# Potential of Semantic Web Technologies to Support Knowledge Transfer in Forest Management

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Abstract: We introduce a Knowledge Transfer Portal (KTP) which supports knowledge transfer among researchers and forest managers. The KTP will be used for supporting transfer of knowledge generated in the FunDivEUROPE (FUNctional significance of forest bioDIVersity in EUROPE) after project life. It uses semantic web technologies to achieve a common understanding throughout a knowledge representation based on an expert elicitation process. Knowledge transfer tools (KTTs) take use of knowledge elements within the knowledge base and implement various knowledge transfer functionalities. The knowledge base shows interactions of biodiversity effects on the sustainable provision of ecosystem services. In this contribution we focus on the ongoing knowledge base engineering process and show first results that were based on a series of workshops with domain experts to generate a common understanding about terms, definitions and their relations. Relations were generated upon FunDivEUROPE project hypothesis with respect to project results and expert beliefs. We use a web-based, collaborative knowledge base engineering cycle and create a thesaurus which was initiated with terms from these expert workshops.

## 1 INTRODUCTION

Semantic web technologies constitute an important step in sharing, integrating and re-using information whereas knowledge management becomes one of the key drivers in semantic web research. Although, few examples, like Rosset (2013), show the potentials of semantic technologies in forest management, semantic web techniques have been hardly adopted in the forestry domain in the past.

Even though functional trait approaches, for example the TRY-database (Kattge et al., 2011) has a large potential to better the understanding of ecosystem changes, they often fail in transferring long term observed knowledge to a broader (nonscientific) community.

At the moment there are large efforts to structure ecology data in common vocabularies. ThesauForm (Laporte and Garnier, 2012; Laporte et al., 2013) or the LTER Controlled Vocabulary (Porter, 2009) are some examples to show how data records can be organized in a standardized way.

Knowledge transfer in FunDivEUROPE (Functional significance of forest biodiversity) aims to support an understanding about the role of biodiversity in securing ecosystem services in forest ecosystems. The identified, produced and evaluated project knowledge will be transferred to politicians, forest managers and other interested user groups. Besides the common shared vocabulary, the major challenge in knowledge transfer between scientists and non-science are the various perspectives on the problem domain. Questions like “Does species mixture matter in improving timber production or enhancing water quality?” need to be answered to serve stakeholders information demands. Therefore the need in knowledge transfer arises to link the research findings of the science community with the practical forest management problems of the stakeholders.

## 2 LITERATURE SURVEY

Basically, knowledge transfer is a form of communication between two individuals where each takes on the role of a sender or a recipient. The questioner communicates his knowledge needs to a sender who acts as knowledge resource and answers the questions of the recipient (Lind and Persborn, 2000). Knowledge Transfer is often labeled time

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consuming with a large need of expert involvement associated with huge costs and many difficulties that hinder a successful competition of knowledge transfer. For example, different background expertise may lead to misunderstanding between the transfer partners in understanding of questioning or answering. These and other difficulties should be seen as characteristics of every knowledge transfer (Szulanski, 2000). Additional to the roles of partners involved in the knowledge transfer also the knowledge itself varies in its type. Nonaka and Takeuchi (1995) differentiate between tacit and explicit knowledge and describe the way how one type of knowledge is transformed into another by various means. Tacit knowledge is hard to be communicated because it states the implicit knowledge bounded to individuals. It has to be made "explicit" in order to make "transferable". On the other hand explicit knowledge can be classified as structured or unstructured and characterized as procedural ("knowing how") or declarative knowledge ("knowing that") that needs to be processed in a different way. In scientific literature transfer of knowledge is often related to transfer between organizations or within an organization/community among its members.

In this contribution we focus on knowledge transfer between forestry experts and various FunDivEUROPE stakeholders. Expert's implicit knowledge needs to be elicited to generate a common understanding of the project domain.

# 3 KNOWLEDGE TRANSFER IN FunDivEUROPE

Key issue of the Knowledge Transfer Platform (KTP) is to facilitate knowledge transfer between researchers and interested end users within the FunDivEUROPE project. It is an easy accessible, modular, web-based platform, which supports knowledge transfer with a set of Knowledge Transfer Tools (KTTs). KTTs add functionalities to allow searching, communicating and exploring knowledge elements. In the context of FunDivEUROPE the KTP should give a frame for researchers and other stakeholders (e.g. forest managers) to interact and exchange various knowledge elements upon a common understanding. Knowledge elements describe semantically enriched content objects enhanced by metadata tags used in the common understanding.

Figure 1 shows the interaction of users with a shared understanding by using, creating or tagging knowledge elements.

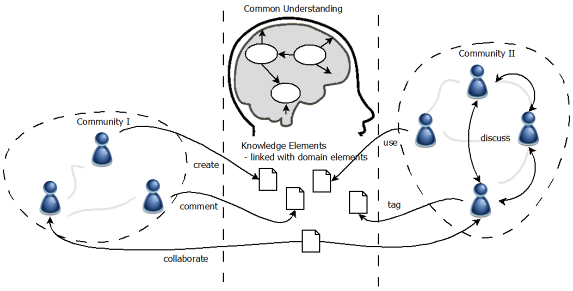


Figure 1: Knowledge Transfer Portal interaction.

## 3.1 Extracts from the KTP Architecture

The architecture of the Knowledge Transfer Portal (KTP), shown in in Figure 2, comprises four main components: Web Content Management System, Toolbox with Knowledge Transfer Tools, Content Crawler and a Semantic Engine. To foster the common understanding of experts and practitioners the KTP uses semantic web technologies to support access of and communication with different knowledge transfer tools. The knowledge base describes a common understanding of the knowledge domain with terms and relationships between knowledge elements.

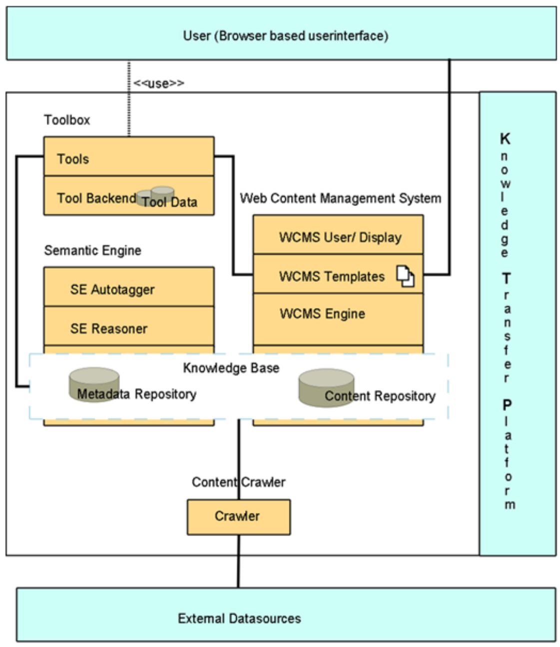


Figure 2: Conceptual Architecture of the KTP.

Each KTT, which aids knowledge elicitation and holds functionalities for decision support, relies on the same knowledge base. In the first prototype we integrate KTTs to search and create project relevant knowledge elements. Additional, a set of advanced tools should be available to explore project findings interactively. For instance a tool to create Frequently Asked Questions (FAQs) on forest biodiversity related issues is implemented in FunDivEUROPE. Another advanced tool, which uses interactive maps, allows comparing the influence of different tree species mixtures on ecosystem services in different European regions.

Figure 2 shows the conceptual architecture of the FunDivEUROPE Knowledge Transfer Platform. The links between the components indicate the interaction of architecture components. With reference to Figure 1 the KTP is placed in between the two communication partners and aid knowledge transfer.

The KTP is designed as web content management system (WCMS) enhanced by a semantic engine for knowledge transfer purposes. The knowledge base holds the content repository of the WCMS and integrates metadata from the enhancement engine. The KTP uses Drupal (Corlosquet et al., 2009) as WCMS and Apache Stanbol (Damjanovic et al., 2011) to support metadata enhancement. The KTTs use the WCMS as presentation layer and rely on the repositories of the semantic engine and the WCMS. Additional a crawler component is responsible for automated retrival of external resources to extend the knowledge base.

# 4 KNOWLEDGE BASE ENGINEERING PROCESS

We use a development process based on expert elicitation originating from a well-accepted methodology in scientific literature. Instead of developing an ontology right from the edge we use a thesaurus form to draft the first prototype of the FunDivEUROPE knowledge base. The thesaurus is described with SKOS (Simple Knowledge Organization System) to use its specifications within the Semantic Web framework. SKOS uses RDF (Resource Description Framework) to allow sharing the knowledge representation on the web and a common understanding of various data sources.

## 4.1 Methodology of the Development Process

We rely on the METHONTOLOGY approach (Fernández-López et al., 1997) to guide the development of the FunDivEUROPE knowledge base used in the KTP.

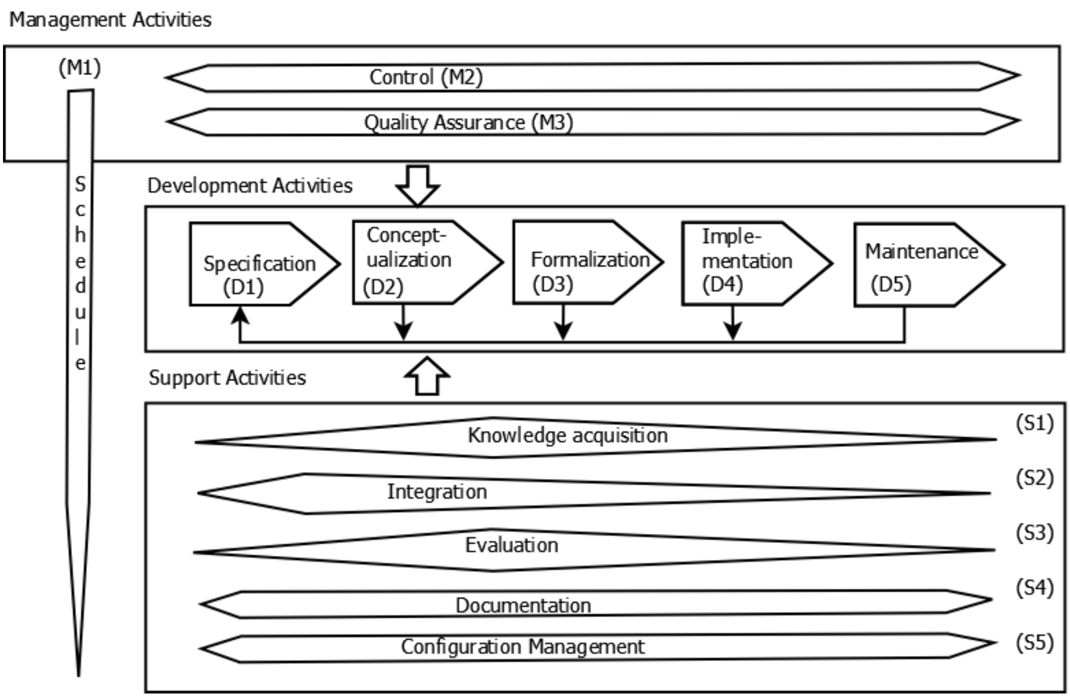


Figure 3: METHONTOLOGY Life cycle.

Figure 3, based on Corcho, et al. (2003) shows the management, development and support activities of METHONTOLOGY. We added shortcuts for each activity to reference our activities of the text below to activities in the methodology.

Development Activities of METHONTOLOGY are used by the means of a spiral model to allow prototyping in the development phase of the KTP.

We also utilize the recommendations of the guidelines for the construction, format, and management of monolingual controlled vocabularies (ANSI/NISO Z39.19, 2005).

### 4.2 FunDivEUROPE Thesaurus Prototype Specification and Conceptualization

After we defined the scope of the FunDivEUROPE thesaurus (D1), we started with a glossary of terms (D2) and a basic network of relations between them. These terms and relations were generated from a series of workshops.

The first workshop was held with a small group of experts and served as a first draft of the glossary of terms relating the FunDivEUROPE project domain. The major challenge was to find a set of terms that not only represents the terms used to formulate research findings but also links issues of interested stakeholders.

Conceptualizations, definitions and relations of the well-known, accepted Millennium Ecosystem Assessment framework (Millennium Ecosystem Assessment, 2005) were applied and extended by findings of Chapin, et al. (2000), Haines-Young and Potschin (2010), Martín-López, et al. (2009), The Economic of Ecosystem and Biodiversity (TEEB, 2010) and Hooper, et al. (2005).

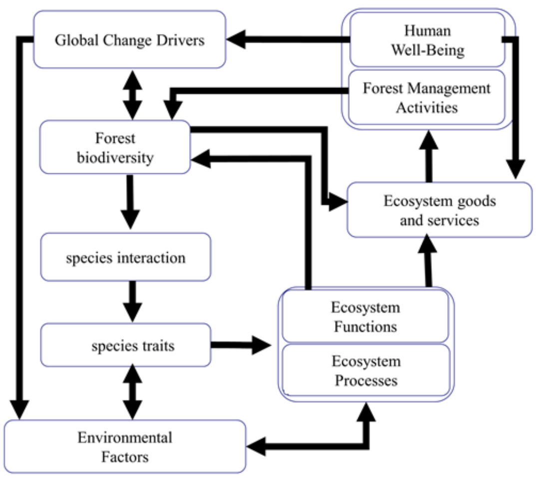


Figure 4: Top-Level interactions.

Figure 4 shows the first Top Level design of the FunDivEUROPE thesaurus, which was a result of intensive literature review on forest biodiversity research (S1, S2). The Top-Level design links ecosystem processes with factors of human well-being and builds a bridge between concepts of interest for different groups of stakeholders.

We assigned terms of the glossary to elements in the framework and used it to confront project experts. Terms and framework were revised in a continuative workshop (S3) as part of the annual project meeting with a larger group of researchers. In this setting experts were asked to formulate their project hypothesis regarding the terms in the glossary. The question included elicitation of relationships between terms for each cause – effect chain belonging to their hypothesis. A project hypothesis "Different tree species mixtures improving timber production" leads to a chain of relevant and related terms e.g. species mixture (a measure of forest biodiversity) influence competition (belonging to species interactions) and cause changes in plant growth rate.

The workshops ended with a revised glossary of terms including relations between these terms and a set of documentation done for each activity (S5).

### 4.3 FunDivEUROPE Thesaurus Prototype Formalization and Implementation

We use Tematres (Gonzales-Aguilar et al., 2012), a web based collaborative approach in thesaurus development, to implement a first version of the FunDivEUROPE thesaurus (D4). Tematres supports a thesaurus definition (D3) to formalize the terms of the previous workshops.

Figure 5 shows a complete structure of the first conceptualization of terms. Afterwards researchers and experts of the project were informed to assist in further thesaurus prototyping.

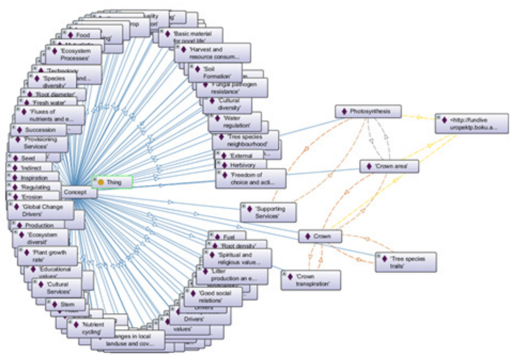

Figure 5: Hierarchy of the FunDivEurope Thesaurus.

# 5 INTEGRATION OF THE THESAURUS INTO THE KNOWLEDGE TRANSFERPLATFORM

In this section we focus on integration of the shared vocabulary with respect to components of the conceptual architecture that shares an interface with the knowledge base.

Figure 2 introduces the interface of the knowledge base to the semantic engine and the WCMS.

We use Apache Stanbol to allow semantic enhanced content management. Stanbol feature a RESTful webservice for easy integration into various content management systems. Furthermore, the VIE (Vienna IKS Editables) JavaScript library was used to provide a set of semantic user interface widgets (Grünwald and Bergius, 2012). These widgets are integrated into the KTPs, Drupal based, WCMS. We use a SKOS definition (Miles and Bechhofer, 2009) of the FunDivEUROPE thesaurus to translate thesaurus definition into RDF (Van Assem et al., 2006). This format allows extending the existing definitions within the Apache stanbol server, which uses dbpedia for metadata enhancement.

# 6 CONCLUSIONS AND FUTURE WORK

We demonstrate how the Knowledge Transfer Tool is used to facilitate knowledge transfer between researchers and other stakeholders. Transfer tools share the same common understanding. A prototype of a thesaurus was developed which represents the domain of the FunDivEUROPE project. We use a prototyping approach and developed a first initializing version of the FunDivEUROPE thesaurus. The thesaurus was integrated within a web content management system via a semantic engine.

Knowledge engineering as we did allows experts to generate a knowledge base which enables to formulate cause-effect relationships on forestry objects (e.g. species traits) and entities known by the stakeholder (e.g. ecosystem goods and services). This effort enables forest managers or politicians to raise general system understanding and increases their sense for influences effecting biodiversity in forests of Europe.

Further work contains constant improvement and extension of the FunDivEUROPE thesaurus and improvements and customizations of user interface integration into the WCMS.

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