Lowland Dry Acid Grassland Ecoservice Provision in the Urban Environment: a case study of London exemplar ecosystems

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Abstract

This study investigates the ecoservices provided by lowland dry acid grassland specifically in the urban environment. The situation of lowland dry acid grassland within or adjacent to urban conurbation may provide new, enhanced, or different ecoservices to those considered for generic lowland dry acid grassland assessment or rural examples where population density pressures are less. This can have important consequences for the wellbeing of urban lowland dry acid grassland users as well as fiscal valuation for conservation and infrastructure development decision making.

Three lowland dry acid grassland cases were studied in London to provide primary data for highly populated urban location examples. Interviews with managing organisation representatives were conducted after a literature review. This provided benchmarking of published research studies and the development of interview questions.

The studied cases generally concurred with the literature review findings regarding ecoservice study focus and gaps in the published research. Supporting ecoservices which categorise primarily biotic ecoservices (i.e., Habitat for Species and Maintenance of Genetic Diversity) received the greatest attention. This may be due to lowland dry acid grassland assignation as a UK Biodiversity Action Plan (B.A.P.) priority habitat for conservation. Differences between urban and rural lowland dry acid grassland typologies regarding flora, fauna and funga species may exist which could have baring on conservation strategies. However, much of the literature could not be qualified as primary data and therein subject to possible bias. Extensive primary data may lie within case management organisations and with researchers but not published in peer reviewed journals.

Both Regulating and Provisioning ecoservices were relatively under reported or studied; this too was mirrored by the London case interviews. Given current climate change concerns, further Regulating ecoservice category research regarding Moderation of Extreme Events (e.g., flooding) and Carbon Sequestration and Storage ecoservices could provide a timely and valuable area of study and collaboration across scientific disciplines.

Challenges exist in differentiation of urban lowland dry acid grassland from other closely associated urban ecosystem typologies (e.g., lowland heathland) where they co-exist in mosaic systems. Such mosaics therefore require extensive detailed mapping or assessment of alternative models for ecoservice economic assessment.

There is a risk of Cultural ecoservices under valuation provided by urban lowland dry acid grassland, in particular the social value of its heritage as well as the recreational benefits to human wellbeing. The geographic, geologic and topographic disposition of these urban ecosystems may have provided favourable conditions for human settlement and subsequent anthropologic development. This continues today where urban lowland dry acid grassland likely provides significant social and fiscal value in provision of wellbeing assets to its urban users. However, consolidation and collaboration regarding current research, prior knowledge and existing primary data is required to close gaps in lowland dry acid grassland ecoservice knowledge and therein a holistic assessment of social and fiscal value.

Key Words: Cultural, Ecoservices, Ecosystem, London, Lowland dry acid grassland, Provisioning, Regulating, Supporting, Urban

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Glossary

Abiotic – physical rather than biological; not derived from living organisms

Axiophyte – indictor plants of high-quality habitat in a particular region important for conservation. Axiophytes are not rare plant species.

Biotic – biological rather than physical; living or once living organism.

Ecoservice – outputs, conditions, or processes of natural systems that directly or indirectly benefit human wellbeing.

Ecosystem – living organisms, their physical environment, and all their interrelationships in a particular unit of space.

Habitat – the natural environment in which an animal or plant usually lives.

Natural Capital – all the ecosystem services (ecoservices) that natural assets provide; natural assets include soil, air, water, and all living things.

Semi-natural grassland – grassland existing because of human activity (mowing or livestock grazing), where environmental conditions and the species pool are maintained by natural processes.

Stands – discrete, relatively small areas of specific vegetation or ecosystem type

1.0 Introduction

In 2000 Kofi Annan, the then United Nations Secretary-General, called for an in-depth international assessment of the services and benefits to human wellbeing provided by natural ecosystems. This Millennium Ecosystem Assessment (2005) was principally driven by ecosystem degradation, continued loss of biodiversity (Dasgupta, 2021) and subsequent fiscal impact at the national level. Since this assessment, research into these ecoservices and their associated benefits to human wellbeing has rapidly increased. Moreover, the fiscal valuation of such ecoservices has become an important component of national wealth estimation and subsequent governmental decision making (Natural Capital Committee, 2014 and The World Bank, 2021).

However, as highlighted in the Millennium Ecosystem Assessment, ecosystem classifications can be broad and not consider the specificity of geographic location, proximity to human conurbation nor user interaction at a local level. This, therefore, can be problematic regarding assessment of habitat ecoservice quantity, type, and ultimately economic value (Joint Nature Conservation Committee, n.d.). Wellbeing benefits may be different in rural locations versus high density, high demand urban locations such as cities and towns where choices between habitat conservation versus infrastructure development can conflict.

One such ecosystem example is that of urban lowland dry acid grassland. At both national and local United Kingdom (U.K.) government level, it is classified as a distinct ecosystem within conservation and fiscal policies. However, ecoservice provision derived from lowland dry acid grassland specifically within an urban environment may lack comprehensive ecoservice understanding because of limited research versus other, higher profile ecosystems such as urban forests (Bengtsson et al, 2019; Buchmann et al, 2021 and United Nations, 2021). Moreover, ecoservice provision compared to less intensely used rural lowland dry acid grassland may be different regarding its type and quantity of ecoservice provision. Previous research studies may not necessarily reflect geographical nor anthropologic differences. These are likely to have an impact upon valuation and quantification of its assets for land managers, planning and human users. Furthermore, human wellbeing motivated by factors such as climate change and the COVID-19 pandemic in expanding urban environments may be a growing and urgent area of study along with mitigation of biodiversity decline of indigenous biota.

1.1 Research question and objectives

This study investigated the research question; what are the ecoservices (i.e., benefits to human wellbeing) provided by dry acid grassland ecosystems in an urban environment within the United Kingdom? The research objectives were:

1) Critically evaluate the ecoservices that dry acid grassland provides in the U.K.; in particular, those within or adjacent to urban situations
2) Identify new, unique, or enhanced ecoservices that result from an urban situation
3) Investigate the current benefits to human wellbeing from a cultural perspective
4) Provide recommendations for ecosystem management and future decision-making regarding lowland dry acid grassland conservation versus urban development needs. These may include knowledge gaps, conflicting data, and experiential findings.

This was investigated by study of three cases within London via interviews with relevant case representatives in conjunction with a literature review. This compared the ecoservices reported in the literature with current primary data from the cases. Valuation of the ecoservices studied was not undertaken within this study. A review of such data was not considered possible given the time and resources available to the author.

It is recognised that the study was subject to limitations. These included a narrow topic scope, low number of cases studied, limited resources, time, and researcher experience. Therefore, generalisation and transfer of findings must be carefully considered. Nevertheless, it was hoped that the findings and recommendations herein contribute to identification and study of any ecoservice knowledge gaps that these ecosystems currently demonstrate. This in-turn may support informed decision-making, stakeholder communication and encourage further research.

2.0 Literature Review

2.1 Ecosystem identity

Lowland dry acid grassland is defined by the U.K. Biodiversity Action Plan (Joint Nature Conservation Committee, n.d.) as having the following attributes:

- occurs over nutrient poor, free-draining soils
- pH levels ranging from 4-5.5
- overlying acid rocks or superficial deposits such as sands and gravels
- below 300m (altitude)

This definition is used too in the U.K. National Ecosystem Assessment (U.K. National Ecosystem Assessment, 2011a) where it is included as a sub-ecosystem within the lowland semi-natural grassland Broad Habitat category, along with other grasslands such as Calcareous, Neutral and Purple Moor grass and Rush pasture. These lowland semi-natural grasslands have resulted from common traditional low-intensity farming practices, therefore, are often subject to academic study or conservation initiatives as a singular grouping (Office for National Statistics, 2018a). The use of semi-natural grassland terminology is common outside of the United Kingdom also (European Environment Agency, 2019 and Andrews et al., 2020) but differing sub-ecosystems to those of the UK may exist based upon the geography and climate of the specific regions. Therefore, care was taken to qualify the relevance of published studies and literature to U.K. sites (Figure A).

Figure A – Lowland dry acid grassland at Risby Warren, Lincolnshire. Typical features of U.K. sites include level topology, low sward height and infrequent stands of scrub.

Semi-natural grassland ecosystems may confer common benefits to human wellbeing such as recreation opportunities, however, they may also offer unique services not necessarily captured at a Broad Habitat category level. Flora and fauna communities demonstrate this (The Royal Parks, 2006 and London Natural History Society, 2022).

The use of the term 'habitat' itself as a descriptor generally regards the biotic component of an ecosystem, particularly within biodiversity conservation contexts (Natural England, 2020). However, abiotic factors (e.g., soil, water) may fundamentally underpin such biotic ecoservices as well as providing services commanding value too (UK National Ecosystem Assessment, 2011). The geography, soil and underlying geology may differentiate urban versus rural lowland dry acid grassland as distinct ecosystems and therein potential for specific ecoservice provision in urbanised situations.

Due to the loss of lowland dry acid grassland area and quality since the middle of the twentieth century (Natural England, 2005 and Pywell, et al., 2015) it has become a priority habitat for biodiversity conservation initiatives and policy studied by researchers, central and regional government, and land managers alike (The Royal Parks, 2006; Doick and Hicks, 2014 and Bedfordshire Local Nature Partnership, 2015). This may explain a preponderance of literature associated with biotic topics. Literature retrieved (43 articles, 52%) during this review which studied such biotic factors outweighed that of abiotic (e.g., geologic) and cultural studies relevant to potential ecoservice provision. While discussed further below, no peer-reviewed academic studies were found concerning possible abiotic nor cultural ecoservices for U.K. lowland dry acid grassland.

Nomenclature of lowland dry acid grassland within the literature was found to be variable therefore care was required to prevent literature search exclusion or confusion with other typologies such as lowland heath or upland acid grassland. Table 1 illustrates differing descriptors found in the literature which required careful review to manage potential inference bias.

Table 1: A variety of descriptors were encountered during literature searching and review for lowland dry acid grassland. This may reflect the use of simpler terminology in grey literature sources such as conservation literature aimed at the general public and/or non-technical policy makers.

Alternative Lowland Dry Acid Grassland Nomenclature	Source Reference
Dry Acid Grassland	Greater Lincolnshire Nature Partnership, (2023)
Lowland Acid Grassland	Doick and Hicks, (2014)
Acidic Grassland	The Royal Parks, (2006a)
Semi-natural Grassland	Pywell et al., (2015)
Acid Grassland	London Natural History Society, (2022)
Calcifugous Grassland	Gowing et al., (2010)
Parched Acid Grassland	Joint Nature Conservation Committee, (2019)
Semi-improved Acid Grassland	The Royal Parks, (n.d.)

Similar challenges were found searching for lowland dry acid grassland specifically within urban environments. Grey literature often referred to lowland dry acid grassland within London as stands or fragments within mixed ecosystem mosaics (Figure B) such as parkland and common land. Here amenity grassland and dry heath ecosystem typologies were intimately present too (Wimbledon and Putney Commons, 2020).

Figure B – Habitat mosaics within Greenwich Park (The Royal Parks, n.d.). Fragmented and rapidly changing habitats at urban locations may provide bias in wildlife biodiversity assessment and valuation for individual ecosystem typology.

Lowland dry acid grassland is also present at infrequently used, less intensively managed urban sites. The National Plant Monitoring Scheme (NPMS) Support (2022) includes churchyards, road and rail verges, golf courses, airfields and post-industrial, 'brownfield' areas as likely sites.

Outside London, a similar risk of confounding ecosystem typology existed compounded by the uncertainty in some literature of distinguishing between urban and rural lowland dry acid grassland data particularly at county level (Ipswich Borough Council, 2003 and Bedfordshire Local Nature Partnership, 2015). The U.K. National Ecosystem Assessment, (2014) found that a lack of systematic mapping and quality of condition was limiting for ecoservice delivery assessment in U.K. urban environments, including urban semi-natural grasslands.

Therefore, the literature concerning urban lowland dry acid grassland that could be readily qualified essentially came from London sites. London as a model for other U.K. urban situations could be advantageous as it may represent extreme ecosystem cases subject to a high population density and low area of greenspace (34%) versus other regions (Greater London Authority, 2022).

Additionally, there may exist unpublished ecoservice primary research information (e.g., monitoring reports, surveys) or prior knowledge within incumbent managing organisations. These may support specific ecoservice identification and quantification to underpin fiscal ecoservice valuation models both within London and urban lowland dry acid grassland generally.

2.2 Ecoservice definition

Ecoservice definition and categorisation is an ongoing area of research and policy development at national and regional level (Fabis Consulting Ltd, 2018; Andrews et al., 2020 and European Environment Agency, 2023). However, for this literature review the Economics of Ecosystems and Biodiversity (T.E.E.B.) typology was selected as a basis for categorisation (The Economics of Ecosystems & Biodiversity, 2011). This typology is a well-established classification system, commissioned post the G8+5 Potsdam meeting of Environmental Ministers in 2007. This classification system was subsequently adopted by the Food and Agriculture Organization of the United Nations. This typology is also elegant with clear ecoservice descriptors which the author considered helpful for efficient review of the literature. Table 2 provides an abbreviated ecoservices classification summary, while detailed descriptors for each ecoservice sub-category are presented in Appendix A, Table 3.

Table 2: Abbreviated categorisation of ecoservices and their sub-categories in accordance with the Food and Agriculture Organization of the United Nations (adapted from Food and Agriculture Organization of the United Nations, 2023)

Ecoservice Category	Ecoservice Sub-Category
Cultural	Aesthetic Appreciation and Inspiration for Culture, Art and Design
	Recreation and Mental and Physical Health
	Spiritual Experience and Sense of Place
	Tourism
Provisioning	Food
	Freshwater
	Medicinal Resources
	Raw Materials
Regulating	Biological Control
	Carbon Sequestration and Storage
	Erosion Prevention and Maintenance of Soil Fertility
	Local Climate Air Quality
	Moderation of Extreme Events
	Pollination
	Regulation of Water Flow
	Waste-water Treatment
Supporting	Habitat for Species
	Maintenance of Genetic Diversity

2.3 Provisioning ecoservices

Of the four ecoservice categories, the least number of literature articles (15%) were retrieved for modern day provisioning benefits. None pertained to lowland dry acid grassland specifically, rather to the study of semi-natural grassland ecosystems where lowland dry acid grassland is present.

Raw Materials, Freshwater and Food ecoservices for livestock derived from lowland dry acid grasslands may have historically delivered indirect benefits to human wellbeing. Livestock grazing of cattle, sheep, and geese, was an important anthropological activity that may have coincidentally supported the formation and maintenance of lowland dry acid grasslands. Along with wild grazing animals such as deer and rabbits (Crofts, 1999), pastoral grazing not only provided sustenance for livestock but also supressed landscape succession of scrub and trees providing establishment opportunities for more ephemeral plant species, particularly those associated with modern day lowland dry acid grasslands. In rural lowland dry acid grasslands such as the New Forest, the Brecklands and Suffolk Sandlings, grazing still occurs to provide livestock food but also provides a low intensity land management approach (Cox and Reeves, 2000). This approach was revisited (Dennis, 2012) and reintroduction of cattle grazing trialled at Wanstead Flats (London City of London Corporation, 2023). Evidence of wider adoption in similar urban locations was not found (Figure C).

Figure C – Wanstead Flats, London has been used for cattle grazing since the late nineteenth century. However, the practice has proved problematic in such an urban environment with containment and subsequent safety to both cattle and humans (Wanstead Wildlife, 2023).

Extraction of gravel and sands from sites associated with lowland dry acid grassland occurred in London through the late 18th to early 20th century. This provided Raw Materials ecoservices for building and road construction, ship ballast, and glass manufacture (Figure D). This activity was particularly prevalent in the London basin area due to the underlying sandy and gravelly geological formations including the Harwich, Lambeth, and Thanet groups (Burgess et al, 2012 and British Geological Survey, 2023).

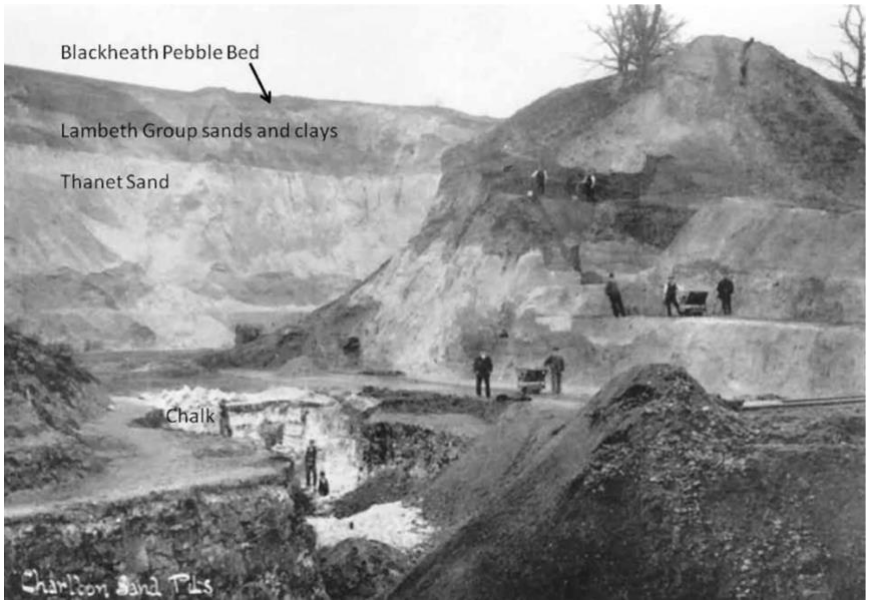

Figure D – Gilbert's Pit, London (1906). The area was heavily quarried until the mid-20th century. It is a geological Site of Special Scientific Interest (adapted from London Geodiversity Partnership, n.d.)

Quarrying continued until the mid-19th century, where the Crown allowed gravel extraction for £56 a year. However, this was effectively stopped in 1866 by the Metropolitan Commons Act. Nevertheless, this provisioning ecoservice activity may have coincidently provided cultural benefits such as Georgian and Victorian landscape painting of London quarrying scenes (Waites, 2006 and Chavez, 2021) and possibly folklore. The first verse of the eighteenth-century nursery rhyme London Bridge Is Falling Down proposes building it up again with 'gravel and stone'. Redundant gravel pits such as those at Blackheath, Chislehurst and Wimbledon Commons now provide different ecoservices in the form of permanent and ephemeral ponds with the return of water-born wildlife including grazing geese (Wimbledon & Putney Commons, 2023).

Historic provision of water for humans too may also have been facilitated by the relatively sparce vegetation cover, light soil and free-draining substrate geology at sites located adjacent to the capital's lowland dry acid grassland. The London Geodiversity Partnership (2019) noted that water percolating through Blackheath's gravelly beds has resulted in several fresh-water springs on the anticline in Greenwich Park where it meets a lower layer of clay. This provided fresh water for the park and the former Royal Hospital of Seamen. Figure E illustrates an analogous situation in Richmond Park, where freshwater springs are present at the interfaces of geologic strata at the landscape anticline (London Geodiversity Partnership, 2018).

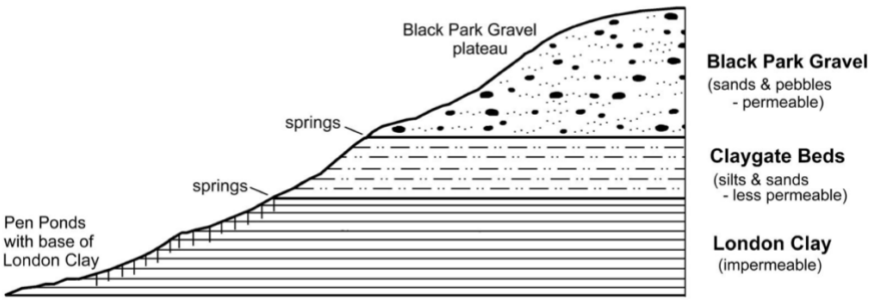

Figure E: Spring line and local strata at the Richmond Common anticline (adapted from Clements, 2010). Similar geology is reported at the Greenwich anticline where water percolation though the Harwich formation on the Blackheath plateau feeds springs.

The assertion that dry acidic grasslands provide a modern-day Freshwater ecoservice may be moot. However, these specific cases may illustrate how lowland dry acid grassland ecosystem biotic and abiotic factors function together holistically. They may provide a continuum of Regulating, Provisioning and possibly Cultural ecoservice assets interdependent upon each other.

2.4 Cultural ecoservices

Definition and fiscal valuation of Cultural ecoservices can be problematic due to the subjective nature of the benefits to human wellbeing and often-qualitative measurement. This can be at odds with quantitative valuation and accounting required for economic decision making such as governmental natural capital accounting as well as financing for conservation and infrastructure development initiatives (The Royal Parks, n.d. and Office for National Statistics, 2019). However, while Cultural ecoservices also remain an active area of research generally, the author's literature search found no studies, either peer reviewed research papers or grey literature, specifically related to lowland dry acid grassland.

The free draining geology and light soils of lowland dry acid grassland along with its characteristic open views due to low vegetation height could, however, provide unrecognised Cultural ecoservices from ancient times which pervade today in the form of natural heritage supporting Spiritual Experience and Sense of Place ecoservices. Lowland dry acid grasslands are semi-natural in character due to their past anthropogenic management to clear forest and manage scrub enabling human settlement upon workable, gravelly soils (UK National Ecosystem Assessment, 2011). Human settlement and land management dating back to the Neolithic times and the early bronze age (4000-800BC) on the Thames gravel terraces has been uncovered during archaeological digs (London Borough of Merton, 2004). Studies at Mitcham Common, Wimbledon Common, Greenwich Park and Wanstead Park have all found Roman building remains including villas and temples as well as burial mounds (Figure F). Vistas from these locations may have been advantageous for settlement regarding safety and Freshwater ecoservices provided by nearby springs (Clements, 2010 and London Geodiversity Partnership, 2019).

Figure F: Saxon burial mounds located where restoration of the ancient site's rare acid Grassland is being undertaken in Greenwich Park, London (The Royal Parks, n.d.).

The historic relationship between humans and urban lowland dry acid grasslands from ancient times to modern day may provide evidence regarding the extent to which these ecosystems and humans have been interdependent. This could be a factor regarding Cultural ecoservice valuation purposes along with the possible inter-relationship of Tourism and Sense of Place ecoservices.

Literature for Recreation, and Mental and Physical Health ecoservices for lowland dry acid grassland specifically was not found. However, particularly in London, anthropogenic use of greenspaces containing lowland dry acid grassland stands such as common land and parks has increased. Historically, these relatively flat, open, free-draining spaces have been used for recreational and sporting purposes. This includes the possible sporting foundations of golf (Browning, 1955) and rugby (Harvey, 2006) at Blackheath as well as tennis on Wimbledon Common (Perry, 2009). However, these physical activities have been superseded today by dog walking and jogging, including the starting point of the annual London marathon at Blackheath (Jones and Shipway, 2008).

Readily accessible urban greenspaces in London saw a significant increase in use during COVID-19 lockdowns of 2020 and 2021; an increase of 20% was reported by The Office of National Statistics (2021) during spring 2020 lockdown (Figure G). Mitcham Common reported a 4-5-fold increase, while Wimbledon and Putney Commons reported 20-30 thousand visitors daily, making weekday visitor numbers similar to those of a typical weekend (Wimbledon and Putney Commons, 2020).

Figure G: Urban lowland dry acidic grassland sites such as Blackheath, London contributed to Mental and Physical heath ecoservices during COVID-19 lockdowns including facilitation of gathering (Associated Newspapers Ltd, 2020).

Other U.K. regions saw falls in public greenspace use which was considered due to a greater availability of private outdoor space (e.g., home gardens). London's population in 2021 was reported at 8.8m people and continues to grow (Greater London Authority, 2022). Therefore, continued use of public greenspaces including stands of dry acid grassland within urban ecosystem mosaics may become more frequent. Management of dry acid grassland, such as considered mowing approaches to differentiate it from neighbouring ecosystems or within mosaics could assist reduction of potential degradation (Reeve, 2015 and Hibner et al., 2020).

2.5 Regulating ecoservices

From the literature three of the eight Regulating ecoservices were described in relation to lowland dry acid grassland or semi-natural grasslands. These ecoservices, namely Moderation of Extreme Events, Carbon Sequestration and Storage and Regulation of Water Flow may be particularly pertinent to present day climate change threats and therefore hold greater significance in populated urban locations.

Carbon Sequestration and Storage is an important ecoservice regarding greenhouse gas management for all ecosystem typologies and has been a rapidly growing academic research area since the latter part of the twentieth century (Chen et al., 2020 and Brandt et al., 2023). However, this literature review yielded limited information for lowland dry acid grasslands. The Countryside Survey: Soils Report from 2007 (Centre for Ecology & Hydrology, 2010) found acid grassland in England to contain relatively high mean carbon density and mean carbon concentration within 0-15cm of ground level compared to other habitats (Table 4). While the researchers acknowledged these data may not be indicative of full soil horizon measurements it did reveal that farmed and improved grasslands were lowest for both carbon indicators studied. Therefore, conversion of lowland dry acid grasslands to these ecosystem types may have a deleterious sequestration effect.

Table 4: Measurement of Broad Habitat carbon sequestration by area and mass in England (adapted from Centre for Ecology & Hydrology, 2010).

Broad Habitat	Mean Carbon Density (t/Ha)	Mean Carbon Concentration (g/kg^{-1})
Broadleaved, Mixed and Yew Woodland	68.8	68.7
Coniferous Woodland	77.9	131.2
Arable and Horticulture	46.9	30.0
Improved Grassland	64.6	53.1
Neutral Grassland	65.9	64.8
Acid Grassland	95.5	209.8
Bracken	94.1	153.5
Dwarf Shrub Heath	96.6	229.2
Fen, Marsh and Swamp	96.7	273.8
Bog	85.2	398.5
All Habitat Types	70.2	75.6

This was noted again by the 2021 Natural England Research Report NERR094 (Natural England, 2021) which also attempted to quantify the consequences of U.K. semi-natural grassland management approaches (e.g., restoration, grazing, burning) for broad habitat carbon emissions and sequestration annually and by area (per Hectare). Restoration provided the only major approach to benefit sequestration at 9 $MtCo_2$-e yr^{-1} while land use change from grassland to arable land cited 14 $MtCo_2$-e yr^{-1} emitted. However, bias in this estimation was acknowledged due to a lack of studies and hence data for restoration indices, management practices and species composition. Smith (2014) also studied the ability for various grasslands, including dry acidic grasslands, to provide a perpetual carbon sink. While the author considered this unlikely due to fluxes in relatively short-term measurement periods, it was easier for grassland soils to lose carbon via poor management than to gain it.

Lowland dry acid grassland ecosystem soil is defined in academic literature, governmental policies, and technical reports as free draining or highly porous (The Royal Parks, 2006 and Joint Nature Conservation Committee, 2019). However, no data was found as part of this literature review to support qualification nor quantification of this definition. Hydrological regulation in urban conurbations is a Moderation of Extreme Events ecoservice associated with management of flooding from heavy storms. Therefore, the gravelly and sandy geology underlying lowland dry acid grassland ecosystems coupled with their anthropogenic vegetation control particularly in urban areas may provide an undervalued ecoservice for attenuating rainwater and subsequent run-off control (i.e., Regulation of Water Flow ecoservice).

A lack of hydrological quantitative information may make ecosystem typology comparison problematic too for ecosystem economic valuation. While semi-natural grasslands generally in England have been cited as supporting drainage and reduced run-off, further study was recommended to further determine these factors (UK National Ecosystem Assessment, 2011).

Brazier et al., (2009) reported that grassland transition to scrub in New Mexico increased water run-off which was also postulated to lead to sediment transportation. While only this non-U.K. study was found relating vegetation cover to water regulation, it may indicate an important topic for further research related to ecosystem change pressures. These include management of scrub succession and afforestation initiatives (Greater London Authority, 2023). In the case of lowland dry acid grasslands this may be a factor too for Maintenance of Soil Fertility ecoservice. Here lower fertility is desirable versus typically higher fertility for other ecosystem types.

Studies conducted by Bobbink et al. (2010) regarding European acid grasslands, including those in the United Kingdom, over 70 years indicated a decline in dicot richness in favour of grasses associated to atmospheric nitrogen deposition. At a local level, eutrophication risks due to dog fowling were reported (London Biodiversity Partnership, 2005a and London Natural History Society, 2022). Only one peer-reviewed scientific study was found (Buchholz et al., 2021), yet the growth in dog ownership, particularly in urban areas such as London (84% ownership increase) during the COVID-19 pandemic, (Kilraine, 2021 and Braemar Finance, 2023) may necessitate further site management to off-set any potential risk.

Pollination as a Regulating ecoservice sub-category is described in the context of agricultural and horticultural crop production. However, crop production within U.K. lowland dry acid grassland is not a major activity. Here Pollination ecoservices are primarily related to Maintenance of Genetic Diversity ecoservices and is therefore discussed within the Supporting ecoservices section below.

2.6 Supporting ecoservices

The Supporting ecoservice category contains two ecoservices sub-categories, Habitat for Species and the Maintenance of Genetic Diversity. These provide indirect benefits to humans like gene-pool diversity for species adaptation and survival versus direct ecoservices such as Raw Materials. Identification of wildlife species accounted for most of the literature found during the search. Here, 43 articles (52%) were retrieved focussed predominantly upon flora and fauna species and habitat conservation. However, no quantitative information was found for species abundance.

Lowland dry acid grasslands are variable in flora species richness ranging from 5->25 species per $4m^2$ (National Plant Monitoring Scheme (NPMS) Support, (2022). The low growing habit of many lowland dry acid grassland wildflowers coupled with sward maintenance at a low level (10-30cm) may provide a lack of floral interest and identity. When compared to more floriferous grassland types such a calcareous meadow the perception of Maintenance of Genetic Diversity ecoservices value could be compromised (Reeve, 2015 and Dubeux Jr et al., 2019).

The 2005 study by Natural England reported that only 23% of lowland dry acid grassland stands at non-statutory protected sites assessed were in favourable condition. Here the lack of wildflower indicator species and prevalence of coarse grasses accounted for their poor rating. Erosion of flora and soil associated with increased human use may also compromise species richness and therein Habitat for Species and Maintenance of Genetic Diversity ecoservice quality. Such degradation of these ecoservices could provoke transition towards a species poor, lower value amenity grassland typology (London Natural History Society, 2022). Fragmentation too of urban lowland dry acid grassland may affect valuation of these Supporting ecoservices. Isolation of habitat and subsequent reduction of the gene-pool affects species ability for genetic adaptation to stress such as disease and potential detrimental inbreeding (Goulson, 2014 and Pywell et al., 2015).

A published comprehensive record of flora and funga species pertaining to lowland dry acid grassland generally, or specifical to urban situations, was not found during the literature review. Therefore, quantification of Habitat for Species ecoservice for biodiversity or fiscal value would be problematic. Also, assessment of Maintenance of Genetic Diversity ecoservice is difficult if species identification and species abundance data is lacking or subject to bias.

Flora and funga species named in the reviewed literature is presented in Appendix B, Table 5. These species were categorised by the author based upon their family, genera, and species taxonomy and well as geographic location to aid a basic assessment of unique or common Habitat for Species ecoservice. Drawing any qualitative or quantitative conclusions was problematic due to multiple sources of potential bias discussed in Appendix C. Nineteen plant species were cited as either rare, scarce or at risk of extinction. Only three funga species were reported, however, from observations of lowland dry acid grassland at Blackheath, Beale (2023, pers. comm.) claims to have also further identified the lichens *Cladonia furcate*, *Cladonia scabriscula* and *Cetraria aculeata.*

Habitat for Species and Maintenance of Genetic Diversity ecoservices for lowland dry acid grassland fauna was excluded from the literature review. Collation and interpretation of the literature was beyond the resources available for this review and was considered to compromise time available to review other ecoservice categories sufficiently. While researching flora and funga Habitat for Species and Maintenance of Genetic Diversity ecoservices, arthropod fauna of the orders Diptera (Winch, 2019), Hymenoptera (Notton, 2015 and King, 2017), and Lepidoptera (Burton and Freed, 2009) were found to be particularly associated with lowland dry acid grassland biodiversity conservation (Figure H). Their contribution to Pollination ecoservices, as well as allied mammal and bird species biodiversity and abundance was not reviewed.

Figure H: A 2018 Citizen Science study on Yellow Meadow ants in the dry acid grasslands of Richmond Park estimated more than 400,000 anthills, some over 150- years old are present. This may provide a method to determine the age of the grassland as well as determination of other associated species biodiversity (Shersby, 2018).

Literature regarding biodiversity and habitat conservation initiatives indicates that a significant body of primary data may exist to initiate a holistic quantitative assessment of Supporting ecoservices for animal species associated with lowland dry acid grassland. However, qualification of these data resides in grey literature sources or literature not readily accessed in this review. A systematic literature review focussed upon fauna or collaboration with researchers and land management organisations could further investigate these findings.

Conclusions drawn from this review found a paucity of literature relating to Cultural, Provisioning and Regulating ecoservices. This may indicate a significant gap in understanding that could offer research opportunities. Moreover, further study could explore unique or enhanced ecoservices at the urban interface which were not identified from the literature herein. Extensive literature regarding Supporting ecoservices may available but require consolidation and review to again identify knowledge gaps, qualify grey literature and avoid bias.

Gaps in the published literature retrieved as part of this study, compounded with variable ecosystem definition, and limited geographic area mapping suggest ecoservice identification, qualification and quantification is underdeveloped and therefore fiscal valuation problematic. Grey literature published by land-management bodies and policymakers indicates that a significant body of primary data or existing knowledge may reside within these organisations. Herein, assimilation and peer-reviewed publication of such prior knowledge may provide an opportunity to optimise lowland dry acid grassland ecoservice assessment.

3.0 Methodology

3.1 Methodology selection

The methodology for this study considered three London lowland dry acid grassland cases to address the research question. The case study included a narrative literature review and interviews with appropriate representatives of the cases. The interviews followed a semi-structured question format to facilitate subsequent data for analysis and interpretation.

3.2 Literature review

A traditional (narrative) literature review was undertaken versus systematic (Boland et al., 2017) and scoping (Levac et al, 2010) types as it best met the requirements of the research objectives (Machi, 2016), literature types and time-constraints (i.e., less than 3 months to complete).

The number of scientific publications containing the term 'ecosystem services' increased dramatically from 2005 (Figure I). Therefore, the literature search only considered material from 2005 onwards unless it was of particular importance to the topic area.

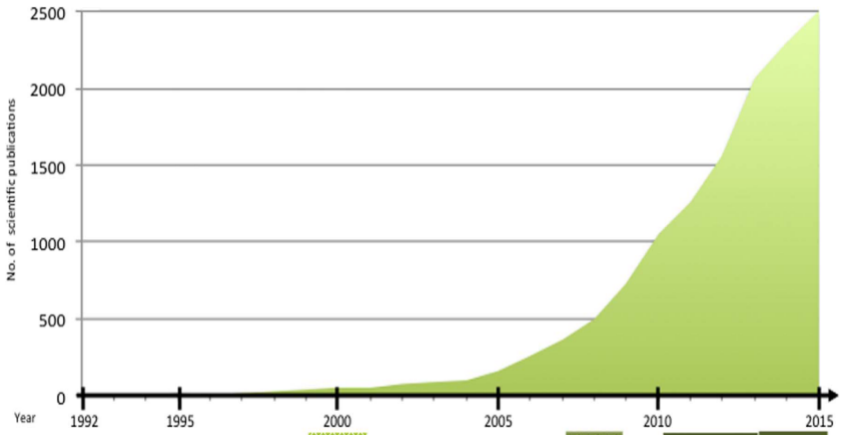

Figure I: The number of scientific publications containing the term 'ecosystem services' until 2008 were below 500. However, this doubled within two years (adapted from Bouwma et al, 2018).

Data retrieval sources were Google Scholar, JSTOR and RHS Library Service for academic, peer reviewed publications as well as Google for grey literature and policy documents.

3.3 Case Study

3.3.1 Justification of cases

Three cases were studied: Blackheath, Greenwich Park and Wimbledon Common (Appendix D, Table 6). A multiple case-study approach was considered appropriate for the research objectives (Denscombe, 1998 and Thomas, 2011). Supporting factors include:

- the cases outwardly share features in common, i.e., lowland dry acid grassland ecosystems in busy urban locations within London and representative of similar phenomena
- ability to acquire in-depth data and open-ended questioning
- expert and experienced knowledge may show how theory relates to real-life examples
- the cases are self-contained entities within defined boundaries
- the cases represent phenomena present during and after research

3.3.2 Primary data acquisition

Primary data was obtained by semi-structured interview with open questions as this approach has suited similar exploratory research previously (Brett Davies, 2007 and Yin, 2018). These were conducted face-to-face. Based upon a pilot interview, the number of interview questions was reduced from ten to eight to keep the process and data analysis manageable within the time available, see Table 7.

Table 7: Interview questions and phasing during the interview.

Question Number	Question	Interview Phase
1	Could you tell me broadly about the dry acid grassland you are responsible for?	Initial Phase: Broad, open questions, put interviewee at ease
2	In your experience what are the benefits to human wellbeing, either direct or indirect, to the users provided specifically by the dry acid grassland at your site?	
3	What awareness do you think the users have of this dry acid grassland specifically?	
4	Dry acid grassland is also situated in less populated areas; would you anticipate any differences in benefits they provide their users?	Middle Phase: Focusing on research question objectives
5	What unique benefits to human wellbeing to its users does dry acid grassland provide?	
6	Are there any other habitats/ecosystems in your care that receive greater resources for their management?	
7	From your knowledge could you explain if your dry acid grassland is historically significant?	
8	What degree of collaboration do you have with other managers of similar spaces of dry acid grassland?	Concluding Phase: Clarification of assertions, probing

There is no single definition for ecosystem services (Department for Environment, Fisheries and Rural Affairs, 2007), thus interviewee participants may have been confounded by its meaning. The phrase 'benefits to human wellbeing' was used in conjunction with 'ecoservices' for each interview question. This terminology was used to mitigate constrained responses bound by formal definition, jargon or preconceived service categories as interviewee responses may have identified new or unique ecoservices. Questions 7 and 8 were based upon the findings of the literature review where a lack of Cultural ecoservices and land management forums for lowland dry acid grassland were found.

3.3.3. Primary data analysis

A thematic approach was used to analyse the data and to identify themes for subsequent investigation. Thematic analysis is also suited to the primary methodology herein due to its use for a range of study questions, commonality searching as well as use for novice researchers, where time and resources may be limited as for this study (The University of Auckland, n.d.). Table 8 shows the deductive and inductive methodology coding approaches employed for the interview design (Bingham and Witkowsky, 2022).

Table 8: Deductive (C,P,R,S,E codes) and inductive (C/P, M, O codes) thematic coding used for analysis of interview questions responses.

Ecoservice	Code	Ecoservice Sub-Category
Cultural Ecoservices	C1	Aesthetic Appreciation and Inspiration for Culture, Art and Design
	C2	Recreation and Mental and Physical Health
	C3	Spiritual Experience and Sense of Place
	C4	Tourism
Provisioning Ecoservices	P1	Food
	P2	Freshwater
	P3	Medicinal Resources
	P4	Raw Materials
Regulating Ecoservices	R1	Biological Control
	R2	Carbon Sequestration and Storage
	R3	Erosion Prevention and Maintenance of Soil Fertility
	R4	Local Climate Air Quality
	R5	Moderation of Extreme Events
	R6	Pollination
	R7	Regulation of Water Flow
	R8	Waste-water Treatment
Supporting Ecoservices	S1	Habitat for Species
	S2	Maintenance of Genetic Diversity
Ecosystem Identity	EI	Not Applicable
Ecoservice Definition	ED	Not Applicable
Non-ecoservice Topic	C/P	Conservation/Protection
	M	Management
	O	Other

3.3.4 Bias and quality

Bias sources that were anticipated to potentially impact quality (Silverman, 2005 and Brett Davies, 2007) prior to the study stages considered are listed in Appendix E, Table 9. Care was taken to minimise such bias sources for this study approach.

3.3.5 Practical considerations

A study information sheet (Appendix F) and an informed consent sheet (Appendix G) were sent to the interviewees prior to the interviews to outline the research objectives and ensure concordance to the General Data Protection Regulation (G.D.P.R.), also known as the Data Protection Act, 2018.

4.0 Primary Research

4.1 Interviewee and general considerations

Upon the author's request, three senior management level candidates were proposed by The Blackheath Society, Wimbledon and Putney Commons Conservators and The Royal Parks to represent Blackheath, Wimbledon and Putney Commons, and Greenwich Park sites respectively.

The interviews were conducted at the case sites apart from the Lewisham London Borough Council Representative who was interviewed at the author's home as the interviewee lived close by and a suitable quiet space could not be found on the day of interview. All interviews were conducted during March 2023 and recorded on the author's iPhone Voice Memos app.

The Blackheath Society initially proposed a candidate with expertise and published academic articles in local wildlife conservation. However, the candidate was rejected as the author wished to avoid possible bias for specific ecoservice categories (i.e., Supporting). The interviews ranged from 41 to 77 minutes duration. Editing from the audio transcription was required to eliminate irrelevant discussion and dialogue. The transcription in Table 10 (Appendix H) was intentionally not adjusted regarding the discussion grammar or discussion style of the interviewees to maintain authenticity and avoid bias.

5.0 Discussion

Figure J illustrates the code count from the interviewee discussions versus the ecoservice categories, sub-categories and non-ecoservice categories. This was not intended to provide a rigorous qualitative assessment of the results but rather provide a comparative indication as to response frequency to support qualitative analysis and discussion below.

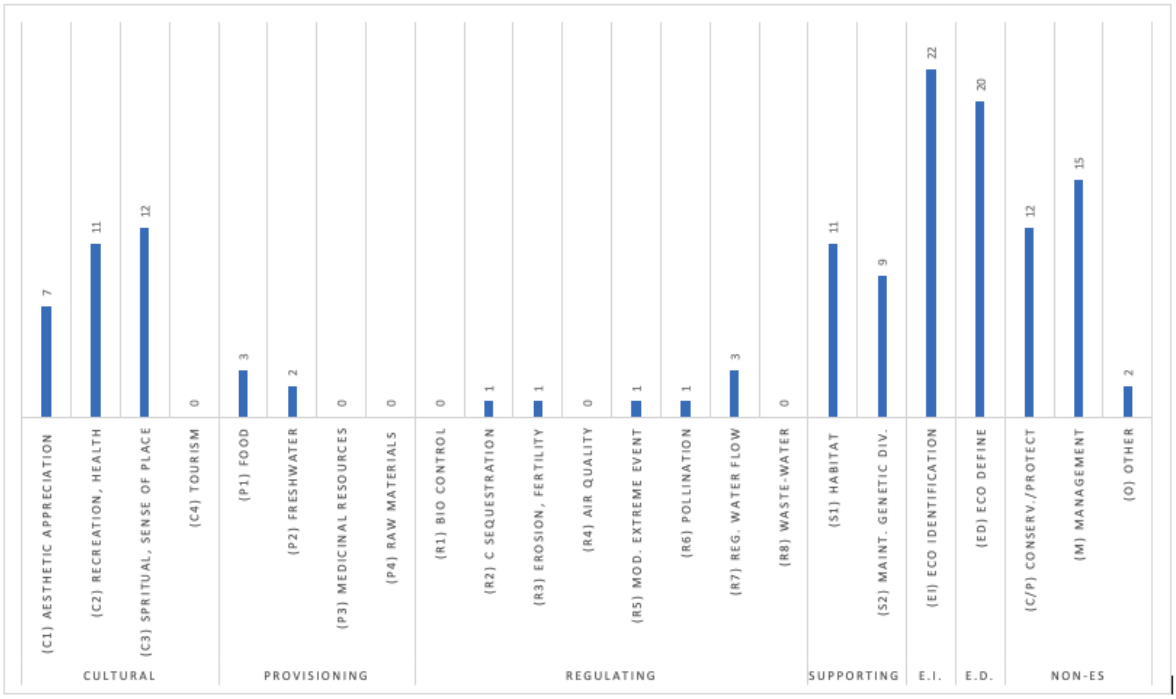

Figure J: Ecoservice code count from Table 8.

5.1 Ecosystem identity

Identification of lowland dry acid grassland (E.I.) scored the highest from the thematic analysis. While question 3 was targeted to ascertain responses to this theme specifically and therefore likely to have positively affected the theme count, ecosystem identity arose throughout the interview questions and across all three participants. These data indicate that lowland dry acid grassland cases managed by the interviewee organisations primarily exist as mosaics amongst other ecosystem typologies. This concurs with the literature where underdeveloped area mapping and definition of boundaries between adjacent mosaic ecosystems typologies, including other semi-natural grassland could make specific ecosystem valuation problematic. Interviewees concurred those human users of lowland dry acid grassland had little awareness of it, nor the ability to differentiate it from other grassland ecosystems. Reflecting the literature review findings, the nomenclature used, such as heath, heathland, commons, and wasteland make assessment of historic Cultural ecoservices (e.g., recreational activities) difficult to specifically attribute to lowland dry acid grassland.

5.2 Ecoservices definition

The interviewees were familiar with the overarching ecoservice category terms (i.e., Cultural, Regulating), however, only the Lewisham London Borough Council representative specifically referred to sub-category terms. These were Recreation, Mental Health, Physical Wellbeing, and Carbon Sequestration. The use of the terms 'ecosystem' and 'habitat' was in the ratio of 1:2.6 respectively. This may infer that the interviewees were more familiar or biased towards the term or topic of habitats versus ecosystems. All three interviewees had conservation experience therefore a possible bias to biotic themes than abiotic ecosystem elements.

Sub-category Spiritual Experience and Sense of Place (C3 coding) was used to capture historical and heritage cultural themes, which accounted for the 59% of the score. No reference to Spiritual experience was made by any interviewee as an ecoservice nor did a related theme arise. Adjustment of the ecoservice sub-category terms to include historical or heritage as a separate sub-category may benefit any further Cultural ecoservice research approaches such as subsequent interviews.

5.3 Cultural ecoservices

In accordance with the literature findings, none of the interviewees responded that lowland dry acid grassland, as a specific ecosystem typology, provided discrete Cultural ecoservices. However, as part of a mosaic, the ecosystem may provide significant benefits to human wellbeing.

All interviewees reported such mosaic sites containing lowland dry acid grassland were frequently used for physical health activities and recreational activities with a substantial increase in use during the COVID-19 lockdowns. The free-draining, dry, level topology with low sward height and long, open views may have provided accessible and safe areas for social distancing activities and subsequent maintenance of mental health. These attributes may also support the cultural value of these sites regarding the U.K.'s sporting heritage. The literature referred to major sports development associated with such London mosaics containing lowland dry acid grassland. The evolution of Polo at Richmond and Hockey in Bushy Park were mentioned during interview and attributed, in part, to the advantageous ground properties to run upon.

The demographic of users, both human and canine changed due to COVID-19 lockdown. Younger people were reported to use the areas and the increase of dogs, and their walkers was discussed by both Lewisham London Borough Council and Wimbledon and Putney Commons representatives. This concurs with the literature retrieved referencing increased recreational visiting of such areas as well as dog ownership increase during the COVID-19 pandemic.

Aesthetic appreciation (coding C1) was discussed by the interviewees but not in the ecosystem sub-category context of culture, art, and design. Consensus was that lowland dry acid grassland provides limited floral aesthetic interest for most of the year, apart from Sheep's sorrel which was notable as a visual signature of the ecosystem. However, it may be that the open, relatively vegetation-sparse aspect and long views may have provided a unique type of ecosystem service regarding safety and observation to past and present human users. Referred to as possibly 'unnerving' during The Royal Parks interview, and described historically as wasteland, the cases may present a differentiation regarding a Sense of Place ecoservice from the surrounding urban infrastructure. A survey of the ecosystem users may aid further understanding of Aesthetic Appreciation ecoservice value.

The history and heritage of the cases from both the literature review and case study interviews was a recurrent theme. Human habitation and intervention such as livestock grazing and disturbance coupled with reciprocal services provided by the ecosystem such as free draining, workable soil for building were discussed. Cultural associations from early Bronze age, through Saxon and Roman occupation, Wat Tyler's medieval uprising, Georgian gravel pit extraction and later World War II rubble back filling and anti-aircraft gun batteries upon Wimbledon Common were cited. All interviewees were knowledgeable regarding their case's heritage and further specific discussion could yield further primary data to support Cultural ecoservice assessment and valuation. Again, differentiation of specific lowland dry acid grassland services within the case mosaics is anticipated to be problematic. Nevertheless, these urban cases may necessitate an alternative approach to valuation versus their rural counterparts regarding the anthropogenic utility of these areas. A heritage continuum of modern day ecoservices may persist with the cases used for wellbeing and recreational purposes during the unprecedented COVID-19 global pandemic.

5.4 Regulating ecoservices

Case study interviews mirrored the literature with a paucity of Regulating ecoservice information found. Regulating ecoservice assets such as Regulation of Water Flow, Moderation of Extreme Events and Carbon Sequestration and Storage may become more pressing with climate change concerns.

This appears to present an area that lacks research and at valuation risk for this ecosystem typology. Urban ecosystems may justify greater valuation versus rural locations due to the greater potential risks to infrastructure assets damage and population safety from events such as flooding.

Vegetation succession and/or woody plant establishment including trees intended to offset climate change effects could degrade Regulating ecoservice assets. Further primary data, technical information, and expertise for this ecoservice category may be available within other academic and technical disciplines such as geological and hydrological fields. This was not retrieved during this study nor was it the inherent expertise or experience of the case study interviewees.

5.5 Provisioning ecoservices

This category of ecoservices was referenced least in terms of literature and subsequent case study interview responses. While Food, Fresh Water and Raw Materials (e.g., gravel) were relevant up to the 19th century they were not found to be utilised today. This may be a direct result of modern urban infrastructure, conservation protection and commercial trends where agriculture, mains drinking water and construction materials are supplied remotely such as importation. Provisioning ecoservices may today be the least valuable category of lowland dry acid grassland's benefits to human wellbeing, however, they appear to be important parts of the history and heritage of such urbanised ecosystems and thus contribute indirectly to Cultural valuation.

5.6 Supporting ecoservices

Due to the relatively abundant amount of literature retrieved upon the Supporting ecoservice sub-categories of Habitat for species (S1 coding) and Maintenance of Genetic diversity (S2), the interview questions developed did not specifically focus upon these services to facilitate a deeper examination of the other ecoservice categories.

From the interviews it was apparent that significant quantity of information regarding the flora and fauna, and to a much lesser degree funga, present at the case sites was known from previous, ongoing or planned future research. However, these data were retained in the management organisations repositories such as monitoring reports or annual management plans. The interviewees acknowledged a lack of peer reviewed research publications were available.

The Royal Parks interviewee stated that the problematic nature of quantifying urban lowland dry acid grassland habitat specificity in mosaic systems and potential bias in the literature may be compounded due to the methodology employed during initial vegetation classification studies. The author presents a summation of flora species discussed from the literature search in Table 5, yet geographic surveying to develop the National Vegetation Classification handbook for individual habitat typology and monitoring appears not to have covered the greater London area significantly (Figure K). This may partly explain an over focus upon certain indicator species and under identification of urban species.

Figure K: Geographic distribution of sampling for development of the National Vegetation Classification user handbook. Each dot represents the number of samples in a 10x10km grid square. The pink square indicates no sampling within the London area (adapted from Rodwell, 2006).

This supports the author's conclusion that the flora species data collected regarding geographic locations stated in the literature is likely to be biased. Moreover, assignation of axiophytes or indicator species as well as identification of unique or rare flora for urban lowland dry acid grassland may require further research to qualify. Unpublished primary data relating to rare or unique flora may support further ecoservice value as well as possible habitat protection for conservation purposes.

Similar assessment of fauna species, particularly invertebrates may further benefit Supporting ecoservices asset assessment. The management organisations for the cases may hold in-house information, to assist building a holistic biotic overview for urban sites which could be compared to rural locations. Therefore, publication of in-house primary data would be a value exercise for lowland dry acid grassland custodians.

The Royal Parks has significant primary data; 600 years of managing the same land and 1500 surveys. Human disturbance at the case sites and other urban examples could create unique ecosystems different to rural sites regarding species communities and population abundance such as the extensive Meadow Ant systems found in Bushy Park. Here, these biotic components of the lowland dry acid grassland may interface with the abiotic ecoservices. King (2006) considered that aeration, drainage, and nutrient diversity were ecological services provided by the ants along with increased flora species richness and the ability to alter soil pH.

Funga species appear generally understudied at the case locations with no interviewees alluding to existing or planned research. The interdependence of flora, fauna and funga was not mentioned during the interviews. Without a consolidated assessment of the species present and their abundance, accurate Pollination ecoservice assessment is unlikely as well as valuation of the benefits from food dependant higher fauna such as ground nesting birds. The contribution of funga species to sequestered carbon mass measurements as well as biodiversity contribution may be important ecoservice components.

5.7 Non-ecoservice factors

Management of the cases was a reoccurring theme albeit not one specifically designed into the interview questionnaire. Nevertheless, these aspects were considered by the author important primary data potentially affecting ecoservice quality and hence variables that could impact future valuation of both wellbeing and fiscal importance.

Sward management in all cases was by mowing and baling to limit residence of cut grass and subsequent eutrophication. Contractors undertook this on behalf of Blackheath and Wimbledon and Putney Commons due to the scale of mowing required. Differing mowing regimes regarding timing were noted however cutting depth which could affect vegetation distribution and pollination opportunity was not mentioned. For both these cases a proportion of the grassland was left uncut for wildlife but neither case received greater resources for their management versus other ecosystems in the interviewees experience. Both these cases also reported a high number of dogs and dog walkers since COVID-19 lockdowns. The interviewees did not mention eutrophication concerns associated with fowling but rather general disturbance with trampling caused by the increase volumes of human users too.

The three cases are all subject to protective mechanisms against development either directly or indirectly associated with conservation or legacy legal acts. Greenwich Park also has physical protection from enclosure and in-house policing. Lowland dry acid grassland stands under the management of The Royal Parks such as Bushy Park and Richmond Park are designated as S.S.S. I's partly due to their lowland dry acid grassland. All three cases therefore currently benefit from anthropogenic protection mechanisms from infrastructure development.

Implementation of local nature recovery strategies was mentioned in relation to further restoration focus of lowland dry acid grassland in London, however, no forums were reported to currently exist for land managers or researchers to specifically exchange knowledge or best practice locally. This had previously occurred under the auspices of the Biodiversity Action Planning (B.A.P.) initiative, however, successive governmental and therein green policy changes have rendered this defunct. There is a gap in communication and collaboration between lowland dry acid grassland land managers within and outside of London.

6.0 Conclusions and Recommendations

This study provides a brief and broad analysis of the ecosystem services provided by lowland dry acid grassland, particularly stands in London which provided the greatest opportunity to determine new, unique, or enhanced ecoservices provided in urban environments.

Many gaps in reported ecoservice study are apparent. However, this may be due to a lack of peer reviewed research articles available for retrieval rather than a lack primary data available. Managing organisations such as those from the cases studied may hold primary data or prior knowledge useful for valuation purposes. Caution regarding the use of grey literature for decision making purposes is recommended due to inconsistencies in nomenclature, specificity of ecosystem typology and uncertainties in data sourcing (e.g., indicator species assignation). It is recommended that primary data from research studies is formalised into peer reviewed literature to better consolidate and share information on this ecosystem typology. Findings may support understanding and valuation assessment in analogous lowland dry acid grassland ecosystems globally too.

Primary research particularly for Supporting ecoservices is likely to be significant if consolidated by researchers and managing organisations together. Without such holistic treatment and peer review of available primary data, bias may be present regarding assumed species populations and possible ignorance of potentially rare or unique species. Inconsistent biodiversity understanding and associated interdependence, not only biotic but also regarding abiotic ecoservices could be at risk of undervaluation. Reestablishment of a subject matter network or forum is recommended that would significantly aid understanding and sharing of best practices.

Study of Provisioning and Regulating ecoservices was minimal particularly in relation to U.K. lowland dry acid grassland and the specific London cases studied. Given current pressing climate change concerns and growing urban population densities, ecoservice sub-categories such as Moderation of Extreme Events (e.g., flooding) and Carbon Sequestration and Storage could provide significant modern-day ecoservices and natural capital assets. Mitigation of financial and wellbeing risks associated with these ecoservices is recommended for research prioritisation. Furthermore, review of Regulating ecoservice degradation and hence risk to human and asset wellbeing by infrastructure development and afforestation pressures may require greater awareness amongst decision makers.

These factors could also augment conservation and restoration arguments than purely Supporting or biotic ecoservices alone (e.g., protected species habitat). These ecoservices could provide useful focus for further research with abiotic stakeholders such as geology and hydrology researchers too.

Modern Cultural ecoservices as exemplified by COVID-19 lockdown mental and physical health mitigation could provide a rich area of research and significant contribution to Cultural ecoservice value. The author asserts that humans are keystone species for urban lowland dry acid grassland. They are responsible for its initial creation for settlement, maintenance, and protection of its current character but also ultimately responsible for future conservation or development interventions.

Alternative Cultural ecoservice sub-categories such as Natural Heritage and Education could provide further routes to determine holistic Cultural ecoservice assessment versus just those used during this study. It is recommended that research exploring the specific Cultural ecoservices of lowland dry acid grasslands both rural and urban is undertaken. This may also present an opportunity to determine differences or similarities in Cultural ecoservices provided by other closely associated ecosystem typologies such as lowland heath.

While differentiation of ecoservices from other ecosystem types in urban landscape mosaics may be problematic, increased collaboration and communication across land management disciplines may provide opportunities to enhance characterisation, mapping, and subsequent valuation of urban lowland dry acid grassland to better inform conservation and development decision making. It is recommended that a similar study for rural lowland dry acid grassland cases would augment the findings from this study to further ascertain new, unique, or enhanced ecoservices provided by urban examples. In addition, research and primary data publication including wildlife species qualification and land management practices may support future biodiversity best practices in urban grasslands.

The research objectives from this study are considered to have been partly met. The methodology used determined that published studies and responses from London case interviews provided limited primary data regarding specific urban lowland dry acid grassland ecoservice understanding. However, alternative methodology could yield further assessment of the research question as significant primary data may exist or be accessed via other investigative approaches. Nevertheless, the study highlights the complexity in assessment of such urban ecosystem typologies but also opportunities for additional academic research and collaboration of lowland dry acid grassland stakeholders.

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8.0 APPENDICES

Appendix A

Table 3: Categorisation and full description of Ecoservices and their sub-categories in accordance with the Food and Agriculture Organization of the United Nations, 2023.

Ecoservice Category	Ecoservice Sub-category	Ecoservice Sub-category Descriptor
Cultural	Aesthetic appreciation and inspiration for culture, art and design	Animals, plants and ecosystems have been the source of inspiration for much of our arts, culture, and design; they increasingly inspire science as well.
	Recreation and mental and physical health	Nature-based opportunities for recreation play an important role in maintaining mental and physical health, e.g., walking and playing sports in parks and urban greenspaces.
	Spiritual experience and sense of place	Nature is a common element in most major religions. Natural heritage, spiritual sense of belonging, traditional knowledge, and associated customs are important for creating a sense of belonging.
	Tourism	Enjoyment of nature attracts millions of travellers worldwide. This cultural ecosystem service includes both benefits to visitors and income opportunities for nature tourism service providers.
Provisioning	Food	Virtually all ecosystems provide the conditions for growing, collecting, hunting or harvesting food.
	Freshwater	No water, no life. Ecosystems play a vital role in providing the flow and storage of fresh water.
	Medicinal resources	Natural ecosystems provide a variety of plants and mushrooms which offer effective cures for many kinds of health problems. They are used in popular and traditional medicine, and for developing pharmaceuticals.
	Raw materials	Ecosystems provide a great diversity of materials including wood, biofuels, and fibres from wild or cultivated plant and animal species.
Regulating	Biological control	The activities of predators and parasites in ecosystems that act to control populations of potential pests and disease vector.
	Carbon sequestration and storage	Ecosystems regulate the global climate by storing greenhouse gases. For example, as trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.
	Erosion prevention and maintenance of soil fertility	Vegetation cover prevents soil erosion and ensures soil fertility through natural biological processes such as nitrogen fixation. Soil erosion is a key factor in the process of land degradation, loss of soil fertility and desertification, and contributes to decreased productivity of downstream fisheries.
	Local Climate Air Quality	Ecosystems influence the local climate and air quality. For example, trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.
	Moderation of extreme events	Ecosystems and living organisms create buffers against natural disasters. They reduce damage from floods, storms, tsunamis, avalanches, landslides, and droughts.

	Pollination	Insects and wind pollinate plants and trees which is essential for the development of fruits, vegetables, and seeds. Animal pollination is an ecosystem service mainly provided by insects but also some birds and bats. In agro-ecosystems, pollinators are essential for orchard, horticultural and forage production, as well as the production of seed for many root and fibre crops. Pollinators such as bees, birds and bats affect 35 percent of the world's crop production, increasing outputs of around 75% of the leading food crops worldwide.
	Regulation of Water Flow	Water flow regulation is a key service provided by land cover and configuration, but its dynamics are poorly understood by most policy makers and land management organisations.
	Waste-water treatment	Ecosystems such as wetlands filter effluents, decompose waste through the biological activity of microorganisms, and eliminate harmful pathogens.
Supporting	Habitat for species	Ecosystems provide living spaces for plants and animals; they also maintain a diversity of complex processes that underpin the other ecosystems services. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others; these are known as 'biodiversity hotspots'
	Maintenance of genetic diversity	Genetic diversity (the variety of genes between, and within, species populations) distinguishes different breeds or races from each other, providing the basis for locally well-adapted cultivars and a gene pool for developing commercial crops and livestock.

Appendix B

Table 5: Flora and Funga species referenced within all the lowland dry acid grassland literature retrieved (author's own). The Literature Geographic Location (L.G.L.) descriptor was used to sort the plants referenced within the literature retrieved to assess any specific observations for urban dry acid grassland sites. Urban L.G.L. refers to urban sites referenced only (e.g., within London); Urban and General LGL refers to urban and general references (e.g., governmental conservation report) only; Non-urban L.G.L. refers to non-urban sites referenced only (e.g., lowland dry acid grassland in Breckland, Suffolk). Binomial and common names listed in alphabetical order. References using both binomial and common name are listed above those citing just the common name.

Literature Geographic Location	Binomial Name	Common Name	Plant Family	Reference Frequency	Comments
Urban	*Lathyrus nissolia*	Grass Vetchling	Fabaceae	1	-
	Lotus corniculatus	Common Bird's-foot Trefoil	Fabaceae	1	-
	Medicago arabica	Spotted Medick	Fabaceae	1	-
	Medicago lupulina	Black Medick	Fabaceae	1	-
	Scilla autumnalis	Autumn Squill	Asparagaceae	3	'Nationally scarce'
	Trifolium arvense	Hare's-foot Clover	Fabaceae	1	-
	Trifolium micanthrum	Slender Trefoil	Fabaceae	1	-
	Trifolium tormentosum	Woolly Clover	Fabaceae	2	'Only stable UK population'
	Spergularia rubra	Sand Spurrey	Caryophyllaceae	2	-
	-	Bee Orchid	Orchidaceae	1	-
	-	Blue Speedwell	Veronicaceae	1	-
	-	Cat's Ear	Asteraceae	2	-
	-	Clustered Clover	Fabaceae	4	'Nationally scarce'
	-	Germander	-	1	-
	-	Gorse	Fabaceae	2	-
	-	Mayweed	Asteraceae	1	-
	-	Heath Woodrush	-	1	-
	-	Pink Waxcaps	Hygrophoraceae	2	'Flagship Species'
	-	Upright Chickweed	Caryophyllaceae	2	'Nationally scarce'
	-	Waxcaps	-	1	
Urban and General	*Agrostis capillaris*	Common Bent	Poaceae	8	-
	Avenella flexuosa, syn. Deschampsia flexuosa	Wavy Hair Grass	Poaceae	10	'Indicator species'
	Betonica officinalis	Betony	Lamiaceae	2	'Rare in London' 'Indicator species'
	Calluna vulgaris	Heather	Ericaceae	7	-
	Campanula rotundifolia	Harebell	Campanulaceae	9	'Indicator species' 'Extinction Risk' 'Flagship Species'
	Dactylorhiza maculate subsp. ericetorum	Heath Spotted-Orchid	Orchidaceae	2	'Extinction Risk' 'Rare in London area'
	Erodium cicutarium	Common Stork's-Bill	Geraniaceae	4	-
	Festuca ovina	Sheep's Fescue	Poaceae	9	-
	Filago germanica	Common Cudweed	Asteraceae	1	-
	Galium saxatile	Heath Bedstraw	Rubiaceae	14	'Indicator species' 'Flagship Species'
	Galium virum	Lady's Bedstraw	Rubiaceae	11	'Indicator species'
	Genista tinctoria subsp. Tinctoria	Dyer's Greenwood	Fabaceae	1	'Rare'
	Medicago minima	Bur Medick	Fabaceae	2	'Rare and scarce'
	Nardus stricta	Mat Grass	Poaceae	4	-
	Ornithopus perpusillus	Bird's-Foot	Fabaceae	9	'London notable species'
	Plantago coronopus	Buck's-Horn Plantain	Plantaginaceae	4	-
	Polygala serpyllifolia	Heath Milkwort	Polygalaceae	5	-
	Potentilla erecta	Tormentil	Rosaceae	12	'Indicator species'
	Rumex acetosella	Sheep's Sorrel	Polygonaceae	15	'Indicator species' 'Flagship Species'
	Trifolium campestre	Hop Trefoil	Fabaceae	2	-
	Trifolium dubium	Lesser Trefoil	Fabaceae	2	-
	Trifolium glomeratum	Clustered Clover	Fabaceae	6	'Rare and scarce'
	Trifolium repens	-	Fabaceae	2	-

	Trifolium scabrum	Rough Clover	Fabaceae	1	'Extremely rare in London'
	Trifolium striatum	Knotted Clover	Fabaceae	2	-
	Trifolium subterraneum	Subterranean Clover	Fabaceae	1	-
	Trifolium suffocatum	*Suffocated Clover*	Fabaceae	2	-
	Ulex europaeus	European Gorse	Fabaceae	4	-
	Ulex minor	Dwarf Gorse	Fabaceae	2	-
	Veronica officinalis	Heath Speedwell	Veronicaceae	5	'Indicator species'
	-	Bird's-foot Trefoil	Fabaceae	3	'Indicator species'
	-	Early Hair Grass	Poaceae	3	'London notable species'
	-	Lichen	-	4	'Rare', 'Rich'
	-	Mouse-ear Hawkweed	Asteraceae	3	'Indicator species'
	-	Parsley Piert	Rosaceae	3	'Indicator species'
	-	Red Fescue	Poaceae	4	-
	-	Yarrow	Asteraceae	2	-
Non-urban	*Achillea millefolium*	-	Asteraceae	1	-
	Agrostis curtisii	Bristle Bent	Poaceae	4	-
	Anthoxanthum ororatum	Sweet Vernal Grass	Poaceae	3	-
	Bellis perennis	-	Asteraceae	1	-
	Blechnum spicant	*Hard-Fern*	Blechnaceae	1	-
	Carex arenaria	Sand Sedge	Cyperaceae	4	-
	Cerastium spp.	-	Caryophyllaceae	1	-
	Cladonia spp.	Reindeer Moss	Cladoniaceae	1	
	Crassula tillaea	Mossy Stonecrop	Crassulaceae	1	'Rare and scarce'
	Erica cineria	-	Ericaceae	1	-
	Herniaria glabra	Smooth Rupturewort	Caryophyllaceae	1	'Rare and scarce'
	Hypochaeris radicata	Common Cat's Ear	Asteraceae	1	-
	Jacobaea vulgaris	-	Asteraceae	1	-
	Juncus squarrosus	Heath Rush	Juncaceae	1	-
	Leontodon hispidus	-	Asteraceae	1	-
	Lotus angustissimus	Slender Bird's-foot Trefoil	Fabaceae	2	'Rare and scarce'
	Lychinis Viscaria	Sticky Catchfly	Caryophyllaceae	1	'Rare and scarce'
	Moenchia erecta	Upright Chickweed	Caryophyllaceae	1	-
	Petrorhagia prolifera		Caryophyllaceae	1	'Nationally rare'
	Pilosella peleteriana	Shaggy Mouse-ear Hawkweed	Asteraceae	1	'Rare and scarce'
	Pulicaria dysenterica	-	Asteraceae	1	-
	Ranunculus spp.	-	Ranunculaceae	1	-
	Rubus fruticosus	-	Rosaceae	1	-
	Stellaria graminea	-	Caryophyllaceae	1	-
	Ulex galii	Western Gorse	Fabaceae	1	-
	Vaccinium myrtillus	Bilberry	Ericaceae	4	'Indicator species'
	Veronica arvensis	Wall Speedwell	Veronicaceae	1	-
	Veronica verna	Spring Speedwell	Veronicaceae	1	'Rare and scarce'
	-	Bell Heather	Ericaceae	1	-
	-	Biting Stonecrop	Crassulaceae	1	'Indicator species'
	-	Bitter Vetch	Fabaceae	1	'Indicator species'
	-	Blue Fleabane	Asteraceae	1	'Indicator species'
	-	Bracken	Dennstaedtiaceae	1	-
	-	Breckland Speedwell	Veronicaceae	1	-
	-	Common Centaury	Gentianaceae	2	'Indicator species'
	-	Common Rock-Rose	Cistaceae	1	'Indicator species'
	-	Common Stork's Bill	Geraniaceae	2	'Indicator species'
	-	Common Vetch	Fabaceae	1	
	-	Coral Fungi	-	1	
	-	Devil's-Bit Scabious	Caprifoliaceae	1	'Indicator species'
	-	Heath-Grass	Poaceae	1	'Indicator species'
	-	Lesser Hawkbit	Asteraceae	1	'Indicator species'
	-	Lousewort	Orobanchaceae	1	'Indicator species'
	-	Maiden Pink	Caryophyllaceae	1	'Indicator species'
	-	Milkworts	Polygalaceae	1	'Indicator species'
	-	Mosses	-	1	
	-	Mossy Stonecrop	Crassulaceae	1	
	-	Pignut	Apiaceae	1	'Indicator species'
	-	Purple Milk-Vetch	Fabaceae	1	'Indicator species'
	-	Rough Hawkbit	Asteraceae	1	'Indicator species'
	-	Saw-Wort	Asteraceae	1	'Indicator species'
	-	Sheep's-Bit	Campanulaceae	1	'Indicator species'

	-	Shepherd's-Cress	Brassicaceae	1	'Indicator species'
	-	Spring Speedwell	Veronicaceae	1	
	-	Thymes	Lamiaceae	1	'Indicator species'
	-	Violets	Veronicaceae	1	'Indicator species'
	-	Wild Strawberry	Rosaceae	1	'Indicator species'
	-	Wood Anemone	Ranunculaceae	1	'Indicator species'
	-	Wood Sage	Lamiaceae	1	'Indicator species'

Appendix C

Multiple sources of potential bias

i) In most cases it was difficult to determine if species habitats were purely from dry acid grassland stands or from other ecosystem types (e.g., heathland) in proximity or as part of a mosaic landscape (Figure B). Data reported, such as annual ecological monitoring reports (e.g., Wimbledon Common) did not explicitly study dry acid grassland stands within the location but rather the general area where they are present.

ii) Plant nomenclature was inconsistent due to the use of common names generally within grey literature. An example was the use of Bird's-foot (*Ornithopus perpusillus*) and Bird's-foot Trefoil (*Lotus corniculatus)* which could be confused.

iii) None of the comments referring to individual species abundance (e.g., Nationally scarce) were qualified by data in their literature sources. Some species named as indicator species were frequently named, such as *Rumex acetosella* (Sheep's Sorrel) with 13 citations. However, other indicator species were infrequently cited, such as Stonecrop, cited only a single time. The infrequent citation of some supposed dry acid grassland flora axiophytes is paradoxical. Moreover, it is also possible that some plant species cited in the grey literature may simply have been taken from other grey literature sources without proper qualification.

iv) Species from the Fabaceae family were cited most often within the Urban and Urban and General literature geographical location categories. However, these species were noted by a small number of more specific literature sources. Therefore, this flora family and its species may be present in non-urban dry acidic grassland stands but not sufficiently studied nor reported. Only two references to funga were found from the literature, namely Pink Waxcaps and *Cladonia spp.* (Reindeer Moss).

Appendix D

Table 6: Contact organizations with responsibilities and staff that provided candidates for interview.

Case/ Responsible Organisation (weblink)	Case Suitability	Interviewee Case Role
Greenwich Park/ Royal Parks (www.royalparks.org.uk)	Long term management of the case Management of other urban dry acidic grassland habitats On-going restoration of dry acid grassland in Greenwich Park	Head of Programmes, Volunteers and Conservation
Blackheath/ The Blackheath Joint Working Party (www.blackheath.org)	Long term management of the case Co-ordinates managing organisations (e.g., Lewisham Council, maintenance contractors, conservation societies)	Lewisham London Borough Council Ecological Regeneration Manager
Wimbledon & Putney Commons/ Wimbledon & Putney Conservators (www.wpcc.org.uk/about-us/about-us)	Long term management of the case. The case contains four dry acid grassland areas Facilitates a range of activities and personnel including rangers and maintenance teams	Conservation and Engagement Officer

Appendix E

Table 9: A summary of potential bias that could affect justification, data acquisition and analysis.

Bias Type	Case Study Stage	Risk	Proposed Mitigation
Case selection based on personal preference	Case justification	Not representative of a true case nor research subject. Subsequent data not supportive of research question	- use of well-known and established examples of the habitat in question - multi-case model versus single case, increases sample size
Interviewee suitability	Data acquisition	Could be positively or negatively biased to particular subject matter and/or case. Preconceived ideas, anecdotal evidence	- interviewee screening pre-interview - make interview themes (i.e., ecosystem classification) explicit pre-interview - avoid personal-based/direct question
Data quality	Data acquisition	Interview data incorrect or gaps due to delay in collation Cannot retrieve data to recall or check	- Capture data during interview (both recording and transcription) not after - Store data for retrieval in accordance to data protection protocols
Generalisation/overlap/mistaken case specifics	Data acquisition	Interviewee may confuse the case with adjacent or similar cases (i.e., adjacent habitats, mosaic habitat influence)	- State the habitat type (i.e., dry acidic grassland) in supporting documentation pre-interview - State habitat type in each question where appropriate
Incomplete Data	Data acquisition	Insufficient time for interview and fully considered responses	- Reduce question number - Allow sufficient interview time (pilot on non-participant subject)
Confirmation bias	Data analysis	Can falsely support the researcher's hypothesis	- Use of deductive analysis to maintain research objective focus
Pre-empting thematic analysis themes	Data analysis	Provide imprecise categorisation, subsequent coding and final narrative	- Adoption of best-practice model e.g., six phases for analysis (Braun and Clarke, 2006)

Appendix F

Information Sheet for Case Study Interviews

You are being invited to take part as current knowledge and experience of this ecosystem type particularly in an urban context will form part of a case-study to address the research question: ***What are the benefits to humans (i.e., ecosystem services) provided by dry acidic grassland in urban settings?***

The objectives of the study are to;

5) Critically evaluate the ecosystem services that dry acidic grasslands provide, in particular those within or adjacent to urban situations in England
6) Identify new, unique, or enhanced benefits to human wellbeing from exemplar ecosystems in London today
7) Review historic anthropological use of lowland dry acidic grassland to support enhanced understanding of cultural ecosystem services
8) Provide a synthesis of findings and recommendations to support future decision making for conservation, urban development, and social value.

Your participation will require you to do be interviewed, which will take place in-person and will take approximately 1 hour to complete.

The interview shall be recorded on an audio device as well as the interviewer taking written notes. You have a maximum of 7 days to change your mind about taking part in the study and have your data withdrawn from it, after which point it all personal, sensitive and identifiable data will be anonymised, which means that withdrawal will not be possible.

Your data will be kept secure in the following way:
- written notes shall be stored in a locked cupboard at the interviewer's home
- audio data shall be stored as a file on the interviewer's iPhone Voice Memos app.

The above will be strictly confidential at all times. Only your anonymised data will be stored.

Your anonymised data will be used for this study and potentially other research but will be destroyed after three years from the date of your participation. If you have a query or question regarding the study, please contact [redacted] by email ([redacted]@hotmail.co.uk).

Appendix G

Informed Consent for Human Participants (online and in-person interviews and in-person surveys)

I, the undersigned, voluntarily agree to participate in the study regarding the research question: ***What are the benefits to humans (i.e., ecosystem services) provided by dry acidic grassland in urban settings?*** ☐

I have read and understood the information sheet provided. I am therefore aware of the nature of the study and my involvement in the study. I have been given the opportunity to ask questions on all aspects of the study and fully consider my participation in it. ☐

I understand that I am free to withdraw from the study within 7 days without needing to justify my decision and without prejudice. ☐

I consent to my anonymised personal data, as outlined in the accompanying information sheet, being used for this study and potentially other research. I understand that all participant data is held and processed in the strictest confidence, and stored securely, and in accordance with the General Data Protection Regulation (GDPR), also known as the Data Protection Act, (2018). ☐

I understand that my anonymised data will be destroyed after approximately three years from the date of my participation. ☐

I confirm that I have read and understood the above, and freely consent to participating in this study. I have been given adequate time to consider my participation and agree to comply with the instructions and restrictions of the study. ☐

Name of participant (BLOCK CAPITALS): ……
Signature: ……
Date: ……

Name of researcher (BLOCK CAPITALS): ……
Signature: ……
Date: ……

Appendix H

Table 10: Edited transcription of case study interview questions, responses, and thematic analysis coding.

Lewisham London Borough Council Representative	Wimbledon and Putney Commons Representative	The Royal Parks Representative
Q1: Could you tell me broadly about the dry acid grassland you are responsible for?		
• Blackheath has some dry acidic areas but is mostly not. Beckenham Place Park has a little. In general, dry acid grass is a rare habitat (ED). It is treated no differently from other areas on Blackheath. (EI) • Recently slight change of mowing regime, meadow cuts; every 6 weeks, longer and 1-2 times a year. Glendale, an eternal contractor, is the parks manager for Lewisham, Greenwich have in-house management. They are cutting but not collecting, nutrients go back into the soil (R3) • Parks are a difficult balancing act between recreation uses (C2), Blackheath is a metropolitan site of nature conservation (S1,S2). People don't want to look at acid grassland, it doesn't have a lot of pretty flowers, it is species poor, Sheep's sorrel isn't like an Ox-eye daisy. It has rare clovers but for the average person this is not satisfactory (C1). I haven't seen a waxcap which is a signature fungi but it doesn't mean it's not there! (S1, S2)	• Our acid grassland falls under the same management plan as heathland. We have a Countryside Stewardship (CS) agreement with Natural England. We take soil samples of all grassland, all the patches, they then take away to their lab, then they look at the one that's got potential or within the parameters of acid grassland it then comes into our grant. (EI) • Areas that fell out of that, nearly there, ourselves have cut and collected each year to reduce the nutrients (M) • On the common under the CS agreement, we've only got three areas of acid grassland at the moment, the Plain, about 11 hectares, a much smaller meadow and one near Tibbets Corner the roundabout by the A3. They fell into the CS agreement. With those basically we cut and collect which we get contractors in in August, cut, bale and remove. (EI,M) • That been happening probably the last 10-15 years, the acid grassland is actually becoming closer to heathland. Before the CS agreement they would just cut and leave it.	• The acid grassland is really on three main parks, Richmond Park, Bushy Park are the big ones, but elements in others, here at Greenwich Park and smaller areas in Kensington Gardens and Regents etc. (EI) • In terms of area, we've never put it together but have just completed Phase 1 habitat surveys, just converting those to UK Habs, a new system of high-tech mapping. It must be over 500 hectares. (EI) • We're concerned with the quality of the grassland. (EI)

	(M) Somehow yellow rattle came in then all the wildflowers since. In springtime it really does look quite amazing. (C1) • This is a really heavily used site, the amount of dogs has increased massively, the way we protect that, in March we put up posts and notices, 34, around the Plain. It's for acid grassland but ground nesting birds as well, it the last site on the Common where we had Skylarks nesting. We leave a hectare each year uncut and move that around for ground nesting birds and migratory birds. (S1) • People say this place is timeless, their busy life. (C2)	
Q2: In your experience what are the benefits, either direct or indirect, to the users provided specifically by the dry acid grassland at your site?		
• The experts who know what to look for use the dry acid grassland, the public do not use the biggest patch on Blackheath, or other out of the way patches. (EI) • Harebells are in the Vanbrugh pits, main area of the Blackheath are small patches which can be seen when Sheep's sorrel flowers but people don't use a close to the road (A2).(S1,S2) Patches remain where less use, more heavily used area like sports pitches are treated as amenity grassland. (EI) • Most people who are not you or biologists just see it as grassland, but from wildlife the levels / structural diversity can make a difference, grass or bare ground for solitary bees. (EI,S1,S2)	• The Commons are a Site of Special Scientific Interest for the dry acid grassland and heathland matrix. We have a legal obligation to manage these areas. (C/P) • Acid grassland doesn't provide the most colourful wildflower meadow, they are pretty important as most of our grassland sites are fragmented, small and rank grass. (C1,E1) • In 1970 my predecessor said when you came into Wimbledon village you could see the Windmill clearly, so what looks like established woodland there is only 50 years old.(O) • Many years the Common was managed by disturbance (M), the National Rifle	• Across all our eight parks in 2014 we had 77 million visitors. Richmond Park is designated as a triple S.I., national nature reserve and a special area of conservation. There and Bushy is designated for its acid grassland, veteran trees and beetles. Richmond represents just over half the national nature reserve what England presents. (C/P) • Golden opportunity to engage the visitor but also endure the downsides, compaction, waste, fires and miscomprehension of what the habitat is.(M,ED) • During COVID far greater numbers of young adults came into the parks, people new to the parks themselves, the regulars for exercise. (C2)

• Kite fliers and obviously dogs are everywhere and dog walkers. (C2)	Association. Pre 1871 it was Lord Spencer's waste ground, when he came to sell it for development the local people bought it for exercise and recreation. (C2) • Maps from 1870 show barely a tree up here, RAF maps from 1930, barely a tree, there was an Anti-aircraft gun battery on the big plain in World War two. The disturbance stopped in the 1960's let's say, some of the Common's was taken for agriculture during the war, its poor soil, but those areas have shrunk and shrunk and shrunk of grassland. That plain there, that 10 hectares, we've actually got back from woodland. (C3)	• Because of social distancing the path in Richmond Park was effectively 30 metres wide. You could see it in the compaction, spent last two years repairing the main route. (M)
Q3: What awareness do you think the users have of this dry acid grassland specifically?		
• Probably not really. Expert for clovers has created a newsletter she puts out in Blackheath station. There are signs at different points talking about it, I'm not sure a lot of people know about it. (EI)	• I wouldn't say an awful lot. We have 24 big noticeboards, so we put up to date information there and we keep our website updated. The vast majority of people when they ask us about anything say 'I saw on your notice-boards'. The most low-tech thing gets the most amount of people looking. (EI) • The vast majority of people up here, do they know what the habitats are, probably not. People love woodland, love trees, it's an easy one to like. • When I sat on an acid grassland forum, someone said 'whoever does the PR for woodland has a very easy job, whoever does the PR for grassland has a tougher job ahead', especially acid grassland which doesn't jump out at you. (C/P)	• No there's not. People accept chalky, neutral no idea, but acid is something that burns your skin, not good for you, acid rain. Acid doesn't have good connotation at all. We don't say alkaline grassland, we say chalk or limestone. Perhaps use sandy, pebbly grassland, better describes what it is, people might remember that. (EI) • People don't know what that means, even ecologists and land managers. (EI) • When we do the soils surveys there's a great continuum between the swards, in Croydon you get acid grassland next to chalk grassland. (EI) On the South Downs you get a mosaic of acid grassland and chalk in a crazy pattern, difference in geology. I'd love people to understand the geology of London more. The ice age 10,000-12,000 years ago

	• The priority is exercise and recreation and walking the dog. (C2)	spread the sands and gravels across London in an almost haphazard way. • I think people understand the habitat (ED) as sandy, scrubby open spaces, full of gorse and sounds of invertebrates and intrigue as well as somewhere that's not like a soft park, a little unnerving. (C1)
Q4: Dry acid grassland is also situated in less populated areas; would you anticipate any differences in benefits they provide their users?		
• My feeling is acid grassland outside urban areas even of the same size is less used definitely. Every single patch of urban land is a lot more used. (C/P) • There is a lot more litter, crows from the litter bin or wind blew out or picnicers. (C2)	• We face a much higher amount of pollution, aerial and through dogs. A huge population around it, for a pretty small area. Trampling is a huge issue for us, lock-down really brought it to a tee, we had paths through the grassland about a metre wide which became 5, 6, 7 metres. I don't know if there's more respect in rural areas or just a far lighter footfall. (C/P) • Grazing on the common last occurred, if you're not talking about rabbits and the odd Muntjac happened in 1922. Some cattle were here because the Scots Guards brought them over from the Western Front, they supplied milk for the officer's mess so they let them carry-on! (P1)	• For London sites, openness, out in the wild, sense of contact with nature. (C3) • Acidic grassland in its own right and how its managed in the parks is part of the mosaics, short grass, long grass movement and views. That mix adds to something that feels natural even though quite heavily managed. (C1) • People can see it as nature, semi-natural, but also a threat, that scrubby bit of gorse. These sites outside the parks are accessible at night, for dumping, burnt out cars. Its appealing but also threatening, marginal wasteland. (C3) • In Richmond, that dry acid site has 43 sports pitches a hundred years ago, we now have four. Football, rugby, cricket, polo, the rules of polo were invented there, hockey was invented on the acid grassland in Bushy Park. Park run started in Bushy Park, again free draining as it's something you can run on. (C2) • We have ant hills in Bushy Park that are three hundred years old, so that means we have acid grassland there that has not been ploughed or improved for three hundred

		years. There's very few places you can say that. We have three billion meadow ants in each of the parks. They weaken the coarser grasses; the fine fescues and bents have a lot more room to survive. They have underground networks which allows the water to drain better, taken to the right place for the root hairs of the grass. (S1,S2)
Q5: What unique benefits to its users does dry acid grassland provide?		
• The acid bit is specific so I don't see it would have different uses than any other bit of Blackheath for example. • In terms of ecosystem services (ED) definitely, Blackheath as a whole provides a lot of cultural, recreation, mental health and physical wellbeing like boot-camps, people running and cycling. (C2) • Provisioning ecosystems services (ED) like pollination because there's a lot of insects. (R6) • In not sure if dry acid grassland has a different carbon sequestration than other grasslands. But when it comes to carbon and climate people want to plant trees everywhere. There are some people would plant trees all over Blackheath, but most people don't know grasslands are just as good as trees for sequestering carbon in the soil. (R2) • Water purification and flood risk, if we paved all over Blackheath which is also on top of a kind of a hill, all the water would just go	• No, only floral diversity. Not another unique selling point. (S2) • When it's there and its visual, it's easy. (C1) • Most of our questions are about Skylarks, it's about what's in there people are interested in. (S1)	• We're in 10-15 minutes' walk of millions of people, that for me is the biggest ecosystem service (ED) and overrules anything you'll find in the countryside. (C2) • The feeling underneath your feet of walking on acid grassland, it tends to be that sandy, gravelly type of feel, very different from walking on amenity grass or tarmac. (C3) During a wet period, walking without deep mud on acid grassland bits and in summer those areas heat up more, sunbathing and lounging around, that's beneficial. • Its free draining, drier parkland for people. Looking at compaction, soil samples, there's lots of bomb rubble generally on acid grassland. Sands, gravels and clay, almost three different pans. Surface water runs off our acid grasslands now far quicker than it every used to. There's opportunities for our acid grasslands to retain more water. (R7) • Greenwich is a classic one, we have Blackheath and Reading beds, sandy gravels with a big slope overlooking Canary wharf

down both sides and flood down there. I think there is a lot of ecosystem services (ED) grasslands, Blackheath and the acid bits provide. (R5,R7)		slumped, it's quite fragile, people's feet or tobogganing in the snow. That erosion of bank side can be significant. (M) • There's two spring lines, where the water come through the sand and gravels and hits the clay. It was tapped in the conduits, that's why we have Greenwich village instead of drinking sea-water from the Thames. Similar for Richmond Palace and Kew, areas of acid grassland and clay underneath which produces direct water which supports civilisation. A local historic connection. (P2) • For me an acid grassland is a fertile habitat (ED), not an infertile habitat. (EI) • A constant feature is disturbance, if you don't have disturbance, you have scrub and secondary woodland, disturbance grazing, agriculture, trampling otherwise you wouldn't have acid grassland. We're holding it as a succession stage, but it's a very niche type thing. It's a suspended fertile habitat (ED), it's the management of the habitat that stops the nutrients building up, same on chalk. (M)
Q6: Are there any other habitats/ecosystems in your care that receive greater resources for their management?		
• It's a tricky one, Blackheath is a big area with a lot of stakeholders so we need to make sure its managed properly, so I don't think it would be a fair comparison. There are so many eyes on it and people that live around it, it's an important park and habitat. (S1, ED)	• No, the biggest habitat (ED) as far as resources is the heathland. If you don't include the acid grassland into that matrix, we have 20 hectares without grazing. It looks good but by springtime the amount of saplings that come up, you're pulling your hair out again. Last year volunteer groups on the heathland, about 60 volunteer groups	• We're doing more to control the bracken and bramble. The actual acid grassland itself we leave to natural processes rather than cutting of coarse grasses. We don't take a tractor across the ant hills. (M)

• A farmer cuts the meadow, proper agricultural thing, small places are strimm'ed off. (M) • Its probably similar to chalk grassland. (M) • For cutting, grazing would be best for any kind of grassland but it's not possible in the Blackheath or the borough, so we do mowing. If you leave an area, then coarse grasses and everything else but if you do too much that's not great either. So, we try to do as mosaic but that's usually more difficult or expensive sometimes. I definitely wouldn't say we're spending more money, but maybe we should. (M)	each with about 15 people in each group just getting the scrub at bay. Then after that our own teams follow-up. We do heather cutting on rotational basis, scrapes for bare ground. We try to encourage the acid grassland around the edge of the golf course by scraping off the top turf, probably about 140 sessions staff and volunteers per year on the heathland. So, the grassland is fairly low maintenance. Contractors come in early August, it's quite low. (M) • It's a balancing act, could we get another acid grassland probably, but we'd need to lose another habitat (ED).	
Q7: From your knowledge could you explain if your dry acid grassland is historically significant?		
• Historically acid grasslands internationally were heathlands, and they are unique habitats (ED), quite a high percentage are in the UK, some in France and other western Europe countries. (S1, S2) • These places had gorse and people could hide and rob tradesmen, Blackheath has historical relevance for Wat Tyler, the farmers and peasants who gathered here to go to London with Wat Tyler. (C3) • Historically it's because of heathlands and acid grasslands together. People would keep their cattle on the grassy areas, cattle and horses are not going to graze on gorse or heather. It's just my speculation but probably why Blackheath is mostly grass as people value grass rather than gorse as it not used that much. (P1)	• Primarily, it's habitat (ED) specific in our Act there's something that says, 'keep the Commons in its natural aspect', written in 1871. What was the natural aspect in 1871?! (EI) • We were in a more rural environment then, part of the Common was bought for us in 1920 because they were going to build on it. (C/P) • Its habitat (ED) mainly but then there is something about the historic aspect, we cherish it. (C3) • During the two years of COVID from dawn till dusk it was like a high street, so busy. Some people moaned about it, but a lot of people don't have gardens round here, where are they going to go? The place was set up for the purposed of exercise and recreation of	• We have 600 years of history of managing the same bit of land, that's unique in an urban area. When the fence went round it in the 1400's early 1500's, it encapsulated acidic grass and stopped development, medieval landscape. (C3) • Caught archaeological remains and features, in Greenwich we employ an Archaeologist. We have Angelo-Saxon burial mounds. Because they are mounded, they have their own unique flowers and invertebrates. We have Roman remains as well. In Richmond we have Bronze age burial mounds which supposedly Henry the Eighth stood on looked at his deer hunting and St Pauls. (C3) • For burial mounds, it's easier soil to dig into but also on a prominent hill, it makes a

• The grass was a safer place as it provided longer views. (C3) • The two pits on the two sides of the heath were dug for gravel, (P2) originally, I'm sure they were flat similar to the rest of Blackheath. But now in Vanbrugh pit is the only place we have proper gorse stands, that was the only place it remained, and that area is probably more acidic than the rest of Blackheath. I'm sure they also put fertiliser, so the grass grew better for the cattle. (P1)	the local population, that is the core driver, the second was to protect the gorse and firs etc etc. We didn't quite realise how special it was then because it was part of a rural type landscape. COVID really really knocked us for six, the recovery was quite quick, the amount of people up here now would have dropped since COVID but it's a lot higher than it was before. (C2) • The amount of dogs up here has increased, the main things that's had on, not just grassland are our ponds (M) • The 1871 Act, it's very loose in terms of direct conservation protection but if you look at other Commons let's say like other London Commons like Clapham or Wandsworth, we have no and then a party-political pressure here either. We're run by the Ministry of Defence for historical purposes, DEFRA and the Home Office, they don't bring party politics in. We fall into three Councils, Merton, Wandsworth and a sliver of Kingston but they don't have any jurisdiction, its private land and that's the reason why, for better or worse why there's not a playground there and then a lido. It's really really protecting then obviously you've got triple S.I. designation for dry acid grassland and heathland, SAC for the same but also because were considered central to south London distribution of stag beetles. (S1,S2, C/P)	statement. If it was wooded no one could see it. (C3,C1) • In Bushy there's medieval field systems, big earth mounds that delineate the field boundary. You can see in only a few places, one or two in Yorkshire, bulwarks. I've got some consultants in doing a hydrological study, something about the percolation rates through the soil. (R7) • When this park was remodelled by Le Notre in 15-1600's, acidic grassland was a huge component of these huge avenues. (C3)
Q8: What degree of collaboration do you have with other managers of similar spaces of dry acid grassland?		

• There was a working group within the London biodiversity action plan group. I don't know when it stopped, probably in the mid 2000's, I went on a few meetings as a volunteer. There were working groups for chalk grassland and an acid grassland group. There is no London biodiversity action group but now we have a London boroughs biodiversity forum, an informal forum for ecologists in the London boroughs. We do work together but not necessarily on acid grassland, there is a network but not specifically on habitats (ED). • It might change now with the environment act, biodiversity net gain and local nature recovery strategies coming in, the GLA is directly responsible for the local nature recovery strategy for London, the boroughs will feed into it but because acidic grasslands are a priority habitat (ED), I'm sure there will be something on them. (C/P) • GiGL is the network centre for London, Lewisham's data, we have a service level agreement, they are curating it. Don't fully understand what's going on with BAP, probably still a live document but still an important document to refer to. GiGL has all the data for acid grassland so they could create an acid grassland map for London. (EI) • SINC's, sites of importance for nature conservation, they usually have habitat (ED) data for all SINC sites. Blackheath had a	• There was, but not now. Was led by a Natural England officer, there was an acid grassland forum. They would get together a few times a year from all round the Greater London area and we could talk. It was good network group. Natural England have had a lot of pressures with staffing and cuts, the resources were so stretched. Maybe they didn't have time to do that? The only other people I know that have acid grassland is Barnes Common, very small, patchy areas, but that's only because they're our neighbours. It's not so much an advisory thing. (C/P) • Acid grassland, it gets enveloped in this heathland/ acid grassland, its managed as part of the whole CS agreement. (EI)	• I wrote the first biodiversity action plan in London in 97, which included something on acid grassland. The acid grassland group, part of the London Biodiversity Partnership, I was there at the very first meeting and the very last! That was so good as we came together as land managers and conservationists to raise the importance of nature in those sites. We lack that cohesion, group of people. It stopped because of government change, done BAP, now do G.I. It took away the focus from nature. (C/P) • Charles Darwin did his research on acid grassland in London 1850's, he called it heath, it goes back to Thomas Hardy's blasted heath, wasteland. (C3) • When it comes to acid grassland, if it needs cutting or grazing, that's what we should be doing to maintain it for the invertebrates and flowers etc and enjoy it. We don't need it to absorb rainwater or be a recreational space, there great things to have but not its purpose. (M) • The hope is through the local nature recovery strategies, talk about nature again and fight off G.I. and people who talk about ecosystem services. (ED,O) • There's a lack of peer-reviewed academic studies, we have 1500 scientific surveys on our books we've done about our parks. We spend a significant amount of money on

separate vegetation survey in 2016 for where the stands are. (C/P) • The Lewisham BAP encourages developers to protect it and to see if they have acid grassland. For the BAP it not just us to manage it or where it is but mostly for planning. A lot of conservation in the UK and urban areas comes down to planning applications, a SINC doesn't mean any kind of protection other than the planning system. Blackheath is metropolitan open land so you cannot build much and metropolitan SINC status, these are planning protection not statutory. For Blackheath if you want to do anything you need permission from the Secretary of State. There's a parliamentary act about planting trees, there only allowed on the sides. (C/P) • Obviously acid grasslands are very interesting, but they are usually remnants here and there so difficult to say any specific benefits. (EI)		surveying and monitoring. Have done a fungi survey, bryophytes, lots of different invertebrates, dung beetles, meadow ants and flora of acid grassland. What we're less good at is the condition, grassland condition survey. Deer like heath bedstraw, won't like Cocksfoot, you're not going to get the usual suit of acidic grassland wildflowers. (EI,S1,S2) • The NVC, when Rodwell did his 10,000 quadrats he didn't do them in any urban areas. The NVC barely works in an urban area, least of all for acid grassland. We've assumed the assemblage. (EI)