Where Beetles are crawling and Honeybees are humming.

A summary of biodiversity research by Dr. Gunter Mann, Optigreen International.

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Abstract

The terms “extensive” and “intensive green roofs” are based on the plants these systems support and the degree of maintenance they require. Depending on plant species and varieties used, green roofs can also support a diversity of fauna. Dr. Gunter Mann, born 1967 in Horb near Stuttgart, Germany, studied biology at the University of Tübingen (founded in 1477) and has been in Research and Development for Optigreen Germany since 1992. In 1993, Dr. Mann began the world’s first research program studying wildlife use on various types of green roofs. This research is ongoing and has uncovered an astonishing diversity of fauna on green roofs, including the usual suspects like butterflies, ladybugs, ground-nesting birds and spiders, but also snails, worms, and many families of insects. It is an honour to summarize this research, and we hope to motivate people across Canada and the US to pursue similar research on green roofs that are older than 5 years.

Introduction

As children, we all learned the old story about the honey bee and the flower. Without the diligent services of bees (and other pollinators), many of the flowering plants on this earth will not produce their fruit. This in turn implies the risk of population decline, genetic impoverishment and, for human and other consumers, potential food shortages. Today when we look in the newspaper we can read about a mysterious illness which is killing tens of thousands of honeybee colonies around the world, threatening the production of honey and of the crops that require bees for pollination. Even in our high-tech world, it is amazing how dependent we still are on flora and fauna.

Today, modern green roof technology is being sold as a tool for stormwater retention, thermal insulation and many with other natural benefits. To this we might question, “How natural is a green roof? Do we bring back only flora, or what about the fauna?”

Further to these questions, as part of his Diplom-Arbeit (Master's Degree) in 1993, Dr. Gunter Mann also asked in the following questions to evaluate the ecological aspects of green roofs:

- Do insects accept green roofs as an alternative habitat?
- Is it possible to establish arthropod populations (spiders, insects etc.) in the long run?
- Are there differences in faunal use between extensive, semi-intensive or intensive green roofs?

The bibliography at the close of this paper summarizes Dr. Mann's work, and those of his collaborators. Due to the focus of this paper on these works, the biodiversity research that has been conducted in Switzerland and England have not been included here. These studies should, however, be sought out by anyone interested in green roofs for biodiversity.

Observations

Dr. Mann began his research on 4 small projects in Sindelfingen/ Böblingen near Stuttgart and continues his research and observations today. These studies include more than 125 green roofs, up to ½ million ft^2, from ground level to a nearly 400 ft high-rise building. The four original sites are described below, with accompanying images.

(1) Extensive green roof, 80% Sedum species, 20% herbaceous plants, 3 inch total thickness and approximately 5000 ft^2.
(2) Extensive green roof, 60% Sedum species, 35% herbaceous plants, 5% small woody plants, 4 inch total thickness with a few, 6 inch high "mounts".
(3) Semi-intensive green roof, 50% Sedum species, 30% herbaceous plants, 20% woody plants, 4 to 10 inch total thickness, 6000 ft^2. (75% 4 inch, 25% 10 inch)
(4) Intensive green roof, 50% herbaceous plants and 50% woody plants, shrubs, 12 to 14 inch total thickness, 1000 ft^2.

Materials and Methods

Since the filter layer is typically the natural possibility to retreat, thermisters were installed on the filter layer of these green roofs to measure temperature over the course of one year. Equipped with butterfly net and yellow bowls (water or adhesive), the "hunting season" went from 6 April 1993 until 21 September 1993.

Given that a 3 inch extensive system can dry out quickly, remain dry for extended periods and drop below freezing temperatures, it was anticipated that this system would not support many ground-dwelling fauna. This would be expected to create missing links in the potential food web, which would limit overall biodiversity (Fig. 1).

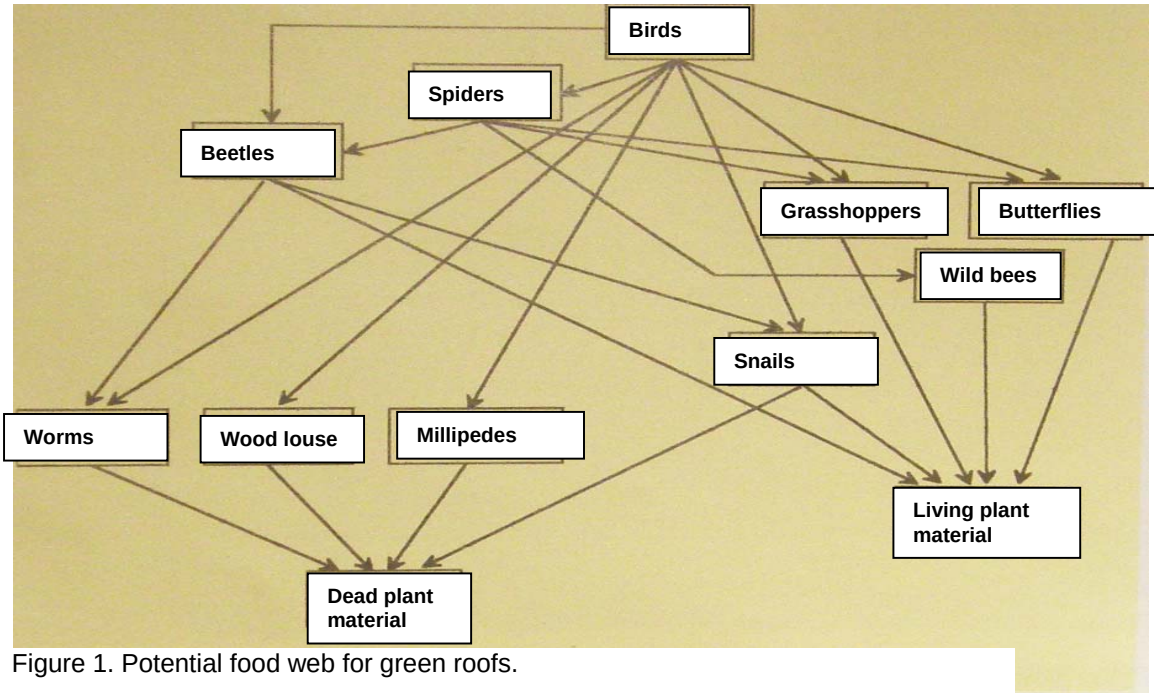

Figure 1. Potential food web for green roofs.

The conclusions from Dr. Mann's first study in 1993 confirmed that growing medium depth, plant varieties and plant groups play a significant role on biodiversity. The chart below (Fig. 2) lists the species found on each project. While total species richness would only become a topic of interest later on, this original study made an interesting discovery: On Project 1 (5000 ft^2 with 3 inch growing media), 29 individuals of ground beetles were identified; on Project 4 (1000 ft^2 10 inch growing media), 315 individuals. Nearly 10 times more individuals of ground beetles were found on an intensive green roof that was 5 times smaller than a 3 inch thin layered extensive green roof.

One reason for this huge difference of species and individuals are parallel with climatic data. With every new season, the species occurring on thin-layered extensive green roofs must start new life cycles. Thin layered extensive green roofs are typically only seasonal habitats, and the extreme conditions of winter don't support much survival. However, the green roof can turn into permanent habitat with deeper growing media and more plants types (Sedum, herbs, shrubs etc.).

	Objekt 1	Objekt 2	Objekt 3	Objekt 4
Ground Beetles	3	3	17	5
Wild Bees	17	23	27	19
Butterflies	2	3	8	3
Grasshoppers	1	2	3	1
Summe:	23	31	55	28

Figure 2. Summary of the biodiversity of observed faunal groups at four green roof study sites.

Dr. Gunter Mann's conclusions of his first research questions:

- Do insects accept green roofs as an alternative habitat?
  Yes, all green roofs are accepted as alternative habitat, although the degree of biodiversity and species richness varies.
- Is it possible to establish arthropod populations in the long run?
  The establishment of long-lasting and self-sustaining populations is only expected on thicker green roof layers, or in areas where plants have greater rooting volume.
- Are there differences between on extensive, semi-intensive or intensive green roofs?
  The various types of green roofs studied here had very different results in terms of biodiversity. A mix of extensive green roofs (4 inch) with some intensive areas (10 inch) was rated to be the most ecological and economical balance. Thin (3 inch and less) extensive green roofs serve as stepping-stone habitats, or as incomplete food sources for honey bees.

As a result of his findings, Dr. Mann expressly underlined that faunal considerations should be integrated into the German ecological rating system which is vaguely comparable to LEED™.

In the years following his original research, Dr. Mann continued his research on different locations and started the important discussion about the zoological and ecological role of green roofs. Today green roofs are an important key in the German biotope/ habitat network and are acknowledged to serve as alternative habitats and stepping-stone biotopes.

In 2005, as part of one of his latest studies, Dr. Mann responded to the question of the Senate for Building Land Matters in Berlin, Germany: do high-rise buildings (higher than 120 ft) create habitats which fit into the German biotope/ habitat network? The Senate chose Dr. Gunter Mann because of his experience on the topic, and because through Optigreen he could acquire a sizeable sample size. Optigreen maintains the largest green roof franchise, comprising a network of companies with 30 years experience in the green roof business. With little effort, Dr. Mann found three sites for this study.

(5) Extensive green roof, 100% Sedum species, 4 inch total thickness, over 16,000 ft^2, 100 ft above ground, surrounded by roadways and many other buildings. 1 year old.

(6) Extensive green roof with intensive planted areas, 70% Sedum species, 20% herbaceous plants, 10% small woody plants, 4 inch total thickness with 12 inch intensive areas. Approximately 4,500 ft^2. 150 ft above ground, surrounded by other buildings and some industrial areas. 15 years old.

(7) Intensive green roof, 10 % Sedums, 60% herbaceous plants, 30% woody plants, 14 inch total thickness with automatic base water level irrigation, 1500 ft^2 and 400 ft above ground in impervious downtown core. 8 years old.

Project 5 did not support any ground-dwelling creatures were found, as expected. This project had been installed just one year earlier using Sedum cuttings, which creates a rather sterile environment in the first 5 years. During the day, however, the roof was visited by various bee species. Obviously the *Sedum album* and *Sedum sexangulare* flowers were worth the vertical journey 100 ft up. We know that wild bees do not seek a variety of plant species; they simply require a great number of certain flowers.

Project 6 and 7 looked different because these roofs are older, they support more plant diversity, and they are furnished with elements like concrete pavers, wooden edging or granite edging, etc. Most areas of these projects were planted and the roofs were older than 5 years.

In examining the species list below, it is interesting to note that the Common Woodlouse represents the majority of species observed. Dr. Mann speculates that furnishing elements create an ideal environment for this species, which is completed by the plants.

Projekt: 6

(Fangzeitraum: 20.06. - 06.07.2005)

Tiergruppe	Falle 1 extensiv	Falle 2 Hochbeet	Falle 3 Hochbeet	Summe
Ground Beetles	1	2	4	7
Spiders	3	1	0	4
Fliegen	4	10	14	28
Grasshoppers	2	0	0	2
Ants	22	3	5	30
Zikaden	23	3	1	27
Wanzen	2	4	2	8
Wood Louse	ca. 1.600	ca. 1.800	ca. 1.800	ca. 5.200
Snails (shell)	0	5	3	8
Slugs	0	0	3	3
Centipedes	2	2	2	6
Millipedes				5.323

Project: 7

(Fangzeitraum: 20.06. - 06.07.2005)

Tiergruppe	Falle 1 Beet 1	Falle 2 Beet 2	Falle 3 Beet 2	Summe
Ground Beetles	4	16	8	28
Spiders	2	1	0	3
Flies	1	1	0	2
Grasshoppers	1	0	0	1
Ants	14	24	68	106
Moths	0	0	4	4
Wanzen	0	12	0	12
Wood Louse	98	33	175	306
Snails (shell)	30	10	20	60
Slugs	13	0	16	29
Centipedes	62	4	7	73
Millipedes	2	0	2	4
				628

During the investigations on Project 6, only a few plants were flowering and most of the species observed in a particular area of the roof were bee species defending territorial boundaries.
Hardly any bumble-bees were found on Project 7 since the only flowing plants at the time of the study were Iris species which are not interesting for daily visitors. The maintenance crew reported innumerable bumble bees and other bees whenever *Alchemilla mollis* was flowering.

Captured ground-dwelling organisms:

In conclusion of his latest research, Dr. Gunter Mann concludes that various organisms can be found on green roofs, including green roofs on high-rise buildings. The species and families of organisms found on green roofs will depend on the type of green roof, its components, the thickness of the growing media and the vegetation used.

In comparing Mann's latest research with his earlier studies (1994, 1995, 1996 and 1998), it is apparent that green roofs 400 ft above the ground plane support the same biodiversity as green roofs on lower buildings.

Contrary to popular belief, the existence of certain faunal groups and the "ecological value" of green roofs depend mostly on the type of green roof; the height of the building has no significant influence. Even a low-profile 1 year-old extensive green roof that is located 100 ft. above the ground attracts numerous bee species.

While comparing green roofs on high-rise and lower buildings, Dr. Mann established some mentionable items:

- All kinds of bee species recognized flowering green roofs and visited the roofs regularly in great numbers.
- Bee body sizes vary, suggesting that small and large species are able to reach all roofs.
- The faunal group "beetles" was less represented in more recent research, with some small winged beetles found but no ground beetles.
- Butterflies weren't found in the latest research, however on earlier research they were found on comparable locations, many of these wind-exposed.

Conclusion

After nearly 15 years of research, Dr. Gunter Mann established meaningful results with regards to green roofs serving as permanent and temporary wildlife habitat. The height and exposure of the building are less relevant than the size of the green roof, the depth of the growing media, rooting volume and plant varieties. Furnishing large extensive green roofs with small intensive areas, some temporarily open water, dead wood with drilled holes of varying diameters, areas of coarse rock, breeding boxes for insects and nesting boxes for birds provide significant support for increasing the ecological value of green roofs. At the very least, such amendments can improve temporary or stepping-stone habitats into permanent habitat for some species.

The idea of creating native habitat on the roof is an illusion since rooftops are not connected to native habitats on the ground. This disconnect eliminates great components of the greater food web, such as larger mammals. However, it is possible to support the upper tiers of the food chain by installing large, inexpensive, standardized extensive green roofs with 5% - 10% intensive islands. Such designs support higher ecological value than the sum of all corn fields.

Many well-known ecologists in Germany also agree that providing both temporary and permanent habitat for a diversity of organisms is important for self-sustaining green roofs. Standardized components following the FLL guidelines boost these benefits to get healthier plants, higher reproduction of plants and, ultimately, less maintenance.

This field of research has begun to draw attention in recent years in Europe, but remains widely unexplored in North America. Dr. Mann's example shows that such work can be done simply, inexpensively and without high-tech but nonetheless yield meaningful results. It must be noted, however, that working with nature requires patience.

Expression of thanks

It is an honor to translate and present segments of the research of Dr. Gunter Mann, Optigreen International, Germany. His ongoing research on green roofs has contributed greatly to the success of green roofs in Europe, where more than 75 square miles of green roofs cover the landscape.

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