Impact of Conservation Tillage on Landscape & Ecological Services: Challenges and Opportunities

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Environment Canada's (EC) mandates to protect and strengthen Canada's environment and economy can be achieved more effectively by working cooperatively with individuals and agencies in agricultural and other sectors. To help in achieving these overarching environmental and economic goals, EC has been working with the agricultural sector, governments and landowners to help identify, evaluate and implement agricultural practices, programs and policies to maintain or enhance Canada's air, water and biological resources and Canada's economic competitiveness. These environmental and economic goals also are critical components of EC's Science Plan (2006) and its results planning structure.

In this presentation, I will review briefly the main environmental challenges and opportunities concerning the continued use and development of no-till operations. Although there is a range of conservation seeding practices, here I focus on no-till, a practice that involves a single pass of equipment over a field with direct seeding into the previous year's crop. This executive summary is organized on the basis of key EC mandates noted above, with special emphasis on natural upland and wetland habitats of the Canadian prairies.

Broad Overview

- Area of cropland in summer fallow dropped steadily from ~9 million ha in the early 1960s to ~4 million ha by 2006 (Stats Canada 2006).
- In some areas of the Prairies, notably in Saskatchewan, >55% of land is now under no-till management with direct seeding (Hoffman 2006).
- A significant direct benefit of no-till operations for producers and the environment is the substantial reduction in fuel usage, a savings estimated at ~6 liters of diesel ha^{-1} for every pass eliminated (Boame 2005).
- Greenhouse gas mitigation potential from changes in all agricultural operations are high, and an estimated mean of 0.17 t C02 eq ha^{-1} yr^{-1} could result from improved tillage and residue management (Smith et al. 2008). However, there is high variation in this estimate resulting from uncertainty about fluxes in N_2O from these systems.

Clean Air and Water

- Adoption of no-till farming has produced considerable benefits in terms of reductions in wind and water erosion over the past ~25 years. The risk of soil loss is now considered to be very low in much of the prairies and most other regions of Canada (Lefevre et al. 2005).
- Recent work by EC scientist J. Elliot and colleagues in EC and AAFC suggests that sediments in runoff waters from no-till fields may be reduced by 50-80%

when compared fields under conventional tillage. However, they also reported high mobilization potential for phosphorous (P) at the soil surface, so P losses may be more pronounced in low tillage systems.

- Unpublished survey data collected in the last 10 years indicate similar frequency of herbicide detection in conventional and zero tillage systems (J. Elliott, pers. comm.). Nonetheless, movement and fate of these and other chemicals must be understood and mitigated. Because of the increased crop residue, there could be increased use of pesticides (insecticides and herbicides) in conservation tillage versus conventional tillage (ftp://ftp-fc.sc.egov.usda.gov/WHMI/WEB/wildlife/ctlit.pdf). In general, glyposate is considered non-toxic to birds and mammals (review in Giesy et al. 2000); however, the surfactant POEA often used with glyposate has been shown to be toxic to tadpoles of some amphibians (Howe et al. 2004, Relyea 2005).
- Under some circumstances long term no-till could improve soil structure, aggregate stability and hence infiltration (e.g., Elliott and Efetha 1999 CJSS, Elliott et al. 2001) but this effect is not universal and may depend on soil type and whether the conventional tillage practice includes fall tillage among other things.

Wetlands

- Continued loss and degradation of natural wetlands remain a concern for EC.
- Retaining natural buffer areas around wetlands can reduce impacts of overland movements and drift of agrochemicals on wetlands (e.g., papers in Thomas 2005), and thus protect water sources used by producers and wildlife.
- One objective of retaining stubble on fields is to trap snow, creating a potential conflict between producers and wetlands for limited water and this issue deserves further evaluation to identify risks (i.e., loss, salinity, degradation) as well as field management opportunities.
- Recent EC-supported studies of carbon sequestration and GHG fluxes in prairie wetland systems indicate considerable potential for carbon storage (e.g., Bedard-Haughn et al. 2006, Pennock 2003).
- Scaling studies to estimate prairie-wide impacts of wetland protection and restoration have yet not been fully completed, but initial estimates of net GHG fluxes (methane, nitrous oxide and carbon dioxide) and carbon storage in restored wetlands are consistent with restored wetlands being net sinks (P. Badiou, DU Canada, pers. comm.).

Wildlife and Biodiversity Conservation

- With increased crop residue, there is usually an increase in bird species and nest densities compared to conventional tillage (waterfowl: Cowan 1982; songbirds, pintail, upland sandpiper: Lokemoen and Beiser 1997; songbirds, waterfowl: Shutler et al. 2000; songbirds: Martin and Forsyth 2003).
- There is often an increase in nest success due to lower risk of farm machinery directly destroying nests, and/or increased cover resulting in decreased predation

rates (e.g., Cowan 1982). Martin and Forsyth (2003) reported an increase in productivity of songbirds in minimum till versus conventional tillage fields.

- Nest destruction by farm machinery depends on the timing and amount of machine passes during the breeding season, so reduced tillage can be an ecological trap due to the increased cover attracting birds whose nests are then destroyed (Best 1986).
- Recent studies suggest winter wheat can be quite valuable for priority waterfowl (northern pintail) and shorebirds (long-billed curlews (listed as Special Concern) and marbled godwits) in terms of nest densities and nest success (Devries et al. 2008).
- Several studies have shown an increase in the diversity and abundance of arthropods (including beneficial insects) in conservation tillage, which provide food for wildlife (e.g., Warburton and Klimstra 1984, Thomas 2005).

Conclusions

- Adoption of no-till management has produced numerous environmental benefits. Obviously, no-till cannot begin to approximate the natural capital values of wetland and grassland systems; However, conservation tillage, especially no-till, has much potential to enhance biodiversity and sustainability of these systems where this practice is economically viable.
- Conservation tillage is only beneficial to wildlife if it replaces more intensive forms of tillage, not if it replaces native grassland, hayland, wetlands or pasture.
- More favourable conditions can be met if machine passes during the breeding season are kept to a minimum, pesticide use is not elevated, and pesticides less toxic to wildlife are used.
- Of the forms of conservation tillage, winter wheat may be the most beneficial, especially to waterfowl and some shorebirds.

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