33. Conversion of cropland to grassland

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1. Description of the practice

Grassland conversion is defined as converting land previously used for crop (arable) production to grassland cover. Converting cropland to grassland has been demonstrated to increase soil C content and net soil C storage worldwide (Jones, 2010; Khalil and Osborne, 2018). While SOC densities/stocks decrease significantly (and often rapidly) in response to the cultivation of both arable and grassland (temporary, permanent or leys), SOC accumulation is a slow and continuous process after the conversion of cropland to grassland (Popleau *et al.*, 2011). There are different supporting mechanisms to convert land from cropland to grassland, usually in response to land degradation, such as the "Grain-for-Green" program started in China in 2000 and the US Conservation Reserve Program (CRP) initiated in 1985. In Western Europe, an arable land "set-aside" supporting mechanism started in 1988 in response to overproduction of commodity crops in EU countries. After 1992 it became compulsory and arable land was taken out of production, either for one year (rotational set-aside) or for a longer period (non-rotational set-aside) as part of the EU farm subsidy programme (Gosling *et al.*, 2017).

2. Range of applicability

The practice is applicable worldwide under a wide range of pedoclimatic conditions. On average, SOC sequestration could be about 0.8 tC/ha/yr over a 50-year period (IPCC, 2000), but with a large variability mainly due to climate conditions, soil texture, crop productivity and management intensity (Vleeshouwers and Verhagen, 2002). A study for European agricultural soils (Freibauer *et al.*, 2004) reported that SOC could increase from 0.6 to 3.1 tC/ha/yr.

3. Impact on soil organic carbon stocks

Global literature reviews show that the lowest C storage ranges from 0.30 to 0.33 tC/ha/yr while the highest storage may reach 1.44 tC/ha/yr after 5 years in Europe under various climatic conditions (Table 144). The most common values are in the range of 0.62-0.75 tC/ha/yr in cool temperate, as well as humid to semiarid climates. Interestingly, C accrual after cropland conversion to grassland was measured at a rate of 0.92 tC/ha/yr the first 20 years after conversion (i.e. the period assumed for a new equilibrium to occur after conversion) but decreased to 0.59 tC/ha/yr if calculated over 100 years after conversion (Popleau *et al.*, 2011).

Table 144. Evolution of SOC stocks after conversion from cropland to grassland

Climate zone	Soil type	Baseline C stock (tC/ha)	Additional C storage (tC/ha/yr)	Duration (Year)	Depth (cm)	Methodology	Reference
Global studies							
Temperate	Various	46.2±20.7	0.92±0.10 0.59±0.14	20 100	0-23.5	CRFs	Popleau *et al.* (2011)
Various		NA	1.01	From 1 to 80	0-32.5	MA	Conant, Paustian and Elliot (2001)
Various		NA	0.33	NA	0-29.5	LR	Post and Kwon (2000)
Humid to semiarid		NA	0.75	14	0-30	MA	Kämpf *et al.* (2016)
All		21.1	0.30	20	0-20	LR	Deng *et al.* (2016)
Regional and national studies							
Warm and cool temperate moist + dry	NA	NA	1.44	5	0-30	MO	Vleeshouwers and Verhagen (2002)
Cool temperate	NA	NA	0.62	20	0-10	FE	McLauchlan, Hobbie and Post (2006)
Cool temperate moist	40% clay	NA	0.71	28	0-20	FE	Miao, Qiao and Zhang (2015)

CRFs: carbon response functions, simple statistical models describing the relative SOC stock change with time after LUC or management change, FE: field experiment, LR: literature review, MA: meta-analysis, MO: modelling.

4. Other benefits of the practice

4.1. Improvement of soil properties

Decrease in bulk density (Miao, Qiao and Zhang, 2015) result from the improved soil structure and porosity, which in turn, improves root penetration and water holding capacity in grassland compared with cropland. Increase of microbial biomass and activity (soil respiration) due to the greater root biomass and increased active C inputs (De *et al.*, 2020) also stimulate the microbial population to produce more soil enzymes (Yu *et al.*, 2017). More efficient internal N cycling due to the increased soil C levels and high C:N ratio of inputs, linking to microbial immobilization of N resulting in low N mineralization (McLauchlan *et al.*, 2006) and significant reduction in soil NO_3^-–N and less excess N on conversion from arable to set-aside due to the lack of fertilization (Gosling *et al.*, 2017) have been reported.

4.2. Minimization of threats to soil functions

Table 145. Soil threats

Soil threats	
Soil erosion	Reduced surface runoff and increased stream flow in the dry season (Qiu *et al.*, 2011). Minimize surface erosion due to lack of tillage and continuous soil cover (Lozano-García, Muñnz-Rojas and Parras-Alcantara, 2017).
Nutrient imbalance and cycles	Decreased potential for net N mineralization, i.e. N supply for plant and microbial uptake (McLauchlan *et al.*, 2006), reduction in NO_3^-–N losses (Gosling *et al.*, 2017).
Soil salinization and alkalinization	Gradual decrease of soil salinity and sodicity in semi-arid agroecosystems (Yu *et al.*, 2018).
Soil contamination/pollution	Change in inputs (e.g. sewage sludges, herbicides, pesticides, etc.) in grassland (Diaz *et al.*, 2012).
Soil acidification	May be reduced due to the absence of acidifying fertilisers application (Schroder *et al.*, 2011).
Soil biodiversity loss	Increased soil respiration (Zhang *et al.*, 2015) and enzyme activities (Yu *et al.*, 2017) foster soil fertility improvement thus increasing .autochthone plant species biodiversity, which is a strong driver of the structure and functioning of soil food webs (microorganisms, nematodes, microarthropods) in grasslands (Eisenhauer *et al.*, 2013).
Soil compaction	Decreased bulk density and thereby compaction (Miao, *Qiao and Zhang*, 2015).
Soil water management	Less water required compared to croplands (Qiu *et al.*, 2011).

4.3. Increases in production (e.g. food/fuel/feed/timber/fibre)

Conversion of cropland to grazed grassland can provide meat or milk, wool, forage for stable livestock and direct feed for grazing animals (Sanderman *et al.*, 2010).

4.4. Mitigation of and adaptation to climate change

Some CH_4 (32±6.8 g CO_2eq/m^2/yr) and N_2O (14±4.7 g CO_2eq/m^2/yr) emissions can arise during grazing (Soussana *et al.*, 2007). However, N_2O emissions are lower than those deriving from the intensive use of fertilizers in croplands (Ahlering, Fargione and Parton, 2016). The technical GHG mitigation potential of converting cropland to grassland ranges from 4.4 to 6.2 t CO_2eq/ha/yr (Freibauer *et al.*, 2004; Feliciano *et al.*, 2013). In more detail, mean estimates for the United Kingdom of Great Britain and Northern Irelandrange from 0.53 to 5.34 t CO_2eq/ha/yr for the conversion cropland to temporary (< 5 yr) and permanent (> 5 yr) grassland, respectively (Smith *et al.*, 2010).

4.5. Socio-economic benefits

Grasslands provide additional valuable ecosystem services, such as biodiversity conservation, habitat for wildlife, aesthetic value and recreational opportunities.

4.6. Other benefits of the practice

Investment security can be achieved by selecting lands with high-carbon sequestration potential over similar lands that cannot potentially sequester as much carbon. This could result in a carbon cap-and-trade system and an economic market for carbon sequestration products.

5. Potential drawbacks to the practice

5.1. Tradeoffs with other threats to soil functions

Table 146. Soil threats

Soil threats	
Soil erosion	Heavy grazing decreases plant cover leaving the soil exposed and vulnerable to erosion (Vanderburg *et al.*, 2020).
Soil compaction	Animal trampling increases bulk density, with larger effects at higher grazing densities, particularly under wet soil conditions and fine-textured soils (Hamza and Anderson, 2005). On the other hand, compaction may decrease due to less machine traffic in the field.

5.2. Increases in greenhouse gas emissions

The emission of GHGs per unit of land area, particularly N_2O, is generally higher from grassland compared to cropland. However, emissions of N_2O and CH_4 in European grasslands resulted in a 19 percent offset of the net ecosystem exchange of CO_2 sink activity in managed grasslands that included N fertilization and grazing (Soussana *et al.*, 2007) in line with values reported by Khalil and Osborne (2018).

5.3. Conflict with other practice(s)

Converting arable/cropland to grassland might result in a loss of financial income for farmers in some regions. For this reason, grasslands are frequently converted to cropland, including fruit orchards and vineyards (Francaviglia *et al.*, 2012).

5.4. Decreases in production (e.g. food/fuel/feed/timber/fibre)

Grassland production could be low in the beginning following conversion, until the full establishment of grasses.

5.5. Other conflicts

In some developing countries, more cropland could be required to sustain food production due to population growth.

6. Recommendations before implementing the practice

When turning arable lands to grasslands in the first-year, legumes should be used to improve soil N status and sustain grassland productivity; then hay-seeding is advised or sowing with a mixture of species to foster nutritional value of forages and attain a more complex grassland composition. Depending on local soil, climatic and hydrological conditions, grazing should be applied after about 10 years to allow the vegetation recovery and grassland production of biomass, and enhancing soil microbial activity, soil fertility and SOC storage, and managed to avoid over grazing.

7. Potential barriers for adoption

Table 147. Potential barriers to adoption

Barrier	YES/NO	
Biophysical	Yes	Low farm size is a constraint for conversion to grassland that requires large areas in case the final use is livestock grazing (Kuivanen *et al.*, 2016).
Cultural	Yes	Farmers are not experts in grassland management, and they are reluctant to changes in farming activities (European Commission, 2017).
Social	Yes	Age of farmers, older farmers are less prone to change land uses on their fields.
Economic	Yes	Competition with more profitable land uses is preferred for higher financial benefits (Francaviglia *et al.*, 2012). Less land for production (Freibauer *et al.*, 2004).
Institutional	Yes	Inefficient government policies to support the conversion, with limited transfer of knowledge, training, and promotion of adoption for farmers (European Commission, 2017).
Legal (Right to soil)	Yes	Farmers cultivating on rented lands are unlikely willing to adopt the practice (Carolan *et al.*, 2004).
Knowledge	Yes	Managing the grassland to increase financial incomes is a requisite to encourage farmers to convert cropland to grassland (Freibauer *et al.*, 2004).

Photos of the practice

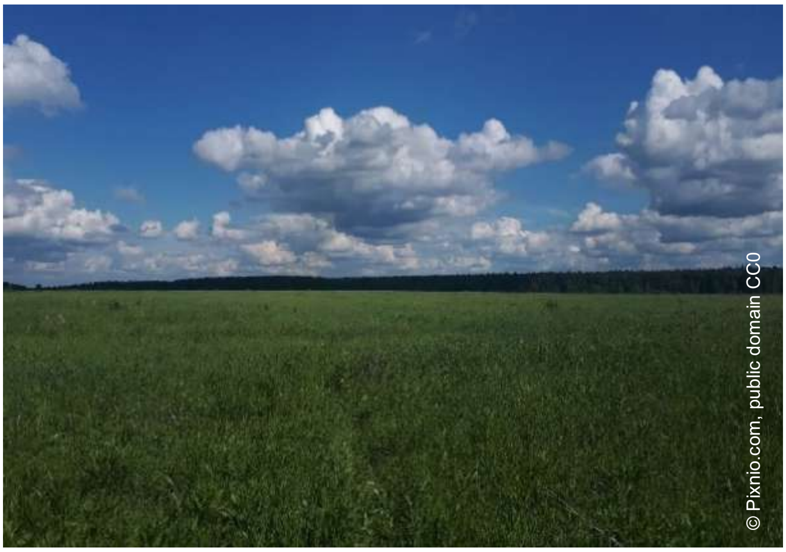

Photo 42. Conversion of cropland (top) to grassland (bottom)

Table 148. Related cases studies available in volumes 3 and 5

Title	Region	Duration of study (Years)	Volume	Case-study No.
Avoidance of land use change (LUC) from grassland to arable land, Germany	Europe	1 to 7	3	13

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