Knepp Castle Estate
Scrub and hedgerow changes 2001 – 2015
Southern Block

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Table of Contents

Introduction

The Knepp Castle Estate manages the land through a naturalistic grazing regime with large herbivores. As a result, the vegetation has changed since starting this management regime in 2000. Currently the Estate wishes to understand and, if possible, quantify the changes that have taken place, particularly concerning the extent of scrub and hedgerows. This technical note describes the methodology and results of a change analysis carried out for scrub and hedgerows between 2001 and 2015.

The analysis focused on the Southern Block (see Figure 1), for which aerial photography was made available covering the years 2001, 2007, 2012 and 2015. Aerial photography provided in folders 'new 2001', '2007 WSCC' and '2015 WSCC' were used in the hedgerow analysis. Scrub extent was digitised from the aerial photographs 'wscc2012' and 2015 WSCC'.

Figure 1 Project study area, with 2015 aerial photography in the background

Methodology

Hedgerows

The hedgerows were identified on the 2001 aerial photography. A line shapefile was created in GIS to contain the hedgerows. For each recognisable hedgerow, a line was digitised to capture the hedgerow with the length subsequently calculated in GIS. Where trees were encountered as part of the hedgerow, the line continued if the hedgerow appeared to do so. Gaps in the hedgerow wider than two metres were assumed permanent gaps and the digitised line interrupted. Generally, these were gaps for vehicle access or connecting two fields by means of a gate.

The width of the hedgerows was measured at the midpoint of the hedgerow line, where possible, and recorded in a point shapefile. If the midpoint fell on a section of hedgerow obscured by a tree canopy then the midpoint was moved to the nearest clear hedgerow section and the width measurement taken at that location. The shapefile attribute table shows these points with the remark 'midpoint moved'.

The width measurement shows a precision of 10cm. In reality, this is arbitrary as the resolution of the 2001 data is 25cm. However, the hedgerow widths were measured as accurately as possible with the aerial photography viewed at scale 1:400 - 1:500 in all cases. Resolution of the 2007 and 2015 aerial photography is 12.5cm making the 10cm precision more realistic.

The comparison used all three dates in order to analyse width changes over time, while length measurements were taken only from the 2001 photographs. Very few hedgerows completely disappeared since then; one location showed the loss of a hedgerow of 87 metres (recorded in the notes of the shapefile), another location showed a section of 8 metres of hedgerow removed in favour of a building. Other hedgerows became so wide that it was impossible to tell where hedgerow ended and scrub began. Such instances were marked with the no data value -99. The no data value was used also where shade or overhanging trees made it impossible to measure the width at the midpoint or nearby.

The length of hedgerows in the Southern Block is recorded in the shapefile Hedgerow.shp, with the width measurements recorded in the shapefile Hedgerow_MeasurePnts.shp. The two files may be linked based on the Hedge_ID field. The Excel file Hedgerow_Knepp_SouthernBlock.xlsx combines both attribute tables based on the Hedge_ID field.

Scrub

The scrub change analysis utilised the aerial photography of the years 2001, 2007, 2012 and 2015 to capture the most significant vegetation changes. The aerial photo interpretation focused on two types of scrub: thorny scrub and leafy scrub. In practice, these could not be distinguished as they generally occurred as a mixture of both. Where there clearly was a mixture, the scrub type was listed as Mixed Scrub (MS). Where leafy scrub appeared to dominate the scrub was classified as Leafy Scrub (LS). The areas with scrub were digitised from the 2015 aerial photographs considered to represent the largest extent to date.

Further scrub extent was digitised from the 2012 aerial photographs in order to estimate the overall change in scrub extent between 2012 and 2015. Earlier aerial photography of 2007 showed no mappable scrub cover. Aerial photography of 2001 showed arable fields under cultivation.

The total area for the different types of scrub is calculated using GIS. An indication is given for the density of the scrub vegetation according to the classification in Table 1.

Table 1Scrub cover density classes

Scrub cover classes	% cover
Dense scrub	>70%
Open scrub	41-70%
Scattered scrub	10-40%
Emerging scrub	1-10%

The density classes are approximate and were assigned 'by eye'. Figure 2 shows examples of each class. The density classification represents lateral scrub extent only, but obviously shrubs change in height as well. Shadows giving an indication of height are visible for bigger leafy shrubs, but generally not for lower growing or very slender shrubs. A minimum mappable unit of 25m^2 is considered reasonable for digitising at scale 1:500, although smaller areas were mapped in this project.

Figure 2 Density classes used in digitising scrub cover.

Results and discussion

Hedgerows

The total length of hedgerows measured in the Southern Block is 26,862m (26.86km). This includes hedgerows that could be classed as lines of trees and some that were already overgrown in 2001. Lines of trees marked in the shapefile were removed from the calculations in the edited version and all further calculations were carried out with the total length of 25,713m (25.71km). Table 2 lists the attributes of the hedgerow shapefile, while Table 3 lists the attributes of the hedgerow measurement points shapefile.

Table 2 Attributes of the hedgerow data (line shapefile Hedgerow.shp)

Attribute	Type	Explanation
Hedge_ID	Integer	Unique id for the hedgerow
Length	Double	Length calculation in m
Mid_X	Double	X coordinate of midpoint along the hedgerow
Mid_Y	Double	Y coordinate of midpoint along the hedgerow

Table 3 Attributes of the hedgerow width measurement points (point shapefile Hedgerow_measurepnts.shp)

Attribute	Type	Explanation
Hedge_ID	Integer	Unique id for the hedgerow
Width_2001	Double	Width measurement in m for 2001
Width_2007	Double	Width measurement in m for 2007
Width_2015	Double	Width measurement in m for 2015
Notes	Text	Comments

Table 4 shows the summarised results of the width and length measurements. The table with measured widths and lengths of each hedgerow is delivered separately in the Excel file Hedgerow_Knepp_SouthernBlock.xlsx.

Table 4 Summary of hedgerow widths from 2001 to 2015.

Measurement	Width 2001 (m)	Width 2007 (m)	Width 2015 (m)	Increase 2001 – 2007 %	Increase 2007 – 2015 %	Increase 2001 – 2015 %
Average	2.4	3.6	5.9	51%	61%	144%
Max	7.6	9.3	10.9			
Min	0.7	0.8	2.2			

Combining the length and width of the hedgerows gives us an approximation of the total area of hedgerow in Table 5 (total length * summarised width) and the increase over time. The percentage increase in two periods of 6 and 8 years respectively is very similar around 50% indicating a steady rate of growth. The overall change over the 14 year period is considerable at 132%.

Table 5 Total area of hedgerow

Total area 2001 (m^2)	Total area 2007 (m^2)	Total area 2015 (m^2)	Increase 2001 – 2007 %	Increase 2007 – 2015 %	Increase 2001 – 2015 %
61,426	93,207	142,261	52%	53%	132%

A separate calculation shows the total length of hedgerows over three width classes with the percentage width increase over 6 and 14 years (Table 6). The calculations indicate that the largest width increase occurred for hedgerows in the narrowest width class. Hedgerows of more than 3m wide in 2001 increased by less than double the width, while hedgerows in the narrowest class more than tripled in width over a period of 14 years.

Table 6 Summary of hedgerow width increase by width class.

Width class	Total length (m)	Average Width 2001 (m)	Average Width 2007 (m)	Average Width 2015 (m)	% Increase 2001-2007	% Increase 2001-2015
>= 3.1m	4,463	4.2	5.4	7.7	29%	83%
2.1 – 3.0m	9,638	2.6	3.7	5.8	42%	123%
<= 2.0m	11,128	1.6	3	5.4	88%	238%

Limitations of the hedgerow data

The width measurements were taken at the midpoint (or nearby) of each hedgerow. In 2001, the hedgerows were maintained to an even width over the entire length and the midpoint measurement provides a representative width for the whole feature. Following years of leaving the hedgerow to grow wild differences in width do occur along the feature. An alternative method would take additional width measurements along the hedgerow (e.g. at ¼ and ¾ length in addition to the midpoint) and use the average width as the 2015 measurement. The present scope of this project did not call for such detail.

As mentioned previously, the precision used for width measurements of the 2001 hedgerows was better than the resolution of the aerial photography, making the measurements not entirely accurate. Resolution improved for 2007 and 2015. Presence of shadow, angle of lighting on the aerial photographs and operator skill also influence the accuracy of the measurements. It is not possible to quantify these errors, but they should be considered consistent throughout the project.

Scrub

Scrub cover in the Southern Block is recorded in polygon shapefiles in GIS (Scrub_2015.shp and Scrub_2012.shp). Geometric calculations in GIS provide the total area of each polygon. Table 7 lists the attributes recorded in GIS.

Table 7 Shapefile attribute table (Scrub_2015.shp and Scrub_2012.shp)

Attribute	Type	Explanation
ScrubID15	Integer	Unique id for the polygon
ScrubID12	Integer	UniqueID for the polygon (in Scrub_2012.shp only)
ScrubType	Text	LS (Leafy Scrub), TS (Thorny Scrub), MS (Mixed Scrub) or P (Plantation)
POLY_AREA	Double	Area calculation in m^2
DetailScrb	Text	Comment about the scrub type
Density	Text	Dense, Open, Scattered, Emerging

Scrub cover was initially assessed over the same three periods used in the hedgerow assessment (2001, 2007 and 2015) with 2001 forming the baseline data. However, both 2001 and 2007 showed no mappable scrub cover. Areas appeared rougher in 2007 with some small shrubs appearing, but no consistent areas of scrub had formed. Therefore the 2012 aerial photographs were used instead to enable an assessment of change in the scrub vegetation over the 3-year period to 2015.

In many cases, it was not possible to distinguish thorny and leafy scrub as they occurred mixed together. Leafy scrub seemed to dominate even mixed areas, with thorny scrub creating areas with open or scattered scrub. Figure 3 a thru d show the progression of scrub formation in a field in the southern part of the Southern Block.

Figure 3a Arable field recently cultivated in 2001.

Figure 3b The arable field is no longer cultivated, showing rougher patches where scrub is likely to develop.

Figure 3c Scrub development is taking place in a discrete area.

Figure 3d Most recent stage in scrub development in this area (2015).

Some digitised areas are actually plantations, with regular rows of shrubs or small trees. These are marked in the attribute table and listed separately in the calculations (see also Example 1 in the final section).

The outlines of scrub areas were digitised and a density class assigned according to the approximate percentage cover shown in table 1. The class 'Emerging scrub' was introduced in the 2012 scrub data in order to enable percentage change calculation over the period 2012-2015. Where no scrub exists initially, a percentage change cannot be calculated. Where possible the attribute 'DetailScrb' was filled in, most commonly in areas of apparent uniform vegetation such as bramble and sallow.

The total area of scrub in 2015 was calculated as 88.11ha, compared to 82.96ha in 2012 this means a 6.2% increase (excluding plantations). Table 8 shows the change in extent by scrub type over the same period, while Table 9 lists the change in density.

The plantations extent did not change over time and as it is not part of the natural scrub development it is mentioned, but excluded from the calculations below.

Overall scrub extent increased over the 3-year period, but perhaps more interestingly are the scrub density changes. The emerging scrub class diminished over time and became largely scattered scrub. Equally, scattered scrub in some areas became open scrub, which more than doubled its extent. Dense scrub increased by nearly a third in the same period (Table 9) consisting mainly of leafy scrub (Tables 10 and 11).

Table 8 Totals and percentage change in scrub types between 2012 and 2015

Scrub type change	Total area of scrub in ha in 2012	Total area of scrub in ha in 2015	% Change
Including all types	98.41	103.55	5.22%
Excluding plantations	82.96	88.11	6.21%
Leafy scrub (LS)	48.64	51.47	5.82%
Thorny scrub (TS)	3.7	3.75	1.35%
Mixed scrub (MS)	30.62	32.89	7.41%
Plantations (P)	15.45	15.45	0.00%

Table 9 Totals and percentage change in scrub densities between 2012 and 2015

Scrub density change	Total area in ha in 2012	Total area in ha in 2015	% Change
Dense scrub	18.82	24.56	30.50%
Open scrub	19.47	40	105.44%
Scattered scrub	33.65	23.49	-30.19%
Emerging scrub	11.02	0.06	-99.46%

Excludes plantations

Tables 10 and 11 give further detail on the scrub mapping, with total extents by type and density, in hectares and in percentage cover of the Southern Block area (471.8 ha). Dense scrub is dominated by leafy scrub both in 2012 and 2015, with 3.9% and 4.8% respectively. Similarly open scrub is mainly leafy scrub, with 3.1% in 2012 and 5.7% in 2015 (numbers rounded). Scattered scrub is more likely to be mixed, nearly 4% in 2012 and 4.5% in 2015.

Table 10 Summary of scrub presence in 2012 in hectares (ha) and the percentage coverage of the Southern Block.

2012	Total area of scrub in ha and %		Total area dense scrub in ha and %		Total area open scrub in ha and %		Total area scattered scrub in ha and %		Total area emerging scrub in ha and %	
Including all types	98.41	20.86%	34.27	7.26%	19.47	4.13%	33.65	7.13%	11.02	2.34%
Excluding plantations	82.96	17.58%	18.82	3.99%	19.47	4.13%	33.65	7.13%	11.02	2.34%
Leafy scrub (LS)	48.64	10.31%	18.39	3.90%	14.53	3.08%	12.55	2.66%	3.17	0.67%
Thorny scrub (TS)	3.7	0.78%	0.43	0.09%	0.75	0.16%	2.43	0.52%	0.09	0.02%
Mixed scrub (MS)	30.62	6.49%	0	0.00%	4.19	0.89%	18.67	3.96%	7.75	1.64%
Plantations (P)	15.45	3.27%	15.45	3.27%	0		0		0	

Table 11 Summary of scrub presence in 2015 in hectares (ha) and the percentage coverage of the Southern Block.

2015	Total area of scrub in ha and %		Total area dense scrub in ha and %		Total area open scrub in ha and %		Total area scattered scrub in ha and %		Total area emerging scrub in ha and %	
Including all types	103.55	21.95%	40	8.48%	40	8.48%	23.49	4.98%	0.06	0.01%
Excluding plantations	88.11	18.67%	24.56	5.21%	40	8.48%	23.49	4.98%	0.06	0.01%
Leafy scrub (LS)	51.47	10.91%	22.57	4.78%	26.98	5.72%	1.91	0.40%	0	
Thorny scrub (TS)	3.75	0.79%	0.43	0.09%	2.83	0.60%	0.5	0.11%	0	
Mixed scrub (MS)	32.89	6.97%	1.56	0.33%	10.19	2.16%	21.08	4.47%	0.06	0.01%
Plantations (P)	15.45	3.27%	15.45	3.27%	0		0		0	

By comparison, the total area of hedgerow (based on the figures in Table 4) represents 3% of the Southern Block area in 2015.

Combining the results of tables 10 and 11 allows the calculation of percentage change by both scrub type and density. Table 12 lists the percentage change of each of the combinations of scrub type and density. The development of more densely growing scrub communities is apparent, with a clear reduction of total extent of scattered scrub and emerging scrub. As mixed scrub appeared to have no presence in 2012 in the dense category, a percentage change could not be calculated for that combination.

Table 12 % change of scrub type by density between 2012 and 2015.

Scrub type and density change 2012 - 2015	% change in dense scrub	% change in open scrub	% change in scattered scrub	% change in emerging scrub
Leafy scrub (LS)	22.7%	85.7%	-84.8%	-100.0%
Thorny scrub (TS)	0.0%	277.3%	-79.4%	-100.0%
Mixed scrub (MS)		143.2%	12.9%	-99.2%

Limitations of the scrub data

Digitising scrub extent is not an exact science and depends on the interpretation by the operator as well as resolution, contrast, presence of shadows and angle of light on the aerial photographs. Especially areas classed as open or scattered scrub could be digitised differently on different occasions and by different operators. Likewise the density classification of each area of scrub is also subjective. Shadows limit visibility and in those cases only visible areas of scrub were digitised, which may lead to a slight underestimation in some areas.

Hedgerow expansion was not included in the scrub increase, as this is covered in the hedgerow width analysis and would cause double counting.

The minimum mappable unit of 25m^2 set for digitising at scale 1:500 prevents very small areas or single shrubs from being digitised separately. In this project the minimum mappable unit was reduced to account for more isolated areas of scrub, most commonly bramble. Inevitably areas of scrub have been missed, especially in areas shaded by trees, where the surrounding vegetation obscured small shrubs or where the aerial photographs show insufficient contrast or texture to distinguish features. Further aerial photo interpretation in the near future could potentially show these areas differently so the scrub may be mapped and compared to the 2015 and 2012 data to see if the scrub was already present at these earlier times.

It is likely that the figures for thorny scrub underestimate the actual expanse in favour of leafy scrub, especially in areas with a mixture dominated by leafy scrub, which is much more visible on the aerial photographs.

Recommendations

Further analysis of scrub development could focus on ground truthing the mapped areas for 2015 to establish a definitive scrub type for each area, although the rate of change is quite substantial and current (2017) presence of scrub does not necessarily mean the same scrub type or density was present in 2015.

Future mapping of scrub would be useful in 2 to 4 years for comparison with the 2015 outlines. Some fields showed no scrub development at all and it may be worthwhile to investigate why this is the case. It is not possible to determine the reason for this issue from the aerial photography alone.

Hedgerows have in some cases expanded beyond the definition of hedgerows in 2015 and may need a different form of assessment if future comparisons are required.

Examples

The shapefile Examples.shp holds several locations of interest, as follows:

Example 1 Plantation

Example 2 Wetland area with scrub

Example 3 Sallow scrub (Leafy Scrub - LS)

Example 4 Open mixed scrub

Example 5 Scrub development starting at the centre of the field

Example 6 Scrub development starting at the edge of the field