Appendix A: Initial datasets considered for the project

ID	Indicator Type	Exposure Type	Land Use Type	Potential Indicator	Accessible Data Sources	Further Contact	Comments
C1	**Land use type**	**Land Use**	**Croplands**	**Croplands**	**LCM2007 (Arable); ALC**		**A cropland mask will be created using the LCM2007 data Arable Class. This data will be enriched using Land Suitability Data from the NE Agricultural Land Classification dataset. NB: the energy crops layer from NE will also be used to provide a subset of the cropland mask.**
C2	**Exposure indicators**	Threat	Croplands	Proportion/area/type of croplands at risk from coastal erosion	NCERM		HRW have already processed this to reference grid. Mike Panzeri will coordinate.
C3	**Exposure indicators**	Threat	Croplands	Proportion/area/type of croplands at risk from salinization	Coastal Proximity; Expert Guidance	Cranfield	Coastal proximity can be calculated with simple buffer analysis using a UK boundary layer. Cranfield may be able to provide further information
C4	**Exposure indicators**	Threat	Croplands	Proportion/area/type of croplands at risk from fluvial and tidal flooding	NAFRA08		HRW have already processed this to reference grid. Mike Panzeri will coordinate.
C5	**Exposure indicators**	Threat	Croplands	Proportion/area/type of croplands in water-stressed zones/areas of relative aridity	EA_WS; UKCP09 Rainfall; EA Guidance	EA	EA maps of relative water stress at the regional level are available. Contact with EA will be made to ascertain if further detail is available.
C6	**Exposure indicators**	Threat	Croplands	Proportion/area/type of croplands losing soil organic carbon (SOC)	C1; ESDB; ESDB_MESALES; ESDB_SEI	Cranfield	European soil erodability data is available at the 1km resolution (MESALES) and 10km scale (K-index). Cranfield may provide expert additional expert knowledge.

C7	**Exposure indicators**	Opportunities	Croplands	Proportion of croplands in areas with >x Growing Degree Days (GDD)	C1; UKCP09 baseline		GDD > X can be calculated from monthly temperature data following the methodology of Brookes (1943). Interpolation tables for daily values of meteorological elements, Q. J. Roy. Met. Soc., 69, 160-162.
C8	**Exposure indicators**	Indirect	Croplands	Proportion/area/type of croplands at risk from pests and diseases	C1; FARMSTATS; Expert Guidance;	Rothamsted, Cranfield, FERA	FC has strong contacts with partners at FERA who monitor pests and diseases in both croplands and forests. Rothamsted have long term records of aphid populations for selected monitoring sites. FARMSTATS can provide data at a country level on the proportions of arable land under different crop types. This can be linked to the pests' individual to particular crops (e.g. Colorado potato beetle) with expert risk information from Rothamsted, Cranfield or FERA.

C9	**Exposure indicators**	Indirect	Croplands	Proportion/area/type of croplands reliant on insect pollination	UKNEA; MAGIC; FARMSTATS; Expert Guidance;	Reading University (Simon Potts); FERA;	The UKNEA chapter on Supporting Services provides significant information on the trends in pollination. However it also identifies absence of available data for pollination/pollination services. Key pollinator species distribution data, where available, could be used in addition to expert knowledge. Current NE protocols for pollinator species suggest that NE's habitat inventories (available through MAGIC) provide the best available data. FERA and academic pollinator experts at Reading University will also be able to advise. County level crop data from DEFRA Farming Statistics may help to link expert opinion to spatial data.
C10	**Exposure indicators**	Contextual	Croplands	Proportion/area/rate of development/mineral extraction on croplands	BGS_Minerals	BGS	BGS mineral maps for large regions are available as printed reports, but access to digital data is licenced.
C11	**Vulnerability indicators**	Threat	Croplands	Proportion/area/type of croplands dependent on water pumping	IDBs	HRW, ADA	Internal Drainage Board maps will provide an indication to areas in need of water pumping. The ADA can provide specialist knowledge, and maps are available on the DEFRA website. Internal Drainage Board datasets are available through HRW.

C12	**Vulnerability indicators**	Threat	Croplands	Proportion/area/type of croplands below sea level	OS_PANORAMA		OS PANORAMA DEM provides altitude data at a 50m resolution and is free of charge. A mask of areas below sea level can be created from this.
C13	**Vulnerability indicators**	Threat	Croplands	Proportion of croplands vulnerable to coastal erosion and flooding benefitting from defences	C2,	HRW	Flood defence data is included in the NAFRA08 dataset analysed by NRW in the previous proposal. The same data can be used here and overlaid on the vulnerable cropland layer.
C14	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in water-stressed zones producing water-intensive crops	C5, FARMSTATS	NFU, Cranfield	The proportion of water-stressed crops can be amalgamated to the county level for comparison with county level farm statistics. However without spatial disaggregation of these statistics it is impossible to tie the proportion for water-intensive crop to water-stressed zones. NFU/Cranfield may offer expert knowledge.
C15	**Vulnerability indicators**	Threat	Croplands	Water demand/abstraction for cropland production (by crop type)	FARMSTATS, ADAS	NFU, Cranfield	Crop type data is not available with the LCM2007. Inferences can be made based on county level crop data from DEFRA and irrigation recommendations by crop data from ADAS (2003, p14-16) or an update thereof, or an alternative dataset recommended by experts. Cranfield/NFU may also offer expert knowledge.
C16	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion: being double-	C6	NFU, Cranfield	Double cropping data is not readily available. Consult expert knowledge held by

				cropped			NFU and Cranfield
C17	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion: ploughed on slopes	C6	NFU, Cranfield	Slope identification is possible with a DEM but would be too time consuming within the scope of this work, and would be impossible to link to ploughing. As such, expert knowledge from NFU/Cranfield will be consulted.
C18	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion: reliant on deep ploughing	C6	NFU, Cranfield	No available deep-ploughing datasets. NFU/Cranfield could offer expert knowledge.
C19	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion on deep peat soils	C6, P1	NFU, Cranfield	Intersection of the soil erodability layer (C6, above) and deep peat mask (P1, below). NFU/Cranfield could offer expert knowledge also.
C20	**Vulnerability indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion suffering from soil compaction and/or poaching	C6, ESDC_COMP	NFU, Cranfield	Data on soil compaction is available from the European Soil Database for research purposes. The map provides a four class compaction index that can be used in combination with the soil erodability index (C6). NFU/Cranfield can offer expert knowledge also.
C21	**Vulnerability indicators**	Indirect	Croplands	Reliance on/use of chemical controls	FARMSTATS, FERA_PEST, FERA_PCROP	FERA, NFU, Cranfield	Expert knowledge and data is available on pesticide use through FERA (PUSSTATS). Linking this to space will require use of FARMSTATS and so be limited to a county level. FERA, NFU and Cranfield may all have expert knowledge to contribute.

C22	**Vulnerability indicators**	Contextual	Croplands	Rate of development in water-stressed zones where irrigation is 10%+ of total demand	C5	EA	Draw on water stress dataset and expert advice from EA.
C23	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: making irrigation more efficient (e.g. drip as opposed to spray irrigation)	C5	NFU, Cranfield, EA	Data on these aspects are relatively scarce. Consultation with relevant experts at Cranfield, NFU and EA.
C24	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: using mulches to conserve water	as C25	as C25	as C25
C25	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: increasing water storage capacity on farms	as C25	as C25	As C25 with DEFRA.
C26	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: use of drought-tolerant crops or tree species	as C25	as C25	as C25
C27	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: water efficiency measures on farm buildings	as C25	as C25	as C25
C28	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to water stress: changing cultivation practices (e.g. minimum tillage systems)	as C25	as C25	as C25
C29	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in floodplain: riparian tree planting	C4, W4	FC, EA, NFU	Combine floodplain cropland data (C4) with new planting woodland layer (W4). Expert knowledge from NFU, EA and FC.
C30	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in floodplain: protecting floodplain	C4, C13	HRW	Intersection between the croplands in floodplain (C4) and protected floodplain (C13) layers.

C31	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in floodplain: buffer strips/fencing alongside water courses	C4	as C25	as C25
C32	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion using: soil conservation techniques (no-till/min.till, cover crops, contour ploughing, rotational ploughing)	C6	as C25	as C25
C33	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion using: measures to avoid soil compaction and erosion	C6	as C25	as C25
C34	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in areas vulnerable to soil erosion using: buffer strips/fencing along watercourses	C6	as C25	as C25
C35	**Actions indicators**	Threat	Croplands	Proportion/area of croplands in floodplain: organic returns	C4	as C25	as C25
C36	**Actions indicators**	Opportunities	Croplands	Proportion/area of croplands in areas with >x GDDs: protecting the genetic diversity of plants/animals to provide a range of options for changing species/provenances under a changing climate	C7	NFU, Cranfield, EA, Rothamsted	As C25 with extra consultation with Rothamsted.
C37	**Actions indicators**	Opportunities	Croplands	Proportion/area of croplands in areas with >x GDDs: making changes to the supply chain/ market to support new crops/ tree products	C7	NFU, Cranfield, EA, Seed companies	As C25 with Seed Companies as additional knowledge source.
C38	**Actions indicators**	Opportunities	Croplands	Proportion/area of croplands in areas with >x GDDs: creating better access to new crop/tree/livestock varieties	C7	NFU, Cranfield, EA, Seed companies	As C25 with Seed Companies as additional knowledge source.

C39	**Actions indicators**	Opportunities	Croplands	Proportion/area of croplands in areas with >x GDDs: diversification of crops/trees/livestock on one site	C7	NFU, Cranfield, EA, FC, DEFRA	As C25 with FC and DEFRA.
C40	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands vulnerable to pests and diseases using: measures to protect/enhance natural predator species	C8	as C25	As C25 also FERA (Sarah Hugo) for biocontrol information.
C41	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands vulnerable to pests and diseases using: genetic adaptations to make crops more resilient	C8	as C25	as C25
C42	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands vulnerable to pests and diseases using: monitoring/early warning systems	C8	As C25 with UK Phenology Network.	As C25 with UK Phenology Network.
C43	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands vulnerable to pests and diseases using: Integrated Pest Management (e.g. crop rotation)	C8	as C25	as C25
C44	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands reliant on pollination: protecting/enhancing key pollinating species	C9	as C25	as C25
C45	**Actions indicators**	Indirect	Croplands	Proportion/area of croplands reliant on pollination: using/researching alternative pollinators	C9	as C25	as C25
C46	**Actions indicators**	Contextual	Croplands	Area of compensatory/reinstated cropland		County councils	Data may be held by county councils.

E1	**Land use type**	**Land Use**	**Energy crops**	**Energy crops**	**NE_EnergyCrop**		**An Energy Crop mask will be created using the Energy Crop shapefile available from NE. It will be combined with the arable layer to separate 'energy crops' and 'other arable'. All the same analyses will be applied to derive indicators from both total arable (for the cropland indicators) and energy crops. FR staff were involved in a consortium project led by Pete Smith Aberdeen on energy crop mapping under current an future climate change scenarios for UKERC. The project is largely finished, in the paper writing stage. It might also be possible to use some of the outputs from that work (including various constraints mapping from Ian Bateman, UEA). Some of the underlying work with SRC willow and poplar mapping of potential production have been published - Talllis et al., GCB Bionergy earlier this year**
E2-10	**Exposure indicators**	T/O/I/C	Energy crops	As for croplands.	See above (but using Energy Crop mask)	See above (C2-10 = E2-10)	See above
E11-22	**Vulnerability indicators**	T/O/I/C	Energy crops	As for croplands	See above (but using Energy Crop mask)	See above (C11-22 = E11-22)	See above
E23-46	**Actions indicators**	T/O/I/C	Energy crops	As for croplands	See above (but using Energy Crop mask)	See above (C23-46 = E23-46)	See above

G1	**Land use type**	**Land Use**	**Grasslands**	**Grasslands**	**LCM2007 (Improved Grassland; Semi-natural Grassland); MAGIC**		**An Improved Grassland (IG) mask will be produced using the LCM2007 Improved Grassland class. As many key vulnerability hotspots, particularly in the context of biodiversity, are within Semi-Natural Grasslands (SNG) a second mask that combines the LCM2007 classes Rough Grassland, Neutral Grassland, Calcareous Grassland, Acid Grassland, and Fen, Marsh and Swamp will be used for SNG. The NE habitat inventory datasets will be consulted, and datasets enriched with this information also if appropriate.**
G2-10	**Exposure indicators**	T/O/I/C	Grasslands	As for croplands	See above (But using IG/SNG mask)	See above (C2-10 = G2-10)	See above
G47	**Exposure indicators**	T/O/I/C	Grasslands	Proportion/area of livestock production at risk from heat stress	UKCIP09, FarmStats, CCRA_Ag, DEFRA_LIVESTOCK	NFU	DEFRA also have livestock data at 5km grid scale presented as an output map. Consult DEFRA. In addition the CCRA provides information on animal heat stress for multiple breeds. Livestock number data is supplied at a county level by FARMSTATS. CCRA for agriculture (Figure 4.7 and 8) links cow milk production and mortality to Thermal Humidity Index (and provides the equation to calculate this from temperature and humidity).
G11-22	**Vulnerability indicators**	T/O/I/C	Grasslands	As for croplands	See above (But	See above	See above

					using IG/SNG mask)	(C11-22 = G11-22)	
G48	**Vulnerability indicators**	T/O/I/C	Grasslands	Proportion of livestock reared indoors/outdoors		NFU/DEFRA	Consult NFU
G23-46	**Actions indicators**	T/O/I/C	Grasslands	As for croplands	See above (But using IG/SNG mask)	See above (C23-46 = G22-46)	See above
G50	**Actions indicators**	T/O/I/C	Grasslands	Proportion/area of livestock farms at risk from heat stress using: measures to manage heat stress for livestock	G49	DEFRA/NFU	This information will require consultation with NFU.
G51	**Actions indicators**	T/O/I/C	Grasslands	Proportion/area of livestock farms at risk from heat stress using: genetic adaptations to make livestock more resilient	G49	DEFRA/NFU	This information will require consultation with NFU.
G52	**Actions indicators**	T/O/I/C	Grasslands	Proportion/area of livestock farms at risk from heat stress using: tree/hedgerow planting for shading	G49	DEFRA/NFU	This information will require consultation with NFU.
W1	**Land use type**	**Land Use**	**Woodlands**	**Woodlands**	**LCM2007 (Broadleaf; Conifer); FC_NFI; FC_SCDB; FC_WGS**	**Direct Access to FC forestry datasets and forestry experts through FR Consortium Member**	**The LCM2007 classes Broadleaf and Conifer will be used to define two separate woodland masks. Data from FC's National Forest Inventory can be used to enrich this dataset. Furthermore, FC'c Sub-compartment database and Woodland Grant Scheme datasets will be used to differentiate ownership between public and 'grant-funded private forests'. Any forests in neither dataset will be kept separate as 'purely private forests'. This gives the potential to provide a six-class mask with public, funded private and purely private conifer and**

							broadleaved woodlands differentiated. The division in level of privacy is significant in terms of the extent to which the forestry standard applies, and is relevant for W10-15. Use of the FC SCDB & WGS for these purposes would need consultation with the FC with respect to licencing/ privacy concerns.
W2	**Exposure indicators**	Threat	Woodlands	Proportion/area/type/location of woodland at risk from wildfire	W1, CCRA_F	FC, HRW	The CCRA for forestry summarises the risks. The McArthur Forest Fire Danger Index is available for 1980 and 2080. Assessment of likelihood is also reported in the CCRA.
W3	**Exposure indicators**	Threat	Woodlands	Proportion/area/type/location of woodland at risk from drought	W1, CCRA_F; UKCP09	FC, HRW	FR and HRW compiled the forestry component of the CCRA. They used soil moisture deficit calculated fromUKCP09 data. A similar methodology can be followed using the equations in Figure A3.4 of the report, and either accessing the FR/HRW data or calculating soil water deficit directly.
W4	**Exposure indicators**	Opportunities	Woodlands	Area/type/location of new woodland planting	W1, CCRA_F; FC_NFI; FC_WGS		The NFI includes information on 'young trees'. Woodland Grant Scheme data has potential to help further identify areas where funding has been applied for to support planting. The FR

							consortium member and other FC experts will be able to advise further particularly with regard to licensing and privacy issues with respect to high resolution data.
W5	**Exposure indicators**	Indirect	Woodlands	Proportion/area/location of woodland at risk from pests and diseases	W1, CCRA_F; UKCP09	FC, HRW, FERA	The FR consortium member has direct access to forestry experts on pests and pathogens and strong links with partners at FERA, who monitor pests and diseases in both croplands and forests. The CCRA for Scotland reviewed current knowledge of forest condition. It focused on Red needle blight (affecting pine forest) and Green spruce aphid (affecting spruce forest). This information could be extrapolated to the managed forest estate using species data from the FC_SCDB and response functions based on UKCP09 summer and winter temperatures. A projected regional vulnerability to both species is available for 2050s and 2080s using broad regions (e.g. SW, SE etc.).
W6	**Vulnerability indicators**	Threat	Woodlands	Proportion/area of existing woodlands under active management	W4,	FC, CONFOR, EWTP	Consult with FC experts as well as private forestry bodies such as confederation of forest industries (CONFOR) and the England Woodland and Timber Partnership (EWTP).
W7	**Vulnerability indicators**	Opportunities	Woodlands	Proportion of new woodland created in areas at risk from	W4; W1/W2	See above	Intersection of the new woodland and

				wildfire/drought			wildfire/drought layers.
W8	**Vulnerability indicators**	Opportunities	Woodlands	Proportion of new woodland created on agricultural land/deep peat soils	W4, P1	See above and below (W4 and P1)	Intersection of the new woodland and the cropland/peatland layer. FR point out that no public or grant funded woodland would be planted on peats > 1m deep.
W9	**Actions indicators**	Threat	Woodlands	Proportion of woodlands at risk from wildfire	W1, W2	See above	Intersection of woodland and wildfire layer.
W10	**Actions indicators**	Threat	Woodlands	Proportion of woodlands at risk from wildfire taking actions to minimise risk: fire plans/maps/operating procedures	W9, W1(FC_SCDB, FC_WGS), FCS	FC, CONFOR, EWTP	All FC managed/grant supported land would be expected to follow the FC Standard. Conversations with FC and private forests can help ascertain the extent to which this is realised in practice and the factors that affect the level to which this guidance is considered sufficient to minimise vulnerability.
W11	**Actions indicators**	Threat	Woodlands	Proportion of woodlands at risk from wildfire taking actions to minimise risk: linear fire breaks/belts	as W10	As W10	as W10
W12	**Actions indicators**	Threat	Woodlands	Proportion of woodlands at risk from wildfire taking actions to minimise risk: prescribed burning	as W10	As W10	as W10
W13	**Actions indicators**	Opportunities	Woodlands	Proportion of new woodland creation/planting using: species/provenance selection suited to current and future climate	W4	FC (John Weir)	John Weir (Adviser for Woodland Creation and Resilience at FC England) will be contacted to identify the best approach to collecting data around issues of species provenance selection. Also consideration will be given to

							exploring options via consultation with tree nurseries.
W14	**Actions indicators**	Indirect	Woodlands	Proportion of woodlands at risk from pests and diseases taking actions to minimise risk: pest/disease risk assessments	W4, W5, W1 (WGS/SCDB)	FC, CONFOR, EWTP, FERA	As W10 with regard to Forest Standard. Additional input with regard to pests and diseases will be sought from FERA.
W15	**Actions indicators**	Indirect	Woodlands	Proportion of woodlands at risk from pests and diseases taking actions to minimise risk: preventative measures (felling)	W4, W5, W1 (WGS/SCDB)	FC, CONFOR, EWTP, FERA	Can identify felled trees from NFI, but as it will be difficult to identify areas at risk from pest and diseases in a truly spatial manner, it will be impossible to tie the felling of trees to evidence of preventative measures. Instead the consultation-based approach set out in W10 will be followed.
W16	**Actions indicators**	Indirect	Woodlands	Proportion of woodlands at risk from pests and diseases taking actions to minimise risk: silvicultural systems (avoid high structural uniformity)	W4, W5, W1 (WGS/SCDB)	FC, CONFOR, EWTP, FERA	as W10

P1	**Land use type**	**Land Use**	**Peatlands**	**Peatlands**	**JNCC_PEAT; MAGIC; LC2007**	**JNCC, IUCN-UKPP**	**Freely available GIS information available in MAGIC datasets (Ramsar sites, Blanket Bogs, Fens, Lowland Raised Bogs) can be consolidated to a peatlands mask and enriched with information from the Mountain, Heath and Bog classes from LCM2007 (Heather, Heather Grassland, Bog and Montane Habitats). The JNCC assessment of the state of the UK's peatlands will inform the process, and a separate deep peat layer would be created with reference to maps of England's deep and shallow peats located within the JNCC report (Figure 4). The IUCN-UK Peatland Partnership (IUCN-UKPP) can provide additional expert knowledge.**
P2	**Exposure indicators**	Threat	Peatlands	Carbon losses from all peatland soils (CO2 and DOC/POC)	P1	JNCC, IUCN-UKPP	Total peat area can be calculated and multiplied by the loss factor from expert opinion and the academic literature. Durham University (Fred Worrall), the IUCN-UK Peatland Partnership and the authors of the JNCC assessment of peatlands could provide expert knowledge.
P3	**Exposure indicators**	Threat	Peatlands	Proportion/area of upland blanket bog habitat dominated by: Sphagnum moss, Heather, Bracken, Grasses, Woodlands	P1, LCM2007	JNCC, IUCN-UKPP	The JNCC peatland assessment has a map (Figure 5) of the current land cover over peat. Contact will be made with JNCC. The map may be digitised or the

							peatland layer compared with LCM2007 data.
P4	**Vulnerability indicators**	Threat	Peatlands	Proportion/area/type of peatland habitats drained/over-grazed/rotationally burnt/extracted	P1	JNCC, IUCN-UKPP	The JNCC peatland assessment has a map (Figure 4) of the location of peats damaged by drainage/cultivation etc. This would provide an indication of the areas of peatland lost.
P5	**Vulnerability indicators**	Threat	Peatlands	Amount (tC)/location of peat extraction	P5,P2	JNCC, IUCN-UKPP	Combination of a spatial map of extraction with a conversion factor, identified through consultation with experts, to determine amount lost.
P6	**Vulnerability indicators**	Threat	Peatlands	Proportion of peat used in composting materials by horticultural industry		DEFRA	Consult DEFRA
P7	**Actions indicators**	Threat	Peatlands	Proportion/area/type/location of peat restoration schemes		JNCC, IUCN-UKPP	The IUCN-UK Peatland Partnership has information on the location of peatland restoration schemes. In addition many MAGIC datasets identify conservation areas, including government supported schemes.
CR1	**Land use type**	**Land Use**	**Coastal and river floodplains**	**Coastal and river floodplains**	**NAFRA08**	**HRW**	**NAFRA08 dataset delimits floodplains.**
CR2	**Exposure indicators**	Threat	Coastal and river floodplains	Proportion/area of freshwater habitats at risk from coastal erosion/squeeze	CCRA_B; CCRA_CE	HRW, DEFRA	DEFRA have already identified coastal habitats at risk from coastal erosion/squeeze. The CCRA for floods and coastal erosion and biodiversity provides some information at the national scale. HRW have this data.

CR3	**Vulnerability indicators**	Threat	Coastal and river floodplains	Area/condition of inter-tidal/floodplain habitats	UKNEA_CM	JNCC	UKNEA has information about the area of floodplain/intertidal habitats (Sand Dunes, Machair in Scotland, Saltmarsh, Shingle, Sea Cliffs (more than 20m high) and Coastal Lagoons) from JNCC data by county. Contact the relevant authorities.
CR4	**Vulnerability indicators**	Threat	Coastal and river floodplains	Proportion of coastline with fixed defences/artificial beach nourishment		EA	Contact EA.
CR5	**Vulnerability indicators**	Threat	Coastal and river floodplains	Proportion of rivers modified/separated from floodplain		HRW	Underlying dataset to the flood defence layers. HRW have this data.
CR6	**Actions indicators**	Threat	Coastal and river floodplains	Area/type of inter-tidal/floodplain habitat creation		EA, RSPB, NE, DEFRA	Consult relevant authorities.
CR7	**Actions indicators**	Threat	Coastal and river floodplains	Area of managed realignment schemes		DEFRA, RSPB	Consult relevant authorities.
CR8	**Actions indicators**	Threat	Coastal and river floodplains	Length of river restoration		EA, NE	Consult relevant authorities.
WS1	**Land use type**	**Land Use**	**Wildlife sites**	**Wildlife sites**	**MAGIC**	**NE, DEFRA**	**The MAGIC datasets contain the SSSI layer for England, which will itself include SACs and SPAs. Other layers may be considered if they bring significant additional data.**
WS2	**Exposure indicators**	Threat	Wildlife sites	Proportion of freshwater wildlife sites in water-stressed areas	WS1, C5		Intersection of the water stress layer from C5 and the wildlife site mask.
WS3	**Exposure indicators**	Threat	Wildlife sites	Ability of wildlife to track climate space			Will vary with species.
WS4	**Vulnerability indicators**	Threat	Wildlife sites	Condition/median size of wildlife sites	WS1	NE, JNCC	Calculate median size from the wildlife site mask. For condition assessments consult the relevant authorities.

WS5	**Vulnerability indicators**	Threat	Wildlife sites	Scale of connectivity between wildlife sites	WS1		Calculate metrics of distance from habitat patches. UKNEA suggests using LCM2007, MAGIC habitat types, specific species distributions and the FRAGSTATS programme from University of Massachusetts.
WS6	**Vulnerability indicators**	Threat	Wildlife sites	Rate of hedgerow/pond loss	NBN/LRCs, Pond Conservation	DEFRA, NE, EA, NBN/LRCs, Pond Conservation	Consult with relevant authorities. Phase 1 habitat surveys, available from National Biodiversity Network (NBN)/Local Record Centres (LRCs), include data on ponds and hedgerows. NGOs such as Pond Conservation have some public-driven web maps of pond locations and identify ponds at risk.
WS7	**Vulnerability indicators**	Threat	Wildlife sites	Proportion of ancient woodlands affected by conifer/non-native tree planting	MAGIC, FC_NFI, LC2007	FC, NE	MAGIC ancient woodland data layer can be cross-referenced with LCM2007 conifer data and NFI new planting/conifer data.
WS8	**Actions indicators**	Threat	Wildlife sites	Uptake of agri-environment scheme options	MAGIC	NE	NE report 'Agri-Environment schemes in England 2009' contains a map of agri-environment scheme coverage (Figure 12). Consult NE for access to underlying data. Environmental Stewardship Scheme data also available from MAGIC.
WS9	**Actions indicators**	Threat	Wildlife sites	Uptake of agri-environment scheme options: rate of hedgerow/pond creation	as WS6	as WS6	as WS6
WS10	**Actions indicators**	Threat	Wildlife sites	Uptake of agri-environment scheme options: uptake of buffer strips	C31, WS8	NE, NFU	When consulting on buffer strips, discuss Wildlife Sites at the same time as Croplands (C31).

WS11	**Actions indicators**	Threat	Wildlife sites	Uptake of landscape-scale conservation schemes		DEFRA, NE, EA, FC re NIAs; also NT, RSPB and TWTs re NGO schemes.	Consult relevant authorities over Nature Improvement Area (NIA) and NGO schemes.
WS12	**Actions indicators**	Threat	Wildlife sites	Area/type of habitat restoration/creation	BARS	DEFRA, NE	See NIA indicator protocol for habitat recreation, based on BARS actions for priority habitats "to increase habitat resource by" either "restoring features using appropriate management" or "creating new areas using appropriate management".

Appendix B: Tree species classification

Below is the breakdown of beech, oak, pine and spruce tree species as included within the forestry analysis.

BE	Beech	Beech	*Fagus sylvatica*
FOR	Beech	Oriental beech	*Fagus orientalis*
OK	Oak	Oak (robur/petraea)	*Quercus* spp.
POK	Oak	Pedunculate/common oak	*Quercus robur*
QAL	Oak	White oak	*Quercus alba*
QCE	Oak	Turkey oak	*Quercus cerris*
QFR	Oak	Hungarian oak	*Quercus frainetto*
QIL	Oak	Holm oak	*Quercus ilex*
QPU	Oak	Downy oak	*Quercus pubescens*
QPY	Oak	Pyrenean oak	*Quercus pyrenaica*
ROK	Oak	Red oak	*Quercus borealis*
SOK	Oak	Sessile oak	*Quercus petraea*
XOK	Oak	other oak spp.	*Quercus* spp.
AUP	Pine	Austrian pine	*Pinus nigra var nigra*
BIP	Pine	Bishop pine	*Pinus muricata*
CP	Pine	Corsican pine	*Pinus nigra var maritima*
LP	Pine	Lodgepole pine	*Pinus contorta*
MAP	Pine	Maritime pine	*Pinus pinaster*
MCP	Pine	Macedonian pine	*Pinus peuce*
MOP	Pine	Mountain pine	*Pinus uncinata*
PAR	Pine	Armand's pine	*Pinus armandii*
PAY	Pine	Mexican white pine	*Pinus ayacahuite*
PBR	Pine	Calabrian pine	*Pinus brutia*
PDP	Pine	Ponderosa pine	*Pinus ponderosa*
PEL	Pine	Slash pine	*Pinus ellottii*
PKO	Pine	Korean pine	*Pinus koreana*
PMO	Pine	Western white pine	*Pinus monticola*
PTA	Pine	Loblolly pine	*Pinus taeda*
PWA	Pine	Bhutan pine	*Pinus wallichiana*
PYU	Pine	Yunnan pine	*Pinus yunnanensis*
RAP	Pine	Monterey pine	*Pinus radiata*
SP	Pine	Scots pine	*Pinus sylvestris*
WEP	Pine	Weymouth pine	*Pinus strobus*
XP	Pine	other pines	*Pinus* spp.
NS	Spruce	Norway spruce	*Picea abies*
OMS	Spruce	Serbian spruce	*Picea omorika*
ORS	Spruce	Oriental spruce	*Picea orientalis*
SS	Spruce	Sitka spruce	*Picea sitchensis*
XS	Spruce	other spruces	*Picea* spp.

Appendix C: HLS options classified as used in this report

OPTCODE	OPTTITLE	Relevant for Peat	Relevant for Soils	Biodiversity Indicator Relevant	Linear Features	Creation	Restoration	Maintenance
A13	Non payment option - permanent grassland for Article 13	0	0	1	0	0	0	1
EC1	Protection of in-field trees (arable)	0	0	1	0	0	0	1
EC2	Protection of in-field trees (grassland)	0	0	1	0	0	0	1
EC24	Hedgerow tree buffer strips on cultivated land	0	0	1	1	0	0	0
EC25	Hedgerow tree buffer strips on grassland	0	0	1	1	0	0	0
EC4	Management of woodland edges	0	0	1	1	0	0	0
ED2	Take archaeological features out of cultivation	0	1	0	0	0	0	0
ED3	Low depth, non-inversion cultivation on archaeological features	0	1	0	0	0	0	0
ED4	Management of scrub on archaeological features	0	0	0	0	0	0	0
ED5	Management of archaeological features on grassland	0	0	0	0	0	0	0
EE1	2m buffer strips on cultivated land	0	1	1	1	0	0	0
EE10	6m buffer strips on intensive grassland next to a watercourse	0	1	1	1	0	0	0
EE2	4m buffer strips on cultivated land	0	1	1	1	0	0	0
EE3	6m buffer strips on cultivated land	0	1	1	1	0	0	0
EE4	2m buffer strips on intensive grassland	0	1	1	1	0	0	0
EE5	4m buffer strips on intensive grassland	0	1	1	1	0	0	0
EE6	6m buffer strips on intensive grassland	0	1	1	1	0	0	0
EE7	Buffering in-field ponds in improved grassland	0	0	1	1	0	0	0
EE8	Buffering in-field ponds in arable land	0	0	1	1	0	0	0
EE9	6m buffer strips on cultivated land next to a watercourse	0	1	1	1	0	0	0
EF1	Field corner management	0	1	1	1	0	0	0
EF11	Uncropped, cultivated margins for rare plants on arable land	0	0	1	1	0	0	0
EF2NR	Wild bird seed mixture	0	0	1	0	0	0	1
EF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land	0	0	1	0	0	0	1
EF4NR	Nectar Flower mixture	0	0	1	0	0	0	1
EF5	ASD to Dec 2008 Pollen + nectar flower mixture on	0	0	1	0	0	0	1

	set-aside land							
EF7	Beetle banks	0	0	1	0	0	0	1
EG2NR	ASD to Jan 2010 Wild bird seed mixture in grassland areas	0	0	1	0	0	0	1
EG3	ASD to Jan 2010 Nectar flower mixture in grassland areas	0	0	1	0	0	0	1
EJ1	Management of high erosion risk cultivated land	0	1	0	0	0	0	0
EJ5	In-field grass areas	0	0	1	1	0	0	0
EJ9	12m buffer strips for watercourses on cultivated land	0	1	1	1	0	0	0
EK1	Take field corners out of management: outside SDA & ML	0	1	1	1	0	0	0
EK2	Permanent grassland with low inputs: outside SDA & ML	0	0	1	0	0	0	1
EK3	Permanent grassland with very low inputs: outside SDA & ML	0	0	1	0	0	0	1
EK4	Manage rush pastures: outside SDA & ML	0	0	1	0	0	0	1
EK5	Mixed stocking	0	0	1	0	0	0	1
EL1	Field corner management: SDA land	0	1	1	1	0	0	0
EL2	Permanent in-bye grassland with low inputs: SDA land	0	0	1	0	0	0	1
EL3	In-bye pasture & meadows with very low inputs: SDA land	0	0	1	0	0	0	1
EL4	Manage rush pastures: SDA land & ML parcels under 15ha	0	0	1	0	0	0	1
EL5	Enclosed rough grazing: SDA land & ML parcels under 15ha	0	0	1	0	0	0	1
EL6	Moorland and rough grazing: ML land only	0	0	1	0	0	0	1
HB11	Maintenance of hedges of very high environmental value (2 sides)	0	0	1	1	0	0	0
HB12	Maintenance of hedges of very high environmental value (1 side)	0	0	1	1	0	0	0
HB14	Management of ditches of very high environmental value	0	0	1	1	0	0	0
HC1	Protection of in-field trees on arable land	0	0	1	0	0	0	1
HC10	Creation of woodland outside of the SDA & ML	0	0	1	0	1	0	0
HC11	Woodland livestock exclusion supplement	0	0	1	0	0	0	1
HC12	Maintenance of wood pasture and parkland	0	0	1	0	0	0	1
HC13	Restoration of wood pasture and parkland	0	0	1	0	0	1	0
HC14	Creation of wood pasture	0	0	1	0	1	0	0
HC15	Maintenance of successional areas and scrub	0	0	1	0	0	0	1
HC16	Restoration of successional areas and scrub	0	0	1	0	0	1	0
HC17	Creation of successional areas and scrub	0	0	1	0	1	0	0
HC18	Maintenance of high value traditional orchards	0	0	1	0	0	0	1
HC19	Maintenance of traditional orchards in production	0	0	1	0	0	0	1
HC2	Protection of in-field trees on grassland	0	0	1	0	0	0	1
HC20	Restoration of traditional orchards	0	0	1	0	0	1	0
HC21	Creation of traditional orchards	0	0	1	0	1	0	0

HC24	Hedgerow tree buffer strips on cultivated land	0	0	1	1	0	0	0
HC4	Management of woodland edges	0	0	1	1	0	0	0
HC5	Ancient trees in arable fields	0	0	1	0	0	0	1
HC6	Ancient trees in intensively-managed grass fields	0	0	1	0	0	0	1
HC7	Maintenance of woodland	0	0	1	0	0	0	1
HC8	Restoration of woodland	0	0	1	0	0	1	0
HC9	Creation of woodland in the SDA	0	0	1	0	1	0	0
HD10	Maintenance of traditional water meadows	0	0	1	0	0	0	1
HD11	Restoration of traditional water meadows	0	0	1	0	0	1	0
HD2	Take archaeological features out of cultivation	0	1	0	0	0	0	0
HD3	Low depth, non-inversion cultivation on archaeological features	0	1	0	0	0	0	0
HD4	Management of scrub on archaeological features	0	0	0	0	0	0	0
HD5	Management of archaeological features on grassland	0	0	0	0	0	0	0
HD6	Crop establishment by direct drilling (non-rotational)	0	1	0	0	0	0	0
HD7	Arable reversion by natural regeneration	0	1	1	0	0	1	0
HD8	Maintaining high water levels to protect archaeology	0	0	0	0	0	0	0
HD9	Maintenance of designed/engineered water bodies	0	0	0	0	0	0	0
HE1	2 m buffer strips on cultivated land	0	1	1	1	0	0	0
HE10	Floristically enhanced grass margin	0	0	1	1	0	0	0
HE11	Enhanced strips for target species on intensive grassland	0	0	1	1	0	0	0
HE2	4 m buffer strips on cultivated land	0	1	1	1	0	0	0
HE3	6 m buffer strips on cultivated land	0	1	1	1	0	0	0
HE4	2 m buffer strips on intensive grassland	0	1	1	1	0	0	0
HE5	4 m buffer strips on intensive grassland	0	1	1	1	0	0	0
HE6	6 m buffer strips on intensive grassland	0	1	1	1	0	0	0
HE7	Buffering in-field ponds in improved permanent grassland	0	0	1	1	0	0	0
HE8	Buffering in-field ponds in arable land	0	0	1	1	0	0	0
HF1	Management of field corners	0	1	1	1	0	0	0
HF10NR	Unharvested cereal headlands for birds and rare arable plants	0	0	1	1	0	0	0
HF11	Uncropped, cultivated margins for rare plants	0	0	1	1	0	0	0
HF12NR	Enhanced wild bird seed mix plots	0	0	1	0	0	0	1
HF13NR	Uncropped cultivated areas for ground-nesting birds - arable	0	0	1	0	0	0	1
HF14NR	Unharvested, fertiliser-free conservation headland	0	0	1	1	0	0	0
HF15NR	Reduced herbicide cereal crops following overwintered stubble	0	0	1	0	0	0	1
HF20NR	Cultivated fallow plots or margins for arable plants	0	0	1	1	0	1	0
HF2NR	Wild bird seed mixture	0	0	1	0	0	0	1
HF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land	0	0	1	0	0	0	1
HF4NR	Nectar flower mixture	0	0	1	0	0	0	1
HF5	ASD to Dec 2008 Pollen & nectar flower mixture on	0	0	1	0	0	0	1

	set-aside land							
HF7	Beetle banks	0	0	1	0	0	0	1
HF9NR	Cereal headlands for birds	0	0	1	1	0	0	0
HG2NR	ASD to Jan 2010 Wild bird seed mixture	0	0	1	0	0	0	1
HG3	ASD to Jan 2010 Nectar flower mixture in grassland areas	0	0	1	0	0	0	1
HG6NR	Fodder crop management to retain or re-create an arable mosaic	0	0	1	0	0	1	1
HG7NR	Low input spring cereal to retain or re-create an arable mosaic	0	0	1	0	0	1	1
HIOS1	Landscape management [check what this is]	0	0	1	1	1	1	1
HIOS2	Management of rare arable bulb/flora	0	0	1	0	0	0	1
HIOS3	Reintroduction of conservation grazing to St Mary's	0	0	0	0	0	0	0
HIOS4	Reintroduction of conservation grazing other than St Mary's	0	0	0	0	0	0	0
HJ1	Cropping restrictions on high erosion risk fields	0	1	0	0	0	0	0
HJ11	Maintenance of watercourse fencing	0	0	0	0	0	0	0
HJ3	Reversion to unfertilised grassland to prevent erosion/run-off	0	0	0	0	0	0	0
HJ4	Reversion to low input grassland to prevent erosion/run-off	0	0	0	0	0	0	0
HJ5	In-field grass areas to prevent erosion or run-off	0	1	0	0	0	0	0
HJ6	Preventing erosion or run-off from intensively managed grassland	0	1	0	0	0	0	0
HJ7	Seasonal livestock removal from intensively managed grassland	0	0	1	0	0	0	1
HJ8	Nil fertiliser supplement	0	0	1	0	0	0	1
HJ9	12 m buffer strips for watercourses on cultivated land	0	1	1	1	0	0	0
HK1	Take field corners out of management	0	1	1	1	0	0	0
HK10	Maintenance of wet grassland for wintering waders and wildfowl	0	0	1	0	0	0	1
HK11	Restoration of wet grassland for breeding waders.	0	0	1	0	0	1	0
HK12	Restoration of wet grassland for wintering waders and wildfowl	0	0	1	0	0	1	0
HK13	Creation of wet grassland for breeding waders	0	0	1	0	1	0	0
HK14	Creation of wet grassland for wintering waders and wildfowl	0	0	1	0	1	0	0
HK15	Maintenance of grassland for target features	0	0	1	0	0	0	1
HK16	Restoration of grassland for target features	0	0	1	0	0	1	0
HK17	Creation of grassland for target features	0	0	1	0	1	0	0
HK18	Supplement for haymaking	0	0	1	0	0	0	1
HK19	Raised water levels supplement	0	0	1	0	0	0	1
HK2	Permanent grassland with low inputs	0	0	1	0	0	0	1
HK3	Permanent grassland with very low inputs	0	0	1	0	0	0	1
HK4	Management of rush pastures	0	0	1	0	0	0	1
HK5	Mixed stocking	0	0	1	0	0	0	1

HK6	Maintenance of species-rich, semi-natural grassland	0	0	1	0	0	0	1
HK7	Restoration of species-rich, semi-natural grassland	0	0	1	0	0	1	0
HK8	Creation of species-rich, semi-natural grassland	0	0	1	0	1	0	0
HK9	Maintenance of wet grassland for breeding waders	0	0	1	0	0	0	1
HL1	Take field corners out of management in SDAs	0	1	1	0	0	0	1
HL10	Restoration of moorland	1	0	1	0	0	1	0
HL11	Creation of upland heathland	1	0	1	0	1	0	0
HL12	Management of heather, gorse and grass	1	0	1	0	0	0	1
HL13	Moorland re-wetting supplement	1	0	1	0	0	1	0
HL15	Seasonal livestock exclusion supplement	0	0	1	0	0	0	1
HL16	Shepherding supplement	0	0	1	0	0	0	1
HL2	Permanent grassland with low inputs in SDAs	0	0	1	0	0	0	1
HL3	Permanent grassland with very low inputs in SDAs	0	0	1	0	0	0	1
HL4	Management of rush pastures in SDAs	0	0	1	0	0	0	1
HL5	Enclosed rough grazing	0	0	1	0	0	0	1
HL6	Unenclosed moorland rough grazing	1	0	1	0	0	0	1
HL7	Maintenance of rough grazing for birds	1	0	1	0	0	0	1
HL8	Restoration of rough grazing for birds	1	0	1	0	0	1	0
HL9	Maintenance of moorland	1	0	1	0	0	0	1
HN2	ASD to Nov 2010 Permissive open access	0	0	0	0	0	0	0
HN3	ASD to Nov 2010 Permissive footpath access	0	0	0	0	0	0	0
HN4	ASD to Nov 2010 Permissive bridleway / cycle path access	0	0	0	0	0	0	0
HN5	ASD to Nov 2010 Access for people with reduced mobility	0	0	0	0	0	0	0
HN6	ASD to Nov 2010 Upgrading access for cyclists/horses	0	0	0	0	0	0	0
HN7	ASD to Nov 2010 Upgrading access - people with reduced mobility	0	0	0	0	0	0	0
HO1	Maintenance of lowland heathland	0	0	1	0	0	0	1
HO2	Restoration of lowland heath	0	0	1	0	0	1	0
HO3	Restoration of forestry areas to lowland heathland	0	0	1	0	0	1	0
HO4	Creation of lowland heathland from arable or improved grassland	0	0	1	0	1	0	0
HO5	Creation of lowland heathland on worked mineral sites	0	0	1	0	1	0	0
HP1	Maintenance of sand dunes	0	0	1	0	0	0	1
HP10	Supplement for extensive grazing on saltmarsh	0	0	1	0	0	0	1
HP11	Saltmarsh livestock exclusion supplement	0	0	1	0	0	0	1
HP2	Restoration of sand dune systems	0	0	1	0	0	1	0
HP4	Creation of vegetated shingle and sand dune on grassland	0	0	1	0	1	0	0
HP5	Maintenance of coastal saltmarsh	0	0	1	0	0	0	1
HP6	Restoration of coastal saltmarsh	0	0	1	0	0	1	0
HP7	Creation of inter-tidal and saline habitat on arable land	0	0	1	0	1	0	0
HP8	Creation of inter-tidal and saline habitat on grassland	0	0	1	0	1	0	0

HP9	Creation of inter-tidal and saline habitat by non-intervention	0	0	1	0	1	0	0
HQ1	Maintenance of ponds of high wildlife value < 100 sq m	0	0	1	0	0	0	1
HQ10	Restoration of lowland raised bog	1	0	1	0	0	1	0
HQ11	Wetland cutting supplement	0	0	1	0	0	0	1
HQ12	Wetland grazing supplement	0	0	1	0	0	0	1
HQ13	Inundation grassland supplement	0	0	1	0	0	0	1
HQ2	Maintenance of ponds of high wildlife value > 100 sq m	0	0	1	0	0	0	1
HQ3	Maintenance of reedbeds	0	0	1	0	0	0	1
HQ4	Restoration of reedbeds	0	0	1	0	0	1	0
HQ5	Creation of reedbeds	0	0	1	0	1	0	0
HQ6	Maintenance of fen	1	0	1	0	0	0	1
HQ7	Restoration of fen	1	0	1	0	0	1	0
HQ8	Creation of fen	1	0	1	0	1	0	0
HQ9	Maintenance of lowland raised bog	1	0	1	0	0	0	1
HR1	Grazing supplement for cattle	0	0	1	0	0	0	1
HR2	Grazing supplement for native breeds at risk	0	0	1	0	0	0	1
HR4	Supplement for control of invasive plant species	0	0	1	0	0	0	1
HR5	Bracken control supplement	0	0	1	0	0	0	1
HR6	Supplement for small fields	0	0	1	0	0	0	1
HR7	Supplement for difficult sites	0	0	0	0	0	0	0
HR8	Supplement for group applications	0	0	0	0	0	0	0
ILC	Improved land conversion payment	0	0	1	0	1	1	1
OC1	Protection of in field trees - rotational land	0	0	1	0	0	0	1
OC2	Protection of in field trees - grassland	0	0	1	0	0	0	1
OC24	Hedgerow tree buffer strips on rotational land	0	0	1	1	0	0	0
OC25	Hedgerow tree buffer strips on organic grassland	0	0	1	1	0	0	0
OC4	Management of wood edges	0	0	1	1	0	0	0
OD2	Take archaeological features out of cultivation	0	1	0	0	0	0	0
OD3	Low depth, non-inversion cultivation on archaeological features	0	1	0	0	0	0	0
OD4	Management of scrub on archaeological features	0	0	0	0	0	0	0
OD5	Management of archaeological features on grassland	0	0	0	0	0	0	0
OE1	2m buffer strips on rotational land	0	1	1	1	0	0	0
OE10	6m buffer strip on organic grassland next to a watercourse	0	1	1	1	0	0	0
OE2	4m buffer strips on rotational land	0	1	1	1	0	0	0
OE3	6m buffer strips on rotational land	0	1	1	1	0	0	0
OE4	2m buffer strip on organic grassland	0	1	1	1	0	0	0
OE5	4m buffer strip on organic grassland	0	1	1	1	0	0	0
OE6	6m buffer strip on organic grassland	0	1	1	1	0	0	0
OE7	Buffering in-field ponds in organic grassland	0	0	1	1	0	0	0
OE8	Buffering in-field ponds in rotational land	0	0	1	1	0	0	0
OE9	6m buffer strips on rotational land next to a	0	1	1	1	0	0	0

	watercourse							
OF1	Field corner management	0	1	1	1	0	0	0
OF2NR	Wild bird seed mixture	0	0	1	0	0	0	1
OF4NR	Nectar Flower mixture	0	0	1	0	0	0	1
OF7	Beetle banks	0	0	1	0	0	0	1
OG2NR	ASD to Jan 2010 Wild bird seed mixture in grassland areas	0	0	1	0	0	0	1
OG3	ASD to Jan 2010 Nectar flower mixture in grassland areas	0	0	1	0	0	0	1
OHC1	Protection of in-field trees on rotational land	0	0	1	0	0	0	1
OHC2	Protection of in-field trees on organic grassland	0	0	1	0	0	0	1
OHC4	Management of woodland edges	0	0	1	1	0	0	0
OHD2	Take archaeological features out of cultivation (Org)	0	1	0	0	0	0	0
OHD3	Low depth, non-inversion cultivation on archaeological features	0	1	0	0	0	0	0
OHD4	Management of scrub on archaeological features	0	0	0	0	0	0	0
OHD5	Management of archaeological features on grassland	0	0	1	1	0	0	0
OHE1	2 m buffer strips on rotational land	0	1	1	1	0	0	0
OHE2	4 m buffer strips on rotational land	0	1	1	1	0	0	0
OHE3	6 m buffer strips on rotational land	0	1	1	1	0	0	0
OHE4	2 m buffer strips on organic grassland	0	1	1	1	0	0	0
OHE5	4 m buffer strips on organic grassland	0	1	1	1	0	0	0
OHE6	6 m buffer strips on organic grassland	0	1	1	1	0	0	0
OHE7	Buffering in-field ponds in organic grassland	0	0	1	1	0	0	0
OHE8	Buffering in-field ponds in rotational land	0	0	1	1	0	0	0
OHF1	Management of field corners	0	1	1	1	0	0	0
OHF11	Uncropped, cultivated margins for rare plants	0	0	1	1	0	0	0
OHF13NR	Uncropped, cultivated areas for ground-nesting birds	0	0	1	0	0	0	1
OHF2NR	Wild bird seed mixture	0	0	1	0	0	0	1
OHF4NR	Nectar flower mixture	0	0	1	0	0	0	1
OHF7	Beetle banks	0	0	1	0	0	0	1
OHG2NR	ASD to Jan 2010 Wild bird seed mix in grassland areas (organic)	0	0	1	0	0	0	1
OHG3	ASD to Jan 2010 Nectar flower mixture in grassland areas	0	0	1	0	0	0	1
OHJ11	Maintenance of watercourse fencing	0	0	0	0	0	0	0
OHJ5	In-field grass areas to prevent erosion and run-off	0	1	0	0	0	0	0
OHJ9	12 m buffer strips for watercourses on rotational land	0	1	1	1	0	0	0
OHK1	Take field corners out of management	0	1	1	1	0	0	0
OHK2	Permanent grassland with low inputs	0	0	1	0	0	0	1
OHK3	Permanent grassland with very low inputs	0	0	1	0	0	0	1
OHK4	Management of rush pastures	0	0	1	0	0	0	1
OHK5	Mixed stocking	0	0	1	0	0	0	1
OHL1	Take field corners out of management in SDAs	0	1	1	1	0	0	0
OHL2	Permanent grassland with low inputs in SDAs	0	0	1	0	0	0	1

OHL3	Permanent grassland with very low inputs in SDAs	0	0	1	0	0	0	1
OHL4	Management of rush pastures in SDAs	0	0	1	0	0	0	1
OHL5	Enclosed rough grazing	0	0	1	0	0	0	1
OJ1	Management of high erosion risk cultivated land	0	1	0	0	0	0	0
OJ5	In-field grass areas to prevent erosion or run-off	0	1	0	0	0	0	0
OJ9	12m buffer strips for watercourses on cultivated land	0	1	1	1	0	0	0
OK1	Take field corners out of management: outside SDA & ML(organic)	0	1	1	0	0	0	1
OK2	Permanent grassland with low inputs: outside SDA & ML(organic)	0	0	1	0	0	0	1
OK3	Permanent grassland with very low inputs:outside SDA&ML(organic)	0	0	1	0	0	0	1
OK4	Manage rush pastures: outside SDA & ML(organic)	0	0	1	0	0	0	1
OK5	Mixed stocking	0	0	1	0	0	0	1
OL1	Field corner management: SDA land(organic)	0	0	1	0	0	0	1
OL2	Permanent in-bye grassland with low inputs: SDA land(organic)	0	0	1	0	0	0	1
OL3	In-bye pasture & meadows with very low inputs: SDA land(organic)	0	0	1	0	0	0	1
OL4	Manage rush pastures: SDA land & ML parcels under 15ha(organic)	0	0	1	0	0	0	1
OL5	Enclosed rough grazing:SDA land & ML parcels under 15ha(organic)	0	0	1	0	0	0	1
OU1	Organic Management	0	0	0	0	0	0	0
PROL	Potential rotational option location (non payment)	0	0	0	0	0	0	0
REF10	No longer used Non payment version of EF10	0	0	0	0	0	0	0
REF6	No longer used Non payment version of EF6	0	0	0	0	0	0	0
REF8	No longer used Non payment version of EF8	0	0	0	0	0	0	0
REF9	No longer used Non payment version of EF9	0	0	0	0	0	0	0
REG1	No longer used Non payment version of EG1	0	0	0	0	0	0	0
REG4	No longer used Non payment version of EG4	0	0	0	0	0	0	0
REG5	No longer used Non payment version of EG5	0	0	0	0	0	0	0
REJ2	No longer used Non payment version of EJ2	0	0	0	0	0	0	0
RHF10	No longer used Non payment version of HF10	0	0	0	0	0	0	0
RHF12	No longer used Non payment version of HF12	0	0	0	0	0	0	0
RHF13	No longer used Non payment version of HF13	0	0	0	0	0	0	0
RHF14	No longer used Non payment version of HF14	0	0	0	0	0	0	0
RHF15	No longer used Non payment version of HF15	0	0	0	0	0	0	0
RHF16	No longer used Non payment version of HF16	0	0	0	0	0	0	0
RHF17	No longer used Non payment version of HF17	0	0	0	0	0	0	0
RHF18	No longer used Non payment version of HF18	0	0	0	0	0	0	0
RHF19	No longer used Non payment version of HF19	0	0	0	0	0	0	0
RHF20	No longer used Non payment version of HF20	0	0	0	0	0	0	0
RHF6	No longer used Non payment version of HF6	0	0	0	0	0	0	0
RHF8	No longer used Non payment version of HF8	0	0	0	0	0	0	0
RHF9	No longer used Non payment version of HF9	0	0	0	0	0	0	0

RHG1	No longer used Non payment version of HG1	0	0	0	0	0	0	0
RHG4	No longer used Non payment version of HG4	0	0	0	0	0	0	0
RHG5	No longer used Non payment version of HG5	0	0	0	0	0	0	0
RHG6	No longer used Non payment version of HG6	0	0	0	0	0	0	0
RHG7	No longer used Non payment version of HG7	0	0	0	0	0	0	0
RHJ2	No longer used Non payment version of HJ2	0	0	0	0	0	0	0
ROF6	No longer used Non payment version of OF6	0	0	0	0	0	0	0
ROG1	No longer used Non payment version of OG1	0	0	0	0	0	0	0
ROG4	No longer used Non payment version of OG4	0	0	0	0	0	0	0
ROG5	No longer used Non payment version of OG5	0	0	0	0	0	0	0
ROHF6	No longer used Non payment version of OHF6	0	0	0	0	0	0	0
ROHF8	No longer used Non payment version of OHF8	0	0	0	0	0	0	0
ROHG1	No longer used Non payment version of OHG1	0	0	0	0	0	0	0
ROHG5	No longer used Non payment version of OHG5	0	0	0	0	0	0	0
SPR	Special project - revenue	0	0	0	0	0	0	0
TFC	Top fruit orchards conversion payment	0	0	1	0	0	0	1
UC22	Woodland livestock exclusion	0	0	1	0	0	0	0
UD13	Maintaining visibility of archaeological features on moorland	0	0	0	0	0	0	0
UHC22	Woodland livestock exclusion	0	0	1	0	0	0	1
UHD13	Maintaining visibility of archaeological features on moorland	0	0	0	0	0	0	0
UHL18	Cattle grazing on upland grassland and moorland	0	0	1	0	0	0	1
UHL20	Haymaking	0	0	1	0	0	0	1
UHL21	No cutting strip within meadows	0	0	1	0	0	0	1
UHL23	Management of upland grassland for birds	0	0	1	0	0	0	1
UJ12	Winter livestock removal next to streams, rivers and lakes	0	0	1	0	0	0	1
UL17	No supplementary feeding on moorland	0	0	1	0	0	0	1
UL18	Cattle grazing on upland grassland and moorland	0	0	1	0	0	0	1
UL20	Haymaking	0	0	1	0	0	0	1
UL21	No cutting strip within meadows	0	0	1	0	0	0	1
UL22	Management of enclosed rough grazing for birds	0	0	1	0	0	0	1
UL23	Management of upland grassland for birds	0	0	1	0	0	0	1
UOC22	Woodland livestock exclusion	0	0	1	0	0	0	1
UOD13	Maintaining visibility of archaeological features on moorland	0	0	0	0	0	0	0
UOHL20	Haymaking	0	0	1	0	0	0	1
UOJ12	Winter livestock removal next to streams, rivers and lakes	0	0	1	0	0	0	1
UOL17	No supplementary feeding on moorland	0	0	1	0	0	0	1
UOL18	Cattle grazing on upland grassland and moorland	0	0	1	0	0	0	1
UOL20	Haymaking	0	0	1	0	0	0	1
UOL21	No cutting strip within meadows	0	0	1	0	0	0	1
UOL22	Management of enclosed rough grazing for birds	0	0	1	0	0	0	1
UOL23	Management of upland grassland for birds	0	0	1	0	0	0	1

UOX2	Grassland and arable	0	0	0	0	0	0	0
UOX3	Moorland	1	0	1	0	0	0	1
UX1	Commons and shared grazing	1	0	1	0	0	0	1
UX2	Grassland and arable	0	0	0	0	0	0	0
UX3	Moorland	1	0	1	0	0	0	1

Appendix D: Coastal Research Project. HR Wallingford additional contract (MAM6953)

This documentation for this additional HR Wallingford contract has been submitted separately.

HR Wallingford
Working with water

ASC natural resource indicators

Coastal research project

MAM6963-RT001-R03-00

June 2013

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E MN Hall		

Shoreline Management Plan Economic Review

Shoreline management plans (SMPs) are large-scale assessments of the risks associated with coastal processes. They aim to reduce the risks to people and the developed, historic and natural environment and are an important aspect of the Government's (of England and Wales) strategy for managing flooding and coastal erosion.

This review aimed to understand the total cost of implementing all of the preferred management options in the published SMPs for England. The results show that the FV cost of implementing all preferred policy options to the year 2105 across all English SMPs is £19.6 billion and the PV cost of this is £5.4 billion. The PV costs reported for protecting the English coastline varies considerably depending upon the location. Total PV costs to 2105 for each SMP varies between £20 million (SMP1 Scottish Border to the River Tyne along the Northumberland coastline) and £1.1 billion (SMP22 Great Ormes Head to Scotland along the North West coastline).

Key characteristics of the economic assessment within each SMP were recorded so that three SMPs could be chosen for a more detailed review of how the Defra guidance for the economic assessment of SMPs was implemented. This appraisal process of the economic analysis undertaken for English SMPs has highlighted some inconsistencies with the approaches taken to implement the guidance provided by Defra. Whilst different approaches for determining the preferred policy option and reporting the economic appraisal may be necessary to capture local specificities, this makes comparison at a national scale more challenging.

Contents

1. Overview

Shoreline Management Plans (SMPs) are large-scale assessments of the risks associated with coastal processes. They aim to reduce the risks to people and the developed, historic and natural environment and are an important aspect of the Government's (of England and Wales) strategy for managing flooding and coastal erosion. The first SMPs were undertaken in the late 1990s. The second round of SMPs was completed between 2010-11. This review provides an inventory of the economic information presented in the SMPs (Round 2) for England and a summary of the policy options chosen for each SMP. This review has also investigated the costs of three of the SMPs in greater detail.

There are now 20 SMPs for England (and two for Wales) and they define coastal management options for three different timescales (called 'epochs') up to the year 2025, up to 2055 and up to 2105. Each SMP covers a particular stretch of coastline, which is split into Policy Development Zones, Management Areas and Policy Development Units. Each of these is allocated a management option that is appropriate to the conditions for the geographic area and physical characteristics. The Environment Agency commenced the National Coastal Erosion Risk Mapping (NCERM) project in 2006 (Halcrow, 2012), which mapped the English and Welsh coastline at risk from coastal erosion. The data were released in Feb 2012 following validation by each of the regional coastal authorities. For each SMP epoch and each policy unit, NCERM describes the projected distance of coastal retreat under a scenario of no active intervention and under the management policy option from the SMP:

- **Hold the line:** The existing defence is maintained by either maintaining or changing the standard of protection.
- **Advance the line:** The existing defence line is advanced by building new defences on the seaward side of the original defences.
- **Managed realignment:** The shoreline is allowed to move backwards or forwards, with management to control or limit movement.
- **No active intervention:** There is no investment in coastal defences or operations.

This review provides:

1. An inventory for each SMP with respect to the costs associated with the preferred policy, split by epoch.
2. A record of the discount rates and periods used in each of the SMP calculations.
3. A calculation of Future Value (FV) i.e. non-discounted costs, based upon the information provided for Points 1 and 2.
4. A summary, per SMP and overall, of the policy options chosen in the preferred policy as recorded by the NCERM project.
5. A more detailed review of SMPs 6, 11 and 15 to assess the ways in which the Defra guidance has been implemented.

Review Points 1 to 4 are provided in the spreadsheet that accompanies this report. The results of review Point 5 are described in Section 3.

2. Review the costs of implementing the SMPs preferred policy options

This review aimed to understand the total cost of implementing the preferred policy options in the published SMPs. The costs of implementing the preferred options were identified by reviewing the economic appraisal annexes of all 20 English SMPs and the Future Values of the costs were calculated accordingly. Key characteristics of the economic appraisals undertaken were recorded so that three SMPs could be chosen to take forward for further, more detailed, review. In addition, the total length and percentage of the coastline that is covered by each of the four potential policy options has also been recorded.

The methods, clarity of assumptions made and the types of information presented by the SMPs varies considerably. In particular, the same terminology is used slightly differently between SMPs and, as a result, it is more challenging to make comparisons across the different reports. In this review, high level results are presented in a consistent manner, however, the data that feeds into these results may differ between reports. These differences have been recorded in the accompanying spreadsheet to this report to provide transparency in the review. In particular, the use of the terms Capital Value and Management Costs are inconsistently used between the SMPs.

In order to compare the different costs outlined in the SMPs it was necessary to convert the costs presented in the SMP reports into Future Values (FV) i.e. values that have not been discounted for future epochs, but that do include both optimism bias and increases as necessary for climate change. For around 60% of SMPs, Present Value (PV) costs are presented with optimism bias and climate change. For these SMPs, the FV costs are simply the result of removing the annual increases in each epoch (usually 3.5% for 2025, 3.0% for 2055 and 2.5% for 2105 as recommended by the Defra, 2006, SMP Guidance). For the rest of the SMPs, either PV costs were not presented either at all or by epoch, or, FV costs were also presented (referred to as Capital Value, CV, costs or Management Costs that included optimism bias and climate change factors). In these cases, the calculated HR Wallingford FV cost uses these costs directly.

An overview of the results of this review are shown in Table 2.1 below. The results show that the FV cost of implementing all preferred policy options to the year 2105 is £19.6 billion. Note that SMP22 for Great Ormes Head to Scotland and SMP3 Flamborough Head to Gibralter Point have particularly high costs, with total FV costs of more than £3.1 billion each. It is not clear why the cost estimates provided in these SMPs are substantially higher than in other SMPs.

Table 2.1: SMP Review Results. Those SMPs that were taken forward for a more detail review are highlighted in blue. All costs are FV unless stated otherwise.

SMP Ref. No.	SMP name	PV total (m£)	2025 (m£)	2055 (m£)	2105 (m£)	Total (m£)	Author
1	Scottish Border to the River Tyne	20	48	13	16	18	Royal Haskoning
2	The Tyne to Flamborough Head	150	309	269	24	16	Royal Haskoning
3	Flamborough Head to Gibraltar Point	453	3153	593	1003	1557	Scott Wilson
4	Gibraltar Point to Hunstanton (The Wash)	138	288	25	39	64	Royal Haskoning
5	Hunstanton to Kelling Hard	143	362	29	240	93	Unknown
6	Kelling to Lowstoft Ness	62	617	73	376	168	AECOM
7	Lowestoft Ness to Felixstowe Port	95	95	53	56	156	Royal Haskoning
8	Essex and South Suffolk	341	1134	55	747	332	Unknown
9	River Medway to Swale Estuary	344	1565	276	775	513	Halcrow
10	Isle of Grain to South Foreland	0	1262	39	488	735	Halcrow
11	South Foreland to Beachy Head	453	1695	308	410	977	Unknown
12	Beachy Head to Selsey Bill	160	792	52	279	462	Halcrow
13	Selsey Bill to Hurst Spit	1056	2405	1111	700	607	Unknown
14	Isle of Wight	38	193	21	42	130	Royal Haskoning
15	Hurst Spit to Durlston Head	98	438	45	55	338	Royal Haskoning
16	Durlston Head to Rame Head	298	877	224	300	353	Halcrow
17	Rame Head to Hartland Point	105	237	97	66	75	Royal Haskoning
18	Hartland Point to Anchor Head	149	478	124	119	235	Halcrow
19	Anchor Head to Lavernock Point	219	530	146	283	101	Atkins
22	Great Ormes Head to Scotland	1109	3156	441	808	1906	Halcrow
	TOTAL	**5431**	**19634**	**3994**	**6827**	**8836**	

Source: Various

	2025	2055	2105
Advance the line	0%	0%	0%
Hold the line	47%	41%	39%
Managed realignment	9%	14%	16%
No active intervention	43%	44%	44%
No policy specified in NCERM	1%	1%	1%

Figure 2.1: Percentage contribution of each policy option type in National Coastal Erosion Risk Management system for the preferred SMP plan for England only.

Source: Halcrow, 2012

In addition to the review of the costs for the preferred plans for each SMP region, this review also summarised the total length and percentage of the coastline within each SMP that was categorised under each type of policy option, see Figure 2.1. This information has been extracted from the National Coastal Erosion Risk Management (NCERM) database.

This review indicates that over time, the number of actions relating to 'Hold the line' policies will reduce and the number of actions relating to managed realignment schemes will increase. Areas where no active intervention will take place remain about the same. There are a number of areas within the NCERM dataset where the policy option is not specified. All of these relate to flooding, although not all flooding related risks are blank in terms of policy options in NCERM.

3. Defra SMP guidance implementation review

This review carried out an assessment of the way in which Defra's guidance on economic appraisal was implemented. On the basis of authorship SMPs 6, 11 and 15 were chosen for this review stage. This aspect of the review considers whether all the parameters included within the guidance have been assessed and also considers whether the approaches set out in the guidance have been used. An overview of the findings of this review can be found in the sections below. A table detailing the results can be found in Appendix A.

Defra guidance

The guidance document for SMPs highlights the requirement for using an economic assessment to illustrate the viability of potential policy options for coastal management but does not require the coastal operating authorities to undertake a full benefit-cost ratio assessment. The guidance is flexible, to allow operating authorities to use local research and knowledge and tailor the SMP to local requirements. However, in order to encourage SMP economic assessments that are comparable, the guidance suggests the following:

- Where detailed local assessments are not available, MDSF and RASP should be utilised to appropriately estimate the benefits and costs of schemes when compared to 'no active intervention' schemes.
- Costs (replacement and maintenance) should be calculated for three epochs:
  - 0-20 years;
  - 20-50 years;
  - 50-100 years.
- Adjustments should be made to account for:
  - Present day values (PV): According to the latest Defra schemes guidance, currently 3.5% for 0-30 years, 3% for 31-75 years and 2.5% for 76-100 years;

    - Climate change: 0% for epoch 0-20; 1.5 times present days rates for epoch 20-50; 2 times present day rates for epoch 50-100;
    - Optimism bias: 60%;
    - The design-life of assets: full scheme reconstruction required at least once every 100 years for linear defences such as seawalls, every 50 years for beach schemes and every 30 years for groynes.
- Whilst MDSF and RASP can be used to calculate the costs to property and associate social costs, there are also ways in which agricultural land and infrastructure can be valued. At a high level, the mechanisms for doing this are outlined.
- The guidance provides three tables, with examples, to suggest how the economic information and cost calculations should be presented.

Approximately half of the Defra guidance for economic appraisal concerns the way in which MDSF and RASP may be used to calculate costs and benefits. In general terms, the guidance highlights the principles of the analysis that may be adopted but the language used is not prescriptive and, with the exception of the tables suggested to present the material, no examples are given for how the assessment should be carried out. The guidance also does not provide detailed explanations or definitions of most of the economic terminology that it uses. In particular, Capital Value (CV), management and maintenance costs are not defined. The guidance is therefore open to interpretation and it encourages the inclusion of local knowledge. In terms of management at the SMP scale, this flexibility may be beneficial; it does, however, introduce challenges when making comparisons between SMPs at the national scale, as the SMPs are inconsistent with each other. Where the guidance is specific, such as for the rate used for optimism bias, the SMPs tend to be more consistent.

SMP6 – Kelling to Lowerstoft Ness

Overall, SMP6 closely aligns to the Defra guidance. Where the guidance document has provided advice and recommendations this has mostly been followed. As per the Defra guidance, the terms CV and management costs have not been defined, however, explanation for the headings in the economic appraisal tables has been provided. It is assumed that management costs are equal to Future Value costs i.e. that they include allowances for climate change and optimism bias but do not include discounting. Whilst the inclusion of optimism bias is explicit in the main text of the economic appendices, the labelling in the economic appraisal tables is not explicit. It is therefore not clear whether all values do include optimism bias or not.

SMP11 – South Foreland to Beachy Head

This SMP has followed the Defra guidance quite closely. The SMP deviates from the Defra guidance with regard to some of the summary tables used, however there remains sufficient information for the results to be compared to other SMPs. Similarly to SMP6, whilst the inclusion of optimism bias is explicit in the main text, the labelling in the economic appraisal tables is not explicit. It is therefore not clear whether all values do include optimism bias or not. Also, there is an assumed understanding of technical terms such as Capital Value, rather than an explicit definition provided.

SMP15 – Hurst Spit to Durlston Head

This SMP has not followed the Defra guidance for most aspects of the economic appraisal. This SMP deviates from the Defra guidance with regard to the datasets used to undertake the analysis; the assumptions made with regard to discounting, design-life and climate change are either different or not explicit; and, the way in which the results are presented does not follow the guidance.

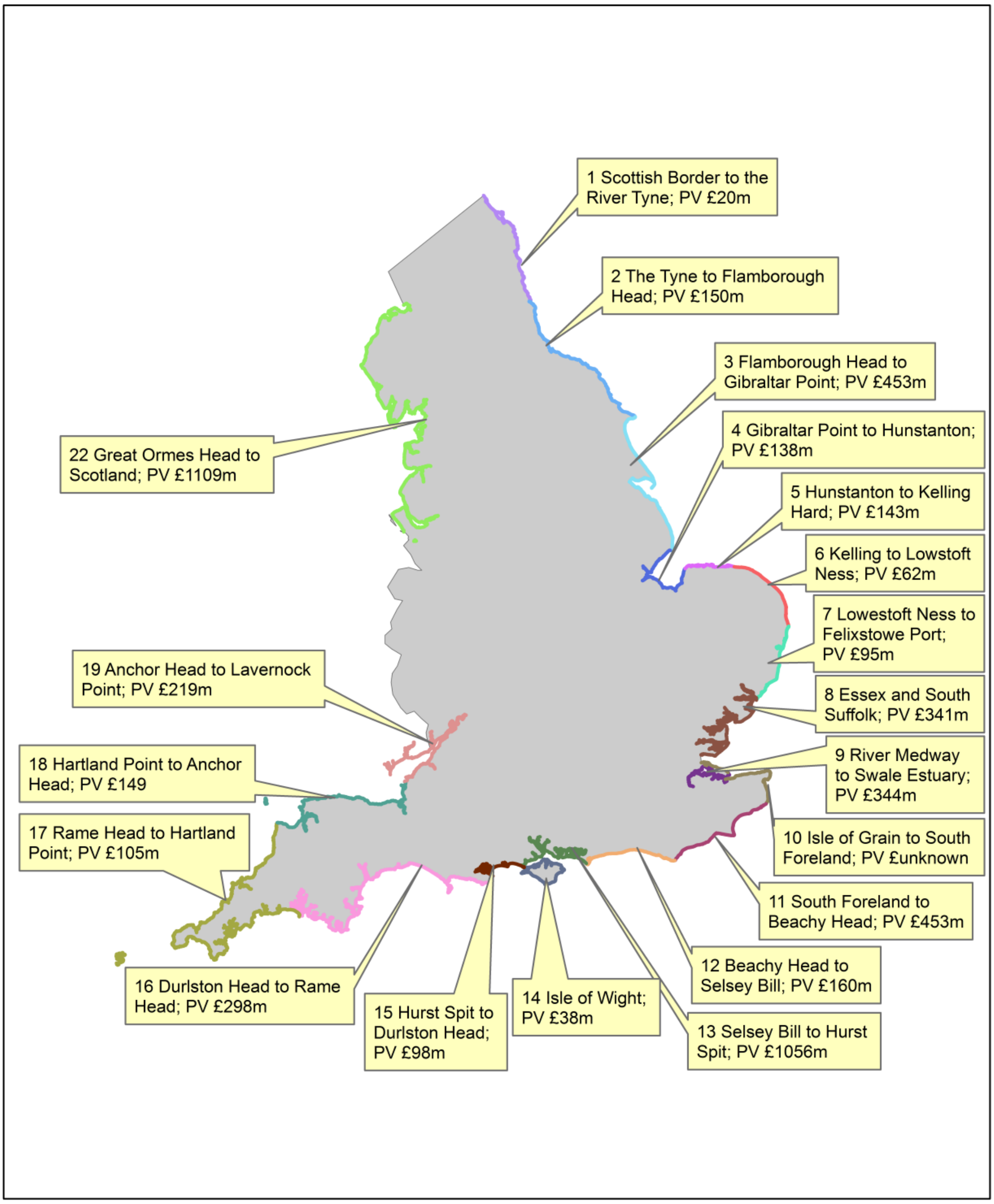
4. Conclusions

This appraisal process of the economic analysis undertaken for English SMPs has highlighted some inconsistencies with the approaches taken to implement the guidance provided by Defra. There are differences in the estimated costs of implementing preferred policy options between each SMP around the coastline of England.

The PV results for all English SMPs are shown in Figure 4.1.

In conclusion:

- The process for determining the preferred policy option and reporting the economic appraisal varies considerably between SMPs and makes comparison at a national scale challenging. In particular:
  - It is not clear in some SMPs whether a preferred policy option has been chosen;
  - Replacement and maintenance costs are not always recorded separately;
  - It is not always clear which costs include climate change and optimism bias;
  - Economic terminology is rarely properly defined and therefore it is difficult to understand what has or has not be included in a given cost calculation;
  - Despite the tables for presentation recommended by Defra, not all SMPs chose to use these summary tables to present costs.
- The PV costs reported for protecting the English coastline varies considerably depending upon the location:
  - Total PV costs to 2105 for each SMP are between £20 million (SMP1 Scottish Border to the River Tyne along the Northumberland coastline) and £1.1 billion (SMP22 Great Ormes Head to Scotland along the North West coastline);
  - The largest PV costs tend to coincide with those areas of the coast that are heavily populated and/or areas that are more prone to erosion, such as the east coast;
  - SMP 13 (Selsey Bill to Hurst Spit along the south coast) and SMP 22 both have PV costs of over £1 billion. The next highest cost is £453 million (for SMPs 3 and 11). The reason for this large difference in costs is not clear.
- Some SMPs also provide costs that appear to be equivalent to FV costs.
- The most prevalent policy options chosen are ‘Hold the line’ and ‘No active intervention’. ‘Managed realignment’ becomes more popular choice for the end of the century.



Shoreline Management Plan 2 location plan including the total estimated Present Value (PV) costs.
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Coastal Research Project

March 2013

No. 1

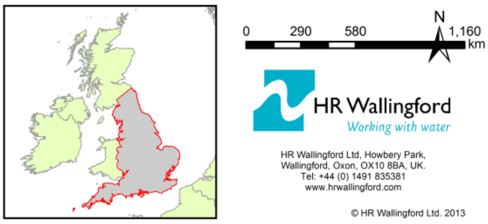

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Figure 4.1: SMP2 locations and total PV costs

Source: Various

5. References

For access to the SMPs, see http://www.environment-agency.gov.uk/research/planning/105014.aspx

Defra (2006) Shoreline Management Plan Guidance. Defra, UK

Halcrow (2012) National Coastal Erosion Risk Mapping (NCERM). Online: https://race.halcrow.com/ncerm/home.aspx . Environment Agency, England.

Appendices

A. Assessment of the implementation of the Defra guidance on economic appraisal within SMPs

Table A.1: An assessment of the way in which the Defra SMP guidance has been followed for three SMPs.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
Review economic viability for the preferred plan	Yes, this is the justification given for the economic analysis undertaken.	Yes, this is the justification given for the economic analysis undertaken.	Yes, this is the justification given for the economic analysis undertaken.
Where there is not existing other information, the Modelling and Decision Support Framework (MDSF) tool and a data management toolkit may be used. Can only calculate the losses/benefits for residential and commercial property.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	In some instances, earlier strategies that are not similar to the current SMP in terms of timescale considered or geographical area have been adapted to allow them to be used in the SMP.
Determine damages and benefits; a comparison between the preferred plan and NAI. • 0-20, 20-50 and 50-100 years, • No consideration of knock-on impacts down the coastline, • No account of standards of protection.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	GIS was used to determine damages. Data was drawn from various sources including address point data (similar to that used in MDSF) and other shapefiles held by the contractor. MDSF is not explicitly mentioned in the economic appendices of this SMP. This SMP explicitly highlights that the costs reflect the connectivity of the coastline.
Use MDSF to calculate the Capital Value (CV) and discounted Present Value (PV). • For CV and flood risk simply sum the CV for all built assets.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	MDSF is not explicitly mentioned in the economic appendices of this SMP. Costs are discounted as recommended by the Treasury.
Calculate replacement and maintenance costs for each epoch either from the management approaches that are	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	Maintenance and replacement costs are calculated, but not presented.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
developed or from nationally available information: • Replacement costs: Environment Agency dataset and adjust for local factors. • Maintenance costs: Defra National Appraisal of Defence Needs and Costs (NADNAC) study (2004). For cost calculations, assume the following: • full scheme reconstruction required (i.e. design life) is at least once every 100 years for linear defences such as seawalls, • every 50 years for beach schemes, and • every 30 years for groynes. Maintenance can be assumed to be at the same rate throughout the life of the scheme.			The SMP quotes specific costs for different defence types. The source of these costs is not clear. It is unclear whether the design life of schemes has been considered or whether the guidance was followed.
Climate change. Increase costs to account for climate change based upon the factors in the NADNAC study accordingly: • 0% for epoch 0-20, • 1.5 time present days rates for epoch 20-50, • 2 times present day rates for epoch 50-100.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	Sea level rise rates are used but the NADNAC factors are not incorporated into the analysis.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
Optimism bias should be 60% and applied to all costs.	Yes, this SMP closely aligns with the advice in the guidance in the text description, but in the heading of the economic appraisal tables, it is not made explicit under PV costs, only under total costs (that is assumed to be the CV costs).	Yes, this SMP closely aligns with the advice in the guidance in the text description, but in the heading of the economic appraisal tables, it is not made explicit under PV costs, only under CV costs.	60% optimism bias has been added to PV costs.
Full benefit-cost ratio (BCR) analysis is not required. It is advised that it may be useful to compare costs using PV for the full 100-year timescale. PV is defined as “Present Value is the value of a stream of benefits or costs when discounted back to the present day using the latest factor provided by Defra for assessment of schemes.”	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	This SMP has calculated BCR.
When calculating PV damages and PV benefits, MDSF can be used to approximate the timing of property losses so that the discount factor can be applied accordingly.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	MDSF is not used.
Maintenance costs should be discount according to the total discount rate for that epoch.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	Maintenance costs are discussed but it is unclear whether they are part of the PV costs that are presented.
The guidance suggests the use of tables for economic review, summary tables and cost calculations. Examples of these are shown in Appendix B.	Yes, this SMP closely aligns with the advice in the guidance and uses the tables suggested. However, this SMP goes one step further and provides an explanation for the	This SMP presents the economic review table and the cost calculation table. This SMP provides two further summary tables that outline damages and benefits and a	The tables suggested by the guidance are not used.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
	columns in the summary and cost calculations tables that is not provided by the guidance. This is particularly helpful. What is not very clear is why there are some gaps for the cost calculations in the table.	sensitivity assessment in the place of the summary table recommended.	
The guidance provides details regarding the benefits of using MDSF to calculation both monetary damages as well as providing a toolkit to appraise the extent and nature of areas potentially at risk from flooding and erosion. The text implies strongly that MDSF should be used in the SMP process.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	MDSF is not used.
The guidance illustrates the minimum level of appraisal that could be undertaken to evaluate economic and social damages. They are as follows: • NAI: Assume that all properties are 'written off' within the flood risk area following defence failure using EA flood zones (1:3yr), Digital Terrain Models and extreme water level data. • Use RASP HLM as an approximation of 'hold the line' scenario damages. • Use RASP 1km grid results to estimate 'managed realignment'. • Estimate 'advance the line' damages from 'hold the line' damages.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether the principles in this aspect of the guidance was followed. However, MDSF and RASP were not used.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
• Calculate erosion damaged for all epochs and scenarios through the development of future erosion contours in conjunction with MDSF.			
Use the erosion loss calculation provided by the guidance to calculate economic losses from anything with capital value i.e. property, infrastructure assets, agricultural land (grades 1-5) etc.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether this aspect of the guidance was followed.
In instances where coastal flooding would occur more frequently than annually, cap the PV losses incurred to the 'write off' value i.e. total market value. In other instances where property value is calculated, then use of the median of the relevant council tax bracket is usually sufficient.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	It is not made explicit within the SMP whether this aspect of the guidance was followed.
For non-residential properties, commercial property rates are the recommended method of comparative analysis.	Yes, this SMP closely aligns with the advice in the guidance.	Yes, this SMP closely aligns with the advice in the guidance.	It is not made explicit within the SMP whether this aspect of the guidance was followed.
Recreational and amenity benefits should be counted, but care must be taken to avoid double-counting. The use of the Middlesex manual is advised.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	Amenity benefits are part of the appraisal discussion.	Amenity benefits are part of the appraisal discussion.
If infrastructure only services those properties that are lost, then no extra cost is attributed, if they service properties that are not lost, then additional cost for disruption are added.	Infrastructure losses are not explicitly included in the cost calculations.	Infrastructure losses are not explicitly included in the cost calculations but are part of the appraisal discussion.	Infrastructure losses do not form part of the economic assessment.

Defra Guidance	SMP6 – Kelling to Lowerstoft Ness	SMP11 – South Foreland to Beachy Head	SMP15 – Hurst Spit to Durlston Head
Agricultural Land Valuation: • Estimate the Agricultural Land Classification (ALC) grades within the erosion zone for each loss period, • Use FPD Savills land price index to estimate the land value, • Add a 45% multiplier to all land values to capture subsidies.	It is not made explicit within the SMP whether this aspect of the guidance was followed.	Agricultural land is explicitly included in the costs calculations, but it is unclear how these calculations were made.	Agricultural land losses are part of the appraisal discussion but not explicitly part of the economic costs estimates.

Source: Defra, 2006; AECOM, 2010; Anonymous, 2006 and Royal Haskoning, 2011

B. Economic assessment data tables recommended by Defra for SMPs

Table C1: Economic assessment summary

The Table below provides a summary of the economic review of the preferred plan for each Policy Unit; it outlines any information used in this review, including benefits (**property only**) and costs, together with a statement on economic robustness. This table could also be used to present any economic sensitivity analysis.

Supplementing these tables are summary pages setting out the economic damages for No Active Intervention and the Preferred Plan, together with a calculation sheet identifying the build up of defence costs; these are included in Annex H1.

Location		Calculation of Damages and Benefits		Assumed Defence Works & Costs Broad-scale Economic Review			Comments
		Previous Studies	**Broad-scale Review (this SMP)**	**Years 0 to 20**	**Years 20 to 50**	**Years 50 to 100**	
3b02	Sheringham	Strategy study in progress – no data currently available.	***NAI Damages:*** By 2025: none By 2055: up to £1.8m By 2105: up to £106.9m ***Preferred Plan Damages:*** By year 2025: none By year 2055: none By year 2105: none	Extend linear defences. Maintenance of all structures. Cost: £1.8m See details for years 50 to 100	Extend linear defences. Reconstruct groynes. Maintenance of all structures. Cost: £7.3m See details for years 50 to 100	Reconstruct linear defences. Maintenance of linear defences. Cost: £14.0m The plan for this Policy Unit to hold the present line over 100 years is **Economically Robust**. Whilst the PVbenefit of up to £8.1m compares to a PVcost of £5.0m, the capital value of property protected is £107m, compared to a cost over the same period of only £23m, a ratio of nearly 5:1.	*It is possible that under NAI the seawall along the main frontage could fail earlier than anticipated which would increase the PVbenefit.* *It should also be noted that only property benefits have been considered and that inclusions of other assets could increase the PVBenefit.*

Figure B.1: Economic review table recommendation from Defra for SMPs

Source: Defra, 2006

Table C2: Supporting economic data

Summary Table

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
POLICY UNIT	YEAR	ASSET VALUE LOSS PER EPOCH (DAMAGES)		CUMULATIVE PROPERTY DAMAGE / LOSS (PV)		MANAGEMENT COST PER EPOCH (PREFERRED PLAN)	PREFERRED PLAN		SENSITIVITY ANALYSIS	
		NAI	PREFERRED PLAN	NAI	PREFERRED PLAN		PROPERTY DAMAGES AVERTED (PV)	COSTS (PV)	BENEFITS (PV)	COSTS (PV)
3b02 Sheringham	**20**					£1.8m		£1.2m		
	50	£1.8m		£0.4m		£7.3m	£0.4m	£3.6m		
	100	£106.9m		£8.1m		£14.0m	£8.1m	£5.0m		

Cost Calculations

(a)	(b)	(c)	(d)	(e)			(f)			(g)	(h)	(i)	(j)	(k)	(l)	(m)
POLICY UNIT	PERIOD	NOTES	REPLACEMENT				MAINTENANCE				TOTAL COST			PV COSTS		
			LENGTH			COST	LENGTH			COST	TOTAL COST	WITH OPTIMISM BIAS	CUMULATIVE TOTAL	REPLACEMENT	MAINTENANCE	CUMULATIVE PV TOTAL
			B	L	G		B	L	G							
3b02 Sheringham	0 - 20			0.2		£0.54m		1.3	1.5	£0.56m	£1.10m	£1.76m	£1.76m	£0.61m	£0.64m	£1.25m
	20 - 50			0.4	1.7	£2.10m		1.5	1.7	£0.96m	£4.59m	£7.34m	£9.10m	£1.59m	£0.73m	£3.57m
	50 - 100			1.3		£3.51m		1.7		£0.85m	£8.72m	£13.95m	£23.06m	£1.18m	£0.28m	£5.03m

Figure B.2: Supporting summary table and cost calculation table recommended by Defra guidance for SMPs

Source: Defra, 2006

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Appendix E: Reviewers comments and responses

Iain Brown Comments

Comment	Response
Comments on ASC Report 1 Whilst acknowledging the time pressures involved in the production of the report, I had the following comments. **General** Each section uses different combinations of scenarios and baselines. Confusing! Would benefit from some standardisation or a common reference against the UKCP09 projections. Some sections look at current climate change, others do not.	**ECI**: The fundamental drivers of the approach are the datasets available. This is not a project developing new primary research but one that consolidates existing datasets. Where possible we focused on 2050 as our time frame and collected data on current condition, measured trends, potential future vulnerability and action. However, the approach was reflexive and driven by data availability and access
Information is mainly provided for average-type conditions, but not extremes despite their key role in driving adaptation. Reference is sometimes made to reference 'dry years' but no detail given. An exception is the assessment of water resources that uses samples from the upper and lower 10% (wet and dry) from UKCP09. Use of 2020s low and high emissions scenarios is superfluous as there is virtually no difference in climate change from emissions then (and very little even for 2050s).	**HR WALLINGFORD:** The rainfall scenario is combined with the demand scenario (Table 3.1) so the wet and dry scenarios are quite different in their assumptions.
Is the analysis based upon the Spatially Coherent Projections from a single member or an average of all 11?	**HR WALLINGFORD:** The baseline climate is spatially coherent data but the projections used are the UKCP09 regional data which are not spatially coherent.
The ecosystems services framework is only rather loosely followed. The role of the ecosystem (including ecosystem function) is not usually at the centre of the analysis and a systematic structure approach has not been adopted which means that key interactions and indirect effects between indicators are not identified. This may be	**ECI**: We acknowledge both of these points. The introduction now clearly states the nature of the report as one designed to provide data that feeds into the ASC's own report. It is that report which will adhere more coherently to the ecosystem service framework.

understandable in the time available but there should be a section or table at the start to identify how much the framework has been followed. Similarly, a land systems approach has not been followed which could have been used to investigate conflicts and synergies (multiple benefits) between different land uses following on from the recent Foresight land use study. The role of multifunctional land use as a key topic for joined-up adaptation policy is not mentioned as a rationale for the indicators.	
Some important ecosystem services are excluded, notably the key role of some habitats in regulating river flows, reducing the risk of both flooding and severe low flows. Again there might be a reason for this (data etc.), but it should be given.	**ECI**: Again the introduction now clearly states the nature of the report as one designed to provide data that feeds into the ASC's own report. The analyses performed were driven by data availability and prioritised by the ASC in consultation with the consortium.
Agriculture This section is very complex and difficult to follow. The analysis is based upon ALC classes assuming that they are static but in reality ALC has been modified by climate change and this has often influenced the associated land use (and will do in the future).	**ECI**: This is indeed the assumption that the analysis is based on. The current ALC maps are seen as the best currently available data on ALC. This is now explicitly stated in section 2.1.2.
Some of the maps are misleading and seem incorrect; especially the change maps (e.g. see Fig 2.6c West Midlands area).	**ECI**: The map to which you refer was an error where the two years maps had been inverted. This has been rectified.
The key seems wrong: if it is hectares then the maximum would be 10000ha. Or is the key meant to be in % in which case the change maps are based upon % of % which would explain the anomalies.	**ECI**: The key was in km^2. The change is % change between the two absolute values shown in figures a and b. The legend has been updated and there is a note explaining this in detail before the graphs.
There is an issue with inferring a trend by taking just two years (2000 and 2010) as agricultural land use at crop level inevitably varies on shorter term cycles (e.g. due to commodity prices) and the two years may not necessarily be representative of the	**ECI**: Agreed. This would make an excellent further extension.

general trend. This seems borne out by the analysis where most of the change patterns seem at best semi-random. It would be better to use the sample data for all of the years from a longer period to infer a trend. Alternatively analysis of broad land use patterns (e.g. arable, permanent grassland, woodland etc.) would probably be more robust as land use decisions at this level are more long-term.	
Is the analysis of Woodland land use in this section the same as the Forestry section?	**ECI**: No. It is on-farm woodland reported within the JAC. It has been re-titled as "woodland on farms" to reduce confusion.
Clarification on the use of irrigation for some crops compared to others would be useful. Does it include cereals?	ECI: I'm not sure I understand the question? Are you asking which crops are most commonly irrigated? Root crops and potatoes are most commonly irrigated and cereal crops tend to be rain fed.
With regard to development on prime agricultural land is it actually 'on' this land. The text seems to prefer the use of the word 'in' which is different as the development could be adjacent.	**HR WALLINGFORD:** Edits made – text changed to 'on'.
Forestry Generally OK, results plausible, builds on CCRA. Minor comments.	**ECI**: no action required
Water Supply/Demand Simple analysis, results plausible, would have preferred more explanation including explicit acknowledgement that the demand-side analysis uses socio-economic scenarios as well as climate change (especially for those of us not familiar with the EA Case for Change project).	**HR WALLINGFORD:** Text added to explain this.
An important omission is seasonal changes. The public water supply may be the biggest demand but for some locations the requirements for agriculture provide a significant extra seasonal demand at a time of lowest supply (summer) - this is also the time when the natural environment also	**HR WALLINGFORD:** It was not within the scope of the few days that we had to work on the water indicators to consider seasonal variation in supply and demand. Text added to the start of the section to note this limitation.

requires this water.	
Curious to know where the figure of 30% demand for 'environmental demand' comes from – is there a rationale for this? How does the relate to environmental flow requirements for a healthy ecosystem (and associated services)?	**HR WALLINGFORD:** This is based on hands off flow requirements for the River Thames. There was not time within this project to carry out a more extensive review of the spatial variation in environmental water demand.
Peatlands Some definitions required to resolve to avoid confusion. Notably the definition of peat soils (by convention >25cm surface organic layer in England?) compared to general organic soils.	**ECI**: The peatland layer used here is defined at the end of section 4.1.1 as areas with any peat > 25cm.
Need to highlight the key distinction between active peat and degraded peat as this is important for BAP habitat definition and ecosystem services such as C sequestration. Linked to this is the key role of sphagnum species and the hydrology of active peatlands. Hence the damage caused by artificial drainage systems (grips etc.). Peatlands have an important lag effect. It is possible that larger areas of current peatlands may be defined as 'climatically unsuitable' but their hydrology and water retention properties means that the ecosystem can counteract this and provide in-built resilience. Mention the possible carbon and methane loss of degraded peatlands? Surprised that there is no mention of the reports from the recent IUCN UK Peatlands Review	**ECI**: All of these aspects are factors that the ASC are likely to expand on in greater detail in their report.
Flooding/Erosion Quite cryptic and technical in places, therefore could do with some further explanation. What is the definition of the 'coastline'? Do you mean the defence line?	**HR WALLINGFORD:** We used the NCERM delineation of the coastline. Text added to explain.
Many of us regard the coastline as a transition zone rather than a line and this would be consistent with an ecosystems approach.	**HR WALLINGFORD:** Text added to explain: "Note that the coastal area is generally a transition zone rather than a line; the coastline is, however, referred to here in the

	context of the reference position from which spatial analysis was carried out.”
Presumably the flooding analysis includes the EA Indicative Floodplain to define the risk zone but it is not mentioned.	**HR WALLINGFORD:** The flood area benefitting from defences was calculated by a back-casting method – this has now been added to the report.
Section 5.2 particularly difficult to follow. Some processes are separated (notably flooding and erosion) which in reality occur together.	**HR WALLINGFORD:** This section is on coastal erosion, as explained in the title and the text. Additional edits made to the text to hopefully make this clearer.
Also the beneficial effects of erosion are not included, notably in providing sediment that protects areas downcoast from flooding/erosion. Again reference to the ecosystem approach would be useful.	**HR WALLINGFORD:** Text added to the overview section to mention this.
Some of this section is not consistent with the title (regulating ecosystem services) as reference throughout to ‘defences’ seems to imply artificial defences. Needs clarifying.	**HR WALLINGFORD:** Text added to Section 5.2 to clarify.
There is not much here on the key role of coastal ecosystems in buffering change at the coast.	**HR WALLINGFORD:** We considered the role of coastal habitats in defending against flooding (Section 5.5) but were not asked to consider the role of coastal habitats in coastal evolution/erosion protection.
Also, many artificial defences are protected by natural habitats on their seaward (tidal) side. Is this included?	**HR WALLINGFORD:** Section 5.5 identifies areas of the floodplain that are protected by flooding from both artificial defences and coastal habitats. These results do not give information on the length of artificial defences that are protected by natural habitats – this would require extra analysis.
Section 5.4 – submergence is another form of coastal squeeze (often it combines with erosion to cause loss of habitat)	**HR WALLINGFORD:** Text added to Section 5.4.
Extreme events ??? e.g. storm surge.	**HR WALLINGFORD:** Text added
Section 5.7 is clearest	**HR WALLINGFORD:** No action required
Biodiversity	**ECI**: The model on which the analysis is

Clear text, plausible results, good discussion (especially on fragmentation). Some clarity on priority/broad/BAP habitats would be useful.	based (NBCCVM) has at its base habitat masks for all priority habitats AND the broad habitat deciduous woodland. This has been explained.
Discussion on p255 et seq on conservation objectives is very good and deserves to be highlighted further in overall conclusion linked to adaptation objectives. Possibly some contradiction with section 4 (peatlands) – different definitions/mapping? Surprised that calcareous grasslands are considered of low climate sensitivity as there may be a threshold effect beyond which communities are lost rather than gradual change.	**ECI** : No response required
Synthesis Not much on cross-sectoral interactions here. Compare uplands and lowlands (etc.) in terms of resilience of ecosystem services? If biodiversity underpins other services what do the implications of the biodiversity analysis mean for the other sectors?	**ECI**: further synthesis of these factors is beyond the scope of the project

Ian Brown Specific comments on text

Comment	Response
A1: And exposure	**ECI**: The terminology used comes from the ASC call.
A2: What about other types of farmland – improved grassland and rough grazing etc. ?	**ECI**: See below: grassland categories are included in the analysis as recorded in the JAC.
A3: Some of the discussion below goes beyond 'crop production' and includes the use of land (e.g.. grass) for other services such as livestock production	**ECI:** Renamed "changes in JAC crop production and farm land use"
A4: How was this amalgamation done? Was it by field or by holding? Does it include the % of each 'crop' per 10km square or is it just the primary crop? These decisions can influence the final results.	**ECI**: more detail on method added
A5: Need to say something about the general distribution of crops in 2000 or earlier to establish a baseline reference point against which 2010 changes are compared	**ECI**: Information on the distribution of crops in 2000 has been added to Table 2-1.
A6: This is an unusual result Is this a data artefact or is there an explanation?	**ECI**: issues with bare fallow and setaside are now explained in the text
A7: Winter wheat presumably ? Is there no spring wheat grown in England?	**ECI**: The category available from JAC is wheat class is not split into spring and winter wheat
A8: It would be useful to include a baseline crop area so that there is a reference point for understanding the relative importance of the temporal changes Notes section 2.13 includes a baseline for 1961-90 so why not include this here also?	**ECI**: Information on the distribution of crops in 2000 has been added to Table 2-1. Within the timescale available we focused on 2000 and 2010 surveys for JAC. It would be possible to construct a baseline from the JAC data but this would require significant additional work. The 1969-90 baseline of generated by the Cranfield researchers and was not available for the 23 datasets studied here.
A9 Don't think the classification in the key is very helpful. There are actually 10,000 ha in each 10km cell therefore the key must be in %. So then is change map % of % change? Also classification needs to be in regular subdivisions rather than irregular A10 Better to use actual rather than % change as these figures are misleading in showing change with regard to the baseline of crop distribution. Many of the green areas have only seen a small actual change based upon a very low baseline and I doubt that this shows a trend (more consistent with annual variation and crop rotation)	**ECI**: The classification is mislabelled. It is in hectares not km^2. The two top maps map real area values. Maps have been changed during the anonomisation process to mask sites with few records. This has in turn reduced the issues of "over egging" small changes. The aim here is to map changes rather than to tie them to particular causal factors. Some of the larger shifts are likely to be representative of real changes.

A11 Is map c correct – look at W Midlands should be an increase here?	**ECI**: Well spotted, map for 2000 and 2010 were incorrect way around, this has been rectified.
A12 Including root and beet fodder crops? See section below	**ECI**: no action required
A13 Fallow is not planted!	**ECI**: Changed
A14 How much is grown under cover – this could be an adaptation indicator?	**ECI**: Unknown, this is a question for DEFRA Agricultural statistics.
A15 This is often grass as part of a rotation therefore taking 2 years 10 yrs apart does not show the true picture	**ECI**: added a caveat to this effect
A16 Is this all woodland or just farm woodland? Some areas of large-scale plantation do not apparently show (eg Keilder)?	**ECI**: on farm woodland – labels changed to reflect this
A17 Note that the climate has changed since then! The analysis below assumes that ALC is static but this is not so A18 But these have changed in distribution since the ALC was last updated in 1988	**ECI**: noted and caveat added to this effect
A19 Woodland often cannot be easily returned to agriculture	**ECI**: punctuation error fixed to improve clarity.
But in some locations the land grade has changed hence influencing the associated land use	**ECI**: Agreed. See caveats entered to text. This is what was asked for by the ASC. The ALC is a freely available national scale dataset and we did not have access to a more updated version.
A21: This title needs editing for clarity A22: How does this relate to ALC classes?	**ECI**: The title was very wrong. It has been corrected. This section focuses on modelled land suitability not on ALC.
A23 What are Average wet and dry years? A24 Need to define typical dry year and typical wet year	**ECI**: see Daccache et al
A25 Don't think you can infer trends based upon just 2 years because of shorter term variability	**ECI**: It would certainly be good to perform further analysis to reinforce the differences identified between the two years. Within the scope of this project there wasn't sufficient time to analyse more years although the data does exist within the JAC.
A26 Potatoes are grown successfully in locally favourable locations of these areas – scale issue	**ECI**: Caveat added as footnote.
A27 Does this include soil drainage schemes?	**ECI:** Yes. See Daccache et al for more detail on their method

A28 NB specifically winter wheat here whereas above it is just wheat	**ECI**: correct. The Cranfield datasets make this specification, however the data from JAC is for "wheat". As the analysis is exploratory it is not expected that this factor will significantly influence the results.
A29 Are the results and maps in Fig 27 presented for an individual SCP member or as an average of all 11?	**ECI:** They are for UKCIP09 2050 with low and high emissions scenarios not for individual SCPs.
A30 Does this not include irrigation like analysis for potatoes and carrots?	ECI: Correct, it does not. The full dataset is used and there are no areas flagged as suitable with irrigation for winter wheat or barley. It clearly reflects a decision of the Cranfield modellers, probably reflecting the fact that these crops are generally rain fed rather than irrigated. Irrigation influence on for these crops is not an output from their modelling (see references in this section).
A31 Direction and magnitude of what?	ECI: Clarified
A32 Does this mean spring barley? Do cereals include the benefits of irrigation the same s potatoes and carrots? A33 Does this include irrigation benefits? It would be much clearer if results for all crops were summarised as with and without irrigation !	**ECI**: See responses to A30. The maps have been reproduced to map with and without irrigation with colours and crosshatches. This makes it much easier to differentiate the overall trends in both. A34 What is this section aiming to show? **ECI**: Aim and key message added
A35 Is this just spring barley?	**ECI**: No. Total Barley
A36: Between 2000 and 2010 ??? Quite confusing	**ECI**: There is a smaller area of wheat in 2010 than there is in 2000. This is a reduction in the area of wheat.
A37 What is the water exploitation index???	**ECI**: section 3.3 see Table 3-4 and Figure 3-5
A38 Is this based upon UKCP09 SCP again? What are the wet and dry scenarios?	**ECI**: A footnote has been added: The wet and dry scenarios use the median of the 1000 wettest and driest points in the 2050s low emission scenario. See Section 3.1 for more detail.
A39 Cannot infer this just from one year 2010	**ECI**: Caveat to this effect added in concluding paragraph
A40 These diagrams more useful to show vulnerability	**ECI:** noted, no action required
A41 This key point needs to be more clearly demonstrated	**ECI**: Stressed in section 2.1.4 and in the take home messages
A42 'within'? Does this mean 'on' as the title for section 2.2 suggests or does it mean something else?	HR Wallingford: text edited
A43 Section 2.1 suggests it was updated in 1988	HR Wallingford: Edit made
A44 Should this be 'on'	HR Wallingford: Edit made

A45 The key indicator should be NEW developments on agricultural land. Does this table purport to show this? Does it show change ?	HR Wallingford: The datasets enable us to present the table as it is. Change in figures can be related to new development and removal of old properties.
A46 Is the development on or adjacent to high grade land?	HR Wallingford: Edit made
A47 I think the key is misleading as to the magnitude of vulnerability. Many of the red areas only have a small amount of high grade land	HR Wallingford: Agreed – map removed.
A48 Could use national and regional planning structure plans?	HR Wallingford: Not possible within scope of project.
A49 In or on?	HR Wallingford: Edit made
A50 A50 Does that not imply that they are supporting services rather than regulating services per se?	**ECI**: added regulating and supporting
A51 Does this include the depth to which the samples were taken?	**ECI**: 15cm. see comments from Ian Crute
A52 Why just topsoil?	**ECI**: that is the standard method applied by both the CS and NSI
A53 Is this realistic for the 2020 projections???	**ECI**: it is an extrapolation. The 2020 projection is for illustrative purposes only and based on rates of change.
A54 Is this consistent with DOC stream data?	**ECI**: we did not look at DOC data within this project
A55 agree A56 the analysis does not really try to distinguish between climate change and land use change as causative effects for SC loss	**ECI**: correct.
A57 Is this caption correct???	**ECI**: Removed the a) and b) and the reference to map b.
A58 Thought that spruce would be more at risk of drought in 2050? Is this because spruce in England is mainly in the uplands (organic soils)?	**ECI**: Figure 2-61 shows that spruce has the greatest available climate space of all the species. It is really only the east of England that is unsuitable. As such the existing distribution of spruce matches well with future climate space. Northern forests such as Kielder are likely to be particularly suitable as the suitability in much of the north is predicted to increase or at least remain suitable.
A59 Key point here – most new woodland planted now is private A60 Turnover faster for conifers than broadleafed therefore this can act to reduce their vulnerability	**ECI**: no action taken, points already raised.
A61 This seems very confusing. Why not use one baseline and infer present and future change against this as a consistent reference point?	HR Wallingford: Climate baseline needs a longer period than abstraction as its necessary to represent as an average. No change made.

A62 So these are socio-economic scenarios that are combined with the climate scenarios – more info required	HR Wallingford: edit made
A63 There is no difference in UKCP09 from emissions in 2020s and very little by 2050s.By far the biggest difference is climate model parameterization as reflected in the UKCP09 probability levels	HR Wallingford: no change made, we are simply reporting the data used here
A64 This is quite a big assumption but probably justifiable with the limited time available	HR Wallingford: no change made
A65 This soil property is usually known as available water capacity	HR Wallingford: hydrologists normally refer to soil moisture storage/deficits/capacity – no change made.
A66 A brief mention of the seasonal changes would be important as they are particularly relevant for agriculture and the natural environment	HR Wallingford: We have not assessed this and therefore have no results to discuss.
A67 Is the actual evaporation? Or is it potential evapotranspiration for a reference land cover?	HR Wallingford: edit made
A68 A brief reference here to environmental flow and the regulatory requirements would be appropriate	HR Wallingford: edit made
A69 Is there a reason for 30%?	HR Wallingford: addressed in another comment
A70 Is there a reference to this project?	HR Wallingford: edit made
A71 I think we need an explanation for these changes in agricultural demand – is it related to food security or demand for improved quality produce etc.? Assumptions in socio-economic scenarios? A72 This repeats information above but still provides no more info on changes in agricultural demand	HR Wallingford: Readers can refer the EA reference for more info
A73 Needs completing	HR Wallingford: edit made, thanks
A74 Map is very coarse – why not use the actual water body boundaries for reference?	HR Wallingford: the water balance has been carried out at UKCP09 basin scale due to project time constraints
A75 But there is an established indicator for environmental flow eg Q95 ….	HR Wallingford: edit made
A76 It may be useful to define peat soils here and habitats that develop on peatlands (blanket bog etc.) including the key role of sphagnum spp.	**ECI**: Peatlands are introduced. The ASC report goes into more detail with regard to Sphagnum
A77 There is confusion here. A soil with a surface organic layer <25cm would not be defined as peat under the standard definition in England	**ECI**: Quite. That is why we focus on sites with >25cm peat depth. The map is modelled and so predicts peat depths below the 25cm limit.
A78 How does this compare with the recent IUCN UK Peatland Review?	**ECI**: a question for Natural England. We are reporting the dataset we used.
A79 The BAP and Annex 1 habitats are defined based	**ECI**: comment added with respect to this

upon active peat formation	
A80 i.e. the peatlands have been drained	**ECI**: no action taken
A81 Would place wet heath lower in the descending order as it modifies peatland hydrology less than cultivated land uses and trees. The hydrology is key for maintaining sphagnum	ECI: This does raise an interesting point. However “wet heath” is not available as an LCM category only “heather” and “heather grassland”.
A82 (is blank) A83 Fire is a particular risk for peatlands because of the high fuel load and the risk of large-scale and lengthy outbreaks. Subsequently it is unlikely that peatland habitat would be restored A84 Extensive areas of deep peat are likely to be more resilient than shallow peat because of their self-sustaining hydrology	**ECI**: Added to text
A85 and erosion (and other services such as C storage	HR Wallingford: edit made
A86 ‘lost’ is not the right word here – ‘converted’ would be more neutral	HR Wallingford: edit made
A87 What is Flood Zone 2?	HR Wallingford: edit made
A88 i.e. reaches a dynamic equilibrium	HR Wallingford: no edit made
A89 explanation?	HR Wallingford: just another way of referring to the erosion projections
A90 Does this mean there is only information on low and medium sensitivity (which are stated above to be less vulnerable to climate change)?	HR Wallingford: no – just that there is no documentation to explain what is classed as high sensitivity. Sentence removed as not required.
A91 Are these man-made or natural defences?	HR Wallingford: edits made (“Defences are referred to in a broad sense; the approach to defending areas through hold the line or managed realignment may include management actions such as beach nourishment or shingle bank maintenance and may not necessarily always include the use of hard defences.”)
A92 If these are made-made defences then how does this relate to the title of this section which is about regulatory ecosystem services?	HR Wallingford: see above – edit made. The whole section relates to natural hazard regulation.
A93 Does this mean that they benefit from ecosystem services at the coastline?	HR Wallingford: edits made to explanatory text
A94 Inundation via submergence is actually another form of coastal squeeze as it modifies the hydrodynamic conditions that favour intertidal habitat	HR Wallingford: edit made
A95 Coastline? Does this mean the line of man-made	HR Wallingford: relates to the NCERM coast position –

defences? Not clear how this relates to tidal zones	<u>edit made</u>
A96 But the processes do combine together as submergence increases the likelihood of loss of vegetation and then erosion	<u>HR Wallingford: beyond project scope to model this complexity at England level</u>
A97 Which data?	<u>HR Wallingford: edits made</u>
A98 Artificial defences are also protected by coastal habitats on the seaward side	<u>HR Wallingford: edit made</u>
A99 How is economically viability determined ? Reference?	<u>HR Wallingford: Approach described fully in text – no economic assessment was carried out.</u>
A100 So BAP habitats are not priority habitats in this case? This probably needs more explanation, especially as broad habitats are often used to define ecosystem services (although less useful for biodiversity).	<u>**ECI**: Text added to clarify</u>
A101 200x200 does not equal 200m2! Just define as a 200m cell	<u>**ECI**: corrected</u>
A102 So this is proportion of BAP habitat fragmentation defined according to Broad Habitats so it tells us also about level of fragmentation of broad habitats	<u>**ECI**: added clarity on how the NBCCVM habitat fragmentation classes are to be understood</u>
A103 Is it possible that the levels of fragmentation for some classes, notably coastal habitats are partly an artefact of the datasets (misclassification in LCM2007 etc.)?	<u>**ECI**: comments added on issues with levels of fragmentation. The NBCCVM is based on natural england's priority habitat inventories. LCM misclassification will not be an issue unless these datasets are based on LCM. It is possible however that the use of the mean high water mark as a hard limit will reduce the possibility for coastal habitats to be near as much habitat as their inland equivalents. This is a question for Natural England.</u>
A104 Rather cryptic? Which EA map does this refer to?	<u>**ECI**: this has been corrected and the method streamlined.</u>
A105 How does this relate to the analysis of peatlands in section 4?	<u>**ECI**: it is the same issue.</u>
A106 This reinforces concerns about the use of the peatland mask in section 4	<u>**ECI**: Yes and no. The peatland mask is the best freely available peatland map we could access. The question is whether the priority habitat mask should represent areas actively forming peat or all areas where peat is present. Which do we have a responsibility to improve? It is useful to have looked at both</u>
A107 10x10 = 100km2	<u>**ECI**: noted and corrected</u>
A108 Need to update section number	<u>**ECI**: Corrected. Section 6.1.4</u>
A109 are key issues to emphasise in the final	

discussion	**ECI**: added to the key messages and conclusion sections
A110 Inferring trends in agriculture from the differences between 2 years should be caveated as these 2 years may not be representative	**ECI**: Caveat added
A111 No mention of irrigation requirements ??????	**ECI**: is mentioned in 7.2.1 but added here too
A112 With implications for agricultural production? A113 Yet spruce is known to be vulnerable to drought so current planting is assumed to be on land with a low drought risk?	**ECI**: moisture defecit is included within the FC's suitability model.
A114 Peatlands also have an important role in regulating water flow and water quality but this is scarcely mentioned	**ECI**: point added to intro
A115 This is over-simplistic! Erosion on some parts of the coast provides the sediment that protects other adjacent areas from flooding and erosion	**ECI**: The preferred policy options will not protect all parts of the coast. It is not suggested that they should.
A116 Topography rather than elevation is important for peat formation – link to hydrology again	**ECI**: changed.
A117 How do artificial defences provide an ecosystem service?	**ECI**: No change made

Ian Crute Comments

Comments	Response
Overview This is a long and data-heavy report which conveys some important but unsurprising messages. Working with data sets that have limitations, the authors have done their best to extract value from them. Their analyses are more descriptive than interpretative and while there are few new insights, the work does serve to underline areas of uncertainty where more work is warranted. Overall, I feel that the volumes of data presented (much of which is difficult to draw meaningful conclusions from) tend to obscure the key messages from the work and an Executive Summary would have been particularly helpful as a navigation tool.	This is a technical report providing data to the ASC. The ASC's own report will better address many of the issues raised here.
I have paid particular attention to Sections 2.1 (Crop production); 2.2 (Development on agricultural land); and 2.3 (Soils). I have however also registered some comments on Sections 3.3 (Water demand) and 4.1 (Peat). Section 2 This opens with the following statement: *"About 70% of England is managed as farmland and is important in providing food. There has been an increase in self-sufficiency in food production in the UK over the last 50 years and most of this increase in agricultural production has been in England (Berry and Hopkins, 2011)."* It is true that self-sufficiency increased during the 1960s/70s but I think the data now shows a declining trend. The reference cited is not in the listed bibliography of the report.	**ECI**: The self-sufficiency reference is from a DEFRA food-security report from 2006. The other comments are from the NEA England synthesis chapter (Berry and Hopkins, 2011) this has been clarified and the references inserted into the reference list.
Section 2.1 This section covers 65 pages of the report and the analysis concerns: *"Changes in spatial distribution of crop production and relationship with areas of climate suitability".* This includes an analysis of land suitability for purpose and future trends in relation to land classification. Data collected from the Defra June Agricultural Census in 2000 and 2010 (a 10 year interval) is used to try and discern tends in: *"spatial distribution and area of crop production"*.	**ECI**: Some very useful and insightful comments. The purpose of the analysis was to identify the current condition of these crops and to identify where patterns in cropping were changing. The intention was to identify whether the current patterns, and areas crops are being moved are likely to be more or less vulnerable to climate change. It was not the intention to assume that the patterns formed were in any way driven by climatic factors.

The time duration between these two surveys reflects no more than two conventional arable rotations and it would be surprising if there were any meaningful trends to be observed over such a short time period. Any changes are more likely to reflect market conditions and profitability of particular commodities than shifts in spatial distribution due to climate. In addition, many crops such as potatoes and some vegetables are produced by specialist growers who seek out and rent land in different locations to ensure appropriate durations between cropping the same ground. The most significant change I would anticipate being able to observe over this relatively short time interval is an increase in silage maize production in livestock areas in the west of Britain – there is an increase in the area grown and this crop is now being grown further north. This is reflection of the availability of varieties with increased chilling tolerance in spring and also elevating spring temperatures (maize is particularly vulnerable to chilling after emergence). Mention of changes in areas of sugar beet are probably a reflection of the closure of sugar processing factories and the sale of "quota" from one farm business to another. Sugar beet can only be sold to one purchaser – British Sugar who has a monopoly and the amount of sugar been cultivated is determined by a quota system. Only those farming businesses that have a quota grow the crop which is now confined to areas within reasonable distance of a sugar processing factory (of which there are now fewer that in former times). In the case of strawberries, the scale of production has increased substantially based on new growing systems. So it may be that areas have declined while production has increased. Raspberries follow a similar pattern. In summary, the factual analysis and graphical presentation of the data for the 10 year period are highly unlikely to reveal any signals of cropping or other land use which are driven by climatic factors. The strongest signals of change in this period will be due to market drivers and	

changes in technology as well as trends towards contract growing and land rental arrangements for specialist crops.	
The detailed analysis of land-use suitability is over-elaborated and hard to derive clear messages of relevance.	**ECI:** Key messages have been added to this section.
However, the summary on p75 regarding the impact of water deficiency and adequacy of access to irrigation at the right time and in the right quantities is a good synopsis of one of the most significant impacts of climate change. Crops that are routinely irrigated (potatoes, vegetable crops etc…) are likely to move to areas where water extraction is least constrained (provided soil type and climatic factors are appropriate). It is also possible that rain-fed crops (cereals, oilseed rape etc….) may relocate.	**ECI:** These comments added to expand on the existing summary
The interaction between temperature (and crop development/maturity), water availability (including soil water from winter rain) and crop genetic adaptation is complex (cf. modelling work of Mikhail Semenov in this area). The analysis in this report is seeking to interpret observed data over quite short time periods. A modelling based approach to these questions is likely to be more informative and can take account of genotypic adaptation in the breeding and selection of crop varieties which is already ongoing.	**ECI:** The purpose was not to map the impacts of climate change on genetic adaptation but to identify current condition and trends based on data. This has been clarified in the aims section.
Section 2.2 Development on agricultural land This section addresses an important issue although the analysis, unsurprisingly, indicates rather small changes and the data are difficult to interpret. In the face of climate change, highly productive and resilient agricultural will be of increasing importance and value; it must be protected. Recently, there has been significant relaxation of the previously applied policy of not allowing development on Grade 1 and 2 agricultural land. A key adaptation measure to secure future agricultural productivity must surely be to identify and spare the highest grade land from development or only allow alternative uses that will make future reversion to agriculture	**HR WALLINGFORD:** No changes made in response to this comment – more appropriate for the ASC to respond.

possible.	
Section 2.3 Productive capacity of soils The authors rightly draw attention to the complex issue of soil carbon (or perhaps more appropriately Soil Organic Matter – SOM). They highlight the key controversy which is really an admission that we do not have the data we need at the appropriate resolution. It is also the case that there is no reliable and recognised set of measurements by which to gauge soil "quality", "health", "fertility" or "productive capacity" – all terms that tend to be used interchangeably. "Resilience" is another characteristic of soil of relevance in the context of climate change and extreme weather events. In this context, soil erosion by wind and water is easier to define and measure. By comparison with many parts of the world, soil erosion is not considered a particularly serious issue for the UK although it should not be ignored.	**ECI**: No response necessary
There is a general acceptance that mineral arable soils, predominantly used for arable production in the East are deficient in SOM (and are losing stocks of carbon). There is some evidence that productivity is declining and that this is linked to soil "quality". It takes a long time to build levels of soil carbon in soils that are regularly cultivated and improved grassland that is regularly re-seeded (every 4-5 years) is probably not very different to arable production in terms of the turn-over of carbon stocks (the data are not extensive on this). As the authors allude to, the jury is out on whether stocks of carbon under permanent pasture (essentially rough grazing land) are increasing, staying the same or decreasing. We need to know this.	**ECI**: No response necessary
Adequate SOM is a necessary characteristic of a resilient soil with regard to water-holding capacity but it is unclear how much SOM represents the "right" amount. Also, the geographic disconnect between livestock production and arable cropping is such that sources of organic matter for soil amendment are in the wrong place. We need more information about requirements for SOM and sources of supply – have we got enough organic matter to meet demand and what are the best	**ECI**: No response necessary

sources? Addressing these issues is an important aspect of adaptation to climate change (as well as mitigation) and it seems likely that co-location of more large-scale housed livestock production systems in proximity with arable areas would provide several beneficial outcomes: access to organic material for soil amendment (beneficial for soil resilience/productivity and for C storage) and ability to provide a semi-controlled environment for livestock (heat stress etc.) plus more effective health/stress management (with impacts on productivity and GHG emissions per unit of product – fewer animals required to meet demand for milk, meat etc.…).	
The report deals well with the available data on soils as it relates to questions of adaptation. However, this review serves to indicate the controversy about what the trends are for soil carbon. A major conclusion must be that sound advice on action for purposes of adaptation requires more and better data as well as in-depth studies on the quantity/quality of organic materials available for soil amendment and how they should be used for safe and optimal benefit.	**ECI**: Have added comments to the conclusion to bolster the call for better data.
Section 3 Water supply The authors have provides a thorough analysis of available data. The current conflict in some water-limited areas between water for crop production and other uses is only going to intensify. Adaptation measures must include: more investment in carbon capture and storage; management of SOM (see above) and investment in water use efficiency measures such as new technologies for irrigation scheduling etc. Useful data to acquire would be the extent to which the agriculture industry is investing capital in water-use efficiency measures and whether this is adequate when set against the time trajectory for change. The return on actions to provide incentives for investment in this area is likely to be highly positive and could be quantified. Land-drainage is one area of water management of relevance to adaptation that the report did not appear to deal with. Intense rainfall evens or higher winter precipitation will increase flooding risks and waterlogged farmland is the	**HR WALLINGFORD:** No changes made in response to this comment – more appropriate for the ASC to respond.

consequence with knock-on effects on productivity. Land-drainage is one component of resilience and is an area much neglected. There may be only limited data on the status and effectiveness of land drains in different regions and on different soil-types in different catchments. As with water capture and storage, investment in effective and efficient drainage is going to be a key adaptation measure. The operation and involvement of of the Internal Drainage Boards in any adaptation planning will be essential.	
Section 4 Peat The authors provide evidence for the scale and location of the loss of carbon stocks from highly organic peat soils. Peat soils are vulnerable to erosion by wind and water which is well covered by the authors. However another threat comes from land use change and relates to soil management alluded to in Section 2.3. The sort of scenarios that need to be explored could include a response to policies for increased biofuel production for example coupled with a northwards movement of cropping in response to climate change. An increase in the cultivation for crops (e.g. as a knock-on from increased demand for wheat for biofuel production) on highly organic soils in the north (converted from grassland) could result in rapid and substantial loss of carbon stocks.	**ECI**: Noted. More appropriate for ASC to respond?

Andy Whitmore comments

Comment	**Response**
P83 Focusses largely on carbon. There is no quantitative inference of how Ecosystem Services and t'he productive capacity of land' are delivered. Little on the productive capacity of the soil. What is productive capacity of the soil? Is this defined?	**ECI:** The section has been retitled "changes in soil carbon" to remove this confusion. An aim has been added to each section to explain the reasoning behind the analysis. As stated in the introduction the focus on soil carbon was driven by the availability of data at a national scale. The problem being that there is not data available to truly explore changes in productive capacity. Soil carbon was used as a proxy for the quality of the soil resource
Why is the NEA not cited?	**ECI:** Citation to NEA added
Poorly worded in places ungrammatical in others things missing in others.	**ECI:** Edits made
The words 'stocks' and 'concentration' seem to be used interchangeably to describe the carbon content of soil. The depths over which stocks are calculated is not defined. As a result it is ambiguous as to what changes are taking place.	**ECI**: all values used within the analysis are carbon concentrations calculated following the methods set our in table 2-10. National scale "Stocks" are calculated by NSI and CS by extrapolating up from these values but this analysis was not performed here.
Soil provides physical support for plants (ie resistance to lodging) as we as habitat for organisms Was the ECN considered?	**ECI:** The Environmental Change Network was not considered in this project, but would certainly be worth including in further work. The ECN has good long-term data but has very few (<10) terrestrial sites. We were looking for a national scale coverage.
Confused terminology and rather non-specific. Eg soil has a certain buffering capacity to enable it to cope with acidification. This is not 'resilience' which is used as a catch-all SOM isn't really responsible for the retention of P and certainly not K SOM alone doesn't determine habitat. That is the result of the interaction between SOM and the mineral particles This whole section needs citations to back up the assertions. I'd like to see support for the claim about reducing temperature. It is possible this has something to do with	**ECI**: text refined drawing on a quote from the DEFRA soil strategy for England supporting documentation.

colour and soil albedo but it needs explaining	
How can 'losses be present'?	**ECI**: Changed
P84 Soil 'remains an important with respect'?	**ECI**: rephrased
What does 'this' mean on the next line? Something missing at the end of the paragraph	**ECI**: rephrased
P85 What is soil volume and how do you model it?	**ECI**: Bellamy et al equations are based on soil carbon concentration, text changed to reflect this.
P86 20 g kg-1 is a concentration not a stock	**ECI**: corrected throughout
In general to what depth are stocks calculated? 15cm? as in the NSI. There is much carbon to a metre and beyond. Isn't the point what this carbon does not how much of it there is?	**ECI**: The data being used *is* the NSI data. The aim of this section is now clearer. We cannot map productive capacity, here we are replicating the work of Bellamy et al to map carbon concentrations by ALC to see if there is what is happening.
You can't sum concentrations!	**ECI**: Removed
P86 Legend: what does carbon stock in from Topsoil mean and what is the topsoil depth? What about the subsoil?	**ECI**: This is stated in the method section. "NSI Topsoil" 1983 and 1995 are datasets. Their depth is 15cm as stated in Table 2-10. This has been included in the text to improve clarity.
P88 Data in table are quoted with a very large number of significant figures. What are the uncertainties associated with each of these numbers and in general with most of the numbers quoted in this section?	**ECI**: The work here essentially re-presents the work of Bellamy et al. (2005) which address the issue of uncertainty. The accuracy of the C_{org} measurement in the laboratory was +/-1 g kg^{-1}, however the accuracy of equation 1 varies with the original organic carbon content. Have reduced the number of significant figures to use 1 significant figure following Bellamy (2005).
P89 I don't understand how you can have g C kg	**ECI:** Have simplified the table to Change in average modelled soil carbon change rate by

year-1 site-1 or g C kg-1 year-1 km-2. What do these things mean?	ALC class
P93 I don't understand why specific analyses are made of the modelled data but only general properties of the distribution of the measurements? Surely it would be better to analyse the measurements fully?	**ECI**: This is explained at the beginning of section 2.3.4. The priority was to identify the spatial patterns in soil changes at full national scale spatial datasets. The measured data are only available for a subset. A more detailed analysis would be good but it was not a priority within the timescale of the project.
The CS data have a number of broad habitats. Have the agricultural habitats been extracted before this analysis along the lines of grades of agricultural land?	**ECI**: No. The idea is to look at an overview of soil changes across potential agricultural productivity (ALC) not at current land use.
P96 Fig 3-65 or 2.54?	**ECI**: Corrected
Most of the trends in Fig 2-54 do not look significantly different from zero to me which is what I think the CS concluded. Can the statements about Trends be supported? In particular is it sensible to look at trends in percentiles? I suggest a statistician have a look at this.	**ECI:** Added the results from the Country Side Survey report (which noted no significant trend in the mean values for 1978-1998 and a trend significant at $P<0.05$ for 1998-2007) as context.Explained the potential utility of the quantile approach for describing the dataset and flagging the fact that the trends in the "median site" doesn't necessarily tell the whole story and that very different things may be happening in terms of carbon concentrations at sites with a very high or very low carbon. However, the as previously stressed the extreme sites are supported by lower data numbers and are less likely to be statistically significant. As such, added in a caveat about the need for more detailed statistical analysis and stressed the approach as descriptive and exploratory.
P97 What is the basis for the conclusion that some areas are experiencing erosion? Erosion has not been measured.	**ECI**: replaced "soil erosion" with "soil carbon loss".
P101 Is direct drilling meant instead of deep drilling?	**ECI**: yes. Changed

P102 There is confusion of terminology here. The authors appear to use 'conservation' tillage as a catch all terms for reduced cultivation of any kind. It is not. It refers to the practice in dry areas of reducing cultivation and leaving crop residue mulches on the surface in order to retain water to avoid a period of fallow. Because such soils are cropped more frequently than conventional practice they often do increase in carbon	<u>ECI: text changed to clarify</u>
Strictly Powlson et al pointed out that 310 +/- 180 was not significantly different from zero. It is debateable whether reduced cultivation alone will offset losses of carbon reported earlier	<u>ECI: text changed to clarify</u>
P103 The conclusions start with ecosystem services. Almost nothing in this section deals with ecosystem services. It has all to do with soil carbon	<u>ECI: Text updated to clarify this point and make explicit the inferences from soil carbon to ecosystem services</u>

Appendix F: Summary of indicators

2.1.1 Current trends in the spatial distribution and area of JAC crop production and farm land use

Aims:
The purpose of this indicator is to identify 1) how England's crops are distributed and 2) how this spatial pattern has changed with time. An understanding of these spatial pattern is essential to match these patterns with future threats (either climate change or otherwise) to identify potential future vulnerability. This is an indicator of current condition and measured trends. It is not intended to imply causal relationships between climate and crop patterns.

Key messages:
Winter barley, wheat sugar beet and late potatoes show the greatest decreases in area 2000-2010. Farm grassland has increased and winter oilseed rape, maize and spring barley are the crops that show the greatest increases.

2.1.2 Current crop production trends in relation to the agricultural land classification (ALC)

Aims:
The intention was to use agricultural land suitability from the ALC as a unifying strand that could underlie all analyses of agricultural indicators within this report. This aim of this indicator is exploratory: to identify what crops are grown on the best and worst agricultural land, and how this has changed with time. This is an indicator of current condition and measured trends.

Key messages:
The majority of crops are grown on good/moderate quality agricultural land (Grade 3), which is the most widespread of the ALC classes. Crops showing trends tend to have stronger trends in Grade 3 land (presumably due to there being greater scope for change within this class). Winter wheat, winter barley and late potatoes show decreasing trends of which winter barley is the strongest; spring barley and maize show increasing trends of which maize is the stronger. Late potatoes have a higher proportion of their crop on grade 1 land than the other crops studied.

2.1.3 Projected future agricultural land suitability for five key crops

Aims:
The purpose of this indicator is to explore how England's agricultural crops may be impacted under future climate scenarios. This is an indicator of both current condition and potential future vulnerability.

Key Messages:
Potato and carrot crops are currently highly dependent on irrigation and will become even more so with climate change; irrigation may be an adaptation mechanism for these crops. Wheat, sugar beets and barley are relatively well suited under current conditions, but many of the areas currently suitable are projected to decline to marginal quality with climate change. This factor varies spatially, and for some areas such as the SW England climate change is projected to increase in suitability (from unsuitable to marginal).

2.1.4 Crop area by UKCP09 river basins

Aim
The aim of this section is to identify planting patterns in River Basin Districts to allow these patterns to be matched to future water stress. It is not the intention to draw a causal link between these changes and any other factor. Thus, although water management issues are one of the many factors that can influence crop planting patterns, presenting data at the water basin scale does not imply that that the changes identified are necessarily driven by these issues. This is an indicator of current condition and future vulnerability.

Key messages
The Anglian, Humber and Thames water basins provide a large proportion of the England's key crops, particularly the Anglian basin which supplies the majority of potato and sugar beet production. Across basins crop changes are generally decreases in barley, wheat, potatoes and sugar beet and increases in maize and oilseed rape; the most significant changes are in crops the Anglian and Humber river basins. Section 3 identifies that the key catchments for agriculture are also expected to be particularly stretched in terms of water supply, particularly the Anglian and Thames regions. This will have significant implications for both irrigation and public water supply and may lead to some very difficult decisions needing to be made.

2.2 Development on agricultural land

Aim

The aim of this indicator is to identify areas where development is taking place on agricultural land and identify the extent to which high grade agricultural land is being converted by development. It is an indicator of current condition and measured trends.

Key messages

There has been an increase in the number of properties on High Grade Agricultural land, however, the relative percentage of manmade area on each ALC category does not change significantly between 2001 and 2011. The greatest rates of increase in numbers of property on agricultural land have been in East England and in Cornwall.

2.3.1 Trends in Soil Carbon using NSI data

Aim

The purpose of this indicator is to map the trends in soil carbon as they have been identified by the National Soil Inventory. The aim is to identify where the greatest losses of soil carbon are and to determine where these losses are taking place with respect to agricultural land quality. Changes in soil carbon are an indicator of measured trends.

Key messages

The largest projected losses in soil carbon in 2020 are projected to be in upland areas such as the Pennines.

2.3.2 Changes in soil organic carbon by agricultural land classification

Aim

This indicator has been used to identify whether changes in SOC are related spatially to ALC farm quality grades. This is an indicator of current condition, measured trends and potential future vulnerability.

Key messages

In keeping with previous research, it was found that the largest SOC losses occued in areas which had the largest stock. Grades 2 and 3 were found to have the lowest average soil carbon concentrations, whereas poor quality land (Grade 5) such as that in upland areas was found to have the largest stocks, which were expected to see the greatest losses.

2.3.3 NSI Soil organic carbon: rates of change

Aim

The intention here was to identify differences in the rates of change both between agricultural grades and spatially using NSI data. These will later be compared with results from other data sources. Rate of change of SOC is an indicator of measured trends.

Key messages

It was found that Grade 5 land experienced significantly larger changes in SOC over time than any other ALC grade. Variable rates were found for different regions and land quality, for example a loss in SOC was found in East England for Grade 2 land, with an increase in SOC seen for the East and West Midlands. Overall soils in Grades 4 and 5 land saw a higher proportion of carbon losses than gains.

2.3.4 NSI Soil organic carbon: Measured changes (1983-1995 surveys)

Aims

The purpose of this section is to examined the measured changes in SOC using empirical data from 1983-1995, so as to compare these to the NSI data. This indicator looks at measured trends.

Key messages

The findings are in agreement with the general trends found in the modelled data. It therefore confirms that patterns in the previous sections also exist in real measured changes of SOC. As with the previous indicator, Grade 5 land was associated with the greatest losses and gains of SOC. Grade 1 land was associated with areas of high SOC losses.

2.3.5 Changes in soil carbon concentration from CS data

Aim

The use of CS data to examine changes in SOC is undertaken here to compare findings with NSI topsoil data from 1993 and 1995. Changes in SOC is an indicator of measured trends.

Key messages

CS data showed changes in SOC in Grade 4 and 5 soils to be variable; sites with the highest SOC seeing increases over the period 1978-1998, and decreases in 2007. In contrast, sites which originally had low SOC saw little change. Both NSI and CS data highlight large SOC losses on low Grade soils. There are however some significant differences in the results from the two datasets, in that SOC loss was slower in the CS data and the maximum rate of SOC loss was also much lower here than for the NSI dataset. Reasons for these differences are unclear, and could be the result of a number of factors.

2.3.6 Changes in soil management from FERA data

Aim

This section aims to examine changes in soil management practices in relation to wheat production from 1985-2010, and their impact on soil carbon. These are conventional ploughing, shallow ploughing, reduced cultivation and deep drilling. This is an indicator of action.

Key messages

The use of soil management practices varied over the period, with a general shift seen in increasing uptake of reduced cultivation. For example, by 2010 over 50% of farms on Grade 4 land used this management practice. Such a shift could offset some of the previous carbon losses.

2.4.1 Woodland area and tree species information availability

Aim

Information on woodland area and tree species (broadleaf and conifer) are examined to identify current conditions, changes in woodland area from 1978-2010 (i.e. measured trends) as well as to identify trends in the current and past distributions of tree species. This is therefore an indicator of current condition as well as measured trends.

Key messages

The current main broadleaf species were found to be oak, beech, sycamore, ash and birch; whereas the main conifer species are sitka spruce, scots pine, Corsican pine, Norway spruce and larch. Analysis of the area of tree restocking and planting highlights that over half of UK woodland is recently planted, although the majority of this has been on PFE land. The number of new plantings was found to have decreased in the last three years.

2.4.2 Projections of species suitability from ESC

Aims

The ESC tool is used to classify the suitability of 30 species under climate change assuming no adaptation. These are divided into key conifer and broadleaf species, with future climate scenarios used to simulate suitability in 2050 and 2080. Projections of species suitability is an indicator of potential future vulnerability.

Key messages

Results show that the main conifer species are located in suitable areas. By 2050, under a high emissions scenario, it is suggested that Western and North Western upland areas will increase in suitability for these species, moving into the very suitable classification, although on the whole changes in suitability are limited. In contrast, on a longer time horizon of 2080, warmer, drier conditions will likely decrease suitability especially in the South West. Key broadleaf species experience similar trends, habitat remaining suitable in 2050, although the climate in 2080 sees a substantial decline in suitability of areas due to a water deficit.

2.4.3 Trends in key species planting dates

Aim

The purpose of this section is to find trends in planting dates, estimate the age of the existing stock, and its composition. These may have implications for climate adaptation, and is an indicator of past trends.

Key messages

The trends observed are likely to be a result of management and objectives rather than a result of climate change. Disease was identified as a driver of recent changes, with the cessation of further Corsican pine planting in PFEs. Results show decadal trends in planting, and a lack of species diversity in PFE sites, with almost 70% of planting in all PFEs relating to the main groups of beech, oak, pine and spruce.

2.4.4 Future climatic suitability by age class

Aim

Projecting the future suitability under climate change of various age classes was conducted to examine vulnerability and potential changes to yield, hence this is an indicator of potential future vulnerability.

Key messages

Substantial increases in suitability for sitka spruce were found, with trees recently planted being better matched, and those planted pre-1970 experiencing a small decline in suitability. In contrast, pine species planted before 1970s are expected to see increases in suitability under future change. Broadleaf species appear to be more vulnerable, with oak seeing a substantial decline in suitability by 2050, and beech also showing a decline. The results do not find declines in potential yield to be as great as previous studies, although these are expected for the 2080 period.

3.1 Total annual renewable freshwater resource

Aim

The purpose of this indicator is to estimate mean annual runoff and recharge for the baseline period, and also for wet and dry climate scenarios in 2020 and 2050 for river basins. This is an indicator of current conditions, measured trends and potential future vulnerability.

Key messages

The amount of available freshwater was found to decrease under all scenarios for the Thames and Anglian catchments. The ARFR revealed a decreasing trend for the majority of scenarios in the Solway, Humber, Northumbria and Western Wales catchments. Projections of changes to ARFR both the 2020 and 2050 wet scenarios were found to be insignificant. For the dry scenarios, a similar decrease in ARFR was seen for the Severn, North West of England, South East of England and the South West of England.

3.2 Water demand and supply-demand balance from public supply, agriculture and industry

Aim
Water demand has been used to assess whether there is a surplus or deficit of water available for use by the public, agriculture and industry for current and future periods. This is used to examine how supply or demand may change in the future, and takes into account population change. This is an indicator of current conditions, trends and potential future vulnerability

Key messages
A supply-demand deficit was found for all scenarios for the Thames catchment, highlighting future challenges for this basin. For all other basins, wet scenarios led to a supply-demand surplus. This was found to remain the case under dry scenarios for three basins, but to lead to a deficit in the projections for catchments including Northumbria, Anglian, South East and South West England.

3.3 Water exploitation index

Aim
This index has been used to assess the impacts of changing water abstraction and ARFR. It can be used as another indicator of water stress. The water exploitation index shows current condition, measured trends, and potential future vulnerability.

Key messages
Pronounced regional contrasts in water exploitation are found in this assessment. The Thames, Anglian and South East England basins are currently under water stress, with the Humber region experiencing low stress, and all others experiencing none. The wet scenario for the 2020 simulates increases in WEI and hence increased water stress, although these are the same as current conditions. For the dry 2020 scenario, water stress increases, with the Thames under severe water stress, and occurrences of water stress and low water stress increasing. Trends continue under the 2050s scenarios.

3.4 Change in ecological status of river water bodies in areas of water stress and in areas of no water stress

Aim
The aim of this section is to calculate the change in area of ecological status which are under water stress, and which are not. The ecological status is used to represent the ecological quality of rivers for 2010-2011. This measure indicates current conditions and trends.

Key messages
Within the time period examined results were variable, and when results are examined by length, the majority of water bodies did not see a change in status. South East England (an area of increased water stress) experienced the largest percentage of river length change in status, with slightly more increases as opposed to decreases in status. Results highlight that ecological status is affected by more drivers than simply water stress.

3.5 Development within areas of water scarcity

Aim

This section aims to find trends from 2001-2011 in the types of development (residential and non-residential) occurring in areas experiencing water scarcity. Examining the types of development provides an indicator of the current condition and experienced trends.

Key messages

A large increase in the number of buildings has been recorded over the study period. It was found that 45% of properties are situated in areas of water scarcity, with the remainder in areas of less-no water stress. Spatial patterns were also found for the change in number of residential properties within areas of water stress, with the highest increases in number found for regions of the Thames, Humber, and Anglia.

4.1.1 Peat coverage

Aim

The aim of this section is to map and estimate the total peat coverage in England. This will be used in later sections to assess vulnerability. This is an indicator of the current peat coverage.

Key messages

Peat was found to cover 5% of England's total land area, which is in line with previous findings. The estimate here however neglects the coverage in shallow peaty soils and peaty pockets.

4.1.2 Peat by priority habitat

Aim

The goal in this section was to classify peat coverage in the BAP habitats of Fenland, Blanket Bog and Lowland Raised Bog. This coverage is used to examine spatial overlap and used to identify areas of peat which are protected. This is an indicator of current condition.

Key messages

The various habitats were found to occupy different areas of the country, with Blanket Bog located in uplands (e.g. the Peak District), Fenland located in low lying wetland areas (e.g. the Norfolk Broads), and Lowland Raised Bog found in similar areas to, and overlapping with Fenland (e.g. the Somerset Levels). The majority of peat coverage (68%) was located outside of the BAP habitat areas, in the east of England as well as north and south-western areas.

4.1.3 Peat coverage by land cover class

Aim

The purpose of this indicator is to see which land classes are underlain by peat. This would allow for the identification of which land uses restrict peat development, and contribute to the degradation of peat habitats. Coverage by land cover class is an indicator of current condition.

Key messages

Over two-thirds of the land cover identified on deep peat has high potential to restrict peat-formationand/or lead to degradation. This included land covers such as arable/horticulture, and improved grasslands. These two land covers make up one third of all land use types identified on deep peat. This highlights the need of land managers to prevent negative impacts on the ecosystem services supplied by peatlands, and the complex trade-offs which exist in the agricultural sector.

4.1.4 Peat coverage within SSSI

Aim

The aim of this indicator is to see visually where peat coverage overlaps with, and falls outside SSSI. This identifies the peat habitats that are of national importance for their biodiversity. This is an indicator of current condition.

Key messages

40% of the Natural England peatland mask falls within existing SSSI in England. The majority of deep peat is located in the North-West, North-East, and Yorkshire and Humber regions, but the proportion of SSSIs within these regions are 41%, 47% and 57% respectively. For peatland areas that are within Natural England's priority habitat inventories, a higher proportion is located within SSSIs: for blanket bog it is 66%, and 84% and 88% for Lowland Raised Bog and Fenland respectively.

4.1.5 Peatland SSSI condition

Aim

This section assesses the condition of peatland within SSSI, ranking condition from favourable to destroyed or part destroyed for 2003 and 2013. This allows the spatial distribution of SSSI condition to be examined. This measure indicates current condition, and measured changes.

Key messages

Peatland condition in SSSI saw large improvements over the study period, with the sum of favourable and unfavourable recovering classes increasing from 35% in 2003 to 95% in 2013. This reflects a large number of sites now having a management plan in place that, if fully implemented, may lead to the site returning to favourable condition. It is not possible to tell from this to what extent recovery has in fact taken place which suggests a different recording system may be needed to allow this to be monitored. Furthermore, there has been a decline in the area in the "favourable" class from 19% to 16%. This reflects a real change in condition: some sites no longer meet their management objectives despite having the management in place to encourage recovery and is clearly a cause for concern.

4.1.6 Land use and condition 2013

Aim

This section maps present land use and condition to overlay this data with that on SSSI condition, habitat coverage, and peatland area. It indicates current condition.

Key messages

The majority of peatland sites are in favourable or unfavourable recovering condition irrespective of land cover. Lowland Raised Bog and Fenland priority habitats have a proportionally greater area in the "unfavourable, no change" and "unfavourable declining classes".

4.1.7 Uptake of restoration options: Entry Level and Higher Level Stewardship options for peatlands

Aim

The purpose of this section is to examine the overlap between Environmental Stewardship Schemes and peatland sites. This allows for a spatial analysis of High Level Stewardship schemes, and can again highlight vulnerable areas. This is an indicator of current condition and action being taken.

Key messages

Stewardship schemes focusing on maintenance contributed the greatest proportion to the area addressed by ELS/HLS options. In fact 83-85% of Stewardship schemes on blanket bog, lowland raised bog and fenland habitats addressed maintenance. Restoration schemes were also present but contributed considerably smaller proportion (8-13%) and creation schemes contributed a very minor part (<1%). The spatial pattern revealed areas of England where maintenance options are the only options applied.

4.1.8 Action in areas beyond ELS/HLS

Aim
The aim of this section is to examine peatland management projects which exist outside of ELS/HLS. This enhances the previous coverage of protected peatland areas. This is an indicator of current condition as well as of where actions are taking place.

Key messages
Results show that peatland management projects cover almost 30% of peat area in England. Such projects can upgrade the condition of areas which do not have nearby HLS options, with main restoration options for moorland, fenland and lowland raised bog totalling an area of 1976 km^2.

4.1.9 Vulnerability of peat to future climate

Aim
An eight model ensemble was used to project areas of future climatic suitability for the blanket bog priority habitat. The aim was to begin to explore the extent of the vulnerability of this habitat to future climate. This is an indicator of potential future vulnerability.

Key messages
An overall reduction in the area suitable for supporting blanket bog priority habitat is found. The area projected to be suitable for blanket bog in 50% of the models reduces from 94% to 69% in 2050. This would mean that 590 km^2 (31%) of current priority peat would be in climatically unsuitable areas in 2050; this increases to 1248 km^2 (65%) under the high emissions scenario.

5.1 Land use at risk from coastal erosion

Aim
This indicator is used to assess the spatial distribution of sites benefitting from coastal erosion defences. It is also used to identify where designated sites are unprotected. This measure indicates current conditions, measured trends and potential for future vulnerability.

Key messages
Results show that only a small proportion of total agricultural area in England is not benefitting from defences in the short, medium and long term. In the long term it is found that 4% of the area benefitting from defence is high grade agricultural land, with a small percentage of land of each major crop type benefitting from coastal erosion defences. Natural land was the use found to have no benefits from all epochs. Other manmade land is found to be unprotected, although they amount to less than 0.5% of England's land area. It is important to note that 44-52% of the area not benefitting from defences in any epoch falls within designated sites.

5.2 Land use at risk from saline intrusion

Aim

This indicator aims to identify land use at risk from saline intrusion and, the area of various agricultural land use in regions at risk from intrusion. It is an indicator of current condition and measured trends.

Key messages

Large areas exist along the east coast in the Anglian region which are classified as 'probably at risk' or 'at risk' of saline intrusion. This is also found to exist in the south east and along the Mersey Estuary. Results show that a small proportion of the major crop types are located within areas of probable risk, or risk of saline intrusion.

5.3 Area of coastal habitats at risk of being squeezed with sea level rise

Aim

The aim of this section is to highlight areas where habitat is most vulnerable to sea level rise as a result of coastal squeeze and submergence for each epoch. This is an indicator of potential future vulnerability.

Key messages

Modelling results predict a loss of sand dunes and vegetated shingle as a result of coastal squeeze, which relate respectively to 0.5% and 4.5% of their current area in England. Saltmarsh and mudflat are found to be much more vulnerable. It is highlighted that mudflat will experience the greatest losses as these habitats are located at a lower, shoreline level.

5.4 Land in coastal floodplain benefitting from flood protection by coastal habitats and/or artificial defences

Aim

The purpose of this indicator is to examine the land use in coastal floodplain which benefits from either protected habitats or defences. This is an indicator of current conditions and managed trends

Key messages

This indicator shows that 271,000 hectares of land located in the coastal floodplain is protected from flooding by artificial defences or coastal habitats. Not all coastal floodplain is afforded protection and some areas are afforded protection by both coastal habitats and artificial defences. Artificial defences are also protected by coastal habitats on the seaward side. 1-2% of the total property in England was in coastal floodplain areas protected by coastal habitats or artificial defences.

5.5 Area of non-built up land currently protected by a 'hold the line' policy

Aim

The purpose of this indicator is to assess the area of land which would be impacted if no active interventions are taken. This is an indicator of current condition

Key messages

This section finds that numerous coastal policy units exist where the preferred management option in the long term is to hold the line, but where no further active interventions would be considered more viable in economic terms. If management is changed, but there are no active interventions 75 ha of non-built up land may be eroded, and 10,000 ha flooded.

5.6 Land use change due to previously implemented managed realignment schemes

Aim

The aim is to examine the area of land which has changed land use as a result of managed realignment schemes. This is an indicator of current conditions.

Key messages

Results find the total area lost to realignment is currently 1,396 ha, of which 419 ha was high grade agricultural land, and over 700 ha on Grade 3-5 agricultural land. The remainder was either non-agricultural or unspecified.

6.1.1 Extent of priority habitat in England classified according to level of fragmentation

Aim

The purpose of this indicator is to classify England into three classes by using the fragmentation of its habitats to create three classes summarising the overall level of biodiversity within the area. Areas with large amounts of priority habitat in close connection are considered to have a higher overall biodiversity than heavily fragmented habitats where priority habitats are absent or are broken up by land use classes with less biodiversity. This classification underlies all following analyses in the biodiversity section of this report. It is an indicator of current condition.

Key messages

The National Biodiversity Climate Change Vulnerability Model (NBCCVM) fragmentation index was used to classify the areas of England containing priority habitat into areas with high, moderate and low fragmentation. 14% of priority habitat in England was classified as having "low" levels of fragmentation; these areas include core areas of natural habitat such as the Lake District and Peak District, Dartmoor and the Somerset Levels. 28% of the NBCCVM area was classified as having "high" levels of fragmentation. This included many river networks, and other priority habitat sites predominantly in urban and arable areas, particularly in the Midlands and the East of England.

6.1.2 Land cover within each NBCCVM habitat fragmentation class

Aim
The aim of this indicator is to identify for each of the LCM land cover classes what proportion is identified in each BCCVM fragmentation class. For semi-natural land use classes this gives an indication of the extent to which each of these land cover classes is located in areas with high or low fragmentation. For classes such as urban and arable that map less easily to priority habitats it provides an indication of the extent to which these classes contribute to fragmentation. It is an indicator of current condition.

Key messages
The LCM land cover classes "bog", "calcareous grassland", "heather" and "montane habitats" have the greatest proportion of their NBCCVM distribution in areas of low fragmentation, whilst classes such as "rough grassland" and "deciduous woodland" have relatively low proportions in this class. Urban and suburban landuses have the greatest proportions in the high fragmentation class, followed by arable and horticulture.

6.1.3 SSSI land use from 2013 SSSI data

Aim
The aim of this indicator is to quantify the overlap between SSSIs and the NBCCVM and to explore whether the SSSI network is in general located in areas where biodiversity is least fragmented. Land use, as recorded in the SSSI database, is also explored by fragmentation class in this indicator. It is an indicator of current condition.

Key messages
Results show that the majority of SSSIs are in areas of moderate fragmentation, with some experiencing low fragmentation, and only a small proportion highly fragmented. It is important to note that large areas of SSSI fall outside the NBCCVM. Many of these are in coastal areas as the NBCCVM stops at mean high water mark. There is also an anomalous large area of NBCCVM priority habitat in Cambridgeshire that has no SSSI coverage.

6.1.4 Priority habitats by NBCCVM habitat fragmentation class and SSSI cover

Aim
This indicator focuses in more detail on the priority habitat inventories. It takes a group of seven targeted priority habitats and aims to determine the level of fragmentation identified within each. It does this for both the full SSSI dataset and sub-set of this dataset. It is an indicator of current condition.

Key messages
Blanket Bog, Upland Heath and Lowland Raised Bogs were found to have the largest areas in the least fragmented class. Broadleaf Woodland is more fragmented, with most of this habitat being moderate to highly fragmented, although there are various possible explanations for this.

6.1.5 Trends in habitat extent from Countryside Survey data

Aim

The purpose of this section is to assess trends in changes to habitat extent. Countryside Survey data is used as this provides a time series for priority habitats. This is an indicator of managed trends and current condition.

Key messages

Areas classified as Class 1 contain a diverse range of habitats, whereas over half of Class 2 areas comprise only “arable and horticulture” and “improved grassland”. Class 3 areas consist almost entirely of “arable and horticulture”, although the data did show a reduction in the area of this classification level. Increases in habitat were found for “improved grassland” and “mosaic habitats” amongst others in almost every fragmentation class.

6.1.6 Proportion of climate sensitive priority habitat by NBCCVM habitat fragmentation class

Aim

The aim of this indicator is to get a feel for potential future sensitivity to climate change and to identify if this varies by fragmentation class. This is an indicator of current condition and an indication of future sensitivity.

Key messages

A greater proportion of Class 1 habitats have a high climate sensitive and a lower proportion low climate sensitivity in comparison to Class 2 and Class 3. The high climate sensitivity habitats are predominantly located in low-lying wetland and coastal locations, such as the Somerset Levels, Kent and Essex Marshes, Norfolk Broads, The Wash, and the Humberhead Levels. They tend to be present in larger consolidated areas (low fragmentation). Conversely, high sensitivity classes in the uplands (“montane” and “upland hay meadows”) are fragmented and cover a small area.

6.2.1 SSSI Condition

Aim

The aim of this section is to identify trends in the condition of SSSIs. SSSI condition data from 2003 and 2013 is used to analyse trends. The analysis is split by NBCCVM habitat fragmentation class to explore whether there are differences in condition and trends between the low and high fragmentation classes. This is an indicator of current condition and measured trends.

Key messages

A large percentage of SSSIs which were in ‘unfavourable condition’ in 2003 had improved by 2013 to be included in the ‘appropriate management’ category. However, there was also a decline of 4% in sites which were in ‘favourable condition’ in 2003. Changes in condition were larger in the low NBCCVM fragmentation class (Class 1) - both in terms of improvements and declines. It is not possible to tell from this dataset to what extent recovery has in fact taken place due to the classification system focusing on management rather than recorded recovery. This suggests a different recording system may be needed to allow this to actual recovery to be monitored. The 4% decline in the “favourable” class is a cause for concern as it reflects a real change in condition. It shows that some sites are no longer meeting their management objectives despite having the management in place to encourage recovery.

6.2.2 Priority habitat condition from SSSI condition data

Aim

The aim of this section is to identify the condition for selected priority habitats and changes from 2003 to 2013. The purpose is to determine the direction of trends and to identify whether these differ or are consistent across habitats. This is an indicator of current condition and measured trends.

Key messages

The results show a significant shift from 2003 to 2013 in terms of habitats becoming classified as ‘unfavourable recovering’. There are substantial differences in habitat condition between priority habitats. Changes in ‘unfavourable recovering’ reflect suitable management being put in place and, as such, may not reflect biological recovery. Conversely, declines in the area of Lowland Heath and Fenland classified as ‘favourable’ suggest a real cause for concern as they indicate that the relevant SSSIs no longer meet their conservation objectives. Coastal grazing marsh raises an interesting consideration with respect to policy targets as it meets Biodiversity 2020’s target for 50% habitat in “favourable” condition but does not meet the previous 2010 target for 95% habitat in “unfavourable recovering or favourable”. Whilst the existing targets are not habitat specific the issue does have implications with regard to which policy target to prioritise.

6.2.3 Water quality data from EA WFD dataset

Aim
The purpose of this indicator is to classify the ecological status of rivers in relation to the NBCCVM fragmentation classes. It is an indicator of current condition.

Key messages
Results showed that an estimated 20% of rivers had good status, over half were moderate, and around a quarter had poor ecological status. A very small percentage of rivers were found to have poor status. A greater proportion of rivers with poor status were identified in areas outside of the NBCCVM area (i.e. in locations with no priority habitat) and a greater proportion of rivers with high status included Class 1 and Class 2 habitats.

6.3.1 Natural connections: change in area of ponds from Countryside Survey

Aim
Ponds are key stepping stones for many species. The purpose of this indicator is to identify trends in these and to see if there is a difference in pond creation or loss in areas of high and low fragmentation. This is an indicator of measured trends.

Key messages
Countryside Survey data indicates that, between 1998 and 2007, the total area of ponds has increased by 6.6 ha. 73 sites stayed stable, 37 were gained and 11 lost. For sites where changes are taking place, the average gain in pond area is greater in areas of low fragmentation and the rate of loss is greater in areas of high fragmentation. In terms of numbers of sites gained, areas of moderate fragmentation have the highest proportion of gains and the lowest proportion of losses.

6.3.2 Natural connections: Change in length of woody linear features from Countryside Survey data

Aim
Hedgerows and other woody linear features provide important habitat corridors that reduce the fragmentation of the landscape. This indicator aims to identify trends in woody linear features between 1998 and 2007 and if different trends can be identified in the NBCCVM habitat fragmentation classes. This is an indicator of measured trends.

Key messages
All fragmentation classes experienced similar levels of decline in the average length of features.

6.4.1 Uptake of Environmental Stewardship options

Aim:

The aim of this section is to identify where Environmental Stewardship options (both Entry Level Stewardship and Higher Level Stewardship) have been taken up in a way that will benefit biodiversity. It is used as an indicator of where action is taking place, but is not as an indicator of total action applied to biodiversity.

Key messages

Findings show that, since 2005, the largest number of HLS actions concerned habitat maintenance. Examination of ELS and HLS by fragmentation class showed again that most actions were focussed on habitat maintenance. The number and size of actions concerning habitat restoration and creation, along with non-biodiversity actions, need to increase to create a more coherent ecological network.

6.4.2 The extent of landscape-scale initiatives

Aim

The aim of this indicator is to (a) examine the spatial extent of landscape-scale initiatives, and (b) to see how they cover the three fragmentation classes. This is an indicator of current condition and of action being taken.

Key messages

Landscape-scale initiatives cover almost one-third of England's land area, with the 'Living Landscape' scheme having the greatest coverage (over 18% of total land area). The main benefit of such schemes is that they cover a larger range of fragmentation classes than targeted Environmental Stewardship schemes, thereby increasing the resilience of the country's ecological network.