

# RECONNECTING NATURAL AND CULTURAL CAPITAL

CONTRIBUTIONS FROM SCIENCE AND POLICY



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Printed by Imprimerie Centrale in Luxembourg

Manuscript completed in December 2017

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Luxembourg: Publications Office of the European Union, 2018

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Print	ISBN 978-92-79-59949-1	ISSN 1018-5593	doi:10.2788/09303	LB-NA-28023-EN-C
PDF	ISBN 978-92-79-59948-4	ISSN 1831-9424	doi:10.2788/258513	LB-NA-28023-EN-N
EUR	28023			

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Graphic Project by Giorgio Moretti (Rome), Italy

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# A closer look at Norway's natural capital—how enhancing urban pollination promotes cultural ecosystem services in Oslo

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## Introduction

Insect-mediated pollination is both an ecological process and an ecosystem service that advocates of biodiversity conservation frequently highlight and promote because of its important role in food production. Yet the benefits for human well-being provided by pollinators extend beyond pollinators' contributions to producing many of our food sources (Garibaldi et al., 2016). An estimated 250 000 species of flowering plants depend on biological pollinators (Abrol, 2012). Pollinators are involved in the reproduction of plants that contribute to the provision of fibres, forage, timber and other forest products, from firewood to medicinal products (Kremen et al., 2007). Pollinators are also integral in the life cycles of the many wild plant species that provide other ecosystem services involved in regulating and maintaining desired ecosystem functions. The flowers that plants produce to attract insect pollinators have broad aesthetic appeal, and their occurrence in a landscape helps define many of the attributes that contribute to the values we assign to virtually all cultural ecosystem services.

Many of the ecosystems that provide important provisioning and regulating services are located far outside cities, rendering these ecosystems services virtually invisible to city inhabitants. However, city residents are able to directly perceive and experience many cultural ecosystem services more locally. Cultural ecosystem services therefore provide clearer and more intuitive examples of environment-to-benefit linkages than many material ecosystem services and can be a useful tool for both managing urban green spaces and promoting urban sustainability (Anderson et al., 2015). As an ecological process, pollination is either directly or indirectly involved in a wide array of cultural ecosystem services. Pollination is crucial for cultivating fruits and vegetables that many urban residents grow in back yards or allotment gardens. Fruit and vegetable gardening in urban environments is in many ways more of a recreational pursuit that provides an opportunity to learn about natural processes and transfer this knowledge across generations and social groups (Barthel et al., 2010) than a means of producing food. The gardens, orchards and other urban green spaces where pollinators forage and facilitate plant reproduction are often landscape features that help define many urban residents' sense of place and their cultural heritage. The increased contact that residents have with green spaces in urban environments has many health benefits as well, including positive psychological effects (Tzoulas et al., 2007), and decreasing the prevalence of allergies and chronic inflammatory diseases (e.g. Hanski et al., 2012) and others.

Urban beekeeping (or apiculture) is an activity whose popularity has increased noticeably in the past decade in many European and North American cities. While a portion of urban beekeepers keep and maintain beehives primarily for consuming the honey that bees produce—a provisioning ecosystem service—a good deal of the motivation for urban beekeeping for many stems from the cultural and non-consumptive aspects of beekeeping. Over half of the world's population and nearly three quarters of Europe's population lives in cities (United Nations

Population Division, 2015). The highly modified character of urban areas often limits residents' contact and familiarity with the natural components of ecosystems and the ecological processes that support human societies. Urban apiculture is a way of re-establishing the connections between city residents and their natural environment by both raising awareness of pollination's central role as an ecological process and ostensibly increasing the capacity of a city's pollinators to assist the reproduction of plants growing in urban green areas. Urban apiculture can also contribute relational values (Chan et al., 2016) of urban nature when beekeepers practice beekeeping with family members, together in local beekeeping groups, and promote awareness of the urban landscape through courses, market days and other similarly social activities.

### Urban beekeeping and pollinator awareness in Oslo, Norway

ByBi (Norwegian for 'city bee') is an urban beekeeping organisation founded in Oslo in 2012 and a chapter of the national Norwegian Beekeepers Association (Norges Birøkterlag). Its membership consists of both practicing beekeepers and others who are generally interested in various aspects of bee pollination. The group's goals are to both promote the positive attributes of honey (culinary, nutritional and medicinal) produced by domestic bees and to create educational opportunities and raise awareness of the importance of all insect pollinators. ByBi's organisers' intention that the group's activities can help improve conditions for both domestic and wild bee pollinators in the Oslo area and thereby contribute to improving the Oslo metropolitan area's overall biodiversity. (More information about the group and its activities can be found at the group's website: <http://www.bybi.no>.)

ByBi organisers operate a handful of apiaries where visitors can come and learn about beekeeping from an experienced beekeeper. Interested individuals can participate in the care and maintenance of the cubes or

even help harvest the honey that bees produce. ByBi also contributes to education about pollinator ecology by offering courses for first-time beekeepers who are interested in establishing their own beehive (Figure 1). The rise in urban beekeeping has contributed to reversing the decline in the number of beekeepers in Norway: the number of registered Norwegian beekeepers has increased considerably from its lowest number (2 501) in 2011 to 3 715 in 2015 (Norwegian Beekeepers Association, 2016). Together



Figure 1

ByBi provides instruction in the fundamentals of apiculture, enabling urban residents who are new to beekeeping to enjoy the activity and increasing the overall benefit of this cultural ecosystem service (photo: ByBi).

with the apiaries operated by private individuals who are also affiliated with ByBi, the Oslo urban area has been home to around 50 apiaries during the past 3 to 4 years, with locations distributed throughout the 250 km<sup>2</sup> of the city's developed area. The scale of these urban apiaries is quite modest compared with honeybee colonies used in commercial honey production and crop pollination. While one or two of the locations operated by ByBi have

as many as 10 cubes, the average size of an apiary is three cubes. In the 2015 season, ByBi-affiliated beekeepers with hives located in the Oslo metropolitan area produced roughly 3 600 kg of honey, most of which was for private consumption.

### Pollinator Passage

An effort that best illustrates ByBi's interest in promoting insect pollination in general is their role as initiator, creative executor and coordinator for the 'Pollinator Passage' project (*Pollinatorpassasjen*; <http://www.pollinatorpassasjen.no>). The project has also received financial and infrastructural support from the Norwegian Environmental Agency, a gardening-oriented NGO called Det Norske Hageselskapet (the Norwegian Garden Collective) and a handful of companies based in the Oslo area. As its name indicates, the Pollinator Passage aspires to increase the connectivity of Oslo's existing green areas with areas containing newly planted flowering vegetation, creating a corridor through the city where pollinating insects can find both sufficient floral resources and nesting sites. The corridor is to extend from the Sognsvann lake in the north-western portion of Oslo to the Nøklevann lake in Oslo municipality's south-eastern extent, passing through the more densely developed area in the urban area's centre. The principle is that the city's intensely developed centre, with its high degree of impermeable surfaces, lacks sufficient resources for insect pollinators and thereby limits their occurrences and hinders their movement through this landscape. To rectify this, the project is promoting an increase in both the density and duration of flower availability for nectar-rich floral resources in Oslo's developed area. Participants are encouraged to plant bee-friendly flowers in boxes, flowerbeds and rooftops. Pollinator Passage also promotes constructing and mounting boxes that can serve as 'bee hotels' for bumblebees with a variety of nesting substrates (Figure 2), or increasing the availability of dead wood that also serves as nesting sites for many solitary bee species.

The organisers behind the Pollinator Passage project clearly designed it to encourage participation by city residents, particularly those who might be more ecologically uninitiated. Project materials distributed during promotional events and published on the project's website invite people to consider the landscape from a pollinator's perspective in a way participants can identify with: as a tourist in the big city. The materials ask participants the following: 'Where would you go, and what would you do? How is the nightlife for pollinators in Oslo? Where are the meeting places and the good pick-up spots? Where are the restaurants with the best food and where can one find a hotel? Is it at all possible for a pollinator to get a bite to eat and find shelter in this city?' Promotional materials provide general information about pollination as an ecological process and its general importance, stressing how changes in land use have decreased the floral



Figure 2

A bee hotel: functional ecological design improving bumblebee habitat quality in Oslo's Sagene neighborhood, constructed as part of the Pollinator Passage project (photo: ByBi).

resources and nesting sites for many species of pollinating insects. Materials also describe the main groups of insect pollinators, including the three groups of bees (honeybees, bumblebees and solitary bees), along with butterflies, flies and beetles.

Materials inform participants about what constitutes an ideal habitat for pollinators, using anthropocentric terms selected to reinforce a sense of solidarity between people and pollinating insects. Floral resources ('food') are described using terms like menu, ingredients, dishes and restaurants. Nesting sites ('housing') are discussed using terms like hotels, furniture, rooms, roofs and carpeting to describe the ways participants can construct or otherwise provide for the different types of nesting sites used by different groups of bees. The overall tone suggests

a good dose of playfulness and fun that makes the activities particularly attractive to children (and their parents). The project also has a mascot, Polli Pollinator, further increasing its appeal to the younger crowd.

A major component of the project's website aims at fostering collective participation through mapping the contributions project participants have made to increase the city's habitat quality for pollinators (Figure 3). After registering with a user name and password, participants can add features to the map—preferably with pictures—that illustrate where participants have made improvements in the availability of nectar-rich flowers. Contributors can register their eating site as

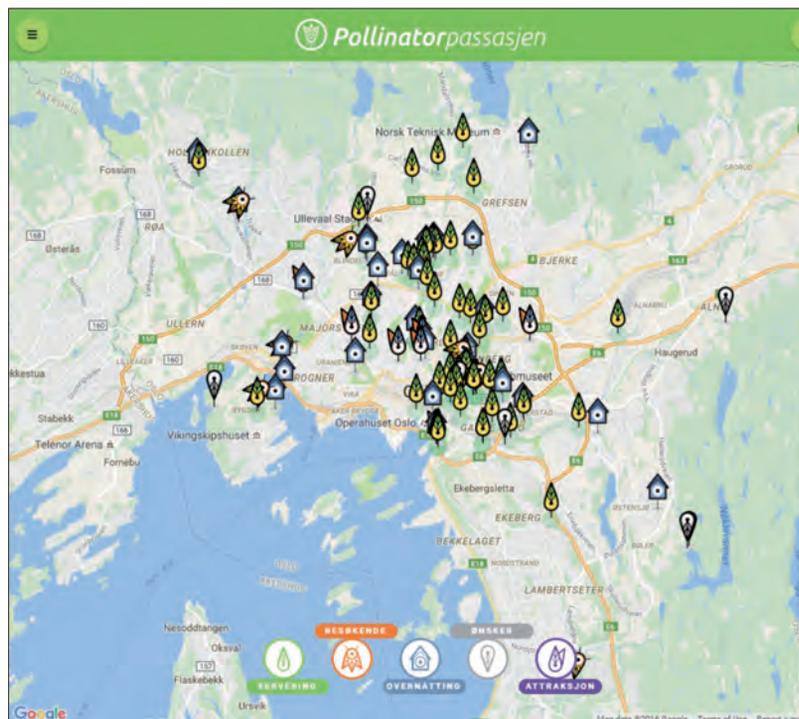


Figure 3  
Interactive map from the Pollinator Passage project's website, illustrating where project participants have recorded the locations of floral resources, nesting sites, and observations, and other attractions related to all types of bees (photo: ByBi).

either pots, flowerbeds, roofs, gardens, housing association property, small plots of land (including publicly owned land) or other 'unusual places'. Participants can register locations for overnight housing, selecting from a menu that includes dead wood, insect hotels, sandy soil nests, other bumblebee nests, walls, flowers and honeybee hives. Participants can also register where they observed insect pollinators, or attractions of general interest such as locations of honeybee hives.

### Mapping Oslo's pollinator habitat quality

Other efforts are also underway to assess how conditions for pollinating insects and other aspects of Oslo's natural capital might vary across the city. ESTIMAP is a collection of spatially explicit models developed to support the mapping of ecosystem services at a national and continental scale to provide informational support necessary for drafting and enforcing EU environmental policy (Zulian et al., 2013). ESTIMAP's pollination model was

developed based on the InVEST model (Sharp et al., 2016), and uses land-cover category data to estimate the capacity of different landscapes for providing pollinating insects with food and shelter. Experts on pollinator biology provide value weights for land-cover categories that reflect the availability of floral resources and nesting sites. The model also incorporates the foraging distances for a given group of pollinator bee species, combined with an activity index based on local climatic conditions (temperature and solar irradiance), to derive an index of relative pollinator abundance for each cell of a land cover map. At the European continental scale, the model uses Corine Land Cover data, which produces an output map with a 100 × 100 m (1 ha) resolution that is particularly useful for illustrating where agriculture might experience pollinator deficits at a regional scale.

Researchers from the Norwegian Institute for Nature Research (NINA) and the European Commission's Joint Research Centre, with cooperation from the Urban Environment Agency in Oslo municipality, are exploring ESTIMAP's utility as a tool for informing and assisting urban planning. By utilising the city's high-resolution spatial data, ESTIMAP has the potential to illustrate how habitat quality for pollinators varies within the municipality and to depict the distribution of an important aspect of Oslo's overall biodiversity. Oslo is Europe's fastest growing capital city, and city planners are interested in finding and using tools that can ensure the city's expected growth does not compromise its existing natural capital. ESTIMAP mapping also has the potential to inform current management decisions directly connected to insect pollinators. While the primary motivation for urban apiculture is to improve or enhance the city's biodiversity, there is a concern that an increased population of domestic honeybees might compete with a number of threatened native bumblebee and solitary bee species. As a precautionary measure, the Urban Environment Agency recently proposed establishing 'honeybee-free zones' to protect wild bee populations within the city limits.

Applying the ESTIMAP pollination model to the city of Oslo represented an opportunity to test the model's capacity to describe variation in pollinator habitat quality at the spatial scale required to identify existing gaps where pollinator passageways could be strengthened. Combining pollinator-habitat hotspot mapping with locations of threatened wild bee species could also provide greater accuracy for identifying actual no-go areas for domestic honeybee hives. Oslo municipality has a wealth of high-resolution land-cover data (10 × 10 m rasters) available for model inputs. Experts on bee ecology from the NINA provided the parameter weighting for the landscape attributes described in the municipality's data to reflect land cover's relative habitat suitability, scaled from 0 (completely unsuitable) to 1 (ideal habitat). The resulting output map (Figure 4) displays the variation in habitat quality for the built areas of Oslo municipality. This map illustrates a number of areas with high pollinator habitat quality, identified by blue

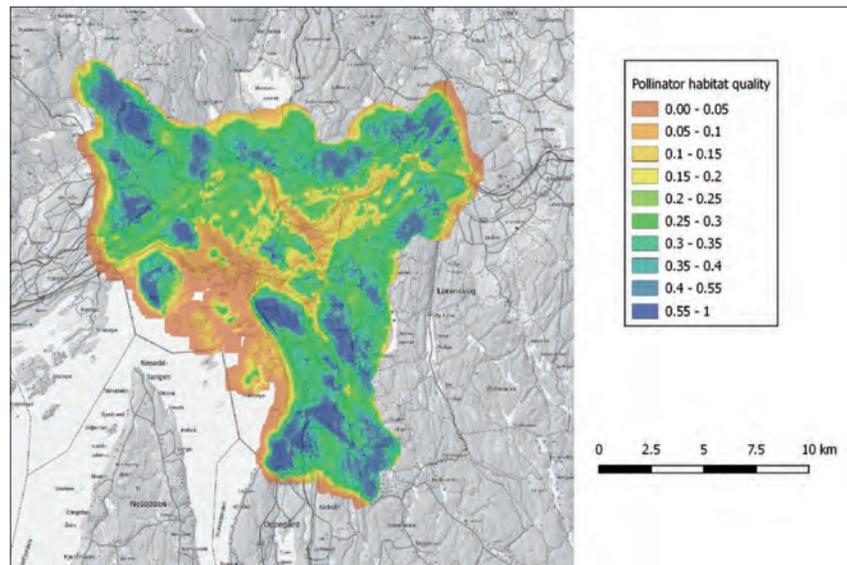


Figure 4  
Example of ESTIMAP output map that displays variation in pollinator habitat quality in Oslo, Norway.

colours, which correspond to areas featuring greater proportions of green infrastructure. The map illustrates a number of areas where pollinator habitat quality is far lower, particularly the city's centre and a stripe extending from the city centre to the north and east, where a transport and heavy industrial activities dominate the city landscape.

We employed two methods for assessing the validity of the ESTIMAP model and the estimated weights of land-cover categories' value for urban pollinating insects. The first involved sampling the community of pollinating

insects using pan traps (Figure 5). Trap samples provided estimates of the overall abundance and species diversity of the three types of bees (honeybees, bumblebees and solitary bees), along with other insect pollinators (beetles, flies, moths/butterflies and other insects) attracted to the traps. Honey-production figures, supplied by ByBi-affiliated beekeepers, also provided a complementary method for assessing the quality and quantity of floral resources available to Oslo's honeybees. Unfortunately, these two complementary approaches provided neither a clear confirmation nor a negation of the ESTIMAP map output. Population abundance and community diversity did not vary significantly according to the mean ESTIMAP scores of areas that surrounded trap locations as defined by potentially relevant foraging distances (500 m, 1 000 m or 1 500 m radii). Honey production also did not vary according the mean ESTIMAP scores of areas surrounding beehive locations.

The lack of a relationship between the ESTIMAP model and sampled pollinator abundance does not necessarily imply either that pollinator habitat quality is uniform across the city

or that the model is incorrect. Pollinating insects are highly mobile, and thus able to access patches with floral resources provided the patches are within reasonable proximity of other foraging areas. Unfortunately, this makes it difficult to verify the ESTIMAP pollination model at the spatial resolution necessary for urban land use management—either with the methods we used or any others that are appropriate for sampling pollinating insects. The high degree of heterogeneity in the urban landscape also suggests that the initial parameter weights used in the ESTIMAP first output map may need to be adjusted to reflect a greater habitat suitability than was originally assumed by the bee ecology experts.

The ESTIMAP model identified numerous areas with low proportions of flowering vegetation that correspond to the areas that the Pollinator Passage project seeks to improve. However, even in these areas we find small patches of flowers along roadsides and abandoned lots, or maintained flowerbeds. Results from this trap-based sampling indicate that the distribution of these patches has sufficient connectivity to allow for considerable numbers of pollinators to reach and forage among the more isolated flowers. Domestic honeybees appear

Figure 5

Pan traps used for sampling insects, here located in a small patch of native vegetation near Oslo's harbor (photo: Erik Stange).



similarly able to overcome the existing gaps between patches with floral resources such that variation in honey production appears to be unrelated to the abundance of high-quality foraging areas in the area immediately surrounding the beehives.

The ESTIMAP verification results actually provide information that is uplifting and useful for both the Pollinator Passage project and conservation of urban pollinating insects in general. First, the mapping exercise more explicitly describes the distribution of variation in pollinator habitat quality across the city, confirming the project's initial intent to focus on improving conditions in the central portions of Oslo and identifying additional areas where measures might be of use. Yet more importantly, the sampling indicates that even small areas are often capable of providing sufficient floral resources to attract pollinators. Other studies have shown that flower availability in small patches correlates positively with both bee density and diversity (Bennett et al., 2014; Kallioniemi et al., 2017). We can reasonably expect that any efforts made to increase the overall density of patches in the landscape will also improve the conditions for insect pollinators by both providing additional flowers and decreasing the pollinators' energy demands for foraging.

## Conclusions

The mapping activities from both the Pollinator Passage and the ESTIMAP model provide information that strengthens the links between Oslo's natural and cultural capital. The improvements to the connectivity of pollinator habitat that are inspired by the Pollinator Passage project enhance an important component of Oslo's green infrastructure and are in line with the European Commission's green infrastructure strategy (European Commission, 2013). Cooperation between the researchers working with ESTIMAP and individuals involved in ByBi's activities enhance opportunities for learning and discovery about the city's green spaces. The Pollinator Passage's interactive map invites greater resident participation by permitting citizens to submit information on observations and interventions that can enrich pollinator habitat quality. ESTIMAP provides a model that can eventually incorporate this information into a more detailed mapping of gaps in and hotspots for pollinator habitats. Together these activities provide city planners with a tool for visualising and quantifying both the quality and distribution of an important aspect of the city's biodiversity, such that the natural capital can continue to provide cultural ecosystem services for future generations of Oslo residents.

## Acknowledgements

This work was funded by the European Union EU FP7 project OpenNESS (Grant agreement no. 308428) and URBAN SIS (Strategiske instituttsatsinger / SIS 2016-2019, Norwegian Research Council)

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