

Conservation Science in Context



Review of Strategic Reviews relating to Conservation Science

Report to the ICCROM Forum working Group 2

July 18, 2013

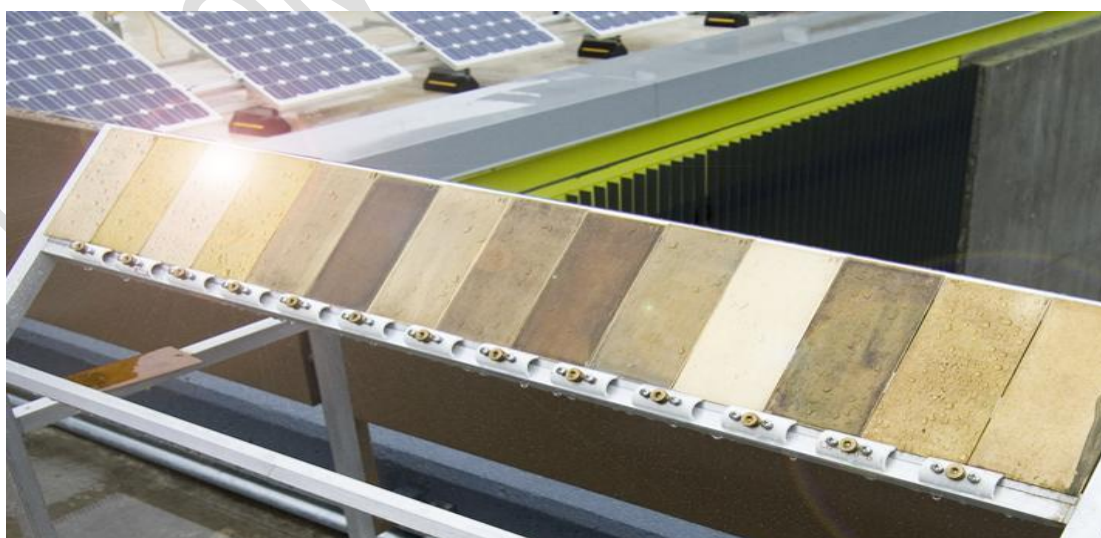


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Executive summary

Pre-ample

For decades conservation of cultural heritage was focused on the maintenance of an acceptable condition of cultural heritage, which was thought to be of value. Within the field of conservation craftsmanship evolved to into a science of conservation with a strong focus on material research.

Material scientists in cooperation with restorers and curators took up this challenge and a relatively new academic specialisation came into existence: conservation science. At present, conservation science is strongly alive, but not yet everywhere an established and well recognised science embedded in the academic curricula.

Society has also changed, but conservation of cultural heritage is still important or even more important in an ever changing world with less clear national identities. At present the conservation professional is faced by new societal needs and expectations. This is combined with new technological opportunities. Conservation has to take into account issues ranging from climate change impact, resilience to earthquakes, visitor impact, risk analysis, material decay and a huge demand for more accessibility to our common heritage and socio-economic accountability. So conservation these days is pretty complex and challenging.

ICCROM has taken up this challenge, in cooperation with some national partners, by setting up an Forum dedicated to conservation science. This forum will provide strategic orientations for future planning and policy making, create leverage for research funding and new collaborative ventures, promote greater inclusivity and ensure more effective integration between sciences and between science and practice. In this way conservation science can maintain its licence to operate in a changing socio-economic environment.

In order to collect evidence for trends with relevance to conservation science, this report reviews various previous strategic studies relating to conservation science from both national groups (8) as well as from some European networks (3). Relevant information from these strategies is being assessed, synthesized with special attention to wider societal priorities, such as sustainability.

Findings

The wide variety of strategic documents examined made a first step necessary of developing a template with some kind of standardisation, thus making a comparison across the very different types of strategies possible. The next step was the definition of categories which linked to the issues brought forward by the preparatory working group of the ICCROM-forum. Based on this quick scan method, several recommendations can be proposed, although the representativeness of the examined strategies is limited and the implementation will be highly dependent on the national or regional context.

This review shows that enhanced cooperation within the field of cultural heritage is already resulting in a better visibility and a stronger advocacy on the importance of conservation science there in. These cooperative networks should open up to a broad group of professionals, including scientists as well as practitioners and link these to colleagues abroad building strong international networks. New media and technologies can improve further the visibility and accessibility of the work and significance of conservation scientists and the cultural heritage they are inspired by.

The already mentioned networking results in a stronger binding between all stakeholders involved, but even more these networks have produced very clear strategic research agendas. These strategic

research agendas take also into account societal and economic needs, needs from related professional fields like the construction and technology branches in which conservation science can take up a n important role, a clear definition of conservation knowledge deficiencies and future capacity building.

The research themes range from material research such as characterisation of materials with special focus on modern materials and composites, their behaviour to different environmental impacts and their decay and aging processes, also on the development or adaptation of more accurate analysis and monitoring technologies with a better spatial resolution and preferably non-invasive, portable and remote controlled. But also the research on risk-analysis in the conservation and management of cultural heritage is often mentioned and some other cross-related themes form ICT, economic and social sciences.

Also the long term monitoring of the effectiveness of earlier conservation and consequences of slow environmental impact are being mentioned as important new research themes. Over all these strategic research agendas point to an broader orientation from conservation (purely)science themes to more general research themes.

In order to live up to these new evolving needs for conservation research it is important to invest in capacity building of heritage professionals, who can attribute to the above stated research objectives. However, this review did not allow for a thorough investigation of educational infrastructures at national, European or even a global scale. This subject deserves more attention and future reviews on education and capacity building should take into account the specificity of national and regional contexts.

Another prerequisite for successfully taking up the challenges posed by our present day society on the conservation and management of cultural heritage and the role conservation science or research can play there in, is sufficient funding. This report does not present an overview of funding opportunities for the different countries and networks included, but it shows clearly that the conservation professional is well aware of limited research budgets, and is capable, often in cooperative networks, to prioritise across the possible conservation research themes, to contribute through research efforts to the benefit of our society.



Introduction

ICCROM Forum

In the fall of 2013, ICCROM organizes a Forum on conservation science. ICCROM is the intergovernmental organization uniting countries and professionals actively involved in the conservation of cultural heritage. As such ICCROM can act as an engine and catalyst within the field by developing, discussing, promoting and disseminating the newest ideas and ways to advance the practice and serve its constituency.

The ICCROM Forum on conservation science will serve as a platform for scientists and other conservation professionals to discuss the role of science in conservation, its strengths and weaknesses, and future opportunities and threats. It will also explore the benefits of improving communication, scientific and conservation literacy, and interdisciplinary research in conservation, and ways to promote them.

The Forum will provide strategic orientations for future planning and policy making, create leverage for research funding and new collaborative ventures, promote greater inclusivity and ensure effective integration between science and practice, which is important in a time of limited resources.



In order to collect evidence for trends with relevance to conservation science, the ICCROM Forum Working Group 2 issued a Review on Previous Strategic Reviews relating to Conservation Science. The purpose of this review is to synthesize relevant information from the existing strategic reviews of the conservation field and to make a qualitative assessment of the strengths of the various reviews.

The outcome of this review should give special emphasis to the theme of the ICCROM Forum, namely “The relevance and impact of conservation science to the conservation of cultural heritage and to wider societal priorities. Moreover, it includes

information on the relevance of conservation to conservations needs, ways in which conservation science is incorporated in training and how conservation science impacts conservation practice.

In recommendations the future benefits of conservation science for cultural heritage conservation will be addressed, themes or strategic orientations for future conservation research and ways in which conservation science can contribute to sustainability issues both within and beyond the cultural sector.

For this review the following definition of Conservation science has been used:

Conservation science is the application of science and technology to the conservation of cultural heritage.

In this review over a decade of strategies have been surveyed originating from eight countries and covering a wide range of heritage research and related activities in different languages. Also several strategies from European networks have been taken into account. From the 40 documents 14 “national” strategies have been selected to be included in the research (see list relevant strategic reviews) and 3 strategies from the European networks (see appendices B and C).

The strategies examined do not represent a global overview, since it appeared to be difficult within the time available to get hold of recent strategies from South America and Africa.

From South America several documents on museum policy and strategic action plans from internet sites have been consulted, but since the information sought was spread over so many different institutions and strategic plans, I have decided not to include them in this survey. Moreover, the here presented ones can form a basis to build upon further. At a later stage I included some findings from the website of the Korean National Research Institute of cultural Heritage (NRICH).

Methodological aspects

In order to make comparison possible across the very different types of strategies examined and the ways these strategies describe objectives and research themes, the development of a template with some kind of standardisation was an absolute necessity.

For this, classes and categories were established which were linked to the requirements as stated in the Terms of Reference set up by the preparatory working group 2 of the ICCROM Forum in February 2013. These requirements itself cover a wide range of subjects such as:

- Who commissioned the strategy?
- Why was the review/strategy undertaken?
- What were the aims of the strategy?
- What are the implications of the strategy?
- Which aspects do they cover?
- What methodologies were used to come up to the final strategic documents?
- What is the scale for which the strategy has relevance?
- What is the relation of the review to its context?
- How is dealt with societal priorities?
- How do these strategies deal with very specific themes, such as:
 - Implications of conservation science on conservation practice
 - Incorporation of conservation science in current training
 - Future conservation research themes
 - Ways in which conservation science can contribute to sustainability issues

The examined strategies had all very different ways to describe, define or address these themes if they did address them at all. The first step therefore was to find out which more or less comparable issues were being addressed and how these were being linked to the requirements.

Furthermore, to make a qualitative comparison across the different strategies possible some kind of weighing had to be complemented on to the observation whether a certain issue was being addressed or not. When addressed the subject was given a value of 1, when the subject was not addressed it was given the value 0. In addition, more detail could be added by giving values between 0 and 1, when the issue was mentioned, but not elaborated upon.

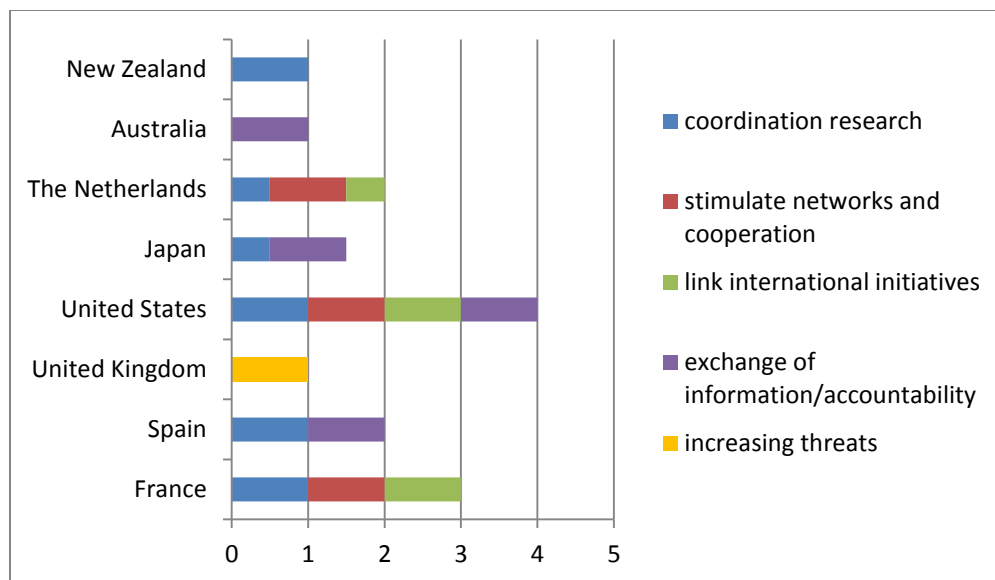
For example several strategies mention the importance of conservation of cultural heritage for the benefit of society, but did not give a elaboration with show cases. In this case the value of 0.5 was given onto the account to which this subject was being addressed.

Another example was the strategic orientations of future research in conservation. Sometimes environmental impact on cultural heritage was being mentioned, but no research questions were being stated. Values between 0.2 and 0.4 were given to this, depending on the degree of vagueness of the research objectives. The vaguer the research objectives, the lower the given value.

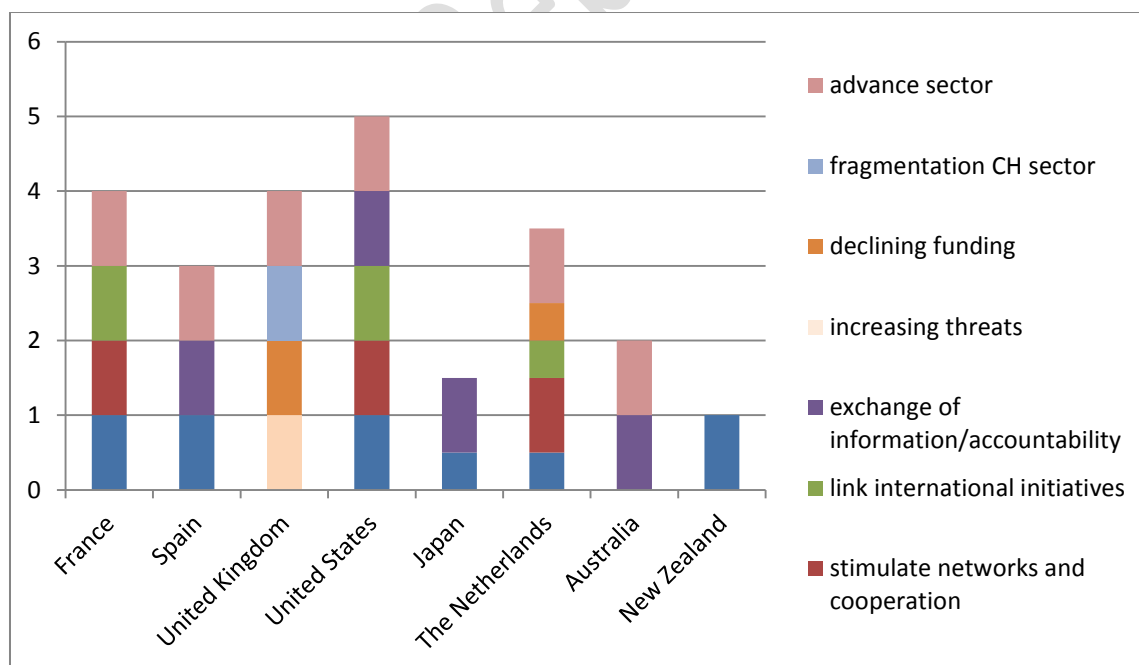
This methodology has of course its limitations and is by no means a perfect scientific approach. However, it allows for an initial comparison across the different strategies “at a glance”.

Characterisation of the selected and examined strategic documents

A close look at the different national strategies reveals that the majority was initiated by the Ministry of Culture and also that often the opinion of professionals from the conservation sector was sought or even they actively participated in the conception of the strategy.



The graph above shows for the selected national strategies, why these were undertaken in the first place. Most of these strategies are a follow-up of a new law (Australia, Japan) a political advocacy (House of Lords; United Kingdom), new organisation of the involved ministries (New-Zealand) or a continuation or update of a cycle of agenda making and reporting on future and past research efforts (Spain and France). Often the completion of these strategies have taken more than a year.

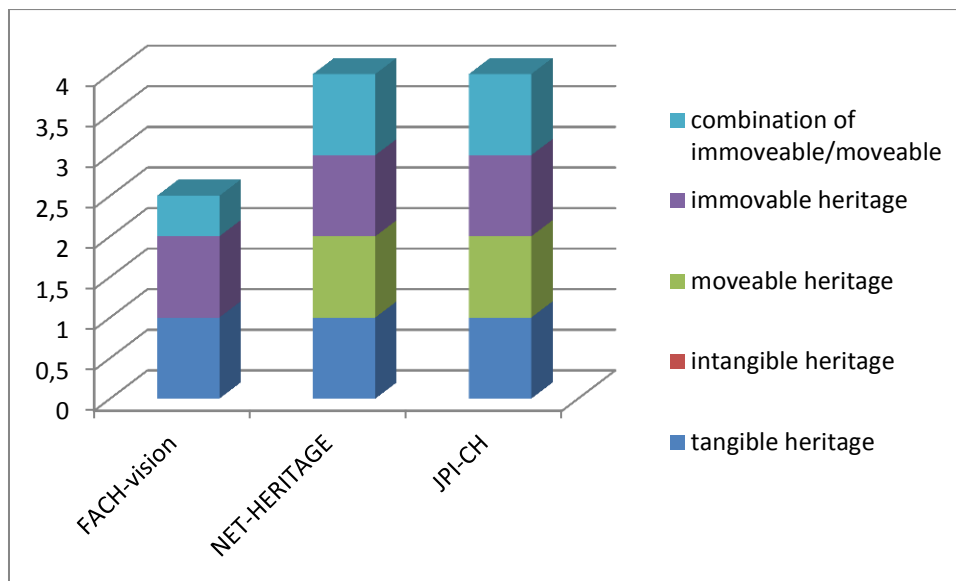


In the graph above, different reasons are mentioned for the publication of a strategy on science in the field of cultural heritage. Most strategies aim for the advance of the field of cultural heritage.

The selected strategies are often not purely concentrated on conservation or heritage science, but often cover the larger context of cultural or historical heritage. Therefore, not only research plans are presented, but these strategies are often an advocacy for the importance of cultural heritage for our national identities.

The three strategic documents from the EU networks, Fach Vision of the European Construction Technology Platform (ESTP), NET-HERITAGE and its follow-up the Joint Programming Initiative on Cultural Heritage (JPI-CH) give a very good overview of state of the art heritage research and its future challenges. None of those include intangible heritage, but although FACH vision is concentrated on the construction industry, it makes some cross-overs to moveable heritage.

All three address sustainability issues and even climate change. Also societal aspects are seen as of importance.



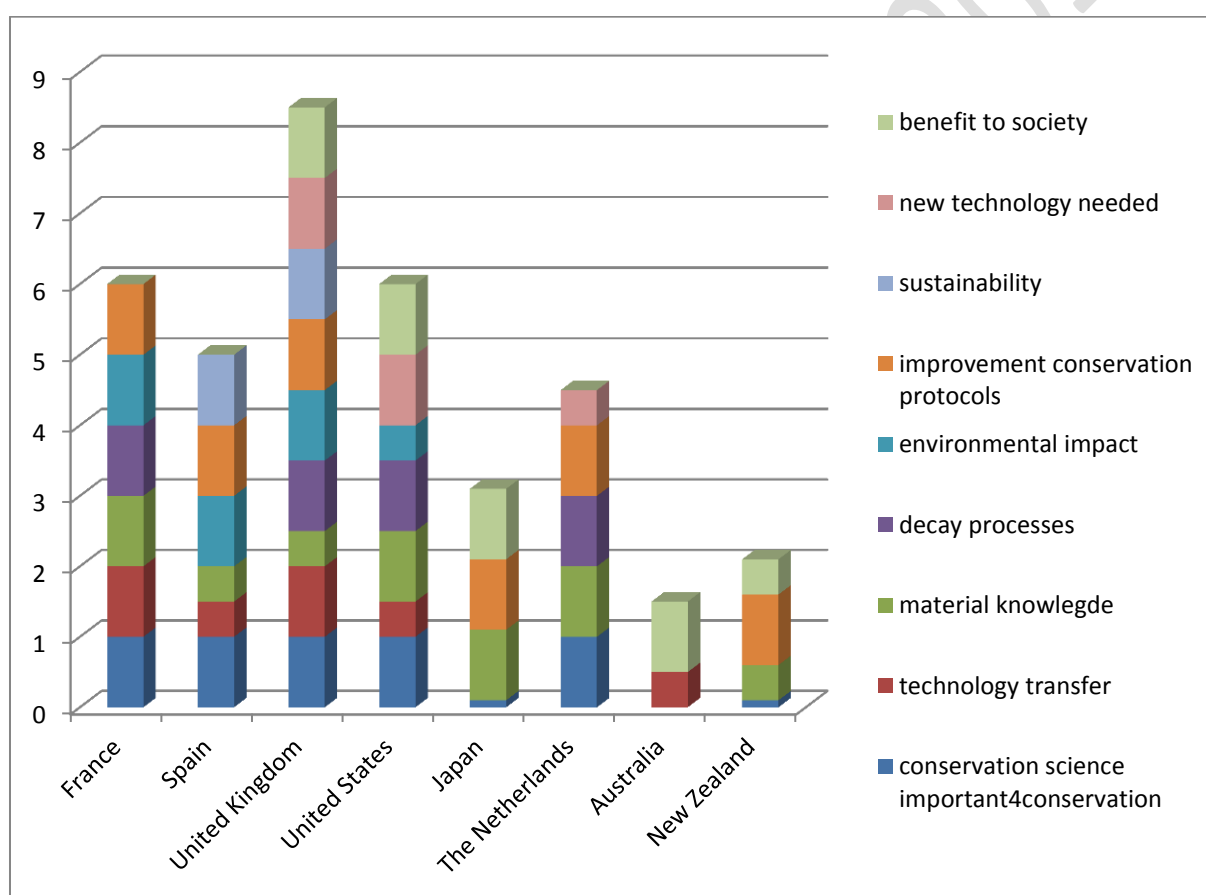
For these reports it is apparent that professionals from the Cultural Heritage sector are prominently involved into the process of drafting strategic research agenda's. For NET-HERITAGE and the Joint Programming Initiative (JPI-CH) these professionals work mostly at governmental organisations, universities and NGO's; for FACH-vision also private companies have been involved.



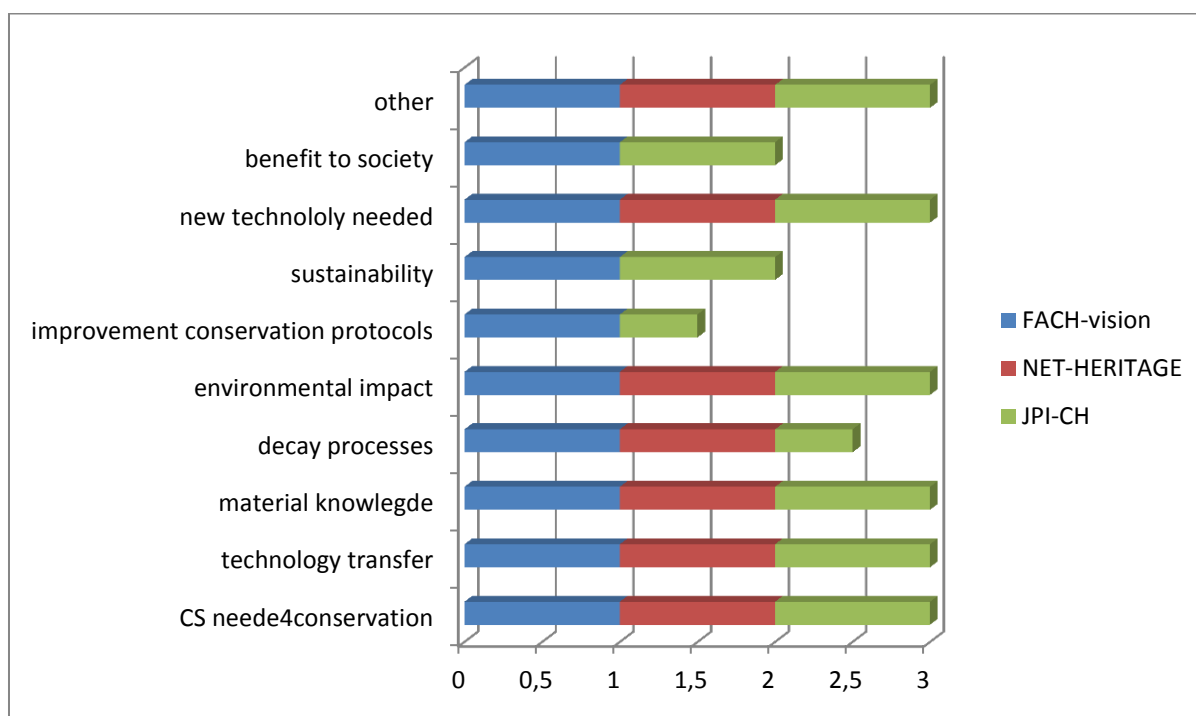
Results or Findings

General benefits of conservation science for cultural heritage conservation

Five countries confirm explicitly the importance of conservation science for the conservation and restoration of cultural heritage. Six countries hope that conservation science will result in better conservation protocols and hence better preservation of cultural heritage. Most countries indicate that knowledge of cultural heritage materials is a prerequisite in the conservation of cultural heritage and they may implicitly assume that knowledge of the materials also includes knowledge on decay processes, although this is not necessarily true. Another group of five countries believes research in cultural heritage will enhance the public benefit.



The strategies from the three European networks all whole heartedly convinced of the importance of research and conservation science in particular for the conservation and restoration of cultural heritage. Only NET-HERITAGE is not explicit on the need for “benefits for society”, whether research should be focussed on “sustainability issues” and whether the protocols for conservation should be improved. Besides the conservation needs mentioned in the national strategies, they mention several other research topics, such as research on risk and disaster management; research on security technologies and the applicability of measurements instruments for end-users. Another striking topic is the need for more research on all aspects regarding materials used in contemporary art and architecture.



Education and conservation science in current training

Most strategies mention that education should be strengthened, however often it is not clear what the current status is on education. Whether the education should be strengthened in conservation science is even made less explicit.

An exception on these form the strategies of the United Kingdom and the United States in which education in conservation science is mentioned with regard to attracting more than the strictly chemically interested students to science and that is important to invest in capacity building through education. This is also the case for NET-HERITAGE.

In Creative Australia education plays an important role, but this is linked more to a cultural awareness than to conservation science.

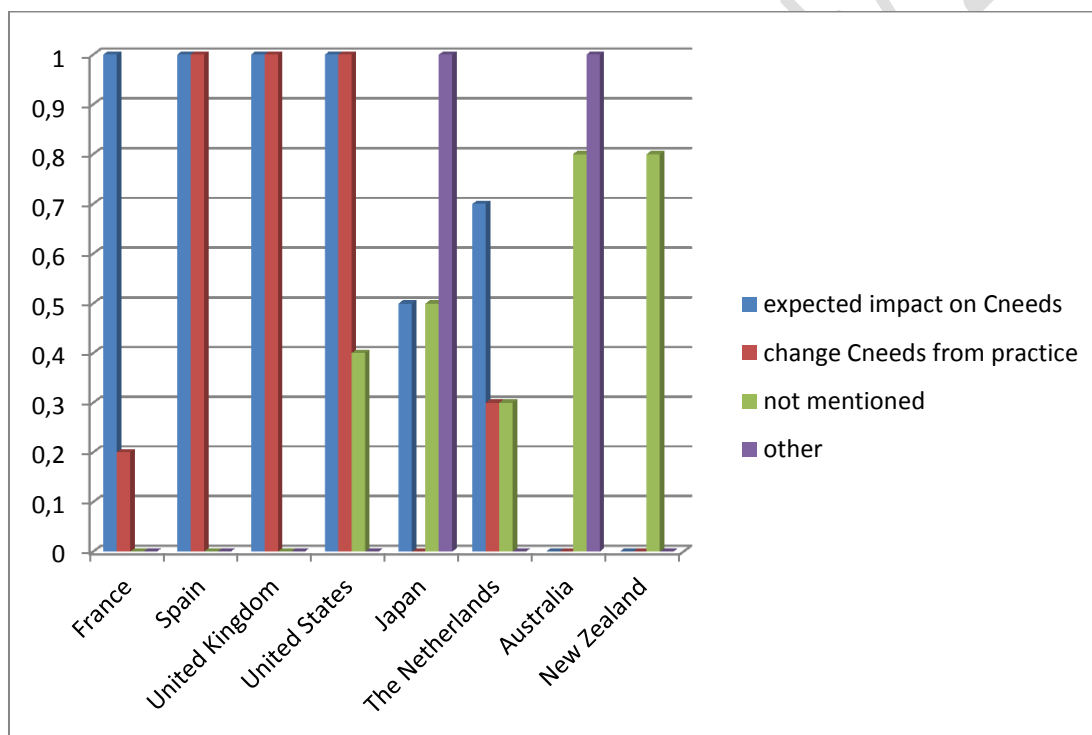
There is much more to state on education and conservation science in current training of especially conservators, but there is hardly any specific information available in the collected strategies. No doubt this type of information is available at universities that offer training for conservators/restorers and organisations like the European Confederation of Conservator Organisations (ECCO) or RESTAURO.



Impact of conservation science on conservation needs

Conservation science definitely has impact on conservation needs. However, the evidence found in the examined strategies and other documents is somewhat circumstantial. It is difficult to prove that research opportunities and new methodologies give room for new needs in the conservation practice. It is more the suggestion that new methodologies, experiments and less invasive techniques to determine material characteristics make that solutions for “old needs” may become available through conservation science. Also, the use of new materials or new combinations of existing materials brings up new needs. Lastly, changing society and issues, like diversified communities, climate change and sustainability, poses new challenges to conservation and hence to conservation science.

Another issue linked to the above is the communication of the potential of conservation science in meeting the needs of present day conservation of cultural heritage. This is more than advocating the benefits of conservation science, but it includes also the explanation of conservation science, the cooperation with heritage professionals, research funding for applied projects and help in setting up research proposals.

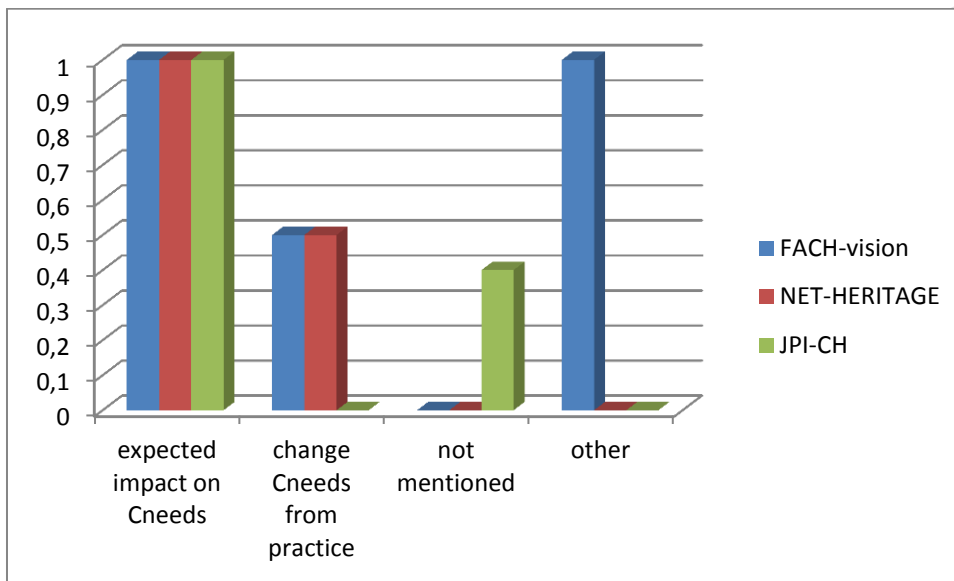


The graph above shows that France, Spain, United Kingdom and the United States are all very convinced that conservation science will have impact on the conservation needs. However, only Spain and the United Kingdom have involved conservation practitioners, whereas in France and the United States mostly conservation scientist were involved in the setup of the examined strategies. To a lesser extent this is also true for the Netherlands and Japan.

Australia and New Zealand do not really mention an impact of conservation science. A remarkable similarity between Australia and New Zealand occurred on their mentioning of the need for new research on measuring public value or effectiveness of cultural investments and monitoring trends in these, but also in the preservation condition of cultural heritage. Not really conservation science. Also the fact that new digital technologies allow for different conservation strategies was specifically mentioned. From the examined documents of Japan ancient conservation techniques are brought up as being important and that conservation science might play a role in this.

When the three European networks are considered (see graph below), they all expect that conservation science will have impact on conservation needs. Often this is one of the reasons they exist. When compared, there are some minor differences. FACH-vision and NET-HERITAGE have included practitioners or practical cases of conservation needs which can be fulfilled through conservation science and research. The Joint Programming Initiative on Cultural Heritage (JPI-CH) is much more focussed on already existing European research efforts and funding and concentrates on bringing research groups together and enhance the success of receiving European funding. Conservation science as such is not mentioned, but research and conservation are stated as separate entities.

On the other hand expectations by FACH-vision of conservation science are very high (category other in graph). They hope conservation science will help in the development self-healing materials, all kinds imaging and 3D-surveying.



Strategic orientation future conservation research

Prior to presenting an overview of strategic orientations in future conservation research based on the examined strategies and documents, some standardisation remarks have to be made. The strategic research themes taken from these documents encompass a wider area than what we defined earlier as conservation science sensu strictu; ***“Conservation science is the application of science and technology to the conservation of cultural heritage”***.

It is however valid to do so, since on one hand this paragraph deals with future conservation research, so it may include themes, which were before not part of conservation science as we know it. On the other hand, “application of science and technology to the conservation of cultural heritage” allows for a broad interpretation of science and technology needed in order to enhance conservation of cultural heritage.



Beato Angelico's Crucifixion – courtesy of Daniela Dini

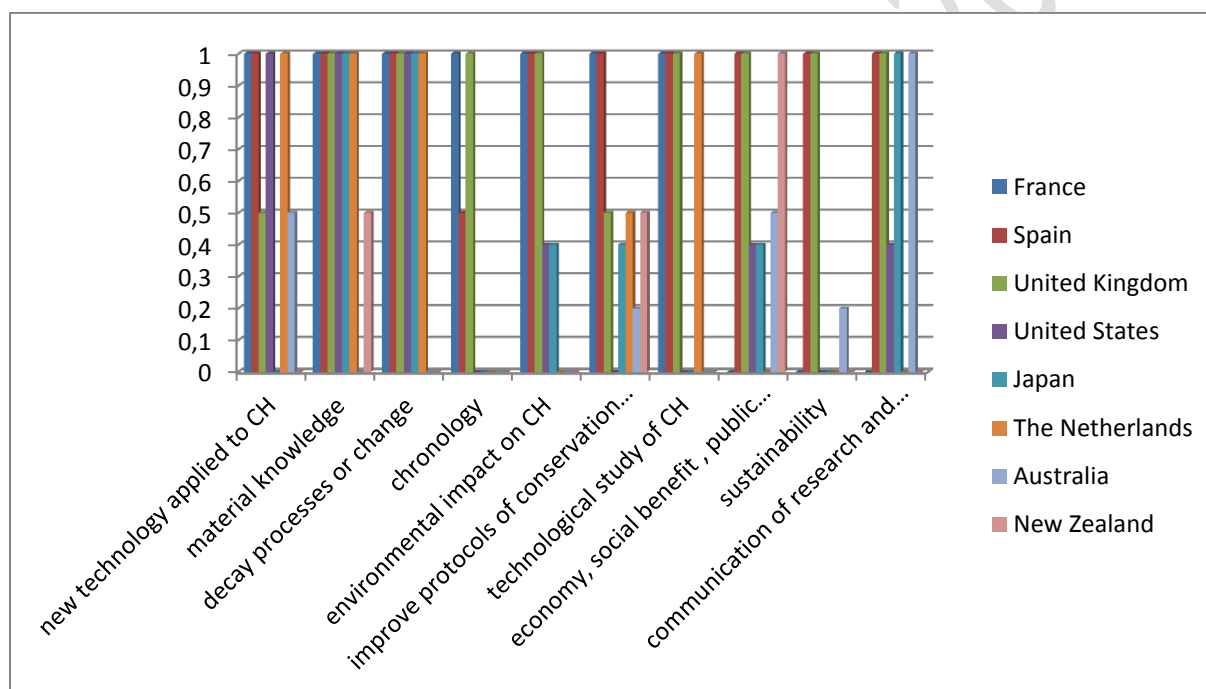
Lastly the term science differs slightly from the term research, the latter also includes also other research fields such as humanities, arts and social sciences.

In the graph below research themes as described in the examined strategic documents are grouped in the same class based on

similarity, although they may have some minor differences in their research approaches. Since a more detailed description of research themes per country is not feasible in such a graph, I have presented these in a separate table (appendix A-a).

Many countries mention as important research themes: material knowledge and linked to these the improvement of protocols of conservation and restoration (7 out of 8 countries), development or application of new technologies in the conservation of cultural heritage and research on decay processes (6 out of 8 countries), but also a relatively new theme as research on economic and social benefits, public value and methods to monitor and analyse possible trends in these. Most strategic documents have linked to their strategic research agenda a provision foreseen for the communication or exchange of research results and for seeking advice through a website or helpdesk facility.

The improvement of protocols of conservation and restoration or not necessarily a research theme in itself, but when new insights from science or from the restoration practice ask for some experimental research on for example the effectivity of restoration treatments, it becomes part of conservation science.



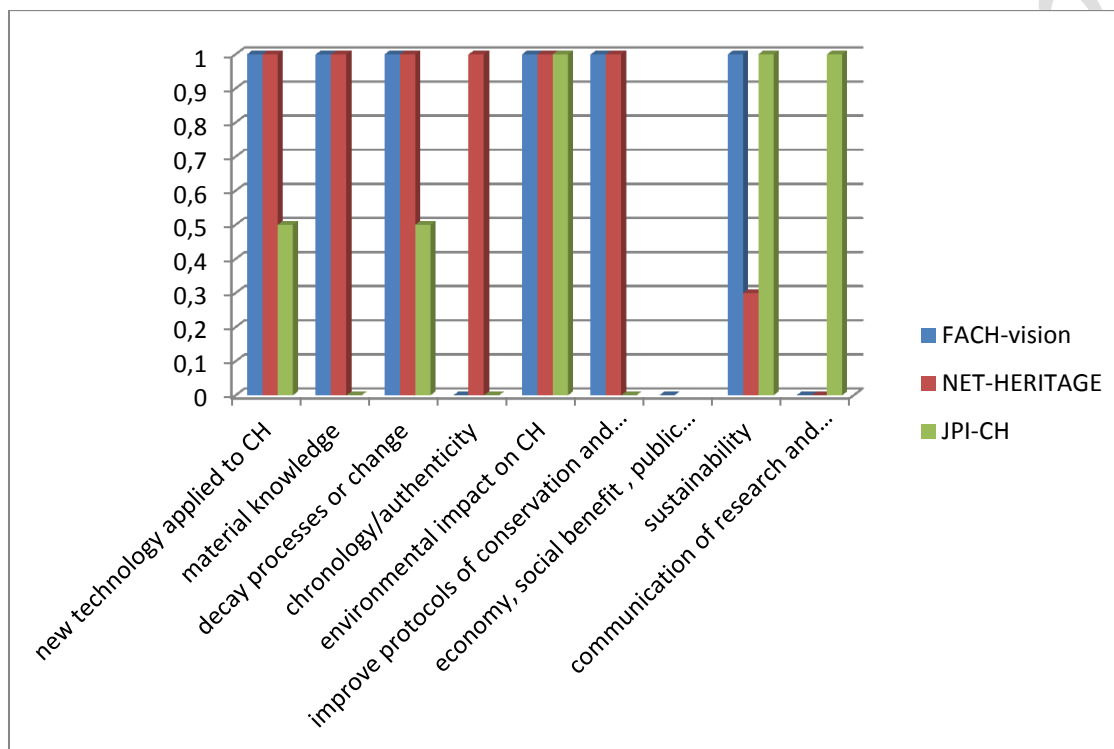
Remarkably, sustainability as research theme has not been mentioned, although often sustainable approaches in conservation of cultural heritage are being mentioned. It appears that understanding materials and processes that form and occur in cultural heritage are sufficient to fulfil the needs of sustainable conservation.

When a similar overview (see graph page 11) is made of research themes or priorities stated in the strategic documents of the three examined European networks, sustainability related research themes are being mentioned and in the case of the Joint Programming Initiative on Cultural Heritage (JPI-CH) is one of their major challenges. However, these JPI-CH challenge are now in the process of transforming into a strategic research agenda. Than it will become clear whether and how this is translated into research themes. A full overview of research themes or challenges per European network is presented in a table in appendix A-b.

The strategies of Fach-vision and NET-HERITAGE pose similar priorities on research on material knowledge, on new technologies applied in the conservation of cultural heritage, on decay processes and change, on environmental impact on cultural heritage and on the improvement of protocols of

conservation and restoration as a consequence of new research insights. Fach-vision places more emphasis on research themes, which promote more sustainable conservation and management of cultural heritage than NET-HERITAGE. For NET-HERITAGE research on chronology and authenticity is also important, although this is predominantly focussed on movable heritage.

The Joint Programming Initiative on Cultural Heritage (JPI-CH) foresees new opportunities in exchanging cultural heritage information through new media and digitisation. Opposite to the other strategic documents of Fach-vision and NET-HERITAGE the research orientation of the Joint Programming Initiative on Cultural Heritage (JPI-CH) does not seem to be focussed towards material research in the broadest sense. This might change, when the challenges are being translated into more concrete research themes.



Conservation science and sustainability

Sustainability seems to be an important aspect in all strategic documents, but not necessarily a prioritised research theme and even less a research theme of conservation science in a strict sense.



It is clear from the different consulted strategies, whether they are at a national or European network scale, research is affected by the striving for more sustainable approaches in the conservation and management of cultural heritage. However, this is not always easy to translate in research on material behaviour or other on themes, which are familiar in conservation science. Often other expertise or research fields have to be consulted in order to make management and conservation more sustainable. For example, other sustainable sources of energy supply for environmental control systems can be identified and adjusted to fit in a cultural heritage context. These sources have to be sustainable on the long term as well, so long-term monitoring and evaluation becomes important in order to prevent harmful consequences for the heritage objects at hand. Moreover sustainable management of cultural heritage and thus conservation as well often deals with the human factor. Do visitors expect a tour through a heated monument and do we have to light all objects of an exhibition; even when no visitors are present in certain rooms? To improve the sustainability of cultural heritage management and conservation other research fields such as humanities, arts and social sciences, should be included in addition to the already mentioned more material oriented research themes in all consulted documents (appendices A-a and A-b) .

Funding opportunities in relation to other research funding

Based on the examined strategic documents it becomes clear that there is a widely recognised concern that funding for research on conservation of cultural heritage and even more so on conservation science is diminishing and the necessity often overlooked. The examined strategies are an important step in demonstrating the societal benefits that can be expected from conservation and conservation science in particular. Also the efforts made to come up with prioritised strategic research agendas and sometimes proposals to find external funding are promising.

However, it would take another in-depth study to investigate all possible funding opportunities and also to make a comparison of the amount of funding for other research areas versus the funding opportunities for conservation science. The OECD websites contain valuable information to execute such a study. Prior to conducting this study, a general consensus on to what type of research conservation science can be linked or even can be extended, is preferred.



Evaluation of findings and discussion

Distinction between different scopes: global versus national context; general versus specific

Comparing the different strategies, it is clear that the strategic documents of European networks address more global issues than the national strategies. Still, also national strategies take into account global issues like climate change and its impact on cultural heritage besides addressing the more national encountered issues like the fragmentation of the cultural heritage sector or supporting traditional cultural elements as part of the national identity (Japan and Australia).



As mentioned before the examined strategies are not really representative of a global perspective. The emphasis is on European and North American conservation strategies. Japan has very similar approaches to conservation science as the European and North American ones.

New Zealand has a cultural heritage conservation strategy as part of a larger environmental conservation strategy. The strategy of Australia is more a policy on culture, of which a follow up might be more cultural heritage conservation oriented.

Over-all the examined strategies are typically of countries with a strong knowledge infrastructure like universities and research institutes and a conservation practice which is open for use of well-developed technologies. Research and technology are part of their daily life.

This might not be the case in Africa, countries in South America or the Middle East, although by no means these countries are comparable.

The interest for intangible cultural heritage and the inclusion of other cultural identities as part of the national identity are intriguing aspects of the Australian and Japanese strategic documents. For both Japan and Australia they expect that research and new media will help in the conservation of these objectives.



For both the national strategic documents as well as the ones of the European networks the main objectives differ and therefore a varying degree of attention is given to more generic or specific themes, besides the recurrent advocacy for the importance of the conservation of cultural heritage. That is a common denominator for all examined documents.

The French, Spanish, Dutch, North American strategic documents and to a lesser extent the one from New Zealand are all documents which are a kind of call-for-research proposals and at the same time a prioritisation of research on conservation. France and Spain also account for spent funding on research. The United Kingdom has a very well established strategy addressing a broad diversity of themes with ample attention to societal impact. However, although a national Conservation Science Forum has evolved from these efforts, it is not clear yet whether this will be followed by substantial research funding.

Several countries are very explicit in how much funding (mostly tax payers money) is spent on cultural heritage activities or more specific on cultural heritage science. This is true for France, Spain and Japan. The Australian policy on culture gives an extensive overview of what amounts of Australian dollars will be invested in a creative and competitive Australia.



The strategic documents also differ in the degree to which they address the specific material/tangible aspects of cultural heritage. The Australian policy is the least oriented on actual conservation of tangible heritage, followed by the one of New Zealand. This is also the case for the strategic document of the European network of the Joint Programming Initiative on Cultural Heritage (JPI-CH); this will probably change when the strategic research agenda is completed.

The Dutch strategy (Science4Arts) is limited to movable heritage and only a small number of research proposals could be supported. A special feature in these was the interdisciplinarity and the involvement of the restoration practice.

The European networks Fach-vision and NET-HERITAGE have extensive inventories of research priorities, the first having a strong focus on construction and therefore on immovable heritage in its spatial context. Both networks are also very strong in their attention on practical application of research outcomes.

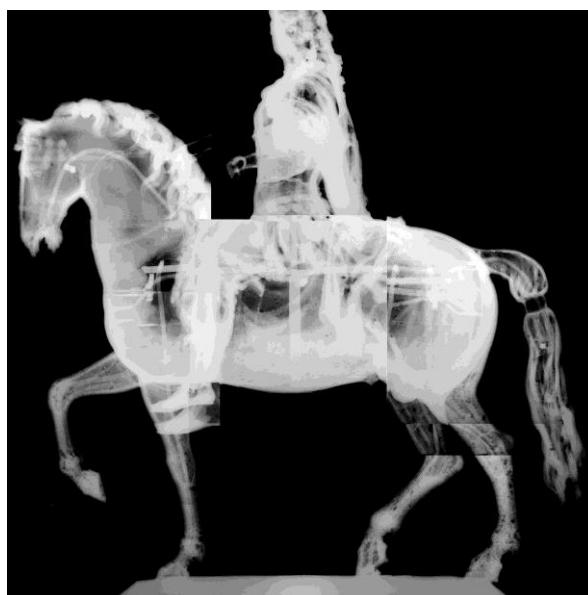
Synthesis on the various strategies and methodologies used to come up to these strategies

The difference in strategies is also a reflection of the ways these strategies have been composed. They reflect not only the professionals consulted, but also whether the strategy is a mere follow-up of already existing strategies, or the outcome of one or several workshops or brainstorm sessions.

Some strategies have taken several years to draw up (United Kingdom and Spain) and included both scientists as well as conservation and restoration practitioners both of the field of movable and immovable heritage, from museums, ministries and independent professionals.

When predominantly scientists are involved this is reflected in research themes with a high technological character like the use of mass accelerators or the development of very precise, non-invasive, portable, remotely controlled instruments, although at the same time, they find it important to make these instruments accessible for practical use. Also, the improvement of protocols of conservation and restoration are mentioned in most strategic documents; even in the more technology oriented ones.

the more policy like documents are stronger in their societal focus; however it seems to be



difficult to translate these into practical research priorities. Other concrete actions are mentioned to involve the general public through education, websites, helpdesks and the funding of local “visitor-centres” often at sites.

Relevance of conservation science to conservation needs

Most, but not all strategies, explicitly state that conservation science contributes to better management and conservation of heritage. Whether this is strictly conservation science or a broader range of research necessary to meet the requirements depends largely on the methodology used to come to the strategy. The strongly research oriented national strategies are not that explicit on the societal

benefits, but still 5 out of 8 strategies mention the societal benefits of research based conservation of heritage.

Conservation science throughout the strategic documents ranges from a very strict purely science based approach to conservation, to multidisciplinary approaches and even economy and social sciences, which might lead to the term conservation research.

Outcome of this type of research should help in the over-all decision making not only in the conservation, but also in the management of cultural heritage. Science plays still a role, but the science needs to be combined with other disciplines in order to be effective for conservation needs. This seems to be a trend, which might hamper the visibility and recognition of conservation science in the stricter sense.



Conservation science in training

It appeared difficult to shed much light on education in conservation science. Often education is mentioned as being of importance. It was however not so clear how this has to be materialised.

An exception forms the National Heritage Science Strategy from the United Kingdom. In order to find out the needs for education for heritage science, they performed a thorough review of the current status and capacity of the different types of heritage scientists now active in the field of conservation followed by an assessment of possible shortages in either capacity, capability and equipment availability. An inventory of the different training routes was being made, although in the UK these are apparently solely academic training routes. Lastly, recommendations are posed to improve future capacity.

Whether the UK situation can easily be applied on the other countries included in this review is doubtful. From the other national strategies no basic information on the educational infrastructure was presented and it is therefore difficult to draw conclusions from these. However, there is some light at the end, since a number of European countries (not UK, but Italy, Greece, the Netherlands, Denmark, Spain, Hungary, Romania) have joined to set up a Marie Curie funded heritage science PhD-program

called Episcon, which has a recent follow-up in the EU Erasmus programme, which includes an exchange programme for master students in conservation science.

Impact of conservation science on conservation practice

In almost all national strategies conservation science is being aimed at having impact on conservation practice. This is mainly effectuated through making research results available to conservation and restoration practitioners and use the outcome of research to improve protocols for restoration and conservation.

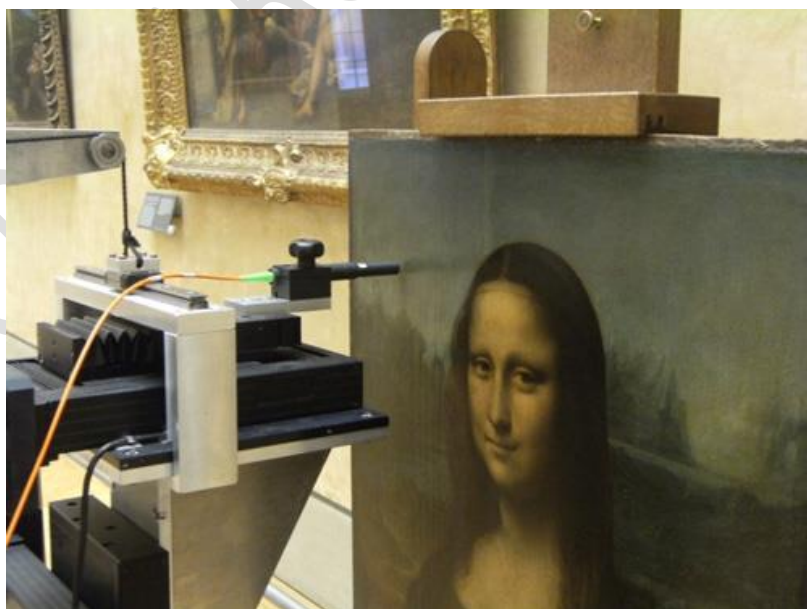
Especially the strategies of the two European networks Fach-vision and NET-HERITAGE advocate both for a better access to research facilities for heritage professionals , setting up help desks to explain the applicability of research results better and deducing from their list of research priorities they include research themes which are closely linked to practical needs.

In addition some strategies mention training courses to let practitioners make better use of research outcomes, working in close cooperation and the setting up of funding for applied research projects. Sometimes, help in setting up research proposals that are scientifically sound, but also leading to practical solutions, might be determining last step.

Strategic orientations for future conservation research

Although in the general findings future conservation research themes are being presented, a more elaborated overview is to be found in appendices A-a and A-b. It will be interesting to combine the different research disciplines and at the same time to try to distinguish research from application.

The outcome of this process of combination and distinction will find its way in the different national cultural infrastructures. These will be no doubt context dependent outcomes.



Recommendations

The field of conservation science

Conservation science is threatened and at the same time very promising. However, it needs to make itself more visible, not only in its role in the management and conservation of cultural heritage, but also as a very exciting and satisfying subject for interdisciplinary research with societal benefits. Conservation science is not only a challenging field for cultural heritage professionals, but also for professionals in the creative industry and for the academia.

The use of new media can certainly help in making this role more visible, but websites, public workshops and contact persons remain equally important as well as publishing in grey literature. New visualisation and mapping techniques can be used to make the information itself more accessible. Access to research results, conservation information, the development of guidelines, the improvement of protocols for restoration and conservation, and access to research facilities itself will also help.

Bringing together appealing examples of “conservation-science-in-action” (in-situ measurements and analysis on cultural heritage with a public audience) from different regions worldwide will be a very effective and inspiring advocacy for the field of conservation science.

Expanding research themes: from science to research

Joining forces in the field of cultural heritage is already taking place and has to go further. The methodologies used to come up to the strategies examined for this review form a very strong binding mechanism between all involved in the process. The evolving strategic research agendas that are being produced will help even more in prioritising research funding that can count on approval of the professionals active in the field of conservation.

The strategic orientation for future conservation research should include, besides material oriented research themes also cross-related themes from ICT, economic and social sciences in order to be able to add value to the enlarging field of conservation practice of cultural heritage.

The material research themes have developed to a higher level, such as characterisation of modern, complex and composite materials, their behaviour to different environmental impacts and their decay and aging processes, and the development or adaption of analysis and monitoring technologies with even more accuracy, a better spatial resolution, and which will be non-invasive, portable and remote controlled.

Lastly, the long term monitoring of the effectiveness of earlier conservation and consequences of slow environmental impact will become more important also.

Education and funding

In order to give recommendations on education and training it is prerequisite to investigate the educational infrastructures present at national, European and global scales. Furthermore possible deficiencies should be identified linked to conservation needs. Recommendations on education should take into account the different national and regional contexts.

Research funding of conservation science is hardly addressed in this review, since based on the examined strategies it was not feasible to make a valid comparison of research funding throughout other research disciplines. Based on a further study of OECD reports and a study of the budgets of national science foundations, this issue can be clarified.

Sustainability and conservation science

The contribution of conservation science to sustainability issues will be primarily focussed on the sustainable use of materials and energy. If the definition of sustainability by the Brundtland Report – Our Common Future (1987) is being used, sustainability can be divided into three constituents: “planet”, “profit” and “people”, the current focus of conservation science is on the environmental sustainability or “planet”. However, when conservation science is linking up to the economic and social sciences, it can also contribute to the other two aspects of sustainability namely people and profit, or the socio-political and economic sustainability.

Appendix A-a-1

Research themes based on the examined national strategies in conservation science

France	Spain
technology transfer and new techniques of analysis non invasive portable tools applicable on mixed materials characterisation of decay follow path of gases and liquids in porous CH measurement of effectivity of treatment material knowledge understanding lifespan of CH through material analysis origin, context, techniques of production and restoration biological materials - archeological studies decay processes or change different behaviour of composites in aging recognition of decay products impact of earlier conservation treatment environmental impact on CH air, soil and water quantitative impact on CH evaluation of pollution impact (in- and exterior) microclimatic studies in CH including visitor impact climate change scenarios in relation to threats to CH improve protocols of conservation and restoration protocols not up to date expected effectivity of treatment not realized interaction between restoration material and CH object	material knowledge, new technologies and analytical methods quality control and optimization of analytical techniques experimental techniques on preventive conservation & restoration study of dynamics of change/decay in situ investigation of CH, non invasive and portable tools imaging techniques for documentation and presentation technological study of CH understanding the lifespan of CH through material analysis origin, context, techniques of production and restoration investigation of historical documentation environmental impact on CH monitoring of environmental pollutants study of impact of pollutants on CH risk analysis on CH and the environment human risk analysis of conservations treatments and materials energy saving solutions for monuments that contain CH climate change and its impact on CH and the conservation of CH economy, social benefit and sustainability conservation of CH and employment develop parameters on economic impact of conservation actions conservation and restoration should lead to more sustainability value assessment of CH in its context promotion of sustainable conservation combined to access to CH communication of science outcomes to society and educational centres improve methods and protocols of conservation and restoration Recognition of limits and demands of sustainable and sensible application promotion of the use of heritage conservation in its cultural context investigation of the value of methods and materials, technology transfer develop standards and quality control on materials and methods attention to the conservation of new not yet recognised heritage promotion of in situ conservation and restoration develop website/portal on research and conservation Helpdesk improve cooperation in research also on international scales knowledge transfer between scientists, media, society and institutes promotion of activities from the national plan on conservation and research

Appendix A-a-2

Research themes based on the examined national strategies in conservation science

United Kingdom	United States
understanding material behaviour decay rates and mechanisms special attention to modern materials <i>biological materials - archeological studies</i> <i>origin, context, techniques of production and restoration</i> understanding environments adapting to and managing environments <i>microclimatic studies in CH including visitor impact</i> improving practices improved monitoring and assessment tools past, present and future conservation techniques access to equipment and information development of tools and access to equipment portable, non-intrusive improve access to fixed equipment improvement to tools, more precise, larger cover area raising awareness of existing techniques and application guidance and advice data use and management peer reviewed journals make grey literature accessible make information on-line accessible digital data storage and sharing widening access to data public engagement measure economic and social benefit link heritage science to other issues (sustainability) improve public access explain to wider audience coordination of guidance /standards	materials and structural characterisation material and structural complexity spatial resolution volume restrictions remote sensing minimal invasiveness improved surface-sensitive techniques use of large scale facilities, synchrotron sources, X-ray tomography measurement of organic materials understanding material degradation and aging composite materials and their decay multiple environmental stressors ultraslow processes impact of chemical and physical processes on performance of CH materials stabilization, strengthening, monitoring, and repair dynamic imaging and ultrasensitive sensors improvement of solvents used in cleaning or restoration reversible adhesion returning material strength to decayed material transport phenomena education and broader impact

Appendix A-a-3

Research themes based on the examined national strategies in conservation science

Japan	The Netherlands
assessment environmental impact on CH monitoring micro-climatic impact on CH developing preventing methods for deterioration evaluation of restoration materials microbial deterioration - archeological studies monitoring micro-climate and migration of water evaluation of conservation measures at excavations technology transfer to local staff conservation of mural paintings cleaning and reinforcing plaster reconstruction methods selection and development of restoration material surveying wall paintings for conservation and restoration survey of condition survey of material and techniques used study of deterioration mechanisms study of different restoration techniques used reconstruction of original appearance recording intangible heritage - rituals sustainable digitization of recordings on tape dissemination and utilization of research information	understanding function, context and significance CH artist intention, significance and historical context authenticity understanding physical condition, materials and decay study of production processes art technological research aging and decay of materials evaluation of conservation practice study of strategies for conservation, restoration, treatment decision making in conservation and restoration implementation of conservation and restoration strategies new and integrated methodologies historical and technical reconstructions model simulations computer imaging non invasive analytical techniques synchrotron radiation artist interview and documentation strategies
Australia	New Zealand
digitisation use emerging and converging technologies digital based media improve access to collections and programs monitoring economic value of art, Creative Industry and CH measuring public value of cultural investment tracking and targeting	understanding the importance of heritage places assessment of relative heritage value application of best practices in heritage management monitoring condition of heritage materials development of guidance for interpreting monitoring results analysis of trends and performance of heritage preservation technology assessment of public engagement monitoring of trends and effectiveness of visitor engagement understanding needs of stakeholders and possible business customers

Appendix A-b-1 Research themes European networks

Research themes in conservation science based on the examined strategies from European networks

NET-HERITAGE research gaps and scientific priorities
environmental assessment and monitoring (pollution, climate change, seismic risk) determine critical levels of synergic pollutants in context of environment preventive approaches against extreme natural events and first aid measures impact of climate change on materials and structures, adaptation of mitigation technologies development of stabilising technologies for historic structures, when hydrogeology changes
investigation of damage mechanisms to establish conservation strategies multidisciplinary approach on synergetic interactions between environment and materials study of interaction of environmental impact on complex artifacts by different materials determine best conservation practices against specific attacks to prevent damage develop damage mitigation - salvage, recovery, recycling and re-use of materials
development of measurement instruments of practical relevance for end-users develop portable instruments for in-situ measurements develop non-invasive instruments and methodologies for diagnosis and monitoring develop intelligent multi-sensor systems for early warning, including telediagnosis re-engineering of instruments and techniques to simplify and adapt their use
innovation of materials and technologies for conservation and maintenance development of new and appropriate materials and technologies for upgrading conservation define guidelines and pre-standards on identification and assessment on fitness for use
evaluation of treatments and materials used in (present & recent) conservation to assess suitability and consequences solution for development, assessment & reporting of analysis protocol for evaluation of time effects of treatments & materials innovative solutions for compatibility, durability and reversibility of new materials and treatments modelling and simulation for predictive evaluation and validation of materials and treatments impact of modern finishing materials and techniques on historic structures
alteration & conservation of materials - modern materials in CA and architecture combined with documentation strategies development of strategies and procedures for storage and preservation of multi-media supports and sustainable content access innovative proposals for conservation and durability of contemporary art materials
evaluation of anthropic pressures and management development of management systems on quality and sustainability of in- and outdoor CH environments development and validation of mobility models to reduce environmental impact to unmovable CH (vibration, emission) development of scientific criteria to measure and regulate tourist impact on CH sites
security technologies & systems in museums, libraries, archives and for the movement of artefacts develop sensors for safe handling, movement, transport and exhibition of artefacts together with guidelines develop integrated systems for effective prevention, detection and reaction to risk situations at different scales techniques for supporting identification of fakes or stolen artefacts techniques for inventory, cataloguing and traceability of cultural heritage objects
Telesurvey and GIS for protection and management of tangible cultural heritage web mapping and GIS innovative tools for monitoring and remote control of archaeological sites and landscapes development of innovative and aesthetically acceptable tools for telesurvey of movable artefacts development of advanced systems for telesurvey and remote fruition of underwater CH

Contemporary cultural heritage in spatial contexts

preservation of industrial heritage

preservation of 20th century military heritage

prenormative studies for guaranteed protection and management of cultural heritage

development of quality management systems addressed to the process of conservation of CH

prenormative studies to improve reproducibility and repeatability of testing results

JPI-CH challenges**climate change**

adaption measures in CH mitigating climate change, energy saving, sustainable materials and passive design

re-learning of old traditions and practices

adaption of mitigation measures for preventing catastrophic events induced by climate change

protection and security of cultural heritage

integrated approach and risk analysis of environmental and anthropic treats to CH

study of resilience of CH

sustainable development and sustainable access

transformational challenge of cultural heritage

foster role of CH as factor of cohesion in diversified communities

use of new technologies (ICT) communicating all aspects of CH (access, information exchange, intangible aspects)

linking indissoluble relationship between tangible and intangible heritage

sustainable digitisation to enhance accessibility

develop new preservation technologies

Appendix A-b-2 Research themes European networks

Research themes in conservation science based on the examined strategies from European networks

FACH-vision SRA
assessment, monitoring and diagnosis development of non and minor destructive techniques/sensors semi-automatic testing and investigating critical areas detection and identification of surface damage processes non- and semi invasive surveying and documentation archaeology biotechnical techniques for damage diagnosis and microbial contamination understanding limits and accuracy of technologies quality assurance of NDT and MDT and data analysis development of intelligent monitoring systems
materials (incompatible materials and interventions/decay mechanisms) development integral strategy for value assessment creation of proper materials for protection of CH quality assurance protocols for replacement materials development of knowledge based DSS development of smart materials embedded intelligence of materials structure and molecular dynamics validation of quality control system
intervention techniques elaboration database on typologies/morphologies of structural elements elaboration of catalogue of intervention techniques and effectivity development of reliable traditional and innovative intervention techniques optimisation or integration of intervention techniques selection of enhanced and intelligent systems improvement analytical tools on structural assessment, simulation of interventions development of smart systems for monitoring development of protocols and guidelines proper methodology for analysis of seismic vulnerability and hazard mitigation smart technologies in large scale application of integrated interventions
environment and energy develop risk management methodologies on environmental impact on CH map and research micro environment on CH surface identification of optimum management in terms of energy saving sustainable solutions in conservation identification of sustainable sources of energy supply for environmental control systems identify CH zones linked to climate, environment and geology for sustainable stewardship application satellite technologies, multispectral scanners in assessment of damage

Appendix B - Overview collected documents (40)

2001:

- Technological requirements for solutions in the conservation and protection of historic monuments and archeological remains, Working paper of the STOA (Scientific and Technological Options Assessment) unit, Directorate General for Research (Division for Industry, Research, Energy, Environment and STOA)

2002:

- Programme National de Recherche sur le Patrimoine Culturel, conseil ministerial de la recherche, comite scientifique: analyse, conservation, restauration des biens culturels. **France**

2004:

- London Declaration – European conference Declaration on sustaining Cultural Heritage Research; an initiative to protect and safeguard European Cultural heritage through scientific and technological research. **UK**

2005:

- Conservation Science Research: Activities, Needs, and Funding opportunities. A report to the National Science Foundation, funded by Mellon foundation. **US**
- nCrisp: Construction Research & Innovation in the heritage sector – Foresight planning for a research strategy for the construction industry, May 2005 + appendix: construction research and innovation in the historic environment sector. **UK**
- Climate Change and Historic Environment by May Cassar, UCL Centre for Sustainable Heritage, August 2005, **UK**
- A proposal to develop a UK research strategy for the historic environment and its sustainable management by John Fiddler, Conservation director English Heritage, October 2005, **UK**
- English Heritage Research Agenda: an introduction to English Heritage's research themes and programmes. **UK**
- Discovering the Past, shaping the Future: providing the knowledge base for the historic environment and its sustainable management – English Heritage Research Strategy 2005 – 2010. **UK**

2006:

- Report on Scientific Research for Moveable Heritage in the UK, centre for sustainable heritage, UCL, London. **UK**
- Cultural Heritage – Vision 2030 & Strategic Research Agenda – Focus Area Cultural Heritage, February 2006, European Construction Rechnology Platform (ECTP). **EU**
- PLF 2006, Programme 175: Patrimoines: les orientations strategiques du programme. La politique patrimoniale de l'Etat s'articule autour de trois finalités principaux: rendre accessibles au plus grand nombre les oeuvres capitales de l'humanité et de la France, sauvegarder, protéger et mettre en valeur le patrimoine culturel dans toutes ses composantes, favoriser la qualité architecturale, urbaine et paysagere du cadre de vie des Francais, encourager les initiatives culturelles locales, developper les liens entre les politiques culturelles de l'Etat et celles des collectivités territoriales. **France**
- PLF 2006, Programme 186: Recherche culturelle et culture scientifique. Ce programme, qui appartient a la Mission interministerielle recherché et enseignement supérieur, contient deux grands axes d'action: l'un portant sur la politique de recherché dans le domaine de la culture et l'autre sur la diffusion de la culture scientifique et technique aupres du public. **France**
- Towards an EU-wide strategy for research into the historic environment and its sustainable management, John Fidler and James Stevens, Prague 2006, **UK**

2007:

- Government response to the House of Lords science and technology Select Committee report on Science and Heritage (HL256), session 2005-2006, Department for Culture, Media and Sport, presented to the parliament January 2007, **UK**
- Declaration of the City of Salvador, first Ibero-American Meeting of Museums, June 2007, city of Salvador, Bahia, Brazil – **Ibero-America**

2008:

- List of regional research projects in Spain on conservation of Cultural Heritage. **Spain**
- FACH Vision 2030 & Strategic Research Agenda, Focus Area Cultural Heritage (FACH) of Europe, linked to ECTP (European Construction Technology Platform), Public version #3, March 2008, **EU**

2009:

- Chemistry and Materials – Research at the interface between Science and Art, report of a workshop co-sponsored by the National Science Foundation and the Andrew W. Mellon Foundation, July 6-7, 2009, Arlington, Virginia. **US**
- National Heritage Science Strategy (NHSS) Report 1 – The role of science in the management of the UK's heritage by Jim Williams, April 2009. **UK**
- National Heritage Science Strategy (NHSS) Report 2 – The use of science to enhance our understanding of the past by Jim Williams, July 2009. **UK**

- National Heritage Science Strategy (NHSS) Report 3 – Understanding capacity in the heritage science sector by Jim Williams, September 2009. **UK**

2010:

- National Heritage Science Strategy (NHSS); Vision and Strategy by NHSS steering group, March 2010. **UK**
- The Joint Programming Initiative (JPI) on Cultural Heritage and Global Change: a new challenge for Europe. Vision document and annex, June 2010 and general brochure. **EU**
- JHEP: Coordination Programme of JPI-CH, Joint Heritage European Programme. Part of this is network building and the development of a European Research Agenda on CH. **EU**
- NET-HERITAGE – European network on research programme applied to the protection of Tangible Cultural Heritage, deliverable 3.1: report on common research gaps and priorities.
- Plano nacional setorial de museus 2010-2020, (in Portuguese), IBRAM, Ministerio da Cultura, Brasilia, 2010, **Brazil**.

2011:

- A road map for cultural heritage research in Europe – results of the project NET-HERITAGE. Net-heritage and Deutsche Bundesstiftung Umwelt. **EU**
- Science4Arts – a multidisciplinary research programme for the conservation and restoration of art objects, NWO, Dutch Science Foundation, January 2011, **NL**
- Plan Nacional de Investigacion en Conservacion de Patrimonio Cultural. **Spain**
- Science counts! The department of Conservation's Strategic Science and Research Priorities 2011-2016. June 2011, **New Zealand**.
- Thirteen chapters on the organization of culture in Japan, April 2011, **Japan**
- Outline of the Nara National Research Institute for Cultural Properties – www.nabunken.go.jp (English), latest update 2011, **Japan**
- IBRAM – instituto brasileiro de museus, Ministerio da Cultura, document explaining IBRAM (in English), 2011, **Brazil**.

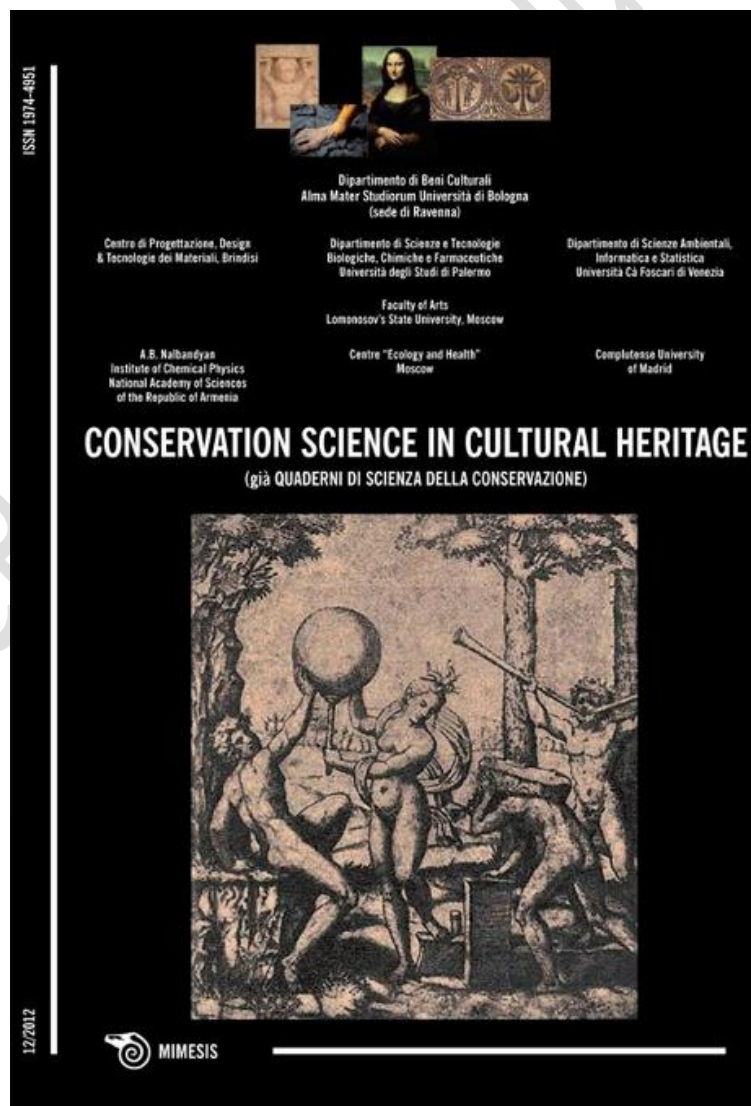
2012:

- Programme national de recherche sur la connaissance et al conservation des materiaux du patrimoine culturel (PNRCC), appel a projets de recherché 2012. Ministere de la culture et de la communication, secretariat general, service de al coordination des politiques culturelles et de l'innovation, departement de la recherché, de l'enseignement superieur et de la technologie. **France**

- Annuaire de Laboratoires d'analyse prestataires de services pour la conservation des biens culturels. **France**
- National Research Institute for Cultural Properties, Tokyo, Profile 2012 (English), **Japan**.

2013:

- Creative Australia; national cultural policy. Australian Government. Commonwealth of Australia. 2013; **Australia**.
- Australia takes an 'arts turn'; an appraisal of Creative Australia, Australia's new National Cultural Policy by Veronica Bullock, significance international, May 2013, **Australia**.
- Museumbrief, samen werken, samen sterker (museum letter, collaboration makes stronger), Ministry of Education, Culture and Science, June 2013, **The Netherlands**.
- NRIC: http://www.nrich.go.kr/english_nrich - National Research Institute of Cultural Heritage, **Korea**.



Appendix C - Relevant strategic reviews:

France

- Programme national de recherche sur la connaissance et al conservation des materiaux du patrimoine culturel (PNRCC), appel a projets de recherché 2012. Ministere de la culture et de la communication, secretariat general, service de al coordination des politiques culturelles et de l'innovation, departement de la recherché, de l'enseignement superieur et de la technologie. **2012**

Spain

- Plan Nacional de Investigacion en Conservacion de Patrimonio Cultural. **2011**

United Kingdom

- National Heritage Science Strategy (NHSS); Vision and Strategy by NHSS steering group, March 2010. **2010**
- National Heritage Science Strategy (NHSS) Report 1 – The role of science in the management of the UK's heritage by Jim Williams, April 2009. **2009**
- National Heritage Science Strategy (NHSS) Report 2 – The use of science to enhance our understanding of the past by Jim Williams, July 2009. **2009**
- National Heritage Science Strategy (NHSS) Report 3 – Understanding capacity in the heritage science sector by Jim Williams, September 2009. **2009**

The Netherlands

- Science4Arts - a multidisciplinary research programme for the conservation and restoration of art objects (in Dutch), NWO, Dutch Science Foundation, January **2011**
- Museumbrief, samen werken, samen sterker (museum letter, collaboration makes stronger), Ministry of Education, Culture and Science, June 2013

United States

- Conservation Science Research: Activities, Needs, and Funding opportunities. A report to the National Science Foundation, funded by Mellon foundation. **2005**
- Chemistry and Materials – Research at the interface between Science and Art, report of a workshop co-sponsored by the National Science Foundation and the Andrew W. Mellon Foundation, July 6-7, 2009, Arlington, Virginia. **2009**

Japan

- Thirteen chapters on the organization of culture in Japan, April 2011
- National Research Institute for Cultural Properties, Tokyo, Profile 2012 (English)

Australia

- Creative Australia; national cultural policy. Australian Government. Commonwealth of Australia. 2013; **Australia.**
- Australia takes an 'arts turn'; an appraisal of Creative Australia, Australia's new National Cultural Policy by Veronica Bullock, significance international, May 2013, **Australia.**

New Zealand

- Science counts! The department of Conservation's Strategic Science and Research Priorities 2011-2016. June 2011,

Various supernational

EU:

- NET-HERITAGE: A road map for cultural heritage research in Europe – results of the project NET-HERITAGE. Net-heritage and Deutsche Bundesstiftung Umwelt. **2011**
- The Joint Programming Initiative (JPI) on Cultural Heritage and Global Change: a new challenge for Europe. Vision document and annex, June 2010 and general brochure. **2010**
- JHEP: Coordination Programme of JPI-CH, Joint Heritage European Programme. Part of this is network building and the development of a European Research Agenda on CH. **2010**
- FACH Vision 2030 & Strategic Research Agenda, Focus Area Cultural Heritage (FACH) of Europe, linked to ECTP (European Construction Technology Platform), Public version #3, March **2008**