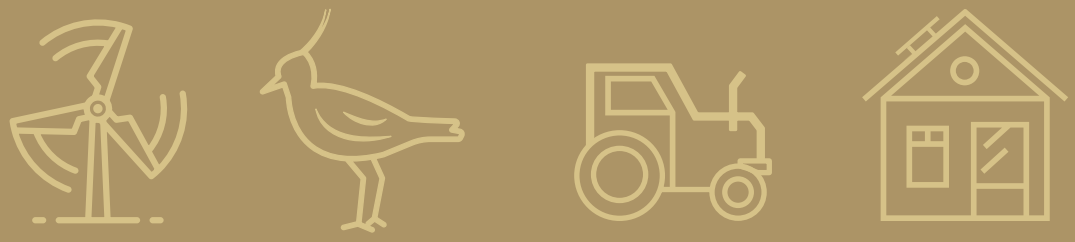
Rialtas na hÉireann
Government of Ireland

Land Use Review

Land Use Indicators



National Land Use Evidence Review Phase 1 Document 05

Report Title

Land use review phase 1: Indicator Assessment

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This is document number 05 in a series of 10 reports produced as part of the Evidence Review Phase 1.

Contents

Problem statement

An objective of Phase 1 of the Land Use Evidence Review is to determine the environmental and ecological characteristics of Ireland's land use. To determine environmental characteristics requires the use of data that indicates what the environmental status is (indicators). Environmental indicators tend to be developed to measure implementation of environmental legislation or strategies. As there is no central land directive or policy, existing indicators used for other environmental reporting requirements were examined using a land use lens.

Introduction

Environmental indicators are measures that provide evidence about the status of the environment. Environmental indicators include results of environmental monitoring (air, water, soil, ecology etc), information collected via earth observation, progress of environmental actions under different plans or strategies or data about the status of policies or plans to protect the environment.

In Phase 1 of the Land Use review indicators are used as a part of the overall evidence for the impacts and status of land use in Ireland. All indicators were considered. The purpose of assembling the indicator catalogue (Appendix A – C) was to assess the environmental impact of land use using existing available data. It was envisaged that any land use plan or policy would lead to the selection of a smaller set of land use indicators for Ireland: Phase 1 of the Land Use review didn't pre-judge what that selection might be. New indicators might also be needed, depending on the measures or actions defined for land use in Ireland: a lack of soil data or soil indicators was identified as an evidence gap, with a recommendation that more work be done to assemble data on the status and health of Ireland's soils.

All the indicators that were considered are catalogued in Appendix A. They were drawn from a variety of sources, most notably:

- European Environment Agency indicators
- UN Sustainable Development Goal indicators
- Data reported to satisfy environmental legislative requirements
- National or International reports on biodiversity, referenced by the NPWS, EEA or EPA

Categorisation of Indicators

The list includes three categories of indicator:

i. *Environmental condition*: These are indicators that indicate on the ground status or condition. They are determined from field measurement or a proxy for it (e.g. modelling). They include measurable on the ground condition of land, animal or plant species condition and human health condition (including lives lost in both cases)

ii. *Social condition*: These are indicators that relate to "human" constructs (they cannot be measured as on the ground environmental conditions). They relate to governance, democracy, economy, justice and human quality of life (e.g. including quality of employment but excluding environmental health impacts, like air quality and noise).

iii. *Progress of measure*: These are indicators that measure the progress in implementing actions, plans or strategies to improve a social or environmental condition. The measure might improve an environmental condition, but the indicators itself is only tracking the progress in implementing the measure.

Prioritisation of Indicators

Any indicator that had a land use element was included in the catalogue (Appendix A). The indicators were screened for land use relevance (high, medium and low). This screening was subjective based on a review of the data collected for each indicator: more systematic screening could be done and may yield different results.

Only indicators that were screened as "high" land use relevance were assessed for Phase 1 of the land use evidence review. It is recommended that the catalogue of indicators should be revised as Phase 2 of the land use evidence review progresses to assess what indicators are required and what new indicators need to be developed. This review should include all the indicators, not just those screened as having high land use relevance.

Indicator Assessment

Assessment Part 1: European, International, and other indicators

EEA land use indicators

The EEA track four land use indicators across the European Union, listed below, and one land use indicator related to Climate Change Mitigation:

i. Vegetation productivity
ii. Soil moisture deficit
iii. Imperviousness and imperviousness change in Europe
iv. Landscape fragmentation pressure and trends in Europe
v. Greenhouse gas emissions from land use, land use change and forestry

Soil Moisture Deficit, Vegetation Productivity and the impact of land use on vegetation productivity.

Indicator Category: Environmental Condition

Soil moisture is essential for the development of plants. It regulates soil temperature, salinity, the availability of nutrients and the presence of toxic substances, and it gives structure to soil and contributes to preventing soil erosion. Monitoring trends in soil moisture can signal pressures on crop yields and support the assessment of drought-tolerant, resilient and vulnerable ecosystems (EEA 2021a). Vegetation productivity indicates the spatial distribution and condition of the vegetation cover – a key characteristic of ecosystem condition. Ecosystem degradation can occur through intensive land use and land use change as a result of human activities (EEA 2021b).

Soil indicators are being developed under the new European Union Soil Health Law. A limitation of the Land Use Evidential Review (Phase 1) is limited assessment of soil and the impact of land use on Irish soils: anticipating the development of a set of soil indicators, this review has not pre-empted what that list might be. Soil moisture deficit and vegetation productivity are included as they are already defined as indicators by the EEA.

Driver(s)

Soil moisture is measured in standardised anomalies, i.e. in standard deviations from the long-term (1995-2019) normal conditions. Negative values indicate deficit in soil moisture content whereas positive values indicate more than average soil moisture content. Climate is one of the main determinants of ecosystem composition and functioning, providing a multitude of ecological functions and services that human well-being depends upon. Extreme climate events, such as drought, can alter ecosystem processes, such as nutrient, carbon and water cycling, in ways that are not yet well understood. Although the primary driver of drought is a shortage of precipitation, its definition may depend on, among other factors; location, time of year, soil type, land use class and the context of the impact. The climatic drivers of precipitation, frost days and temperature are shown to have a significant effect on vegetation productivity, causing trends in increase and decline across Europe. Land use and land use change however create the most notable impacts on this indicator. Across Europe, these impacts are particularly evident where changes in agricultural land management and conversion of land to agricultural uses increased vegetation productivity, with urban sprawl causing a decline.

Data Limitations

The analysis for these indicators is based on EU level data**.** National level data should be sourced and analysed for any subsequent land use policy implementations.

Trend

Overall, across Europe the long-term average soil moisture is trending to deficit, with Forest and Woodland showing dominantly. However, the long-term average and trend of soil moisture deficit for Ireland in the period 2000-2019 is positive, i.e. tending to show a slight surplus rather than deficit, with the data showing a yearly soil moisture deficit area of only ~335km^2. While Forest and woodland is strong here too, so too is grassland and inland wetlands, see Figure 1 (EEA 2020b). It's worth stressing though that this graph is showing the areas in these land cover categories affected by soil moisture deficits, rather than the percentage area of the national land cover affected.

Figure 1: Area of Soil Moisture Deficit by year, per Tier 1 Land Cover in Ireland

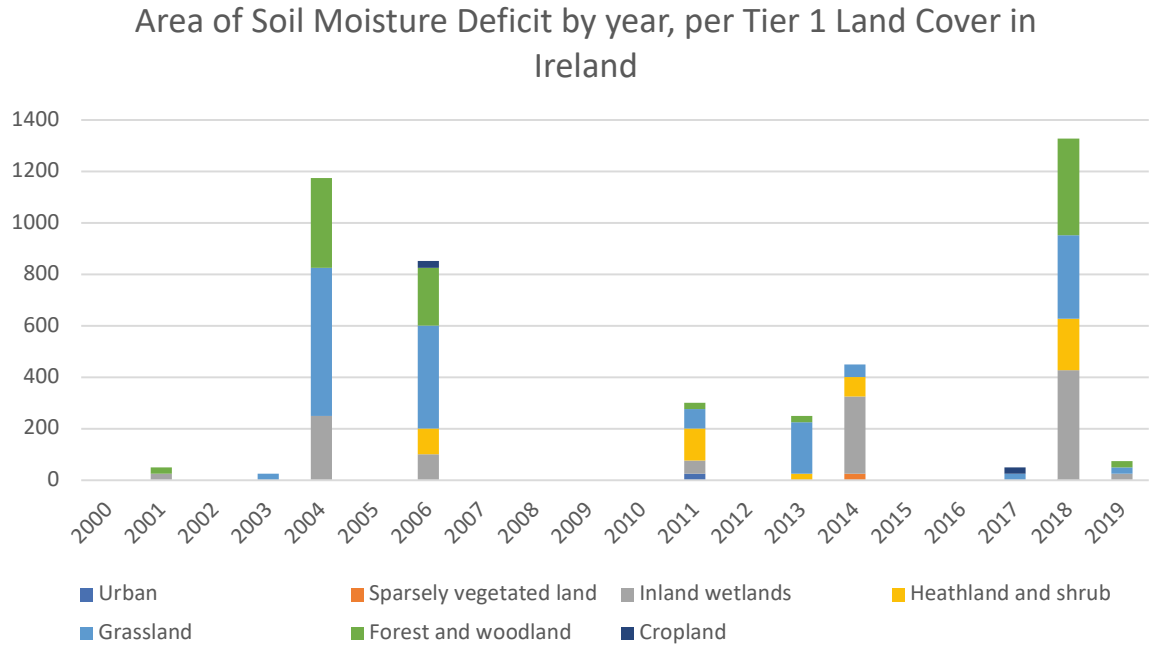


Figure 2: Long term average soil moisture (2000-2019)

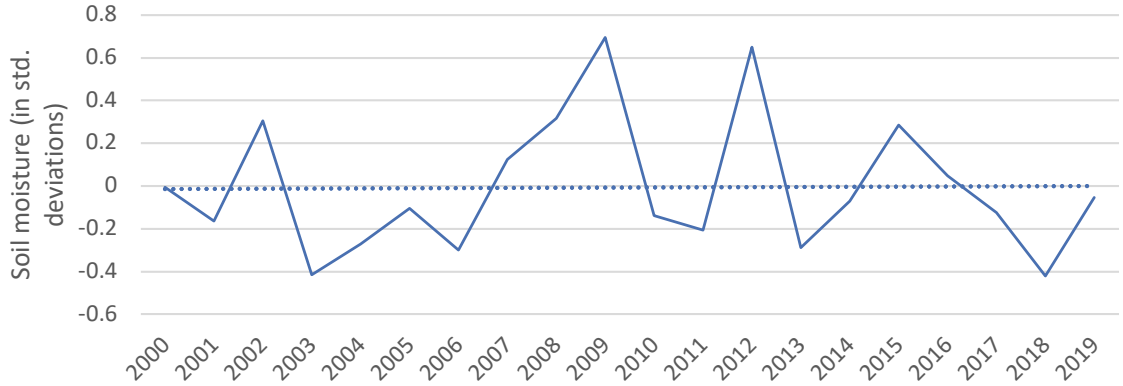
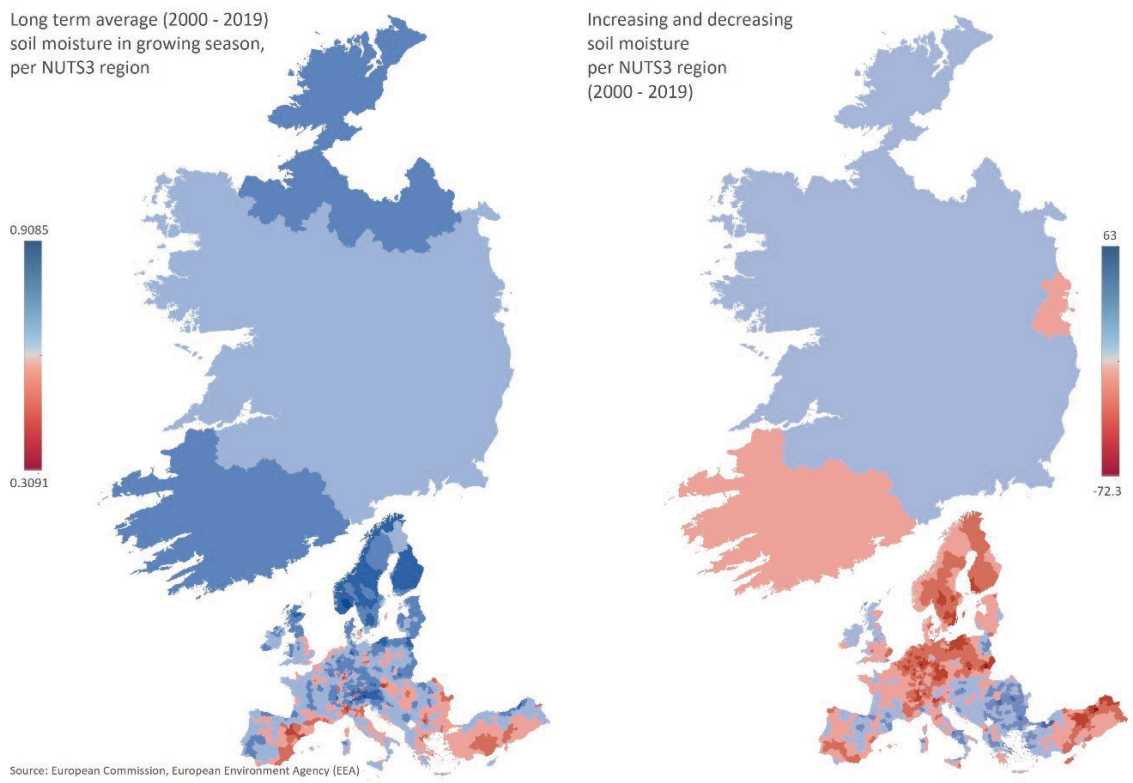


Figure 3: Long term average soil moisture (2000-2019) in growing season per NUTS region



Vegetation productivity in Europe on average has a regional pattern of increase and decline. Increase was observed most in South Eastern Europe, over croplands and wetlands in the Steppic region and grasslands and sparsely vegetated lands and in the Black Sea and Anatolian regions. Decline happened most over croplands and grasslands in the Atlantic region as well as over wetlands in the Alpine region. Figure 4 shows the four land use transition types impacting areas greater than 500km^2 that resulted in a reduction in vegetation productivity in Ireland in the period 2000-2016. Although in some instances the reduction in vegetation productivity is significant, the impacted area is relatively low (EEA 2021). Figure 5 maps the spatial distribution of vegetation productivity change during the same period (EEA 2021c).

Figure 4: Effect of land use change on vegetation productivity

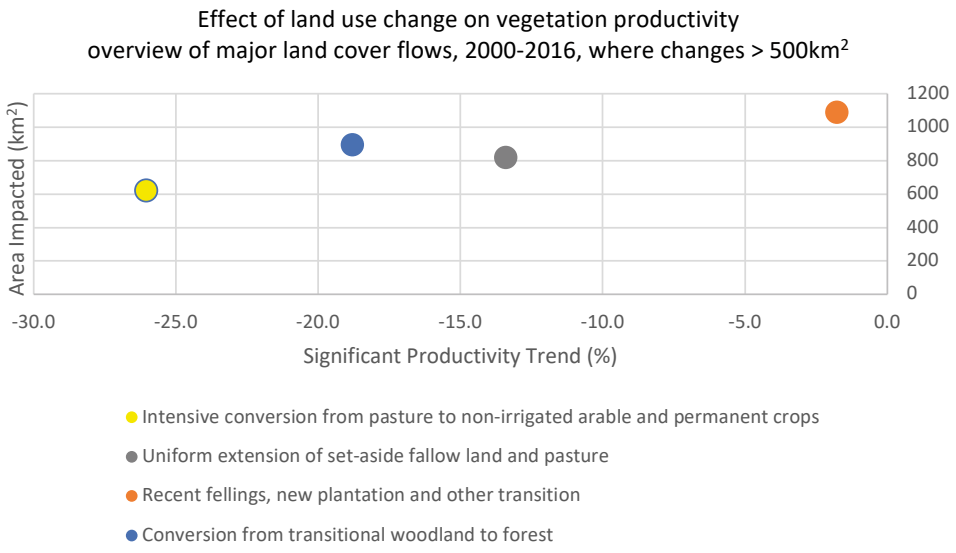
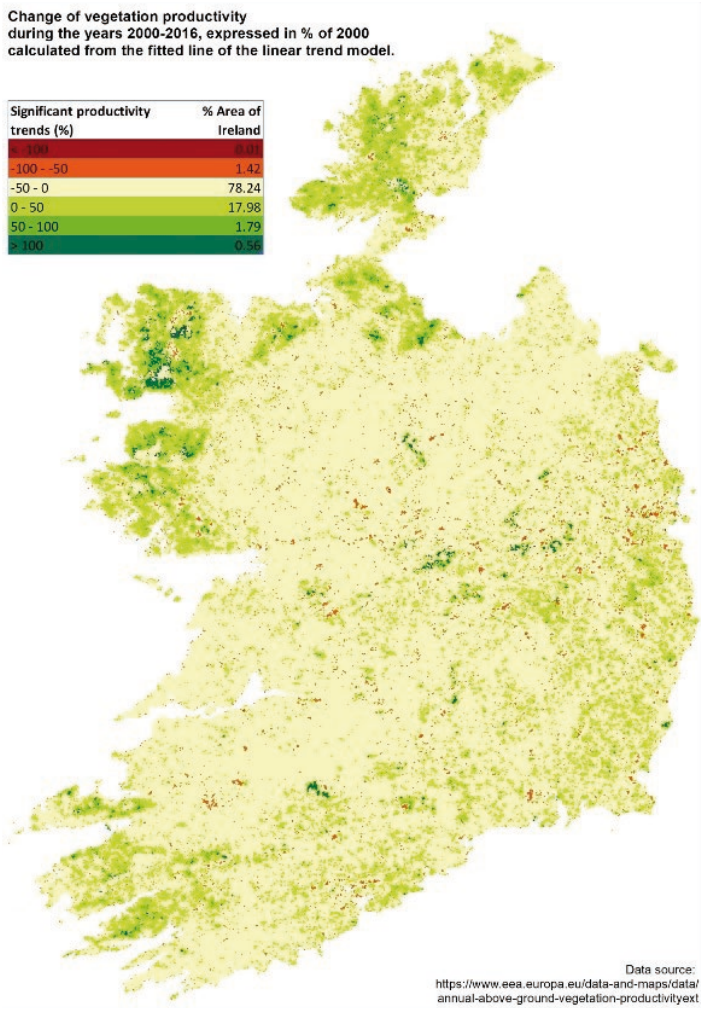


Figure 5: Change in vegetation productivity (2000-2016)



Land use Implications from these indicators

As soil moisture content is an important indicator of soil condition and the overall state of the land system, it determines land use suitability.

A decrease in vegetation productivity can lead to ecosystem degradation which in turn threatens ecosystem services, biodiversity and resilience to climate change, and tackling it is a major goal of EU environmental policy.

Understanding and monitoring the pressures of drought on terrestrial ecosystems allow a better understanding of potential changes to ecosystem services that are linked to human well-being and, as a result, of how to address disparate problems in land systems such as poverty and biodiversity conservation.

Imperviousness and imperviousness change

Indicator Category: Environmental Condition

Imperviousness means the covering of soil with an impermeable surface, such as concrete (a process called soil sealing). Sealed soil cannot sequester carbon or absorb water as easily. Impervious surfaces cannot support healthy ecosystems. Corine Land Cover data shows that 2.41% of Ireland's land was classified as "artificial surfaces" in 2018 but that the rate of soil sealing had almost doubled since 1990. In 2018, sealing affected 97,744 km^2 (2.23%) of EU plus United Kingdom territories (EEA, 2022a).

Drivers

Ireland is unusual in Europe: most of the landcover sealed in Ireland was grassland. In other EU Member States, the sealing was at the expense of cropland. Soil sealing is driven by the concretisation of land for housing, industrial use and for infrastructure.

Data Limitations

This indicator is based directly on the mapping of soil sealing/imperviousness using Earth observation data at about 10-m spatial resolution: this means that very small sealed surfaces (such as one-off housing) may not be detected, so the overall level of sealing might be underestimated.

Land use Implications from these indicators

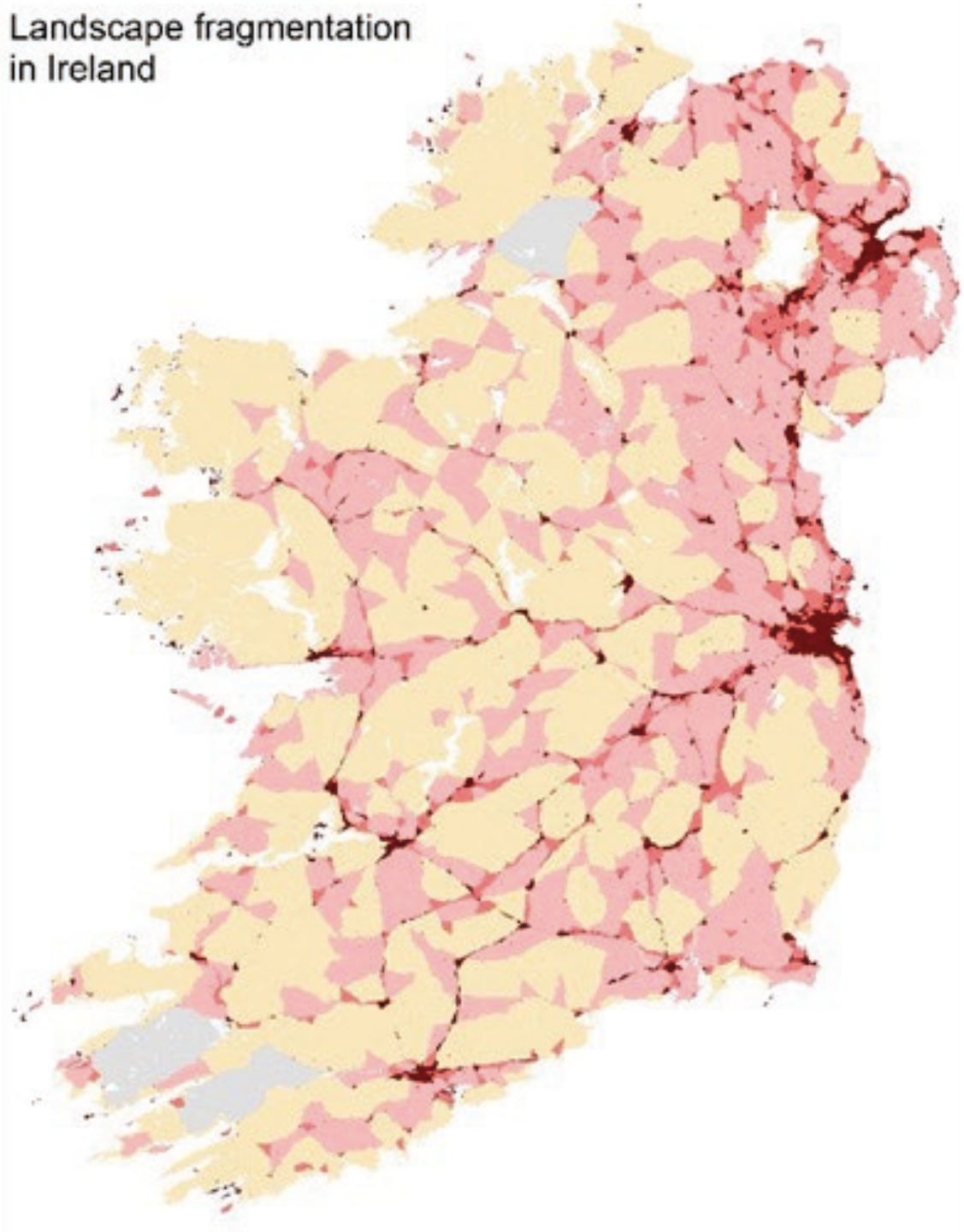
Once soil is sealed, it narrows the land use options for that location: impervious soil is not able to support ecosystem uses or agricultural or forestry land uses.

Landscape fragmentation

Indicator Category: Environmental Condition

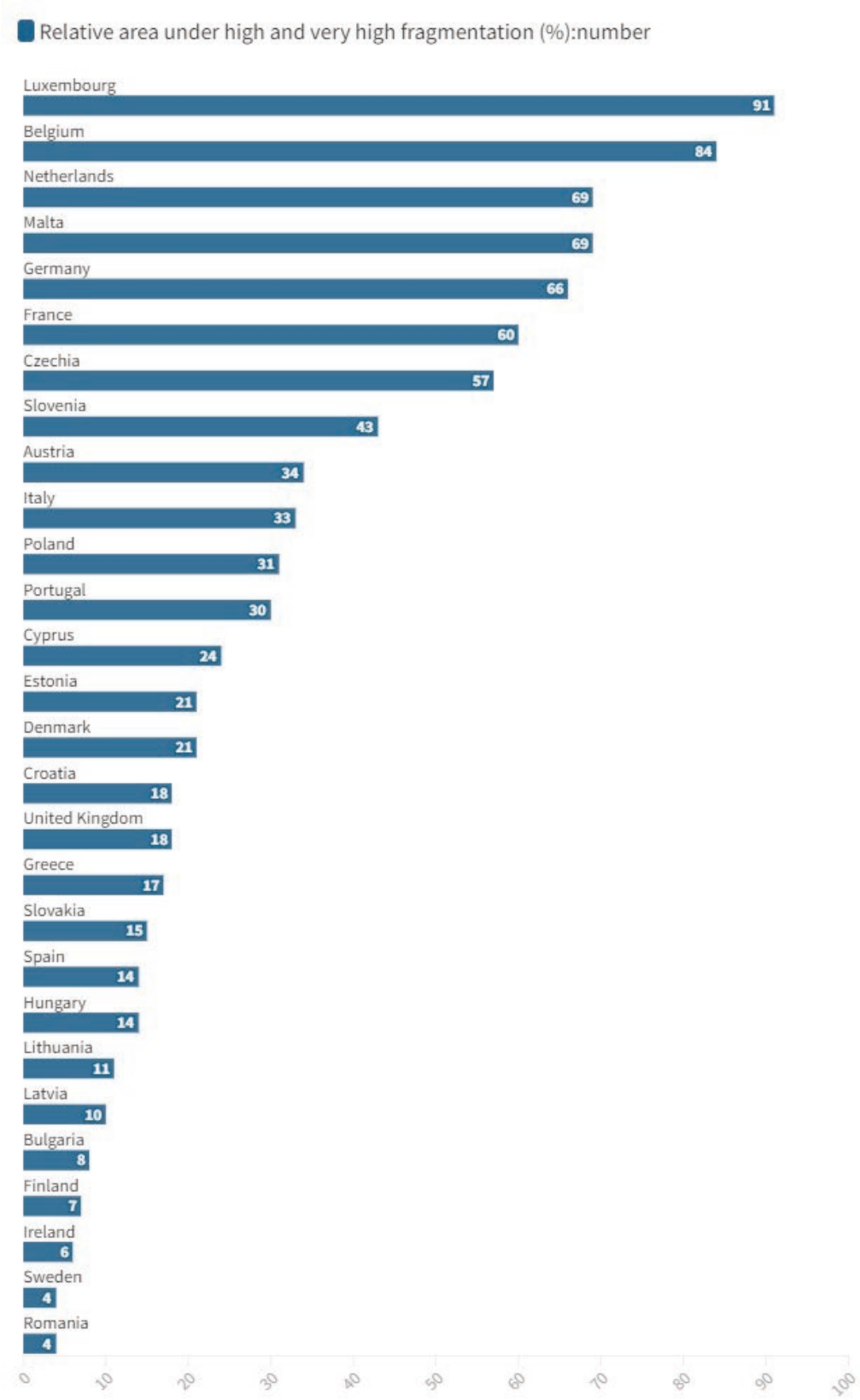
Fragmentation refers to the "break up" of continuous landscape, most often by land use (built areas, road networks, changing of one vegetation or habitat type to another (e.g. clearing of vegetation). This is a pressure on habitats and species because it can limit the area available to forage for food and it breaks the populations down into smaller (and then possibly less genetically diverse) communities. Fragmentation indirectly influences human communities, agriculture, recreation and landscape quality. The National Biodiversity Indicators C.1.i rates fragmentation as "Amber" on a Red-Amber-Green scale (NBDC, 2021).

Figure 6: Landscape Fragmentation in Ireland



The EEA measure fragmentation by assessing the relative area of a Member State that is under high and very high fragmentation (based on 2018 data). Ireland's high fragmentation area is 6%. The highest rate is Luxembourg at 91%, and the lowest is Sweden and Romania, both at 4% (see Figure 7).

Figure 7: Landscape fragmentation in European countries, 2018, EU-27 and the UK from https://www.eea.europa.eu/ims/landscape-fragmentation-pressure-in-europe



The EEA do not have a threshold or a target for fragmentation. The four main aspects of fragmentation are:

i. The overall level of fragmentation
ii. The percentage of land area that is highly fragmented
iii. The types of land that are most impacted by fragmentation
iv. The connectivity of landscapes: if a landscape is fragmented, how well is it connected to other similar landscapes and/or habitats.

Drivers

Fragmentation is driven by creation of physical barriers through building of roads, railways, physical barriers such as walls and housing. It is also driven by forestry and agricultural land uses where one habitat type can be removed or converted to another type.

Data Limitations

Fragmentation data is useful but ideally should be combined with ecological data to determine where it is having the most acute impact in Ireland, and what thresholds should apply for different habitat or land use types. As a national measure, the degree of fragmentation is useful, but it would be more powerful if it was regionalised based on the places where it imposes the greatest risk or impact on ecology. For instance, pristine habitats should ideally have a "zero" fragmentation target, and tolerance (or thresholds) for fragmentation would be lower in certain land use types than others.

The EEA indicator is based on roads and artificial surfaces: it doesn't include fragmentation resulting from causes other than roads or building. Data on fragmentation caused by fires, removal of vegetation or other causes would make this a more complete indicator and give more precision to the measures required to manage it.

Data from the new national landcover map, or a further derived product, could help to identify the potential for increasing landscape connectivity (biodiversity corridors etc). This would help subdivide fragmented areas into those that have some potential to increase connectivity in the very short term.

Greenhouse gas emissions from land use, land use change and forestry

Indicator Category: Environmental Condition

Carbon dioxide (CO_2) from the atmosphere can be stored as carbon in vegetation and in soils, meaning that terrestrial ecosystems have the potential to become carbon sinks. Land use, land use change and forestry (LULUCF) refers to the impacts of human activities on carbon dioxide levels through land use activities, including forestry.

The EEA have identified that CO_2 removals from LULUCF have decreased in the past 10 years (EEA, 2022b). This is attributed to increased harvest rates, decreasing sequestration of carbon by ageing forests, and increasing frequency of natural disturbances (wind throws, forest fires, droughts). At an EU level croplands, grasslands, wetland and settlements are all sources of CO_2.

Regulation (EU) 2018/841 stipulates that Member States should commit to balancing LULUCF emissions with CO_2 removal for 2021-2030 (a no-debit rule). Ireland's LULUCF activities are a net source of emissions and are projected to remain so for the next decade (along with the Netherlands and Denmark) (EEA, 2022b).

The EU has proposed a more ambitious target of net removal of 310 $MtCO_2e$ by 2030 (for the whole EU, with national targets for each Member State). Projections based on existing measures predict a removal rate of 190 $MtCO_2e$ by 2030. With additional measures, the removal could be 209 $MtCO_2e$

by 2030. Both fall short of the 310 $MtCO_2e$ by 2030 removal target, meaning more ambitious removal measures must be implemented along with further reductions in emissions (EEA, 2022b).

Sustainable Development Goals Indicators

Ireland's hub for Sustainable Development Goals, an online public resource developed by OSi, CSO and ESRI, provides resources and data on Irelands activities toward achieving the SDGs. Data might be made available at various geospatial scales, at national scale, or not sourced. For those indicators that were classified as of high land use relevance and where geospatial data is available, a brief account is given in the section below. Indicators where geospatial data has not been sourced are listed but not discussed.

Goal: SDG 15 Life on Land

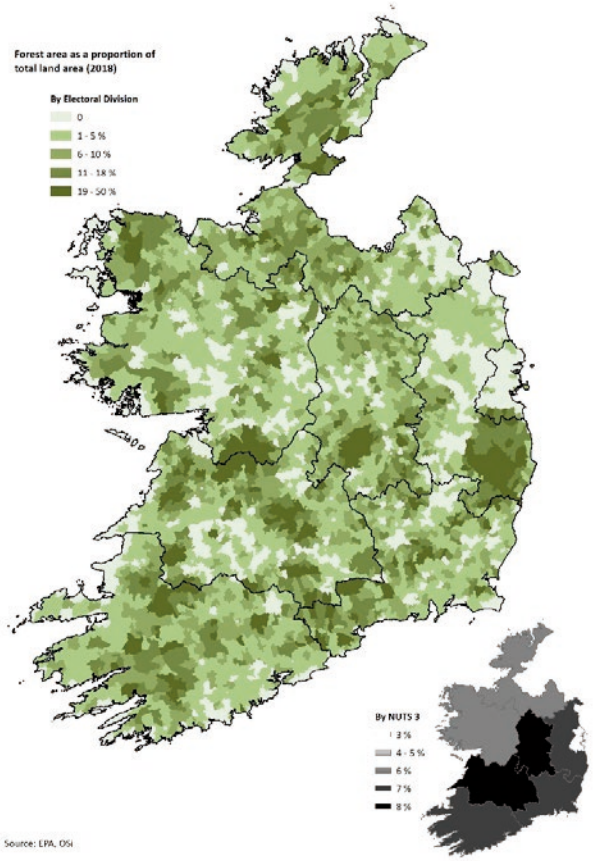
Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. The 2021 Eurostat monitoring report (often based on data up to 2019) on progress toward the SDGs in an EU context found that while Ireland was above the EU average for Goal 15 Life on Land, progress was slowing on this goal (Eurostat, 2022).

Target: 15.1

By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

Data availability for target 15.1

Indicator	Data Type
15.1.1 Forest area as a proportion of total land area	Geospatial
15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	Geospatial



Indicator: 15.1.1 Forest area as a proportion of total land area.

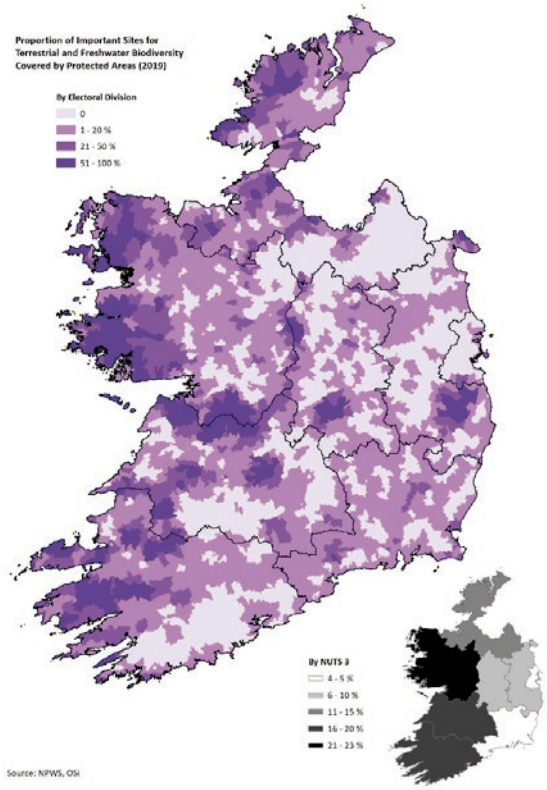
Indicator category: Environmental condition

Ireland's target is to have 18% forest cover by 2046 (DAFM, 2015). However, 2018 data indicates that no NUTS 3 area has more than 8%, and the median county percentage is closer to 6%. There are however some more localised areas that have reached or are closer to this target. The main map in Figure 8 shows the percentage of forest cover per Electoral Division based on Corine Land cover 2018 data. The inset shows the percentage of forest cover at NUTS 3 level based on Corine land cover 2018.

Indicator: 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas

Indicator category: Progress of measure

According to the Sustainable Development Goals Policy Map 2022, the key policies with overlapping objectives for this target are the National Biodiversity Action Plan 2017-2021, National Peatlands Strategy and the National Raised Bog Special Areas of Conservation management Plan 2017-2022 (DECC 2022). The main map in Figure 9 shows the proportion of important sites covered by a protected area at electoral division level; at this level we can see areas particularly along the western coast with high levels of coverage. The inset shows the levels of coverage at NUTS 3 level.



Targets 15.2, 15.3

Data availability

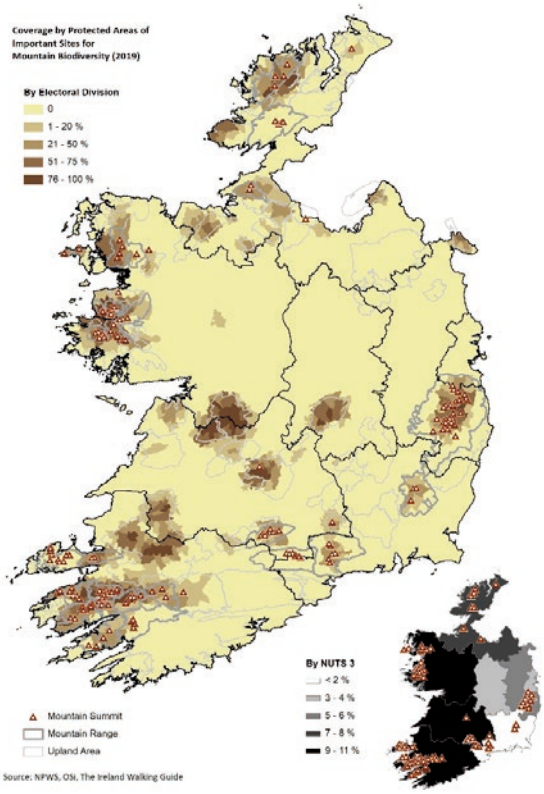
Target	Indicator	Data Type
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management. **Indicator category**: Progress of measure	Not sourced
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area **Indicator category**: Environmental condition	National

Target 15.4

By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

Data availability for target 15.4

Indicator	Data Type
15.4.1 Coverage by protected areas of important sites for mountain biodiversity	Geospatial
15.4.2 Mountain Green Cover Index **Indicator category**: Environmental condition	Not sourced



Indicator: 15.4.1 Coverage by protected areas of important sites for mountain biodiversity.

Indicator category: Progress of measure.

The main map in Figure 10 shows percentage of coverage at electoral division level for this indicator, while the inset map shows coverage at NUTS 3 level, based on NPWS data from 2019. There are many variations on the definition of 'upland areas' or 'mountain ranges'; the data shown in Figure 10 was derived using the criteria defined by Kieron Gribbon while compiling Ireland's range high points. (Ireland Walking Guide – Upland areas, 2015)

Table 1. Other land use relevant SDG indicators with insufficient data

Target	Indicator	Data Type
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020 **Indicator category**: Progress of measure	National
15.a Mobilise and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems **Indicator category**: Progress of measure	Not sourced
15.b Mobilise significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems **Indicator category**: Progress of measure	Not sourced

National Biodiversity Indicators

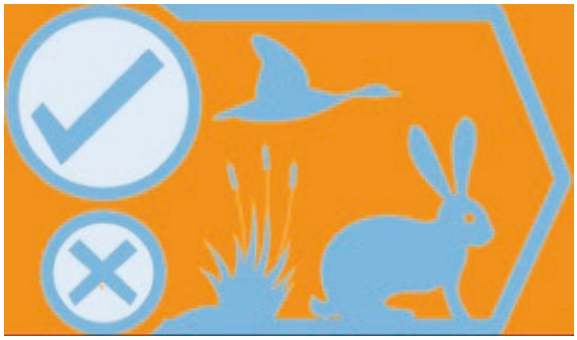
National Biodiversity Indicators are a collection of indicators that monitor changes in Ireland's species, habitats and landscapes, as well as reflecting broader changes relating to biodiversity in Irish society. These indicators provide an important source of evidence for the public and decision makers on the state, trends, pressures and conservation actions relating to biodiversity. The indicators also facilitate reporting on Ireland's progress towards attaining national, European and global biodiversity targets. (National Biodiversity Data Centre, 2021)

This section provides a brief overview of the 2020 status and trends for the headline National Biodiversity Indicators with high land use relevance. These headline indicators are informed by a series of sub-indicators which are not discussed in this document. The National Biodiversity Centre's Indicator website provides a comprehensive account of all indicators and can be found here https://indicators.biodiversityireland.ie/, including a 2020 Status and Trends Report which includes trends (in current, short and long term), interpretation, commentary and caveats on the usage of these indicators.

The remaining indicators of A. Awareness of Biodiversity, E. Measures that Mainstream Biodiversity, and H. Knowledge of Irish Biodiversity are not summarised in this document as they pose less direct relevance to land use.

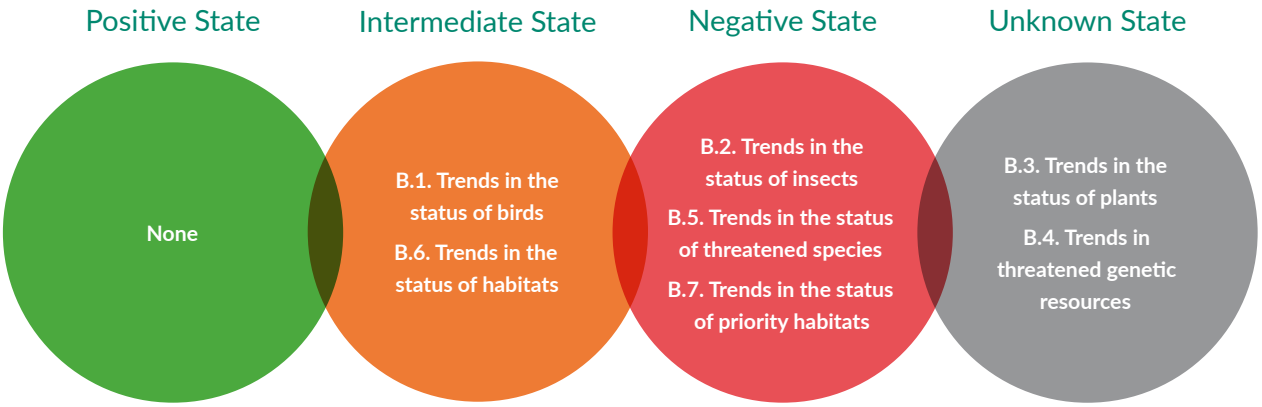
B. Status of biodiversity

Indicator category: Environmental condition



This indicator provides the trends and status of wildlife and habitats which helps identify favourable management practices. These learnings can then inform conservation efforts and contribute to the sustainable development of natural areas. Overall, this indicator is of poor to intermediate status with no significant change in the short term. Figure 11 provides a breakdown of the current status for each of the headline indicators.

Figure 11: Current status of headline indicators for B. Status of biodiversity

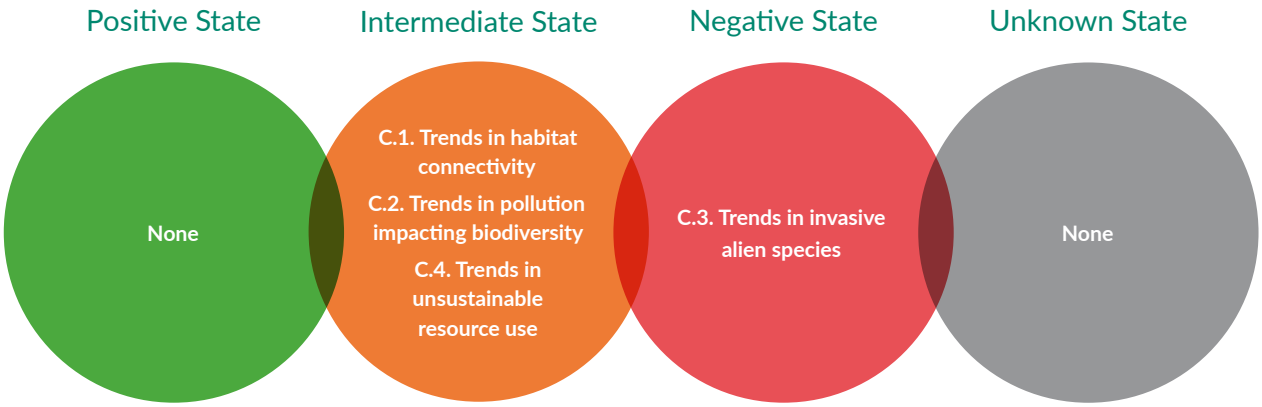


C. Threats to biodiversity

Indicator category: Environmental condition

This indicator tracks the main drivers of biodiversity loss which include habitat loss, habitat fragmentation, unsustainable exploitation, pollution and invasive alien species. They can then inform strategies to reduce these direct pressures. The overall current status of this indicator is intermediate. The long-term status of some sub-indicators is positive, suggesting certain mitigation strategies are working. There are however many sub-indicators where the current status is poor or intermediate suggesting a possible increase in threats or decrease in effectiveness of measures in the shorter term. Figure 12 provides a breakdown of the current status for each of the headline indicators.

Figure 12: Current status of headline indicators for C. Threats to biodiversity

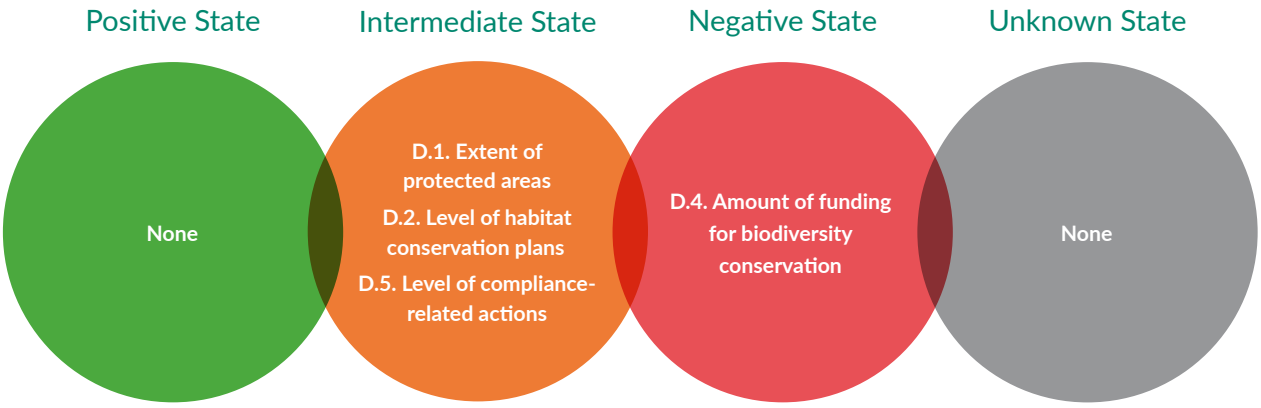


D. Measures that safeguard biodiversity

Indicator category: Progress of measure

This indicator provides a status for the effectiveness of the implementation of national and international biodiversity protection policies, and enforcement of biodiversity protection, thereby supporting the sustainable use of natural resources. The overall current status of this indicator is poor to intermediate with no significant change in the short term. Figure 13 provides a breakdown of the current status for each of the headline indicators.

Figure 13: Current status of headline indicators for D. Measures that safeguard biodiversity

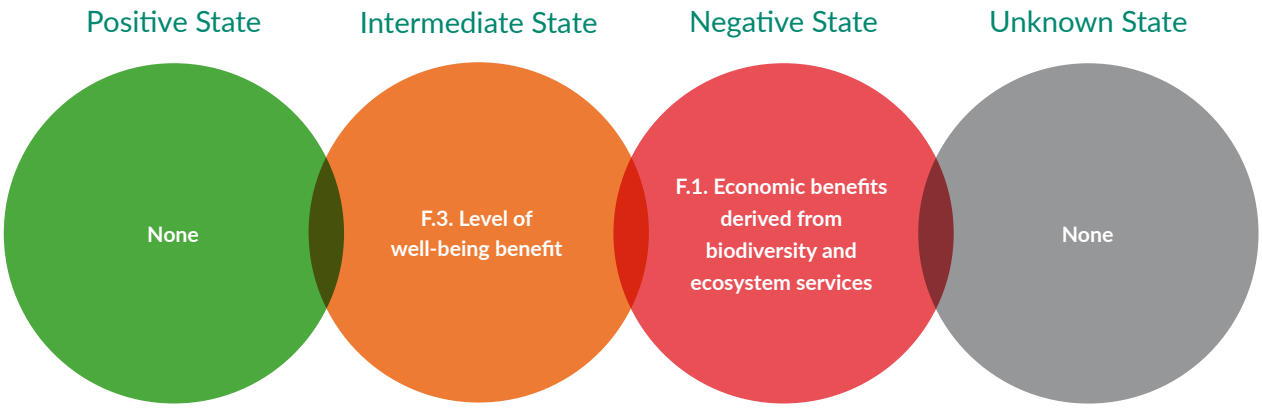


F. Benefits derived from biodiversity and ecosystem services

Indicator category: Social condition

Biodiversity and ecosystem services offer benefits in economic, health and cultural realms. This indicator provides a value for these, allowing us to fully appreciate these benefits, and the impact any loss of biodiversity would have. However, data is lacking for many of the sub-indicators leading to an unknown overall status and change in status. Figure 14 provides a breakdown of the current status for each of the headline indicators.

Figure 14: Current status of headline indicators for F. Benefits derived from biodiversity and ecosystem services

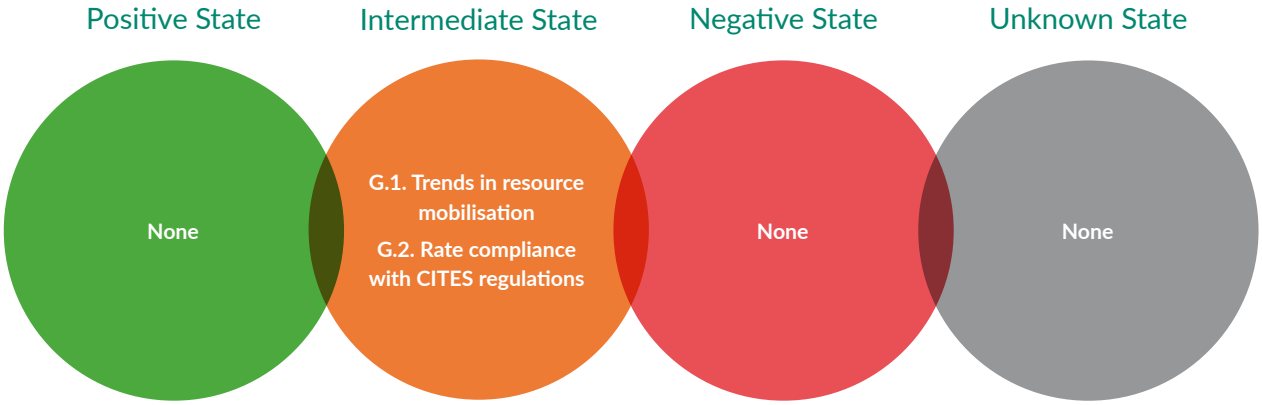


G. Impacts on biodiversity outside of Ireland

Indicator category: Environmental condition

While implementation of conservation measures may be carried out at national level, international collaboration is essential to ensuring a broad geographical impact is achieved. The overall current status of this indicator is intermediate with no improvement in the short term. Figure 15 provides a breakdown of the current status for each of the headline indicators.

Figure 15: Current status of headline indicators for G. Impacts on biodiversity outside of Ireland



Assessment Part 2: Land use as a driver of Impacts

Indicator data was assessed to determine if a land use class was having an impact on the environment. The Copernicus EAGLE land use classification system was used (Table 2)

Table 2: Copernicus EAGLE Land Use Attributes

Level 1	Level 2
Primary Production	Agriculture
	Forestry
	Mining and Quarrying
	Aquaculture and Fishing
	Other Primary Production (e.g. Hunting, Apiculture)
Secondary Production	Manufacturing
	Energy Production
	Other Industry
Tertiary Production	Commercial Services
	Financial, Professional and Information Services
	Community Services
	Cultural, Entertainment and Recreational Services
	Other Services
Transport Networks, Logistics and Utilities	Transport Networks
	Logistical and Storage Services
	Utilities
Residential Use	Permanent Residential Use
	Residential Use with Other Compatible Uses
	Other Residential Use
Other Uses	Transitional Areas
	Natural Areas Not in Other Economic Use
	Flood Protection

Each land use class was assessed to determine what different indicator data showed about the impacts of the land use class. Metadata for these indicators can be found in Appendix B. A summary of the assessment can be found in Appendix C. The information in Appendix C is a summary of the assessment of all land use classes (Column A – I) to determine where there is evidence that the land use is driving an impact on the environment. The state of the impact and the units of measure are recorded in columns J to N. Notes about the trends and the significance of the land use pressures are included in columns O to Q.

The first step of the assessment was to determine if the indicators were showing that the land use class was having a positive or negative effect on the environment. As land use is driven by humans, it was often found that a land use had benefits to humans but may have had a negative impact on biodiversity. Therefore, the indicator assessment is carried out for two aspects: how the impact of the land use on the environment impacts on humans and how it impacts on non-humans (nature).

This is summarised in the "circles" diagrams that are included in the assessments, below, which is drawn from the assessment in columns U to AF of Appendix C. There is one set of circles for each land use type. The circles are made up of concentric rings: each ring is a dimension of the environment. Clean air is the innermost ring: all species, including humans, need clean air to survive. The next ring is water, followed by food and shelter. The outermost ring is "Sustainable Through Generations" – this ring tracks whether land use is having an overall positive or negative impact on the ability of a species or community to survive or thrive into the longer term.

All indicators are plotted as dots on this diagram. If the indicator is showing that land use is having an impact on air, then it will plot in the innermost "Air" ring. The same indicator can be plotted on more than one ring.

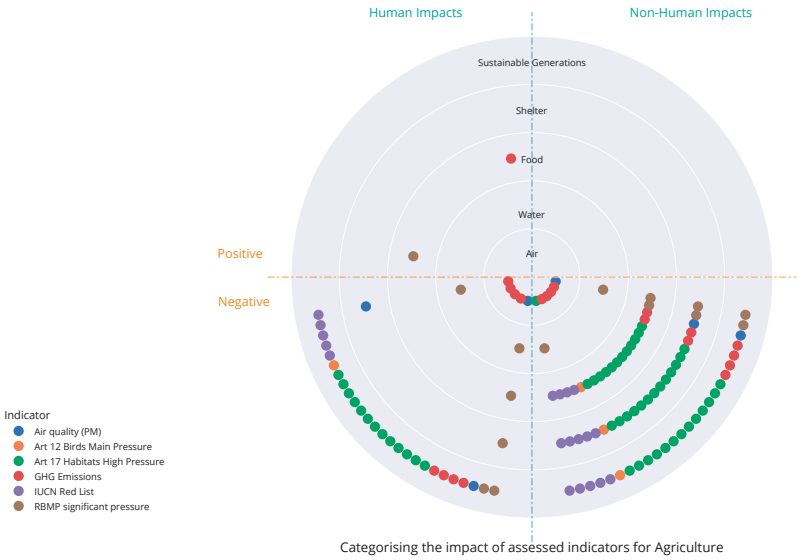
If the indicator is showing a positive impact from the land use, then it is plotted as a dot above the "equator" line on the circles. If it is showing a negative impact, then the dot is below the line.

Finally, the left of the circle tracks the impact of the land use on the environment from a human perspective and the right of the circle tracks the impacts on nature.

The circles diagram is only a high-level view. It does not show the magnitude of the impact: the dot is the same size regardless of whether the indicator suggests that land use is having a large impact or a small impact. Another limitation is that the assessment is biased towards negative impacts: the creation and measurement of indicators tends to be in response to known issues, where effort is invested to understand and respond to environmental problems.

Agriculture

Figure 16: High-level assessment of Agriculture impacts on humans and ecology



Agriculture as a driver of impacts on water
Indicator category: Environmental condition

The Water Framework Directive requires waterbodies to achieve good status. The EPA completed a catchment characterisation to assess water bodies' risk of not achieving WFD objectives. The outputs from this characterisation underpin the 2022-2027 River Basin Management plan (DHLGH, 2021). It identifies agriculture as the most frequent significant pressure on Ireland's waterbodies: 62% of Ireland's water bodies have agriculture as a significant pressure.

Agriculture drives pressure on water quality through:

i. Runoff of nutrients (N and P) and sediment from agricultural land and farmyards
ii. The contamination of surface waters with pesticides
iii. Hydromorphological changes due to land drainage for agricultural purposes.

The EPA Water Quality in Ireland 2016-2021 report (EPA, 2022d) identified an increase in nutrients over the last decade. This negatively impacts on humans through impacts on water quality as a potable source and as a resource for recreation. It negatively impacts on ecology – particularly aquatic species – by direct pollution of aquatic habitat leading to limitations on food and habitat availability leading to longer term impacts on populations of aquatic species.

Agriculture as a driver of impacts on climate and air
Indicator category: Environmental condition

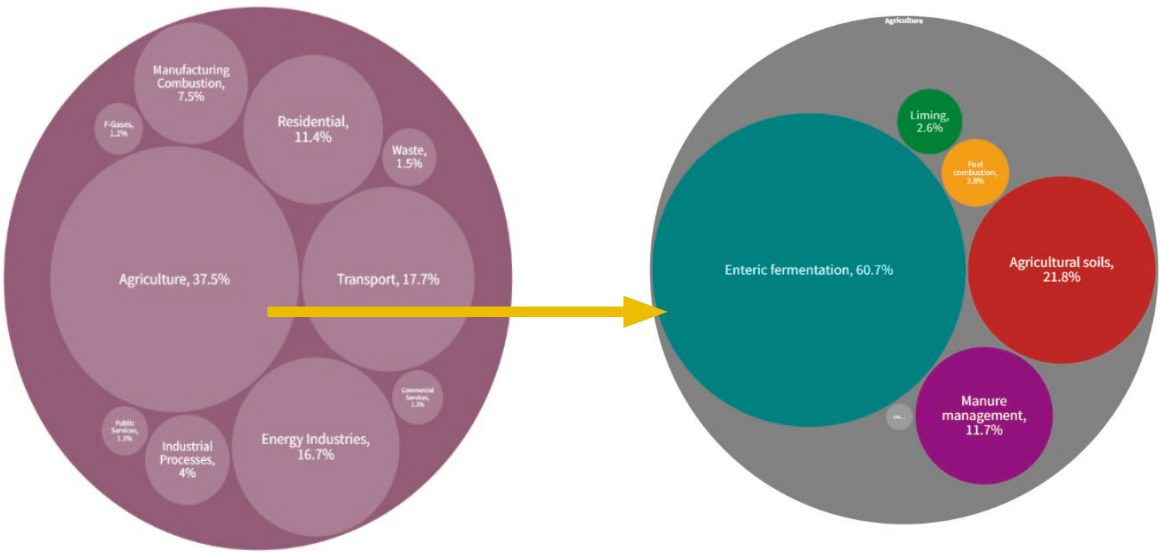
This indicator assessment has identified three categories of agricultural pressure on our atmosphere related to climate change:

i. Agricultural Carbon Dioxide Emissions
   a. Carbon Dioxide (CO_2) emissions from grasslands are currently a net source of CO_2 emissions. They have the potential to be a net sink of CO_2 (which some grasslands already are).
   b. Carbon dioxide emissions from Liming, Urea Application and fuel combustion. This is a much smaller source of agricultural CO_2 emissions. While the emission levels are increasing, the use of lime reduces the need for nitrogen fertiliser which is beneficial to soil fertility in the longer term.

ii. Agricultural Methane Emissions from Enteric Fermentation, Manure Management and fuel combustion. Enteric fermentation is part of the natural digestive process of ruminants like cows: it produces methane as a by-product. Methane has a higher warming potential as a greenhouse gas in the short term. EPA emissions inventories (EPA, 2022) calculate that methane emissions are 69.9% of Ireland's agricultural emissions and increased since 2020. Methane emissions from agriculture are steadily increasing when a significant reduction is needed to meet the commitments of the Climate Action Plan 2021.

iii. Agricultural Nitrous Oxide Emissions originate from manure management, agricultural soils and fuel combustion. N_2O emissions have increased since 2020. Like methane, N_2O has a higher warming potential than CO_2.

Figure 17: Ireland's greenhouse gas emissions by sector in 2021 (left), and the sources of agricultural emissions (right)



The evidence shows that greenhouse gas emissions from Agriculture are getting worse

(EPA, 2022a). This will have a negative impact on society and ecology through the pollution of the atmosphere and on sustainable generations through the warming impacts of methane, N_2O and CO_2 contributing to climate change. At present, the net emissions incurred in the production of food for humans has yet to be scored. To apply a score would require a deeper assessment of whether emissions could feasibly be avoided or reduced to achieve adequate food production, and the health benefits of the food produced. Evidence on the relative benefits and sustainability of different diets is accumulating but is beyond the scope of this land use evidential assessment.

Teagasc Marginal Abatement Cost Curve (MACC) (Teagasc, 2019) is based on an extensive range of research projects to assess the potential to reduce agricultural emissions and to sequester carbon. The MACC is a graph that plots the greenhouse gas abatement potential versus the costs. Teagasc (2019) identified that achieving climate targets for agriculture would be challenging, and that mitigation of methane and N_2O, along with carbon sequestration, could deliver 4.82 $MtCO_2e$ emission reduction during 2021-2030, at a net cost of €20 million per annum.

Although the main source of particulate matter is the burning of solid fuels in the home, agriculture poses another source of $PM_{2.5}$ and PM_{10}, particularly from the formation of secondary particulate matter from nitrogen use.

Agriculture as a driver of impacts on nature
Indicator category: Environmental condition

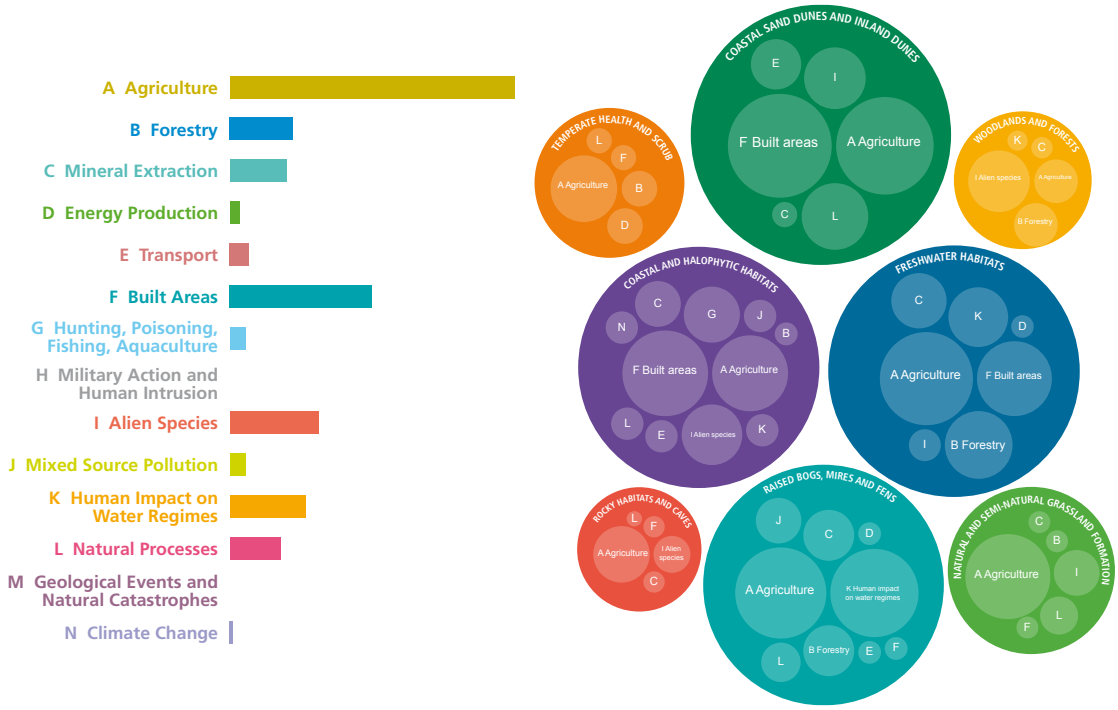
Indicators from three sources have been reviewed: Article 17 Habitats Directive Reports, Article 12 Birds Directive and European Red List of Birds, and the International Union for Conservation of Nature (IUCN) Red Lists.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

The Article 17 Habitats Directive report is compiled by the National Parks and Wildlife Service (NPWS) every six years, as required by Article 11 of the Directive. The report contains assessments of the conservation status of the habitats and species in the Annexes and under Article 17. It's important to note that these habitats are listed specifically because they are rare and/or under threat.

The 2019 report includes assessments of 59 habitats and 60 species. Each habitat and species on the list are assessed and the pressures (activities having a negative impact during the reporting period) and threats (activities that are expected to negatively impact in the next twelve years) identified. Agriculture is the most prevalent pressure and threat to Article 17 Habitats (NPWS, 2019). It has the highest percentage of high-importance pressures on species and this is predicted to increase over the next twelve years (NPWS, 2019). Figure 18 below shows the frequency of pressures across the habitat types assessed.

Figure 18: Frequency of different pressure types (left) and prevalence across the different habitat types assessed (right). (Pressures have been abbreviated to their one letter code in the circle graph: the full version of the code is given in the bar chart on the left).



It is important to note that there are many Irish habitats and species that depend on agricultural land. There are agricultural land use practices that are beneficial to biodiversity. A limitation of the indicator assessment that follows is that it focuses on pressures and threats that have been identified. Data on beneficial links is not as readily available: having this data would be helpful to identify practices that could be supported, encouraged and incentivised.

This assessment focussed on the "high" pressures on habitats and species. For habitats, the most frequently occurring high pressure is intensive grazing or overgrazing by livestock. The next most frequent high-importance agricultural pressure is activities generating diffuse pollution to surface or ground waters. NPWS (2019) has identified that "All eight of the habitats affected by diffuse pollution are either lake or groundwater dependent habitats." Impacts from agricultural activities are reported in a wide range of species (aquatic and terrestrial animals and plants). This is because the agricultural activities can impact a wide area beyond the farm boundaries particularly if watercourses or groundwater are affected (NPWS, 2019).

All the agricultural pressures identified for the 2013-2019 reporting period are also identified as ongoing threats for the next twelve years.

ii. Article 12 Birds Directive (NPWS) & European Red List of Birds (European Commission, 2022)

The Article 12 Birds Directive report is compiled by the National Parks and Wildlife Service (NPWS) every six years. Agricultural pressures account for 4.39% of the pressures reported on bird taxa under the Birds Directive, and 7.89% of the threats (EEA, 2020c).

The European Red List of Birds identifies the intensification of agriculture as one of the drivers of bird population declines observed across Europe (European Commission, 2022)

iii. International Union for Conservation of Nature (IUCN) Red List assessments

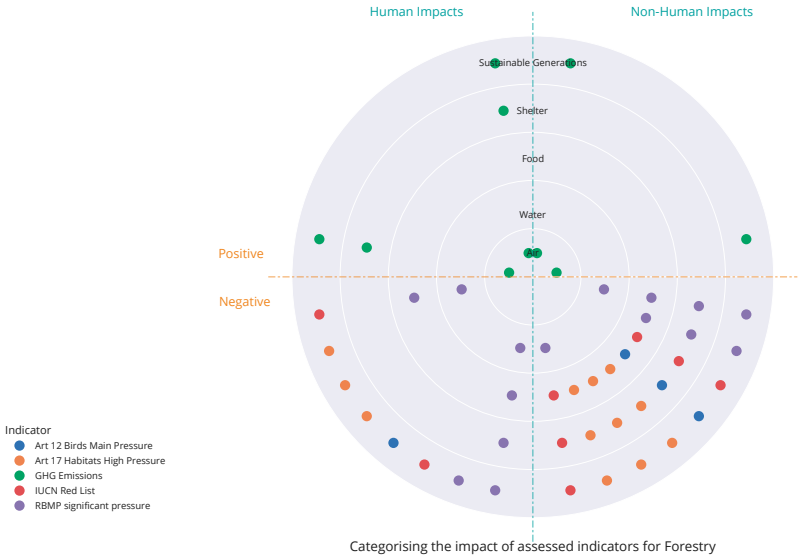
Established in 1964, the International Union for Conservation of Nature's Red List of Threatened Species has evolved to become the world's most comprehensive information source on the global extinction risk status of animal, fungus and plant species. The IUCN identifies species across regions (e.g. Europe) that are under threat: the specific threats often include land use threats. NPWS conducts Red List assessments for Ireland. Where relevant, regional IUCN assessments identify land use activities as a threat to the species being assessed. Agriculture is specifically identified as a threat that contributes to the decline in:

- Some Bryophyte species, via livestock grazing either through excessive nutrient enrichment or physical damage to habitat through inappropriate grazing regimes. Bog bryophytes have declined through habitat destruction: sometimes this is land drainage for agricultural purposes (Lockhart *et al.*, 2012)
- Some Amphibian, Reptile & Freshwater Fish species are impacted by over-grazing in uplands which has resulted in siltation in gravel beds in rivers, in the west of Ireland. Abstraction of water for agricultural purposes – in particular tillage – can cause fluctuations in lake water levels impacting on trout and char species (King *et al.*, 2011).
- Decline in Butterfly species throughout Europe is attributed to changes in land management: agricultural intensification and abandonment of grazing on marginal land were assessed to have the most significant impact on reducing extent and quality of flower rich habitats required by butterflies (Regan *et al.*, 2010)
- Freshwater Pearl Mussel (FWPM) are listed as endangered. This is due to a range of threats, one of which is agricultural practices (Moorkens *et al.*, 2017). This is expanded in the forestry section, below.

In summary, agricultural pressures on nature impact on habitats for a range of priority species under Article 17 of the Habitats Directive or included in IUCN lists as "threatened". Agriculture has been identified as a pressure in all previous Article 17 Habitats Directive reports and as a threat in the 2019 report: it is expected to have an impact over the next twelve years. Due to these historic and future trends of the impact of agriculture on nature in mind, agriculture is identified as having a negative impact on sustainable generations.

Forestry

Figure 19: High-level assessment of Forestry impacts on humans and ecology



Forestry as a driver of impacts on water
Indicator category: Environmental condition

The Water Framework Directive requires waterbodies to achieve good status: the EPA completed a catchment characterisation to assess water bodies' risk of not achieving WFD objectives. The result of this characterisation is used in the 2022-2027 River Basin Management plan (DHLGH, 2021), where forestry is identified as the third most frequent pressure on Ireland's water bodies, affecting 16% of waterbodies. Forestry can impact on waterbodies by physical alteration to habitats, excessive nutrients and sediment and changes in water level and/or flow (DHLGH, 2021). The need to protect and restore high status waterbodies is a high priority in the 2022-2027 RBMP; forestry pressures are particularly evident in high status waterbodies.

Hydromorphological modification means change to the physical habitat, and/or a water bodies' natural functioning caused by, for example, channelisation which is the dredging and straightening of rivers, land drainage, or hard infrastructure. Hydromorphological changes can be made to facilitate forestry work. Hydromorphological pressures are significant pressures for 442 waterbodies but only a portion of the hydromorphology changes may be attributed to forestry.

Box 1: Forestry Impacts Commentary from Forest Service, DAFM

Since the publication of the second-cycle River Basin Management Plan, the assessment by the Department of Agriculture, Food and the Marine (DAFM) of licence applications for key forestry activities including afforestation, forest road construction and tree felling has undergone significant changes. These changes are having a significant overarching effect in terms of further strengthening the protection of water from forestry-related sources. While the extent of the changes involved was not envisaged for forestry during the second-cycle, it is important to highlight them now to maintain an accurate record of the changes in land use planning and development that contribute towards the achievement of WFD objectives. The changes involved relate primarily to the application of Appropriate Assessment, as required under Article 6(3) of the Habitats Directive and transposing legislation. Of particular impact was the European Court of Justice ruling C-323/17 ('People Over Wind'), which resulted in approximately 80% of forestry applications being screened in for Appropriate Assessment. In order to deal with the increased demand for ecological input into the assessment process, and to address the resulting backlog in applications and the knock-on detrimental impact on the forestry sector, DAFM increased its full time ecologist equivalents. DAFM also published the interim Standards for Felling and Reforestation (October 2019) and has increased the level of ecological and environmental information to be submitted as part of a licence application in relation to afforestation, roading and tree felling (the latter including thinning and clear-felling/reforestation projects). This has also prompted the increased engagement of consultant ecologists by Registered Foresters when developing projects, something which DAFM has facilitated by their creation of a Directory for Professional Ecologists who are available to work on forestry projects. While many of these changes revolve around the implementation of the Habitats Directive, due to the intersection between forestry sites, water and downstream European Sites, much of the mitigation arising from the Appropriate Assessment process is focused on eliminating sedimentation and nutrient sources and preventing pathways that might otherwise transport these to adjoining or nearby waterbodies. The dramatic increase in ecological input into the evaluation of licence applications since early 2019 will have a beneficial impact in relation to the protection of water from forestry activities, adding to the measures for forestry identified in the second-cycle plan.

Forestry as a driver of impacts on climate and air
Indicator category: Environmental condition

Land use, land use change and forestry (LULUCF) data shows that land use in Ireland is a net carbon emitter, but forestry is a major carbon sink that mitigates this. Forests store (sink) greenhouse gas emissions through absorption of CO_2 through living biomass. Harvested wood products are also a carbon sink in all years (EPA, 2022a). LULUCF data shows that the levels of CO_2 absorbed by forests have declined since 2000.

Forests have the capacity to mitigate air pollution but no data on the measured air quality impacts of forestry in Ireland could be discovered.

Forestry as a driver of impacts on nature
Indicator category: Environmental condition

Forests are necessary habitats for certain species. The indicator assessment that follows uses information about pressures and does not include information about the forests that are providing support to ecosystems. Data was not available to make this assessment, but it is important to note that the right kind of forests in the appropriate locations are necessary to support some of Ireland's habitats and species.

Indicators from three sources have been reviewed: Article 17 Habitats Directive Reports, Article 12 Birds Directive and European Red List of Birds, and the International Union for Conservation of Nature (IUCN) Red Lists.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

Forestry impacted 35% of the Article 17 Habitats Directive habitats assessed in 2019 (NPWS, 2019). Forestry impacts habitats in Ireland through:

- Conversion to forest from other land uses, or afforestation (excluding drainage), where a non-woodland habitat is removed or reduced for tree planting. This pressure has been identified as a high pressure on wet heaths, Molinia meadows, blanket bogs, transition mires and rhynchosporion depressions.
- Forestry activities generating pollution to surface or ground waters has been identified as a high pressure on freshwater habitats.
- Modification of hydrological conditions, or physical alteration of water bodies and drainage for forestry (including dams) has been identified as a high pressure on oligotrophic isoetid and acid oligotrophic lake habitats.

All the forestry pressures identified in the Article 17 Habitats Directive report have also been identified as threats. This implies that there was no evidence that there would be any major decline in pressures over the next twelve years (NPWS, 2019).

Ireland has four types of temperate forest habitat. The Article 17 Habitats Directive report concluded that three were at bad status, and that this had not changed across the three reporting periods (2007, 2013, 2019). The pressures on these habitats were agriculture, forestry and alien species. Bog woodland status was favourable. The pressures on bog woodland were agriculture, forestry, mineral extraction, alien species and human impact on water regimes.

ii. Article 12 Birds Directive (NPWS) & European Red List of Birds (European Commission, 2022)

The Article 12 Birds Directive report is compiled by the National Parks and Wildlife Service (NPWS) every six years. Forestry pressures account for 2.63% of the pressures reported on bird taxa under the Birds Directive, and 3.51% of the threats (EEA, 2020c)

The European Red List of Birds identifies unsustainable forestry practices as one of the drivers of bird population declines observed across Europe (European Commission, 2022)

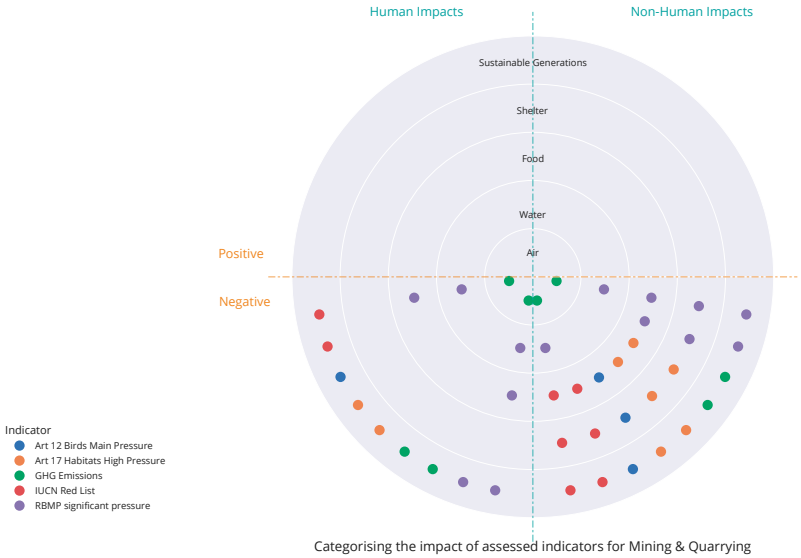
iii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

The Irish IUCN assessments below identify forestry as a threat that contributes to the decline in the species being assessed.

- Many Bryophyte species on the Red List taxa are under varying degrees of threat: one contributory factor is conifer afforestation impacting riverine species. Several bog bryophytes have declined through habitat destruction: sometimes this due to forestry (Lockhart *et al.*, 2012)
- Some Amphibian, Reptile & Freshwater Fish species are impacted by silt and nutrient loadings in rivers, some of which is due to forestry. This is occurring in rivers which would otherwise be pristine as there are no other anthropogenic pressures (NPWS, 2011). Forestry has also contributed to acidification of some streams resulting in fishless streams in poorly buffered upland catchments (King *et al.*, 2011).
- Spread of forestry had been of some benefit to mammals but woodland management was an important factor: the importance of careful planning at clear-felling was emphasised to continue to support healthy mammal habitats (Marnell *et al.*, 2010)
- Freshwater pearl mussel (FWPM) require very clean and free flowing rivers in order to reproduce. Recruitment rates have fallen consistently enough for the species to be listed as endangered (Moorkens *et al.*, 2017). The sedimentation and nutrient enrichment that remove the clean substrate for FWPM to reproduce can be caused by a range of land use activities (Moorkens *et al.*, 2017). Forestry activities such as clear felling can be a major source of nutrients and sediment, especially where the forest has been planted on peaty soils.

Mining & Quarrying

Figure 20: High-level assessment of Mining & Quarrying impacts on humans and ecology



Mining & Quarrying as a driver of impacts on water
Indicator category: Environmental condition

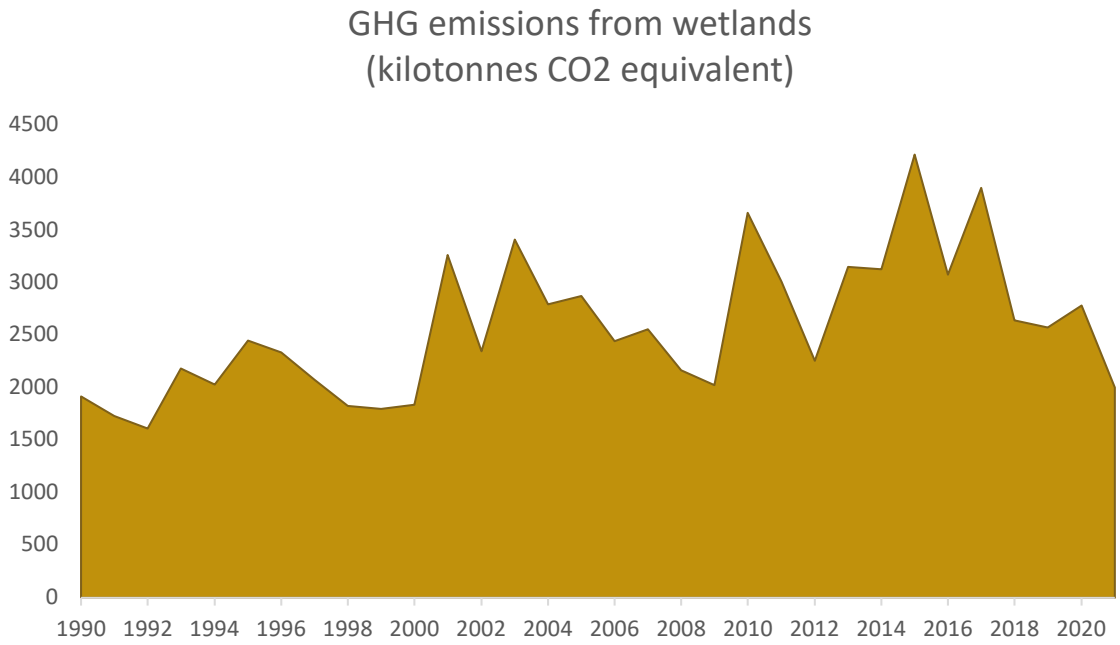
Peat extraction and the associated drainage can release ammonium and fine-grained sediments, which can impact water quality and river habitats (DHLGH, 2021). Drainage can also impact on the hydromorphological condition of rivers (DHLGH, 2021). Restoration or rehabilitation of peatlands can improve water quality in the catchment. The assessment of waterbodies for the 2022 Draft River Basin Management Plan found that peat extraction impacted 106 waterbodies, with peat being the only pressure on 28 of these. (DHLGH, 2021).

Dewatering from mines and sediments from quarries can both negatively impact water quality. Mines and quarries are a significant pressure for 6% of Ireland's waterbodies: for 6 waterbodies, mining or quarrying is the only pressure that puts the waterbody at risk of not achieving its water status objectives (DHLGH, 2021). Emissions of metals to water have shown a significant decrease in the past 5 years and the largest improvements were from the mining sector (EPA, 2020).

Mining & Quarrying as a driver of impacts on climate and air
Indicator category: Environmental condition

Land use, land use change and forestry (LULUCF) is the part of the greenhouse gas (GHG) emissions inventory that tracks emissions relating to land use. LULUCF data shows that land use is a net emitter of greenhouse gases: the main source of land emissions is the drainage of grasslands on organic soils and the exploitation of wetlands for peat extraction (EPA, 2022a).

Figure 21: Emissions from wetlands from EPA 1990-2021 emissions data



EPA GHG emissions data shows that after a fluctuating general rise in emissions since 2000 greenhouse gas emissions from wetlands appear to be declining.

Peatland has potential to store carbon and so could be a net sink for carbon instead of a source of emissions: this requires restoration of peatland.

Mining & Quarrying as a driver of impacts on nature
Indicator category: Environmental condition

Some Irish species are entirely dependent on peatland for their habitat: industrial extraction of peat (and drainage of peatland for extraction or other purposes) compromises this unique habitat.

Indicators from three sources have been reviewed: Article 17 Habitats Directive Reports, Article 12 Birds Directive and European Red List of Birds, and the International Union for Conservation of Nature (IUCN) Red Lists.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

Mining and quarrying impacted 32% of the Article 17 Habitats Directive habitats assessed in 2019 (NPWS, 2019). Mining and quarrying impacts habitats in Ireland through:

- Negative impacts of extraction of minerals directly on habitats
- The loss of peatland habitat from extraction of peat
- Negative impacts on freshwater habitats from water quality issues arising from peat extraction

All the mining and quarrying pressures identified in the Article 17 Habitats Directive report have also been identified as threats. This implies that there was no evidence that there would be any major decline in pressures over the next twelve years (NPWS, 2019).

ii. Article 12 Birds Directive (NPWS)

The Article 12 Birds Directive report is compiled by the National Parks and Wildlife Service (NPWS) every six years. Mineral extraction pressures account for 0.88% of the pressures reported on bird taxa under the Birds Directive, and 0.88% of the threats (EEA, 2020c).

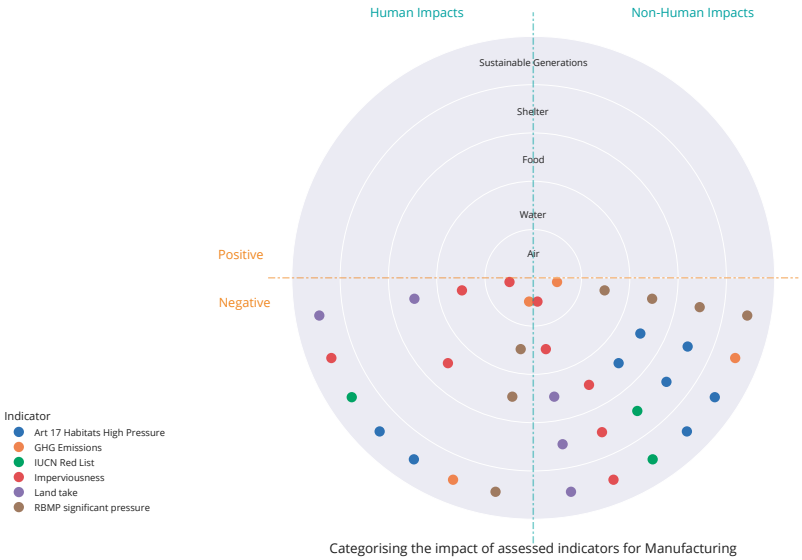
iii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

The Irish IUCN assessments below identify mining and quarrying as a threat that contributes to the decline in the species being assessed.

- Many Bryophyte species on the Red List taxa are under varying degrees of threat. Lockhart *et al.* (2012) found that lowland taxa are threatened by development pressure including housing projects and quarrying, often placing them under more threat than upland taxa.
- Habitat loss due to wetland drainage (in some cases for peat extraction) is a major threat to Irish amphibians (King *et al.*, 2011).
- Freshwater pearl mussel is listed as endangered. Peat extraction is cited as one of the threats to this species (Moorkens *et al.*, 2017).

Manufacturing

Figure 22: High-level assessment of manufacturing impacts on humans and ecology



Manufacturing as a driver of impacts on water
Indicator category: Environmental condition

The 2018 draft River Basin Management Plan identified industry as a significant pressure in 89 water bodies identified as being At Risk of not meeting their WFD objectives (DHLGH, 2021). Pressures include facilities licensed by the EPA and industries with Section4 Discharge to Water licences issued by local authorities. Programmes that support organisations to move beyond just focusing on regulatory compliance are a welcome development. Irish Water's Water Stewardship Programme provides training for organisations to adopt a more holistic water stewardship approach in their own business and in the wider catchment.

Adequate supplies of clean water are important to industry. The availability of clean water is important to attract foreign direct investment and support indigenous industries (DHLGH, 2021).

Industrial pollutant releases to water can be direct to water or indirectly via sewers (EPA, 2020). Industrial emissions to water represent a small proportion of the emission to water that are routinely monitored. However, emerging and trace pollutants are not commonly monitored, and this needs greater focus (EPA, 2020).

Manufacturing as a driver of impacts on climate and air
Indicator category: Environmental condition

Industrial Processes and Manufacturing combustion emitted 7.05 Mt CO_2 eq in 2021, which accounted for 11.5% of Ireland's total emissions in 2021. This was a 0.9% increase on the previous year. Some subsectors decreased their combustion emissions (chemical and the food processing, beverages and tobacco sector). Combustion emissions from non-metallic minerals (including cement) increased significantly by 10.5% (EPA, 2022a).

Emissions of other air pollutants from licensed industry come mainly from the energy and mineral sectors (including cement): 45% sulphur dioxide, 15% nitrous oxides and 15% of $PM_{2.5}$ (EPA, 2020). Industry can also be responsible for emissions of heavy metals such as cadmium, lead and mercury: the impact on local air quality is determined by how quickly these pollutants disperse in the atmosphere (EPA, 2020).

Manufacturing as a driver of impacts on nature
Indicator category: Environmental condition

Indicators have been reviewed for Article 17 Habitats Directive Reports, the International Union for Conservation of Nature (IUCN) Red Lists and a synthesis of other environmental impacts from various sources.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

Contaminated or abandoned industrial sites generating pollution to surface or ground water were identified as a high pressure on one protected habitat: hard water lakes.

ii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

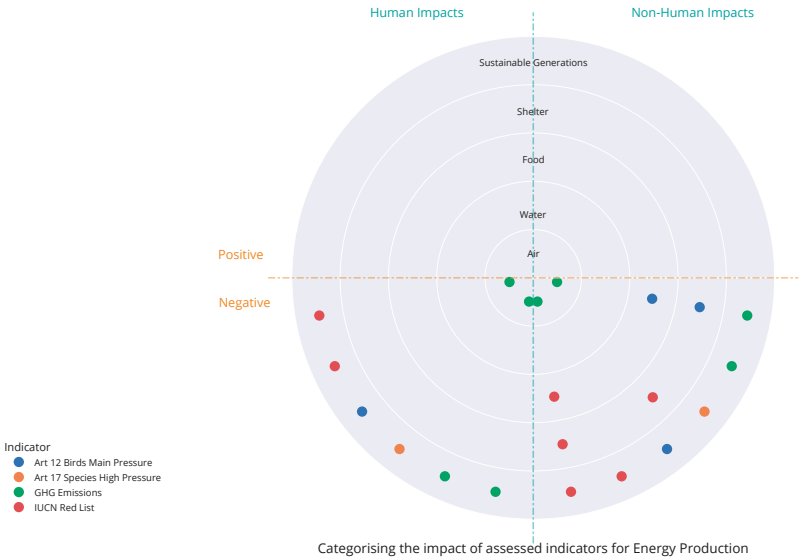
Abstraction of water from rivers and lakes for industrial processes can cause fluctuation in water surface levels. This has been identified as a threat for some species of freshwater fish (King *et al.*, 2011).

Other environmental impacts from industry are.

- Waste Generation. Industrial sectors account for 67% of the hazardous waste and 56% of the non-hazardous waste generated in Ireland (EPA, 2020).
- Noise. Almost one-third of complaints received by the EPA about EPA licensed facilities relate to noise issues (EPA, 2020).
- Soil sealing and land take. Industrial land uses are on built land. Built land also includes service, infrastructural and residential land use. Pressures from built land or urbanisation are discussed separately as they relate to a group of land use types.

Energy

Figure 23: High-level assessment of energy production impacts on humans and ecology



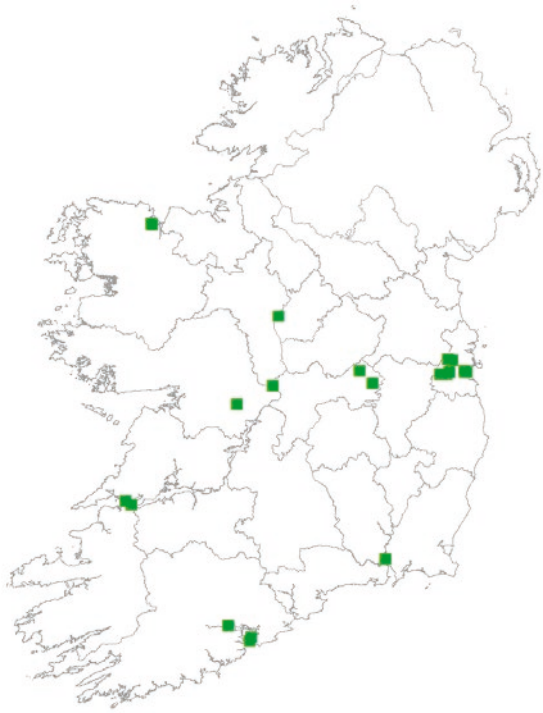
Energy production as a driver of impacts on water
Indicator category: Environmental condition

The impact of energy generation on water bodies is expressed in two ways in the 2021 Draft River Basin Management Plan (DHLGH, 2021):

i. Under the industry category. EPA licensed facilities include energy generation (See Figure 24, below). Industry is treated as a single pressure: more investigation would be required to ascertain if any of the EPA licensed energy facilities are a local pressure on waterbodies in surrounding catchment areas.

ii. As part of abstraction pressures. Energy generation, drinking water supply, quarries/mining and industrial processing were identified as the sectors abstracting the most water. However, abstraction for drinking water was the predominant risk factor for abstraction. Abstraction pressures were grouped into the "Other Pressures" category in the 2021 Draft RBMP. The "Other Pressures" group accounted for 16% of pressures on at risk waterbodies (DHLGH, 2021).

Figure 24: EPA licensed energy facilities



Energy production as a driver of impacts on climate and air
Indicator category: Environmental condition

The EPA GHG emissions for 2021 show that emissions from energy industries increased by 17.6% on 2020 levels, due to an increased use of coal and oil in electricity generation (EPA, 2022a). Electricity generation from peat continued to decline.

The GHG emissions from energy industries had shown a consistent long-term reduction since 1990 (EPA, 2022a). EPA GHG emissions projections predict a decrease of 37.8% from 2020 to 2030 with existing measures, and a decrease of 48.9% over the same period with additional measures (EPA, 2022b).

Energy production as a driver of impacts on nature
Indicator category: Environmental condition

i. Article 17 Habitats Directive Reports (NPWS, 2019)

Energy production impacts on Article 17 Habitats relate to peat extraction: this is covered in the section on mining and quarrying land use (above).

Hydropower generation (dams, weirs, run-off-the-river) is a high pressure (and high threat) for Sea Lamprey, and a high threat for River Lamprey (NPWS, 2019).

ii. Article 12 Birds Directive (NPWS) & European Red List of Birds (European Commission, 2022)

The Article 12 Birds Directive report is compiled by the National Parks and Wildlife Service (NPWS) every six years. Energy production pressures account for 0.88% of the pressures reported on bird taxa under the Birds Directive, and 7.02% of the threats (EEA, 2020c).

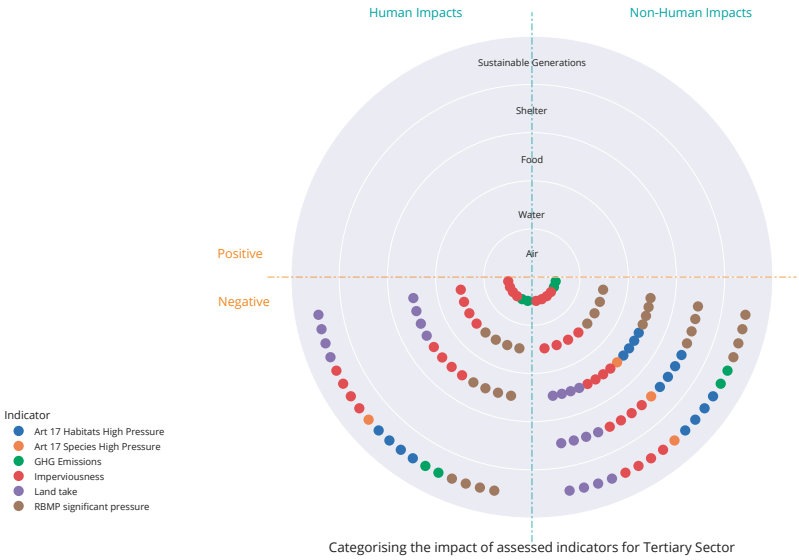
iii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

The impact of peat extraction on bryophyte species has been covered in the section on mining and quarrying land use (above).

The installation of natural and artificial weirs for small-scale electricity generation can impact on fish species. Salmon and sea lamprey are impacted by large hydroelectric schemes, such as those on the Shannon, Erne, Lee and Liffey (King *et al.*., 2011).

Tertiary

Figure 25: High-level assessment of tertiary sector impacts on humans and ecology



Tertiary production as a driver of impacts on water
Indicator category: Environmental condition

Urban run-off accounts for 12% of the pressures on at risk waterbodies in the 2021 Draft River Basin Management Plan. As urban run-off pressures relate to urban buildings and infrastructure together, this is discussed separately.

Domestic wastewater accounts for 12% of the pressures on at risk waterbodies. Domestic wastewater is primarily related to residential land use in rural areas, so is discussed in the residential land use section below. Tertiary production contributes to this pressure where some services (such as hospitality businesses or nursing homes) may have unauthorised septic tanks that should have Section 4 licenses from the local authority (Section 4 of the Local Government (Water Pollution) Act 1977 as amended by the Local Government (Water Pollution) Amendment Act 1990).

Tertiary production as a driver of impacts on climate and air
Indicator category: Environmental condition

Commercial services accounted for 1.3% of Ireland's GHG emissions in 2021. Public services accounted for 1.1%. These emissions arise from fuel combustion for heating of water and buildings (EPA, 2022a).

Emissions from Commercial Services and Public Services decreased by 3.0% and 3.8% respectively from 2020 emission levels (EPA, 2022a). The EPA GHG emissions projections report outlines an expected 30.3% decrease in commercial and public services between 2020 and 2030 under existing climate action measures relating to energy efficiency and decarbonisation of energy supply (EPA, 2022b). With additional measures outlined in the Climate Action Plan 2021, emissions from commercial and public services between 2020 and 2030 could decrease by 45.5%.

Air pollution from fuel combustion in urban areas for transport and building heating can partially be attributed to tertiary production but this is discussed in the section on urban pressures.

Mining & Quarrying as a driver of impacts on nature
Indicator category: Environmental condition

The Article 17 Habitats Directive habitats assessed in 2019 (NPWS, 2019) identifies that tertiary production pressures tend to have an impact on coastal habitats, due to tourism and recreational activities and infrastructure. The specific high pressures are:

- Conversion from other land uses to housing, settlement or recreational areas (excluding drainage and modification of coastline, estuary and coastal conditions) is a high pressure on coastal machair habitats (machair are dune grassland habitats unique to north west Ireland and Scotland).
- Sports, tourism and leisure activities are a high pressure on three types of coastal habitats (Atlantic salt meadows, embryonic shifting dunes and marram dunes).
- Modification of coastline, estuary and coastal conditions for development, use and protection of residential, commercial, industrial and recreational infrastructure and areas is a high pressure on four coastal habitats (drift lines, vegetated shingle, embryonic shifting dunes and marram dunes).
- Residential or recreational activities and structures generating marine pollution (excl. marine macro- and micro-particular pollution) are a high pressure on three coastal habitat types (estuaries, mudflats and large shallow inlets and bays).

All the high pressures listed are also listed as high threats, meaning no improvement is currently anticipated over the next twelve years.

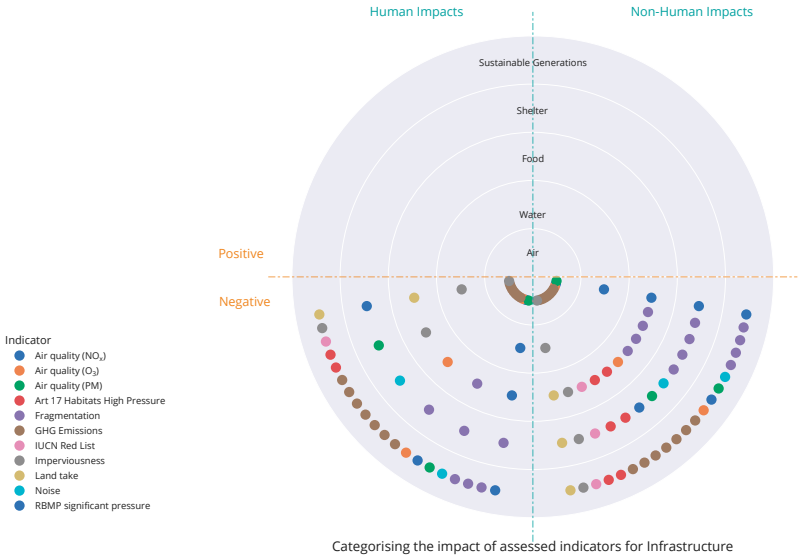
The Article 17 Habitats Directive report identifies that modification of hydrological conditions for residential or recreational development is a high pressure on freshwater pearl mussel. Abstraction of ground and surface waters (including marine) for public water supply and recreational use is a high pressure on pollan (a fish species that occurs in Irish lakes).

Other environmental impacts from tertiary production are.

- Waste Generation. Ireland generated 3.1 million tonnes of municipal waste in 2019, up 6 per cent from 2.9 million tonnes in 2018 (EPA, 2021a). Of this, 48% came from commercial sources. Recycling of municipal waste decreased in 2019: 37% of the total municipal waste was recycled: the EU recycling target for 2025 the target is 55%. Ireland produced 1 million tonnes of packaging waste in 2019, an 11% increase on 2018 (EPA, 2021b). Ireland's Waste Action Plan for Circular Economy includes measures aimed at preventing packaging waste, including restrictions on single use plastics. Ireland generates over 1 million tonnes of food waste annually (EPA, 2020). The commercial sector is responsible for 32% of this food waste (EPA, n.d.). A survey of brown bin use in the commercial sector found that 30% of the businesses surveyed did not use a brown bin (EPA, 2020).
- Soil sealing and land take. Tertiary production land uses are on built land. Built land also includes manufacturing, infrastructural and residential land use. Pressures from built land or urbanisation are discussed separately as they relate to a group of land use types.

Infrastructure

Figure 26: High-level assessment of infrastructure impacts on humans and ecology



Infrastructure as a driver of impacts on water
Indicator category: Environmental condition

Urban run-off accounts for 12% of the pressures on at risk waterbodies in the 2021 Draft RBMP. As urban run-off pressures relate to urban buildings and infrastructure only a portion relates to the services in these areas, so this is discussed separately.

Infrastructure as a driver of impacts on climate and air
Indicator category: Environmental condition

Transport is Ireland's second highest source of greenhouse gas emissions, after agriculture: it accounts for 17.7% of emissions (EPA, 2022a). Road transport is the main source of transport emissions (94% in 2020) (EPA, 2022b). With existing measures, transport emissions are projected to account for 20% of Ireland's emissions by 2030. Existing measures include increased biofuels and the uptake of 556,000 electric vehicles. Existing measures also include the DART expansion and BusConnects programmes to increase public transport capacity in the Dublin area (EPA, 2022b). With additional measures, transport emissions are projected to decrease by 28% from 2020 to 2030. The additional measures scenario assumes incremental increase in biofuels and 944,600 electric vehicles on the road by 2030 (EPA, 2022b).

In 2021, international aviation contributed 1.32Mt CO_2eq: this was lower than previous years, as COVID was still having an impact

on international travel. International aviation emissions averaged 3Mt CO_2eq prior to COVID restrictions, and annual emissions had been rising each year since 2012 (EPA, 2022a)

In Ireland, road transport is the principal source of several air pollutants: nitrogen oxides (NO_X), carbon monoxide, copper, zinc and black carbon emissions (EPA, 2020). Road transport is a significant source of particulate matter (PM), lead, mercury and chromium (EPA, 2020). Poor air quality is associated with long term health implications including chronic asthma, cardiovascular disease and reduced liver function (EPA, 2020).

Ozone is formed when heat and sunlight cause chemical reactions with ozone precursor compounds from transport, e.g. NOx, carbon monoxide. Exposure to high concentrations of ground level ozone can cause chest pains, nausea and coughing in humans. Long term exposure to moderate concentrations can potentially causes a reduction in lung capacity and can worsen heart disease, bronchitis, emphysema and asthma.

Infrastructure as a driver of impacts on nature
Indicator category: Environmental condition

Indicators from four sources have been reviewed: Article 17 Habitats Directive Reports, European Red List of Birds, the International Union for Conservation of Nature (IUCN) Red Lists and fragmentation.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

The Article 17 Habitats Directive habitats assessed in 2019 (NPWS, 2019) identifies roads, paths, railroads and related infrastructure as a high pressure on one of the Article 17 Habitats (petrifying springs).

ii. European Red List of Birds (European Commission, 2022)

The European Red List of Birds identifies the development of infrastructure as one of the drivers of bird population declines observed across Europe

iii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

Infrastructure is specifically identified as a threat that contributes to the decline in:

- Some mammal species via road kills which may play a critical role in local population status. This affects species that are reliant on commuting corridors for dispersal and migration (e.g. otter, pine marten, red squirrel and lesser horseshoe bat) (Marnell *et al.*, 2019)
- Some species of bryophytes rely on wayside trees and clumps of elder which that can be removed for road-widening projects (Lockhart *et al.*, 2012)

iv. Fragmentation

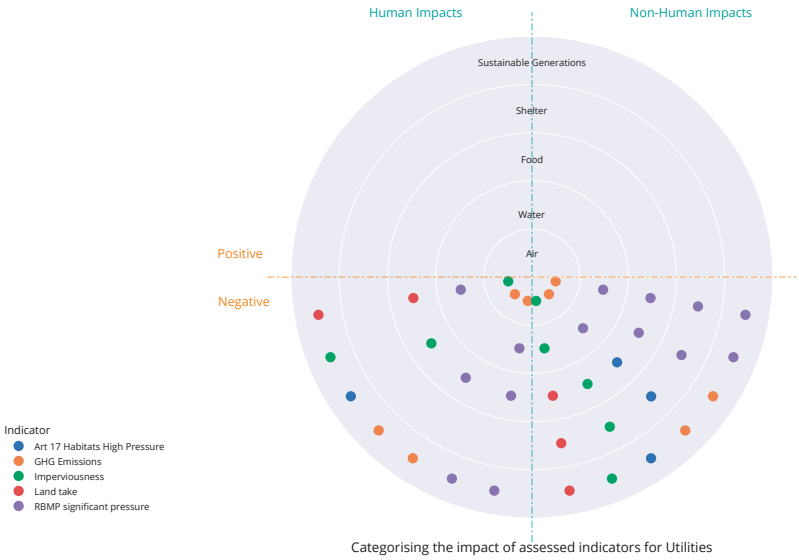
Fragmentation refers to the "break up" of continuous landscape features and/or continuous ecosystems. It has been discussed in Part 1, above.

Other environmental impacts from infrastructure are.

- Statistics on road traffic collisions are collated by the Road Safety Authority (RSA). In 2019 there were 48,843 collisions recorded, in which 5,699 people were injured (RSA, 2022a). There were 137 people killed on Irish roads in 2021 (RSA, 2022b).
- Noise from transport networks is the most widespread source of environmental noise exposure in Ireland (EPA, 2020). Excessive noise is a health risk with impacts on sleep, cardiovascular and metabolic function. Noise modelling in Ireland estimates that 15.6% of the population are exposed to road traffic noise levels over the WHO recommended daytime noise levels.
- Soil sealing and land take. Infrastructure land uses are on built land. Built land also includes manufacturing, tertiary production and residential land use. Pressures from built land or urbanisation are discussed separately as they relate to a group of land use types.

Utilities

Figure 27: High-level assessment of utilities impacts on humans and ecology



Utilities as a driver of impacts on water
Indicator category: Environmental condition

Impacts from urban wastewater (UWW) include nutrient and organic pollution. Poorly treated sewage poses a public health risk by potentially contaminating the source of drinking water supplies, and recreational blue spaces with harmful bacteria and viruses. Urban wastewater is a result of urbanised land use, which is made up of residential, industrial, infrastructure and services land use. This is dealt with separately, below.

While urban wastewater is a result of urbanisation, any poor performance or inadequacy of utilities also contributes to poor water quality. This could be because the urban wastewater treatment plant is not high enough capacity to treat the volume of wastewater or it could be because the plant is not performing as it should. The EPA regulates urban wastewater treatment plants and takes enforcement actions when the wastewater plants breach any of their licensing conditions.

Utilities as a driver of impacts on climate and air
Indicator category: Environmental condition

Waste does not originate from waste treatment plants, but the impact of waste treatment plants is included in this section because different types of waste treatment infrastructure have different environmental impacts. Decreases in the waste sector are mainly due to a decrease in methane emissions from landfill as municipal solid waste is now combusted in Waste to Energy plants rather than in landfills. Increases in the use of composting and anaerobic digestion facilities to treat organic and garden waste results in significantly lower GHG emissions than landfills (EPA, 2022a).

Utilities as a driver of impacts on nature
Indicator category: Environmental condition

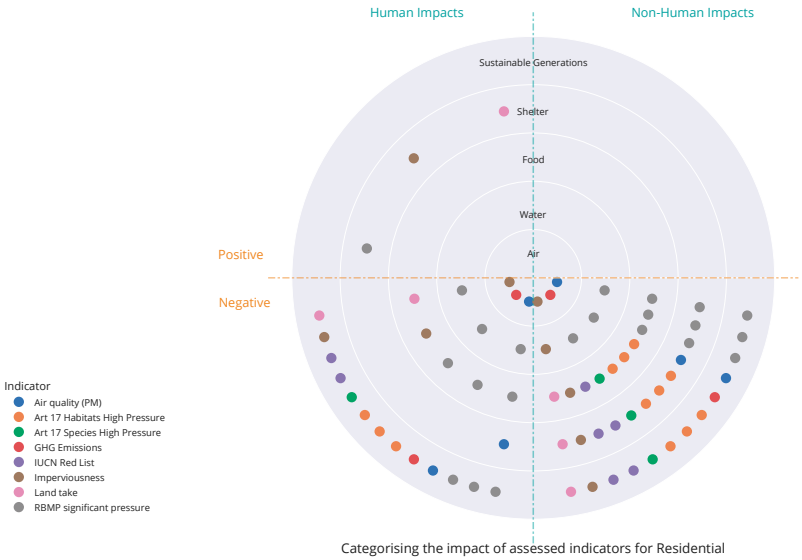
Urban wastewater impacts four of the Article 17 habitats: this is covered under urban pressures, below.

Other environmental impacts from utilities are:

- Electromagnetic fields (EMF) are created around all electrical and telecommunications equipment. International guidelines for public exposure to electromagnetic fields (EMF) are developed and regularly updated by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These guidelines have been endorsed by the World Health Organization (WHO) and the European Commission (EC). According to the WHO, no health effects have been identified for members of the public at EMF exposure levels below ICNIRP's guidelines. The EPA is responsible for monitoring exposure to EMF.
- Soil sealing and land take. Utilities land uses are associated with built land. Built land also includes manufacturing, tertiary production and residential land use. Pressures from built land or urbanisation are discussed separately as they relate to a group of land use types.

Residential

Figure 28: High-level assessment of residential impacts on humans and ecology



Residential land as a driver of impacts on water
Indicator category: Environmental condition

Urban run-off accounts for 12% of the pressures on at risk waterbodies in the 2021 Draft RBMP. As urban run-off pressures relate to urban buildings and infrastructure only a portion relates to the services in these areas, so this is discussed separately.

Domestic wastewater treatment (DWWT) discharges account for 12% of the pressures on at risk waterbodies in the 2021 Draft RBMP. DWWT discharges can come from septic tanks at individual houses or from communal discharges from housing estates that are not treated by a licensed urban wastewater treatment plant.

Hydromorphological modification means change to the physical habitat, and/or a water bodies' natural functioning. Some examples of this include channelisation (the dredging and straightening of rivers), land drainage, or hard infrastructure such as dams, weirs, barriers, locks, embankments, culverts, piers, ports and sea walls. One of the reasons for such modifications in urban areas is to reduce the risk of flooding in residential areas. In this way this practice has a positive impact, but it also negatively impacts the supply of clean water for humans and causes a degradation of the all aspects of the habitat for aquatic life.

Residential land as a driver of impacts on climate and air
Indicator category: Environmental condition

Residential emissions come from space and water heating. Energy efficiency measures (including decreases in coal, peat and kerosene use) lead to a reduction in GHG emissions per household but this historic downward trend has flattened since 2014, indicating a need for increased energy efficiency retrofit activity (EPA, 2022a).

The main source of particulate matter is the burning of solid fuels in homes. Particulate matter can have significant impacts on the respiratory system including – irritation, inflammation and infections, asthma and reduced lung function, COPD and lung cancer. Particulate matter can also have impacts on the central nervous system, cause cardiovascular diseases, irritation of the eyes, nose and throat, and impact on the reproductive system. In recent years there have been breaches of the WHO guideline values in some of Ireland's towns (EPA, 2020).

Residential land as a driver of impacts on nature
Indicator category: Environmental condition

Indicators from four sources have been reviewed: Article 17 Habitats Directive Reports, European Red List of Birds, the International Union for Conservation of Nature (IUCN) Red Lists and fragmentation.

i. Article 17 Habitats Directive Reports (NPWS, 2019)

The Article 17 Habitats Directive habitats assessed in 2019 (NPWS, 2019) identifies built areas as a high pressure on thirteen of the Article 17 Habitats. The specific pressures are:

- Conversion from other land uses to housing, settlement or recreational areas (excluding drainage and modification of coastline, estuary and coastal conditions) is a high pressure on coastal machair habitats (machair are dune grassland habitats unique to north west Ireland and Scotland).
- Sports, tourism and leisure activities are a high pressure on three types of coastal habitats (Atlantic salt meadows, embryonic shifting dunes and marram dunes).
- Modification of coastline, estuary and coastal conditions for development, use and protection of residential, commercial, industrial and recreational infrastructure and areas is a high pressure on four coastal habitats (drift lines, vegetated shingle, embryonic shifting dunes and marram dunes).
- Discharge of urban wastewater (excluding storm overflows and/or urban run-offs) generating pollution to surface or ground water is a high pressure on three freshwater habitats and on two Article 17 freshwater species.

- Residential or recreational activities and structures generating marine pollution (excl. marine macro- and micro-particular pollution) are a high pressure on three coastal habitat types (estuaries, mudflats and large shallow inlets and bays).
- Other modification of hydrological conditions for residential or recreational development are a high pressure on FWPM.

ii. European Red List of Birds (European Commission, 2022)

The European Red List of Birds identifies the development of infrastructure as one of the drivers of bird population declines observed across Europe (European Commission, 2022)

iii. International Union for Conservation of Nature (IUCN) Red List (IUCN, 2021)

Abstraction of water for residential drinking water supply can cause fluctuations in lake water levels impacting on trout and char species (King *et al.*, 2011).

Other environmental impacts from residential are:

- Soil sealing and land take. Infrastructure land uses are on built land. Built land also includes manufacturing, tertiary production and residential land use. Pressures from built land or urbanisation are discussed separately as they relate to a group of land use types.
- Landscape fragmentation (see Part 1, above).

Assessment Part 3: Urbanisation

Some of the indicators outlined in Phase 1 Document 05: Land Use Indicators apply to urban land use types, or land use types that rely on soil sealing.

Urban pressures on water

Urban run-off accounts for 12% of the pressures on at risk waterbodies in the 2021 Draft RBMP (DHLGH, 2021a). Urban run-off is a mixture of sewer leakage, missed connections and water running off paved areas. More frequent and more intense rainfall as a result of climate change will make the management of urban water more challenging: in response, nature based sustainable urban drainage is identified as a key consideration to be included in the RBMP.

Urban wastewater is a significant pressure for 208 of Ireland's 1603 "at risk" waterbodies. This has decreased by 83 waterbodies since the risk characterisation done for the 2018 RBMP. Wastewater from residences and businesses that is not treated (or not adequately treated) can cause pollution by releasing nutrients that lead to excessive and unwanted growth of algae and plants and by depleting oxygen levels in the water. Pollution can also happen if untreated sewage escapes from sewers and pump stations (EPA, 2021d). Untreated, or inadequately treated, wastewater can also impact the quality of bathing water where the presence of E. coli can cause health issues for water users. The 2020 EPA Urban Wastewater report concluded that while there were some positive achievements including an increase in the number of large towns complying with EU treatment standards, wastewater treatment in Ireland was not as good as it needs to be. The report noted repeated delays and lack of a clear timeframe for improvements by Irish Water, and the need to collect information on wastewater collecting systems and risks arising from storm water overflows (EPA, 2021d). The NPWS Article 17 Habitats report identified urban wastewater and storm water overflows as a high pressure on four protected habitats, all freshwater habitat types.

Urban or soil sealing pressures on air

Particulate matter ($PM_{2.5}$) is a mixture of very small particles suspended in the air. PM particles can penetrate deep into the lungs causing health problems. In urban areas, PM originates from residential solid fuel combustion and from emissions from vehicles (EPA, 2022c). Nitrogen dioxide (NO_2) originates from vehicle emissions and is worse in our urban areas, where traffic emissions are most concentrated. EPA monitoring shows that $PM_{2.5}$ and NO_2 are within EU legal limits in Ireland but exceed the World Health Organisation (WHO) Air Quality guidelines for health (EPA, 2022c). While $PM_{2.5}$ and NO_2 levels are strongly related to residential and infrastructure land use, changes to residential fuel types and Ireland's transport model (away from private petrol and diesel vehicles towards active travel and cleaner modes of public transport) bring the possibility to break this link between land use and air pollution.

Urban or soil sealing pressures on nature

Urbanisation and soil sealing destroy or reduce natural habitat areas. If a natural habitat is not destroyed by soil sealing it can be reduced in size or fragmented (see Imperviousness and imperviousness change section, in Part 1 of this report). EU strategies relating to no net land take are important to preserve intact habitats: the potential impact of urban development on habitats can be mitigated by land recycling and densification of urban areas rather than land take from agricultural land, forestry or wetlands.

Summary

- This assessment uses existing indicators to assemble evidence of the environmental characteristics of land use in Ireland. There is an opportunity to develop new indicators or extend existing indicators. More indicator data is needed to assess soil health in Ireland.
- EEA indicators are particularly useful as they offer the ability to compare Ireland's data to other EU member states. While the indicators suggest that soil moisture deficit and fragmentation levels are not as much of a concern in Ireland as they are for other Member States, our fragmentation level was classified as "amber" status in the national biodiversity indicators. Ireland's emissions and projected emissions for GHG from LULUCF are behind EU targets.
- Agriculture, forestry, mining and quarrying and residential land use were all linked to significant pressures on water bodies in the 2021 River Basin Management Plan pressures assessment.
- Greenhouse gas emissions from agriculture, energy transport and residential all increased in 2021.

References

DAFM (Department of Agriculture, Food and Marine). 2015. Forestry Programme 2014-2020: Ireland. Available online: https://www.gov.ie/en/publication/forestry-policy-and-strategy/

(Accessed April 2022)

DHLGH (Department of Housing, Local Government and Heritage) 2021. Draft River Basin Management Plan for Ireland 2022-2027. Available online: https://www.gov.ie/en/consultation/2bda0-public-consultation-on-the-draft-river-basin-management-plan-for-ireland-2022-2027/. (Accessed July 2022).

DETE (Department of Enterprise, Trade and Employment). 2019. Future Jobs Ireland 2019. Available online: https://enterprise.gov.ie/en/publications/future-jobs-ireland-2019.html

EPA (Environmental Protection Agency, Ireland). 2020. Ireland's Environment: An Integrated Assessment 2020. Available online: https://www.epa.ie/our-services/monitoring--assessment/assessment/irelands-environment/state-of-environment-report-/#

EPA (Environmental Protection Agency, Ireland). N.d. Food Waste: https://www.epa.ie/our-services/monitoring--assessment/assessment/irelands-environment/waste/current-trends-waste/ (Accessed August 2022)

EPA (Environmental Protection Agency, Ireland). 2021a. Municipal waste statistics for Ireland. Available online: https://www.epa.ie/our-services/monitoring--assessment/waste/national-waste-statistics/municipal/ (Accessed August 2022)

EPA (Environmental Protection Agency, Ireland). 2021b. Waste packaging statistics for Ireland. Available online: https://www.epa.ie/our-services/monitoring--assessment/waste/national-waste-statistics/packaging/ (Accessed August 2022)

EPA (Environmental Protection Agency, Ireland). 2021c. National Hazardous Waste Management Plan 2021-2027. Available online: https://www.epa.ie/publications/circular-economy/resources/national-hazardous-waste-management-plan-2021---2027.php (Accessed August 2022)

EPA (Environmental Protection Agency, Ireland). 2022a. Ireland's Provisional Greenhouse Gas Emissions Available online: https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-provisional-greenhouse-gas-emissions-1990-2021.php

EPA (Environmental Protection Agency, Ireland). 2022b. Ireland's Greenhouse Gas Emissions Projections 2021-2040 Available online: https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-greenhouse-gas-emissions-projections-2021-2040.php

EPA (Environmental Protection Agency, Ireland). 2022c. Air Quality in Ireland Report 2021. Available online: https://www.epa.ie/publications/monitoring--assessment/air/air-quality-in-ireland-2021.php (Accessed September 2022)

EPA (Environmental Protection Agency, Ireland). 2022d. Water Quality in Ireland 2016 - 2021. Available online: https://www.epa.ie/publications/monitoring--assessment/freshwater--marine/WaterQuality_SummaryReport.pdf

EC (European Commission). 2022. European Red List of Birds 2021: Compiled by BirdLife International. Available online: https://www.birdlife.org/wp-content/uploads/2022/05/BirdLife-European-Red-List-of-Birds-2021.pdf (Accessed July 2022)

European Commission, European Environment Agency (EEA), 2020a. Long term soil moisture and soil moisture trends. Available online: https://www.eea.europa.eu/data-and-maps/figures/long-term-average-soil-moisture (Accessed January 2022)

European Commission, European Environment Agency (EEA). 2020b. Soil Moisture Dashboard. Available online: https://www.eea.europa.eu/data-and-maps/data/data-viewers/soil-moisture (Accessed October 2022)

European Commission, European Environment Agency (EEA). 2020c. National summary dashboards – Birds Directive – Art.12. Available online https://www.eea.europa.eu/themes/biodiversity/state-of-nature-in-the-eu/article-12-national-summary-dashboards (Accessed August 2022)

European Commission, European Environment Agency (EEA). 2021a. Soil Moisture Deficit Indicator. Available online: https://www.eea.europa.eu/ims/soil-moisture-deficit. (Accessed September 2022)

European Commission, European Environment Agency (EEA). 2021b. Vegetation Productivity and land use 2000-2018. Available online: https://www.eea.europa.eu/data-and-maps/dashboards/vegetation-productivity-and-land-use (Accessed September 2022).

European Commission, European Environment Agency (EEA), 2021c. Significant vegetation productivity trends 2000-2016. Map available via map server: https://land.discomap.eea.europa.eu/arcgis/services/Phenology/Productivity_2000_2016_significant_change (Accessed January 2022)

European Commission, European Environment Agency (EEA), 2022a. Imperviousness and imperviousness change in Europe. Available online: https://www.eea.europa.eu/ims/imperviousness-and-imperviousness-change-in-europe (Accessed October 2022)

European Commission, European Environment Agency (EEA), 2022b. Greenhouse gas emissions from land use, land use change and forestry in Europe. Available online: https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-land (Accessed October 2022)

Eurostat. 2022. Sustainable development in the European Union. Monitoring report on progress toward the SDGs in an EU context. Available online: https://ec.europa.eu/eurostat/documents/3217494/14665254/KS-09-22-019-EN-N.pdf/2edccd6a-c90d-e2ed-ccda-7e3419c7c271?t=1654253664613 (Accessed October 2022).

Department of the Environment, Climate and Communications (DECC) 2022. Sustainable Development Goals Policy Map 2022. Available online: https://assets.gov.ie/236606/471a20e3-165f-4c7d-acd2-1576e95b1e00.pdf (Accessed October 2022).

Government of Ireland. 2021 Climate Action Plan 2021. Available online: https://assets.gov.ie/203558/f06a924b-4773-4829-ba59-b0feec978e40.pdf

The Ireland Walking Guide, Upland areas in Ireland. 2015. Available online: https://www.theirelandwalkingguide.com/upland-areas.html#Criteria

The Ireland Walking Guide. N.d. Upland areas, mountain ranges and summits. https://www.google.com/maps/d/viewer?mid=1ook-LfAzALI4DH_ZDh7qKKaA2OGiEZDs&ll=52.99512118796089%2C-5.937666314510692&z=10

King, J.L., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J.M., FitzPatrick, Ú., Gargan, P.G., Kelly, F.L., O'Grady, M.F., Poole, R., Roche, W.K. & Cassidy, D. (2011) Ireland Red List No. 5: Amphibians, Reptiles & Freshwater Fish. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland. Available online https://www.npws.ie/sites/default/files/publications/pdf/RL5.pdf

Lockhart, N., Hodgetts, N. & Holyoak, D. (2012) Ireland Red List No.8: Bryophytes. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland. Available online: https://www.npws.ie/sites/default/files/publications/pdf/RL8.pdf

Marnell, F., Looney, D. & Lawton, C. (2019) Ireland Red List No. 12: Terrestrial Mammals. National Parks and Wildlife Service, Department of the Culture, Heritage and the Gaeltacht, Dublin, Ireland.

Moorkens, E., Cordeiro, J., Seddon, M.B., von Proschwitz, T. & Woolnough, D. 2017. Margaritifera margaritifera (errata version published in 2018). The IUCN Red List of Threatened Species 2017: e.T12799A128686456. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T12799A508865.en. Accessed on 17 August 2022.

National Biodiversity Data Centre (NBDC). 2021. National Biodiversity Indicators. https://indicators.biodiversityireland.ie/ (Accessed October 2022)

NPWS (National Parks and Wildlife Service). 2019. The Status of Protected Habitats and Species in Ireland. Volume 1: Summary Overview. Unpublished report. NPWS, Dublin. Available online: https://www.npws.ie/sites/default/files/publications/pdf/NPWS_2019_Vol1_Summary_Article17.pdf (Accessed July 2022).

Ordnance Survey Ireland (OSI), Central Statistics Office (CSO). N.d. Ireland's hub for Sustainable Development Goals. https://irelandsdg.geohive.ie/ (Accessed October 2022).

Ordnance Survey Ireland (OSI). 2019. SDG 15 Life on Land Indicators datasets. Available online: https://irelandsdg.geohive.ie/search?groupIds=d8ab902405a1459b89109cd27ee6d0fb

Regan, E.C., Nelson, B., Aldwell, B., Bertrand, C., Bond, K., Harding, J., Nash, D., Nixon, D., & Wilson, C.J. (2010) Ireland Red List No. 4 – Butterflies. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Ireland.

RSA (Road Safety Authority). 2022a. Road Casualties and Collisions in Ireland 2019. Tables – Provisional. Available online: https://www.rsa.ie/docs/default-source/road-safety/r2---statistics/road-collision-annual-reports/road-casualties-and-collisions-in-ireland-2019.pdf?Status=Master&sfvrsn=a6dcadd8_3 (Accessed August 2022)

RSA (Road Safety Authority). 2022b. 2021 Road Safety Review Infographic. Available online: https://www.rsa.ie/docs/default-source/road-safety/r2---statistics/provisional-reviews/2021-road-safety-review-infographic.pdf?Status=Master&sfvrsn=766622df_3 (Accessed August 2022)

Teagasc, 2019. An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030. Prepared by the Teagasc Greenhouse Gas Working Group, Gary J. Lanigan & Trevor Donellan (eds). Teagasc. https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf

Other reports in the series:

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Phase 1 Document 04: Land Use Policy Catalogue (Appendix)

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