Consideration of possible futures for peri-urban sites based on restabilising ecosystem processes:

rewilding nature and people

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Abstract

Inadequate funding, the shifting baseline syndrome phenomena, and the prescribe and protect approach to conservation collectively hinders ecosystem function. Rewilding offers an alternative solution without the same limitations. While it is documented that large-scale rewilding projects have seen an increase in biodiversity, further empirical evidence is needed to establish whether rewilding can be applied to small-scale, peri-urban sites.

A Geographical Information System (GIS) was used to produce historical and contemporary data on the vegetation type and cover of Upper Moss Side (UMS), a small-scale site in the Upper Mersey Estuary between Warrington and Runcorn. Two scenarios were tested - passive management and rewilding - using local ecological data, which was input into a Markov model for the former, and analysed against a critical review of the relevant literature for the latter. These scenarios, plus underpinning data, were presented to local stakeholders via a workshop. The workshop data were analysed using thematic analysis focussed on the practicality and acceptability of the rewilding approach.

Under the passive management scenario the Markov model calculated a transferal in landcover from a diverse mosaic of habitats to a predominantly woodland with patches of grassland and scrub and lowering biodiversity. Under the rewilding scenario the model predicted a mosaic of habitats that increases biodiversity when missing ecological functions are reoccupied. Feedback from the workshop demonstrated that while everyone agreed it is acceptable to rewild some thought it was not practical.

This study has shown that rewilding can be a suitable strategy in a small-scale, peri-urban landscape, and highlighted some of the many challenges associated with this approach. Elements of rewilding could be applied to UMS that could benefit the wider area, e.g. increased flood protection. The exploration of stakeholder values and ecological data, as presented here, can be used to evaluate the suitability of future rewilding projects in the UME and elsewhere.

Wilderness without animals is dead – dead scenery.

Animals without wilderness are a closed book.

(Crisler, 1958, p. 92)

1. Introduction

Based on the premise that the planet will provide, humankind has modified the landscape, altered the course of rivers, domesticated plants, and animals, and brought about the extinction of most of the megafauna that once roamed Earth (Shivanna, 2020). The disappearance of megafauna has had many environmental consequences affecting the worlds ecology, such as, vegetation cover (Johnson, 2009), plant–animal interactions (Guimarães, Galetti, & Jordano, 2008), ecosystem structure (Bakker et al., 2016), trophic interactions (Estes, Terborgh, & Brashares, 2011), fire regimes (Rule et al., 2012), biogeochemical cycling (Doughty, Wolf, & Malhi, 2013), and climate (Doughty, Wolf, & Field, 2010).

Concern for our diminishing wildlife led to the development of the nature conservation movement, with the aim of safeguarding our flora and fauna (Sheail 1998). In 1889 the Royal Society for the Protection of Birds (RSPB) was founded by a group of women in Manchester as a result of the exploitation of birds' feathers to adorn women's hats and in 1895 the National Trust was established by Octavia Hill, Sir Robert Hunter, and Canon Hardwicke Rawnsley. Then in 1912, Nathanial Rothschild founded the Wildlife Trust. In the late 20th and early 21st century to try and overcome the decline in species many other trusts were established for the protection of one taxon and their habitat (e.g. Butterfly Conservation Trust established in 1968, Bat Conservation Trust 1999, Buglife 2002, Bumblebee Conservation Trust 2006, and Amphibian and Reptile Conservation Trust 2009), but not in the wider interests of the land itself (Fisher, 2003). Single species conservation became a novel approach to conservation as a result of a lack of funding and/or time (Simberloff, 1998). It is seen as a more efficient way to conserve at an ecosystem level, therefore strengthening most animals within that area, however, these shortcuts have not always proven to be wholly beneficial (Simberloff, 1998). Single species conservation focuses on one particular species, for instance, umbrella species are selected for making conservation decisions because that species indirectly protects many other species. Flagship species are chosen to raise support for biodiversity conservation in a place or societal context and keystone species are an organism that helps define an entire ecosystem. Without its keystone species, the ecosystem would be dramatically different or cease to exist altogether. Certain species may seem obvious conservation targets but lack important conservation elements. One study noted, flagship and keystone don't automatically add up to umbrella species (Johnson, Ober, & Adams, 2017) and some umbrella species may not have a positive effect on all background species (Noss, Quigley, Hornocker, Merrill, & Paquet, 1996).

Today, there is a growing recognition that past actions have not been successful in conserving nature. The State of Nature Report 2019 found that 60 per cent of the species studied have declined over recent decades (Hayhow et al., 2019), while Natural England (2019) reports only 39 per cent of Sites of Special Scientific Interest (SSSI) sites are in favourable condition. SSSIs are designated to protect nature and are the building blocks of the site-based conservation approach in the UK, but they are failing. For example, during the 20th Century alone, more than 100 species were lost from the UK, including 7 per cent of dragonflies, 5 per cent of butterflies, and over 2 per cent of both fish and mammals (Anon, 1995, cited in Laycock, Moran, Smart, Raffaelli, & White, 2009), and 28 per cent of native British plant species have declined over the past 40 years, along with 54 per cent of birds and 71 per cent of butterflies over the last 20 years (Thomas et al., 2004). The loss of biodiversity over recent years has raised alarm in the conservation world (Ceballos, Ehrlich, & Dirzo, 2017; Dirzo et al., 2014; Shivanna, 2020).

For generations, the approach to conservation has been based on protection and prescription, for example, a species in decline is typically given legal protection and conservation programmes provide prescriptive habitat management plans to landowners and farmers which fail if carried out poorly (Dent, 2017). In practice, many conservation resources are managed for multiple objectives, including societal constraints. Narrow and inflexible management prescriptions designed for one purpose can lead to habitat homogenization that compromises the outcome for other conservation objectives (Hiers, Jackson, Hobbs, Bernhardt, & Valentine, 2016).

The protection and prescription approach does not address the real issues. Protection does not stop the spread of invasive, non-native species (e.g. grey squirrel *Sciurus carolinensis*) (Sainsbury, Nettleton, Gilray, & Gurnell, 2000) or curb the intensification of agriculture (Chalkhill Blue butterfly *Polyommatus coridon*) (Brereton, Warren, Roy, & Stewart, 2008). Management planning by prescription provides instructions on how to manage nature and describes the steps needed to obtain a certain habitat without stating a particular result, but is limiting and restricts the range of outcomes that can be successfully achieved, especially in a changing environment (British Ecological Society, 2016).

Our knowledge of the natural environment is limited. Policy, which produces conservation action on the ground, is generated from experiments and observations, conducted by researchers who are continually trying to find answers to the gaps in our knowledge. In a changing environment where species adapt and evolve or go extinct, this can be challenging. What is observed to be a species occupying one habitat may shift over time to another due to their needs changing or another habitat becoming more accessible. For example, formally considered a woodland species, the purple emperor butterfly (*Apatura iris*) has been observed favouring sallow (*Salix*) which is a small scrub-forming tree. Another woodland species, the nightingale (*Luscinia megarhynchos*), has been observed favouring thorny scrub on land that has been released from intense arable farming and allowed to scrub up naturally (Tree, 2018b, 2018a). Nightingales are increasingly occupying more scrub; in the last 30 years, surveys have found that more and more territories are located in scrub, the figures having risen from approximately a quarter of nightingales in the 1970s to more than 50 per cent in recent years (British Trust for Ornithology, 2015).

This narrative on the failure of the current conservation strategy suggests that a different approach is needed, one that allows for natural dynamics to occur and provides species with the space they require to roam, graze and behave in a way that maintains a resilient relationship with the plants and other species they have co-evolved with. A more natural solution to reverse the demise of nature is not humankind but nature itself. Rewilding offers a new holistic approach to conservation, one that removes the limitations and constraints of today's practice and allows nature to take its natural course, whatever that may be (Rewilding Britain, 2018). The focus of the study reported here is to illuminate the drivers and barriers of the natural and social processes (social-ecological system) pertaining to the rewilding of the Upper Moss Side (UMS) and more widely, the Upper Mersey Estuary.

Within the literature review (Chapter 2) the lack of funds available in conservation, the shifting baseline syndrome phenomena, and the problem with the prescribe and protect approach used in conservation are highlighted. The literature reviewed undertaken highlighted the need for a new approach to conservation, one that works with nature and its natural processes while encouraging people to reconnect but revealed a gap in knowledge around the practicality of one such approach - rewilding - and the possible ecological impact it may have in the long-term.

The approach used in this study is particularly pertinent due to the peri-urban location of UMS. Natural land cover occupies over 30 per cent of the urban area in Great Britain (Office for National Statistics, 2019) which presents many opportunities for land owners and conservationist. However, there are challenges associated with peri-urban green spaces, therefore, a mixed method approach using ecological data and stakeholder feedback would underpin facilitate such a project.

The methods used for the various elements of the study are detailed in Chapter 3. Two approaches were used to produce two scenarios – passive management and rewilding – for the future management of UMS which were then reviewed by a group of stakeholders with knowledge of the study site and the area around it. For the passive management scenario, a Phase 1 Habitat Survey was carried out and overlaid on to the most recent aerial photo, 2018. The same process was applied to aerial photos from 2005 and 2009 in order to establish a historical habitat site map of the different landcover categories. The quantified data are applied to a Markov model which extrapolates the changes in vegetation and highlights the trajectory of the different habitats at UMS, while an examination of the current management plans was carried out to see if there are any major habitat modifications planned to happen that could affect the Markov model trajectory.

The data received from RECORD (the Local Records Centre for Cheshire) and the review of the literature on rewilding projects provided the information/evidence on what species would be most appropriate for reintroduction to UMS and informed the construction of the rewilding scenario.

All these data and all the information gathered were presented at a workshop to an invited group of local stakeholders to gain qualitative feedback on the practicality and acceptability of the rewilding approach in comparison to the data presented on the potential outcome under the current management plan. The participants were asked a variety of questions that ultimately led to the final question: is it acceptable and/or practical to rewild UMS. Feedback from the workshop underwent a thematic analysis in order to break down the participant response/opinion.

1.1 Aims and objectives

The aim of the research is to ascertain the acceptability and practicality of rewilding Upper Moss Side. This will be achieved by developing future scenarios for the site and presenting them to local stakeholders at a workshop for their feedback and opinions.

In order to fulfil the aim a number of objectives were addressed:

1) an assessment of the historical and baseline landscape data;
2) used a Markov model to describe a possible future under the current management plans;
3) a critical review of the literature to identify appropriate species for reintroduction to UMS under the rewilding scenario;
4) present the findings to local stakeholders via a workshop;
5) learn if the stakeholders, from their professional opinion, deemed it was socially and professionally acceptable and practical to rewild UMS based on the two scenarios presented; and
6) analyse the feedback to ascertain the acceptability and practicality of rewilding UMS in comparison to its current management plans.

2. Literature review

The lack of funds in conservation and the policies associated with safeguarding the natural environment has hindered the goal of increasing biodiversity and restoring natural ecosystem function (RSPB, 2018; Spierenburg, 2012). One alternative approach available is: rewilding. This is a contentious approach that requires clarity around its history, meaning, and the different classifications associated with this highly flexible term. Frans Vera, a Dutch ecologist, has influenced the rewilding movement in Europe, and later in Britain, through his work which theorised that large herbivores are a key factor in determining vegetation dynamics (Knepp Wildlands Project, 2017; Vera, 2009). The interactions between trophic levels play an important role in shaping the landscape and the complexities within ecosystem functioning (Fisher, 2016; Fortin et al., 2005; van Klink, Ruifrok, & Smit, 2016). The ecological impacts of large free roaming herbivores modify abiotic conditions and abiotic composition through disturbances, their natural behaviours make them ecosystem engineers (Coverdale et al., 2016; Pringle, Prior, Palmer, Young, & Goheen, 2016). Their successes are documented and visible at sites across Europe and Britain (Rewilding Britain, 2020b, 2020a; Rewilding Europe, 2020b, 2020a). But there is another side to rewilding, one that can connect humans to wild nature and improve mental health and well-being (Monbiot, 2013). The relevance of this study is evident in the UK Government's 25-Year Environment Plan in which there is a discussion of the many benefits of nature for the health of the people and its recovery of biodiversity and ecosystem function through natural flood management solutions and creating a nature recovery network (DEFRA, 2018).

2.1 Lack of funds

There is a crisis in conservation. The Department for Environment, Food and Rural Affairs (Defra) has seen its budget halve since 2017 (Simkins, 2019), and many charities risk losing millions of pounds in European Union funds because of the withdrawal of the United Kingdom from the European Union (Ferrell-Schweppenstedde, 2017). The lack of funds, both national and local scale, may sway governing bodies to re-evaluate the way habitats are managed, which may drive a new way of conservation management.

2.2 Prescribe and protect

Conservation has operated for decades with a prescribe and protect policy which is not working (Hayhow et al., 2019). With each generation the ecological baseline shifts so that the natural condition is further eroded and the state of nature that follows is seen as the norm. The management and appearances of nature is rooted in our culture; for centuries, land has been cleared to provide humans with food and shelter and with each generation the new nature is accepted and becomes the status quo (Vera, 2010). A shifting baseline presents a considerable challenge for conservation, restoration, and management while the consequence is an increased tolerance for gradual environmental degradation (Soga & Gaston, 2018). The practice of organised habitat restoration can, therefore, produce undervalued habitats that are deficient in species and their functionality weakened as a result (Guerrero-Gatica, Aliste, & Simonetti, 2019). Many of the tasks involved in habitat restoration include the removal of invasive species and the planting of trees which is labour intensive when operating at large-scales. The current system is costly, in 2017/18 non-governmental organisations (NGOs) spent £239 million on biodiversity and/or nature conservation in the UK (DEFRA, 2019b). In comparison, an alternative form of management that is less intense and more passive than active could be more beneficial economically. Rewilding advocates the use of herbivores and carnivores to re-establish the connections required for functioning ecosystem services which reduces direct human involvement.

But, what would this mean for small peri-urban green spaces? What would they look like if managed using the rewilding theory? What effect could rewilding peri-urban sites have on ecological functioning and ecosystem services?

2.3 What is rewilding

2.3.1 Conservationists and biologists in North America

The origin of the recent rewilding movement started in North America in the mid-twentieth century when conservationist and biologists became increasingly concerned for the rapid decline in many species across the globe, which led to a myriad of ecological research and the evaluation of nature reserve design (Foreman, 1998). In 1991 wilderness activist Dave Foreman and conservation biologist Dr Michael Soule launched a new group, North American Wilderness Recovery (NAWR) (now known as Wildlands Network) that looked to protect nature at a continental scale (Wildlands Network, n.d.). They recognised that most protected areas were too small and isolated to function effectively and are inadequate to the formidable challenge of conserving most living species (Soulé & Terborgh, 1999). The aim of that project was to create top-down regulation using ‘carnivores’ and keystone species in ecosystems and the need for large ‘core’ areas and regional ‘connectivity’, which have been summarised as the three Cs: Cores, Corridors and Carnivores (Soule & Noss, 1998). However, the foundation for the ecological research is far broader and includes extinction dynamics, island biogeography, metapopulation theory, natural disturbance ecology, top-down regulation by large carnivores, and landscape-scale ecological restoration (Foreman, 2004).

2.3.2 The RE in rewilding and definitions

The earliest use of the word ‘rewilding’ in print was in 1991 in the magazine *Wild Earth*, which was connected to the Wildlands project (Soule & Noss, 1998). The prefix re- means to ‘do again’ according to the Cambridge English Dictionary. However, in the case of rewilding, the word surfaced as a result of the main focus of the NAWR: wilderness restoration. The ‘re‘ arose from the word <u>*RE*</u>covery which later evolved to <u>*RE*</u>storation and was then fused with wildland or wilderness to produce rewilding (Rewilding Earth (Producer), 2018). The small prefix and the many broad definitions of the ‘new’ word since it was first used in print has caused much confusion within scientific circles (Jørgensen, 2015). Rewilding has become increasingly popular and sounds as if its meaning should be straightforward, but it is laden with many varied connotations (Gammon, 2018; Jørgensen, 2015) and there have been many definitions of rewilding, none of which have necessarily replaced an earlier one. Debating the word rewilding may seem an arcane indulgence, however, clarity and precision are required for policy makers and funders in order to avoid poor conservation decisions that stem from a broad ambiguous interpretation and ruin a potential term because it is too confusing (Hayward et al., 2019). Some broad definitions describe the desired outcome whereas the more detailed definitions will provide the ‘how’ and/or the missing functions – examples are provided in Table 2.1. However, because the term rewilding varies so widely, there is a sense that condensing the word into a single definition could potentially lead to further confusion (Jørgensen, 2015). Yet, the broadness and depth of rewilding is what separates it from present day conservation of prescribe and protect. The approach is functional and focuses on processes of the landscape, the ecosystem, the population and the genes, and can be applied in a flexible manner (Noss, 1990). Therefore, because of the many possible uses over a variety of scales and its elasticity, the definitions cited thus far range from broad to detailed depending on context.

There are, however, a lot of challenges associated with rewilding (Nogués-Bravo, Simberloff, Rahbek, & Sanders, 2016). In fact, Macdonald & Willis (2013) and Pereira & Navarro (2015b), who are proponents, readily recognise the theoretical and ecological underpinnings of rewilding and the lack of cost-benefit analyses of rewilding plans are a challenge.

Table 2.1.Definitions of rewilding depending on scale.

Type	Definition	Reference
Broad	Rewilding broadly refers to a restoration strategy to promote self-sustaining ecosystem and enhance the conservation of biodiversity while re-engaging people with nature	(Torres et al., 2018)
Broad	"an ambitious and optimistic agenda for conservation', with projects that share an ethos of 'maintaining, or increasing, biodiversity, while reducing the impact of present and past human interventions through the restoration of species and ecological processes"	(Lorimer et al., 2015)
Detailed	"an ecological restoration strategy based on reintroducing missing animal species to promote self-regulating biodiverse ecosystems via restoring trophic top-down interactions and associated cascades as well as non-feeding related processes such as trampling, wallowing, and other disturbances"	(Svenning et al., 2016)

2.3.3 Wilderness

Even the word wilderness has caused much debate when discussed in the context of rewilding. Wilderness has been deeply rooted in western cultural history since ancient and medieval times, yet, it has proven difficult to define (Carver, 2007; Leopold, 1925; Oelschlaeger, 1991). The Merriam-Webster English dictionary describes it as an area essentially undisturbed by human activity together with its naturally developed life community (Merriam-Webster, n.d.). In a typical sense, wilderness constitutes land unaffected by human impacts (Kowarik, 2018) but today, especially in the British context, this simply does not exist (Carver & Fritz, 1995). According to Aldo Leopold (1942, p. 24-25), a renowned environmentalist and wildlife ecologist, *no tract of land is too small for the wilderness idea*. It is no surprise then that a novel wilderness has emerged that incorporates the human dimension in to the concept (Diemer, Held, & Hofmeister, 2003; Kowarik, 2011b, 2011a; Threlfall & Kendal, 2018; Zefferman, McKinney, Cianciolo, & Fritz, 2018).

2.3.4 Classification of rewilding approaches

The concept of rewilding that seeks to increase *wildness* has offered, due to its flexibility, many ways in which this can be achieved. When agricultural land is abandoned, species start to colonise, this natural process may be termed 'passive rewilding' as the process of rewilding happens spontaneously and unaided without direct human intervention or influence. Another approach of rewilding is 'active rewilding' which involves the re-introduction of species and assisted regeneration. The active approach helps degraded land repair and rebuild. Rewilding actions can start out as active or passive and change overtime and the same could apply across a project area with different approaches being applied spatially depending on site requirements. Rewilding can also be classified according to spatial extent: small-scale (patch) medium-scale (mosaic or group), and large-scale (landscape) (Carver, 2019), however, Pereira & Navarro (2015) refer to the overall all-inclusive benefits that arise when rewilding is applied to large-scale areas that encompass multiple ecotones, groups and mosaics.

2.3.5 Rewilding Europe and Britain

Land abandonment is a phenomenon occurring across Europe and an important narrative in the rewilding of this continent. Rewilding Europe, a non-profit organisation based in Nijmegen, Netherlands, was established in 2011 with the aim to protect wild areas whilst focussing on biodiversity conservation attributes, such as, functional ecological processes and presence of native species (Sylven & Widstrand, 2015). The reintroduction of keystone species (usually large herbivores or carnivores) and the availability of space and connectiveness are also important to their narrative (Keenleyside & Tucker, 2010). However, the scale of Europe and the availability of space allows this notion, but this is not the case in Britain. There is a high population density in many parts of the country accompanied with intense land-use. In comparison to Europe, Britain lacks many keystone species, is depleted of large carnivores, utilised agricultural area covers 71 per cent of the land (DEFRA, 2019a), and the woodland cover is among the lowest in Europe (Forest Research, 2016). Rewilding Britain was established as a charity in 2015 and has, to some extent, adapted the North American and European approach of rewilding but to fit within the British context and define the term as:

> *… the large-scale restoration of ecosystems where nature can take care of itself. It seeks to reinstate natural processes and, where appropriate, missing species – allowing them to shape the landscape and the habitats within. Rewilding encourages a balance between people and the rest of nature where each can thrive. It provides opportunities for communities to diversify and create nature-based economies; for living systems to provide the ecological functions on which we all depend; and for people to re-connect with wild nature* (Rewilding Britain, 2018, para 1).

2.4 Ecosystem functions

Ecosystem functioning reflects the collective life activities of plants, animals, and microbes; it looks at the combination of all processes in an ecosystem and how they work together (Jax, 2010). The full extent of the interaction was not known until recently. It was believed that much of Great Britain and Europe was a closed canopy forest until Frans Vera (2000) challenged that idea when he published his book Grazing Ecology and Forest History. The presence of carnivores or large mammalian herbivores impact the landscapes and alter the structure and composition of vegetation (Palazon, 2017; Young et al., 2013).

2.4.1 Frans Vera

The principles of rewilding are influenced by many of Frans Vera's ideas. His research focused on the wood pasture system of non-linear, cyclic succession of European wooded landscapes. Frans Vera theorised that large herbivores are a key factor in determining vegetation dynamics, creating a diverse mosaic of open, closed, and re-vegetating habitats through grazing, in combination with other natural processes (Vera, 2000).

2.4.2 Trophic functions

Natural processes depend on the presence and abundance of organisms with particular yet diverse functional traits. These traits or trophic functions are the interaction between animals and plants, fungi and bacteria in a food chain or web. The greatest possible dynamic interaction in natural processes comes when the functional or trophic diversity is greatest, when species are present in all trophic levels of a natural system, including top predators, middle (meso) predators, plant eaters (herbivores), plants, carrion and detritus feeders, and decomposers (Fisher, 2016). A trophic cascade occurs when the animals at the top of the food chain - the large carnivores - modify the numbers and behaviour not just of their prey, but also of species with which they have no direct connection. In the absence of large carnivores, humans can act as the main control on the numbers of large herbivores, but they do not affect their behaviour, for instance, wolves (*Canis lupus*), through their hunting behaviour, influence the behaviour and the areas which elk (*Cervus canadensis*) browse resulting in a localised reduction in the use of aspen (*Populus tremuloides*, a deciduous tree) (Fortin et al., 2005). The impact elk and other large herbivores exert on their environment can radically change the ecosystem. Large-bodied herbivores modify the physical environment by altering the structure of plant-dominated ecosystems; they exert strong influences on the diversity and abundance of other taxa such as, birds, small mammals, insects (Foster, Barton, & Lindenmayer, 2014; Van Klink & WallisDeVries, 2018). The novel ecological interactions that occur as a result can impact the food web or food cycle at multiple levels.

2.5 Large free roaming herbivores

Large free roaming herbivores (LFRH), such as, European bison (*Bison bonsus*) and Konik ponies (*Equus ferus caballus*), have been introduced as part of many rewilding projects in Europe to act as proxies for the extinct ancestors which once grazed, fertilized and trampled much of Europe and Asia from the Atlantic to the Pacific coast acting as keystone species. Moreover, the late Pleistocene megafauna directly influenced the landscape by limiting the spatial distribution of secondary succession (Kuiters & Slim, 2003; Laskurain, Aldezabal, Olano, Loidi, & Escudero, 2013). The impact on the vegetation is the driving force behind many of the projects undertaken by Rewilding Europe; a review of their website revealed they have been involved in 50 translocation projects involving 26 species, mainly large mammals, across 17 European countries (Rewilding Europe, 2017b).

2.5.1 Disturbance – grazing/rooting on vegetation

LFRH used in rewilding projects have shown to produce a vegetation structure that is uneven, varied in height and unpredictable (Dennis, 1998). In systems where all year-round grazing is allowed, large herbivores consume only some parts of the plant in the growing season because of the different levels of intensity, while in the winter months when the growth stagnates those parts are consumed (Vera, 2000). The drivers and impact of large herbivores on forage selection and intensity has been studied at the Knepp Wildlands Project in West Sussex. Dando & Sandom (2018) found that herbivore foraging was non-uniform and that there was a disparity in foraging intensity with areas of overlap between species (ponies (*Equus* sp.), cattle (*Bos* sp.), pigs (*Sus* sp.), and deer (Cervidae)) resulting in clear pressure points and reduced pressure in areas giving rise to scrub encroachment. In another study, Rheinhardt & Rheinhardt (2004) found that horses (*Equus caballus*) show a seasonal preference when they have free range over a variety of habitats: in winter they favour forests over marsh and in summer they select wet grassland over dry. While Wood & Brenneman (1980) found that feral pigs prefer freshwater marshes and brackish water marshes to saltmarsh and will graze swamp habitats all year round. Saltmarshes are internationally important coastal wetland that require a certain level of sensitive grazing (Barbier et al., 2011; Boorman, 2003) to prevent the marsh from closing up (Vera, 2000). Horses have been reported to significantly impact vegetation and habitat structure on a saltmarsh in North Carolina by grazing heavily on bulrush (Porter et al., 2014) which prevents the swamps and open water patches from constricting or vanishing altogether. On the Kissimmee River floodplain, rooting by feral pigs has significantly increased the diversity of wetland plant assemblages and positively affected the soil characteristics (Arrington, Toth, & Koebel, 1999). The varying concentration in foraging activities will most likely support an open mosaic habitat.

The style of grazing varies between the different herbivores which impacts the landscape and affects which species occupy the area. When cattle (*Bos taurus*) graze they tear up the grass with their tongue and keep the grass short – they generally graze at a height between 5–6 cm minimum (Crofts & Jefferson, 1999) – this stimulates regrowth of grasslands which attracts greylag geese (*Anser anser*) and red deer (*Cervus elaphus*). The short grass provides nesting sites for ground nesting birds such as northern lapwings (*Vanellus vanellus*). Northern lapwings require a tussocky, hoof-printed sward of 5 cm or less, whereas curlews (*Numenius arquata*) prefer a taller, tussocky sward of 15 cm that provides camouflage (RSPB, 2015). Greylag geese also prefer the shorter grazed vegetation and through their foraging behaviour create a mosaic of open water and marsh vegetation that attracts crabs (*Brachyura*) which is a food source for European otters (*Lutra lutra*), grey heron (*Ardea cinereal*), and curlew.

Horses nip and nibble the tougher grasses – at a minimum of 2 cm (Crofts & Jefferson, 1999) - which stimulates regrowth and attracts deer and rabbit (*Oryctolagus cuniculus*). They graze on dead grass and in doing so recycle the nutrients back into the soil more effectively stimulating healthy soil texture, structure, and nutrient content. Below ground fauna and insects are more abundant in healthier soils and as a consequence foraging birds benefit from their abundance. Horses also graze on coarse, abrasive grasses that are less palatable to other grazers which results in a mosaic of high and low vegetation in grasslands.

Pigs, on the other hand, reduce dense ground vegetation, such as, bracken (*Pteridium aquilinum*), couch grass (*Elymus repens*), bramble (*Rubus agr*), and rose (*Rosa* sp) by rooting; the ground that is then exposed creates seedbeds for natural regeneration. Thus, pigs act as natural predators for invasive species and reduces the need for weed control (Mayle, 1999). Their diet changes with the season, in the summer months pigs will graze on dock (*Rumex*), spear thistle *(Cirsium vulgare*), bracken, and the new shoots of rhododendron resulting in an open sward for flowers to grow, which provides nectar and pollen for an abundance of insects. In autumn pigs gorge on fallen acorns preventing them from settling in the ground and germinating (Sweitzer & Van Vuren, 2002) and killing saplings. This function maintains a semi open mosaic landscape (Jørgensen, 2013), which has the potential to support a high level of biodiversity (Walz, 2011; Walz & Syrbe, 2013). Pigs are, however, disreputably known for their rooting behaviour where they use their snout to push or nudge into something repeatedly, normally the ground, causing it to turn over and expose bare soil. Nuthatch (*Sitta europaea*) feed on the arthropods as they become more abundant in the soil, earthworms provide food for small mammals such as the European mole (*Talpa europaea*) and hedgehog (*Erinaceinae europaeus*) which are then consumed by foxes (*Vulpes vulpes*), weasel (*Mustela*), hawks (Accipitridae), and owls (Strigiformes). Rooting also naturally regenerates the seed bank so that native flora can flourish and allows pioneer plants to establish. Certain pioneer species, such as, sallow scrub (*Salix cinerea*) attracts purple emperor butterfly (*Apatura iris*), whereas wildflowers, such as, scarlet pimpernel

(*Anagallis arvensis*), common fumitory (*Fumaria officinalis*), vetchling (*Lathyrus*) and knotgrass (*Polygonum aviculare*) feed turtle doves (*Streptopelia turtur*) and their young.

In areas of high plant productivity, mixed species grazing by herbivores of varying size has shown to have a positive impact on plant diversity and species richness (Bakker, Ritchie, Olff, Milchunas, & Knops, 2006). Van Wieren (1995, p. 17) believes that if all major feeding styles are present within the ecosystem then ecosystem function will be at its greatest; he states that 'when grazed systems are allowed time to develop, structural variation is increased and favourable conditions for 'specialists' arise, so that species richness can increase even further'.

2.5.2 Disturbance - shrub layer and larger trees

Large free roaming animals not only create and maintain structural and species diversity within the ground flora but also impact the shrub layer and larger trees; however, the impact varies between species (Mayle, 1999). Continual rooting by pigs can significantly reduce tree sapling survival and acorn survival in oak (*Quercus*) woodlands (Sweitzer & Van Vuren, 2002). The rooting behaviour will turn over the ground layer, disturb scrub and uproot the roots of larger trees (Mayle, 1999). In a review by Barrios-Garcia & Ballari (2012), wild boar (*Sus scrofa*) reduce tree recruitment, stem density, and species richness, and the effects of rooting can reduce plant growth by 50 per cent; their behaviour can also cause damage to trees by nest building and rubbing up against them after wallowing. Conversely, a study on fenced populations of wild boar showed that their rooting behaviour can create germination niches (Sandom, Hughes, & Macdonald, 2013b) and contribute to forest regeneration. The level of impact is due to density; if wild boar numbers are high then damage is likely, reducing the numbers would lower the impact from intense damage to mild disturbance (Barrios-Garcia & Ballari, 2012).

Niches are created when cattle and horses de-bark the trees. Horses debark poplars (*Populus*), willows (*Salix*), spruce (*Picea*) and beech (*Fagus*), thus opening up patches of closed forests (Linnartz & Meissner, 2014). While cattle with horns de-bark, they also pollard the higher branches on trees and shrubs and strip the leaves from the trees when they browse (Rotherham & Handley, 2011). A low stock of cattle can create disturbances throughout their range through trampling, pollarding, and browsing; these functions can reduce competition, create niches, and enable light to return to the ground and the existing seed bank to develop. Birch (*Betula*) seedlings can regenerate, and bluebell (*Hyacinthoides non-scripta*), yellow archangel (*Lamium galeobdolon*), and early purple orchid (*Orchis mascula*) are able to bloom. Field vole (*Microtus agrestis*) benefit from eating the seeds, roots, and leaves and further up the food chain, they form an extremely important part of the diet of many predators, such as kestrel (*Falco tinnunculus*), weasel, and barn owl (*Tyto alba*).

Large herbivores have grazed the land for millennia and have therefore co-evolved with the natural vegetation. Trees and shrubs have developed, over time, a tolerance to browsing or morphological traits, such as, chemical repellents or thorns so that the plant is avoided (Milchunas & Noy-Meir, 2002). With the aim to increase or maintain ecosystem function and biodiversity, three-dimensional structural features of forest canopies should be incorporated into management plan (Ishii, Tanabe, & Hiura, 2004). Disturbances by large herbivores have been, and still are, the norm – the non-linear model of shifting forest pasture landscapes hypothesised by Vera (2000) illustrates this.

2.5.3 Dung

Large herbivores are not good at digesting their food. Typically, they extract only 10–30 per cent of the nourishment it contains and expel the rest as dung (Newton, 2019). One cow can produce about 4 tons of dung per year, this breaks down to about 10 cow pats or about 23 kg of dung per day and about 30 cm in diameter (Dennis, 1998), in the areas where dung is deposited, tall vegetation is allowed to develop as cattle avoid feeding around these patches (Mayle, 1999). The nutrient content of horse dung has been shown to correlate with the nutrient quality of pasture land which may subsequently benefit biodiversity (Ringmark, Skarin, & Jansson, 2019). Defecation by grazing animals can also influence the distribution of nutrients in the soil; deposits on grasslands tends to lead to a high concentration in the surface layer. Furthermore, eating in one place and defecating in another assists in the transportation of nutrients causing local difference in soil fertility (Vermeulen, 2015). The deposit hotspots are associated with the areas where they tend to congregate or shelter overnight (Bilotta, Brazier, & Haygarth, 2007). Dominant stallions will defecate on top of dung from lower ranking individuals so that they have the most dominant scent, the effect produces huge dunghills that provide an influx of nutrients (Vermeulen, 2015). The spatial variation in large herbivore excrement causes local differences in plant communities. Dunging is also an effective way of dispersing seeds, moreover, the passage of seed through the gut of cattle and pigs improves germination of woody plant species (Lynes & Campbell, 2000; Tjelele, Ward, & Dziba, 2015) which makes cattle and pigs effective facilitators of a woody pasture. Cattle have been recorded to transport up to 230 species of plants around a landscape through their gut, hooves, and fur (Knepp Wildlands Project, 2019). The re-cycling of nutrients and organic matter through animal waste can be considered to be beneficial to plant growth, long-term fertility, and soil structure in grassland environments (Bilotta et al., 2007).

The input of dung and urine indirectly affects other species. The accumulation of waste returns organic matter and nutrients to the soil, building soil fertility and quality which attracts insects. This process increases earthworms (*Lumbricina*) and provides food for a range of birds and mammals, such as, badger (*Meles meles*), fox, shrew (*Soricidae*), hedgehog, starling (*Sturnus vulgaris*), jackdaw (*Corvus monedula*), bats (Chiroptera) and waders.

2.5.4 Detritivores

Detritivores are extremely important components within ecosystems since they help break down dead animals and plants and return the nutrients held within them back to the ecosystem. Studies suggest that the disturbances caused by LFRH may influence the abundance of detritivores which will severely impact on the ecosystem functioning. For instance, the presence of feral pigs have shown to increase the decomposition rates in deciduous forests; they break down the leaf litter and therefore facilitate the process of decomposition which returns the leaf litter back into the soil (Singer, 1981; Singer, Swank, & Clebsch, 1984). Grazing increases below ground biomass (López-Mársico, Altesor, Oyarzabal, Baldassini, & Paruelo, 2015) as well as aboveground and whole grassland productivity (Frank, Kuns, & Guido, 2002). This has a positive relationship with the abundance and diversity of soil microarthropods (Clapperton, Kanashiro, & Behan-Pelletier, 2002) which have a role as regulators of key processes, such as plant litter decomposition and mineralization (Kampichler & Bruckner, 2009). This make them an important component in the terrestrial ecosystem and the decomposition process. Wild boar also play a role in the propagation of spores of underground fungi necessary for forest regeneration, by the genetic mixing of populations of spatially separated fungi populations (Génard, Lescourret, & Durrieu, 1988). Many rare species of fungi have been recorded at the Knepp Wildlands Project since it began, which they consider to be a clear indication that the soils are reviving through the disturbance and mixing of nutrients; they have seen the appearance of a mycorrhizal mushroom boletus (*Boletus mendax*) associated with old oaks, milkcaps (*Lactarius*) linked with sallow scrub and fly agaric (*Amanita muscaria*) that typically forms associations with birch trees. Furthermore, plants that depend on subterranean mycorrhizal fungi, such as common spotted (*Dactylorhiza fuchsia*), southern marsh (*Dactylorhiza praetermissa*) and early purple orchids (*Orchis mascula*) are present in former arable fields (Tree, 2018a). Beetles (Coleoptera) also play a role in the decomposition process. Beetles rely on dead and rotting trees in their lifecycles and they are a key component for woodpeckers (*Picidae*), bats, and fungi (Schepers & Blom, 2017). Therefore, the disturbances created by behaviours such as pollarding and trampling, even though they seem damaging, go on to benefit many creatures that rely on a certain level of disturbances and the subsequent deadwood.

Detritivores play a key role in the food web, earthworms, for example, are mobilised by the breakup of the soil and provide food for small mammals, amphibians, and green woodpeckers (*Picus viridis*) who also feed on the anthills that can form following the rooting behaviour. The disturbance and mixing of nutrients initiated by pigs which encourages the growth of a mycorrhizal mushroom and the associated plants that depend on subterranean mycorrhizal fungi also provide food for deer, badger, fox, and beetles.

2.6 Rewilding projects

These intact and operative ecosystem functions are being achieved in many of the publicised rewilding projects, although, they are taking place on large tracks of land. For example, the Knepp Castle Estate rewilding project has been a great success, ecologically and financially. The passive management of the 1400 ha estate allowed nature to take the driving seat, which saw an increase in biodiversity as a result of introducing hardy breeds of domesticated large herbivores (Old English longhorn cattle (*Bos primigenius*), Exmoor ponies (*Equus ferus caballus*), and Tamworth pigs (*Sus scrofa domesticus*)) (Overend & Lorimer, 2018). On a larger scale, the

Carpathian Mountains in Romania has around 1 million ha of protected land where Rewilding Europe are releasing Bison, which went extinct in 1927, back into the wild; the goals include restoring grasslands and ecosystem functions (including predation), and creating a rural tourist economy (Carey, 2016). A third example is Oostvaardersplassen in the Netherlands, a 5000 ha landscape in close proximity to a number of cities and which is an expanse of land made up of wetland, grassland and small woodlands with free roaming red deer (*Cervus elaphus*), Konick horses (*Equus ferus*) and 'Heck' cattle (*Bos taurus*). It has a resemblance of a wild African savannah (Aykroyd, 2005). Therefore, is rewilding only successful on large areas of land? Do smaller sites have the capacity to be rewild?

2.7 Human element

George Monbiot is an advocate of rewilding and his columns in The Guardian and his popular book Feral: Rewilding the Land, Sea, and Human Life (2013) have introduced rewilding to a broader audience. Monbiot (2015) defines rewilding concisely as 'the mass restoration of ecosystems', but this has implications both for the ecosystems in question and for the lives of the humans involved; local communities and their economics will be severely affected by the practise of rewilding. But, in statements from Rewilding Britain (2017) and Rewilding Europe (2018) they stress that there is an unequivocal aim to move away from extractive and consumptive uses and develop alternative economic activities that focus on nature based economics and eco-tourism (Ayres & Wynne-Jones, 2014; Rewilding Europe, 2017a; Wynne-Jones, Strouts, & Holmes, 2018). Reflecting back on the definition from Rewilding Britain (2018, para. 2), they mention the 'balance between people and the rest of nature where each can thrive' and the 'opportunities for communities to diversify and create nature-based economies'. Furthermore, they have a desire for 'people to re-connect with wild nature'.

George Monbiot's vision of rewilding is as much about rewilding human life as it is about rewilding British landscapes. Rewilding is not solely about the delivery of material benefits, there are the immaterial, spiritual benefits to be reaped (Fredrickson & Anderson, 1999). Lately, it has taken on a new social meaning, that of rewilding human beings and releasing children back in to the wild. For example, Monbiot (2013), in his book, Feral, describes his personal experiences and need to be closer to nature and the health and well-being benefits that are so freely available to all. Therefore, rewilding is not just about a mass restoration of ecosystems but a rewilding of lives, a re-enchantment, a discovery of the wonders and delights of nature and all its uses and values.

2.8 The UK Government's 25-Year Environment Plan

The inverse correlation between people and nature has recently been addressed in the UK Government's 25-Year Environment Plan (DEFRA, 2018). In summary, the aim of this plan is to help people improve their health and wellbeing by using green spaces and encourage children to be closer to nature while making it possible that people from all backgrounds can engage with nature and improve the environment. The report also aims to improve soil health and expand woodland cover as well as take action to reduce the risk of harm from flooding and coastal erosion as a result of sea level rise attributable to climate change. The government seeks to use natural flood management solutions, such as, building small-scale woody dams, reconnecting rivers with their flood plains and storing water temporarily on open land. One of the most crucial points mentioned in the report is the intention to develop a Nature Recovery Network to protect and restore wildlife and provide opportunities to re-introduce species that have been lost from our countryside. This a key step forward by the UK Government.

Professor Sir John Lawton conducted an independent review of England's wildlife sites and ecological network: Marking Space for Nature (2010). The review summarised what needed to be done in four words: more, bigger, better, and joined up. The UK Government's broad response is set out in the Natural Environment White Paper (DEFRA, 2011). Seven years later, the DEFRA's 25-Year Environment Plan (DEFRA, 2018) reiterated many of those ideas and also reiterated international requirements set out by the Convention on Biological Diversity (CBD). The CBD, an international organisation set up by the United Nations Environment Programme (UNEP), requires all countries signed up to the programme to demonstrate that they have implemented strategies to protect and enhance their environment.

How might rewilding, as a concept, be applied to support the aims of the Government's 25-Year Environment Plan? Applying the concept will challenge the status quo with regards to habitat management and seek to restore habitats and re-establish natural processes and functions with a focus on natural regeneration rather than conserving their current state or trying to create a past condition. Managing habitats is about stopping succession at various points, whereas, rewilding can be seen as a softer, more gentle approach that allows nature to regain control and function as normal so that natural processes are reinstated, and ecosystem services are resumed. By allowing nature to grow and develop with minimum intervention then a robust natural environment will, it is postulated, emerge that is resilient to change (Navarro & Pereira, 2012). Complex ecological processes can be restored (hydrological processes, nutrient cycling, carbon storage) and with an introduction of absent species, many biotic processes will be established (grazing, dam building, burrowing, seeding, micro-biotic activity, predator/prey relationships, scavengers) (Carey, 2016). The impact will affect the surrounding landscape and the urban environments by providing clean air and water, reduced pollution levels, flood mitigation, improved soil health, and a landscape resilient yet open to change (Sylven & Widstrand, 2015). The concept of rewilding has been explored, as detailed above, in large, open areas, but with increasing urban populations and with that the growth of peri-urban environments, there is a need to explore the adoption of the rewilding concept in these areas.

2.9 Gaps in the evidence

Evidence-based research on rewilding has mostly examined the predicted ecological benefits such as increased provision for ecosystem service (e.g. Cerqueira et al., 2015; Hodder et al., 2014; Keesstra et al., 2018) while some researchers have attempted to map priority areas for rewilding using attributes such as projections of land abandonment (Ceaușu et al., 2015) or perceptions of wilderness (Carver, Comber, McMorran, & Nutter, 2012; Carver, Evans, & Fritz, 2002). Other studies have focused exclusively on sparsely populated upland areas (Sandom et al., 2018) but do not mention specific scenarios that could be trialled in these areas. In densely populated areas where a top-down approach to rewilding would cause conflict (Lorimer et al., 2015) the combination of mappable characteristics and stakeholder input is appropriate for assessing feasibility. Loth & Newton (2018) explored specific options for rewilding using ecological and stakeholder-derived data but the study was conducted on rural lowland agricultural landscape and on a large county scale. While Carver et al. (2012) stressed that the results from their study are applicable to a range of spatial scales, their focus was explicitly on upland areas.

No previous study has applied ecological and stakeholder-derived data to evaluate opportunities for rewilding in a small-scale peri-urban environment. This project will, therefore, provide local councils, landowners, non-governmental organizations (NGOs) and the general public with options for alternative ways in which to manage habitats. The focus is on providing a place for people to feel immersed in wild lands while allowing the natural processes to establish.

3. Method

3.1 Description of Site

The Mersey Estuary stretches for a distance of about 48 kilometres from the upper tidal limit of Howley Weir in Warrington to the sea. Upper Moss Side (UMS) (OS Grid Reference SJ 5601 8523) is situated in the Upper Mersey Estuary on partly active flood plain and lies to the east of Runcorn and south west of Warrington in a peri-urban area. Although there are areas of high population surrounding UMS it has a very rural ambience albeit dominated by views of the cooling towers and other buildings of Fiddlers Ferry Power Station to the west. The section of the estuary where UMS sits is narrow and consists largely of a single, tidal, meandering channel. A little more than 5 kilometres south west of UMS, after the Silver Jubilee Bridge, the estuary opens up into a wide basin, the inner estuary (Figure 3.1).

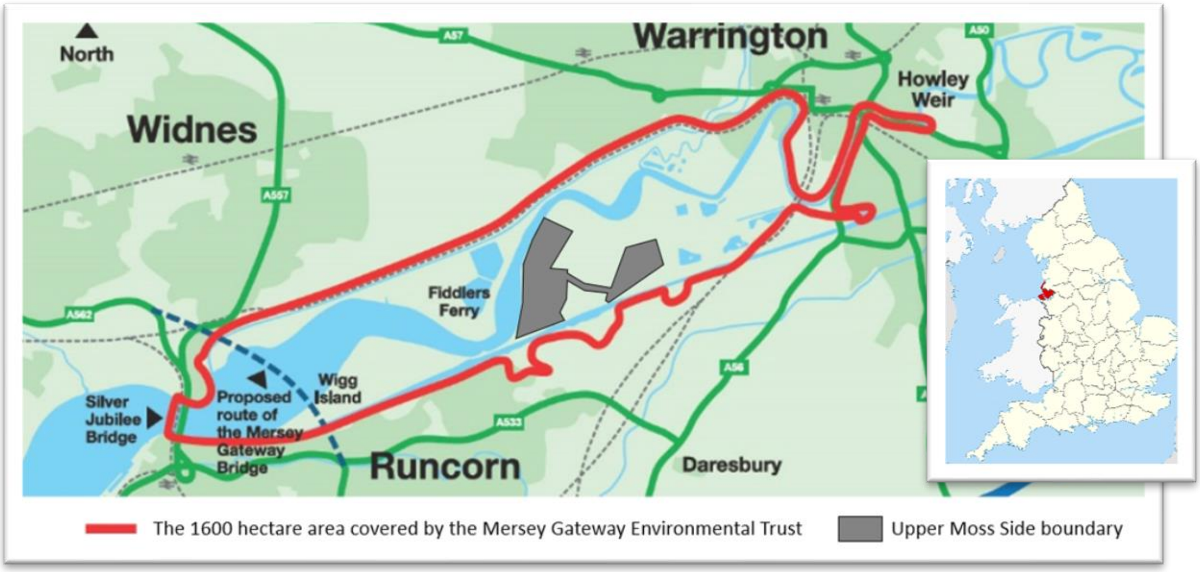

Figure 3.1. Red line indicates the boundary area managed by the Mersey Gateway Environmental Trust 2014-2044; grey area is Upper Moss Side. Insert indicates the approx. position in the UK. Sourced: Mersey Gateway Environmental Trust and Ordnance Survey Open Data. Contains OS data © Crown copyright and database right 2020.

UMS is 71.4 ha in size and until 2002 was farmed with crops of potatoes, wheat/barley, oil seed rape, and beans. Small patches of land to the north and south of UMS still remain active farmland and directly to the east is Moore Nature Reserve which comprises of almost 80 ha of woodland, meadows, lakes, and ponds. Moore Nature Reserve is managed by wardens employed by FCC Environment the operators of Arpley Landfill site located north of the reserve. Arpley Landfill covers more than 200 ha and is being restored to a mix of woodland and grassland that will merge with Moore Nature Reserve (*Figure* 3.2).

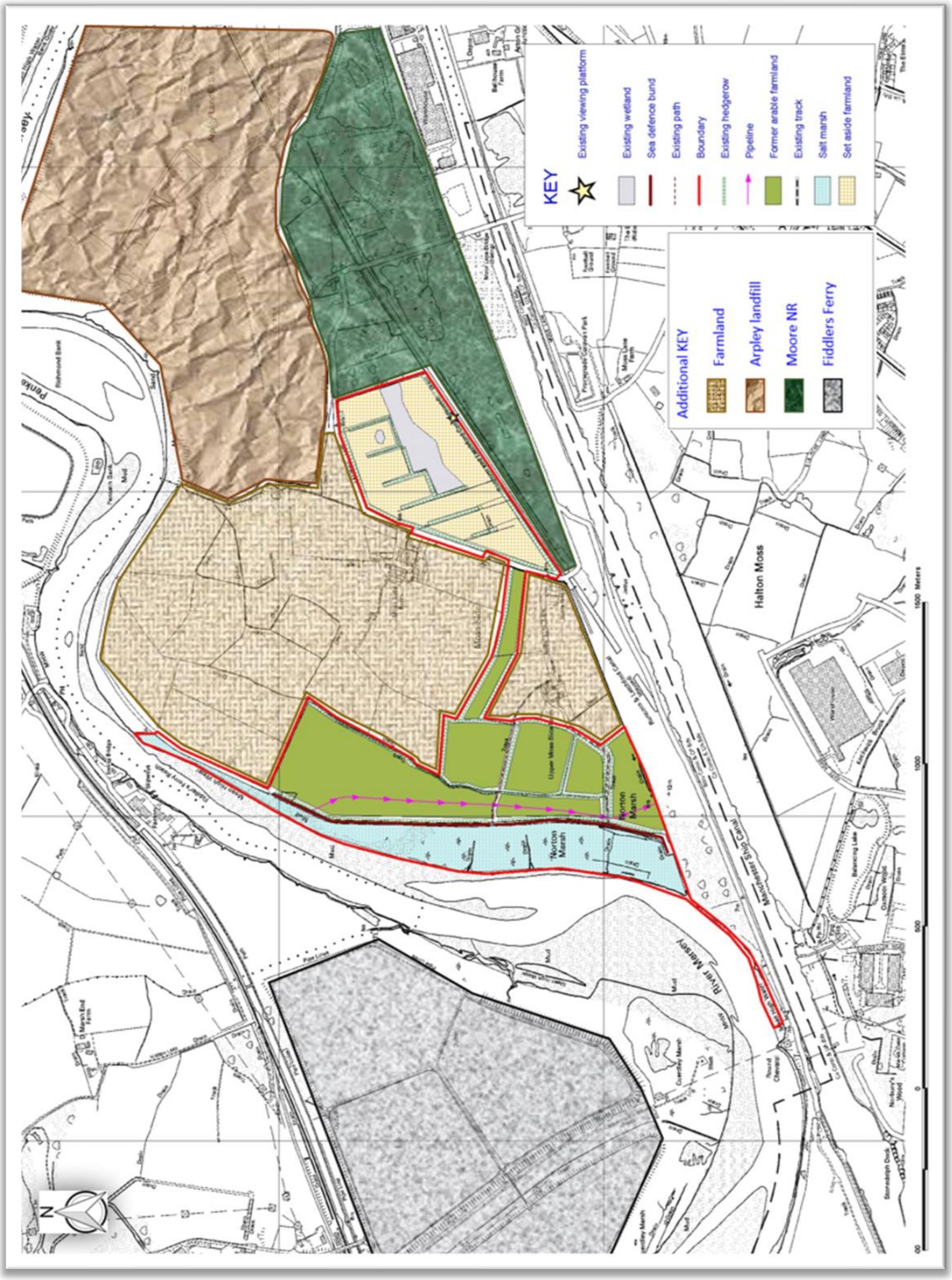

Figure 3.2. Forestry Commission map of the UMS marked out in red. Additional areas of interest have been highlighted; additional key added. Sourced from Digimap. Contains OS data © Crown copyright and database right 2020.

3.2 Summary of Methods

The study aims to identify and critically evaluate what UMS may look like at a future date if the current management plan were to remain in place or if a rewilding approach was undertaken. To demonstrate this and to gain understanding of the practicality and acceptability of the research, a mixed method approach was used incorporating quantitative and qualitative data. The term 'mixed method' refers to the systematic integration of quantitative and qualitative data within a single study (Wisdom & Creswell, 2013). Pairing qualitative and quantitative methods is increasingly recognized as valuable, because the strengths of each approach are drawn on (Jick, 1979). The advantage of using this approach is that it can expand the scope of the study in a dynamic way (Sandelowski, 2000), thus generating more complete data (Curry, Nembhard, & Bradley, 2009). However, mixing methods in a single study can have its limitations and it is, therefore, necessary to clarify *how* and *what* is being mixed as it may be no more than the sequential use of different methods (Bazeley, 2004). Nevertheless, mixed methods research responds to the interests and needs of diverse stakeholders in research offering more possibilities than a single method approach for responding to decision makers' agenda (Greene, 2005).

In order that changes in vegetation could be mapped as a basis for the scenario building, baseline ecological data (quantitative data) were collected on site followed by an analyse of the current management plans. The changes in the vegetation over time were quantified and fed into a Markov model. The model produces a probability matrix from which changes in vegetation can be extrapolated A number of researchers have testified to the accuracy of the Markov model (Jianping, Bai, & Feng, 2005; Zhang et al., 2011). For the rewilding scenario, the baseline ecological data were used and combined with a critical review of the literature undertaken to choose the most appropriate species for reintroduction. The review also enabled a depiction of a possible future scenario under a rewilding regime. Data for both scenarios were presented to a number of local stakeholders at a workshop to gain qualitative feedback on the practicality and acceptability of the rewilding approach in comparison to the data presented on the potential outcome under the current management plan. By analysing the qualitative feedback received from the workshop this builds on and enriches the results of the quantitative phase (Greene, Caracelli, & Graham, 1989; Wisdom & Creswell, 2013). The opportunities to expand the rewilding approach in a larger geographical area around UMS were explored by mapping the important nature conservation sites within a 10 km radius of UMS. The diagram in Figure 3.3 shows how each element served each phase of the study. This study represents the first known attempt to assess the acceptability and practicality of rewilding UMS as a conservation strategy using quantitative and qualitative data.

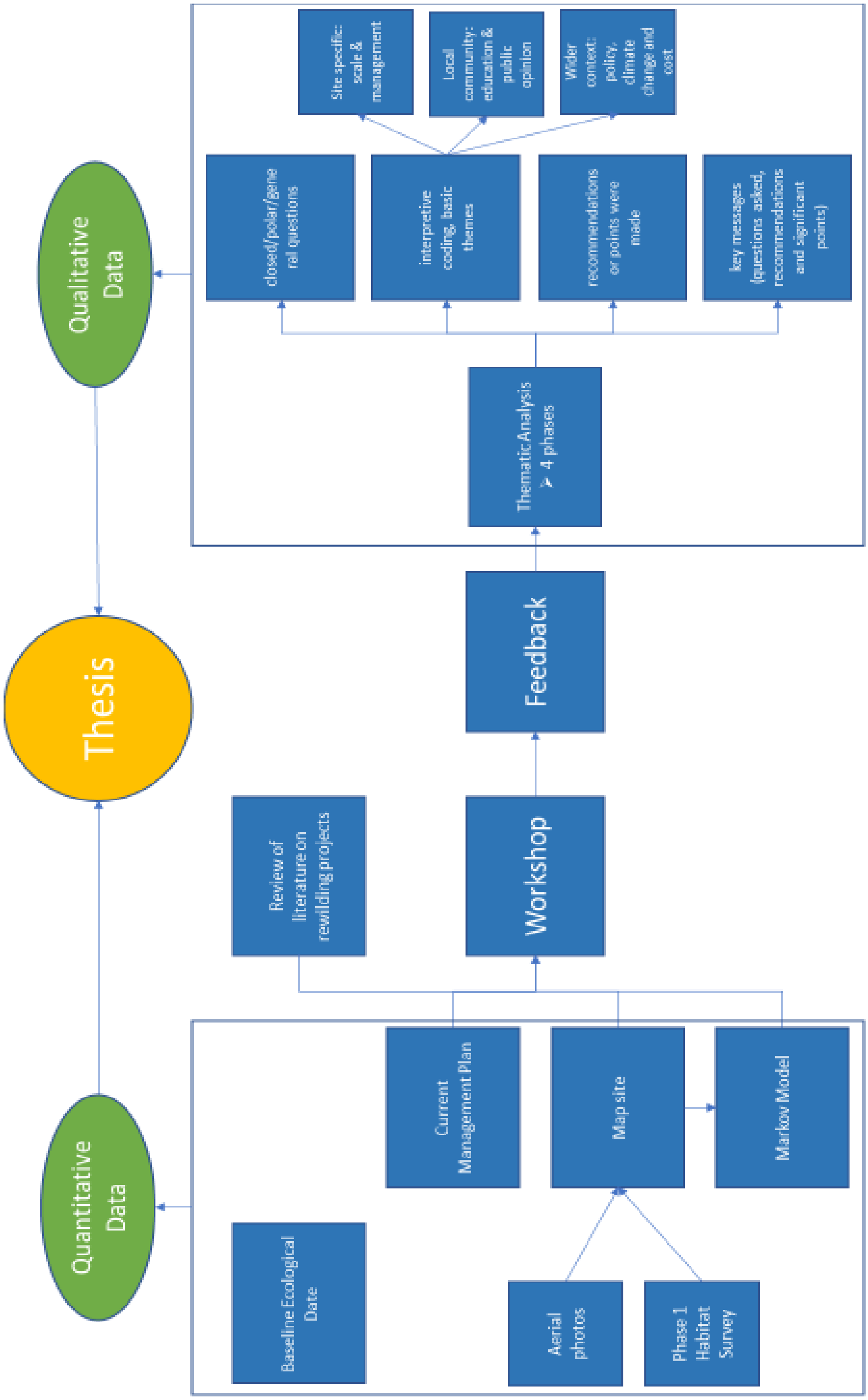

Figure 3.3. Diagram/flowchart of research approach.

3.3 Techniques

3.3.1 Landcover

Google Earth is an application that accesses remotely sensed satellite and aerial imagery, ocean bathymetry and other geographic data from the internet to render a 3D representation of Earth and produces seamless imagery (Stahley, 2006). Images produced via remote sensing are frequently identified as a powerful tool for detecting change (Kennedy et al., 2009). The purpose of using remotely sensed imagery is to explore the changes that have taken place in the different habitats present at UMS. A time series of images, from December 2005 and June 2009 and 2018 with a resolution of 1570 x 944, were saved as a .jpg. The reason for choosing those years was to show the year before any Forestry Commission development (2005) and three years after (2009) plus the most recent (2018) image of the same area to show its current state after nine years without extensive management. The .jpg images were used in ArcGIS 10.5 (ESRI, 2016) to map, using polygons, the different vegetation types (Table 3.1).

Table 3.1. Area of each habitat in square meters for year 2005, 2009, and 2018.

	2005	**2009**	**2018**
	Square metres		
Arable	480298.00		
Grassland		399514.60	240135.22
Saltmarsh	159802.00	155335.80	134497.97
Scrub	42036.00	744.52	11198.14
Swamp	8213.00	25824.32	52894.14
Hedgerow	21068.00		
Trees		139268.20	288123.43
Water		4512.73	7380.37

Because the boundary of the site was not defined and, therefore, changed over time due to the reedbed and saltmarsh expanding and contracting in the river and the tree canopy spreading, a 20-meter buffer zone was created so that the total extent of the site including the buffer zone remained the same. The buffer zones were labelled according to the land cover that was being affected - farmland, river, road, and other vegetation (Table 3.2). Also included in Table 3.2 is the bund which runs down between the saltmarsh and moss side fields (highlighted in section 3.2.5, Figure 3.5), this landcover did not form part of the analysis as it held no value. The defined area of the site is 770,000 square meters, however, the total area, including the 20-meter buffer zone, is 916,034 square meters which allowed for the fluctuations.

Table 3.2. Area of each buffer zone in square meters for year 2009 and 2018 including the bund.

	2009	**2018**
	Square Metres	
Bund	10759.26	10739.84
Farmland	60946.84	60609.63
River	70799.25	61801.06
Road	20880.97	19824.81
Other vegetation	27448.29	28830.20

The comparison of remote-sensed images are widely used to assess changes over time and to build future scenarios based on a long-term set of observations (Liu, Hu, Chang, He, & Zhang, 2009; Poorzady & Bakhtiari, 2009).

3.3.2 Phase 1 Habitat Survey

A Phase 1 Habitat Survey was undertaken with Duncan Macnaughton (Forestry Commission warden of UMS at the time), with reference to the Handbook for Phase 1 Habitat Survey (JNCC, 2010) to establish the presence and distribution of habitat types within the site. In the UK, Phase 1 Survey is a standard method of habitat mapping that has been used widely for environmental assessment and management planning (Cherrill & McClean, 1999a). Whilst the Phase 1 approach was intended primarily as a mapping system it also contained a classification of land cover (Hearn et al., 2011). The site field survey was carried out on 23rd October 2018 in damp weather conditions. The timing of the survey (due to the availability of Duncan Macnaughton) was just outside the optimal season for habitat assessment, which runs from April to mid-October (JNCC, 2010), however, because of the broadness of the type of habitat that were being surveyed, it was possible to identify and classify all habitats. The timing and the weather conditions were not considered to be a significant constraint on the survey findings. The habitat was mapped by hand using a paper map from Digimap/ordinance survey and transferred to ArcGIS 10.5.

Analysis of completed Phase 1 Habitat Surveys have highlighted inconsistences and inaccuracies (Cherrill & McClean, 1999b; Stevens, Blackstock, Howe, & Stevens, 2004), therefore to limit the number of classification errors and the difficulties with ‘transitional’ vegetation, subcategories were grouped into broader categories (Table 3.3).

Table 3.3. Grouping of Phase 1 classifications into categories.

Category	Phase 1 subcategory	Phase 1 code
Trees	Broadleaved woodland semi natural	A1.1.1
	Broadleaved woodland plantation	A1.1.2
	Broadleaved parkland scattered trees	A3.1
	Intact hedge - species poor	J2.1.2
	Hedge and trees - native species rich	J2.3.1
Grassland	Poor semi improved grassland	B6
	Acid grassland semi improved	B1.2
	Marshy grassland	B5
	Improved grassland	B4
Saltmarsh	Saltmarsh dune interface	H2.3
Swamp	Swamp	F1
Scrub	Scrub scattered	A2.2
Water (ponds/scrapes)	Standing water	G1

3.3.3 RECORD

RECORD is the Local Biological Records Centre (http://www.record-lrc.co.uk/) serving Cheshire, Halton, Warrington, and Wirral. A species record list for UMS and the surrounding area going back to the year 1834, which was when records began, was provided upon request. The list included plants and animal species plus the location and date it was recorded. These data were arranged in excel using a pivot table and put in to one of nine categories: amphibians, birds, fish, fungi, insects, mammals, plants, mosses and algae, and trees and shrubs. However, for the purpose of the study only five categories were analysed - amphibians and reptiles, birds, mammals, invertebrates and invasive species. The other categories – fish, fungi, plants, and mosses and algae - were excluded from the analysis due to the extent of the data and the time allowed to complete the research. The data for the five categories were split by year and location so that only the most relevant data were analysed. Bird of Conservation Concern 4 (BoCC4) which is a collaboration between the Statutory Nature Conservation Bodies (SNCBs), RSPB (Royal Society for the Protection of Birds), BTO (British Trust for Ornithology), WWT (Wildfowl and Wetland Trust), GWCT (Game and Wildlife Conservation Trust), and several other organisations were also highlighted along with the level of protection for mammals. Identifying what has previously inhabited the local area and what is there presently provides a reference point; it also highlights what is possible with regards to wildlife comeback.

3.2.4 Management plans

After acquiring the site in 2002, the Forestry Commission created a design plan in 2005 that transformed the landscape from farmland to a more woodland/grassland habitat that is shown in the most recent image (2018). The site is noted for its ornithological interest over two habitats - wetland/saltmarsh and farmland/grassland - with significant numbers of breeding and wintering farmland birds and wintering waders.

In 2017 the site became part of the Forestry Commissions St. Helens management plan 2017–2027, which included another five sites, collectively to be managed under one plan. The management objectives, which include the economy, people and nature were analysed together with the woodland management approach. In addition, the Mersey Gateway Environmental Trust (MGET) was established in 2010 to promote the conservation, protection, and improvement of the 1600 ha area from the Silver Jubilee bridge to Warrington (Figure 3.1). That said, MGET have not published any management plans for UMS. There is a chance that the findings from this study could influence the future management of the site. On a larger scale, The Mersey Forest was established in 1990 which covers an area of 1370 km^2 across Merseyside and North Cheshire, including UMS. Their vision is to get ‘more from trees’ and create a community forest that can build a healthier and more prosperous society (The Mersey Forest, 2014).

3.2.5 Markov model

Scenarios have been used by environmental managers to explore a number of issues at a variety of spatial and temporal scales (Peterson, Cumming, & Carpenter, 2003).

A Markov model was used on account of a number of researchers that have testified the accuracy (Jianping et al., 2005; Zhang et al., 2011).The process models the future state of a system purely based on the immediately preceding state. A description of the land cover from one period to another is used for the basis to project future changes which is achieved by developing a transition probability matrix of land cover – the matrix shows the nature of change while still acting as the means for projecting to a later time period (Logsdon, Bell, & Westerlund, 1996). The methodology required for the Markov model is explained below.

Converting one state into another state of a system is called state transition. If P is transition probability, namely the probability of transitioning from one state to another in a single time unit, the expression is as follows:

(Equation 1)

$$P = P_{ij} = \begin{vmatrix} P_{11} & P_{12} & \dots & p_{1n} \\ p_{21} & p_{22} & \dots & p_{2n} \\ \dots & \dots & \dots & \dots \\ p_{n1} & p_{n2} & \dots & p_{nn} \end{vmatrix},$$

where P stands for probability from state i to state j (Guan, Gao, Watari, & Fukahori, 2008; Jianping et al., 2005). Equation (1) must satisfy the next two conditions:

(Equation 2)

$$\sum_{j=1}^{n} P_{ij} = 1,$$

(Equation 3)

$$0 \leq P_{ij} \leq 1.$$

The key step of the Markov model lies in getting a primary matrix and matrix of transition probability (P_{ij}). Then the Markov forecast model is as follows:

(Equation 4)

$$P_{(n)} = P_{(n-1)} \quad P_{ij} = P_{(0)} P_{ij}^{n},$$

where P_n stands for state probability of any time and $P_{(0)}$ stands for primary matrix. A primary matrix $P_{(0)}$ was calculated for each habitat type with the six LC classes.

Transition speed from one state to another state is named transition probability, and it may be calculated through annual mean transition rate of a certain land cover type. The transition probability of the area in square kilometres for the six land cover classes, including the buffer zone, can be found in the Appendix 1 (Table 1a to 1d). According to the definition, transition matrix gives the probability that a given land cover class will change to another class in the future, given the present state of the class.

Simply put and relevant to this study, the probability is calculated based on the change in land cover from 2009 to 2018. The change in area occupied by one habitat in 2009 to another habitat in 2018 is the change from one habitat in 2009 divided by the total of all the habitats that changed from that one habitat in 2009 to another in 2018. This then gives the probability that the habitat is likely to change at a future date in time which is calculated by taking the total sum of one habitat in 2018 and multiplying it by the probability (Figure 3.4).

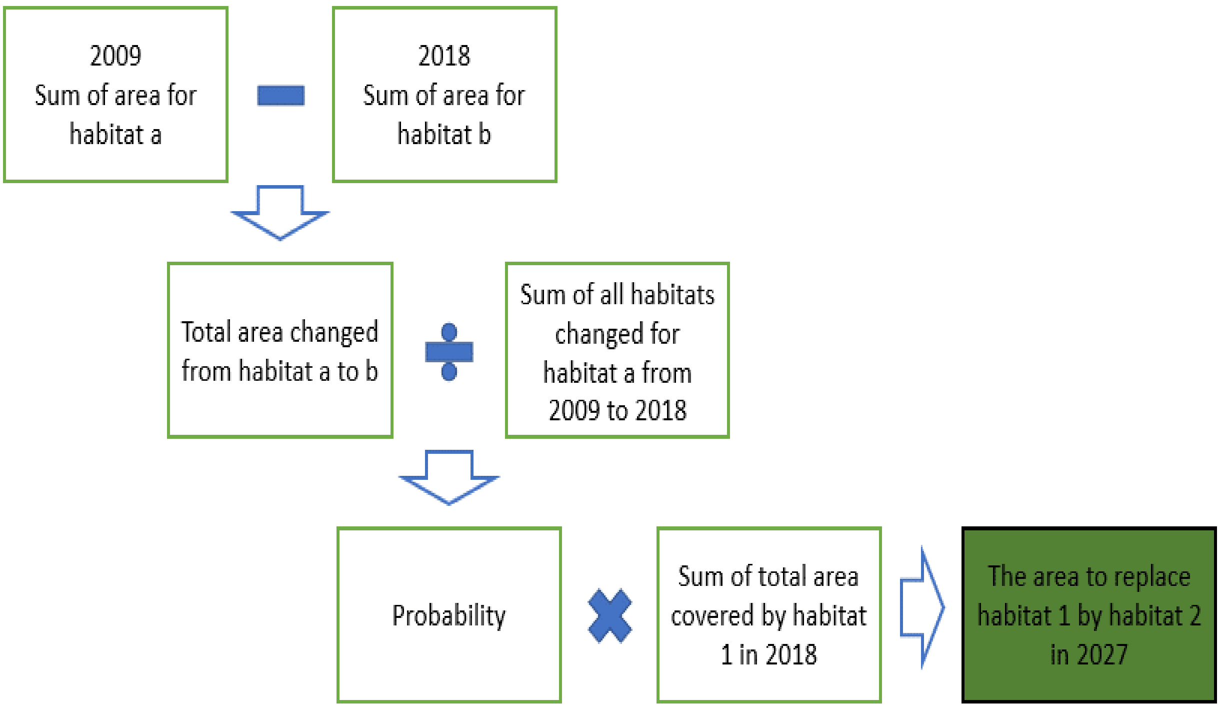

Figure 3.4. The Markov model calculation steps.

For further certainty around transition and succession rate within the Markov model, the site was divided into three areas: Norton, which is classified as a saltmarsh; Moss Side, which is ex-arable farmland and is a mix of mixed woodland and grassland; and Lapwing, which is mainly marshy grassland and woodland (Figure 3.5).

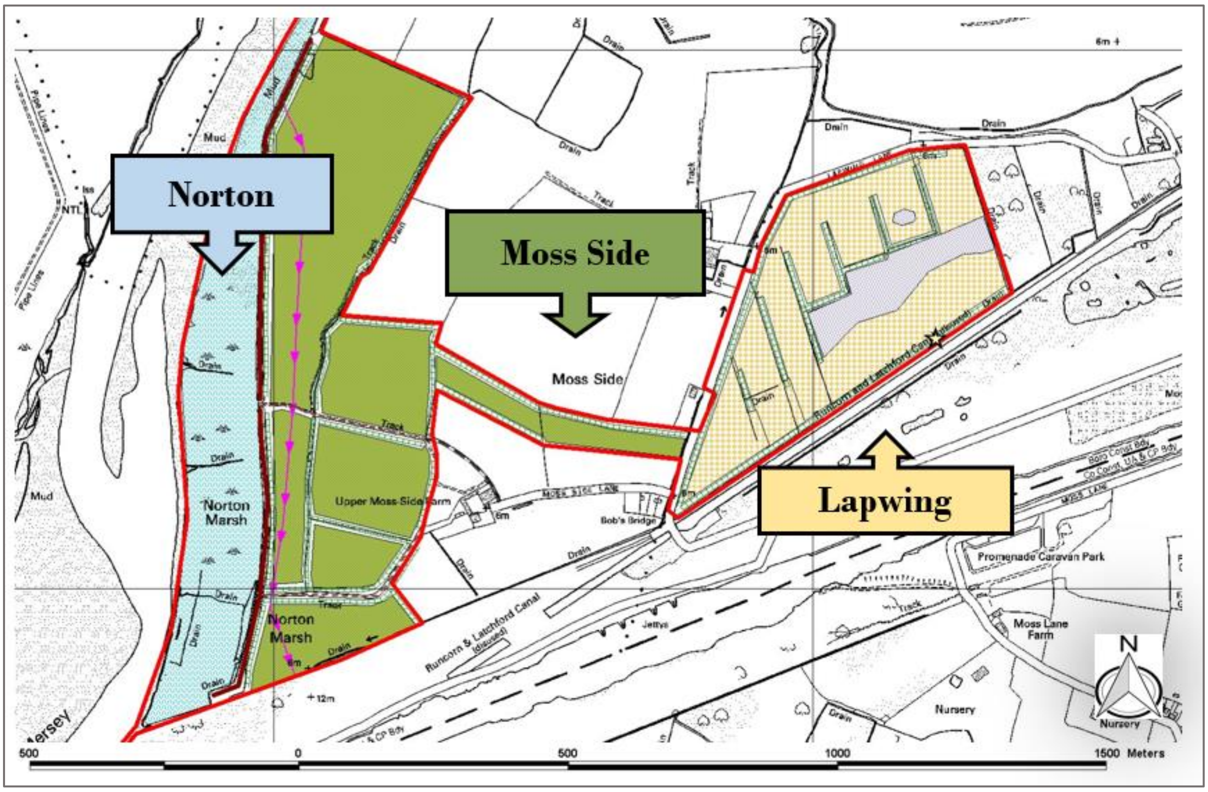

Figure 3.5. Map indicating the different habitats by name and their location. Sourced from Digimap. Contains OS data © Crown copyright and database right 2020.

3.2.6 Workshop

A one-day stakeholder workshop was hosted by the MGET and took place at their offices in Widnes in June 2019. Workshops are used most often in participatory action research (PAR), since they provide a forum where researchers and local people can work together on issues of shared concern (Newing, 2011). They are an important tool in formal strategic planning processes as they rely on a discursive approach (Hodgkinson, Whittington, Johnson, & Schwarz, 2006). The workshop was based on a consultation methodology which has been previously used and tested to gain feedback from local stakeholders and interested parties on issues, such as, rewilding as a restoration strategy (Loth & Newton, 2018), natural grazing (Jepson, 2019), and landscape scale restoration of the Cambrian Mountains (Land Use Consultants, 2011). However, this study represents the first known attempt to assess the acceptability and practicality of rewilding a peri-urban area as a conservation strategy.

Invitations to attend the workshop were sent out to twenty individuals and a total of ten participants attended the workshop (Table 3.4). Although invited, no one from the Forestry Commission was able to attend the workshop. As the research was focused on an alternative management plan of UMS, the participants needed to have knowledge of the site, however, any prior knowledge about rewilding was not necessary as the presentation for the workshop was designed in a way that provided an overview of the concept.

The involvement of stakeholders in workshops that focus on conservation planning and land management can facilitate the development of many conservation projects (Burton, Metzger, Brown, & Moseley, 2019; Gatewood, 1999; Kizos et al., 2018; Loth & Newton, 2018).

*Table 3.4. Summary of participants, organisation they are associated with and attendee number for reference. * An informed consent form was signed by all participants on the day of the workshop.*

Participant	Organisation	Attendee Number
Independent ecologist		1
Independent ecologist		2
Company secretary	Mersey Gateway Environmental Trust	3
Ranger	Moore Nature Reserve	4
Surveyor	at Woolston Eyes SSSI	5
Contractor	Landscape and conservation management	6
Biodiversity officer	Environment Agency	7
Biodiversity manager	Mersey Gateway Environmental Trust	8
Student	Wildlife conservation at John Moore University	9
Student	Wildlife conservation at John Moore University	10

The objective for the workshop was to learn if the stakeholders, from their professional opinion, deemed it was socially and professionally acceptable and practical to rewild UMS. The workshop sought to develop further understanding about which challenges and benefits would most influence the project. Participants were also asked which reintroduced species could assist in increasing the sites biodiversity and improve ecosystem services. This was achieved via a series of open-ended questions, and a Likert rating scale to address the severity of some of the challenges. The questions were asked at specific intervals within the workshop rather than being left to the end as to avoid any incidents of 'failure to recall'. A copy of the template can be found in Appendix 2. The workshop was broken up into sections and questions were asked at the beginning and the end of those sections. Table 3.5 shows the structure of the workshop and indicates the section and stage of each question.

Table 3.5. Workshop program by section and the sequence of questions.

Question section: B, M, E stands for - B is at the beginning of the section, M is in the middle of that section and E indicates the question was asked at the end of that section.

Section	Content	Question
1. Introduction to rewilding	History of rewilding Rewilding Britain definition and principles Rewilding projects in Britain Rewilding in the context of UMS	B. What is your understanding of REWILDING? E. Has this changed anyone's understanding of rewilding?
2. Information on UMS	History Soil & Geology Vegetation Satellite imagery from 2005, 2009 and 2018 Graph showing the land cover change	
3. Markov model	Graphs showing the predicted change in the landcover for each section of UMS: Norton saltmarsh, Ex-arable and Lapwing field Plus, the development efforts of the Forestry Commission	
4. Species re-introduction	Land abandonment Reintroducing missing ecological functions Reasons for the species Flow diagrams highlighting the ecological benefits Frans Vera theory Proposal	B. What's (more) important for UMS: Managing for a target habitat/species OR increased biodiversity and resilience? E. Are the reintroduced species presented acceptable for UMS?

	Knepp Wildland video	
5. Benefits	Rewilding people Ecosystem services Natural capital How is that applicable to UMS	
6. Challenges	Discussed word cloud List of common challenges Practical and logistical issues Administration and planning considerations	B. Word cloud – list 3 limiting factors that could influence this project. M. Likert scale – rate the challenges listed on their severity E. Do the challenges outweigh the benefits or vice versa?
7. Conclusion	Overview of conservation in the UK	E. Is it ACCEPTABLE to rewild UMS? And why? Is it PRACTICAL to rewild UMS? And why?

The workshop feedback was analysed using conventional qualitative techniques of thematic coding and sorting. Thematic analysis is a method for identifying, analysing, organizing, describing, and reporting themes found within a data set (Braun & Clarke, 2006). In addition to the preceding analysis, local stakeholder opinion on the different management options for UMS was of value; themes ranging from broad issues such as climate change and policy to public opinion and education were created. The method used to analyse the data in this study was not technical; it relied on colour coding excel to decode the data and create the themes. During the planning stage of the workshop, prior consideration had been given to the analysis section, which meant the questions and answers were already grouped into subjects.

Several phases were carried out during the analysis that were crucial to deconstruct the key messages, view similarities and build theory from the data gathered (Braun & Clarke, 2006). In this study four analysis stages were carried out. The first stage determined the answers to the closed/polar/general questions; the number of times they were repeated was recorded. While analysing the data, a number of recommendations or points were made to back up/support the answer, this was also documented. Then, in the stage of interpretive coding, basic themes were recognised:

- Site specific: scale & management
- Local community: education & public opinion
- Wider context: policy, climate change and cost.

Key messages, further questions, recommendations, and significant points made by the participants were logged.

In section six, the interactive discussion tool called ’Mentimeter’ (https://www.mentimeter.com/) was used to enhance participant learning and engagement (Iona, 2018). A word cloud was introduced that asked the participants to list three potential limiting factors that could influence the project. A Likert scale was used to gauge the severity of a number of common challenges associated with rewilding that were listed on the screen. The Mentimeter tool was conducted live, but anonymously, so the participants could see the common consensus.

3.2.7 Wider spatial context

To investigate the wider spatial context and opportunities statutory and non-statutory designated sites within 10 km of UMS were mapped along with the recorded species in that area. As a result of the single, multiple site management plan and to comprehend the possible ecological scope of the project in relation to the surrounding area, an assessment of the local area, via Defra’s MagicMap website (https://magic.defra.gov.uk/), for statutory and non-statutory designated sites and an exploration of the types of habitat surrounding UMS was carried out. The purpose of the desk-based study was to identify relevant background ecological information on the site, in terms of habitats and species, which would help to identify its ecological baseline/condition.

4. Results

4.1 Overview of Results

The landcover at Upper Moss Side (UMS) has changed considerably over the last 20 years. In 2002, the Forestry Commission acquired UMS, which was previously a working arable farm, and in 2006 began work to increase woodland cover, diversify the grassland, and create ponds and scrapes; the change in vegetation is evident in images taken from Google Earth in 2009 and 2018 in comparison to 2005. To quantify the changes in vegetation, a baseline assessment of the landcover, through a Phase 1 Habitat Survey and using Google Earth imagery was carried out for 2005, 2009, and 2018 with the addition of an on the ground assessment (section 4.2). The 2005 design plan details the work undertaken (section 4.2.1). The local records centre (RECORD LBR (Local Biological Records)) provided historical data of species recorded at UMS and the surrounding area. For analysis, the data were broken down into five groups for analysis: amphibians and reptiles, birds, mammals, invertebrates, and invasive species (section 4.3). In order to ascertain what the future might look like for UMS, a thorough examination of all extant management plans that could affect the site was carried out (section 4.4); the information will influence the detail within the Markov model.

So that it was possible to generate a future landcover scenario of UMS, historical images from 2009 and the data from 2018 (section 4.2) were quantified and put into the Markov model. By utilising the Markov model, it was possible to identify scenarios for the different parts of UMS – Norton, Moss Side, and Lapwing – in which there had been a shift in landcover from 2009 to 2027 (section 4.5).

The logic behind the RECORD LBR data analysis was to discover which species were present, and from that knowledge to assess which ecological functions were present, and therefore, which were absent. The missing ecological functions exposed by the analysis of the RECORD LBR findings were used when considering which species were suitable for reintroduction to UMS. Their ecological function, activities, and feeding strategy from other conservation grazing or rewilding projects provided evidence of the kind of impact they are likely to have on the vegetation and the wildlife at UMS (section 4.6).

The scenario generated through the Markov model for 2027 and the rewilding scenario were presented at a workshop where local stakeholders provided feedback, which was analysed using a thematic method and broken down into a number of different topics (section 4.7).

Looking further afield at the landcover of the surrounding areas (section 4.8) and nearby designated sites (section 4.9), using Defra's MagicMap software, may inform a decision on possible wildlife comeback at UMS and the potential connectivity routes for species to migrate along and/or utilise.

4.2 Landcover changes

After acquiring UMS in 2002, the Forestry Commission reserved any development until 2006, therefore, the Google Earth Images taken in 2005 show landcover prior to any tree planting or modification and provides evidence that UMS was once an arable landscape. The work carried out by the Forestry Commission in its 2005 Design Plan offers a detailed insight into the extent and whereabouts of the activities. The 2005 Design Plan also provided a guide when mapping the Phase 1 Habitat Survey for 2009. The Google Earth image taken in 2009 and the quantified data generated through mapping the landcover are later used as part of the Markov model (Section 4.5).

The Phase 1 Habitat Survey for 2005 using a Google Earth image (Figure 4.1) shows that grassland and saltmarsh were the predominant landcover – 65.5 and 22.1 per cent, respectively. Scrub, trees, and swamp cover small areas – 5.9, 5.4 and 1.1 per cent (Table 4.1). There are several ditches, combined length 4,238 metres, that had been dug for various reasons around UMS and which may explain the lack of water.

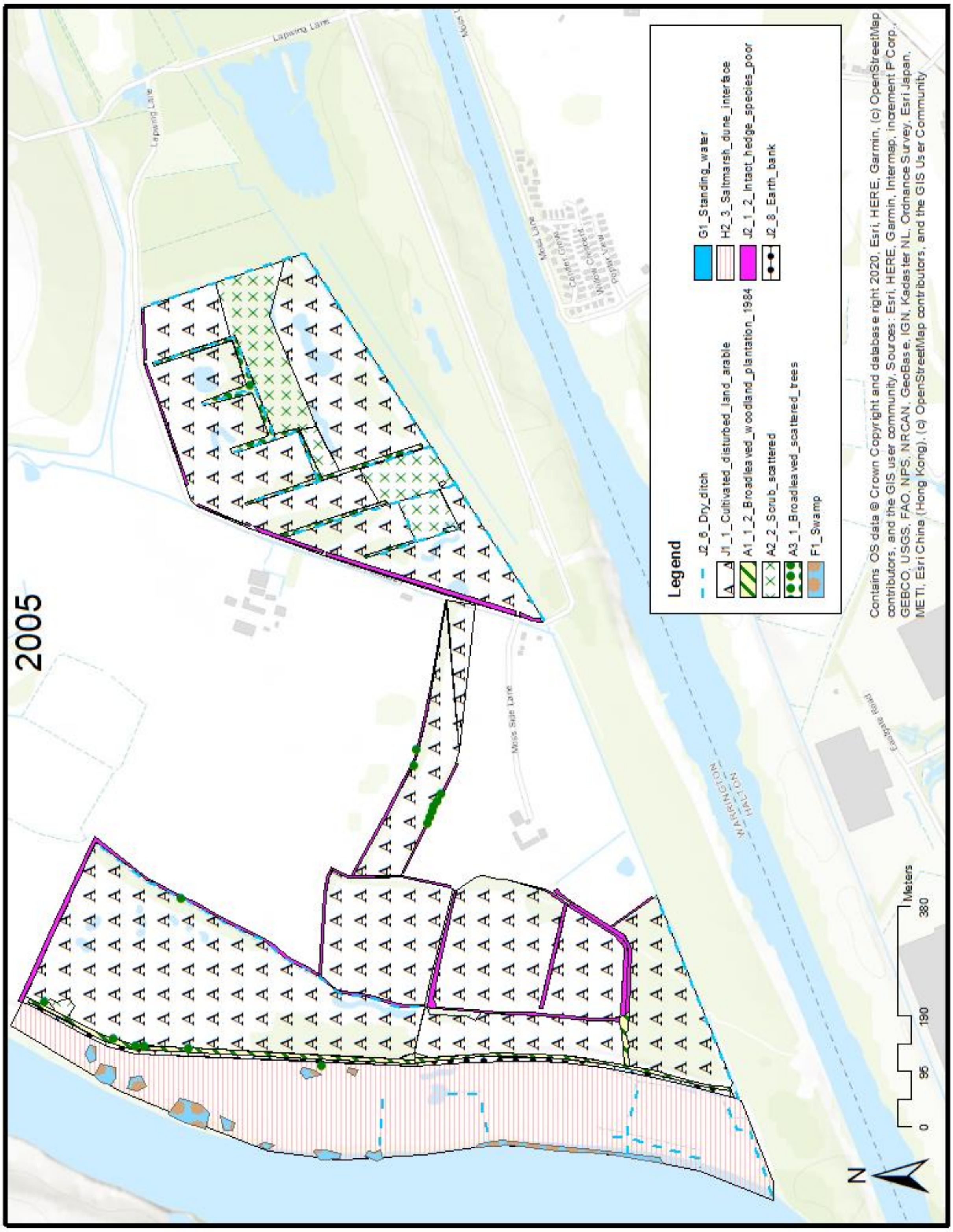

Figure 4.1. Phase 1 Habitat Survey for 2005. Base map sourced from ESRI. Contains OS Data © Crown Copyright and database right 2020.

Table 4.1. Land cover for the whole site in 2005 in square meters.

	Square Metres					
Year	Grassland	Saltmarsh	Scrub	Swamp	Trees	Open water
2005	473,039	159,802	42,277	8,213	38,875	0
%	65.5	22.1	5.9	1.1	5.4	0

4.2.1 Forestry Commission Design Plan 2005

In 2005, the Forestry Commission published a design plan for UMS, which set out to diversify UMS and in 2006 work commenced. In order to pinpoint the whereabouts of the work carried out at UMS, each field was labelled (Figure 4.2).

The Forestry Commission planted over 20,000 trees across 6ha throughout the site; the predominant tree species were oak (*Quercus*), birch (*Betula*) and ash (*Fraxinus*) in sections A, C, D, E, WC and G (Figure 4.2). A wildflower and bird crop seed mix consisting of reed canary grass (*Phalaris arundinacea*), chicory (*Cichorium intybus*), kale (*Brassica oleracea*), phacelia (*Phacelia tanacetifolia*), sweet clover (*Melilotus officinalis*), Lucerne (*Medicago sativa*), and utopia (*Bacopa utopia*) along with another blend of barley (*Hordeum vulgare*), wheat (*Triticum* sp.), triticale (*Triticosecale*), linseed (*Linum usitatissimum*), red millet (*Eleusine coracana*), white millet (*Panicum miliaceum*), and reed millet (*Echinochloa esculenta*), and dwarf sorghum (*Sorghum bicolor*) was sown on sections A, D, E and WC. In 2011 work began on creating a series of ponds and scrapes as part of the Million Ponds Project, which aimed to create an extensive network of new ponds across the UK to reverse a century of pond loss (Pond Conservation, 2012). The ponds and scrapes were created in section A, B and G. Between 2016 and 2018 cattle grazed sections A and B both adjacent to the saltmarsh at 1 - 1.25 animals per ha. A rotation of cattle through the three sections was: year 1 – 17 ha of saltmarsh; year 2 – 16 ha of grassland (A); and year 3 – an additional grassland (B).

Since the extensive development in 2006 and the construction of the ponds in 2011, the only management of the whole site has been the limited grazing on a small area of the site, the remainder has been left unmanaged.

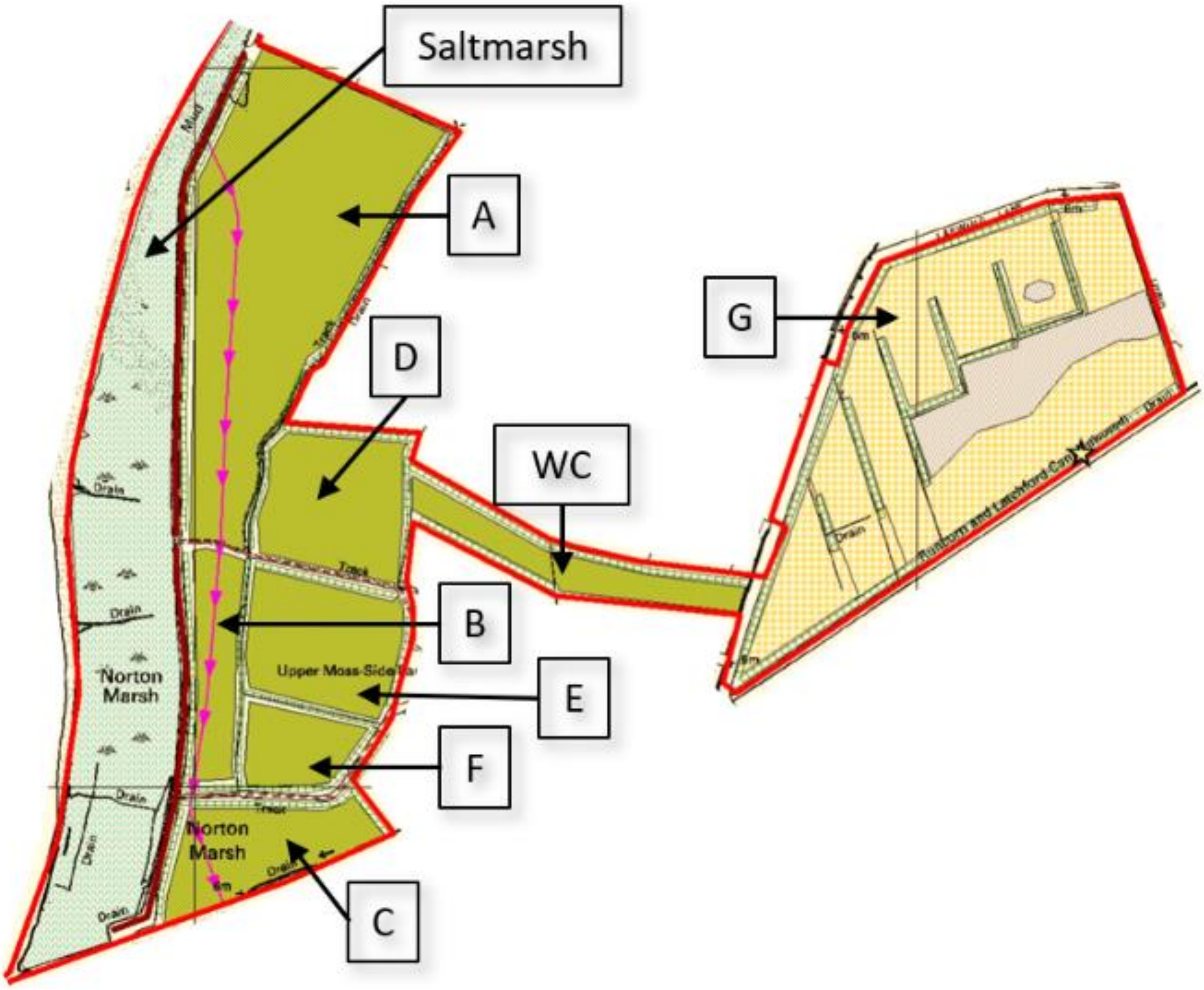

Figure 4.2. Labelling of the different sections within Upper Moss Side. Sourced from Digimap. Contains OS data © Crown copyright and database right 2020.

The Phase 1 Habitat Survey using a 2009 Google Earth image (Figure 4.3) shows the landcover at that time to be predominantly grassland across the whole site. For clarity, Figure 3.5 in the methods section indicates the location of the three identified habitats that are discuss here: Norton, Moss Side, and Lapwing. Norton saltmarsh was dominated by saltmarsh with little swamp coverage and marginal pockets of water – 85.0, 8.5 and 0.6 per cent, respectively. Moss Side is covered by either grassland, which dominated, or trees – 74.6 and 24.8 per cent respectively – scrub, swamp, and water cover just 0.6 per cent collectively. Grassland dominated again at Lapwing with 68.3 per cent and tree coverage 25.6 per cent, however, the marshy area also included areas of swamp and water – 4.7 and 1.4 per cent, respectively. The number of individual trees counted was 97.

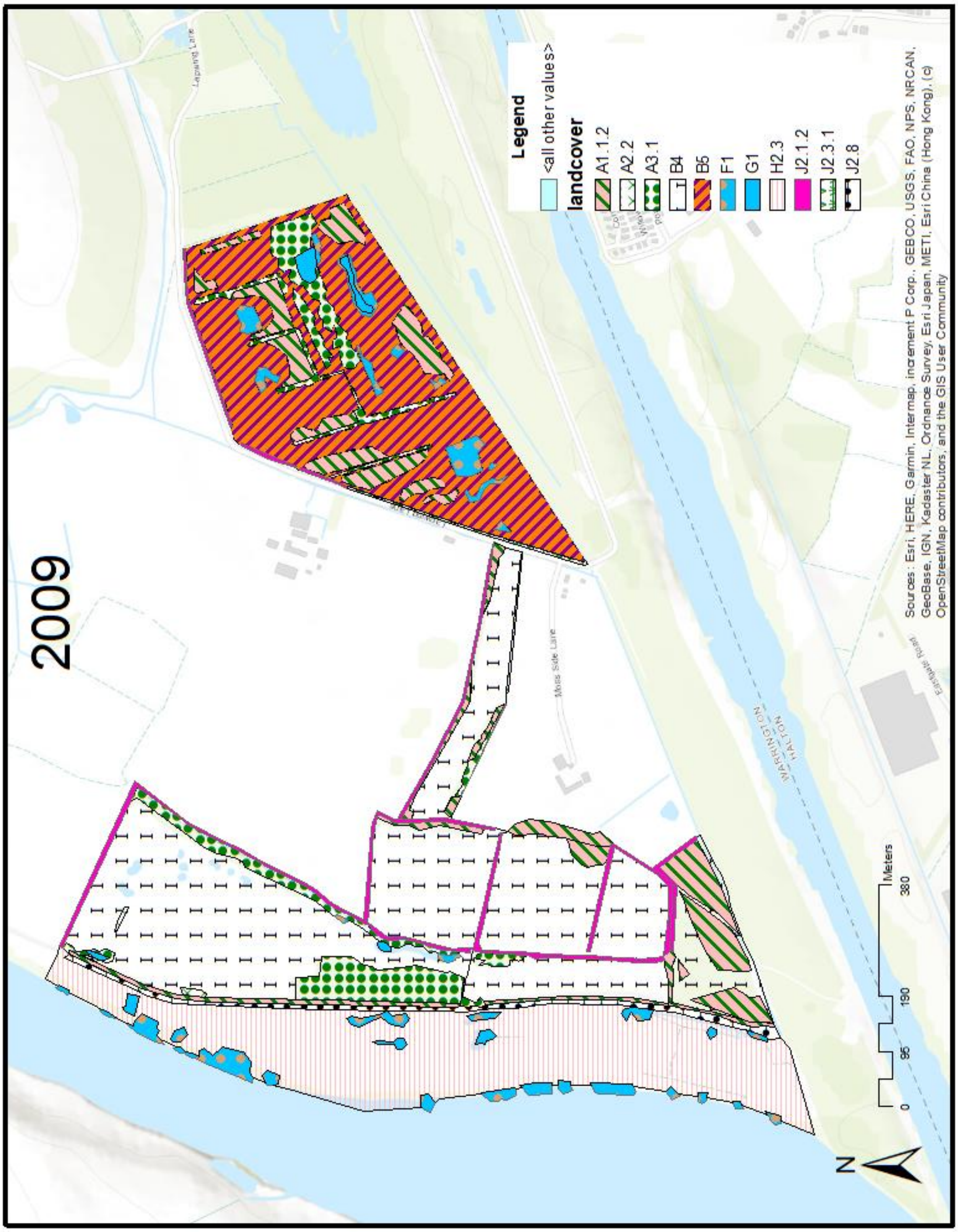

Figure 4.3. Phase 1 Habitat Survey for 2009 – See Table 4.2 for legend description. Base map sourced from ESRI. Contains OS Data © Crown Copyright and database right 2020.

Table 4.2. Legend codes used in Figure 4.3, their Phase 1 Habitat Survey description, and the group to which they have been allocated.

Code:	Phase 1 Habitat Survey Description	Group
A1.1.2	Broadleaved woodland plantation	Trees
A2.2	Scrub scattered	Scrub
A3.1	Broadleaved Parkland/scattered trees	Trees
B4	Improved grassland	Grassland
B5	Marsh/marshy grassland	Grassland
F1	Swamp	Swamp
G1	Standing water	Open water
H2.3	Saltmarsh dune interface	Saltmarsh
J2.1.2	Intact hedge species poor	Tree
J2.3.1	Hedge with trees - native species-rich	Tree
J2.8	Earth bank	None

Table 4.3. Land cover for the whole site in 2009 in square meters.

	Square Metres					
Year	Grassland	Saltmarsh	Scrub	Swamp	Trees	Open water
2009	399,515	155,336	745	25,824	139,268	4,513
%	55.1	21.4	0.1	3.6	19.2	0.6

The Google Earth images in Figure 4.1 and Figure 4.3 show the change in vegetation cover from 2005 to 2009. During this period UMS experienced a 10 per cent decrease in grassland and an increase in tree cover by 14 per cent; the number of individual trees increased from 15 to 97. Scrub was only recorded in Lapwing in 2005 but by 2009 cover had decreased dramatically. Some of which may have matured into tree cover while other patches have either been browsed or the ground has become too wet meaning the marshy grassland cover has succeeded.

Within the four years (2005 to 2009), these figures show a shift away from a grassland vegetation and a progression towards a woodland habitat, whilst the change in area covered by saltmarsh is negligible, which was part of the Forestry Commission plan.

Assessing the current landcover is important for a couple of reasons. Firstly, in order to use the Markov model to simulate the possible landcover at a given point in time, the current and historical land cover details are necessary. The quantified data were fed into the model and the element of change is used to display the potential future state of UMS. Secondly, the habitat must be suitable for the proposed reintroductions, thus, an understanding of the vegetation type is crucial if the species are to survive; it is also key when considering which species will colonise naturally. Finally, it is important to know how well the site integrates and supports the surrounding green spaces and whether it can add value by creating a bigger, better, and more joined up area along the Upper Mersey Estuary.

The habitats identified in the Phase 1 Habitat Survey, carried out in October 2018 were mapped on to a Google Earth image. The habitats comprised of mixed woodland and open grassland with marshy areas and a section of saltmarsh running along the estuary bank (Figure 4.4).

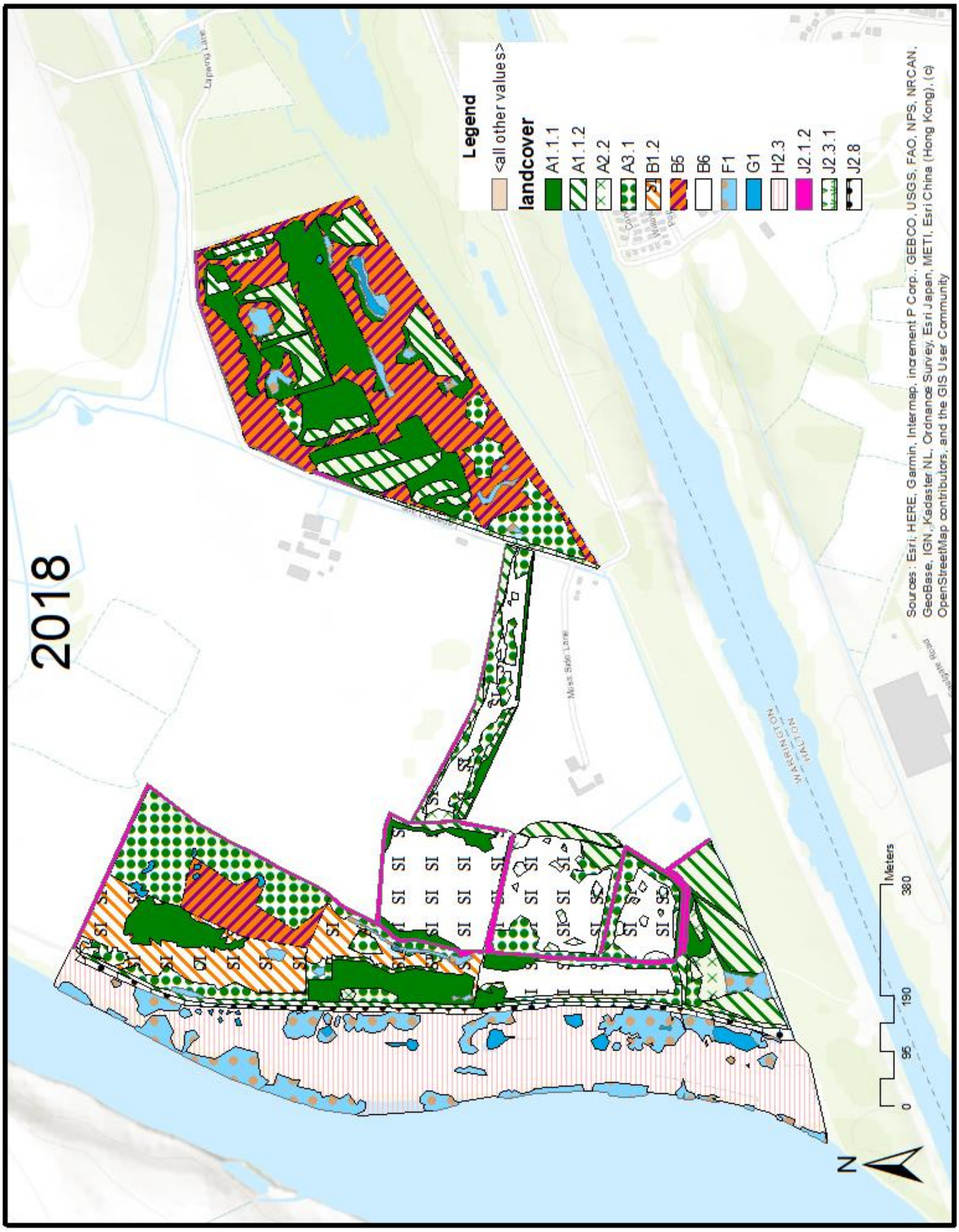

Figure 4.4. Phase 1 Habitat Survey for 2018 – See Table 4.4 for legend description. Base map sourced from ESRI. Contains OS Data © Crown Copyright and database right 2020.

Table 4.4. Legend codes used in Figure 4.4, their Phase 1 Habitat Survey description and the group to which they have been allocated.

Code:	Phase 1 Habitat Survey Description	Group
A1.1.1	Broadleaved woodland semi natural	Trees
A1.1.2	Broadleaved woodland plantation	Trees
A2.2	Scrub scattered	Scrub
A3.1	Broadleaved Parkland/scattered trees	Trees
B1.2	Acid grassland semi improved	Grassland
B5	Marsh/marshy grassland	Grassland
B6	Poor semi improved grassland	Grassland
F1	Swamp	Swamp
G1	Standing water	water
H2.3	Saltmarsh dune interface	Saltmarsh
J2.1.2	Intact hedge species poor	Tree
J2.3.1	Hedge with trees - native species-rich	Tree
J2.8	Earth bank	None

The various habitat categories were grouped and quantified. This illustrated the extent of the mixed habitats with tree cover dominating by 39.2 per cent and grassland by 32.7 per cent. The mosaic of vegetation within these dominant habitats was made up of 7.2 per cent swamp, 1.5 per cent scrub and 1.0 per cent open water plus the saltmarsh that made up 18.3 per cent of the landcover (*Table 4.5*).

Table 4.5. Land cover for the whole site in 2018 in square meters.

	Square Metres					
Year	Grassland	Saltmarsh	Scrub	Swamp	Trees	Open water
2018	240,135	134,498	11,198	52,894	288,123	7,380
%	32.7	18.3	1.5	7.2	39.2	1.0

Norton saltmarsh was dominated by saltmarsh with swamp patches and marginal pockets of water – 70.2, 21.6 and 2.5 per cent, respectively. Moss Side was inhabited mainly by grassland and trees – 44.5 and 50.4 per cent respectively, but with 3.2 per cent scrub and 0.3 per cent water in areas where work was carried out as part of the Million Ponds Project. Similar to Moss Side, grassland and tree cover dominated Lapwing with 41.5 and 54.7 per cent respectively, however, the marshy area also included areas of swamp and open water – 3.2 and 0.6 per cent, respectively. Over the entire area, 1137 individual trees were counted.

The Google Earth images in Figure 4.3 and Figure 4.4 show the change in vegetation cover from 2009 to 2018. Across the whole site, from 2009 to 2018, the grassland decreased by 25 per cent and the tree cover increased by 35 per cent and the number of individual trees, which are not shown on the maps, increased from 97 to 1137. Norton saltmarsh decreased slightly from 2009 to 2018 by 7 per cent, the greatest increase in landcover was water then swamp cover – 65 and 45 per cent. In 2009 only grassland and tree inhabited Moss Side, but, in 2018 grassland had decreased by 25 per cent, while scrub, swamp, trees and water all increased – 88, 80, 34 and 33 per cent, respectively. Grassland, swamp, and water all decreased at Lapwing between 2009 and 2018 by 24, 19 and 37 per cent, it was only tree cover that increased by 36 per cent.

The 2018 data was fed into the Markov model, along with the historical 2009 data. This enabled the model to simulate a possible future outcome for UMS based on minimum intervention (see section 4.5).

4.3 Species presence

Biodiversity richness boosts ecosystem productivity where each species, no matter how small, has an important role to play (Shah, 2014). Knowing what species are present in the area is an indication of what functions and ecological processes are occurring, and, in contrast, what are missing. The study reported here has used that information in the decision-making process when considering which species to reintroduce in order to fill the missing ecological function.

The records returned by RECORD LBR (Local Biological Records) – the local records centre for the area in which UMS sits - are set out below. Biological recordings, however, have their limitations even though the concept is simple: the recording of a species at a physical location at a certain time. The recordings are normally collected by volunteers at times and places that suit the volunteer and in some cases the data are ‘presence-only’ and lack more detailed information, such as, ‘not-present’ and abundance. Some taxa are not recorded due to a lack of resources or a lack of interest in a certain species (Isaac & Pocock, 2015).

The species recorded by RECORD have been broken down into five groups: amphibians and reptiles, birds, mammals, invertebrates, and invasive plant species. When common species are missing, but where there is suitable habitat plus anecdotal evidence of their presence, or they have been recorded within the vicinity, then they will be discussed within this section. Classification was devised for this study to facilitate the interpretation of the data available from RECORD.

The five groups will also be discussed on three different spatial scales - UMS will refer to the actual site in question, while Moore NR and Arpley will refer to the area included in the greater boundary (Figure 4.21 outlines that boundary) and the rest of Cheshire and Merseyside will be referred to as the wider area. The extent of the recordings and their proximity to UMS is shown in Figure 4.5.

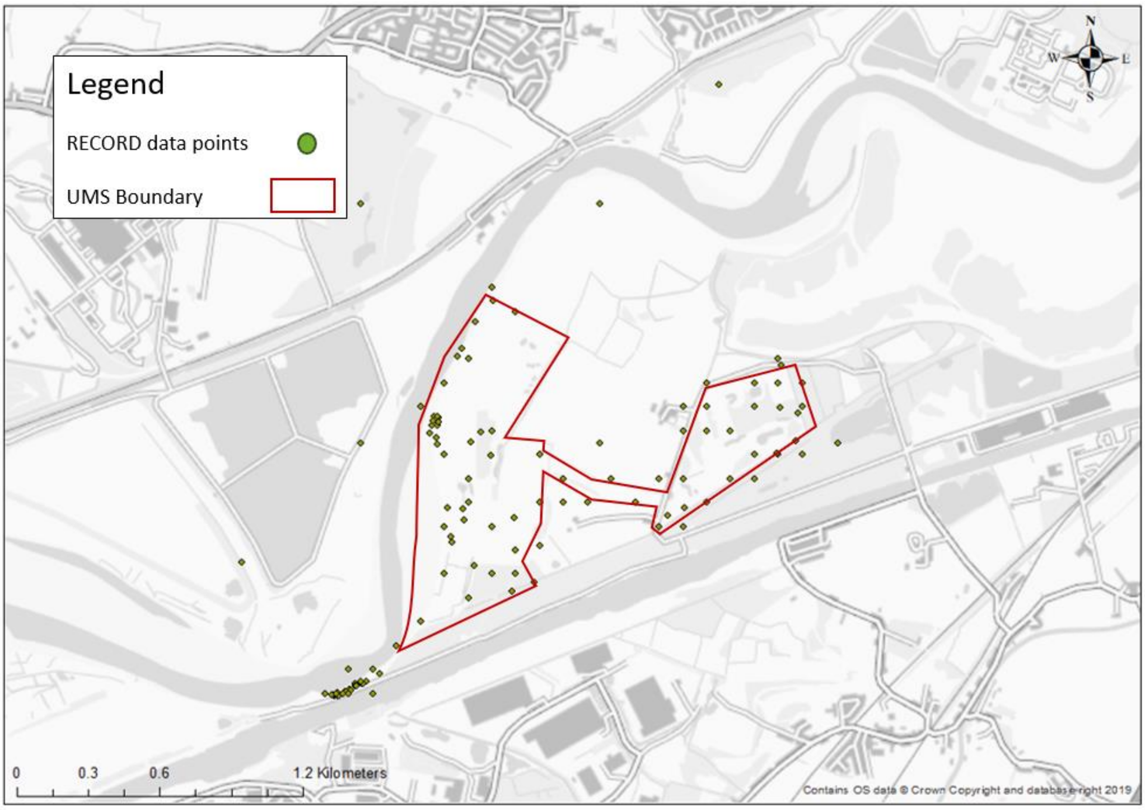

Figure 4.5. Point data for all 11,344 data points received from RECORD and their proximity to UMS. Contains OS data © Crown copyright and database right 2019.

All analysis of species presence/abundance is since 1990 unless otherwise stated, recordings prior to this year account for 14 percent of all recording. Also, anything likely recorded prior to this date may be extinct from the area with no way of returning.

4.3.1 Amphibians and Reptiles

There are no records of amphibians or reptiles recorded at UMS or in the wider area, however, there have been sightings of common frog (*Rana temporaria*) and common toad (*Bufo bufo*) at the adjacent Moore Nature reserve. UMS does have habitats suitable for amphibians and reptiles with areas of grassland, woodland, and ponds. One would expect to find common frogs, common toads, and newts (Pleurodelinae) in the area, however, it appears the data provided by RECORD is lacking in these taxa.

4.3.2 Birds

Of the bird species recorded, 151 different species have been recorded, 142 were recorded within the greater boundary including UMS, while 95 were recorded within the UMS boundary. In order to understand the vulnerability and conservation status of the birds recorded at UMS we have referred to the Birds of Conservation Concern 4 (BoCC4) report published in 2015 (Eaton et al., 2015). BoCC4 is a collaboration between the Statutory Nature Conservation Bodies (SNCBs), RSPB, BTO, WWT, GWCT and several other organisations. It uses an approach based on quantitative assessments against standardised criteria in order to place individual bird species on 'Red', 'Amber' or 'Green' lists to indicate different levels of conservation concern (Eaton et al., 2015).

Bird species that are listed as Red on the BoCC4 that have been recorded at UMS are shown in Figure 4.6. The graphs show the year of observation plus a crude evaluation of abundance. The gaps in the data seen in the graphs suggest that the species were not present, however, this could be one of the limitations with the data generated from RECORD and the methods used to accumulate such data. Of the 151 different bird species recorded across the wider area, 40 appear on the BoCC4 Amber list and 35 on the Red list (Table 4.6. Birds recorded at Upper Moss Side that are on the red and amber list of Birds of Conservation Concern.

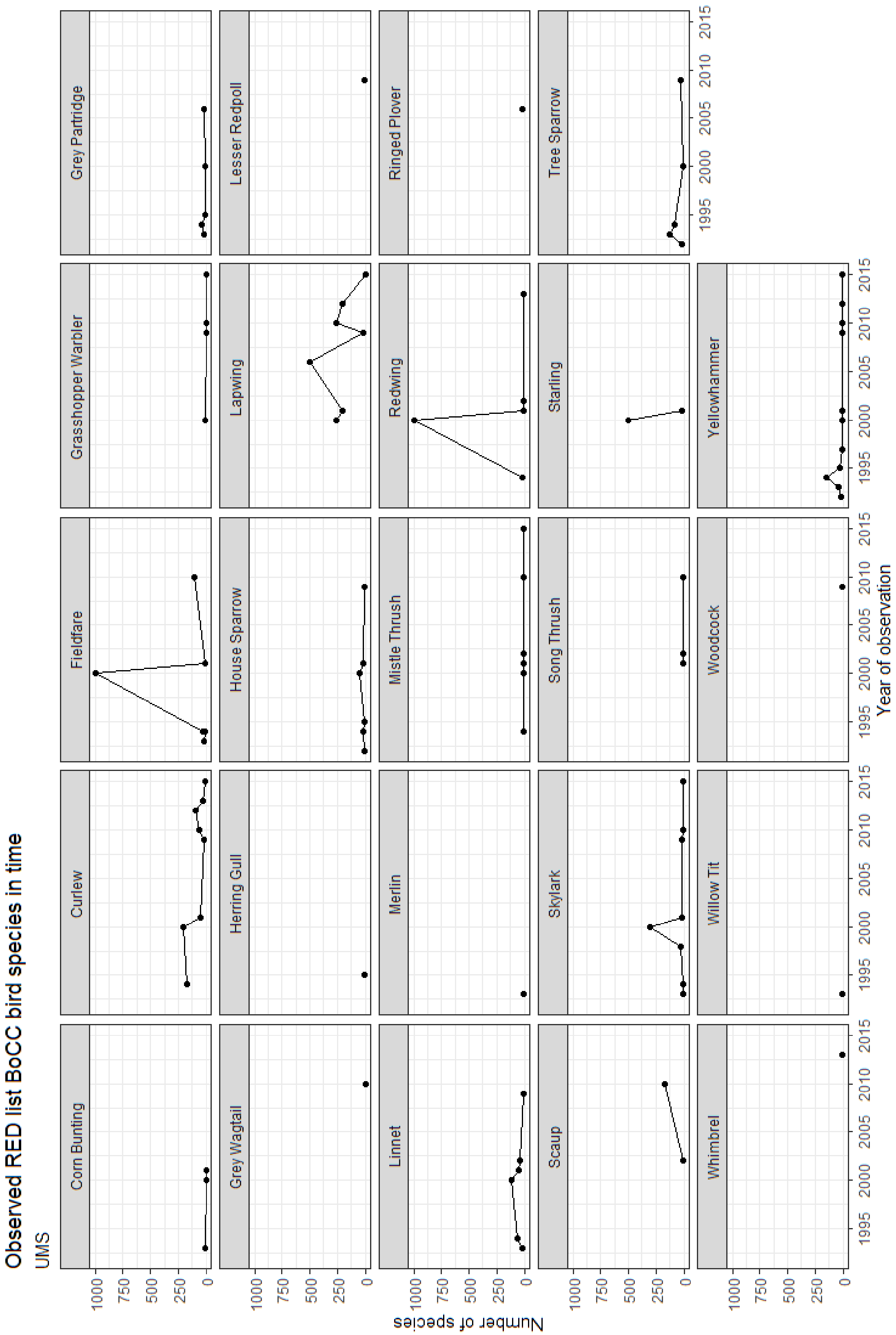

Figure 4.6. Number of Red list Birds of Conservation Concern recorded at Upper Moss Side observed by year and abundance (all counts recorded as 'several' were recorded as 5 and those that were recorded as present were noted as 1 to be as crude as possible. This method was devised for this study).

Table 4.6. Birds recorded at Upper Moss Side that are on the red and amber list of Birds of Conservation Concern.

Birds of Conservation Concern – status RED		Birds of Conservation Concern – status AMBER	
Common name	*Scientific name*	Common name	*Scientific name*
Corn Bunting	*Emberiza calandra*	Barnacle Goose	*Branta leucopsis*
Cuckoo	*Cuculus canorus*	Bittern	*Botaurus stellaris*
Curlew	*Numenius arquata*	Black-headed Gull	*Chroicocephalus ridibundus*
Fieldfare	*Turdus pilaris*	British Lesser Black-Backed Gull	*Larus fuscus subsp. graellsii*
Grasshopper Warbler	*Locustella naevia*	Bullfinch	*Pyrrhula pyrrhula*
Grey Partridge	*Perdix perdix*	Common (Mealy) Redpoll	*Acanthis flammea*
Grey Wagtail	*Motacilla cinerea*	Common Sandpiper	*Actitis hypoleucos*
Herring Gull	*Larus argentatus*	Dunlin	*Calidris alpina*
House Sparrow	*Passer domesticus*	Dunnock	*Prunella modularis*
Kittiwake	*Rissa tridactyla*	Gadwall	*Anas strepera*
Lapwing	*Vanellus vanellus*	Glaucous Gull	*Larus hyperboreus*
Lesser Redpoll	*Acanthis cabaret*	Goldeneye	*Bucephala clangula*
Lesser Spotted Woodpecker	*Dendrocopos minor*	Great Black-backed Gull	*Larus marinus*
Linnet	*Linaria cannabina*	Green Sandpiper	*Tringa ochropus*
Marsh Tit	*Poecile palustris*	Greylag Goose	*Anser anser*
Mistle Thrush	*Turdus viscivorus*	House Martin	*Delichon urbicum*
Pochard	*Aythya ferina*	Iceland Gull	*Larus glaucoides*
Redwing	*Turdus iliacus*	Kingfisher	*Alcedo atthis*

Ring Ouzel	*Turdus torquatus*
Ringed Plover	*Charadrius hiaticula*
Scaup	*Aythya marila*
Skylark	*Alauda arvensis*
Song Thrush	*Turdus philomelos*
Spotted Flycatcher	*Muscicapa striata*
Starling	*Sturnus vulgaris*
Tree Pipit	*Anthus trivialis*
Tree Sparrow	*Passer montanus*
Turtle Dove	*Streptopelia turtur*
Whimbrel	*Numenius phaeopus*
Whinchat	*Saxicola rubetra*
Willow Tit	*Poecile montana*
Wood Warbler	*Phylloscopus sibilatrix*
Woodcock	*Scolopax rusticola*
Yellow Wagtail	*Motacilla flava*
Yellowhammer	*Emberiza citrinella*

Lesser Black-backed Gull	*Larus fuscus*
Mallard	*Anas platyrhynchos*
Meadow Pipit	*Anthus pratensis*
Mediterranean Gull	*Larus melanocephalus*
Mute Swan	*Cygnus olor*
Osprey	*Pandion haliaetus*
Oystercatcher	*Haematopus ostralegus*
Pink-footed Goose	*Anser brachyrhynchus*
Pintail	*Anas acuta*
Redshank	*Tringa totanus*
Reed Bunting	*Emberiza schoeniclus*
Shelduck	*Tadorna tadorna*
Short-eared Owl	*Asio flammeus*
Shoveler	*Anas clypeata*
Smew	*Mergellus albellus*
Snipe	*Gallinago gallinago*
Stock Dove	*Columba oenas*
Swift	*Apus apus*
Teal	*Anas crecca*
Water Pipit	*Anthus spinoletta*
Wigeon	*Anas penelope*
Willow Warbler	*Phylloscopus trochilus*

Twenty-eight Red and Amber listed species were recorded at the greater boundary and the wider area but not UMS, these include the cuckoo (*Cuculus canorus*), marsh tit (*Poecile palustris*), lesser spotted woodpecker (*Dendrocopos minor*), pochard (*Aythya ferina*) Tree pipit (*Anthus trivialis*).

Birds of prey species primarily hunt and feed on vertebrates while some also eat carrion. The presence of carnivorous bird species indicates a presence of prey, i.e. small vertebrate and other bird species. The abundance of birds of prey species in the wider area and the counts before and after 2006 is listed in Table 4.7. This should provide an indication of habitat suitability for carnivorous bird species before and after any Forestry Commission work was delivered.

Table 4.7. Abundance of the birds of prey species in the UMS area including years recorded, total abundance and the abundance pre and post 2006 (- no records).

Order	Species	Between years	Counts	Pre 2006	Post 2006
Falconiformes	Buzzard (*Buteo buteo*)	1980 – 2015	102	36	66
	Hen Harrier (*Circus cyaneus*)	1974 – 2002	4	4	-
	Hobby (*Falco Subbuteo*)	2010	1	-	1
	Kestrel (*Falco tinnunculus*)	1974 – 2015	101	71	40
	Marsh Harrier (*Circus aeruginosus*)	1998 – 2011	7	1	6
	Merlin (*Falco columbarius*)	1974 – 2000	7	7	-
	Osprey (*Pandion haliaetus*)	2014	1	-	1
	Peregrine (*Falco peregrinus*)	2000 – 2006	8	6	2
	Red Kite (*Milvus milvus*)	2010	1	-	1
	Sparrowhawk (*Accipiter nisus*)	1974 – 2015	51	34	17
Strigiformes	Barn owl (*Tyto alba*)	1974 – 2009	9	5	4
	Little owl (*Athene noctua*)	1974 – 2010	7	5	2
	Long-eared owl (*Asio otus*)	1996 – 1999	5	5	-
	Short-eared owl (*Asio flammeus*)	1974 – 2000	12	12	-
	Tawny owl (*Strix aluco*)	1978 – 2012	7	4	3

Canada goose (*Branta canadensis*) and the ruddy duck (*Oxyura jamaicensis*) are classified as invasive, however, the Canada goose is a lot more prevalent with more than 62,000 pairs breeding in the UK compared to fewer than 100 breeding birds of the ruddy duck (RSPB.org.uk, n.d.). The Canada goose has had many sightings across the area from 1978 to 2015 and the ruddy duck was recorded on Moore Nature Reserve between 1995 to 1997.

4.3.3 Mammals

Seven species of mammal have been recorded at UMS, however, there have been no bats recorded there. Table 4.8 shows the year in which the species were present but not the abundance as it is not clear that the species recorded is a duplicate from a previous sighting, therefore, presence that year is sufficient. All wild animals listed on schedule 5 are protected in the UK under the Wildlife and Countryside Act 1981, details of protection are listed in Table 4.8.

Table 4.8. Mammals recorded at UMS.

Species	Year		Ecological Role	Protection
Brown Hare (*Lepus europaeus*)	2011 2015	Introduced	Graze on grasses	Wildlife and Countryside Act 1981 – protected in the closed season. Hunting Act 2004 offers some protection
Badger (*Meles meles*)	1990 2014 2016 2018	Native	Omnivores, dig tunnels, use forage for bedding	Protection of Badgers Act 1992
Common Shrew (*Sorex araneus*)	2009	Native	Insectivore Food for many sp.	Wildlife and countryside Act 1981 – protected under schedule 6
European Mole (*Talpa europaea*)	2010 2015	Native	Insectivore Aerate the soil	No additional protection
Water Vole (*Arvicola amphibious*)	2009	Native	Herbivores Create burrows and promotes soil microbial activity	Wildlife and countryside Act 1981 – fully protected under section 5
Polecat (*Mustela putorius*)	1995	Native	Eat rabbits and rats	Countryside and Rights of Way Act 2000
Hedgehog (*Erinaceus europaeus*)	1993	Native	Eats insects, carrion, fungi, bird eggs and small mammals	Wildlife and Countryside Act 1981 – protected under schedule 6

In addition to the seven species at UMS, grey squirrel (*Sciurus carolinensis*), rabbit (*Oryctolagus cuniculus*), deer (Cervidae), red fox (*Vulpes vulpes*), stoat (*Mustela erminea*), and weasel (Mustela) were recorded in the greater boundary plus five species of bat (*Myotis daubentoniid, Pipistrellus pipistrellus, Plecotus auratus, Nyctalus noctule, Myotis mystacinus*), which were recorded in 1999 only within the greater boundary. In the wider area, only the brown rat (*Rattus norvegicus*) and pygmy shrew (*Sorex minutus*) have been recorded in addition to what was documented. Figure 4.7 shows all the points where mammals have been recorded, most of which are in close proximity to UMS.

Due to the varied grassland/woodland habitat at UMS, it may be assumed that the additional seven species recorded in the greater boundary would use UMS and it is a limitation to the survey methods. There are recordings of badger (*Meles meles*) in the area, and there is a badger sett situated at the most northern section of the bund which is active. American Mink (*Neovison vison*) are an invasive non-native species that has caused seabird colonies and water vole numbers to plummet in the UK (Bonesi & Palazon, 2007). They have been recorded on UMS in 2010 and again in 2015 on Oxmoor local nature reserve 0.5km away. Muntjac deer (*Muntiacus reevesi*) have been seen in field F (see Figure 4.2): there are clear signs of browse in the vegetation.

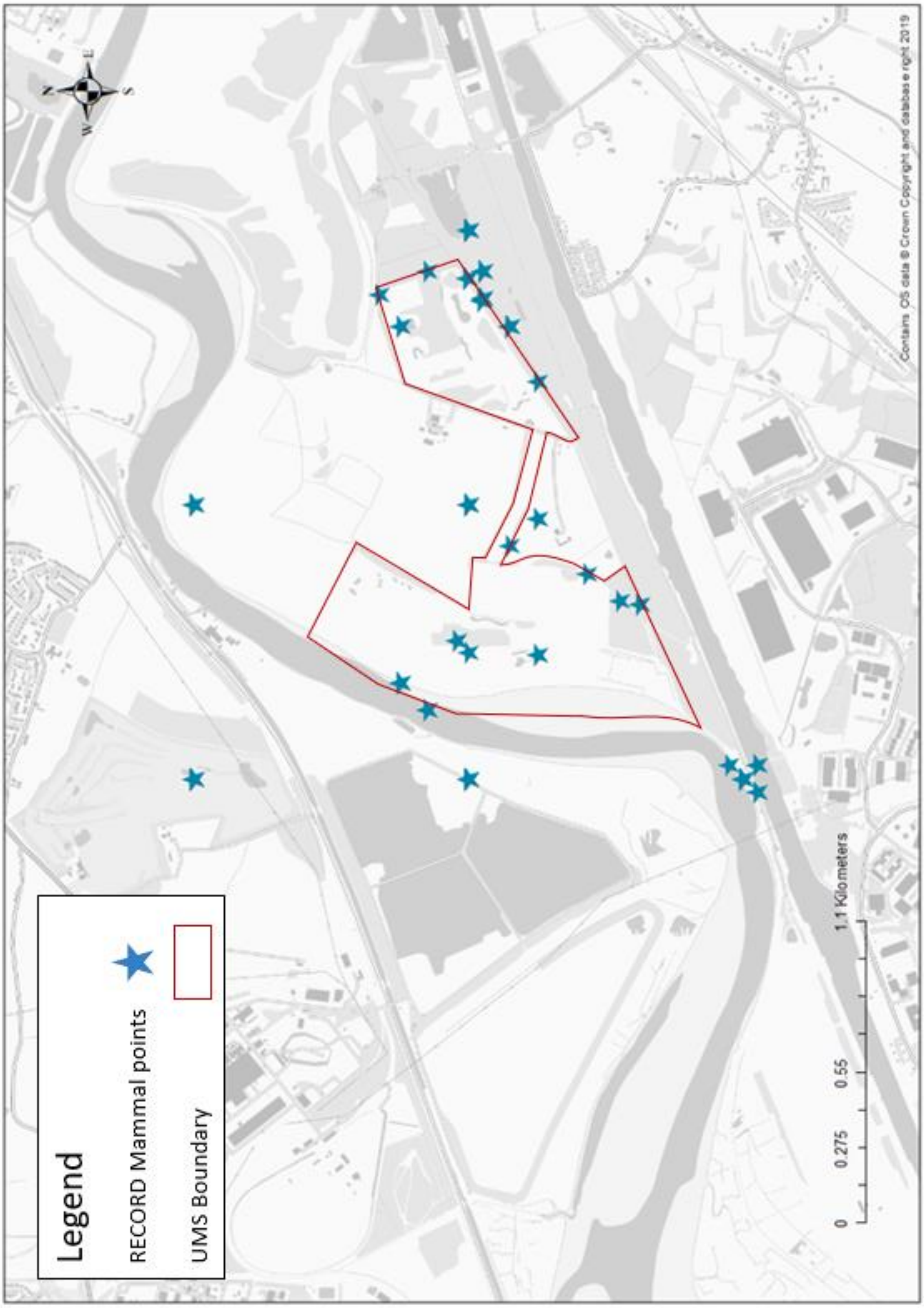

Figure 4.7. Point data for all mammal data points received from RECORD and their proximity to UMS. Contains OS data © Crown copyright and database right 2019.

4.3.4 Invertebrates

Since records began in 1900, 608 different species of invertebrate have been recorded in the Cheshire & Merseyside area. Since 1990, 392 different species have been recorded across the same area. At UMS, 38 different species have been recorded, while a much higher figure of 384 were recorded at the greater boundary and 79 different species over the wider area. It is possible that more species have been recorded at the greater boundary due to survey intensity focusing on the greater boundary and fewer efforts at UMS. However, the recordings that are out of UMS are still within close proximity and for most, the boundary would not be an issue, except for those on the other side of the River Mersey.

4.3.4.1 Beetles (Coleoptera)

Beetles are excellent indicators of terrestrial ecosystems (Ghannem, Touaylia, & Boumaiza, 2018). The only beetles to have been recorded at UMS are water ladybird (*Anisosticta novemdecimpunctata*) and red-headed cardinal beetle (*Pyrochroa serraticornis*), both recordings were in 2016 on Norton Marsh. On Greater boundary there have been 47 different species recorded. No beetles were recorded in the wider area. The ecological role of each family found in the area is displayed in Table 4.9.

Table 4.9. Beetle families found in the area and their ecological role in the ecosystem.

Family	Common name	Ecological role
Anobiidae	Wood boring beetle	Decomposers and recyclers of organic nutrients
Byrrhidae	Pill beetles	Regulate primary production and recyclers of organic nutrients
Byturidae	Fruit worm beetles	Regulate primary production and recyclers of organic nutrients
Cantharidae	Soldier/Sailor beetles	Biological control of insects & Regulate primary production
Carabidae	Ground beetles	Biological control of insects & Regulate primary production
Cerambycidae	Longhorn beetles	Decomposers and recyclers of organic nutrients. Pollinators
Chrysomelidae	Seed and leaf beetles	Regulate primary production and recyclers of organic nutrients
Coccinellidae	Ladybirds	Biological control agents of aphids and scale insects.
Cryptophagidae	Silken fungus beetles	Decomposers and recyclers of organic nutrients
Curculionidae	Weevils	Decomposers and recyclers of organic nutrients
Dytiscidae	Diving beetles	Biological control

Elateridae	Click beetles	Decomposers and recyclers of organic nutrients
Gyrinidae	Whirligig beetles	Biological control
Haliplidae	Crawling water beetles	Biological control
Histeridae	Hister beetles, clown beetles	Decomposers and recyclers of organic nutrients
Hydrophilidae	Water scavenger beetles	Decomposers and recyclers of organic nutrients
Kateretidae	Short-winged flower beetles	
Latridiidae	Minute brown scavenger beetles	Regulate primary production and recyclers of organic nutrients
Malachiidae	Soft-winged flower beetles	Decomposers and recyclers of organic nutrients
Melolonthidae	Scarab Beetles	Pollinators
Nitidulidae	Sap beetles, pollen beetles	Decomposers and recyclers of organic nutrients
Pyrochroidae	Cardinal beetles	Biological control of insects. Pollinators
Rhynchitidae	Tooth-nosed snout weevils	Disturbance
Rutelidae	Shining leaf chafers	Pollinators
Scarabaeidae	Dung beetles	Decomposers and recyclers of organic nutrients
Scirtidae	Marsh beetle	Regulate primary production and recyclers of orgainic nutrients
Silphidae	Sexton beetles, burying beetles, carrion beetles	Decomposers and recyclers of organic nutrients
Staphylinidae	Rove beetles	Biological control agents of aphids and scale insects. Decomposers and recyclers of organic nutrients

4.3.4.2 Bees, and Ants (Hymenopterans)

Of the family Apidae in the order hymenopterans, the buff-tailed bumble bee (*Bombus (Bombus) terrestris*), large red-tailed bumble bee (*Bombus (Melanobombus) lapidarius*), and the common carder bee (*Bombus (Thoracombus) pascuorum*) have been recorded at UMS. The greater boundary have a presence of the western honey bee (*Apis mellifera*), buff-tailed bumble bee, and the common carder bee. In the wider area, buff-tailed bumble bee, small garden bumble bee (*Bombus (Megabombus) hortorum*), large red-tailed bumble bee, early bumble bee (*Bombus (Pyrobombus) pratorum*), common carder bee, and white-tailed bumblebee (*Bombus lucorum/terrestris*) have been recorded. In total, there were 23 recordings from 1985 to 2015. Other families within the hymenopterans have been recorded at UMS and the greater boundary - Argidae, Cephidae, Tenthredinidae (sawflies); Crabronidae, Pamphiliidae (wasps); Cynipidae (gall wasps). There have been no recordings of the family Formicidae (ants) of any kind.

4.3.4.3 Butterflies and Moths (Lepidoptera)

In total, there have been 193 different species of butterfly and moth recorded. Twenty-one different species of butterfly and moth have been recorded at UMS plus another 120 at Moore, however of the 141 recorded at Moore, 111 were unique to Moore and of the 38 species recorded in the wider area, 9 were unique to the wider area and not found at UMS and Moore.

The abundance of the 21 species found at UMS have been shown in Figure 4.8. The species with a single mark represents a single recording. Again, this is subject to limitations as the data were collected in a casual unstructured way and, therefore, the absence of a record does not necessarily indicate absence of species.

The most notable variation in Figure 4.8 are the graphs that show the hedge brown (aka Gatekeeper) (*Pyronia tithonus*) numbers have increased considerably since 2012 and Meadow brown (*Maniola jurtina)* numbers increased in 2005 to 508 but has plateaued to around 300 and 400 between 2012 and 2016.

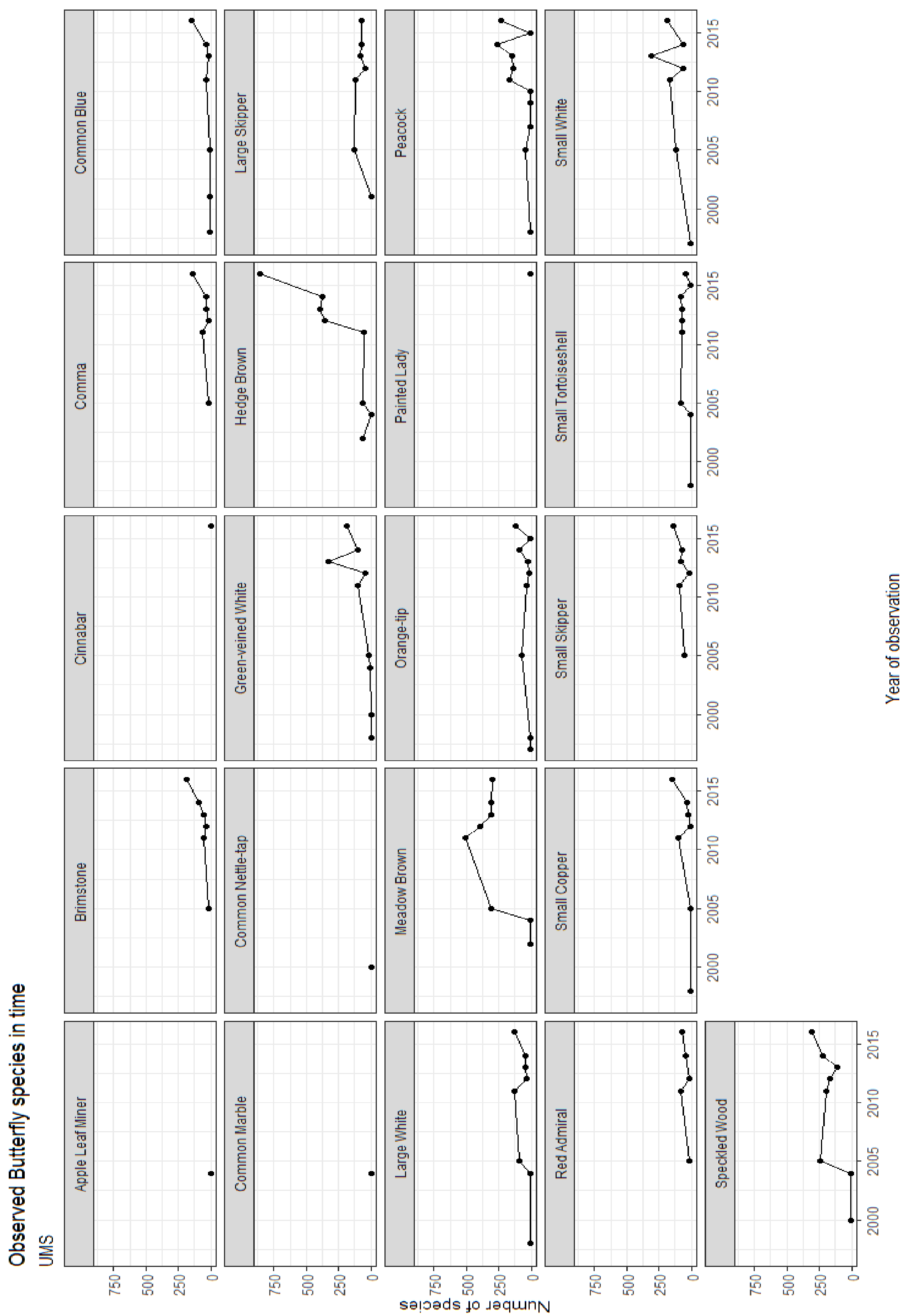

Figure 4.8. Observed butterfly and moth species abundance at Upper Moss Side in time since 1990.

4.3.4.4 Invasive plants species

Himalayan balsam (*Impatiens glandulifera*) is present on site, specifically at Lapwing, but has not been recorded with RECORD LBR. Invasive plant species that have been recorded in and around the area of UMS are listed in Table 4.10.

Table 4.10. Invasive species recorded with RECORD LBR including year and location of recording.

Invasive species	Year	Location
Japanese Knotweed	1975	Moore Nature Reserve
(*Reynoutria japonica*)	1985	Moore Nature Reserve
	2003	Fiddler's Ferry, Penketh, Warrington
	2003	Fiddlers Ferry E Site
	2016	Norton Marsh, Moss-side
New Zealand Pigmyweed (*Crassula helmsii)*	1997	Moore Nature Reserve

4.3.5 Species record conclusion

The proportion of recordings in the UMS boundary and those in close proximity, which highlights the narrow range when discussing the spatial scales are shown in Figure 4.5.

The limited recordings of amphibians and reptiles implies that they are not present, yet the habitat is more than suitable, therefore, it would be misleading to conclude their absence. The graph of BoCC4 bird species suggests the numbers have been low since 2005, except for Northern lapwings (*Vanellus vanellus*), but their numbers have declined, therefore, according to the recordings, no species of concern is increasing. Birds of prey species are present, however, since 2006 the numbers are declining in most species recorded. The number of mammals recorded are low with only one count or presence recorded in most cases. All five species of bat that were recorded were recorded at Greater boundary in 1999, thus, it cannot be ruled out that they may be present at UMS. There is a bias towards the greater boundary for recording invertebrate numbers and a tendency to record one species over another, such as the lack of data on the hymenopterans. Overall, the data suggest insect numbers are declining which is in line with the current State of Nature Report (2019).

The graph for butterfly species at UMS indicates either an increase in some species of butterfly or they have stayed at the same level.

From a functionality viewpoint, the mammals recorded are all small in size yet they play certain roles in the ecosystem, such as, food in the food web, biological control of insects and rodents, consume plant material and recycle it back into the soil, seed dispersal, and excavate tunnels in the ground adding nutrients and aerating the soil. However, the lack of large grazing herbivores and browsers that create natural disturbance, control invasive or dominant species, trample, pollard, rootle, and dung is missing from UMS. Based on the result supplied by RECORD, there seems to be a scarcity in the diversity of insects in the area which may be affecting the pollination of plants, however, this scarcity may be due to under recording.

4.4 Current management plans

UMS is part of two current management plans. The largest, in area covered, is The Mersey Forest plan that covers Merseyside and North Cheshire (The Mersey Forest, 2014). The geographically smaller St. Helens Plan looks after another five sites within the St. Helens area (Forestry Commission England, 2017). UMS also lies within the MGET's boundary, however, there are no management plans for UMS. An assessment of the management plans was necessary to identify any actions planned that would alter the natural succession of UMS as this would have to be considered when developing the possible future scenario using the Markov model.

In the early 1990s, 12 areas of England were chosen by government to be the focus of long-term tree planting programmes to improve their environment and benefit local communities. The largest of these 'Community Forests' was named The Mersey Forest covering an area of 1370 km^2 across Cheshire, Halton and Merseyside and is highlighted in Figure 4.9. The Mersey Forest works in partnership with seven local authorities, Natural England, the Forestry Commission, the Environment Agency, landowners, businesses and local communities who collectively seek to improve health and wellbeing in the community and work with businesses, provide opportunities, and increase prosperity (The Mersey Forest, 2014).

The Mersey Forest plan is a long-term continuous plan that will be refreshed every ten years, which allows consideration to be given to resource availability at the time (The Mersey Forest, 2014). The current plan is to increase woodland cover across the whole area. On Lapwing field, which is classed as part of the Forest Park[1] and includes Moore Nature Reserve and Arpley Chord and Landfill site (Figure 4.9 - W13), the plan is to create a new landscape structure and support woodland planting on tipped and industrial land either side of the River Mersey from Fiddlers Ferry Power Station (grid reference SJ 54471 86444) to Bank Quay (grid reference SJ 60005 87966) and joining to strategic green links and greenway network of the Trans-Pennine Trail that runs along the St. Helens Canal, and the Mersey Valley (Figure 4.10). The existing mosaic of woodland, grassland and open water on Moore Nature Reserve is to be retained and managed and to ensure any new planting complements important open grassland habitat for ground-nesting birds in the area and maintains views of the estuary. For UMS specifically, there are no plans to increase the tree cover on Norton or Moss Side (Figure 4.9 - W15), the only management mentioned is of the hedgerows and of the estuary edge.

[1] The Forest Parks are a number of areas that are discussed in terms of policy units and have been proposed to be more connected for people and wildlife.

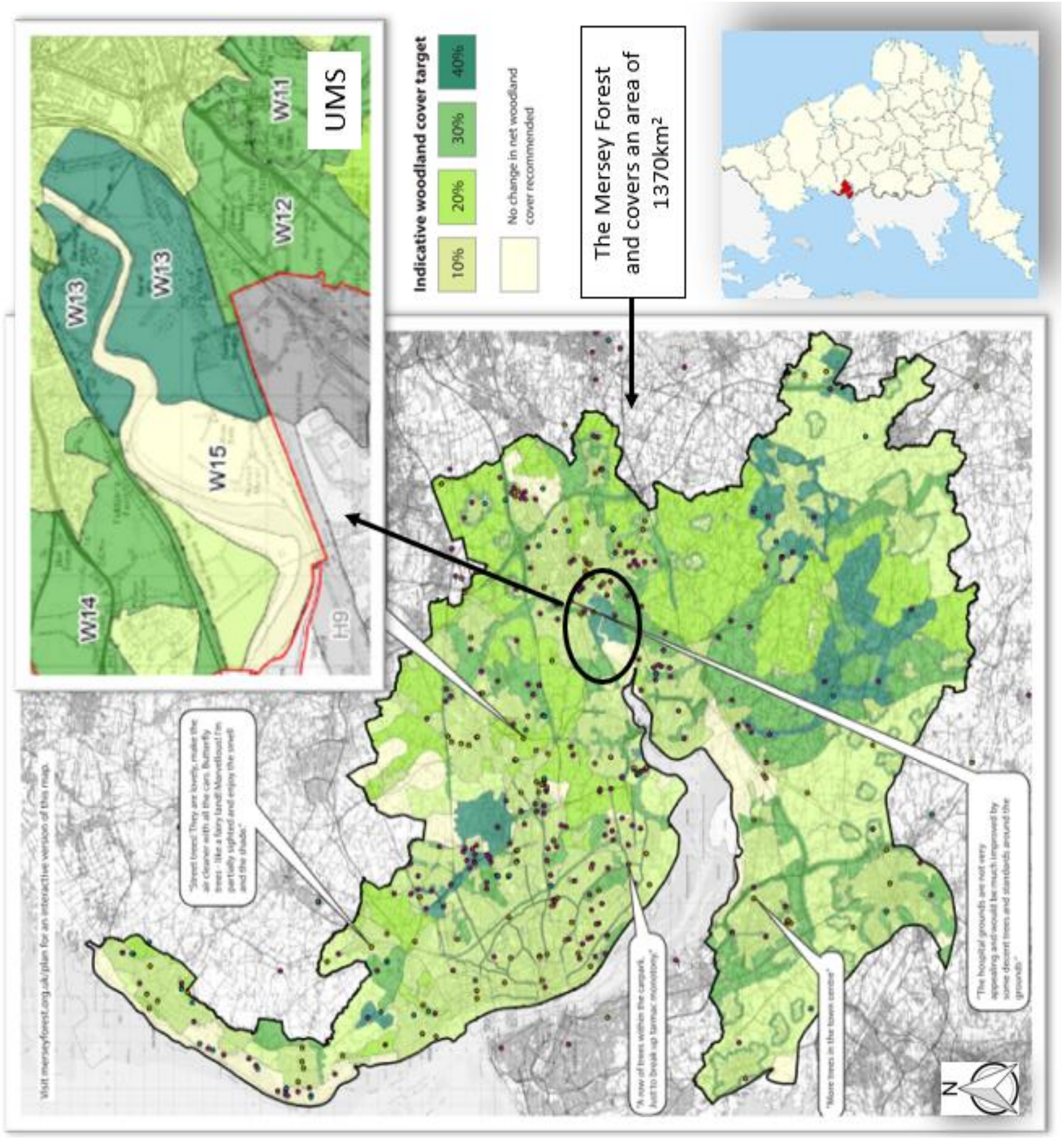

Figure 4.9. The area covered and location of The Mersey Forest in the UK, including a focus on the Warrington area that covers UMS. The shades of green are indicative of the woodland cover target (the darker the shade the higher the per cent) for The Mersey Forest plan. Sourced from The Mersey Forest, 2014, Forest Plan (merseyforest.org.uk/plan).

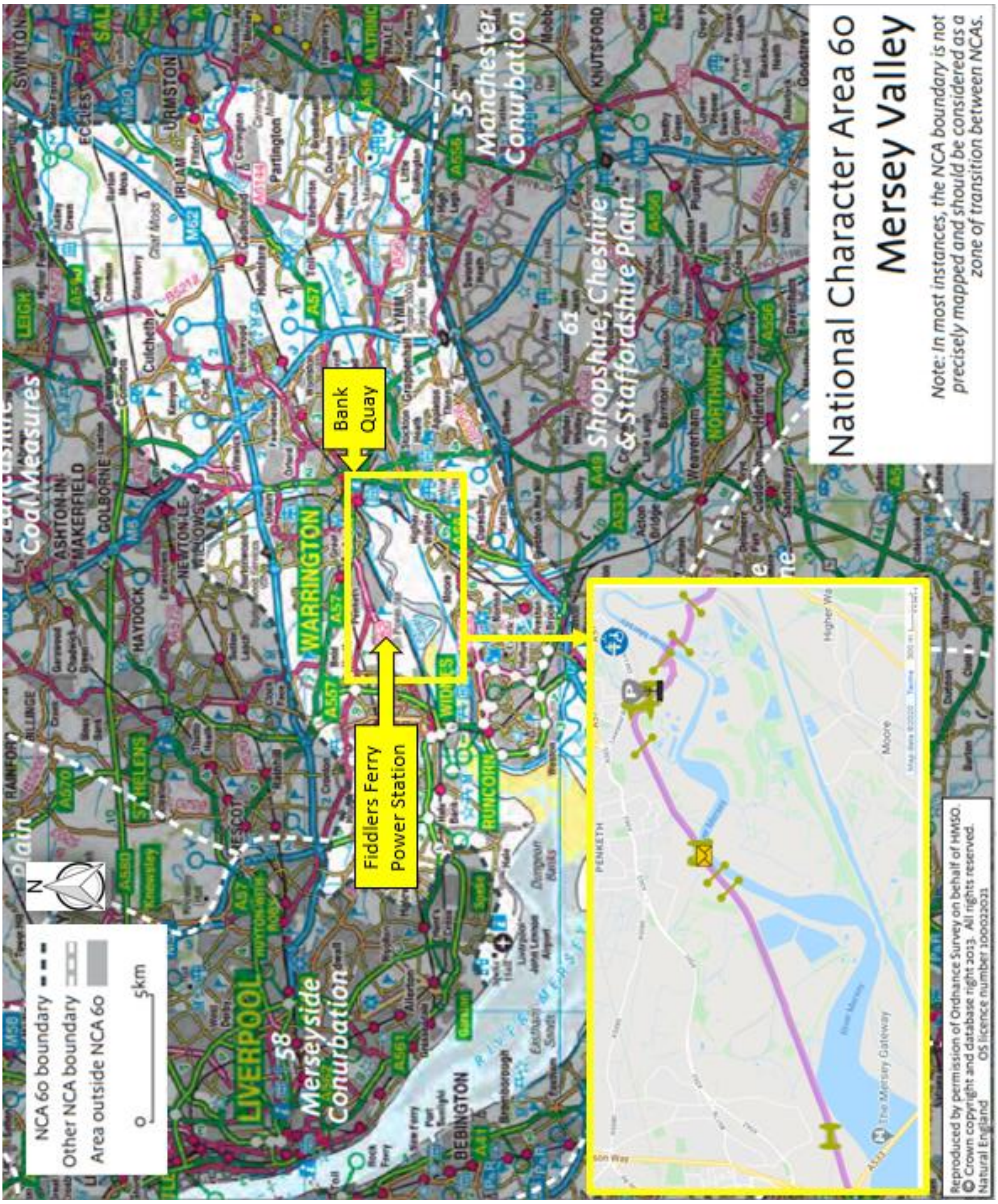

Figure 4.10. Map showing the various points within the Mersey Valley from Fiddlers Ferry Power Station to Bank Quay. Sourced from Natural England - National Character Area profile: 60. Mersey Valley. Insert shows the joining strategic green links and greenway network of the Trans-Pennine Trail that runs along the St. Helens Canal until Warrington. Sourced from transpenninetrail.org.uk. Contains Map Data © 2020.

On a smaller geographical scale the Forestry Commission designed the St. Helens Forest plan 2017-27 that sits in the Mersey Forest boundary and comprises of six woodland – UMS (73 ha), Sutton Manor (62 ha), Wheatacre (22 ha), Whiston wood (20 ha), Maypole (13 ha), and Brickfields & Red Quarry (12 ha) - that lie within 10 km of Liverpool, Warrington and St. Helens. The location of each woodland plus the Bold Forest Park and larger Mersey Forest is indicated in Figure 4.11. The management of the six sites collectively is discussed in the Forest Plan without providing any clear exclusive direction for UMS other than the location selected for some low impact felling activity.

The management plans objectives across the six sites are:

- Grow commercial crops (trees/wood) on a sustainable basis,
- Diversify the forest structure through thinning and new planting,
- Increase the number of Trees of Special interest and deadwood habitats,
- Improve the value of the woodlands for butterflies, and
- Maintain the public access facilities.

The woodland habitats, open habitats and fauna associated with it are the principal ecological interest in the Forest Plan. The Forest Plan will depend on active forest management to help develop a diverse woodland structure that will be achieved specifically through:

- The retention of some strands of trees in perpetuity,
- The development of mixed open stands along water courses,
- Introduction of evergreen conifers to create mixed broadleaved / conifer woodlands, and
- Increased length of woodland edge habitat.

The Forest Plan describes a low impact silvicultural system across the six sites, which involves several felling systems (shelterwood, group felling, selection systems) to avoid large-scale felling coupes so that one or more levels are retained in the forest canopy. The areas proposed for a low impact silvicultural system at UMS are shown in Figure 4.12.

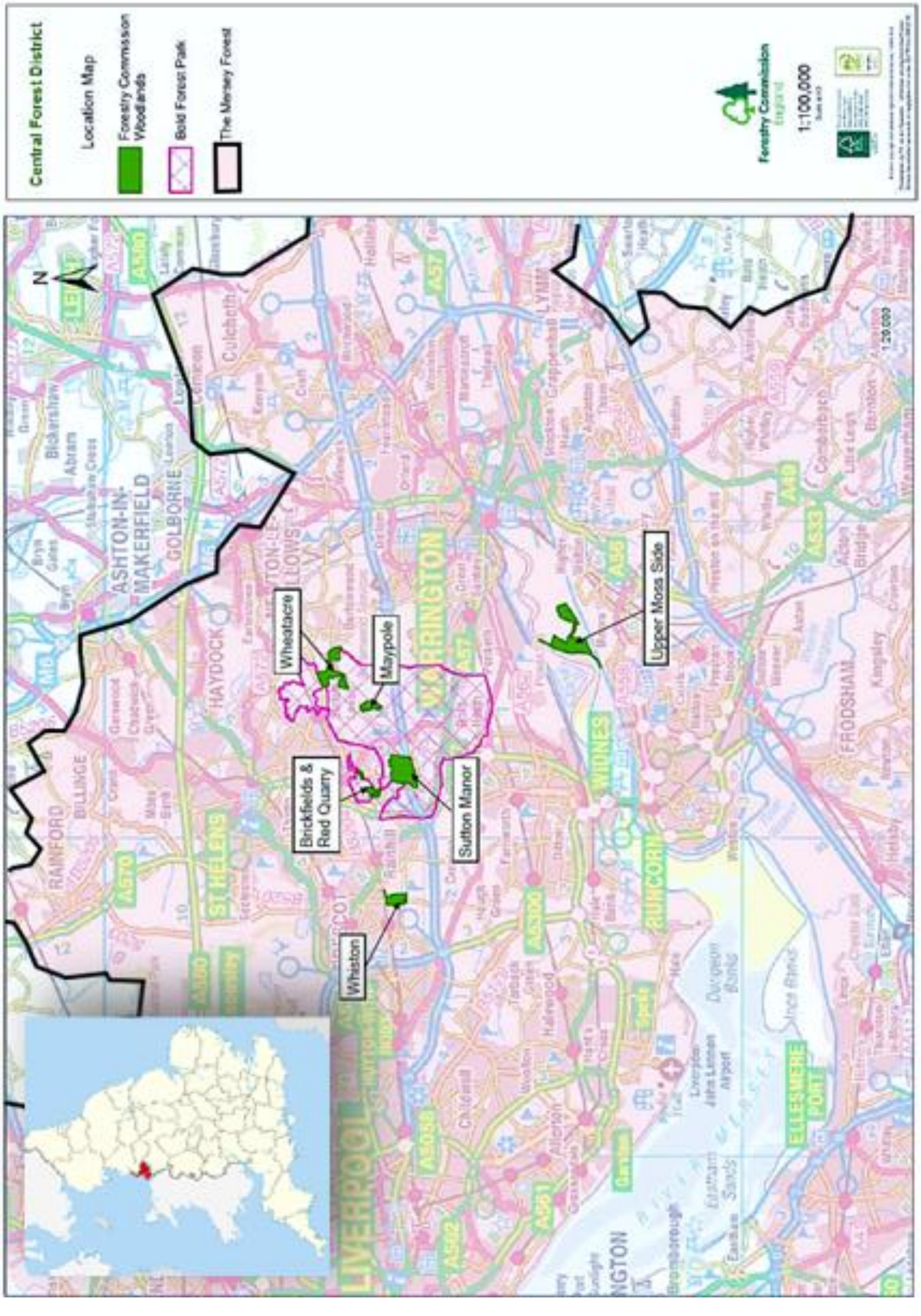

Figure 4.11. Location map highlighting the six woodlands managed by the Forestry Commission plus the larger Bold Forest Park and the greater Mersey Forest. Sourced from Forestry Commission England, 2017, St Helens Forest Plan.

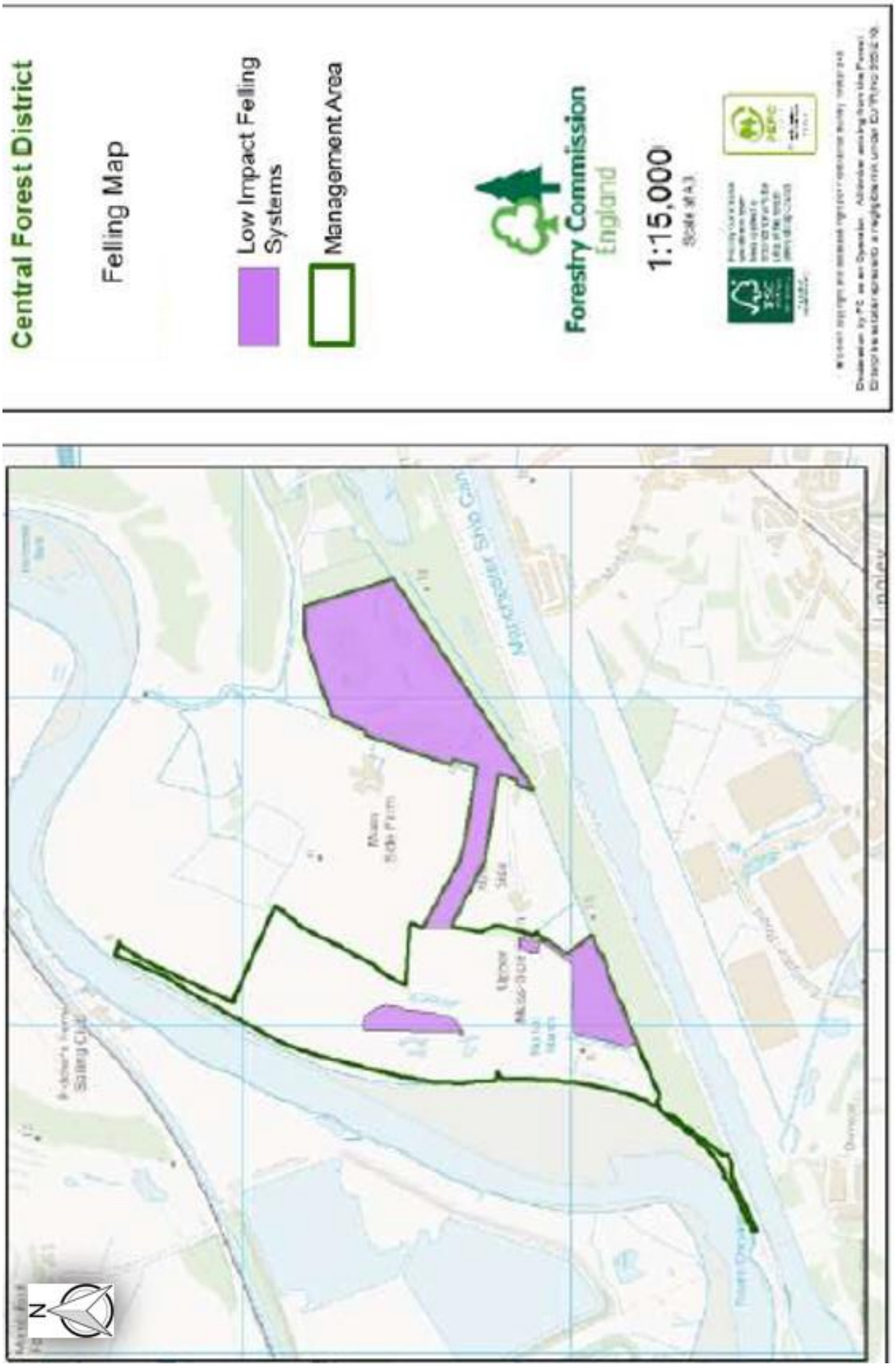

Figure 4.12. Felling map at Upper Moss Side. Sourced from Forestry Commission England, 2017, St Helens Forest Plan.

The management objectives are:

- Protecting and Expanding England's Forests and Woodlands, and
- -Increasing their Value to Society and the Environment.

*To achieve this, the senior district management staff, the local team and planners identified the management objectives and grouped the important themes into key areas of interest – economic, environmental and social (*Table 4.11*). Initially, there will be limited revenue opportunities from timber sale until the crop reach a more sustainable mature age. Another potential future income could also come from education and recreation with potential employment in the local area. Environmentally, the design of the Forest Plan provides a mosaic of habitat while trying to increase biodiversity through introducing deadwood and installing artificial nest boxes. Socially, the emphasis will be on creating a safe welcoming environment to be enjoyed by local families and visitors to the area.*

(Forestry Commission England, 2017)

Table 4.11. Key areas of interest with corresponding theme and the issues to be addressed in the St. Helens Forest plan 2017-27. Source: Forestry Commission Forest Plan.

	Important Themes	**Particular Issues to be addressed**
Economy	Timber Production	Establish economically and ecologically sustainable crops employing low impact silvicultural systems wherever possible Establish an appropriate balance between open space and woodland
Environment	Soil Conservation	Employ minimal invasive silvicultural techniques to maintain soil structure, stability and site infrastructure
	Trees of Special Interest and Deadwood	Identify existing locations of TSIs and demonstrate appropriate management to both maintain the current resource and to recruit future veteran replacements. Identify appropriate areas to increase

		deadwood habitat and propose management to maintain a sustainable resource.
	Species and habitats	Identify key species and sites and make appropriate provision for their requirements Demonstrate appropriate management to enhance and maintain the ecological value of the non-designated priority habitats.
People	Landscape	Diversify species composition and structure, and plan sympathetically designed and appropriately scaled interventions to improve and maintain the visual integration of the forest into the wider landscape.
	Informal Public Access	Maintain existing public access and enhance where possible.

4.4.1 Conclusion of the Current Management Plans

UMS sits within the remit of two active management plans - The Mersey Forest Plan and St. Helens Forest plan – and a potential management plan – MGET plan. The Mersey Forest plan is to manage the hedgerow and the estuary edge in Norton and Moss Side and increase tree cover in Lapwing while maintaining a mosaic of woodland, grassland, and open water. More specifically, the St. Helens Forest plan, refers to planting mixed conifer/broadleaf woodland trees and diversifying the structure through low impact silvicultural systems while maintaining some trees of special interest in perpetuity and allowing deadwood to amass.

On the whole, the plans seek to increase tree cover and maintain a mosaic of diverse habitats while improving the area for people to enjoy and the economy. However, because the site is part of two bigger picture management plans for the surrounding area that have a minimal human intervention approach of tree planting and low impact felling, the site will lack other important disturbances vital for creating niches and supporting a range of organisms.

4.5 Future landcover – 2027 (Markov model)

A possible future scenario for UMS was determined using the Markov model. This model indicates the trends forecast and, if current artificial factors continued, how the results would change along a certain trend and stabilize in the longer term to reach a steady state. Equation (4) (section 3.2.5) was used to find the change in trend of land cover types in 2027.

4.5.1 Upper Moss Side inclusively

The simulated results based on a Markov model indicate that by 2027 grassland will cover 20.4 per cent of the whole site while tree coverage will rise to 52.1 per cent. The saltmarsh is predicted to decrease slightly to 16.0 per cent along with scrub presence, down to 1.0 per cent. The area of swamp may increase, whereas open water remains the same – 9.4 and 1.1 per cent respectively (Table 4.12).

Table 4.12. Land cover for the whole site in 2027 in square meters.

	Square meters					
Year	Grassland	Saltmarsh	Scrub	Swamp	Trees	Open water
2027	151,269	118,423	7,519	69,805	385,805	8,295
%	20.4	16.0	1.0	9.4	52.1	1.1

The Markov model shows a shift in landcover away from a grassland dominant habitat to a predominantly woodland habitat in the years from 2009 to 2027 (Figure 4.13). What the Markov model was not able to predict is the increase in the number of individual trees that rose from 97 in 2009 to 1137 in 2018 on UMS. The limitation with the model means it is not possible to see how the number of individual trees may affect the UMS in 2027, but, observing the historical increase one may assume that the individual trees will have increased and, therefore, adding to the extent of the tree coverage and the prevailing woodland habitat.

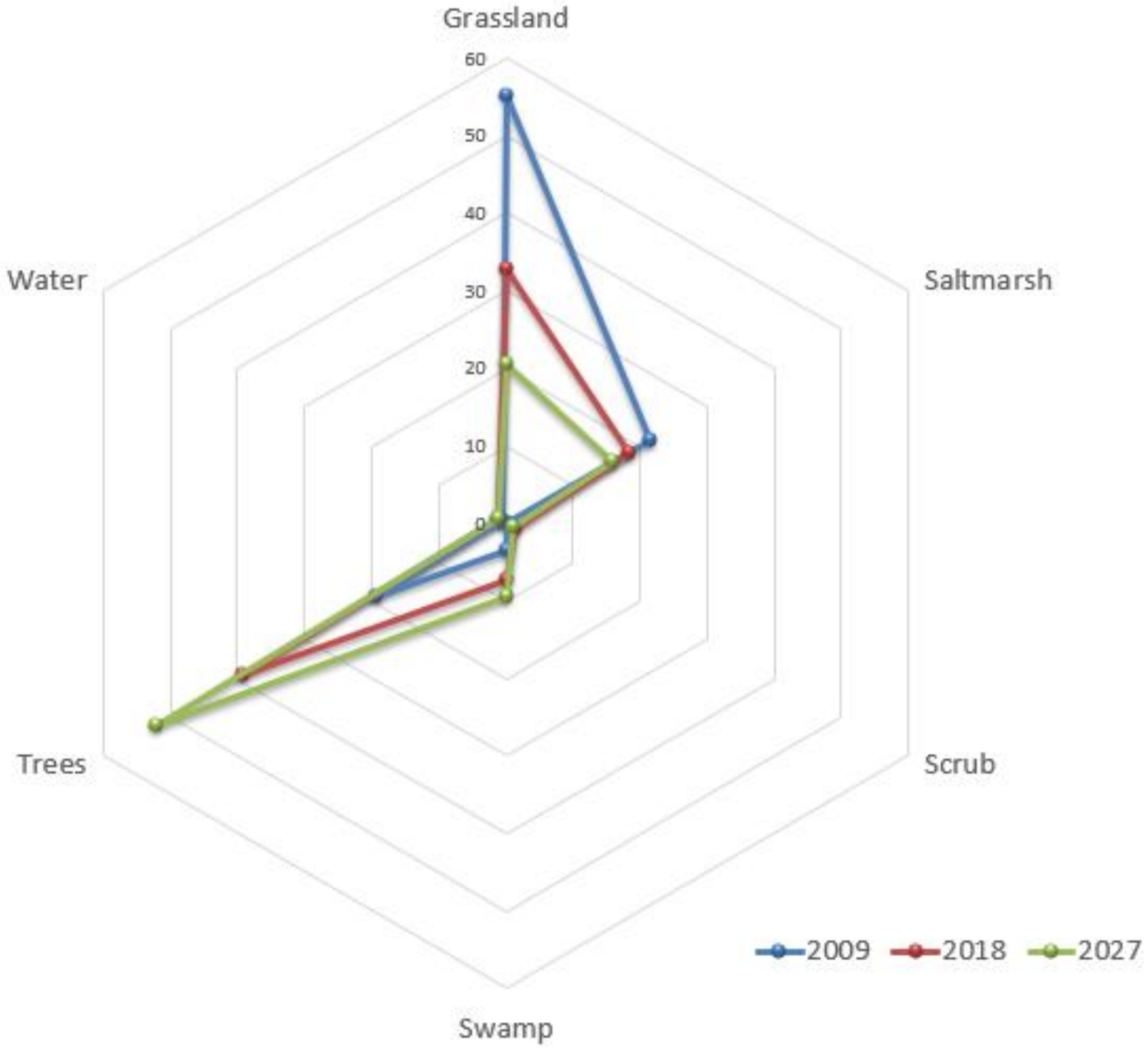

Figure 4.13. The shift in dominant vegetation across the whole site from 2009, 2018 and 2027.

4.5.2 Norton

The saltmarsh is a very different habitat to the rest of UMS. Figure 4.14 shows the change in landcover based on a Markov model. The model has shown that the area of saltmarsh will decrease to 60.5 per cent in 2027, while swamp coverage will increase to 29.6 per cent along with presence of open water, 4.3 per cent. The remaining 5.5 per cent makes up the flood defence bund that runs along the eastern edge of the saltmarsh separating it from the arable fields (Figure 4.14).

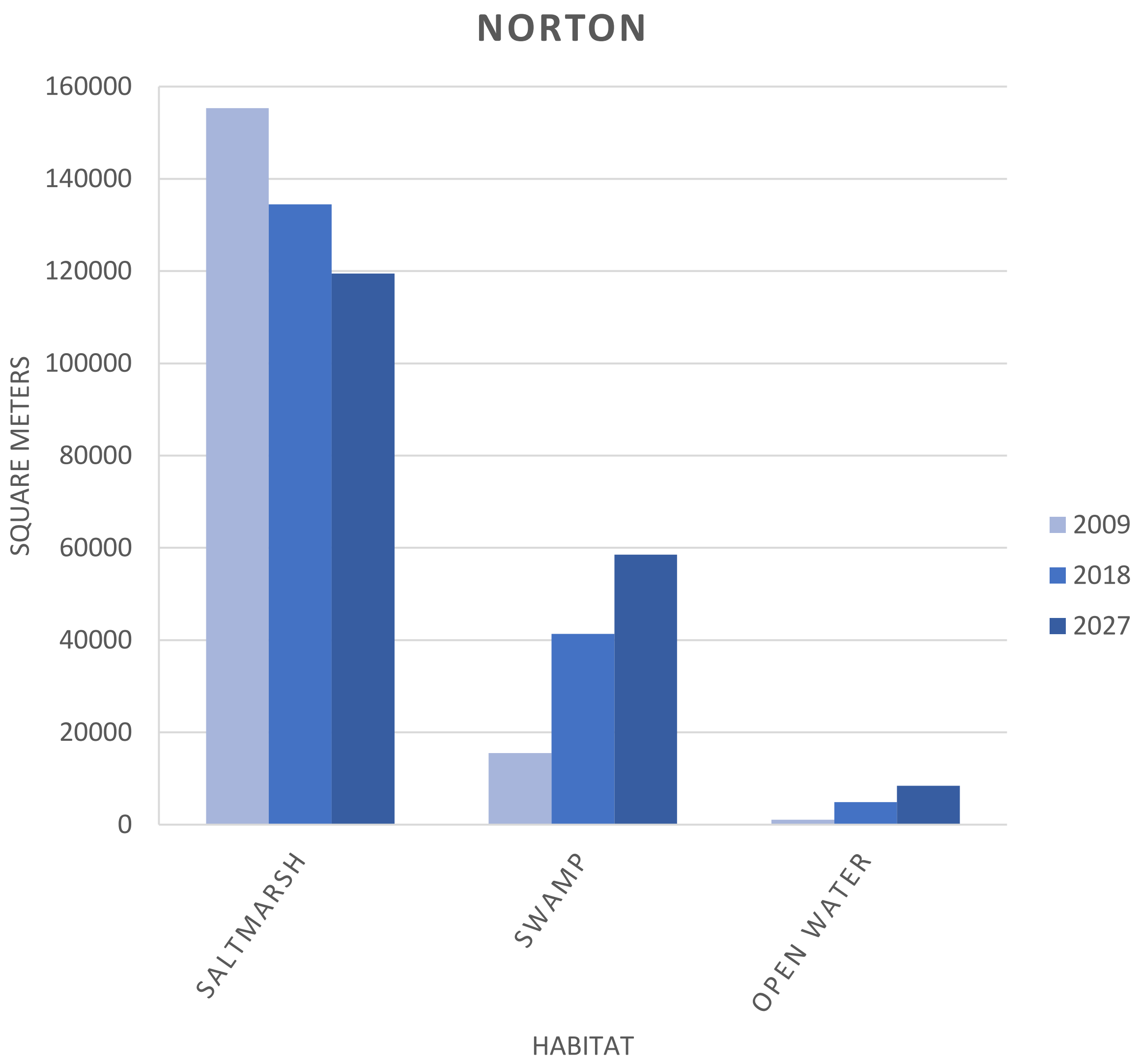

Figure 4.14. Simulated land cover change for Norton from 2009 to 2027 in square meters.

4.5.3 Moss Side

Based on the Markov model, the former arable fields in the middle section of the site produce simulated results that indicate a shift in landcover. The major changes are the decrease in grassland coverage to 26.8 per cent and the increase in tree cover to 68.1 per cent. Other minor changes are a slight decrease to 2.2 per cent in scrub cover and a slight increase in swamp to 2.6 per cent (Figure 4.15).

Figure 4.15. Simulated land cover change for Moss Side from 2009 to 2027 in square meters.

4.5.4 Lapwing

The marshy grassland at Lapwing simulated results similar to that of UMS in that the habitat is shifting away from a grassland and more towards a woodland habitat. Based on a Markov model, the results show a decrease in grassland, swamp, and water cover in this area to 27.2, 2.4 and 0.3 per cent respectively, and an increase in tree cover of 68.8 per cent. Furthermore, the results also suggest that the area is becoming desiccated and less marshy (Figure 4.16).

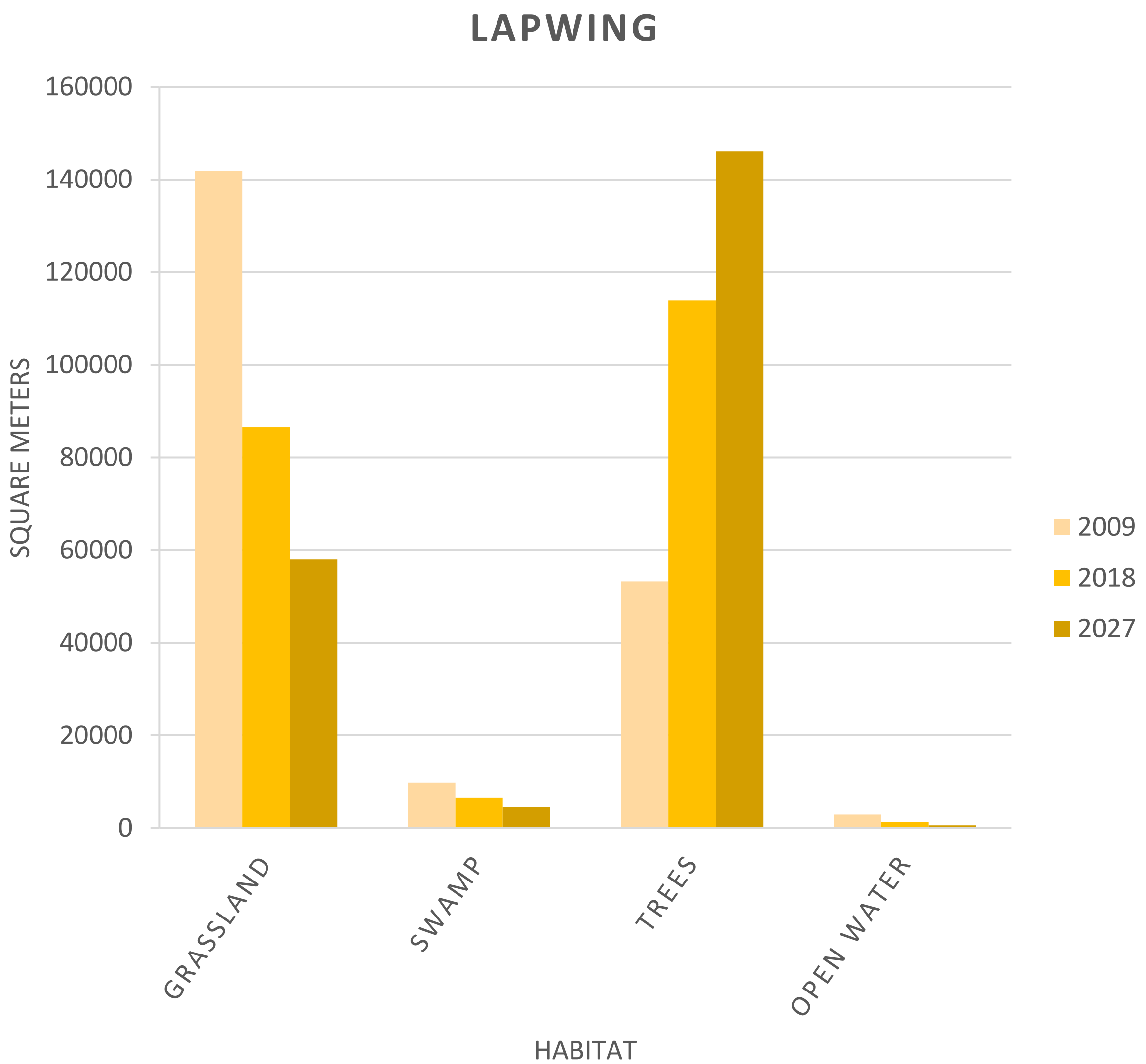

Figure 4.16. Simulated land cover change for Lapwing from 2009 to 2027 in square meters.

4.5.5 Future landcover conclusion

Looking at the figures overall from 2009 and 2027, UMS is set to lose its grassland and become a woodland habitat and the saltmarsh is predicted to shrink while the areas of swamp and open water are set to increase. The grassland to tree shift will be most prominent at Moss Side, and Lapwing, jointly; the areas are expected to see an increase in tree cover of 46 per cent and a decrease in grassland cover of 45 per cent from 2009 to 2027. Lapwing, however, may dry up with the swamp and water coverage predicted to decrease by 37 and 64 per cent, respectively. Conversely, Moss Side may see a sizable increase of 88 per cent in swamp cover, however this may be a misrepresentation due to the Million Ponds Project (programme run by the Freshwater Habitats trust) dug in 2011. Moss Side has also been allowed to scrub up and it is predicted that the coverage will increase by 82 per cent by 2027. As the water decreases on both Moss Side and Lapwing jointly, the saltmarsh may decrease slightly by 13 per cent from 2009 to 2027, but the site is predicted to become more of a swamp and cover a third of the saltmarsh in 2027.

4.6 Rewilding scenario

The data provided by RECORD disclosed which species have been reported present at UMS and the surrounding area. These data enable which ecosystem functions are present and those that are absent to be identified. In order for UMS to become a fully functioning ecosystem an assessment of which species could be introduced to UMS in order to fulfil those missing functions is required.

The principle of rewilding and wood pasture dynamics in the presence of free roaming large herbivores together with the location and scale of UMS has been taken into consideration when assessing which species are most suited in the rewilding scenario. The findings of section 4.3 posit that functions such as, defecate, graze, browse, trample, pollard, gorge, rootle, and de-bark are missing from UMS and therefore species that perform such behaviours would be most desirable.

A common species that is often managed domestically yet performs many of the missing functions when left to behave naturally is cattle. During 2016 to 2018 belted Galloways (*Bos* sp.) roamed UMS, but their presence was brief, limited in range, and they lack a feature which can cause some disturbance: horns, a feature possessed by the extinct aurochs (*Bos primigenius*). An alternative would be English Longhorn

(*Bos* sp.). The notable long, curved horns that point down to their nose have been used to rub the branches, as a result the leaves and bark are stripped off (Tree, 2018b), which has a kind of pollarding or coppicing effect on trees and shrubs. Their activities focus on open grassland, small flushes and glades and have been used in rewilding projects across the UK - Knepp Wildlands Project, Wild Ennerdale, Wicken Fen – because of their adaptability to naturalistic living.

Some species act as facilitators for other species. Horses, for instance, can survive on nutrient poor grasses and eat dead grasses as a major part of their diet. By removing the dead grassy material, they stimulate regrowth, enabling cattle and deer to live in greater numbers in nutrient-poor landscapes. Horses also debark poplars, willows, spruce and beech (Linnartz & Meissner, 2014). Their habitat preference ranges from grasslands and scrub, saltmarsh, wetland, heathland, open woodland and mosaic forest-open vegetation where they will adjust their diet to ensure maximum intake of digestible dry matter that is high nutritional quality (Putman, Pratt, Ekins, & Edwards, 1987). The Exmoor pony (*Equus ferus caballus*) is the closest descendant of the wild horses of Europe and is considered the most primitive breed of horse in Great Britain (Hovens & Rijkers, 2013). Due to their extremely efficient double-layered winter coat that can cope with heavy rain they are regarded as a very hardy animal able to withstand the hostile winter elements (Hann, 1980) making them an ideal candidate for re-introduction.

Different species occupy different niches: pigs graze throughout the summer and in the autumn gorge on fallen acorns, and so reduce oak dominant landscapes. When the ground is soft, from autumn through to late spring, they rootle, turning over lumps of meadow with their snouts, in search of roots and rhizomes, earthworms and other invertebrates (Grazing Animals Project, 2016). Rooting is beneficial for pioneer plants, fungi, and the natural regeneration of the seed bank. Their habitat preference is mainly around patches of woodland, but will forage on pasture or meadowland (The British Pig Association, 2017) for the deep, strong roots of docks and thistles. The Dangerous Wild Animals Act 1976 prohibits the introduction of wild boar, so Tamworth pigs (*Sus scrofa domesticus*) would act as a proxy.

Their combined impact on the landscape is much more than the impact of one single species. The collective feeding strategies of the different species constitute a system of checks and balances preventing any one species of vegetation becoming dominant (Vera, 2009). Deposits of dung left by animals enriches the soil and creates patches of valuable habitat. Their heavy hooves trample the ground and push seeds into the earth while producing a network of tracks (Dennis, 1998). The Longhorn cattle, Exmoor pony, and Tamworth pig are all proxies for native wild breeds, either extant or extinct. Their activities and habitat preference range from open grassland to saltmarsh to patches of woodland with varying intensity, pressures and overlap presence (Dando & Sandom, 2018). They are robust breeds yet docile and show good mothering abilities and intelligence, furthermore, they are built to withstand the British weather (Table 4.13).

Table 4.13. Proposed species reintroduction characteristics: Method of feeding, dietary preferences, and habitat effects. Source: (Mayle, 1999)

Species	Proxies	Feeding strategy	Feeding method	Selectivity	Diet preference	Seasonal variation	Ref.	Characteristics	Status – RBST.org.uk
Longhorn cattle	Aurochs (extinct)	Ruminants Bulk grazer/browser Herbivores	Tear-off long vegetation by wrapping tongue around and pulling. Grasp short vegetation between lower incisors and horny upper pad. Ruminants feeding for 60% of the day.	Low	High quality grasses, bent/fescue. Low quality communities: bog-rush fen, mat grass/purple moor-grass, heather (ling).	Low - Broadleaves bark stripped when forage availability low (winter), or in response to mineral deficiency (summer).	3,5,7,8,9	Good mothers, docile, robust, thrifty, agile, and adaptable	Rare, but increasing in numbers
Tamworth pigs	Wild boar	Non-Ruminants Rootle/Grazer Omnivorous	Take invertebrates, tubers, fungi, fruits seeds, grasses, and carrion, much of which is obtained by rooting in the leaf litter.	Low	Anything tasty	Low - Fruits and seeds (particularly acorns) taken in autumn	16	Good mothers, docile, hardy, the most resistant to sunburn	Vulnerable between 200-300
Exmoor ponies	Tarpan (extinct)	Non-Ruminants Bulk grazer/browser Herbivores	Bulk grazer – Nip herbage close to ground with upper and lower incisors. Non- ruminant. Feeds for 75-88% of the day.	High	Bent/fescue grasses Purple moor-grass, heather, gorse, and holly. Sedges/rushes and ferns. Native breeds take more coarse grasses.	High - Bent/fescue grasses preferred. Purple moor-grass, sedges, rushes, and ferns taken late spring and summer. Bark stripped when forage availability low.	7,9,10	Versatile, adaptable, and very strong, double-layered winter coat, intelligent	Endangered between 300-500 Globally 'critical'

4.6.1 Rewilding conclusion

The proposed reintroduction of Longhorn cattle, Exmoor ponies, and Tamworth pigs successfully fulfil the missing ecological functions - defecate, graze, browse, trample, pollard, gorge, rootle, and de-bark - at UMS. These functions are necessary if the site is to become a fully functioning self-sustaining ecosystem. The large free roaming herbivores will affect vegetation succession by creating disturbances and altering the vegetation structures which contribute to a dynamic, ever-shifting mosaic of valuable habitats.

4.7 Feedback from workshop

The workshop was an opportunity to present the findings and to gather opinion and feedback from local stakeholders on the acceptability and practicality of rewilding UMS in comparison to how the site may look in 2027 in terms of habitat coverage generated by the Markov model.

The format of the workshop was sectioned into categories which enabled the participant to provide their level of understanding prior to a series of information sharing activities that went on to explain that topic before a final question was asked to explore their agreement on that subject. Ten participants contributed their feedback on the issues covered during the workshop. The data analysis initially focused on the closed questions then later concentrated on the detail.

4.7.1 Closed questions' answers

During each section a closed question was asked to gauge the opinion of the participant before giving an explanation as to why they agreed or disagreed with question (Table 4.14). More than two-thirds believed that managing UMS for increased biodiversity and resilience was more important than managing the site for a target habitat and/or species. Eighty per cent of the participants agreed that the species proposed for reintroduction are acceptable for UMS, however, half of those that agreed did so with a condition, while the others were just unsure due to the scale and potential damage that could be caused. All but one of the participants believed the benefits (B) outweighed the challenges (C) (B>C), however, one participant who agreed that the B>C did so whilst emphasising many caveats in their explanation. The one participant that did not agree that the B>C, did not wholly disagree either, but leant towards the idea that B>C by suggesting: *We need to look* *at new approaches and rewilding is certainly worth an investigation* and *the people benefits are under resourced* (attendee – 3). No one suggested the challenges outweigh the benefits (C>B). The final question explored the acceptability and practicality of rewilding UMS and was asked separately. Unanimously, everyone agreed that it is acceptable to rewild UMS but only half of the participants thought it was practical (four were unsure and one disagreed totally).

Table 4.14. Direct answers to the questions asked during the workshop.

Questions	***Agreed***	***Disagreed***	***Unsure***
What's (more) important for UMS: /			
Managing for a target habitat/species	3		
Managing for increased biodiversity and resilience?	7		
Are the reintroduced species presented acceptable for UMS?	8		2
… Conditions/Considerations			4
Challenges vs Benefits			
Benefits outweigh challenges	9	0	2
Is it ACCEPTABLE to rewild UMS?	10		
Is it PRACTICAL to rewild UMS?	5	1	4

4.7.2 Detail behind the questions

As well as answering the closed question, all participants gave a more detailed qualitative explanation as to why they answered yes or no. This section sets out the detail behind the closed questions.

4.7.2.1 Understanding of rewilding

When asked 'what is your understanding of rewilding', many answers referred to the features of rewilding. The common features and the number of times they appeared in the answers is shown in Table 4.15: the most common feature was reduced management followed by, contradictorily, human management. The presence of species and their ecological function plus the restoration of nature (species and/or nature) scored the same.

Table 4.15. The number of times a key aspect of rewilding was mentioned.

What is your understanding of rewilding?	*Repetitions*
Reduced management	6
Management	5
Keystone species / ecological function	5
Restoration (sp./habitats)	5
Pre-historic	2
Future minded	2
Eco-tourism	1
Disturbance	0

Many of the participants understood the meaning of rewilding but missed some important elements, while one constructed a well-rounded explanation saying:

> *Manage the land with its original component parts. Re-introduction of keystone species, soft approach to conservation/habitat management… promotion via eco-tourism.* Attendee – 02*.*

Another participant's interpretation was:

> *Re-educating local schools and communities to look after local areas of ecological interest.* Attendee – 06.

The number of participants whose understanding of rewilding had changed after the current understanding of the concept 'rewilding' was established and the concept was then clarified and put into context are shown in Figure 4.17. Two people had not realised that rewilding was not about land abandonment, while another recognised that there can be a small element of ecological management but that it is about trying to become less human managed.

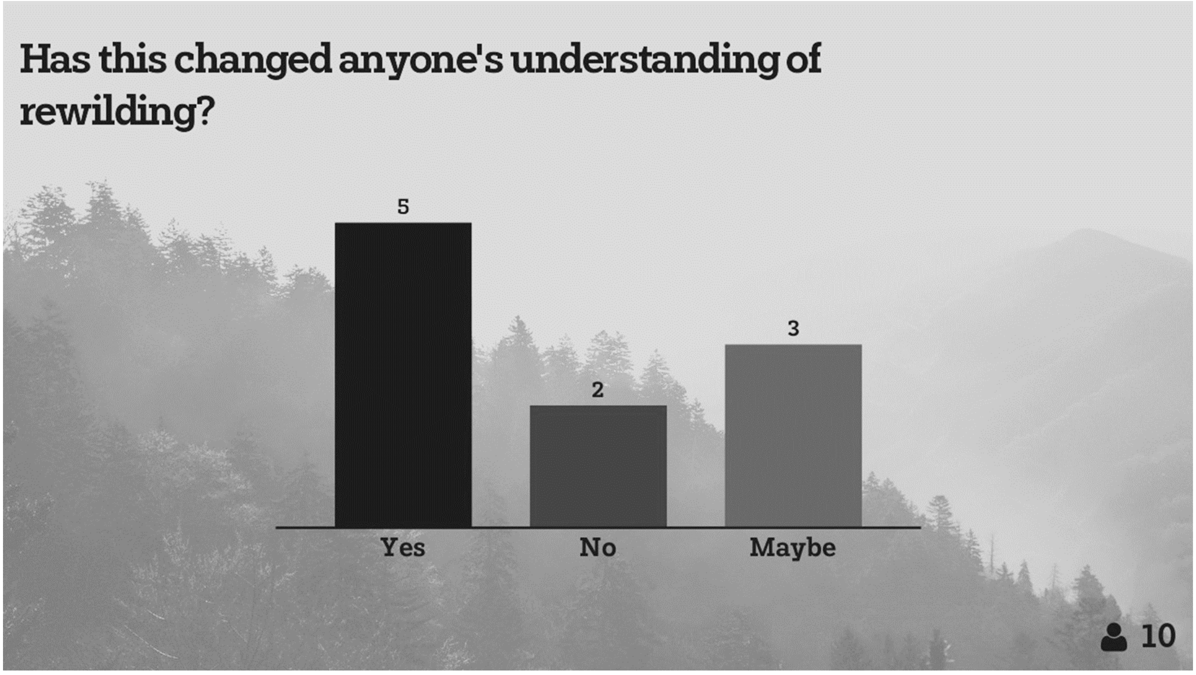

Figure 4.17. The number of participants whose understanding had changed, had not changed, or had maybe changed.

4.7.2.2 Preferred management of UMS site

Although the overall majority agreed that it is more important to manage the site for increased biodiversity and resilience, a number still believe that the existing habitats and wildlife are more important, and that the future management of UMS should be species and habitat focused. Two participants agreed that resilience against sea level rise as a result of climate change was important, but then suggested this may be achieved by way of wetland management and another proposed the management plan should include coppicing trees for re-growth.

4.7.2.3 Acceptability of proposed reintroduced species

As well as the species proposed (Table 4.13), the participants recommended a number of species, such as: deer (Cervidae), wild boar (*Sus scrofa*), sheep (*Ovis aries*) (including ancient breeds), pine marten (*Martes martes*), European beaver (*Castor fiber*), and Konik ponies (*Equus ferus caballus*) (listed in order of popularity – 3, 2, 2, 1, 1, 1 respectively) that could also be considered for reintroduction to UMS. One issue raised about the reintroduction of the proposed species is the level of damage they are liable to cause - the shoreline management plan is to protect the defence bund, which may become damaged if species are introduced to site. This plan is only in place until 2030 and the defence needs to be set back to account for sea level rise. Another issue is the size of UMS and whether it has the capacity to cope with species and the consequent disturbance.

4.7.2.4 Word cloud

Prior to discussing the potential challenges, the following question was put to the participants: What limiting factors would influence this project? Using three different words the participants, collectively yet individually, produced a word cloud (Figure 4.18). The word cloud shows money received the most mentions (7) and therefore being the most influential in this project followed by conflict and scale (4 mentions) and acceptance, economic, land, perception, and policy (2 mentions).

Figure 4.18. Word cloud produced by the participants when answering the question.

4.7.2.5 Likert scale

A number of common challenges appear in the rewilding literature, therefore, to understand how the participants felt about the severity of those challenges they scored each challenge from 1 (strongly disagree – not a challenge) to 5 (strongly agree – a sizeable challenge) on a Likert scale shown in Figure 4.19. The challenge with the highest score and, therefore, perceived to be the most challenging was the landowners and neighbouring landowners with 3.9 with the scale/size of UMS, public perception/opinion, and cost next with 3.6, 3.4, and 3, respectively. The less contested challenges are: timescale, the lack of targets, and uncertainty around the outcome, scoring 2.9, 2.8, and 2.5, respectively. However, all of the challenges mentioned so far either scored the same or higher than the 2.5 midpoint. The challenge of least concern was the negative ecological interactions which scored 2.2.

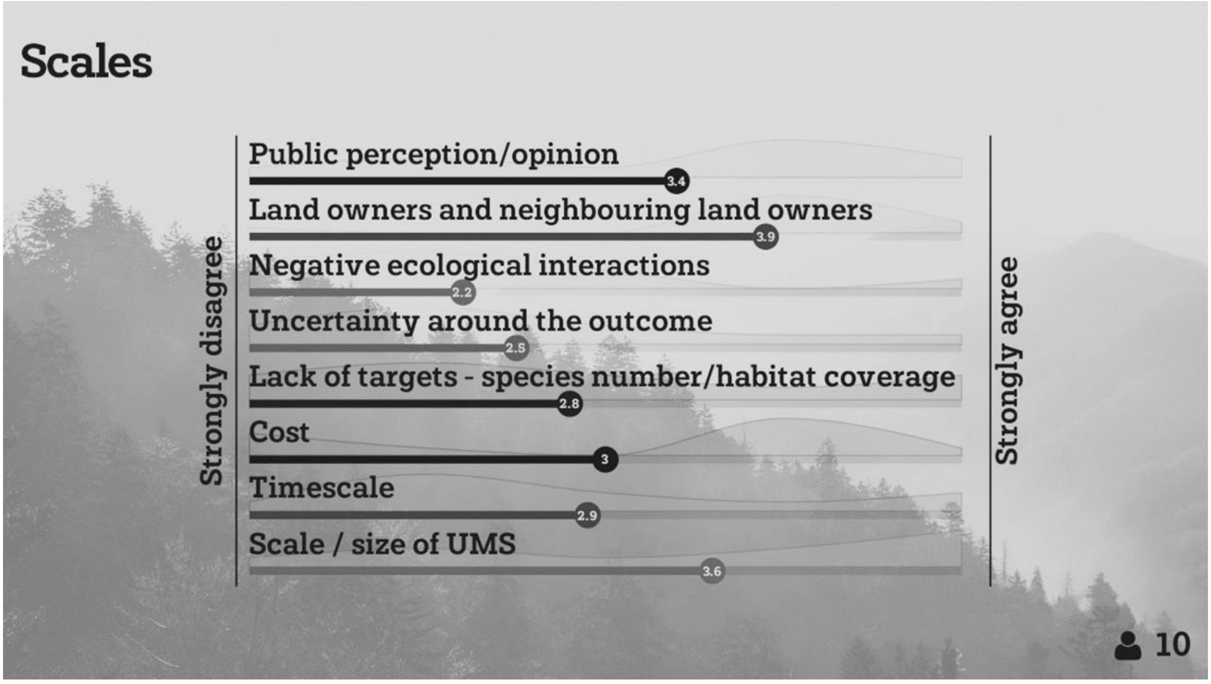

Figure 4.19. Likert scale showing the participants perception of the severity of the challenges listed.

4.7.2.6 Challenges vs Benefits

Overall, the participants that voiced their concern over challenges, such as, public perception, the opinion of the adjacent landowner's, plus maintaining funding and the costs involved, also believed they could be overcome if local landowners, stakeholders and all concerned worked together during the planning stages combined with the installation of appropriate signage around the site to educate the public. Of the benefits mentioned, one participant remarked on the reduced public spending on flood defences and increased flood water storage. The benefits to people was mentioned a number of times stating public health, social problems and mindfulness as areas that would benefit. Other benefits include ecological, wildlife, biodiversity, and the ability to adapt to climate change.

4.7.3 Common themes

Several common themes emerge from the data. These categories are: size of UMS, education, policy, climate change, management, public opinion, and cost/funding. The themes are context specific and have been grouped in terms of scale (Table 4.16). Scale, as a range of magnitude, was used to group the reoccurring areas mentioned in the feedback. The themes within the groups – wider context, local scale, and site specific - are connected by the level of responsibility and accountability. These themes are viewed as essential to determining the concerns of all the participants.

Table 4.16. Common themes grouped in terms of scale.

Group	*Themes*
Wider context	Policy, climate change, cost/funding
Local scale	Education, public opinion
Site specific	Size of UMS, management

4.7.3.1 Wider context

Sea level rise as a result of climate change and policy were of most concern in the wider context followed by costs and funding. The saltmarsh was viewed as being beneficial and could increase flood water storage through natural processes, which would have a positive effect if sea levels were to rise. Many found that it was important to allow nature to become resilient and adaptable to the possible novel and unpredictable future climatic conditions. As for today's political climate, some were unsure how rewilding might work calling it *a whole new can of worms* (Attendee – 02), yet, another participant questioned the alternative. One participant believed *rewilding is a policy and aim that deserves serious consideration for many sites* (Attendee – 05). In spite of this, there are numerous complexities to overcome: social, political, and economic. Just over half of the participants were concerned with the costs and maintaining funding and felt the economic side of rewilding could be a challenge. Nonetheless, one participant saw a long-term positive (+100 years) in the reduced public spending on flood defences.

4.7.3.2 Local scale

At the local scale, public opinion and acceptance was the most pressing issue, while education was mentioned a number of times as a tool for public acceptance. It was believed that good interpretation around the site was an essential factor if the local community were to recognise the long-term benefits. The benefits of rewilding were accepted at the workshop, but the need to engage, educate and positively influence the local community, and politicians were considered a challenge. However, it was suggested that education did not stop with the politicians, the local community, and the site users. Biological recordings for scientific research purposes in the field of rewilding and natural grazing were recommended and are urgently needed in this field. It was clear that education on many levels was key and could encourage people to be more accepting. In spite of this, one participant felt that a shift in mindset away from dictating what is right for nature was needed, but this is only achieved through education and raised awareness. Acceptance from the adjacent landowners and the public on the proposed reintroduced species were thought to be issues but one person suggested involvement from an early stage to be crucial if people are to be on board. The general consensus amongst the attendees was that local public opinion and their viewpoint may interfere and that this could pose a challenge/problem.

4.7.3.3 Site specific

The scale of the project seemed to be an issue and possibly the main practical challenge. It was believed that 'we' cannot dictate for small-scale conservation goals. With regards to the reintroduced species, participants were concerned with the capacity of UMS and whether it would be able to withstand the potential damage. One participant believed it is important to manage large-scale but with species focus. Management of UMS was the most discussed theme on the day. Whether that was to increase biodiversity or for greater flood management, the majority believed that a good long-term management plan was necessary. One participant suggested grazing the saltmarsh with different species for the benefit of multiple species. Another participant suggested culling the reintroduced species as a form of management as the prospect of natural predations is very limited. A couple of management options were offered that are not a standard feature of rewilding, such as, coppicing the trees to create re-growth, while another suggestion was the maintenance of paths and hides, but it was noted that this might be controversial in the context of the main [rewilding] concept. Managing the site ecologically was not the only form of management discussed; three participants commented on the need to address peoples innate desire to control nature and the way in which challenges are managed, however, they believed this shift in mindset to be within our reach. Most of the participants have extensive experience of land management and have demonstrated good environmental improvements, but one participant acknowledged that this is against a national/global backdrop of declining species and habitat loss etc. They believed a new approach was needed and recommended rewilding as a concept worth investigating.

4.7.4 Positive and negative comments

Most comments were neutral. A number of comments, however, were more positive and pro rewilding of UMS and a few had a negative connotation – there were five participants on either side.

4.7.5 Acceptable

Seven people answered a direct yes, while others suggested their agreement by saying *I don't see why not* (Attendee – 05) and *absolutely – why would it not be?* (Attendee – 01) and *It is worth changing the current management* (Attendee – 03). One of the participants that answered a direct yes only agreed it was acceptable in the long-term, from 2030 onwards and went on to say:

> *After this time, stakeholder engagement with the local community (including the seven properties currently protected by the sea defence embankment) will have reached an acceptance that the most sustainable solution (as set out in the shoreline management plan) is to re-wild and set back sea defences.* Attendee – 07.

4.7.6 Practical

Five people agreed that it was practical to rewild UMS; four people were unsure or presented an uneasy comment:

> *A whole new can of worms! Just from an economic sense, to practically and politically.* Attendee – 02*.*

> *Maybe, it depends on the people involved and their determination and vision to drive the project.* Attendee – 05*.*

> *Possibly not in the short-term (i.e. next 10 years). There are numerous complexities to overcome – social, political, economic.* Attendee – 07*.*

> *Though it might not always be practical, I do not think this is a reason not to do something, especially when it is something so important.* Attendee – 10*.*

One person completely rejected the idea (i.e. responded ‘no’ to the closed question) but added:

> *We have taken farming and land management to the apex of practical. That does not mean we should not do it – systemic change can only come if we disrupt the status quo – that is not always practical.* Attendee – 09*.*

4.7.7 Feedback from workshop conclusion

Overall, the feedback was positive and supportive with a few concerns. Unanimously, everyone agreed that it is acceptable to rewild UMS but not everyone agreed it was practical.

Current management objectives (set out by Forestry England and The Mersey Forest) are defined by the Government and the European Union targets which effects the conservation of habitats and species in the UK. The targets influence the way conservation work is carried out, however, the consensus on the day was for increased biodiversity and resilience as opposed to the current approach using targets; only a few opposed. In order to increase biodiversity and resilience, the proposed reintroduction of large free roaming herbivores was acceptable to the majority with a few concerns raised regarding damage and disturbance; conversely this is one of the principal features of rewilding that was not fully understood or approved of by the group. The challenges of rewilding are well documented, and, through the workshop and corresponding feedback, the participants raised questions or concerns around resources and funding, conflict with the neighbouring landowners and the size of UMS. All but one of the participants believed the benefits outweighed the challenges. The areas thought to benefit the most include wildlife, ecological function, increased flood water storage, and the social, and physical and mental wellbeing of the people.

4.8 Surrounding Habitats

UMS is in a peri-urban setting with similar yet varying habitats that surround the site. To help determine the potential connectivity routes for species to migrate along and/or utilise, an assessment of the different types of habitats was conducted. This knowledge may influence future management decisions.

UMS sits to the west of Moore Nature Reserve and Arpley landfill which are bounded by the Mersey Estuary to the north, east and west and the Manchester Ship Canal to the south (Figure 4.20) – this wider area, the greater boundary, is 505.5 ha. The habitats within that greater boundary are all similar in nature, except the area highlighted as active farmland. To the south and across to Moore Nature Reserve, the area is predominantly woodland of some description: deciduous woodland, young trees, broadleaved woodland and low-density woodland; to the west there is the intertidal substrate consisting of the river Mersey and mudflats (Figure 4.20).

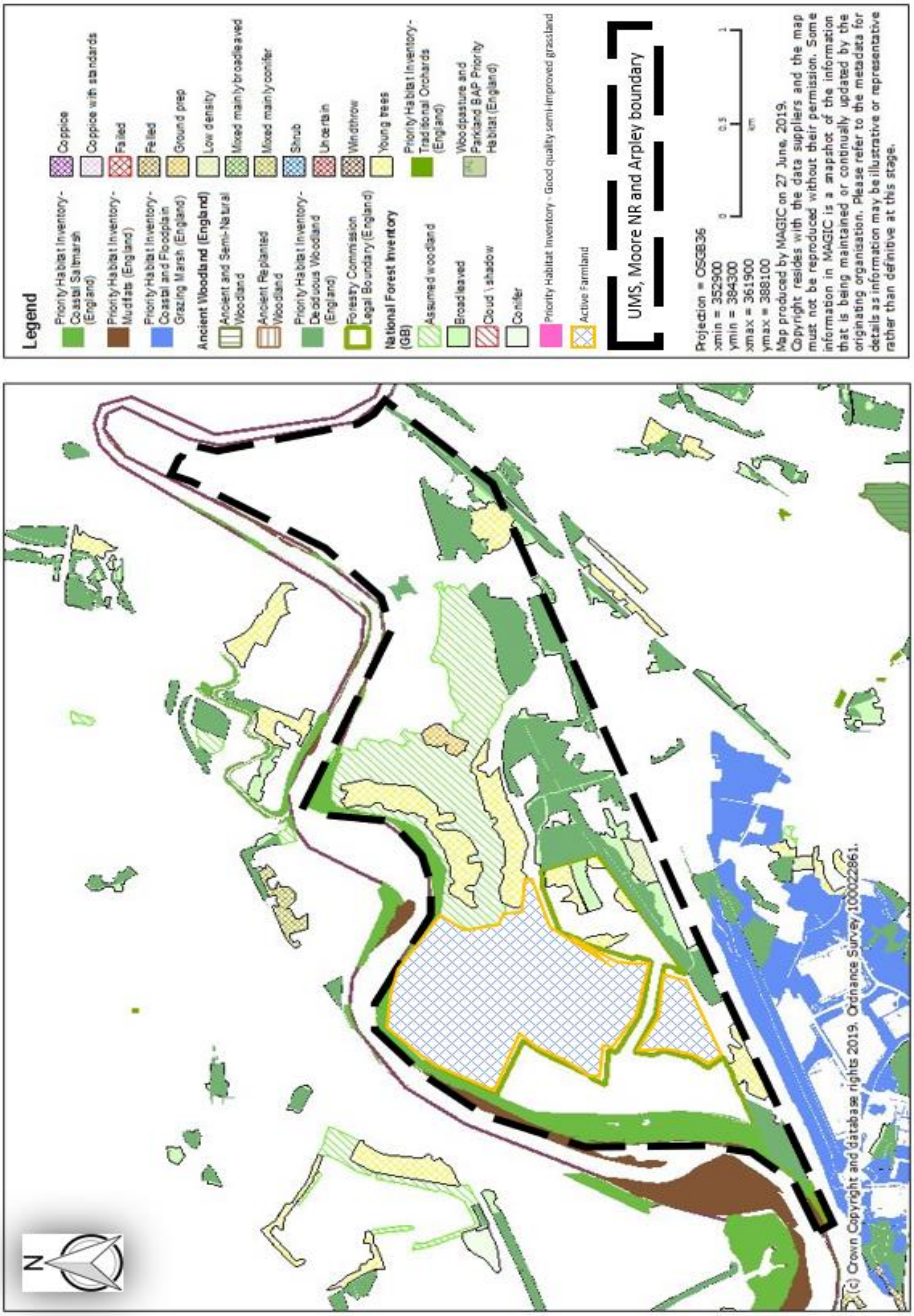

Figure 4.20. Landcover/habitats surrounding Upper Moss Side. Sourced: Defra – MagicMap (https://magic.defra.gov.uk/). Contains © Crown Copyright and database rights 2019. Ordnance Survey 100022861.

However, the habitat similarities between UMS and the greater boundary area are not displayed in their entirety in Figure 4.20. To address this an aerial image taken from Google Earth, dated 2018, is provided (Figure 4.21) to illustrate the likeness of the ground cover across both sites.

On the eastern and western parts of Arpley the area supports a mosaic of reed stands, interspersed with grassland, shallow ditches, small ponds, scrub, and a broadleaved plantation. While to the south, the area visible on Figure 4.21, is revegetated improved grassland. Moore Nature Reserve comprises five large lakes surrounded by extensive mainly broadleaved woodland, meadows, wetlands, and ponds.

4.8.1 Surrounding habitats conclusion

UMS forms part of a 505.5 ha expanse of woodland, grassland, swamp, and wetland habitats. The greater boundary is noticeably similar in vegetation and is bound by the Mersey Estuary to the north, east and west and the Manchester Ship Canal to the south. Species present will more than likely utilise the greater boundary and disperse freely across the larger area. There is scope for the greater boundary to become a core area or a connectivity route for local wildlife.

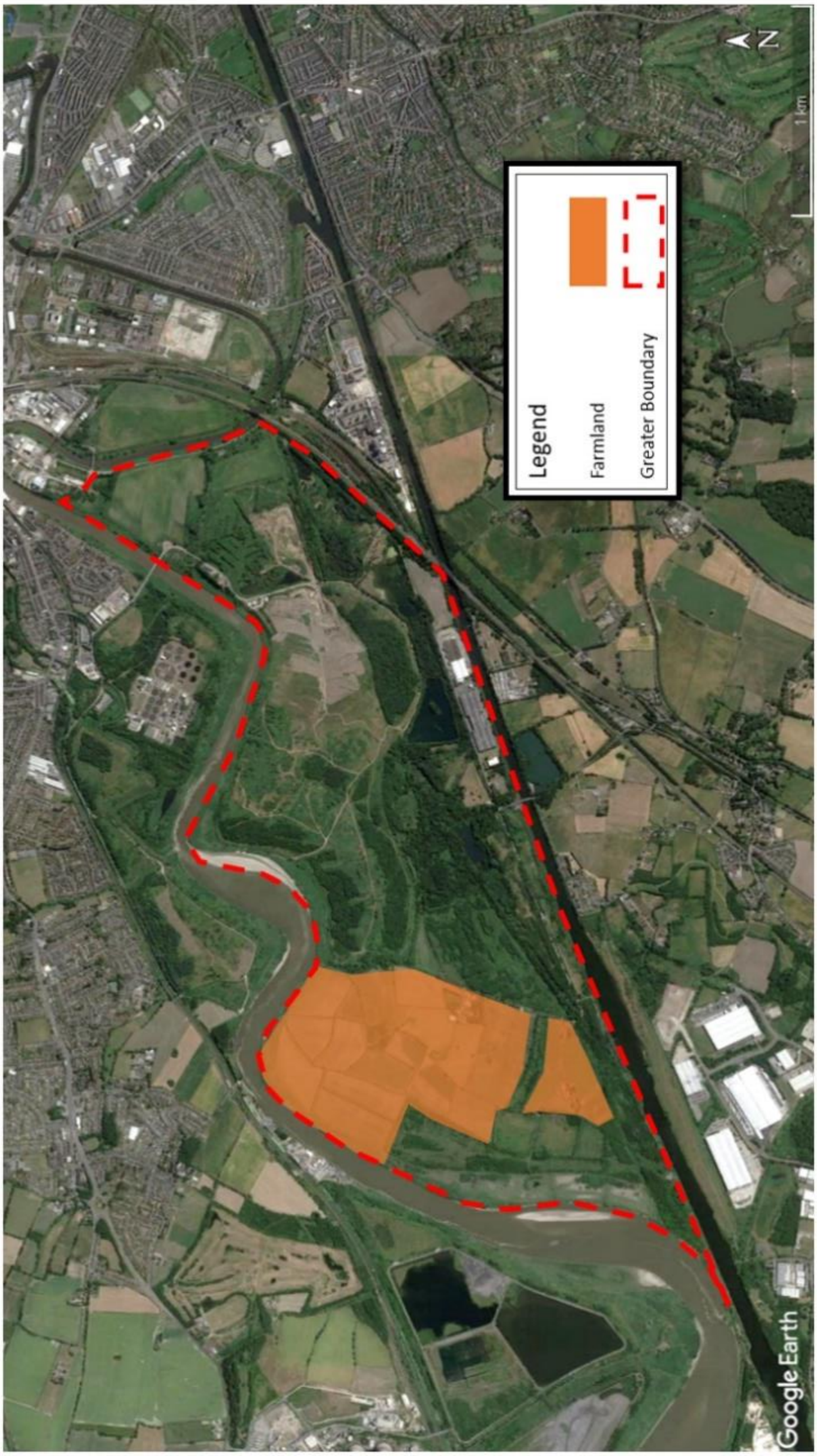

Figure 4.21. Google image taken in 2018 highlighting the habitat characteristics of the greater boundary which includes; UMS, Moore Nature Reserve and Arpley Landfill. Base map sourced from Google Earth. Image © 2020 Maxar Technologies.

4.9 Designated sites

If UMS was to become a fully functioning, species rich habitat with a diverse structure that attracted many iconic species such as otter (*Lutra lutra*) and European beaver (*Castor fiber*), then there is a possibility the area may add to the existing pool of valuable habitats and increase crucial habitat space and maybe become a designated site in its own right.

The 2005 Forestry Commission Design Plan states aspirations to extend the River Mersey SSSI/Ramsar further upstream to UMS. As well as the Mersey Estuary SSSI, there are a number of wildlife sites within 10 km of UMS (Table 4.17). The proximity of these sites may be of importance for bird and mammal species, therefore, extending the SSSI/Ramsar to UMS could have positive implications further afield.

Table 4.17. Designated sites within 10km of UMS.

Site name	Designation	Size (ha)	Straight line Distance from UMS (km)
Woolston eyes	SSSI	269.8	6.9
Paddington meadows	LNR	34.5	6.2
Runcorn hill	LNR	16.7	5.6
Mersey estuary	SSSI	7,714.0	4.9
Mersey estuary	Ramsar	5,023.0	4.9
Mersey estuary	SPA	5,023.0	4.9
Flood brook clough	SSSI	5.3	5.0
Murdishaw wood	LNR	31.0	3.8
Wigg island	LNR	24.6	2.3
Daresbury firs	LNR	10.7	2.4
Doncaster park	LNR	3.3	1.2
Oxmoor wood	LNR	7.4	0.3

There are other areas with designations in the surrounding area that are highlighted in Figure 4.22. The estuary runs directly past UMS but does not hold any designations; the cut off for the designation 5.2 km west of the UMS is also shown in Figure 4.22.

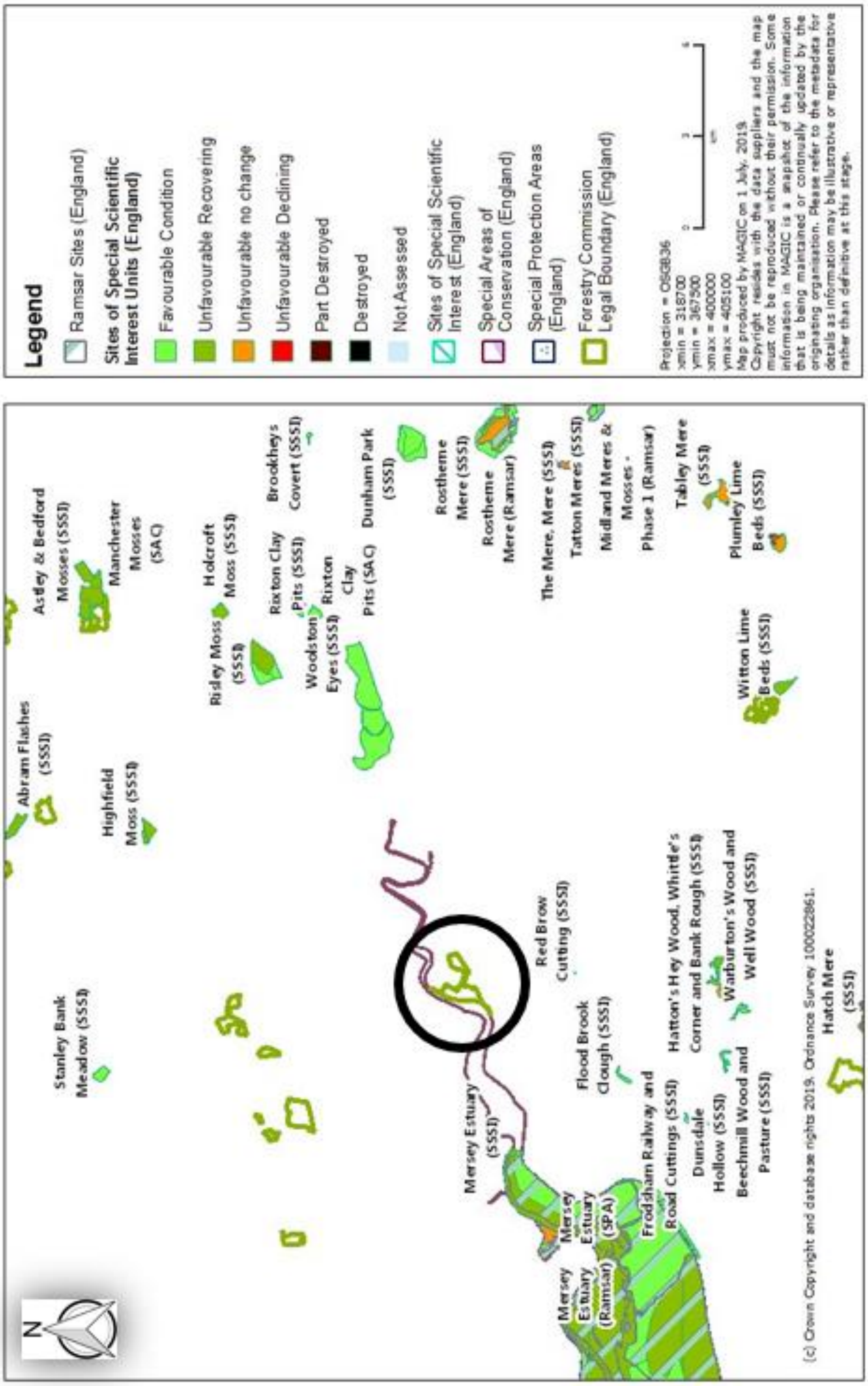

Figure 4.22. The black circle indicates the location of UMS in relation to the other sites with statutory designations. Sourced: Defra – MagicMap (https://magic.defra.gov.uk/). Contains © Crown Copyright and database rights 2019. Ordnance Survey 100022861.

In addition to nature designations UMS falls with the Halton Borough Council's green belt land (Ministry of Housing Communities & Local Government, 2018), which is a policy to control urban growth and prevent sprawl resulting in permanently open land (Figure 4.23).

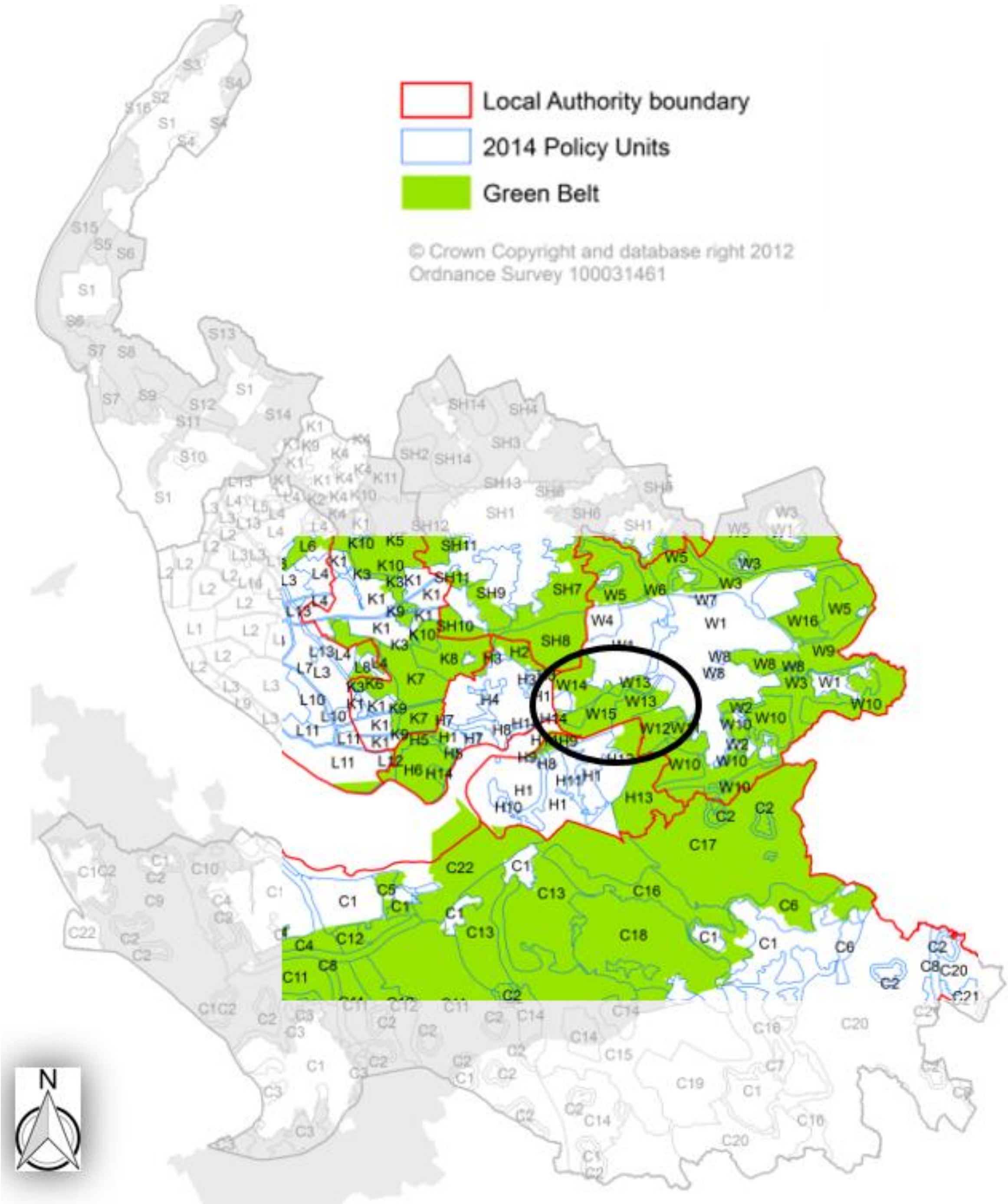

Figure 4.23. Green Belt in relation to the 2014 Mersey Forest Plan policy units. Sourced: The Mersey Forest, 2014a, Forest Plan. Contains © Crown Copyright and database rights 2012. Ordnance Survey 100031461.

5. Discussion

New opportunities are arising throughout Europe and Britain due to a shift in agricultural practices resulting in land abandonment and the resultant landscape changes (Pereira & Navarro, 2015). Once land is abandoned succession is able to progress without any control. Gathering baseline ecological data and mapping the change is a way of monitoring the changing landscape (Schulz, Cayuela, Echeverria, Salas, & Rey Benayas, 2010). Decisions on conservation and land management options in the work reported here are being made using historical data fed into a Markov model to predict the trajectory of abandoned landscapes (Ruiz-Benito, Cuevas, Bravo, Garcia-del-Barrio, & Zavala, 2010). Studies have responded to the shift in agricultural practices and sought to assess rewilding opportunities on areas expected to be abandoned (Carver et al., 2012; Ceausu et al., 2015). Yet, despite the opportunities the process of rewilding in Britain with species reintroductions is slow and arduous as they unsettle social and ecological norms (Crowley, Hinchliffe, & McDonald, 2017). Selecting the right species for reintroduction is essential in order to gain public support but the species proposed must also fulfil certain niches for the reintroduction to be ecologically viable (Zamboni, Di Martino, & Jiménez-Pérez, 2017). Without public support around acceptability and practicality then opportunities simply remain ideas. To facilitate the process, workshops designed to share scientific data, systematically address problems, and generate support for action are an effective tool to gain feedback and opinions (Adams, Tulloch, & Possingham, 2017; Wheeler, Chambers, Sims-Castley, Cowling, & Schoeman, 2008). The opportunities for rewilding in England are vast, and there are many scenarios to be considered and explored (Sandom, 2016).

Upper Moss Side (UMS) has changed considerably since the Forestry Commission acquired the site in 2002 when it was fields of desiccated arable grassland, marginal hedgerows and a saltmarsh which was equally dry with minimal swamp coverage. Habitat work on the site, endorsed and commissioned by the Forestry Commission, began in 2006 and finished around 2009. The restoration of UMS started with the Forestry Commission 2005 Design Plan (Forestry Commission England, 2005) and subsequently the planting of over 20,000 trees, and digging many scrapes and ponds, revamping the grassland communities with wildflowers and bird crop seed, and more adding and reinforcing of hedgerows. The restoration work was varied across the site. Section 4.2.1 in the results provides details of the work undertaken, Figure 4.2 indicates where this took place, and Table 4.1, Table 4.3, and Table 4.5 shows how UMS has developed and evolved. Figure 4.4 demonstrates, via a Phase 1 Habitat Survey conducted in October 2018 overlaid onto an aerial photo taken in June 2018, the resultant habitat diversity and varying tree structure, revamped grassland communities, large wetter areas, and a well-established scrub layer. The result, thirteen years after beginning the work, is a mosaic of grassland and woodland of equal coverage interlaced with areas of scrub, swampy vegetation, ponds and scraps. The active restoration work carried out by the Forestry Commission is a common practice in conservation and rewilding.

Many rewilding projects have begun by planting trees or sowing seeds. For example, the conservation charity, Trees for Life, have established 44 tree planting sites and planted nearly two million trees with the aim to rewild the Scottish Highlands by enabling the restoration of the globally unique Caledonian Forest (Featherstone, 2019). The southern block at the Knepp Wildland Project experienced a similar process to what happened in UMS. The block was taken out of arable production and left some 4–6 years before it was grazed, which meant a large amount of scrub was allowed to grow and establish (Greenaway, 2011). This major change in the vegetation structure at Knepp Wildland Project has been beneficial for many of the species that now inhabit the wildest and woolliest part of the project while also sustaining a larger number of herbivores, including pigs (*Sus* sp.) (Tree, 2018a). The low impact management and the lack of disturbance resulting in the development of scrub is a good indication that UMS, in its current state, could contend with the degree of disturbance generated by large free roaming herbivores (LFRH). Knepp Wildland Project has also involved the sowing of 28 ha of former arable and commercial grassland with native grasses and wildflower mix as part of the initial stages of the rewilding project (Greenaway, 2006), and in 2011 participated in the Million Ponds Project with the aim of creating ten ponds a year so that a strategic network of around 100 new ponds are created over the next decade (Pond Conservation, 2011). Actively planting trees and sowing seed will help accelerate the initial stages of a restoration project. This bottom up approach to rewilding can kick start some ecological processes that have not been present for decades. Similarly, the restoration work carried out by the Forestry Commission at

UMS is, in some ways, comparable to some rewilding projects. Because of the bottom up management approach taken by the Forestry Commission, UMS is more in keeping with its surrounding environment (Section 4.8) and has the potential to become something greater.

The local records centre (RECORD LBR (Local Biological Records)) provided historical data of species recorded at UMS and the surrounding area. For analysis, the data were broken down into five groups: amphibians and reptiles, birds, mammals, invertebrates, and invasive species (section 4.3). The limited records of amphibians and reptiles implies that they are present at Moore Nature Reserve but not present at UMS, yet the habitat is more than suitable, therefore, it would be misleading to conclude their absence. The graph of BoCC4 (Bird of Conservation Concern) bird species (section 4.3.2) suggests the numbers have been low since 2005, except for Northern lapwings (*Vanellus vanellus*), but their numbers have declined, therefore, according to the records, no species of concern is increasing. No species in the same graph increased as a result of the conservation grazing regime during 2016 and 2018. This could be because the landscape was still in the early stages of change and the effect of the cattle had not altered the structure and composition of the vegetation enough at UMS to affect the bird community and population numbers (Priestman, 2017b; Söderström, Pärt, & Linnarsson, 2001).

In general, the changes in grassland management over the latter half of the 20th century have reduced the suitability of grassland for feeding (loss of seed resources) and breeding habitat (deterioration of sward height for nesting) for birds (Vickery et al., 2001). Birds of prey species are present, however, since 2006 the numbers are declining in most species recorded. The number of mammals recorded are low with only one count or presence recorded in most cases. All five species of bat (Chiroptera) that were recorded were recorded within the greater boundary in 1999, thus, it cannot be ruled out that they may be present at UMS. There is a bias towards the greater boundary for recording invertebrate numbers and a tendency to record one species over another, such as the lack of data on hymenoptera. Overall, these data suggest insect numbers are declining which is in line with the current State of Nature Report (2019). The graph (Figure 4.8) for butterfly (species Rhopalocera) at UMS indicates either an increase in some species of butterfly or they have stayed at the same level.

From a functionality viewpoint, the mammals recorded are all small in size, except for Badger that is classed as a medium sized mammal. Small mammals play certain roles in the ecosystem, such as, prey in the food web, biological control of insects and rodents, consuming plant material and recycling it back into the soil, seed dispersal, and excavation of tunnels in the ground adding nutrients and aerating the soil. However, the lack of large grazing herbivores and browsers that create natural disturbance, control invasive or dominant species, trample, pollard, rootle, and dung is missing from UMS. Furthermore, based on the result supplied by RECORD LBR, there seems to be a scarcity in the diversity of insects in the area which may be affecting the pollination of plants (Section 4.3.4).

The RECORD LBR data were also used to discover which species and ecological functions were absent. The missing ecological functions exposed by the analysis of the RECORD LBR findings were used when considering which species were suitable for reintroduction to UMS. Their ecological function, activities, and feeding strategy from other conservation grazing or rewilding projects provided evidence of the kind of impact they are likely to have on the vegetation and the wildlife at UMS.

Longhorn cattle (*Bos primigenius*), Exmoor ponies (*Equus ferus caballus*), and Tamworth pigs (*Sus scrofa domesticus*) are known to impact the landscape in a way that can interfere with the course of succession and provide the missing ecological functions absent from UMS. Tropic interactions will increase as a result of certain behaviours and functions of the reintroduced herbivores which will impact the food web.

5.1 Future scenarios

The Future of UMS is set out below under both scenarios. The passive management scenario uses the Markov model which provides an insight into the habitat trajectory for UMS and how that may impact the local biodiversity. Furthermore, an assessment of the plausibility of the current management plans and the likelihood of success is also outlined together with the possible effects of land abandonment. Under the rewilding scenario, a description is provided of how the reintroduced species may impact the landscape. An explanation of how their natural behaviour will encourage and stimulate the movement and regeneration of some plants while disturbing the progression and advancement of others.

5.1.1 Scenario: Passive management

Environmental scientists are often looking at historical ecological change as a useful tool to explain the present ecological state as well as anticipating the future (Jackson, 2007) and models are frequently being used in this process. The Markov model was used to extrapolate current trends to predict a future landcover scenario and many previous researchers have tested and validated this method (Biondini & Kandus, 2006; Halmy, Gessler, Hicke, & Salem, 2015; Roy & Upadhyay, 2015; Weng, 2002). According to the Markov model, the future state of UMS is likely to transition to a woodland habitat while the swamp on the saltmarsh is predicted to expand.

The transition suggested by the Markov model could be perceived as land abandonment. The style of management proposed by The Mersey Forest (2014) and the Forestry Commission (2005) is passive, in which, human intervention is kept to a minimum (Carver, 2019). However, there are different forms of abandonment, such as, land abandonment in Europe when people move from rural to urban areas and just leave the land. The Forestry Commission has not abandoned UMS in that sense of the word, but it has ceased active management or it is allowing succession to proceed. Land abandonment in Europe poses a great opportunity for rewilding (Pereira & Navarro, 2015) since the land, generally in remote regions, is released from agricultural activities and left to regenerate naturally (Keenleyside & Tucker, 2010). Depending on how abandonment is studied and understood, it can be characterised as a threat or an opportunity (Otero et al., 2015). Some studies suggest that land abandonment can have a negative effect on biodiversity (MacDonald et al., 2000), particularly farmland birds. Open habitat bird species seem to be the most sensitive and affected by the habitat loss (Shumka & Topi, 2013; Zakkak et al., 2015).

In the absence of large grazers, natural succession on abandoned farmland often moves from grassland to spiny scrubland (Benjamin, Domon, & Bouchard, 2005). Scrub is a facilitator for tree regeneration as it provides a refuge from browse-sensitive species – pedunculate oak (*Quercus robur*) and alder buckthorn (*Frangula alnus*) (Kuiters & Slim, 2003; Tree, 2018a). The process of succession from abandoned land will move through different stages. In a study conducted in the UK, Harmer, Peterken, Kerr, & Poulton, (2001) found that natural regeneration of woodland on farmland can eventually develop into a dense canopy cover with little direct human intervention. A closed canopy woodland with few strata is typically low in biodiversity with few fungi, plants and invertebrates associated with it (Forestry Commission England, 2009). The impacts of land abandonment on biological diversity may vary for geographic locations, scales, and taxa (MacDonald et al., 2000; Renwick et al., 2013). In areas where agricultural activities are unproductive, measures to maintain open grassland habitats by introducing wild grazers is considered a solution to the negative impacts of land abandonment and has proven effective in areas of Northern Europe (Kuiters & Slim, 2003; Navarro & Pereira, 2012). In cases where corridors and/or core areas are close to abandoned land, ungulates and predators are likely to colonise naturally. The phenomena of wildlife comeback has shown to have a positive impact on the ecosystem (Deinet et al., 2013). As with any change in habitat, there will be winners and losers: farmland birds may decrease in favour of more woodland species as shrubs and trees replace the grassland habitat through the process of natural succession (Plieninger, Hui, Gaertner, & Huntsinger, 2014; Regos et al., 2016). What is evident in the literature is that habitat diversity and niche dimensionality are important for increased biodiversity and improved ecosystem function (Harpole & Tilman, 2007; Loreau et al., 2001).

The possibility of ungulates and predators returning to UMS spontaneously is near impossible, which means it would eventually turn into a woodland habitat that would rely on human intervention as its only form of impactful disturbance.

5.1.2 Scenario: Rewilding

Under a rewilding scenario, it is thought that the spontaneous restoration of mainly native vegetation will take place in the absense of direct human intervention, together with a return of full trophic processes through in migration of species, such as, insects, birds, amphibians, reptiles, and mammals, including top predators and the process of decomposition (Carver, 2019). In the case of UMS, the reintroduction of top mammalian predators is not considered practical; it is too small to support top predators and the presence of top predators could pose a threat to the local communities, towns and cities.

Grazing animals are a crucial part of a terrestrial ecosystem. Historically, they have shaped grasslands, heathland, wood pasture, floodplain and coastal marshes; the plants and animals within these habitats depend on some form of grazing in order to maintain the structure and composition (English Nature, 2005). Removing wild grazers and replacing them with high-density domestic animals has led to overgrazing, soil compaction, erosion and habitat degradation (Priestman, 2017b). The decision to introduce a small number of cattle to ‘conservation’ graze the saltmarsh was to have a positive impact on the vegetation community but avoid the negative impact of overgrazing (Halton Borough Council, 2011). Conservation grazing is used to improve and maintain the habitats which have co-evolved with herbivores and is a widespread method of management (English Nature, 2005). As well as grazing intensity, there are other aspects of this method that are particularly important, such as, stock type, timing of grazing, fencing and barriers, and the resulting habitat structure (Mason, Feather, Godden, Vreugdenhil, & Smart, 2019). Rewilding, on the other hand, acknowledges the benefits of grazing herbivores, but avoids the need to control where and when animals graze and the outcome. In areas where land is unproductive for food production, rewilding is seen as the perfect alternative if the right species and density are selected (Navarro & Pereira, 2012).

UMS has a mixture of habitats and may benefit from the reintroduction of LFRH: Longhorn cattle, Exmoor ponies, and Tamworth pigs. These animals are known to impact the landscape and could potentially create a more diverse environment; they will create disturbances and alter vegetation structures which contribute to a dynamic, ever-shifting mosaic of valuable habitats (Tree, 2018b). Grazing by large herbivores has shown to increase belowground biomass, belowground net primary production and carbon turnover in grassland ecosystems (López-Mársico et al., 2015). Vera (2000) hypothesised that the cycle of open grassland and woodland dynamics are driven by large herbivores; he observed this phenomenon in the high public profile rewilding project at Oostvaardersplassen (Vera, 2009). In the management of ecosystems using large herbivores, density is perhaps the single most important variable. Increasing density beyond the ecological carrying capacity will deplete resources (Van Wieren, 1995).

Since 2009, UMS has experienced very little management which has meant the site has been able to scrub up. Part of the success of the Knepp Wildlands Project is the amount of scrub in the southern block. During the time grazers were excluded from that section for around 10 years until the fencing was put in place in 2009, natural succession developed into a landscape thick in scrub. Once the animals were introduced, the impact of the disturbance was not as severe, and the scrub remains well established and able to withstand the level of impact of various grazers and browsers combined with the rootle behaviour of pigs.

5.2 Feedback from workshop

This study represents the first known attempt to assess the acceptability and practicality of rewilding UMS as a conservation strategy. Studies in other locations have looked at increased provision of ecosystem services (Cerqueira et al., 2015; Keesstra et al., 2018) and the challenges and opportunities for rewilding (Ayres & Wynne-Jones, 2014; Galetti, Root-Bernstein, & Svenning, 2017) but few have studied stakeholder opinion needed for projects to materialise. The results and feedback from the workshop provided a lot of detail on the many issues surrounding the idea. Those opinions and perceptions in comparison to the general consensus on rewilding as a conservation strategy will be discussed in this section.

5.2.1 What do local stakeholders, ecologists and conservationists think of rewilding UMS

As the word rewilding is a multifaceted term that has a complex history of its meaning (Jørgensen, 2015), to clear any misunderstanding as to what rewilding means globally and in the context of UMS, one of the first questions put to the participants was concerning their understanding of the term rewilding and what it meant to them. The most common feature mentioned at the workshop was ‘reduced management’ which corresponds to a number of definitions when referring to rewilding in the European context (Höchtl, Lehringer, & Konold, 2005; Navarro & Pereira, 2012). Conflictingly, *management* was mentioned numerously along with *keystone species and ecological function*, and the *restoration of species and habitats*. The confusion around ‘management’ as a feature of rewilding could be related to the landscape management through species reintroductions that is happening in Europe (Pereira & Navarro, 2015). *Keystone species and ecological function*, and the *restoration of species and habitats* fits well with the concept of rewilding (Rewilding Britain, 2017). Many of the participants understood the meaning of rewilding, which roughly corresponds with the percentage that understood the meaning in a study in Dorset (Loth & Newton, 2018), although the participants largely understood, some important elements of rewilding were missing. This is most likely because there are several uses of the term that all relate to different points in time, geographical context, to different types of species, and with dissimilar reference points. Jørgensen (2014) considers a word almost meaningless if it can be applied to a broad range of activities such as rewilding. Nonetheless, after an overview on the history and the multiple framings of rewilding together with the Rewilding Britain principles, plus some examples of projects, half of the participants felt their understanding of rewilding had changed (Figure 4.17).

The rewilding approach taken in this study is to reintroduce a wild or naturalistic grazing regime, using large herbivores, to mimic wild and natural behaviours that are missing from the landscape. Large herbivores are reintroduced to restore grazing, browsing, dunging, and trampling as processes to allow ecosystems to respond naturally or to maintain or improve the ecological condition (Sandom et al., 2018). However, much consideration should be applied to the type of disturbance required and the appropriate grazer for the task. See Table 4.13. Proposed species reintroduction characteristics: Method of feeding, dietary preferences, and habitat effects. Source: (Mayle, 1999) which lists the species (Longhorn cattle, Tamworth pigs, Exmoor ponies) and the type and level of impact they are likely to have. The results show the majority of the participants felt that the reintroduced species were acceptable for UMS, which is similar to conservation management in the area, and two participants were unsure. Similarly, a naturalistic grazing regime emerged as the most suitable scenario overall from the study in Dorset, while reintroducing wild boar (*Sus scrofa*) was less favourable (Loth & Newton, 2018). Wild boar can cause a large degree of damage to crops and their predation and habitat destruction can greatly affect animal communities (Barrios-Garcia & Ballari, 2012). Similar concerns were raised by some participants, section 4.7.2.3 shows how they remarked on the possible level of damage the reintroduce species are liable to cause and whether UMS has the capacity to deal with it. The level of disturbance caused by pigs or wild boar can be quite substantial when you are investigating the direct damage, but, their spatial and temporal behaviour has shown to positively affect the landscape indirectly indicating that wild boar can be important ecosystem engineers (Sandom, Hughes, & Macdonald, 2013a).

The participants recommended a number of other species, such as: deer (Cervidae), wild boar, sheep (*Ovis aries*) (including ancient breeds), pine marten (*Martes martes*), European beaver (*Castor fiber*), and Konik pony (*Equus ferus caballus*) to be introduced either instead of or alongside the proposed species. Deer numbers in the UK are increasing and government policy has recently moved to encourage more culling (Leadbeater, 2011), introducing this species could be classed as unethical and inappropriate. The wild boar on the other hand is prohibited from reintroduction due to the Dangerous Wild Animals Act 1976. There are currently between 500 to 1000 wild boar in the UK, and none in the area around UMS – they are established on the Kent/East Sussex border, in Dorset, in Devon and in Gloucestershire (Forest of Dean). Animals from the latter site have crossed into Wales and become established in Monmouthshire (Aebischer, Davey, & Kingdon, 2011; Priestman, 2017a), therefore, the chances of recolonization of UMS are low. The European beaver and pine marten were popular choices for reintroduction in a study carried out in Dorset (Loth & Newton, 2018) which shows an appeal for reintroducing flagship species. The issue with the Konik ponies is that it is not a native breed. In areas of Wales they are grazing the uplands instead of the native Welsh mountain pony and this has caused anguish amongst locals (Murray, 2006).

Overall, the participants had a relatively good understanding of rewilding at the outset with only a few misunderstandings that could occur as a result of the concept's many framings. Once more context had been given and more of the participants were cognisant to the meaning of rewilding in the context of UMS, their opinion around the reintroduction of LFRH was pertinent. For the majority, the species proposed were acceptable, however, there were concerns for the level of damage the reintroduced animals might inflict on the vegetation and suggested alternatives species that have been used in other projects. Not all species are appropriate for reintroduction across all sites and some of the species proposed by the participants were not entirely suitable for UMS given the legalities, ethical aspect, and the location of UMS.

5.2.2 Common themes

Several common themes emerge from the data (Section 4.7.3, Table 4.16).

Policy only received two mentions on the word cloud but was of most concern in the wider context by receiving the most mentions throughout the day along with sea level rise as a result of climate change, which is understandable considering the recent departure from the European Union and the uncertainty around new environmental policies. Rewilding is no different to conservation which operates in the context of regulations and policies that govern biodiversity, agriculture, animal welfare, and public safety. The institutions related to these sectors specify the rules and regulations and provide adequate management practices (Gooden, 2016). The policy areas that are particularly relevant to rewilding are biodiversity policy, and agriculture and land-use policy. In the EU, the current biodiversity policy is underpinned in legislation by the Birds Directive and Habitats Directive. These directives are based on highly-managed prescriptive goals, built on the protection of particular species assemblages and habitat types (Jepson, 2016). Rewilding projects focus on ecosystem processes and embracing uncertain outcomes could be difficult to accommodate within this policy framework (Pettorelli et al., 2018). As stated in section 4.7.3.1 the participants warned of social, political, and economic complexities and feared the proposal could *open a whole new can of worms* (Attendee - 02). Contrary to this, one participant believed it was worth incorporating into policy which was the theme at a rewilding workshop in January 2019. Ecosulis (a leading ecological consultancy) identified and discussed complex areas where more supportive policy is required. The aim of the workshop was to clear issues relating to current policy and potentially shift the barriers that are preventing the implementation of rewilding as a conservation strategy (Jepson, 2019).

Another common theme mentioned a great deal was sea level rise as a result of climate change and the impact it may have on UMS. The effect on the estuarine environment varies in the UK; some estuaries are vulnerable to sea-level rise and others more resilient depending on estuary area, sediment supply, sediment transport potential and human interference (Robins et al., 2016). According to Surging Seas Mapping Choices (2020) sea level is likely to affect UMS, a 2°C warming would inundate the majority of UMS while a 4°C warming would put the whole of UMS under water, the point at which this will occur is unknown. For now, the participants accepted UMS would act to increase flood water storage through natural processes which would benefit the surrounding towns (Runcorn, Warrington, and Halton) in the event of sea-level rise. Looking at a global scale and the efforts to minimise the inexorable effects of climate change, Cromsigt et al. (2018) discusses rewilding as a climate change mitigation strategy, however, the effects vary from different biomes and from species to species, plus, there are many unknowns. There are global instances that show rewilding to be effective in the cause to help slow climate change, such as, increasing albedo in the Arctic, carbon storage in tropical forests, and reduce wildfires in areas prone to drought (Bakker & Svenning, 2018). It is possible that rewilding landscape can create a resilient ecosystem, which many participants found important in light of a future climate that is novel and unpredictable.

Another term that was used a great deal during the workshop and can be discussed in the wider context was money, for instance, costs and/or funding. The word money received the most mentions (seven shown in section 4.7.2.4) when the participants were asked *What limiting factors would influence this project?*, but, when asked to rate the level of challenge on the Likert scale (section 4.7.2.5), cost rated a score of 3 out of a possible 5 (5 being they strongly agree that it is a sizeable challenge). The participants did not specify what they meant by *'money'* in the word cloud, but given costs received a score of 3 and was not classed as the greatest challenge then one could presume that they were referring to funding when they wrote money. Their concern around funding is reasonable, raising funds for a conservation project can be complicated. This is because the time frames for government grants and political cycles are in some cases shorter than the time needed to allow ecological processes to operate (Root-Bernstein, Gooden, & Boyes, 2018), which would prove more difficult for a rewilding project since the time frame is even greater still. Another challenge is that funding is unreliable and can shift, for instance, in Europe, the funding has now shifted toward mitigating the impacts of agricultural intensification and the funding for wildlife habitat has decreased (Ceausu et al., 2015), therefore, the application for funds needs to meet the specified government criteria at the time in order to obtain the funds. In order to incorporate rewilding into UK policy, a shift in mindset is needed to allow for flexibility, long-term thinking and adaptive learning, which could ensure rewilding success in practice (Root-Bernstein et al., 2018).

From a management costs point of view, one participant saw a long-term positive (+100 years) in the reduced public spending on flood defences, which is representative of many wetland restoration and water management projects organised and financed by Rewilding Europe (Rewilding Europe Capital, 2017). Rewilding UMS and, thereby, restoring dynamic, self-sustaining ecosystems and significantly reducing management costs would alleviate the pressure downstream in the future (Jepson & Schepers, 2015).

At the local scale, public opinion and acceptance were the most pressing issue, while education was mentioned a number of times as a tool for public acceptance, the results are shown in section 4.7.3.2. This has been validated by Gundersen et al. (2017) who found that education is an important method in communicating knowledge and bridging the gap. In a forest study, he found that people tended to dislike forest stands with structures like windfall or dead wood; providing information about the ecological function of such components, however, led to more positive valuations. It is a similar case in cities, Kowarik (2018) found that people's valuation patterns can change when information about historical, social, and ecological functions of urban wilderness is provided. It was clear amongst the participants that education was key and could encourage people to be more accepting, especially at the early stages through community meeting. Signage around UMS was recommended by one participant who believed it is a good way to communicate and educate the public. Interpretation provides the communication link between a landscape and its visitor; it can engage and encourage people to explore nature and care about the environment (Honig, 2000).

Participants suggested offering UMS as a site for biological monitoring and research. As rewilding is gaining popularity across Europe, it is important that scientific research follows. While there are plenty of popular rewilding projects (Bulkens, Muzaini, & Minca, 2016; Galetti, Pires, Brancalion, & Fernandez, 2017) there is little empirical evidence to support their success. There is anecdotal evidence, personal experience, expert opinion and conventional wisdom to confirm that rewilding has, in most cases, had a positive impact on the landscape, however, empirical evidence is required to support these claims; although much could be achieved by adequately synthesising existing information (Pettorelli et al., 2018). Recent reviews have concluded that the literature on rewilding remains heavily dominated by essays and opinion pieces, rather than data-driven studies (Lorimer et al., 2015; Svenning et al., 2016). Science has a clear role in identifying, understanding, and restoring ecosystem functions, but more research is needed to understand the novel interactions and outcomes possible with rewilding. As a process, it can reveal new information about the functioning of the natural world and in this way advance ecological theory. Monitoring and reporting on rewilding projects will help overcome the challenges and the polarization that has occurred around this form of conservation (Torres et al., 2018).

UMS could offer students at all levels (under- and post-graduate) the opportunity to add to a database of growing empirical data on rewilding. Baseline studies and continuous monitoring of open-ended large-scale projects is important because they are largely exploratory and unpredictable thus long-term monitoring is vital. Reporting back to stakeholders and the local community on the progress and developments will keep them informed and engaged, and through various measures, the value of the project can be understood (Hughes et al., 2011). UMS offers the research world, from many science and social disciplines, an opportunity to monitor the impact of rewilding with LFRH. Quantitative and qualitative, data-driven research is needed to plug these gaps in knowledge (Pettorelli et al., 2018).

On the word cloud 'conflict' received four mentions. The type of conflict was not specified, but, in conservation the most common types of conflict are human-wildlife or between people. In the case of rewilding, the major issue is between groups of people: Carver (2016) and Saunders (2016) agree that conflict between parties, such as, NGOs, landowners, farmers, foresters, gamekeepers, and water companies is an issue. The different levels of conflict range across issues such as political drivers, human-nature relationships, cultural anxieties, and the neoliberalisation of nature (Carver, 2016). The participants at the workshop acknowledge this view by rating landowners and neighbouring landowners the highest score of 3.9 on the Likert scale and, therefore, the greatest challenge.

Opposing views can occur between those that regard cultural heritage (a human-centered view of the landscape because it offers a sense of place and meaning) to be more valuable than the natural environment (values rich biodiversity and landscapes for their natural value) or vice versa, because each party sees the landscapes differently and have different interpretations (Drenthen, 2018b). Public perception/opinion scored 3.4 on the Likert scale which confirms the opposing views.

Drenthen (2018a) writes about the views of those that live in culturally saturated landscapes who reject rewilding projects because they are deeply connected to their environment and care about old cultural values. The idea of unmanaged nature is generally accepted in western societies but mainly with young educated urban dwellers with little connection to the land (Bauer & Von Atzigen, 2018). It is local residents that generally oppose the establishment of new wilderness areas as it may be perceived as land abandonment (Hunziker et al., 2008). Bauer, Wallner, & Hunziker (2009) believe it is crucial to take public opinion into account if future landscape management, in the form of rewilding, is to be supported. Knowledge can play a role in influencing attitudes; people can become more positive when they are provided with information about ecological functions (Gundersen et al., 2017). There is a need for rewilding to be flexible in these situations and keep an open dialogue with society (Svenning & Faurby, 2017).

The participants mentioned ‘scale’ four times in the word cloud and on the Likert size/scale it scored 3.6. This study shows that the size of the land area is of importance when contemplating rewilding and can be considered a challenge. Perhaps this notion has developed through the purest view of rewilding which is that of the restoration of self-regulated wilderness areas and top down cascades provoked by top predators which Foreman (2004) applies to vast areas of land in North America. Small-scale rewilding scenarios such as those explored in this study have been criticised as being just as engineered and artificial as other types of land management and, therefore, not worthy of the name rewilding (Corlett, 2016b). Others argue that opportunities for restoring ecological processes exist at all scales and in all landscapes (Jepson, 2016; Moorhouse & Sandom, 2015). During the 19th century, large natural areas were the focus of conservation efforts (Oelschlaeger, 1991), but areas of wilderness are now observed in urban landscape from woodlands to abandoned allotments, river corridors, and derelict or brownfield sites (Diemer et al., 2003; Jorgensen & Tylecote, 2007). Rewilding in the city is actively being promoted with small scale rewilding projects occurring on the streets with projects such as ‘Rewild my street’ which seeks to inspire and empower London residents to adapt their own homes, gardens and streets for wildlife (Moxon, 2019). It is no surprise that some participants felt UMS is possibly too small for rewilding or does not have the capacity to cope with LFRH since wilderness and urban environments have long been traditionally viewed as antithetical (Vicenzotti & Trepl, 2009).

When it comes to the management of UMS, the majority believed that a good long-term management plan was necessary. The bigger the areas and the wilder it seems to be the less management is required and the more natural it is, but with UMS, their seems to be a level of management necessary because of its size and location. When the participants were asked *what's (more) important for UMS* the majority thought managing for increased biodiversity and resilience was more important than managing for a target habitat and target species indicating the opportunities out way the risks. The perception of the participants as to what style of management is appropriate may well depend on their view of what is possible at UMS. Sandom et al., (2018) found that participants perception of risks and opportunities associated with the reduction or cessation of human management increase with spatial scale. In large intact ecosystems where recolonization is high, passive management is perceived to allow natural process to occur and support a functional and diverse ecosystem. However, a more impoverished ecosystem that has a low natural recolonization potential and currently supported by human management, may risk further homogenizing of the system because of missing ecological processes. Those participants that believed it is more important to manage for a target habitat and target species may feel the risks out way the opportunities in this instance.

Most of the participants have extensive experience of land management and have demonstrated good environmental improvements, but one participant acknowledged that this is against a national/global backdrop of declining species and habitat loss etc. According to the Living Planet Index, a biodiversity metric that measures the average change in species abundance over time, there has been a 60 per cent decline in vertebrate population abundance from 1970 to 2014 (WWF, 2018). The failure to halt the loss of biodiversity has sparked a debate about the effectiveness of traditional conservation practices aimed at protecting selected at-risk species (Lorimer, 2015). Increasingly, the focus of conservation practice has shifted from the maintenance of specific species assemblages towards the promotion of naturally functioning and self-regulating ecosystems at larger scales (Corlett, 2016a). The focus of rewilding is on restoring ecological processes to create more self-organizing and self-sustaining ecosystems. Rewilding is aimed at delivering positive outcomes for biodiversity and society in general terms, but it typically represents a move away from species-and habitat-specific targets, allowing nature to determine these outcomes instead (Sandom & Wynne-Jones, 2018).   One participant disagreed with that concept but believed it is important to manage large-scale but with species focus while another believed a new approach was needed and recommended rewilding as a concept worth investigating.

Three participants commented on peoples' innate desire to manage and control nature. Bauer et al. (2009) has studied the relationship of humans with nature and identified four possible general attitudes towards nature: nature lover, nature sympathiser, nature-connected user, or a nature controller. The latter can be considered to have an old-fashioned anthropocentric value, but it is not fixed in time and may shift as their circumstances change or if their level of knowledge or experience changes. Rewilding can challenge our view of nature and take us beyond the mindset of good nature/bad nature to acknowledging that nature doesn't work to human rules (Carver, 2016).

5.3 Connectivity

Connectivity is the degree to which landscapes and seascapes allow species to move freely and ecological processes to function unimpeded (Taylor, Fahrig, Henein, & Merriam, 1993), unfortunately, many habitats are fragmented which reduces biodiversity and weakens ecosystem function and the effects are greatest in small isolated fragments (Haddad et al., 2015). The peri-urban location of UMS, situated on the Mersey Estuary corridor, puts it in a position to be part of something bigger. UMS is cocooned by the Mersey Estuary and Manchester ship canal with Moore Nature Reserve to the east and north of Moor Nature Reserve is the former landfill site, Arpley. However, there are a number of stakeholders in and around UMS, such as, The Peel Group (a major, local land owner), Forestry Commission, Mersey Gateway Environmental Trust, United Utilities, and independent farmers with varying interests and plans for how the land should be used or managed, which could be a barrier to the potential project. The surrounding landscape provides rewilding opportunities beyond the boundary of UMS. Further afield to the east and west along the Mersey Estuary are SSSIs, SPAs and LNRs which are disconnected. UMS has the potential to form part of a connectivity network in the area and would provide refuge for the local wildlife making the journey along the river. This section will consider the possible opportunities of extending UMS to the Greater boundary and the impact that may have on the surrounding designated sites.

Within a 10 km radius of UMS there is over 18,000 ha of designated areas – SSSI, SPA, Ramsar, and LNR - Table 4.17 in section 4.9 lists the sites within the radius plus their size in ha and distance from UMS. To the north and south of the river, these sites are fragmented and difficult to reach due to urban sprawl, but the sites to the east and west – Woolston eyes and the Mersey Estuary – are directly along the river - Figure 4.22 shows the location of UMS in relation to those sites.

Designated sites are crucial for species to survive, therefore, identifying the proximity and likelihood of possible connectivity or dispersal is fundamental when considering the future management of any site. The area around UMS is relatively urbanised, however, there are fragmented areas of green space that are in favourable condition and relatively close to UMS. UMS, part of a green belt, is currently protected from urban sprawl and has the potential to become a designated site for its nature conservation importance either by the extension of the Mersey estuary or by joining up with Moore Nature reserve and possibly Arpley Landfill. A designation will provide protection and the already valued habitats that surround UMS will be enhanced spatially.

SSSIs have a high level of protection but were not designed to include a coherent and resilient ecological network. To enhance their resilience Lawton et al. (2010, p. 56) suggests *we… enhance connections between, or join up, sites, either through physical corridors, or through 'stepping stones*. In doing so, species are able to move between core areas using the corridors or 'stepping stone' sites when in search for food, nest sites, or a mate. Wildlife are known to move parallel along riparian corridors (Sánchez-Montoya, Moleón, Sánchez-Zapata, & Tockner, 2016). Some species rely on riparian areas at some point in their life history (Naiman & Decamps, 1997). Corridors allow species to traverse freely through the various habitats that align the banks. Habitat loss and fragmentation are a huge challenge for wildlife but rivers have the capacity to connect vast areas of land, they meander through a variety of habitats from the sea to the great forests inland and the upland moors (Taylor, 2013). Fremier et al. (2015) highlighted the importance of rivers and riparian corridors as a strategy for connecting protected areas as they have a higher rate of conservation management than terrestrial lands.

Increasing the number of wildlife habitats along the Mersey Estuary or adding to the network of corridors may increase the number of species that recolonise naturally. Reconnecting isolated areas of wild nature via wildlife corridors can provide an effective method of enhancing biodiversity and boosting animal populations. The exchange of individuals from different populations can increase gene flow, ease intraspecific competition, mitigate inbreeding, boost population size and lead to more viable populations (Lacy, 1997; Rewilding Europe, 2018c; Wasserman, Cushman, Shirk, Landguth, & Littell, 2012). Dispersal between metapopulations maintains local demographic and increases the probability of species persistence (Keyghobadi, 2007). The improvement of connectivity within and among landscapes to promote dispersal is an important feature in the rewilding approach (Perino et al., 2019). However, there is no guarantee that species will recolonise just because the habitat has been created. A self-assembling ecosystem is appealing when time and budgets are limited but the dynamic nature of community assemblages makes this difficult to predict (Miller & Hobbs, 2018). That said, the provision of a suitable environment to allow wildlife to return is more beneficial than not. Through a reduction in threats, increased conservation efforts and a change in land use, Europe is currently witnessing high levels of wildlife comeback across the continent with the help of viable wildlife corridors that are connecting core areas (Deinet et al., 2013).

Under the rewilding scenario, the species reintroduced are not intended to roam beyond the limits of UMS or the Greater boundary, if extended. Therefore, reintroducing animals to a fenced reserve will present issues if the natural population rises above the carrying capacity and results in overcrowding. To begin with, herbivore species and densities affect vegetation-structure patchiness (Nolte, Esselink, Smit, & Bakker, 2014), and at high densities vegetation becomes overgrazed which may result in a total ecosystem collapse (Kondoh, 2003). With nowhere else to graze, the matter then moves to that of an animal welfare issue. At Oostvaardersplassen, man-made natural barriers were created around an area provisioned for wilderness and the population became overcrowded; the barriers were unnatural and robbed the animals of the possibility to fend for themselves in adverse times (Theunissen, 2019). The rewilding project at Oostvaardersplassen lacked the three Cs that underpin rewilding: cores, corridors, and carnivores. In the absence of free movement between core areas and the impossibility of introducing predators then compassion must be shown (Kopina, Leadbeater, & Cryer, 2019). The option of lethal control or culling seems the most plausible form of action; humans are accountable for the welfare of the animals in a reserve that has been created by humans. The culling of animals however should be for the benefit of the animal(s), not for the interest of increasing biodiversity, as is the case with deer culls, and one species should not be more favourable than another because of the value we ascribe to them (Leadbeater, 2011). A non-lethal method of limiting population size is fertility control which has been effective at limiting the number of free roaming feral cattle in Hong Kong with no adverse effects (Massei et al., 2018). In order to reduce overcrowding and maintain a healthy population of LFRH that do not overgraze then some form of control is essential.

5.4 Flood protection

The Environment Agency has managed the bund that separates the saltmarsh from the rest of UMS for the protection of the properties that are on the floodplain. The saltmarsh acts as a natural sponge by retaining water in the river basins, slowly releasing water down river and into groundwater. Moreover, the saltmarsh plays a fundamental role in the water cycle regulation, filtering out pollutants, water purification, and flood/storm protection (Pereira & Navarro, 2015). The bund acts as a defence in times of high water but the maintenance of it has now ceased and in time the land behind the bund will be connected with the Mersey estuary and store water temporarily to alleviate the risk of floods in Warrington. This practice is being carried out elsewhere in the UK. Dingle Marsh is a 93 ha wild marshland in Suffolk that has been classed as one of the UKs most exciting rewilding projects by Trees for Life (2019). The flood defence at Dingle marsh is no longer being maintained which will result in landward retreat as a result of the increasing pressure from sea level rise. The habitat, currently grazed by cattle and horses, will naturally evolve and transition overtime, a concept accepted by the Environment Agency (Franks, Pearce-Higgins, Ausden, & Massimino, 2016). Grazing is normally associated with reduced above ground biomass and soil compaction potentially impairing coastal protection through diminished wave attenuation and high rates of runoff (Davidson et al., 2017; Mason et al., 2019). Allowing the bund to weaken and using nature based solutions, such as, low density cattle and horse grazing to maintain the vegetation and structural diversity and facilitate better soil structure and infiltration (Bilotta et al., 2007; English Nature, 2005) could leave UMS less susceptible to high rates of runoff creating an important flood mitigation zone. Other projects that have identified the importance of restoring hydrological processes on marshland, fen, and along the coast also use a low density grazing regime (Hodder, Douglas, & Newton, 2010). For example the Great Fen, Cambridgeshire has been working to connect up protected areas of fenland as it recognises the benefits of scale and connectivity across the landscape for flood mitigation (The wildlife Trust, 2019) and Soar Valley, Leicestershire is working with natural processes to reduce the amount of water in a flood and delay its arrival flow downstream (Devine, 2020). On a greater scale in Europe, Kempen-Broek, in the Netherlands, is a large rewilding project that has sort to consolidate areas of marshland. The area is naturally grazed by herds of cattle, horses, and red deer; their actions have created a landscape mosaic that is now rich in biodiversity and increased ecological function (Rewilding Europe, 2018b). The outcome has been an increase in water storage leading to a reduction in downstream flood management (Jepson, Schepers, & Helmer, 2018). Similarly, in the Ukraine and Romania, bunds have been opened up in the Danube Delta, which has restored the flood regime in agriculture polders leading to a good recovery of the diversity and a reconnection to the river and restored ecosystem processes and productivity (Jepson, Schepers, & Helmer, 2018). Rewilding with LFRH on wetlands is proving successful, but more research in this area is needed to understand the mechanisms behind the process to support the initiative. The cessation of the bund maintenance at UMS will allow tidal water to inundate the rest of UMS but increasing the scale to incorporate Moore Nature Reserve and Arpley Landfill will lessen the impact of flooding downstream. As climate change accelerates sea-level rise will cause some marine habitats to expand, and others diminish (Robins et al., 2016), UMS may lose its existing saltmarsh or it could retreat inland which would also see a shift in the existing habitats. Increasing the scale to the Greater boundary would not only increase flood protect but could allow animals to retreat inland too, reduce water pollution, increase carbon storage and restore degraded soils in the long term (Hodder et al., 2010).

The benefits of improved ecosystem function over a larger scale are recognised elsewhere. Ambitious rewilding projects across the UK are working towards increasing the scale of their work to create large core areas, for example, the Cambrian Wildwood project is now part of a wider vision covering 10,000 ha of the Cambrian Mountain and Trees for Life have a 200-year ambition of rewilding an enormous core area in the Scottish Highlands (Sandom & Wynne-Jones, 2018). Connecting the greater boundary will create one big core area and could be among the bigger rewilding projects in the UK covering over 500 ha.

5.5 Conclusion

The aim and objectives of this study set out to discover whether it was acceptable and practical to rewild UMS using stakeholder-assisted multi-criteria analysis. By way of a workshop that included participants who are involved in the management of the area or have an interest in how it is managed, ecological data was presented along with a history of rewilding and what it meant for UMS plus the opportunities and challenges associated with this relatively new concept.

While this study has shown that rewilding can be a suitable strategy in a lowland landscape comprising of mixed habitats and in close proximity to the urban environment, it is important to stress that this does not apply to all definitions of rewilding. Not only does UMS lack size but it also lacks wilderness in its truest form, therefore, some academics might criticise the project as being artificial and not worthy of the name rewilding (Corlett, 2016b), which is worthy of consideration when comparing UMS to rewilding projects in North America and some parts of Europe. The participants at the workshop who point out the challenges associated with rewilding UMS did so with good reason; the area is too small, it is not a core protected area, and it lacks predators. However, there are elements of rewilding that can apply that would benefit biodiversity. The participants were in favour of reintroducing species and believed the idea of rewilding UMS was acceptable. The practicality of rewilding UMS comes with issues and challenges that need addressing, but this is something that could be resolved if all the involved parties work in partnership. It is also an opportunity to bring nature, semi-wild free roaming nature closer to urban areas for the benefit of the people.

There are a number of limitations within this study which if addressed would improve the quality of the outputs. The data received from RECORD have limitations. These data are derived from volunteers who collect data when they visit sites. Often these data are not collected following scientific protocols. There is also biases towards certain taxa and the data are recorded as ‘presence-only’ and lack more detailed information, such as, ‘not-present’ and abundance. Improved data would facilitate refining the baseline ecological data. The method used in this study is applicable and transferrable to other sites if the ecological data are available. However, the limitation are not exclusive to this study, incomplete ecological records would pose the same issues regardless of site or study.

The increase in the number of individual trees from 2009 to 2018 at UMS was a limitation as the Markov model was not able to predict how many individual trees may be present at a future date based on historical data in the same way it can for the area of specific land covers.   The number of trees rose considerably from 2009 to 2018 which would add to the extent of the tree coverage and the prevailing woodland habitat. This underestimation lessened the degree to which woodland would succeed in 20027. This limitation could be overcome by using a polygon that has an area surface instead of a point. By using a polygon all the vegetation at UMS would be included in the trajectory. The Markov model has been used and proved in research, it is applicable to any land cover and is transferrable to other sites provided historical data or aerial imagery is available.

The absence of the Forestry Commission and The Peel Group, who are major stakeholders in the Upper Mersey Estuary, from the workshop was another limitation to the study. The lack of engagement from these and other organisations suggests that more work is necessary to ensure a full and comprehensive view on the rewilding of UMS is received and analysed. The opinion and feedback from major actors at the workshop would strengthen and bolstered the results. Workshops are an effective strategy for sharing ideas, voicing concerns, and gaining support from the local community and its stakeholders, without the view and perspective of key players the project lacks backing, and results are weakened.

There is ample opportunity to research alongside the findings of this study. The framework that underpins this study could be extended to the whole of the Upper

Mersey Estuary. On the assumption that the same or similar data were obtainable then it has the potential to be applied further afield to other estuaries around Britain and small peri-urban sites. The assessment of natural capital and the implications rewilding UMS might have on the wider community on a financial level was not studied here but offers the potential for future research. If the rewilding scenario was to move forward and actioned, then there are many monitoring opportunities available to strengthen and support the limited empirical data available on the implications of rewilding.

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Appendices

Appendix 1. Table 1a-d showing land cover transitional matrix for Upper Moss Side (inclusively), Norton, Moss Side, and Lapwing between 2009 and 2018 (square meters).

Table 1a. Land cover transitional matrix between 2009 and 2018 (square meters) for Upper Moss Side (inclusivley).

	2018										
2009	Bund	Farmland	Grassland	River	Road	Saltmarsh	Scrub	Swamp	Trees	Vegetation	Open Water
Bund	0.975658	-	-	-	-	0.000502	0.000008	0.000516	0.023316	-	-
Farmland	-	0.987135	0.000056	-	-	0.000022	-	-	0.010801	0.001986	-
Grassland	-	0.000218	0.588478	-	-	-	0.026391	0.010196	0.367985	0.004168	0.002563
River	-	-	-	0.857950	-	0.038187	-	0.103863	-	-	-
Road	-	0.001296	0.005741	-	0.948812	-	-	-	0.041968	0.002183	-
Saltmarsh	0.001118	-	-	-	-	0.837612	0.000002	0.137770	-	-	0.023497
Scrub	-	-	-	-	-	-	-	0.138495	0.861505	-	-
Swamp	0.000770	-	0.036473	0.041002	-	0.062692	-	0.762344	0.088043	-	0.008676
Trees	0.000351	0.002388	0.026160	-	0.000066	0.000015	0.003484	0.001412	0.966081	0.000044	-
Vegetation	-	-	0.009594	-	0.000128	0.000718	0.006152	-	0.000019	0.983389	-
Open Water	-	-	0.012815	-	-	0.007905	0.000001	0.016427	0.412761	-	0.550091

Table 1b. Land cover transitional matrix between 2009 and 2018 (square meters) for Norton.

	2018							
2009	Bund	River	Saltmarsh	Scrub	Swamp	Trees	Vegetation	Open Water
Bund	0.975658	-	0.000502	0.000008	0.000516	0.023316	-	-
River	-	0.857950	0.038187	-	0.103863	-	-	-
Saltmarsh	0.001118	-	0.837612	0.000002	0.137770	-	-	0.023497
Scrub	-	-	-	1.000000	-	-	-	-
Swamp	0.001284	0.068337	0.104488	-	0.811824	-	-	0.014067
Trees	1.000000	-	-	-	-	-	-	-
Vegetation	-	-	-	-	-	-	1.000000	-
Open Water	-	-	0.034064	-	-	-	-	0.965936

Table 1c. Land cover transitional matrix between 2009 and 2018 (square meters) for Moss Side.

	2018									
2009	Bund	Farmland	Grassland	Road	Saltmarsh	Scrub	Swamp	Trees	Vegetation	Open Water
Bund	1.000000	-	-	-	-	-	-	-	-	-
Farmland	-	0.987135	0.000056	-	0.000022	-	-	0.010801	0.001986	-
Grassland	-	0.000339	0.594426	-	-	0.040917	0.015782	0.340017	0.004545	0.003974
Road	-	0.166390	0.059123	-	-	-	-	0.774487	-	-
Saltmarsh	1.000000	-	-	-	-	-	-	-	-	-
Scrub	-	-	-	-	-	-	0.138495	0.861505	-	-
Swamp	-	-	0.041569	-	-	-	0.904739	0.053692	-	-
Trees	0.000058	0.003869	0.004119	-	0.000024	0.005644	0.002288	0.983997	-	-
Vegetation	-	-	-	-	0.003095	0.026506	-	0.000083	0.970317	-
Open Water	-	-	0.100090	-	-	0.000005	0.126717	0.541557	-	0.231632

Table 1d. Land cover transitional matrix between 2009 and 2018 (square meters) for Lapwing.

	2018					
2009	Grassland	Road	Swamp	Trees	Vegetation	Water
Grassland	0.577672	-	0.000048	0.418797	0.003483	-
Road	0.005322	0.956258	-	0.036219	0.002200	-
Swamp	0.093979	-	0.675912	0.229486	-	0.000623
Trees	0.061744	0.000172	-	0.937969	0.000114	-
Vegetation	0.012493	0.000167	-	-	0.987340	-
Open Water	0.000001	-	0.000320	0.536679	-	0.463000

Appendix 2. Questionnaire used at the workshop.

MERSEY GATEWAY ENVIRONMENTAL TRUST

University of Salford MANCHESTER

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Question 1.

Name:

What is your understanding of REWILDING? Key characteristics Principles Aim/ambition
And now...?

Question 3.

Name:

What's (more) important for UMS: Managing for a target habitat/species <u>OR</u> increased biodiversity and resilience?
How and why?

Question 4.

Name:

Are the reintroduced species presented acceptable for UMS?
If not, why and what would you change?

University of Salford MANCHESTER

Question 6.

Name:

Do the challenges outweigh the benefits or vice versa? Please explain your answer.

Question 7 & 8.

Name:

Is it ACCEPTABLE to rewild UMS? And why?
Is it PRACTICAL to rewild UMS? And why?

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