Dealing with complexity in pollination management

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Interactions between pollinators and agricultural production are complex to understand and lack of knowledge is, therefore, a challenge for legislation and management. Knowledge tends to be partial and specific to particular systems. Thus, there is a critical need for structural knowledge that can generate an integrated and coherent picture of what is known, and what is not known. This, however, is a complex challenge that involves application of conceptual models to disclose knowledge structures and chains of cause and effects. Here we describe the principle of such a conceptual model for supporting legislation and management to secure the livelihood of bees. Our model combines mind mapping, graphically based structuring techniques and evidence evaluation schemes based on a wide range of specific detailed investigations undertaken in the EU project STEP (http://www.step-project.net/). The description of the conceptual model is based on the following governing question: "How to manage ecosystems to protect bees (native/domestic)?". The general structure is shown in Figure 1, which defines a three step approach[1].

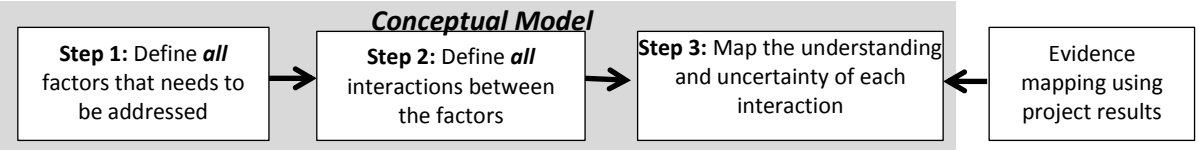

Figure 1. General structure of the concept model. The steps 1, 2 and 3 are explained in the text below.

Step1: Aim to identify a "complete" list of factors that control the presence and abundance of bees, including the human activities that have an influence on these factors. If the defined list of factors is "incomplete", then the subsequent understanding, based on the concept model, will also be incomplete and important topics may be ignored. This is a fundamental problem in modeling (Walker et al., 2003 and Sørensen et al., 2010) and it is, thus, important to make a careful mind map in Step 1 to define factors in order not to overlook topics that may have high relevance to the governing question, see Figure 2. The method in Step 1 is a refinement of the method suggested by Sørensen et al. (2010) and is combined with the hierarchical sub-divisions of questions as suggested by Biesmeijer et al. (2011) which identified important pollination ecology research questions. Figure 2 shows the principle applied here using a simple example for illustration. The complete conceptual model can contain up to 100 factors. Too many factors will make the model inaccessible for management and too few factors will make the model too broad and, thus, result in only trivial conclusions.

[1] The concept model is available in a beta version for testing (contact first author pbs@dmu.dk for application of the model).

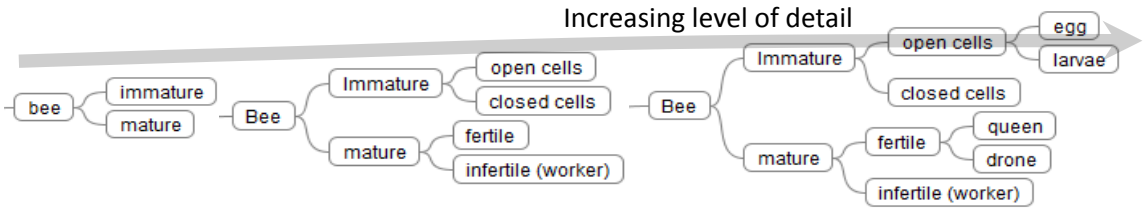

Figure 2. Example of systematic subdivision into detailed factors (life stages of bees). The final factors of “egg”, “larvae”, “closed cells”, etc. are added to the list of factors used for Step 3.

Step 2: In Step 2, some factors are defined to have casual effects on other factors. This is shown through an example in Figure 3, where the application of an insecticide can cause contamination of pollen and thereby expose both larvae and worker (and the other life stages of a bee; not shown in our simple example). Thus, in Figure 3, arrow No 1, relates contamination of pollen to negative effects on the larvae, while arrow No. 2 relates insecticide application to contamination of pollen. These two relations are different in the way that arrow No. 1 not only considers insecticides, and arrow No.2 does not consider how contaminated pollen can affect larvae, but rather how insecticides can end up contaminating pollen; this is a subtle but important difference. The final conceptual model will be much more complex, having hundreds of relations in a network connecting the factors. **Step 3**: The importance of the relations defined in Step 2 (shown as arrows in Figure 3) are evaluated based on available lines of evidences. This forms an efficient way to map the knowledge and to integrate different pieces of evidence into a coherent analysis of understanding and uncertainty. The pieces of evidence are collected from research results and can include a broad range of sources such as peer-reviewed studies and expert opinion. Once populated with evidence the conceptual model can then facilitate policy and practitioners to identify the key relevant evidence available to help inform decision making on a particular aspects of pollinators.

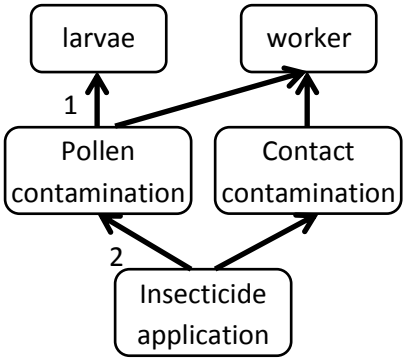

Figure 3. Example showing relations between factors

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