ESEE 2015: Transformations

2. Natural resources, ecosystem services and environmental quality

2.3 Ecosystem services: debating, valuing, preserving and providing

The economic insurance value of wild pollinators in almond orchards

Summary

Biodiversity provides an economic insurance value against the uncertain provision of ecosystem services for risk-averse economic agents. For pollination services, we determine the economic insurance value of wild pollinators in almond orchards for a risk-averse farmer. We develop an ecological-economic model to determine the risk premium and insurance value of wild pollinators in general, and employ empirical data of flower visits of honeybees (*Apis mellifera*) and wild pollinators such as several wild bee species (e.g., *Andrena* spp., *Osmia* spp.) and hover flies (Syrphidae) to almond trees in California. We predict a positive risk premium and insurance value because several wild pollinators, in contrast to the European Honeybee, forage even under inclement weather conditions. This result should be taken into account when deciding on how much to invest in the conservation of wild pollinators. Additionally, this model can be applied to other ecosystem services and supports an increase in biodiversity conservation.

Extended abstract

Biodiversity can provide insurance against the uncertain provision of ecosystem services. In the case of wild pollinators providing farmers with crop pollination services, we determine the risk premium and the economic insurance value of the wild pollinators. Under uncertainty risk-averse decision-makers tend to diversify their sources of income to reduce the risk of losing their income at once. For instance, farmers grow different crops species or varieties to reduce the probability of a total loss. In other words, if yield of one particular crop species suffers from fluctuations in environmental conditions, other crops can match the resulting yield loss of. Thus, diversity provides insurance for risk-averse economic agents (Baumgärtner 2007, Baumgärtner and Strunz 2014).

A similar effect has been observed in ecosystems. An increase in the level of biodiversity in terms of species richness can enhance the provision of ecosystem services. One explanation is that the probability of the occurrence of a key species for providing the target ecosystem service is increased (Tilman et al.

1997, Hooper et al. 2005). Additionally, an increase in the level of biodiversity can stabilize ecosystems and their properties. Several species contribute to ecosystem functioning but respond differently to environmental disturbances and fluctuations. Under uncertain and changing conditions the ecosystem functioning and thus, the ecosystem service can often be maintained with a high level of biodiversity (Walker et al. 1999). This is, a high level of biodiversity can provide an insurance against the under- or overprovisioning of ecosystem services (Walker et al. 1999, Loreau et al. 2001, Hooper et al. 2005, Baumgärtner 2007).

The ecosystem service of pollination is crucial for humans because 35% of the world crops depend to some degrees on pollination (Klein et al. 2007). Many of the pollinator dependent crops rely on the pollination of the European Honeybee (*Apis mellifera*) (Committee on the Status of Pollinators in North America 2007). However, there is a severe decline in honeybee stocks in the USA and Europe (Committee on the Status of Pollinators in North America 2007, Stokstad 2007) due to several drivers, e.g. pests and pathogens, environmental stressors and a lack of genetic diversity and vitality (Potts et al. 2010). Thus, the honeybee is sensitive towards several influences. Wild pollinators, such as several wild bee species (e.g., *Andrena* spp., *Bombus* spp. *Osmia* spp.) and hover flies (Syrphidae), are known to forage even under inclement weather conditions and can be effective pollinators (Willmer et al. 1994, Goulson 2003; Garibaldi et al. 2013). Yet, they are not always taken into account when managing crops that benefit to some degree from insect pollination.

Therefore we take an interdisciplinary approach and

1. develop an ecological-economic model to determine the risk premium and the economic insurance value of wild pollinators in general and
2. employ empirical data about species-specific flower visits and fruit set in almond trees in California to quantify the risk premium and the economic insurance value of wild pollinators in almond orchards.

We assume a risk-averse farmer who strives to maximize his expected utility because most of the people have shown to be risk-averse (Holt and Laury 2002).

We predict a positive risk premium and insurance value of wild pollinators because of the farmer's risk-aversion and because wild pollinators forage also under more difficult weather conditions. For instance, several wild-pollinating species forage under low temperatures (<12°C) and cloudy skies and with wind speeds higher than 2.5 m s^{-1}, whereas the European Honeybee forages when temperatures are above 13°C with sunny to lightly overcast skies and low wind speeds (Burrill and Dietz 1981, Vicens and Bosch 2000, Brittain et al. 2013).

Results indicate that wild pollinators can provide an insurance value against the uncertain provision of ecosystem services. That is, wild pollinators can compensate a possible under-provision of the ecosystem service of pollination by the honeybee under changing environmental conditions.

In conclusion, this result should be taken into account when deciding on how much to invest in the preservation of wild pollinators. Additionally, this model can be applied to other ecosystem services and supports an increase in biodiversity conservation.

References:

Baumgärtner, S. 2007. The insurance value of biodiversity in the provision of ecosystem services. Natural Resource Modeling **20**:87-127.

Baumgärtner, S. and S. Strunz. 2014. The economic insurance value of ecosystem resilience. Ecological Economics **101**:21–31.

Brittain, C., N. Williams, C. Kremen, and A. M. Klein. 2013. Synergistic effects of non-Apis bees and honey bees for pollination services. Proceedings of the Royal Society B. Biological Sciences **280.**

Burrill, R. M., and A. Dietz. 1981. The response of honey bees to variations in solar radiation and temperature. Apidologie **12**:319-328.

Committee on the Status of Pollinators in North America. 2007. Status of Pollinators in North America,. The National Academies Press, Washington D.C.

Garibaldi, L.A., Steffan-Dewenter, I., Winfree, R., Aizen, M.A., Bommarco, R., Cunningham, S.A., Kremen, C., Carvalheiro, L.G.,Harder, L.D., Afik, O., Bartomeus, I., Benjamin, F., Boreux, V., Cariveau, D., Chacoff, N.P., Dudenhöffer, J.H., Freitas, B.M., Ghazoul, J., Greenleaf, S., Hipólito, J., Holzschuh, A., Howlett, B., Isaacs, R., Javorek, S.K., Kennedy, C.M., Krewenka, K., Krishnan, S., Mandelik, Y., Mayfield, M.M, Motzke, I., Munyuli, T., Nault, B.A., Otieno, M., Petersen, J., Pisanty, G., Potts, S.G., Rader, R., Ricketts, T.H., Rundlöf, M., Seymour, C.L., Schuepp, C., Szentgyörgyi, H., Taki, H., Tscharntke, T., Vergara, C.H., Viana, B.F., Wanger, T.C., Westphal, C., Williams, N., and Klein, A.M. 2013. Wild pollinators enhance fruit set of crops regardless of honey-bee abundance. Science 339:1608-1611.

Goulson, D. 2003. Conserving wild bees for crop pollination. Food, Agriculture & Environment **1**:142-144.

Holt, C. A., and S. K. Laury. 2002. Risk aversion and incentive effects. American economic review **92**:1644-1655.

Hooper, D. U., F. S. Chapin, J. J. Ewel, A. Hector, P. Inchausti, S. Lavorel, J. H. Lawton, D. M. Lodge, M. Loreau, S. Naeem, B. Schmid, H. Setälä, A. J. Symstad, J. Vandermeer, and D. A. Wardle. 2005. ESA Report. Effects of Biodiversity on Ecosystem Functioning: A Consensus of Current Knowledge. Ecological Monographs **75**:3-35.

Klein, A. M., B. E. Vaissiere, J. H. Cane, I. Steffan-Dewenter, S. A. Cunningham, C. Kremen, and T. Tscharntke. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B. Biological Sciences **274**:303-313.

Loreau, M., S. Naeem, P. Inchausti, J. Bengtsson, J. P. Grime, A. Hector, D. U. Hooper, M. A. Huston, D. Raffaelli, B. Schmid, D. Tilman, and D. A. Wardle. 2001. Biodiversity and ecosystem functioning: current knowledge and future challenges. Science **294**:804-808.

Potts, S. G., J. C. Biesmeijer, C. Kremen, P. Neumann, O. Schweiger, and W. E. Kunin. 2010. Global pollinator declines: trends, impacts and drivers. Trends in Ecology & Evolution **25**:345-353.

Stokstad, E. 2007. The case of the Empty Hives. Science **316**:970-972.

Tilman, D., C. L. Lehman, and K. T. Thomson. 1997. Plant diversity and ecosystem productivity: Theoretical Considerations. Proceedings of the National Academy of Sciences **94**:1857-1861.

Vicens, N., and J. Bosch. 2000. Weather-Dependent Pollinator Activity in an Apple Orchard, with Special Reference to Osmia cornuta and Apis mellifera (Hymenoptera: Megachilidae and Apidae). Environmental Entomology **29**:413-420.

Walker, B., A. Kinzig, and J. Langridge. 1999. Plant Attribute Diversity, Resilience and Ecosystem Function: The Nature and Significance of Dominant and Minor Species. Ecosystems **2**:95-113.

Willmer, P. G., A. A. M. Bataw, and J. P. Hughes. 1994. The superiority of bumblebees to honeybees as pollinators: insect visits to raspberry flowers. Ecological Entomology **19**:271-284.