Assessing the resource protection impacts of a zero% rate of set-aside

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SUMMARY

The overall objective of this project was to quantify the impacts of setting a zero percent (%) rate of set-aside on water quality (nitrate, phosphorus and sediment).

In England in 2007, there were 369,000 hectares of compulsory set-aside land, of which approximately 172,000 ha (46%) was in uncropped non-rotational set-aside, 106,000 ha (29%) was uncropped rotational set-aside and 91,000 ha (25%) was in industrial crops.

Our assessment of the impacts of setting a zero% rate of set-aside included the testing of specific field-scale scenarios, linked to the way that the majority of rotational and non-rotational set-aside was managed. We carried out assessments at the catchment scale for 9 selected England Catchment Sensitive Farming Delivery Initiative (ECSFDI) catchments. For the catchments that had significant (> 4%) areas of set-aside, we applied export coefficients (kg N/ha) to assess the impact of zero% set-aside on nitrate leaching losses, and for phosphorus (P) and sediment losses (where the scientific evidence base required to underpin the development of export coefficients/detailed catchment modelling was less extensive) we applied a risk assessment approach. Our conclusions were:

i) Nitrate leaching

- Net nitrate leaching losses were estimated to be higher (c.15 kg N/ha) during and in the first year following the ploughing out of one-year rotational set-aside (net leaching loss – 55 kg N/ha), compared with winter cereal cropped land (typical leaching baseline loss 40 kg N/ha).
- During and in the first year following the ploughing out of non-rotational set-aside (as an average over a four year period), net nitrate leaching losses were estimated to be lower at c.20 kg N/ha, when compared with winter cereal cropped land (typical leaching baseline loss 40 kg N/ha).
- If all previously uncropped set-aside land (i.e. 46% non-rotational set-aside and 29% rotational set-aside) was returned to winter cereal cropping, we estimated that these changes would result in a 5 kg N/ha increase in nitrate leaching on the area to which the change was applied, which was largely as a result of the change from non-rotational set-aside to winter cereal cropping. Taking into account these changes at the catchment scale would result in increased leaching losses of 0.5-1.5% (upper and lower bounds -0.5 to +4.0%) over the arable land area in each ECSFDI catchment.
- Assuming that 85% of uncropped rotational and 35% of uncropped non-rotational set-aside was returned to arable production in 2007-08 (Defra, 2008), we estimated that this shift would effectively result in no net change in nitrate leaching losses on the area to which the change was applied (i.e. land previously in set-aside), or at the catchment scale. The return of set-aside land to crop production on the scale observed in 2007-08 has avoided peaks in nitrate leaching losses that would have occurred if all set-aside land had been returned to crop production in the first year. Similar conclusions would apply to the conversion of other uncropped land (e.g. GAEC12) to winter cereal cropping.
- Advice: Retaining non-rotational set-aside land for long periods (>3 years) provides significant benefits in reducing nitrate leaching losses.
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ii) Phosphorus and sediment:

- Phosphorus and sediment losses are likely to be higher following the removal of set-aside on erosion prone sandy and silty soils in sloping landscapes (>3°), particularly in the Test and Itchen, Walland Marsh, Hampshire Avon and Till/Tweed catchments (40-58% of arable land areas were assessed to be in moderate/high/very high erosion risk categories). In contrast, in the Wensum and Deben, Alde and Ore catchments, only 4-5% of arable land was assessed to be in moderate/high/very high erosion risk categories.
- Advice: Removing non-rotational set-aside, and particularly field margins and corners (which help to break up landscape connectivity) in parts of the Test and Itchen, Walland Marsh, Hampshire Avon and Till/Tweed catchments will increase the risks of particulate P and sediment losses to surface water systems.

iii) Overall:

- In catchments where there are significant areas of moderate/high/very high erosion risk land, the impact of setting a zero% rate of set-aside is probably greater for particulate P and sediment losses than nitrate losses.
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1. Introduction
In September 2007, EU agriculture ministers approved the proposal to set obligatory set-aside levels to zero%. This came about as a result of lower than expected world cereal production and increasing demand and consumption in recent years. The unusually dry April and adverse weather throughout the summer in 2007 had led to a poor harvest across Europe resulting in reduced cereal intervention stocks, compounded by a tight world supply situation and rising grain prices. By reducing the amount of set-aside it is expected that grain production across the EU can be boosted by at least 10 million tonnes per annum, releasing some of the pressure on the cereals market. It is important to note that recent increases in grain/oilseed prices have resulted in a greater amount of land in England being taken out of set-aside management than would have been the case had prices remained low.

Set-aside was originally introduced to limit the production of certain arable crops in the EU, with compulsory rates varying annually between 5% and 15%. In addition, farmers could also leave land uncropped as voluntary set-aside or bare fallow (post Single Payment Scheme in 2005; GAEC-12).

Land under set-aside is subject to certain management restrictions and crops should not be planted (unless under non-food contracts). This land (out with non-food crops) is therefore subject to lower inputs than conventionally farmed land. Set-aside has been demonstrated to provide (indirect) environmental benefits, including reductions in diffuse pollution, provision of habitat for wildlife and protection of sensitive habitats. However, the picture is not simple and it is important from an environmental viewpoint to make a broad distinction between rotational set-aside, which sits within an arable rotation and is cultivated each year, and permanent (non-rotational) set-aside, which is uncultivated for a number of years, although drawing such a clear distinction can be difficult in practice.

Natural England, the Environment Agency and environmental and conservation groups have expressed concern about the possible negative environmental consequences of a reduction in the set-aside area. If all set-aside land is/was ploughed up there may be increased risks of water contamination from nitrate, phosphorus and sediment losses, as a result of changes in the timing and extent of cultivation, a larger area of ‘bare’ soil in autumn/winter and increased nutrient applications. Defra has commissioned other work to cover potential impacts on farmland birds and rare arable plants.

Defra has a departmental objective to improve water quality, and a national obligation to ensure that the UK complies with the EU Water Framework Directive (WFD). Although set-aside was an EU scheme introduced to control production of agricultural commodities, it had a number of indirect environmental effects on water quality. With its reduction to zero%, and likely abolition of the policy itself under the CAP Health Check, Defra has to assess the likely impacts on WFD commitments and the scale of any mitigation measures that may be needed.
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2. Objectives

Overall objective:

- To quantify the impacts of setting a zero% rate of set-aside on water quality (nitrate, phosphorus and sediment).

Detailed objectives:

- To estimate the impact of reducing the area of set-aside land based on a literature review.
- To estimate the general effects of setting a zero% rate of set-aside on a small number of typical scenarios based on the available experimental evidence base.
- To investigate more detailed modelling of the impacts on nitrate, phosphorus and sediment losses in nine selected ECSFDI catchments, using the knowledge embedded in existing diffuse pollution models and evidence-based export coefficients.
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3. **Set-aside management**

The impacts of setting a zero% set-aside rate were estimated, taking into consideration:

1. The amount and management of previous set-aside land.
2. The change in area of set-aside land.

Three 'typical' management practices on set-aside land were evaluated, viz.:

1. Rotational set-aside – land that was left as set-aside for only one year before coming back into production.
3. Non-food crops grown on set-aside – this allowed farmers to grow arable crops on set-aside land under contract for non-food use.

Figures from the Defra Agricultural Change and Environment Observatory (Steve Langton, pers. comm., 2008) indicated that of the 369,000 ha of set-aside land, an estimated c.106,000 ha was managed as rotational set-aside, c.172,000 ha as non-rotational set-aside land and c.91,000 ha was industrially cropped set-aside (Table 1). Of the non-rotational set-aside, an estimated 39,000ha was thought to be in field margin and corner (blocks of less than a quarter of the field area) management.

While the total area in blocks comprising less than a quarter of the field area was small (about 10% of compulsory set-aside land), these small land units (assumed to be non-rotational) made up almost 40% of discrete set-aside land units (Defra, 2007), thereby playing an important role in creating heterogeneity in the agricultural environment by breaking up cropped areas/slopes etc..

Overall in England, 29% of compulsory set-aside land was rotational, 46% was non-rotational and 25% of set-aside was under industrial crops (Table 1).

Table 1. Estimated area and % of set-aside types in England 2007

<table>
<thead>
<tr>
<th>Set-aside type</th>
<th>Area (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotational</td>
<td>106,000</td>
<td>29%</td>
</tr>
<tr>
<td>Non-rotational (&gt;40% of a field)</td>
<td>133,000</td>
<td>36%</td>
</tr>
<tr>
<td>Non-rotational (&lt;40% of a field)</td>
<td>39,000</td>
<td>10%</td>
</tr>
<tr>
<td>Industrial crops</td>
<td>91,000</td>
<td>25%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>369,000</td>
<td></td>
</tr>
</tbody>
</table>

Source: Steve Langton (Defra Agricultural Change and Environment Observatory)
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3.1 Rotational set-aside
Rotational set-aside was used as a ‘break crop’ on many farms and was a good opportunity for controlling any difficult weed problems. Management was generally kept to the minimum required in order to comply with the rules, with predominantly natural re-generation used as a cover crop, few cultivations, no fertiliser application (other than solid manure storage and, in some circumstances, application), glyphosate applications after 15 April for weed control and cultivations from 15 July in preparation for the following crop. Typical cropping before set-aside is summarised in Table 2.

Table 2. Typical crops grown before rotational set-aside

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Cereal</th>
<th>Potatoes/Beet</th>
<th>Maize</th>
<th>Oilseeds/Protein</th>
<th>Grass</th>
<th>Other/Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal farms</td>
<td>95%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>General cropping</td>
<td>85%</td>
<td>10%</td>
<td>-</td>
<td>-</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Mixed farms</td>
<td>80%</td>
<td>15%</td>
<td>-</td>
<td>-</td>
<td></td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: Observatory report 8 (Defra, 2007) and ADAS/industry estimates.

The management of set-aside land following cereals, late harvested crops and grass is summarised in Tables 3, 4 and 5.

Table 3. Rotational set-aside management following cereals

<table>
<thead>
<tr>
<th>Crop cover and autumn cultivations</th>
<th>85% natural regeneration so no cultivations other than small area of surface cultivation to stimulate weed growth 10% sown grass cover, with cultivations in Aug/Sept to establish crop 5% others – wild bird cover, clover, mustard etc requiring cultivations in autumn</th>
<th>Observatory report 8 (Defra, 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>5% cut between 1 March and 15 July to control weeds (but not encouraged) - not usually effective for problem weeds such as resistant black-grass. More likely to spray after 15 April Little cut between 15 July and 15 August as most cultivated for following crop.</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Fertiliser and manure</td>
<td>None other than solid manure storage followed by spreading after 15 July</td>
<td>Scheme rules</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Glyphosate used for weed control after 15 April, but timing variable</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>100% cultivated from 15 July to prepare for following crop. Level of activity depended on weather, but early where oilseed rape was the following crop, some into August/September for cereals</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Following crop</td>
<td>Cereals 90%, oilseed rape 10%</td>
<td>ADAS/Industry estimate and Observatory report (Defra, 2007)</td>
</tr>
</tbody>
</table>
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Table 4. Rotational set-aside management following late harvested crops (e.g. potatoes, sugar beet, maize)

<table>
<thead>
<tr>
<th>Crop cover and autumn cultivations</th>
<th>Land left bare so no cultivations unless to rectify any harvest damage</th>
<th>ADAS/Industry estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertiliser and manure</td>
<td>None other than solid manure storage followed by spreading after 15 July</td>
<td>Scheme rules</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Glyphosate used from 15 April to control weeds</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>20% cultivated from 1st July to control weeds. Remaining 80% cultivated from 15 July to prepare for following crop. Level of activity depended on weather, but early where oilseed rape was following crop, some into August/September for cereals</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Following crop</td>
<td>95% cereal, 5% maize</td>
<td>ADAS/Industry estimate</td>
</tr>
</tbody>
</table>

Table 5. Rotational set-aside management following grass

<table>
<thead>
<tr>
<th>Autumn cultivations</th>
<th>Cover already established so no cultivations required</th>
<th>ADAS/Industry estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>10% cut between 1 March and 15 July to control weeds (but not encouraged) 100% cut between 15 July and 15 August (unless cultivated)</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>None</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Glyphosate used after 15 April to destroy cover prior to cultivations for following crop</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>Cultivations from 15 July to prepare for following crop. Level of activity depended on weather, but early where oilseed rape was following crop, some into August/September for cereals</td>
<td>ADAS/Industry estimate and Scheme rules</td>
</tr>
<tr>
<td>Following crop</td>
<td>Cereals 95% (although most will be effectively non-rotational and stay as grass)</td>
<td>ADAS/Industry estimate</td>
</tr>
</tbody>
</table>

NB: ADAS/Industry estimates are based on experience of working directly with farmers/agricultural supply trade/consultants etc...

3.2 Non-rotational set-aside

Non-rotational set-aside, as whole fields or field margins, remained in the same place for more than one year, with particular areas set-aside for a specified period.

Defra (2008) data indicate that since 2000, 70% of non-rotational set-aside was out of production for three years or more. There was some regional variation, with most non-rotational set-aside in the South-East and least in the East Midlands. Tables 6 and 7 summarise typical management practices on non-rotational set-aside land.

3.3 Non-food crops on set-aside

Growing non-food crops (e.g. oilseed rape or wheat as an industrial crop) on set-aside land allowed farmers to produce from whole fields and carry on with normal inputs (Table 8). However, some fields would still have margins or unproductive part fields that would be managed as non-rotational set-aside. It is noteworthy that this cropped area would most probably have increased even without the setting of a zero% set-aside rate in response to increased cereal/oilseed prices.
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Table 6. Non-rotational set-aside management – whole fields

<table>
<thead>
<tr>
<th>Non-rotational set-aside</th>
<th>Whole fields</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn cultivations in 1\textsuperscript{st} year</td>
<td>50% natural regeneration (so no cultivations) 50% grass (so cultivations to establish following harvest)</td>
<td>Observatory report 8 (Defra, 2007)</td>
</tr>
<tr>
<td>Cutting</td>
<td>Almost 100% cut between 15 July and 15 August – although some exemptions for habitats, perhaps 5%?</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>None</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Uncommon</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>None until final year in set-aside then cultivations from 15 July</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Following crop</td>
<td>Set-aside or cereals</td>
<td>ADAS/Industry estimate</td>
</tr>
</tbody>
</table>

Table 7. Non-rotational set-aside management – part fields and margins

<table>
<thead>
<tr>
<th>Non-rotational set-aside</th>
<th>Part fields and margins</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn cultivations in 1\textsuperscript{st} year</td>
<td>40% natural regeneration (so no cultivations) 40% grass (so cultivations to establish following harvest) 20% wild bird cover requiring cultivations to establish (usually once every 2 years)</td>
<td>Observatory report 8 (Defra, 2007)</td>
</tr>
<tr>
<td>Cutting</td>
<td>80% cut between 15 July and 15 August – although some exemptions for habitats perhaps 5%? 20% wild bird cover not cut</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>80% None 20% wild bird cover, some for establishment</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Uncommon, but some of wild bird cover</td>
<td>Scheme requirement</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>None until final year in set-aside then cultivations from 15 July</td>
<td>ADAS/Industry estimate</td>
</tr>
<tr>
<td>Following crop</td>
<td>Set-aside or cereals</td>
<td>ADAS/Industry estimate</td>
</tr>
</tbody>
</table>

NB: ADAS/Industry estimates are based on experience of working directly with farmers/agricultural supply trade/consultants etc...

Table 8. Management of non-food crops on set-aside

<table>
<thead>
<tr>
<th>Non-food crops</th>
<th>Oilseed rape, cereals, others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn cultivations</td>
<td>Following harvest of previous crop (late July for oilseed rape and barley, August for wheat)</td>
</tr>
<tr>
<td>Weed control</td>
<td>As required by crop</td>
</tr>
<tr>
<td>Pesticides</td>
<td>As required by the crop/site</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>As required by the crop</td>
</tr>
<tr>
<td>Summer cultivations</td>
<td>Following harvest (late July for oilseed rape and barley, August for wheat)</td>
</tr>
</tbody>
</table>
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4. Nutrient and sediment losses - literature review

4.1 Nitrate

In order to estimate the impact of removing set-aside, we needed to consider the typical pattern of nitrate leaching losses during and after the set-aside period, in relation to typical set-aside management practices (Section 3).

i) Land going into set-aside

Table 2 shows that 95% of set-aside land on cereal farms, 85% on general cropping and 80% on mixed farms was preceded by a cereal crop. Other preceding crops included late harvested crops such as maize, potatoes and sugar beet, and grass. Defra Observatory report 8 (Defra, 2007) indicated that less than 10% of land going into set-aside was cultivated. This can be compared with land going into cereals, which (other than a small amount of direct drilled land), would be cultivated as a matter of course. It is well established that soil disturbance stimulates soil nitrogen mineralisation (Catt et al., 1992; Jordan and Hutcheon, 1993; Goulding et al., 2002) and that overwinter nitrate leaching losses tend to be closely correlated with post harvest soil mineral N (SMN) levels and drainage volumes (Webster et al., 2003). We can therefore deduce that land going into set-aside management should result in slightly lower nitrate leaching losses than land going into cereal cropping. Cuttle et al. (2007) estimated that leaving land undisturbed over winter would 'typically' reduce leaching by about 10 kg/ha N, compared with cultivation for winter cereal cropping in the autumn.

During the set-aside period, scheme rules determine that no fertiliser can be applied to the land during the set-aside period and the soil cannot be cultivated before 1 July of the following year. Nitrate leaching losses during the set-aside period are therefore likely to be lower than losses during cereal cropping.

ii) Land coming out of rotational set-aside

Scheme rules allow set-aside land to be cultivated from 15 July (or 1 July where weeds are a problem). Defra Observatory report 8 (Defra, 2007) estimated that around 90% of set-aside (established after a cereal crop) was followed by a cereal crop and 10% was followed by oilseed rape (Table 3), and that 95% (established after a late harvested crop) was followed by a cereal crop and 5% was followed by oilseed rape (Table 4). Where oilseed rape was the following crop and on the majority of medium to heavy soils where winter cereals were the following crop, the land was generally cultivated as soon as possible after 15 July. Farm manures and biosolids (treated sewage sludge) were also applied at this time on some arable farms.

Lord et al. (2007) reported SMN and nitrate leaching loss data from 18 catchments in England between 2004 and 2006. Autumn SMN levels (before the onset of winter drainage) were on average higher after set-aside (mean 201 kg/ha N; 6 measurements) than after all the other arable crops (means ranging between 50 and 93 kg/ha N) studied (Table 9). The elevated SMN levels were most probably due to cultivation (post 15 July) and the incorporation of vegetative cover, which would have stimulated the mineralisation of soil organic matter reserves and plant residues. Froment et al. (1999) showed that, compared to cereal cropping, there was a build up in soil mineral nitrogen (SMN) during uncultivated set-aside (kept weed free), but a reduction under ryegrass. Indeed, in Defra’s Fertiliser Recommendations for Agricultural and Horticultural Crops booklet – RB209 (Anon., 2000), the Soil Nitrogen Supply (SNS) Index following set-aside is one to two Index values higher than
Assessing the resource protection impacts of a zero% rate of set-aside following winter cereal cropping (in low to moderate rainfall areas). The elevated SMN levels following set-aside were associated with increased nitrate leaching losses and concentrations (mean loss 43 kg/ha N; mean flow weighted concentrations 406 mg/l NO$_3$) compared with cereal cropping (means ranging between 16 and 38 kg/ha N; mean flow weighted concentrations between 96-154 mg/l NO$_3$).

Table 9. Autumn SMN and nitrate leaching from 18 groundwater sites (winter 2005/6).

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>Autumn SMN (kg/ha)</th>
<th>n</th>
<th>N leached (kg N/ha)</th>
<th>Drainage (mm)</th>
<th>Nitrate (mg/l)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set-aside</strong></td>
<td>201</td>
<td>6</td>
<td>43</td>
<td>66</td>
<td>406</td>
<td>3</td>
</tr>
<tr>
<td>Wheat (winter)</td>
<td>89</td>
<td>48</td>
<td>38</td>
<td>103</td>
<td>129</td>
<td>18</td>
</tr>
<tr>
<td>Barley (winter)</td>
<td>68</td>
<td>26</td>
<td>16</td>
<td>74</td>
<td>96</td>
<td>14</td>
</tr>
<tr>
<td>Spring (winter)</td>
<td>85</td>
<td>33</td>
<td>27</td>
<td>90</td>
<td>154</td>
<td>12</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>50</td>
<td>14</td>
<td>6</td>
<td>78</td>
<td>40</td>
<td>4*</td>
</tr>
<tr>
<td>Peas</td>
<td>80</td>
<td>10</td>
<td>38</td>
<td>66</td>
<td>207</td>
<td>3</td>
</tr>
<tr>
<td>Potatoes</td>
<td>93</td>
<td>5</td>
<td>31</td>
<td>118</td>
<td>147</td>
<td>3</td>
</tr>
<tr>
<td>Grass ley &gt; 3 years</td>
<td>96</td>
<td>21</td>
<td>26</td>
<td>94</td>
<td>84</td>
<td>14</td>
</tr>
<tr>
<td>Grass / clover</td>
<td>97</td>
<td>5</td>
<td>13</td>
<td>148</td>
<td>37</td>
<td>4</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>88</strong></td>
<td><strong>205</strong></td>
<td><strong>27</strong></td>
<td><strong>94</strong></td>
<td><strong>126</strong></td>
<td><strong>87</strong></td>
</tr>
</tbody>
</table>

* Standard deviation.

The data from porous cup measurements accumulated over many years of ongoing Nitrate Vulnerable Zone (NVZ) and previous Nitrate Sensitive Area (NSA) monitoring (1990-2007) are summarised in Table 10. Mean nitrate-N losses and concentrations are shown following rotational set-aside, winter wheat cropping and on NSA Premium A land (i.e. former arable land which was converted to unfertilised, ungrazed grassland). None of the set-aside or winter wheat sites received manure. The NSA Premium A land can be considered to be broadly analogous to non-rotational set-aside, as neither land use is cultivated and both have crop cover (under most circumstances).

Table 10. Nitrate leaching from NSA and NVZ sites (1990-2007).

<table>
<thead>
<tr>
<th>Land use</th>
<th>n</th>
<th>N leached (kg/ha)</th>
<th>Nitrate (mg/l)</th>
<th>Drainage (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>mean</td>
<td>mean</td>
</tr>
<tr>
<td>Rotational set-aside</td>
<td>42</td>
<td>62</td>
<td>123</td>
<td>201</td>
</tr>
<tr>
<td>Wheat (winter)</td>
<td>165</td>
<td>40</td>
<td>103</td>
<td>198</td>
</tr>
<tr>
<td>NSA Premium A</td>
<td>13</td>
<td>3</td>
<td>13</td>
<td>122</td>
</tr>
</tbody>
</table>

* Standard deviation.

The NSA/NVZ data showed mean N losses of 62 kg N/ha following rotational set-aside and corresponding nitrate concentrations of 123 mg/l. Losses from winter wheat over the same period averaged 40 kg N/ha and corresponding nitrate concentrations of 103 mg/l nitrate. However, there were a wide range of values in the dataset. Nevertheless, these data support the findings of Froment et al. (1999) who indicated that, compared with continuous cereals, there was an increased nitrate
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leaching risk in the winter following the ploughing out of (natural re-generation) rotational set-aside.

In conclusion, we would expect a higher nitrate leaching loss risk of 20-30 kg N/ha (Chalmers, 2002) over-winter following the ploughing out of rotational set-aside when compared with continuous cereal cropping.

iii) Land in non-rotational set-aside

The data in Table 10 indicate that nitrate leaching losses from land in NSA Premium A grassland (analogous to non-rotational set-aside) were lower than losses from land in cereal cropping. This is supported by work reported by Chalmers et al. (2001) where nitrate leaching risks for each year of non-rotational (3-5 year) set-aside management were lower than from continuous cereal cropping.

IGER (2005) in their modelling of the effect of permanent set-aside on nitrate leaching used unfertilised grass (similar to NSA Premium A land) as a surrogate for non-rotational set-aside. They predicted that unfertilised grass would be a very effective measure for reducing N losses in systems not applying organic manure (IEEP, 2008). For example, on dry clay soils without manure, set-aside was estimated to reduce nitrate N loss from 33 kg/ha/year to 1 kg/ha/year, a reduction of 97% during the period of non-rotational set-aside.

In conclusion, we would expect nitrate leaching losses from land in non-rotational set-aside to be around c.5kg N/ha. This is slightly higher than the data for NSA Premium A land (Table 10) would suggest, because unlike Premium A land, not all non-rotational set-aside is managed explicitly to maintain grass cover (and it’s associated long growing season).

iv) Land coming out of non-rotational set-aside

Silgram (2005) suggested that short-term nitrate-N losses following non-rotational set-aside were likely to be elevated (compared with winter cereal cropping) in the first one, and maybe up to two years, following cultivation. Similarly, Chalmers et al. (2001) reported that the ploughing out of both 3-year and 5-year covers increased soil N supply and potential over-winter nitrate leaching losses, compared with continuous arable cropping. Indeed, spring SMN measurements in the second year after the ploughing out of set-aside covers showed negligible increases in residual soil N supply after both 3-year and 5-year covers, compared to continuous arable cropping.

IGER (2005) acknowledged that the ploughing out of non-rotational set-aside could lead to an increase in nitrate leaching losses when compared with cereal cropping, and that these leaching losses could potentially be higher than expected following the ploughing out of rotational (1 year) set-aside.

In conclusion, we would expect a higher nitrate leaching loss risk of 20-30 kg N/ha (Chalmers et al., 2001) following the ploughing out of non-rotational set-aside when compared with continuous cereal cropping. However, we would not expect the increased risk to continue for more than one year. The first season increase in nitrate leaching following the ploughing out of non-rotational set-aside would not be particularly high and is likely to be similar to the increase following the ploughing out of rotational set-aside at c.65 kg N/ha, because there would have been no great N storage in the soil system while in set-aside.
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4.2 Phosphorus
Phosphorus is lost from agricultural land through three main routes:

- Incidental losses associated with fertiliser and manure spreading.
- Soluble losses as reactive P (RP) in solution.
- Particulate P (PP) losses through soil erosion (i.e. sheet wash and rills/gullies) and in drainflow.

On set-aside land, incidental losses may occur following the spreading of manure. However, these manures would still be spread as part of a ‘normal’ arable rotation when set-aside is removed, so in this project we have assumed no change in losses from spread manure sources. Fertiliser cannot be spread on (non-industrial) cropped set-aside land. So, the removal of set-aside (where it is replaced by cropped land) could result in a marginal increase in incidental P losses from fertiliser sources.

Overland flow is the main route of P loss from arable land in Britain (Catt et al., 1998; Dawson & Johnson, 2006). RP and PP are lost in association with sediment, particularly from erodible sandy and silty soils on sloping land, due to their susceptibility to surface crusting and dispersion. Chambers et al. (2000) monitored soil erosion and P losses in 385 fields in England and Wales between 1989 and 1994. Erosion was recorded in 38% of fields, with around 80% of the erosion events occurring on land cropped to cereals. Poor crop cover (<15%) was one of the main factors associated with erosion events. Evans (1990) suggested that a vegetation cover of 25 to 30% was generally enough to protect the soil from erosion. Hence, P losses from set-aside land (which generally have good crop cover and are in uncultivated stubble) are likely to be lower than from cereal cropped land, especially where winter cereals are sown after early October and crop cover is low (Chambers et al., 2000). We would therefore expect on sloping land (>3°), and particularly on erosion-prone sandy and silty soils, an increase in PP losses where set-aside land was removed and replaced by winter cereal cropping. Where set-aside land followed late-harvested crops (10% of set-aside on “General cropping” farms and 15% on “Mixed” farms – Table 2) we would expect P losses to be similar to winter cereal cropped land.

Field margins and corners made up 40% of individual set-aside land units (distinct whole fields or parts of fields) in 2007 (Defra, 2007), and can provide important barriers to flow (particularly overland flow), thereby reducing hydrological connectivity in the landscape and the proportion of PP (sediment) delivered to surface waters. These smaller blocks of set-aside land are more likely to have been retained in 2007-08, however, there is insufficient information at this stage to be certain.

It is important to bear in mind that the transport of P (both PP and RP) from agriculturally managed soils to water is extremely complex (Dawson and Johnston, 2006). Predicting P losses at the catchment scale requires knowledge of a wide range of geographical (e.g. slope), hydrological and land use factors that include information on site specific factors (Edwards and Withers, 1998; Heathwaite et al., 2000; Watson and Foy, 2001). Indeed, critical source areas (e.g. areas close to a water course that require low rainfall intensity and quantity thresholds to generate overland flow) are thought to have a disproportionate effect on overall P and sediment loads within a catchment (Haygarth et al., 2000). Also, as mentioned above, the degree of hydrological connectivity within a catchment is important in determining the amount of PP and sediment stored within fields, and the amount that actually reaches a water course. The contribution of roads, septic tanks, roofs,
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farmyards and other ‘diffuse’ rural sources adds another layer of complexity to the task of predicting the effect of small changes in land management practices on PP and RP loads and concentrations (Withers et al., 2008).

The relative importance of critical source areas is driven by both hydrological factors (that determine whether P is transported in eroded material or in solution) and soil factors (which include the amount and forms of P in soil). As far as PP is concerned, the removal of set-aside is likely to increase losses from sloping land (>3°), particularly on erosion-prone sandy and silty soils, because of the greater amount of vegetative cover on set-aside compared with winter cropped cereal land. Indeed, the “Controlling Soil Erosion Manual” (MAFF, 1999) assessed late sown winter cereals as being a highly susceptible land use for soil erosion, and spring sown cereals (which would be akin to set-aside in the autumn/winter) or early sown winter cereals/oilseed rape as moderately susceptible land uses.

Our analysis indicates that a shift away from set-aside management to winter cereal cropping on sloping land (>3°) will increase the risk of PP and sediment loss at both the field and catchment scales, particularly from erosion-prone sandy/silty soils.

4.3 Sediment
The factors controlling PP losses from agricultural land apply equally to sediment losses (see Section 4.2). We would therefore expect an increase in sediment losses from sloping land (>3°) following the removal of set-aside and its replacement by winter cereal cropping, particularly on erosion susceptible sandy/silty soils.
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5. Scenario testing

Using the NIPPER nitrate leaching model (Lord and Anthony, 1999), we assessed the impact of rotational set-aside on N losses. The modelling runs indicated that rotational set-aside management would increase nitrate leaching losses by 10-30 kg N/ha compared with continuous winter cereal baseline losses of c.40 kg/ha N (where cultivation occurs later and there are lower amounts of plant residue return to soils). These modelled losses were consistent with the NSA and NVZ loss data presented in Section 4.1.

To investigate the impact of rotational set-aside we ran rotations of:

- WW-WW-WW
- SA-WW-WW
- WW-SA-WW
- WW-WW-SA

WW = winter wheat
SA = set-side

Set-aside was ploughed out on 15 August in each year. Winter wheat was sown on 21 September each year and harvested on 1 August in the following year, and received 2 fertiliser applications of 96 kg N in mid March and mid April (BSFP, 2006). The average amount of predicted mineralisation in the autumn/winter period following the ploughing out of set-aside was approximately 30 kg/ha higher than after winter wheat cropping, which was somewhat lower than the autumn SMN levels measured following set-aside compared with winter cereal cropping (Table 9), but was close to the difference (i.e. 22 kg N/ha) in nitrate losses between set-aside (no manure) and winter wheat (no manure) presented in Table 10.

We used the NIPPER model data to underpin the nitrate leaching loss export coefficients that we have used to assess the effects of rotations with set-aside, compared with ones without, on nitrate losses. However, we were not able to apply the NEAP-N nitrate leaching model at the catchment scale, as site specific data on set-aside management was not available (i.e. proportions of land in rotational or non-rotational set-aside, types of cover, individual cropping, etc.). For similar reasons, we were not able to apply the PSYCHIC phosphorus loss model at the catchment scale to simulate the impact of setting the set-aside rate at zero% on PP and sediment losses.
6. **Catchment scale assessment**

6.1 Nine ECSFDI catchments

The project assessed the potential impacts of set-aside removal in nine ECSFDI (England Catchment Sensitive Farming Delivery Initiative) catchments selected by the EA, where potentially more detailed land use/management and water quality monitoring data were available, viz:

- River Test, South East – ECSFDI catchment number 29
- Eastern Rother & Walland Marsh - 35
- River Yealm & Erme, South-West - 38
- Hampshire Avon - 24
- River Wensum, East Anglia - 2
- Rivers Deben, Alde & Ore, East Anglia - 15
- River Tweed, North East - 25
- River Wyre, NW - 11
- River Eden, Cumbria - 32

Figure 1 shows the location and extent of the ECSFDI catchments. As a first step, we assessed the spatial distribution of land use data (agricultural census data from 2004, which we had digitally available) within each of the catchments, to determine where set-aside land was most extensive. Figures A1 to 8 (in Appendix I) show the distribution and extent of set-aside in the target ECSFDI catchments.

Our assessment of nine ECSFDI catchments indicated that six out of the nine warranted more detailed investigating. The Yealm and Erme, River Wyre and River Eden and Tributaries each had less than 1,200 ha of set-aside land (i.e. less than 4% of the agricultural land area in the catchment) and were predominantly grassland catchments where the impacts of set-aside removal were likely to be minimal. We also contacted the Catchment Sensitive Farming Officers (CSFOs) to obtain additional information on typical farming practices and water quality issues within the six main catchments of concern. The catchment profiles are summarised in Table 11 (see Appendix II for details of dataset interpretation).

The catchments could be split into 3 main types (Table 11):

1. Predominantly combinable crops, with root crops.
2. Combinable crop rotations, with some mixed farming.
3. Predominantly grassland, with some arable and forage crops.
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Figure 1. Selected ECSFDI catchments
Assessing the resource protection impacts of a zero% rate of set-aside

Table 11. ECSFDI Catchment profiles

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Grassland</th>
<th>Typical rotation</th>
<th>Set-aside</th>
<th>Profile group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deben, Alde, Ore Estuaries</td>
<td>&lt;15%</td>
<td>Predominantly arable - with potatoes and sugar beet in rotation with cereals</td>
<td>8% - likely to be higher proportion of industrial set-aside</td>
<td>1</td>
</tr>
<tr>
<td>River Wensum</td>
<td>&lt;15%</td>
<td>Predominantly arable - with sugar beet in rotation with cereals</td>
<td>8% - likely to have higher proportion of industrial set-aside</td>
<td>1</td>
</tr>
<tr>
<td>Walland Marsh</td>
<td>58%</td>
<td>Winter combinable crop rotation</td>
<td>8%</td>
<td>2</td>
</tr>
<tr>
<td>Rivers Test and Itchen</td>
<td>27%</td>
<td>Winter combinable crop rotation, often with grassland/mixed farms</td>
<td>10% - higher rate reflecting more environmental schemes?</td>
<td>2</td>
</tr>
<tr>
<td>Hampshire Avon System</td>
<td>37%</td>
<td>Winter combinable crops and maize – mixed farms</td>
<td>8%</td>
<td>2</td>
</tr>
<tr>
<td>Tweed Catchment Rivers – England data only</td>
<td>48%</td>
<td>Winter combinable crops – mixed farms</td>
<td>5%</td>
<td>2</td>
</tr>
<tr>
<td>Yealm Estuary</td>
<td>72%</td>
<td>Predominantly livestock - combinable rotation in arable areas</td>
<td>4%</td>
<td>3</td>
</tr>
<tr>
<td>River Wyre</td>
<td>82%</td>
<td>Cereals and maize – predominantly livestock with arable</td>
<td>1%</td>
<td>3</td>
</tr>
<tr>
<td>River Eden and Tributaries</td>
<td>86%</td>
<td>Cereals and maize – predominantly livestock with arable</td>
<td>1%</td>
<td>3</td>
</tr>
</tbody>
</table>

Within each of the nine selected ECSFDI catchments we considered two scenarios: a) transfer of all (100%) of set-aside into winter cereal crop production; and b) a forecast based on the results presented in Defra Observatory Report 10 (Defra, 2008):

- the area of non-rotational set-aside reduced by 35%
- the rotational area reduced by 85%

6.2 Feedback from CSFOs

We contacted the CSFOs and associates from the six arable-mixed farming catchments to source additional information about the management of set-aside land, the proportion of rotational and non-rotational set-aside in the catchment, and the amount of set-aside that had been returned to arable production. The CSFOs and their associates were not able to provide detailed (quantitative) on the ground information on the effects of setting a zero% rate of set-aside on the management of previously rotational/non-rotational set-aside land, however, there was a strong body of anecdotal evidence to indicate that a significant proportion of set-aside land had been ploughed out.

Within the Hampshire Avon catchment (number 24), nitrate losses were highlighted as a particular issue in the arable areas of the catchment on shallow soils over chalk. Also, phosphorus and sediment losses were highlighted as issues on the more steeply sloping parts of the catchment (i.e. the Sem and Nadder catchments, the Upper Avon and hydrologically connected areas over the rest of the chalk land) (Robson, 2008). However, no data on set-aside management was available.
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In the Till/Tweed catchment (number 25) information provided by the three largest land owners indicated that a large proportion of set-aside had been or would be returned to arable production. The area returning to arable crop production included many of the former set-aside field margins and corners. The picture was similar in the Deben, Alde and Ore catchment in Suffolk (number 15), where it was anticipated that all but the most marginal non-rotational set-aside land would be returned to production. Much of this non-rotational set-aside was on the steeper sloping land and on poorer (sandy) more erosion-prone soils.

Although strong anecdotal evidence was available to indicate that large areas of rotational/non-rotational set-aside had been (or would be) returned to cereal production, the level of detail was not sufficient to underpin detailed modelling at the catchment scale level, using the NEAP-N nitrate leaching model. Also, the NEAP-N model (in its present form) is not sufficiently parameterised to represent the complex changes in N losses that occur as a result of returning rotational/non-rotational set-aside to arable production. However, we were able to robustly apply evidence-based export coefficients (see Section 6.3) to estimate the effects of returning rotational/non-rotational set-aside to winter cereal crop production on nitrate leaching losses.

6.3 Nitrate-N losses

6.3.1 Nitrate loss export coefficients

The nitrate loss data from NVZ and NSA porous cup monitoring between 1990 and 2007 (summarised in Table 10) and NIPPER modelled data were used to derive the following evidence-based export coefficients for rotational/non-rotational set-aside land and winter wheat cropping:

Rotational set-aside land – 55 kg N/ha
Non-rotational set-aside land (4 year period) – 20 kg N/ha
Winter wheat cropping – 40 kg N/ha
Industrial oilseed rape cropping – 50 kg N/ha

The export coefficient for rotational set-aside takes into account the fact that during the set-aside period we would expect N losses to be lower than from winter cereal cropping, due to the lack of autumn cultivation ahead of the set-aside period. The overall export coefficient of 55 kg N/ha comprises an export co-efficient of 65 kg N/ha (following set-aside) minus 10 kg N/ha (for reduced losses during the set-aside period compared with continuous cereals – Cuttle et al., 2006).

The mean export coefficient for non-rotational set-aside (including ploughing out), as an average over a 4 year period (20 kg N/ha) takes into account the lower leaching losses in year 1 (30 kg N/ha) and years 2 to 4 (5 kg N/ha), and increased losses following ploughing out (65 kg N/ha) compared with continuous winter cereals:

Year 1: 30 kg N/ha
Years 2 to 4: 5 kg N/ha
Following year: 65 kg N/ha (analogous to ploughing out rotational set-aside)
Average: c. 20 kg N/ha

We have used the above export coefficients to estimate the impact of returning all set-aside land to continuous winter wheat production, assuming that 46% of set-aside was non-rotational and 29% rotational, and that the industrial set-aside area
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remained. The numbers set out below represent the change from a situation where set-aside land is in equilibrium to a situation where cereal and oilseed rape cropping (once set-aside has been removed) are in equilibrium. Using the above export coefficients and assumptions, these changes would result in a 5 kg N/ha increase in nitrate leaching on the former set-aside area (i.e. from 38 kg N/ha to 43 kg N/ha), which was largely as a result of returning non-rotational set-aside land to winter cereal cropping. This represents a 10-15% increase in nitrate leaching losses across the 5-10% set-aside land area in the six ECSFDI catchments.

### Land in set-aside

\[
\text{N losses} = (55 \times 0.29) + (20 \times 0.46) + (50 \times 0.25) = 38 \text{ kg N/ha}
\]

### All set-aside returned to arable crop production

\[
\text{N losses} = (40 \times 0.29) + (40 \times 0.46) + (50 \times 0.25) = 43 \text{ kg N/ha}
\]

At the catchment scale, and assuming that set-aside land occupied between 5-10% of a catchment, this would result in increased nitrate leaching losses of 0.5-1.5% in each catchment.

### 6.3.2 Sensitivity analysis

We applied upper and lower bounds to our export coefficient estimates (i.e. they were increased and decreased by 25%) to account for the fact that leaching from rotational/non-rotational set-aside may be higher or lower than our mean estimated values. Using the ranges presented below, we estimated that nitrate leaching losses could potentially change by between -5% and +40% through returning former set-aside land to winter cereal cropping. This represents a change in nitrate leaching of between -0.5% and +4% across each ECSFDI catchment.

### Ranges used for set-aside export coefficient sensitivity analysis

- Rotational set-aside: 40-70 kg N/ha
- Non-rotational set-aside: 15-25 kg N/ha

### 6.3.3 Uncropped GAEC12 land

For nitrate, the loss changes detailed above in Section 6.3.1 can not be directly interpolated to the conversion of voluntary uncropped (i.e. GAEC 12) land to winter cereal cropping, as the proportion of rotational to non-rotational land was different for GAEC12 land (Steve Langton, pers. comm.), compared with compulsory set-aside land. For GAEC 12 land, the proportion of rotational/non-rotational land was 60:40, while for compulsory uncropped set-aside land it was approximately 40:60. Using the above export coefficients, we estimate that conversion of all GAEC12 land to winter cereal cropping would effectively result in no change in nitrate leaching loss (mean export coefficient = 41 kg N/ha compared with 40 kg N/ha for winter wheat cropping) from the area of land to which the conversion was applied. However, using the above upper and lower bounds (export coefficients increased and decreased by 25%) our sensitivity analysis concluded that the change in nitrate leaching losses could potentially range from -25% to +30%.

### Land in GAEC-12

\[
\text{N losses} = (55 \times 0.6) + (20 \times 0.4) = 41 \text{ kg N/ha}
\]

### All GAEC-12 land returned to arable crop production

\[
\text{N losses} = (40 \times 0.6) + (40 \times 0.4) = 40 \text{ kg N/ha}
\]
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6.3.4 Rotational reduced by 85% and non-rotational reduced by 35%
Defra Observatory Report 10 (Defra, 2008) estimated that 85% of uncropped rotational set-aside and 35% of uncropped non-rotational set-aside was returned to arable crop production in 2007-08. Using these figures and the above evidence-based export coefficients, we estimated that these changes would effectively result in no net change in nitrate leaching losses (i.e. a 1 kg N/ha decrease from 38 kg N/ha to 37 kg N/ha). Interpreted literally, this represents a c.2% decrease in nitrate leaching losses across the 5-10% set-aside land area in the six ECSFDI catchments.

<table>
<thead>
<tr>
<th>Land in set-aside</th>
</tr>
</thead>
<tbody>
<tr>
<td>N losses = (55 x 0.29) + (20 x 0.46) + (50 x 0.25) = 38 kg N/ha</td>
</tr>
</tbody>
</table>

85% of rotational and 35% of non-rotational set-aside returned to arable production

\[
\text{N losses} = R \text{ losses} + \text{former R-WW losses} + \text{NR losses} + \text{former NR-WW losses} + \text{OSR losses} = \\
(55 \times 0.04) + (40 \times 0.25) + (20 \times 0.30) + (40 \times 0.16) + (50 \times 0.25) = 37 \text{ kg N/ha}
\]

Where:
- R = rotational set-aside
- WW = winter wheat
- NR = non-rotational set-aside
- OSR = oilseed rape

Using upper and lower bounds (Section 6.3.2) our sensitivity analysis concluded that for this scenario, the change in nitrate leaching losses could potentially range between -15% and +15%. This demonstrates that the proportion of rotational and non-rotational set-aside, and the amount of each that is returned to winter cereal cropping is important in determining the long-term direction of change in nitrate leaching, but that the overall changes in nitrate leaching are small at a catchment scale.

*Our assessment also indicates that the return of set-aside land to crop production on the scale observed in 2007-08 has avoided peaks in nitrate leaching losses that would have occurred if all set-aside land had been returned to crop production in the first year.*

6.4 Phosphorus and sediment loss assessments

We investigated use of the PSYCHIC model to estimate the impact of setting set-aside at zero% on P and sediment losses in the six selected ECSFDI catchments. However, we were not able to apply the PSYCHIC phosphorus model as site specific data on set-aside management was not available (i.e. proportions of land in rotational or non-rotational set-aside, cultivation type and timings, crop covers etc.) to underpin detailed modelling at the catchment scale.

As an alternative methodology, we used a risk-based approach, based on assessing the prevalence of erodible sandy/silty soils and the prevalence of slopes >3° within each catchment. The risk categories were based on the latest Defra guidance (Defra, 2005), and are presented in Table 12. Appendices III and IV present the spatial distribution of mean slopes and pre-dominant topsoil texture categories at the 1km² scale for each catchment.
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Table 12. Erosion risk categories (Defra, 2005).

<table>
<thead>
<tr>
<th>SOIL ERODIBILITY CATEGORY</th>
<th>STEEP SLOPES &gt;7°</th>
<th>MODERATE SLOPES 3-7°</th>
<th>GENTLE SLOPES 2-3°</th>
<th>LEVEL GROUND &lt;2°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy and light silty soils</td>
<td>Very high</td>
<td>High</td>
<td>Moderate</td>
<td>Lower</td>
</tr>
<tr>
<td>Medium and calcareous soils</td>
<td>High</td>
<td>Moderate</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>Heavy soils</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
</tr>
</tbody>
</table>

The higher risk categories in Table 12 represent the landforms and soils that will be most susceptible to P and sediment losses (soil erosion) following the removal of set-aside. The topsoil textures that correspond to the soil erosion risk soil erodibility categories are presented in Table 13.

Table 13. Soil erodibility category soil textures.

<table>
<thead>
<tr>
<th>SOIL ERODIBILITY CATEGORY</th>
<th>TOPSOIL TEXTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy and light silty soils</td>
<td>Sand, Loamy Sand, Sandy Loam, Sandy Silt Loam, Silt Loam</td>
</tr>
<tr>
<td>Medium and calcareous soils</td>
<td>Sandy Clay Loam, Clay Loam, Silty Clay Loam</td>
</tr>
<tr>
<td>Heavy soils/peaty soils</td>
<td>Sandy Clay, Clay, Silty Clay, Peat / Peaty</td>
</tr>
</tbody>
</table>

It is important to note that the risk categories given in Table 12 provide an initial assessment of susceptibility to soil erosion, based on simple categories of slope and soil erodibility. The risk assessment suggests that in very high risk areas and where the soil is not protected by crop cover, rills are likely to form in most years and gullies may develop in very wet periods. However, it is also possible that on rare occasions, gullies may also form in areas defined as moderate risk in Table 12. According to feedback from the CSFOs, this is the case for sandy soils on some gentle to moderate slopes in, for example, the Deben, Alde and Ore catchment. In practice, when soil management plans are produced in the field, ‘real-world’ soil erosion observations should override the risk assessments derived from Table 12 (Defra, 2005).

A Geographic Information System (GIS) was used to map slopes and soils at the catchment scale, using National Soil Resources Institute (NSRI) pre-dominant topsoil textures (1km²) and digital elevation data to derive mean average slopes at the 1km² scale. Then, using the risk categories in Table 12, each 1km² cell was assigned a risk category according to the pre-dominant topsoil texture and slope.

The percentage of each risk category in arable areas (i.e. >30% of land use is arable) for each catchment is summarised in Table 14, and the spatial distribution of risk categories within each of the six selected catchments is presented in Figures 2 to 6.
Assessing the resource protection impacts of a zero% rate of set-aside

Table 14. Percentage coverage of each soil erosion risk category in arable-mixed farming areas (>30% arable land) within six selected ECSFDI catchments.

<table>
<thead>
<tr>
<th>ECSFDI Catchment</th>
<th>Lower</th>
<th>Moderate</th>
<th>High &amp; Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEBEN, ALDE, ORE ESTUARIES</td>
<td>95%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>HAMPSHIRE AVON SYSTEM</td>
<td>43%</td>
<td>41%</td>
<td>16%</td>
</tr>
<tr>
<td>RIVER WENSUM</td>
<td>97%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>RIVERS TEST AND ITCHEN</td>
<td>60%</td>
<td>38%</td>
<td>2%</td>
</tr>
<tr>
<td>TWEED CATCHMENT RIVERS - ENGLAND</td>
<td>53%</td>
<td>27%</td>
<td>20%</td>
</tr>
<tr>
<td>WALLAND MARSH</td>
<td>42%</td>
<td>31%</td>
<td>27%</td>
</tr>
</tbody>
</table>

Much of the very high risk land in the Till/Tweed and Hampshire Avon catchments is in areas that are dominated by grassland (<30% arable). However, in both catchments there is still a significant area of moderate to high/very high risk land (47% and 57%, respectively) for which erosion risks will be increased as a result of a switch from set-aside to winter cereal cropping (Figures 5 and 6). There are also significant areas of moderate to high/very high soil erosion risk land in the Walland and Test and Itchen catchments (58% and 40%, respectively - see Figures 4 and 5). In moderate to very high risk areas where PP and sediment are significant water quality issues, retaining former set-aside field margins and corners as uncropped land will be of particular importance in breaking up catchment connectivity.

The above particulate P and sediment loss risk assessment can be directly interpolated to a switch from voluntary uncropped (i.e. GAEC12) land to winter cereal cropping.

The remit in this project was to assess the impact on nitrate, phosphorus and sediment losses to water of setting a zero% rate of set-aside. However, it is also likely that the policy, combined with shifts in commodity prices, will also have had an effect on the loss of pesticides to water.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure 2. Spatial distribution and extent of land at risk of soil erosion in the Deben, Alde, and Ore Estuaries catchment (Areas with >70% grassland are shown as white cells).

Final Risk Score

- > 70% Grassland
- Very High
- High
- Moderate
- Lower

![Map showing spatial distribution and extent of land at risk of soil erosion](image-url)
Assessing the resource protection impacts of a zero% rate of set-aside

Figure 3. Spatial distribution and extent of land at risk of soil erosion in the River Wensum catchment (Areas with >70% grassland are shown as white cells).
Assessing the resource protection impacts of a zero% rate of set-aside

Figure 4. Spatial distribution and extent of land at risk of soil erosion in the Walland Marsh catchment (Areas with >70% grassland are shown as white cells).
Assessing the resource protection impacts of a zero% rate of set-aside

Figure 5. Spatial distribution and extent of land at risk of soil erosion in the Rivers Test and Itchen, and Hampshire Avon catchment (Areas with >70% grassland are shown as white cells).
Assessing the resource protection impacts of a zero% rate of set-aside

Figure 6. Spatial distribution and extent of land at risk of soil erosion in the Till/Tweed catchment (Areas with >70% grassland are shown as white cells).
Assessing the resource protection impacts of a zero% rate of set-aside

7. Conclusions

- If all previously uncropped set-aside land (i.e. 46% as non-rotational set-aside and 29% as rotational set-aside) was returned to winter cereal cropping, we estimate that these changes would result in a 5 kg N/ha increase in nitrate leaching on the area to which the change was applied, which was largely a result of the change from non-rotational set-aside to winter cereal cropping. Taking into account these changes at the catchment scale would result in increased leaching losses of 0.5-1.5% (upper and lower bounds -0.5 to +4.0%) in each ECSFDI catchment. Retaining non-rotational set-aside land for long periods will provide significant benefits in reducing nitrate leaching losses.

- Assuming that 85% of uncropped rotational and 35% of uncropped non-rotational set-aside was returned to arable production in 2007-08 (Defra, 2008), we estimate that these changes would effectively result in no net change in nitrate leaching losses. The return of set-aside land to crop production on the scale observed in 2007-08 has avoided peaks in nitrate leaching losses that would have occurred if all set-aside land had been returned to crop production in the first year. Similar conclusions would apply to the conversion of other uncropped land (e.g. GAEC12) to winter cereal cropping.

- Phosphorus and sediment losses are likely to be higher following the removal of set-aside on erosion prone sandy and silty soils in sloping landscapes (>3°), particularly in the Test and Itchen, Walland Marsh, Hampshire Avon and Till/Tweed catchments (40-58% of arable land areas were assessed to be in moderate/high/very high erosion risk categories). Retaining non-rotational set-aside, and particularly field margins and corners (which help to break up landscape connectivity) in parts of these four catchments would have significant benefits in reducing particulate P and sediment losses.
Assessing the resource protection impacts of a zero% rate of set-aside

8. References


Assessing the resource protection impacts of a zero% rate of set-aside


Johnson, P.A., Shepherd, M.A., Hatley, D.J. and Smith P.N. (2002). Nitrate leaching from a shallow limestone soil growing a five course combinable crop rotation: the effects of crop husbandry and nitrogen fertiliser rate on losses from the second complete rotation. Soil Use and Management 18, 68-76.


Appendix I – Distribution and extent of set-side in the target ECSFDI catchments
Assessing the resource protection impacts of a zero% rate of set-aside

Figure A1.1. Distribution and extent of set-side in the Deben, Alde, and Ore Estuaries catchment

Figure A1.2. Distribution and extent of set-side in the River Wensum catchment
Assessing the resource protection impacts of a zero% rate of set-aside

Figure Al.3. Distribution and extent of set-side in the Walland Marsh catchment

Figure Al.4. Distribution and extent of set-side in the Yealm Estuary catchment
Assessing the resource protection impacts of a zero% rate of set-aside

Figure Al.5. Distribution and extent of set-side in the Rivers Test and Itchen, and Hampshire Avon catchments

Figure Al.6. Distribution and extent of set-side in the River Wyre catchment
Assessing the resource protection impacts of a zero% rate of set-aside

Figure A1.7. Distribution and extent of set-side in the River Eden and Tributaries catchment
Assessing the resource protection impacts of a zero% rate of set-aside

Figure A1.8. Distribution and extent of set-side in the Till/Tweed catchment
Assessing the resource protection impacts of a zero% rate of set-aside

Appendix II – Datasets used to assess 9 ECSFDI catchments

Classification of set-aside:
- The spatial dataset (2004) used to generate the catchment land uses precedes the introduction of the Single Payment Scheme (SPS) in 2005. The set-aside areas include both compulsory and voluntary set-aside.
- Following the introduction of the SPS, more livestock farms set aside land, partly due to set-aside being allowed following temporary grassland. However, the impact was not large with the only change being a reduction in fertiliser use (Defra, 2007). However, the amount of set-aside in the predominantly grassland catchments in 2004 may be an underestimate for 2007.
- The cropping information can only been used to give a guide to the characteristics of the catchment rather than absolutes.

Changes in cropping due to other factors:
- There have been changes in the relative profitability of arable and livestock farming, particularly during 2007, which may have affected cropping balances.
- Some commodity prices have more than doubled (cereals, oilseeds and protein crops), however, sugar beet prices have declined due to changes in the EU regime. Potato prices have remained similar.
- At the same time, the livestock sector has been subject to movement restrictions due to foot and mouth disease and blue tongue, which has affected export markets and depressed prices at the same time as increasing feed costs.
- These changes alone, in the absence of zero% set-aside, may have had an environmental impact, as market forces have encouraged the production of more cereals on livestock farms, non-food crops on set-aside etc. (see below).

Non-food crops on set-aside
- There are no catchment scale figures for non-food crops grown on set-aside (NFSA) land. The NFSA scheme allows the planting of crops on set-aside, if under contract for non-food uses, and has grown increasingly popular since its introduction. In 2007, there were a total of around 91,000ha of non-food crops on set-aside land, with around 17% cereals and 83% oilseeds. There were regional differences with the largest areas grown in the Eastern, East Midlands and Yorkshire and Humber regions. The regions with the highest percentage of non-food crops were Yorkshire and Humber (27%) and Eastern region (21%).
- Land that was already in NFSA crops was not considered part of the change in set-aside area.
- It is likely that due to high commodity prices there would have been a further increase in NFSA crops in the absence of the zero% set-aside rate.
Assessing the resource protection impacts of a zero% rate of set-aside

Appendix III – Spatial distribution of topsoil textures in the target ECSFDI catchments
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIII.1. Spatial distribution of topsoil textures in the Deben, Alde, and Ore Estuaries catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIII.2. Spatial distribution of topsoil textures in the River Wensum catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIII.3. Spatial distribution of topsoil textures in the Walland Marsh catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIII.4. Spatial distribution of topsoil textures in the Rivers Test and Itchen, and Hampshire Avon catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIII.5. Spatial distribution of topsoil textures in the Till/Tweed catchment.
Appendix IV – Spatial distribution of slopes (mean slope at 1km² resolution) in the target ECSFDI catchments
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIV.1. Spatial distribution of slopes (mean slope at 1km\(^2\) resolution) in the Deben, Alde, and Ore Estuaries catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIV.2. Spatial distribution of slopes (mean slope at 1km$^2$ resolution) in the River Wensum catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIV.3. Spatial distribution of slopes (mean slope at 1km² resolution) in the Walland Marsh catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIV.4. Spatial distribution of slopes (mean slope at 1km$^2$ resolution) in the Rivers Test and Itchen, and Hampshire Avon catchment.
Assessing the resource protection impacts of a zero% rate of set-aside

Figure AIV.5. Spatial distribution of slopes (mean slope at 1km² resolution) in the Till/Tweed catchment.