



Wildwork

HELPING PEOPLE HELP NATURE HELP PEOPLE

Wild Work, Climate Change and Amenity Grassland Management

*In terms of the climate crisis, what benefits can be gained
from changing how we manage public green spaces*

Structured Learning Placement - Research Project Report

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Wild Work is an initiative of SECAD Partnership

SECAD  PARTNERSHIP



Contents

Background on this Research Project Report	3
<i>Executive Summary</i>	3
<i>Introduction</i>	6
About Wild Work	6
Wild Work's Social Ethos	6
How We Manage Our Landscape	7
Ecosystem Services	7
The Potential of Green Spaces	8
<i>What is Amenity Grassland?</i>	10
Ways to Manage Grassland for Biodiversity	10
<i>Wild Work Approaches to Adapting Amenity Grassland Management</i>	11
Approach 1 - Pollinator-Friendly Lawn Management	12
Approach 2 – Meadow Lawn Management	13
<i>Key Aspects of Climate Change and Biodiversity Loss</i>	15
What is Biodiversity?	15
How are the Global Climate Change and Biodiversity Crises Related?	15
How is Ireland Tackling Climate Change and Biodiversity Loss?	16
Mitigating Climate Change in Ireland via Carbon Sequestration	19
The Potential for Green Spaces to be used for Carbon Sequestration	21
The Carbon Cost of Lawn Management	22
Case Study: Cork Airport	23
<i>Management Effects on Reducing Emissions</i>	25
Approach 1- Pollinator-friendly Lawns	25
Approach 2- Meadow Lawns	25
<i>Management Effects on Carbon Sequestration</i>	26
Current Research	26



Limitations with the Current Research	28
<i>Other Potential Benefits to Wild Work Approaches</i>	29
Changing Attitudes	29
<i>Knowledge Gaps and Future Research</i>	31
Conclusion	32
References	33
Figure References	39
Appendix	40

Table 1: Summary of Wild Work’s two main approaches to managing amenity grassland for biodiversity .. 14

Figure 1: Breakdown of Ireland’s greenhouse gas emissions. Source: EPA, 2019 17

Figure 2: Diagram showing the carbon sequestration cycle in grassland. Source: Created by Rachel Hayden
 19

Figure 3: Breakdown of Ireland’s land use cover and average carbon sequestration rates (CS). Source:
 Created by Rachel Hayden 20

Picture 1: An abandoned site being reclaimed by nature. Source: Rachel Hayden, August 2020 9

Picture 2: A wildflower meadow. Source: Wild Work, 2020 9

Picture 3: A public park with both amenity grassland (pathway) and meadow lawn (tall grasses). Source:
 Rachel Hayden, July 2020 10

Picture 4: Meadow grassland. Source: Rachel Hayden, July 2020 10

Picture 5: Showing approach 1 and 2 together; driveway managed as pollinator-friendly lawn with verge
 managed as meadow lawn. Source: Wild Work, August 2020 11

Picture 6: Pollinator-friendly lawn in the foreground with conventional amenity grassland in the
 background Source: Wild Work July 2020 12

Picture 7: Roadside lawn with the back section of it by the wall managed as Meadow Lawn Source: Wild
 Work, July 2020 13

Picture 8: Pollinator friendly meadow established at Cork Airport with conventional amenity lawn in the foreground. Source: Wild Work, 201923

Picture 9: Pollinator friendly meadow establishing in the foreground with conventional amenity lawn in the background divided by a fence outside Cork Airport terminal 1. Source: Wild Work, 201823

Picture 10: Close up of Wildflowers Growing in the Established Meadow. Source: Wild Work, 2020.....24

Appendix 1: Infographic of Wild Work’s Pollinator Project. Source: Wild Work, 202040

Background on this Research Project Report

This report is the result of a student project conducted by Rachel Hayden during a structured learning placement with Wild Work as part of a [Masters in Ecological Management and Conservation Biology](#) at Queens University Belfast.

The project was agreed by the student, SECAD’s Wild Work initiative and the School of Biology, Queen’s University Belfast.





Executive Summary

How we manage our landscape is a significant factor in terms of climate change, and as such, Wild Work wants to learn more about the climate change impacts associated with biodiversity-friendly approaches to grassland management.

In the context of what's happening in Ireland, this report summarises a broad range of current literature related to climate change and amenity grassland management; with regard to Wild Work approaches, reducing emissions and absorbing carbon from the air through carbon sequestration in soil and vegetation.

Wild Work generally advocates two main approaches that can be taken in adapting the management of amenity grasslands, such as lawns and other green spaces, for the benefit of biodiversity: Pollinator-friendly Lawn Management and Meadow Lawn Management. Both approaches benefit pollinators, such as bees and butterflies and also other wildlife. In adopting either of these two approaches, amenity grassland becomes less intensively managed, (i.e. less mowing and no pesticide and fertiliser input).

Reduced mowing and other factors associated with Wild Work grassland management approaches can result in at least a 50% reduction in carbon emissions.

Understanding how emissions are created from different approaches to landscape management is half the battle in tackling climate change impacts associated with land use management, the remainder is in understanding how our actions affect the relationship between climate and biodiversity. Ecosystems, and biodiversity within, are vital in tackling the climate change crisis. The natural environment lessens the impact felt from extreme weather events and offsets greenhouse gas emissions, but climate change in turn is disrupting biodiversity and the natural environment's ability to protect humankind from these impacts. According to a large body of research, climate change and biodiversity loss are global crises that must be addressed together to stem the decline of plant and animal species as well as reduce the impacts of climate change on the planet.

Coupled with work that is happening regionally and in local communities, national plans such as the All-Ireland Pollinator Plan 2015-2020 and Ireland's Biodiversity Action Plan 2017-2020 are working to restore natural habitats. The All-Ireland Pollinator plan, with help from initiatives like Wild Work, has set in motion the development and restoration of pollinator-friendly lawns and meadows throughout Ireland. Ireland has the potential to offset some of our greenhouse gas emissions by developing carbon management practices



for grassland and other habitats. Cities and other urban areas could aid climate mitigation measures by optimising on carbon sequestration in green spaces.

Research predominantly from the US and Scandinavia, investigating the impact grassland management has on increasing carbon sequestration rates shows that inputs such as fertilisers and grass clippings increase lawn productivity which in turn increase carbon sequestration. Although it is true that inputs can help increase carbon sequestration under some conditions, it is worth bearing in mind that the methods used can also create a large amount of greenhouse gas emissions too. Low emission alternatives to chemical fertilisers, such as composting or mulching of clippings, have been shown to increase carbon sequestration in amenity lawns. However, compost and grass clippings are not suitable treatments for biodiversity focused lawns as they can create conditions where wildflowers become out competed by grasses.

More research is needed to fully understand the effect various management treatments have on carbon sequestration rates in different grassland lawns cognisant of the need to also enhance biodiversity as part of the process.



Introduction

About Wild Work

Wild Work is an initiative of SECAD Partnership CLG, developed in response to a need identified by SECAD from years of experience supporting environmental projects in local communities. Wild Work supports everyone committed to helping nature. The initiatives primary focus is to connect business, biodiversity, and local communities. Wild Work also supports the work of local and national organisations involved in the conservation and protection of our natural environment. With practical expertise, Wild Work helps people create and care for meadows, woodlands, beaches, rivers, and other natural habitats, in urban and rural settings. Wild Work strives to work in line with best practice; working with nature and not against; and values research as a key component of their work. Wild Work's aim is to understand the bigger picture, to help people do the right thing.

Wild Work supports: businesses big and small; local community groups and individuals; schools and colleges; local authorities and other state bodies; farmers; and other conservation organisations and charities.

Wild Work's Social Ethos

To benefit society and nature;

Wild Work fosters people's good will to ensure local flora, fauna and habitats are protected, valued and enhanced. Wild Work wants people who connect with the Wild Work movement to benefit positively in terms of improved health and well-being.

To educate and raise awareness;

Wild Work follows a place-based approach, working with nature and the environment in a positive way to have a real and practical impact on environmental issues; because increasing people's awareness, respect and understanding, helps them care more effectively for our natural world.



How We Manage Our Landscape

The key to maintaining biodiversity is by protecting and managing spaces for nature conservation. Adapting the ways in which we manage our landscape and ecosystems is necessary to stem the loss of biodiversity and the degradation of habitats¹. Targeted actions such as the All-Ireland Pollinator Plan 2015-2020 are designed to implement measures that change how we manage the landscape for biodiversity. How we manage our landscape is also a significant factor in the amount of greenhouse gas emissions produced, which in turn influences climate change^{2,3}.

The All-Ireland Pollinator Plan is supported by over 68 government and non-government organisations - including SECAD and the Wild Work initiative⁴. The plan aims to raise awareness on the decline of bees, butterflies, and other pollinators in Ireland and to create and maintain pollinator-friendly grassland and meadows in support of pollinators⁵(Appendix 1). Wild Work's Pollinator Project actively works toward these goals in helping communities develop wildflower corridors to connect patches of pollinator-friendly grassland throughout Cork and beyond⁶. As part of their work, Wild Work also maintains a number of amenity grassland sites.

The Pollinator Project and similar conservation actions have a huge impact on biodiversity and the wider ecosystem through a chain of positive effects. Establishing wildflower meadows not only increases plant and animal abundance and diversity, but also helps restore the health of our ecosystem through enabling ecosystem service functions^{5,6}.

Ecosystem Services

Ecosystem services are the goods and services derived, indirectly or directly, from natural processes⁷. Ecosystem services can take place both on a local and global scale. Water, food, raw materials, and medical resources are some of the material benefits we derive from provisional services^{7,8}. We also benefit from cultural services such as beautiful scenery, wildlife watching, or resources such as wind and waves for recreation⁹; these are non-materialist but contribute to human health and wellbeing^{9,10}. Regulatory services



are also non-materialistic but focus on maintaining or controlling ecological processes in ecosystem services such as water and air quality, soil quality, pollination, and biological control⁸.

Climate regulation is a major regulatory ecosystem service that we depend on to protect us from the impacts of climate. Ecosystems and living organisms can create physical buffers against extreme weather events such as tsunamis, storms, heatwaves, and floods⁸. Ecosystems help reduce the impact felt from climate change. Additionally, ecosystem services regulate chemical processes on Earth by cycling carbon, oxygen, nutrients and water through the atmosphere and terrestrial biomes inclusive of the land, ocean and living organisms⁸.

Biodiversity is a key element in climate regulation. A healthy ecosystem with a diversity of plant and animal species is able to optimise ecosystem functions and services, in turn, optimising climate control. Biodiversity influences and is influenced by climate. Biodiversity is being impacted by climate change along with a number of other significant issues resulting in the loss of global and local biodiversity; all of which effects ecosystems capacity to mitigate climate change¹.

The Potential of Green Spaces

All around us there are numerous natural places that are not being used to their full potential. Wild Work recognises the capacity green spaces can have for supporting biodiversity¹¹, especially in urban areas typically characterised by low biodiversity when compared to surrounding countryside¹². Amenity lawns cover a significant part of urban areas, including both public and private¹³. Research has shown the plethora of benefit biodiversity gain from establishing green spaces in cities¹⁴, with functions such as microclimate regulation and human-wellness¹⁵. Gardens can decrease energy use within buildings by cooling air temperature in the summer and reducing drafts in the winter; and they also help prevent flooding¹⁶. Gardens and lawns can also be home to a considerable range of animals that have adapted to live in urban areas such as solitary bees, hoverflies, bumblebees, and small and larger mammals¹⁷.



Wild Work is inspired by the range of benefits urban green spaces can have for animals and humans, and as such, wants to take advantage of green spaces to enhance biodiversity. Within urban settings there are other areas, outside of designated green spaces, that can also be changed to improve nature and the visual surroundings. Places like road verges, abandoned lots and unused industrial areas can be transformed into wild places to benefit people and nature¹⁸.



Picture 1: An abandoned site being reclaimed by nature. Source: Rachel Hayden, August 2020



Picture 2: A wildflower meadow. Source: Wild Work, 2020



What is Amenity Grassland?

Amenity grassland is frequently mowed lawn, managed for human recreational use¹⁹. Examples include sports facilities, like golf courses and sport pitches, and public or private lawns, gardens, and parks. Amenity grassland is typically associated with high intensity grassland management techniques, including frequent mowing anywhere from 20-30 cuts in a growing season and large amounts of inputs, such as, irrigation, fertiliser, and a range of pesticides¹⁸. Overall, this management style is thought to decrease biodiversity by increasing monoculture grassland⁵. Sown amenity grasslands, such as meadows and pollinator lawns, can support more plant and animal diversity than mown grassland¹⁹. Community composition can be different between both sites, creating a mosaic of habitats which is better for biodiversity¹⁹.



Picture 3: A public park with both amenity grassland (pathway) and meadow lawn (tall grasses). Source: Rachel Hayden, July 2020

Ways to Manage Grassland for Biodiversity



Given the diversity of green spaces and grassland habitat types, it is important to acknowledge the variety of management techniques used for non-agricultural grassland and the influence management techniques can have on biodiversity. Biodiversity will benefit more from having a range of urban green spaces, such as amenity grassland and urban meadows, to maximise natural resources such as plant forage and shelter diversity¹⁹.

Picture 4: Meadow grassland. Source: Rachel Hayden, July 2020



Wild Work Approaches to Adapting Amenity Grassland Management

When it comes to what can we do with amenity grassland, Wild Work generally advocates two main approaches in which amenity grassland management can be adapted to enhance biodiversity: Pollinator-friendly lawns and meadow lawns. Pollinator-friendly lawns and meadow lawns typically have a higher ratio of wildflowers to grass species^{5,20}. By having a high functional diversity and density of wildflowers in a small area, both of these approaches can support a greater range of pollinators and other wildlife by providing a variety of food and energy sources^{5,21}.

If possible, alternative tools (hand clippers, scythe) should be used in place of gasoline powered tools (such as lawn mowers). Grazing animals are also definitely worth considering where appropriate. Moving away from the usage of powered equipment will further reduce emissions and disturbance factors for pollinators and other wildlife²².



Picture 5: Showing approach 1 and 2 together; driveway managed as pollinator-friendly lawn with verge managed as meadow lawn. Source: Wild Work, August 2020



Approach 1 - Pollinator-Friendly Lawn Management



Picture 6: Pollinator-friendly lawn in the foreground with conventional amenity grassland in the background Source: Wild Work July 2020

Pollinator-Friendly lawn management reduces the typical conventional amenity lawn mowing regime by half. Pollinator-friendly Lawns should only be cut 10-15 times a year, and ideally not when flowers are in full bloom. Lawn height should not exceed 150 mm and should be cut to a height of 10mm-50 mm. The approach prevents wildflowers such as clovers and dandelions from being out competed by grass species²³.

Additionally, no fertiliser or pesticides should be used, and all grass clippings should be removed and composted elsewhere. Fertilisers should not be applied as they can unbalance the natural nutrient balance in the soil^{5,20,23}. Pesticides should not be applied as they harm a range of pollinators and other insects as well as reduce “weeds” that are actually very beneficial for pollinators^{23,24}.



Approach 2 – Meadow Lawn Management



Picture 7: Roadside lawn with the back section of it by the wall managed as Meadow Lawn Source: Wild Work, July 2020

When conventionally managed amenity grass is allowed to grow long, the resulting landscape is considered meadow. There are many types of meadows, from hay meadows to wildflower meadows, but what they all have in common is that the way they are managed will influence the type of meadow you will have²³. Unlike wildflower lawns, meadows should generally only be cut once a year in late autumn to help maintain a diversity of grasses and wildflowers²³. Additional cuts can be done at other times of the year and this can result in more diversity in terms of flowering throughout the growing season. However, additional cuts will also take more effort. Aside from the differences with the mowing, all other management applied to pollinator lawns should be applied to meadows, including removing clippings and not using fertiliser or pesticides. Although not necessary, a border of grass can be kept short around the meadow edges to have a neater appearance and pathways can be cut into the taller grassland to allow people to walk amongst nature²³.



Table 1: Summary of Wild Work's two main approaches to managing amenity grassland for biodiversity

Approach	Pollinator-friendly Lawn	Meadow lawn
Fertiliser	Fertiliser should not be used at all.	
Pesticides	Pesticides should not be used at all, inclusive of edges, borders and around tree bases.	
Management	Approximately 10-15 cuts annually dependant on seasonal growth rates.	One cut annually. This is best done in mid-late autumn.
	(Each cut 10 to 50mm)	Additional cuts can done at other times of year and this can result in more diversity in terms of flowering throughout the growing season. However, additional cuts will also take more effort.
	Lawn height should not exceed 150mm	
	Ideally, lawns should not be cut while in full flower. Overtime, experience-based judgement can be applied in deciding when to cut.	
	All grass clippings to be removed (to keep down fertility and help wildflower species compete with existing grasses).	
	Within lawns, Grass can be allowed to grow around tree bases in an attractive circular shape to be maintained by the mower, up to 50 cm from the tree base, or less as desired; and manually removed once a year.	
	Though not entirely necessary, if desired, a neat border of grass kept constantly short can be maintained around lawn edges to have a neater appearance.	
	Use alternative tools (hand clippers, scythe) to fossil-fuelled lawnmowers when cutting if possible.	
	Lawns should be monitored for pollinators and to see what diversity of flowers will emerge because of new management system.	
	Native low-growing wildflower seed can be broadcasted on the lawn as a way to increase the species diversity. Best to wait for at least one year before deciding to do so.	

Key Aspects of Climate Change and Biodiversity Loss

What is Biodiversity?

Biodiversity is a shorthand way to describe 'biological diversity' and refers to all the different types of species or living things in a given place; and the amount of those living things in that place also. Therefore, increasing biodiversity in Ireland is to increase the diversity and amount of life in Ireland. Typically, when people speak about biodiversity, they aren't speaking about humans, but humans are a species just the same as everything else and therefore we are part of biodiversity too (Wild Work 2020, *personal communication*, 17th August).

How are the Global Climate Change and Biodiversity Crises Related?

In 2019, Ireland declared both a climate and biodiversity emergency²⁵.

The relationship between climate change and biodiversity is complex. Climate change influences and is influenced by biodiversity and this is observed in the increasing rate of climate change and biodiversity loss²⁶. Climate has changed multiple times in the past and with-it various plants and animals have come and gone. But what is different with the current situation is just how quickly the Earth's temperature is increasing. Historically, Earth's global temperature took over 5,000 years to rise by 4 -7 °C, but in the past 200 years alone global temperature has increased by 1.1 °C and is estimated to continue increasing by 0.2 °C every 10 years^{27,28}. With this in mind, global temperature is predicted to be 2 – 6 °C higher than our current average in the next 100 years. Warmer temperature causes more extreme weather events such as wildfires, droughts, and floods²⁹. Most of us have already experienced the impact of climate change in some form or another, and those same weather events are also felt by our natural environment. Many plants and animals are displaced from their home range due to the effects changing weather conditions have on the availability of food, shelter and breeding grounds. If a species cannot relocate for one or another reason (physical barriers, immobility, specialised diet, life cycle requirements, environmental requirements), then they may go locally extinct, causing a decline in biodiversity^{30,31,32}

Furthermore, biodiversity has the challenging role of adjusting to new environmental conditions in order to be resilient to climate change. This is a particularly difficult task as climate is altering at a rate often too fast for many species to keep up with, thus leading to further biodiversity loss. It is now accepted that over 1 million plants and animal species around the world are threatened with extinction and climate change is a



major contributor³¹. Climate change and biodiversity loss are a symptom of how mankind is treating the world. We produce excess greenhouse gases from burning fossil fuels and alter the natural landscape which removes a variety of habitats, including important connecting corridors between habitats^{31,33,34}. Shifts in weather conditions and reduced natural habitats results in higher biodiversity loss, as species cannot easily relocate to more suitable habitats. However, changes in our climate also enable a few species to spread into new areas and become more abundant³¹. This could have good and bad consequences for biodiversity; the economy and agriculture; disease and pest control. For example, rising temperatures will allow northern regions to grow more cereal and fruits but will hinder the same crop production in already warm regions of the world³⁵.

The decline of habitats and species can dramatically affect ecosystem functions and services that help protect us from the impacts of climate change^{8,26,31}. Ecosystems have a key role in regulating climate. It has been shown that entire ecosystems and habitats can reduce the effects of climate change by removing carbon from the atmosphere and reducing physical weather impacts. For example, mangroves and coral reefs can block the worst of waves hitting a shore, reducing the impacts of tsunamis and storms; forests and plants can cool the air temperature around them reducing urban heat island effect; permeable surfaces like soils can reduce the severity of floods by becoming water saturated and filtering water slowly⁸. These are just some example of how nature protects us. In terms of biodiversity loss it's not necessarily all bad, as some habitats like mangroves are increasing due to global warming, but if the diversity of plants and animals continues to decline than we are losing our greatest ally in the fight against climate change^{26,36,37,38}.

The impacts of climate change on biodiversity have been well documented around the world, but there are still limitations in our understanding of the timeframe and how climate change will disrupt biodiversity; and then how biodiversity will respond in turn. It is our job to enable nature to adapt to new environmental conditions by helping restore the balance between climate and biodiversity. This can be done by reducing human contributions to climate change and through our efforts to enhance biodiversity.

How is Ireland Tackling Climate Change and Biodiversity Loss?

Carbon dioxide is the most man-made and long-lasting greenhouse gas³⁹. As such other gases are scaled to the impact of carbon dioxide when discussing their effect on climate change and added together to calculate how much CO₂ would be needed to have the same impact (or CO₂ equivalent)^{39,40}. Greenhouse gas emissions

can be calculated for an entire country, activity, lifestyle, or item – this is a carbon footprint which considers all greenhouse gas emissions produced at every step in the supply chain and utilisation⁴¹. Carbon footprints are used to compare greenhouse gas emissions from various sectors which enables emissions to be offset by actively taking carbon out of the atmosphere or reducing our energy use. For example, for a single passenger an economy return flight from London to Hong Kong has an estimated carbon footprint of 3.4 tonnes CO₂e⁴². This is the equivalent to the carbon footprint of 340,000 disposable plastic carrier bags⁴². By recycling just over 1 tonne of mixed recyclables (e.g. paper, metal, plastics), more than 3 tonnes of CO₂e can be offset⁴³.

In 2018, Ireland’s greenhouse gas emissions were 60.93 million tonnes (Figure 1)⁴⁴. For each person this equates to a carbon footprint of 13.3 tonnes CO₂e, the third highest emissions per capita in Europe⁴⁵. This does not mean that each person creates this much carbon output, but as a country we must try much harder to reduce national emissions where possible. By taking early action to combat climate change, we are putting ourselves in a better position to protect and enhance Irish biodiversity. This is vital as over 14% of the Island’s plant and animal species are classified as under threat of extinction, including over 1/3 of all bee species, 202 bird species and one of the few amphibians native to Ireland - the Natterjack toad⁴.

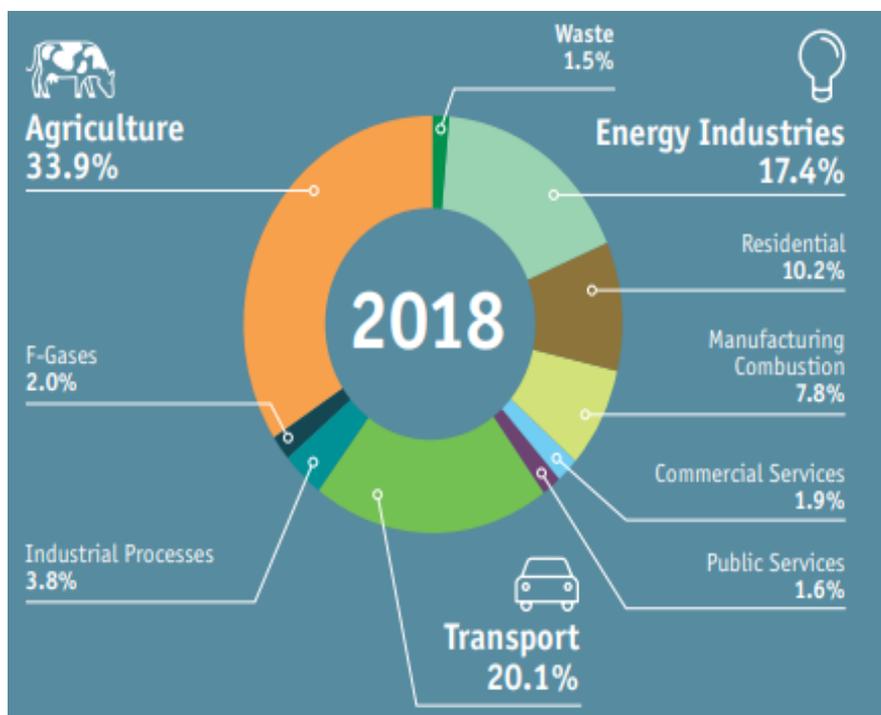


Figure 1: Breakdown of Ireland’s greenhouse gas emissions. Source: EPA, 2019

In response to climate change, Ireland has signed up to multiple international climate agreements such as the Kyoto protocol, the Paris Agreement, and the EU Sharing Agreement with the intention of reducing national greenhouse gas emissions^{3,46}. One of the targets is to reduce greenhouse emissions created from homes, cars, agriculture, and small businesses (non-trade emissions) by 20% by 2020⁴⁷. Another is for Ireland to become net zero for carbon emissions by 2050⁴⁸. This means any man-made carbon emissions will be offset by reducing national energy use, using alternatives to fossil fuel and by enhancing carbon capture from the atmosphere, also known as carbon sequestration^{47,48}.

In 2019, Ireland became the second national government, after the UK, to declare a climate emergency which acknowledges the connection between climate change and biodiversity loss²⁵. With the declaration of a climate emergency comes a climate action plan which falls in line with the Paris Agreement and will set out to: better understand the interactions between climate change and biodiversity; protect, restore and enhance biodiversity to increase the resilience of natural systems to climate change; enhance and increase landscape connectivity in the face of restricted movement; and increase monitoring to quantify the effects of climate change²⁵. Additionally, Ireland established a new National Biodiversity Action Plan 2017-2021 which set out new biodiversity targets with climate change being a significant factor¹. One of the objectives is to support national and local projects, such as the All-Ireland Pollinator Plan, to implement on the ground action to enhance nature and raise awareness through education¹.

Unfortunately, up until this point we have had minor success in meeting the international targets agreed for 2020 (with emissions set to be only be 4-6% below 2005 levels)⁴⁹, but that does not mean that Ireland cannot meet future targets. New national targets came into effect at the start of 2020 and aim to reduce Ireland's greenhouse gas emissions by 30% by 2030⁴⁷. While most efforts to offset greenhouse gas emissions have focused on reducing activities that produce greenhouse gas emissions (or finding fossil fuel alternatives), there is a lot of potential in the earth itself to offset emissions. The term 'carbon sequestration' refers to the process of transferring carbon dioxide from the atmosphere to land and is synonymous with the act of changing landscape management practice to add extra organic carbon to soil and vegetation⁵⁰. With new targets to meet, Ireland is allowed to offset 5.6% of national emissions through carbon sequestration⁴⁶. Capturing carbon is not a silver bullet to solving climate change but it is a complimentary action in reducing carbon emissions.

Mitigating Climate Change in Ireland via Carbon Sequestration

There are five major carbon sink sources that remove excess carbon dioxide: atmosphere, ocean, organic soils (peatland, bogs), vegetation, and mineral soil⁵¹. Globally, soil and vegetation stores roughly three times the amount of CO₂ present in the atmosphere - 74% of which is held in soil⁵². Vegetation captures CO₂ through photosynthesis which is converted to sugars and stored in the shoot or root of a plant. When a plant dies it breaks down into humus in the upper soil layer which is composed of organic carbon⁵³ (Figure 2).

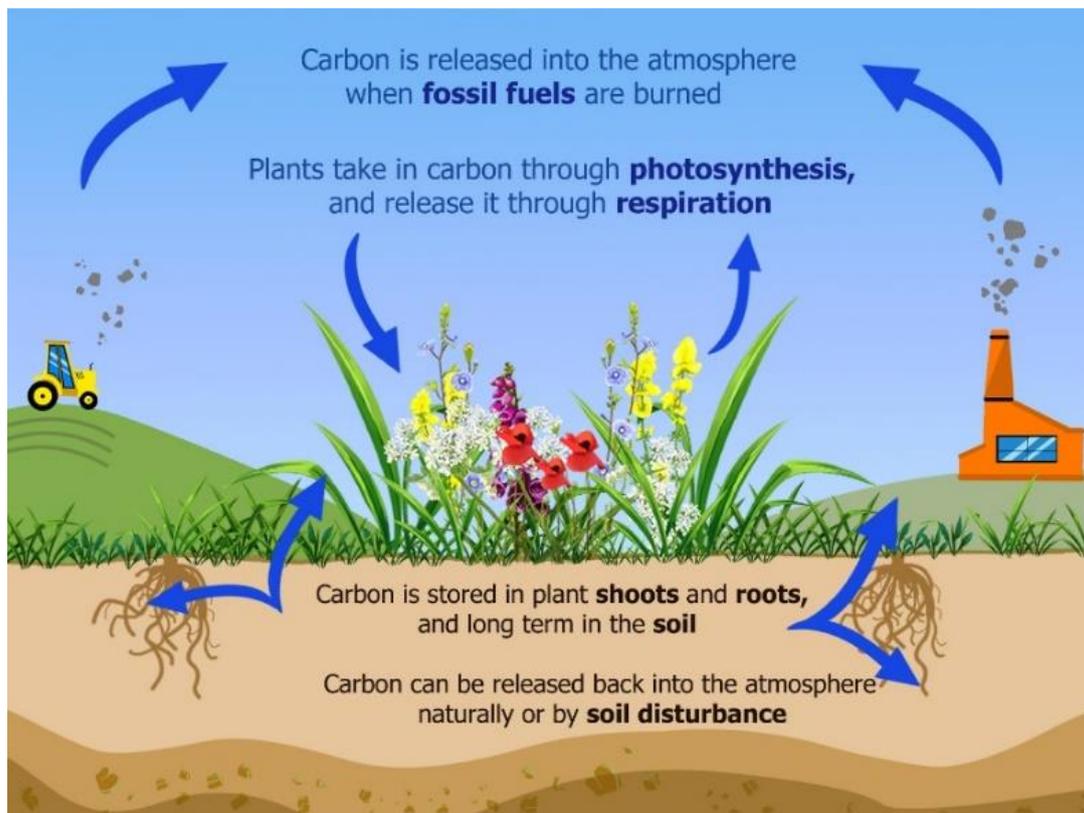


Figure 2: Diagram showing the carbon sequestration cycle in grassland. Source: Created by Rachel Hayden

Across Europe, grassland sequesters more carbon in soil than woodland sequesters in soil. However, this may in large be due to the fact that trees store more carbon in their woody tissue than in the soil underneath⁵⁴. A single tree can capture as much carbon (or more) as one hectare of grassland in a year⁵⁵. Hedgerows and shrubs can also sequester the same amount of carbon as grassland over the same land area and have been shown to increase carbon storage the bushier they grow^{46,56}. In Cork alone, mature hedgerows, individual trees, and non-forest woodland cover 57,000 hectares (140,850 acres)⁵⁷. Woody plants are great for carbon capture, but trees release high amounts of carbon when deforested or burned⁵⁸. Irish grassland has huge potential to be a major carbon sink as Ireland has one of the largest grasslands covers in Europe at over 60% land use⁵⁹ (Figure 3). Although forestry and woodland are a great carbon

capture source, only 11% of Irish land is composed of forestry⁶⁰, and as such we should look at how we manage grassland to increase current carbon capture and create conditions for deep, long term carbon storage, as well as look to increase woodland and hedgerows for the same purpose.

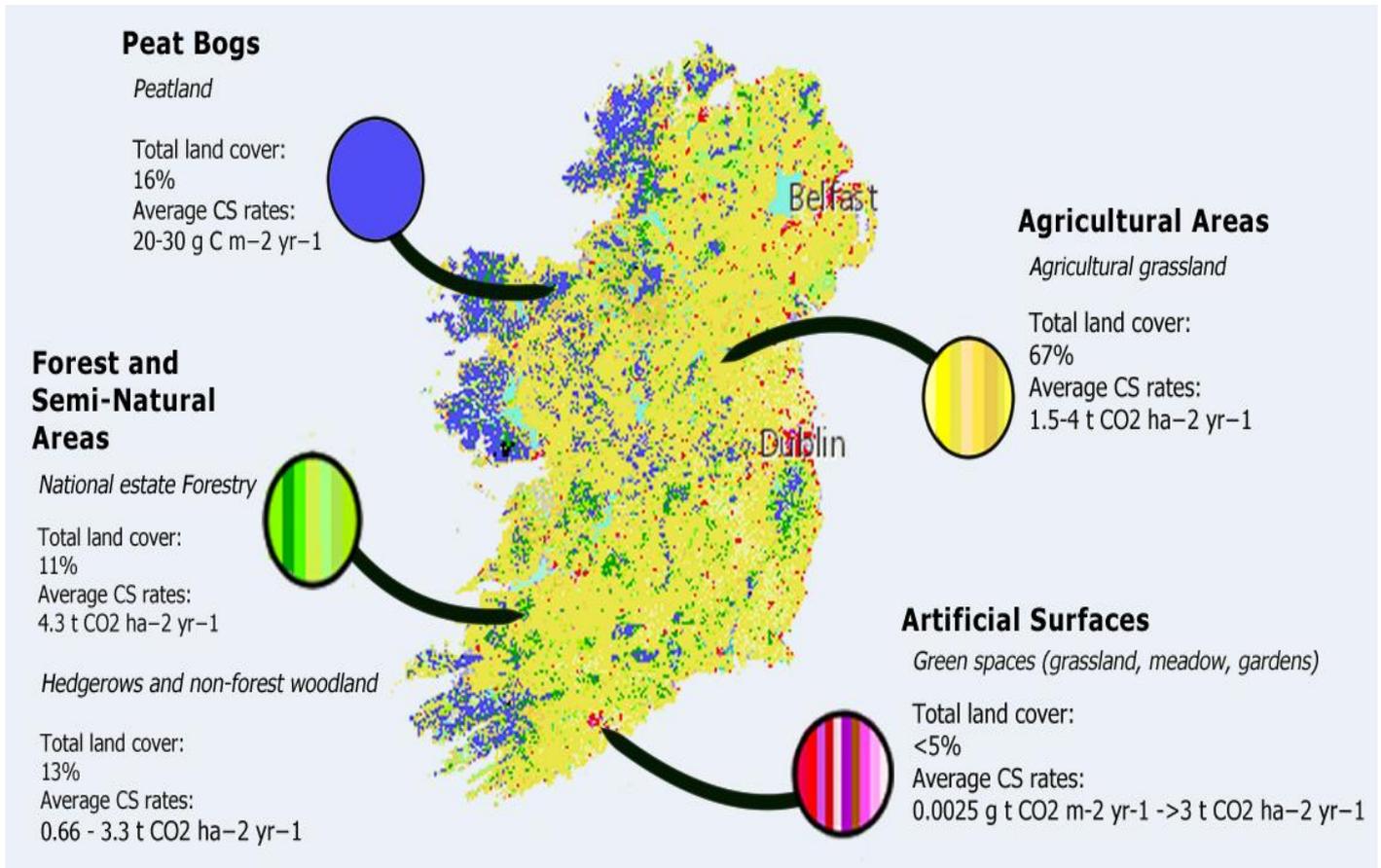


Figure 3: Breakdown of Ireland's land use cover and average carbon sequestration rates (CS). Source: Created by Rachel Hayden

Organic carbon storage and carbon sequestration rates are highest in the western edge of Europe where soil is more moist⁶¹. This suggests that Ireland has an ideal temperate climate and landscape cover to optimise on carbon sequestration in mineral soils. Current Irish mineral soils store 30 years' worth of emissions and are heavily under saturated meaning there is the possibility to capture a lot more carbon before soils reach a maximum for organic carbon sequestration^{46,62}. The capacity for soils to capture carbon is greatly influenced by environmental conditions, such as soil type, soil pH, water content, temperature, geology, and vegetation composition⁵⁹. Most carbon sequestration occurs in the top 10 -50 cm of soil and so can be lost through any action that disturbs the soil^{59,63,64}. This poses a considerable problem for carbon sequestration in Ireland as 4.4 million hectares, of a total of 6.9 million ha of land cover in Ireland, is used for agriculture - 80% of which is devoted to pasture, hay, and grass silage⁶⁵. Intensive agriculture has the ability to release

more carbon stored in soil than grassland soils can sequester. On top of that monoculture systems and intense management reduces biodiversity⁶⁶.

An additional carbon sink for Ireland to consider may be urban green spaces. Some studies have shown that urban areas have large carbon stores and that urban landscapes are not as frequently disturbed as agricultural landscapes which is better in terms of not releasing carbon into the atmosphere. Carbon sequestration is highly variable in urban settings due to the variety of landscape designs⁶⁷ and the types and amount of plants present⁶⁷. As Ireland's urban areas continue to expand⁶⁸, the potential for more biodiversity-rich green spaces will be created, and as such it may be worth looking at the role that non-agricultural grassland and urban green spaces can have in capturing carbon to reduce man-made emissions while improving biodiversity to combat climate change.

The Potential for Green Spaces to be used for Carbon Sequestration

Under the category of Artificial Surfaces Land Cover based on CORINE 2012, less than 1% (63,842 acres) of Irish land is composed of green spaces which include city bound public and private parks, botanical and ornamental gardens, allotment gardens, formal parks, camping sites, reclaimed natural sites and sports and leisure facilities in and outside of city limits inclusive of golf courses and sports pitches⁶⁹. Other sites like roadsides, industrial estates, and abandoned lots (not included in the aforementioned green spaces) can be developed or adapted with carbon sequestration in mind. This means that excluding waterbodies and the agricultural landscape, that a further 1%-5% of Ireland's landscape can be used to mitigate climate change as most of this public green space incorporates grassland (and other habitats like woodland) in some way.

The average sequestration rate of grassland is 3 tonnes of CO₂e per hectare per year. There is approximately 63,842 acres of green urban areas and sports and leisure facilities in Ireland⁶⁹. At the most basic assumption, if all of this land were able to absorb carbon at the same rate as grassland can, then approximately 191,526 tonnes of CO₂e could be captured annually^{46,69}. Although this value might be unrealistic, as it does not consider all factors related to carbon sequestration, it does show that green spaces do have good potential for mitigating climate change.



The Carbon Cost of Lawn Management

Maintaining a lawn can in itself have a large carbon footprint depending on the type of management used on the land. The hidden carbon costs of lawn management come from using chemical fertilisers, pesticides, water, and lawn equipment like gasoline-powered lawn mowers^{16,70}. All these actions produce a number of greenhouse gases that contribute to climate change⁷¹.

Making chemicals, such as material for fertilisers and pesticides, requires heat, pressure, and a lot of fossil fuels⁷². As such, fertiliser and other chemical inputs are one of the largest sources of greenhouse gas emissions associated with lawn care. One tonne of fertiliser can produce 2.7 tonnes CO₂e if made and used efficiently, or, as high as 12.3 tonnes CO₂e if made and used inefficiently⁴². Urban lawns treated with fertiliser can release up to 10 times more nitrous oxide (300 times more powerful than CO₂) than neighbouring agricultural grassland due to regular irrigation and higher urban temperatures¹⁶. Over 50% of US domestic water is used for lawn irrigation⁷³. Too much water can also cause fertiliser runoff, nutrient leaching, and saturation in soil⁷³.

Mowing lawns consumes a lot of fossil fuels. Using a lawn mower for one hour can have the same global warming impact as driving a car for just over 1.6 km and ride-on lawn mowers are shown to have higher emissions than push lawn mowers - even if used for a shorter time⁷⁴. It can take up to 2 ½ hours to mow one acre of amenity grassland (sports field) with a push- lawn mower or 30 minutes with a 60" ride-on mower⁷⁵. The number of cuts also contributes to climate change because more cuts produces more emissions. It is possible that under certain conditions, the carbon cost of lawn management may produce more emissions that the grassland green space can capture and so it would take a long time for soils to offset the GHG emissions from mowing and fertilisation^{76,77}.

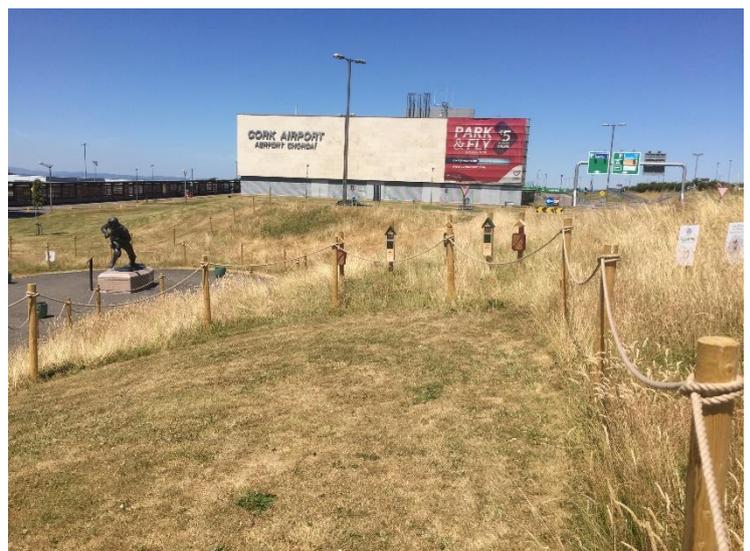
Case Study: Cork Airport

Cork Airport is the second largest airport in the Republic of Ireland and handles over 2.5 million passengers annually, making it the second busiest airport in Ireland. In terms of land area, Cork Airport has expanded in response to passenger demand⁷⁸. Cork Airport is fully committed to meeting the demands of sustainable development and protecting the natural environment when doing so. Cork Airport continuously aims to improve environmental practices by monitoring air and water quality, noise, waste management and energy use and this is on top of enhancing the visual environment and preserving local habitats and nature⁷⁹. One of Cork Airports biggest achievement is the participation in the Airport Carbon Accreditation Programme which oversees all carbon emissions created and has a goal of carbon neutrality by 2050. Cork Airport has managed to cut CO₂ emissions by 17% per cent compared to 2017 levels and has seen a 44% reduction compared to 2009 emissions⁸⁰.

Wild Work began working together with Cork Airport in 2017 and in 2018 developed a project to establish a pollinator-friendly green space on the grass hill located in front of the main building. This project is a signature site as part of Wild Work’s Pollinator project in Cork (pg.40)⁶. Wild Work created a range of habitats including native wildflower patches, nesting sites for solitary bees and converted lawn to meadow (Approach 2) with the aim of providing a range of resources close to one another to benefit pollinators, while also being aesthetically pleasing to enhance visitor experience (Wild Work, *personal communication*, July 2020). Since then this site has been managed with great success.



Picture 9: Pollinator friendly meadow establishing in the foreground with conventional amenity lawn in the background divided by a fence outside Cork Airport terminal 1. Source: Wild Work, 2018



Picture 8: Pollinator friendly meadow established at Cork Airport with conventional amenity lawn in the foreground. Source: Wild Work, 2019





As Cork Airport looks to expand pollinator-friendly spaces in the coming years, they can also benefit in part from reducing emissions through changing landscape management. Additionally, biodiversity focused green spaces such as those found in Cork Airport can help raise awareness and positively influence visitor attitude towards wildflower meadows, which in turn can influence visitors to learn more about how they can manage their lawns and gardens to reduce emissions and increase biodiversity.



Picture 10: Close up of Wildflowers Growing in the Established Meadow. Source: Wild Work, 2020

For example:

- Cork Airport receives 2.5 million visitors every year⁷⁸.
- Let us say, 10% or 250,000 visitors to Cork airport notice the new approach to green spaces and change their attitude towards pollinator-friendly lawns and meadows.
- Of the 10% of visitors that changed their perception, 1/8th or 31,250 visitors do not have a garden (based on British households)^{81*}
- This leaves 218,750 garden owners attitudes that can be changed to reduce emissions by up to 50% if lawn management practices were adapted.
- Lets' further reduce this number of gardens by 50%, as some of these people will share the same lawn and some of them may already be managing their lawn in pollinator friendly way already. That leaves us with 109,375 gardens.
- The average medium garden size is 140 m² (based on London households)⁸¹. Let's call that 100 m² of lawn to allow for shrubbery and other areas.
- Then 2702.72 acres of amenity lawn would be converted to pollinator-friendly lawn (109.375 x 100m² = 10,937,500m²). This equivalent to 1,351 soccer pitches (average soccer pitch size is 2 acres)⁸²

Take-home message: If 2.5 acres of newly converted lawn sequester 3 tonnes of CO₂e annually, then 3243.26 tonnes of CO₂e could be captured every year (2702.72 acres/2.5 = 1081, x 3 tonnes CO₂e = 3243.26). This could offset approximately 13,514 passenger journeys on one-way flights from Cork to London, Stansted, UK (Flight carbon footprint = 0.24 tonnes of CO₂e every year⁸³).

*Values are not available for Irish household. Instead values have been obtained for Britain's National Statistics office.

Management Effects on Reducing Emissions

Small changes in management techniques can have a large impact on the amount of carbon emitted when keeping a lawn, while having the added benefit of being more cost effective⁷¹. This includes reducing or finding alternatives to lawn equipment and the use of garden waste (clippings). Wild Work promotes two approaches to amenity grassland management that reduce emissions compared to conventional amenity lawn management. As well as improving lawn biodiversity, these approaches have broad benefits to climate change by reducing greenhouse gas emissions created through lawn management.

Approach 1- Pollinator-friendly Lawns

To reduce carbon emissions, it is better to use fertiliser in small dosage or for spot treatment. Pollinator-friendly lawns do not use chemical inputs whatsoever and by doing so do not contribute in this way to lawn management emissions. Furthermore, this approach can reduce emissions produced from mowing by 50%. This is because pollinator lawns require half the number of cuts per season than conventional amenity lawns, (10-15 instead of 20-30) which halves the amount of fossil fuel consumed, burned, and released into the atmosphere. One study found that some turfgrass lawn management in the US can produce up to 2443 kg CO₂e per hectare per year⁸⁴, the same as a return flight between London and Los Angeles. By reducing emissions by 50% this would produce a carbon equivalent more like a flight between London and New York City⁸⁵.

Leaving clippings on grass does not follow pollinator-friendly management in that this creates conditions that are less favourable for wildflowers⁵. However, removing grass clippings can account for the loss of up to 100 pounds of nitrogen per acre annually and so clippings should be composted elsewhere and used to add organic matter, or carbon, to soil where it may be needed, such as in vegetable beds⁷³. Though composting also has its own carbon footprint, it has added benefit in reducing household waste reaching landfills which reduces landfill methane emissions (methane is 26 times more potent than carbon dioxide)⁸⁶.

Approach 2- Meadow Lawns

In addition to the benefits associated with pollinator-friendly lawns, this approach may also further reduce greenhouse emissions produced from mowing, as cutting is reduced to just one or two times a year²³.



Management Effects on Carbon Sequestration

Current Research

The effects of grassland management on carbon sequestration is complex and therefore not straight forward to calculate. Measuring the rate of carbon sequestration involves the consideration of a variety of environmental conditions on top of lawn management emissions. Most investigations into the effects of management (mowing, fertiliser use, irrigation) on lawn carbon sequestration are currently coming from the U.S. and Scandinavia. Of this research most investigate the effect different management treatments have on turfgrass/amenity lawn. There is little to no current research carried out in Ireland to look into carbon sequestration in urban green spaces inclusive of pollinator-friendly lawns, meadows, and other amenity lawn types. This is not ideal as Ireland has different geology, soil types, environmental parameters (organic layer, water table content, soil temperature) and weather conditions that could change the rate of organic decay, carbon storage, and subsequent carbon sequestration rates compared to other countries.

Regardless, studies comparing lawn carbon sequestration suggest that managing a lawn to increase herbaceous biomass (how much grass grows) improves carbon sequestration within soil by adding more organic matter post mowing^{71,87,88}. Most experiments use fertiliser to increase above ground biomass and once the grass is cut, leaves the clippings to return carbon to the soil through vegetation decomposition. Leaving clippings on lawns provides benefits for soil health and carbon sequestration and can reduce the need for fertiliser (to improve soil health) by naturally restoring the nitrogen to carbon ratio^{84,89,90}. Available research does not indicate how often a lawn should be cut to optimise carbon sequestration but does state that amenity lawns with faster growing species and more clippings left on grass have higher carbon sequestration rates over those that go without⁸⁸.

Research did not indicate if a one cut system used in meadows sequesters the same amount of carbon as a multi-cut lawn and this may be an important factor to consider. Meadows are long growing, tall structures and as such can amass the same biomass weight as shorter grass that is frequently cut throughout a growing season. While amenity grasslands with inputs can enhance carbon capture it is possible that meadows, with biomass accumulated throughout a growing season, do not need such inputs to sequester the same amount of carbon. This could be worth investigating further.



Current research available for lawn management would suggest that frequent mowing is better for grassland carbon sequestration, but it is possible that the frequency of cutting is not as important as the height at which grass is cut. Grass height can affect primary production which is key for capturing carbon in photosynthesis. For example, closer mowing to the ground reduces leaf surface area where photosynthesis takes place. This means grass is slower to recover from tight mowing and does not capture as much carbon in the meantime. Conversely, not cutting grass for long periods can result in overcrowding, causing shadows that reduce light and soil temperature needed for growing⁵⁹. A recent meta-analysis focusing on papers dedicated to influencing sequestration factors showed that reducing plant biomass always leads to a decrease in soil carbon⁹¹. Importantly, lawn mowing frequency does not directly influence temperature, moisture, CO₂ inputs and outputs as well as plant root mass in soil^{87,92}. Root growth was not found to be a major contributor for carbon sequestration rates in amenity grassland, instead shoot growth is the vital factor for carbon capture in vegetation, and in turn, soil⁸⁷.

Grasslands with more plant diversity may be better for carbon storage than species poor grasslands as plant diversity increases soil microbial activity and productivity, and mediates higher root inputs^{93,94,95}. Clover, for example, is an excellent nitrogen fixer and increases carbon storage in grassland^{96,97}. Lawns that are managed for biodiversity, by mimicking natural habitats, are less likely to release carbon. However they can take longer to be effective carbon sinks as they often take time to establish¹⁶.

Converting degraded agricultural land to amenity grassland, such as golf courses, often uses chemical fertilisers to increase soil nutrients and this can in turn increase carbon storage potential⁹⁸. As with biodiversity management practices, without chemical fertilisers some restoration projects can take a longer time to begin capturing carbon⁹⁸. This being said, some studies have reported that in the first year or two after grassland restoration using fertiliser application; gas fluxes between soil and air for carbon dioxide, methane and nitrous oxide were all outputs – meaning greenhouse gases were released, not captured⁵⁴. If an established grassland has never been treated with chemical fertiliser than it is better to not use it, as an influx of chemicals will unbalance the natural system that is in place and potentially release more nitrous oxide in the process¹⁸. Although pollinator-friendly lawns and meadows may be better at long term carbon storage, little to no research was found to show how biodiversity focused management practices effect carbon sequestration rates.



Limitations with the Current Research

Current research comparing management techniques for carbon sequestration rarely account for the carbon emissions that are being created at the same time. Fertiliser and grass clippings may increase soil and vegetation productivity but are themselves a great source for emissions^{16,70}. Extra inputs are needed to increase carbon sequestration under certain conditions, but when lawn equipment creates the same or more emissions than soil can sequester then carbon management does not serve its purpose^{76,77}. For this reason, all factors within lawn management must be considered when discussing emissions and carbon sequestration.

Furthermore, the benefits derived from chemical inputs, such as fertiliser, have been shown to decrease over time. Carbon sequestration was found to increase in golf courses when fertiliser was used in the early stages of establishment but decreased in the following 30 years when kept under this treatment⁷¹. Though mulching grass clippings can reduce the need for fertiliser by half for amenity grassland⁸⁹, it is worth remembering that approaches such as those recommended by Wild Work, to manage these same green spaces to help pollinators and other wildlife, are advocating no use of fertiliser and/or mulching of grass clippings. Additionally, grass clippings are not beneficial for carbon sequestration if they do not decay at a rate faster than they are added to the grass. Grass clippings can be a source for nitrous oxide during decay and can become clumped when too much is added or when they become wet, forming a thick layer over grass which affects soil temperature and evaporation rates important for gas exchange^{87,98,99}.

An alternative low emission solution to stem emissions created through fertiliser and decay of grass clippings is to compost garden waste and then return it to the soil where it is needed elsewhere. So for instance, grass clippings could be taken from the lawn, creating better conditions for wildflowers in the lawn, and could then be used as a mulch on vegetable beds or around fruit trees. Based on an Australian study, over 180 kg CO₂e can be avoided by using 10 tonnes of garden organic compost continuously per hectare or 5,046 kg CO₂e over 20 years¹⁰⁰. Composting has been found to be very successful in increasing carbon sequestration and for follow-on-effect of enhanced soil health and other benefits in conventionally managed amenity grassland¹⁰⁰.



Other Potential Benefits to Wild Work Approaches

Wild Work also approaches grassland management using handheld tools like scythes and rakes where possible instead of machinery to cut and collect grass. This further reduces emissions. Part of the idea behind using simple equipment has to do with developing management techniques which could be implemented by most people inexpensively. Using traditional methods like scything is beneficial in biodiversity focused management for a number of reasons such as minimising noise pollution and protecting soft ground as the equipment is lightweight¹⁰¹.

Increased biodiversity, associated with pollinator-friendly lawns and meadows, can have interconnected benefits for habitat function such as aiding soil carbon sequestration and stabilising organic matter, nutrients, pH, and the water table within soil^{5,23}.

Changing Attitudes

Despite the biodiversity and human-wellness benefits pollinator-friendly lawn and meadows offer, they can still be disliked, or misunderstood by the general public (Wild Work 2020, *personal communication*, 17th August). If wildflower lawns and meadows are not managed correctly, they can become untidy looking, particularly in autumn when grassland begins to die back. This can look aesthetically unpleasing to the public in comparison to neatly mown amenity grassland and as such negatively influences public perception of wildflower green spaces¹⁰². When managed correctly these sites can look well, leading to better public engagement and acceptance for these new approaches to green spaces¹⁰³. Recent studies have shown that over 70% of Europeans are now familiar with the term “biodiversity” and more people now understand the importance of biodiversity for humans and climate change and the responsibility we have to look after nature¹⁰⁴.

These management approaches advocated by Wild Work can be a great way to re-connect people with nature and the history of meadows and biodiversity within the Irish landscape.

Public green spaces, because of where they are located, can be utilised to make lots of people more aware of the environmental factors associated with how our food is produced. Visible examples of biodiversity-friendly landscape management in public settings may inevitably influence consumer demand in terms of people wanting food to be produced in a more biodiversity and climate friendly way, especially if these visible examples lead to increased levels of understanding of how farmed landscapes are managed. Consumers have a substantial influence in shaping the food and farming system, resulting in economic shifts towards





Wildwork

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local or sustainably produced (i.e. organic, free-range etc.) food which is better for biodiversity¹⁰⁵. In turn helping biodiversity improves food quality and food security¹⁰⁶. This is just one suggestion of how changing attitudes on landscape management can have a significant impact on biodiversity and human health and wellbeing.

Knowledge Gaps and Future Research

Within Ireland, research is being carried out by institutes like UCC and UCD into the rate of carbon capture in forestry and agricultural grassland^{107,108}. State bodies, like Teagasc, are investigating the carbon footprint of different agricultural sectors to see how farmland management affects the capture rate and release of carbon from soil⁴⁸. This research will prove indispensable in the coming years as Ireland aims to completely offset carbon emissions by 2050⁴⁶. Irish research also looks to be heading towards refining specific soil carbon sequestration rates to account for soil type and land use which will greatly benefit our understanding of human effects on carbon capture and storage.

Current Irish research may not address the potential of urban landscapes, including urban green spaces, to contribute to mitigating climate change. It is possible that the scale of agriculture and urban green space land cover in Ireland is the reason that green spaces are not typically included in carbon sequestration investigations. This may change in the future as every possible land-use should be considered to offset greenhouse gas emissions to mitigate climate change. Urban green spaces have already been shown to reduce the impacts of weather conditions^{8,16}, and as such, should be included in future research into management effects on carbon sequestration and indeed emissions reduction.

The existing knowledge on the global warming impact from lawn management is limited¹³. To be able to reduce climate impacts from lawn management we need to develop sustainable management practices. Future research should compare the impacts conventional and alternative management can have on emissions and carbon sequestration in a variety of amenity lawn types. Furthermore, this should include investigating the effect mowing regimes have on carbon sequestration in lawns as the frequency of mowing is one of the biggest differences between grassland management practices.

Biodiversity plays a key role in controlling climate, both in terms of mitigation and adaption, and as such should be fully considered as part of carbon management. Conversely, biodiversity-friendly grassland management practices such as those used in Pollinator-friendly lawns and Meadow lawns are capable of storing carbon⁵⁹, but more study must be done to understand the impact this type of management has on carbon sequestration rates.



Conclusion

In terms of amenity grassland management, approaches advocated by Wild Work produce less emissions than conventionally managed lawns. Emissions can decrease by at least 50% by reducing annual cuts from 20 - 30 per season to 10 - 15 cuts, or further by using hand tools instead of machinery. This is without taking into consideration the emissions associated with the production and transportation of input materials such as fertilisers and pesticides. Wild Work approaches support a diversity of plant and animal species which enhance habitat quality and optimise ecosystem functions. Ecosystem services, in turn, help protect us from climate change by physically blocking weather events and actively taking carbon out of the atmosphere which mitigates carbon's contribution to global warming. Lawn inputs are needed under certain conditions to increase carbon sequestration rates in amenity grasslands, but the type of input is vital to keeping lawn management emissions under control.

Within urban areas, green spaces have the potential to aid climate mitigation while benefiting nature and human-wellness. Furthermore, biodiversity focused green spaces can also help change people's perception and attitude towards pollinator-friendly lawns and meadows by showing the benefits both have for biodiversity and climate mitigation. If pollinator project sites, such as the one located in Cork Airport, can have an influence on the way just 10% of visitors manage their lawns this could have a massive wider impact on reducing lawn emissions and improving biodiversity as well.

The ability of amenity lawns to sequester and store carbon is highly variable and is greatly affected by landscape management. Carbon sequestration is influenced by different environmental factors, but long-term carbon storage is most affected by soil health and soil disturbance from human activities. More Irish research is needed to look at refining carbon sequestration in different soil types and under different land-uses, cognisant of the need to also help biodiversity in the process.



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Figure References

Figure 3

Land cover: CORINE (2014)

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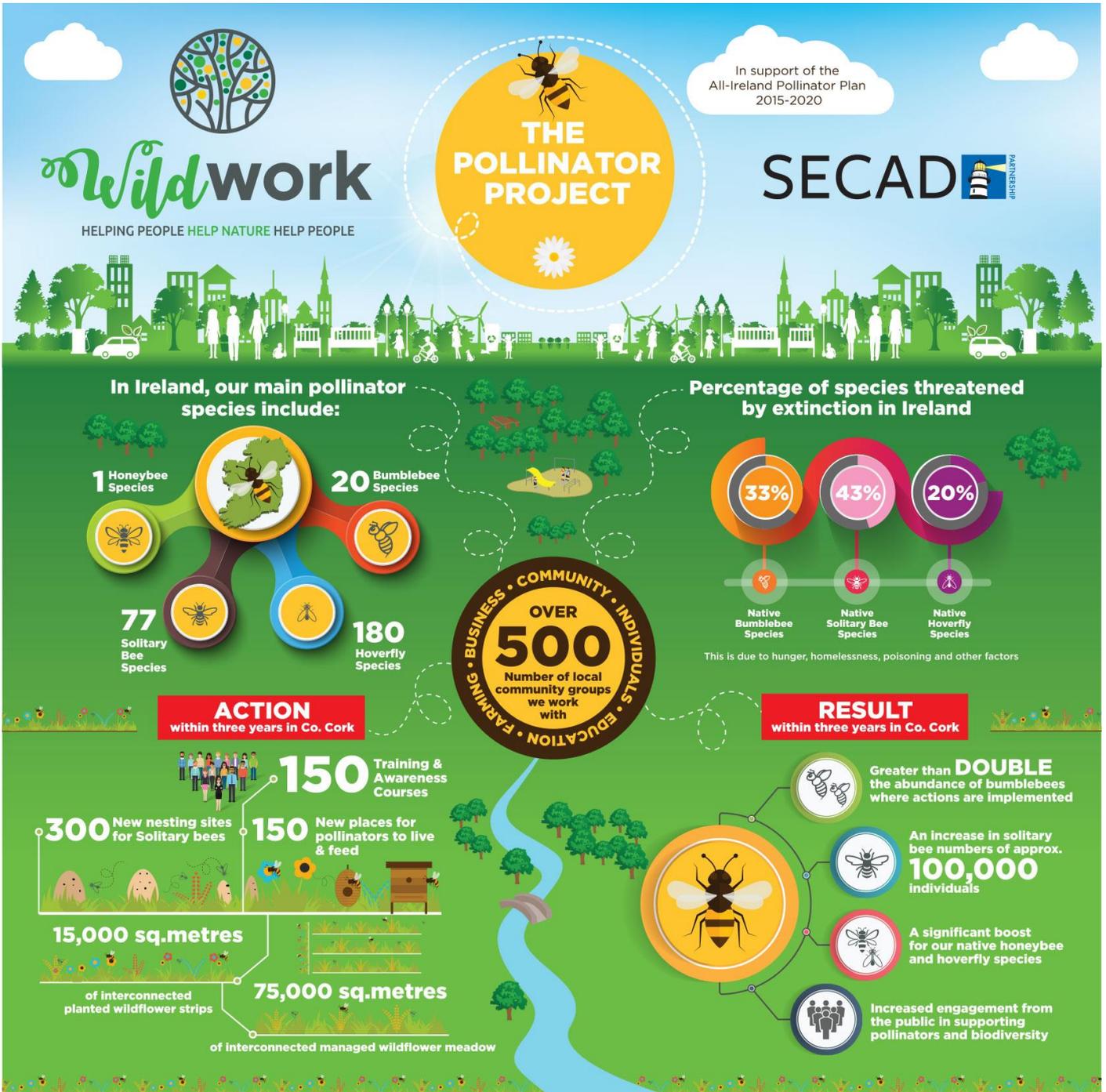
Green Space/Gardens - Cameron et al. (2012)



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Appendix



Appendix 1: Infographic of Wild Work's Pollinator Project. Source: Wild Work, 2020