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Public demands on intensive grassland systems and agri-environmental policies of OECD members

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Introduction Public demands are expressed by several actors of the society. The role of lobbies is undoubtedly important in the media and has a direct influence on decision makers. Their common influence is the result of diverse interests that are often partly or totally contradictory like those of agro-industries, farmers, scientists, environmentalists and consumers. The resulting perception of the problems and challenges by politicians is finally reflected in public policies. With regard to agriculture and environment problems, these policies changed rapidly in many OECD countries in the last decades.
Public demand related with agriculture is associated mainly with food security, food safety, soil protection, water quality and availability, climate change, animal welfare, biodiversity conservation, landscape quality and recreation opportunities. The sensitivity of the public varies although widely in space, between continents, between countries of the same continent, between social groups within a country. It varies also with time; food safety, environmental problems and animal welfare for instance are increasingly important in the public mind and in policies of many countries. In the last decades, there has been an obvious evolution of public demands on intensive grasslands.
Intensive farming is not easy to define! It can be related to the use of land, labour or capital. It is usually presented as a type of agriculture that uses high quantity of inputs per surface unit (land), like fertilizers, feeds, seeds, pesticides, irrigation water and energy. Most of these inputs are non-renewable energy dependent. It is frequently associated with high investments (capital) in machinery and/or buildings and sometimes with high land prices. It can also be characterized by labour-intensive systems. In grassland, intensive systems are using high amounts of fertilizers, especially nitrogen, associated with high stocking rates and animal performances per ha. Although these systems are able to respond to an increasing World food market at relatively low prices and provide relatively high income to farmers, they present several environmental shortcomings that are more and more badly perceived by the public.
This paper presents and analyses case studies in OECD countries or State Federation that are all concerned by intensive farming: the European Union (EU), the United States of America (USA), Canada, New Zealand (NZ) and Australia. All parts of their territory are not concerned by intensive systems, but they have all developed public policies about grasslands as a result of public demand. More emphasis is given to the case of the EU that includes very intensive grassland systems and has developed a complex legislation about environmental problems in agriculture. For each case study, the importance and the evolution trends of grassland areas are described, the main environmental challenges in agriculture and grassland are identified and the policy responses are discussed.

Grassland functions and values Public demands on grasslands are related with their multiple functions and values. These functions and values are defined by USDA (2004) as follows.
Grazers: provision of forage for grazing and browsing animals, both domestic and wild.
Water: enhancement of recharge of groundwater areas, water quality and provision of a clean water source for communities.
Atmosphere: ability to sequester carbon and enhancement of clean air.
Soil: protection of the soil from wind and water erosion and build-up of organic matter in soils.
Biodiversity: support of the biodiversity of wildlife and provision of habitats.
Rural economies: support of rural communities, their infrastructure and tax incomes.
Quality of life: support of landscapes that are aesthetically pleasing, provision of recreational opportunities and open space, and improvement of the quality of life.

European Union Policy In 2005 (EU27), grasslands and rangelands covered 56 million ha (33% of the Agricultural Area (AA)) including about 17.5 million ha of rangelands (10% AA) in mountain areas notably (Eurostat, 2008). There are big differences between Member States. In West Europe, the proportion of grasslands in the AA is usually higher, like in UK (62%) and Ireland (73%), while in East Europe the proportion is usually lower like in Poland (21%) and Rumania (33%). That reflects the differences of ecological conditions and also of meet consumption between the richest countries of the North West and the poorest countries of the East. The situation could change and grassland area could increase with the economic development and the improvement of living standards in the East.

Between 1975 and 1990 (EU15), the grassland area was significantly reduced in favour to the production of fodder maize and cash crops. After 1989, many agricultural areas and especially grassland areas were abandoned in countries in transition. Even in the EU15 countries, marginal grasslands tended to be abandoned, especially in mountain areas.

Two major trends characterized grassland management since 1960: intensification or abandonment. In the lowlands, nitrogen fertilization in grassland became used at a large extent since the 1960s. Stocking rate, frequency of cutting for conservation, fertilizer use, drainage, irrigation, re-sowing and over-sowing, weed control with herbicides became increasingly important. The number of plant species and especially dicots fell dramatically in grassland swards while forage yields increased and feeding quality improved. Insect and bird populations followed the same trend than plants. Ground waters were polluted by increasing concentrations of nitrate, notably in arable land areas but also in grassland areas especially in intensive dairy systems and when pig and/or poultry slurry was applied on grassland. The monitoring networks implemented recently by the European Commission and the Member States indicate that over 20% of ground waters and 30-40% of lakes and rivers are showing excessive nitrate concentrations. Nitrogen from agricultural sources accounts for 50-80% of the nitrates entering Europe's water (Europa, 2007). Surface waters are polluted by the discharge of groundwater tables, by the run-off of phosphate and nitrate and by the access of cattle to rivers. At the same time, the traditional landscape was modified by the enlargement of plot size that followed the fast reduction of farm numbers and increase of farm size. In 'bocage' regions, most hedges and traditional orchards disappeared in grasslands in the last 50 years which badly affected landscape. That had a huge negative impact on wildlife too. The specialisation of productions resulted in the progressive disappearance of mixed farming. Some regions specialised in arable crops while other regions specialised in animal husbandry. The importance of temporary grasslands and especially lucerne declined. The use and the proportion of legume species in swards were also reduced by a widespread and almost general use of nitrogen fertilizers. These two last trends, specialisation of production and reduction of forage legume species, had a very negative impacts on farmland bird populations (PECBMS, 2007) that often need both grassland and crop for their feeding and nesting requirements (Robinson *et al.*, 2001; Robinson *et al.*, 2002; Benton *et al.*, 2003). These birds are finding much more food in legume-based swards than in pure grass swards or in crops. On the other hand, many marginal grasslands were abandoned, especially in mountain areas. These plots were invaded by shrubs and trees according to a natural succession process or planted by trees and this resulted in a marked reduction of patrimonial species linked with grassland and extensive animal husbandry. Additionally, in these areas, grassland management often changed: species-rich cutting meadows at high altitude, remote or located on slopes, tended to be uniquely grazed which also reduced plant diversity.

Two main policy programmes are addressing environmental problems in agriculture: the agri-environmental scheme (regulations 2078/92 and CEE 1257/99) and the Nitrate Directive (Directive 91/676/CEE). They are both dating back to the early 1990s. Some Member States tested Agri-Environment Measures (AEM) as early as in the 1980s. The idea was adopted by the EU in 1985 in Article 19 of the Agricultural Structures Regulation, but remained first optional for Member States. In 1992, it was introduced for all Member States as an 'accompanying measure' to the Common Agricultural Policy (CAP) reform. AEM are designed to encourage farmers to protect and enhance the environment on their farm. Farmers receive a payment in return for a service. Their commitment of improving the environment is only rewarded if it goes beyond the application of usual 'Good Farming Practices' (GFP). These GFP are defined in a code formalised in national legislations. At the EU level, the maintenance of the present grassland area is included in these GFP. It is a recognition of the positive impact of grasslands compared to crops for biodiversity, landscape, carbon storage in soil organic matter (SOM), soil fertility, protection of water quality and replenishment of ground water reserves. Farmers sign a contract with their local administration and are paid for the additional cost of implementing the measures and for any losses of income notably due to reduced production. Agri-environmental payments are co-financed by the EU and the Member States. The contribution from the Community budget varies from 60 to 85%. AEM are adapted to local farming systems, ecological conditions and environmental issues that vary greatly throughout the EU; they are designed at national, regional or local level. This makes agri-environment a flexible tool. AEM have two main objectives: reducing environmental risks associated with modern farming on the one hand, and preserving biodiversity and cultivated landscapes on the other hand. They are based on the following principles: they are optional for farmers; they are site-specific, they can be adapted to different agronomic and environmental circumstances; they have a minimum duration of 5 years since environmental issues require a structured and long-term approach; MAE contracts must compete with the most profitable land use, so payment levels have to be sufficiently high to attract farmers; agri-environment payments may only be made for actions above the reference level of mandatory requirements defined by codes of GFP (this is an application to agriculture of the Polluter Pays Principle); Member States have a wide degree of discretion in how to design and implement AEM. The agri-environmental policy is notified to the World Trade Organisation. Since agri-

environmental payments are 'limited to the extra costs or loss of income involved', they are classified in the 'Green Box' which implies that agri-environment payments are not considered to be trade-distorting (Anon., 2005b). AEM include the support of the conversion to Organic Farming (OF) and in some Member States to the maintenance of OF. This type of farming has developed rapidly since the implementation of the AEM, with more than 5.8 million ha, 3.4% of the AA and almost 140,000 organic farms in 2004 (EEA, 2007b). Some examples of AEM related with grasslands are given in table 1.

Table 1 AEM types and environment parameters where positive effects are expected (Anon., 2005b)

Measure types	Soil quality	Water quality	Water quantity	Agricultural biodiversity	Wild biodiversity	Landscape
Input (fertilizer, pesticide) reduction	x	x			x	
Organic farming	x	x		x	x	x
Extensification of livestock	x	x		(x)	x	x
Conversion of arable land to grassland and rotation measures	x	x	x		x	x
Actions in areas of special biodiversity interest		(x)	(x)		x	x
Genetic diversity				x		(x)
Maintenance of existing extensive systems	(x)	(x)			x	x
Farmed landscape					x	x
Water use reduction		x	x			

Legend: x=primary effect; (x)=secondary effect.

In 2002, the EU15 spent 2 billion euros for AEM implementation *i.e.* about 4.6% of the total amount of CAP funds. About 85% is still devoted to the first pillar of the CAP: the support to production through surface subsidies. In 2000-2003, 16.3 euros were spent in average per ha AA of the EU for AEM. It reached 89 euros per ha AA in Austria. An average of 89 euros were received by EU farmers per ha under AEM contract. In 2002, the share of agricultural land enrolled in AEM in the EU15 reached about 25% AA but it varies from less than 5% in the Netherlands and Greece to more than 80% in Austria, Sweden, Finland and Luxemburg (EEA, 2006).

In contrast to AEM, the Nitrate Directive is mandatory for farmers. Under this Directive, Member States must identify on their territory surface and ground waters affected or which could be affected by pollution, as well as vulnerable zones which contribute to pollution. They must define a code of GFP to be implemented by farmers. They must design and implement action programs in respect of each vulnerable zone. These action programs must include the measures prescribed in the codes of GFP. They must also include measures to limit the spreading on arable and grasslands of any fertilizer containing nitrogen and they have to set limits for the spreading of livestock effluents. These limits imply a control of stocking rate on the farm area. Farmers are also required to have the storage capacity for their manure in order to be able to spread them in optimal conditions. For slurry storage, this capacity reaches about 6 months in many regions. That represents a significant financial investment. Member States must monitor water quality, applying standardized reference methods to measure the nitrogen compound content. This Directive is at an advanced stage of implementation by Member States and it has a significant influence on farm structures and practices.

Two other directives have an impact on the agricultural area even if their application concern the whole area of the EU, including outside the AA, like woodlands, wetlands, coastal and marine areas for instance. It is the Bird (79/409/EEC) (1979) and Habitat (92/43/EEC) (1992) Directives. They are focusing on biodiversity conservation. These directives are the legal basis for the NATURA 2000 network that is now covering almost 20% of the EU land mass. Socio-economic activities are maintained in this network when applicable, farming can thus be concerned. It is estimated that approximately 16% of the habitats in NATURA 2000 areas depend on a continuation of extensive farming practices especially the continuation of an extensive grassland management (EEA, 2007a). Measures must be taken for maintaining or restoring, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest. Financing of the network management is coordinated with existing financial instruments. Farming inside NATURA 2000 sites is thus part of the CAP financial support and, structural interventions, being part of rural and regional development policies. That induces a strong relation between AEM and NATURA 2000 implementation on agricultural land. The network area is almost complete but management agreements with landowners and managers are still under intense, and sometimes difficult, discussions. The identification and conservation of High Nature Value (HNV) farmland was given high priority in the Kiev Resolution on Biodiversity (2003). It was agreed to identify all HNV areas by 2006 and that a significant proportion of these areas would be under biodiversity sensitive management by 2008. A map of HNV farmland prepared for the European

Environment Agency is currently being updated, but a limited proportion of HNV farmland is designated as protected sites. Management of these areas has still to be implemented (EEA, 2007b).
Other citizen expectations are covered by the EU product quality policy (European Commission, 2007). It is dealing with the protection and the promotion of products of local origin introduced in 1992 (PDO - Protected Designation of Origin, PGI - Protected Geographical Indication and TSG - Traditional Speciality Guaranteed) (EC No 1898/2006) and OF. Healthy food, superior taste and positive effects on the environment are the main expectations of the consumers related to these aspects. Organic farming legislation started in the EU in 1991 (regulation CEE 2092/91 completed and revised several times since then), it is supported by legislation and direct payments (EEA, 2007b).
In the 2004-2006 period, total support to producers fell to 34% Producer Support Estimate (PSE), still above the OECD average (29%) (OECD, 2007). Many efforts have been made recently to simplify the CAP and the procedures.

United States Policy Historically, grasslands and shrub lands occupied about one half of the territory of the 48 contiguous United States (US); about 50% of these lands have been converted to cropland, urban areas and other land uses. In 2002, grassland pasture and range land covered 238 million ha (25.9% of the US land area and 57% AA) (Lubowski, 2002). Their surface increased by almost 2.8 million ha (±1%) from 1997 to 2002. Total grazing land area (grassland pasture and rangeland, cropland pasture and grazed forests) accounted for 317 million ha in 2002, which is about 35% of US land area. In contrast with the surface of grassland pasture and range land only, it decreased from 1997 to 2002, continuing a decline since the 1940s. Pasture and range surface are converted to arable land when demand for crop products is high. However, grazing lands have been more often shifted to recreational, wildlife and environmental uses. Under favourable growing conditions, particularly in the East, pasture land may revert to forest. Many rangelands are subject to brush invasion if fire is excluded and some of these brush species are fire tolerant and very difficult to control. A significant and rapidly expanding land area is being converted to urban expansion and use. These forces explain the long-term net decline in pasture and range.
The main environmental problems associated with intensive grassland systems are soil erosion, air and water pollution, wetland and other wildlife habitat conservation. Soil erosion is particularly important in mountain areas and in the Prairie ecosystem where soils are particularly sensitive to all forms of erosion including that provoked by wind. The problem is however more acute in arable land than in grassland. As in the EU, major pollutants associated with animal production are nutrients (nitrogen and phosphorus), ammonia, methane, odorous gases, pathogens and dust. Animal husbandry is a significant contributor to water pollution in several regions. For instance, in the Mississippi basin, it is considered that animal manure contributes to 15% of the nitrogen load entering the Gulf of Mexico. Animal manure has been estimated to contribute to 50% of all anthropogenic ammonia emissions, 25% of nitrous oxide emissions and 18% of methane emissions (USDA, 2007a). About one half of the total manure amount is generated in pasture-based systems, the other half by confined animals. In certain conditions, livestock grazing is also considered a factor in the decline of threatened and endangered species (USDA, 2007b). The main causes of grassland and rangeland habitat degradations are overgrazing, fire suppression and invasive species.
The US policy for protecting the environment in agriculture includes education, organic and other eco-label certification, financial incentives, taxation, compliance mechanisms and regulatory requirements (USDA, 2007c and 2007d). The Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) is the basis of policies that provide monetary supports to farmers who develop environmentally beneficial activities. It authorized the implementation of the Environmental Quality Incentives Program (EQIP) (1996) that provides technical and financial assistance for managing natural resources in farms and ranches. Payments are made under 5- to 10-year contracts for eligible practices defined at farm level in an approved conservation plan. Livestock production attracts 60% of the funds. In 2004, more than $95 million was devoted to unconfined livestock but most of this amount is targeted to usual grazing operations and not to environmental problems. The 2002 Farm Bill includes several other programs. The Grassland Reserve Program (GRP) (2002) is a voluntary program offering landowners the opportunity to protect, restore, and enhance grasslands on their property (USDA, 2004). The program aims to conserving vulnerable grasslands from conversion to cropland or other uses and to conserving valuable grasslands by helping maintain viable ranching operations. The easements and rental agreements must permit common grazing practices, mowing and harvesting with restriction during the nesting season of some bird species, fire rehabilitation, construction of fire breaks and fences. The conservation practices are generally designed to provide feed and water for livestock production; enhance wildlife diversity and habitat; protect air, soil and water resources; and provide a basis for diversifying farm income. Practices involve prescribed grazing (manipulation of stocking rate, duration and distribution of grazing), prescribed burning, establishment of native or introduced forage species, planting of shrubs and trees, brush management, fencing, nutrient management for optimizing yields while minimizing the risk of water pollution, pest management, watering facility development, upland wildlife habitat management. Several enrolment

options are possible for periods from 10, 15, 30 years and even permanent easement. Between 2002 and 2007, 809,000 ha had to be restored or improved for up to $254 million. Other USDA voluntary programs for landowners and managers in grassland include the Conservation Reserve Program (CRP) (1985), the Conservation Security Program (CSP) (2002) and the Farm and Ranch Lands Protection Program (FRPP) (1996). The CRP supports the removal of environmentally sensitive lands (especially marginal croplands) and the establishment of long-term covers including native grass covers. Haying and grazing are not allowed on these areas but in time of critical need such as extreme drought. In this condition, permission to graze or hay can be requested and permitted in some restrictive conditions as part of an approved conservation plan but not during the bird nesting period (15 May to 1st August). The CSP provides technical and financial assistance to exemplary land managers. The FRPP aims at maintaining management to several types of official organisations and NGOs for conservation purposes. Two other programs can be adopted by farmers in grassland areas although not directly targeting grasslands: the Wetlands Reserve program (WRP) (1985) ($2.125 billion between 2007-2017) and the Wildlife Habitat Incentive Program (WHIP) (1998). They are offering financial incentives for enhancing wetlands on marginal agricultural land retired from production for the control of the water cycle and biodiversity conservation (WRP) and for establishing and improving wildlife habitats (WHIP). In the 2007 Farm Bill, several programs have been reorganised or merged with others for avoiding redundancy and overlapping; the GRP for instance has been reorganised with other programs into a new 'Private Lands Protection Program' but all these programs were consolidated. Five billion dollars a year will be spent for improved soil, water and wildlife resources on 2.1 million farms. More than 16.19 million ha of important habitat for prairie birds and waterfowl will be conserved (NWF, 2007).

The main regulatory requirements for grassland farmers are defined in the Clean Water Act (CWA) (1972) and the Endangered Species Act (ESA) (1973) (USDA, 2007d). The Nonpoint Source Program of the CWA requires States to develop management programs in agriculture. They are usually based on voluntary actions and funded ($200 million in 2005) for the adoption of best management practices for animal manure and land manager education programs. Confined animal feeding operations (feed lots) that are considered as point source of pollution under the CWA, must obtain permits for the production area (animal housing and manure storage) and for the land area where the manure is spread. This regulation may impose significant costs for manure management. Under the ESA, private landowners cannot develop activities in grasslands that can harm endangered species unless they obtain a permit from the US administration. ESA may also concern the irrigation of intensive grasslands because water pumping must not threaten the flow of rivers supporting endangered species like salmon.

In 2006, total support to producers fell to 11% PSE, less than the half of the OECD average (OECD, 2007), and 11% was devoted to conservation and forestry on agricultural land (USDA, 2007e). Although the GRP is a relatively new program, several other programs were initiated at the end of the eighties or in the beginning of the nineties of the 20th century. The conservation policy in agriculture as a whole clearly tackles all environmental aspects, with a relatively strong emphasis on wildlife and habitat conservation and restoration. In the last Farm Bill, there is a trend of a better horizontal integration of environmental problems in the legislation. An improvement in analytical methods for the evaluation of agri-environmental policies is desirable for a better targeting of fields and farmers to be supported in order to achieve better environmental results (OECD, 2007).

Canada Policy Agricultural land in Canada occupies 68 million ha which corresponds to only 7.3% of total country land mass. That reflects the huge importance of the taïga and the tundra in this immense country. Grazing land (30% AA and about 20 million ha) and forage crops (11% AA and about 7 million ha), including lucerne (7% AA), cover 41% of the AA. About 80% (23 million ha) of native rangeland and seeded forages are located in the Prairie Provinces. Crop land and set-aside were reduced in favour to cultivated and sown grazing land due to the decrease of agricultural income, low prices and natural disasters. For instance, the area of crop land was reduced by 1.3% between 2001 and 2006 and, more importantly, the surface of sown grazing land has increased by 18.5% between 1956 et 2006, because crop land and set-asides have been sown with forage plants for grazing in order to cover the feeding needs of cattle that were not slaughtered because of the crisis of Bovine Spongiform Encephalopathy (BSE). The surface of 'other agricultural lands' that include woodlands and wetlands (9% AA), has increased by 12.9% between 2001 and 2006 as a result of governmental policies that pay farmers for the management of the environment or by the fact that some farmers can find other incomes sources by producing wood instead of food. During the same 5-year period, low crop prices and high input prices have lead farmers in many provinces to abandon annual crops for perennial forage plants like lucerne, cropped hay and sown grazing land (Statistics Canada, 2008).

Prairie soils are sensitive to wind, water and tillage erosion. Some of them are affected by salinity (about 1.4 million ha are moderately to severely affected). They lost 14-40% of their organic matter originally present before cultivation began. Water quality can be a problem for the same reasons than in the EU. Although grasslands and rangelands offer a protection for these sensitive Prairie soils, notably against soil erosion, a survey has shown that

more than half of Prairie rangelands is in less than good condition. Their condition could be improved through the implementation of planned grazing systems combined with some range management techniques. That could increase production, reduce soil erosion, create wildlife habitats and increase SOM contents. The group of farms that is the most specialised in grassland use (more than 70% of their land used for grazing and forage) is located in the drier areas and along the geographical limits of agriculture. These farms are very important areas of biodiversity. In 1996, 71% of their farmland was in native vegetation (Smith & Hoppe, 2000). The main factor responsible of degradations of the grassland area has been an intensification of agriculture across much of the country (McRae & Smith, 2000).
Agricultural policy is defined in a Policy Framework (AFP) (AAFC, 2008). It is revised every 5 years (2003-2008) and includes an environmental pillar. This program aims to enhance soil, water, air and biodiversity. Among the goals being considered for environment are the implementation of conditions that ensure compatibility between biodiversity and agriculture as well as the reduction of (i) water contamination from nutrients, pathogens and pesticides, (ii) agricultural risks to soil health and soil erosion, (iii) particulate emissions, odours and greenhouse gases. The environmental pillar of the AFP include several programs, some of them are related directly with grasslands: Environmental Farm Planning (EFP), Greencover Canada, National Agri-Environmental Standards Initiative (NAESI), National Agri-Environmental Analysis and Reporting Program (NAHARP), National Farm Stewardship Program (NFSP), National Water Supply Expansion Program (NWSEP), Shelterbelt Enhancement Program (AAFC, 2008). It is not possible to describe them all in this paper. The Greencover Canada program ($110 million in 5 years) aims at improving grassland-management practices, protect water quality, reduce greenhouse-gas emissions, and enhance biodiversity and wildlife habitat by converting environmentally sensitive land to perennial cover, including on agricultural land near water, and by planting trees on agricultural land. The Shelterbelt Enhancement Program offers an increased access to trees, weed-controlling materials and specialized mulch application equipment for the planting of hedges.
The Community Pasture Program is managed by the Prairie Farm Rehabilitation Administration. It is not an AFP program. It is the largest and longest-running contribution to soil conservation. Created in the 1930s to reclaim badly eroded areas on the Prairies, the program has returned more than 145,000 hectares of poor-quality cultivated lands to grass cover. It currently encompasses in excess of 900,000 hectares of productive rangeland. The program uses cattle grazing as a tool for maintaining a diverse landscape, representative of the natural Prairie ecosystems. It aims at combining an environmentally responsible management of bio-diverse rangelands with the utilization of the resource to complement livestock production. The program involves each year about 3,000 producers, 220,000 head of livestock and over 3,000 bulls. The Prairie Shelterbelt Program is another non-AFP environment program: it offers the opportunity to producers in the Prairie to get tree and shrub seedlings for the cost of shipping and handling.
In particular, biodiversity conservation goals in grassland are achieved mainly through the following programs: EFP, NFSP, Prairie Shelterbelt Program and Shelterbelt Enhancement Program. Experiences of invasive species control in grassland have been conducted by agreements between the Prairie Farm Rehabilitation Administration and the Canadian Wildlife Service. Cattle are used on site at risk for the implementation of good grazing practices that increase the number of different plant species on rangeland and create patchy habitats which enhance biodiversity.
In the 2004-2006 period, total support to producers fell to 22% PSE, below the OECD average (OECD, 2007). In the past, agricultural policy has focussed mainly or exclusively on economic and production objectives. Recent policy reforms have been guided by environmental considerations, along with more traditional social and economic criteria (MacGregor & McRae, 2000). Although, agriculture has made since then considerable progress in conserving the natural resource, some soils remain at risk of severe degradation and agriculture's compatibility with natural systems is still in balance. Conversion of arable land into permanent grassland cover offers a good opportunity to mitigate greenhouse gas effects by increasing SOM contents, especially in the Prairie soils that were originally rich in carbon and that can fix a lot of this element.

New Zealand Policy About 45% of the NZ territory is used for agriculture (all types of woodland and shrubland excluded). Grasslands and other grazing areas occupy the main part of the AA (11.5 million ha). In 2002, grassland represented 68% (8.2 million ha), tussock and *Danthonia* used for grazing 27.5% (3.3 million ha), arable land including fodder crops 3.5% and horticulture 1%. Between 1994 and 2002, the importance of grazing and arable lands has decreased by 12%, while horticultural land use and wine grapes have increased. The area planted in production forest has increased by more than a quarter since 1994 as marginal farming land is converted. The intensity of grassland use has increased as sheep numbers continue to decrease and dairy cattle numbers increase (Statistics New Zealand, 2007). Deer numbers have now approached those of cattle.
NZ lost much of its original biodiversity and habitats since colonization by man: 90% of wetlands, 85% of lowland forest areas and 90% of tall tussock grasslands were destroyed, 50% of endemic bird species are extinct. Most grassland swards are dominated by exotic species, including European forage grasses and legumes. The biological

context of the country ecosystems is thus particularly artificial but agriculture kept for long a 'green and clean' image because the farming economy was dominated by extensive sheep and beef systems using low levels of inputs. Grassland production was traditionally based on grass-clover mixtures and the use of synthesis nitrogen fertilizers was much lower than in many European countries yet attained similar levels of animal production. In recent years, the fast intensification of NZ grassland systems exerted an increasing pressure on the environment and biodiversity. Intensification occurred from increasing dairy cow numbers through conversions from sheep and beef farming and intensification of dairy systems themselves (up to 3.0 - 3.5 cows/ha now). That lead to significant increases in inputs, both nitrogen and concentrated feed, and hence losses of nutrients. Surface and ground water quality is threatened by the increase in the use of synthetic fertilizers, especially nitrogen and phosphorus. A growing use of irrigation water depleted water reserves and increased nitrate leaching. Higher stocking rates induced microbial pollution in surface water. Increasing numbers of animals, especially dairy cows, lead to high emissions of methane and ammonia into the atmosphere. Intensification of grassland management is threatening local biodiversity. The quality of the environment degraded thus rapidly because of these changing farming structures and practices (PCE, 2005).

NZ is now at a turning point for improving environmental impacts of its agriculture. The Polluter Pays principle has never been applied in the past and very few specialised programs helped or constrained farmers to take actions (Salmon, 2007). Some regulations are dealing with animal welfare, use of chemical pesticides and veterinary drugs, natural resource and conservation but the most significant legislation about the impact of farming on the environment is the Resource Management Act 1991 (RMA). The objective of this Act is to promote the sustainable management of natural and physical resources including soil, water, air, biodiversity and the coastal environment. It should be implemented through national policy statements and till now only one has been released, on air quality, in 2004. Most responsibilities under the RMA are assigned to regional and district councils. Regional councils develop their own plans on air, water and soil, and provide frameworks for district plans on land use, landscape and biodiversity (PCE, 2005; Anon., 2005; OECD, 2007). The Sustainable Farming Fund (SFF) (2000) is another policy program that aims at improving the productive and environmental performances. It is based on community-driven projects. Many projects funded under SFF focus on efficient water use. In recent years, a project has been developed around Lake Taupo, which is under severe threat of eutrophication, for the control of water quality and nitrogen release by farming activities. The discussions with relevant partners are still under progress. The expectation is that nitrogen use on intensive pastures will decline and NZ will aim to return to the high quality grass, clover pastures that sustained dairy farming for much of the past century. That will though probably require a reduction in stocking rates. The Pastoral Greenhouse Gas Research Consortium (PGGRC) was established in 2002 and combines the industry and the government. It aims at discovering innovative ways to reduce CH_4 and N_2O emissions.

Two recent programs (2003) are focusing on water quality: the Sustainable Water Program of Action and the Dairying and Clean Streams Accord. The objective of the first one is maintaining water quality and ensuring water availability including for irrigation. The Program of Action, co-led by the Ministry of Agriculture and Forestry and the Ministry of Environment, aims *inter alia* at raising public awareness on water management issues and to disseminate good practices for riparian management and fertilizer and pesticide uses. The second program, grouping the dairy cooperative 'Fonterra', the ministries and regional councils, has developed targets for achieving clean water in dairying areas including stock exclusion and regulating stream crossings.

The expectation of New Zealanders for a quality environment is obvious and that is the reason why a report, 'Growing for Good', has been coordinated by the Parliamentary Commissioner for the Environment for analysing the situation and exploring tracks of solutions (PCE, 2005). The Government decision on climate change in 2007 could be a first step in a change of attitude of public authorities towards the responsibility of the farming sector for its impact on the environment. It expresses a willingness to put a price on agriculture's greenhouse gas emission. However, farmers will be exempted of payment until 2013 and will not pay the full cost of their emissions before 2025 (Anon., 2007). This legislation could lead to other regulations on the protection of water and soil resources in agriculture (Salmon, 2007). There is thus an urgent need for an organisation that could: stimulate a constructive dialogue around the farming sector, create a vision for NZ farming that should be more sustainable, facilitate research to support dialogue and promote technical solutions (PCE, 2005). At this stage, working groups, research and innovation, technology transfer including in pilot projects, communication and engagement seem to play a crucial role for moving forward. In the dairy sector, the main priorities are the control of nitrate and phosphate losses to water, of microbial contamination of surface water, of water availability and of greenhouse gas emissions (Anon., 2006).

Total support to producers was 1% PSE in 2004-2006. It is the lowest of the OECD. The 2007 OECD report concludes that 'efforts for environmentally sustainable development should continue'. The new environmental policy for agriculture in NZ could guarantee the access of farming products to overseas markets where good environmental practices could be required for the access to the market.

Australia Policy About 59 to 67% (according to the way of calculation) of Australia land's area is used for agriculture in the World's driest inhabited continent. The vast majority of this farmland (408 million ha and 90% AA) is rangeland and is used extensively with sheep and beef cattle though native kangaroos still contribute significantly to grazing pressures, particularly since more watering points were developed. A particular feature of the continent is the high rainfall variability which makes optimising pasture management, stocking rates and avoiding over-grazing very difficult. Sown pastures and grasses occupy 5% (24 million ha) and crops 5% (Australian Bureau of Statistics, 2007). Intensive pasture-based dairy production has been located along coastal fringes especially in the South-East where soils and rainfall are the more favourable and also in inland irrigation districts, particularly along the increasingly stressed Murray and other rivers. The trend has been for dairy farms to move inland, in part because of high land values on the coast, and also to be closer to where cereals are grown to reduce feed costs, to access irrigation and to access more land. On intensive farms, the typical forages vary from temperate perennial grasses and legumes, to tropical perennial grasses and to annual forage crops. No native species are used, they are more relevant in medium to low rainfall areas and for sheep and beef cattle. The availability of quality land is though a constraint, which leads to pressures to intensify production and attendant environmental issues. Land prices are though less than in New Zealand which has resulted in New Zealand farmers crossing the Tasman Sea to expand dairy farming.

In recent years, all livestock type numbers increased except sheep. Total cattle numbers are now twice that of sheep, on an animal unit basis. The number of dairy cows increased from 1.65 million in 1989/1990 to 2.37 million in 2001/2002. Intensive production systems are thus increasing in importance. In 1999-2000 for instance, the crop area increased by 2% and the area devoted to sown pastures and grasses by 6%. Irrigation is crucial; the irrigated area is only about 5% but it produces about 25% of the gross agricultural production value. Irrigation of pastures is though increasingly considered an important cause of salinisation and waste of water, though many dairy farms depend upon it. Soil degradation caused by farming activities is a major problem. It includes soil salinity in irrigated and non-irrigated lands, soil sodicity and soil acidity. Soil sodicity together with overgrazing induce soil erosion which contributes to a large sediment loading of rivers. Water quality is severely threatened by farming activities also because of increasing sodium, nutrient and pesticide concentrations in rivers. In part, this reflects the low flow rates in rivers, which increases concentrations. Soil acidity is increased through pasture improvement and nitrogen fertilisation (PCE, 2005), mainly on the less productive land; lime applications are more profitable on more profitable land.

Since 2001, the country has faced an extensive and devastating drought that has focussed the attention on water utilisation and quality. The areas irrigated declined dramatically and the cost of purchased fodder escalated.

The Natural Heritage Trust (NHT) has been created in 1997 by Environment Australia and the Ministry of Agriculture, Forestry and Fisheries for restoring and conserving the environment and natural resources. It builds on earlier programs originally developed in partnership with farmer organisations and relies heavily on community volunteers. It has three objectives: biodiversity conservation, sustainable use of natural resources, community capacity building and institutional change. The Trust provides funds for environmental activities at three levels: national investment delivered in accordance with the National Strategic Plan, regional investment delivered in conjunction with the NAP (see below) and local action delivered through the Australian Government Envirofund. The Government committed $1.975 billion for 5 years from 2008-2009 to 2012-2013. The following 10 areas of activity define the scope of the NHT:

- protecting and restoring the habitat of threatened species, threatened ecological communities and migratory birds;
- reversing the long-term decline in the extent and quality of native vegetation;
- protecting and restoring significant freshwater, marine and estuarine ecosystems;
- preventing or controlling the introduction and spread of feral animals, aquatic pests, weeds and other biological threats to biodiversity;
- establishing and effectively managing a comprehensive, adequate and representative system of protected areas;
- improving the condition of natural resources that underpin the sustainability and productivity of resource-based industries;
- securing access to natural resources for sustainable productive use;
- encouraging the development of sustainable and profitable management systems for application by land-holders and other natural resource managers and users;
- providing land-holders, community groups and other natural resource managers with the understanding and skills necessary to contribute to biodiversity conservation and sustainable natural resource management;
- establishing institutional and organisational frameworks that promote conservation and the ecologically sustainable use and management of natural resources.

While these programs are not directly aimed at agriculture, they have influenced the ways farmers manage their land.

The National Land and Water Resources Audit was organised by the NHT for assessing the status of natural resources notably on soil, water, vegetation cover and rangeland monitoring.
The Australian State and territory governments adopted the National Action Plan for Salinity and Water Quality (NAP) in 2000. In conjunction with the NHT, it forms the basis for the delivery of Australia's integrated regional natural resource management initiatives. NAP funding reaches $1.4 billion over seven years (2001-2008). The NAP is jointly delivered at a regional level with the NHT. Under this program, government, community groups, individual land managers and local businesses work together to reduce salinity problems and improve water quality at regional level. It supports practical remedies such as the protection and rehabilitation of waterways, improvements of native vegetation, engineering works, and land and water use changes (Australian Government, 2008). The National Landcare Program (NLP) funding is delivered under the Natural Resources Management Act 1992. It is a longstanding program within the Department of Agriculture, Fisheries and Forestry. It is an additional and complementary program to the NHT. It is financially supported by the Government ($151 million over 4 years from 2008-2009 to 2011-2012) and provides funding to encourage action that will result in enhanced sustainable natural resource management (land, water and biodiversity) at the farm, catchments and regional level. It stimulates landholders by supporting collective action by communities. The NLP has been highly effective in encouraging farmers to adopt sustainable management practices and improve their productivity, profitability and the condition of natural resources, both on and off farms. Around 75% of primary producers are involved in Landcare type activities or benefit from the shared knowledge gained from these activities (Landcare Australia, 2008). The main concerns have been that many activities have focused on 'hot-spots' in the landscape, limited work has been done at *e.g.* farm scale and most land managers have only adopted part of better environmental management practices on their own properties. Ways of demonstrating the production benefits from improved environmental practices are seen as a needed area of research to continue to improve on-farm practices. The Program is though judged a great success at reversing many problems and at improving land management generally.
In 2006, the National Agriculture and Climate Change Action Plan 2006-2009 was released. It identifies four key areas to manage climate change risks: adaptation of agricultural systems, mitigation to reduce emissions from agriculture, research and development investment, awareness and communication to improve the understanding of the problem by rural communities. Several audits have been carried out for agricultural sectors and regions. They have identified problem areas. That was the basis for actions implemented in collaborations between local governments, industries and other organisations. They have defined codes of good practices. The good management practice schemes are considered to be successful because they are industry led, implemented on a voluntary basis and strongly supported by external organisations. They are flexible and simple to use, they have clear and achievable objectives and focus on practical issues.
Achieving results for the environment in agriculture in Australia was delayed for long by conservative, market-oriented federal policies. Until recently in Queensland and earlier in other States, to retain their rights over leased land, farmers were required to clear the land irrespective of the merits of doing so! However, Australian citizen's attitudes are changing; farming is no more a question to conquer the land but to adapt the systems to the natural limits. Experience has been that most farmers would now retain or restore 10% or so of their farms in a natural state, but going beyond this limit requires Government support. Biodiversity conservation on farms has seen some experimental approaches. In the State of Victoria, farmers were invited to tender for the cost of restoring or maintaining special areas on their farms. This has proved popular and more cost-effective than setting payments by Government. Dairy farms are conscious of limiting any nutrient losses into waterways and more riparian zones are fenced to exclude livestock. Models to help farmers better manage nutrients are available, backed by research which showed that the economic levels of fertiliser were often significantly lower than what farmers were applying.
Recent years have highlighted the need to better manage water in the landscape. Better pasture management will result in more water being captured and used on farms. Water ways are likely to be constructed on farms as a 'chain of ponds', which improve the available water for pastures in lower parts of the landscape. The net effect could be less water in rivers and for irrigation in below average rainfall years, but limited change in above average years. How intensive livestock industries adapt to this will take time to resolve.
Total support to producers was 5% PSE in 2004-2006. It is the second lowest of the OECD after NZ. The agri-environmental policy aims have been to encourage self-regulation by industries and to find market-based solutions wherever possible to provide in-built incentives for change. The 2007 OECD report concludes that although natural resource policies have been expanded and strengthened, concerns remain for soil quality, pressure from sheep and cattle grazing on sensitive habitats, state and fragmentation of habitats in some areas. As for NZ, future exports of agricultural products should be ensured by a reinforcement of agri-environmental policies.

Discussion Intensive grassland systems have succeeded in increasing yields and quality of forages. That ensured a fast increase of the total production of milk, meat and fibres and these productions per ha. This process was accompanied by many other fundamental changes that can be called the 'silent revolution' of traditional farming systems. These changes included a huge decrease of farmer's population, an increase of farm size, a general modernisation of agriculture that used much more inputs than in the past like nitrogen and other fertilizers, soil amendments, herbicides, irrigation, concentrate feed, fodder crops including maize. Many investments were made in buildings and machinery. Specialisation in animal husbandry systems lead to important differences in grassland management. All these changes induced enormous productivity gains whose benefits were largely transferred to the rest of the society. The farming sector provided also the manpower that was necessary in other sectors of the economy. These systems provided safe food at a relatively low price and in a regular manner (food security) for the consumers. The success of intensive grassland systems in reaching its goals is thus unquestionable.

However, several unforeseen effects of these systems progressively appeared: landscape changes, biodiversity reduction, pollution, misuses of natural resources and degradation in product taste. In some areas, irrigated forage production started to compete with industry and urban areas for water use. The geographical concentration of the systems induced abandonment of marginal areas and a reduction of landscape diversity in intensive regions. Many changes had a negative impact on the attractiveness of tourist regions and on recreation possibilities in general. All these consequences of intensification changed the vision of citizens on agriculture that was no longer considered as a 'clean' activity, close to nature, but as an industry like another. Grasslands are however considered as less detrimental than crops. At the same time, grassland farming is keeping a particular responsibility in the society because it is managing important surfaces (especially in the EU, USA, Australia and NZ). In the future, although modern grassland systems must be market-oriented, they must also be environment-friendly and multifunctional for responding to all demands of the society. For instance, in some regions tourism now generates more income than livestock *e.g.* semi-arid Australia, Pantanal in Brazil, Portugal and Spain which means that farmers seek to keep their grasslands in an attractive state but that is a trend for extensive grassland systems rather than for intensive ones.

Policy responses to these problems were very diverse across the continents. All agri-environmental policies are focusing mainly on reduction of nitrate and phosphate pollutions, biodiversity conservation or restoration, landscape protection including aspects of the natural and the cultural heritages, better use of soil and water resources. More recently, policies were developed on climate change mitigation. In Europe, policies on local origin products, OF and the promotion of tasty products are particularly important. Many questions can be raised about the efficiency of these policies. Are the funds sufficient compared with the challenges and other agricultural policies? Are the programs efficient for improving the environment and restoring biodiversity? Are the methods of the programs adequate? It appears that the budget associated with environmental policies remains rather modest. Support to farmer's income should be more envisaged as a reward for their positive contribution to land and natural resource management as well as to biodiversity restoration instead as a financial help for supporting them to compete with other producers on the World market. Environmental payments need to be a separate income stream that should be divorced from any considerations of production, so that they do not distort markets for agricultural products. The transition between this new agricultural policy and the old ones based on price or production support is not yet totally achieved, especially in the EU, USA and Canada. In Australia and NZ, the situation is almost the reverse with regard to the World market, but the proportion of the budget devoted to agri-environmental policies is still too small, much smaller than in the other OECD countries. Studies on the efficiency of AEM in the EU have shown hat they were relatively unable to restore biodiversity and even to slow down its decline (Kleijn, *et al.*, 2001; Kleijn *et al.*, 2004; Feehan *et al.*, 2005; Aviron *et al.*, 2007; Wilson *et al.*, 2007). They should be better targeted, farmers should receive more advice from experts and AEM contracts should last longer for producing results. Although more expensive to control, performance-based measures are probably more effective than measures based on mean obligations. For instance, a minimum plant species density in a meadow could be a better target of an AEM compared with the date of a late cut. A revolution has still to be done in farmer's mind to transform them in biodiversity and landscape producers in addition to their role of food, fuel and fibre producers. In most cases AEM were also unable to recreate an ecological network because they are applied at a farm and not at a landscape level. Community projects should thus be encouraged like it is in Australia for instance. These projects, associating several farmers working in the same area, could take different forms that should be experimented and progressively formalised. The identification of HNV farmlands in Europe is an excellent initiative but specific funds should be associated to the implementation of managements adapted to these areas. The same is true for the management of NATURA 2000 areas. With regard to natural resources and pollution, better results are expected compared with biodiversity. Long-term programs are although also necessary.

Considerable efforts have been devoted to the development of agri-environmental indicators but data are still dramatically lacking on species-rich grasslands and on plant and insect diversity in grasslands. Almost no data are

available on soil life that is though extremely important for the ecosystem. More data are available on birds and chemical components of the grassland habitat. Environmental agencies should devote more efforts to collect data on the field and by remote sensing techniques. It is difficult to design and to evaluate policies without this crucial information. Applied research, policy evaluation and continuous adaptations of these policies are necessary to achieve tangible results in the improvement of the environment. Although socio-economic and ecological conditions are very different from one continent to another, lessons from failures and successes of agri-environmental programs should be more exchanged between OECD members.

Results achieved by agri-environmental policies are now facing a new threat, the development of agro-fuels. Agro-fuels from the first generation could induce a reduction of grassland surface and a further intensification of grasslands. That would provoke new environment degradations. Second generation agro-fuels could be an opportunity if perennial forage plants could be used for the purpose of energy production. Much attention should be paid to this new challenge of the World agriculture.

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References

AAFC (Agriculture and Agri-Food Canada), 2008. Agricultural Policy Framework. http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1173969168670&lang=e

Anon., 2005a. Strategic framework for New Zealand's future dairy farming and industry 2005-2015. New Zealand Dairy Industry: 13 pp.

Anon., 2005b. Agri-environment Measures. Overview on General Principles, Types of Measures, and Application. European Commission, Directorate General for Agriculture and Rural Development: 24 pp.

Anon., 2006. Dairying for the environment, a summary of the Sustainable Environmental Management Strategy. New Zealand Dairy Industry: 7 pp.

Anon., 2007. New Zealand's climate change solutions: Sustainable land management and climate change. Plan of action, a partnership approach. Ministry of Agriculture and Forestry: 18 pp.

Australian Bureau of Statistics, 2007. Products by topics. http://www.abs.gov.au/AUSSTATS/abs@.nsf/ProductsbyTopic/A89F51DCB5E2E31BCA2568A900139429?OpenDocument

Australian Government, 2008. National Action Plan for Salinity and Water Quality. http://www.napswq.gov.au/

Aviron, S., Jeanneret, Ph., Schüpbach, B., Herzog, F., 2007. Effects of agri-environmental measures, site and landscape conditions on butterfly diversity of Swiss grassland. Agriculture, Ecosystems & Environment 122(3): 295-304.

Benton, T.G., Vickery, J.A., Wilson, J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? Trends in Ecology & Evolution 18, 182–188.

EEA (European Environment Agency), 2006. Integration of environment into EU agriculture policy — the IRENA indicator-based assessment report. EEA Report No 2/2006: 60 pp.

EEA (European Environment Agency), 2007a. Estimating the environmentally compatible bioenergy potential from agriculture. EEA Technical report: 134 pp.

EEA (European Environment Agency), 2007b. Europe's Environment. The fourth assessment. EEA: 452 pp.

Europa, 2007. Pollution caused by nitrates from agricultural sources. http://europa.eu/scadplus/leg/en/lvb/l28013.htm

European Commission, 2007. European Policy For Quality Agricultural Products. Fact sheet. European Communities: 11 pp.

Eurostat, 2008. Agriculture and Fisheries. http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136206,0_45570464&_dad=portal&_schema=PORTAL

Feehan, J., Gillmor, D. A., Culleton, N., 2005. Effects of an agri-environment scheme on farmland biodiversity in Ireland. Agriculture, Ecosystems & Environment 107(2-3): 275-286.

Kleijn, D., Berendse, F., Smit, R., Gilissen, N., 2001. Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes. Nature 413, 723-725.

Kleijn, D., van Zuijlen, G. J. C., 2004. The conservation effects of meadow bird agreements on farmland in Zeeland, The Netherlands, in the period 1989–1995. Biological Conservation 117(4): 443-451.

Landcare Australia, 2008. http://www.landcareonline.com/

Lubowski, R. N., Vesterby, M., Bucholtz, S., Baez, A., Roberts, M. J., 2006. Major Uses of Land in the United States, 2002. Economic Information Bulletin No. (EIB-14): 54 pp.

MacGregor, R.J., McRae, T., 2000. Driving Forces Affecting the Environmental Sustainability of Agriculture, in

'Environmental sustainability of Canadian agriculture, Report of the agri-environmental indicator project', McRae, T., Smith, C.A.S., Gregorich, L.J. (editors). Research Branch, Policy Branch, Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada: 21-28.
McRae, T., Smith, C.A.S., 2000. Conclusions in 'Environmental sustainability of Canadian agriculture, Report of the agri-environmental indicator project', McRae, T., Smith, C.A.S., Gregorich, L.J. (editors). Research Branch, Policy Branch, Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada: 197-203.
NWF, National Wildlife Federation, 2007. Conservation priorities for the 2007 Farm Bill. NWF: 3 pp.
OECD, 2007. Agricultural policies in OECD countries: monitoring and evaluation 2007. OECD: 240 pp.
Parliamentary Commissioner for the Environment (PCE), 2005. Growing for Good: Intensive farming, sustainability and New Zealand's environment. Wellington, Parliamentary Commissioner for the Environment: 236 pp.
PECBMS, 2007. State of Europe's Common Birds, 2007. CSO/RSPB: 24 pp.
Robinson, R.A., Sutherland, W.J., 2002. Post-war changes in arable farming and biodiversity in Great Britain. Journal of Applied Ecology 39, 157–176.
Robinson, R.A., Wilson, J.D., Crick, H.Q.P., 2001. The importance of arable habitat for farmland birds in grassland landscapes. Journal of Applied Ecology 38, 1059–1069.
Salmon, G., 2007. Sustainability issues in New Zealand agriculture – and possibilities for collaborative resolution of them. Proceedings of the New Zealand Grassland Association 69, 11-15.
Smith D.G., Hoppe T.A. (eds), 2000. Prairie Agricultural Landscapes. A Land Resource Review. Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration: 179 pp.
Statistics Canada, 2008. Agriculture. http://cansim2.statcan.ca/cgi-win/cnsmcgi.pgm?Lang=E&SP_Action=Theme&SP_ID=920
Statistics New Zealand, 2007. Primary production. http://www.stats.govt.nz/economy/primary-production/default.htm
USDA, 2004. Grassland Reserve programme. Environmental Assessment. USDA, Natural Resources Conservation Service, Farm Service Agency: 28 pp. + 7 annexes.
USDA, Economic Research service, 2007a. Environmental Interactions with Agricultural Production: Animal Agriculture and the Environment. http://www.ers.usda.gov/Briefing/AgAndEnvironment/animalagriculture.htm
USDA, Economic Research service, 2007b. Environmental Interactions with Agricultural Production: Grazing Lands and Environmental Quality. http://www.ers.usda.gov/Briefing/AgAndEnvironment/grazinglands.htm
USDA, Economic Research service, 2007c. Environmental Interactions with Agricultural Production: Policy Instruments for Protecting Environmental Quality. http://www.ers.usda.gov/Briefing/AgAndEnvironment/policy.htm
USDA, Economic Research service, 2007d. Environmental Interactions with Agricultural Production: Federal Laws Protecting Environmental Quality. http://www.ers.usda.gov/Briefing/AgAndEnvironment/federallaws.htm
USDA, 2007e. 2007 Farm Bill. http://www.usda.gov/wps/portal/usdafarmbill?navtype=SU&navid=FARM_BILL_FORUMS
Wilson, A., Vickery J., Pendlebury, C., 2007. Agri-environment schemes as a tool for reversing declining populations of grassland waders: Mixed benefits from Environmentally Sensitive Areas in England. Biological Conservation 136(1): 128-135.