

The Environmental Archaeology Laboratory

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SEAD - The Strategic Environmental Archaeology Database

Progress Report Spring 2014

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Terminology and abbreviations

API - Application Programming Interface

ECDS - Environment Climate Data Sweden - a Swedish service facilitating the searching, publication and long-term storage of data for research in the fields of environment and climate. <http://www.smhi.se/ecds>

FMIS - RAÄ's Fornminnesregistret, the Swedish sites and monuments record. <http://www.fmis.raa.se/cocoon/fornsok/search.html>

GAL - Geoarkeologiska laboratoriet, Geoarchaeological Laboratory, Swedish National Heritage Board, Uppsala. http://www.arkeologiuv.se/cms/extern/arkeologiuv/tjanster_uv/analyser_uv/geoarkeologi.html

HUMLab - The Humanities Computing Lab at Umeå University. <http://www.humlab.umu.se>

KFL - Keramiska forskningslaboratoriet, Laboratory for Ceramic Research, Department of Geology, Lund University. <http://www.geol.lu.se/kfl/>

K-SAMSÖK - Swedish Open Cultural Heritage; <http://www.ksamsok.se/>

Legacy data - archived analogue or digital data not part of current operations

LOD - Linked Open Data

MAL - Miljöarkeologiska laboratoriet, Environmental Archaeology Lab. Department Historical, Philosophical & Religious Studies, Umeå University. <http://www.idesam.umu.se/english/mal/>

Neotoma - Neotoma Paleoecology Database and Community is an online hub for data, research, education, and discussion about paleoenvironments. <http://www.neotomadb.org/>

RAÄ - The Swedish National Heritage Board <http://www.raa.se/>

SEAD - The Strategic Environmental Archaeology Database, <http://www.sead.se>

SND - Swedish National Data Service

The partners - Organisations represented by the co-applicants of this application: MAL, HUMLab and VDL (see below)

VDL - Nationella laboratoriet för vedanatomi och dendrokronologi, National laboratory for wood anatomy and dendrochronology, Department of Geology, Lund University. <http://www.geol.lu.se/dendro/>

WMS - Web Map Services

1 Description of the infrastructure (Beskrivning av forskningsinfrastrukturen)

This report provides an overview of the progress and results of the VR:KFI infrastructure projects 2007-7494 and (825-)2010-5976. It should be considered as a status report in an on-going long-term research infrastructure development project.

1.1 How the infrastructure fulfils the required criteria (Hur uppfyller infrastrukturen de kriterier som krävs)

1.1.1 Wide national interest (Brett nationellt intresse)

Figure 1.1 shows the distribution of sites currently available through SEAD, divided into the four current main constituent databases. The >2000 mapped points represent the work of over 500 individual environmental archaeologists, palaeoecologists, Quaternary scientists and ceramics experts from almost 100 years of research and consultancy. This represents an unprecedented dataset for Sweden and one of the largest online multi-proxy environmental archaeology records in the world; perhaps second only in scope to Neotoma (within which SEAD is a partner; see 1.2.4) as a research database providing full access raw data.

The currently data have been ingested or entered from four digital and analogue master databases. These are referred to as the constituent databases of SEAD:

- a) BugsCEP, the international database insect ecology and fossil records (Buckland & Buckland 2006).
- b) Geochemistry and physical properties, plant macrofossils and pollen data from Environmental Archaeology Lab (MAL), Umeå.
- c) Ceramic thin section data from the National Laboratory for Ceramic Research (KFL), Lund (see Eriksson & Lindahl 2013).
- d) Dendrochronological results from Småland (test dataset) from the National Laboratory for Dendrochronology, Lund (see Meissner *et al.* 2013)

The latter three laboratories are national resource labs supported by the Swedish Research Council, each with the responsibility for providing access to a number of natural science based methods in archaeology. A large part of the data produced by these facilities has been published in report form, with the raw data not easily accessible. A primary aim of SEAD is to make these (grey literature) data easily available for the research community, online. The combined accessibility of these different types of data, through GIS based and faceted browsing technology will open up new possibilities for regional syntheses and aggregate analyses (Buckland *et al.* 2010). The importance of access to archaeological data, and the cross-linking of different databases for research purposes, was also emphasised by Kristiansen & Buckland, 2007, and is the study of the Swedish Research Council funded project ARKDIS, run by Isto Huvila in Uppsala (<http://www.abm.uu.se/research/Ongoing+Research+Projects/ARKDIS/>).

As yet, the SEAD is too young to have resulted in a significant number of research publications in itself (see section 1.3 for an overview usage statistics and publications). The BugsCEP constituent database (Buckland & Buckland 2006), however, which has been ingested into SEAD since 2009 and represents the largest spread of points on the map, has resulted in at over 110 publications since the year 2000. Considering the broader range of data in the scope of SEAD, and thus greater potential for interest, we expect at least a similar publication pattern to emerge for the system over the coming years.

Although the main interest is from research professionals, there is a growing demand (expressed through contact with the infrastructure staff) from the commercial archaeological community. This group has arguably provided the larger part of the data in SEAD, and should

not be underestimated in terms of its value as a user community and benefit to the research community.

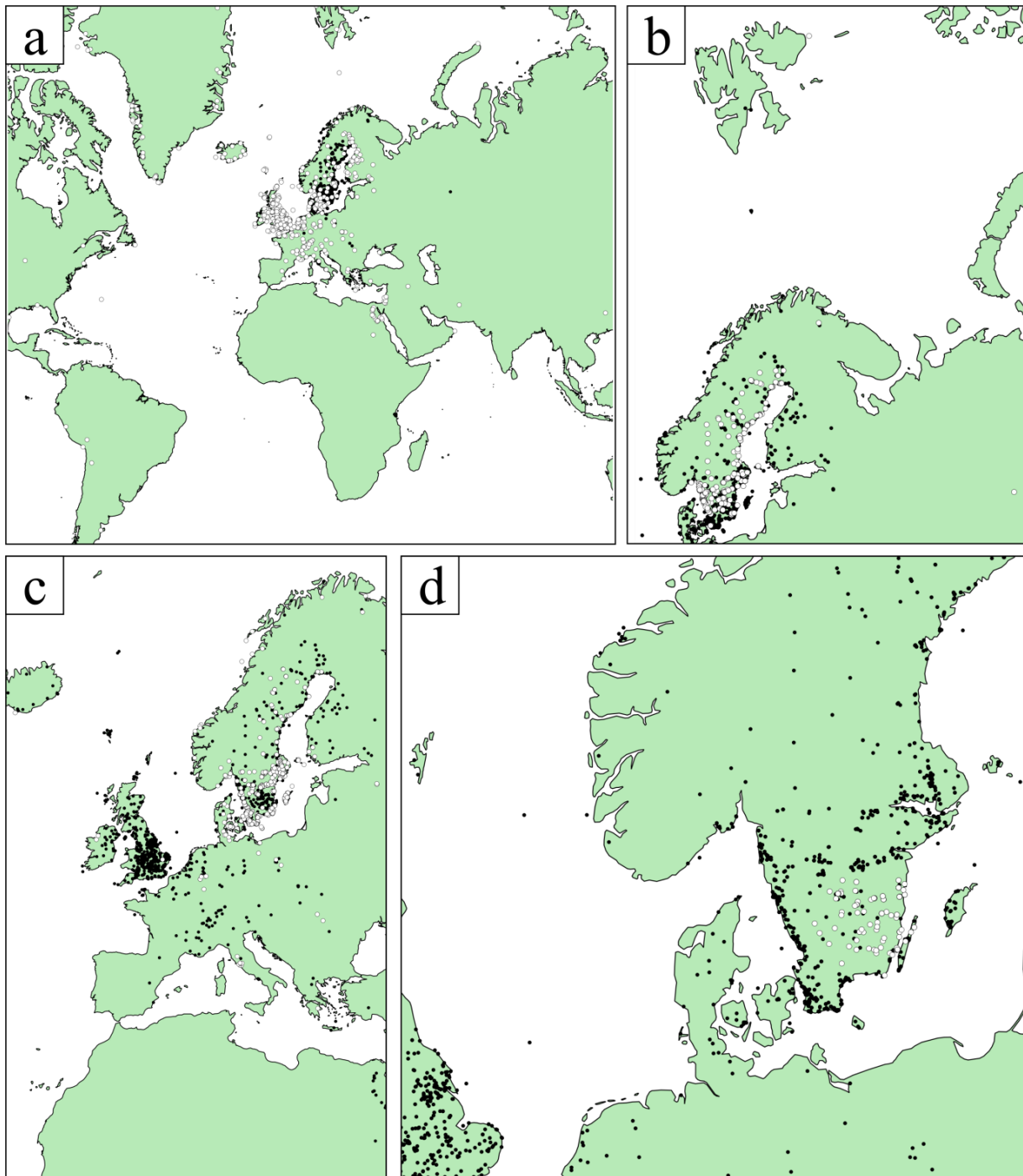


Figure 1.1. Four maps showing the geographical location of sites currently available through SEAD. The **white points** in each map indicate the sites originating from one of the initial four master datasets: a) BugsCEP; b) Environmental Archaeology Lab, Umeå; c) National Laboratory for Ceramic Research, Lund; and d) National Laboratory for Dendrochronology, Lund (Småland test data).

1.1.2 Facilitating world-leading research (Förutsättningar för världsledande forskning)

Access to quality assured data is of key importance in any empirical study. Research databases such as SEAD, where data quality and availability are assured by long term

management and funding are essential for reproducible scientific studies. These data are of critical importance to our understanding of past human societies and their utilisation of the landscape around them, information which in itself can tell us much about the potential for our own time's sustainability in terms of farming, erosion, forestry, water course management and much more. They are also of such a scale, complexity and volume that they can only be comprehensively analysed through the use of databases. The environmental archaeological and palaeoenvironmental data of SEAD are of importance in a number of key areas of science, including:

- i. Long term environmental changes at various scales (e.g. Mitchell 2011)
- ii. Past human and animal living conditions (e.g. Forbes *et al.* 2010)
- iii. Past human activities, ranging from food use (e.g. Murphy *et al.* 2012) to large scale landscape change (e.g. Panagiotakopulu *et al.* 2012)
- iv. Past and contemporary climate change (e.g. Bartlein *et al.* 2010)
- v. Biogeography and extinctions (e.g. Barnosky *et al.* 2011) and mapping past vegetation zones (e.g. Binney *et al.* 2009)
- vi. Forensic science (e.g. Erzinçlioğlu 2000)
- vii. Conservation management and habitat restoration (e.g. Jackson & Hobbs 2009)
- viii. Integrated approaches to environmental reconstruction (e.g. Buckland *et al.* 2010)

SEAD currently includes data useful for the study of all of the above themes and more. With time, and as new datasets are acquired the scale and resolution of the research achievable through the analysis of data in SEAD will increase. Publication statistics from the BugsCEP database (Figure 1.2), suggest a general trend in the use of and citation of databases. These statistics should, however, be considered as minimums due to the poor tradition of citing databases in the research community, especially in the humanities.

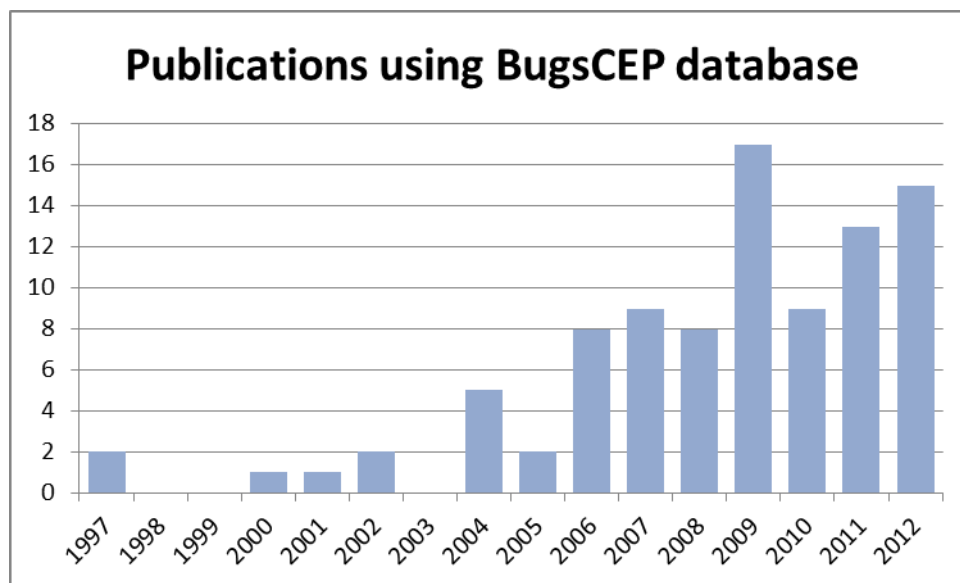


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There is a growing trend in the use of palaeoecological data in empirical studies of ecology (Brewer *et al.* 2012), to explain modern species distributions and test models of migration, and genetic diversification. For example, SEAD can be used to rapidly assess the past occurrence of now extinct species in a geographical area. Buckland & Buckland (2012) did

this recently for the Coleoptera of the UK, the results of which can be mapped (Figure 1.3). Due to the inclusion of ecological coding and modern habitat reference data in the database it is a simple step to then take these results and investigate potential environmental explanations for these extinctions (see figure text; Buckland *et al. in prep.*).

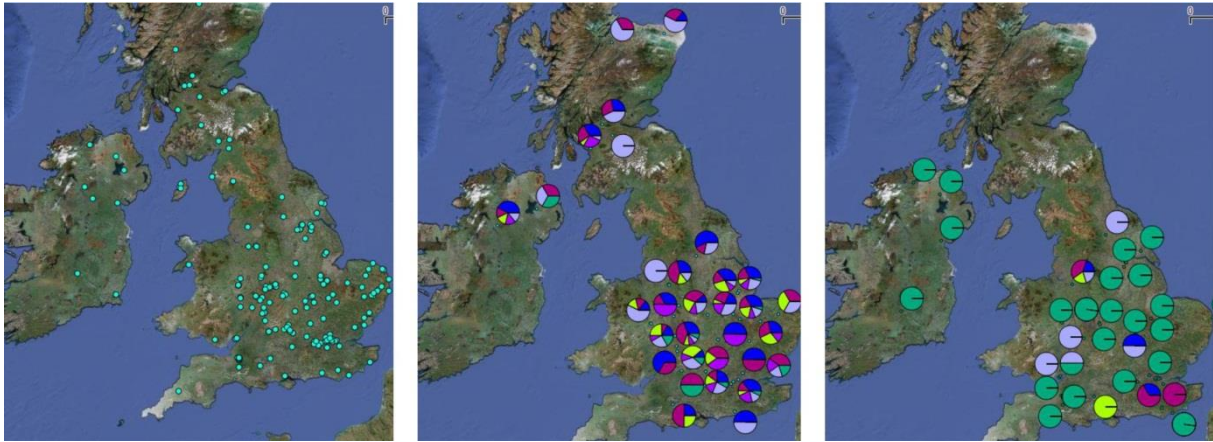


Figure 1.3. Data extracted from SEAD used to study biogeography. The left panel shows sites in the UK where species which are now extinct have been found fossil. The middle panel shows habitat reconstructions for the species which were alive around the last glaciation. The right hand panel shows habitat reconstructions for species which were alive during the mid-Holocene warm period. The reconstruction may suggest that species which were to be found during the mid-Holocene may have been subsequently lost due to loss of woodland habitat (Buckland *et al. in prep.*).

In addition to the direct benefits to research, the system will facilitate more rapid dissemination of results and thus the re-use of data essential for the advancement of science (Wolkovich, 2012). The on-going collaboration with RAÄ (FMIS/K-SAMSÖK) and plans under discussion with SND will ensure that the archaeological community has access to open data, and that the examples above can be complemented with equally useful insights from archaeology (e.g. Beck & Neylon 2012).

The proposed inclusion of dendrochronological data will expand on this research base by facilitating advanced studies into climate, hydrology and pollution (e.g. Klaminder *et al.* 2010). These data will also allow for the spatial and temporal analysis of historic buildings, shipwrecks, archaeological construction timber and the conservation of historic monuments (Meissner *et al.* 2012). Preliminary studies on the more extensive ceramic thin section data show considerable promise for spatiotemporal analyses of source materials, types, manufacturing process and social implications of these (Eriksson & Lindalh 2013).

SEAD also contributes to placing Swedish cultural heritage in a global context, promoting international collaboration, and is a planned partner in current infrastructure and research applications to the National Science Foundation (NSF, USA), Future Earth (ICSU), JPI Cultural Heritage, as well as Swedish financiers. The system is designed to meet standards for public data access as defined by the Swedish Research Council and coordinated by the Swedish National Data Service (SND; <http://snd.gu.se/en>) and Environment Climate Data Sweden (ECDS; <http://www.smhi.se/ecds>), although neither of these systems provide adequate support for the diversity of data and metadata provided through SEAD. The project also integrates with digital humanities networks including DARIAH (especially NeDiMAH and Infoviz, <http://www.nedimah.eu/>) and the recently established ARIADNE (<http://ariadne-infrastructure.eu/>). SEAD's PI's are especially active in the Special Interest Group for Scientific Data within ARIADNE (<http://www.ariadne-infrastructure.eu/Community/Special-Interest-Groups/Scientific-Data>).

By way of its relational architecture and extensive metadata and sample data storage, SEAD is also design to be able to integrate with any forthcoming archaeological excavation databases. It should also, in theory, be easy to link SEAD to an Intrasis site database for the transfer of or cross-correlation of data.

The real power of SEAD has yet to be revealed, but should be anticipated when archaeologists, palaeoecologists and mathematicians team up to dig deep into the data.

1.1.3 Used by several research groups or users with advanced research projects (utnyttjas av ett flertal forskargrupper eller användare med högt kvalificerade forskningsprojekt)

The national research laboratories have an extensive national and international user base as reflected by their respective points on Figure 1.1. These users welcome the development of SEAD and are being encouraged to use it not only for the deposition of data but for advanced research projects. SEAD is still young, and so few large projects have been started where it forms a key role. The recent addition of dendrochronological and ceramics data is anticipated to have an accelerative effect on use. There is, however, a considerable need for more funds for actively marketing the system and supporting new users in terms of data entry, extraction and research use.

Dendrochronological data is of particular interest to a variety of research sectors from forestry to building conservation. Research on the cultural environment of buildings is often of a regional character, with few significant national overviews having been produced since Erixon 1947. SEAD will facilitate new growth in this neglected area of synthesis and research. The database will allow for the mapping, and potentially explanation, of different building traditions, techniques and settlement patterns.

The following research publications have specifically used SEAD in their analyses (see section 1.6 for more publications using the constituent databases, or references to SEAD in other publications):

- Lemdahl, G., Buckland, P. I. & Fischer Mortensen, M. 2014. Lateglacial insect assemblages from the palaeolithic site Slotseng – new evidence concerning climate and environment in SW Denmark. *Quaternary International*.
<http://dx.doi.org/10.1016/j.quaint.2014.01.050>
- Buckland, P. I. 2014. The BugsCEP database -1000 sites and half a million fossils later. *Quaternary International*. <http://dx.doi.org/10.1016/j.quaint.2014.01.030>
- Eriksson, T. & Lindahl, A. 2013 The Handicrafts of Iron Age Pottery in Scandinavia: Regionalities and Traditions. *Lund Archaeological Review* 18 (2012), pp. 45-60
- Buckland, P.I. & Buckland, P.C. 2012. Species found as fossils in Quaternary sediments. In Duff, A.G., Checklist of Beetles of the British Isles, 2nd Edition. A.G. Duff, Wells, Somerset, United Kingdom. pp. 127-130. <http://www.coleopterist.org.uk/>
- Grabowski, R. 2011. Changes in cereal cultivation during the Iron Age in southern Sweden: a compilation and interpretation of the archaeobotanical material. *Vegetation History and Archaeobotany*, 20(5), 479-494. DOI:10.1007/s00334-011-0283-5
- Palm, F. 2009. Abstracting query building for multi-entity faceted browsing. *Lecture Notes in Computer Science*, 2009, Volume 5822/2009, 53-63. DOI:10.1007/978-3-642-04957-6_5
- Vickers, K. & Buckland, P.I. (*accepted*). Predicting island beetle faunas by their climate ranges – the tabula rasa/refugia theory in the North Atlantic. *Journal of Biogeography*.

Buckland, P.I., Buckland, P.C. & Duff, A. (*in prep.*). The environmental implications of Coleoptera once found, but no longer extant in the United Kingdom.

Lemdahl, G, Buckland, PI and Olsson, F. (*in prep.*). Holocene environmental and climate change in the Abisko region as derived from subfossil Coleoptera.

The results of the dendrochronology pilot project are available in:

Meissner, K., Buckland, P.I., Linderson, H. & Hammarlund, D 2012. Pilotprojekt "Dendro-databas" i SEAD April 2012-juni 2012. MAL rapporter nr. 2012-23. Umeå universitet & Lunds universitet. (In Swedish). http://www.sead.se/files/pilotprojekt_dendro_2012.pdf

Ongoing PhD projects in Sweden, Finland and USA are also currently using SEAD in their research.

1.1.4 Too comprehensive to be driven by any one group alone

(Så omfattande att enskilda grupper inte kan driva dem på egen hand)

Data going into SEAD represents a wide area of expertise, covering a number of source materials and fields; including insects, plant remains and seeds, sediments, geochemistry, soil magnetic and physical properties, wood, dendrochronology, ceramics, pollen. Expert knowledge of such a breadth of analysis methods is beyond the scope of any single research group in Sweden, and it would be extremely difficult for any one research group to uphold the academic standards necessary for research level data quality across all of these. Supervision of the entry of specific data types is therefore delegated to the relevant experts outside of the host group (MAL). In this phase of the project, VDL will take responsibility for the dendrochronological data and discussions are underway with KFL to extend the scope of the ceramics data (which currently covers only thin sections). Similar discussions are also underway with other Swedish archaeological research laboratories as well as RAÄ on using SEAD as a national repository and data provider. SEAD and RAÄ have co-hosted a number of workshops and "hacks" with an aim towards promoting this cooperation and involving new partners.

SEAD is also a technical database and software development project, and therefore also a collaboration between MAL and HUMlab. The latter ensures access to the cutting edge of developments in the digital humanities, along with the more practical aspects of access to technology and programmers as required. Such inter-infrastructure collaboration is essential for bootstrapping the advancement of the development and use of infrastructures not only within the humanities, but also originating in the humanities and more broadly used.

Data quality in SEAD is ensured by a set of clearing house officers (see 1.2.5) and a data review process facilitated by the downloadable SEAD application. The software allows for remote management, and although continuity of staff is always favourable for maintaining quality assurance standards, these officers may be inter-changed and spread across the country and world as necessary.

Future plans for the system include active SND and National Heritage Board participation and collaboration workshops and data-hacks having been held in 2012, 2013 and 2014. Both of these organisations are represented on the SEAD reference group. A plan for the incorporation of data from GAL into SEAD will be developed during 2014.

1.1.5 Long-term plan for scientific aims, financing and usage

(Långsiktig planering för vetenskapliga mål, finansiering och utnyttjande)

1.1.5.1 General long-term aims of SEAD

The overall long-term aims of the SEAD project are outlined below. The mechanisms for accomplishing these are outlined here and constitute a baseline funding for the project.

- i. Make raw data and results currently held at the Swedish national archaeological research laboratories (MAL, KFL, VDL) available to the international research community through an online database system. This includes the digitalization of legacy data and the continued entry of new data and full transparency of the analysis chain from raw data to publications.
 - Implemented through the continuous ingestion and entry of both old and new data from the three primary sets of data. Over time, all (as far as possible) legacy data (=old data) at these sites will be published through SEAD. However, new data will be continually inputted as the labs maintain active research portfolios and develop new analysis methods. There will therefore always be the need for an active database maintenance and development team.
- ii. Provide and support interfaces and tools necessary for entering, quality assurance, analysis, advanced and intuitive searching, querying, retrieving and mapping of data related to environmental archaeological and palaeoecological.
 - By continuing to work closely with the domain science community, user needs can be assessed and fulfilled as required through an active development chain. Feedback with the research community will be aided by the information officer and overseen by the SEAD director. It is always advantageous for developers to maintain a working understanding of the scientific implications of the system, and are able to communicate the requirements of the users into working, easy to use software.
- iii. Mediate links with national and international partners (e.g. Neotoma, RAÄ, SND) and networks (e.g. DARIAH, ARIADNE) involved in related infrastructure ventures, and ensure long-term system sustainability.
 - Discussions are underway to ensure the long-term sustainability of the data by relocation of physical storage to SND. There are, however, uncertainties as to the nature of the service provided by SND and as to whether active server hosting can be covered by this. Irrespectively, an active development team will be retained in Umeå to ensure the other aims are met. Members of the SEAD team are actively involved in digital humanities, archaeological and palaeoenvironmental research and infrastructure networks and will continue to promote the system and engage with related projects. SEAD is represented on the Umeå University working groups for research infrastructure at the faculty and university levels.
- iv. Actively engage potential new users and acquire new data to ensure the long-term scientific lifetime of the infrastructure.
 - The SEAD team will actively seek out new data sources to ingest or link to. One advantage of large scale databases is the capacity for overview of the state of knowledge in a field, area or timeframe. SEAD can be used to identify key areas for future data collection. New research avenues may also open up as the result of other research; the need for complementary data collection or analyses. The SEAD project will also be made visible in the research community by continuing to showcasing projects at conferences and publish on the database. This project phase will be complemented by the employment of an information officer to improve the

public relations capacity and ensure continual update of the website. The project is particularly interested in making grey literature (mainly from private or state consultancy work) and its data available to the research community.

- v. Facilitate the flow of information on scientific methods and data in archaeology within and between research, public and private sectors.
 - Providing it lives up to quality assurance standards, data from any source is potentially of value to research. By working closely with the research community and demonstrating the utility of SEAD (conferences, workshops, publications) the information on both scientific methods and their impact on interpretations can be disseminated. Furthermore, the active contributors (KFL, MAL, VDL) all participate actively in archaeological investigations and can therefore feed information back into the archaeological community.

1.1.5.2 Specific short term goals

The specific aims of the SEAD project over the next few years are outlined below, although it should be noted that these aims will be revised as new possibilities and opportunities arise and needs are defined by the user community.

- a. Extend the functionality of software tools as demanded by the user community.
- b. Continue to establish protocols and mechanisms for interacting with related archaeological infrastructures (e.g. FMIS) and palaeoecological databases (e.g. Neotoma).
- c. Investigate the possibilities and mechanisms for integrating with biodiversity databases and portals (e.g. GBIF, LifeWatch).
- d. Target dendrochronological data entry and dissemination (VDL).
- e. Improve information dissemination through the project website and printed information material and database portals (e.g. SND, ECDS). (It should be noted that neither of these portals currently provide an adequate service for disseminating SEAD's comprehensive metadata).
- f. Provide support for existing and new users, including data import collaboration.

1.1.5.3 Long-term financing plan (Långsiktig planering för finansiering)

Note that the SEAD financing plan is currently being revised in discussion with Umeå University central and Arts Faculty management. The SEAD team and reference group are of the opinion that the Swedish Research Council can no longer be considered a reliable source of long-term funding for research infrastructure for the humanities and that additional sources of support must be secured.

Currently, the plan is for long-term financial security to be assured through:

- i. Diversifying the development and maintenance funding portfolio to include sources other than the Swedish Research Council, including internationally.
- ii. Annually auditing the infrastructure's budget (internally) and making revisions as appropriate to ensure the achievement of the scientific aims.
- iii. Preparing renewed RFI and other grant applications in good time before current grant expires and seeking further infrastructure funding from other sources.
- iv. Encouraging external research grants to include their own data digitalisation, archiving and dissemination costs where appropriate (access to SEAD for deposition and retrieval will continue to remain free).

- v. Research staff associated with the database and their organisations will continue to seek involvement in externally funded projects where analysis results will be deposited in SEAD, presenting an example of best practice with respect to research transparency (e.g. the Wallenberg foundation funded MOBIMA research and development project www.idesam.umu.se/english/research/research-projects/mobima--mobile-imaging-in-archaeology/). Research staff associated with the database will, where available, also seek faculty based research resource allocation for financing of research and development connected to the database.
- vi. Striving to retain existing and obtain new users by offering high quality support and efficient and user-friendly software interfaces. Staff will continue to actively participate in conferences to attract new users.

1.1.6 Open and easy to access for researchers, industry and other parties and with a plan for accessibility (Öppna och enkelt tillgängliga för forskare, industri och andra aktörer, ha en plan för tillgängligheten)

The resource is fully open to any interested party and information on its availability is clearly available online. SEAD sets no restrictions on data access, and is a registered research database at ECDS and SND (<http://snd.gu.se/en/catalogue/study/629>; <http://ecds.smhi.se/ecdsportal/srv/en/metadata.show?uuid=2b5a90f9-1530-4b66-a987-27060d9e60ef>), where high level metadata is searchable. The provision of these facilities (SND and ECDS) for comprehensive searching of SEAD's more than 600 metadata types is, however, unavailable and is considered by the SEAD team as being essentially outside of their scope. Further discussions with the repositories and Swedish Research Council are necessary on this front. As a research tool the primary access path for SEAD is through the SEAD website (<http://www.sead.se>) and the online query tool QSEAD (<http://qsead.sead.se>), which provide advanced access to the low level metadata and data. Data entry is accomplished through downloadable software which also allows for simple data browsing, offline working and synchronisation with the public database (via clearing-house). The development team offers ingestion services for larger datasets and constituent databases.

The intention is to increase the scope of access facilities of SEAD by providing access to research reports through the central website and deposited in open access archives for Swedish University publications, DiVA (<http://www.diva-portal.org>).

The SEAD team is actively seeking new datasets to ingest into the database. SEAD can store information on reference collection availability, both modern and experimental result specimens and fossil, processed remains. This facility will provide access to useful information on the location of specimens, as well as increase the accessibility of the specimen repositories themselves (such as MAL's world leading seed and plant macrofossil collection).

In order to ensure longitudinal data access, the potential for SND to provide database hosting is being investigated. SND is also a certified DOI issuer and will provide DOIs at strategic levels in the database (e.g. samples, sites). This will enable the flow of information across different domains and different databases. By attaching DOIs to data stored in SEAD, the data may potentially be more easily aggregated and disseminated by metadata portals such as K-SAMSÖK, SND and ECDS, although all these latter systems currently require comprehensive redevelopment in order to facilitate such functionality for the scope of SEAD's datasets. These portals currently only provide search facilities for high level aggregated metadata. SEAD, by providing a publicly searchable database with domain science specific interfaces and APIs enables additional research using information not available at these higher portal aggregate levels, and it is not anticipated that higher level portals will be able to replicate this functionality within the current scope of their mandates and resources.

1.2 General description of SEAD (Övergripande)

1.2.1 Operational description (Infrastrukturens verksamhet)

SEAD is designed to be an integrated part in the workflow of the environmental archaeologist (or palaeoecologist/Quaternary scientist), as illustrated in Figure 1.4.

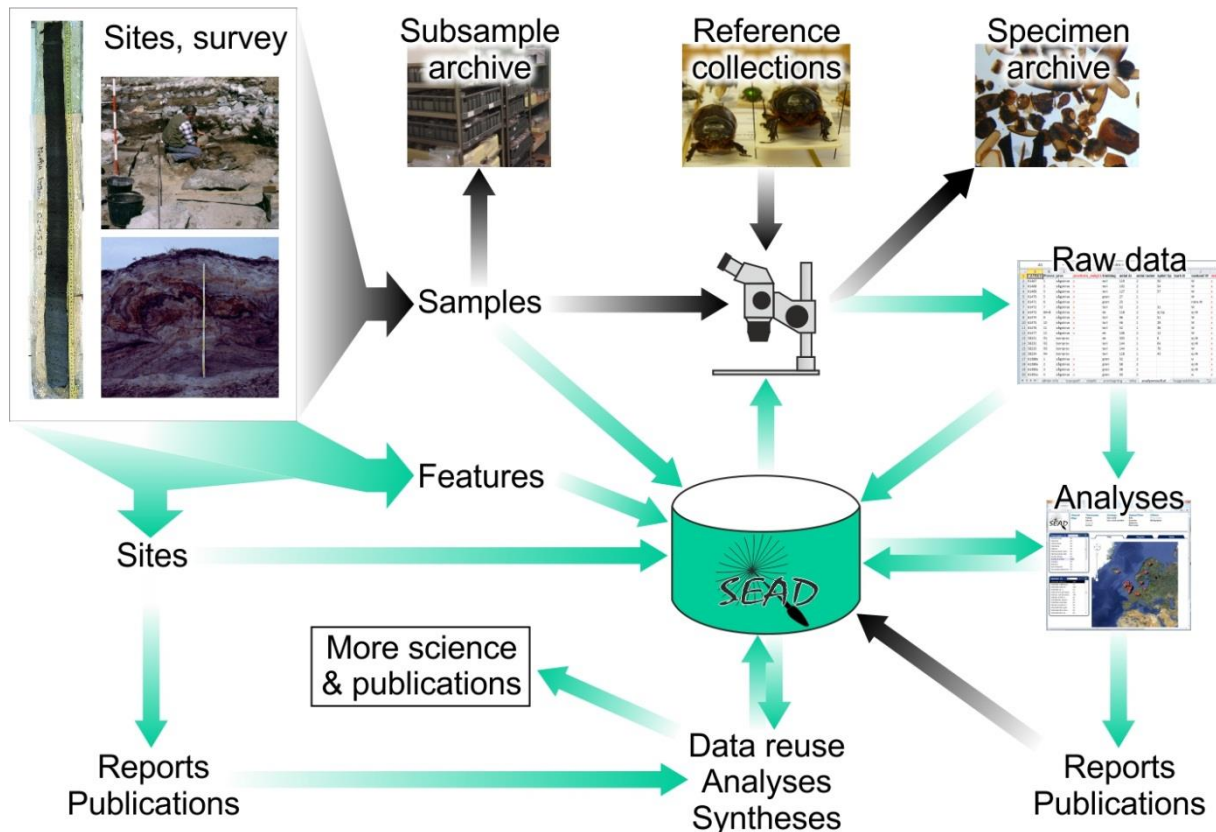


Figure 1.4. How SEAD fits in the archaeological workflow. SEAD provides for the storage of sampling data and metadata, analysis results and reports. It can also provide the user with information of use when identifying or interpreting species, such as habitat information or taxonomic notes. We anticipate that future generations of archaeologists will systematically work with databases in this manner.

Whilst most analysis work is undertaken in labs where internet connection is available, the nature of archaeological work often results in the need for existing offline. In order for the database to be a viable solution for field archaeology, an offline system is therefore available. This enables users to interact with the database without an internet connection facilitating the use of the stored data in the field, and the entry of data to a local copy from remote or ad-hoc field stations. The offline version of the database is synchronized with the public, online version, upon user request, which gives the user a high degree of control for when data is made public. This ensures individual researchers to use the public data, as well as guaranteeing that individual researchers are in control of which data gets submitted. However, each user is encouraged to upload and disseminate as much data as possible.

The infrastructure provides means for users to fulfil open access dissemination requirements as specified by funding agencies such as the Swedish Research Council.

Research orientated online browsing of data, aggregation and data extraction is primarily achieved through the QSEAD faceted web interface. This system is continually updated to improve functionality and visualisation. The example in Figure 1.5 shows part of the investigation process which would help further analyse the results shown in Figure 1.3. In this

case, it shows sites with indications of woodland in their palaeo fauna/flora, but filtered to species classed as currently extinct in the UK. The data can subsequently be downloaded for offline analysis in third party GIS and statistical software, and GIS objects are being integrated in the SEAD API and integration services (WMS, LOD).

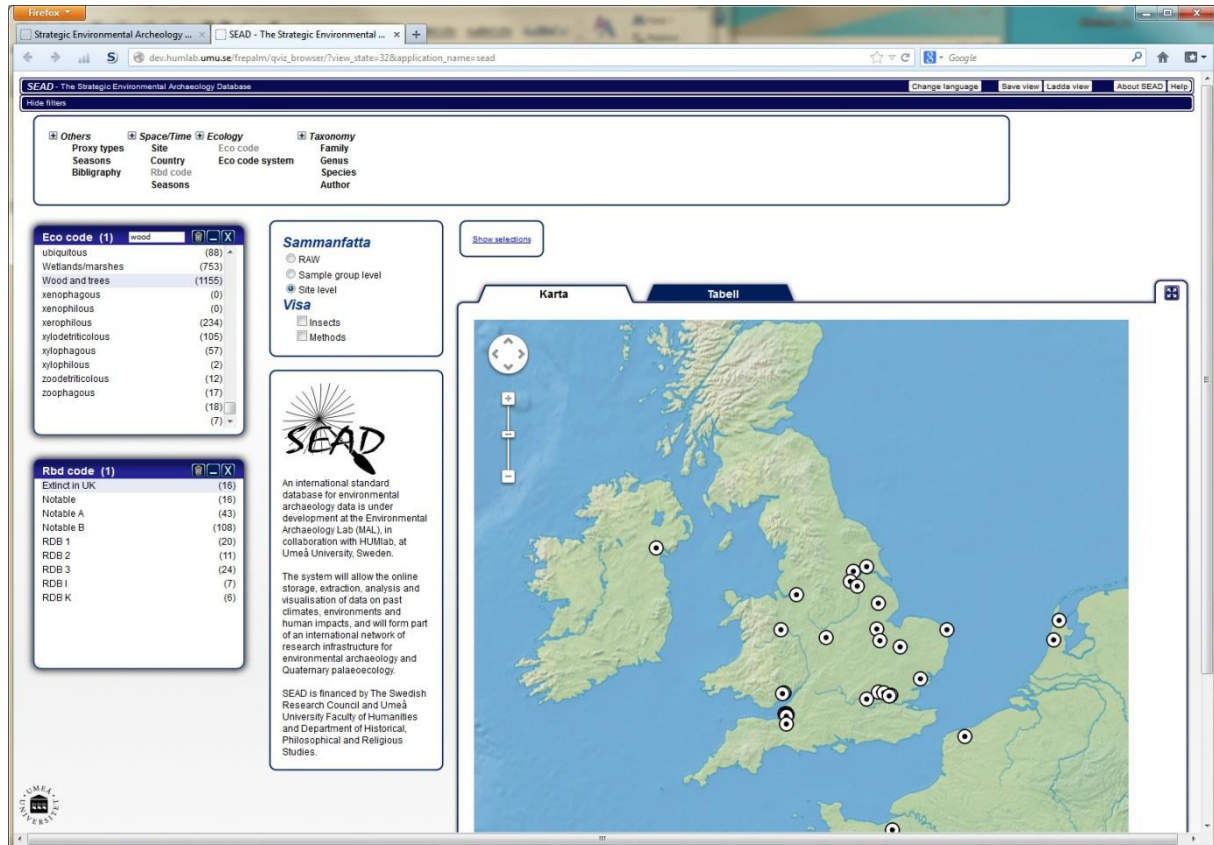


Figure 1.5. The release version of the QSEAD online interface, available at <http://qsead.sead.se/>. This version uses the open source map database from Natural Earth (<http://www.naturalearthdata.com/>) thus avoiding potential trouble with Google maps copyright issues for users wishing to publish maps directly from the system (Google is used in the alternative prototype http://dev.humlab.umu.se/frepalm/sead_demo/).

The offline data entry application is an advanced software suite for entering the full scope of SEAD's data and all associated metadata (Figure 1.6). It allows copy and paste from external applications such as Excel or delimited text files as well as the import of standard some external datasets for palaeoecology (e.g. Tilia XML, BugsCEP XLS). It also includes comprehensive validation functionality for data entry as a stage one quality assurance step prior to clearing house validation.

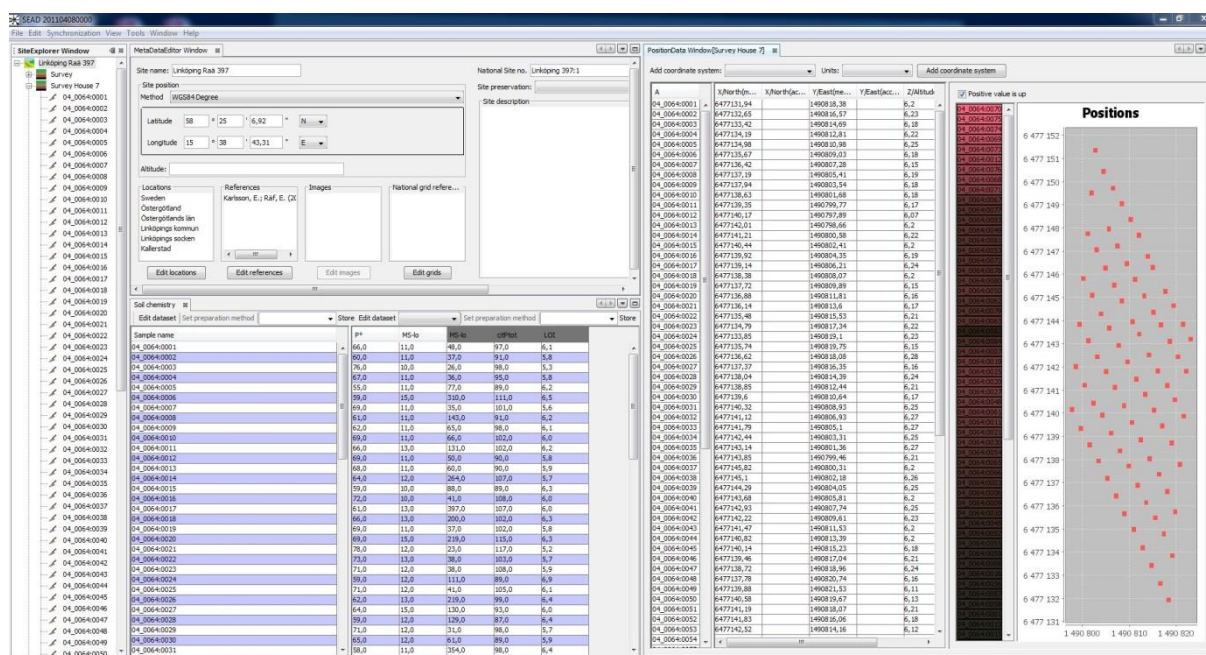


Figure 1.6. The SEAD data entry application, showing several windows open at the same time for the entry of soil chemistry prospection data (note the positions preview map for checking coordinates) and metadata. Datasets can be browsed hierarchically in the tree structure to the left.

1.2.2 Equipment needs for the infrastructure or other relevant existing or planned resources (Behov av utrustning eller andra befintliga eller planerade resurser relevanta för infrastrukturen)

No major purchases are planned for the immediate phase of the database development plan. The existing infrastructures of HUMlab, MAL and VDL provide the framework for the continuation of the project. Standard computers will be purchased to upgrade existing equipment.

Storage facilities for the database may potentially be provided by SND on existing resources for snapshot archival storage, although this is currently being investigated. Live database service will require additional funding and options are being investigated to improve on the current solution using the resources of MAL and HUMlab. The long-term intention is to store all release data on SND server space in addition to maintaining (virtual) development and clearing servers at HUMlab. HUMlab is currently investigating virtual server hosting options for the support of infrastructure development. The migration to SND server space would require some software installation on-site (open source and free of charge) and time invested by SEAD and SND staff. Maintenance costs would be incurred for all partners irrespective of solution.

The domain name sead.se is already registered and renewals are needed throughout the project, in addition to web hosting for the software and website.

Note that investigations on the cost-efficiency of using traditional university based IT-services (ITS in Umeå) rather than HUMlab and in-house (MAL) services indicate that the former is not currently a viable option due to the external consultancy orientated nature of the IT-services.

1.2.3 Scientific life-expectancy and future upgrades to the infrastructure for extending its scientific life-expectancy (Vetenskapliga livslängd)

As an internationally accessible database containing data of high scientific relevance to a wide range of fields, it is unlikely that demand will reduce for SEAD in the foreseeable future. In order to supply this demand two criteria must be met. Firstly, the storage of the database must be long-term. Secondly, maintenance of the infrastructure must be upheld in order to accommodate the changing dynamics of the internet, software and research community.

By using SND as the database main storage point stability is ensured for as long as SND is funded. SND is situated within the technical infrastructure of University of Gothenburg and as such will benefit from first-level security threat aversion, via firewalls. Additional backup is also provided by SND. However, the database integrity must be actively monitored in order to guarantee data integrity, a service not provided by SND and requiring domain science knowledge. By using a set of authorized clearing house officers the most obvious data pollution acts can be minimized.

Given that the infrastructure is available, publicly, online the changing nature of technical solutions to a number of applications must be met through active software maintenance. This type of maintenance includes updates to existing software for errors found, security threats (often unforeseeable) and changes to the availability of technical solutions (mapping systems, internet browsers, supported programming languages, operating system updates, etc.).

New research questions, as formulated by users, may also require software development in order to facilitate data harvesting or entry. The SEAD application is programmed in a manner to reduce the amount of work needed to extend base functionality, and can be considered a platform upon which future developers can expand. The application also comes with its own API that enables external developers a high-level access to both the public and the offline database. The development platform for the SEAD desktop application is the Netbeans (www.netbeans.org) RCP (rich client platform). This platform enables easy functionality extension without impacting on the previous experience. This means that SEAD application development can benefit from previous developments on the Netbeans platform. This means that functionality such as advanced GIS computations, advanced visualisation, 3D rendering etc. can be introduced into the SEAD application without too much work. Furthermore, solutions for tie-ins with existing statistical packages are being investigated in order to benefit from pre-developed and tested mathematical solutions for extending the analytical functionality of SEAD.

For SEAD to remain competitive it must continue to develop, exploring new forms of human-data interaction and visualisation. When academics use software systems they generally prefer it to remain exactly the same for its entire lifespan. Unfortunately this clashes with the software developer ideal of constantly improving systems, which provides for new users and interacts with the changing technology of the time. HUMlab will ensure such needs are catered for by providing further access to programmers and an environment where interfaces can be evaluated. Further options for collaboration with ITS (Umeå) on the *development* level are currently being investigated.

1.2.4 Similar and related infrastructure, and the possibilities for using these (Liknande och relaterade infrastrukturer, nationellt och internationellt, och vilka möjligheter som finns att nyttja dem)

SEAD is unique in scope for Sweden, combining multiple analytical methods with modern reference data for the reconstruction of past habitats and climates. A number of systems internationally cover part of the functionality of SEAD and are described below.

PANGAEA - Publishing Network for Geoscientific & Environmental Data (<http://www.pangaea.de/>). Primarily an archiving service with a strong emphasis on the long term preservation and dissemination of research data and results. It is an Open Access library (<http://www.pangaea.de/about/>) in which data from SEAD may be archived. The system has dataset retrieval facilities but no interactive or advanced (aggregated or interpretation based), multi-site query, analysis or visualisation facilities. It also has not facility for complex archaeological ontological modelling and no capacity for modern ecology and climate reference data.

BugsCEP - The Bugs Coleopteran Ecology Package (<http://www.bugscep.com/>). The BugsCEP dataset has been ingested into SEAD, and parallel ingestion routines have been developed. The system's full, advanced research functionality will be made available through this project with time.

Neotoma - <http://www.neotomadb.org/>. The Neotoma Paleoecology Database and Community is an online hub for data, research, education, and discussion about paleoenvironments. The SEAD team are in active communication with this US lead initiative. There is a degree of overlap between the projects, although Neotoma does not cater for detailed archaeological context mapping or SEAD's habitat and climate reference data. SEAD will be partially mirrored in Neotoma and the two systems will complement each other.

European Pollen Database (EPD) <http://www.europeanpollendatabase.net/>. The European Pollen Database stores fossil pollen data from research investigations within Europe and is supported by the Neotoma platform. The data are primarily from lake and bog profiles, no archaeological or consultancy based data are included. SEAD will not duplicate data found in the EPD, and EPD includes no data found in SEAD. The interconnection of the databases will be explored, most likely using the Neotoma platform. The EPD website includes a variety of interface components for finding, mapping and visualising data.

Archaeological Data Services (ADS). ADS maintains an Environmental Archaeology Bibliography which stores reports on relevant material from the British Isles, maintained by Allan Hall (York, UK) (http://ads.ahds.ac.uk/catalogue/specColl/eab_eh_2004/index.cfm?CFID=4074893&CFTOKEN=18461445). It contains no raw data, although ADS does include a small number of datasets of interest to environmental archaeology. The ADS interfaces are orientated towards the retrieval of archaeological site and report metadata. There are clear collaboration angles between ADS and SEAD which are being explored. ADS is the established authority on archaeological data storage in the UK and a well-respected driving force in Europe; instrumental in the formation of ARIADNE.

The Archaeobotanical Computer Database (ABCD)

<http://www.york.ac.uk/media/archaeology/documents/ABCD-webpage.doc>. The ABCD is an MS Access desktop database of British archaeobotanical records, with no online interface and only a limited, report orientated, data retrieval system. The database is available on request from Allan Hall (York, UK) and discussions have been initiated on collaboration and data cross-querying possibilities with Allan Hall (York, UK). It may be ingested into ADS in the future, but SEAD is also a viable option.

FMIS - RAÄ's Fornminnesregistret, the Swedish sites and monuments record. <http://www.fmis.raa.se/cocoon/fornsok/search.html>. Collaboration is underway for the linking of FMIS and SEAD, as well as investigating the potential for transferring archive responsibility for environmental archaeology data to SEAD at a national level.

GBIF/Lifewatch - international biodiversity database, portal and analysis tools (under development). Inter-database linking options are being investigated as are inter-project tool development possibilities.

DCCD. As opposed to other existing databases designed specifically for online archiving of dendrochronological data, e.g. the Digital Collaboratory for Cultural-Historical Dendrochronology (DCCD; <http://dendro.dans.knaw.nl/>), SEAD is more advanced and multi-faceted system that allows searches targeting even the smallest defined data units. User interfaces specifically designed for this type of data enable surveys and analyses of the material based on a variety of scientific approaches, and multi-proxy analyses allow cross-disciplinary assessments of dendrochronological data in the light of other environmental archaeology data included in SEAD. These new tools will provide the cultural heritage community with opportunities for novel research activities targeting the unique material available at VDL in Lund.

ARIADNE - <http://www.ariadne-infrastructure.eu/> is a European archive integration project in which SEAD is an active development partner and potential data provider. It is not anticipated that ARIADNE will duplicate the functionality and analytical power of SEAD and that involvement in this network may provide useful contacts for the expansion of SEAD's user network.

Others. There are a number of local authority and private company managed regional archaeological databases which contain environmental or palaeoecological data (e.g. Cheshire County Council, UK). The scope of these is currently not known and none of them seem to be easily accessible over the internet. Similar databases exist for ceramics and dendrochronology. It is possible that there are useful data in these that could be made available through SEAD and such options will be investigated over time.

1.2.5 Data management in the infrastructure

(datahantering vid infrastrukturen. Ange vilken typ av data som genereras och hur den tas om hand vid infrastrukturen, inklusive lagring och tillgängliggörande)

SEAD serves as a data management architecture for other projects. It is stored in a PostgreSQL (www.postgresql.org) database, the model managed using MicroOlap (<http://www.microolap.com>). Details of the data model are openly available online at (<http://sead.se/database>).

Currently, SEAD accommodates the data types show in Table 1.1. All data are linked to a bibliography and comprehensive method descriptions are stored, allowing transparency from analysis lab, method and analysis tools through to final publication data. **Over 600 standardised and flexible metadata types and categories are covered by SEAD and over 130 methods and method variations described.** All data are accompanied by comprehensive metadata, biological taxa are defined by taxonomic lists with synonyms where necessary. Ontologies are provided for archaeological, limited geomorphological and other terms data to enable scientifically meaningful searching and data interchange with other systems. All terms are stored in English but Swedish equivalents are being implemented as a result of user requests.

Proxy data sources	
Biological proxies	Raw counts of insects/arthropods, plant macrofossils, pollen, molluscs
Geoarchaeology	Soil chemistry (pH, phosphates) and physical properties (conductivity, organic content, colour)
Ceramics	Thin section quantification and properties (e.g. tempering material, inclusions, firing temperature, vessel characteristics)
Dendrochronology	Dates and support data, tree species, building history, dated object description and location (e.g. church, west tower, third beam from roof)
Dating evidence	
Scope	¹⁴ C and other radiometric methods, dendrochronology, archaeological typology dates, period classifications, calendar dates and ranges, tephras
Chronological extent	Theoretically unlimited, but current range from 2.4 MyBP to present day.
Bibliographic data	
References	May be linked to site, sample group, sample and dataset levels as well as to methods, ecological codes and more.
pdf files	For references where available and not restricted by copyright
Modern reference data	
Abstracted text	Insect habitats and distributions, abstracted from trusted sources, with citations
Coded descriptors or classifications	Insect ecology, in-house system and Koch (1989-1992). Used for quantitative habitat reconstruction/visualisation (Buckland 2007)
Climate	Beetle Mutual Climatic Range (MCR) temperature reference data
Location data	
Coordinates	Three dimensional at site, sample group and sample levels (latitude, longitude, altitude and project survey grids). Capacity for national grid based storage. See section 2.6 and figure 3 for current geographical extent
Depth	Multiple types of depth recorded as positive or negative numbers, e.g. depth from lake/soil surface, depth from datum line or reference level (especially useful for stratigraphic sequences)
Archaeological, geological and sampling data	
Descriptive metadata	Site, feature and sample metadata to allow correlation between environmental and archaeology or lithology datasets. Sample names (e.g. field label, lab number, museum number). Descriptive information for all objects
Sample dimensions	Capacity for multiple measurements (volume, size, weight) at multiple stages of analysis (initial sample, analysed subsample, residue etc.). Position in sample group
Images	Scans, photographs, plans etc. for multiple levels in the site hierarchy and reference data (e.g. seeds, insects) [Yet to be implemented]

Table 1.1. Summary of primary data types facilitated by SEAD. *This is not an exhaustive list.*

SEAD is considering the implementation of storage for multispectral data (e.g. NIR, ICP-MS, XRF; see www.idesam.umu.se/english/research/research-projects/mobima--mobile-imaging-in-archaeology/) and archaeometallurgical data (in discussion with GAL, Uppsala).

The integrity and quality of data is ensured through the use of a clearing house which vets uploaded data before publication (Figure 1.7). Each clearing house officers is a domain scientist employed under shorter periods for the evaluation of submitted data. For example, a palynologist vets pollen data (currently Jan-Erik Wallin, Umeå) whereas a palaeoentomologist vets insect data (currently Paul Buckland, Sheffield). Validation jobs are notified by email, and currently undertaken in the downloadable client software, although this function is to be migrated to online interfaces for greater portability. Ideally, and in order to reduce the management overhead, clearing house officers should also have some experience of either

SEAD, related infrastructures, or working with databases in their research. The clearing house can be seen as a quality control layer between actively interacting participants and the database.

Figure 1.7 illustrates the general data flow model and the clearing house's position in this. The general data flow is as follows:

- 1) Users enter data into their local database.
- 2) Users opt to upload a newly entered dataset.
- 3) A clearing house officer is notified of the newly updated dataset.
- 4) The clearing house office reviews the data uploaded and corrects any obvious errors (linkage to prior uploaded data, such as locations or methods).
 - a) If the clearing house officer has made any changes to the dataset the primary uploader can respond to the changes made. This is enabled through the SEAD data entry interface.
 - b) Each change can be discussed until all issues are resolved between clearing house officer and the primary uploader.
- 5) Once the clearing house process is deemed complete and the dataset is considered acceptable the clearing house officer imports the dataset into the public database.
- 6) The uploading user is notified of the import automatically through the SEAD data entry interface.
- 7) All other users are notified of a change in the public database and the new public data is pushed through to the local databases.

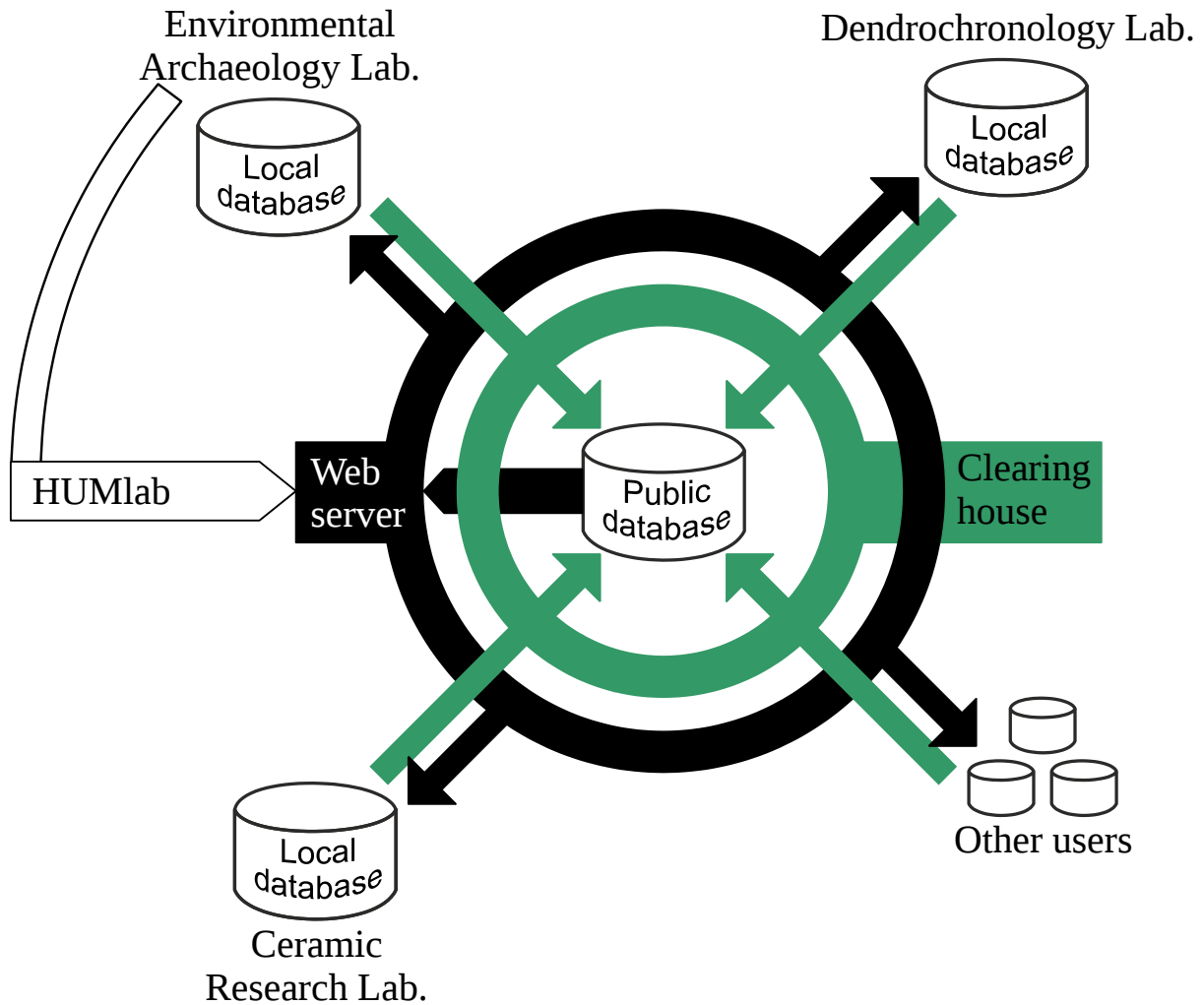


Figure 1.7. SEAD data management process model. Data are entered into local client databases and submitted for publication via the client's synchronisation tool. Clearing house officers are allocated data verification tasks in the platform's administrator interface, and publish to the online database after discussion with the data submitter on eventual problems. HUMlab develops and maintains the web interface (QSEAD).

According to Research council requirements usage of the infrastructure will be maintained. Data contributors are registered and listed by way of the database submissions system. SEAD employs full open access policies and therefore does not maintain individual user data for data retrieval. Academic usage will be monitored through citations and references to SEAD are required by those using the database as a source of information, although experience has shown that this is difficult to enforce.

For web usage only anonymous aggregated access statistics will be provided. If more detailed user information is required, a question can be sent to known and potential users to provide profiling of the user community.

1.2.6 Reference group

SEAD is supported by a scientific and user reference group which provides development feedback and strategy advice on a regular basis. This support is provided by ad-hoc communications, co-participation of conferences, and organised meetings and workshops. The members of the group have varied, but stabilised as listed in Table 1.1.

Name	Institution	Area of expertise
Ulf Jakobsson	SND, Sweden	National infrastructure services
Marcus Smith	RAÄ, Sweden	Cultural heritage databases and Digital Archaeological Processes (DAP)
Daniel Löwenborg	Uppsala University, Sweden	Archaeological data, GIS
Julian Richards (or replacement)	ADS, UK	Archaeological databases, international infrastructures
Paul Buckland	Retired/Private consultant, UK	Environmental archaeology data, insect databases
Eric Grimm	Neotoma, USA	Palaeoecology databases, pollen
Eva Panagiotakopulu	Edinburgh University, UK	Archaeology, insects

Table 1.2. SEAD reference group as of Spring 2014.

Further advice is sought through these contacts and others as required, see the introductory acknowledgements for more information.

1.3 Progress report for existing infrastructure (Rapport för befintlig forskningsinfrastruktur)

1.3.1 Development and utilisation

SEAD is a long term project where the aims must be periodically revised to match user demands. The project therefore now encompasses more data types than originally intended, a benefit to the user community which has required more time invested in development than originally intended. This includes the ingestion of ceramics data and dendrochronological data pilot study. Completed documentation and applications are available through <http://sead.se> an online functionality through <http://qsead.sead.se>.

1.3.2 Progress in relation to previous application (Dnr 2010-5976) and plans

The progress stipulated in the grant given in 2010 (Dnr 2010-5976) included a prioritized list of tasks. A number of these tasks, especially data entry, are continuous. To date, 2013-03-26, this progress can be reported as follows (original priority reported in parenthesis):

- Data entry – biological proxies (1): on-going continuous process
- Data entry – measured (geophysical) proxies (1): on-going continuous process
- Data entry – import of MAL data (1): on-going continuous process
- Database structure – finalized structure (1): completed
- Database structure – support for GIS (1): done for coordinate based data; for polygon and larger geospatial objects, initiated – but down-prioritized; point validation functionality moved from database to SEAD data entry application.
- Documentation – Database documentation (1): completed
- Documentation – Webservices (2): completed for clearing house services, nearing for search functionality
- Documentation – API documentation (1): completed
- Programming – Desktop application browsing (3): completed as part of data entry system, some functionality replaced by web-interface
- Programming – Statistical tools (2): evaluating implementation solutions and seeking international development partners
- Programming – Webservices (2): Browsing: on-going; Synchronization: completed; Downloading: completed
- Programming – module specification and API (1): Phase completed, but user requested additions under development or prototyped

SEAD can be said to be on target as to the realisation of its scientific aims.

1.4 Economic report 2008-2013 (Ekonomisk redovisning 2008-2013)

1.4.1 SEAD 2008-2010

A budget report has been submitted to the Research Council, a copy is included here in Table 1.3.

Bidragmottagarens namn Philip Buckland	Organisation (universitet/högskola/institution/företag) Idé- o samhällsstudier Umeå universitet
Bidragmottagarens adress 901 87 Umeå	Kontraktets/kontraktens beteckningar 825-2007-7494
Kontraktetsbelopp 4 500 000:-	Bidragsperiod fr.o.m. – t.o.m. 2008-01-01--2010-12-31
Bidraget får disponeras t.o.m. (= avstämningdag) 2012-12-31	Redovisningen skall vara finansären tillhanda senast 2013-03-31

OBS! Alla belopp skall avrundas till hela kronor

Löner och arvoden ¹	3 806 127
Resor	94 667
Utrustning ²	10 902
Materiel m m ³	146 866
Övriga kostnader	216 300

Påslag ⁴ (redovisas för bidrag beslutade t.o.m. 2009-12-31)

Indirekta kostnader	108 138
Lokalkostnader	117 000

Summa	4 500 000
Ev överskott ⁵	

Table 1.3. Budget report for SEAD 2008-2010.

1.4.2 Full project costs and co-financing 2008-2013

Over the period 2008-2012 SEAD has been financed according to Table 1.4, including a prognosis for 2013 at the time of conclusion of the VR:RFI grant. Prof. Karin Viklund and Dr. Johan Linderholm have also used faculty resources to contribute to the development of the database, in particular supervising data collation for archaeobotany and geoarchaeology as well as exploring potential research angles. Note that the start-up times for project phases do not coincide with year starts.

	2008	2009	2010	2011	2012	2013
VR SEAD part.1	1029	1165	1107	620		
Idésam co-financing of overheads, part.1	244	281	265	239		
VR SEAD part.2				222	2351	1580
Idésam co-financing of overheads, part.2				29	625	409
Buckland, Quality Based Resource allocation		320		500	360	320
Sum Umeå	1273	1766	1372	1610	3336	2309
Ceramics postdoc, Lund					648	
Dendro pilot project (co-finance)					60	
Total	1273	1766	1372	1610	4044	2309

Table 1.4. SEAD financing history 2008-2012, including 2013 prognosis. Idésam = Department of Historical, Philosophical and Religious Studies at Umeå University. The Quality Based Resource allocation is the Faculty of Art's productivity/quality reward system; this is primarily used for research and development time. All figures in thousands of Swedish kronor.

1.5 Usage data (Redovisa användningen av infrastrukturen)

Access data is currently not retained for the database itself, but may be implemented with the transfer of storage to SND. SEAD website usage statistics show a general trend towards an increased use of the website. However, server issues have impeded an accurate recording of a number of these statistics and alternative analysis methods are being investigated.

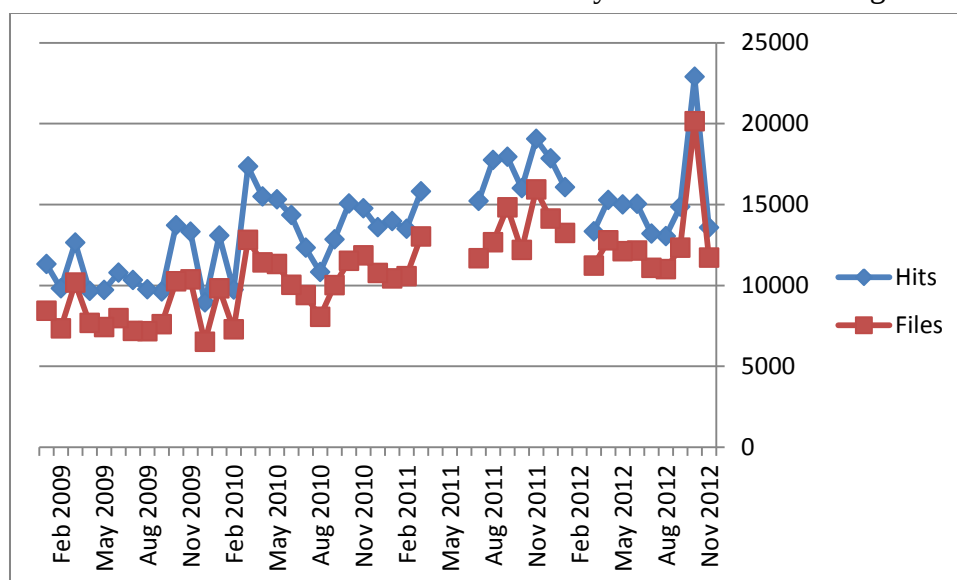


Figure 1.8. Graph of web hits and files for sead.se 2009-2012. Hits are any requests made to the webserver, files are requests which return something to the client, such as a webpage, image etc. (Note that the gaps are the result of a hacking attempt on the webserver and upgrade of servers respectively making later data incomparable).

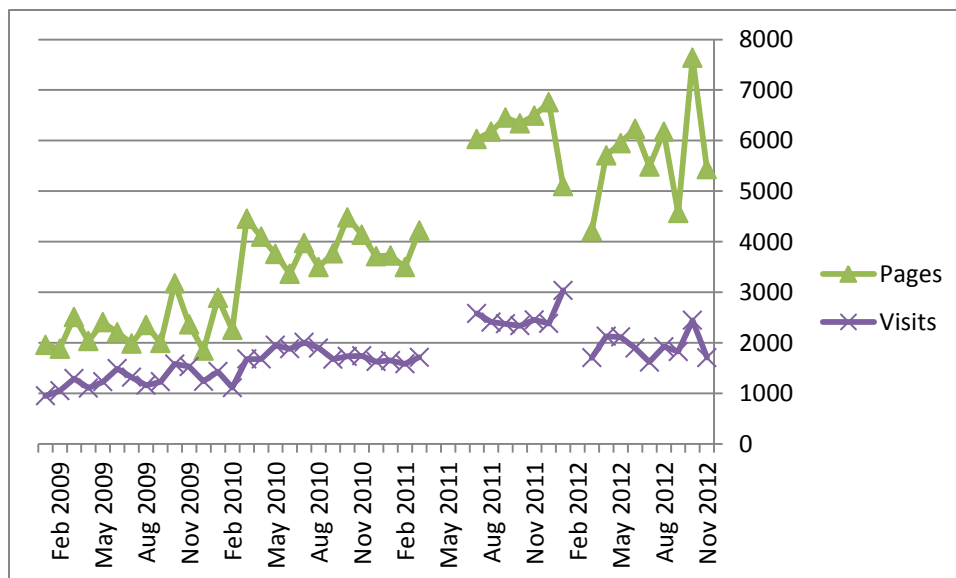


Figure 1.9. Graph of web pages visits for sead.se 2009-2012. Pages are actual webpages, or anything that generates HTML content, and perhaps a more reliable indication of web browsing than hits or files. Visits should be regarded as the minimum number of unique visits to the web pages at sead.se (but excludes direct visits to images and other files)

Statistics for last year show an accelerated growth in access to the site.

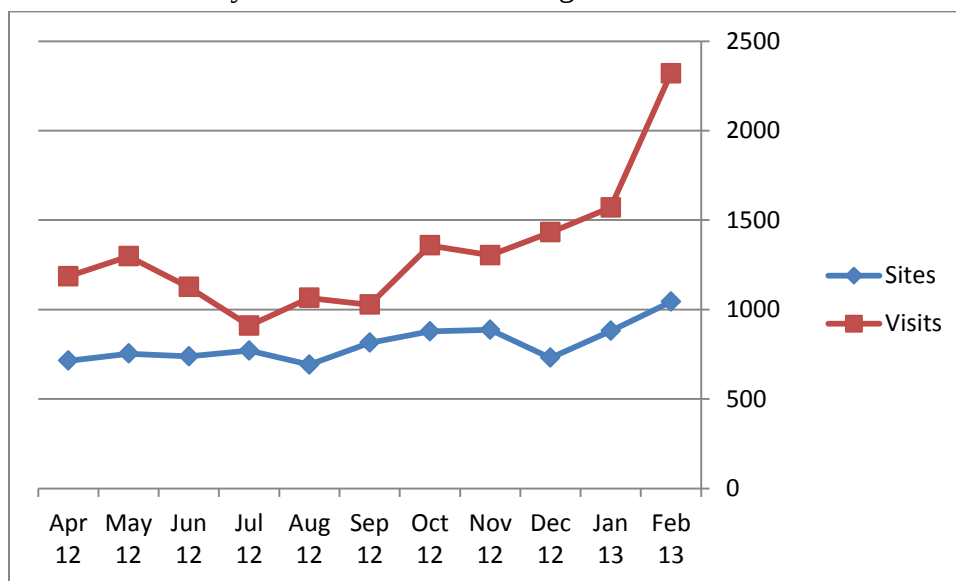


Figure 1.10. Graph of web hits, files and pages for sead.se from April 2012 to February 2013. Hits are any requests made to the webserver, files are requests which return something to the client, such as a webpage, image etc. Pages are actual webpages, or anything that generates HTML content, and perhaps a more reliable indication of web browsing than the other statistics.

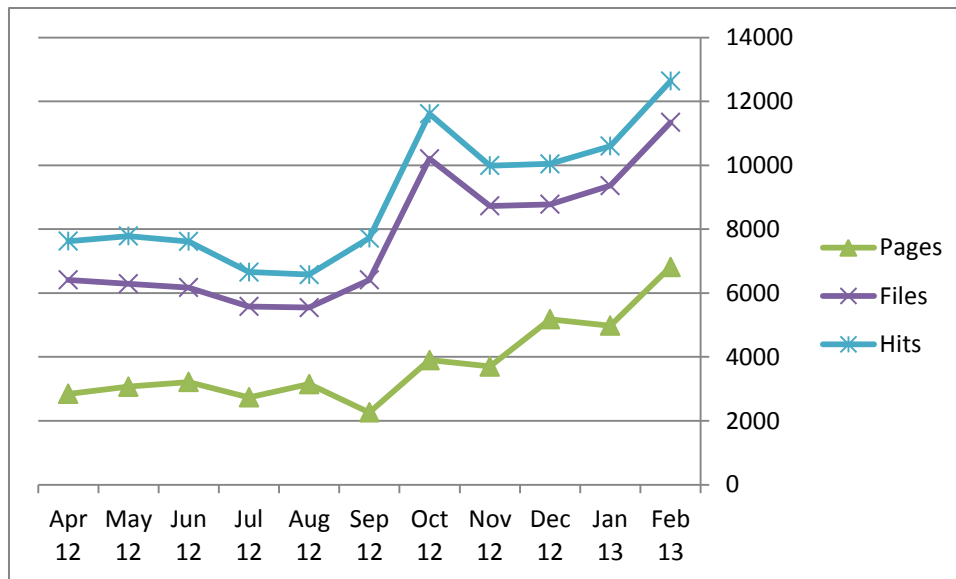


Figure 1.11. Graph of web hits, files and pages for sead.se from April 2012 to February 2013. Hits are any requests made to the webserver, files are requests which return something to the client, such as a webpage, image etc. Pages are actual webpages, or anything that generates HTML content, and perhaps a more reliable indication of web browsing than the other statistics.

1.6 Brief list of research projects where SEAD and its constituent databases have contributed

(Kortfattat ett urval av forskningsprojekt (max 10) till vilka infrastrukturen har bidragit)

1.6.1 Publications about SEAD or its components and constituent databases

- Buckland, P.I. 2010. SEAD - The Strategic Environmental Archaeology Database. An international research cyber-infrastructure for studying past changes in climate, environment and human activities. *Journal of Northern Studies*. No.1 2010.
- Buckland, P.I. 2010. Environmental Archaeology, Climate Change and E-Science. *Skytteanska Samfundets årsbok*, Thule.
- Buckland, P.I. 2011. Freeing information to the people. *International Innovation, EuroFocus*, 2011 Issue 4: Nordic Spotlight, pp. 51-53.
- Buckland, P.I. 2014. SEAD - The Strategic Environmental Archaeology Database. Inter-linking multiproxy environmental data with archaeological investigations and ecology. In: Graeme Earl, Tim Sly, Angeliki Chrysanthi, Patricia Murrieta-Flores, Constantinos Papadopoulos, Iza Romanowska & David Wheatley (Ed.), *CAA2012, Proceedings of the 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA)*, Southampton, England. Amsterdam.
- Buckland, P.I. 2014. The Bugs Coleopteran Ecology Package (BugsCEP) database: 1000 sites and half a million fossils later. *Quaternary International Special Issue: Russell Coope Honourary volume*. <http://dx.doi.org/10.1016/j.quaint.2014.01.030>
- Buckland, P.I., Buckland, P.C. & Olsson, F. (2014). Paleoentomology: Insects and other Arthropods in Environmental Archaeology. In Smith, C., Lanteri, C., Reid, J., Smith, J. & Krauss, T.M. (in press). *The Encyclopedia of Global Archaeology*. Springer.

- Buckland, P.I. & Eriksson, E.J. 2014. Strategic Environmental Archaeology Database (SEAD). In Smith, C., Lanteri, C., Reid, J., Smith, J. & Krauss, T.M. (2014). The Encyclopedia of Global Archaeology. Springer.
- Buckland, P.I., Eriksson, E.J., Linderholm, J., Viklund, K., Engelmark, R., Palm, F., Svensson, P., Buckland, P.C., Panagiotakopulu, E. & Olofsson, J. 2011. Integrating Human Dimensions of Arctic Palaeoenvironmental Science: SEAD - The Strategic Environmental Archaeology Database. *Journal of Archaeological Science*, 38 (2), pp. 345-351. DOI:10.1016/j.jas.2010.09.011
- Buckland, P. I., Olofsson, J. & Engelmark, R. 2006. Planning Report: SEAD. Strategic Environmental Archaeology Database. Environmental Archaeology Lab. Internal Report Nr. 2006-031. Department of Archaeology & Sámi Studies.
- Eriksson, T. & Lindahl, A. 2013 The Handicrafts of Iron Age Pottery in Scandinavia: Regionalities and Traditions. *Lund Archaeological Review* 18 (2012), pp. 45-60
- Meissner, K., Buckland, P.I., Linderson, H. & Hammarlund, D. 2012. Pilotprojekt ”Dendrodatabas” i SEAD April 2012-juni 2012. MAL rapporter nr. 2012-23. Umeå universitet & Lunds universitet. (In Swedish).
- Palm, F. 2009. Abstracting query building for multi-entity faceted browsing. *Lecture Notes in Computer Science*, 2009, Volume 5822/2009, 53-63. DOI:10.1007/978-3-642-04957-6_5

1.6.2 Books, anthologies and encyclopaedias citing SEAD or its constituent databases

- Buckland, P.I. & Buckland, P.C. (2014). BugsCEP, an entomological database twenty-five years on. *Antenna (Journal of the Royal Entomological Society)* 38(1), 21-28.
- Elias, S.A. 2010. Advances in Quaternary Entomology. *Developments in Quaternary Sciences* Volume 12, 2010, Pages 229-234
- Richards, J. D., Niven, K., & Jeffrey, S. 2013. Preserving Our Digital Heritage: Information Systems for Data Management and Preservation. In *Visual Heritage in the Digital Age* (pp. 311-326). Springer London.
- Reitz, Elizabeth J. & Shackley, Myra. 2012. Environmental Archaeology. *Manuals in Archaeological Method, Theory and Technique*. Springer. ISBN: 978-1-4614-3337-8 (Print) 978-1-4614-3339-2 (Online). http://dx.doi.org/10.1007/978-1-4614-3339-2_1

1.6.3 Selected publications specifically utilising SEAD for part of the research

- Buckland, P.I. 2014. The Bugs Coleopteran Ecology Package (BugsCEP) database: 1000 sites and half a million fossils later. *Quaternary International Special Issue: Russell Coope Honourary volume*. <http://dx.doi.org/10.1016/j.quaint.2014.01.030>
- Buckland, P.I. & Buckland, P.C. 2012. Species found as fossils in Quaternary sediments. In Duff, A.G., Checklist of Beetles of the British Isles, 2nd Edition. A.G. Duff, Wells, Somerset, United Kingdom. pp. 127-130. <http://www.coleopterist.org.uk/>
- Buckland, P.I., Buckland, P.C. & Duff, A. (*in prep.*). The environmental implications of Coleoptera once found, but no longer extant in the United Kingdom.
- Eriksson, T. & Lindahl, A. 2013 The Handicrafts of Iron Age Pottery in Scandinavia: Regionalities and Traditions. *Lund Archaeological Review* 18 (2012), pp. 45-60

- Grabowski, R. 2011. Changes in cereal cultivation during the Iron Age in southern Sweden: a compilation and interpretation of the archaeobotanical material. *Vegetation History and Archaeobotany*, 20(5), 479-494. DOI:10.1007/s00334-011-0283-5
- Lemdahl, G, Buckland, P.I and Olsson, F. (*in prep.*). Holocene environmental and climate change in the Abisko region as derived from subfossil Coleoptera.
- Vickers, K. & Buckland, P.I. (*accepted, revisions pending*). Predicting island beetle faunas by their climate ranges – the tabula rasa/refugia theory in the North Atlantic. *Journal of Biogeography*.

1.6.4 Research publications using SEAD or its constituent databases

This section is provided to illustrate the exceptionally wide scope of application of the data in SEAD and its constituent database, a fact which is well illustrated by the broad range of scientific journals and reporting channels through which users and developers have published (Table 1.5).

Journal or magazine	Publishing bodies/agencies
American Association of Petroleum Geologists' Studies in Geology	Bioforsk
Annales Societatis Scientiarum Færoensis	Durham County Council
ANTAEUS	English Heritage
Antenna (Journal of the Royal Entomological Society)	English Nature
Antiquity	Fornleifastofnun Islands (Icelandic Institute of Archaeology)
Archaeologica Islandica	Irish Department of Agriculture, Fisheries and Food
Archaeology and Environment	Irish National Strategic Archaeological Research (INSTAR) Programme
Biodiversity and Conservation	MAL Reports
Biological Invasions	Natural England
Biology & Environment: Proceedings of the Royal Irish Academy	NOAA/NCDC Paleoclimatology Program
Boreas	Oslo University Museum of Cultural Heritage
Britannia	Royal Entomological Society
British Archaeological Reports	Scottish Archaeological Internet Reports
British Wildlife	United States Department of Agriculture Reports
Bulletin of the Entomological Society of Egypt	Vetenskapsrådet (DISC)
Cambridge Archaeological Journal	Scottish Archaeological Research Framework
English Heritage	Society of Antiquaries of Scotland
Entomological Review of Japan	
Entomologist's Monthly Magazine	
Environmental Archaeology	
Forensic Science International	
Freshwater Biology	
Geografiska Annaler: Series A, Physical Geography	
Global Ecology and Biogeography	
Graellsia	
Human Ecology	
	Reference works
	A review of the scarce and threatened Coleoptera of Great Britain
	Checklist of Beetles of the British Isles
	Developments in Quaternary Sciences
	Encyclopedia of Quaternary Science
	Handbook of Environmental Change
	Handbooks for the Identification of British Insects
	Environmental Archaeology. Manuals in Archaeological Method, Theory and Technique

Insect Conservation and Diversity	The Encyclopedia of Global Archaeology
International Innovation	
Journal of Animal Ecology	PhD Theses
Journal of Archaeological Science	C. Schölzel, Bonn, Germany (Natural Sciences)
Journal of Biogeography	G. de Mendoza Barberá, Barcelona, Spain (Ecology)
Journal of Northern Studies	G. King, York, UK (Archaeology)
Journal of Paleolimnology	G.W. Altherr, Basel, Switzerland (Natural Sciences)
Journal of Quaternary Science	N. Brouwers, Bournemouth, UK
Journal of the North Atlantic	P. Buckland, Umeå, Sweden (Environmental Archaeology)
Lecture Notes in Computer Science	R. Grabowski, Umeå, Sweden (Environmental Archaeology)
Lund Archaeological Review	S. Khorasani, Edinburgh, UK (GeoSciences)
Naturwissenschaften	S. M. Norton, Birmingham, UK (Archaeology)
PNAS (Proceedings of the National Academy of Sciences USA)	V. Forbes, Aberdeen, UK (Archaeology)
Polar Research	
Quaternaire (Paris)	
Quaternary Geochronology	
Quaternary International	
Quaternary Proceedings	
Quaternary Science Reviews	
The Coleopterist	
The Holocene	
The Journal of Geology	
The SAA Archaeological Record	
Trends in Ecology & Evolution	
Vegetation History and Archaeobotany	
ZooKeys	

Table 1.5. List of publication channels, agencies and PhD these for research and development using SEAD or one of its constituent databases. Note that this list includes publications using the BugsCEP database (Buckland & Buckland 2006) which has been ingested into SEAD. Conference proceedings have been omitted as they are rather difficult to trace.

As an illustration a bibliography of publications using the BugsCEP/Bugs constituent database, as of 7th May 2014 is provided below. Databases have rarely been cited correctly there are undoubtedly papers missing. Some detective work has been required to establish the use of the database in publications and details of how any paper uses SEAD or Bugs are available on request. Note that the bias towards invertebrates reflects how long data have been available through the Bugs/BugsCEP constituent database (Buckland & Buckland 2006). SEAD has also been used in a number of environmental archaeology analysis reports not listed here.

1. Abellán, P., Benetti, C.J., Angus, R.B. & Ribera, I. 2011. A review of Quaternary range shifts in European aquatic Coleoptera. *Global Ecology and Biogeography*, (Global Ecol. Biogeogr.) (2011) 20, pp 87-100. http://molevol.cmima.csic.es/ribera/pdfs/abellan_etal2010_fossils.pdf
2. Alexander, K. N. A. (2014). A review of the scarce and threatened beetles of Great Britain Buprestidae, Cantharidae, Cleridae, Dasytidae, Drilidae, Lampyridae, Lycidae, Lymexylidae, Malachiidae, Phloiophilidae and Trogossitidae. Species Status No.16. Natural England, Peterborough.
3. Altherr, G.W. 2007. From genes to habitats – effects of urbanisation and urban areas on biodiversity. Inauguraldissertation zur Erlangung der Würde eines Doktors der Philosophie vorgelegt der Philosophisch-

- Naturwissenschaftlichen Fakultät der Universität Basel (PhD Thesis).
http://edoc.unibas.ch/683/1/DissB_8084.pdf
4. J. Arroyo, A. de la Riva-Caballero, J. C. Iturrondobeitia, J. M. Bermúdez de Castro, E. Carbonell, J. L. Arsuaga, C. Díez. 2007. Primera aproximación a la Paleontología de los yacimientos de la Sierra de Atapuerca (Burgos, España): la fauna subfósil de Oribátidos (Acari, Oribatida). *Graellsia*, Vol 63, No 1 (2007):27-34 10.3989/graelisia.2007.v63.i1.77.
<http://graelisia.revistas.csic.es/index.php/graelisia/article/viewArticle/77>
 5. Ashworth, A.C. 2001. Perspectives on Quaternary beetles and climate change. In, L. C. Gerhard, W. E. Harrison & B. M. Hanson (eds.) *Geological perspectives of global climate change*. American Association of Petroleum Geologists' Studies in Geology, 47, 153-168.
 6. Bailey, Greg, Cassie Newland, Anna Nilsson, John Schofield, Steve Davis, and Adrian Myers 2009. Transit, Transition: Excavating J641 VUJ. *Cambridge Archaeological Journal* 19(1):1-27.
 7. M.D. Bateman, P.C. Buckland, B. Chase, C.D. Frederick and G.D. Gaunt, (2008). The Late-Devensian proglacial Lake Humber: new evidence from littoral deposits at Ferrybridge, Yorkshire, England, *Boreas* 37, pp. 195–21
 8. Bain, Allison & King, Gary, 2011. Asylum for Wayward Immigrants: Historic Ports and Colonial Settlements in Northeast North America. *Journal of the North Atlantic* 2011 2 (sp1), 109-124.
<http://www.bioone.org/doi/abs/10.3721/037.004.s101>
 9. M. Bárta, A. Bezděk, 2008 "Beetles and the decline of the Old Kingdom: Climate change in ancient Egypt", in: H. Vymazalová, M. Bárta, eds., *Chronology and Archaeology in Ancient Egypt (The Third Millennium B.C.). Proceedings of the Conference Held in Prague (June 11-14, 2007)*, Prague 2008, 214–222.
 10. Bertran, P., Allenet, G., Fourloubey, C., Leroyer, C., Limondin-Lozouet, N., Maazouzi, Z., ... & Detrain, L. (2009). Paléoenvironnements tardiglaciaires en Aquitaine: la séquence alluviale de la Brunetiere (Bergerac, France). *Quaternaire (Paris)*, 20(2), 161.
 11. Boswijk, G. & Whitehouse, N.J. 2002. Pinus and Prostomis: a dendrochronological and palaeontological study of a mid-Holocene woodland in eastern England. *The Holocene* 12,5 (2002) pp. 585–596. <http://www.ltrr.arizona.edu/webhome/rebecca/Fall2006/Fall%2006/journalClub/Boswijk2002.pdf>
 12. Branch, N. P., Whitaker, J., Matthews, I., Young, D., Pritchard, O., Elias, S., & Denton, K. Examining the relationship between climate change and human activities in the wetlands of Ireland: Annual report; 5th December 2008 Irish National Strategic Archaeological Research (INSTAR) Programme 2008.
http://www.heritagecouncil.ie/fileadmin/user_upload/INSTAR_Database/Climate_Change...Progress_Report_08.pdf
 13. Brewer, S, Jackson, ST, Williams, JW. 2012. Paleoeoinformatics: applying geohistorical data to ecological questions. *Trends in Ecology & Evolution*, 27(2):104-112.
<http://www.sciencedirect.com/science/article/pii/S0169534711002692>
 14. Briant, M. & Bateman, M. 2009. Luminescence dating indicates radiocarbon age underestimation in late Pleistocene fluvial deposits from eastern England. *Journal of Quaternary Science* 24(8) 916–927. DOI: 10.1002/jqs.1258
 15. O'Brien, C., Elliott, L., Cameron, N., Gidney, L. & Davis, S. (2012). O'BRIEN, C., ELLIOTT, L., CAMERON, N., GIDNEY, L. & DAVIS, S. (2012) Plant macrofossils, wood, diatoms, faunal remains and insect analysis. In, P. Arrowsmith & D. Power, *Roman Nantwich: a salt-making settlement. Excavations at Kingsley Fields 2002*, 152-173 + cd appendix.
 16. Brooks, S. J., & Langdon, P. G. (2014). Summer temperature gradients in northwest Europe during the Lateglacial to early Holocene transition (15–8 ka BP) inferred from chironomid assemblages. *Quaternary International*.
 17. Brouwers, N., 2008. *Analysis of the ecological principles underpinning forest landscape restoration: a case study of wood cricket (Nemobius sylvestris) on the Isle of Wight (UK)*. PhD Thesis (PhD). Bournemouth University. http://eprints.bournemouth.ac.uk/10448/1/Brouwers,Niels_Ph.D._2008.pdf
 18. Brouwers, N.C., Newton, A.C. 2009. Movement rates of woodland invertebrates: a systematic review of empirical evidence. *Insect Conserv Divers* 2, 10-22.
 19. Buckland, P. C. 2009. Insect remains. In, C. Allen, *Exchange and ritual at the riverside: Late Bronze Age life in the lower Witham valley at Washingborough, Lincolnshire*, 107-112 + cd tables 5.11 & 5.14. *Pre-Construct Archaeology (Lincoln)*, Monograph Series 1, Lincoln.

20. Buckland, P.C. 2009. Insect remains. P. Daniel (ed.) *Archaeological Excavations at Pode Hole Quarry: Bronze Age occupation of the Cambridgeshire fen-edge*: 102-104. BAR British Series 484. Oxford: Archaeopress
21. Buckland, P.C., Buckland, P.I. & Hughes, D. 2005. Palaeoecological evidence for the Vera hypothesis?. In Hodder, K.H., Bullock, J.M., Buckland, P.C., & Kirby, K.J., Large herbivores in the wildwood and modern naturalistic grazing systems. English Nature Research Reports, No. 648.
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<http://www.antiquity.ac.uk/ProjGall/buckland315/>
23. Buckland P.C., Edwards K.J., Panagiotakopulu E., Schofield J.E. 2009. Palaeoecological and historical evidence for manuring and irrigation at Garðar (Igaliku), Norse Eastern Settlement, Greenland. *Holocene* 19:105–116. doi: 10.1177/0959683608096602. <http://sphol.highwire.org/content/19/1/105.abstract>
24. Buckland, P. C., Hey, D., O'Neill, R., & Tyers, I. The Conisbrough Estate and the southern boundary of Northumbria. Environmental and archaeological evidence from a late sixth/early seventh century structure and a later deer park boundary at Conisbrough, South Yorkshire.
25. Buckland, P. C. & Panagiotakopulu, E. (2010) Reflections on North Atlantic Island Biogeography: a Quaternary entomological view. In, S.-A. Bengtson, P. Buckland, P. H. Enckell & A. M. Fosaa (eds.) *Dorete – her book:– being a tribute to Dorete Bloch and to Faroese nature*. *Annales Societatis Scientiarum Faeroensis Supplementum* 52, 187-215. Faroe University Press.
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http://bugscep.com/phil/publications/bucklandetal2004_antaeus.pdf
27. Buckland, P.C., Panagiotakopulu, E. & Buckland, P.I. (2004). "What's eating Halvdan the Black? Fossil insects and the study of a burial mound in its landscape context". In J. Henning Larsen & P. Rolfsen (eds), *Halvdanshaugen – arkeologi, historie og naturvetenskap*. University Museum of Cultural Heritage, Occasional papers 3. Oslo University. http://bugscep.com/phil/publications/bucklandetal2004_halvdan.pdf
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31. Buckland, P.I. (2007). "The Development and Implementation of Software for Palaeoenvironmental and Palaeoclimatological Research: The Bugs Coleopteran Ecology Package (BugsCEP)". PhD thesis, Environmental Archaeology Lab. Department of Archaeology & Sámi Studies. University of Umeå, Sweden. *Archaeology and Environment* 23, 236 pp + CD. URL: <http://www.diva-portal.org/umu/abstract.xsql?dbid=1105>
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<https://www.researchgate.net/publication/261297772...> or <http://umu.diva-portal.org/smash/record.jsf?pid=diva2:709837>
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37. Buckland, P.I. 2010. "Environmental Archaeology, Climate Change and E-Science". Skytteanska Samfundets Årsbok, Thule. http://bugscep.com/phil/publications/buckland2010_thule.pdf
38. Buckland, P.I. (2011). **Freeing information to the people**. *International Innovation*, EuroFocus, 2011 Issue 4: Nordic Spotlight, pp. 51-53. Download here, or [see the whole issue here](#)
39. Buckland, P.I. (2014). The Bugs Coleopteran Ecology Package (BugsCEP) database: 1000 sites and half a million fossils later. *Quaternary International*. <http://dx.doi.org/10.1016/j.quaint.2014.01.030>
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1.6.5 Conference/workshop presentations about SEAD and its projects

- 2014 ArkHack 2014, Humlab-X, Umeå, Umeå University, Sweden.
- 2014 SEAD, SND, RAÄ, workshop on research infrastructures for cultural heritage. Umeå University, Sweden.
- 2013 Sorting the Digital Humanities out (Workshop), HUMlab, Umeå University, Sweden.
- 2013 Computer Applications in Archaeology Sweden (CAA-SE), Lund University. Joint presentation with Swedish National Heritage Board (RAÄ).
- 2013 Boundaries in Pre-modern Studies, Umeå university, Sweden.
- 2013 Global Human Econdynamic Alliance (GHEA) Open Workshop, University of Maryland, USA. Invited speaker.
- 2013 Workshop on e-Infrastructure, Swedish Research Council, Stockholm, Sweden.
- 2013 ArchHack, Swedish National Heritage Board (RAÄ), Visby, Gotland, Sweden.
- 2012 Workshop Databasutveckling: dataflöden, visualisering. MAL/HUMlab, Umeå.
- 2012 Workshop digitala databaser inom arkeologin RAÄ och CAA-SE, SHM/RAÄ Stockholm
- 2012 Russell Coope Memorial Lectures. Royal Holloway, University of London, UK.
- 2012 Nordic Archaeobotanical Group meeting. Bergen, Norway.
- 2012 CAA, Computer Applications in Archaeology. Southampton, UK.
- 2012 September, Workshop at ECDS on invitation by Cecilia Bennet at SMHI (ECDS-host).
- 2011 DARIAH Nedimah (InfoViz) workshop: Reading and thinking with visual tools and methods in digital humanities, Umeå, Sweden.
- 2011 CAA-SE, Computer Applications in Archaeology, Uppsala, Sweden.
- 2011 Nordic Archaeobotanical Group meeting, Vadstena, Sweden.
- 2011 Society of American Archaeologists 76th Annual Meeting, Sacramento, California, USA. Archaeological Cartographies Symposium.
- 2011 GIS & Landskap Seminarium, Uppsala, Sweden.
- 2011 GIS-data workshop, National Heritage Board (RAÄ).
- 2010 Workshop: Launching Phase 2 of the Neotoma Paleocommunity Database”, Madison, Wisconsin, USA.
- 2010 Research workshop visit to Penn State University, State College, Pennsylvania, USA. Visit to Department of Geosciences, Earth and Mineral Sciences Museum and Art Gallery, The Center for Environmental Informatics, The Visualization Group, Research Computing and Cyberinfrastructure Unit.

- 2009 The development of analysis and visualisation tools for database orientated environmental archaeological, palaeoenvironmental and palaeoclimatic studies - workshop, Umeå, Sweden.
- 2009 QRA Annual Discussion Meeting: The human dimension in rapid environmental change, University of Oxford, UK.
- 2009 8th International Conference on Flexible Query Answering System, Berlin.
- 2008 Human Dimensions in the Circumpolar Arctic, IPY conference, Umeå, Sweden.

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