Re-wetted land use capability assessment for North West England

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Summary

There has been renewed interest surrounding the long-term environmental sustainability of wetlands in the UK, stimulating a move away from non-essential artificial drainage in low-lying agricultural areas. This paper uses a variety of geospatial datasets alongside the ecosystem service models within LUCI to assess the current state of ecosystem services in Alt and Crossens catchments. Outputs for alternative future scenarios, based on the anticipated levels of re-wetting, identify where alternative management strategies are required to benefit both the environment and stakeholders in the long-term.

KEYWORDS: ecosystem services; artificial drainage; wetlands; carbon storage; land-use change

1. Introduction

Ecosystem services are the benefits that people obtain from ecosystems (Millennium Ecosystem Assessment, 2005). These services are so diverse and widespread within society that humans are fundamentally dependent on the flow of resources throughout the environment. Wetland habitats play an important role in the function and processes underpinning various services, creating a foundation for provisioning, regulating, cultural and supporting ecosystem services (Kadykalo and Findlay, 2015). One particularly significant service in wetlands is peat development; peatlands cover 3% of the global land area, yet they store 600 gigatonnes of carbon (Yu et al., 2011).

For the last 300 years humans have heavily managed the environments around themselves to preferentially maximise the yields of specific services over others, leading to the degradation of 60% of global ecosystem services (Millennium Ecosystem Assessment, 2005). This is particularly prominent in wetland ecosystems whereby artificial drainage is a major method of land modification. Through the lowering of water tables, notably by pumping stations, 68% of organic soils in the UK have been drained (RRR, 2017). Despite the increase in the land fertility, rates of peat degradation are now 50-100 times greater than peat accumulation, causing the transition of peatlands from a sink to a net source of carbon emissions (Environment Agency, 2011).

Due to recent budget cuts and changes to DEFRA policy, the Environment Agency (EA) has committed to phase out non-essential drainage works (LCC, 2014). Unless an alternative public body, such as an Internal Drainage Board, steps forward to fund the future maintenance and operation of drainage channels and pumping stations, re-wetting will ensue. This has stimulated an on-going debate with land owners as reduced crop yields from conventional agriculture are expected (Millennium Ecosystem Assessment, 2005). However, re-wetting has been shown to mitigate against land degradation, and benefits other ecosystem services. One option for this is a phased approach, involving the closure of low-priority pumping stations as well as the reduced maintenance of arterial drains in sub-areas. This will limit the restoration of the natural water table within cell boundaries whilst providing localised flood storage.

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2. Aims

The focus of this research is to inform policy makers and land owners about the potential for alternative land use and land cover (LULC) combinations in the Alt-Crossens catchments under future, wetter soil conditions. This paper reviews the current state of ecosystem services in these study areas by assembling and manipulating appropriate datasets to create useful inputs that can be processed by ecosystem service models. Following the creation of a baseline representing present-day ecosystem benefits, local data and knowledge will be integrated to augment the analysis under future environmental conditions.

3. Site Description

The Alt-Crossens study area is 454km^2 in size, consisting of predominantly low-lying, agricultural land between the Ribble and Mersey Estuaries in South West Lancashire. A large proportion of both catchments lie within 5 metres of the sea level and are naturally prone to flooding. Around 27% of the land is urbanised whilst 40% of the area contains fertile, peaty soils that support a wide variety of agricultural processes (**Figure 1a**). 60% of the grade 1 and grade 2 agricultural land across the north west of England is located in the Alt-Crossens (Environment Agency, 2009), symbolising the area's economic importance and capacity to support a wide range of arable crops. This is predominantly due to the operation of the Altmouth and Crossens pumping stations alongside several smaller satellite stations (**Figure 1b**), which have a combined annual cost of £3 million (Environment Agency, 2010; Environment Agency 2011). Peat wastage, the term associated with the shrinkage, compression, oxidation and erosion of peatlands, is driven by drainage practices for conventional agriculture. Reported wastage rates are 0.44-0.79m per century in pasture fields, and up to 5m per century for arable farming and horticultural practices (EA, 2011). Studies identify a 20% decrease in yield models over a period of 20 years, highlighting the importance of sustainable practices on peat soils in Alt-Crossens (Graves et al., 2015).

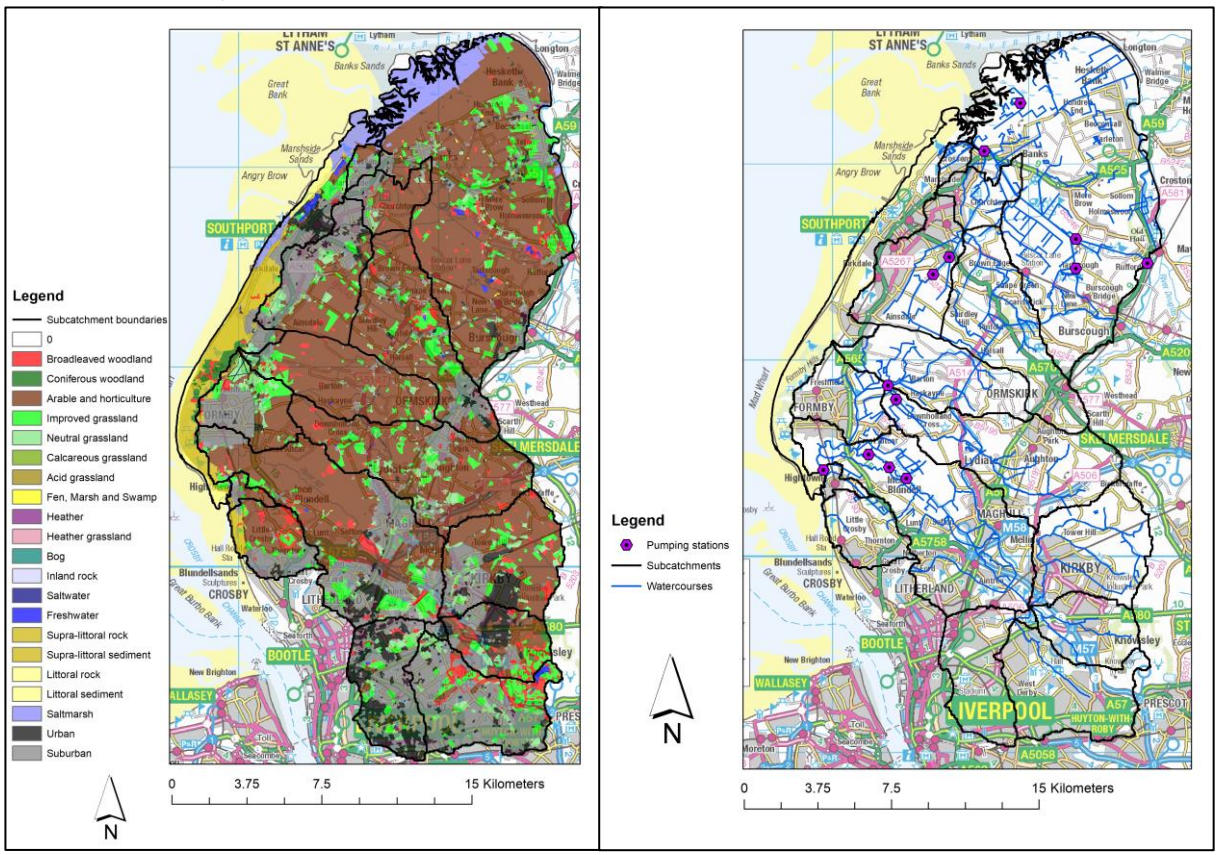

Figure 1a: Reported Land Cover in the Alt-Crossens catchments.

Figure 1b: Water pumping stations and watercourses within the Alt-Crossens.

4. Materials and methods

Bagstad et al (2013) identifies how LUCI (Land Utilisation and Capability Indicator) shares a number of features with other decision support frameworks, whilst being the only tool that is suitable for both landscape and site-scale modelling. Despite this, the extensive application of the model within the UK has been limited to the Conwy catchment, Wales (Sharps et al., 2017). LUCI, a spatially-explicit ArcGIS-based toolkit, explores how changes in the configuration of landscape features influence the holistic and spatial manner of ecosystem services (Trodahl et al., 2017). Ecosystem services provided by contemporary land management are compared against estimates of the future capabilities, and utilise these outputs to identify candidate areas for intervention, or whether maintenance of the status quo is suitable (LUCI, 2018).

LUCI produces a variety of map outputs within ArcMap to represent the spatial extent and wealth of different functions within ecosystem services. The toolkit functions processes inputs data for multiple ecosystem services simultaneously, predicting the future mix of services based on environmental conditions governing land cover (LUCI, 2018). Using high-resolution datasets (**Table 1**), supplemented by detailed local knowledge, a framework will be created to determine the most-suitable land management practices for the Alt-Crossens catchment (**Figure 2**).

A multiple-criteria decision analysis (MCDA) will enable informed decisions to be made for different LULC scenarios, determining the most-appropriate management strategy across candidate areas. Integrating the requirements of stakeholders, land managers and policy-makers helps identify the most-suitable areas for LULC change, their spatial relevance in relation to re-wetting, the economic feasibility of decisions and the expected benefits. As reported in Thomas et al (2013), an extensive analysis of the relevant literature can be utilised as a proxy to create a decision framework. This enables logical decisions and outputs to be created whilst satisfying multiple demands, such as the economic output of the land and biodiversity benefits.

Table 1: A list of the basic data requirements for modelling ecosystem services.

Input layer	Resolution	Source	Ecosystem services
Digital Terrain Model	5m	Ordnance Survey	Production, Erosion, Sediment retention
Slope	5m	Derived from Ordnance Survey DTM	Production
Aspect	5m	Derived from Ordnance Survey DTM	Production
UK Land Cover Map 2015	25m	Centre for Ecology and Hydrology	Carbon stock, Sediment retention and Carbon stock
Soilscapes NATMAP	5m	Cranfield University	Carbon stock and Erosion
Agricultural Land Classification	5m	Natural England	Economic land valuation
Drainage	5m	Derived from Ordnance Survey DTM	Production

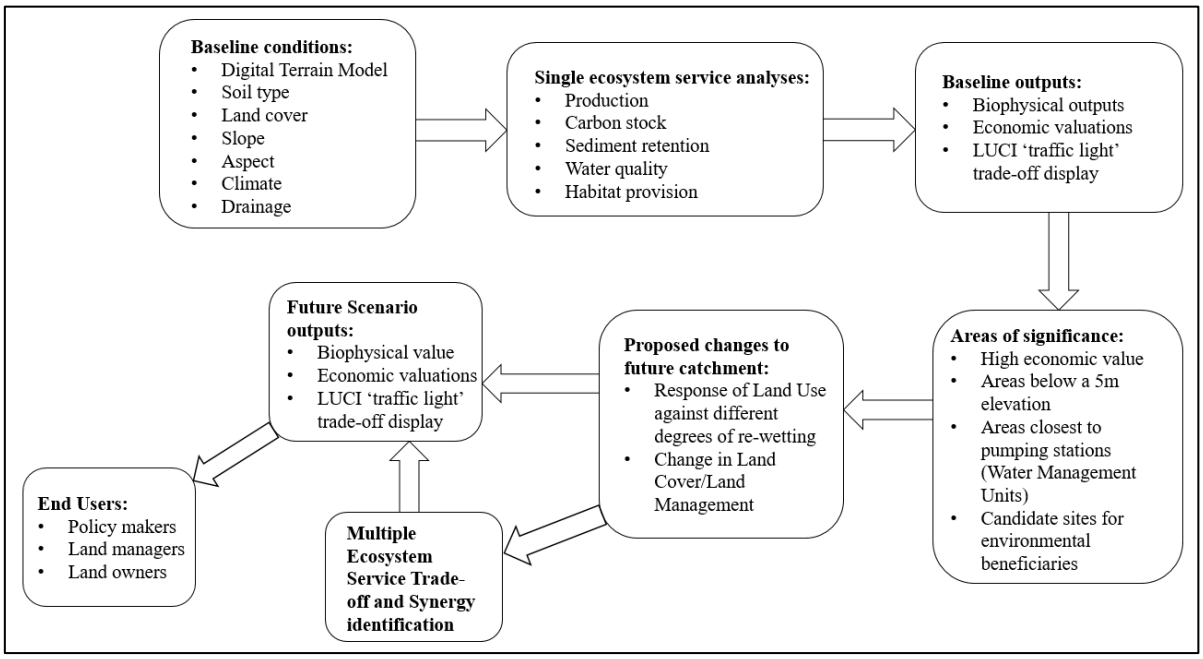

Figure 2: Proposed LUCI process diagram

5. Results

As an increased level of re-wetting will occur through the closure of publicly-funded pumping stations, there will be a clear change in the mix of ecosystem services available, stimulating the need for innovative land management practices. Groundwater levels will increase, modifying the balance between ecosystem services (**Table 2**), notably through increased carbon sequestration rates as waterlogged soil conditions re-establish. Low-lying areas (**Figure 3**) will principally experience significant decreases in crop, livestock and timber production. As analysis is ongoing, results for baseline and future scenarios are yet to be completed, with the intention to present these findings at the conference in April.

Table 2: Provisional results showing the benefits and implications that re-wetting has upon ecosystem services.

Ecosystem service	Effect of re-wetting in Alt-Crossens
Carbon storage	+
Agricultural production	-
Sediment retention	+
Water Quality	+
Habitat provision	+

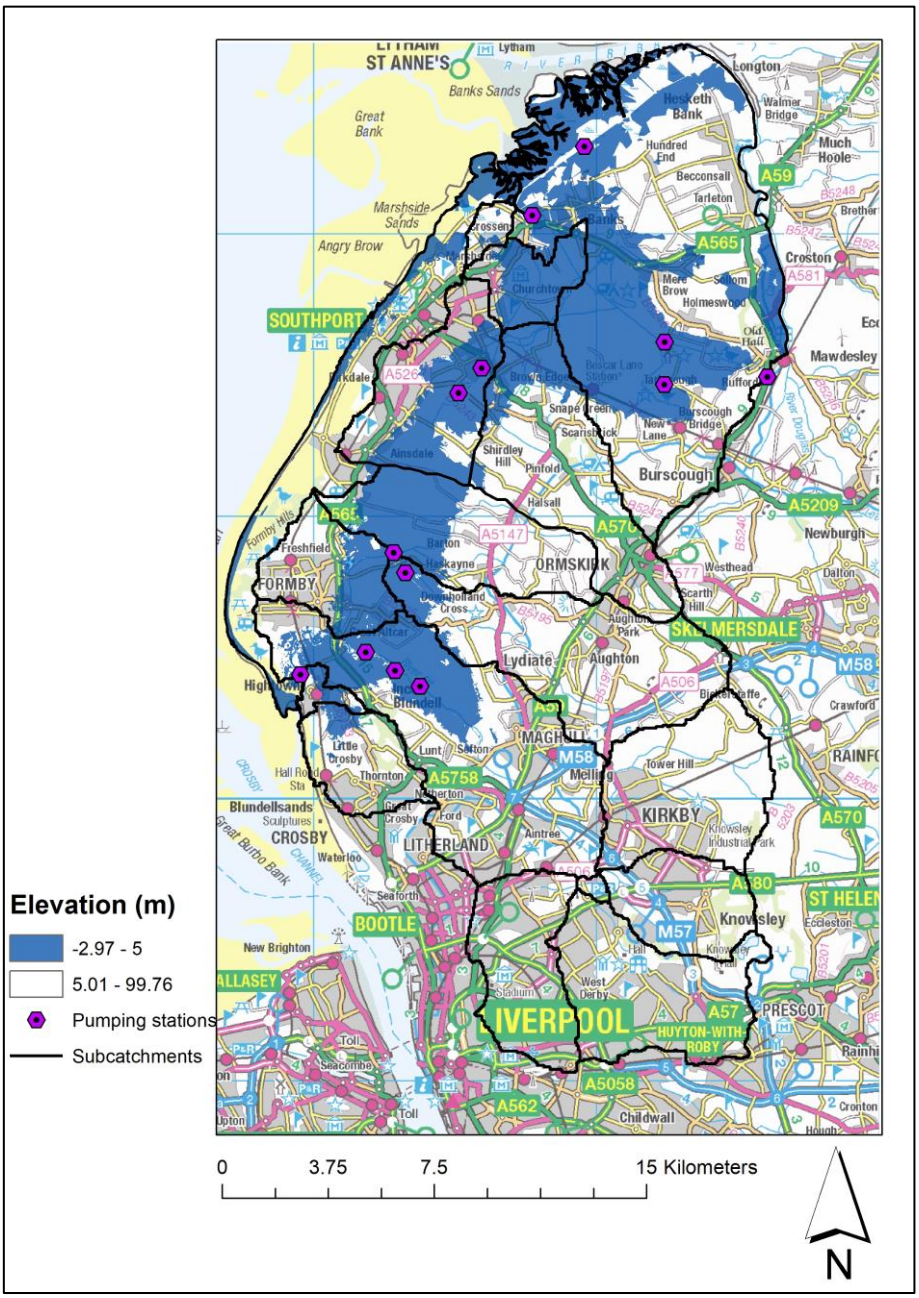

Figure 3: Areas within 5m of the sea level, highlighting the dependency of drainage and likelihood of flooding.

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Biographies

James graduated from the University of Leeds in 2018 with a degree in Geography (BSc). As a keen environmentalist, his interests are in water management and ecology. He is now involved in a Masters by Research project at Lancaster University, investigating the sustainable management of ecosystem services in UK wetlands.

Dr Duncan Watson is a Senior Lecturer in Environmental Governance at Lancaster University. His research and teaching interests involve the governance of natural resources and their management, principally water resources and the development of integrated approaches for both catchments and river basin systems.

Dr Duncan Whyatt is a senior Lecturer at Lancaster University with a background in Geography and Computer Science. He uses Geographical Information Systems to visualise, integrate and analyse spatial data from a variety of different sources across the spectrum of Human and Physical Geography, Ecology and Environmental Science.