to RS, but nevertheless little difference was recorded in nitrate concentration between the BS and RS reservoirs in the ditch. We calculated BSE in several ways based on groundwater concentration, loads to the reservoirs, flow concentration, for several time periods and accumulated discharge amounts, etc. Though based on the same data, each gave quite different results. Therefore a thorough discussion is needed to establish an objective method to calculate BSE under deltaic circumstances.

Modelling the effectiveness of unfertilized field edges in the Netherlands

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In the Netherlands we are currently carrying out field experiments at five locations differing in geohydrological conditions, to determine the effectiveness of dry unfertilized buffer strips (BS) (see accompanying contribution of Heinen, Noij & Heesmans). Since the number of locations is small we could not vary all factors that determine the BS effectiveness (BSE), such as ditch distance and aquifer thickness. So we need additional tools for scaling up field results and for the assessment of the spatial variability of BSE. The model study aims to identify the dominant key factors, which control the nutrient load from these unfertilized strips. The measurements of the field study will be used to calibrate and validate the model calculations. The model calculations will provide estimates for the variation in BSE over the Netherlands according to varying soil conditions and hydrology. For this purpose we are using a) detailed mechanistic simulation models that describe hydrology and nutrient dynamics, and b) simplified analytical models. We will present the first results, focussing on the latter type.

SESSION 3

Managing buffer strips for multiple pollutant and biodiversity benefits

Chair: Wim Chardon, Wageningen University and Research, The Netherlands

Are environmental win-wins achievable on Scottish dairy farms

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There is increasing concern about the need to improve the overall biodiversity value of intensively managed grasslands. The intensity of management of the fields themselves coupled with the fact that such grasslands dominate much of the lowland landscape means that there are few opportunities for many plants, invertebrates, birds or mammals to survive. We have been working to gain an increased understanding of the factors affecting the biodiversity value of grassland field margins, diffuse pollution buffer strips and water margins on grassland-dominated dairy farms within the Cessnock catchment in Ayrshire.

This catchment has been established as a Monitored Priority Catchment by the Scottish Environmental Protection Agency (SEPA) because it represents land use patterns typical of west-coast dairying and because it is at risk of not meeting the environmental objectives of the Water Framework Directive (WFD). The Cessnock is a tributary to the River Irvine which discharges at Irvine Beach. This is a designated Bathing Beach and the condition of bathing waters here have a historically poor quality record because of the presence of agriculturally-derived faecal matter in the freshwater.

In our research, we have been looking to see if win-wins can be achieved, i.e. if fencing off the margins of intensively managed fields next to watercourses to control diffuse pollution has any positive impacts on biodiversity (based on assessments of vegetation composition and condition and the structure of assemblages of invertebrates of importance as food stuffs to farmland birds). This presentation will highlight some of the main findings from this research, indicate some of the conflicts which we have identified and suggest ways of managing diffuse pollution buffer strips to increase their potential to also provide wider biodiversity benefits.

Importance of stream and buffer zone characteristics for bank erosion and phosphorus inputs to surface water

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A recent Danish national upscaling exercise on the importance of different pathways for diffuse phosphorus losses to surface waters showed that bank erosion was one of the most important sources. As an outcome a research project was initiated with the aim of testing the hypothesis if stream banks and buffer strips were a major P source to surface waters. In the project (BUFFALO-P), bank erosion has been studied along thirty six 100 m reaches in the River Odense catchment during three years (2006/07, 2008/09 and 2008/09). Two replicate 100 m stream reaches covering different stream sizes (3 stream orders), channel planform (channelized versus naturally meandering), uncultivated buffer zone width (< 2m and > 10 m) and buffer zones with low (grass/herbs) and high vegetation (trees) were selected utilising a stratified random procedure in GIS. Each reach was instrumented with five 1 m x 1.6 m plots each consisting of three verticals lines of erosion pins deployed 5 cm, 10 cm, 20 cm, 40 cm, 80 and 160 cm above the stream bed. A total of 180 erosion plots were established in autumn 2006 having a total of *ca.* 3000 erosion pins deployed (60 cm long steel pins). The results show that neither stream size, nor stream planform or the width of uncultivated buffer zone had any significant ($p<0.05$) influence on the bank erosion measured as bank retreat (mm) during each of the three years studied. Vegetation type in the buffer strip showed to significantly influence bank erosion as buffer zones with natural trees lowered the annual bank retreat significantly as opposed to buffer zones with grass and herbs. Bank slope and vegetation cover on the banks was also significant factors influencing bank erosion. We conducted a GIS analysis of the different stream and buffer zone types in the 485 km^2 River Odense catchment that enabled us to perform a calculation of the gross sediment and phosphorus input from bank erosion during all three study years. Average annual gross bank erosion during the first wet winter of 2006/2007 amounted to 41.2 tonnes sediment km^{-1} stream channel and 27 kg P km^{-1} stream channel. The total gross erosion of sediment and phosphorus amounted to 15,800 tonnes sediment and 10,300 kg phosphorus (0.21 kg P ha^{-1} catchment area) within the entire catchment. This equals 325 tons sediment ha^{-1} and 0.19 kg P ha^{-1} catchment area. Although part of the eroded sediment and phosphorus is stored within the channel or captured on natural or restored flooded riparian areas, bank erosion seems to be a significant source of total and particulate P in lowland streams.

Diversity and distribution of riparian plant communities in relation to stream size

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Riparian areas are recognised as one of the most species rich environments due to high levels of spatio-temporal heterogeneity. Within the last decade, however, there has been an increasing concern regarding the disappearance of species-rich plant communities in riparian areas, and a huge effort is made at both national and international levels, e.g. EU Habitat Directive and Water Framework Directive, to conserve species rich riparian areas that still remain. Furthermore, rehabilitation of former species rich areas through various restoration efforts as well as establishment of uncultivated buffer zones along stream reaches are also widely implemented.
The present study was conducted to investigate the diversity and distribution of plant communities in riparian areas along a lowland stream-size gradient (1^{st} to 5^{th} order). We hypothesise that 1) there is an overall increase in community diversity with increasing stream size and 2) the distribution of the various community types is closely linked to their tolerance towards eutrophication. To test these hypotheses we use vegetation data from a total of 1,823 plots located in 50 representative Danish riparian areas. Following vegetational analysis each plot was classified into a habitat type using a species-based classification model that builds on habitat types protected by the EU Habitat Directive.
We found a positive correlation between stream size and number of habitat types (r^2 = 0.75) which seem to be coupled to the intensity in the interaction between the stream and the riparian area. Furthermore we found that the tolerant habitat types were widely distributed e.g. tall herb fringes and mesophile pastures, whereas more vulnerable types like fens and meadows were more restricted in their distribution. These results demonstrate the need for conservation or reestablishment of natural hydrological processes to conserve or restore diversity in riparian areas and also that special attention regarding excess nutrient loadings should be allocated towards riparian areas and buffer zones with sensitive habitat types to prevent their future decline with respect to both quantity and quality.

Evaluating the effectiveness of buffer strips using riparian plants and beetles as indicators

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Despite the widespread use of riparian buffers as a management tool to maintain a variety of ecological functions there has been little experimental evaluation of how effective these buffers are (Kiffney et al 2003, Goodwin et al 1997), and no consideration of riparian organisms (Jahnig et al 2009). Where monitoring has occurred the results are inconsistent and their scope beyond the immediate area limited. There is therefore a need to develop monitoring techniques which are informative, repeatable and with wide applicability. Two catchments in north-east Scotland were studied over a two year period. We investigated plant and beetle (Coleoptera; Carabidae and Staphylindae) responses to buffer strips and the potential for these taxa to act as indicators of habitat quality and consequently successful improvement. The assemblage structure of both the plants and beetles was shown to change in relation to buffering and also showed a response in relation to the length of time a buffer strip has been established. This demonstrates the potential for biodiversity monitoring of buffer strips to indicate wider ecological influences of this type of riparian management.

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Seed germination from deposited sediments during high winter flow in riparian areas

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Flooding has long been recognized as an important factor structuring vegetation in riparian areas mediated through different hydro-morphological processes. Flooding may also affect the vegetation by supplying seeds and vegetative fragments that may establish in the areas. In this study we investigate seed germination from deposited sediment in different distances from a re-meandered river channel along River Odense, Denmark and examine how richness, diversity and composition vary along gradients in sediment characteristics. We established a transect perpendicular to the stream channel extending 101 m into the stream valley. Sediment samples were collected in a total of twenty five 20 x 20 cm artificial grass mats positioned 2, 16, 23, 41, 70 and 101 meters from the stream. The germination was followed for 6 weeks under respectively moist and wet conditions in a greenhouse with a natural light regime and a mean temperature of 20 °C. The germination was most successful under moist conditions where the number of seedlings emerging ranged from 1050 to 3817 m^{-2}. Species richness (10.7±1.5 species), diversity (2.13± 0.13) and evenness (0.90±0.03) peaked in samples taken 16 m from the stream channel. Overall the number of seedlings correlated positively with distance from stream and organic matter content in the sediment, and negatively to the C/N content of the sediment. Conversely species richness and diversity correlated negatively with distance from stream and organic matter content but positively to C/N. Our results clearly demonstrate that deposited sediments have large contents of viable seeds and also the potential to introduce variability in compositional patterns in riparian areas where the interaction between river and riparian areas is rehabilitated through active or passive restoration

SESSION 4

Combining biophysical knowledge, socio-economics and practicalities

Chair: Marc Stutter, The Macaulay Land Use Research Institute, UK

Cost-effective targeting of buffer strips for phosphorus mitigation: the case of Rescobie Loch

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The European Community Water Frame Directive requires Member States to set water quality objectives and identify cost-effective mitigation measures to achieve good ecological status for all waters in Europe. This requires control of both point and diffuse pollution. Agricultural sediments and diffuse phosphorus (P) pollution are among the key contributors in affecting water quality. Measures targeting 'transport controls', such as buffer strips, are among the principal options of P pollution mitigation. However, the costs and effectiveness of such measures vary significantly in the landscape.

Taking the case study of Rescobie Loch in Lunan catchment, Angus, Scotland, this study aims to investigate the optimal targeting of buffer strips for P mitigation and how placement of buffers influence costs and effectiveness. For this purpose an integrated economic, hydrologic, and GIS modelling framework is being developed.

The modelling results show that: (1) Lower P reduction target can be achieved cost-effectively by establishing 2 m width buffers on selected fields; (2) For higher P reduction targets cost-effectiveness increases by targeting both the spatial configuration of fields and buffer width variability; and (3) For higher P reduction targets the marginal abatement cost increases at an increasing rate.

Buffers for Biomass – a review and synthesis of options and practicalities in Denmark

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The recent ´green growth´ initiative by the Danish government among other things contains legislation and incentives to further the expansion of biomass production for heat and power generation. It allows for planting of energy crops directly up to lakeshores and stream banks which otherwise cannot be used for agricultural production. This represents an opportunity for larger scale implementation of vegetated buffer structures to meet both bioenergy production and ecosystem service goals. More than 90 articles and other publications covering hydrology, P&N dynamics, forestry, farm management and related topics were reviewed, compiling options for combining biomass production, water management and reduction of nutrient losses by using vegetated buffer strips in temperate northern agriculture.

The most versatile and also most promising way of including productive buffers in the farming landscape identified is a three-zone structure consisting of a grass filter strip right up to the field, a middle zone of short rotation coppice/forestry and largely undisturbed, permanent woody vegetation along the stream bank. This agroforestry system can be designed for production of energy grass and woodchips, firewood or even timber but also for silage, grazing, enhancement of hunting opportunities or purely for conservation or aesthetic purposes.

Practical details are discussed in relation to buffer design in various landscape settings, species choice, planting and establishment, weed control, harvesting, nutrient cycling, how to deal with drainage and options for fitting the system into the single farm payment and other possible schemes. Product options, marketability and farmer views and preferences are explored. It is concluded that riparian buffer strips can function as truly multifunctional structures and could be a conservation tool appealing to both an environmentalist and a productivist mindset.

POSTER ABSTRACTS

The impact of erosion control systems on soil losses in Perieni county

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Buffer strips are a very important practice in preventing surface run-off and sediment entering watercourses. However, they are effective solution to reduce sediment pollution of water or the leaching of nutrients.

The paper presents the results obtained in long term studies and research carried out in Perieni, Plateau Bârlad, regarding to the structure and crop rotation on sloping land, culture systems and different measures to prevent and reduce erosion processes on sloping land: buffer strips; contour farming; strip cropping.
Using the buffer strip system, in the condition of Plateau Bârlad, the soil and water losses were reduced by 3 to 4 times compared with unprotected cultivated slope.

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Factors controlling organic and inorganic phosphorus speciation, and their retention and release kinetics in soils within agricultural buffer strips

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Most research into phosphorus (P) loss from agricultural soils has focussed on inorganic P, as organic P was not considered to be readily available to plants and microorganisms. However, in recent years it has been shown that some organic P compounds are more bioavailable than previously thought, and may therefore cause a pollution risk. This is particularly notable as organic P can have a greater contribution than inorganic P to total P in leachate from grassland (Preedy, McTiernan et al. 2001).

Buffer strips have been shown to be effective at retaining P, but many studies have focussed on inorganic P retention or total P retention, with organic P dynamics being inferred by difference. Characterisation of the organic species in drainage water from grassland is still in its infancy, and it is unknown whether there is a net retention or release of organic P from buffer strips. Phosphorus cycling within the buffer strip will affect the P species present in, and released from, the buffer strip. However, what the effect will be and how factors such as retention time, redox potential, aerobic status and temperature affect P cycling, speciation and retention and release kinetics from the soil in buffer strips are still unclear. Here we present lab, mesocosm and plot scale experiments which will be carried out to address these questions. There will be a particular focus on dissolved P because despite previous research into buffer strips being on the retention of particulate P, it is now becoming clear that majority of total P export may be in the dissolved form (Turner and Haygarth 2000).

These experiments will investigate the impacts on organic and inorganic P loads in 2 and 6m wide buffer strips, as currently recommended by the Environmental Stewardship Scheme. Experiments will also aim to quantify the effect of slope on P retention and release within the buffer strips.

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Riparian buffers of small streams have larger phosphorus mobilization potentials than adjacent farmland in Eastern Denmark

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The mandatory establishment of 10 m riparian buffer zones is a prioritized means of legislators to reduce phosphorus (P) transfer from agricultural land to water in Denmark. Whereas the buffer zones' retention potential for surface transported P is well documented in the international literature, relatively little is known about their overall source or sink function for P transport in landscapes. In Denmark riparian buffers have previously been found to be more P-enriched than adjacent agricultural land indicating amongst others a correspondingly higher P leaching potential. The objective of our study was to compare the P mobilization potential in soil profiles along short transects spanning from the crest of stream banks across 3 m wide riparian buffers into adjacent arable fields. The selected four sites were situated in the River Odense catchment at 1st or 2nd order streams and representative for intensively farmed land in the Weichsel moraine landscape of Eastern Denmark. We discuss the spatial distribution of different P forms and the degree of P saturation in different soil profiles in relation to general soil properties, land use, management of riparian buffers and stream typology. Additionally, the P mobilization potential is related to P concentrations in the shallow ground water obtained with piezometers along the transects. Our study questions the effectiveness of riparian buffers in reducing subsurface P losses the low order streams.

The impact of buffer zones on the water quality of East Mediterranean streams

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The effect of three most commonly practiced vegetative buffer zones along the reconstructed Jordan stream and drainage canals on landscape biodiversity and water and ecosystem quality was examined. The buffer zone habitats included low harvested grasses, high perennial mixed- reeds (*Phragmites australis*), and perennial grasses with woody species. The shallow groundwater at each buffer zone was sampled at 3 different sites and analyzed for their salinity content, total P, total dissolved P, soluble reactive P, chlorite, nitrate and sulfate. The flora biodiversity was determined by field survey along a 10 m transect parallel to the stream and canals. A total of 37 species were recorded at all sites where most of the species were defined as low grasses or forbs, with an average cover of 57%. The average cover of high perennial species was 38% and 5% of trees. The six dominant species that covered 80% of the area were *Cynodon dactylon*, *Phragmites australis, Sorghum halepense*, *Nerium oleander*, *Malva nicaeensis* and *Conyza albida.* The woody habitat exhibited greater number of species compared with the other buffer zones ($P = 0.05$). No significant differences were found in nutrient concentrations of groundwater draining the fields and water samples taken within the buffer zones. These results suggest that the buffer zones serve mainly as enriching habitats for nesting birds and small mammals and are important for thriving ecotourism industry in this area but they do not serve as an affective hydrochemical barrier between farm lands and waterways.

Catch crops for phosphorus

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Catch crops have successfully been used to mitigate losses of nitrogen (N) from agricultural land, but their impacts on phosphorus (P) losses are uncertain. Cultivating catch crops of appropriate species and varieties may effectively reduce P losses through surface runoff and erosion by increasing water infiltration and improving soil structure. In addition, catch crops may act as a sink of plant-available P after the main crop has been harvested. Opposite, they may act as a source, since P may leach from the very plant cells e.g. when destroyed by frost. This is of great concern for Nordic countries with cold winter climate and many freezing-thawing cycles of the soil. As a part of the understanding of the role of plant, including those on buffer strips, for P retention, the leaching from some selected plants are studied after freezing and thawing the whole plants including the soil.

In laboratory P leaching from various potential catch crops after a problematic winter climate is simulated through seven repeated freezing-thawing cycles. Lysimeters with five plants representing two different clay soils from two climatic regions in Sweden are used. The plants presently tested are: ryegrass (Lolium perenne L.), cocksfoot (Dactylis glomerata L.), oil radish (Raphanus sativus L.), honey mustard (Phacelia tanacetifolia L.) and chicory (Cichorium intybis L.). In each cycle, the plants and soils are frozen 12 hours at -18^{o}C and thawed another 12 hours at +18^{o}C. The soil columns (20 cm in diameter × 25 cm in height) are repeatedly irrigated with a total of 70 mm water, with the intensity of10 mm·h^{-1}, before and after freezing-thawing cycles. Basic soil physical and chemical properties, P content in plant, and dissolved reactive P (DRP), particulate bound P (PP) and total P (TP) in the water leachate are analyzed as well.

Modelling of the buffer strip effect on surface P losses from agricultural fields

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The ICECREAM model (Tattari et al. 2001, Larsson et al. 2007) is frequently used to estimate phosphorus (P) losses from Swedish agricultural fields (Naturvårdsverket 2008). Since buffer strips are one of the most important farming practices to reduce surface P losses from agricultural land it is important to be able to represent the effects of buffer strips in an accurate way in the simulations. In this study the model option to divide the field into different segments with different slopes, crops, and management was tested to simulate the reducing effects of grass buffer strips (BS) on P losses. The simulations were carried out with two segments of which one represented the cultivated field and the other the BS. Currently several modelled scenarios considering different soil types, climates and buffer strip widths (BSW) have been evaluated. The change of soil types in the simulations led to highly variable surface P losses which amounted e.g. in scenarios with spring barley and a southern Swedish climate from 0.14kg ha-1 (sand) up to 1.7 kg ha-1 (silty clay). Irrespective of soil type, the introduction of a 10m BS halved the surface P losses, with a reduction ranging e.g. from 51% for clay to 59% for silty clay loam. The total reduction of surface P losses increased with the BSW. However the increase in reducing efficiency was lower with each extra meter the BSW was expanded (18% for BSW 1m; 57% for BSW 10m, and 76% for BSW 30m on a silty loam). Amount of precipitation was the most important climatic factor for the annual average surface losses of P, while winter conditions with incidental snow melt events had a lower effect. In the future a further evaluation of the results will be undertaken. Additionally the possibility of transferring the field scale simulation results to catchment and regional scale will be investigated.

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Evaluating the effectiveness of buffer strips in the Austrian agri-environmental programme

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In the period 2007-2013, the Austrian agri-environmental programme (ÖPUL) subsidizes installation of buffer strips along permanent streams as means to reduce sediment and nutrient input into water courses. Subsidies are linked to certain management restrictions (50 m grassed buffers, no fertilisation, only one cut per year). To evaluate the potential for this kind of buffer strips to reduce sediment input into water courses we attempted to apply a scaled modelling approach. VFSMOD (Muñoz-Carpena et al, 1999), a plot scale filter strip model with high spatial and temporal resolution was validated and used to obtain buffer strip effectiveness for a wide range of combinations of those input variables with highest sensitivity to sediment delivery. Using these results, a retention effectiveness matrix was built. Main parameters of this matrix were slope of the filter strip, soil texture and amount of sediment input. To apply the matrix to large areas we used an erosion model as surrogate for sediment input. Soil information was obtained from available digital soil maps and slopes were calculated from DEMs. Due to the very low participation levels of the subsidy program a comparison between potential and actual effectiveness turned out to be a rather useless exercise. The low participation levels stimulated the search for optimisation of the present subsidy scheme. Using VFSMOD again we explored the possibilities of reducing buffer strip length.

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