MONITORING THE HISTORIC ENVIRONMENT: THE ARCHAEOLOGICAL RESOURCE

FINAL REPORT MARCH 2008

Report prepared for Cadw by the Countryside and Community Research Institute and the Dyfed Archaeological Trust

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EXECUTIVE SUMMARY

The overall aim of the project was to develop a workable methodology to monitor the condition of and threat to the archaeological resource on agricultural land in Wales based on the cost–effective use of existing data sources wherever possible.

The specific objectives of the project identified by the project brief were to:

- Build on the work undertaken by Dwyer et al (2006), Gaskell et al (2007) and Hossell et al (2007) and review existing literature/reports on the likely impacts of Common Agricultural Policy (CAP) reform on the archaeology of Wales.
- Build on the work undertaken by DAT (2006) and evaluate the data sources that could provide indicators to monitor the condition of and threat to the archaeological resource.
- Design operational indicators to monitor the condition of and threat to the archaeological resource.

The project was carried out in three main stages:

- Stage 1: Literature review;
- Stage 2: Evaluation of data sources;
- Stage 3: Design of operational indicators.

Stage 1: Literature review

A review of existing literature on the likely impacts of CAP reform, and other drivers of agricultural change, on the archaeological resource of Wales was undertaken. The review contributed to the production of summaries of the CAP reforms, impacts on farm management and implications for the archaeological resource.

Building on the literature review, the types of change likely to take place and their potential impact on the archaeological resource were evaluated by the research team. A series of pro-formas were completed which cross-tabulated the different types of management change with the likely impacts on the archaeological resource.

This analysis allowed the identification of key factors relevant to the survival and condition of the historic environment within the farmed landscape.

The principal negative factors are:

1. Expansion of areas of cultivation;
2. Deeper cultivation;
3. Increasing stocking levels;
4. Replacement of lighter livestock by heavier animals;
5. Increased farm infrastructure – tracks, buildings etc;
6. Abandonment and uncontrolled scrub development.

These can be summarised as those which cause or encourage erosion and soil loss and which generally affect large tracts of land (1-4), those which allow other agencies of damage to develop, also over potentially large areas (6), and those which are individual and isolated activities determined by specific farm business requirements (5).

Conversely there are positive factors associated with some changes that contribute to the wider protection and preservation of the historic environment:

- Reduction in cultivation;
- Lower stocking levels in areas where erosion is a problem;
- Replacement of heavy animals – beef or dairy cattle – by sheep;
- Maintaining appropriate stock levels to control scrub development.

It is the interaction between these positive and negative factors which is likely to be most critical in monitoring the condition of the historic environment of rural Wales over the coming decades.

Stage 2: Evaluation of data sources

An evaluation of the data sources that could provide indicators to monitor the threat to and condition of the archaeological resource was undertaken. The evaluation included sources already assessed - the Welsh Archaeological Trusts' threat-related assessments - and considered a range of other data sources including vertical and oblique aerial photography, Light Detection and Ranging surveys (LiDAR), Cadw field monument warden Scheduled Ancient Monument (SAM) files, Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW) upland survey data and Tir Gofal agri-environment scheme generated historic environment data.

The different data sources were evaluated to determine which were best suited for monitoring change. Two types of indicator were proposed:

- *Early warning indicators*: Using Agricultural Census data to identify changes in stock numbers and cropping area and satellite imagery to identify changes in vegetation cover.
- *Actual impact indicators*: Using data sources identified by Cambria Archaeology (2006) combined with aerial photography and field survey to identify changes in the condition of archaeological sites.

Stage 3: Design of operational indicators

Operational indicators were then designed to monitor the threat to and condition of the archaeological resource. The information required to instigate a monitoring programme was identified, including the estimated resources required for collecting the data, frequency of survey and sampling strategies.

This resulted in a suite of six early warning and five actual impact indicators being designed

Indicator Type	Indicator name	Description	Data source
Early warning	Arable area	This indicator monitors changes to the area of arable land recorded by the Agricultural Census in each of the five Area Types on an annual basis	Agricultural Census
	Sheep numbers	This indicator monitors changes to the number sheep in each of the five Area Types on an annual basis	Agricultural Census
	Unimproved permanent grassland	This indicator monitors changes in the area of unimproved permanent grassland in the five Area Types on an annual basis	Satellite imagery
	Wetland	This indicator monitors changes in the area of wetland vegetation in the five Area Types on an annual basis	Satellite imagery
	Scrub and woodland	This indicator monitors changes in the area of scrub and woodland in the five Area Types on an annual basis	Satellite imagery
	Arable	This indicator monitors changes in the area of arable vegetation in the five Area Types on an annual basis	Satellite imagery
Actual impact	Buildings	This indicator monitors changes to sites in the buildings category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Other stone structures	This indicator monitors changes to sites in the other stone structures category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Earthworks	This indicator monitors changes to sites in the earthworks category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Megaliths	This indicator monitors changes to sites in the Megaliths category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	No upstanding remains	This indicator monitors changes to sites in the no upstanding remains category in each of the five Area Types on a quinquennial basis.	WAT-HER Vertical AP Field visit

Recommendations

In order to fully develop and operationalise the indicators it is recommended that a staged programme of work should be carried out:

- Stage 1 Preparation of baseline data:
    - Early warning indicators;
    - Actual impact indicators.
- Stage 2 Repeat monitoring survey and analysis:
    - Early warning indicators;
    - Actual impact indicators.

Stage 1 Preparation of baseline data

Early warning indicators

- An initial project should be undertaken to identify potential synergies with the development of indicators of biodiversity change outlined in the report by Hossell *et al* (2007). This may lead to significant cost savings in the construction of the early warning indicators for monitoring the archaeological resource.
- Baseline data should be collected and analysed for the six early warning indicators. A simple database should be constructed for this purpose. The base-year for the indicators using Agricultural Census data is dependent on the completion WAG geo-referencing programme which will allow the data to be analysed by Area Type. The base-year for the indicators using satellite imagery is dependent on the completion of the CCW and WAG vegetation-monitoring programme (scheduled for summer 2008).

Actual impact indicators

- An initial project should be undertaken to filter the WAT-HER database of unreliable records. It is estimated that up to 25% of records may require removal.
- The Main Sample of 2,000 sites should then be selected following the sample framework proposed. This should be kept confidential so far as this is possible to ensure objectivity and reduce any risk of manipulation.
- Each site should then be assessed for its suitability based on adequacy of information contained within the record to provide baseline information and accuracy of locational information.
- A dossier for each site should be collated including:
    - Print out of computerised HER data;
    - A map indicating the location of the site;
    - Copies of relevant supporting documents (sketches, plans, photos etc) held by Trusts;
    - Copy of report entry for any recent Cadw-funded projects;
    - Copies of aerial photographs (WATs / RCAHMW);
    - Copies of aerial photographs (2006 VAPs).
- A recording protocol should be developed for the assessment of sites with a scoring system for quantifying condition, vegetation, land use, development, potential threats and change over time. The recording protocol should be piloted and revised as required to ensure its robustness.
- The WAT-HER sample database should be developed to store the monitoring information which will allow the retrieval and interrogation of the collected data.
- Analysis of the 2006 VAPs for each site in the Main Sample should be carried out to establish baseline information.
- A report should be compiled to establish the framework of the project and its future objectives.

It is recommended that in order to test the methodology and to establish a clear framework for time estimates that a rapid pilot survey of 20 sites should be carried out. This will also give an opportunity to develop the methodology, check recording mechanisms and verify the VAP analysis by conducting field visits.

Stage 2 Repeat monitoring survey and analysis

Early warning indicators

The early warning indicators should be updated and analysed on an annual basis to identify trajectories of change.

Actual impact indicators

Each future cycle of monitoring and analysis should consist of two work packages, the first being the analysis and interpretation of the new VAP data to be followed by detailed site recording through site visits and the verification of VAP analysis. These two work packages should be carried out in quick succession in order to provide more accurate analysis of the VAP interpretation.

Work package 1: VAP analysis

Time series data should be collected at intervals of every 5 years corresponding with the updating of the new digital VAP mapping data.

Future cycles should consist of:

- Data collection - repeat analysis of the VAPs and evaluation of change;
- Recording information;
- Reporting and analysis.

Work package 2: Field visits

Field visits should follow the VAP analysis.

Future cycles should consist of:

- Sample Field Visits – assessment of site condition and verification of VAP analysis on 125 sites;
- Inputting and recording information;
- Reporting and analysis.

CONTENTS

1. PROJECT AIMS AND OBJECTIVES

1.1 Introduction

The historic environment of rural Wales is a complex matrix of archaeological sites, traditional buildings, early field boundaries, designed landscapes, ancient woodlands, and many other relicts of past activity. These features survive in the context of a farmed landscape which has changed radically in recent decades, and which faces further change as it adapts to the political, economic and environmental challenges of the 21st century. Cadw has identified a lack of information on the nature and extent of such change and recognises that this information is needed for the development of effective management policies across all levels of government in Wales. In September 2007, as a first step toward monitoring the rural historic environment, Cadw commissioned the Countryside and Community Research Institute (CCRI) and the Dyfed Archaeological Trust (DAT) to develop a workable methodology to monitor the condition of the archaeological resource on agricultural land in Wales. This project forms part of a broader research strategy to monitor the condition of the historic environment in Wales.

1.2 Aims and objectives

The overall aim of the project was to develop a workable methodology to monitor the condition of and threat to the archaeological resource based on the cost–effective use of existing data sources wherever possible.

The specific objectives of the project identified by the project brief were to:

- Build on the work undertaken by Dwyer *et al* (2006), Gaskell *et al* (2007) and Hossell *et al* (2007) and review existing literature/reports on the likely impacts of Common Agricultural Policy (CAP) reform on the archaeology of Wales.
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1.3 Report structure

The remainder of this report is divided into five sections. Section 2 describes the approach and methods adopted in carrying out the research. Section 3 provides a picture of the main drivers of change affecting agriculture in Wales and then considers the changes taking place to farm practice and the implications for the archaeological resource. Section 4 provides an evaluation of the data sources available to construct indicators of change. Section 5 focuses on the development of operational indicators to monitor the condition of and threat to the archaeological resource. Finally, in Section 6, a series of recommendations are made for a programme of work to make the monitoring indicators a reality.

2. RESEARCH METHODS AND APPROACH

The project was carried out in three main stages:

Stage 1: Literature review

A review of existing literature on the likely impacts of CAP reform, and other drivers of agricultural change, on the archaeological resource of Wales was undertaken. The review contributed to the production of summaries of the CAP reforms, impacts on farm management and implications for the archaeological resource.

Building on the literature review, the types of change likely to take place and their potential impact on the archaeological resource were evaluated by the research team. A series of pro-formas were completed which cross-tabulated the different types of management change with the likely impacts on the archaeological resource.

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- *Early warning indicators*: Using Agricultural Census data to identify changes in stock numbers and cropping area and satellite imagery to identify changes in vegetation cover.
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Stage 3: Design of operational indicators

Operational indicators were then designed to monitor the threat to and condition of the archaeological resource. The information required to instigate a monitoring programme was identified, including the estimated resources required for collecting the data, frequency of survey and sampling strategies.

3. AGRICULTURAL CHANGE AND THE IMPLICATIONS FOR THE ARCHAEOLOGICAL RESOURCE

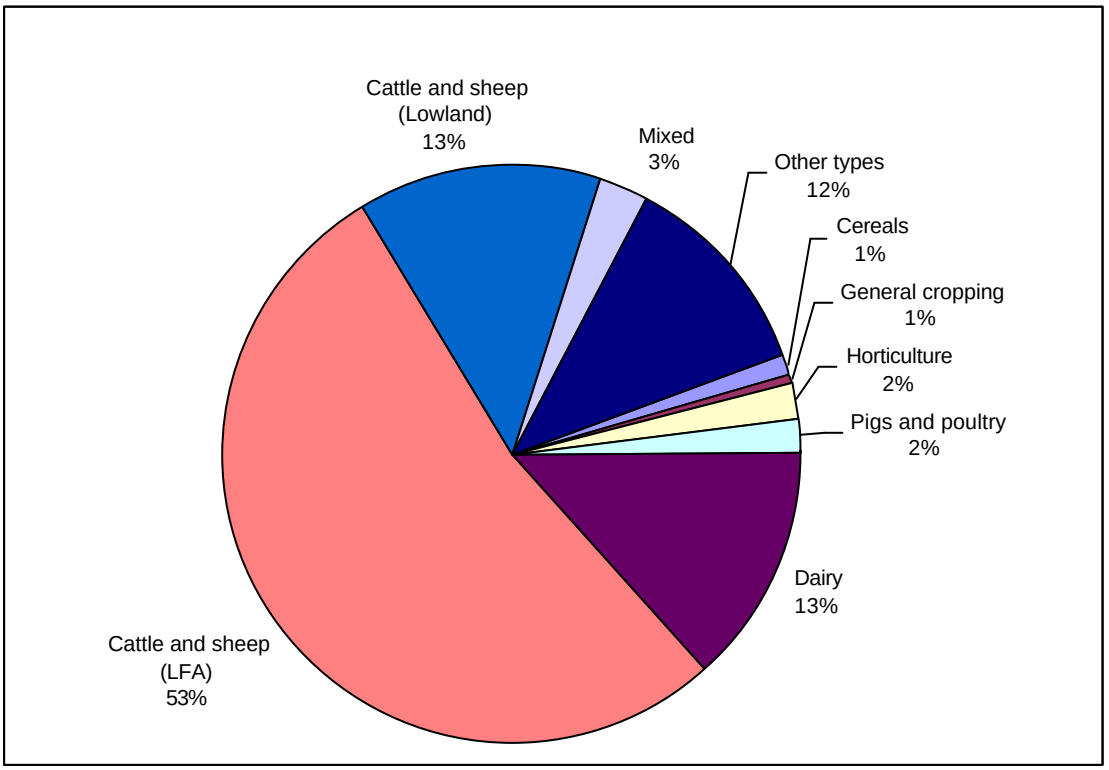
3.1 Introduction

The purpose of this section is to present the findings of the literature review on the drivers of change within Welsh agriculture and the likely impacts of changing farm management practice on the archaeological resource. The section is divided into four parts. Section 3.2 presents a brief overview of Welsh agriculture. Section 3.3 provides a summary of the main driving forces for agricultural change operating in Wales, beginning with CAP reform, before examining other policy influences and economic factors. Section 3.4 provides an assessment of current and potential changes taking place to different farming sectors and farm practice and Section 3.5 considers the implications of such change for the archaeological resource.

3.2 Welsh agriculture

Wales covers an area of 2.07 million hectares and of this land 1.6 million hectares is used for agriculture (WAG, 2007a & b). Approximately 80% of the total area of Wales is covered by the current Less Favoured Areas (LFA) designation, which closely parallels the mountainous and upland areas. Welsh agriculture is dominated by livestock farming with over half of the farm holdings (53%) being classed as cattle and sheep farms within the LFA (Figure 3.1). Lowland cattle and sheep enterprises (13%) and dairying (13%) are also numerically important.

Figure 3.1 Farm types in Wales (2004)



Source: Welsh Agricultural Census, June 2004

There are 24,000 agricultural holdings in Wales, of which approximately 17,000 received over £200 million in funding from the Single Payment Scheme (SPS) (WAG,

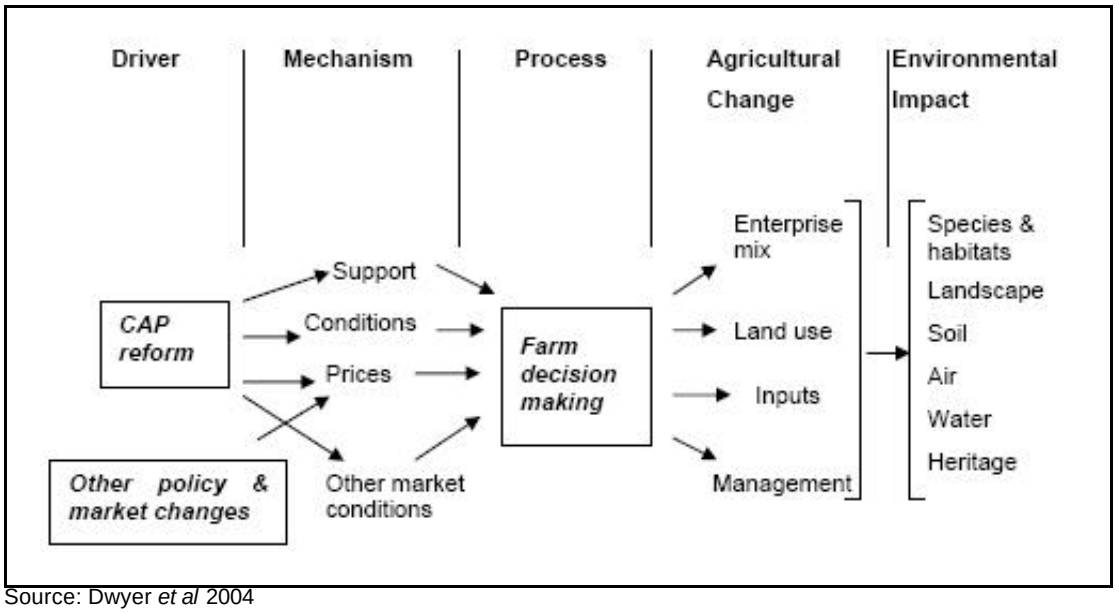
2007b). According to the Situational Analysis prepared for the Draft Rural Development Plan for Wales (WAG, 2007a) the agricultural industry plays a key role in managing and enhancing the environment and contributes significantly to the economic, social, environmental and cultural cohesion of rural Wales. However, it is also recognised that the focus for agricultural production remains commodity based and unless significant changes take place, marketing opportunities could be affected by international competition.

3.3 Welsh agriculture and the drivers of change

Introduction

Change in the use of agricultural land is a key influence on the management of the archaeological resource in Wales. The type of land-use management, whether for crops, improved pasture, rough grazing or a range of alternative enterprises, will have a major impact upon the conservation of the archaeological resource (Figure 3.2). It is therefore important to gain a deeper understanding of the forces that cause change in Welsh agriculture. Since the Second World War agricultural production has been transformed by the adoption of new technologies and management techniques, which combined with CAP and other policy reforms, international trade agreements, changing markets and prices and outbreaks of animal disease, has placed Welsh agriculture under considerable economic, social and environmental pressure. To a large degree, it is how farmers respond to these drivers that will determine the future of much of the archaeological resource in Wales.

Figure 3.2 Flow diagram showing steps leading from policy drivers to environmental impacts



Source: Dwyer *et al* 2004

Overview of the 2003 CAP reforms

The CAP provides funding for agriculture through two Pillars of support: Pillar I (direct income payments) and Pillar II (rural development). As a result of the most recent CAP reforms in 2003, most farmers will be more exposed to market signals for the agricultural aspects of their businesses. This will influence the relative viability of

different types of livestock enterprise, crop selection and management decisions both agricultural and non-agricultural.

Such changes could have both positive and negative consequences for the environment. Some land may be farmed more intensively and some less so, while agricultural production on some marginal land may cease. Energy crops and other non-food crops may replace traditional crops to some degree. Changes to support payments are accompanied by environment and rural development measures, e.g. cross-compliance attached to the SPS, and a new agri-environment scheme with an Entry Level Scheme (Tir Cynnal) open to all. These substantial changes to the policy environment for farming could have profound impacts on the archaeological resource.

Single Payment Scheme and cross-compliance

The main change in support resulting from the 2003 CAP reforms in Wales has been the decoupling of aid to producers in the principal sectors which have benefited from CAP subsidy in the past, namely: beef, sheepmeat, dairy and arable, From 1 January 2005, all former direct payments to producers have been combined into a single payment per hectare of eligible land, based upon a pattern of allocation which is based upon levels of historic receipts.

The SPS replaced the following CAP subsidy schemes:

- Arable Area Payments Scheme (AAPS);
- Beef Special Premium Scheme (BSP);
- Extensification Payment Scheme (EPS);
- Sheep Annual Premium Scheme (SAPS);
- Suckler Cow Premium Scheme (SCPS);
- Slaughter Premium Scheme (SPS);
- Dairy Premium and Additional Payment.

Decoupling does mean that, henceforth, decisions about what and how much to produce from farmland will not affect support levels under the SPS, so farmers can change their farming systems and practices in response to other market and external signals in line with demand. Recent research for Defra in England has shown that farmer response to the implementation of the SPS is being strongly influenced by market conditions. The recent increase in cereal prices has lessened the pressure for business adjustment in the cereal sector in the short to medium term. In contrast, the pressure for business restructuring remained across the livestock rearing and breeding sectors in both the uplands and lowlands (Gaskell *et al*, 2007).

In order to continue to receive SPS, beneficiaries have to uphold a prescribed list of basic standards as set out in EU legislation (on health, welfare and the environment), and manage their eligible land according to a set of criteria of 'Good Agricultural and Environmental Condition' (GAEC), which are designed to ensure that the environment is protected and land retains its productive capability in the long term. These sets of conditions are collectively termed 'cross-compliance' and are divided between a set of 19 'statutory management requirements' (SMR) and 11 GAEC measures (Tables 3.1 & 3.2).

Table 3.1 Good Agricultural and Environmental Condition (GAEC) measures

GAEC	Title
A1	Soils erosion
A2	Soil organic matter
A3	Soil structure
B	Overgrazing
C	Under grazing/Under management
D	Supplementary feeding
E	Boundaries
F	Historical features
G	Permanent pasture
H	Heather and grass burning
I	Environmental Impact Assessment (EIA)
J	Tree felling and preservation
K	Sites of Special Scientific Interest

Source: http://new.wales.gov.uk/

Table 3.2 Statutory Management Requirements (SMRs)

SMR code	Title
1 & 2	Framework for the identification and registration of bovine animals regarding the labelling of beef and beef products
3	Identification and registration of animals
4	Sheep identification and registration requirements
5	Protection of groundwater against pollution
6	Conservation of fauna and flora
7	Conservation of wild birds
8	Protection of water in Nitrate Vulnerable Zones
9	Protection of the environment, and in particular soils, when sewage sludge is used in agriculture
10	Ban on using substances having a hormonal or thyrostatic action and beta-agonists in farm animals
11	The placing of plant protection products on the market
12	Prevention, control and eradication of transmissible spongiform encephalopathies
13	Control and eradication of Foot and Mouth
14	Control and eradication of Swine Fever
15	Control and eradication of Bluetongue
16	General principles and requirements of food law
17	Welfare standards for the protection of animals kept for farming purposes
18	Welfare standards for the protection of calves
19	Welfare standards for the protection of pigs

Source: http://new.wales.gov.uk/

GAEC F, Historic features[1], and GAEC E, Boundaries[2], are of most clear relevance to the protection of archaeology with clear guidance on avoiding damage to historic features, including archaeology. The main requirements of GAEC F are:

- There must be no damage to scheduled historic features through activities which cause or encourage soil erosion or ground disturbance on ancient monuments: e.g. overgrazing, inappropriate supplementary feeding, heavy vehicles, new cultivation, farm building etc.;
- Prevent the growth of vegetation which might obscure or whose roots might disturb remains below ground;
- Prevent trampling and erosion on monuments;
- Do not damage historic features by vehicles;
- Materials and rubbish must not be stored or dumped on historic features;
- No work to a Scheduled (i.e. protected) Monument may be carried out without formal consent from Cadw.

The main requirements of GAEC E that affect archaeology are:

- All stone walls, stone faced banks, hedges, and earthbanks, slate fences, stone gate posts and traditional stiles must be retained. Their removal or destruction on land subject to cross-compliance will not be allowed without consent from the relevant authority;
- Do not widen an existing gap to more than 10 metres to enable machinery or animal access.

While the focus is on the protection of habitats and biodiversity, GAEC A1, B, C, G and H also afford some protection to archaeology. The archaeological resources is protected from significant environmental damage caused by agricultural intensification through GAEC I[3] which covers the Environmental Impact Assessment (EIA) regulations for the use of uncultivated land and semi-natural areas. Under the regulations it is illegal to proceed with agricultural intensification projects without either obtaining a screening decision that the project will not have significant environmental effects or obtaining EIA consent. However, the archaeological resource on is not protected from agricultural operations, such as stone removal, that do not involve an intensification of production.

Set-aside

In July 2007 the EU Agriculture Minister announced a proposal to set at 0% the obligatory set-aside rate for the 2008 scheme year. This proposal was accepted by the EU Agriculture Council in September 2007 and means that farmers are not required to manage any land as set-aside in 2008, although they would still be able to set land aside on a voluntary basis. It is also anticipated that the Commissioner will propose the ending of set-aside after 2009, as part of the 2008 CAP health check.

Aid for Energy Crops

Aid for Energy Crops is separate to the SPS and may be paid in addition. It is paid on crops grown for the production of energy (heat, electricity or transport fuels) on land that has not been set-aside in the same year. The low level of payment available suggests that few farmers will be attracted to specifically grow bioenergy crops by

[1] http://new.wales.gov.uk/docrepos/40382/4038231121/403822/501383/gaec_f_e.pdf?lang=en
[2] http://new.wales.gov.uk/docrepos/40382/4038231121/403822/501383/gaec_e_e.pdf?lang=en
[3] http://new.wales.gov.uk/docrepos/40382/4038231121/403822/501383/gaec_i_e.pdf?lang=en

this scheme, particularly given the alternative option of selling onto more profitable cereal and oilseed food and feed markets under current conditions (Gaskell *et al* 2007).

Tir Mynydd

The Tir Mynydd scheme is part of Pillar II of the CAP and is delivered through Axis 2 (measures targeting the sustainable use of agricultural land) of the Draft Rural Development Plan for Wales. The scheme was introduced in 2001 to replace Hill Livestock Compensatory Allowances. It is a compensatory scheme, which provides payments to livestock farmers in the LFAs of Wales who face significant natural handicaps because of difficult topography, poor soil and climate. The objective of the scheme is to support the maintenance of livestock production in order to prevent land abandonment and rural depopulation (WAG, 2007c).

In its original form Tir Mynydd consisted of two elements. Element 1 comprised LFA land area payments, while Element 2 provided for payment enhancements to Element 1 for confirmed environmental practice. Since its inception the scheme has provided considerable financial support to eligible livestock farmers in the LFA. Between 2001 and 2006, it is estimated that payments under Tir Mynydd totalled around £230 million. For the 2005 scheme year, average payments were some £3,583 for the Severely Disadvantaged Areas (SDA) and £1,308 for the Disadvantaged Areas (DA) (WAG, 2006).

The revised Tir Mynydd Scheme for 2007 and 2008 does not include Element 2, because the new Tir Cynnal scheme (see below) has taken over the role of supporting sustainable environmental practice. A successor to the Tir Mynydd scheme will be announced in 2008 following the conclusion of the review of all land management schemes included in the Draft Rural Development Plan for Wales that is currently being carried out by the Welsh Assembly Government (WAG, 2006c).

Agri-environment schemes

In Wales two major agri-environmental schemes are used to directly meet objectives for the conservation and enhancement of the archaeological resource: Tir Cynnal and Tir Gofal. A further scheme, the Catchment Sensitive Farming Scheme, indirectly contributes to the conservation of the archaeological resource through soil protection. Currently, all of these schemes receive funding under Axis 2 of the Draft Rural Development Plan for Wales (WAG, 2006c).

Tir Cynnal

Tir Cynnal is the agri-environment entry-level scheme for Wales. Land managers, usually farmers, who join this scheme must protect the important environmental areas and features on their land. It is a 10-year scheme. It provides support to farmers to protect archaeological and historic sites. Tir Cynnal is a whole farm scheme and farmers must agree to enter all their land and meet the conditions of the scheme.

The scheme's four objectives are to:

- Prevent loss of biodiversity on the farm by protecting wildlife habitats;
- Protect important landscape features on farmland, including traditional field boundaries;
- Safeguard the historic environment by protecting the archaeological and historic sites and features from damage;

- Help protect and improve the quality of water, soil and air by measures to reduce pollution and raise awareness of the risks.

There are five main components of the scheme and one condition (under Historic and Traditional Landscape Features) relates specifically to the protection of the archaeological resource:

- Safeguard any archaeological or historic features, including un-scheduled monuments, from damage by stock, vehicles, cultivation or land reclamation. Trees should not be planted on these sites nor stones removed for any purpose.

Tir Gofal

Tir Gofal is designed to protect and enhance the Welsh landscape by making payments to farmers who make a commitment to sustaining the environmental, historical and cultural features on their land (WAG, 2006c). The scheme builds on the experience of previous schemes, such as Environmentally Sensitive Areas (ESAs) and Tir Cymen. Agreements apply to the whole farm and last for ten years with a break clause after five years. As of August 2007 the scheme covered 2,958 farms and 333,000 hectares of land (AGW, 2007). During the last application window, which closed on 30th November 2006, over 1,500 applications were received. Successful applications are being processed with a view of signing up to 1,000 new agreements by March 2010.

The schemes' principal objectives are to:

- Benefit farm wildlife via the promotion of positive management of existing wildlife habitats and the encouragement of habitat restoration and re-creation;
- Protect characteristic rural landscapes and promote the management and restoration of significant landscape features;
- Protect the historic environment, including both historic landscapes and features by encouraging farming practice compatible with their conservation and enhancement;
- Deliver enhanced public access to the countryside.

A general requirement of the scheme is for the protection and maintenance of all historic earthworks, stone structures and archaeological sites. Table 3.3 shows that as of 31st July 2006 there were over 600 Scheduled Ancient Monuments and over 13,000 other historic features on Tir Gofal registered land.

Table 3.3 Scheduled Ancient Monuments and other historic features on Tir Gofal land at 31st July 2006

Type of feature	Number	No. farms
Scheduled Ancient Monuments Sites of national importance protected by the Ancient Monuments and Archaeological Areas Act 1979	651	251
Other historic features Archaeological sites, earth work monuments, ruined structures and individual historic garden features (e.g. post-medieval pond or weir)	13,242	1,950

Source: AGW (2007 p26)

However, a report by the Auditor General for Wales, on the performance of the scheme, concluded that it was difficult to measure the impact of Tir Gofal on the maintenance and restoration of the historic environment, as there was no routine monitoring and evaluation:

> *Features of interest are identified during the application appraisal process and the archaeological trusts make judgements about their importance. However, the condition of each feature is not formally assessed and thus there are no baselines against which to measure changes in condition* (AGW, 2007, p26)

Catchment Sensitive Farming Scheme

In response to the Water Framework Directive (see below), the Catchment Sensitive Farming Scheme is being introduced to mitigate pollution by improving land management practices (WAG, 2007c). It will be available to all farms in the target catchments irrespective of whether they belong to another agri-environment scheme.

The scheme's justification lies in its contribution to:

- Natural resource protection (focusing on the management of water and soil),
- Mitigating pollution by improving land management practices,
- Identifying crop nutrient needs and area fertiliser requirements after taking into account manure inputs,
- Identifying areas that pose high risks in terms of pollution from manure, nutrients and soil erosion,
- Identifying specific changes in farming practices that are needed to address manure, nutrient and soil erosion needs,
- Implementing changes in land management practices to accommodate identified needs.

At a farm level the scheme will help the conservation of the archaeological resource through changes in land management practices to prevent soil erosion (e.g. land use, stocking and cultivation).

Other policy influences

The EU Water Framework Directive (WFD)

The aim of the WFD is to achieve a good level of water quality for all rivers, lakes, estuaries, coastal water and groundwater in the European Union by 2015. Under the WFD, three River Basin Districts (RBDs) have been established in Wales. By December 2009 River Basin Management Plans (RBMPs) will be prepared for each RBD to deliver the water protection measures required by the WFD (WAG, 2007c). The Welsh Assembly Government has the policy responsibility for the implementation of the WFD in Wales. Axis 2 measures within the Draft Rural Development Plan for Wales (Catchment Sensitive Farming Scheme, Tir Gofal and Tir Cynnal) along with the cross-compliance regulations of the SPS are the main management tools being used to safeguard and improve water resources.

Currently, RBMPs are being prepared to include all surface and ground water bodies. Objectives include preventing deterioration in water status; restoring surface waters to good ecological and chemical status by 2015; reducing pollution from priority substances and phasing out certain priority hazardous substances; achieving objectives for EU protected areas; contributing to mitigating the effects of floods and droughts; preventing and/or limiting pollution input into groundwater; and balancing abstraction and recharge.

The largest impact on farm practice affecting the archaeological resource will be actions taken to mitigate the effects of floods and droughts. Greater control of water

release from the uplands may lead to a reduction of erosion and a higher water table. In the lowlands there should be greater protection of floodplains from development.

Proposed EU Soils Directive

The proposed EU Soils Directive aims to establish a common framework to protect soil on the basis of the principles of preservation of soil functions, prevention of soil degradation, mitigation of its effects, and restoration of degraded soils.

The proposed Directive recognises that soil performs many functions and delivers services vital to human activities and to the survival of ecosystems. These functions include biomass production, storing, filtering and transforming nutrients and water, hosting the biodiversity pool, acting as a platform for most human activities, providing raw materials, acting as a carbon pool and storing the geological and archaeological heritage (CEC, 2006).

Potentially, this Directive could have a major impact on soil management in Wales, with beneficial outcomes from the conservation of the archaeological resource through the prevention of soil erosion and the maintenance of high water tables in organic soils susceptible to oxidisation and erosion.

Biofuel targets

The European Union has set a target of 10% of all transport fuel to be derived from biofuels by 2020. In the UK, the Renewable Transport Fuel Obligation (RTFO) sets a requirement for road transport fuel suppliers in the UK to ensure that by 2010, 5% by volume of all road vehicle fuel is supplied from sustainable sources. It is predicted that biofuel demand and production will increase in response to these mandates (Gaskell *et al*, 2007).

Trade Policy Instruments and WTO

The process of trade liberalisation, particularly through the WTO, and the process of CAP reform, will probably increase Welsh agriculture's exposure to the world market. The WTO is seeking to achieve liberalisation of agricultural trade through the multi-lateral negotiations initiated under the Doha Development Round (DDR). The objective of the negotiations is to seek the elimination of export subsidies and significant reductions in import tariffs and trade distorting domestic support policies (Gaskell *et al*, 2007).

Policies for the protection of archaeology

A small proportion of the historic environment is protected by the state, under the legislative framework of the Ancient Monuments and Archaeological Areas Act 1979[4]. There are 3,975 Scheduled Ancient Monuments (SAMs) across Wales, these represent the very best examples of sites of their type and are considered to be of national importance. SAMs encompass site types across the archaeological resource and range across a wide time span.

The aim of scheduling is to ensure the long-term preservation of a site. Works within a scheduled area which would have the effect of demolishing, destroying, damaging, removing, repairing, altering, adding to, flooding or covering up must not be carried out unless scheduled monument consent has been obtained. Currently there are exemptions to this where certain activities (agricultural, horticultural and forestry work with certain exemptions) have been carried out in the preceding six years and are allowed to continue.

[4] http://www.culture.gov.uk/NR/rdonlyres/02D66156-A8A6-4889-888A-497C95FE6F55/0/AncientMonumentsAct1979forCase3276.pdf

Proposals to change the way archaeology, buildings, marine archaeology and parks and gardens are protected are currently being formulated following consultation of the joint England and Wales White Paper (March 2007). A draft Heritage Protection Bill will be published in the 2007/08 Parliamentary Session.

Recent changes in markets and prices

Gaskell *et al* (2007)[5] have recently reviewed the major changes in markets and prices:

- *Dairy and livestock:* In 2006 dairy farmers continued to suffer from erosion of the milk price and escalating costs leading to pressure on profits. The market situation for dairy farmers improved during 2007 due to a strong demand from European and World markets, reduced output and low stocks. It is predicted that these prices will be sustained until 2008/09. Market conditions for beef farmers improved during 2006 and the first half of 2007, helped by the lifting of the ban on older cattle in the food chain at the end of 2005 and the relaxation of EU restrictions on UK beef exports. However, markets have been affected by the recurrence of Foot and Mouth Disease (FMD) which has resulted in a fall back in prices. Markets for sheep farmers followed the general seasonal trend in 2006. In 2007 the seasonal peak for lambs was depressed due to market competition from New Zealand. The outbreak of FMD and subsequent export ban has resulted in a fall in the price for lamb. In October 2007 finished lamb prices at auction fell to their lowest point since October 2000.
- *Arable:* In 2006 the average price for cereals rose by 12%. Global shortages have resulted in a dramatic rise in cereal prices in 2007 with feed wheat and barley prices increasing by over 100% between September 2006 and 2007. This represents a dramatic change to 2005/06 when low wheat prices were predicted to lead to more fallowing, set-aside on marginal land and a look to alternative cropping. Now the incentive is for farmers to expand their wheat planting area. It is anticipated that high prices will be sustained for at least the next 2-3 years given the healthy forward contract prices being offered for 2009.
- *Input prices:* In 2006 the average price of agricultural inputs rose by 3.5%. Since 2002 there has been a significant increase in the cost of energy and lubricants, along with fertilisers and soil improvers. In the long term, the increase in the price of fertilizers and energy is set to continue. High cereal prices are feeding through to increase the cost of animal feed. This will affect livestock farmers in all sectors.

Profitability

In 2006, in the UK, Total Income from Farming rose by 7% in real terms overall, with the greatest improvement in profitability in the arable sector, on the back of significant grain price rises (Defra 2006). In real terms, farm incomes for cereals and general cropping farm types are expected to have doubled in 2006/07, while incomes for dairy farms are expected to have fallen by about 20%. For the livestock sector, profitability in the future will be determined by costs of production, ensuring competitiveness, environmental regulations and health of stock (Gaskell *et al*, 2007). In Wales it is estimated that most farm businesses will not be able to survive on the financial returns that are currently being generated and that significant restructuring within the agricultural industry is inevitable (2020, Group 2007).

[5] This research provides an update, for 2006-07, on the work undertaken by Dwyer *et al* (2006)

3.4 Changes to farm sectors and farm practice

Hossell *et al* (2007) developed a series of scenarios to cover the likely changes to farm sectors resulting from CAP reform. A summary of their analysis is presented in Box 3.1.

Box 3.1 Potential changes to farm sectors in Wales resulting from CAP reform

- In many ways, the changes that we have anticipated as a result of the 2003 CAP reform would be in a similar direction to trends in the sector over recent years. However, the prediction is that the reform will speed up the pace of change in a number of sectors - this comment would apply to arable in particular, in Wales.
- In relation to dairying, the reforms are likely to have a relatively weak effect on what is already a clear trend of concentration. This trend will continue but it will be driven as much by market and environmental legislation developments as by CAP reform *per se*.
- The sectors where the trends will be most significantly altered by the reforms are likely to be beef and sheep in both lowland and upland contexts. These are sectors that have been highly supported under the old regimes, so decoupling will have the effect of significantly decreasing the inherent profitability of many of these enterprises.
- Wales is the only region within the UK where sheep numbers continued to increase, albeit slowly, during the 1990s, and we predict that as a result of the reforms this will change. The total number of sheep could stabilise but distributions could shift markedly towards more low-lying areas, or total numbers could fall dramatically as the largest upland flocks are reduced and enterprises across Wales opt for more extensive and low cost management regimes.
- For beef, we predict significant change from a slowly increasing herd to a steadily decreasing herd, as numbers fall in response to the generally very low profitability of these enterprises without coupled subsidies. However the change will be cushioned because in the short term, movements out of beef into sheep will be somewhat counterbalanced by moves into beef from dairying - although our different scenarios would suggest varying rates of decline, over time.
- The other area where the reforms will increase the pace of change but build upon already established trends, is in the shift of land from conventional agricultural production into other uses, including novel crops, "horseyculture", hobby farming, leisure use, amenity woodlands and built development. Again, the scale of this change depends upon the scenario selected.

Source: Hossell *et al* (2007)

This picture of farm change is also broadly supported by research undertaken by Gaskell *et al* (2007) which focused on the impacts of the CAP reform on agriculture and the environment in England[6]:

- *Beef and sheep:* The changes in product prices in these sectors have been much smaller than the changes in the arable sector in the period since 2006 and costs have continued to rise. Thus the 2003 CAP reforms continue to be seen as a driver and magnifier of change, with the direction of change often pre-dating the impact of the reforms. In addition, the recent re-emergence of FMD and the outbreak of Blue Tongue Disease (BTD) could further shake confidence in the industry. The economic situation for all types of livestock producers would deteriorate in the medium term due to increasing costs and depressed product prices. The trend towards the extensification of beef production is likely to be magnified and speeded up by the rise in feed prices. It is anticipated that there will be a change in management strategies for common land and rough grazing involving the extensification of sheep production in response to rising input costs and low levels of profitability. The

[6] Although the details of the CAP reforms are different between Wales and England the broad sector changes are considered to be following similar trajectories in both countries.

low profitability of hill sheep production threatens the continuation of traditional flock management practices.

- *Dairy:* Of the main farm sectors, dairying continued to undergo the most radical restructuring during 2006. Improved product prices during 2007 will not negate the pressures for restructuring and increasing input costs and costs associated with Nitrate Vulnerable Zone (NVZ) regulations and the WFD will continue to squeeze profits. It is anticipated that there will be a continued expansion of production on farms remaining in the industry, involving measures to increase yields as well as increasing herd size and farm area. It is also predicted that land coming out of dairying will be used less intensively, with beef finishing being a popular alternative enterprise. Some farmers may decide against using their land for other livestock enterprises, due to low profitability, and manage it in accordance with GAEC rules.

- *Arable*: The recent rise in commodity prices and the announcement that the set-aside will be at 0% for the 2008 season has seen a dramatic change in prospect for the arable sector over the short term at least. The influence of decoupling on farm businesses has been reduced by the increase in prices. The current market price upswing has triggered a significant shift in farmer attitude and confidence in arable farming and has reversed the declining trend in the area of wheat grown. However, input costs, especially energy and fertilisers, continue to rise. Therefore, despite grain price increases, farmers will continue to seek ways to cut costs.

The 2020 Group (2007, p18) have identified a number of farm sector changes that are likely to occur over the medium term (10-15 years).

- Livestock and dairy systems will continue to dominate farming enterprises as a result of the favourable Welsh climate, but such farms may place a greater emphasis on small-scale arable and root cropping to reduce their reliance on purchased inputs.

- Current trends suggest little change in levels of milk production but a reduction in the number of dairy farms with the sector based on large herds engaged in commodity production (circa 250 + cows) and smaller units, including organic herds, producing added value products.

- A significant proportion of the national sheep flock and beef herd may be extensively managed where landscape and ecological management is at least as important as food production. The most extensive systems could maintain hardy sheep flocks and cattle herds comprised of indigenous breeds to manage extensive grazing on a low cost basis. Such systems are unlikely to be profitable in their own right and consequently may require financial incentives to provide environmental goods.

- Animal health planning and bio-security must be a feature of all livestock systems both now and in the future.

- Diversification within agriculture will be more commonplace and is likely to include organic production, horticultural cropping and forestry development.

- Diversification outside mainstream agriculture should also have gained pace with the majority of farm businesses utilizing their land and building resource more widely to pursue a broader range of economic activities such as tourism, food processing, energy production and waste management.

3.5 The impact of changes in farm practice on the archaeological resource

Introduction

The value of archaeological sites lies in the story they can tell (Defra *et al*, 2005), and there can be little doubt that the dominance of pastoral farming in Wales over many centuries has bequeathed us an archaeological heritage of exceptional, possibly international importance.

However, this archaeological resource is non-renewable - once destroyed it is lost forever. The agencies of damage and destruction are more powerful than ever before, and the pressures on individual owners now come from many directions, often well beyond the control of individuals, communities or even governments.

It follows that the prime objectives for conservation must therefore be to prevent destruction and reduce or avoid processes which diminish or erode the resource. Archaeological sites survive in a variety of forms each with slightly different vulnerability.

Earthworks, such as Iron Age hill forts, Bronze Age burial barrows, and Anglo-Norman mottes (or castle mounds) tend to have steep slopes which are susceptible to erosion exacerbated by overgrazing and trampling. They often attract burrowing animals, and might be neglected altogether, becoming overgrown with trees and scrub. The root systems can disturb underlying archaeological deposits and if the trees are blown over they often take a significant portion of the monument with them.

Abandoned and derelict buildings such as bridges, field barns, and early industrial structures, may retain some upstanding masonry which is threatened less by erosion and livestock, but more by farm development and accidental damage by machinery.

Other stone structures – the relicts of Iron Age huts, an abandoned medieval farmstead - may have collapsed to the point where no standing masonry is visible without excavation, but the archaeological deposits beneath the surface can be disturbed by stone robbing, vehicles or excessive concentration of livestock.

A small number of sites comprise just a single standing stone or several large stones. These so-called 'megalithic' monuments might be an indication of more extensive prehistoric activity nearby, generally associated with burial and ritual. There is a tendency for these to become isolated on ever-diminishing islands within cultivation or for their foundations to be de-stabilised by livestock erosion around the base, or by modern machinery.

Finally, there are sites where no visible evidence survives above ground. These monuments are generally located in cultivated ground, or on land which has been cultivated in the past, and are identified as crop marks or by geophysical survey. Clearly much has already been lost from these sites, but significant remains often survive below the level reached by the plough. However progressive soil loss, deeper cultivation and requirements for drainage can all expose the remains to further damage.

Defra *et al* (2005) have considered the main factors that affect the management of archaeological sites on agricultural land and their main findings are summarised below (see Boxes 3.2, 3.3 and 3.4).

Box 3.2 Archaeological Sites in Grassland, Moorland and Heathland

Earthworks and other monuments tend to survive best in unimproved permanent grazing land or improved pasture that is maintained without ground disturbing operations. If archaeologically significant pasture needs to be improved by means other than fertilisers or spraying, ground disturbance should be minimised and direct drilling or slot seeding should be used rather than ploughing. Although sites in grassland are generally well preserved, they can be seriously damaged by erosion around access

routes or by stock. They can also be disturbed by the growth of roots or rhizomes, and their visual amenity can be lost through the spread of scrub, bracken or agricultural weeds.

The maintenance of appropriate stocking levels (to avoid undergrazing or overgrazing), scrub management and the timely management of erosion problems are essential for the continued conservation and public appreciation of historic earthworks.

Problems are also caused by the activities of burrowing animals. Rabbits on archaeological sites should be controlled and preferably eliminated. Moorland and heathland often have extensive areas of well-preserved historic landscapes. The main management need for these historical landscapes is the conservation of the traditional surface vegetation through correct stocking levels to avoid erosion and control scrub and bracken growth. On heather moors, periodic controlled burning or cutting is needed to prevent major fires removing the peat layers that protect archaeological sites and heat-damaging above-ground remains.

Source: Defra *et al* (2005)

Box 3.3 Archaeological Sites in Wetlands

Wetlands are very vulnerable to changes in water levels and water quality, both of which can lead to decay and loss of fragile organic remains. This can happen very gradually, so drained wetlands, which may have low nature conservation value, can still be important for the historic environment. Sites and artefacts in wetlands often remain undetected until disturbed, and care is needed in the management of all wetlands to ensure that damage does not occur.

To protect the historic environment of wetlands, waterlogged conditions should be maintained throughout the year, there should be no ground disturbance and changes in drainage regimes should be reviewed carefully to assess any potential damage. The Code of Good Agricultural Practice for Soil should be followed to prevent the loss of vulnerable peat soils by wind erosion. Measures for nature conservation on wetlands will normally protect the buried archaeological remains.

Source: Defra *et al* (2005)

Box 3.4 Archaeological Sites on Arable Land

As the general rule for protecting archaeological sites is to avoid ground disturbance wherever possible, managing historic sites on arable holdings is a major challenge. The increasing weight and power of farm machines and the repetitive effects of cultivation gradually take their toll. On arable holdings, the main sources of damage to archaeological sites are caused by:

a) Ploughing areas not previously used for cultivation: This causes the most serious damage, because sites in these areas are usually the best preserved. It also begins the process of removing the visible traces of a site which would allow it to be understood and enjoyed;

b) Encroachment on 'island' sites in cultivated fields: Many sites, particularly burial mounds, survive as isolated grassy islands in arable fields. The archaeological value of these sites remains high but gradual encroachment of ploughing into the uncultivated area will cause serious damage to the site as well as spoiling its appearance;

c) Continued 'same depth' cultivation: In some circumstances, continued cultivation to the same depth can also cause gradual damage where soil cover is being compacted or eroded, reducing the depth of the protective layer of plough soil. The use of heavier farm machinery, particularly in wet weather, can cause serious soil compaction, and sites on slopes are particularly vulnerable to erosion;

d) Deeper penetration of the ground: Implements that penetrate the ground more deeply than normal, such as de-stoners, sub-soilers and mole ploughs, will cause serious new damage to archaeological layers lying just below normal plough depth. The use of heavier farm machinery is resulting in more frequent use of sub-soiling to counteract soil compaction.

In cases where cultivation is damaging a significant archaeological site, the most effective management response is to suspend cultivation and establish an appropriately grazed or even mown grass sward. In many cases, however, the establishment of grassland is not a feasible option in terms of farm management. In these cases, consideration should be given to reducing the impact of cultivation by adopting minimum cultivation techniques such as direct drilling, by reducing the depth or frequency of conventional cultivation, and by avoiding the use of machinery such as power harrows.

The effectiveness of these different approaches will depend on factors such as field topography, soil depth and crop type, and specialist advice should be sought before adopting a new cultivation regime. Sub-soiling, pan-busting and the planting of root crops, such as potatoes or sugar beet, that need deeper cultivations, should be avoided on sensitive archaeological sites.

Frequently, farmers do not believe their cultivation operations are damaging underlying remains because they believe them to be more deeply buried than is actually the case or because they believe 'same depth' ploughing will cause no deterioration. Simple measures to reduce compaction or prevent erosion can be beneficial in cases where archaeological sites continue to be cultivated, and particular attention should be paid to avoiding the use of machinery in poor ground conditions.

Where archaeological sites survive as isolated in-field monuments under grass cover, a generous uncultivated margin should be retained around visible earthworks, to avoid damage from gradual encroachment by ploughing. In some cases, such as the burial mound cemeteries of southern England, important archaeological remains can survive between the upstanding monuments. The areas between these mounds should, therefore, be taken out of cultivation wherever possible. Similarly, monuments at the edges of fields should be removed from cultivation, where practicable, by incorporating them in margins retained for wildlife purposes. In all cases, where sites are managed as ungrazed grass, this should be cut periodically to prevent the growth of damaging scrub and weeds. To prevent accidental damage, contractors employed to undertake cultivation should always be informed about the location of sensitive sites.

Source: Defra *et al* (2005)

Assessing the impact on the archaeological resource from changes in farm practice

Hossell *et al* (2007) investigated the likely scale and pattern of CAP reform impacts on biodiversity across Wales. Their analysis was based on five 'Area Types' that broadly characterised the nature of farming in different parts of Wales.

> *The topography and climate of Wales results in five distinct areas, each of which are (sic) dominated by different farming sectors. This is not to say that a farming sector is exclusive to any one area, but rather that it is not a core agricultural practice outside of the areas where it predominates* (Hossell *et al*, 2007, p3).

The Area Type characterisation was then coupled with an analysis of the anticipated impact of CAP reform on both species and habitats. After consultation with the Project Management Group it was agreed that the five Area Types provided a suitable framework within which to analyse the potential impacts of agricultural change on the archaeological resource in Wales.

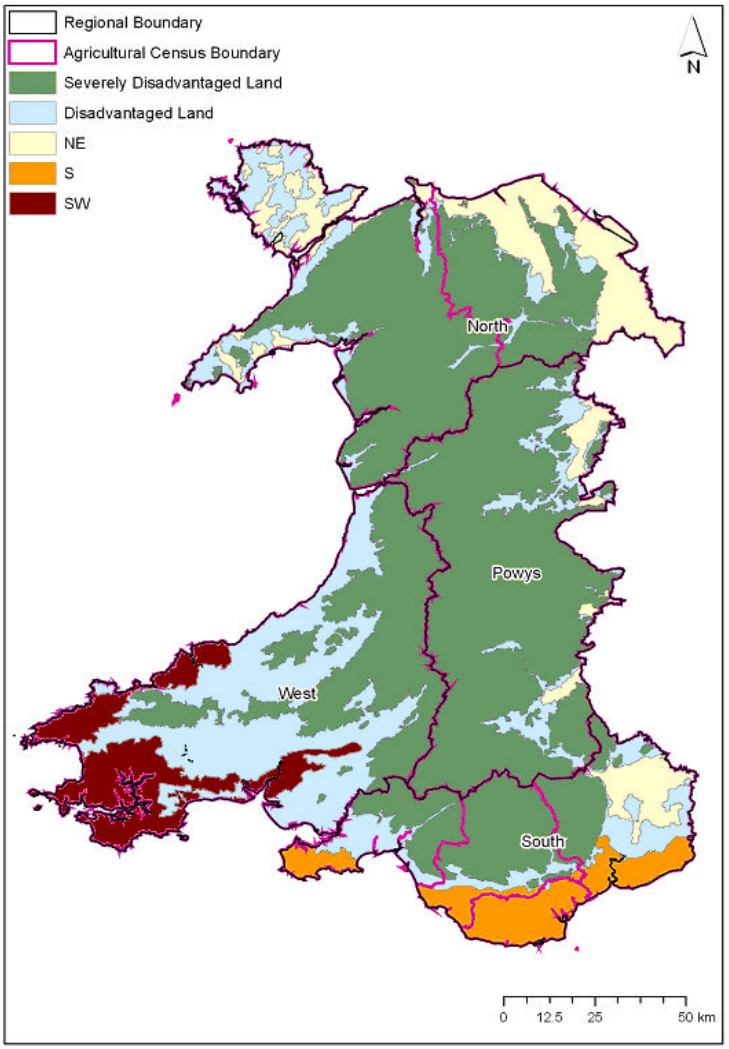
Table 3.4 describes the Area Type characteristics and Figure 3.2 shows the location of the five Area Types.

Table 3.4 Area Type stratification

Stratum Class Name	Description of Farm types
Severely Disadvantaged Area (LFA SDA)	Marginal upland & hill land with predominance of sheep only farming. Some beef & sheep farms
Disadvantaged Area (LFA DA)	As SDA but with higher proportion of beef & sheep or beef alone. Small proportion of dairy holdings. Land generally lower lying with higher but more variable quality than SDA
North and East (NE) Fringes	More intensive beef-based enterprises, mixed farms with dairy, beef & some horticulture. Sheep farms also significant but less dominant than in the SDA.
South West (SW)	Lower-lying land with preponderance of dairy & other cattle enterprises + small areas of horticulture. Some sheep present on holdings.
South (S)	Southern fringe of Wales – main arable area typified by mixed farming & general cropping + a declining number of all-arable farms

Source: Hossell *et al* (2007 p3)

Figure 3.2 Location of Area Types in Wales



Source: Hossell *et al* (2007, p4)

Evaluation of the nature of change and its impact on archaeology

Hossell *et al* (2007) identified 18 different types of farm practice change that are likely to occur and indicated their expected locations in terms of the five Area Types. For this project the 18 types of farm practice change were evaluated in terms of their expected impact on the archaeological resource. After consultation with the Project Management Group an additional six types of farm practice change were evaluated in terms of their likely impact on the archaeological resource.

In order to evaluate the impacts of potential farm practice change on the archaeological resource a pro-forma, consisting of eight sections, was completed for each type of change:

- Farming change: Description of farm change;
- Farm practice outcome: Description of farm practice changes;
- Location: Identifies the Area Types most likely to experience the change;
- Implications for archaeology; Implications of farm practice change for the archaeological resource directly affected;
- Scale: The extent of the impact on the archaeological resource in the context of an individual holding or farm business which adopts the change in question;
- Significance: The significance of the impact of the change on the archaeological resource;
- Evaluation of overall impacts: Summary of impacts;
- Data sources: Potential data sources that could be developed into monitoring indicators. Also identify any gaps in coverage.

Each pro-forma identifies a potential farm practice change scenario, identifying the projected farm practice outcomes and the Area Types most likely to experience this change. Farm practice outcomes are considered in the light of the likely physical impacts to the archaeological resource.

In order to evaluate the scale and significance of the impacts a table has been devised indicating the extent of the impact on the archaeological resource within the farm holding on a scale ranging from 1 = limited or localised impacts to 5 = extensive (see Table 3.5). The significance of each impact is assessed to identify the critical nature of the impact in both positive and negative terms; +3 large beneficial impact which might see a great improvement the condition of an archaeological feature to –3 large negative impact, which may see its severe damage or destruction, with a score of 0 for a neutral impact (see Table 3.6).

Table 3.5 The scale of the impact on the archaeological resource

Scale point	Description
1	Limited (i.e. isolated activity specific to a small defined part of the holding)
2	Moderately limited
3	Moderate
4	Moderately extensive
5	Extensive (affecting most of the holding)

Table 3.6 The significance of the impact on the archaeological resource

Scale point	Description
-3	Large negative impact
-2	Moderately negative impact
-1	Small negative impact
0	Neutral
+1	Small beneficial impact
+2	Moderately beneficial impact
+3	Large beneficial impact

The likely impact on the archaeological resource for each of the proposed types of farm practice change is summarised within a local and national context. The data sources that could be developed to form monitoring indicators are also briefly assessed. The suitability of existing data sources is fully considered in Section 4.

Pro-forma 3.1 Intensification of dairy

Farming change

Intensification of dairy.

Farm practice outcome

Primarily by farm enlargement, dry animals further away from farm buildings on rough grazing.

Increased livestock numbers.

Use of silage maize (to increase productivity) requiring cultivation of temporary grassland, more slurry to land & bare maize ground over winter.

Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs.

Area Type location

SW; NE

Implications for archaeology

A. Increased cultivation will lead to the reduction of earthworks, erosion and potential damage to subsurface archaeological deposits. Cultivation may also cause changes in the chemical equilibrium of the soil affecting artefact preservation.

B. Local compaction and poaching around water troughs and feeding points etc will cause erosion and loss of subsurface archaeological deposits.

C. Compaction and rutting by machinery will damage earthworks, crush artefacts and may lead to further damaging operations such as subsoiling.

D. Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs etc will lead to localised damage to both visible and subsurface archaeological deposits.

E. Areas outside of intensive dairy management may become 'waste' leading to scrub encroachment on archaeological sites. Establishment of scrub may encourage burrowing animals which also damage earthworks and subsurface archaeological deposits.

F. Slurry spreading may cause changes in the chemical equilibrium of the soil affecting artefact preservation.

	Scale		**Significance**	
A	3	Moderate	-3	Large negative impact
B	2	Moderately limited	–2	Moderate impact
C	2	Moderately limited	–3	Large negative impact
D	1	Limited	–3	Large negative impact
E	3	Moderate	–2	Small negative impact
F	4	Moderately extensive	–1	Small negative impact

Evaluation of overall impacts

The intensification of dairy will have an overall negative impact on archaeology, largely due to increased cultivation and more intensive livestock management, but it will be confined largely to the SW and NE areas.

Data sources

Oblique aerial photography; Vertical aerial photography; Field visits; Remote sensing.

Pro-forma 3.2 Change from Dairy or Beef to intensive beef feedlots

Farming change

Change from Dairy or Beef to intensive beef feedlots.

Farm practice outcome

Animals in feedlots using bought in cereals & minimal grass grazing.

Increased muck/slurry leading to increased return to land.

Increased inputs to improved grass.

Intensive silage production, 3 cuts per year.

Conversion of grassland to arable.

Area Type location

SW; NE

Implications for archaeology

A. Increased cultivation for feed will lead to the reduction of earthworks, erosion and potential damage to subsurface archaeological deposits. Cultivation may also cause changes in the chemical equilibrium of the soil affecting artefact preservation

B. Compaction and rutting by machinery will damage earthworks, crush artefacts and may lead to further damaging operations such as subsoiling.

C. Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs etc can cause localised damage to both visible and subsurface archaeological deposits.

D. Slurry spreading may cause changes in the chemical equilibrium of the soil affecting artefact preservation

E. Improved grassland management might entail land drainage to maintain yields; this would have a two-fold detrimental effect on the archaeological resource:

- By localised damage or destruction of archaeological deposits through the cutting of drains;
- By lowering the water table leading to desiccation and decay of organic remains.

	Scale		Significance	
A	3	Moderate	–3	Large negative impact
B	3	Moderate	–3	Large negative impact
C	2	Moderately limited	–3	Large negative impact
D	4	Moderately extensive	–1	Small negative impact
E	3	Moderate	–3	Large negative impact

Evaluation of overall impacts

The overall impact is likely to be negative but the degree depends on the extent to which feed production takes place on farm. This is likely to be extensive if prices are high, but much less if not. The structural and grazing requirements of intensification are likely to be damaging, although largely restricted to the southwest and north-eastern areas.

Data sources

Oblique aerial photography; Vertical aerial photography; Field visits; Remote sensing.

Pro-forma 3.3 Change from dairy to beef & sheep

Farming change

Change from dairy to beef & sheep.

Farm practice outcome

Reduction in stock numbers & replacement of dairy cows with sheep and/or beef cattle.

Reduction in fertilizer & herbicide inputs. Reduction in slurry & spread to land.

Less intensive silage production delayed cutting producing big bale and bulk silage.

Stock on rough grazing in summer & on improved grass or housed in autumn / winter.

Sheep left out longer than cattle, typically to January when brought in prior to lambing in March.

Area Type location

SDA

DA

SW

NE

Implications for archaeology

A. Reduction of stock numbers will reduce risk of erosion to historic features.

B. Although sheep can cause localised damage (sheep scrapes) they generally cause less erosion than cattle.

C. Big bale silage and bulk silage might result in localised vehicle compaction and rutting.

D. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

	Scale	Significance
A	4 Moderately extensive	+2 Moderate benefit
B	2 Moderately limited	+3 Large benefit
C	1 Limited	–3 Large negative impact
D	3 Moderate	+1 Small benefit

Evaluation of overall impacts

Changing from dairy to beef and sheep will have a widespread beneficial effect on the archaeological resource on a national scale, with erosion reducing through lower stock numbers and the more benign impact of sheep. There may be some very localised issues with vehicular erosion.

Data sources

Oblique aerial photography.

Field visits.

Pro-forma 3.4 Change from dairy or beef to sheep only

Farming change

Change from dairy or beef to sheep only.

Farm practice outcome

Replacement of dairy / beef stock with sheep, livestock numbers possibly reduced. If so may switch to more productive sheep breeds which are less adapted to foraging on rough grazing.

Reduction in fertilizer & herbicide inputs to improved grassland.

Less forage cropping.

Less intensive silage production of big bale /clamp silage.

Stock on rough grazing in summer, moving on to improved grass in autumn/winter.

Ewes brought in January for lambing in March.

Area Type location

DA

SW

NE

Implications for archaeology

A. Reduction of stock numbers will reduce risk of erosion to historic features.

B. Insufficient intensity of grazing may lead to the establishment and encroachment of scrub. Establishment of scrub may encourage burrowing animals, which damage earthworks in particular, and subsurface archaeological deposits.

C. Although sheep can cause localised damage (sheep scrapes) they generally cause less erosion than cattle.

D. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

E. Reversion to grassland from cultivation will have a beneficial impact on archaeological deposits by reducing the effects of damaging erosion from ploughing.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderate benefit
B	3	Moderate	–2	Moderate negative impact
C	4	Moderately extensive	+2	Moderate benefit
D	3	Moderate	+1	Small benefit
E	3	Moderate	+3	Large benefit

Evaluation of overall impacts

Overall a beneficial change for the archaeological resource, resulting from less grazing pressure, lighter livestock and therefore less erosion on marginal land and a reduction in cultivation for forage crops. However there may be potential for scrub encroachment in some areas. May be some very localised erosion.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Pro-forma 3.5 Change from Dairy to arable

Farming change

Change from Dairy to arable.

Farm practice outcome

Grass converted to cereals.

Increase in bare soil may increase erosion in winter.

Increase in inputs, particularly pesticides.

No silage cuts.

Area Type location

SW

Implications for archaeology

A. Increased cultivation for cereals will lead to the reduction of earthworks, erosion and potential damage to subsurface archaeological deposits. Cultivation may also cause changes in the chemical equilibrium of the soil affecting artefact preservation

B. Compaction and rutting by machinery will damage earthworks, crush artefacts and may lead to further damaging operations such as subsoiling.

C. Bare earth will allow greater erosion of plough soil and consequently a deepening of cultivation even when cultivating at a constant depth.

D. Slurry spreading may cause changes in the chemical equilibrium of the soil affecting artefact preservation.

E. Areas outside of intensive management may become 'waste' allowing scrub encroachment on archaeological sites.

	Scale		Significance	
A	5	Extensive	–3	Large negative impact
B	3	Moderate	–3	Large negative impact
C	5	Extensive	–2	Moderate negative impact
D	4	Moderately extensive	–1	Small negative impact
E	3	Moderate	–2	Moderate negative impact

Evaluation of overall impacts

Overall the change to arable from dairy would be confined to the southwest but increased area and greater intensity of cultivation would lead to extensive damage of the archaeological resource, largely caused through direct and indirect effects of ploughing.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

LiDAR.

Remote sensing.

Pro-forma 3.6 Extensification (of dairy) to beef &/or sheep

Farming change

Extensification (of dairy) to beef &/or sheep.

Farm practice outcome

Significantly reduced stock numbers.

Farmers may also switch to fewer more productive sheep which are less adapted to foraging on rough grazing.

Silage may be made on improved grassland but latter will have no inputs & is likely to become increasingly weedy.

Reduced muck & slurry inputs.

Stock on rough grassland in summer but latter likely to be under-grazed due to fewer animals.

Potential for bracken, scrub or other species to invade due to lack of grazing.

Area Type location

DA

SW

Implications for archaeology

A. Lower stock numbers will reduce grazing pressure and the consequent risk of erosion to historic features.

B. Insufficient intensity of grazing by reducing stock numbers may lead to the establishment and encroachment of scrub. This may encourage burrowing animals which also damage earthworks in particular and subsurface archaeological deposits. Infestation of bracken, scrub and other species may increase erosion 'pinch points' where animals create paths through rough vegetation and seek shelter beneath scrub. Bracken rhizomes and root penetration from scrubby vegetation will damage subsurface archaeological deposits. Scrub also reduces visibility of archaeological features which become more vulnerable to accidental damage.

C. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately small benefit
B	3	Moderate	–2	Moderate negative impact
C	5	Extensive	+1	Small benefit

Evaluation of overall impacts

The reduction of stock density in the southwest and disadvantaged areas should have a beneficial impact by reducing erosion but this may be partly countered increasing scrub and other damaging vegetation on the archaeological resource.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

LiDAR.

Remote sensing.

Pro-forma 3.7 Change from Dairy, Beef, Sheep or Mixed to Organic Farming

Farming change

Change from Dairy, Beef, Sheep or Mixed to Organic Farming.

Farm practice outcome

Reduction in livestock numbers.

Animals using rough grazing in summer, housed or improved grassland in autumn / winter.

Reduced inputs to grassland & less intensive silage production.

Increase in annual crops for fodder / biodiversity leads also to increase in ploughing. Cropping also for soil management / green manure.

Ground largely covered with crop in winter.

Area Type location

SW

S

NE

Implications for archaeology

A. Lower stocking levels will reduce grazing pressure and the consequent risk of erosion and trampling to historic features.

B. Insufficient intensity of grazing by reducing stock numbers may lead to the establishment and encroachment of scrub. Establishment of scrub may encourage burrowing animals which also damage earthworks in particular and subsurface archaeological deposits.

C. Increased cultivation, especially if deeper than required by non-organic practice, will lead to the reduction of earthworks, erosion and potential damage to subsurface archaeological deposits. This may also cause changes in the chemical equilibrium of the soil affecting preservation.

D. Compaction and rutting by machinery leading to damage to earthworks, crushing artefacts and leading to further damaging operations such as subsoiling.

E. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately beneficial impact
B	2	Moderately limited	–2	Moderate negative impact
C	3	Moderate	–3	Large negative impact
D	2	Moderately limited	–3	Large negative impact
E	5	Extensive	+1	Small benefit

Evaluation of overall impacts

Largely thought to effect the south, southwest and northeast of Wales, the beneficial impacts of reduced inputs and grazing pressure may be outweighed by the detrimental impacts of taking in new areas of land for cultivation and subsequent episodes of ploughing.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.8a Mixed farm changes to specialist dairy

Farming change

Mixed farm changes to specialist dairy.

Farm practice outcome

Inputs maintained, slurry production increases & also spread to land.

Silage production increased & possible cultivation of maize for silage.

Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs.

Area Type location

SW

NE

Implications for archaeology

A. Increased cultivation will lead to the reduction of earthworks, erosion and potential damage to subsurface archaeological deposits. Cultivation may also cause changes in the chemical equilibrium of the soil affecting artefact preservation.

B. Greater numbers of cattle could increase soil erosion and poaching around water troughs and feeding points etc resulting in loss of subsurface archaeological deposits.

C. Compaction and rutting by machinery will damage earthworks, crush artefacts and may lead to further damaging operations such as subsoiling.

D. Areas outside of intensive dairy management may become 'waste' leading to scrub encroachment on archaeological sites. Establishment of scrub may encourage burrowing animals which also damage earthworks and subsurface archaeological deposits.

E. Slurry spreading may cause changes in the chemical equilibrium of the soil affecting artefact preservation.

F. Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs etc will lead to localised damage to both visible and subsurface archaeological deposits.

	Scale		Significance	
A	3	Moderate	–3	Large negative impact
B	3	Moderate	–2	Moderate negative impact
C	2	Moderately limited	–3	Large negative impact
D	2	Moderately limited	–2	Moderately negative impact
E	4	Moderately extensive	–1	Small negative impact
F	2	Moderately limited	–3	Large negative impact

Evaluation of overall impacts

The change from mixed farming to specialist dairy is likely to have a detrimental impact on the archaeological resource in the southwest and northeast, both on a widespread scale through the increased number of animals and associated cultivation, and also by localised damage caused through the construction of ancillary structures.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

LiDAR.

Remote sensing.

Pro-forma 3.8b Mixed farm changes to specialist beef

Farming change

Mixed farm changes to specialist beef.

Farm practice outcome

Inputs reduced, slurry production reduced.

Loss of cropping - replacement by grass.

Less intensive silage production focusing on mature clamp/big bale silage.

Animals on rough grazing in summer.

Area Type location

SW

NE

Implications for archaeology

A. Possible compaction caused by big bale/clamp silage.

B. Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs etc. will lead to localised damage and destruction of earthworks and subsurface archaeological deposits.

C. Localised erosion at pinch points, around water troughs and feeding points.

D. Reversion to grassland from cultivation will have a beneficial impact on archaeological deposits by reducing the damaging effects of ploughing and erosion.

E. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

	Scale		Significance	
A	3	Moderate	–1	Small negative impact
B	2	Moderately limited	–3	Large negative impact
C	2	Moderately limited	–2	Moderately negative impact
D	3	Moderate	+3	Large beneficial impact
E	3	Moderate	+1	Small benefit

Evaluation of overall impacts

The conversion from mixed farming to specialist beef is likely to have extensive beneficial impacts on the archaeological resource by the replacement of cultivation by pasture, although there may however by more localised damage caused by the erosion and construction of ancillary features.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.9 Intensification of beef & sheep or sheep alone

Farming change

Intensification of beef & sheep or sheep alone.

Farm practice outcome

Intensification by farm enlargement - buying up or renting neighbouring land.

Inputs as at present, with supplementary feed.

Possible increase in numbers of stock on rough grazing in summer & possibly a longer grazing period by sheep could lead to some overgrazing.

Improved grassland used for big bale bulk silage.

Stock on improved grassland or housed in autumn (beef)/ winter.

Area Type location

DA

Implications for archaeology

A. Increased number of animals could cause soil erosion and poaching, especially to earthworks, resulting in loss of subsurface archaeological deposits.

B. Localised erosion at pinch points, around water troughs and feeding points.

C. Construction of ancillary structures such as slurry pits, buildings, trackways, water troughs etc will lead to localised damage and destruction of both visible historic features and subsurface archaeological deposits.

D. Improved grassland management might entail land drainage to maintain yields; this would have a two fold detrimental effect on the archaeological resource:

- By localised damage or destruction of archaeological deposits through the cutting of drains;
- By lowering the water table leading to desiccation and decay of organic remains.

	Scale		Significance	
A	3	Moderate	–2	Moderately negative impact
B	2	Moderately limited	–2	Moderately negative impact
C	2	Moderately limited	–5	Large negative impact
D	3	Moderate	–3	Large negative impact

Evaluation of overall impacts

Intensification of stock in disadvantaged areas is likely to have a widespread impact on the archaeological resource through increased erosion and more intensive grassland improvement,

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.10 Change from Dairy or Beef to horses, goats or deer

Farming change

Change from Dairy or Beef to horses, goats or deer.

Farm practice outcome

Horses traditionally used for controlling rank grasses, can graze intensively possibly leading to pasture dominated by *Ranunculus repens and* Senecio *jacobaea.*

Related closely to pony paddocks and the smaller lifestyle holdings.

Goats usually housed indoors because difficult to control outdoors although grazing can be undertaken with appropriate fencing.

Deer require a major shift in fencing / enclosure to maintain a commercial herd.

Area Type location

DA

SW

NE

Implications for archaeology

A. Potential for animals, especially horses, to damage archaeological earthworks by intensive localised erosion and poaching. Goats do much less damage.

B. Insertion of new fencing may cause damage to subsurface archaeological deposits.

C. Construction of ancillary structures such as stables, ménages, water troughs etc will lead to localised damage and destruction of earthworks and subsurface archaeological deposits.

D. Goats and deer are effective at controlling scrub.

	Scale		Significance	
A	3	Moderate	–2	Moderately negative impact
B	1	Limited	–1	Small negative impact
C	2	Moderately limited	–3	Large negative impact
D	1	limited	+1	Small benefit

Evaluation of overall impacts

Taking place in the disadvantaged areas, the southwest and northeast, changes are likely to be moderate or limited in their extent but more severe in their local impacts.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Pro-forma 3.11 Ranching /extensification of beef or sheep on former beef farms

Farming change

Ranching/extensification of beef or sheep on former beef farms.

Farm practice outcome

Cattle on hill & rough grassland in summer, whilst big bale silage made on improved grassland.

Inputs of fertiliser & herbicide reduced.

Cattle brought down to inbye land in autumn / winter.

Fewer stock may lead to gradual increase in coarse grass & weedy species in improved grassland.

Sheep on hill & rough grassland in summer.

On heath, numbers of sheep alone probably insufficient to control rank grasses (*Molinia, Agrostis, Festuca, Deschampsia etc.*).

Dwarf shrub may increase in biomass, rate of cover expansion may be slow due to increased competition with grasses.

Accumulation of grass biomass slower where hill grazed by both cattle & sheep.

Area Type location

SDA

Implications for archaeology

A. Less stock will reduce potential erosion and may improve condition, particularly of archaeological earthworks.

B. Insufficient intensity of grazing by reducing stock numbers may lead to the establishment and encroachment of scrub. Establishment of scrub may encourage burrowing animals, which also damage earthworks in particular, and subsurface archaeological deposits.

C. Possible compaction caused by big bale/clamp silage.

D. Extensification may lead to field boundaries no longer being maintained and becoming no longer stock-proof. Field boundaries often incorporate and reuse archaeological earthworks.

E. Reduction in animal management may lead to uneven grazing as animals favour some areas over others. Some areas may be undergrazed leading scrubbing up and others may be overgrazed leading to erosion.

F. Reduction of inputs on the land will reduce compaction of subsurface archaeological deposits.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately beneficial impact
B	3	Moderate	–2	Moderately negative impact
C	2	Moderately limited	–2	Moderately negative impact
D	2	Moderately limited	–2	Moderately negative impact
E	3	Moderate	–2	Moderately negative impact
F	4	Moderately extensive	+1	Small benefit

Evaluation of overall impacts

Extensification in the SDA areas are likely to have some moderately extensive beneficial impacts through the reduction of stock numbers. There may however, be problems encountered with the increase in scrub and invasive vegetation.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.12 Ranching of beef or sheep

Farming change

Ranching of beef or sheep,

Farm practice outcome

Stock numbers reduced significantly, animals left to fend for themselves.

Sheep brought down for lambing/weaning only, cattle moved to lower ground for autumn & winter.

Some silage made - depending on extent of inbye.

Improved grassland may be expected to become increasingly weedy & rough grassland to increase in biomass.

Potential for bracken, scrub or other species to invade due to lack of grazing.

Area Type location

DA

NE

Implications for archaeology

A. Lower stock numbers will reduce grazing pressure and the risk of erosion to historic features.

B. Insufficient intensity of grazing by reducing stock numbers may lead to the establishment and encroachment of scrub. Establishment of scrub may encourage burrowing animals which also damage earthworks in particular and subsurface archaeological deposits. Infestation of bracken, scrub and other species may increase erosion 'pinch points' where animals create paths through rough vegetation and seek shelter beneath scrub. Bracken rhizomes and root penetration from scrubby vegetation will damage subsurface archaeological deposits. Scrub also reduces visibility of archaeological features which become more vulnerable to accidental damage.

C. Reduction in animal management may lead to uneven grazing as animals favour some areas over others. Some areas may be undergrazed leading scrubbing up and others may be overgrazed leading to erosion.

D. Extensification may lead to field boundaries no longer being maintained and becoming ineffective. Field boundaries often incorporate and reuse archaeological earthworks.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately beneficial impact
B	3	Moderate	–2	Moderately negative impact
C	2	Moderately limited	–2	Moderately negative impact
D	2	Moderately limited	–2	Moderately negative impact

Evaluation of overall impacts

Ranching across DA and the NE is likely to have some beneficial effects through the reduction in stock numbers, however there may be some more moderate to extensive negative impacts due to scrub development and associated problems.

Data sources

Oblique aerial photography; Vertical aerial photography; Field visits; Remote sensing.

Pro-forma 3.13 Replacement of beef by sheep

Farming change

Replacement of beef by sheep.

Farm practice outcome

On former beef / beef & sheep farms, a shift to sheep only grazing results in ewes on the hill in summer (April-October) moving down to inbye/improved land in Autumn.

Minimal inputs of fertilizer& herbicide on improved ground.

Big bale silage cutting continues (as would have occurred under beef).

Sheep on inbye during October-April, which may show increase in coarse grasses & weedy species.

Less trampling & fewer bare areas.

Area Type location

SDA

Implications for archaeology

A. Although sheep can cause localised damage (sheep scrapes) they generally cause significantly less erosion than cattle.

B. Reduction of trampling and erosion by heavy livestock will help the establishment of a stable grass sward.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately beneficial impact
B	3	Moderate	+2	Moderately beneficial impact

Evaluation of overall impacts

The SDA areas would largely see a beneficial impact on the archaeological resource caused by a reduction of grazing pressure, a few areas of localised erosion may occur however.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Pro-forma 3.14 Ranching /extensification of sheep

Farming change

Ranching/extensification of sheep.

Farm practice outcome

Occurring on sheep only hill farms with little inbye.

Sheep numbers reduced & animals left on the hill all year with little management.

Latter could lead to localised overgrazing and significant areas of rank under-grazed grass.

Small areas of inbye so probably no silage made & certainly no inputs used.

Animals left to fend for themselves just brought in for lambing/weaning.

Potential for bracken, scrub or other species to invade due to lack of grazing.

Area Type location

SDA

Implications for archaeology

A. Lower stock numbers will reduce the risk of erosion to historic features.

B. Insufficient intensity of grazing by reducing stock numbers may lead to the establishment and encroachment of scrub. Establishment of scrub may encourage burrowing animals which also damage earthworks in particular and subsurface archaeological deposits. Infestation of bracken, scrub and other species may increase erosion 'pinch points' where animals create paths through rough vegetation and seek shelter beneath scrub. Bracken rhizomes and root penetration from scrubby vegetation will damage subsurface archaeological deposits. Scrub also reduces visibility of archaeological features which become more vulnerable to accidental damage.

C. Extensification may lead to field boundaries no longer being maintained.

D. While sheep may cause local erosion (sheep scrapes) this likelihood is reduced by less intensive grazing.

E. Reduction in animal management may lead to uneven grazing as animals favour some areas over others. Some areas may be undergrazed leading to scrubbing up and others may be overgrazed leading to erosion.

F. Reduction trampling and erosion will allow the establishment a grass sward providing a stable ground cover.

	Scale		Significance	
A	4	Moderately extensive	+2	Moderately beneficial impact
B	3	Moderate	–2	Moderately negative impact
C	2	Moderately limited	–2	Moderately negative impact
D	3	Moderate	+1	Small benefit
E	2	Moderately limited	–2	Moderately negative impact
F	3	Moderate	+2	Moderately beneficial impact

Evaluation of overall impacts

Whilst there may be some extensive benefits to the archaeological resource brought about in the SDA areas by a reduction in grazing pressure, this is likely to countered by the encroachment of potentially damaging vegetation and unbalanced grazing pressure.

Data sources

Oblique aerial photography; Vertical aerial photography; Field visits; Remote sensing.

Pro-forma 3.15 Increased area of horticulture

Farming change

Increased area of horticulture.

Farm practice outcome

For the main part, business as usual, increase accommodated by extending the area farmed under horticulture especially if more demand for local produce, and novel crops grown.

Organic horticulture would lead to reduced inputs.

Area Type location

SW

S

NE

Implications for archaeology

A. Specialist crop requirements may result in deeper and more intensive cultivation which could damage hitherto undisturbed archaeological deposits.

B. Compaction and rutting by machinery may damage underlying archaeological features, crushing artefacts and leading to further damaging operations such as subsoiling.

C. Damage to archaeological features through the clearance of stone in advance of cultivation.

D. Damage to archaeological features and deposits by the introduction of drainage or irrigation features.

E. Construction of ancillary structures such as plant nurseries, trackways, etc will lead to localised damage and destruction of both visible and subsurface archaeological deposits.

	Scale		Significance	
A	3	Moderate	–3	Large negative impact
B	3	Moderate	–3	Large negative impact
C	3	Moderate	–2	Moderately negative impact
D	3	Moderate	–3	Large negative impact
E	2	Moderately limited	–3	Large negative impact

Evaluation of overall impacts

The implications for the expansion of horticulture across the SW, S and NE would have a damaging effect on the archaeological resource largely due to the greater extent of ground disturbance involved in specialist cultivation. The effects could be widespread and severely damaging.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.16 Legumes / barley replaced by wheat

Farming change

Legumes / barley replaced by wheat.

Farm practice outcome

Inputs & cultivations probably not changed too much. Impact on time crop is in the ground and cropping sequence although influenced by commodity prices for cereals in comparison with other crops potential Gross margin per hectare.

Area Type location

S

Implications for archaeology

A. Continued cultivation will continue to erode archaeological earthworks and subsurface archaeological deposits by eroding the subsoil and planning down the archaeological horizon.

	Scale		Significance	
A	4	Moderately extensive	0	Neutral

Evaluation of overall impacts

Although the change would be widespread across south Wales the impact on the archaeological resource would not be significantly different from the previous farming regime.

Data sources

Field visits.

Pro-forma 3.17: Arable land converted to fallow / horses

Farming change

Arable land converted to fallow / horses.

Farm practice outcome

Arable land re-seed for grass, or left uncultivated for the establishments of arable weeds, rough grasses etc.

Area Type location

S

Implications for archaeology

A. Reversion of arable to pasture would stabilise the condition of archaeological earthworks and subsurface archaeological deposits.

B. Potential for animals, especially horses, to damage archaeological earthworks through by localised wear erosion and poaching.

C. Construction of ancillary structures such as stables, ménages, water troughs etc will lead to localised damage and destruction of earthworks and subsurface archaeological deposits.

	Scale		Significance	
A	5	Extensive	+3	Large beneficial impact
B	3	Moderate	–3	Large negative impact
C	2	Moderately limited	–3	Large negative impact

Evaluation of overall impacts

The conversion of arable land to pasture would have a widespread beneficial impact on the archaeological resource although there may be issues with localised damage and erosion.

Data sources

Oblique aerial photography; Vertical aerial photography; Field visits.

Pro-forma 3.18 Arable replanted with novel crops

Farming change

Arable replanted with novel crops.

Farm practice outcome

Inputs & cultivations dependent on crop type.

Uptake of novel crops dependent on market forces and/or incentives.

Potential for energy crops in some localities.

Area Type location

S

Implications for archaeology

A. Cultivation will continue to cause erosion by encouraging soil loss and exposing underlying archaeological deposits to disturbance by the plough.

B. Erosion of subsurface archaeological deposits will be exacerbated where specific crops require deeper cultivation, subsoiling or pan-busting.

C. Damage to archaeological features and deposits by the introduction of drainage or irrigation features.

D. Construction of ancillary structures such as buildings, trackways, etc will lead to localised damage and destruction of earthworks and subsurface archaeological deposits.

E. Energy crops may have a more detrimental impact on archaeological deposits than previous arable cultivation for the following reasons:

- The grubbing out of redundant Short Rotation Coppice and the retrieval of *Miscanthus* rhizomes have the potential to cause significant disturbance of archaeological deposits;
- The root depth of some species may reach up to 1 metre in depth which could cause significant disturbance to archaeological deposits;
- Some crop types have a greater water requirement and can have the effect of lowering the ground water table in some areas, this can have implications for waterlogged archaeological deposits.

	Scale		Significance	
A	4	Moderately extensive	0	Neutral
B	4	Moderately extensive	–3	Large negative impact
C	3	Moderate	–3	Large negative impact
D	2	Moderately limited	–3	Large negative impact
E	5	Extensive	–3	Large negative impact

Evaluation of overall impacts

The effects of the introduction of energy crops is likely to have a widespread detrimental impact on the archaeological resource of south Wales, caused by the introduction of new and potentially more invasive cultivation methods. The effect of other crops will be dependant on specific husbandry requirements, but is likely to be largely negative.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Potential farming changes identified from the literature review not identified by Hossell *et al* (2007).

Pro-forma 3.19 Sheep and beef on marginal land replaced by woodland

Farming change

Sheep and beef on marginal land replaced by woodland.

Farm practice outcome

Planting of rough grazing with woodland.

Uptake dependent on market forces and/or incentives.

Area Type location

SDA

Implications for archaeology

A. Woodland planting on archaeological sites or complexes previously lying within uncultivated farmland would have a detrimental effect on both archaeological earthworks and also subsurface archaeological deposits. Damage caused by root penetration and windthrow lifting root plates and damaging subsurface archaeology.

B. Use of forest machinery for planting furrows, creation of access tracks, harvesting would cause damage to archaeological earthworks and subsurface archaeology.

C. Establishment of woodland or plantation will reduce visibility of archaeological earthworks.

D. Areas outside of active management may be subject to the establishment of scrub on archaeological sites.

E. Compaction and rutting by machinery leading to damage to earthworks and crushing artefacts.

	Scale		Significance	
A	5	Extensive	–3	Large negative impact
B	5	Extensive	–3	Large negative impact
C	5	Extensive	0	Neutral
D	3	Moderate	–2	Moderately negative impact
E	3	Moderate	–3	Large negative impact

Evaluation of overall impacts

The impact of establishing woodland within the SDA areas is likely to be severely damaging on the archaeological resource across a widespread area.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

RCAHMW – Upland Survey baseline data.

Pro-forma 3.20 Increase in homegrown cereals on livestock farms (Dairy, beef and sheep)

Farming change

Increase in home grown cereals on livestock farms (Dairy, beef and sheep).

Farm practice outcome

Increase ploughing of grassland for feed crops.

Potential increase in erosion.

Area Type location

DA

NE

SW

S

Implications for archaeology

A. Potential for previously uncultivated land to be taken into cultivation leading to erosion and damage to hitherto undisturbed historic features, damage to subsurface archaeological deposits and clearance of stone which may include archaeological features.

B. Compaction and rutting by machinery leading to damage to historic features, crushing artefacts and leading to further damaging operations such as subsoiling.

	Scale		Significance	
A	4	Moderately extensive	–3	Large negative impact
B	3	Moderate	–3	Large negative impact

Evaluation of overall impacts

Increasing the area of land being taken into cultivation will have a directly negative impact on the archaeological resource across large areas of Wales.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits.

Remote sensing.

Pro-forma 3.21 Diversification of agricultural land into non-agricultural land use

Farming change

Diversification of agricultural land into non-agricultural land use.

Farm practice outcome

Impacts will be varied, depending on the original agricultural use and the nature of the non-agricultural use.

Uptake dependent on market forces and/or incentives.

Area Type location

All areas

Implications for archaeology

A. May be opportunities for beneficial effects to archaeological resource, particularly if areas are taken out of cultivation and reverted to permanent pasture, may also be opportunities for active management of archaeological sites.

B. May be very damaging to archaeological resource where construction is taking place, for example; new trackways, fishing lakes, buildings or other structures.

	Scale		Significance	
A	1 to 5	Limited – extensive	+3	Large beneficial impact
B	1 to 5	Limited – extensive	–3	Large negative impact

Evaluation of overall impacts

Diversification may present opportunities to improve the condition of the archaeological resource; however it may be also be extremely damaging.

Data sources

Field visits.

Vertical aerial photography.

Oblique aerial photography.

Pro-forma 3.22 Participation in agri-environment schemes

Farming change

Participation in agri-environment schemes.

Farm practice outcome

Impacts will vary depending on farm type, land use and the type of scheme

Area Type location

All areas

Implications for archaeology

A. As a basic minimum, all archaeological sites should be protected from damage.

B. Opportunities for pro-active management of archaeological sites.

	Scale		Significance	
A	5	Extensive	+3	Large beneficial impact
B	2	Moderately limited	+3	Large beneficial impact

Evaluation of overall impacts

Participation in agri-environment schemes is widely beneficial for the archaeological resource enhanced with positive opportunities to improve the condition of archaeological sites.

Data sources

Oblique aerial photography.

Vertical aerial photography.

Field visits (agri-environment scheme visits and others).

LiDAR.

Remote sensing.

Pro-forma 3.23 EU Water Framework Directives

Farming change

Adaptation to comply with the River Basin Management Plans which include all surface and ground water bodies. Objectives include to preventing deterioration in water status; restoring surface waters to good ecological and chemical status by 2015; reducing pollution from priority substances and phasing out certain priority hazardous; substances; achieving objectives for EU protected areas; contributing to mitigating the effects of floods and droughts; preventing and/or limiting pollution input into groundwater; and balancing abstraction and recharge.

Farm practice outcome

The largest impact on farm practice will be actions taken to mitigate the effects of floods and droughts. Greater control of water release from the uplands may lead to a reduction of erosion and a higher water table. In the lowlands there should be greater protection of floodplains from development.

Area Type location

All Areas, but the uplands in particular.

Implications for archaeology

A. Measures to stabilise and reduce erosion generally and in the uplands in particular, should ensure the survival of archaeological features and the retaining or increasing of the water table should also ensure the preservation of organic remains.

B. The protection of lowland areas from development, and the greater control of development should also protect archaeological sites from damage.

C. Specific actions, notably engineering works, could potentially cause local disturbance affecting historic features.

	Scale		Significance	
A	5	Extensive	+ 3	Large beneficial impact
B	2	Moderately limited	+ 3	Large beneficial impact
C	1	Limited	-3	Large negative impact

Evaluation of overall impacts

Measures to protect ground water and stabilising the water table will broadly have a beneficial impact on the archaeological resource although some individual local actions might be damaging.

Data sources

Remote Sensing.

Field visits.

Pro-forma 3.24 Proposed EU Soils Directive

Farming change

Adaptation to comply with Directive regulations to protect soil on the basis of the principles of preservation of soil functions, prevention of soil degradation, mitigation of its effects and restoration of degraded soils.

Farm practice outcome

Protection of upland soils from erosion and loss of organic matter. Raising of water tables.

Protection of soils on slopes from erosion.

Area Type location

All areas, but particularly the uplands and valley sides.

Implications for archaeology

A. Measures to protect and reduce soil erosion should ensure the survival of archaeological features and the retaining or increasing of the water table should also ensure the preservation of organic remains.

	Scale	Significance
A	5 Extensive	+ 3 Large beneficial impact

Evaluation of overall impacts

Measures to protect soils and prevent soil erosion will have a widespread beneficial impact on the archaeological resource.

Data sources

Remote sensing.

Field visits.

Summary

This analysis allows the identification of key factors relevant to the survival and condition of the historic environment within the farmed landscape.

The principal negative factors are:

1. Expansion of areas of cultivation;
2. Deeper cultivation;
3. Increasing stocking levels;
4. Replacement of lighter livestock by heavier animals;
5. Increased farm infrastructure – tracks, buildings etc;
6. Abandonment and uncontrolled scrub development.

These might be summarised as those which cause or encourage erosion and soil loss and which generally affect large tracts of land (1-4), those which allow other agencies of damage to develop, also over potentially large areas (6), and those which are individual and isolated activities determined by specific farm business requirements (5).

Conversely there are positive factors associated with some changes which certainly contribute to the wider protection and preservation of the historic environment:

- Reduction in cultivation;
- Lower stocking levels in areas where erosion is a problem;
- Replacement of heavy animals – beef or dairy cattle – by sheep;
- Maintaining appropriate stock levels to control scrub development.

It is the interaction between these positive and negative factors which is likely to be most critical in monitoring the condition of the historic environment of rural Wales over the coming decades.

4. EVALUATION OF DAT A SOURCES

4.1 Introduction

In developing indicators to monitor sustainable development the UK Government devised a set of scientific and technical criteria which were applied to the indicators before their adoption. The indicators had to:

- Be representative;
- Be scientifically valid;
- Be simple and easy to interpret;
- Show trends over time;
- Give early warning about irreversible trends where possible;
- Be sensitive to the changes they are meant to indicate;
- Be based on readily available data or be available at reasonable cost;
- Be based on data adequately documents and of known quality;
- Be capable of being updated at regular intervals;
- Have a guideline or target against which to compare them.

However, in practice it was found that compromises inevitably had to be made and pragmatism prevailed to ensure that appropriate measures could be established (United Nations Division for Sustainable Development, 2005). These criteria have been used to identify and inform the evaluation of different data sources which have the potential to monitor change in the archaeological resource.

For this project two types of indicator were proposed:

- **Early warning indicators**: These indicators are not based on direct observation of change in the archaeological resource. They are based on surrogate data sources (e.g. using census data to identify changes in stock numbers and cropping area, and using satellite imagery to identify vegetation change) which may indicate land management changes that will impact upon the archaeological resource. As such they may provide an early warning of changes taking place.
- **Actual impact indicators**: These indicators use direct observation to record the condition of the archaeological resource.

4.2 Early warning indicators

Agricultural Census

Hossell *et al* (2007) have considered the potential of the annual Agricultural Census to track some of the effects of CAP reform on biodiversity. They note that the Census data provides information on livestock numbers (by type, age and weight range) and area of different types of crops and grass. Tracking changes in livestock numbers, particularly sheep, could provide a useful early warning indicator of changes in grazing pressure. A reduction in sheep numbers, for example, may result in an increase in scrub vegetation in the uplands, a process known to damage buried archaeology. Tracking changes in the area under ploughed crops could provide an early warning indicator of a threat to buried archaeology.

However, Hossell *et al* (2007) found that the Agricultural Census data was currently not provided at a sufficient degree of resolution to determine changes taking place at the Area Type scale. It was concluded that this level of disaggregation was required to make meaningful statements about the nature of change taking place. Hossell *et al* (2007) also note that given the influence of sample size on statistical power, this dataset holds great promise as it already has many years worth of data and will grow in size each year.

WAG is currently improving the spatial resolution of the Agricultural Census by geo-referencing the data. This means that in future it will be possible to monitor changes in livestock numbers and crop areas at the Area Type scale and even below. A major strength of using information from Agricultural Census is that the data are well organised and analysis is relatively straightforward. The major weakness is that it is a surrogate measure that does not capture actual change to the archaeological resource.

Satellite imagery

A project is currently in development, funded by WAG and Countryside Council for Wales (CCW) to establish a monitoring programme which will allow the tracking of vegetation change across Wales. This will supersede the Phase 1 Habitat Survey carried out by field visits and completed in 1996. The project will allow a constant update of vegetation change across Wales. Habitats categories include arable, heathland, improved grassland, woodland and scrub. The resolution of this survey should be high and allow tracking of vegetation change. The development project should reach completion in the summer of 2008.

In Section 3 it was noted that earthworks and other monuments are often best protected in unimproved permanent grazing land or improved pasture that is maintained without ground disturbing operations. Monitoring changes to these types of vegetation could provide an early warning indicator of a threat to the archaeological resource. It was also noted in Section 3 that wetlands often contain undisturbed archaeological sites and artefacts. Monitoring changes to wetland vegetation types could provide an early warning indicator of a threat to the archaeological resource. As with the Agricultural Census, the data from satellite imagery are well ordered and relatively straightforward to analyse. However, it is also a surrogate measure that does not capture actual change to the archaeological resource.

4.3 Actual impact indicators

A number of data sources have been identified as having potential, these include:

- Welsh Archaeological Trusts' Historic Environment Record (WAT-HER) dataset including the Cadw Threat Related Assessment;
- Vertical Aerial Photographs (VAPs);
- Oblique Aerial Photography;
- RCAHMW Upland Initiative;
- LiDAR;
- Scheduled Ancient Monument Reports;
- Remote Sensing – Satellite Imagery.

Each data source has been considered and information entered into a pro-forma. The pro-formas have been devised to assess each data source in terms of extent of

physical coverage, the resolution of the data, the recording intervals, frequency of data collection and updates, what format it is held in and its accessibility. Information has been collected via a telephone interviews with relevant external organisations and in some cases followed up with a visit. The results of this assessment are collated in the following pro-formas and summarised in Table 4.1.

Pro-forma 4.1 Welsh Archaeological Trusts' Historic Environment Records

DATA SOURCE: Welsh Archaeological Trusts' Historic Environment Records (WAT-HER)
GENERAL DESCRIPTION: The WAT-HER hold the most comprehensive dataset of the known archaeological resource across Wales. This has been gathered from a number of sources including the Cadw Threat related projects reported on in the recent 'Appraisal of Baseline Data for Outcome Monitoring'. The records are variable in extent of information, but those carried out for Cadw Threat Related Projects and for Tir Gofal farm surveys will include descriptions and information on condition. As of December 2007 there were 152,098 site records contained within the HER. Fields within the HER that might be useful for establishing a baseline condition of the archaeological sites include: Brief Description; Condition; Land use and Vegetation.
COVERAGE: Coverage of sites across Wales with all site types included.
METHODOLOGY: Information on sites is collated under various projects within the four trusts.
RESOLUTION: Records created for each site. Records should contain a written description including an assessment of the condition, land use and threats. These records will be included into the HER. Condition and land use should also be filled in for each site record. Ground photographs of archaeological sites provide detailed records, although there may not be extensive coverage of large or complex sites.
RECORDING INTERVALS: One off visits.
FORMAT OF DATA SOURCE: Site records are held in the HER of each of the four regional Welsh Archaeological Trusts. (Many farm databases are awaiting inclusion into the HER which is currently under construction). HER information for all the WAT-HER is currently held in a single temporary database.
HELD BY: Information held by each of the Welsh Archaeological Trusts.
STRENGTHS: Site visits provide detailed descriptions of site at time of visit and photograph of each site. Contains records of sites which are on located on agricultural land.
WEAKNESSES: Variability in the extent of recorded data both within each Trust and also nationally across each Trust. Additional work would be required to transform the HER computer records into a form suitable for inclusion in a monitoring database. Survey spread over a number of years. No systematic updating.
POTENTIAL: Good cross-section of all types of archaeological sites across Wales. There should be sufficient sites with a basic level of field recording, including descriptions with accompanying photographs that will allow the creation of a monitoring database.

Pro-forma 4.2 Vertical Aerial Photographs

DATA SOURCE:

Vertical Aerial Photographs

GENERAL DESCRIPTION:

Vertical Aerial photographs are taken with the camera lens perpendicular to the surface of the earth. The area covered is relatively small when compared to oblique air photographs. The image the portrays a 'bird's eye view' of the land surface. This can give a very accurate portrayal of the ground, and can be used as mapping, however relief does not become readily apparent and depending on the light conditions may 'flatten' out the ground surface, i.e. when the sun is at its highest and shadows are minimal.

COVERAGE:

Complete coverage of Wales – most recent is 2005/6 undertaken by the aerial survey company COWI prompted by the success of the Getmapping data dating from 2000/1.

Also has infrared coverage which is good for depicting different types of vegetation.

RESOLUTION:

COWI resolution up to 25cm, software provided by Blueskies can improve resolution up to 12.5cm.

Getmapping resolution up to 50cm.

RECORDING INTERVALS:

Although there is no fixed programme for further photo mapping to take place, the likelihood is that repeat flights will be taken in order to carry out compliance monitoring every 5 years.

Flights normally take place in early summer when the weather is likely to be better, and is stipulated to be between 10-4pm when there is least shadow.

FORMAT OF DATA SOURCE:

Vertical APs are available as MrSID (*multiresolution seamless image database)* or MapInfo tables to be used with most GIS programmes.

HELD BY:

WAG

STRENGTHS:

Pan Wales coverage.

Short survey period.

High resolution.

Vegetation encroachment could be accurately mapped.

Held by WAG.

WEAKNESSES:

Resolution insufficient for identifying small scale damage or erosion.

Vegetation will obscure detail.

POTENTIAL:

Good potential for accurate mapping of vegetation change and encroachment, also medium to large scale damage or erosion should also be visible.

Pro-forma 4.3 Oblique Aerial Photography

DATA SOURCE: Oblique Aerial Photography

Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)

GENERAL DESCRIPTION:

RCAHMW undertakes aerial reconnaissance which falls into to the following categories:

- Aerial monitoring of Scheduled Ancient Monuments for Cadw;
- Prospecting for previously unrecorded cropmarks or earthworks;
- 'general' photography of sites and landscapes with in a broad recording remit.

Currently the RCAHMW has an annual flying programme of around 40-65 hours.

This allows high quality photographic records to be taken of archaeological sites obliquely from low levels between around 900-2000ft AOD.

COVERAGE:

Every 'photographable' Scheduled Ancient Monument is monitored across Wales. The aim is to monitor 650 SAMs a year thereby covering the 3000 or so SAMs once every 4-5 years.

METHODOLOGY:

The number of photographs taken of each site depends on its complexity; 1 or 2 shots are taken of simple features, more complex sites have several photographs. Where there are signs of damage or wear and tear on a monument then more photos are taken.

Prints are marked with monument number, date and reference number, and sent to Cadw, one for the file and one for Field Monument Warden.

RESOLUTION:

High quality digital images are taken. 17 megapixel camera.

Formally images were taken on a black and white medium format film camera.

Since 2005 the images are exclusively digital.

RECORDING INTERVALS:

SAMs are monitored on a rolling programme once every 4-5 years.

FORMAT OF DATA SOURCE:

Digital since 2005; 50 megabit TIFF file; Equivalent to a medium format camera; Stored on DVD and uploaded onto server and released on Coflein; Two copies of prints are sent to Cadw.

HELD BY:

1 batch of prints goes to Cadw offices; 2nd batch goes to Field Monument Warden; Also held at NMR;

Some earlier flights held in WATs.

STRENGTHS:

Over 30,000 RCAHMW oblique aerial photographs have been catalogued and are available.

3 hour flight can provide up-to-date information on the character, condition and land-use of around 50-75 sites, regardless of their remoteness or inaccessibility.

Threats can be identified; such as ploughing, construction, or quarrying.

Provides comparative data and archive material in the longer time scale, changes in vegetation and land use.

Available on Coflein.

Regular records taken of every SAM.

Other sites also recorded and photos held at NMR but not in any systematic manner. Areas where there is a high concentration of SAMs will get more photographed, likewise those areas where there are few will be considerably less. Therefore there are some areas where there is little coverage.

Very good visibility for small 'discreet' sites – 100% coverage

WEAKNESSES:

Large complex sites will have less that 100% coverage.

Visibility in woodland is poor.

Other sites in the area are also photographed, but this is not carried out in any systematic manner.

Survey spread over a number of years.

No systematic updating.

POTENTIAL:

Useful for detailed recording remotely.

Pro-forma 4.4 Upland Initiative

DATA SOURCE: Upland Initiative

RCAHMW

GENERAL DESCRIPTION:

The aim of the Upland Initiative is to achieve a greater understanding of the archaeology and history of the uplands of Wales, by carrying out exploratory survey and research. This is achieved by field projects undertaken to identify all evidence of human activity, by both enhancing existing records but also targeting areas where there are significant gaps in the archaeological record.

Target date for completion 2012.

COVERAGE:

The target area is over most of Upland Wales (40-50% of the total land area) which is defined as land above 244m or 800ft. Since the late 1990's the emphasis has shifted to prioritise areas of unenclosed, unimproved moorland or heath. Does not include forestry plantations.

The target is 150 km square per year. Since the outset of the project there have been in excess of 20,000 new sites identified.

METHODOLOGY:

Initially the existing HERs are consulted. Air photo mapping precedes each field project, identifying features from existing aerial photographs which can then be investigated in the field survey.

Field survey is carried out in 30-50m transects, recording all artificial features.

Databases are collated at the end of each year and after 6 months are uploaded onto the National Monuments Record Database and then onto Coflein. Not all information is accessible on Coflein though.

RESOLUTION:

Records must conform to the minimum for the Royal Commission's Database Standards and includes a brief description of sites, but no measured survey. Condition of sites is recorded including; present land-use, present state of preservation and an assessment of potential threat. Digital images to be taken at the discretion of the surveyor – recommended on visually striking sites and structures. TIFF files of minimum 11 mb

RECORDING INTERVALS:

One off.

FORMAT OF DATA SOURCE:

Database of site records with completed and supported tables. Held on disk and report archive. Now uploaded onto NMR database and Coflein. Print images held in archive, digital images uploaded onto Coflein.

HELD BY:

Some earlier data is held by the WATs. Now all the digital and archive material is held by the NMR.

STRENGTHS:

Descriptive records held for every identified site in the uplands, including all site types.

Database records land use and condition.

Photographic records held for the majority.

WEAKNESSES:

Data confined to upland areas.

Not all information is accessible on Coflein.

Survey spread over a number of years.

No systematic updating.

POTENTIAL: Useful baseline data.

Pro-forma 4.5 LiDAR

DATA SOURCE:

LiDAR (Light Detection and Ranging) or ALS (Airborne Laser Scanning)

GENERAL DESCRIPTION:

LiDAR is an airborne mapping technique to produce dense and high precision measurements of the topography of the earth's surface. A laser scanner mounted below an aircraft emits short infrared pulses to the earth's surface in different directions and a photodiode records the backscattered echo and determines distance. Essentially this can depict landscapes and topography in relief.

Shading of the DTM can hide certain features because they align with the sun and do not cast shadows. However light sources from different angles and heights can overcome this.

COVERAGE:

Environment Agency have covered most of the major river systems in Wales and their catchment areas which includes surrounding landscape and much upland. Used for flood management planning.

METHODOLOGY:

Airborne scanning of a pulsing laser over the ground surface. Data transformed into a coordinate grid system and can then be transformed into a Digital Elevation Model. Data has a high relative accuracy (10-15cm). Data can then be subject to interpretation in a number of ways to demonstrate height, stripping away vegetation, lighting the landscape from any angle. Vertical aerial photos can then be draped over.

The LiDAR in its basic form will measure only position and height. The data chain is totally digital; the outputs are designed for visual interpretation in any standard GIS package. Any archaeological feature that causes a variation in surface elevation can be monitored. The system has no subsurface capabilities. It is able to collect data day or night at the rate of 30-40 sq. km/hr, thus allowing sites and features to be viewed in context within their surroundings. It is widely used for flood plain mapping, coastal zone management, soil erosion and diffuse pollution studies, recording open-cast mines and quarries, landfill sites, water resources and for near shore bathymetry.

RESOLUTION:

0.25- 2 m

RECORDING INTERVALS:

No programme for updates in place.

FORMAT OF DATA SOURCE:

ASCII files

HELD BY:

Environment Agency

STRENGTHS:

Data usually already processed, but by running particular algorithms these can enhance archaeological features, making it visible to record in greater detail known sites and the discovery of new sites.

Manipulation of data allows vegetation to be stripped away and an accurate 3-D model of the ground surface to be mapped.

The raw data can be used to create high resolution Digital Surface Model (DSM) or a Digital Terrain Model (DTM), which can be interpreted in many different ways. It is possible to influence factors virtually for example shining light and casting shadow which would never be possible in reality.

Raw data can be reinterpreted time after time.

Can generate high resolution Digital Terrain Models which allow landform features to be recorded which are not visible on Aerial photographs.

Short time scale to collect data, the detail and level of accuracy make it suitable for monitoring and mapping the occurrence and extent of damage.

LIDAR can provide a means of measuring the magnitude of change of bare ground, scrub and levels of grazing.

WEAKNESSES

Resolution not universally high – highest in urban areas. Updates and increasing resolution are only likely to take place in urban areas and in those areas at risk of flooding.

Not universal coverage.

No systematic updating.

POTENTIAL:

Good potential for providing measurable data on erosion

Pro-forma 4.6 Scheduled Ancient Monument Reports

DATA SOURCE: **Scheduled Ancient Monument Reports**
GENERAL DESCRIPTION: 3975 every SAMs is visited on a rolling programme every 5 to 7 years by a Cadw Field Monument Warden. The scheduled site is visited, its condition assessed. A report at the end of each round of visits is compiled to assess whether the site's condition is improved or worsened. Where the condition of the monument is poor, a management agreement can be offered to the landowner.
COVERAGE: Every SAM in Wales is visited
METHODOLOGY: A field visit is undertaken, often but not always accompanied by the landowner. The site's condition is assessed and a report written up, sometimes though not always accompanied with a sketch plan and photographed.
RESOLUTION: The monitoring programme results in an assessment of the condition of the monument with supporting documentation and photographs.
RECORDING INTERVALS: Every 5 to 7 years.
FORMAT OF DATA SOURCE: Sites and Monuments Database.
HELD BY: Cadw
STRENGTHS: A regular assessment of the condition of the monument Regular photographs provide an indicator of the condition of the monument. Systematic time series information on archaeological sites across Wales
WEAKNESSES: The sites would benefit from a basic plan on which an assessment of condition could be annotated. Data biased to the protected resource – not necessarily representative of the archaeological resource across Wales.
POTENTIAL: Good time series data available, however this only consists of the protected archaeological resource and does not therefore provide a picture of the unprotected archaeology.

Pro-forma 4.7 Satellite Imagery

DATA SOURCE: Satellite Imagery
GENERAL DESCRIPTION: Satellites collect data by passing the reflected energy from the Earth through filters that separate the energy into small windows of the Electro Magnetic spectrum into discrete spectral bands from the Ultraviolet (UV) to the Thermal Infrared (IR). By assigning any 3 spectral bands into the 3 colors (red, green, and blue), one can create a coloured image that gives our eyes the ability to see data attributes that are not visible to the human eye. (Extract from http://landsat.usgs.gov/resources/remote_sensing/electromagnetic_spectrum.php)
COVERAGE: Pan Wales
METHODOLOGY:
RESOLUTION: Routinely 30m – but higher resolution available up to 1-2m (higher for black and white)
RECORDING INTERVALS: Frequent – the Landsat satellite orbits the earth every 16 days.
FORMAT OF DATA SOURCE:
HELD BY: Various Countryside Council for Wales (CCW)
STRENGTHS: Take images frequently and regularly – large areas can be captured in a smaller time frame, allowing a snapshot of the whole country at one time.
WEAKNESSES: Resolution adequate to pick up widespread change only
POTENTIAL: Project due to complete in 2008, funded by CCW and WAG will look at updating Phase 1 habitat classification through remote sensing technologies. 'Habitat Classification project using Remote Sensing technologies'

Summary

To summarise the strengths, weaknesses and potential of the data sources:

- **Welsh Archaeological Trusts' Historic Environment Record** – data available on all known archaeological sites across Wales;
- **VAPs** – Complete coverage of Wales with high resolution, although no programme for further data collection is established, the likelihood is that further updates will be forthcoming. Capacity to measure vegetation encroachment;
- **Oblique Aerial Photographs** – not currently extensive coverage, but good high resolution. Has the advantage of gaining high resolution but avoids site access issues inherent with field visits. Not appropriate for assessing condition of large or complex sites or those under woodland canopy or other dense vegetation. Could be developed to cover further areas;
- **Upland Initiative** – high quality consistent data with descriptions for archaeological sites in unenclosed upland areas, above 244m. Each site visited and described although condition not necessarily fully documented;
- **LiDAR** – the Environment Agency have extensive coverage of Wales, although not entire - some upland areas have no coverage. Resolution highest in urban flood risk areas. LiDAR has very good potential for future use providing measurable data on erosion;
- **Scheduled Ancient Monument Reports** – currently the only systematic monitoring for the system for the archaeological resource across Wales. Provides a useful format with good quality information, but only covers the protected resource;
- **Satellite Imagery** – regular updates available covering the whole of Wales. Resolution is good and is currently used for mapping vegetational change across Wales by CCW.

The data sources can be divided into those which provide baseline data, i.e. providing detailed information on sites and monuments derived from a one-off event, and those which provide time series data, or have that potential:

- *Baseline:* Two data sources which have been reviewed have the potential to stand as baseline data, the WAT-HER dataset and the RCAHMW Upland Initiative. The WAT-HER dataset has the most extensive coverage of information across Wales and provides a cross section of both site types and geographical location;
- *Time series:* The most likely candidates for time series data include VAPs and Satellite Imagery.

To summarise:

- WAT-HER provide the most systematic and greatest coverage to provide baseline data;
- VAPs also provide good direct observational coverage - pan Wales - high resolution - although small-scale damage might not be picked up;
- Satellite imagery might provide a useful and cost effective way of tying in with vegetation change etc.

In addition the potential for expanding Oblique Aerial Photography coverage should be considered as a cost effective method of obtaining detailed information on site condition remotely. Equally LiDAR has great potential for quantifying physical change where it is otherwise more subjective.

Table 4.1 Summary of existing data sources

DATA SOURCES	EXTENT OF COVERAGE	RESOLUTION	BASELINE/TIME SERIES	HELD BY
WAT - HER Field visits	Pan Wales	High	Baseline – ongoing	WAT-HER
Vertical Aerial Photography	Pan Wales	Medium 0.25 m	Time Series – frequency unconfirmed	WAG
Oblique Aerial Photography	Across Wales	High-Medium	Time Series4-5 years	Cadw / RCAHMW / WATs
Upland Initiative	SDA/DA Areas above 244m OD emphasising moorland	High	Baseline – 1999 - ongoing	RCAHMW
LiDAR	Much of Wales excluding some upland areas, and Anglesey	Medium 1-2 m	Baseline	Environment Agency
SAM reports	Pan Wales	High	Time Series Every 5 to 7 years	Cadw
Satellite Imagery	Pan Wales	Low-Medium 30 -1 m	Time Series<1 year	CCW

5. OPERATIONAL INDICATORS

5.1 Introduction

The evaluation of data sources in Section 4 identified a number of sources that have the potential to be used for identifying changes in and threats to the archaeological resource. The purpose of this section is to show how cost-effective indicators can be created from these sources to monitor the threats and changes. In the next section (Section 6) a number of actions are recommended which will make the indicators a reality.

Two types of indicator were proposed:

- Early warning indicators;
- Actual impact indicators.

5.2 Early warning indicators

Agricultural Census data

Agricultural Census data can be used to create two indicators which can provide early warning of changes in the area of ploughed land and the potential for vegetation change due to changes in grazing:

- **Arable area**: This indicator monitors changes to the area of arable land recorded by the Agricultural Census in each of the five Area Types on an annual basis;
- **Sheep numbers**: This indicator monitors changes to the number sheep in each of the five Area Types on an annual basis.

The construction of both these indicators is dependent on WAG completing its programme of geo-referencing the Agricultural Census to improve its spatial resolution. However, once this is done there is potential to monitor change between and within the five Area Types level. This will help to identify localised threats to the archaeological resource and could be used to inform more targeted monitoring.

Satellite imagery

A monitoring programme to track vegetation change across Wales is being developed by WAG and CCW. The outputs from the monitoring programme can be used to identify potential threats to the archaeological resource between and within the five Area Types. This will help to identify localised threats to the archaeological resource and could be used to inform more targeted monitoring. Change from one vegetation type to another may have a potential beneficial, neutral or detrimental impact on the archaeological resource depending on the nature and trajectory of the vegetation change. It will be possible to construct a matrix of combinations of vegetation change and potential threats to the archaeological resource. Ideally all combinations of vegetation change should be monitored. However, as noted in Section 4, from an archaeological perspective there are a number of types of vegetation change that are particularly important:

- **Unimproved permanent grassland**: This indicator monitors changes in the area of unimproved permanent grassland in the five Area Types on an annual basis;

- **Wetland**: This indicator monitors changes in the area of wetland vegetation in the five Area Types on an annual basis;
- **Scrub and woodland**: This indicator monitors changes in the area of scrub and woodland in the five Area Types on an annual basis;
- **Arable**: This indicator monitors changes in the area of arable vegetation in the five Area Types on an annual basis.

5.3 Actual impact indicators

Creating the baseline data

The Welsh Archaeological Trusts' Historic Environment Record (WAT-HER) database provides the most comprehensive dataset of archaeological records, in terms of covering the spatial distribution of archaeological features and the range of site types. It therefore provides the most suitable dataset from which to establish a baseline for monitoring. However, as noted in Section 4, the WAT-HER database contains records of sites which are not located on agricultural land and records with data of insufficient reliability for monitoring purposes.

As part of this project the WAT-HER database was modified to:

- Remove records of sites which were not located on agricultural land;
- Remove records with unreliable data;
- Allocate each record to one of five archaeological forms;
- Allocate each record to one of the five Area Types.

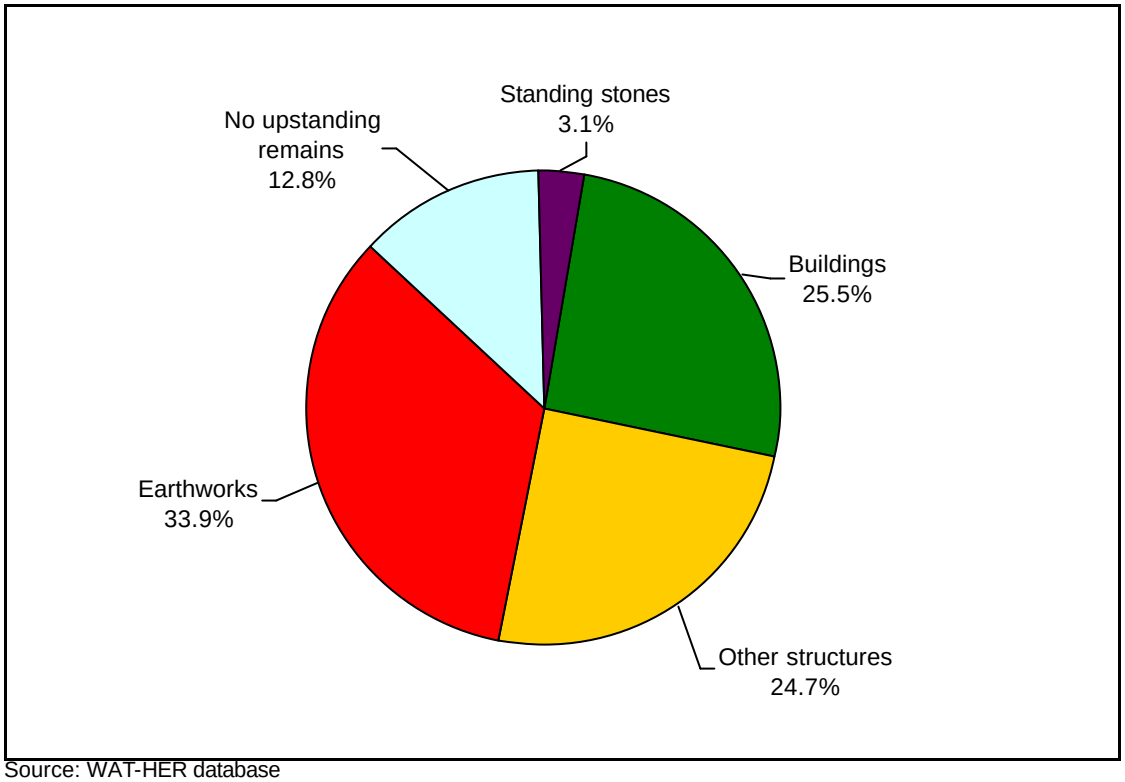
As a result of these procedures the WAT-HER database was reduced form 152,098 to 41,036 records. A detailed description of the database modification is provided in Appendix 1.

The WAT-HER dataset has been categorised to divide archaeological site types into five broad categories which reflect their different vulnerabilities and management requirement:

- **Buildings**: sites with recognisable upstanding masonry (e.g. lime kilns, abandoned industrial structures, but excluding intact, functioning buildings);
- **Other stone structures**: sites which survive as mounds or banks of stone, often the collapsed remains of building but which no longer have any 'built' form (e.g. prehistoric burial cairns, abandoned medieval settlement);
- **Earthworks**: sites which survive as banks or mounds predominantly of earth (e.g. Iron Age hill forts, Anglo -Norman 'mottes', castle mounds);
- **Megaliths:** Massive stones set up singly, in circles or together to form the chambers for prehistoric burial:
- **No upstanding remains**: archaeological sites with no visible surface indications known only by cropmarks, geophysical survey or excavation.

Figure 5.1 shows that the most numerous archaeological form category is Earthworks with 33.9% or WAT-HER records, followed by buildings (25.5%), other stone structures (24.7%), no upstanding remains (12.8%) and megaliths (3.1%).

Figure 5.1 Distribution of WAT-HER records by archaeological form category

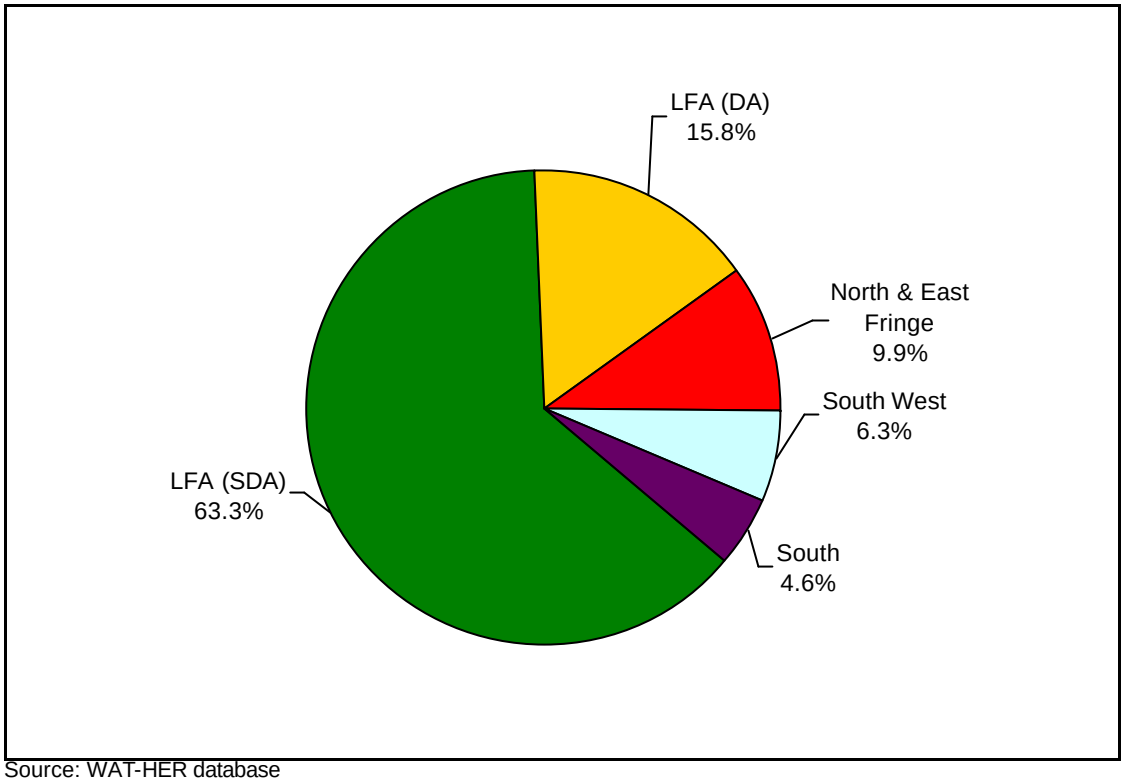


Source: WAT-HER database

Each of these categories may be subject to different pressures by changing agricultural practice, for instance loose stone structures may be at particular threat from stone clearance in advance of cultivation, earthworks may be threatened by poaching or erosion, megaliths may be at particular threat from damage by cultivation practices. Scrub and establishment of woodland is particularly damaging for masonry remains.

The division of the country into the five Area Types as suggested by Hossell *et al* (2007) on the basis of topography, climate and core farming economy has been used as a basis for the development of actual impact indicators. Each of these five areas is subject to specific farming pressures and different types and magnitudes of change, as has been demonstrated in Section 3 (e.g. the likely reduction in sheep number in the LFA SDA area may mean that the archaeological resource may be threatened by scrub encroachment). Figure 5.2 shows that almost two-thirds of the WAT-HER archaeological sites are located in the LFA-SAD (63.3%) followed by the LFA-DA (15.8), North and East Fringe (9.9%), South West (6.3%) and South (4.6%).

Figure 5.2 Distribution of WAT-HER records by Area Type



Source: WAT-HER database

Monitoring data sources

The evaluation of data sources in Section 4 concluded that VAP coverage was the most readily available and cost effective means of monitoring archaeological sites across Wales. Full coverage of high resolution is available and although there is no programme for repeat data capture in place currently, European Union standards require repeat capture every five years to carry out compliance mapping.

The digitally available resource will allow each site to be mapped and broad observations can be recorded on its condition and general statements regarding its current land use. VAP will be useful to record some, but not all, change and detailed information regarding small-scale change will be unattainable through this data source. Some sites, which lie within woodland or under scrub, will also be impossible to observe from aerial photographs. However, it gives the greatest potential to record a large number of sites remotely with sufficient clarity to make an assessment of condition.

Field visits will help to address some of the deficiencies inherent in aerial photographic monitoring, although this will inevitably have to be restricted due to cost and expense. However field visits will be important to provide precise and detailed statements regarding condition and current land use. It will also be effective in providing verification of statements recorded through aerial photographic monitoring.

The use of these three data sources, WAT-HER records, aerial photographic assessment and detailed recording by field visit can be combined in order to provide an operational indicator monitoring the condition of and threat to the archaeological resource in Wales. The filtered WAT-HER records provide the baseline database. A representative sample of sites can then be drawn to monitor change through repeat surveys undertaken every five years using a combination of VAP analysis and field visits.

Five indicators, based on the archaeological form of sites, can be created to monitor changes in the archaeological resource in Wales:

- **Buildings**: This indicator monitors changes to sites in the buildings category in each of the five Area Types on a quinquennial basis;
- **Other stone structures**: This indicator monitors changes to sites in the other stone structures category in each of the five Area Types on a quinquennial basis;
- **Earthworks**: This indicator monitors changes to sites in the earthworks category in each of the five Area Types on a quinquennial basis;
- **Megaliths**: This indicator monitors changes to sites in the megaliths category in each of the five Area Types on a quinquennial basis;
- **No upstanding remains**: This indicator monitors changes to sites in the no upstanding remains category in each of the five Area Types on a quinquennial basis.

5.4 Sampling framework for actual impact indicators

Sample size and precision

Available resources suggest a sample of approximately 2,000 of the 41,036 sites recorded on the WAT-HER database is practicable. This will yield reasonably precise estimates as table 5.1 reveals. The table shows that assuming simple random sampling and maximum uncertainty (i.e. p=50%), the 95% confidence interval for a sample of 2,000 sites is 50% $\pm$ 2.19% and the 99% confidence interval is 50% $\pm$ 2.88. Increasing the sample to 3,000 sites only reduces the 95% and 99% confidence intervals respectively to 1.79% and 2.36%, yielding a modest 20% improvement in precision. In contrast, reducing the sample from 2000 to 1000 sites reduces precision by approximately 40%. Precision can be further improved by stratifying the sample.

Table 5.1 Precision of estimates for different sample sizes

	Precision of estimates			
	95% confidence		99% confidence	
Sample size	p=5%	p=50%	p=5%	p=50%
1000	1.35%	3.10%	1.78%	4.08%
1250	1.21%	2.77%	1.59%	3.65%
1500	1.10%	2.53%	1.45%	3.33%
1750	1.02%	2.34%	1.34%	3.08%
2000	0.96%	2.19%	1.26%	2.88%
2250	0.90%	2.07%	1.19%	2.72%
2500	0.85%	1.96%	1.12%	2.58%
2750	0.81%	1.87%	1.07%	2.46%
3000	0.78%	1.79%	1.03%	2.36%

Sample design

Stratification factors

Stratification is an important means of using knowledge about the variables under investigation to improve the representativeness of the sample and thereby minimize sampling error. In this context it is anticipated that impacts on the condition of the historic environment are likely to vary according to the type of historic site being considered and the nature of pressures for change in local environments. These factors are to be taken into account by stratifying the sample by the following two factors:

1. Archaeological form categories: Buildings, Other stone structures, Earthworks, Megaliths and No upstanding remains;
2. Area Types: LFA-SDA, LFA-DA, North and East Fringe, South West and South.

Table 5.2 shows the number of sites recorded on the WAT-HER database by archaeological form category and Area Type.

Table 5.2 Number of sites in the WAT-HER database by archaeological form category and Area Type

	Archaeological types					
Area Type	**Buildings**	**Other stone structures**	**Earthworks**	**Megaliths**	**No upstanding remains**	**Total**
LFA (SDA)	6,402	7,543	9,574	831	1,630	25,980
LFA (DA)	2,326	1,072	1,808	139	1,154	6,499
North & East Fringe	675	631	1,400	226	1,144	4,076
South West	837	571	587	54	538	2,587
South	239	317	525	15	798	1,894
All Areas	**10,479**	**10,134**	**13,894**	**1,265**	**5,264**	**41,036**

Source: WAT-HER database

Subsample sizes

Using the above two stratification factors results in 25 cells or strata (5 types x 5 regions) from each of which a sample of a given size needs to be selected. The minimum size of strata samples needs to be at least 30 and probably at least 50 to support calculation of percentages. An overall sample of 2,000 represents an average of 80 sites per strata. However the number of sites in each category needs to vary, where possible, to take into account differences in population size and thereby minimize sampling error.

Sample allocation, which is proportionate to population, is best for general estimation purposes but it has the drawback of producing very small samples for many strata in this project. An alternative method is to draw samples of the same size from all strata, which is preferable if estimates for individual strata are the main interest. As overall and strata estimates are of equal importance in this study, a compromise method of sample allocation proposed by Kish (1988) has been used. The sample sizes produced are shown in Table 5.3 with two modifications as the small population sizes in the South/Megaliths and South West/Megaliths categories have necessitated 100% samples.

Table 5.3 Proposed strata sample sizes by archaeological form category and Area Type

	Archaeological types					
Area Type	**Buildings**	**Other stone structures**	**Earthworks**	**Megaliths**	**No upstanding remains**	**Total**
LFA (SDA)	198	230	290	58	72	848
LFA (DA)	87	62	75	53	63	341
North & East Fringe	57	56	67	53	63	297
South West	59	56	56	54	55	225
South	53	54	55	15	58	221
All Areas	453	458	543	165	311	2,000

Selection of the Main Sample

Twenty-five samples need to be selected either as simple random or systematic samples. The main drawback of systematic sampling is the extra work involved in sample selection compared to random sampling. However, systematic sampling has the advantage that the list of sites for each stratum can be ordered in a way that ensures one or more additional factors are correctly represented in the sample drawn. For this reason, systematic sampling is recommended and it is suggested, to ensure good spatial coverage, that sites are listed first according to Archaeological Trust and then by northing for the Gwynedd and the Clwyd-Powys Archaeological Trusts and by easting for the Dyfed and the Glamorgan-Gwent Archaeological Trusts. For each ordered list it will be necessary to determine an appropriate sampling fraction and a random start number. The strata samples collectively form the Main Sample.

Reserve samples

Although every attempt will be made to ensure that the database is limited to appropriate sites, it is anticipated that a substantial number of entries will need to be discarded during the monitoring process[7] (e.g. where a site proves not to be on agricultural land or has been destroyed). To cover this eventuality it is necessary to determine a top-up procedure so that the target sample size and sample design is not prejudiced. The easiest way of achieving this is to replace the eliminated site with either the one preceding it or the one following it on the list from which the sample was selected. If the replacement site also has to be excluded then it is substituted by the remaining site after which no further substitutions can be made.

Verification sample

Information about the condition of sites included in the Main Sample is to be established using VAPs. Field visits are to be conducted at a selection of these sites in order to evaluate the accuracy and completeness of the photographic evidence and gather additional evidence on land use and condition. The number of sites to be visited and the means of selection from the Main Sample should be determined through a pilot study, but is likely to be in the region of five sites per sample strata (5x25) making a total of 125 site visits.

[7] See Appendix 1

6. CONCLUSIONS AND RECOMMENDATIONS FOR PROGRAMME OF WORK

Conclusions

The aim of this project was to develop a workable methodology to monitor threats to and the condition of the archaeological resource on agricultural land in Wales. This was to be based on the cost–effective use of existing data sources wherever possible. The project identified the likely nature and extent of future changes in farm practice in Wales and the likely impact of these changes on the archaeological resource. Attention was then turned to identifying data sources that could be used to construct indicators to monitor threats to and changes in the archaeological resource. This resulted in a suite of six early warning and five actual impact indicators being designed (Table 6.1).

Table 6.1 Proposed early warning and actual impact indicators

Indicator Type	Indicator name	Description	Data source
Early warning	Arable area	This indicator monitors changes to the area of arable land recorded by the Agricultural Census in each of the five Area Types on an annual basis	Agricultural Census
	Sheep numbers	This indicator monitors changes to the number sheep in each of the five Area Types on an annual basis	Agricultural Census
	Unimproved permanent grassland	This indicator monitors changes in the area of unimproved permanent grassland in the five Area Types on an annual basis	Satellite imagery
	Wetland	This indicator monitors changes in the area of wetland vegetation in the five Area Types on an annual basis	Satellite imagery
	Scrub and woodland	This indicator monitors changes in the area of scrub and woodland in the five Area Types on an annual basis	Satellite imagery
	Arable	This indicator monitors changes in the area of arable vegetation in the five Area Types on an annual basis	Satellite imagery
Actual impact	Buildings	This indicator monitors changes to sites in the buildings category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Other stone structures	This indicator monitors changes to sites in the other stone structures category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Earthworks	This indicator monitors changes to sites in the earthworks category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	Megaliths	This indicator monitors changes to sites in the Megaliths category in each of the five Area Types on a quinquennial basis;	WAT-HER Vertical AP Field visit
	No upstanding remains	This indicator monitors changes to sites in the no upstanding remains category in each of the five Area Types on a quinquennial basis.	WAT-HER Vertical AP Field visit

Recommendations

In order to fully develop and operationalise the indicators it is recommended that a staged programme of work should be carried out:

- Stage 1 Preparation of baseline data:
    - Early warning indicators;
    - Actual impact indicators.
- Stage 2 Repeat monitoring survey and analysis:
    - Early warning indicators;
    - Actual impact indicators.

Stage 1 Preparation of baseline data

Early warning indicators

- An initial project should be undertaken to identify potential synergies with the development of indicators of biodiversity change outlined in the report by Hossell *et al* (2007). This may lead to significant cost savings in the construction of the early warning indicators for monitoring the archaeological resource.
- Baseline data should be collected and analysed for the six early warning indicators. A simple database should be constructed for this purpose. The base-year for the indicators using Agricultural Census data is dependent on the completion WAG geo-referencing programme which will allow the data to be analysed by Area Type. The base-year for the indicators using satellite imagery is dependent on the completion of the CCW and WAG vegetation-monitoring programme (scheduled for summer 2008).

Actual impact indicators

- An initial project should be undertaken to filter the WAT-HER database of unreliable records. It is estimated that up to 25% of records may require removal (see Appendix 1).
- The Main Sample of 2,000 sites should then be selected following the sample framework proposed in Section 5.4. This should be kept confidential so far as this is possible to ensure objectivity and reduce any risk of manipulation.
- Each site should then be assessed for its suitability based on adequacy of information contained within the record to provide baseline information and accuracy of locational information.
- A dossier for each site should be collated. At a minimum this should include a hard copy of the full HER record and a location map at an appropriate scale. Where possible it would be desirable to include ground photographs taken during WAT assessments. It would also be desirable to have an oblique aerial photograph which could be supplied by the RCAHMW, however resource requirements for this element have not been included within Table 6.2.
- A recording protocol should be developed for the assessment of sites with a scoring system for quantifying condition, vegetation, land use, development,

potential threats and change over time. The recording protocol should be piloted and revised as required to ensure its robustness.

- The WAT-HER database should be developed to store the monitoring information which will allow the retrieval and interrogation of the collected data.
- Analysis of the 2006 VAPs for each site in the Main Sample should be carried out to establish baseline information.
- A report should be compiled to establish the framework of the project and its future objectives.

It is recommended that in order to test the methodology and to establish a clear framework for time estimates a rapid pilot survey of 20 sites should be carried out. This will also give an opportunity to develop the methodology, check recording mechanisms and verify the VAP analysis by conducting field visits. Following the pilot survey it will be possible to firmly establish the projected resource requirements for each task as set out in Table 6.2.

Stage 1 should be carried out prior to the next round of VAPs being taken, which is to be projected to take place in 2011.Therefore this initial stage of preparation and collecting information to establish baseline data could be carried out over more than one year.

Stage 2 Repeat monitoring survey and analysis

Early warning indicators

The early warning indicators should be updated and analysed on an annual basis to identify trajectories of change.

Actual impact indicators

Each future cycle of monitoring and analysis should consist of two work packages, the first being the analysis and interpretation of the new VAP data to be followed by detailed site recording through site visits and the verification of VAP analysis. These two work packages should be carried out in quick succession in order to provide more accurate analysis of the VAP interpretation.

Work package 1: VAP analysis

Time series data should be collected at intervals of every 5 years corresponding with the updating of the new digital VAP mapping data.

Future cycles should consist of:

- Data collection - repeat analysis of the VAPs and evaluation of change;
- Recording information;
- Reporting and analysis.

Work package 2: Field visits

Field visits should follow the VAP analysis.

Future cycles should consist of:

- Sample Field Visits – assessment of site condition and verification of VAP analysis on 125 sites (5 sites in each of the 25 cells);

- Inputting and recording information;
- Reporting and analysis.

Projected resource requirements

The estimated resource requirements to generate the base-line data and carry out subsequent monitoring surveys and analysis are listed in Table 6.2.

Table 6.2 Resource requirements

Stage 1 Preparation of base-line data	**Days**
Early warning indicators	
Construction of data analysis protocol for Agricultural Census	5
Construction of data analysis protocol for Satellite Imagery	5
Analysis of Agricultural Census and satellite imagery data	5
Reporting and evaluation	5
Total	**20**
Actual impact indicators	
Checking dataset	20
Sample selection	5
Compilation of site dossier – 25 sites per day	80
Development of recording methodology/database	15
Analysis of Vertical Aerial Photographs – 20 sites per day	100
Field visits of 20 sites - 3 sites per day	7
Statistical analysis	5
Reporting and evaluation	20
Total	**252**
Stage 2: Repeat monitoring survey and analysis	**Days**
Early warning indicators	
Analysis of Agricultural Census and satellite imagery data	5
Reporting and evaluation	5
Total	**10**
Actual impact indicators	
Analysis of Vertical Aerial Photographs – 20 per day	100
Field visits of 125 sites - 3 sites per day	42
Statistical analysis	10
Reporting and evaluation	20
Total	**172**

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APPENDIX 1 MODIFICATION OF THE WAT-HER DATABASE

Introduction

The aim of the exercise was to create, from the combined Regional Historic Environment Records (RHERs) of the Welsh Archaeological Trusts, a single project Historic Environment Record (WAT-HER) database from which a statistically valid sample of site records could be selected for monitoring purposes. Significant stages in this process were the combining of the existing regional databases, the elimination of those site records that were unfit for purpose, the elimination of those types of site that would not be suitable for monitoring, the elimination of those sites falling outside agricultural land, the segregation of the reduced data set into broad categories to facilitate comparisons across the country and the identification of sites located in the five Area Types identified by Hossell *et al* (2007).

The work was undertaken by Chris Martin (Clwyd-Powys Archaeological Trust) and Alice Pyper (Dyfed Archaeological Trust) in January 2008. The data were prepared using Access 97, FoxPro 2.6, MapInfo 7.8 and Excel 2000.

Baseline data collection

Wales' four RHERs had been identified as the primary source of baseline data for this project. These records, which cover the whole country and fulfil a number of public and private functions, are maintained and curated, in close co-operation, by the four Welsh Archaeological Trusts. A combined dataset of the RHERs digital databases had been created prior to this project, in connection with the introduction of new computer software by the Trusts, and this data provided the ideal starting point. This inherited all Wales HER dataset contained 152,098 site records.

Only a limited number of data fields were required and these were assembled, from the related databases of the all Wales HER dataset, into a single flat file to create the WAT-HER database. These fields were:

- Originating HER;
- Primary Record Number;
- Site Name;
- Site Form;
- Site Type;
- Site Period;
- Site Description (expressed as four separate text fields);
- Site Status;
- Site Condition;
- Site Last Visited On;
- Site Last Visited By (organisation and project);
- Original Record Compiler;
- Original Record Compiled On;
- Record Copyright;

- National Grid Reference (expressed as eastings, northings and NGR precision);
- An additional date field Version was added to the reduced database to facilitate version control.

Record elimination

While the all Wales HER data were clearly the best available dataset, it was recognised that a number records did not contain sufficient detail to allow their use in monitoring. The bulk of these records were those with poor locational data (e.g. no valid NGRs, or NGRs of less than 6 figures), those with inadequate or missing site descriptions and those where their recorded data (albeit complete) had not been verified in the field within the recent past. These, together with a number of records missing other data or with errors and discrepancies that could not easily be resolved within the time available, were removed from the database.

A second, larger, number of records removed were those for sites that would not be suitable for monitoring purposes. The bulk of these records were for classes of site, which would not have an identifiable physical presence, such as those known only from documentary sources, or from place name evidence, records of casual finds and those of sites known to have been destroyed.

An attempt was also made to remove occupied buildings. This proved only partially successful, those buildings falling inside settlement limits being somewhat easier to spot, using GIS and database searches, than those in rural contexts. At this stage, and for the same reasons of suitability for monitoring, listed buildings were removed from the database.

These two stages of filtering produced a further reduced WAT-HER database of 70,913 records. However, although reasonably successful, none of the above 'trawls' can guarantee to have eliminated all unsuitable records and it is suspected that given significantly more time this database might have been reduced by at least a further 25%.

Identification of sites on agricultural land

The intention of the project is to design indicators to monitor change in the archaeological resource on agricultural land in Wales and the next stage of filtering was designed to eliminate those sites not on agricultural land. The most comprehensive source of data available showing agricultural land in Wales is the register of IACS (Integrated Administration Control System) data kept by the Welsh Assembly Government as part of its administration of the CAP in Wales. These data are held as a GIS layer in the WAG's Land Parcel Information System and identify every field in Wales registered as being in agricultural use. They therefore exclude non-agricultural land such as woodland, settlements, roads, and other built up areas and domestic curtiledge. Confidentiality issues prevent WAG from releasing these data to third parties, so a copy of the WAT-HER data was given to WAG so it could flag up which records fell within registered agricultural land parcels. This information was then used to remove records that were not located on agricultural land.

It was noted at this stage that the comparison of point GIS data, generated from single eastings and northings in the WAT-HER database, with the polygonal IACS land parcel data had produced some anomalies. As each site in the project database is represented by a single NGR, the chosen co-ordinate for larger sites may not fall within a registered IACS parcel even though much of the site lies on agricultural land. Ideally two sets of polygons should have been compared, one representing land

parcels and the other representing the extent of each site. Unfortunately, with one exception, little or no polygonal data exists for the extents of WAT-HER sites and thus such a comparison is not possible at present. That exception is the recently produced Scheduled Ancient Monument polygons, and as a cross-check all of these areas were compared visually (in MapInfo) with vertical AP and 1:25,000 map coverage of Wales. This exercise recovered a number of these nationally important sites that had the potential to be affected by agriculture but which had been excluded by the totally objective but flawed digital comparison. This filtering resulted in the WAT-HER database being reduced to 41,036 records.

Classification of sites by Area Type and archaeological form

Agricultural land varies in its quality across Wales. These variations lead to significant differences in agricultural regime and it is expected that these differences will lead to differential effects on the historic environment. In order to reflect this in the monitoring sample the WAT-HER records were classified into one of the five Area Types. This was derived from a GIS table, made available through Cadw that defined the five Area Types. The records were distributed as follows:

- LFA-SDA 25,980 sites;
- LFA-DA 6,499 sites;
- North and East Fringe 4,076 sites;
- South 1,894 sites;
- South West 2,587 sites.

In any comparison of sites across the country it is desirable to try to ensure that like is being compared with like. Even within the now much reduced WAT-HER database 1,159 separate site types are represented. Ideally each of these types should be present in the final sample, but to draw a statistically valid sample on this basis, and at the same time ensure an even representation from each of the above areas of agricultural land classification, would result in a unmanageably large number of small populations (1,159 x 5 = 5,795). In order to reduce this figure a broader classification of sites was devised placing each record in one of the following five archaeological form categories:

- Buildings 10,479 sites;
- Other stone structures 10,134 sites;
- Megaliths 1,265 sites;
- Earthworks 13,894 sites;
- No upstanding remains 5,264 sites,

thus creating a more manageable number of sampling populations (5 x 5).

Note on sampling

The final WAT-HER database can now be sampled. Because of the various inadequacies still present in the data, described above, a larger than necessary sample will need to be drawn from it. Each record in this oversized sample will then be examined to check that its data meet the required standard and that it can go forward into the monitoring database.