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Rewilding as a restoration strategy for lowland agricultural landscapes: stakeholder-assisted multi-criteria analysis in Dorset, UK

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Abstract

The ongoing loss of global biodiversity suggests that established conservation practices have not been fully successful at halting species decline. Rewilding, a restoration strategy focused on restoring ecological processes, has become increasingly prominent as a potential means of addressing this problem. Rewilding has been described as a versatile approach that is applicable even in areas with dense human populations and productive agricultural landscapes such as the lowlands of Western Europe. Yet little is known about the options that might exist for rewilding such landscapes, or about their relative suitability. The present study addresses this knowledge gap by assessing the relative popularity and suitability of different rewilding scenarios in the county of Dorset, south-west England, involving the consultation of local stakeholders. Survey results showed strong support for rewilding among stakeholders, with the reintroduction of beavers (*Castor fiber*) and pine martens (*Martes martes*) being especially popular. Yet stakeholder perceptions also differed regarding how rewilding should be defined, and what it comprises. The suitability of the proposed rewilding approaches was measured through a spatial multi-criteria analysis using the following variables: popularity among stakeholders, suitability within relevant land cover types, and suitability at the landscape-scale. Naturalistic grazing and farmland abandonment emerged as the most suitable rewilding options overall, although these were not the most popular choices. Overall, these results suggest that land managers in lowland agricultural landscapes could consider rewilding as one of the land management options available to them, provided that the options being considered are ecologically appropriate and local stakeholders have been consulted. In the UK, such rewilding options might be supported by new national agricultural land use policies currently under development. In areas of continental Europe where agricultural land abandonment is more widespread, policy-makers seeking to address the issue could look towards the EU's wilderness guidelines for potential solutions that promote rewilding while offsetting the costs incurred by local stakeholders. In either context, integrated exploration of stakeholder values and ecological data as presented here can potentially be used to evaluate the relative suitability and popularity of different rewilding approaches, and thereby establish priorities.

Keywords: Rewilding, lowland, ecological restoration, reintroduction, multi-criteria analysis, GIS

1. Introduction

There is growing evidence that Earth is currently undergoing its sixth mass extinction, with current and projected rates of species loss orders of magnitude higher than they were during previous extinction events (Ceballos, Ehrlich, & Dirzo, 2017; DeSalle & Amato, 2017). According to the Living Planet Index, a biodiversity metric that measures the average change in species abundance over time, there has been a 58 per cent decline in vertebrate population abundance from 1970 to 2012 (WWF, 2016). The Convention on Biological Diversity's most recent outlook warns that, despite increasing societal awareness and action, the 2020 Aichi Biodiversity Targets will not be met under current projections (CBD, 2014). A recent study by Hallmann et al. (2017) illustrates the extent of biodiversity loss currently occurring in the lowland agricultural landscapes of Western Europe, describing a 76 per cent decline in flying insect biomass in protected areas in Germany since 1989.

The apparent failure of measures aimed at halting 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 (Biermann & Anderson, 2017; Corlett, 2016a). In this context, the concept of rewilding has recently received much attention and been the subject of debate both within and outside traditional conservation circles (Lorimer et al., 2015). In addition to its potential value as an approach for ecological restoration, proponents have pointed to rewilding's popular appeal and its ability to help reframe conservation as a positive, future-oriented discipline (Fernández, Navarro, & Pereira, 2017; Jepson, 2016; Keesstra et al., 2018).

Rewilding was originally defined by Soulé and Noss (1998) as the restoration of wilderness areas free from human activity and regulated by large predators. Since then, the term has been applied to a wide variety of different practices including species reintroductions, taxon substitution, flood pattern restoration and the abandonment of agricultural land (Biermann & Anderson, 2017; Lorimer et al., 2015). In continental Europe, there has been a particular focus on using large herbivores, including proxy species for extinct grazers such as the aurochs (*Bos primigenius*), for naturalistic grazing on abandoned productive farmland and on nature reserves (Jørgensen, 2015; Lorimer et al., 2015; Newton et al., 2009). This approach is central to the work of Rewilding Europe, a Netherlands-based NGO currently supporting rewilding projects in nine European countries, including naturalistic grazing pilot areas covering 15,500 hectares of land (Allen et al., 2017; Lorimer et al., 2015). The restoration of natural river flow regimes has also been a key interest for rewilding advocates in Europe, particularly in lowland areas (Jepson, 2016). Commentators have argued that rewilding ought not to be equated with wilderness in the European context given the strong cultural attachment to anthropogenic agricultural landscapes and the long-term absence of apex predators from many parts of the continent (Ceaușu et al., 2015; Jepson, 2016; Lorimer et al., 2015). Following Rewilding Europe's definition of rewilding as 'moving up a scale of wildness within the constraints of what is possible' (Allen et al., 2017), some authors see scope for rewilding pilot sites to be interwoven into densely populated areas, stressing that such an approach is needed to win the support of the general public who reside, work, and engage in recreation in these areas (Jepson, 2016; Moorhouse & Sandom, 2015; Sandom & Macdonald, 2015).

This profusion of different rewilding definitions and approaches has been criticised by some who fear that terminological imprecision can facilitate misappropriation of the concept and render the term 'rewilding' too fuzzy to be ecologically meaningful (Biermann & Anderson, 2017; Jørgensen, 2015; Nogués-Bravo et al., 2016). However, while contemporary definitions can vary considerably, there is a clear common thread as all commonly used descriptions define rewilding as a strategy for ecological restoration that is process- rather than assemblage-oriented, and that embraces unpredictable, potentially novel outcomes (Biermann & Anderson, 2017; Fernández, Navarro, & Pereira, 2017; Mills, Gordon, & Letnic, 2017; Pires, 2017). Importantly, there is evidence that different types of rewilding projects have been successful in restoring ecological processes, benefitting biodiversity, and increasing the provision of ecosystem services, including the reintroduction of wolves (*Canis lupus*) to Yellowstone National Park (Beyer et al., 2007) and beavers (*Castor fiber*) to the English county of Devon (Brazier et al., 2016), as well as the naturalistic grazing regime put in place at the Knepp Estate rewilding project in West Sussex, England (Hodder et al., 2014). This suggests that rewilding is not only a popular and topical buzzword, but a serious strategy for conservation that merits further exploration.

Effective ecological restoration planning requires the prioritisation of high-suitability areas (Orsi, Geneletti, & Newton, 2011). A number of studies have tried to spatially prioritise potential rewilding sites. Ceaușu et al. (2015) assessed opportunities for rewilding in areas projected to be abandoned by 2040 across continental Europe, using artificial light, human accessibility, ecosystem productivity and deviation from potential natural vegetation as criteria. In the UK, the 'wilderness continuum' concept as developed by Nash (1993) has been used as a means to map the distribution of wild land, and to identity areas suitable for rewilding (Carver, Evans, & Fritz, 2002; Carver et al., 2012). Here, the authors used multi-criteria evaluation to weight and combine different attributes, using qualitative 'perception surveys' to gauge the relative importance of these attributes for different stakeholders.

The combination of mappable attributes with stakeholder-derived weights is an appropriate method for gauging rewilding options, particularly in densely populated areas where a top-down approach to rewilding would inevitably lead to conflicts with local residents (Lorimer et al., 2015). While Carver et al. (2012) stressed that their results are applicable to a range of spatial scales, their focus was explicitly on upland areas. However, options for rewilding in densely populated lowland areas also exist, as shown by the Devon beaver reintroduction and the Knepp Wildland Project in the UK, and the re-flooding of the Oder Delta on the border between Germany and Poland (Allen et al., 2017). No previous study has applied a stakeholder-assisted spatial prioritisation method to evaluate opportunities for rewilding in such areas.

This study aims to address this knowledge gap by scoping rewilding options for the county of Dorset in south-west England as an area representative of agricultural lowlands more generally. As one of the UK's most biodiverse regions, Dorset is rich in nationally and internationally important wildlife species, and has been identified as one of the UK's biodiversity hotspots (Prendergast et al., 1993). However, changes in post-war agricultural policy and associated intensification of production systems have led to a heavy decline in overall biodiversity (Dorset LNP, 2014), providing a strong argument for rewilding as a potential means to restoring ecosystem services and biodiversity in the region (Sandom & Macdonald, 2015).

In order to evaluate rewilding options for Dorset, a threefold approach was adopted. First, local stakeholders were consulted about rewilding and its potential manifestations in the county, and levels of support were gauged using a questionnaire survey. Rather than defining the term 'rewilding' a priori, this survey asked respondents to indicate what they thought it meant in practice. Second, survey results were used as factors in a spatial multi-criteria evaluation exercise in order to assess the relative suitability of selected rewilding options. Third, an additional multi-criteria analysis was applied to all rewilding scenarios to rank them according to their overall suitability within Dorset, and thereby provide recommendations for prioritisation.

2. Materials and Methods

2.1. Stakeholder consultation

A one-day stakeholder workshop was held in Dorchester, Dorset in May 2016. In addition to interested students, naturalists, and other members of the public, the following organisations were represented at the meeting: National and local government agencies (Natural England, Forestry Commission, Environment Agency, New Forest National Park Authority, Christchurch and East Dorset Partnership, Dorset County Council, Purbeck District Council), non-governmental organisations (Dorset Wildlife Trust, Royal Society for the Protection of Birds, National Trust, Rewilding Britain), public utilities (Wessex Water), and research institutions (Bournemouth University, Centre for Ecology and Hydrology, Oxford University, Exeter University, University of Sussex).

Participants were invited to complete a questionnaire designed to capture their opinions on rewilding in Dorset (Supplementary Material, Appendix A). A five-point Likert scale was used to gauge the extent to which respondents agreed or disagreed with each statement. No assumptions were made about unanswered questions, and they were not included in any analyses. The questionnaire was divided into four sections. The first dealt with definitions of rewilding, and its appeal as a general concept. Next, respondents were asked to indicate which areas in Dorset would be most suitable for rewilding. Third, the following five specific rewilding scenarios were proposed to determine which types of projects are most popular among stakeholders (hereafter referred to as 'popularity'): Species reintroductions, farmland abandonment (taking economically marginal, arable land out of production and leaving it to revegetate naturally), naturalistic grazing (using large grazing herbivores without specified targets or herbivore density), river restoration (restoring rivers to their natural flow patterns and reconnecting them to their floodplains), and passive management (allowing natural succession to proceed at selected lowland heath or grassland sites). In addition to species introductions as a general approach, four species were proposed for introduction: Eurasian beaver (*Castor fiber*), European wildcat (*Felis silvestris silvestris*), wild boar (*Sus scrofa*), and pine marten (*Martes martes*). All scenarios and species were chosen after a thorough review of peer-reviewed literature and other published material detailing case studies of rewilding across the UK and other parts of Europe (see Allen et al., 2017; Greenaway, 2011; Hughes et al., 2011; Lorimer et al., 2015; Moorhouse & Sandom, 2015; Sandom & Macdonald, 2015). The reintroduction of large carnivores was not included as this was not deemed feasible in light of Dorset's ecological and socio-political landscape.

To identify potential barriers to implementing the proposed scenarios, the final section asked participants to consider a total of eight factors that could limit their feasibility, and to indicate which of the five scenarios these might apply to: presence of priority habitats on site (as listed under Annex I of the 1992 EC Habitats Directive), presence of priority species on site (as listed under Annex II of the 1992 EC Habitats Directive or Annex I of the 2009 EC Birds Directive), type of land use, type of land ownership, size of area to be rewilded, human population density, impact on ecosystem services, and eligibility for agri-environment schemes. Species reintroductions were included as a general concept here without focusing on particular species. A mean 'constraint score' was assigned to each scenario by counting the number of constraints per scenario per respondent and calculating the mean.

2.2. Spatial multi-criteria evaluation

Questionnaire results were used to derive criteria for spatial multi-criteria evaluation (SMCE), which was implemented in ILWIS v3.08.05 (52° North Initiative for Geospatial Open Source Software GmbH, Münster, Germany). Besides land cover type, protected area (PA) status (using Sites of Special Scientific Interest (SSSI)), biodiversity, and property value were used as variables. LCM 2007 land cover, OS Open Rivers, and UK boundary line vector data were downloaded from Edina Digimap (digimap.edina.ac.uk), while SSSI shapefiles were obtained from the UK government's public database (data.gov.uk) under an Open

Government Licence. Shapefiles were clipped to the county of Dorset using the ceremonial county boundary line data in ESRI ArcMap v10.2.2 (ArcGIS, ESRI, Redlands, CA, USA).

Normalised biodiversity data showed the density of UK Biodiversity Action Plan (BAP) species at 25 m resolution as calculated by Newton et al. (2012) based on BAP species records obtained from the Dorset Environmental Records Centre (DERC) and the Amphibian and Reptile Conservation Trust (ARC). The authors corrected species density values, i.e. the numbers of species per unit area, for variation in the area covered by different land cover types to make the values comparable. Property value was added as an additional variable as high property values are a major constraint to ecological restoration (Gregory et al., 2001). Property sale data for Dorset were obtained from the UK Land Registry and averaged for the period from 2010 to 2015 at a 100 m resolution, with sale prices ranging from 90,208 GBP to 3,271,000 GBP per hectare.

SMCE was used to map all but one of the scenarios mentioned in the survey according to a specific combination of the mapping criteria mentioned above. Wildcat reintroduction was included in the questionnaire to test the appeal of flagship species but excluded from SMCE as it was not supported by a majority of stakeholders. Passive management, while also not supported by a majority, was included in SMCE owing to its relevance for management of lowland heath and grassland sites in Dorset. As ILWIS requires ASCII files with identical spatial extents, all data were resampled in ArcMap if necessary, and converted to ASCII prior to analysis in ILWIS.

For each scenario, land cover type was used as a constraint, meaning that areas were only deemed suitable for rewilding if they comprised an appropriate habitat type for that scenario. For all habitat-focused rewilding scenarios, the land cover types used to describe them in the questionnaire were used. For species reintroductions, additional operations were performed for all three species. Beavers are reported to travel a maximum distance of 100 m from water to feed on predominantly deciduous woody plant species (Gurnell et al., 2009; Haarberg & Rosell, 2006; Lahti & Helminen, 1974). Hence, areas of riverine woodland with deciduous woodland ≤100 m away from the nearest river were deemed suitable habitat for beaver introduction. A 100 m buffer was applied to all rivers in Dorset and intersected with broadleaved woodland polygons, resulting in a new shapefile showing areas of riverine woodland.

For pine martens, the literature indicates that patches of coniferous woodland ≥ 0.86 km^2 (Balharry, 1993; Caryl, 2008) are required. With the largest patch of coniferous woodland in Dorset only 0.16 km^2 in size, no area could be established as suitable habitat for pine martens. However, Pereboom et al. (2008) report that monitored pine martens seemed to not be confined to large forests and have been observed using small plots of woodland and hedgerows. Therefore, it was decided to include pine marten reintroduction in scenario mapping despite the relatively small sizes of coniferous woodlands in Dorset, assigning higher suitability to larger areas. For this, conifer polygons were converted to raster using patch size as value field.

In the case of wild boar there is already a population of roughly 50 introduced animals in Dorset (Sandom & Macdonald, 2015). Wild boar are mainly found in areas of deciduous woodland but are known to raid and damage crops, particularly during summer and autumn (Hahn & Eisfeld, 1998; Wilson, 2004). Studying wild boar activity in Germany, Hahn and Eisfeld (1998) observed that the distance from resting places to adjacent cropland affects crop damage, with animals resting ≥2 km from the forest edge limiting their rooting activity to woodland, whereas animals resting <1 km from the edge regularly raided fields. To include distance to fields as a factor in mapping, distance to the nearest ‘Arable and horticulture’ polygon was calculated for each patch of deciduous woodland, and woodland polygons were then rasterised using the resulting column as value field.

Table 1 summarises the variables applied to each scenario in SMCE. While land cover types were used to constrain the output to relevant habitats, protected area status, biodiversity value, and property value were included as ‘spatial factors’ during analyses and each given an equal, normalised weight. Factors can be treated as either a ‘benefit’ or a ‘cost’. Areas situated outside protected areas were classified as a ‘benefit’ to reflect the higher suitability of non-protected areas for rewilding. The continuous variables for biodiversity and property value were both classified as a ‘cost’ to treat areas with higher values in either dataset as less suitable for rewilding.

Following data preparation, the SMCE was performed and the output raster scaled on a range from 0-100. Upon finishing the analysis, raster cells with a value of 0 were deleted as these represented cells that did not pass the spatial constraint test. The processed files were then exported to ArcMap for visual editing.

Scenario	**Variable type**	**Variable**	**Weighting**
Farmland abandonment	SC	'Arable and horticulture'	n/a
	SF	Protected areas	0.33
	SF	Biodiversity	0.33
	SF	Property value	0.33
Naturalistic grazing	SC	'Improved grassland', 'Neutral grassland', 'Calcareous grassland', 'Conifer', 'Felled', 'Recent (<10 years)', 'Deciduous', 'Mixed' or 'Scrub'	n/a
	SF	Protected areas	0.33
	SF	Biodiversity	0.33
	SF	Property value	0.33
River restoration	SC	Freshwater (OS Open Rivers)	n/a
	SF	Protected areas	0.33
	SF	Biodiversity	0.33
	SF	Property value	0.33
Passive management	SC	'Acid grassland', 'Rough low-productivity grassland' or 'Dwarf shrub heath'	n/a
	SF	Protected areas	0.33
	SF	Biodiversity	0.33
	SF	Property value	0.33
Beaver reintroduction	SC	Deciduous woodland ≤100m from the nearest river (LCM2007 and OS Open Rivers)	n/a
	SF	SSSI RC	0.33
	SF	Biodiversity	0.33
	SF	Property value	0.33
Pine marten reintroduction	SC	'Conifer'	n/a
	SF	Protected areas	0.25
	SF	Biodiversity	0.25
	SF	Property value	0.25
	SF	Conifer patch size	0.25
Wild boar reintroduction	SC	'Deciduous', 'Mixed' or 'Scrub'	n/a
	SF	Protected areas	0.25
	SF	Biodiversity	0.25
	SF	Property value	0.25
	SF	Distance to fields	0.25

Table 1: Variables and settings applied to each scenario during spatial multi-criteria evaluation in ILWIS. Land cover types used as spatial constraints were taken from LCM2007 data unless stated otherwise. 'Spatial constraint' (SC) and 'Spatial factor' (SF) refer to settings in ILWIS which define whether a variable is used to spatially limit the output to its extent (SC), or whether it is one of several contributing factors (SF).

2.3. Scenario ranking using multi-criteria analysis (MCA)

The SMCE described above indicated the suitability of each rewilding scenario within its respective land cover type. However this approach does not provide a measure of suitability at the landscape scale, nor does it account for each scenario's popularity among stakeholders. To address these points, an additional analysis was conducted using the multi-criteria analysis (MCA) software tool DEFINITE 3.1.1.7 (Institute for Environmental Studies, Amsterdam, The Netherlands).

Three criteria were included in this analysis: suitability at the landscape scale, suitability within a land cover type, and suitability according to stakeholder opinion ('popularity'). For a landscape-scale measure of suitability, pixel values from the seven SMCE raster files were reclassified into ten categories from 0-10 to 91-100, and the mean pixel value for each category was calculated. These were then weighted by area in km^2 and summed to quantify each scenario's relative suitability in the wider context of the Dorset landscape. Suitability within land cover type was quantified using the mean pixel value for each land cover type from each raster file. Finally, the percentages of questionnaire respondents who responded to each scenario with 'Agree' or 'Strongly agree' were used as indicator of popularity for each scenario.

Owing to the large difference in area covered by each of the scenarios, there was a concern that equal weighting would favour those scenarios covering larger areas of land while potentially masking the suitability of certain interventions limited to more sparsely distributed habitats such as freshwater (for river restoration) or riverine woodland (for beaver reintroduction). Hence, the MCA was performed three times to gauge whether final scenario rankings would be affected by the setting of different weights. In the first run, all three criteria were weighted equally. This was followed by two runs during which suitability within land cover type and stakeholder popularity were given double weighting, respectively. Figure 1 visualises each step of the methodological work flow.

3. Results

3.1. Stakeholder survey

47 questionnaires were returned at varying completion rates. Respondents identified themselves as follows: 'Conservation practitioner' (55%), 'Academic' (15%), 'Student' (9%),

‘Landowner’ (6%), ‘Farmer’ (2%), and ‘Other’ (28%). In the following, respondents choosing ‘agree’ or ‘strongly agree’ were interpreted as support for a given statement, while ‘disagree’ or ‘strongly disagree’ were interpreted as rejection.

On rewilding as a general concept, a majority of respondents (74%) either agreed or strongly agreed that they had a clear understanding of what the term meant. Opinions on rewilding were largely positive, as 96% and 77% of respondents supported the notion that it could make a positive contribution towards conservation in the UK and in Dorset, respectively. When asked about its primary focus, none of the proposed concepts (species reintroductions, habitat management, or cessation of management) were supported by a majority of respondents. Most notably, the notion of rewilding as synonymous with a lack of active management was rejected by 66% of respondents, while the suggestion that rewilding meant species reintroductions was rejected by 53%. Rewilding as a form of habitat management had the support of 41% of respondents while being rejected by 26%, making it the least contested definition for rewilding overall.

A clear majority (69%) supported the statement that rewilding should occur in areas with low biodiversity value, and 54% rejected the notion of rewilding taking place in protected areas. All but two rewilding scenarios were viewed favourably by a majority, with pine marten and beaver reintroductions proving particularly popular, while only passive management and wild cat reintroductions did not receive majority support (Fig. 2).

Table 2 shows the percentage of respondents who felt that any of the proposed constraints applied to any of the rewilding scenarios. All scenarios had a mean constraint score between 3.7 and 3.8, showing that, on average, respondents did not consider that any one scenario was more limited by constraints than any other. This indicates that there is no benefit to using constraints as a factor in multi-criteria analysis, as the score would be nearly identical for all scenarios.

Constraint	Scenario				
	Species reintroduction	**Farmland abandonment**	**Naturalistic grazing**	**River restoration**	**Passive management**
Presence of priority habitats on site	59.57	40.43	57.45	40.43	85.11
Presence of priority faunal species on site	72.34	29.79	53.19	36.17	70.21
Type of land use (e.g. agricultural, recreational, forestry)	51.06	42.55	38.30	31.91	42.55
Type of land ownership (e.g. public, private, NGO)	57.45	55.32	53.19	48.94	59.57
Size of area to be rewilded	70.21	23.40	48.94	21.28	25.53
Human population density	68.09	17.02	25.53	31.91	25.53
Impact on ecosystem services	34.04	31.91	21.28	27.66	29.79
Eligibility for agri-environment schemes	21.28	51.06	29.79	12.77	36.17

Table 2: Percentages of respondents who indicated that a particular constraint applied to a particular scenario. On average, all scenarios had a mean 'constraint score' (number of constraints per scenario per respondent) between 3.7 and 3.8.

3.2. Spatial multi-criteria evaluation and maps

SMCE resulted in seven 25 m x 25 m raster data sets displaying pixel values between 0 (rewilding scenario not applicable due to unsuitable habitat) and 100 (very high suitability). The resulting maps show the relative suitability of each scenario within its respective land cover type (Table 3; Figs. 3a-g). Farmland abandonment (Fig. 3a) was limited to arable land, which covers 39.81 km² of Dorset, the second largest area available to a rewilding scenario in this study. At 95.34, it has the highest mean pixel value, suggesting high suitability over a large geographic area. At 48.46 km², naturalistic grazing has a larger area of suitable habitat but a slightly lower mean value of 91.32. Although marginally less suitable on average than farmland abandonment, there are noticeably more areas of very high suitability (Fig. 3b).

Relevant grassland and heathland sites comprise an area of 6.84 km^2, making passive management considerably less applicable in terms of geographic extent than either naturalistic grazing or farmland abandonment. Within this area, it was also notably less suitable on average, with a mean pixel value of 84.16. There are more visible cold spots than for any other habitat-related rewilding scenario, and fewer clusters of high suitability areas (Fig. 3c).

Rivers account for only 1.75 km^2 in Dorset, giving river restoration (Fig. 3d) the second smallest geographical area for implementation. Within this limited area, however, the scenario was comparatively suitable with a mean pixel of 88.98, the third highest mean value overall. Although beaver reintroduction (Fig. 3e) ranked lowest in terms of available area (0.96 km^2), its mean value of 83.34 was highest among proposed reintroductions, making it only marginally less suitable on average than passive management while being far more popular among stakeholders.

Pine marten reintroduction (Fig. 3f) applies to an area of 2.72 km^2. At 72.89, its mean pixel value is notably lower than for beavers. 7.74 km^2 of Dorset is covered with deciduous woodland, which makes wild boar reintroduction (Fig. 3g) the most applicable species reintroduction scenario in terms of available land cover type. However, its mean pixel value of 64.3 is lowest among all scenarios, making wild boar less suitable for reintroduction than pine marten despite a wider geographical coverage of relevant habitats.

Scenario	Mean pixel value (± SE)	Area of suitable habitat (in km²)
Farmland abandonment	95.34 (±0.003)	39.81
Naturalistic grazing	91.32 (±0.008)	48.46
River restoration	88.98 (±0.052)	1.75
Passive management	84.16 (±0.036)	6.84
Beaver reintroduction	83.34 (±0.072)	0.96
Pine marten reintroduction	72.89 (±0.028)	2.72
Wild boar reintroduction	64.3 (±0.016)	7.74

Table 3: Mean pixel values and total area available for each rewilding scenario. Values were taken from the raster files produced by ILWIS' spatial multi-criteria evaluation after removing all pixels with a zero value.

3.3. Multi-criteria analysis

Table 4 summarises the input values for each of the three criteria measured using DEFINITE. Applying equal weights to all criteria, naturalistic grazing and farmland abandonment clearly emerged as the highest-ranked rewilding scenarios in Dorset when considering suitability within landscape, suitability within land cover type, and popularity with stakeholders. Alternative weight settings had a negligible impact on this hierarchy. Wild boar reintroduction and passive management, the two lowest-ranked scenarios, exchanged places when extra weighting was applied to suitability within land cover type, while increased weighting for popularity has had no effect on scenario rankings (Fig. 4).

Scenario	'Suitability at landscape' score	'Suitability within land cover' score	'Popularity' score
Farmland abandonment	0.86	95.34	77.42
Naturalistic grazing	1	91.32	81.81
River restoration	0.04	88.98	81.81
Passive management	0.13	84.16	42.42
Beaver reintroduction	0.02	83.34	83.33
Pine marten reintroduction	0.04	72.89	84.1
Wild boar reintroduction	0.11	64.3	72.1

Table 4: Values for multi-criteria analysis in DEFINITE. 'Suitability at landscape' is based on the outputs created during spatial multi-criteria evaluation for each rewilding scenario. The mean pixel value for each decimal bracket (raster values 0 – 10, 11 – 20 etc.) was weighted by the total area occupied by all pixels in that bracket. These values were then summed and normalised to a scale between 0 and 1. 'Suitability within land cover' is the mean pixel value of each raster file (see Table 2). 'Popularity' is the percentage of respondents who agreed or strongly agreed that each scenario would be applicable to Dorset. All values were automatically normalised to the same scale when running the tool.

4. Discussion

This study represents the first known attempt to assess the suitability of rewilding as a conservation strategy in an agriculturally productive lowland landscape. Results indicate that there is strong support for rewilding among local stakeholders. This is a surprising result given the commonly held assumption that conservation practitioners managing land in intensive agricultural landscapes are largely conservative and wary of experiments, particularly when outcomes cannot be clearly predicted (Corlett, 2016a; Hughes et al., 2011). This finding, and the evaluation of the relative suitability of different rewilding scenarios, addresses a significant research gap. Peer-reviewed literature on rewilding has grown substantially in recent years, with a particular emphasis on the European context (Corlett, 2016b). The majority of these publications, however, are editorial-style opinion articles arguing for (or against) rewilding without presenting data related to specific approaches in actual landscapes (e.g. Biermann & Anderson, 2017; Fernández, Navarro, & Pereira, 2017;

Jepson, 2016; Jørgensen, 2015; Lorimer et al., 2015; Moorhouse & Sandom, 2015; Nogués-Bravo et al., 2016; Pettorelli et al., 2018).

Evidence-based research on rewilding has mostly examined the predicted ecological benefits such as increased provision of ecosystem services (e.g. Cerqueira et al., 2015; Hodder et al., 2014; Keesstra et al, 2018), but has not examined stakeholder opinions that are needed to inform feasibility studies of practical rewilding projects. Some researchers have attempted to map priority areas for rewilding using attributes such as perceptions of wilderness (Carver, Evans, & Fritz, 2002; Carver et al., 2012) or projections of land abandonment (Ceaușu et al., 2015). Such studies focus exclusively on sparsely populated upland areas, however, and do not mention specific scenarios that could be trialled in these areas. The present study is the first to explore specific options for rewilding in lowland agricultural landscapes using ecological and stakeholder-derived data.

Interestingly, although species reintroductions were not seen as rewilding's primary focus and only 63 per cent of respondents supported them as a general concept applicable to Dorset, reintroducing beavers and pine martens were the two most popular scenarios overall. This shows the appeal of flagship species even for an audience composed partly of professional conservationists. It also highlights that the most popular scenarios may not always be those associated with the greatest ecological benefits, as biodiversity net gain is likely going to be higher for landscape-scale habitat restoration scenarios such as farmland abandonment or naturalistic grazing (Hodder et al., 2014). In Dorset, there is strong overlap between popularity and ecological benefits in the case of beaver reintroduction. Trials from other parts of the UK have shown that reintroducing beavers has demonstrable ecological benefits (Brazier et al., 2016), and conservation decision-makers in Dorset and other lowland landscapes can point to their popular appeal to make the case for new pilot projects.

Naturalistic grazing emerged as the most suitable scenario overall from the present study. This partly reflects current conservation management practice in Dorset, where successional habitats such as lowland heathland and unimproved grassland are now often managed through grazing approaches involving livestock, despite the lack of evidence regarding their effectiveness (Newton et al., 2009). The implementation of natural grazing regimes elsewhere in Europe has led to debates about the supposed dichotomy between 'wild' and 'domesticated' animals, and about issues of animal welfare (Lorimer et al., 2015). It has also been pointed out that, if not managed appropriately, grazing animals can reduce habitat condition (Hodder et al., 2014; Lorimer et al., 2015). In a study by Hodder and Bullock (2009), land managers identified the difficulties of reconciling the hands-off mentality of naturalistic grazing with the day-to-day realities of site management, which highlights the challenge of implementing rewilding scenarios as part of current UK nature conservation management frames.

It is likely that farmland abandonment, which scored high for suitability within land cover type as well as at landscape-scale, was not as popular among stakeholders owing to concerns over potential conflicts with farmers and landowners. In intensive agricultural landscapes such as Dorset, much conservation practice outside protected areas depends on developing working relationships with farmers and landowners, and using the agricultural subsidies available to support wildlife-friendly land management. The UK's vote to leave the European Union in 2019 could lead to significant changes in the availability of such subsidies. As Gawith and Hodge (2017) point out, the EU's Common Agricultural Policy (CAP) is predominantly a food production subsidy scheme that does not incentivise the provision of ecosystem services more broadly. They envision a new 'British Ecosystem Services Policy' that will encourage land use diversification and a shift towards the wider social values derived from ecosystems. In a report to the UK House of Commons after the Brexit vote, the Environmental Audit Committee (2016) argues along similar lines, stating that future land management payments should address public needs rather than functioning as income support to farmers. Most recently, the UK government's 25 Year Environment Plan (Defra, 2018) states that post-Brexit agricultural policies and financial support mechanisms should have environmental protection as their primary aim. Hence, current barriers to farmland abandonment in the UK may be less pronounced in future, and there may be increased political momentum in support of rewilding approaches.

In the absence of such political restructuring, policy-makers in continental Europe operating within CAP guidelines may not be in a position to propose such radically new land use policies, but could nevertheless consider rewilding wherever appropriate as a potential land use option in agricultural landscapes. The European Union's wilderness guidelines (2013) make specific reference to ‘re-wilding’ and state that the introduction of wild herbivore species could help replace traditional agricultural activities in areas affected by rural land abandonment. The guidelines further state that incentives and compensation measures should be used to engage local stakeholders in areas where natural processes are to replace traditional land uses. Given the fact that rural land abandonment is much more pronounced in continental Europe than it is in much of the UK, there is arguably an even more urgent need to gather evidence and consult stakeholders about rewilding approaches such as naturalistic grazing or farmland abandonment.

While this study has shown that rewilding can be a suitable strategy in intensive agricultural lowland landscapes, it is important to stress that this does not apply to all definitions of rewilding. A purist view of rewilding as the restoration of self-regulated wilderness areas and long-lost trophic cascades is incompatible with areas such as Dorset, except perhaps in coastal or marine habitats, which were not explicitly considered here. Not only does Dorset lack areas free from agricultural land use needed for establishing terrestrial wilderness areas, but it is also rich in disturbance-dependent species of conservation concern that would likely suffer from such an approach (Corlett, 2016b). 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). Other commentators (e.g. Jepson, 2016; Moorhouse & Sandom, 2015) argue that opportunities for restoring ecological processes exist at all scales and in all landscapes. The success of the Knepp Wildland Project in the UK (Hodder et al., 2014), and the preliminary results from beaver trials in Devon, give credence to the latter position.

Clearly the acceptance of rewilding approaches by stakeholders will depend critically upon how the concept is defined, and it is striking that there is currently no consensus on this issue among researchers. This was mirrored in the results of the stakeholder survey presented here, which displayed a wide variety of different interpretations of what rewilding might mean in practice. The level of support for rewilding recorded here could partly be attributed to this uncertainty regarding what it entails. If a narrower definition of rewilding had been presented to stakeholders, such as that provided by Soulé and Noss (1998), it is likely that the level of acceptance would have been much lower. From this it can be seen that wide support for rewilding in lowland agricultural landscapes will be contingent on adopting a more inclusive definition, such as those proposed by Jepson (2016) or Moorhouse & Sandom (2015), yet for some commentators, this would run the risk of devaluing rewilding as a concept.

There are methodological limitations that should be borne in mind when interpreting the results of this study. The questionnaire was completed by a total of 47 respondents, only four of whom identified themselves as either 'farmer' or 'landowner'. It can be assumed that support for rewilding would be weaker among a group comprised mainly of farmers or landowners with financial investments in agricultural land. This problem is common to much survey-based research and is known as the nonresponse bias (Raymond & Knight, 2013). It could be addressed through follow-up surveys with a second group of respondents. The limited scope of this study did not allow us to account for this bias, and it is strongly recommended that other stakeholders be consulted if any rewilding scenarios were to be developed further.

In this initial scoping study, suitability within a land cover type (see Figs. 2a-g) and at the landscape-scale were measured using a small selection of spatial data sets, based on habitat requirements of species and stakeholder responses. Importantly, no models of projected land use change or climate change were included, although such data would need to be factored into any final decisions regarding rewilding, particularly when deliberating species reintroductions. While the questionnaire used the term 'protected area' in a broad sense, only SSSIs were included in spatial analyses. Although SSSIs contain all sites covered by the European Union's Natura 2000 network and by the 1971 Ramsar Convention, they do not necessarily include National Parks, Areas of Outstanding Natural Beauty or other areas with a lower level of protection, which may have skewed results. The property value data set used here is exclusively based on property sales between 2010 and 2015, which represents a further limitation. The value of properties not sold during this period is not included, which may be particularly applicable to properties in protected areas. Furthermore, the lack of an explicit consideration of coastal and marine ecosystems represents an additional gap in our research. This is a feature of the majority of the published literature on rewilding, which is characterised by a strong terrestrial bias; we are aware of no case studies that highlight the potential for rewilding in coastal or marine ecosystems. Yet it could be argued that the UK's seascapes present ample opportunities for rewilding owing to the absence of farming- or landownership-related constraints.

Despite these limitations, rewilding as explored here clearly is a popular conservation strategy that can potentially be applied to lowland agricultural landscapes and could provide a number of potential ecological benefits. These include an increase in species richness (Brazier et al., 2016; Law et al., 2017) and the increased provision of ecosystem services such as carbon sequestration, flood prevention, freshwater provision, and nature-based recreation (Corlett, 2016b; Hodder et al., 2014; Keesstra et al., 2018). It will be important for conservation decision-makers to employ the right messaging when proposing rewilding approaches in intensive agricultural landscapes such as Dorset, and to not get caught up in rhetoric about large-scale trophic rewilding or other outcomes not applicable to intensively used areas. Most crucially, it needs to be made clear that rewilding will need to complement rather than replace existing conservation strategies in order to gain acceptance.

5. Conclusion

This scoping study has shown that there is support for rewilding to be explored as a possible conservation approach in intensive agricultural landscapes such as Dorset, UK. A majority of local stakeholders claimed to have a good understanding of what rewilding means and expressed support for it as a strategy applicable to Dorset. However, there was no clear consensus about rewilding's primary focus, and the most popular scenarios (pine marten reintroduction and beaver reintroduction) did not coincide with the most suitable options at a landscape scale. This shows that the term 'rewilding' has different connotations for different people and currently lacks a clear definition. Hence, it is advisable to refer to specific approaches when discussing rewilding, as implemented here. Care should be taken to ensure that rewilding approaches are appropriate for the scales and landscapes in question and that their differences from conventional conservation practice are clearly communicated and understood.

In Dorset, naturalistic grazing and farmland abandonment emerged as the two most suitable scenarios overall, based on results of the multi-criteria analysis that was performed. These are options that might usefully be considered for wider implementation during development of post-Brexit agricultural policy in the UK, as well as under current EU wilderness guidelines. Despite their small geographic scope, river restoration and beaver reintroduction should also be considered as potential trial projects for rewilding in agricultural landscapes such as Dorset. Passive management of smaller, isolated patches of grassland and heathland in the name of ecosystem service provision may also be feasible, although this approach may be associated with trade-offs that may be difficult to reconcile at the landscape scale (Cordingley et al., 2015).

Our results suggest that land managers in lowland agricultural landscapes should consider rewilding as one of the options available to them, particularly if they wish to increase interest and support among stakeholders and the general public. To this end, they will need to gather evidence regarding the specific approaches that are applicable to their area, and to consult stakeholders about whether or not these would be acceptable. The multi-criteria analysis and mapping approaches described in this study provide tools that could be used to explore these options.

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Supplementary Material

Appendix A: Stakeholder questionnaire

Research project: The feasibility of rewilding in the English lowlands: Scenario mapping for the county of Dorset

Researcher: Arne Loth, arne.loth@gmail.com

Project supervision: Prof. Adrian Newton, Professor and Director Conservation Ecology, anewton@bournemouth.ac.uk

Project support: Arjan Gosal, PhD student, agosal@bournemouth.ac.uk

Survey background: My research project is concerned with exploring the applicability of rewilding as a conservation tool for lowland England in general and Dorset in particular. In order to assess the feasibility of such approaches, it is helpful to incorporate the opinions of conservation stakeholders and decision-makers. We would very much appreciate your help with this process.

In the following, you will be asked a set of questions to capture your opinion on rewilding as a general concept, as well as some concrete examples of rewilding practice that might potentially be relevant to the Dorset landscape. Your participation is entirely voluntary and your personal details, should you wish to provide them, will not be linked to this research in any way. You can choose not to answer particular questions, and can withdraw at any time up to the point of returning the survey sheet.

This project is linked to the Higher Education Innovation Funding (HEIF) project 'Modelling Natural Capital in Dorset', of which my MSc dissertation forms part, with anticipated completion this year. If you would like to receive a copy of the results, or the entire thesis, please indicate this below.

	Please tick here	**Signature**	**Date**
I confirm that I have read and understood the participant information sheet for the above research project and agree to take part in the research.			
I understand that my participation is voluntary and that I am free to withdraw up to the point of returning the survey sheet, without giving reason and without there being any negative consequences.			
I give permission for members of the research team to have access to my responses. I understand that providing contact details is entirely voluntary, that my name will not be linked with the research materials and that I will not be identified or identifiable in any reports that result from this research.			
I would like to receive a copy of the results that have come out of this survey.			

I would like to receive a copy of the final thesis containing the results that have come out of this survey.			

Thank you for agreeing to take part. Please begin by answering the following:

You are (please tick all that apply):

Conservation practitioner	
Landowner	
Farmer	
Academic	
Student	
Other	
Prefer not to say	

Please provide your contact details below (email address will suffice). This information is optional but necessary for me to be able to share results and/or my final thesis with you.

Do you give your consent to be contacted for further feedback? (Please tick)

Yes

No

Thank you. Please continue on the next page.

1. Rewilding as a concept (please tick one box per statement)

Statement		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	I have a clear understanding of what rewilding means					
2	Rewilding can make a positive contribution towards nature conservation in the UK					
3	Rewilding can make a positive contribution towards nature conservation in Dorset					
4	Rewilding is primarily concerned with species reintroductions					
5	Rewilding is primarily concerned with habitat management					
6	Rewilding means a complete cessation of human intervention to let nature manage itself					

2. Prioritising areas for rewilding (please tick one box per statement)

Statement		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
7	Areas with low biodiversity value should be prioritised for rewilding					
8	Areas with high biodiversity value should be prioritised for rewilding					
9	Rewilding should mainly occur in protected areas					
10	Rewilding should mainly occur outside protected areas					

3. Rewilding scenarios for Dorset (please tick one box per statement)

Statement		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
11	Species reintroductions are appropriate for the county of Dorset ("Species reintroduction")					
Continue below (11.1) if chosen 'Neither agree nor disagree', 'Agree' or 'Strongly agree' for statement 11, otherwise continue with statement 12						
11.1	Beavers should be considered for reintroduction in Dorset					
Statement		**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
11.2	Wild cats should be considered for reintroduction in Dorset					
11.3	Wild boar should be considered for reintroduction in Dorset					
11.4	Pine marten should be considered for reintroduction in Dorset					
11.5	*Optional: Suggest other species for reintroduction (fill in suggestion)*					
Continue here if chosen 'Strongly disagree' or 'Disagree' for statement 11						
12	Where economically marginal, arable land should be taken out of production and left to revegetate naturally ("Farmland abandonment")					
13	Naturalistic grazing regimes using large herbivores without specified targets or herbivore density should be implemented at selected pasture or woodland sites ("Naturalistic grazing")					
14	Dorset rivers should be restored to their natural flow patterns and reconnected to their floodplains at					

	selected sites ("River restoration")					
15	Natural succession should be allowed to proceed at selected lowland heath or grassland sites, even if this means a complete loss of habitat at those sites ("Passive management")					

4. Limiting factors

For each of the factors listed in the left-hand column below, please tick all rewilding scenarios to which they act as a potential constraint (i.e. they should play a significant part in the decision-making process).

Limiting factor	**Species reintroduction**	**Farmland abandonment**	**Naturalistic grazing**	**River restoration**	**Passive management**
Presence of priority habitats on site[2]					
Presence of priority faunal species on site [3]					
Type of land use (e.g. agricultural, recreational, forestry)					
Type of land ownership (e.g. public, private, NGO)					
Size of area to be rewilded					
Human population density					

[2] As listed under Annex I of the EC Habitats Directive (1992).
[3] As listed under Annex II of the EC Habitats Directive or Annex I of the EC Birds Directive (2009).

Limiting factor	Species reintroduction	Farmland abandonment	Naturalistic grazing	River restoration	Passive management
Impact on ecosystem services					
Eligibility for agri-environment schemes					
Other (please specify)					